PRELIMINARY OBSERVATIONS OF LUNAE PLANUM, MARS: INTERPRETIVE FRAMEWORK FOR RADAR SOUNDER MARSIS INVESTIGATION OF THE REGION. G. Caprarelli[1-2], M. Cartacci[3] and R. Orosei[4], [1]University of South Australia, Div ITEE, GPO Box 2471, Adelaide SA 5001, Australia. Email: Graziella.Caprarelli@unisa.edu.au, [2]International Research School of Planetary Sciences, Viale Pindaro 42, 65127 Pescara, Italy, [3]Istituto Nazionale di Astrofisica e Planetologia Spaziali, Via Fosso del Cavaliere 100, 00133, Roma, Italy, [4]Istituto Nazionale di Astrofisica, Istituto di Radioastronomia, Via Piero Gobetti 101, 40129, Bologna, Italy.

Introduction: The radar sounder MARSIS has been orbiting Mars on board Mars Express for over 10 years, acquiring data globally, and making it a very useful tool to discover geologically significant subsurface structures. Analysis of the data from a specific study area requires however an accurate description of its surface, and interpretations of the observable surface features aimed at constraining its geologic history. This is problematic if no outstanding morphological features exist in the area.

In the eastern hemisphere of Mars, ground penetrating radar investigations of the Medusae Fossae Formation [1-2], a smooth and relatively featureless geologic unit bounding the dichotomy between the volcanic provinces of Apollinaris Patera and Olympus Mons, revealed a complex interplay of volcanic, glacial and fluvial processes. More recently, MARSIS data collected over Lucus Planum, the central lobe of the MFF, uncovered a variety of materials pointing to different origins by different geological processes [3-4].

It is plausible that Lunae Planum's flat surfaces hide a similarly complex geologic record. The planum is part of a belt of terrains located between the southern highlands and the northern plains, that are transitional in character (e.g., by elevation, age and morphology). These transitional belts are poorly understood, but are highly important to constrain and reconstruct the processes that produced and modified the crustal dichotomy during Mars's geologic past. We have therefore initiated a new investigation of the subsurface of the region centered around this plain.

As a preliminary step in our ground penetrating radar investigation, we carried out observations of the surface of Lucus Planum, integrating interpretation of the observed features with published information. Here we present a synthesis of our preliminary study.

Methods: We examined the study area using available imagery and topographic data, mapped and analysed using the on-line Java Mission-planning and Analysis for Remote Sensing (JMARS) GIS software (https://jmars.asu.edu), the open source GIS software QGIS (http://www.qgis.org/en/site/), and the open source software Python (https://www.python.org) and its scientific libraries.

Geographic and geologic synthesis: Lunae Planum is a vast Martian plain, south-bounded by Echus Chasma, Hebes Chasma, Juventae Chasma and the northernmost chasmata of Valles Marineris, and bounded to its north by Sacra Mensa and Kasei Valles. The plain comprises ridged terrains of Hesperian age, with MOLA elevations ranging from +2500 m to +500 m closer to the chasmata, and gently sloping northward to -500 m (Fig. 1). In planar view it is quasi-rectangular in shape, measuring approximately 1000 km in width, and 2000 km in length longitudinally.

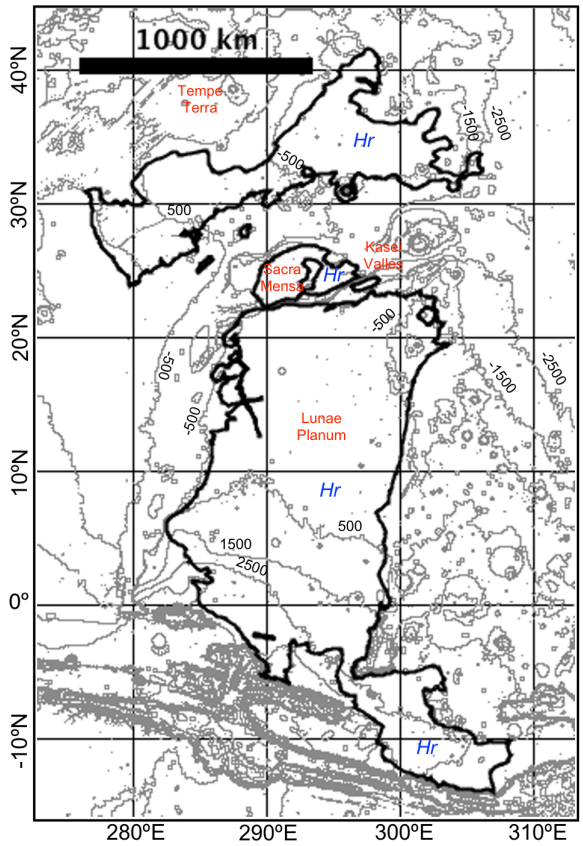

Fig. 1. Geographic context and MOLA topography of the study area shown by contour lines (contour interval: 1000 m). Map prepared using the open source software QGIS. Geologic unit shapefile overlain on basemap is from [5].

In addition to Valles Marineris, Lunae Planum is surrounded by major geologic features, such as the Tharsis Plateau and its volcanoes, the outflow channels

debouching into Chryse Planitia, and the mountainous region of Ceraunius, to the west of which lie Alba Patera and its graben-dyke system. In contrast to these examples of geological structures, among the most impressive in the entire solar system, Lunae Planum appears flat (Fig. 2), which makes it difficult to interpret geologically.

The surface of Lunae Planum is the type area for Hesperian unit *Hr* (ridged plains material), as described in [6]. Here wrinkle ridges, blind thrust faults expressed on the surface by elongated narrow highs often displaying a summit crenulation, are arranged as sub-parallel sets of ridges, regularly spaced (~ 25 km to 40 km by our measurements). The spacing has been suggested to indicate a relatively shallow (~ 30 km) brittle to ductile transition in the rheologic profile of the crust [7], while the ridges themselves suggest compression caused by the presence of thick layers of strata, possibly of volcanic or sedimentary origin.

The presence of fluidized ejecta craters scattered across the plain suggests that at time of impact the subsurface may have contained ice or other volatiles (Fig. 3).

Relevance of geologic context in sounder study: We need to take this geologic context into account when analyzing the MARSIS data set over this region.

Thrust faults are generally of low angle in relation to the strata layers: thus we expect reflections from the fault planes to be difficult to resolve and distinguish from the normal subsurface stratigraphy. We also need to account for the possibility that the thick stacks of rocks in the subsurface may be composed of material with the same physical properties, particularly the same value of the dielectric constant, which would not allow detection of possible geologic discontinuities, unless these are accompanied by density changes. It is also possible that compression of the layers may have forced some volatiles out of the material, which may therefore be compacted throughout regardless of its initial characteristics. However, our observations of fluidized ejecta impact craters cutting across wrinkle ridges (Fig. 3), suggest that the subsurface at the depths excavated by the impactors may have contained ice or volatiles after (probable) compression or compaction and consolidation of the material occurred.

We therefore conclude that is it reasonable to expect that, at least in some portions of Lunae Planum, and up to the depths probed by MARSIS (up to 2-3 km), our analysis of the data might reveal some changes in dielectric constant and density of the subsurface material. Our ongoing investigation will add to our understanding of the geology of this area, and help constrain formation and evolution models of the subequatorial transitional terrains of Mars.

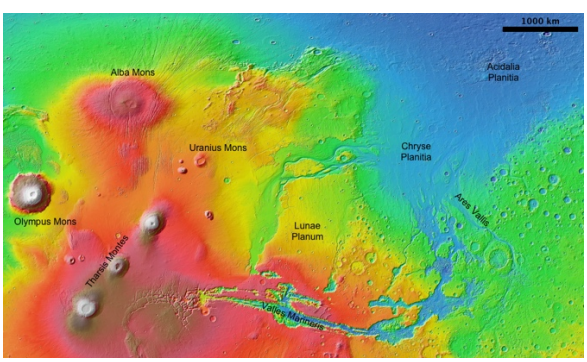

Fig. 2. False color map of the region surrounding Lucus Planum, showing the contrast between the plain and some major morphologic features of the western hemisphere.

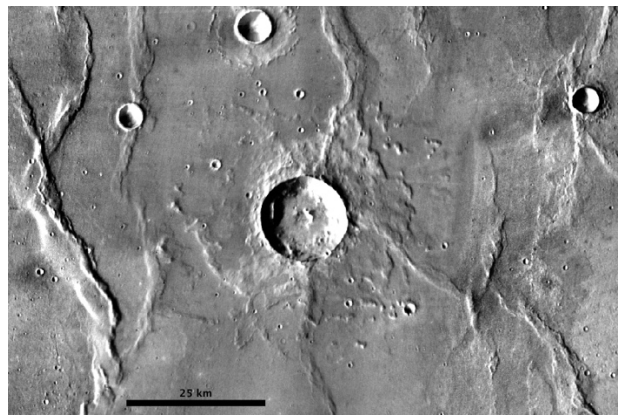

Fig. 3. THEMIS daytime infrared image of a fluidized ejecta crater centered at coordinates {298.695°E; 13.742°N}. Even though the surface is covered by dust and other fines (ref. to thermophysical class 4 in [8]) partially obscuring the morphologies, it is evident that the crater intercepts a wrinkle ridge, but is not displaced by it (the crater rim is circular, except for some minor possible post-emplacement degradation), indicating that the impact occurred after the ridge formation. Other small craters are also observed to cut across the trace of wrinkle ridges, supporting this interpretation.

References: [1] Watters T. R. et al. (2007) *Science*, 318, 1125-1128. [2] Carter L.M. et al. (2009) *Icarus*, 199, 295-301. [3] Caprarelli G. et al. (2016) *AGU Fall Meeting*, Abstract #P51C-2155. [4] Orosei R. et al. (*under review*). [5] Skinner, J. A. et al. (2006) *LPSC XXXVII*, Abstract #2331. [6] Greeley R. and Guest J.E. (1987), USGS Misc. ISM I-1802B, 1:15M. [7] Montési L.G.J. and Zuber M.T. (2003) *J. Geophys. Res.*, 108(E06), 5048, 10.1029/2002JE001974. [8] Jones E. et al. (2014) *Remote Sensing*, 6(6), 5184-5237.