SHARAD ANALYSIS OF PROMETHEI LINGULA (MARS): EVIDENCES OF ANGULAR UNCONFORMITIES AND POSSIBLE "CREVASSE-LIKE" STRUCTURES WITHIN SOUTH POLAR LAYERED DEPOSITS. L. Guallini[1], S. Lauro[2], L. Marinangeli[1], E. Pettinelli[2], R. Seu[3], [1]IRSPS, Università d'Annunzio, V.le Pindaro 42, Pescara, Italy, guallini@irsps.unich.it, [2]Dipartimento di Fisica Università Roma Tre, Via della Vasca Navale 84, Roma, Italy, [3]Dipartimento INFOCOM, Università Roma La Sapienza, Via Eudossiana 18, Roma, Italy.

Introduction: The presence of stratigraphic unconformities within Polar Layered Deposits (PLD) sequences have been observed in both the martian poles through visible images. These surfaces have been suggested as related to periods of erosion of the units, that alternated themselves to depositional stages [1, 2, 3, 4]. In particular, Shallow Radar (SHARAD; [5]) analysis of Promethei Lingula region (PL) evidenced that South PLD (SPLD) can be interested by peculiar reflectors geometries, locally resulting in the interruption of their continuity [3, 6]. These features have been interpreted as lateral pinch-out closure of the sequences, not necessarily entailing surfaces along which reflections are truncated (i.e. angular unconformity surfaces). At the same time, broad deformational systems interesting the SPLD have been identified and structurally characterized along the PL margins, but only in imagery dataset [7, 8].

The present work locates possible radar angular unconformities in PL region (Fig. 1a-d) and, together with visible analysis [4, 9], widens to a regional scale the volume of SPLD interested by a depositional hiatus during the past. In the same region, we found also possible subsurface "crevasse-like" structures (Fig. 1e-f), never reported until now.

Methodologies: To analyze the PL subsurface, several hundreds SHARAD orbits have been screened, covering almost at all the PL region. The sounding radar, provided by Italian Space Agency (ASI), operates at a central frequency of 10 MHz bandwidth (20 MHz of central frequency), with a theoretic vertical resolution of ~7 m in free space (at 10 MHz of bandwidth) and ~15 m (at 20 MHz of bandwidth), an along track footprint of about 0.3 km - 1.0 km and a cross-track footprint of about 3 - 7 km. In the radargrams, the y-axis generally represents the time delay of the echoes (in micro-seconds) but, in the present case, is migrated in depth by using (according to the literature and only below the reflection corresponding to the SPLD surface), a relative dielectric constant of 3.2 (equivalent to water ice mixed with basaltic particles). When possible, radar tracks have been simulated using algorithms developed by the Italian SHARAD team to identify the most important clutters. Topographic basemaps are from MGS MOLA 512 pix/degree (115 m grid spacing).

Radar Unconformities: Several pinch-out structures (28 at all; white and red lines in Fig. 1a) have been mapped, in most of the cases characterized by possible reflectors truncations at angle. In average, the stratigraphic structures have a lateral extension of about 100 km, and are focused in three different areas of PL.

The first one is comprised between 110°E-130°E of longitude and 80°S-85°S of latitude and it is derived from a group of two sets of intersecting radar orbits, all suggesting the same erosional surface. This area is located in the medium part of the PL as an ideal prosecution, equatoward, of the Australi Sulci. With respect to the PL ice-sheet extension, looking at the longitudinal radar profiles (Fig. 1c), two packs of reflectors converge eastward (i.e. toward the PL margins), forming, in section view, a stratigraphic wedge. In particular, down to the base of the upper sequence, some of the reflectors are clearly truncated against the stratigraphic roof of the lower sequence, suggesting an erosional contact between them. This latter is located at the elevation of ~1900 m-2000 m in average (derived from the difference between the elevation of the topographic surface and the inferable depth of the erosional surface). The same structural configuration is derivable looking at the transversal orbits (i.e. looking at the same structures with a different point of view; Fig. 1d), strongly reinforcing the idea that this unconformity is a real structure. The considerable number of radar tracks passing in the same area, allows us to interpolate the single observed 2D unconformities, deriving a continuous plane (approximate area of 10000 km^2), roughly dipping toward SE (~0.05°-0.1° of dip angle). The second location is comprised in the same range of latitude of the previous one, but between the longitudes of 100°E and 110°E. Again, two sets of crossing radargrams show two groups of reflectors, disposed at an angle and, thus, spaced out by an inferable angular unconformity. This latter surface is higher than the one observed in the first radar location, and dips toward the PL margins (i.e. toward East) with a low angle (~ 0.1-0.2°). Imaging to prolong it toward the PL margin, the unconformity intersects the topographic surface in correspondence of the scarp, where an angular unconformity is exposed. The same stratigraphic plane is suggested by transversal radargrams passing in the same area, but resulting, in this direction, sub-horizontal and, possibly, exposed along the Chasma Australe slopes. A third zone of possible subsurface unconformities is placed barely outside the PL ice-sheet (150°E-160°E Lon, 75°S-80°S Lat), nearby the Ultimum Chasma.

Radar "Crevasse-Like" Structures: SHARAD seems to occasionally highlight in the SPLD subsurface peculiar features, characterized by a dark vertical strip (no signal zone) breaking (and sometimes slightly vertically displacing) the continuity of the radar reflectors.

Looking at the PL plan-view, all these structures are located in the medium portion of the ice-sheet, between 81°S-83°S of latitude and 108°E-120°E of longitude (Fig. 1e). The observed dark-zones are inferable as more than 300 m in width and they continue down to several hundred meters. In most of the cases they seem to disappear upward, in correspondence of the SPLD surface (where the radar reflectors are again present) and to interest the entire stratigraphic sequence (Fig. 1f). Even if with different sizes, similar radar features have been widely reported within the terrestrial ice-sheets (e.g. [10, 11]) and are typically inferred as due to the presence of subsurface crevasses, detected by means of the Ground Penetrating Radar (GPR). This subsurface fractures usually form at surface, later buried by the deposition of an upper layers sequence, but can also form at depth, with no rebounds at surface [10]. This last case seems to be consistent with our observations.

Discussion and Conclusions: SHARAD dataset confirm the existence of one regional unconformity in PL subsurface, spacing out two main stratigraphic sequences within the SPLD. These features are consistent with the unconformity Aun2 [4, 9], marking the contact between two regional units, defined in the visible images and with previous authors analysis [1]. Such configuration entails two main depositional phases at least, interrupted by one period of erosion, removing the basal sequence at regional scale. Thus, possible different climate conditions during the past would have occurred, interesting the entire PL region. The presence of "crevasse-like" structures itself, carving the SPLD, would supports this hypothesis. If confirmed (further studies are ongoing) crevasses presence strongly support a regional past ice flow of PL ice-sheet, related to ancient warmer conditions of the southern polar region, as the exposed deformational systems [7, 8] suggest.

References: [1] E.J. Kolb & L. Tanaka (2006) *Mars, 2*, 10.1555/mars.2006.0001. [2] S.M. Milkovich & J.J. Plaut (2008) *JGR, 113*, E06007, 10.1029/2007JE002987. [3] S.M. Milkovich et al. (2009) *JGR, 114*, E03002. [4] L. Guallini et al. (2010) *LPSC 41st*, Abstract #1721. [5] R. Seu et al. (2004) *PSS, 52*, 157-166. [6] R. Seu et al. (2007) *Science, 317*, 1715-1717. [7] L. Guallini et al. (2011) *LPSC 42nd*, Abstract #1678. [8] L. Guallini et al. (under review) *Icarus*. [9] L. Guallini (2012, in prep.), *Ph.D. Thesis,* Università d'Annunzio. [10] Nath P.C. & Vaughan D.G. (2003) *JGR, 108*, B12020. [11] Taurisano et al. (2006) *Cold Regions Science and Techn.*, *45*, 166-177.

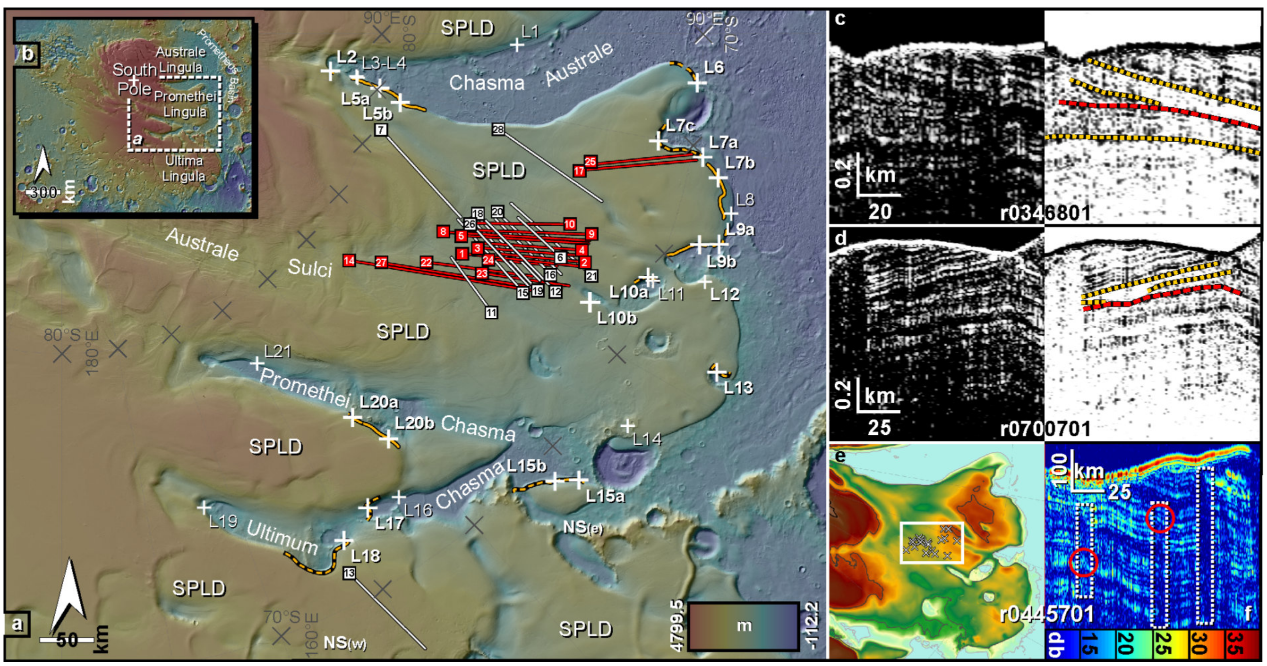

Fig. 1 a, b) PL MOLA topography and plan-view location of mapped subsurface unconformities along SHARAD orbits (red and white lines from 1 to 28). White crosses (L1-L21) indicates the stratigraphic sections analyzed at visible wavelenghts [9]: yellow lines are mapped angular unconformities (dashed lines) or inferable disconformities (solid lines). c, d) Examples of subsurface angular unconformity Aun2 (red dashed line; located respectively along lines 8 and 20 in Fig. 1a) between two sets of reflectors disposed at angle (upper and lower radar sequences). The two crossing tracks observe the same erosional surface with a different point of view (in Fig. 1c West is on the left, whereas in Fig. 1d SE is on the left). e) Plan-view location on MOLA topography of subsurface radar "crevasse-like" structures (white crosses within the inset). f) Crevasse-like structures (white dotted insets) within SPLD (colors represent power of reflection). Several evidences suggest them as real fractures, as mainly: 1) A no-signal zone in their correspondence and a partial hyperbolic shape and/or slight warp of the inferable layers (focused by red circles), as seen from GPR on terrestrial ice-sheets; 2) The presence of reflectors upon the inferred crevasse (entailing continuous layers upon the no-signal zone); 3) The absence of significant topographic irregularities at surface, that could gives rise to false scattering; 4) The absence of peaks on the power reflection of the surface preventing the transmission of the radar waves in the subsurface; 5) The concentration of the surveyed structures in the PL inland, as expected in the ice-sheets.