RADAR SOUNDING BY MARSIS OVER LUCUS PLANUM, MARS. R. Orosei[1], F. Cantini[2], G. Caprarelli[3-4], L. M. Carter[5], I. Papiano[6] and A. P. Rossi[7]. [1]Istituto Nazionale di Astrofisica, Osservatorio di Radioastronomia, Via Piero Gobetti 101, 40129 Bologna, Italy, roberto.orosei@inaf.it. [2]Ecole Polytechnique Federale de Lausanne, Space Engineering Center, EPFL ESC, Station 13, 1015 Lausanne, Switzerland. [3]University of South Australia, Div ITEE, GPO Box 2471, Adelaide SA 5001, Australia. [4]International Research School of Planetary Sciences, Viale Pindaro 42, Pescara 65127, Italy. [5]NASA Goddard Space Flight Center, 8800 Greenbelt Rd, Greenbelt, MD 20771, USA. [6]Liceo Scientifico Augusto Righi, Viale Carlo Pepoli 3, 40123 Bologna, Italy. [7]Department of Physics and Earth Sciences, Jacobs University Bremen, Campus Ring 1, 28759 Bremen, Germany.

Introduction: Lucus Planum, extending for a radius of approximately 500 km around 181°E, 5°S, is part of the Medusae Fossae Formation (MFF), a set of several discontinuous deposits of fine-grained, friable material straddling across the Martian highland-lowland boundary. The MFF has been variously hypothesized to consist of pyroclastic flows [1-3], pyroclastic airfall [4-6], paleopolar deposits [7], or atmospherically-deposited icy dust driven by climate cycles [8]. A branching positive relief system within Lucus Planum was interpreted by [9] as an ancient fluvial system originating from seepage sapping, implying that Lucus Planum was volatile-rich.

Parts of the MFF have been probed through radar sounding by MARSIS [10] and SHARAD [11], synthetic-aperture, low-frequency radars carried respectively by ESA's Mars Express and NASA's Mars Reconnaissance Orbiter. They transmit low-frequency radar pulses that are capable of penetrating below the surface, and are reflected by any dielectric discontinuity present in the subsurface. MARSIS is optimized for deep penetration, with a free-space range resolution of approximately 150 m, a footprint size of 10-20 km in the across-track direction ranges and 5-10 km in the along-track direction. SHARAD enjoys a tenfold better resolution, at the cost of reduced penetration.

The dielectric permittivity of the MFF material, estimated from data of both radars [12-13], is consistent with either a substantial component of water ice or a low-density, ice-poor material. There is no evidence for internal layering in SHARAD data [13], despite the fact that layering at scales of tens of meters has been reported in many parts of the MFF [14]. This lack of detection can be the result of one or more factors, such as high interface roughness, low dielectric contrast between materials, or discontinuity of the layers.

Method: After more than 10 years of observations, MARSIS has acquired about 240 orbits across Lucus Planum, making it possible to map the presence and depth of subsurface interfaces to a much greater detail than in previous works. Radar echoes are affected by dispersion through the ionospheric plasma to an extent determined mostly by the local solar zenith angle and solar activity, but the resulting broadening and weakening of the echoes can be corrected for moderate values of the total electron content and the maximum plasma frequency [15]. Once re-focused, echoes are compared to simulations of surface radar scattering [16]. Any secondary echo visible in radargrams but not in simulations is interpreted as caused by subsurface reflections (see Fig. 1).

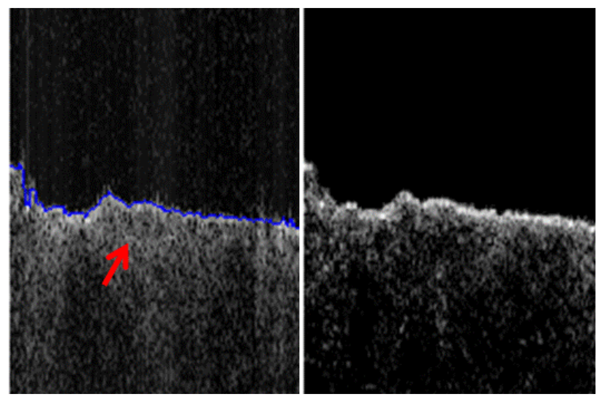

Fig. 1: Comparison between a real (left) and a simulated (right) radargram for orbit 10262. A radargram is a representation of radar echoes acquired continuously during the movement of the spacecraft as a grey-scale image, in which the horizontal dimension is distance along the ground track, the vertical dimension is the round trip time of the echo, and the brightness of the pixel is a function of the strength of the echo. The simulation reproduces echoes from surface topography only, while real data contain both surface and subsurface echoes. The red arrow point at weak subsurface reflections.

Results: The positions and strengths of subsurface echoes were extracted manually from radargrams and mapped across Lucus Planum, converting echo time delay to apparent depth (see Fig. 2). The strongest subsurface echoes, resulting from weak internal attenuation, strong subsurface reflectivity, or both, are found within the deposits located NW of Apollinaris Patera, while no subsurface echoes could be detected in the central section of Lucus Planum, in spite of several high-SNR observations. Subsurface reflections are common in the Eastern and Northwestern sectors, in some cases to depths of more than 2000 m assuming a dielectric permittivity of about 3 [12][13].

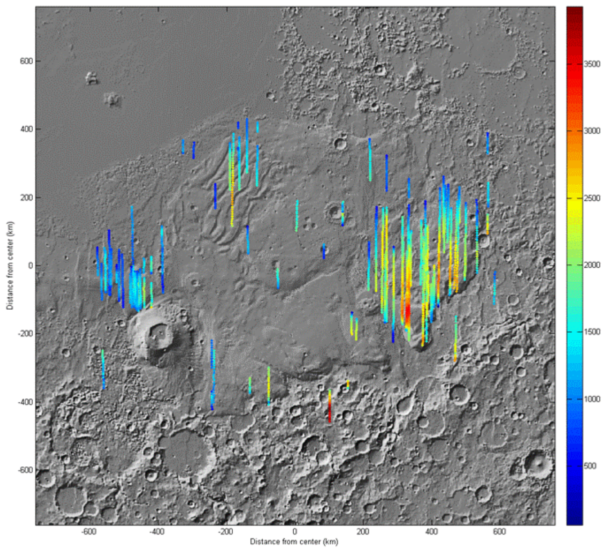

Fig. 2: Shaded relief map of the Lucus Planum area, showing the position and the color-coded apparent depth of subsurface echoes detected by MARSIS. Apparent depth differs from actual depth by a factor given by the square root of the dielectric permittivity. Subsurface echoes are presumably produced by the dielectric contrast between the material of which Lucus Planum is made and the underlying bedrock.

Discussion: The lack of subsurface reflections in the central part of Lucus Planum can be the result of several factors, some of which depend on surface properties. A high topographic roughness at scales comparable to the radar wavelength causes scattering of the impinging pulse, resulting in weaker surface and subsurface echoes. However, surface roughness estimated from MOLA data [17] [18] is higher in the Eastern part of Lucus Planum. Another possibility is that roughness at the base of the deposit is higher in its central part, although there is no indication of such kind of trend in the older surrounding terrains. Because subsurface echoes appear to be closely associated with areas of distinct surface morphology, it is possible that Lucus Planum is in fact laterally inhomogeneous and that the central part consists of denser, more radar-attenuating material.

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