MEEM: AN ORBITAL SYNTHETIC APERTURE RADAR FOR MARS EXPLORATION. Ph. Paillou[1], T. W. Thompson[2], J. J. Plaut[2], P. A. Rosen[2], S. Hensley[2], Ch. Elachi[2], D. Massonnet[3], J. Achache[3]. [1]Observatoire Astronomique de Bordeaux, BP 89, 33270 Floirac, France, paillou@observ.u-bordeaux.fr. [2]Jet Propulsion Laboratory, 4800 Oak Grove Dr., Pasadena, CA 91109, USA. [3]CNES, 2 pl. Maurice Quentin, 75036 Paris, France.

Introduction: The recent results of Mars Global Surveyor (MGS), in particular the ones of MOC (high resolution camera) and MOLA (laser altimeter), have revealed a new face of Mars [1]. They especially rise some crucial questions related to the past existence of liquid water at the surface of Mars [2] and the paleo ocean hypothesis in the Northern hemisphere [3] (geomorphological and sedimentary signatures). MOC images indicate that much of the surface of Mars has been intensely reworked by aeolian processes, and key evidence about the history of the Martian environment seems to be hidden beneath a widespread layer of debris (paleo lakes and rivers) [4]. The global analysis of the Martian topography was made possible by altimetric measurements of MOLA, which provided us a DEM (Digital Elevation Model) of the whole planet with a grid spacing of about one kilometer. Results published up to now relaunch the hypothesis of a northern ocean as an explanation for the North-South dichotomy of Mars, but there are still a lot of questions to answer, needing for finer topographic analysis and subsurface imaging, to understand the history of water on Mars: detection of shorelines and paleo rivers, smoothness of the ocean floor, dating of the associated geological structures.

SAR Capabilities: The Mars Environment Evolution Mission (MEEM) concerns a new instrument, fully original in the Mars exploration history, which allows imaging of the near subsurface geomorphology inaccessible to any other kind of sensor [5]. Earth-based radar imaging of Mars indicates that substantial penetration (meters) is obtained at 12 cm radar wavelength and shuttle radar observations of terrestrial deserts reveal subsurface structures invisible to other sensors (cf. Fig.1), to depths of about 2 meters using L-Band (24 cm) radar [6]. Recent laboratory measurements of terrestrial analogs for Martian soils and rocks, combined to numerical modeling, indicate that a P-Band (70 cm) SAR should penetrate at least 5 meters deep as shown in Fig.2 [7].

Using radar interferometry to produce high resolution DEMs [8] (cf. Fig.3), MEEM will also continue and improve the work initiated by MOLA, with a density of measurement points at least 400 times higher (cf. Fig.4), and the ability to very accurately monitor the temporal changes of the Martian surface [9, 10] (evaporation and deformation of polar caps, dust deposits, tectonics ?). A Mars radar mapping mission will also allow the high resolution mapping of the surface roughness. This roughness information will be used as a new tool to map – and even to perform relative dating of – the Martian geological units, and define future landing sites and rover paths [11]. Such data will permit a comparative study of Martian and Venusian surfaces, by combining MEEM and MAGELLAN radar images [12].

Proposed Mission: The proposed mission [13] would use a dual-frequency SAR (L and P-Bands) to map the planet at 50 m resolution, penetrating 5-10 m over much of the surface (cf. Fig.5). Selected targets will be imaged at 5 m resolution. Using repeat-pass interferometry, a 50 m resolution topographic map will be acquired within a year, and surface changes will be detected and monitored for two additional years. The instrument will also accommodate a nadir-looking high resolution sounding mode, to bridge the gap between the deep subsurface sounding of MARSIS on MARS EXPRESS [14] and the surface imaging of conventional sensors. The mission would launch in August or September 2009, followed by an Earth to Mars cruise with an arrival at Mars in July or August 2010. The orbit would be circularized using aerobraking. Data acquisition for a global radar map of Mars would commence in July 2011 and continue for a year until July 2012.

The Delta IV Med-lite launch vehicle would have a mass margin of over 600 kg which could be used for additional orbital instruments as well as piggyback surface probes or other micro-missions. We assumed an antenna that would support both the SAR and Direct-to-Earth data downlinks. This dual-use SAR/Downlink Antenna would have a 3 m solid interior and a deployed outer mesh creating an aperture with 6 m diameter. An antenna of this size would support data downlink of several Mbits/s, allowing the coverage of the whole Martian surface within the foreseen mission lifetime. The stowed antenna at launch would be only 3 meters in diameter, which fits within the Delta launch vehicle shrouds.

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References:

[1] http://mars.jpl.nasa.gov/mgs/ (2001). [2] Malin, M. C., Edgett, K. S. (2000), *Science*, vol. 288. [3] Head, J. W. III, *et al.* (1999), *Science*, vol. 286. [4] Metzger, S. M. (1999), *5th Int. Conf. Mars*. [5] Thompson, T. W., *et al.* (2000), *LPSC XXXI*. [6] Elachi, *et al.* (1984), *IEEE Trans. Geos. Rem. Sens.*, vol. GE-22. [7] Heggy, E., *et al.* (2000), *EGS'00*. [8] http://www.jpl.nasa.gov/srtm/ (2001). [9] Rosen, P. A., *et al.* (1997), *GRL*, vol. 25. [10] Massonnet, D., et al. (1993), *Nature*, vol. 364. [11] Baghdadi, N., *et al.* (2000), *IJRS*, vol. 21. [12] Head, J. W., *et al.* (1992), *JGR*, vol. 97, no. E8. [13] Team X (2000), *Mars SAR*, JPL. [14] http://sci.esa.int/home/marsexpress/ (2001).

Fig.1: LANDSAT-TM / SIR-A composition of the Northern desert in Sudan (JPL/USGS, 1981). L-band radar reveals paleohydrology covered by dry sand.

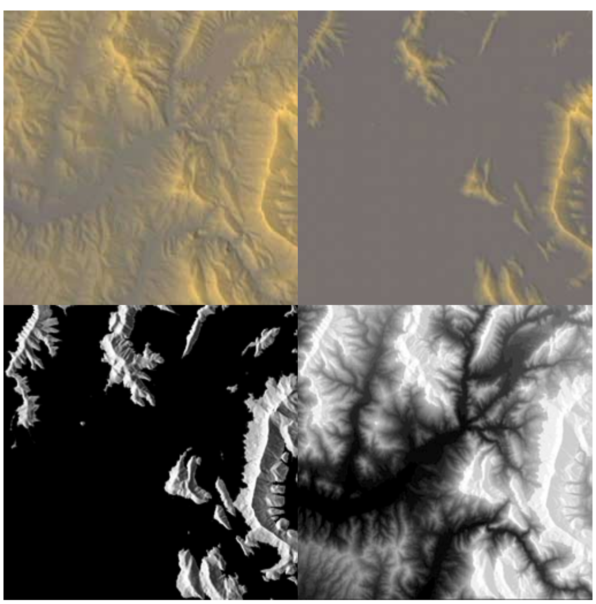

Fig.2: A simulated landscape (top left) covered by 4 m of sediments (top right), and corresponding C-Band (bottom left) and P-Band (bottom right) SAR images.

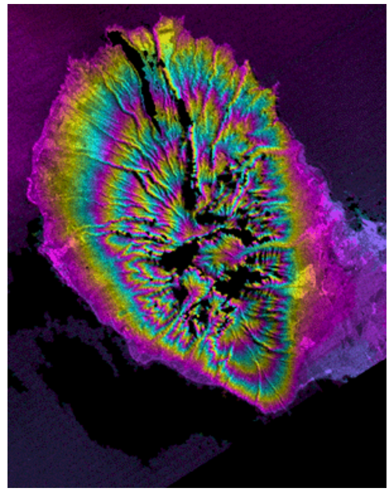

Fig.3: SRTM radar image of West Maui, Hawaii, with wrapped color as height (JPL/NASA, 2000).

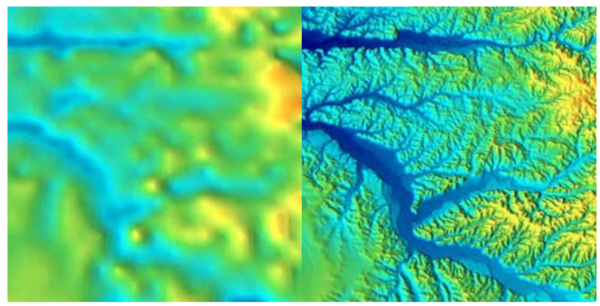

Fig.4: DEM of a valley network in the South of France (IGN, 2000), as seen with the MOLA 1 km grid spacing (left) and the MEEM 50 m grid spacing (right).

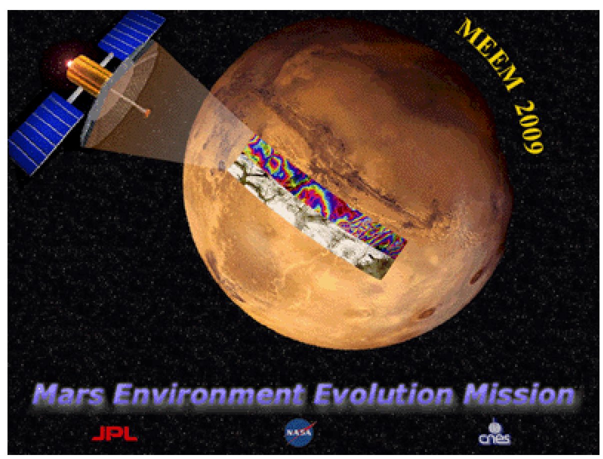

Fig.5: Artist's view of the MEEM mission.