MARSIS SUBSURFACE SOUNDING OBSERVATIONS OF THE SOUTH POLAR LAYERED DEPOSITS OF MARS. J. J. Plaut[1], G. Picardi[2], A. Cicchetti[2], S. Clifford[3], P. Edenhofer[4], W. Farrell[5], C. Federico[6], A. Frigeri[6], E. Heggy[3], A. Herique[7], A. Ivanov[1], R. Jordan[1], W. Kofman[7], C. Leuschen[8], L. Marinangeli[9], E. Nielsen[10], G. Ori[9], R. Orosei[11], E. Pettinelli[12], R. Phillips[13], D. Plettemeier[14], A. Safaeinili[1], R. Seu[2], E. Stofan[15], G. Vannaroni[16], T. Watters[17], I. Williams[18]. [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109, plaut@jpl.nasa.gov. [2]Infocom Department, “La Sapienza” University of Rome, 00184 Rome, Italy. [3]Lunar and Planetary Institute, Houston, TX 77058. [4]Fakultaet fuer Elektrotechnik und Informationstechnik Ruhr-Universitaet Bochum, D-44780 Bochum, Germany. [5]NASA/Goddard Space Flight Center, Greenbelt, MD 20771. [6]Dipartimento di Scienze della Terra, Università degli Studi di Perugia, 06123 Perugia, Italy. [7]Laboratoire de Planetologie de Grenoble, 38041 Grenoble Cedex, France. [8]Applied Physics Laboratory, Johns Hopkins University, Laurel, MD 20723. [9]Int'l Research School of Planetary Sciences, Universita' d'Annunzio, 65127 Pescara Italy. [10]Max Planck Institute for Solar System Resarch, 37191 Katlenburg-Lindau, Germany. [11]Istituto di Astrofisica Spaziale e Fisica Cosmica, Istituto Nazionale di Astrofisica, 00133 Rome, Italy. [12]Dipartimento di Fisica, University of Rome 3, 00146 Roma, Italy. [13]Department of Earth and Planetary Sciences, Washington University, St. Louis, MO 63130. [14]Fakultaet fuer Elektrotechnik und Informationstechnik, Technische Universitaet Dresden, D-01062 Dresden, Germany. [15]Proxemy Research, Laytonsville, MD 20882. [16]Istituto di Fisica dello Spazio Interplanetario, Istituto Nazionale di Astrofisica, 00133 Rome, Italy. [17]Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, Washington, D.C. 20560. [18]Astronomy Unit, School of Mathematical Sciences, Queen Mary, University of London, UK.

Introduction: The polar layered deposits of Mars are ice-rich, finely stratified materials that may provide information on the climate history of the planet. The deposits represent the largest observed reservoir of water on Mars, estimated to be equivalent to a global water layer 22-33 m thick [1]. The Mars Advanced Radar for Subsurface and Ionospheric Sounding (MARSIS) on the Mars Express orbiter obtained data over the North Polar Layered Deposits (NPLD)and found that they were easily penetrated to their base by the radar signal, and that the deposits must be nearly pure ice [2]. In addition, there was no evidence for deflection of the lower contact of the NPLD with the substrate, implying a thick elastic lithosphere beneath that sector of the NPLD. Here we report on new MARSIS observations of the South Polar Layered Deposits (SPLD).

MARSIS Instrument and Data: MARSIS is a multi-frequency synthetic aperture orbital sounding radar. In its subsurface modes, MARSIS operates in four frequency bands between 1.3 and 5.5 MHz, with a 1 MHz instantaneous bandwidth that provides free-space range resolution of approximately 150 m. Lateral spatial resolution for the cross-track footprint is 10-30 km, and for the along-track footprint, narrowed by onboard synthetic aperture processing, 5-10 km. Observations of the SPLD began in early November 2005 and are continuing. As the orbit of Mars Express precesses, the latitude of periapsis and the illumination conditions are nearly optimal for observations of the highest southern latitudes. As of early January 2005, MARSIS has acquired over 100 successful sounding observations of the SPLD, and several hundred more are expected, which should provide nearly complete coverage of the unit. All 4 MARSIS subsurface frequency bands have been used. Most observations were made with two bands simultaneously. In addition to the nominal onboard-processed spectra, raw echoes were recorded and downlinked for selected segments of a number of orbits.

Observations: The radar echoes from the surface of the SPLD are typically comparable in strength or weaker than those from surrounding smooth Mars surfaces. The signals clearly penetrate deep into the deposits at all frequency bands. In most cases, a strong reflection is seen at a time delay consistent with the expected depth of the contact of the SPLD materials with the substrate, as observed on the NPLD [2]. Over the highest elevation SPLD surfaces, near 0° longitude, the estimated depth to the lower interface is about 3 km. In some areas, the lower interface is not clearly detected. Multiple internal interfaces are common. These can be quite continuous, over several 100 km in many cases. Some internal interfaces are substantially brighter than others, and some differences are seen in the apparent internal structure at different MARSIS frequencies. Certain regions observed multiple times consistently show a strong local brightening of the echo from the lower interface. Many areas show a gradual, rather than abrupt, decline in echo strength at time delays beyond the lower interface. Thin layered units off the main SPLD are also penetrated by MARSIS, with a second interface detected at their lower boundaries.

Preliminary interpretations: The deep lower interfaces are interpreted as the base of the ice-rich SPLD unit, in contact with a relatively ice-poor substrate. As in the case of the NPLD, the strong reflection from the lower interface implies very low loss and indicates that the bulk of the SPLD material is likely to be fairly pure ice, with dust fractions of probably only a few percent. The detection of internal layering clearly implies contrasts in electrical properties, but it is not known whether these are due to compositional, density, textural or other differences in the layers. Apparent differences in internal structure seen at different MARSIS frequencies suggests that some wave interference effects may be occurring within the volume of the layers, and/or that multiple fine layers may coalesce into a single observed layer, depending on the radar frequency. The internal layering appears disrupted in certain places, which may be the effect of draping over buried topography, or of post-depositional modification by flow, thermal or impact processes. The MARSIS data of the SPLD will provide the opportunity to estimate the three-dimensional shape of the deposit. This should allow for a new estimate of the water inventory of the SPLD, as well as further examination of effects of the overburden on the martian lithosphere. We also plan to search for correlations between the MARSIS-observed internal layering and that exposed at SPLD troughs and margins.

References: [1] Smith, D.E. et al (1999) Science 284, 1495. [2] Picardi, G. et al (2005) Science 310, 1925.