Direct reconstruction of dielectric constant profile from orbital based radar sounder data

D.V. Kartashov (1), O.B. Shchuko (2), V.I. Turchin (1), R. Orosei (3)

(1) Institute of Applied Physics RAS, Nizhny Novgorod, Russia

(2) Radiophysical Research Institute, Nizhny Novgorod, Russia

(3) Istituto di Astrofisica Spaziale e Fisica Cosmica – INAF, Rome, Italy

(dekart@ufp.appl.sci-nnov.ru / Phone: +7-8312-164907)

Orbital based high frequency sounding radars are considered as very effective tool to investigate the subsurface structure and lithology of planetary crust. For example, the Mars Express spacecraft is carrying space borne radar sounder, called Mars Advance Radar for Subsurface and Ionospheric Sounding (MARSIS), in order to map Mars subsurface dielectric characteristics. MARSIS should provide profiles of the electron density in the Martian ionosphere and detection of dielectric discontinuities in the subsurface. These data will provide a unique ability to detect and to map the subsurface distribution of water which is supposed to be buried under surface on a global basis with a single spacecraft. Such a reconnaissance would likely also yield significant new insights regarding the subsurface structure and lithology of the crust, including the nature of the polar layered deposits. After successful antenna deployment MARSIS has started data acquisition and now these data are under processing by MARSIS scientific team. Another European space project to Mars is SHARAD project for radar based investigations of Martian polar caps deposits.

Detecting discontinuities in the crust presents many challenges for orbital radar sounder: one that must be overcome is the presence of radar scattering from the surface (clutter), expected to be detected by the sounder antennas at the same time as any echoes arising from subsurface interfaces. To evaluate the effects of off-nadir surface clutter on the instrument performance, it is necessary to predict the range of scattering behavior that may be expected from the surface topography. This problem is under intensive investigations today because its importance to evaluate data processing algorithm capable to distinguish parasitic clutter signals from subsurface discontinuities reflections. Assuming that the problem of surface scattering is eliminated due to efficient data processing, there is a problem how to reconstruct dielectric properties of the crust from radar echoes sequence. There are many attempts for indirect solution of this problem. But all these approaches assume some model stratification of Martian crust to calculate numerically reflected echoes which can be compared subsequently with real data set and than some iterative procedure can be implemented to achieve the best agreement between simulations and experiment. However each layer in layered

structure is characterized by two parameters – layer thickness and dielectric constant. Thus iterative procedure becomes very sophisticated if the number of layers is large enough.

In this report we present effective numerical procedure for direct reconstruction of dielectric constant from reflected radar signal. This routine is implemented for reconstruction of dielectric constant distribution of modeling crust structure for different MARSIS working bands. Since discovery of buried water deposits is one of the main goals of MARSIS project we considered dry layered model of crust and porous layered model with pores saturated by water. We discuss also the influence of different factors such as surface clutter, losses, dispersion of refraction index and losses on the stability and reliability of the result of reconstruction and implementation of this technique for processing of SHARAD data.