4-D MODEL OF CO_2 DEPOSITION AT NORTH AND SOUTH OF MARS FROM HEND/ODYSSEY AND MOLA/MGS.

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Introduction: The first 1.5 year of neutron mapping measurements onboard Mars Odyssey spacecraft are presented based on High Energy Neutron Detector (HEND) observations. HEND instrument is a part of GRS suite responsible for registration of epithermal and fast neutrons originating in Mars subsurface layer [4,6]. The scattering of fast neutrons in Mars surface caused by primary cosmic rays is strongly sensitive to presence of hydrogen atoms. Even several percents of subsurface water significantly depress epithermal and fast neutron flux [1,2]. It turns orbit neutron spectroscopy into one of most efficient methods for finding distribution of subsurface water.

The Mars Odyssey observations revealed huge water-ice regions above 60N and 60S latitudes[3-6]. It was founded that distribution of subsurface water has layered structure at these regions. It is thought that more than 50% wt water ice covered by relatively dry layer with different thickness[6,9].

The mentioned South and North areas are highly affected by seasonal CO_2 global circulation process. Thus the CO_2 snow depth varied from tens of cm up to ~1m at the latitudes above 60 degrees [7]. Taking into account that maximal sensitivity of neutrons measurements happened at depths less then 2-3 m one may expect significant variations of neutron signal trough martian seasons. It occurs because CO_2 frost hides upper surface layer from the orbit observations. The first search of seasonal effects in neutron data reveals that possible variation of neutron flux between summer and winter time may vary from several percents at 55^0-60^0 latitiudes up to several times for near polar regions[8,9]. In this study we used more large dataset gathered for the first 1.5 year successful operation of Mars Odyssey mission. It covered time period from late winter up to early fall in Northern hemisphere. It gives the possibility to follow the history of sublimation process of CO_2 frost on the North and its accumulation on the South.

Instrument: HEND consists of four detectors to provide measurements of neutron signal from red planet in broad energy range. Three proportional counters coated by different thickness of moderator have maximal efficiency in 1eV- 1keV, 10eV-100keV and 10ev - 1meV energy ranges correspondingly. The organic scintillator created with using stilben crystal guarantee registrations of very energetic neutrons from 1MeV up to 10 MeV. The spectral shape of signal from this detector is measured with 16-channels resolution which allow to select high energy neutrons with energy more then several MeV for farther analysis. There is direct correspondence between energy of registered neutron and depth where it was produced. The production rate of fast neutrons has maximum at depths less than tens of centimeters while the epithermal neutrons originate in layer placed 1-3 m below the surface. Combining measurements in proportional counters with counts accumulated in different parts of fast neutron spectra measured in stilben detector one may reconstruct the water abundance distribution at different depths starting from thin subsurface layer and going down to several meters depths.

Data analysis: Using this approach we tried to create simple model to describe layered structure of regilith. At first step the summer measurements of Mars surface on South and North regions were extracted from full set of data. It helps to split the task of finding subsurface water distribution from task of measuring thickness of CO_2 frost. In this study we restrict ourselves only by studying regions near Mars poles above 60 degrees for each hemisphere. It was done because the main goal of this research to look at evolution of CO_2 deposits at different near pole areas with time. Deposition of CO_2 below these latitudes is ether absent or so thin that counting statistic cannot provide reliable results. More detail analysis of equatorial regions where presence of water was founded surprisingly high will be considered in other presentations[10].

The surfaces of North and South regions were divided into the network of pixels with 5x5 degree. Each pixel was treated independently in terms of estimation the best parameters of regilith model in given pixel. This choice provides the appropriate space resolution from one side and the reliable statistic (>10 sigmas for each pixel) from another one.

For describing Mars soil we suggest to use two-layers model. It consists of upper relative dry(<3% wt H_2O) layer with variable thickness and bottom semi-infinite ice-rich (>20% wt H_2O) layer. Applying the fitting procedure to the real neutron data in wide energy range the best fit parameters have been estimated for this type of model for each selected pixel.

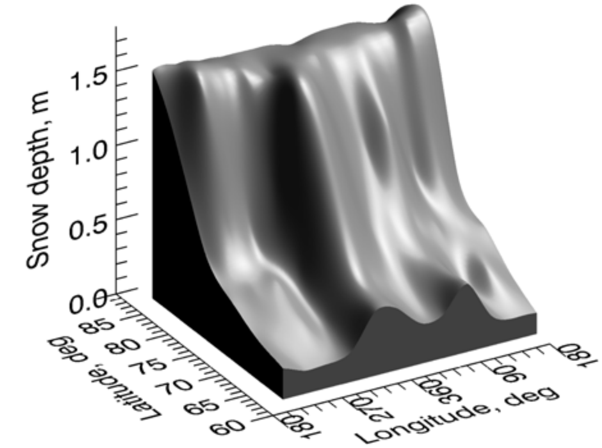

Fig 1a. Map of CO_2 deposit at North region of Mars for Ls=345^{o}.

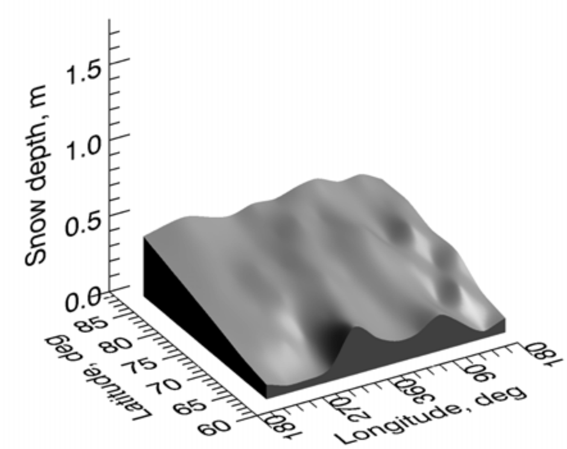

Fig 1b. Map of CO_2 deposit at North region of Mars for Ls=40^{o}.

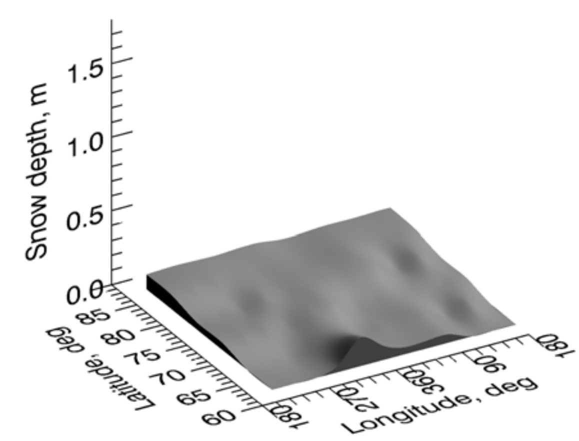

Fig 1c. Map of CO_2 deposit at North region of Mars for Ls=95^{o}.

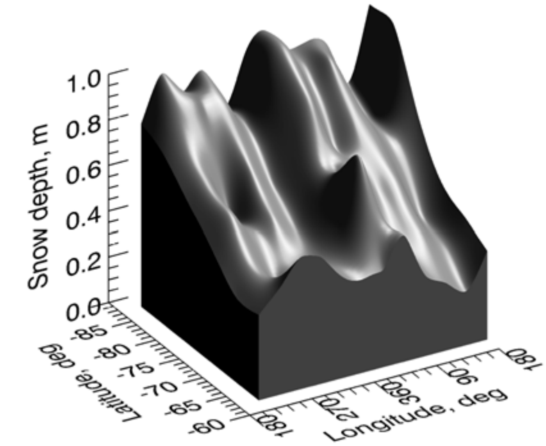

Fig 2a. Map of CO_2 deposit at South region of Mars for Ls=125^{o}.

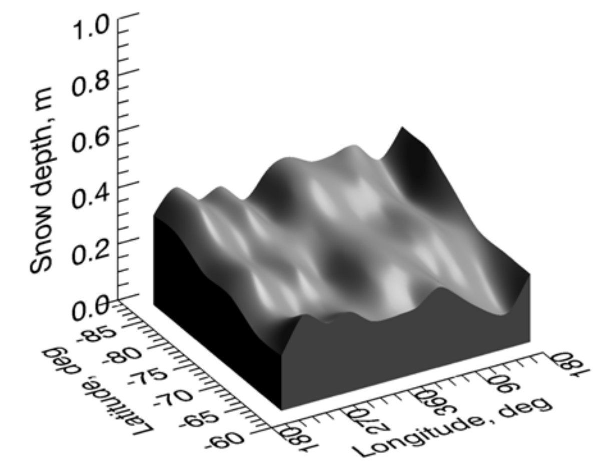

Fig 2b. Map of CO_2 deposit at South region of Mars for Ls=70^{o}.

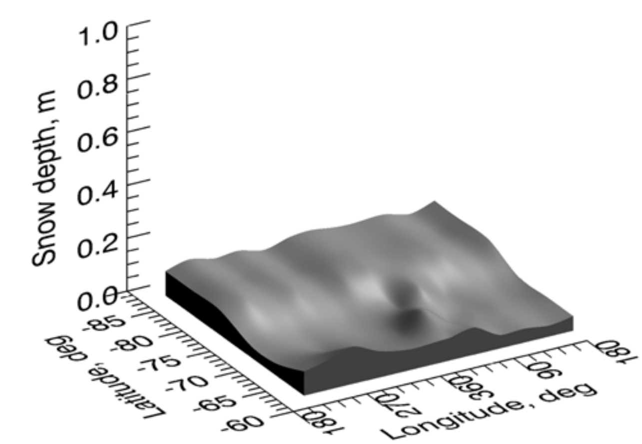

Fig 2b. Map of CO_2 deposit at South region of Mars for Ls=15^{o}.

To take into account scattering and production of epithermal and fast neutrons in the atmosphere the necessary corrections has also been done in this approach. Here we fixed the thickness of atmosphere for each pixel based on CGM prediction at summer period of time. All calculations have been done by help using radiation transport code MCNPX. The soil composition was taken from Mars Pathfinder observation with corrections for surface stones distribution and results obtained with GRS.

The best fit model parameters such as thickness of upper layer, H_2O content in upper and bottom layers were implemented for the next step to perform estimation of CO_2 frost thickness. Before starting this procedure the whole period of observations was divided into episodes with different Ls to follow the evolution of CO_2 coverage in time. Taking into account that global redistribution of CO_2 mass causes significant changes of Mars atmosphere CGM predictions have been added to program to correct the atmosphere thickness for particular period of time. The final results are presented as time sequence of maps for North and South regions. Some of them are shown on fig 1(a-c) and fig2(a-c).

For the previous martian year there were direct measurements of CO_2 snow depth made at different latitudes by MOLA(MGS). It is good possibility to perform additional calibration of suggested regolith model. We have done comparison between HEND data and MOLA observations for the north latitude belts during the same martian seasons. It was found that there is good correlation between two sets of data[8]. Using obtained results we have checked two-layer model of regolith at north near polar latitudes. It turned out that subsurface of Mars may be described by aproximately 75% wt water ice covered by 10-20 g/cm^2 of dry soil at this region. This result is in good agreement with estimations based on HEND data only.

Conclusions: The time sequence of maps of CO_2 snow depth were created at north and south regions poleward 60N and 60S latidues. In fact it presents 4-D model which describes the space distribution of CO_2 frost and its evolution in time between summer and winter seasons. It was found that CO_2 caps on south and north significantly differ from each other. The thickness of CO_2 coverage on the north has achieved maximal values up to 1.5 m which is more than at South pole. It is also observed that the structure of carbonate dioxide deposit on north is more smooth and regular than in South region.

References:

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