Global Distribution of Shallow Water on Mars: Neutron Mapping of Summer-Time Surface by HEND/Odyssey

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Introduction. Orbital mapping of induced neutrons and gamma-rays by Odyssey has recently successfully proven the applicability of nuclear methods for studying of the elementary composition of Martian upper-most subsurface. In particular, the suite of Gamma-Ray Spectrometer (GRS) has discovered the presence of large water-ice rich regions southward and northward on Mars [1-3]. The data of neutron mapping of summer-time surface are presented below from the Russian High Energy Neutron Spectrometer (HEND), which is a part of GRS suite [2, 4]. These maps represent the content of water in the soil for summer season at Southern and Northern hemispheres, when the winter deposit of CO_2 is absent on the surface. The seasonal evolution of CO_2 coverage on Mars is the subject of the complementary paper [5].

Concept of HEND. HEND is based on classical technique of neutron detection [4]. It contains three detectors with similar He^3 proportional counters and different layers of moderation encapsulation, which cover together the broad energy range of epithermal neutrons from 0.4 eV up to 1 MeV, and one sthylbene scintillation detector with 15 energy channels from 0.85 MeV up to >15 MeV. HEND operates synchronously with all GRS suite and has the same accumulation time intervals of about 20 seconds for maps pixelization.

Orbital mapping by HEND. The present maps display variations of neutron flux from Mars at the orbital altitude ~400 km (Figure 1). The local background of Odyssey is subtracted according to 3-D model of craft exposure by galactic cosmic rays, which has been measured during the initial aerobraking stage of orbital flight. The mapping pixels are 2° x 2°, which correspond to 120 km size on the equator. The pixels are narrower for higher latitudes, but total exposure time remains the same for all of them. Dynamic ranges of counts rate variations correspond to factors ~10 and ~3 for epithermal and high energy neutrons, respectively (see colors scaling in the Figure 1). The highest fluxes were detected at Solis highlands around 265° E and 25° S. We postulate that this area has no more than 1 weight % of water, and the content of water at another regions was estimated from the decrease of flux in respect to the reference maximum value.

Northern and Southern Regions of Permafrost. The summer-time map of Mars display two regions of strong depression of epithermal neutrons at polar ward sides from 55°-60° N and 60° S (Figure 1). Joint analysis of data for thermal, epithermal and high energy neutrons and for 2.2 MeV nuclear line of D pointed out that this depression corresponds to the presence of ice-rich layer with 35%-50% of water below the top dryer layer 20-30 g/cm2 with about 3% of water [1-3]. The summer-time map shows that ***Northern Permafros***t and ***Southern Permafrost Regions*** cover together about 15% of the total Martian surface. In north the content of water shows correlation with local elevation [6]. The origin of permafrost is not clear taking into account very different geological conditions at north and at south of Mars [7, 8].

Hydrogen Equatorial Regions. There are two well-pronounced depression regions of epithermal neutrons: ***Arabia Hydrogen Region*** around 30° E and 10° N and ***Memnonia Hydrogen Region*** about oppositional to the first one at 200° E and 15° S (Figure 1). The content of water at these regions is about 5-7% of weight, which is close to upper limit for chemically bound water in the soil. It is quite difficult also to justify the alternative form of water, as a free ice, because ice hardly might survive at the equatorial latitudes. The origin of water at these two hydrogen regions is the subject of separate papers [9, 10].

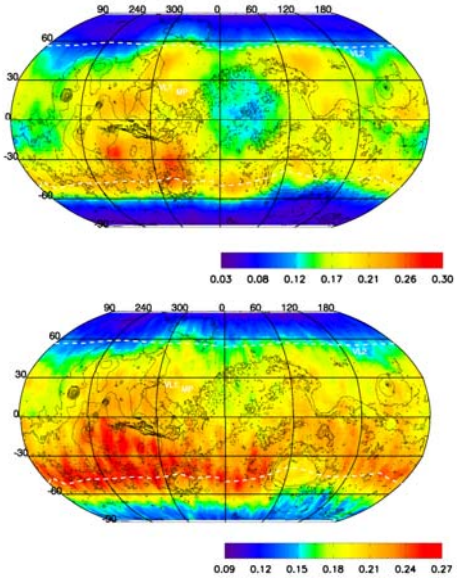

Figure 1. HEND maps of epithermal (top) and fast (bottom) neutrons for summer-time conditions on Mars.

References:

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[4] Mitrofanov et al., this Conference
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