MARS EXPLORATION NEUTRON DETECTOR MEND: INSTRUMENT FOR MAPPING WATER ON MARS WITH HIGH SPATIAL RESOLUTION. I. G. Mitrofanov[1], J. B. Garvin[2] and A. B. Sanin[1], [1]Institute for Space Research, Moscow 117997, Profsojuznaya st. 84/32, Russia, imitrofa@space.ru, [2]NASA/Goddard Space Flight Center, Greenbelt, MD 20771, USA

Introduction: Recent data from the GRS instrument suite on Mars Odyssey has shown [1 – 4] that Mars has extremely variable neutron emission over the entire surface, which points out on high hydrogen content around poles and also at the equatorial belt. We are practically sure that high content of hydrogen in the Martian regolith means high content of water. We believe that for regions above 50 degrees latitude the water is water ice, with mass fraction large enough to say that ice is a major constituent of the soil in these regions. We do not know the form of water in the soil at moderate latitudes below 50°; it could be chemically bound water in minerals, physically adsorbed water on the surface of regolith grains, or even water ice at some particular spots with low sunlight heating.

To study water on Mars, we need to work with neutron data together with data from IR and visual light, but for this work we need much better neutron data resolution than the 200 – 300 km accomplished with Odyssey. One may expect that some future mission will deliver neutron telescope for neutronography of Mars.

The concept of instrument MEND (Mars Exploration Neutron Detector) is presented below, which shall be able to perform these measurements and to provide the neutron data products with high spatial resolution.

Concept of instrument: The concept of MEND is based on the current design of instrument LEND (Lunar Exploration Neutron Detector) for NASA's Lunar Reconnaissance Orbiter of 2008 [5, 6]. LEND will be the first neutron telescope for accurate imaging of lunar emission of epithermal neutrons (Figure 1). LEND design is presented below, as prorotype for MEND.

The primary type of sensors is ^{3}He counter LND 253141, which is used for eight LEND sensors: for four Collimated Sensors of EpiThermal Neutrons (CSETN 1-4), for three Sensors of Thermal Neutrons STN 1-3 and one Sensor of EpiThermal Neutrons (Figure 2). The collimated sensors of epithermal neutrons CSETN are enclosed by Cd shields that absorb all neutrons with energies below ~0.4 eV, which mainly correspond to thermal neutrons. Another sensor with a Cd shield is the external Sensor of EpiThermal Neutrons (SETN) at the top of the instrument (Figure 2), which detects epithermal neutrons from all directions around the instrument. Three other external Sensors of Thermal Neutrons (STN 1-3) detect thermal and epithermal neutrons. One of them, STN 1, is also at the top of the instrument, and it detects particles from all directions. The combination of two external counters, SETN and STN 1, will allow the measurement of local density of thermal and epithermal neutrons around the spacecraft.

Figure 1. General view of LEND, as a prototype for MEND

Four ^{3}He counters, CSETN 1-4, are installed inside the collimating module, which effectively absorbs external neutrons outside of instrument Field of View (Figure 2). Absorbing neutrons is very difficult; one of the best absorbing materials is ^{10}B, and its absorption efficiency becomes much higher when neutrons are slower. We shall use collimators for each counter CSETN 1 – 4 with external layers of polyethylene for moderation of impacting neutrons and internal layers of ^{10}B for their efficient absorption (Figure 2).

The imaging capability of MEND for emission of epithermal neutrons from the Mars is accomplished with the narrow FOV of 5.6 degree opening angle (Half Width Half Maximum).

A second type of sensor is the Sensor for High Energy Neutrons (SHEN), which is a sthylbene scintillator (Figure 2) that produces a flash of light each time a high energy neutron in the range 0.3 – 15.0 MeV collides with a hydrogen nucleus and creates a recoil proton. Special shape-sensitive electronics distinguishes proton counts from electron counts, and an active anti-

coincidence shield eliminates external charged particles. This sensor is installed inside the central hole of collimation unit, and its Field of View corresponds to 40° (HWHM).

Total mass of LEND, as prototype of MEND, is 26 kg (with mass of neutron collimation module about 16 kg), and its power consumption is about 14 Watts. The instrument is developed in the Russian Institute of Space Research, as contribution of Federal Space Agency of Russia to the NASA's Lunar Reconnaissance Orbiter.

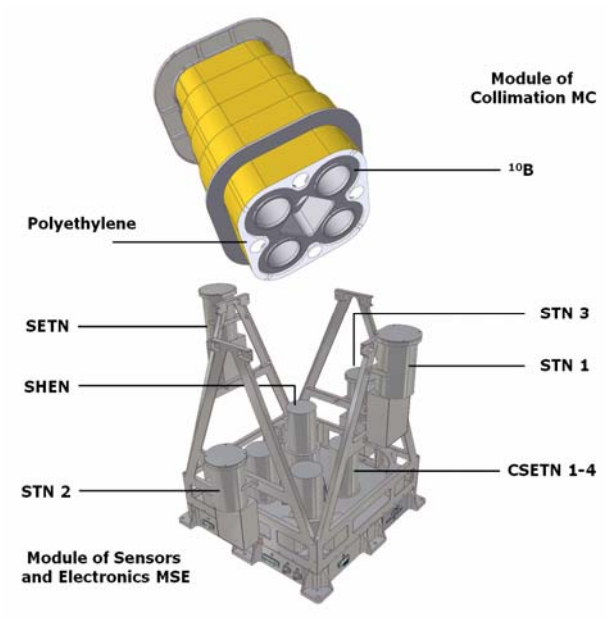

Figure 2. LEND has two separate modules for Sensors and Electronics (bottom element) and for collimation of neutrons (top element)

Conclusion: MEND, as it could be designed according to LEND heritage, at an orbital altitude of 300 km would provide neutron emission maps of the Martian surface with spatial resolution (HWHM) of 30 km. The area of surface elements of resolved image of Mars will be about 100 times smaller than one, which we have now from Mars Odyssey.

Therefore, the instrument like MEND could in the future provide global reconnaissance of the Martian surface with the capability to detect particular regions of 30 km size on the surface of Mars with maximal content of water in the soil. These spots, provided they were also selected by some another particular properties of thermal emission, relief and geology, could become potential sites for future landers and sample return missions.

We know that Mars does not have an active biosphere, but its life could be smoldering in some hydrothermal oases in the shallow subsurface. Martian astrobiological missions will head to these spots sometime in the future, and data from neutrons telescopes, like MEND, will provide the perfect navigation for them.

Références: : [1] Boynton W. et al. (2002) *Science*, 297, 81. Feldman W. et al. (2002) *Science*, 297, 75. [3] Mitrofanov I.G. et al. (2002) *Science*, 297, 78. [4] Mitrofanov I.G. et al. (2003) *Science*, 300, 2081. [5] Chin G. et al. (2007) *Space Sci. Rev.* in press. [6] Mitrofanov I.G. at al. (2007) *Astrobiology*, in press.