FORECAST WATER ICE RESERVES IN THE MOON POLAR REGIONS BY THE "LEND" DATA. E. N. Slyuta[1], O. I. Turchinskaya[1], O. S. Tretyukhina[1], A. B. Sanin[2], I. G. Mitrofanov[2], M. L. Litvak[2], [1] Vernadsky Institute of Geochemistry and Analytical Chemistry of Russian Academy of Science, 119991 Moscow, Russia, slyuta@geokhi.ru, [2] Institute for Space Research of Russian Academy of Science, 117997 Moscow, Russia.

Introduction: The first instrumental confirmation of the possible presence of water ice in the lunar soil was obtained from the LPNS neutron detector data on board the Lunar Prospector spacecraft [1, 2]. The Lunar Research Neutron Detector (LEND) aboard the LRO spacecraft is a collimating spectrometer and provides neutron imaging of the lunar surface with a resolution of about 10 km from an orbit about 50 km high [3]. Based on the neutron count rate data, maps of the lunar epithermal neutron flux with high spatial resolution were created for the Northern and southern Polar Regions of the Moon [4]

WEH content in the lunar soil: Estimates of the water equivalent of hydrogen (WEH) in the study areas were obtained from the relative variations in the neutron count rate in these areas compared to a dry reference area with the highest counts, which is considered anhydrous [4]. The hydrogen content in dry reference regions at the characteristic value of the neutron count for these regions (2.36 cps) was taken to be 50 ppm, which corresponds to 0.045 wt.% of the WEH [4]. Taking this correction into account, the neutron count data in the northern and southern Polar Regions were recalculated to the abundance of WEH in wt %, and a map of the WEH distribution was constructed with a resolution of about 5 km [4].

Water ice deposits: To identify anomalies with a high content of WEH and delineate deposits with a maximum content of water ice, points with a WEH content of less than 0.1 wt.% were removed from the data set. Filtering measurements by this criterion reduced the number of points in the northern polar region by 44.8%, and in the southern polar region by 45.6%. An array of data with a content of more than 0.1 wt.% in the ARCGIS system was processed using a triangulation model, which allows you to create a continuous surface from discrete values. The resulting triangulation model was converted into a raster format with a grid spacing of 625 m, which was superimposed on a digital elevation model (DEM) of the Polar Regions with the same resolution (Fig. 1).

After processing the resulting map in the ARCGIS system, five discrete categories of WEH content were outlined: V>0.1-0.2, VI>0.2-0.3, III>0.3-0.4, II>0.4-0.5, I>0.5-0.53 wt.% (Fig. 2) and the areas occupied by them were calculated (Table 1). Obviously, at the stage of lunar exploration, the categories of water ice deposits with an ice content of >0.3 wt.% are of greatest interest. These categories of deposits were manually outlined from pixel to pixel (Fig. 3, 4) and then the occupied area of each of the deposits of these categories was estimated.

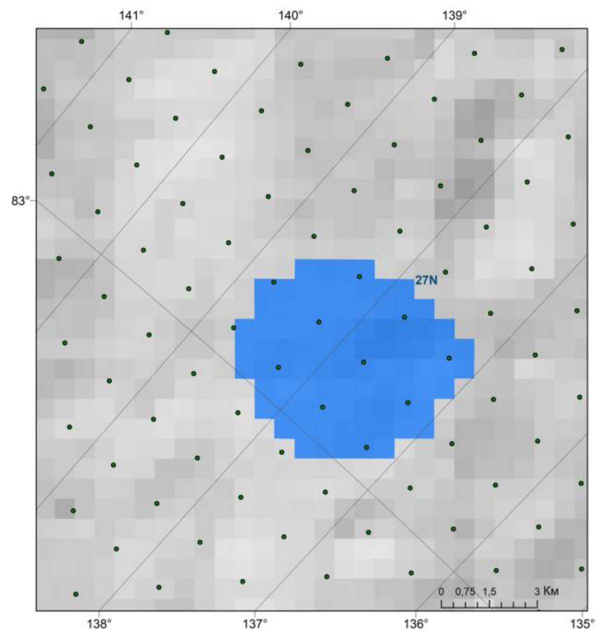

Fig. 1. DEM map with a resolution of 625 m (gray color) with overlaid converted WEH data in the range of 0.3-0.4 wt.% with a similar resolution (blue color). Dots show the distribution of WEH primary data.

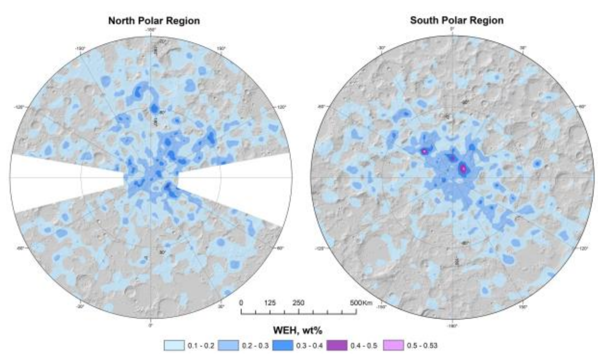

Fig. 2. Distribution map of the distinguished categories of WEH content in the Moon Polar Regions.

To estimate the predicted reserves of water ice, a similar two-layer model of the distribution of the epithermal neutron count rate in the lunar regolith [4, 5] was used: a dry layer of regolith 10 cm thick on top, and a uniform distribution WEH at a depth of 0.1–1 m. The average soil density in a layer from 0.1 to 1.0 m is taken equal to 1500 kg m^{-3} [6]. The average content of water ice in the deposits for the assessment of reserves will be taken equal to the minimum content in the selected categories: I - 0.51 wt.%, II - 0.41 wt.%, III - 0.31 wt.%, IV - 0.21 wt.% and V - 0.11 wt.%. The total probable reserves in the North Polar Region are estimated at about 8.8×10^{8} tons, and in the South Polar Region about 7.6×10^{8} tons (Table 1).

Table 1. Total predicted reserves of water ice in the Moon Polar Regions

I-V	WEH, wt.%	S, km^2	Ice, т
North Polar Region			
II	0.41	126.6	700731
III	0.31	10785.2	45136062
IV	0.21	95649.2	271165482
V	0.11	380454.3	564974636
Total			**881976911**
South Polar Region			
I	0.51	159.0	1094715
II	0.41	1 435.7	7946600
III	0.31	7 138.1	29872949
IV	0.21	86241.8	244495503
V	0.11	318705.9	473278262
Total			**756688029**

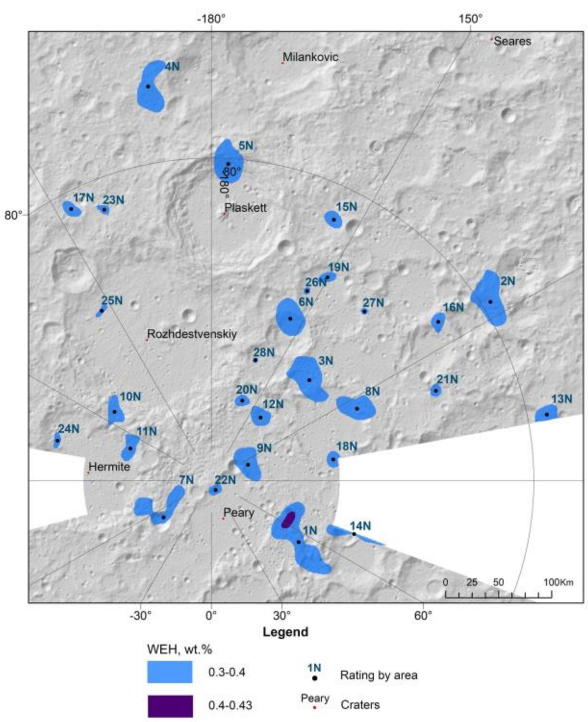

Fig. 3. Ice deposits with content >0.3 wt.% in the lunar soil in the Moon North Polar Region.

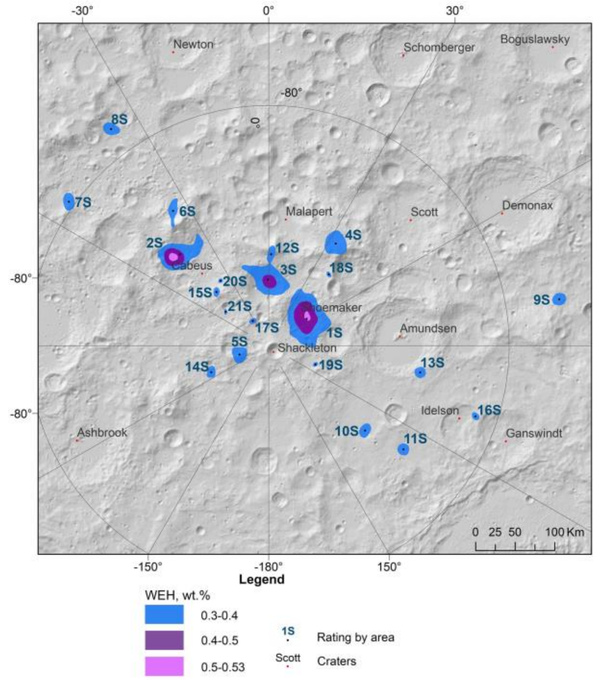

Fig. 4. Ice deposits with content >0.3 wt.% in the lunar soil in the Moon South Polar Region

In the northern Polar Region, 28 deposits of category III and 1 deposit of category II were identified with an area from 20 km^2 to 1400 km^2 and ice reserves from 85 tons to 6.5×10^{6} tons (Fig. 3). In total, the predicted ice reserves in the deposits in the Northern Polar Region are estimated at about 4.6×10^{7} tons. In the Southern Polar Region, 21 deposits of category III, 3 deposits of category II, and 2 deposits of category I with an area from 20 to 1742 km^2 and ice reserves from 83 to 7.3×10^{6} tons were identified and delineated. In total, the predicted ice reserves in South Polar Region deposits are estimated at about 3.9×10^{7} tons (Fig. 4).

Summary: The obtained estimates of the total predicted water ice reserves in the both polar regions according to the data of the LEND (1.6×10^{9} tons) (Fig. 2, Table 1) agree quite well with the estimates obtained earlier using the LPNS data (3×10^{9} tons) [1]. The estimate of probable reserves in the North Polar Region (8.8×10^{8} tons) is also quite close to obtained earlier data on the radar survey of the Chandrayan-1 Spacecraft (6×10^{8} tons) [7].

References: [1] Feldman W.C. et al. (1998) *Science 281*, 1496–1500; [2] Lawrence D. J. et al. (2006) *J.G.R. 111(E08001)*; [3] Mitrofanov I.G. et al. (2010) *Sp.Sci.Rev. 150(1-4)*, 183–207; [4] Sanin A.B. et al. (2017) *Icarus 283*, 20-30; [5] Litvak M.L. et al. (2016) *Plaet.Sp.Sci. 122*, 53–65; [6] Slyuta E.N. (2014) *Sol.Sys.Res. 48(5)*, 330-353; [7] Spudis P.D. et al. (2013) *J.G.R. Pl. 118*, 2016–2029.