ANALYSIS OF LUNAR PYROCLASTIC DEPOSITS USING LEND SPECTROMETER DATA.

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Introduction: Lunar pyroclastic deposits (LPDs) represent some traces of past volcanic activity encountered across the equatorial surface of the Moon [6, 7, 18]. Most of the LPDs are located on the near side, both in marine and highlands regions. Quite a lot of these are directly on the boundary mare/highlands areas [7]. Visually, they are regions of low albedo compared to the surrounding areas. Important component of these deposits is the pyroclastic glass, some examples of which were delivered by Apollo 15, 17 [1]. Such deposits contain information about the deep layers of the mantle. Volatile elements enclosed inside the volcanic glass characterize the composition of ancient lunar matter [6]. By experiment, A. Saal found strong evidence that water and other volatile elements contained within the glass beads, have been voted there just with eruption process [13]. Besides, numerical simulations shows that currently remain some lunar mantle zone, where the concentration of water can reach 600 ppm [13]. Therefore, it can be assumed that epithermal neutrons count rate (inversely proportional to hydrogen content [3]) in LPD areas indicates amount of water in the lunar mantle beneath these deposits. Thus, it makes sense to look for a correlation between indications of LEND neutron spectrometer [12] and the location of LPDs, which are known to about 100 [6, 18]. In this report is the analysis of epithermal neutron [9, 11] flux for the pyroclastic deposits located on the near side of the Moon (mainly in Procellarum KREEP terrain (fig.1)).

Method: The following relation uses to evaluate the difference between a neutron flux in a given area and flux in the vicinity [3]:

$$\delta = \frac{N_{ref} - N_{ex}}{N_{ref}} \quad (1)$$

In this equation: δ - suppression factor; N_{ex} - integral average epithermal neutron count rate in a testing zone; N_{ref} - integral average epithermal neutron count rate in a reference zone (fig. 2).

A positive value of a suppression factor indicates to exceeded concentration of hydrogen in any investigated area. Conversely, negative suppression factor corresponds to reduced level of hydrogen content compared with selected reference zone. To calculate the average neutron flux (count rates) used testimony obtained by collimated (CSETN) and omnidirectional (SETN) sensors of LEND [9, 12]. Collimated sensor was used to determine flux from small area sources (Taurus Littrov), omnidirectional - from extended one (Aristarchus LPD).

Some results: The suppression factors for 21 subjects (LPDs and volcanic domes) summarized in table 1. All of them placed in KREEP terrain on the near side (fig.1) except number 16 (Taurus Littrov LPD). As can be seen, they have positive δ parameters. It means that possible concentration of hydrogen is elevated for all of 21 subjects.

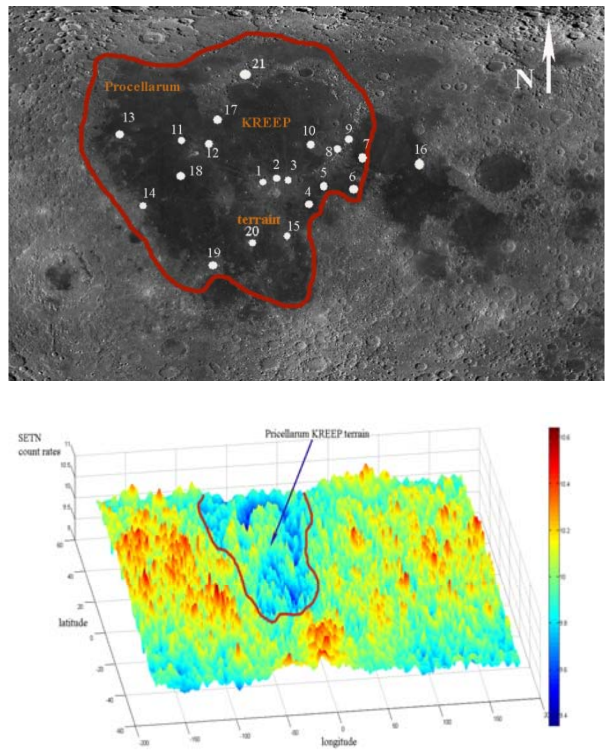
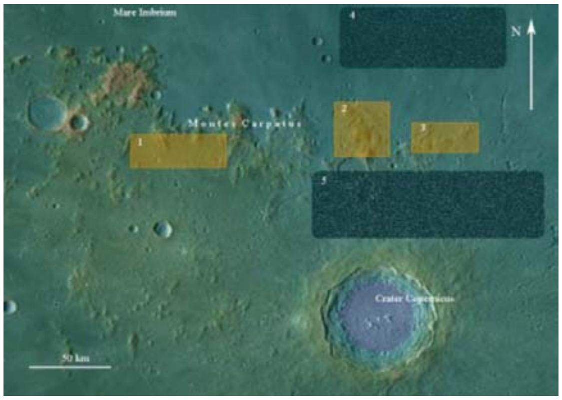


Figure 1: Lunar pyroclastic deposits [6, 7, 18] and volcanic domes [2, 4, 14, 15] on the near side located (above). Epithermal neutrons count rate distribution of LEND omnidirectional detector (SETN) for equatorial surface of the Moon (below). The area corresponding to the suppression of the neutron flux in the vicinity of KREEP circled in red line.

This could mean that increased concentration of hydrogen in this area has a volcanic origin. It also indicates the possible increased concentration of hydrogen in the mantle zone [13]. However, considering trend is not universal for entire lunar surface. The situation is reversed for the opposite side LPDs. As a result, the observed pattern for KREEP LPDs may indicate the indigenous origin of hydrogen on the near side. The obtained results are combined with some data concerning location the recent earthquakes [16] which too correlate with the location KREEP zone on the near side.



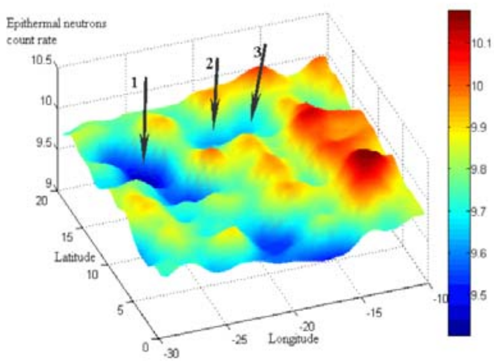


Figure 2: Lunar pyroclastic deposits located in Mountes Carpatus area (above); 1- Mountes Carpatus LPD, 2-Gay-Lussac N LPD, 3-Gay Lussac NE LPD, 4-mare reference zone, 5-highland reference zone.

Epithermal neutrons count rates distribution for Mountes Carpatus area (below).The arrows point to location of neutron flux suppressions correspond to the same LPD.

Discussion: The age of pyroclastic deposits dos not exceed the age of last volcanic process on the near side, and therefore can't be younger than 1 Ga [5]. Hence, LDPs are very mature formations however clear correlation between maturity and concentration of hydrogen has not been identified on the lunar surface. Therefore, it comes to indigenous but not implanted hydrogen most likely. However, there is some reason to believe that suppression factor of epithermal neutrons increased with concentration of rare earth elements in KREEP terrain [10]. But, currently there are no any confident quantitative estimations concerning influence of rear earth elements to decreasing of epithermal neutron flux. In this regard, increasing in the positive value of suppression factor most likely indicate the presence of indigenous hydrogen-containing components in LPDs of lunar near side.

L P D	lat. (deg)	long.(deg)	δ (%)	Standard err. (%)
1. Mountes Carpatus	15	-25	4.1	0.93 (4.4 σ)
2. Gay-Lussac N	14.9	20.7	2.9	0.94 (3.8 σ)
3. Gay-Lussac NE	14.8	18.4	5.3	0.96 (3.0 σ)
4. Aestuum	6.5	-5.9	1.2	0.46 (2.7 σ)
5. Rima Bode	11.9	-3.4	1.1	0.56 (1.9 σ)
6. Vaporum	10.0	7.9	2.1	1.45 (1.5 σ)
7. Sulpicius Gallus	21.7	9.4	1.6	1.01(1.4 σ)
8. Mozart	23.8	1.3	0.8	1.39 (0.6σ)
9. Hadley Cleft	25.2	2.6	2.6	1.47(1.8 σ)
10. Beer	27.2	-8.8	2.4	0.74 (3.2)
11. Aristarchus	26.7	-52.3	3.1	0.30 (10.2 σ)
12. Harbinger	26.6	-43.4	1.7	0.54 (3.2 σ)
13. Briggs A	28.6	-74.2	3.2	0.79 (4.0 σ)
14 Cavalerius	6.4	-66.4	1.8	0.49 (3.7 σ)
15 Fra Mauro	-7.1	-16.8	5.9	2.30(2.5 σ)
16 Taurus Littrov	20.2	30.7	9.6	3.8 0(2.5 σ)
Volcanic formations	**latitude**	**longitude**	**δ (%)**	**Standard err. (%)**
17. Gruithuisen volcanic domes	36.1	-39.6	2.7	0.46 (5.9 σ)
18. Marius hills	14.1	-51.5	1.9	0.54 (3.5 σ)
19. Hansteen, Helmet	-15.3	-43.7	1.5	0.14 (10.5 σ)
20. Hansteen, Helmet	-8.9	-28.0	1.0	0.57 (1.8 σ)
21. Iridum terrain	50.2	-29.8	3.9	0.37 (10.7 σ)

Table 1: Suppression factor (δ) and standard error (σ) for LPD (1-16) and some KREEP volcanic formations (17-21). The red marks correspond to not statistically reliable results (0.6σ -1.9σ), yellow marks – rather reliable results (2.5σ - 2.7σ) and green marks – quite reliable results (more 3.0σ)

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