AN INVESTIGATION OF EPITHERMAL NEUTRON FLUXES FROM LUNAR IMPACT BASINS.

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Introduction: At the present time there are data from two differerent neutron spectrometers: Lunar Exploration Neutron Detector (LEND) and Lunar Prospector Neutron Spectrometer (LPNS) that cover the entire lunar surface including equatorial regions [3,8]. Currently many efforts are devoted to identify the so-called neutron suppression regions (NSR) of epithermal neutrons (EN) near both lunar poles. Analysis of epithermal neutron fluxes obtained by LPNS from the polar areas (especially southern) showed a noticeable excess of hydrogen content (C_H) compared with its average equatorial value [3,4].

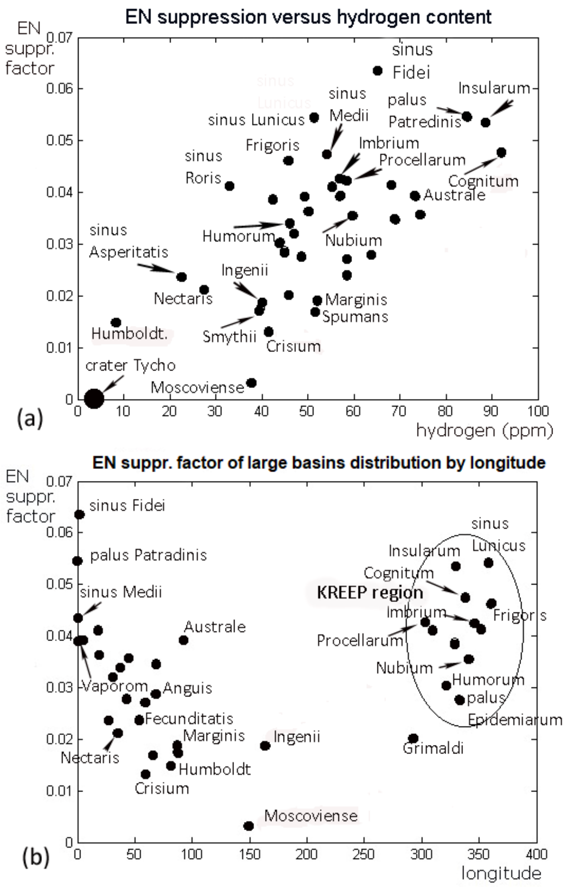

Fig.1 (a) Relation between EN suppression factor δ (LEND) and hydrogen content C_H (LPNS) [9]; (b) longitude distribution of δ for impact basins and other marine formations [9].

The authors have shown that polar areas with enhanced abundance of hydrogen continually overlap the so-called permanently shadowed regions (PSR). But the results obtained by collimated sensor of LEND with significantly higher resolution pointed out that NSRs do not coincide with PSRs on both poles [1]. It is necessary to say that the distribution of EN flux strongly anticorrelated with C_H. At the same time it should be mentioned that the distribution of epithermal neutrons in the equatorial regions still remains relatively unexplored. The authors of LPNS found a moderately good anticorrelation between soil maturity [7] and EN flux. It also points to the lack of a functional connection between the age of surface formations and hydrogen content [5]. In a recent publication of [6] some very insignificant inverse statistical relationship between the surface maturity and bulk hydrogen abundances has been established. But this applies only to the lunar highlands, namely Feldspathic Highlands Terrane (FHT). Finally, the last publication [11] points to the weak negative correlation (the Pearson linear-correlation coefficient is r=-0.096) between C_H and maturity. This report presents the results of studies of EN distribution through all large impact basins and marine formations.

The distribution of EN suppressions in selenographic longitudes: To quantify the estimation of EN flux through the lunar surface, the so-called suppression factor δ has been used [1,10,11]. It shows a relative difference of EN neutron flux in comparison with the area of crater Ticho, where the EN flux (coutn rate of neutron sensor) is maximum. In this study, the suppression factors have been calculated for all lunar impact basins and marina formations around the lunar equatorial surface. [10]. More details of the results of calculations can be seen for Mare Crisium (Fig. 2).The count rates, obtained by omnidirectional sensor SETN of the spectrometer LEND have been used for neutron flux calculations. In the same time the hydrogen contents correspond LPNS data and derived from PDS [13].

The value of suppression factors close to zero correspond to the maximum neutron flux and, accordingly, the minimum hydrogen content (δ=0.0031, mare Moscoviense). The value of the suppression factors close to maximums, typical for the equatorial regions, correspond to a noticeable increase in the hydrogen concentration (δ=0.0636, sinus Fidei). Compleet calculations of the suppression factors and hydrogen contents for all impact basins and mare formations are given in the article [9]. A very convincing correlation between δ and C_H can be seen from the fig.1(a).

Meanwhile, the suppression factor has increased values (δ= 0.02-0.06) in longitudes which correspond to the near side ($300^0 - 60^0$), especially in the so-called KREEP zone (Fig. 1(b)). In contrast, the suppression factors for the far side marine formations like mare Moscoviense and mare Ingenii have significantly lower values. This means that the average hydrogen abundance on the near side lunar basins are noticeably higher than on the far side. The maximum concentration of hydrogen (92.1 ppm) has mare Cognitum (long. = 337^0). In general, as can be seen from the diagram (Fig. 1(b)) the suppression factor is quite noticeably, smoothly changes with longitude and has a maximum near zero degrees (sinus Lunicus, sinus Medii, sinus Fidei, palus Patradinis).

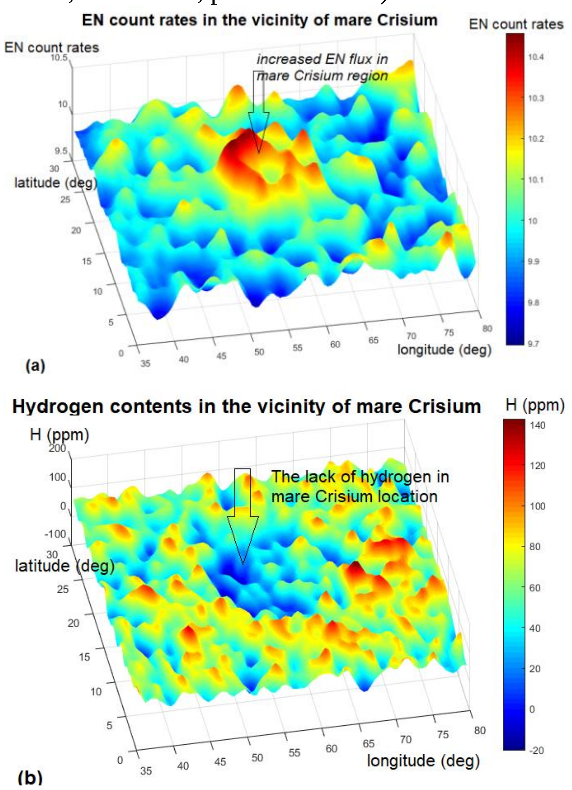

Fig. 2 (a) The distribution of EN and (b) hydrogen content (ppm) in the vicinity of mare Crisium.

Some possible causes for uneven suppressions of EN through longitudes

How can this distribution of suppression of EN by longitudes (Fig. 1(b)) be explained? The first assumption concerns the presence of absorbers of epithermal neutrons such as rear earth elements (Gd, Sm) on the near side in KREEP terrain [2,6]. However, the fact that the presence of absorbers causes the EN suppression on the near side does not has sufficient grounds and, in general, it is not strictly proved [10]. The second assumption is decrees of EN flux in consequence of elastic scattering on nucleus of hydrogen, incorporated by solar wind (SW). Though, recent studies [5,6,10] of neutron distribution in the equatorial regions show that the correlation between the EN flux and maturity (exposure age) of the surface is negligible. In addition, the average maturity of the far side is greater than the maturity of the near side. This means that the EN suppressions on the far side should exceed the one on the nearer side. However, the opposite picture is observed (Fig.1(b)). Consequently, the influence of solar wind protons on the process under consideration could be regarded as insignificant, at least not determining. Therefore, the third and, probably, the main reason for the longitude dependence of the epithermal neutron flux is the elastic scattering of ENs on the indegenius lunar hydrogen-containing compounds [10,11,12].

Summary: To summarize we make the following points: (1) In impact basins there is a rather noticeable relation of average hydrogen contents from the selenographic longitude. Moreover, on the near side of the Moon the average hydrogen concentration (~50-90 ppm) is more than on the far side (~30-50 ppm). (2) The lack of correlation between maturity (exposure age) of the lunar regolith and hydrogen abundance indicates a weak influence of solar wind protons on average hydrogen concentration. (3) It is possible that the dependence of concentration of hydrogen from selenographic longitude points to indigenous origin of hydrogen compounds. (4) The increased concentration of volatile compounds in the lunar mantle may indicate the possible joint formation of Earth-Moon system.

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