Specific petrologic reaction of the lunar lithosphere to Moon moving away from Earth and loosing rotation rate and angular momentum

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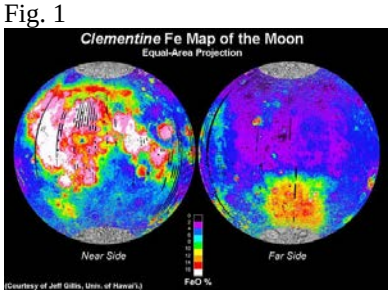
Several enigmatic structural and petrologic features of the Moon are widely discussed: origin and global spreading of the high-Ti lunar basalts, mascons, swirls. The Moon moves away from Earth. Loosing its angular momentum due to slowing rotation a necessary compensation is fulfilled by sending dense materials into the crust (Fig. 1-4). Varying density basalt flows (high, low, very low-Ti) reflect various stages of the slowing rotation process. Various contents of dense mineral component – ilmenite in basalts means various densities of the rock. Iron in basalts can be in less dense dark minerals and denser ilmenite thus influencing overall basalt densities corresponding to requirements of "healing" diminishing angular momentum. Spectral mapping of basalt types [6] indicate that for large parts of Oceanus Procellarum younger basalts are more titanium rich than the older basalts, thus somewhat reversing the trend found in the returned samples [5]. In some smaller basins spectral mapping also shows titanium richer basalts being older than titanium pure ones [4]. Thus, one may conclude that decreasing rotation rate of the Moon was not smooth but rather uneven. The deepest SPA Basin must be filled with denser rocks than the shallower Procellarum Ocean filled with basalts and Ti basalts. The Clementine spectral data show presence of orthopyroxene and absence of plagioclase [7] favoring some dense ultrabasic rocks. An obvious tendency to approach this type of rock would be to observe it in the Luna 24 samples from also very deep (up to 4. 5 km) Mare Crisium. In fragments there prevail pyroxene and VLT-ferrobasalts (Mg-poor). Unusual melt matrix breccia with globules and crystals of Fe metal were also found [1]. Among glass droplets there 40-54 % are irons. Nearly half of the black and brown droplets have either vesicles or iron droplet trains or both [1, 2]. A significant portion of Mg enriched fragments in the Luna 24 soil is also observed. The lunar global magnetic map (Fig. 4) favors a conclusion about some important Fe metal admixture increasing not only magnetism but also overall rock density of the deepest Basins and Mares. An association of Mg-pyroxene enstatite with Fe-Ni metal is well known in cosmic materials (for an example, E-chondrites). On the Moon enigmatic but characteristic swirls with high albedo, elevated magnetism and diffused boundaries could be presented by this type of high-Mg (light in color) with Fe metal rock. The SPA Basin is one of the enriched with swirls relatively magnetic areas (Fig. 4) [3]. In the Reiner Gamma swirl area some small rifts are detectable. Another not less important repairing instrument for the diminishing momentum is an introduction into the crust additional dense masses – mascons. Their bodies are rather typical and characteristic in the lunar crust (Fig 3). An important role of dense minerals (ilmenite, native Fe) in basaltic-UB covers in the lunar crust witnesses a compensating role of these effusions for loosing angular momentum of moving off satellite. Mascons (Fig, 3) appear in the crust for the same reason.

References:

[1] Basu A.et al.(1977) Conference on Luna 24, Houston, LPI Contribution 304, p. 14-17. **[2]** Basu A. et al. (1977) the same, p. 18-21. **[3]** Denevi B.W. et al (2016) Icarus, v, 273, 15 July 2016, 53-67. doi.10.1016/j.icarus.2016.01.017. **[4]** Hiesinger H. et al. (2000) J.Geoph.Res., 2000, v.185, #E12, 29239-275. **[5]** Hiesinger H. and J.W. Head III. (2016) Workshop on New Views of the Moon II, abs.8030. **[6]** Pieters C.M. (1978) Proc. Lunar Planet. Sci. Conf., 9th, 1978, 2825-2849. **[7]** Pieters C.M. (1997) Annales Geophysicae, Suppl. III to v. 15, p. 792.

Fig. 1



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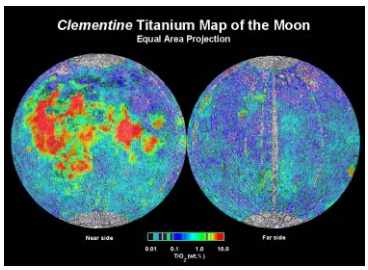

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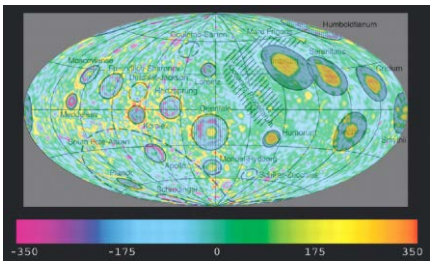

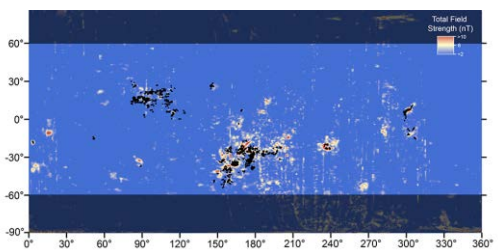

Fig. 4 [3]

In sum, three enigmatic structural-petrologic phenomena are united by one general purpose – to heal the lost angular momentum. For the same purpose slowing rotation and loosing angular momentum much more massive and inertial Earth introduces profuse basaltic masses mainly later, in PZ-MZ.