THE DEPENDENCE OF THE CHEMISTRY ON THE DEPTH FOR THE SOUTH POLE – AITKEN LUNAR BASIN. S. G. Pugacheva, V. V. Shevchenko, V.I. Chikmachev. Sternberg State Astronomical Institute, Moscow University, 13 Universitetsky pr., 119992 Moscow, Russia, pugach@sai.msu.ru.

Introduction. In previous paper we have presented article with results of the hypsometric researches of the SPA structure [1, 2, 3, 4]. The hypsometric map shown in Fig.1 makes it possible to study the generalized structure of the SPA basin relief. The histogram shown in Fig.2 demonstrates the height distribution in the SPA basin region.

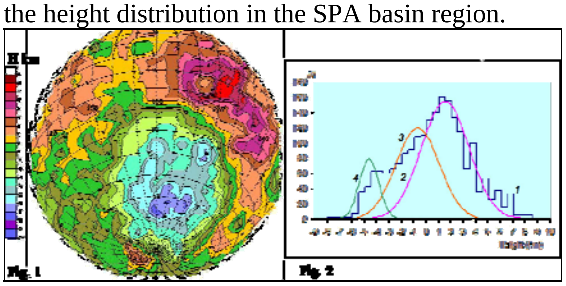

Fig.1, 2. The hypsometric map and the height distribution in the SPA basin region constructed according to hypsometric map data (fig.1): (1) the height distribution within the entire structure; (2) within the basin outer ring; (3) within the first inner ring; (4) within the second inner ring.

A total basin diameter of about 3500 km has been reliably determined for the first time. A unique feature of the basin structure consists in that the arrangement of the basin inner rings does not show a central circular symmetry and have very small depth-diameter ratio. This circumstance makes it possible to put forward the hypothesis that a comet impact produced the South Pole–Aitken basin.

The major chemical elements of the lunar rock in the SPA basin. In the present work, we tried to more specifically trace the material chemistry at different levels within the studied ring structure based on the iron and thorium abundances. To reveal the boundary abundances of individual chemical elements (in this case, those of iron and thorium) depending on depth horizons, we selected a method for analyzing marginal distributions successfully used in a number of studies [2].

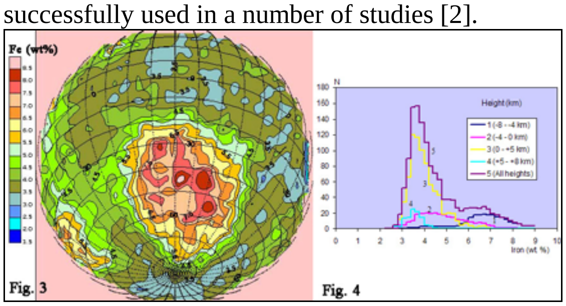

Fig.3, 4. The iron content distributions in the surface layer at different heights of the SPA basin structure.

Figure 4 presents the iron content distribution in the surface layer of the SPA basin, corresponding to the entire formation (distribution *5*) and to different height levels (distributions *1–4*). The presented plots were constructed based of a statistical analysis of the data shown on the iron content map (Fig. 3). Except for distributions *1* and *4*, the remaining distributions have bi-distributions *2* and *3*) and trimodal (distribution *5*) forms. The separation of marginal distributions indicates that the first mode, which is identical for distributions *3–5* and represents an iron content equal to 3.5%, characterizes the rocks at levels higher than km. According to the geochemical estimates, these rocks are of the anorthosite type. The second mode separated in distributions *2*, *3*, and *5* corresponds to an iron abundance of ~4.5%. Finally, the third mode separated in distributions *1–3* and *5* characterizes an iron abundance of ~6.5%.

An analysis of the described marginal distributions indicates that the first boundary level, i.e., the boundary between the first and second distributions (~4% Fe), corresponds to a height of 0 km as compared to the hypsometric map shown in Fig. 1. Similarly, the boundary between the second and third distributions (~5.5% Fe) corresponds to a height of –4 km.

Taking into account that the performed analysis is based on the combined characteristics of the SPA basin central depression, a substantial feature of the rock composition can be the abundance of thorium; as is known, the latter indicates that abyssal rocks of the norite type were carried to the surface. Figure 5 presents the map of the thorium abundance distribution within the SPA formation. The Lunar Prospector measurements were used as the initial data.

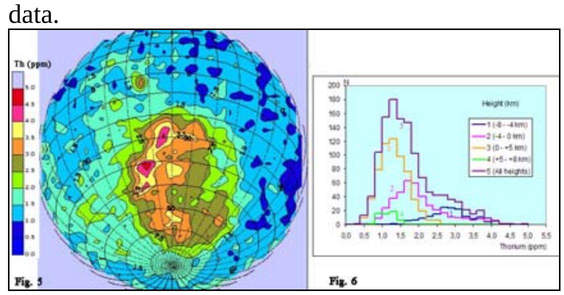

Fig.5, 6. The thorium distributions in the surface layer at different heights of the SPA basin structure.

Figure 6 demonstrates the thorium distributions for the entire formation (distribution *5*) and for different height levels (distributions *1–4*). An analysis of these polymodal distributions indicates that the first mode, corresponding to a thorium abundance of ~1.25 ppm distributions *2–4* and *5*), characterizes anorthosite rocks from the SPA basin outer ring. The second mode corresponds to a thorium abundance of ~1.75 ppm (distributions *1–3* and *5*). The third mode is separated when the thorium content is ~2.75 ppm (distributions *1*, *2*, and *5*). Finally, the fourth mode, which reflects a statistically small part of the studied data set, corresponds to a thorium abundance of ~3.75 ppm (distributions *1*, *2*, and *5*).

A more thorough analysis indicated that the fourth mode (~3.75 ppm Th) shown in Fig. 6 does not correspond to the observed sequence of heights. Different researchers previously assumed that the considered anomaly of the thorium content is the zone of the material carried from outside, i.e., the product of ejecta during the formation of a younger large structure on the Moon.

Multiring structure of the SPA basin. By comparing the hypsometric data with the above analysis of iron and thorium vertical distributions, we can conclude that the character of the structures distinguished in both cases is almost identical. Thus, using two independent methods, it was determined that the SPA basin inner depression has two clearly defined height levels (inner rings): less than 0 and –4 km. Based on the hypsometric map (Fig. 1), we can trace one more small depression considerably shifted toward the south of the entire structure, the heights within which are lower than–6 km. This third ring is not distinguished in the height distribution nor in the distribution of the chemical elements, apparently, because of the small ring area. At the same time, this detail is substantial when the general basin structure is analyzed. Generalizing the analysis of the SPA basin structure, we can refer to the following specific features of this giant formation (Fig. 7).

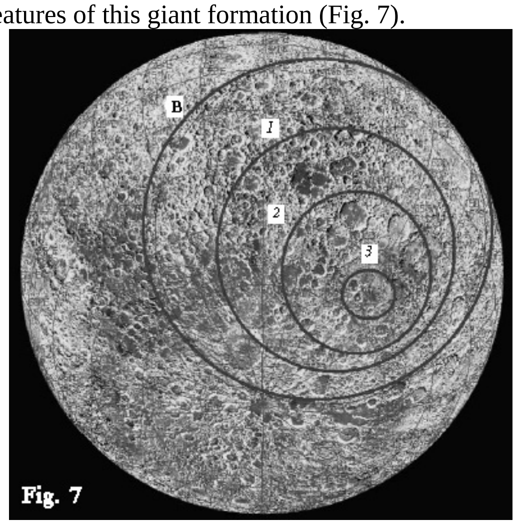

Fig.7. The distinguished rings of the SPA basin structure overlapped on an image of the Moon in the oblique orthographic projection with the 160^{o}E central meridian.

The outer ring marked by *B* in Fig. 7 coincides with the conditional crest of the elevated zone around the basin. The ring shape can be assumed to be circularly symmetric with an average diameter of about 3500 km. The inner boundary of a wide outer ring passes at a height of about 0 km, which geometrically conditionally corresponds to the boundary of the first inner ring.

Ring *1* in Fig. 7 has a clearly defined elliptic shape with the center shifted southeastward from the outer ring center. The major semiaxis of the above ellipse is ~970 km. The average iron abundance below the first ring (4.0–5.5% Fe) corresponds to the characteristics of the breccia samples delivered from the *Apollo-16* (3.88% Fe) and *Luna-20* (5.81% Fe) moon-landing sites (Haskin and Warren, 1995), i.e., to typical continental samples of predominantly anorthosite rocks. The same conclusion is confirmed by comparing the thorium content (1.5–2.0 ppm Th). Thus, we can conclude that the considered zone of the impact structure is located within the upper lunar crust.

Ring *2* in Fig. 7 also has the shape of an ellipse with a major semiaxis of ~640 km as measured along the spherical surface. The center of this ellipse is shifted even further southeastward from the outer ring center.

The surface rock chemistry below ring *2* is characterized by the average iron and thorium abundances higher than 5.5% and 2.5 ppm, respectively. Proceeding from these data, we can conclude that the rocks have been insignificantly carried from the middle and lower crust to the surface in the considered depression zone. The shape of the third distinguished ring is the closest to a circle with a radius of about 210 km. The center of this ring has been shifted by ~730 km from the outer ring center in the same southeastern direction. Increased thorium content was not observed within ring *3*, which belongs to the deepest (to –8.5 km) zone of the SPA basin (Fig. 6). A low thorium content of the rocks in the deepest zone of the present-day SPA basin depression can confirm the assumption that the initial penetration of the impact structure was relatively shallow and did not reach the middle crust. This conclusion quite agrees with the character of the thorium distribution within the SPA basin structure shown in Fig 5.

Conclusions. The SPA basin structure differs from other similar formations on the Moon. An important feature of the proposed model of this ring structure consists in that the arrangement of the basin inner ring differs from the central circular symmetry. A similar feature is possibly typical of lunar megabasins. The results of the independent analysis of the hypsometric characteristics and on the specific distribution of iron and thorium comprehensively confirm that such a model of the basin structure. We can indicate that a hypothetical impactor moved along the trajectory oriented almost normally to ecliptic plane. In combination with the revealed very small depth-diameter ratio (~ 0.004) in the initial basin structure, this circumstance makes it possible to put forward the hypothesis that a comet impact produced the South Pole-Aitken basin.

References. [1] Chikmachev, V.I., Results of Analog Processing of Zond-Probe Photographs, *Aspects of the Complex Investigation of the Moon*, Shevchenko, V.V., Ed., Moscow: Mosk. Gos. Univ., 1986, pp. 42–56.[2] Chikmachev, V.I. and Shevchenko, V.V., *Astron. Vestn.*, 1999, vol. 33, no. 2, pp. 18–28 [*Sol. Syst. Res.* (Engl. Transl.), vol. 33, no. 2, p. 15]. [3] Chikmachev V.I., Pugacheva S.G., Shevchenko V.V.(2005) *Lunar and Planet. Sci. Conf. XXXVI, 2005*, Abstract # 1078. [4] Shevchenko V.V., Chikmachev V.I., Pugacheva S.G. (2007) *Atron. Vestn.* Vol. 41, no. 6, p. 447-462.