ORBITS AND PROBABLE PARENT BODY OF THE KILABO AND BENSOUR LL6-CHONDRITES.

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Introduction: Striking resemblance of two LL6-chondrites fallen within five months of each other in Africa in 2002 attracts general attention [1,2]: the chondrite Bensour of total mass of ~45 kg has fallen on February 11th along the Algerian/Moroccan border, and the chondrite Kilabo of total mass of ~19 kg has fallen on July 21st in northern Nigeria. In particular, their similar petrography and fayalite composition: ($Fa_{30.7}$) and ($Fa_{30.9}$), respectively, could indicate a common source of origin of both the chondrites. Moreover, the parent body of these chondrites is supposed to be the main belt asteroid 3628 Boznemcova: it was shown earlier in [3] that the reflectance spectrum of that asteroid is practically coincident with the average reflectance spectrum of LL6-chondrites and, in particular with that of the Manbhoom LL6-chondrite.

The problem of origin and evolution of meteorites cannot be solved without the knowledge of their orbits. Just the orbits can identify the belonging of meteorites to some family of the celestial bodies, among which the sources of meteorites, their parent bodies, should primarily be looked for. Nowadays, the orbits of only six chondrites are known exactly: Pribram (H5, fall on 7.04.1959, q'=4.05 AU), Lost City (H5, 3.01.1970. q'=2.35 AU), Innisfree (LL5, 5.02.1977, q'=2.76 AU), Peekskill (H6, 9.10.1992, q'=2.10 AU), Neuschwanstein (EL6, 6.04.2002, q'=4.01 AU) and Park Forest (L5, 26.03.2003, q'=4.26 AU), which, at least, testify to the belonging of the chondrites to the bodies of the Solar system, most likely, to the asteroids. In the report we give the estimates of sizes of the Kilabo and Bensour orbits, which really allow us to consider the asteroid 3628 Boznemcova as the parent body of the LL6-chondrites.

Isotopic criterion of size of orbits of ordinary chondrites: The isotopic approach elaborated formerly [4-7], based on the content of cosmogenic radionuclide ^{26}Al, to estimate the position of aphelion q' of orbits of the chondrites under consideration is used. Indeed, according to radioacrivity of ^{26}Al in the chondrites with known orbits (Pribram, Lost City and Innisfree), the galactic cosmic ray intensity gradient of about ~20-30%/AU along the meteorite orbits, average over ~1 My, exists, so that the ^{26}Al content in the chondrites of more prolonged orbits is essentially higher. It is possible, at least within the chondrite orbits (< 5 AU from the sun), to approximate, with regard to experimental errors, the derived growth of ^{26}Al content in the chondrites (corrected, certainly, due to the depth effects), by a broken line corresponding to the ^{26}Al minimal production rate (H_{min}) at the average galactic cosmic ray intensity for the solar cycle in the chondrites with $q' \leq 2$ AU and to the ^{26}Al maximum production rate (H_{max}) at the unmodulated galactic cosmic ray intensity in the chondrites of large orbits. The ^{26}Al production rates H_{min} and H_{max} in L(LL)-chondrites of different sizes , which are calculated with the analytical method [4], are presented in Fig.1.

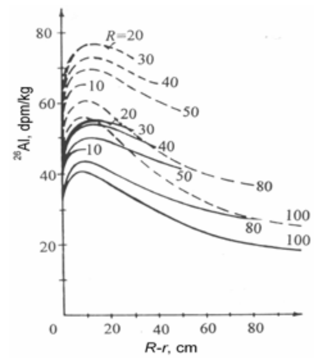

Fig.1 *Depth distribution of the ^{26}Al production rates H_{min} (solid curves) and H_{max} (dash curves) in L(LL)-chondrites of different size (R – radius of chondrites; r – distance from the center; d=R-r –depth from the surface).*

The ^{26}Al measured content, or the ^{26}Al experimental production rate H_{exp} (in dpm/kg) in the chondrites can be expressed in the following form:

$$H_{exp}=H_{min}Z+H_{max}(1-Z), \qquad (1)$$

where H_{min} is the ^{26}Al production rate during the time Z (in parts of the orbital period P) when the chondrite flew inside the range of ≤ 2 AU, and H_{max} is the ^{26}Al production rate when the chondrite flew outside the range of 2 AU from the sun during the rest time (1-Z). Therefore, in the frame of the adopted approximation, one may estimate the orbit size of chondrites if their ^{26}Al content is measured. This regularity can be successfully expressed in the phenomenological form in terms of aphelion q' [4-6]:

$$q'(Z)=1.25+0.13Z+0.53Z^{-1}, \qquad (2)$$

where q' is the aphelion in AU. After determination of Z from (1) (according to the data on ^{26}Al content in the chondrites), one may immediately estimate the aphelion of their orbits from (2). In the case of cosmic bodies, which can fall to the Earth, i.e. for meteorites, the most probable values of the semimajor axis *a* and the eccentricity *e* can be pointed out too [4]:

$$a \sim (q'+1)/2; \qquad e \sim (q'-1)/(q'+1). \qquad (3)$$

Orbits of the Kilabo and Bensour chondrites: According to the ^{60}Co evidence and the evidence of tracks of VH-nuclei, the pre-atmospheric size of the Kilabo chondrite is ~ 34 cm, and the shielding depth of the investigated sample is 6 ± 3 cm [8,9]. The measured content of ^{26}Al in this sample is 68±7 dpm/kg, which corresponds to the orbit with aphelion q' = 3.6±3.1 AU and to the most probable parameters of the orbit: semimajor axis a = 2.3 AU; eccentricity e = 0.565; orbital period P = 1273.2 days. This orbit as the regularity $r(t)$ (where t is time and r is a heliocentric distance), calculated with the Kepler formulae [10], is shown in Fig.2 together with the orbit of the asteroid 3628 Boznemcova (q' = 3.2994 AU, a = 2.538 AU, e = 0.3, P = 1475.81 days [11]). Both the orbits cross at the points at 3.20 AU and at 2.15 AU. The range between 3.1-3.4 AU is characterized with the absence of the chondrite aphelia [7], as well as, apparently, the other cosmic bodies due to some selection of orbits by the dynamical processes in the interplanetary space, by the existence of the Kirkwood ports and secular resonances [12,13], so that any catastrophic collision of the 3628 Boznemcova asteroid in that range was hardly probable. It is believed that just at 2.15 AU, i.e. in such a densely populated range of the interplanetary space, near the inner boundary of the asteroid belt the chondrite Kilabo was excavated from the asteroid 3628 Boznemcova to the more eccentric orbit due to a catastrophic collision with some cosmic body.

Under the reasonable assumption of similar ablation of the Kilabo and Bensour LL6-chondrites (96.4%), the preatmospheric radius of the Bensour chondrite was R ~ 45 cm [8], and the shielding depth of the sample investigated in [2], according to the measured ratio $^{22}Ne/^{21}Ne$ = 1.123, was d ~ 4-7 cm [8]. The measured content of cosmogenic ^{26}Al in that sample is 62±1.2 dpm/kg [2], which corresponds to the following orbit: q' = 3.51±3.48 AU; a = 2.255 AU; e = 0.557; P = 1236 days (see Fig.2). The orbit of the Bensour chondrite is smaller than that of the Kilabo chondrite: seeing the Bensour chondrite had greater mass, it had received a smaller velocity at the explosive pulse. The orbits of the Bensour chondrite and the 3628 Boznemcova asteroid intersect at 2.16 AU and at 3.25 AU, i.e. practically just at the same point near the inner boundary of the asteroid belt, as in the case of the Kilabo chondrite.

Summary: The cosmic ray exposure ages of the Bensour and Kilabo chondrites are different: their

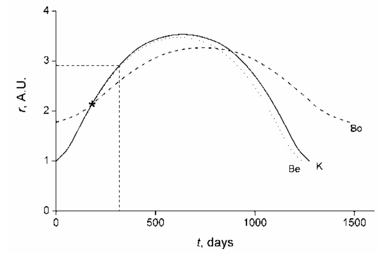

Fig.2 *Orbits of the Bensour (Be) and Kilabo (K) chondrites together with the orbit of the 3628 Boznemcova (Bo) asteroid (dashed lines mark the average heliocentric distance of the Kilabo orbit: r_c = 2.91AU; asterisk marks intersection of the Kilabo and Bensour orbits with that of 3628 Boznemcova)*

exposure ages T_{21} from the content of cosmogenic ^{21}Ne equal 19 and 33 My, respectively [2]. Basing only on these data, one may suppose that the Kilabo chondrite was ejected due to a catastrophic collision of the 3628 Boznemcova asteroid with a cosmic object near the inner boundary of the asteroid belt 33 My ago, and after 14 My the Bensour chondrite was ejected in the recurrent catastrophic collision of the 3628 Boznemcova in that region. However, taking into account the similarity of structure and content of both the chondrites, the vicinity of their orbits, the intersection of the orbits with that of the asteroid practically at the same point, as well as the complex exposure history of the Kilabo chondrite [9], much more preferable is the scenario suggested in [2]: ejection of both the chondrites from the 3628 Boznemcova near ~2 AU from the Sun 19 My ago, the chondrite Bensour being ejected from the deep layers of the asteroid, which were completely screened from the galactic cosmic rays, and the Kilabo chondrite being, probably, exposed to the galactic cosmic rays on the surface of the asteroid during 14 My. The contemporary size of the 3628 Boznemcova asteroid amounts to ~ 7 km in diameter [11].

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