FISSION TRACK DATING OF THE BOLTYSH IMPACT CRATER, UKRAINE

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The Boltysh impact crater, 25 km in diameter, is formed mainly in Pre-Cambrian granites and gneisses, and covered by sedimentary rocks [1]. K-Ar dates of the Boltysh impact melts are in the range of 64-108 Ma [2], and the most plausible K-Ar age is believed to be 88±3 Ma [3]. However the K-Ar age conflicts with biostratigraphical constraints, which point to a Paleocene age of earliest sedimentary rocks filling the crater cavity [4]. In this work we carried out fission track dating of the structure. The fission track age was found to be 65.04±1.10 (1σ) Ma. It suggests a possible link of the Boltysh crater with the K/T boundary impact event.

Samples and method. For this track dating we used an impact melt sampled by the drill hole # 11475 at the depth of 762 m. This melt consists of plagioclase and hyperstene microcrystals embedded into a glass matrix. A sample of the melt was crushed and 262 fragments of pure glass were picked up from a 0.25-1 mm grain-size fraction. The selected fragments were polished and etched by a mixture of HBF_4 (48%), HNO_3 (10%), and CH_3COOH (0.5%) at the proportion of 2:1:2 for 150 min at 20°C. Then densities and diameters (D_s) of fossil tracks were measured. After that the fragments were repolished, irradiated with a neutron flux (F) of 2.15±0.03 (1σ)$*10^{16}$ neutron/cm^2, and etched again under the same conditions to measure diameters (D_i) and densities (ρ_i) of neutron-induced fission tracks. To correct annealing of fossil tracks we used the correction procedure [5] based on the D_s/D_i ratio. The correction function was calibrated experimentally for 21 glass fragments of the same sample. After the track study, all glass fragments were analysed with electron microprobe for major elements.

Results. Totally 4912 fossil tracks and 54166 neutron-induced tracks were identified in the 262 glass fragments. This glass does not show significant compositional variations. The average composition is (wt.%, 1σ error): SiO_2 - 70.7 (1.8), TiO_2 - 0.44 (0.03), Al_2O_3 - 13.25 (0.32), FeO - 2.31 (0.12), MgO - 0.30 (0.05), CaO - 0.64 (0.04), Na_2O - 2.17 (0.17), K_2O - 4.88 (0.16), total - 94.7. The low total can be due to a Na and K loss under the electron beam. The quota of preserved fossil tracks is mostly in the range of 0.14-0.25. It indicates a significant loss of fossil tracks but a similar thermal history of the glass fragments. When corrected for annealing the fossil track densities (ρ_o) correlate strongly with ρ_i/F values (Fig.1). The correlation coefficient is 0.85. The correlation means that the glass fragments have the same age but different uranium concentrations and/or different etching characteristics. A fission track age was calculated for each particle using the ^{238}U decay constant of $7.03*10^{-17}$ y^{-1}. The accuracy of the age values depends mainly on $1/\sqrt{N}$, where N is a number of identified fossil tracks. The data were averaged taking the individual ages with a weight given by N. The weighted histogram is shown on Fig.2. The average was found to be 65.07±1.21 (1σ) Ma. The error of the mean depends on errors of individual ages and a variance of these values. The fission track isochron age [6,7] computed by regressing of ρ_o and ρ_i/F values (Fig.1) using the regression method [8] is equal to 64.87±2.57 (1σ). Seven glass fragments were dated also by the plateau-annealing technique [9]. The measurements gave the age value of 64.5±6.0 (1σ) Ma. The age estimates are independent and can be joint. It leads to a value of 65.04±1.10 (1σ) Ma that is a best fission track estimate of the crater age.

Discussion. The fission track dating demonstrates that the age of the Boltysh crater should be in the range of 61.7-68.3 Ma (3σ). The interval overlaps Maastrichtian and Lower Paleocene and conflicts with the accepted K-Ar age of 88±3 Ma [3]. Nevertheless, the fission track age is within the range of K-Ar dates [2] and compatible with the biostratigraphical constraints [4]. The old K-Ar dates can be due to incomplete outgassing of the Pre-Cambrian basement rocks during the impact melting. Thus the fission track age can reflect better a real age of the Boltysh crater. The fission track age is not distinguishable statistically from the K/T boundary age but the uncertainties of dating are significant and the age

difference between the Boltysh and the K/T impact events may be as large as 5.3 Ma (3σ). Approximately 13 impact craters bigger than the Boltysh crater could be formed on the Earth surface for the time at the normal cratering rate [10]. The probability of two or more independent impacts of the scale on the continental crust is as high as 93%. Thus the age coincidence of the Boltysh crater and the K/T boundary does not prove the same age of the impacts and, therefore, a genetic link between the events.

However it has been shown [11,12], that the Kara crater, 120 km in diameter, could be related to the K/T event. The fission track age of the structure is 64.57±1.56 (1σ) Ma [7]. This age is not distinguishable too from the Boltysh fission track age. The possible age difference between the Kara and the Boltysh impacts is 6.2 Ma (3σ), and a distance between the craters is only 3000 km. One can calculate a probability of two or more impacts, >20 km in resulting crater diameter, of a different age at a distance of ≤ 3000 km. The probability is about 20%. Therefore, there is a probability of about 80% that the Boltysh and the Kara craters are simultaneous or the production rate of impacts at the end of Cretaceous was higher than normal one. The 80% probability is not very high but it points to a possible link between the Kara, the Boltysh and the K/T (Chicxulub) impacts, and, hence, confirms a scenario of a multiple impact event at the K/T boundary.

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