# MAGNETOMETRIC SEARCH OF CHELYABINSK METEORITE'S MAIN MASS

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A light bolide flight was visible at 15 of February 2013 over five regions of Russia: Tyumen, Sverdlovsk, Chelyabinsk and Kurgan regions, and Bashkiria. The cosmic body exploded at a height of 19 - 24 kilometers above the Urals. The largest solid fragment survived in the thermal decomposition in the atmosphere and fall in Chebarkul Lake near the town of Chebarkul. Its mass was approximately 600 kg, plunged through the 80 cm thick ice covering the surface of the lake. The 8 m diameter circular opening in the ice was found shortly after this meteorite event. Fragments from the event were collected soon after the fall and were of an ordinary chondrite composition with the iron/nickel component, providing an opportunity for magnetic detection.

The location of main meteorite body was searched by the staff members and students of the of UrFU Quantum Magnetometry laboratory February and March of 2013. The survey was carried out using high-precision Overhauser magnetometer-gradiometer MMPOS [4]. Magnetic field surveys include the area around the frozen but visible at that time hole in the ice. The precision micromagnetic survey was carried out at the site of 100×100 meters. The analysis of magnetic field map showed fairly good homogeneity of the geomagnetic field near the ice-hole, increase in the number and amplitude of the magnetic anomalies upon approaching the shore, caused by a decrease in the distance from the level of the ice to the bottom of the lake. Several anomalies were identified near the center of ice-hole. More detailed micromagnetic survey over the area of 40×40 m was carried out in steps of 1 m to clarify these anomalies. Four magnetic anomalies of 50 nT were localized as the result of the analysis of the maps by Kletetschka [1]. The magnetic anomalies were located within a 20-meter radius from the ice-hole.

The bolide flight data [3] allowed to make a computer simulation of the anomalies in order to verify the relationship between the observed anomalies and the target object. We performed a simulation of magnetic anomalies in the dipole approximation. We took the initial approximation of bolide body mass as 100 kg, the content of magnetic impurities around 10%, and the depth of lake at 10 meters. Two main hypotheses were considered in the simulation: (i) the meteorite did not split when falling and (ii) the meteorite breaking into two objects. The direction of the sample magnetization was chosen as the modeled parameter. Since the dipole approximation was used for the simulation, positive and negative anomalies of the geomagnetic field (zones in which the value of the field was significantly different from the mean) were considered in the immediate vicinity. The following values were compared during modeling: extremum value of the magnetic anomaly (characteristic point techniques); geometric dimensions, i.e., length of the maximum cross-section connecting the points with the maximum value of magnetic field anomaly to those of 30% for this anomaly (x) and the same but perpendicular to the first (y).

As a result of comparing of the magnetic maps obtained by the computer simulation and micromagnetic survey, the hypothesis about the presence of the meteorite on the bottom of Lake Chebarkul was accepted. The hypothesis presumed that a number of small fragments separated on the impact of the meteorite with the ice but most of the cosmic body was in the form of a sufficiently large fragment.

Data distribution of the magnetic field produced in 2013 by several research groups [2] became the basis for believing that there may be another big fragment of the meteorite on the territory within the boundaries established by the surveys conducted. The repeated magnetic survey was carried out to test the hypothesis. The main difference of the present investigation from the previous ones was marking the entire area, conducting a serial profile survey and constructing a seamless map. It was found that the anomaly observed in 2013 in a layer of mud during the search for the meteorite was no longer there, and the surveyed area did not contain any other characteristic anomalies sufficient to identify a fragment of a meteorite. However, extensive anomalies of low intensity were detected, and their interpretation requires a more detailed study with positioning magnetometers closer to the anomalies source.

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[3] Popova et al (2013) *Science* 6162, 1069-1073
[4] Sapunov V. A. et al. (2015) *Proceedings of International Multidisciplinary Scientific GeoConference SGEM*, Vol. 1, pp. 215–222.