GEOPHYSICAL METHODS IN THE SEARCH FOR EXTRATERRESTRIAL MATTER

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Advantages of magnetometric search

Ground-based magnetometry, along with electromagnetic methods (metal detectors), is one of the main methods for detecting buried iron-containing items, such as unexploded ordnance, as well as meteorites. Despite the presence of high-sensitivity deep metal detectors, the magnetometric search method does not lose relevance, although it is more expensive and slow.

Magnetometer, as a search tool, has a greater target detection depth, because the magnetic field of the object decreases $\sim 1/r^3$, and the signal of the electronic metal detector $\sim 1/r^6$. Detailed magnetic surveys for the searching for unexploded ordnance, meteorites, as well as archaeological sites, are one of the main purposes of ground-based magnetometers [1, 4]. The Meteoritic Expedition of the Ural Federal University has been using pedestrian magnetometers MMPOS [2, 3] to search for meteorites for many years.

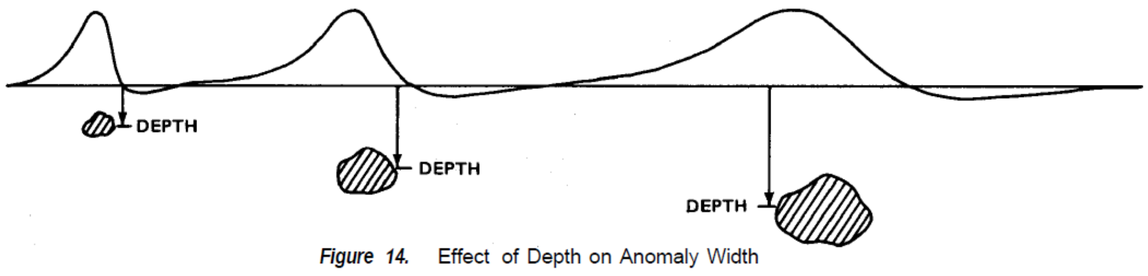


Figure 14. Effect of Depth on Anomaly Width

Method

The search for a meteoritic material is a method of magnetometric searching for any objects containing magnetic elements, for example, iron. A methodology for estimating the size, shape, and other characteristics of the body – the source of the anomaly is needed. The solution of this problem will allow to immediately distinguish the meteorite from other iron-containing objects in the soil, and make a step towards constructing a universal search appliance based on a computer or with the involvement of an operator.

Search technique variants:

Magnetic survey according to the standard method used in geophysical research for the search for minerals.

Free search technique:

- multiple measurements determine the average value of the magnetic field within the investigated area and an approximate dependence on altitude, topography, time.
- systematic measurements of the magnetic field along the selected network are made, during which anomalies are observed (jumps, huge gradients).
- when an anomaly is detected, measurements are made near this point, the purpose of which is to determine the type of anomaly (local increase or decrease, wave, large chaotic field gradients).
- by the type and intensity of the anomaly, we estimate the qualitative characteristics, body dimensions, etc., and make a decision on its extraction.

Application experience

The method of free search can be easily applied by the operator with minimal experience of using the magnetometer.

We have accumulated experience in applying this technique in different conditions:

- in the large magnetic field gradients due to geological features which are typical for the Urals (north of the Chelyabinsk region, the search for the substance of the meteorite shower Kunashak); In a strongly gradient field, the sense in increasing the sensitivity of the instrument is lost, and only fairly large objects can be detected.
- in a sufficiently homogeneous magnetic field which is typical for the steppes of the Lower Volga region (search for a meteorite shower Tsarev). In this case, with the appropriate registration of diurnal geomagnetic variations, large areas can be surveyed and rather deep-lying objects can be found that are inaccessible to the metal detector.
- when working on the water surfaces of lakes in the search for a meteorite, supposedly fallen into a pond.

At the same time, there is a negative experience: when searching for the iron meteorite shower Dronino (Ryazan region), the gradiometer was less effective than the deep pulse metal detector LORENZ PULSE 5 (Lorenz detecting systems, Germany). The anomalous magnetic field of the high-nickel meteorite was small, because almost all the samples were corroded and weathered under the influence of groundwater, were in the ground for thousands of years.

We have experience in conducting a magnetometric survey to investigate a funnel that has a supposedly meteorite origin (found near Severouralsk, the Northern Ural).

Urals Meteoritic Expedition's almost twenty years of experience with the magnetometers MMPOS indicates the successful possibility of carrying out prospecting work for a meteorite substance both on land and in water areas.

High-precision Overhauser magnetometer MMPOS

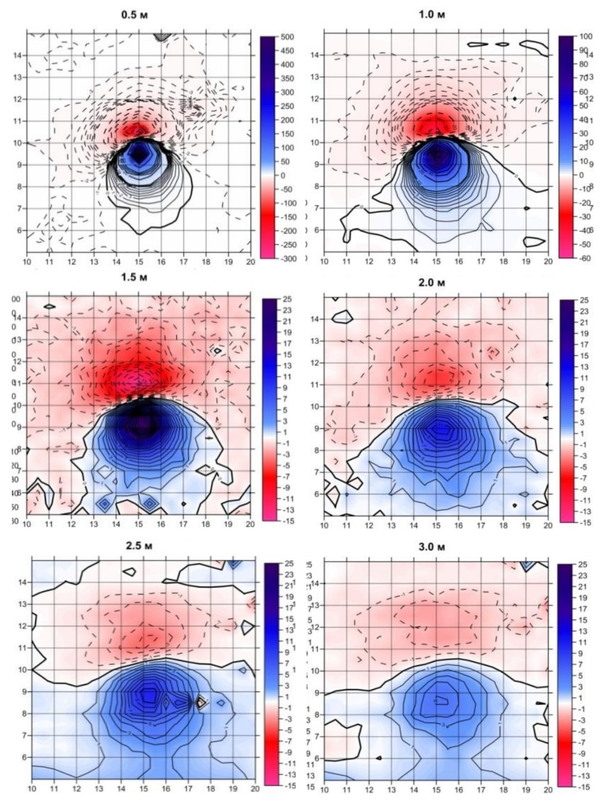
Geophysical exploration instruments: Booklet // San Jose, USA, Geometrix, 1988

Breiner S. Application Manual for portable magnetometers. San Jose, Geometrics, 1973

Stanley, J.M., Cattach, M.K. Developing geophysical techniques for detecting unexploded ordinance. First Break, vol.22, september 2004, p.55-61.

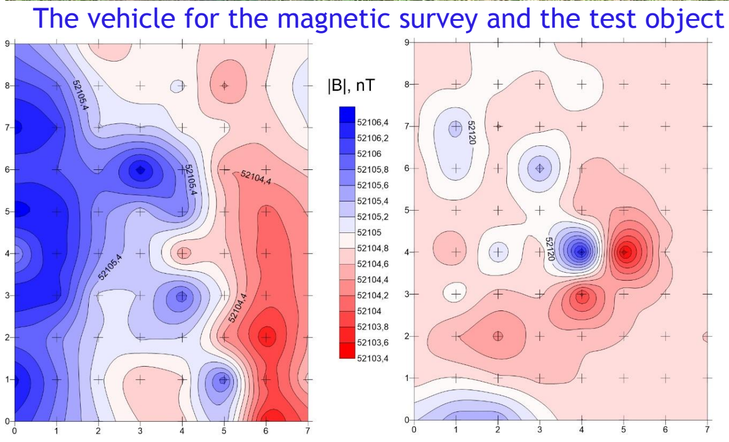
Measurement range	20000 – 100000 nT
Capasity (digits)	0,001 nT
Sensitivity (RMS)	0,02 nT (cycle 3 s), 0,05 nT (cycle 1 s)
Cyclicity of measurements	1, 2, 3 s (up to 0,2 s optional)
Absolute error	1 nT (up to 0,1 nT in the VNIIM)
Gradient resistance	20000 nT/m (40000 nT/m optional)
Temperature range	–30°C / +60°C
Power consumption (3 sec)	2 - 3 W
Stability of the radical	10 years (5 years at +50°C)
Dimensions of electronics	160×90×55 mm
Dimensions of sensor	∅ 69×120 mm
Total weight	1,2 кг (including cable)

Anomalous magnetic field of 15 kg iron cylinder

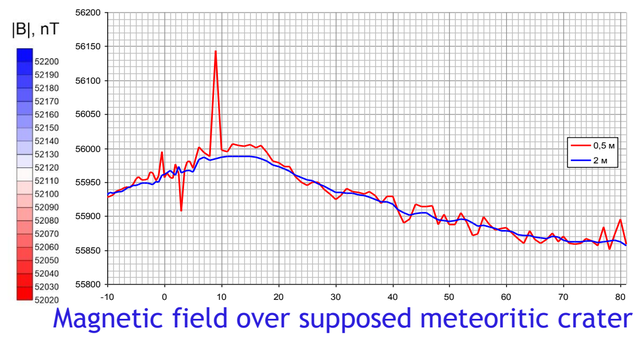


The vehicle for the magnetic survey and the test object

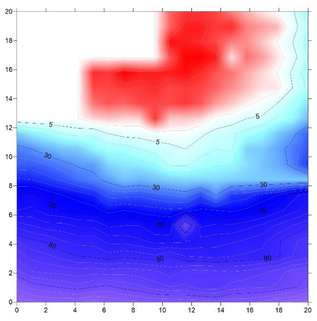
Practical examples



Magnetic survey for search of Dronino meteorite



Magnetic field over supposed meteoritic crater



Magnetic survey for search of Kunashak meteorite

Gradientometric survey (vertical or horizontal gradient of the magnetic field)

References

[1] Breiner S. (1973) Application Manual for portable magnetometers. Geometrics, San Jose, USA, 58 p. [2] Narkhov E. D. et al (2005) AIP Conference Proceedings 1886, 020075 [3] Sapunov V. A. et al. (2015) Proceedings of International Multidisciplinary Scientific GeoConference SGEM, Vol. 1, pp. 215–222. [4] Smekalova T.N. et al. (2005) Magnetic survey in archaeology. 10 years of using of Overhauser GSM-19 gradiomenter. SPb.: Publishing house of Polytechnic University. 68 p

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