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Influence of Impact Ejecta on Crustal Magnetic Field Anomalies.

M. Kuzmicheva, T. Losseva
Institute of Geospheres Dynamics RAS, Russia (kuzm@idg.chph.ras.ru , losseva@idg.chph.ras.ru / Fax: +7 (495) 137 66 11)

Abstract

A role of impact ejecta and post-impact atmospheric plume in providing magnetic anomalies is considered. It is shown that impact-ejecta generated magnetic field can provide both positive and negative anomalies. Geomagnetic field disturbances detected after the Tunguska bolide explosion are discussed.

1. Introduction

Recent interest to the crustal magnetic field on Moon and Mars [1,2] caused this attempt to figure out a role of impact ejecta and post-impact atmospheric plume in providing magnetic anomalies (similar interest in [3]). Actually, we have unique magnetograms of the geomagnetic field obtained by the Irkutsk's geophysical observatory which demonstrate disturbances attributed to explosion of Tunguska bolide [4] which impacted the Earth on the 30th of June in 1908. It was the most powerful documented impact, though no crater-forming [5].

2. Observational data and results of numerical modelling of geomagnetic field disturbances for the Tunguska bolide.

The magnetic field disturbances started approximately 5-6.5 min after the explosion, the disturbances were positive at the beginning and negative later, maximal values were of order of tens of nT, total duration was several hours. The variations were observed both in H- and Z-components. The observatory is located in almost 1000 km from the explosion epicenter, and the bolide itself hadn't been there. Analysis and numerical modeling of the explosion showed that geomagnetic disturbances occur while gas dynamic plume combining the impact ejecta and heated atmospheric gas provides a well-conductive cloud moving across the geomagnetic field [6]. Results of typical magnetic field disturbances on the ground obtained by self-consistent modeling of gas dynamic parameters and 3 D electro dynamics calculations are pictured in Fig.1.

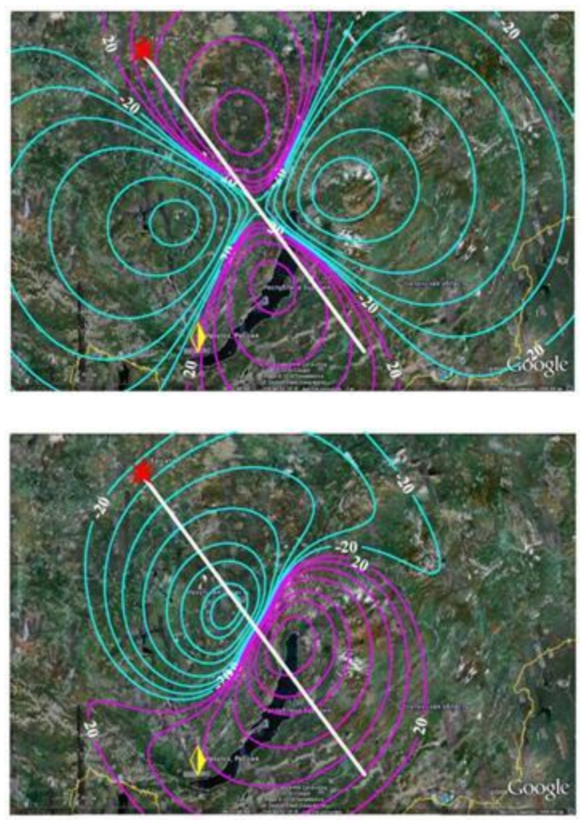

Figure 1: H- and Z-components are presented on the upper and lower panels. The red star marks the epicenter, the diamond-shape symbol marks a site of the observatory, the white line shows trajectory azimuth.

In accordance with the figure a size of the disturbed area is of order of thousand km, maximal values of disturbances are of hundreds of nT, and there are both negative and positive ones in the area. It is important that the induced field is not similar to the field of a magnetic dipole. We anticipate transient magnetic field disturbances at any impact under conditions of non-symmetric flow of conductive ejecta across magnetic field.

3. Application for magnetic crust anomalies.

Elaborate study of crater-forming impacts and impact ejecta deposits [7] showed that directional distributions of ejecta are not regularly shaped in a case of inclined trajectories. Heterogeneity of crust and impactors also influence the spatial distribution. That is confirmed by numerous crater pictures on surfaces of airless moons and planets. For the Moon it is assumed that planetary magnetic field was in past. So these results can shed light on known magnetic crust anomalies on the Moon.

It is known that impact craters on the Earth and Mars are eliminated by negative ring-like magnetic anomaly [8,2]. An assumption that these anomalies are caused by action of shock wave deems the most cogent. However, some patchy positive anomalies are also presented close to crater, which is often attributed to magnetic substance deposit [8], though it may be provided by the magnetic field of ejecta.

Origin of "curved" positive magnetic field anomalies, responsible for bright-colored swirls on the Moon's surface [9] can also be assigned to action of transient magnetic field induced by ejecta of basin-forming event in the ancient lunar magnetic field. Antipodal to basins positive anomalies previously were explained by expulsion of solar wind magnetic field by plasma of colliding impact ejecta [1].

At a present time Martian crustal magnetic field is under investigation, and basin negative anomalies have been found out [2]. So displays of magnetic fields generated by post-impact plumes are also anticipated.

4. Summary and Conclusions

The impact-ejecta generated magnetic field is not like a magnetic dipole field. Maximal field values are order of percentages of the local planetary field. It can provide both positive and negative anomalies.

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