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GEOPHYSICS

1967

SovietRxiv

Abstract

Full Text

UDC 550.382.3 : 553.311

GEOPHYSICS

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CHANGE IN THE REMANENT MAGNETIZATION OF A MAGNETITE DEPOSIT AFTER AN EXPLOSION

(Presented by Academician M. A. Sadovskii, January 20, 1967)

Experimental work carried out in order to clarify the connection between magnetic and seismic phenomena has, as a rule, led to results whose interpretation was ambiguous ([1,2]). Even in those cases when magnetic disturbances were recorded at the moment of an earthquake, the existence of such a connection was only presumed ([3,4]).

Laboratory investigations ([5–8]) show that the magnetization of a rock specimen depends to a considerable degree on the static and dynamic elastic stresses to which the specimen is subjected in experiments. This dependence can be detected by acting on a massive magnetite deposit with the energy of seismic waves excited by an explosion.

An experimental study of the seismomagnetic effect was carried out at three magnetite deposits (First and Second Lisakovsk, Kurzhunkul) and at the Kuibyshev magnetic anomalies in Northern Kazakhstan, as well as at three ore occurrences of the Techa group and the Novosurakov magnetic anomaly in the Middle Urals. Changes in the magnetic field after explosions were recorded at all objects associated with magnetite ore occurrences. As an example, the result is described of an experiment obtained during explosions in one of the boreholes at the First Lisakovsk magnetite deposit.

The magnetic field was recorded with the aid of three-component X, Y, Z magnetovariation stations constructed at the Institute of Geophysics of the Ural Branch of the USSR Academy of Sciences on the basis of V. N. Bobrov sensors, and also with the aid of M-2 and M-17 magnetometers. To exclude natural magnetic variations, simultaneous recording of magnetograms was used at the epicenter of the anomaly (I in Fig. 1) and in the normal field (II). The recording of variations was continuous, with a sensitivity in all components of 3.3 mm/γ. The M-2 and M-17 magnetometers (scale divisions 13 and 10 γ/division) were installed at the epicenter of the anomaly at a distance of 10 m from the variation station, and the X, Y, Z seismic receivers at a distance of 8 m from variometers I and II. All instruments were firmly installed on the ground. A linear charge

Fig. 1. Plan of ΔZ isolines and schematic geological section along profile I at the Pervyi Lisakovsk magnetite deposit.

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was exploded in a borehole drilled at a distance of 40 m to the northeast of the epicenter of the anomaly (Fig. 1). Three explosions were made in this borehole: the 1st—46 kg of tol at a depth of 45-52 m; the 2nd—12 kg at a depth of 7-9 m; the 3rd—8 kg on the ground surface near the mouth of the borehole.

Variations of the magnetic field recorded by stations I and II are shown in Fig. 2. Analysis of the curves shows that the 1st explosion, carried out in Paleozoic bedrock in the immediate vicinity of the magnetite deposit, led to a stepwise irreversible increase in the magnetization of the ore body: the anomalous field increased by 24 γ in Z and by 26 γ in X, and decreased by 3 γ in Y. After the 2nd explosion in sandy-clayey Quaternary deposits and the 3rd explosion on the ground surface, when the seismic action on the ore body was insignificant, the change

no change in the recording level was observed in any component of the field. The 1st explosion caused an increase in the field along Z at the points where magnetometers M-2 and M-17 were installed, by 32 and 35γ, respectively, while after the 2nd and 3rd explosions the readings of these instruments did not change.

Obviously, the jump in the recording level by 24—26γ after the 1st explosion cannot have been caused by displacement of station I, since, with gradients of 0.04γ/mm along X and Y and 0.3γ/mm along Z (measured values), in order to obtain an increase in the reading of instrument I along Z by 24γ, it would be necessary to lower it by 80 mm, whereas the maximum irreversible displacements of the ground at the point of installation of the variometer under the experimental conditions, calculated according to

Fig. 1. Plan of ΔZ isolines and schematic geological section along profile I at the Pervyi Lisakovsk magnetite deposit.
1 —sandy-clayey deposits; 2 —diorite-porphyrites; 3 —magnetite ore and "ore" skarn; 4 —borehole in which the explosions were carried out; 5 —orientation of variometers and seismic receivers; 6 —observation points: I —in the anomalous field, II —in the normal field; 7 —ΔZ isolines (in oersteds).

([9,10]),

should not exceed 0.5 mm. In addition, the absence of shifts in the record after the 2nd and 3rd explosions also shows that the jump in the record obtained after the 1st explosion is not connected with displacement of the station, especially if one takes into account that the magnitude of the charges for all the explosions

Fig. 2. Copies of magnetograms of the anomalous (Z_a, X_a, Y_a) and normal (Z_n, X_n, Y_n) variation stations

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was chosen so that the ground displacements in the area where stations I were installed (the amplitudes of oscillations on the seismograms) were approximately the same.

The recorded jump in the magnetic-field record after the 1st explosion is due to an increase in the residual magnetization of the ore body. We believe that this effect is caused by the appearance of dynamic magnetization J_{rd}, which agrees well both with the results of laboratory experiments on the creation of J_{rd} in magnetite samples from this deposit and with experimental studies of magnetites from other deposits ([4,11]).

Study of samples taken from boreholes showed that the ore body is composed of magnetite, whose natural residual magnetization J_n is not stable (the samples were cubes with a side of 30 mm). In a zero field, J_n is almost completely demagnetized by 6-10 elastic impacts with an energy per impact of 0.18 kgm. Magnetite samples in the Earth' s field easily acquire J_{rd} of large magnitude (up to 0.02–0.03 CGS/cm^3). The principal magnetic

characteristics of the samples: $0.16 \leq \chi \leq 0.45$ CGS/cm^3, $0.001 \leq J_n \leq 0.02$ CGS/cm^3, H'_c = 6-10 oersted; $H_{\sim 0.5}$ = 15-30 oersted; J_s = 120-250 gauss; H_{cs} = 45-62 oersted.

Explosions of identical charges in other boreholes at this deposit showed that changes in magnetization are observed if the distance between the charge and the ore body does not exceed 40-50 m. Similar experiments carried out on non-ore anomalies produced no noticeable changes in the magnetic field.

Thus it has been established that elastic oscillations of a massive magnetite body *in situ*, caused by an explosion, lead to a change in the residual magnetization of the body and, consequently, of the anomalous magnetic field above it.

Fig. 2. Copies of magnetograms of the anomalous (Z_a, X_a, Y_a) and normal (Z_n, X_n, Y_n) variation stations

The experiment performed shows that the elastic stresses of an explosion change the residual magnetization of a body, which gives substantial grounds for expecting success in studies of the magnetic effect of natural earthquakes, especially if strongly magnetic rocks fall within the region of large compressions and extensions.

The observed effect may be used for a qualitative separation of magnetic anomalies into ore-related ones, associated with magnetite deposits, and non-ore ones, caused by magnetic rocks.

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Received
1 XII 1966

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Note: Figure translations are in progress. See original paper for figures.