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SOME DATA ON THE CHARACTER OF THE GEOMAGNETIC FIELD DURING REVERSALS

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Abstract

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GEOPHYSICS

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SOME DATA ON THE CHARACTER OF THE GEOMAGNETIC FIELD DURING REVERSALS

(Presented by Academician V. V. Menner, 16 VIII 1967)

At the present time, paleomagnetic investigations have accumulated a number of data whose interpretation requires the assumption that reversals of the geomagnetic field existed ([5,6]) and others. To construct a consistent theory of terrestrial magnetism, knowledge of the character of the field during the reversal period is necessary. However, different authors treat this problem in different ways ([2,4,7,10,11]).

We have investigated the behavior of the geomagnetic field during the period of accumulation of the terrigenous red-colored deposits of the Evenki suite Cm_3? ([1,3]), developed in the middle course of the Angara River and exposed in the Krasnyi Yar locality. These formations possess ancient magnetization, the direction of whose vector systematically, at various intervals through the thickness, changes its polarity. The correspondence of the magnetization studied to the epoch of rock formation is shown by the following:

1. The coordinates of the ancient magnetic pole, calculated on the basis of study of the collection investigated, agree with fairly good accuracy with the data of other authors who studied coeval formations within the Siberian Platform (Table 1).

Table 1

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Object of study, suite	Coordinates of the sampling area $\phi°$	Coordinates of the sampling area $\lambda°$	Coordinates of the paleomagnetic pole $\Phi°$	Coordinates of the paleomagnetic pole $\Lambda°$	Author of determination
Red-colored siltstones, sandstones Cm_3vl	61	116	−37	116	V. P. Rodionov; E. P. Sidorova
Red clays Cm_3vl	57	107	−41	127	V. P. Rodionov
Same	58	108	−36	119	»
» »	54	106	−33	130	»
Red-colored clays and sandstones Cm_3vl	54	102	−41	126	»
Red-colored and variegated sandstones and argillites Cm_3vl	58	97	−29	116	A. Ya. Vlasov
Red-colored clays, marls, sandstones, limestones Cm_3vl	59	106.6	−34÷−38	120÷−128	V. P. Rodionov

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Object of study, suite	Coordinates of the sampling area $\phi°$	Coordinates of the sampling area $\lambda°$	Coordinates of the paleomagnetic pole $\Phi°$	Coordinates of the paleomagnetic pole $\Lambda°$	Author of determination
Red beds Cm_3vl	55	106	−36	132	V. F. Davydov and A. Ya. Kravchinskiy
Undivided Cm_3vl	68	88	−36	134	G. I. Goncharov
Red beds Cm_3vl	54.3	104.5	−31	133	G. Z. Gurariy
Red beds Cm_3vl	58	97	−37	140	Collection under study

2. Laboratory investigations indicate that the principal ferromagnetic mineral responsible for the remanent magnetization is hematite. Study of the form of hematite grains, its relationship with iron hydroxides and cement indicates, with a high degree of reliability, its clastic origin.

3. The results of redeposition experiments ($I_n/I_{ro} = 0.6 \div 1.7$, avg. 1.16; $I_{n400}/I_n : I_{ro400}/I_{ro} \simeq 1$) are a weighty argument in favor of an orientational origin of the magnetization of the formations studied ([5]).

The complete analogy of the material composition of rocks possessing magnetization of opposite direction, the constancy of the direction of magnetization within a single zone in thickness and strike, independent of the facial variation of the rocks, and the detrital character of the magnetization testify in favor of an external cause for the change in the sign of magnetization and make it possible to interpret the change in the direction of the vector of natural remanent magnetization as the result of inversions of the geomagnetic field.

Laboratory study of the indicated formations and of their remanent magnetization revealed the following regularities:

1. The magnitude of the constant demagnetizing field H'_c decreases, on passing from zones of stable field state to inversion zones, from 40–45 to 25 oersteds (mean values).

2. The magnitude of the external field H_e, producing ideal magnetization I_{ri}, equal to the natural magnetization, correspondingly falls from $0.12 \div 0.15$

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Figure 1

Figure 1: Figure 1

to 0.07 oersted.

3. There is a decrease in the magnitude of the vector of natural remanent magnetization from $(6.5 \div 12) \cdot 10^{-6}$ CGS to $3 \cdot 10^{-6}$ CGS.
4. The ratio of the viscous component, acquired in a laboratory field over two weeks, to the natural remanent magnetization increases (the mean magnitude of the viscous component in this case remains constant).
5. The mean redeposition coefficient decreases from 1.16 to 0.38.

Taking into account the constant values of χ, I_{rs}, and H_c', on average over the section, the data indicated above can be interpreted only as the result of a decrease in the external geomagnetic field during the period of inversions. This is consistent with the data of ([4],[7],[10],[11]).

Such an interpretation makes it possible to outline more precisely the boundaries of the inversion period, which we cannot do by operating directly with the vector of remanent magnetization. Figure 1 presents the paleomagnetic section of the studied samples, on which the layers corresponding to field inversions are distinguished. The thickness of individual transition zones varies rather considerably, sometimes approaching the thickness of zones formed during a stable state of the field.

Fig. 2 illustrates the displacement of the projection of the magnetization vector on the sphere during the period of field inversion. As is evident from this figure, in passing from one stable position to another the vector describes a very complex path, differing from zone to zone

Fig. 1. Paleomagnetic section of deposits of the C_{m3eV} on the middle course of the Angara River (near Krasnyi Yar). 1 –siltstone, 2 –marl, 3 –calcareous sandstone, 4 –sandstone, 5 –zones of direct magnetization, 6 –zones of reverse magnetization, 7 –transitional beds (distinguished in the parts of the section studied in detail)

path. The latter assertion undoubtedly requires detailed verification, for an incomplete removal of the secondary, in particular the modern, component of magnetization may lead to an analogous result. The trajectory of pole motion during a reversal may prove to be an additional characteristic of a particular reversal, and its presence may be connected with the destruction, at that time, of the dipole character of the geomagnetic field and with the reflection, in I_n, of harmonics of higher order ([12]).

Fig. 2. Change in the position of the projection of the vector I_n in transitional layers on the lower (1) and upper (2) hemispheres and the direction of displacement of the projection of the vector I_n (3). A, B, C, D–parts of the section in

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Fig. 2. Change in the position of the projection of the vector I_n in transitional layers on the lower (1) and upper (2) hemispheres and the direction of displacement of the projection of the vector I_n (3). A, B, C, D—parts of the section in Fig. 1.

Figure 2: Fig. 2. Change in the position of the projection of the vector I_n in transitional layers on the lower (1) and upper (2) hemispheres and the direction of displacement of the projection of the vector I_n (3). A, B, C, D—parts of the section in Fig. 1.

Fig. 1.

Thus, on the basis of a study of the natural remanent magnetization of the red beds of the Evenk suite, it appears possible to draw the following conclusions:

1. During the accumulation of the studied formations, the geomagnetic field changed its polarity at least 9 times.
2. During reversals, the intensity of the geomagnetic field decreased considerably.
3. The decrease in field intensity was accompanied by movement of the pole from one stable position to another. The trajectory of pole motion differs for different reversal periods. The observed displacement of the pole may be a reflection of the influence on I_n of higher-order harmonics in the absence of a dipole field.
4. Taking the average rate of sediment accumulation to be constant, the following may be concluded:

a) The time during which the field remains in a stable state fluctuates within considerable limits. Individual epochs are comparable with the so-called “events” established in the study of young formations ([8,9]).

b) Individual reversals are comparable in duration with epochs of a stable state of the field.

c) A relationship is suggested between the duration of reversals and the duration of epochs of a stable state of the geomagnetic field.

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