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TECTONIC PROCESSES IN THE CENTERS OF EARTHQUAKE FORMATION

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Before studying the tectonomagnetic effect, the magnetoelastic effect of rocks was studied under laboratory and field conditions. The results showed that reversible and irreversible changes are manifested in the remanent magnetization.

Until now, the detected changes have manifested themselves in the tectonomagnetic field in the form of reversible changes. The absence of irreversible changes suggests that physical processes are not fully reflected in the tectonomagnetic field.

In 2021, at the geomagnetic station irreversible changes were observed in the tectonomagnetic field, which was a consequence of the foci located 20 *km* from the "Saragyugh" Geomagnetic Station. The observed reversible and irreversible changes fully reflect the process of elastic and plastic deformations occurring in the sources of nearby earthquakes.

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***Keywords*:** tectonomagnetic field, rate of field change, earthquake, magnitude, tectonic stresses, local component of the field, irrevocable changes.

Introduction. It is known that the basis for tectonomagnetism as a method of earthquake prediction is the magnetoelasticity of solid bodies, a well-established physical phenomenon that has been thoroughly studied by many researchers [1–3]. These studies, as a rule, have been performed on metals with residual magnetism, their oxides and alloys. Similar studies were conducted by geophysicists on rocks [4–6], the results of which justified the assumption that the mentioned physical phenomenon can be used for the development of the tectonomagnetic method of earthquake prediction.

For this reason the magnetoelasticity of rocks, especially their piezo properties, were studied under conditions of high pressures and temperatures. The results were more than encouraging. Positive results were obtained in many geophysical centers, as well as in our Laboratory of Geophysics and Engineering Seismology of the NAS of the RA on invstigations of physical properties of rocks.

Under conditions of high pressures (up to 1000 kg/cm^2), both reversible and irreversible changes in residual magnetism were recorded in rocks [4, 5]. Irreversible changes were restored within time. The result was checked on naturally occurred

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rocks under conditions of filling and emptying of big reservoirs, as well under the influence of explosions [7]. Both reversible and irreversible changes were recorded in the Earth's magnetic field, which linearly reflected changes in tectonic stresses. It was assumed that similar changes should be seen as signs during the formation of earthquake foci, but among the thousands of possible signs found, signs of irreversible nature, which are the result of residual deformations, were mostly absent [4, 5, 7].

During 2021, earthquake foci were registered in close to the "Saragyugh" Geomagnetic Station (GMS), the hypocentral distances of which were within 1–20 *km*. Especially small hypocentral distances (1–10 *km*) of the foci were registered in July–August, where magnitudes in the foci reached up to 4.5. Meanwhile, signs of an irreversible nature were found in the tectomagnetic field.

The aim of the work is to show that, in addition to observable changes in the tectonomagnetic field, there are also irreversible changes that are detected at small (up to 20 *km*) hypocentral distances, which are sometimes unique signs for forming centers.

For irreversible changes, the well-known formulas of the tectonomagnetic field [7] are applicable, by means of which, with the magnitude of the irreversible change, the parameters of the foci of earthquakes can also be estimated.

Research Methodology.

Estimation of the Parameters of Foci Formed by Irreversible Signs. During the formation of earthquake foci, their omens are expressed in the absolute values of the tectonomagnetic field, values of field change rates, daily variation and other, reversible changes of various parameters that create an omen process. In this process, from time to time, irreversible changes appear, the conditions of which still remain unexplained. Based on the results of experiments on magnetoelasticity described in the introduction, it can be assumed that irreversible changes are associated with the residual deformations in the zones that can act in the faults of the Earth's Crust.

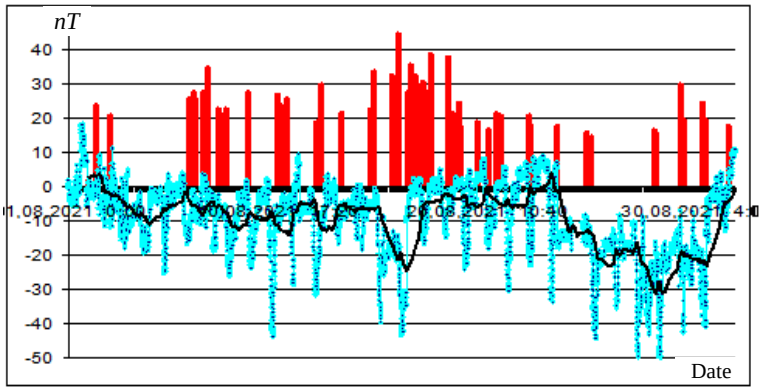

Fig. 1. The histogram of the magnitudes of the earthquakes that occurred during the month of August 2021, the time graph constructed with the absolute values of the tectonomagnetic field and the averaged curve of that graph. For didactic purposes, the histogram of magnitudes is enlarged 10 times.

In the months of July–August 2021, to the "Saragyugh" GMS, irreversible changes were recorded in the absolute values of the Earth's magnetic field, both in the form of a sharp increase and a sharp decrease, the values of which reach the

magnitude of about 23 *nT*. Fig. 1 shows the histogram of magnitudes of earthquake foci recorded during August, the curve of tectonomagnetic field (TE) changes and the averaged appearance of that curve. As we can see, the TE values are lower than 0, which is usually rarely seen in earthquake signals.

The drop in TE values can be explained by the abundance of foci formed by earthquakes near the "Saragyugh" GMS and the proximity of the foci, when in that region, in the Earth's Crust, active residual deformations become dominant.

A low TE background shows dips with large amplitudes, sometimes being earthquake harbingers.

Since irreversible changes occur in the absolute values of TE (Fig. 2), we can use the formulas for estimating the values of the expected magnitude (M) and hypocentral distance [7]:

$$M = \Delta TE/c, \quad (1)$$

where ΔTE is the change in the tectonomagnetic field, c=5.3 *nT* is the tectonomagnetic coefficient of the Earth's Crust.

It is known [7] that the magnitude of the hypocentral distance of the forming hearth is calculated by the formula

$$R_0 = a \cdot M/TEL, \quad (2)$$

where a = 33.4 *nT*/*km* is the magnetic moment of a direct virtual magnet equivalent to the magnetic moment created by the given focus at the point of observation, the local component of the TE field created by the TEL-formed focus, which is apparently equal to the first-order derivative of TE during the period of irreversible change.

Using formulas (1) and (2), for a specific example, let's calculate the magnitudes and hypocentral distances of foci corresponding to irreversible changes in the TE field.

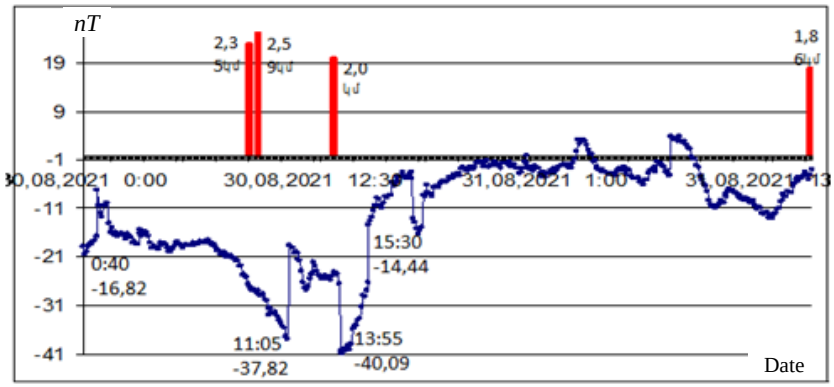

Fig. 2. Irreversible changes registered in the TE field on 30.08.2021 to the "Saragyugh" GMS.

As can be seen from Fig. 2, from 6:00 a drop in the TE field of ΔTE=20.36 *nT* is observed, followed by a sharp increase of ΔTE=19.29 *nT*. A sharp increase is observed twice more during the period of the Fig. 2. This is a typical residual deformation process that accompanies an earthquake. A similar drop in the field,

according to the theory of tectonomagnetism, was accompanied by a transition from elastic deformation to residual deformation.

A sharp drop of 15.65 *nT* was observed from 13:45. The difference 19.29–15.65 = 3.64 *nT* is a residual irreversible change resulting from residual deformation in the fault. If the stresses due to elastic deformation were dominant until 6:45, after that they started to decrease, along with which the residual deformations increased in the hearth. Such processes are constantly operating in focal zones, which are most active before and after a seismic shock.

Due to the distance of the centers, there are no irreversible changes in "Hovit" GMS.

Magnitudes (M), their corresponding signs (ΔTE) and hypocentral distances (R_0) in the epicenters of the earthquakes

No	Date	ΔTE, *nT*	*M*	|VT| avg.	R_0, *km*	*M*	R_0, *km*	Date
1	01.08.2021	11.81	2.23	6.08	12.25	2.2	13.0	18.08.2021
2	01.08.2021	11.57	2.18	5.91	12.30	2.2	13.0	18.08.2021
3	02.08.2021	11.04	2.08	5.55	7.95	2.1	8.0	15.08.2021
4	02.08.2021	17.07	3.22	8.74	12.30	3.3	10.0	15.08.2021
5	02.08.2021	14.21	2.68	5.34	16.80	2.6	15.0	09.08.2021
6	02.08.2021	16.57	3.13	6.72	15.60	3.0	15.0	09.08.2021
7	03.08.2021	18.48	3.49	2.30	51.00	3.5	46.0	07.08.2021
8	03.08.2021	12.05	2.27	6.06	12.50	2.3	11.0	14.09.2021
9	03.08.2021	9.20	1.74	4.90	11.90	1.7	13.0	22.08.2021
10	03.08.2021	11.44	2.16	3.84	18.80	2.2	17.0	13.08.2021
11	03.08.2021	13.03	2.46	6.60	12.45	2.5	10.0	19.08.2021
12	07.08.2021	12.75	2.40	6.63	12.10	2.4	11.0	11.08.2021
13	07.08.2021	8.94	1.69	1.61	35.00	1.7	31.0	28.08.2021
14	07.08.2021	14.49	2.73	7.38	12.40	2.6	12.0	11.08.2021
15	11.08.2021	16.66	3.14	8.66	12.10	3.1	9.0	17.08.2021
16	11.08.2021	15.08	2.84	7.6	12.50	2.8	10.0	14.11.2021
17	14.08.2021	14.13	2.67	7.83	11.40	2.5	10.0	19.08.2021
18	14.08.2021	16.20	3.06	8.80	11.60	3.1	9.00	17,08.2021
19	15.08.2021	12.69	2.39	6.86	11.60	2.4	10.0	17.10.2021
20	15.08.2021	17.36	3.28	9.03	12.10	3.3	10.0	15.08.2021
21	16.08.2021	21.18	4.00	12.51	10.70	3.8	8.0	18.08.2021
22	23.08.2021	20.89	3.94	10.82	12.70	3.8	8.0	03.09.2021
23	29.08.2021	18.81	3.55	9.96	11.90	3.4	11.0	05.10.2021
24	29.08.2021	22.82	4.30	11.68	12.30	4.3	6.0	24.10.2021
25	29.08.2021	8.81	1.66	3.12	17.80	1.7	21.0	26.10.2021
26	30.08.2021	9.49	1.79	5.13	11.66	1.8	12.0	23.10.2021
27	30.08.2021	15.65	2.95	5.25	18.80	3.0	15.0	15.09.2021
28	30.08.2021	19.29	3.64	9.90	12.28	3.4	11.0	05.10.2021
29	30.08.2021	11.89	2.24	6.71	11.15	2.2	11.0	08.09.2021

Let's calculate 11:05–11:10 the parameters of the forming hearth, in which the residual deformation that occurred in the volume has drastically changed the elastic stresses that existed until then.

According to formulas (1) and (2), $\Delta TE=19.29$ *nT* and $R_0=12.28$ *km*. In this way, the parameters of the foci of all nearby earthquakes that occurred in August 2021 were calculated, which are presented in Table.

In the Table, the first column contains the serial numbers of the omens, the second column shows the dates of the omens' appearance, the third column contains the magnitudes of the omens, the fourth column contains the calculated magnitudes, and the fifth column contains the average values of the TE local component (TEL) or, which is the same, the TE change rates in the hearth, in the sixth – the hypocentral distances, in the seventh – the magnitudes according to the seismic catalog, in the eighth – the hypocentral distances according to the seismic catalogue and in the ninth – the date of the earthquakes.

In formula (2), the magnitude of TEL is almost always equal to the magnitude of the modulus of the average rate of change of the tectonic magnetic field of the hearth. For that simple reason, |VT| is used instead of TEL in (2), an average taken from a graph of velocities. It is technically easier and the value of |VT| is determined with an accuracy of 0.01 *nT*.

Conclusion. Before studying the tectonomagnetic effect, the magnetoelastic effect that constitutes it was studied under laboratory and natural rock setting conditions. As a result of those studies, reversible and irreversible changes in the magnetoelastic effect were recorded.

The tectonomagnetic effects discovered so far, or what are the same, the tectonomagnetic signs of earthquakes, are of a reversible nature.

The omens of the earthquakes that occurred in 2021 were recorded as irreversible changes that were very close to the "Saragigh" GMS, at a distance of 1–20 *km*. This gave a reason to confirm that irreversible changes are imagined only in the case of foci very close to the observation station. The observed reversible and irreversible changes reflect the presence of elastic and plastic deformations in the formed foci.

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ՏԵԿՏՈՆԱԿԱՆ ՊՐՈՑԵՍՆԵՐՆ ԵՐԿՐԱՇԱՐԺԵՐԻ ԿԱԶՄԱՎՈՐՎՈՂ ՕՋԱԽՆԵՐՈՒՄ

Ամփոփում

Տեկտոնամագնիսական էֆեկտի ուսումնասիրությունից առաջ այն կազմավորող մագնիսաառաձգական էֆեկտը ուսումնասիրվել է լաբորատոր և ապարների բնական տեղադրման պայմաններում: Այդ ուսումնասիրությունների արդյունքում գրանցվել են մագնիսաառաձգական էֆեկտի դարձելի և անվերադարձ փոփոխություններ:

Մինչև հիմա հայտնաբերված տեկտոնամագնիսական էֆեկտները, կամ որ նույնն է, երկրաշարժերի տեկտոնամագնիսական նախանշաններն ունեցել են դարձելի բնույթ: Անվերադարձ էֆեկտների բացակայությունը հուշում է, որ տեկտոնամագնիսական դաշտում չեն արտացոլվել բոլոր այն ֆիզիկական պրոցեսները, որոնք կարող էին այդ դաշտում ստեղծել անվերադարձ փոփոխություններ:

2021 թ.-ին տեղի ունեցած երկրաշարժերի նախանշանները գրանցվեցին որպես անվերադարձ փոփոխություններ, որոնք գտնվում էին «Սարագյուղ» երկրամագնիսաչափական կայանին շատ մոտ՝ 1–20 *կմ* հեռավորության վրա: Սա հիմք է տվել հաստատելու, որ անվերադարձ փոփոխությունները երևակվում են միայն դիտարկման կայանին շատ մոտ գտնվող օջախների դեպքում: Դիտարկված դարձելի և անվերադարձ փոփոխությունները արտացոլում են կազմավորվող օջախներում ընթացող առաձգական և պլաստիկ դեֆորմացիաների առկայությունը:

С. Р. ОГАНЕСЯН, А. Г. МАКАРЯН

ТЕКТОНИЧЕСКИЕ ПРОЦЕССЫ В ОБРАЗУЮЩИХСЯ ОЧАГАХ ЗЕМЛЕТРЯСЕНИЙ

Резюме

До изучения тектономагнитного эффекта в лабораторных и естественных условиях был изучен магнитоупругий эффект горных пород. Результаты показали, что обратимые и необратимые изменения проявляются в остаточной намагниченности.

До сих пор обнаруженные изменения проявлялись в тектономагнитном поле в виде обратимых изменений. Отсутствие необратимых изменений говорит о том, что физические процессы не полностью отражаются в тектономагнитном поле.

В 2021 г. в тектономагнитном поле, расположенном в 20 *км* от геомагнитной станции “Сарагюх”, как следствие землетрясений наблюдались необратимые изменения. Наблюдаемые обратимые и необратимые изменения полностью отражают процесс упругих и пластических деформаций, происходящих в очагах близких землетрясений.