METHOD FOR SELECTION OF GEOMAGNETIC PRECURSORS OF TECTONIC EARTHQUAKES

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ABSTRACT

On the base of the results of study of magnetic properties of rocks laying in the earth crust of the territory of Armenia, the source of tectonomagnetic effect is justified, which is the inductive component of residual magnetization. The analysis of tectonomagnetic variation and structure of formation of tectonomagnetic field is represented. The method of calculation of tectonomagnetic precursors of earthquakes conducted with the help of empirical formula is offered, into which the concepts of new necessary coefficients: the tectonomagnetic constant of the station of observation and the coefficient of effective effect of local tectonomagnetic effects are entered.

Introduction

The modern level of knowledge in direction of detection of geomagnetic precursors of earthquakes is based on selection of anomalous variations of tectonomagnetic field (TMF). The existing developed methods of [1; 2; 3] selections of geomagnetic precursors allow to detect the precursor of the certain earthquake in the case, when the investigator is experienced and has scientific intuition and when the magnitude of amplitude of the precursor repeatedly exceeds the average value of the amplitude of tectonomagnetic variations. Such methods are not optimal and practical for solving the problem of survey for seismic protection: the evaluations of seismic hazard. Therefore, it was necessary to process a new method, which will enable the operator of seismic prediction to detect independently the precursor of the earthquake, that is very important for early warning.

1. Physics of formation and structure of tectonomagnetic field

The effect of elastic mechanical strains on rocks calls in ferromagnetic grains modification of residual magnetization. The modification of magnetization from pressure is the sum of modifications of a number of components of natural residual magnetization: thermo; pies; viscous, dynamic and inductive magnetizations. Sensitivity to pressure and dynamic characteristics of these components are different. The experimental researchs in more than 2000 exemplars of rocks allowed to install number of regularities different for various kinds of residual magnetization and simultaneously stressed the properties of inductive component, distinguished from the others [2; 3].

1. All rocks have an inductive magnetization $Ji = \chi T$: χ- an initial magnetic susceptibility, T - value of the module of full vector of induction of geomagnetic field (GMF). In majority of rocks, laying in geological structures of third and fourth period, the magnitude of magnetic susceptibility makes ($3*10^{-4}$ - $6*10^{-2}$) CGSM.
2. The inductive magnetization is characterized by rather broad (up to $8*10^{-4}$ CGSM) diapason of modifications in the effect of pressure.
3. With magnification of laying depth of rocks one from primary factors influencing on the amplitude of converted modifications of magnetization of rocks is the temperature. Obtained in the work (1) experimental results show, that the modifications of inductive magnetization of rocks of the territory of Armenia in different temperatures are more stable, than at the other kinds of magnetization, therefore the

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tectonomagnetic effects of the sources of earthquakes, which laying depths are lower then 10 km are registered (Hovhannisyan; Petrosyan).

4. The magnitude and the sign of converted modifications in high pressure are determined by space orientation of axises of tectonic strains and direction of an external magnetic field. When $\varphi = 90^0$ between the axes of compression and by direction of an external geomagnetic field the inductive magnetization is increased converted. The the average angle φ for Armenia is 60^0.

On the base of marked results it is possible to assert, that with magnification of laying depth of rocks in formation of tectonomagnetic effect the modifications of inductive magnetization should play significant role.

Being based on the law of physics of rigid body about modifications of strains and deformations, according to which the process of cracking or dry friction inside the body develops chaotically in time, it will be possible to apply it for the earth crust takind into consideration its heterogeneity. It means, that with increasing tectonic strains in the earth crust the accumulation of elastic strains with plastic deformations is possible which according to the theory of tectono magnetism, generate the geomagnetic field (GMF), increment and recession of significances of the field, accordingly. This process in the earth crust flows irregularly in time and in space complicating the revealing of tectonomagnetic precursor of concrete earthquake. The tectonomagnetic modification in GMF on the territory of Armenia flows as growth - recession. The average curve of this modification has a shape of a bay. The fluctuation displacement of significances of the field from average value of the bay represent the dynamics of a sun-day variation (fig.1). The average bay shape curve represented by a thickened line, has the certain constant value of amplitude, which depends on the magnitude and amount of expected earthquakes. In statistical numbers of observable significances of GMF, bay shape modifications are alternated with different amplitudes and frequencies, making kvazi harmonic variation. As it is visible, there is a certain correlation between the bay shape modifications and seismic activity.It is visible (Hovhannissian and Petrossian), that the beginning and the end of the bay of the active cycle correspond to the beginning and the end of certain seismic active cycle. Therefore, as a regularity, activity of seismic events is high in the beginning and end a bay.

Bay shape modifications are separated from each other and other modifications of the field by initial sharp growth, and in the end of the bay by sharp minimum of significances, which can reach approximately 60 nTl. The periods of growth and recession last from 2 till 6 days.

The tectonomagnetic field (TMF) is a corollary of piezo magnetic effect of inductive component of residual magnetization of rocks, laying in the definite volume of earth crust in the place of observations. The piezo magnetic effect of same rocks is derivated at the expense of accumulation of elastic strains in the earth crust of investigated region and source zone. Therefore GMF is the sum of separate components of fields:

$$TE_f = TE_r + \delta T_r + TEl + \delta TL \qquad (1)$$

By numeral TE_F is designated the full tectonomagnetic effect, which is an absolute modification of the velue of the module of full vector of GMF. TE_r is a regional part with its variation δT_r and TE_l - local part stipulated by dominating forces in the source zone with the variation δT_l.

1.The long-period component of tectonomagnetic field TE_r is formed on the base of piezomagnetic effect of inductive component of residual magnetization of rocks in the effect of regional tectonic strains, which form the regional temporary anomaly in the structure of GMF. The intensity of the field TE_r is directly proportional to piezomagnetic coefficients ($\beta;\gamma$) of rocks and intensity magnitude of earthquakes. It is confirmed by the results of calculations of peak magnitudes of piezomagnetic effect of rocks distributed in the structure of earth crust of the territory of Armenia, and on the base of that are constructed the tectonomagnetic maps of Armenia [4]. The zones of intensive regional tectonomagnetic of effect are unequivocally reflected in the results of observations of tectonomagnetic variations. The periods of formation of the main part of TE of the field TE_r have chronology from several months up to several years. Into the structure of TE_r of the field enters the variable component δT_P, which is a corollary of the dynamics of regional tectonic strains. The sourcef of regional anomaly are the geological structures of seismic active region, laying in the earth crust near the observation station.

2. The short pereod component TE_l of tectonomagnetic field is formed in the cosequence of dynamics of dominant forces originating in heterogeneities of the structure of source zone, which create local temporary anomalies in GMF. The source of local anomalies are the separate forming sources or group of sources of earthquakes. In the structure of tectonomagnetic variations are marked rather long-period - from one week till 25 days and short period - from two days about one week ones. They simultaneously vary on the background of the main part of TE_r.

As follows from the formula (1), for the study of the characteristics of tonomagnetic fields should be studied the characteristics of addends which are included in the sum, were in interdependence with parameters of the sources of earthquakes.
Proceeding from submissions of continuity of the effect of tectonic forces and on the base of the picture of formation tectonomagnetic fields can be assumed, that on the territory of Armenia always exists a tectonomagnetic field with certain variation.

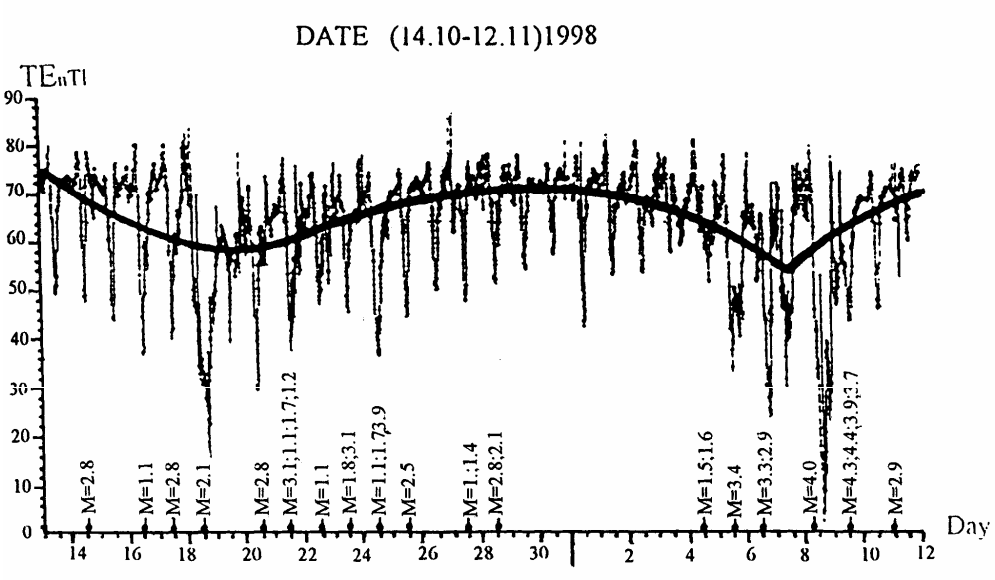

Figure 1. Active cycle of tectonomagnetic field and seismic activity for the period 19.10.98.-08.11.98.

2. Method for calculation of tectonomagnetic precursors of earthquakes.

During modification of tectonic strains in consolidated volume of the future source function regional and dominant forces, which create elastic and plastic deformations. In the result, in the source zone the separate sources of earthquakes were on different stages of formation are located simultaneously with which arise local tectonomagnetic effects appropriate to these stages. Due to this process on stations recording tectonomagnetic a variations, there is a useful total signal.

$$TE_L = \sum_{n=1}^{k} TE_L^1 + TE_L^2 + ... + TE_L^k \qquad (2)$$

The effect created in the source zone is total, and to divide in entries TMF effects of separate earthquakes represents large difficulty. In tectonomagnetic variation pre- and post seismic effects enter, i.e. the effect of accumulation of tectonic elastic strains with positive sign (in our case) and the effect of their dischargment with negative sign, reflected in modifications of tectonomagnetic field. To divide and to pirate them to certain earthquake is difficul, therefore we will consider the sum (1) as a variation of TMF in the form of modular significances.
The significances of modifications of tectonic strains are received in the result of accounts of the magnitude of released seismic energy, which power parameter is the class (K) of earthquakes or magnitude (M). They are in direct proportional connection with tectonic strains. Proceeding from this, and taking into account, that the magnitude of tectonomagnetic effect (as a magnetic field) is inversely proportional to the guadrate of the distance between the source and observation station, it is possible to write

$$TE_l = K' \frac{M}{R^2} \quad (3)$$

On experimental data the dependence of relation of local and integrated tectonomagnetic effects from the distance between the source and observation station is investigated.

The obtained graphic dependence shows back - proportional linear variability between $\frac{TE_L}{TE_R}$ and R (fig.2).

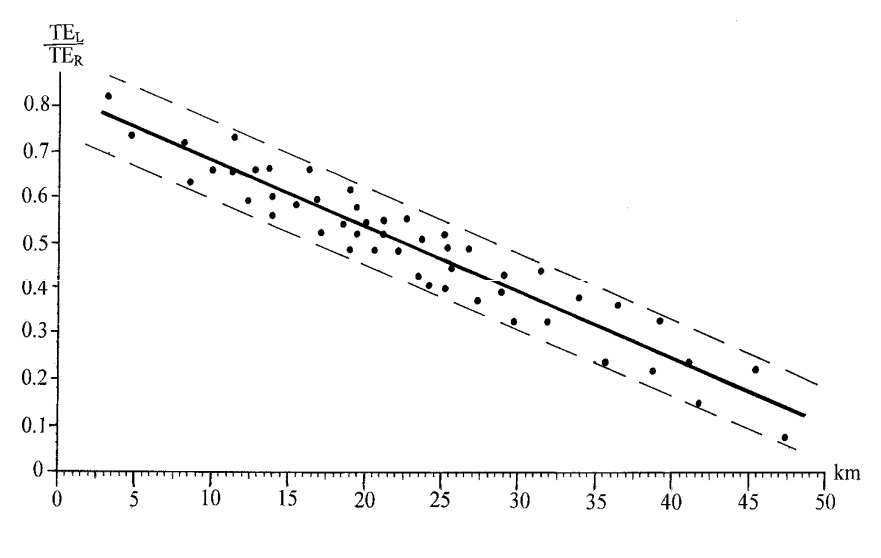

Figure 2. Dependence of relation of lacal TE_L and regional TE_R tectonomagnetic field from distance R.

Therefore it is possible to write

$$\frac{TE_L}{TE_R} = K'' \frac{1}{R} \quad (4)$$

From (3) and (4) we receive

$$TE_L = \frac{K' TE_R}{K''} \frac{M}{R}$$

Let's designate

$$\frac{K' TE_R}{K''} = a \text{ and } \frac{M}{R} = n$$

and receive

$$TE_L = an \quad (5)$$

The value a depends on the value of regional tectonomagnetic effect, which is formed for the account of piezomagnetic effect of rocks, laying in the neighbourhood of the observation station. Actually it reflects the tectonomagnetic properties of the observation station, therefore it we will name as a tectonomagnetic coefficient of the observation station. If the tectonomagnetic effect linearly reflects the process of a modification of tectonic strains, this implies, that for the given point of measurements (geomagnetic station) the coefficient a mast be a constant one.

The value n we will name as a coefficient of effective effect of local tectonic effects in the station. If the significance a is known, after any seismic event it is possible to calculate the magnitude of the amplitude of local tectonomagnetic effect of given source.

To each addend in (2) corresponds a certain coefficient (n). Therefore the total effect of the source zone in the station will be:

$$\sum_{k=1}^{i} = n_1 + n_2 + \ldots\ldots n_i \qquad (6)$$

Due (2) and (5) we receive:

$$|a| = \frac{\sum_{n=1}^{k} \left| TE_1^k \right|}{\sum_{n=1}^{k} n_k} \qquad (7)$$

With the help of (7) were calculated the coefficients a for geomagnetic stations "Bavra", "Gyulakarak", "Artik" for different periods of seismic activity observed for the period 1994-2000, which represent constants for each one from these stations. They are equal:

$$a_{B} = 31.91\text{nTl km}; \quad a_{G} = 58.44\text{nTlkm}; \quad a_{A} = 64.11\text{nTlkm} \qquad (8)$$

Having the constant values of significance a, it is possible to calculate the tectonomagnetic effect for any earthquake.

Conclusion

In work the behaviour of tectonomagnetic field connected to seismic activity of researched region is investigated. It is clarified, that within the limits of one seismic active cycle the relation of the sums of amplitude magnitudes of dynamic modifications of tectonomagnetic field and coefficient of seismic effect on the station is constant and is called by us, as a tectonomagnetic constant of given station. This constant enabled to develop statistical data for the period 1994-2004. and on the base of the results to receive the empirical formula, in which the functional connection between the parameters of the source of earthquakes and tectonomagnetic field is installed, that allowed to calculate the magnitude of geomagnetic precursor of past and expected earthquakes.

Reference

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