THE NATURE OF TECTONOMAGNETIC EFFECTS IN THE TAJIKISTAN SEISMIC REGIONS

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INTRODUCTION

Observations of local variations of the geomagnetic field in the seismic regions of the Tajikistan during two decades have afforded to obtain evidences that the anomalies in these variations are in correlation with the occurrence moments and magnitudes of the definite earthquakes. It provided a basis to name anomalies observed as tectonomagnetic effects. The purpose of the present paper is to investigate the origin and nature of the tectonomagnetic anomalies observed in the Tajikistan's seismic active regions.

MAGNETOMETRIC NETWORK AND METHODS OF OBSERVATIONS

The purpose of high accurate magnetic observations is to identify those features in the local geomagnetic field variations, which originate from the seismotectonic processes, earthquake preparation in particular. The magnetometric network of sites was positioned in the seismic high active areas of Tajikistan, Hissar (1), Simiganch (2), Shar-Shar (3), Garm-Rasht (4, the former site of the Institute of Physics of the Earth, Academy of Sciences, USSR), Komsomolobod-Darband (5), Sultanobod (6), Djerino (7), Chuyangaron (8), Arjinak(9), Djirgatal (10), Gezan (11), Shaartuz (12) (Fig.1 [1]). Here the first order faults are shown, I - Hissar-Kokshaal, II – Darvaz-Karakul, III – Ilyak-Vakhsh, IV - South-Fergan, V - North-Fergan, VI – Vanj-Akbajtal, VII – Pshart-Bartang. Number of another faults pass far away from the network and aren't depictured.

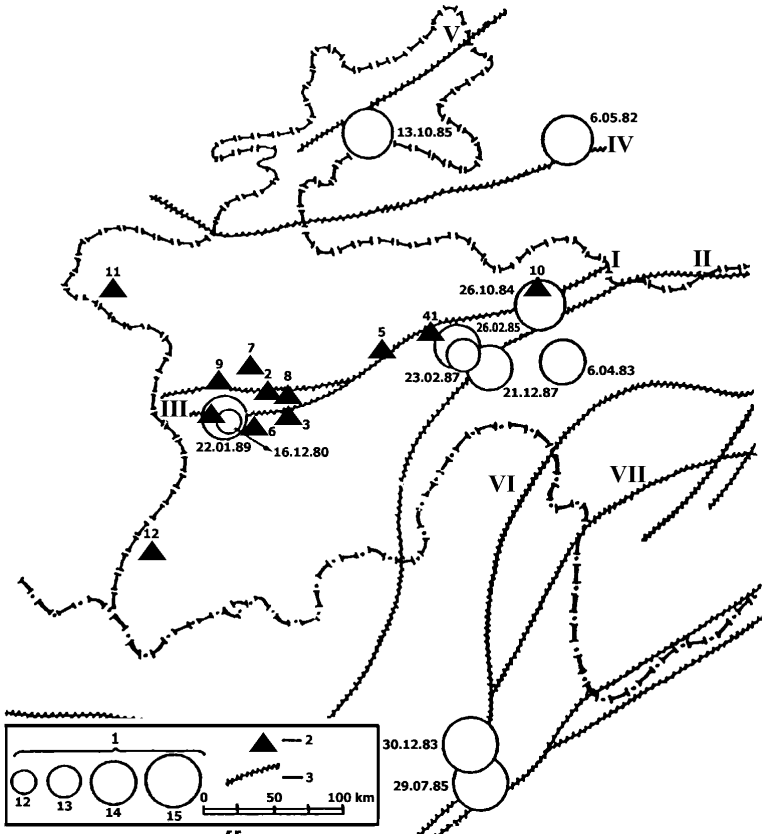

Fig.1. Magnetometric network area.
1. Earthquake epicenters with the energetic classes K,
2. Sites,
3. First order faults.

Circles mark epicenters of most powerful earthquakes with the energetic classes K more than 12 for the period of observations since 1980 until 1990.

The general method of observations consisted of clock round geomagnetic field module sampling with the discreteness 2-10 minutes, comparison of simultaneous data of a couple of sites by differencing, data averaging for the every hour and for the whole day, data smoothing by the sliding method. Every site was equipped by the high sensitive magnetometer MPP-1 with the accuracy about 0.1nTs for the only geomagnetic field sampling.

REGULARITIES IN APPEARANCE OF TECTONOMAGNETIC ANOMALIES

There were the following regularities found out in anomalies' appearance in Tajikistan seismic regions [1]:

- Values of the effects are within 10 nTs (nanoTesla);
- There are focus, near, middle and far zones of tectonomagnetic effects' appearance, within every of which the time duration of the anomaly for the definite earthquake is descending while moving from focus zone to far one;
- In the near, middle and far zones time run dependence of a tectonomagnetic anomaly has a bay-like shape and the main shock moment falls down to the back stage anomaly run to the background level;
- In the focus zone the shape of an anomaly can be both bay-like and sign alternative bringing space mosaic distribution;
- In the near zone the duration of an anomaly and its mean radius, where it appears, are increasing loglinearly versus the magnitude M of preparing earthquake, providing a basis to attribute these anomalies to mean-term ones;
- In the middle zone the duration of an anomaly for the definite earthquake descends with a distance of preparing earthquake's epicenter;
- In the far zone the duration of an anomaly for the definite preparing earthquake is shorter than in the middle and are within one month;
- The anomalies expose anisotropy;
- Sometimes anomalies appear that have trapeze shape with sharp variations up to first nTs during first days, reflecting assumingly earth crust creep processes;
- At the vicinity of large water reservoirs there is an amplification of the tectonomagnetic anomalies stipulated assumingly by the electrokinetic currents in the earth crust.

Typical examples of tectonomagnetic anomalies' time run in the near, middle and far zones are drawn in the fig.2, 3, 4.

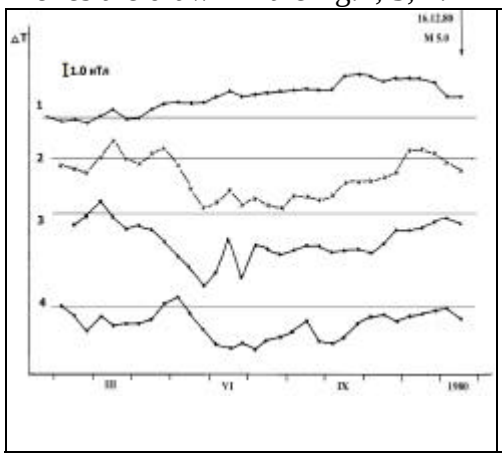

Fig.2. T - anomalies, Dushanbe earthquake 16.12.1980. 1 - (1), 2 - (2), 3 - (3), 4 - (6). (5) - a reference site.

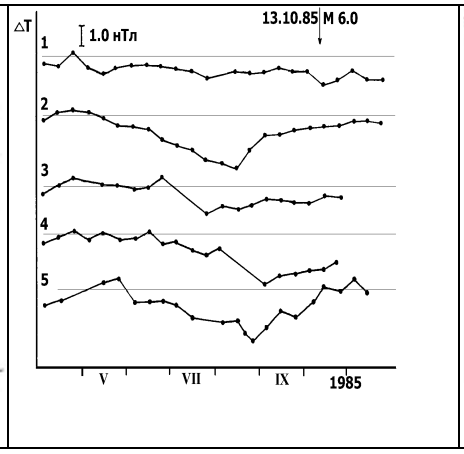

Fig.3.T - anomalies, Kairakkum earthquake 13.10.1985. 1- (5), 2 - (7), 3 - (8), 4- (9), 5- (6). (1) - a reference site.

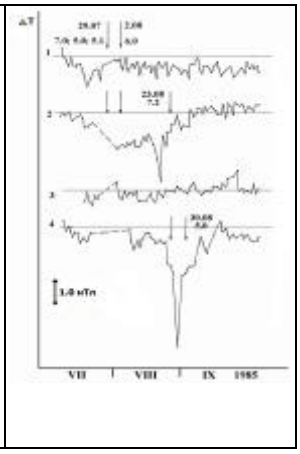

Fig.4.T-anomalies, Hindu-Kush earthquakes. 1 - (5), 2 - (7), 3 - (8), 4 - (6). (1)- a reference site.

It's a striking fact that the main shocks coincide with the back stage anomaly run to the background level independently on zone, where anomalies have appeared.

ANALYSIS OF GEOPIEZOMAGNETIC AND ELECTROKINETIC MECHANISMS

Let's consider possible mechanisms of the tectonomagnetic anomalies basing on contemporary representations about seismic tectonic processes [2]. Tectonomagnetic anomalies are stipulated by two general classes of phenomena, geopiezomagnetic and electrokinetic effects under the action of mechanical, tectonic, stresses [3-5].

According to the general representations about seismic tectonic process the integrant stress in the earthquake preparation zone has bay-like shape [2]. Accordingly, starting from the some moment after beginning of earthquake preparation, when stresses will be raising up to high enough values the tectonomagnetic anomaly appears. Stress accumulation in the preparation zone is conveying by the anomaly's growth. While stresses are narrowing to the location of further main fracturing the integrant stress is descending and an extremum appear at the anomaly's time run. As integrant stress going on the anomaly is further descending and approaching to the original background level. The main shock falls down to the end stage of approaching of anomaly to this level. Therefore appearance of an anomaly in the near zone straight reflects tectonic stresses run in the preparation zone. Delay in anomaly's appearance in the middle zone and more delay in the far one means that in the basis of appearance of tectonomagnetic anomalies an effect of anomaly source propagation lies. Magnetometric site in the near zone begin register an anomaly immediately as far as tectonic stresses became intensive enough. Later on, while preparation zone anomaly sources are approaching middle zone the tectonomagnetic anomalies are beginning raise now here. Anomalies in the far zone are more late because of sources are required more time to propagate and reach this zone. Besides would it be these effects of propagation then the main shock moment in the middle and far zones wouldn't have coincided with the anomaly run end but with the moments, when anomalies are already over. Thus the tectonomagnetic effects are short distance acting rather than long distance acting [5].

For the Kairakkum earthquake, according to the empirical dependencies [3,5] one can obtain 140 kms for the average radius R of the area of anomaly's appearance and duration of the anomaly T in the near zone would have to be 630 days. Because of retard effect the duration turned up to be less. The speed turns out to be from 30 to 150 ms/day, reflecting anisotropy in sources propagation. Highest propagation speed turned up at the direction, where the sites (6-9) are grouped, lowest speed is in the direction of only to the south site (5) (Fig.1). Besides, site (5) is located more close to transition from Tajik depression to Pamirs and therefore where earth crust several times thicker than in the sites (6-9). Probably that is why source propagation in the direction to the site (5) is constrained. For the Hindu-Kush earthquakes the tectonomagnetic anomalies registration sites are turning up located in the far zone at the distances about 300-400 kms. It follows that speeds of anomalies propagation are to be within the interval from 40 to 1,000 ms/day.

Rock magnetizations and magnetic susceptibilities in the area of investigation are relatively low, isn't exceeding 10^{-5} CGS and 10^{-4} CGS respectively, piezomagnetic coefficient is about 10^{-4} bar^{-1} (1bar = 100 kPa). Stresses in the focus and near zones amount about 10^4 bars and are enough in principal to generate geopiezomagnetic effect up to the first nTs. But these values under the tectonic stress descend in the stress inhomogeneous space within the radius r,

$$lgr[kms] = 0.43M, [2], \quad (1)$$

gives r equal about 120 kms for the earthquake with M equal 5. So as (1) shows they are insufficient to generate such anomalies in the middle and the more so in the far zone. Besides, the preparation zone of the deep focus Hindu-Kush earthquakes with the hypocenters in the depth 100-300 kms scarcely comprise magneto active layer located in the upper crust 20-40

kms width, where temperatures doesn't exceed Curie points for the natural magnetite, titanomagnetites etc.

Electrokinetic mechanism of tectonomagnetic anomalies is stipulated by the underground fluid filtration through porous and fractured crust medium. There are a plenty of both surface and underground waters in the Tajikistan region. There are both pure and mineral waters wide spread. The waters salt concentration is up to 600 mg/liter in some sites. The natural underground waters are very good electrolytes and promote appearance of electrokinetic phenomena. In terms of underground water filtration from the earthquake source preparation space the delay of tectonomagnetic effects in the near and far zones can be interpreted by limitedness of filtration speed.

There were natural observations carried out in the vicinities of Nurek water reservoir [5] and Surkhob river [3] to investigate local magnetic field variations. It was found out that seasonal variations of the water reservoir level from about 220 ms in summer to about 270 ms in winter were correlating with the coefficient 0.85 with the local geomagnetic field variations up to 5 nTs in the sites 4 kms aside. Variations of the river water level within 5 ms correlated with the coefficient about 0.9 with the local geomagnetic field variations up to 4 nTs at the sites 200 ms aside the river bed. Obviously, the several ms layer water weight loading on the water reservoir and the river bottom ground is very low to create anomalies up to 1 nTs in order of magnitude generated by means of geopiezomagnetic effect. In contrast, the underground active water filtration and high water mineralization in the vicinities of Nurek water reservoir and Surkhob river, as simple calculations based on double electric layer terms [3] or ion concentrations difference [5] confirm, allow us to explain tectonomagnetic anomalies observed.

CONCLUSION

Researches of the local geomagnetic field anomalies' variations, carried out in the Tajikistan seismic region, have demonstrated that they are correlating with the tectonic earthquake preparation processes. Investigations of the regularities obtained, analysis of geopiezomagnetic and electrokinetic mechanisms of appearance of these tectonomagnetic anomalies have shown that low rock magnetization and magnetic susceptibility make geopiezomagnetic mechanism insufficient to impact into the tectonomagnetic anomalies. Natural explorations in the vicinities of Nurek water reservoir and Surkhob river and calculations have also confirmed that electrokinetic mechanism is effective enough to interpret tectonomagnetic anomalies observed in the Tajikistan seismic region.

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