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Research Article

ANOMALOUS VARIATIONS OF GEOMAGNETIC FIELD IN THE CHARVAK POLYGON

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ABSTRACT
Based on the long-term geomagnetic observations in the area of the Charvak reservoir, the analysis results of geomagnetic variations are presented in the article. It is revealed that local anomalies of geomagnetic field related to the change process of water volume in reservoir and local seismicity happen simultaneously. It is also considered that these results will be used for earthquake forecasting.

Keywords: *Geomagnetic Anomalies, Seismicity, Technogenic Event, Charvak Reservoir*

INTRODUCTION
Earthquake prediction is one of the most important problems in the world, and successful prediction can reduce the earthquake disaster. For many years seismologists have intensely debated whether or not earthquakes can be forecasted by the electromagnetic signals emitted from rocks under stress. Independent knowledge of the physical processes that occur with seismic events can be obtained from observations of electric and magnetic fields generated by these complex processes. During the past few decades, by Institute of Seismology, Academy of Sciences of Uzbekistan, we have seen a remarkable increase in the quality and quantity of electromagnetic data recorded before and during earthquakes or volcanic eruptions. In order to solve this problem, it occurs to learn the apparent peculiarities of earthquake in the special geodynamic fields. It requires a long term observation data. In this situation, making a model in natural condition during the earthquake preparation process may give beneficial results. Technogenic objects might be used as a natural model in order to learn relation between the earthquake preparation process and the appearance of earthquake. Since 1973 the staff of the Geophysics Field Variation Laboratory of the Institute of Seismology in the Academy of Sciences of the Republic of Uzbekistan has been doing the special research on modeling earthquake preparation process in the micro research field of Charvak reservoir under the natural conditions. The similar research works have been implemented in Talbingo reservoir, Australia (Davis and Stasey, 1972), Nurek reservoir, Tajikistan (Karimov and Prokhorov, 1986), Tukhtagul reservoir, Kyrgyzstan (Shakirov *et al.*, 1989), Chirkey reservoir, Dagestan (Suleimanov, 1989), Azat reservoir, Armenia (Oganesyan 2004). In comparison with researches in other places the research in the Charvak research field is superior because of its scale and duration. Tracking results obtained from 1973 to 2011 were published in monographs and articles (Abdullabekov *et al.*, 1979; Birdaliev *et al.*, 1980; Abdullabekov *et al.*, 1983; Abdullabekov *et al.*, 1989; Abdullabekov *et al.*, 2012; Abdullabekov *et al.*, 2011; and Ulomov 1977).

MATERIALS AND METHODS
The purpose of the research is to investigate local changes of the geomagnetic field in relation to volume and level of reserved water in Charvak reservoir and model the earthquake preparation process under the natural condition, i.e. in the area with varying load. The magnetic features of rocks changes under high pressure and temperature. The further experiments were continued in technogenic object Charvak, produced extra pressure and formed special structures, such as oil-gas pits, gas and water reservoirs, and various explosion zones. Charvak reservoir is considered as one of such objects.

RESULTS AND DISCUSSION
Geomagnetic research of Charvak reservoir started in December, 1973. All studies were carried out in observation stations and repeat observation stations located in water basin (Fig. 1). During 1973-2010 the

stationary observation points were located in “Charvak”, “Xumson” and “Yusufxona”. There were 25-40 repeat observation stations, but now there are only 22 Geomagnetic observation stations equipped with magnetometer TMP, APS, and MV-01. The measurement accuracy of magnetometer is 0.1 nTl.

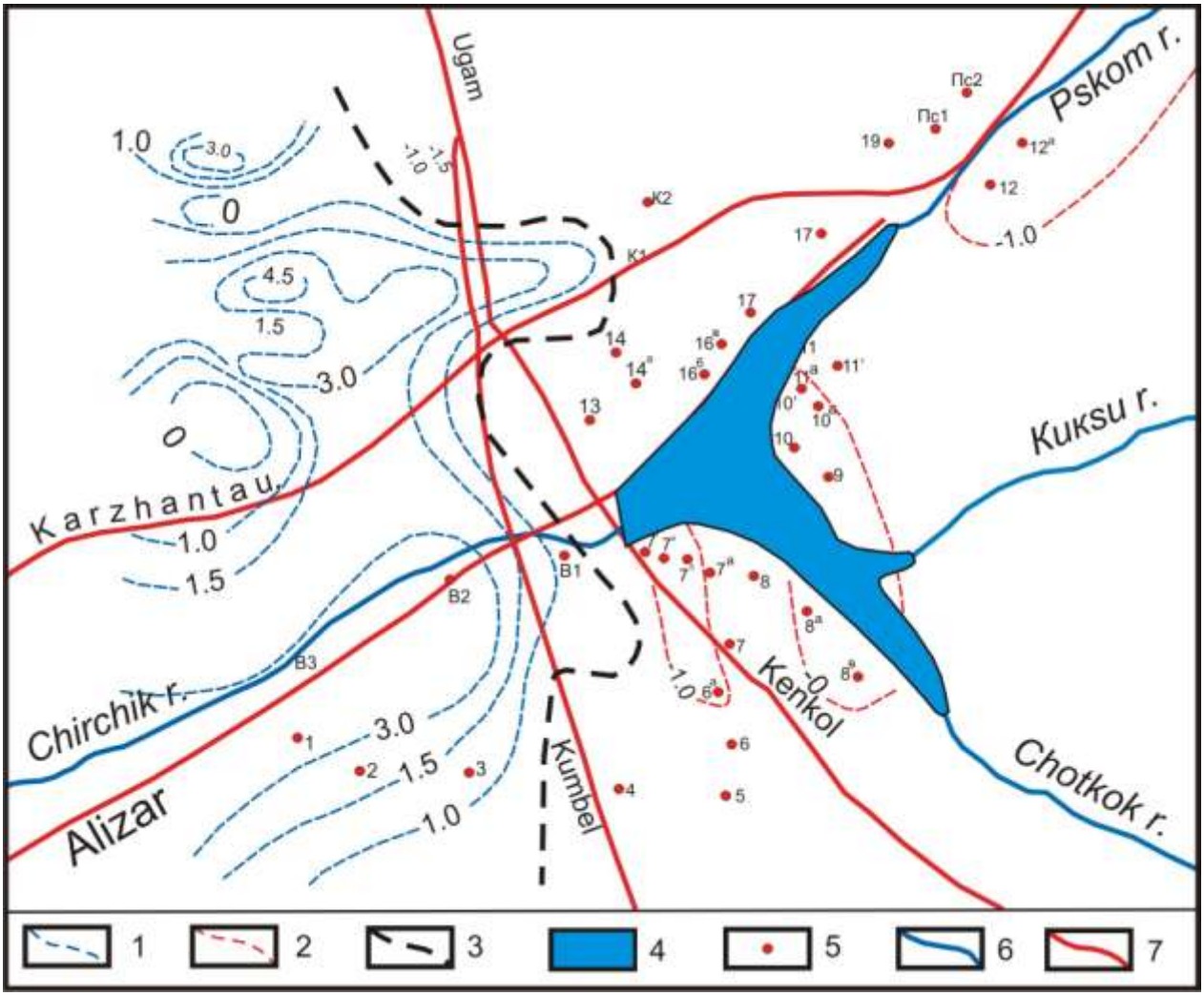

Fig. 1 Sketch map of Charvak research field
Label 1, 2 and 3 are isolines of anomalous magnetic field (1-positive, 2-negative, 3- zero); 4 - the contour of the reservoir, 5 - geomagnetic stations, 6 - rivers, 7 - faults.

116 measurement cycles have been carried out from 1973 to 2011. Long term geomagnetic measurements have been classified and systemized. Short term observation data has been excluded in the time series analysis. The research results were basically calculated according to geomagnetic observation data at the magnetic-ionosphere observatory of “Yangibazar”. The continuous data from 33 repeat stations during 1974-2011 were recalculated against measurement values during the first cycle in December 1973 based on the following equation.

$$\Delta T = \Delta T_{i\ cycle} - \Delta T_{1\ cycle}$$

ΔT- the local geomagnetic field variations
$\Delta T_{i\ cycle}$ – geomagnetic observation data at the stations Charvak
$\Delta T_{1\ cycle}$ - geomagnetic observation data at the magnetic-ionosphere observatory of "Yangibazar" (Stationary station).

In order to find out the local geomagnetic field variations (ΔT), it is needed to subtract the geomagnetic observation data at the magnetic-ionosphere observatory of "Yangibazar" from the geomagnetic observation data at the stations Charvak ($\Delta T_{i\ cycle}$) (Stationary station) ($\Delta T_{1\ cycle}$).

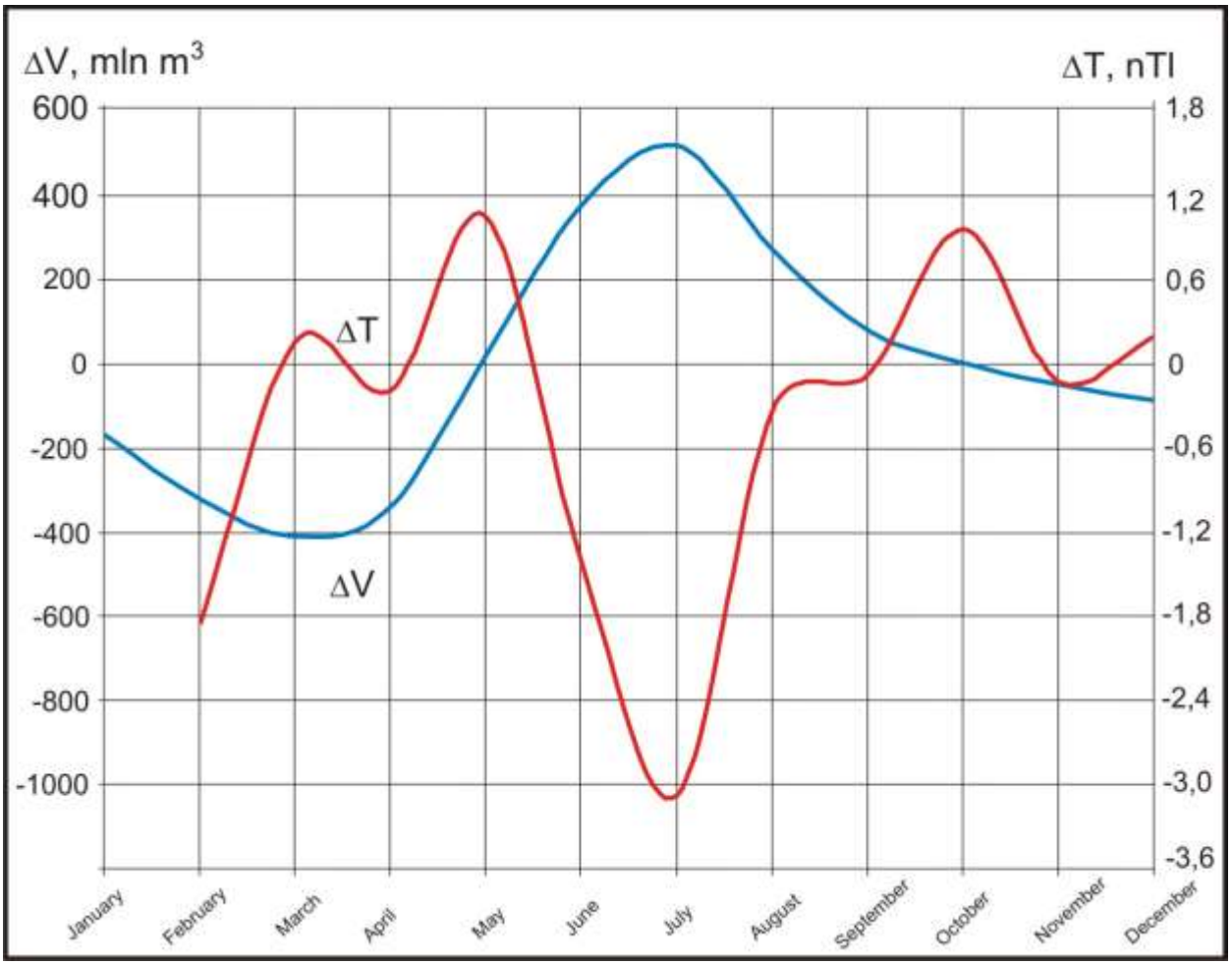

Fig. 2 Anomalous variations of geomagnetic field related to seasonal changes of water volume in Charvak reservoir.

ΔT-represents change of magnetic field
ΔV-represents change of water volume

It was found that each time the changes of water volume and level in Charvak reservoir could lead to a significant change of the magnetic field. The observation and results show that not only water volume and level but also seismotectonic processes in the area of Charvak reservoir and its surrounding areas have strong effects on the changes of magnetic field.

Computation and analysis

In Fig. 2 we can see the results of the observations of local changes of geomagnetic field. Due to the efforts of natural and tekhnogenic processes of the magnetic field, variations associated with the operation mode of the reservoir were revealed. All measurement results were calculated in comparison with the Yangibazar Magnetic Observatory.

Significant variations of the Earth's magnetic field seem to be associated with geodynamic phenomena, particularly volcanic eruptions and earthquakes. The variations have small amplitudes, generally only a few nTl. These small signals are embedded into larger transient variations due to other natural or artificial causes. Several studies have shown that significant signals exist in tectonically active regions: 10–30 nTl for over the period of years; 5–15 nTl for volcanic phenomena; 1–5 nTl for earthquakes.

Table 1: The earthquake catalogue in a radius of R=200 km

Number	**Date**	**Coordinate**		**depth (km)**	**magnitude**	**earthquake**
		λ	φ			
1.	1977.01.31	40.05	70.52	20	5.7	Isfara-Batken
2.	1977.12.06.	41.58	69.68	15	5.3	Tavaksay
3.	1980.12.11	41.33	69.05	10	5.5	Nazarbek
4	1982.06.10	41.35	69.06	10	5.8	Chimiyon
5.	1984.02.17	40.85	71.00	15	5.6	Pop
6.	1985.06.01	41.32	69.11	5	5.5	Kayrokkum
7.	1987.03.26	41.81	69.95	5	5.0	Oltintepa
8.	1987.10.18	42.18	70.10	20	4.0	Angren
9.	1988.10.07	41.83	69.28	10	4.0	Shengeldi
10.	1991.05.23	41.34	69.07	15	4.0	Keles
11.	1992.05.15	40.98	72.38	26	5.5	Izboskan
12.	1992.08.18	42.12	73.61	17	7.5	Susamir
13.	1994.01.20	41.89	70.26	10	4.5	Pskem
14.	1995.08.19	42.07	70.09	5	4.7	Ugam
15.	2003.04.05	41.10	69.44	5	3.0	Toytepa
16.	2004.12.16	41.23	69.06	5	3.0	Yangiyul
17.	2006.05.01	42.04	69.52	5	3.7	Keles
18.	2006.05.01	42.00	69.50	5	4.0	Keles
19.	2007.07.02	42.32	69.79	5	3.6	Lenger
20.	2008.08.22	41.30	69.40	10	4.7	Tashkent
21.	2010.01.23	41.27	69.19	15	3.3	Toytepa

The variations of local magnetic field are presented below during various earthquake preparation processes. The relation between observed geomagnetic data during 1973-2011 in the micropolygon Charvak with both local and regional seismological changes has been studied. The measurement results from 33 repeat stations in 116 observing cycles have been reviewed and classified. In order to compare observed local anomalies of the geomagnetic field, earthquakes which occurred in Charvak reservoir and its surrounding area within a radius of 200 km have been chosen. The earthquakes satisfying the condition of $R < P_{30}$ (Ulomov, 1977**)**, *i.e.*, within a radius of 200 km from the Charvak reservoir, were chosen. The selected earthquakes and their locations were presented in the table 1.

The local geomagnetic field variations and water volumes in the reservoir are presented in Fig 3. For joint analysis, magnitudes of earthquakes which occurred during 1974-2011 are also added in Fig 3. It shows that there are correlations among the anomalous changes of local geomagnetic field, changes of the water volume and the earthquakes in this area. For example, when M=5.3 Tavaksay earthquake occurred in 1977, the local geomagnetic field changed to +5nTl; when M=5.5 Nazarbek earthquake occurred in 1980, the local geomagnetic field changed to +3nTl; when M=5.8 Chimiyon earthquake occurred in 1982, the local geomagnetic field changed to +3.5nTl.

It is known that the anomalous changes of the earth magnetic field were not only observed in the Charvak, but also measured in the three directions (Western, Eastern, Perpendicular) in the Tashkent since 1968. The results obtained in these directions confirmed the local geomagnetic anomalies measured in Charvak reservoir. The average perpendicular changes of the earth magnetic field related to Tavaksay earthquake at the station near the Charvak reservoir and the station 9 in the Tashkent were presented in Fig.4.

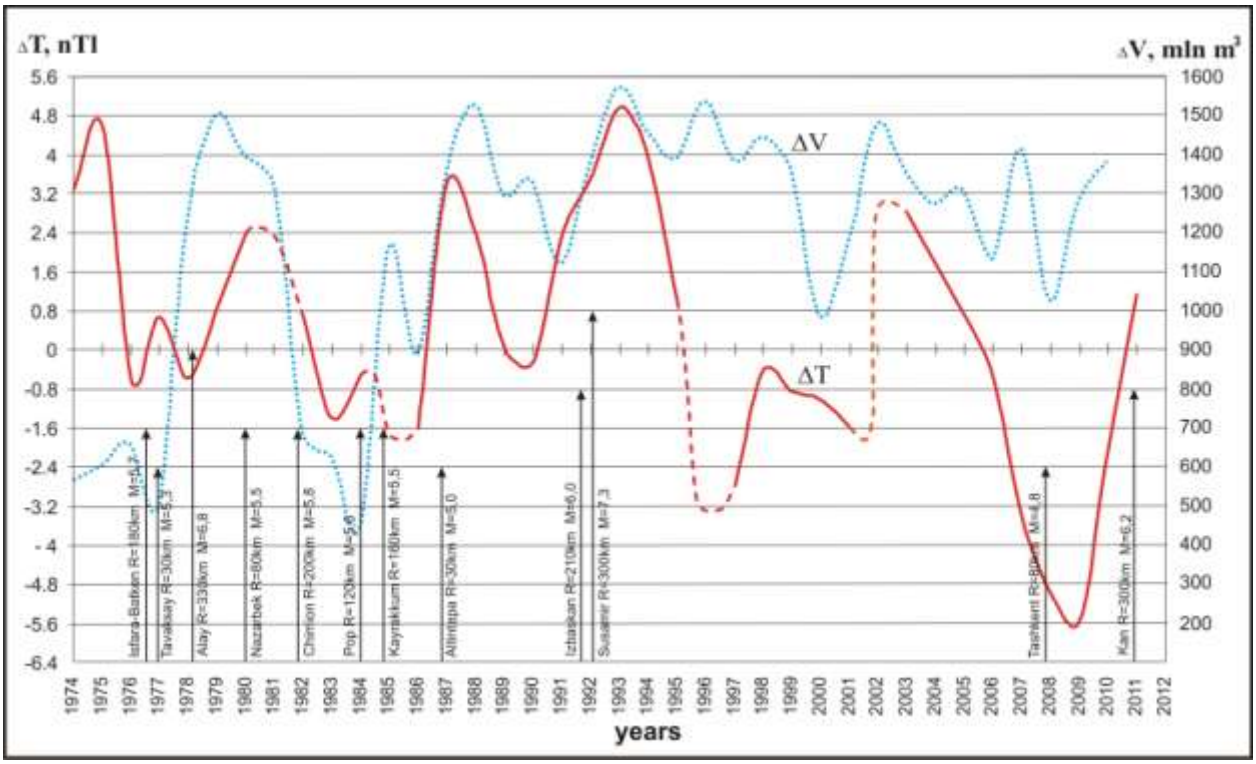

Fig. 3 Anomalous changes of the geomagnetic field related to changes of water volume and the earthquake preparation process in the Charvak.

ΔV-represents change of water volume; ΔT-represents change of magnetic field.

The geomagnetic change in the Tavaksay was +19 nTl from 1975 to 1976, and reached to +18 nTl in the middle of 1977. The stations where geomagnetic anomalies were observed are located 15-20 km far from the earthquake epicenter. The changes measured respectively at the stations in the Charvak and Tavaksay are the same in time and shape, but the latter is about 3-4 times the former. The difference of geomagnetic anomalies is dependent on the distance between their locations. The change in the Charvak is less because the Charvak is 30-40 km far from the epicenter. It means that the local geomagnetic anomalies are connected with the earthquake preparation in Tavaksay. The shapes of anomalous change are similar, which means that their sources are situated in the zones of Karzhantau fault and have the same structure.

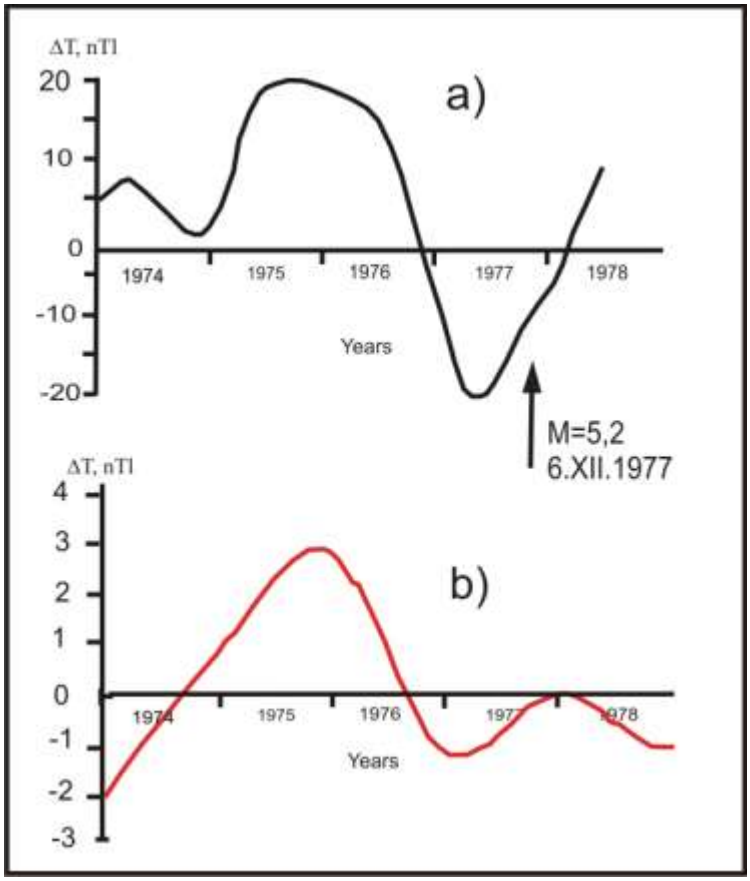

Fig. 4. The anomalous changes of the earth magnetic field linked with Tavaksay earthquake during 1974-1978.
a) The Perpendicular changes at the station 9;
b) The average changes at the stations 13 in the research field of Charvak reservoir.

The Isfara-Batken earthquake in 1977, in spite of being 180 km far from the research field, was the cause of the big anomalous changes. The effect of the 1980 Nazarbek earthquake located in 80 km far from the Charvak appeared as anomalous changes of local geomagnetic field variations in the Charvak. The geomagnetic effect of the 1982 Chimiyon earthquake was not sensed, because its epicenter is located far from the research field. The Oltintepa earthquake caused the big anomalous changes, because the epicenter was located only in 30 km far from the research field. Despite of being 210-300 km far from the research field, the magnitudes of the Izboskan and Susamir earthquakes in 1992 were high, so it brought the big anomalous changes.

Discussion

Based on the average values of the geomagnetic field at 22 repeated observation points and seasonal changes of the water volume in the reservoir, measures hang up to the maximum degree in July; but magnitic field value falls the most minimal degree; for 38 years of the loading-unloading, a local change in the geomagnetic field associated with the operating mode of the reservoir has been revealed. The amplitude of the anomalous changes was from 1-2 nTl to 4-6 nTl, and they have a reversible feature. When the water volume increases, the value of the geomagnetic field decreases and vice versa, which is presented in Fig. 2.

The local changes of geomagnetic field in the Charvak would happen due to not only the effect of the accumulated water in the reservoir but also the effect of the earthquake preparation process in this research field or the effect of seismotectonic process in this area. In Fig. 4, it can be seen that the occurrences of strong earthquakes in this area were the cause of local geomagnetic anomalies. The main reason could be that the regional faults passing in the northeast of the Charvak and the crossing faults, such as Ugam, Kumbel, Alizar, Siddjak and Tavaksay, were active. We can see that the geomagnetic field in the Charvak began to decrease during 2005-2006. The average change is 5-6 nTl. In our opinion, this anomalous change shows that there is a big strain in the Earth's crust of the northeast part of Tashkent. In this zones, if we consider these cases: Pskom earthquake (M=6.5) in 1937, Burchmulla earthquake (M=5.7) in 1959, Tavaksay earthquake (M=5.3) in 1977 and others, the anomalous geomagnetic change is considered as a medium-term precursor of powerful earthquake (M>5). We also would like to point out that the geomagnetic changes are not only related to the changes of the water volume but also the earthquake preparation process on the research territory, which was presented in Fig. 4.

Conclusion

In conclusion, the result of the long-term research of the geomagnetic field around the Charvak reservoir displays that the local geomagnetic anomalies related to the changes of water volume in the reservoir happen simultaneously with the change of local seismic activity. The research results in the area of Charvak reservoir could be used in not only modeling earthquake preparation process and forecasting earthquake but also monitoring seismic activity near the Karzhantau fault zones and the Tashkent city.

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