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ANALYSIS OF GEOMAGNETIC FIELD VARIATIONS DURING THE PERIOD OF SEISMIC ACTIVITY IN THE NORTHERN TIAN SHAN

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ABSTRACT

In this paper the variations of geomagnetic field during three sensible earthquakes in Northern Tien Shan were investigated. The data of the geomagnetic observatory «Alma-Ata» [43.2˚N; 76.9˚E], which is member of the global network of observatories monitoring the Earth's magnetic field (INTERMAGNET), were used for analysis of condition of geomagnetic field before and during the earthquakes.

INTRODUCTION

Anomalous geomagnetic disturbances before earthquakes, which were caused by changes in local area of the Earth's crust in consequence of tectonic processes, were recorded repeatedly Bakhmutov et al. (2003), Beloslyudtsev (1996), Cianchini et al. (2012), Guglielmi and Zotov (2012, 2012), Hayakawa (2011), Ismaguilov et al. (2013), Kurskeev (1990), Rzaev et al. (2006), Tertyshnikov (2013), Uzbekov (2001). Starzhinsky and Nikiforov (2012) mentioned in their paper that «every fact of observation of any anomalous behavior of geophysical fields at time intervals of earthquake should be studied and described in details as much as possible». In this paper, the analysis of variations of the parameters of the geomagnetic field before and during three sensible earthquakes of magnitude $M \geq 4.1$ in the Almaty region in the Northern Tien Shan, is given.

The data of the geomagnetic observatory «Alma-Ata» [43.2˚N; 76.9˚E] were used for investigation of condition of geomagnetic field before and during the earthquakes: minute values of three components (dX, dY, dZ) and full vector F of geomagnetic field. X component is aimed at geomagnetic north, component Y is aimed at east, perpendicular to the axis X and Z is aimed upwards.

DESCRIPTION OF EARTHQUAKES IN ALMATY REGION

We analyzed the condition of geomagnetic field during three sensible earthquakes (http://www.kndc.kz):

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- Earthquake on April 4th, 2012 at 14 h 21 min UT, M = 4.1; h = 10 km, the epicenter of which is located on the border between Kyrgyzstan and China [41.81°N; 79.68°E], 280 km south-east of the city Almaty;

- Earthquake on April 18th, 2012 at 14 h 48 min UT, M = 5.1; h = 0 km, the epicenter [39.99°N; 76.94°E] of which is located in China 352 km south of Almaty. The earthquake was felt in Almaty with the intensity of 2;

- Earthquake on January 28th, 2013 at 16 h 38 min UT, M = 6.1; h = 10 km, the epicenter [42.64°N; 79.76°E] of which is located. After the main shock there occurred a large number of aftershocks, the parameters of strongest aftershocks with magnitude M ≥ 4.0 are given in Table 1 (http://www.kndc.kz). The earthquake was felt in Almaty with the intensity of 4-5.

Table 1. Aftershocks in the seismic center of the earthquake, occurred on January 28th 2013 in Almaty region (http://www.kndc.kz)

Day	Time (GMT)	Epicenter		Magnitude (mb)	Energy class (K)
		Latitude	Longitude		
28.01.2013	**16:38**	**42.64**	**79.76**	**6.1**	**15.3**
28.01.2013	17:09	42.62	79.60	4.3	9.1
28.01.2013	17:12	42.61	79.68	4.4	9.7
28.01.2013	17:31	42.62	79.66	4.8	10.4
28.01.2013	18:49	42.61	79.73	4.3	9.1
28.01.2013	19:11	42.62	79.59	4.5	9.8
28.01.2013	19:47	42.59	79.63	4.8	10.6
28.01.2013	20:37	42.61	79.66	4.8	10.5
28.01.2013	20:40	42.60	79.60	4.5	9.3
28.01.2013	23:49	42.60	79.65	4.2	9.2
29.01.2013	05:19	42.60	79.65	4.1	9.0
29.01.2013	08:57	42.63	79.70	5.0	11.0
29.01.2013	14:50	42.62	79.60	4.0	8.8

Ground location of epicenters of earthquakes is shown in Figure 1.

Earthquakes: 1– 04.04.2012, M = 4.1; 2 –18.04.2012, M = 5.1; 3 – 28.01.2013, M = 6.1

Figure 1. Ground location of epicenters of earthquakes in Almaty region (http://www.kndc.kz)

ANALYSIS OF GEOPHYSICAL CONDITIONS ON THE EVE OF EARTHQUAKES

The earthquakes in Kazakhstan occurred in the year of maximum of the 24th sunspot cycle (2012-2013), however, because of the low solar outburst activity in the 24th cycle the number of the solar flares in this period was low, W=~40. The intensity of the solar radio flux on the wavelength 10.7 cm equaled (F10.7~95), http://cdaweb.gsfc.nasa.gov.

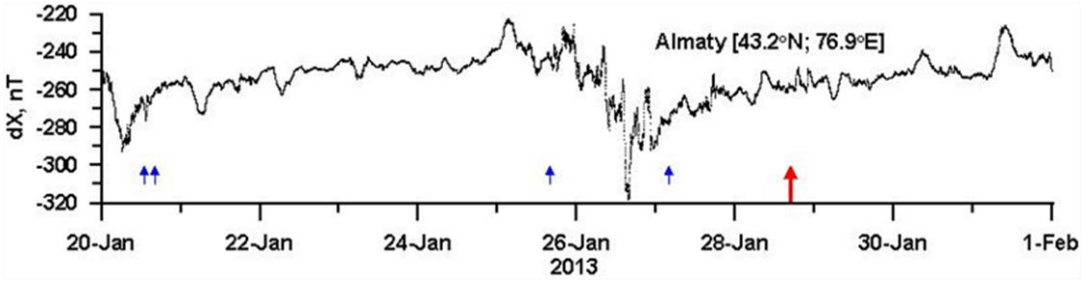
Concerning the geomagnetic situation a day before the earthquake on January 28th, there was a moderate geomagnetic storm, the maximum of the positive phase of the geomagnetic storm (Dst = +22 nT) was observed on January 28th at 20:30 UT, and maximum of the negative phase was observed on 26th January 2013 at 22:30 UT (Dst = -51 нТл). During this geomagnetic storm 3-hour values of the geomagnetic index K equaled approx 40 nT. At the moment of the earthquake, which occurred on the phase of restoring of the geomagnetic storm on January 28th 2013at 16:38:53 UT, the values of the K-index didn't exceed 10 nT, while the values of the Dst-index were negative (Dst = 10). Basically, at the moment of the earthquake the geomagnetic situation wasn't disturbed, because the magnetic field had almost restored after the storm.

The geomagnetic disturbances, registered in the "Alma-Ata" observatory [43.2°N; 76.9°E] within the time range from 10th January to 20th February 2013, can be found in the Table 2. In this period there were 4 small and 5 moderate geomagnetic storms. Description of geomagnetic conditions for the month is given to show the background, in which the earthquake occurred.

Table 2. Geomagnetic disturbances, registered in the «Alma-Ata» observatory within the time range from 10th January to 20th February 2013

Start of the storm (LT)	End of the storm (LT)	Features of the storm	Duration	K-index of the magnetic activity
14.01 from 03h.	14.01 to 09 h.	SMS	6h	4
17.01 from 00h.	18.01 to 03 h.	MMS	27h	5
18.01 from 15h.	19.01 to 09 h.	MMS	18h	5
20.01 from 18h.	20.01 to 21 h.	SMS	3h	4
25.01 from 21h.	27.01 to 09 h.	MMS	36h	5
02.02 from 15h.	03.02 to 03 h.	SMS	12h	4
13.02 from 21h.	14.02 to 21 h.	MMS	24h	5
16.02 from 18h.	17.02 to 03 h.	MMS	9h	5
17.02 from 18h.	18.02 to 03 h.	SMS	9h	4
SMS – a small magnetic storm; MMS – a moderate magnetic storm.				

The variations of minute values of dX-component of geomagnetic from 20.01 to 31.01 2013 are shown in the Figure 2, the blue arrows show the periods of the geomagnetic storms. In variations of the geomagnetic parameters the perturbation of ionospheric and magnetospheric origin, caused by solar activity, are prevalent. In this period there were small and moderate geomagnetic storms.



The blue arrows show periods of the geomagnetic storms. The red arrow – the moment of the main shock.

Figure 2. Variations of dX-component of the geomagnetic field according to data of the «Alma-Ata» observatory [43.2°N; 76.9°E] during the period from 20.01 to 31.01.2013

According to data of geomagnetic observatory «Alma-Ata» during the earthquakes in April 2012 the following magnetic storms occurred:

- Small magnetic storm, which lasted for 12 hours (on April 5th, 2012 from 06 h to 19 h UT UT);
- Large magnetic storm, which lasted for 21 hours (from 15 h UT on April 12th to 12 h UT April 13th).

Geomagnetic condition before and during the selected events was quite, so variations of the parameters of the geomagnetic field display only inner earth processes which are not caused by processes in the near-Earth space.

THE RESULTS OF ANALYSIS

Let's consider the earthquake of magnitude M=6.1 on 28 January 2013 in details. We investigated the daily variations of the minute values of geomagnetic parameters for magnetically quiet days – 21, 22, 23, 24, 28, 30, 31 January 2013. The diurnal variations of the minute values of the dX-, dY-components of the geomagnetic field are given in the Figure 3, dZ-component – in the Figure 4. The investigated period was divided in the periods before the earthquake (21-24 January 2013), see figure 3a, 3c, 4a; and the period, which includes the moment of the main shock and its aftershocks (28-31 January 2013), see figures 3b, 3d, 4b.

Next features in the variations of the geomagnetic field during the earthquake, which occurred in Almaty region on January 28th 2013, were found out:

1) Decrease by ~18-21 nT in diurnal variations of the X-component in magnetic-quite days on January 21th 2013 (7 days before the earthquake), on the day of earthquake on 28th January and 29th January, when there were aftershocks of magnitudes M≥4.5 (see Table 2), compared with magnetically quiet days on 22-24 January and 30-31 January 2013 (Figures 3a and 3b). In the paper of Tertyshnikov A.V. (2013) it was mentioned that in variations of K- and kp-indexes before the powerful crustal earthquakes there were found statistically significant variations relative to background level: they appear 6-7 days before the earthquake in the parameters of the geomagnetic field, and 12-15 hours before strong earthquakes a reduction in the level of geomagnetic activity showed up, 12 hours before the earthquake energy of high-frequency harmonics increased, while a relative power of low-frequency harmonics was falling.

2) A mild diurnal rate in the in variations of dY- and dZ-components on the Sun illuminated side on 23-24th January and 28-30th January 2013 compared with magnetic-quite days on 21, 22, 31 January 2013 (Figures 3c, 3d and 4).

3) Quasi-periodical fluctuation with the period ~1h and amplitudes ~7-9 nT in the variations of the dY-component (Figures 4d) and full vector F of the geomagnetic field on 28th January 2013 after the main shock, when there were aftershocks.

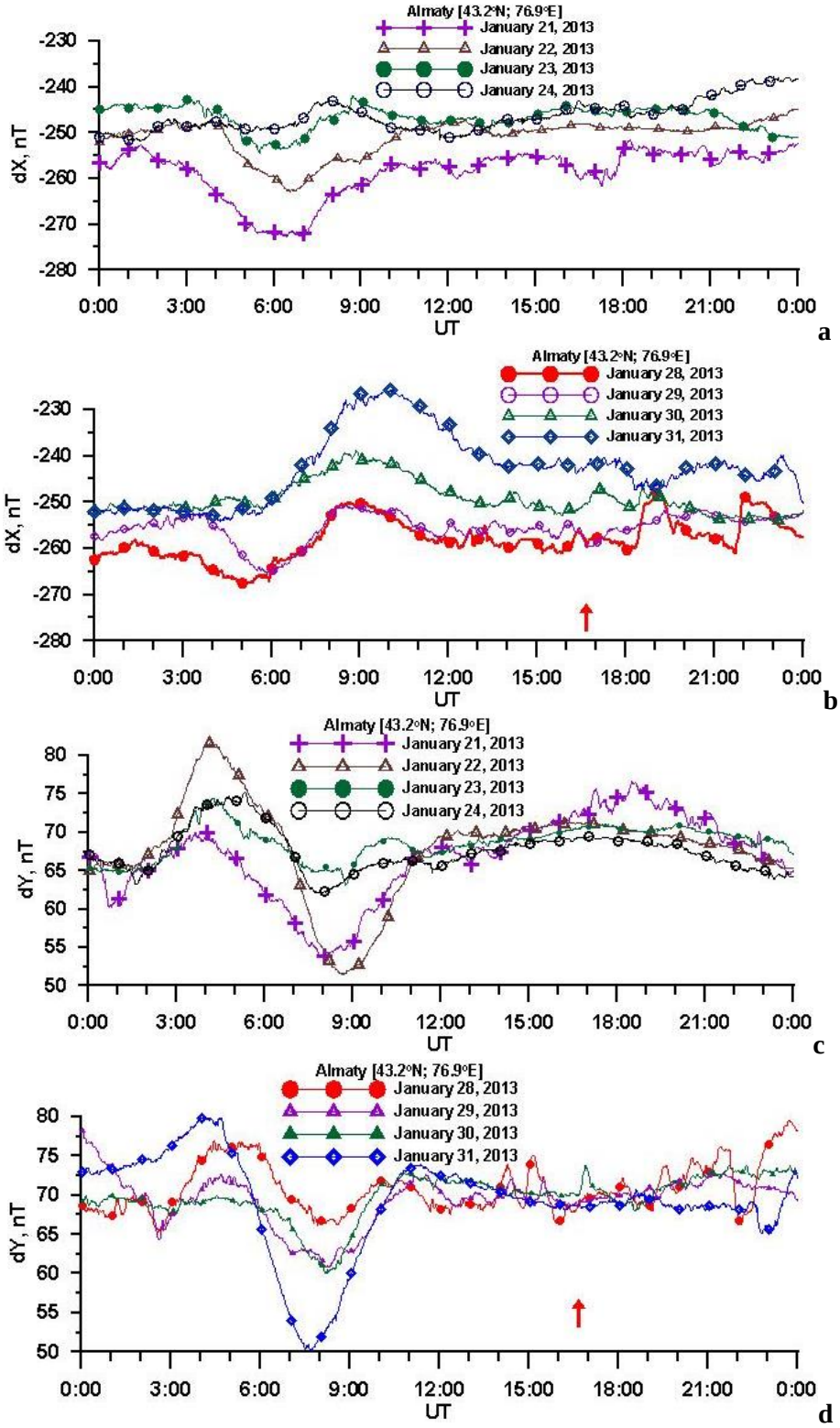
Basically, the earthquake on 28th January 2013 occurred under quiet characteristics of space weather (interplanetary magnetic field and solar wind). Therefore, the variations of the characteristics of the geomagnetic field above ground reflect only in-Earth processes, which aren't determined by processes in the near-Earth Space environment.

The identified geomagnetic effects before the April earthquakes in 2012 manifested themselves in following:

- A day before the earthquake on April 4th, 2012 with a magnitude of M = 4.1: there were found 1) decrease by (8÷12) nT values of X-component; 2) in the diurnal minute values of Y-component from 15 UT to 22 UT there were observed quasi-periodic perturbations of an amplitude ~(7÷9) nT lasting 1-2 hours.

A day before the earthquake on April 18th, 2012 with a magnitude of M = 5.1 there is an increase of values of Y-components from 18 to 21 UT lasting 3 hours of an amplitude ~(17÷19) nT.

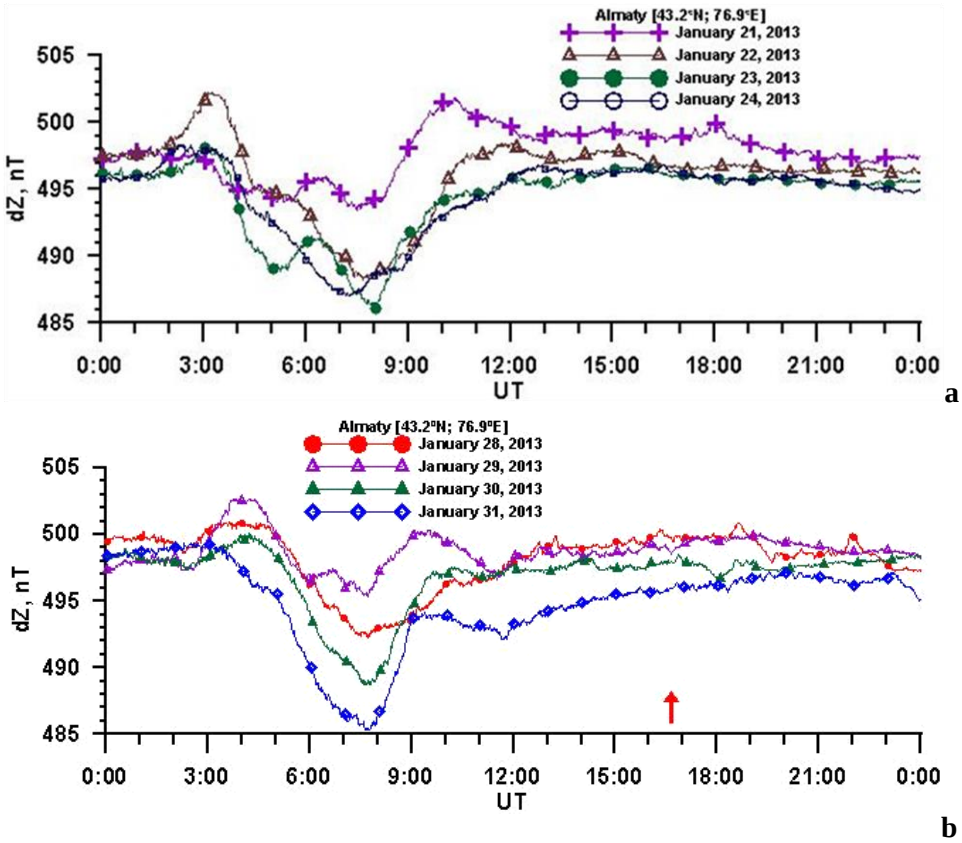
In both issues, before the earthquake on April 4th, 2012 (M = 4.1) and before the earthquake on April 18th, 2012 (M = 5.1), there were found deviations of ~(9÷11) in the variability from day to day of minute values of Z-components between 06 UT to 11 UT comparing with the same time slot in the magnetically calm period of 19-22 April 2012, when the variability from day to day varied on the range ~(3÷5) nT.



The red arrow shows the moment of the main shock.

a) dX – 21-24 January, 2013; b) dX – 28-31 January, 2013;
d) dY – 21-24 January, 2013; c) dY – 28-31 January, 2013

Figure 3. The diurnal variations of the minute values of the dX-component and the dY component according to data of the geomagnetic observatory “Alma-Ata” [43.2°N; 76.9°E]



The red arrow shows the moment of the main shock.

a) dZ – 21-24 January, 2013; b) dZ – 28-31 January, 2013;

Figure 4. The diurnal variations of the minute values of the dZ-component according to data of the geomagnetic observatory “Alma-Ata” [43.2°N; 76.9°E]

CONCLUSIONS

We have studied the variations of geomagnetic field based on data of geomagnetic observatory «Alma- Ata» [43.2°N; 76.9°E] during the earthquakes on the Northern Tien Shan on 28th January of M = 6.1, on April 4th, 2012 of M = 4.1, on April 18th, 2012 of M = 5.1.

There were identified geomagnetic effects before and during the earthquakes as follows:

- 7 days before the earthquake, as well as in the days when there were the main shock and its aftershocks, there was observed a decrease in diurnal variations of the geomagnetic field parameters relative to the background level in magnetically quiet days;

- the anomalous perturbations with periods ranging from ~1 to ~2 hours and amplitudes over ~ (7-13) nT, which aren’t typical for the time of day (00:00÷06:00 h UT) and (18:00÷24:00 h UT), in magnetically quiet periods.

Experimental study of anomalous behavior of the geomagnetic field during periods of seismic activity is a contribution to accumulation of statistical material on nature of such a complex phenomenon as an earthquake and will help in better understanding of this phenomenon.

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