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The geomagnetic variation in Dusheti observatory related with earthquake activity in East Georgia
(January - July 1012)

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Abstract

Before strong earthquake magnetic precursors denoted by many authors, but must to say, that more of them don't satisfy stern criterions.

The method of earthquake's predictions are based on the correlation between geomagnetic quakes and the incoming minimum (or maximum) of tidal gravitational potential. The geomagnetic quake is defined as a jump of day mean value of geomagnetic field one minute standard deviation measured at least 2.5 times per second. The probability time window for the incoming earthquake or earthquakes is approximately ± 1 day for the tidal minimum and for the maximum- ± 2 days. The statistic evidence for reliability of the geomagnetic precursor is based on the distributions of the time difference between occurred and predicted earthquakes for the period January-June of 2012 for Dusheti region.

1. Introduction

The problem of "when, where and how" earthquake prediction cannot be solved only on the basis of seismic and geodetic data (1; 10; 6).

The possible tidal triggering of earthquakes has been investigated for a long period of time.

Including of additional information in the precursors monitoring, such as the analysis of the electromagnetic field variations under, on and above the Earth surface, can contribute towards defining a reliable earthquake precursor and estimating the most probable time of a forthcoming earthquake.

Simultaneous analysis of more accurate space and time measuring sets for the earth crust condition parameters, including the monitoring data of the electromagnetic field under and over the Earth surface, as well as the temperature distribution and other possible precursors, would be the basis of nonlinear inverse problem methods. It could be promising for studying and solving the ,,when, where and how" earthquake prediction problem.

Some progress for establishing the geomagnetic filed variations as regional earthquakes' precursors was presented in several papers (7; 9).

The approach is based on the understanding that earthquake processes have a complex origin. Without creating of adequate physical model of the Earth existence, the gravitational and electromagnetic interactions, which ensure the stability of the Sun system and its planets for a long time, the earthquake prediction problem cannot be solved in reliable way. The earthquake part of the model have to be repeated in the infinity way "theory- experiment- theory" using nonlinear inverse problem methods looking for the correlations between fields in dynamically changed space and time scales. Of course, every approximate model (16; 12; 13; 14; 3; 4; 5) which has some experimental evidence has to be included in the analysis. The adequate physical understanding of the correlations between electromagnetic precursors, tidal extremums and incoming earthquake is connected with the progress of the adequate Earth's magnetism theory as well as the quantum mechanical understanding of the processes in the earthquake source volume before and in the time of earthquake.

The achievement of the Earth's surface tidal potential modeling, which includes the ocean and atmosphere tidal influences, is an essential part of the research. In this sense the comparison of the Earth tides analysis programs (Dierks and Neumeyer, ws) for the ANALYZE from the ETERNA-package, version 3.30 (Wenzel, 1996 a, b), program BAYTAP-G in the version from 15.11.1999 (Tamura, 1991), Program VAV (17) is very useful.

The role of geomagnetic variations as precursor can be explained by the hypothesis that during the time before the earthquakes, with the strain, deformation or displacement changes in the crust there arise in some interval of density changing the chemical phase shift which leads to an electrical charge shift. The preliminary Fourier analysis of geomagnetic field gives the time period of alteration in minute scale. Such specific geomagnetic variation we call geomagnetic quake. The last years results from laboratory modelling of earthquake processes in increasing stress condition at least qualitatively support the quantum mechanic phase shift explanation for mechanism generating the electromagnetic effects before earthquake and others electromagnetic phenomena in the time of earthquake (2; 11; 15). The future epicentre coordinates have to be estimated from at least 3 points of measuring the geomagnetic vector, using the inverse problem methods, applied for the estimation the coordinates of the volume, where the phase shift arrived in the framework of its time window. For example the first work hypothesis can be that the main part of geomagnetic quake is generated from the vertical Earth Surface- Ionosphere electrical current. Sea also the results of papers (Vallianatos, Tzanis, 2003 ; Duma, Ruzhin, 2003, Duma, 2006) and citations there.

In the case of incoming big earthquake (magnitude > 5 - 6 the changes of vertical electropotential distribution, the Earth's temperature, the infrared Earth's radiation, the behaviour of debit, chemistry and radioactivity of water sources, the dynamics and temperature of under waters, the atmosphere conditions (earthquakes clouds, ionosphere radioemitions, and etc.), the charge density of the Earth radiation belt, have to be dramatically changed near the epicentre area- see for example papers .

The achievements of tidal potential modeling of the Earth's surface, including ocean and atmosphere tidal influences, multi- component correlation analysis and nonlinear inverse problem methods in fluids dynamics and electrodynamics are crucial for every single step of the constructing of the mathematical and physical models.

2. Method and data description

In the paper (Mavrodiev,2004) the geomagnetic quake was defined as a jump of the day mean value of the signal function Sig:

$$Sig = \sum_{m=1}^{M} \sigma_{Hm} / M, \qquad \delta Sig = \sum_{m=1}^{M} \delta\sigma_{Hm} / M, \qquad (1)$$

Here *σHm* is the standard deviation of geomagnetic field component *Hh, and δσHm* is the corresponding error,

$$\sigma_{Hm} = \sqrt{\sum_{t=1,N} \frac{(H_t - H_m)^2}{N}}, \qquad \delta\sigma_{Hm} = \sqrt{\sum_{t=1,N} \frac{(\delta H_t - \delta H_m)^2}{N}},$$

Hm is one-minute averaged value of geomagnetic vector projection Hi,

$$H_m = \sum_{i=1}^{N} \frac{H_i}{N} \qquad \delta H_m = \sum_{i=1}^{N} \frac{\delta H_i}{N},$$

M=1440 minutes per day, and N=60 are the samples per minute.

The predicted earthquake is identified by the maximum of the function proportional to the density of the earthquake radiated energy in the monitoring point. The analytical size of this function is:

$$\mathbf{SChtM = 10M / (D+Depth +Distance^2)}, \qquad \mathbf{(2)}$$

Where the distances are in hundred km, fit parameter D = 40 km and M is the earthquake magnitude

Thus, if we have a jump of signal function Sig and its error δSig is such that satisfies numerically the next condition :

SigToday – SigYesterday > (δSigToday + δSigYesterday) / 2, (3)

In the next tidal extreme time the function SChtM will has a local maximum value. The earthquake for which the function SChtM has a maximum can be interpreted as predicted earthquake.

The probability time window for the incoming earthquake or earthquakes is approximately ± 1 day for the tidal minimum and for the maximum- ± 2 days.

The analytical size of the function SChtM as well as one minute time period for calculating the unique signal for geomagnetic quake which is reliable earthquake precursor was established by ***Dubna inverse problem method*** (Dubna Papers).

In the case of vector geomagnetic monitoring, one has to calculate the minute standard deviation as a geodynamical sum of standard deviations of the tree geomagnetic vector components:

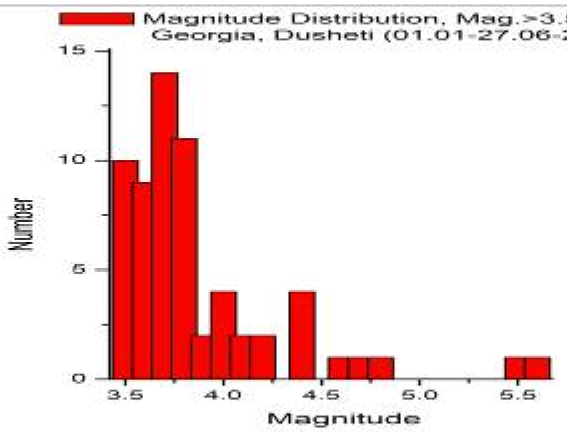
$$\delta_{\mathrm{Hm}} = \sqrt{(\delta^2{}_{Hmx} + \delta^2{}_{Hmy} + \delta^2{}_{Hmz})}$$

Dusheti Geomagnetic Observatory is located in Dusheti town (Georgia, Lat 42.052N, Lon44.42E), Alt900m). It is equipped with modern precise Fluxgate Magnetometer Model LGI and it accomplishes non-stop registration of X, Y, Z elements. The data includes minute and second records of the field elements. It is measured with 0,1nT accuracy daily.

3. Data

There was analyzed earthquakes data in region with Lat42.052N and Long44.42E for January-June of 2012, reported in EMSC: Earthquake research results, magnitude range from 3.5 to 9.0, data selection 62 earthquakes; Minute data of Geomagnetic fields elements received from Dusheti Geomagnetic observatory or 60 samples per hour, with 0,1nT accuracy; Coordinate of Dusheti Geomagnetic observatory: 42.052N, Lon44.42E Alt900m.

The distributions of earthquakes' magnitudes and depths, (Mgnitude >3.5) are presented in Fig.1 and Fig.2. (Epicentral distances up to 300km and magnitudes M>3.5).



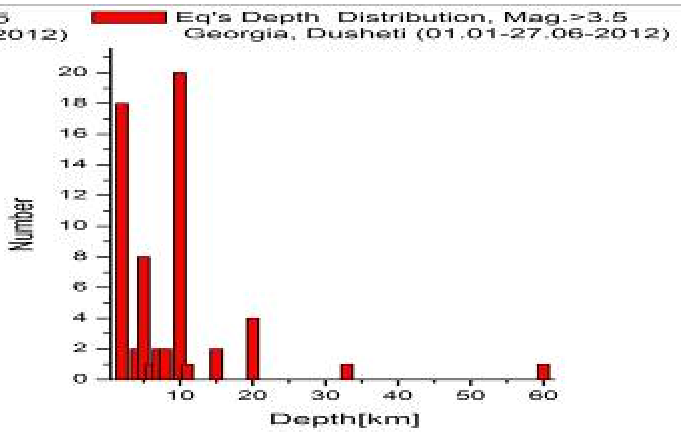


Fig.1. Magnitude distribution

Fig. 2 The earthquake's depth distribution

Fig3. Presents the SChtM and magnitude distribution for all occurred in the region earthquakes as function of distance from the monitoring point with magnitude>3.5.

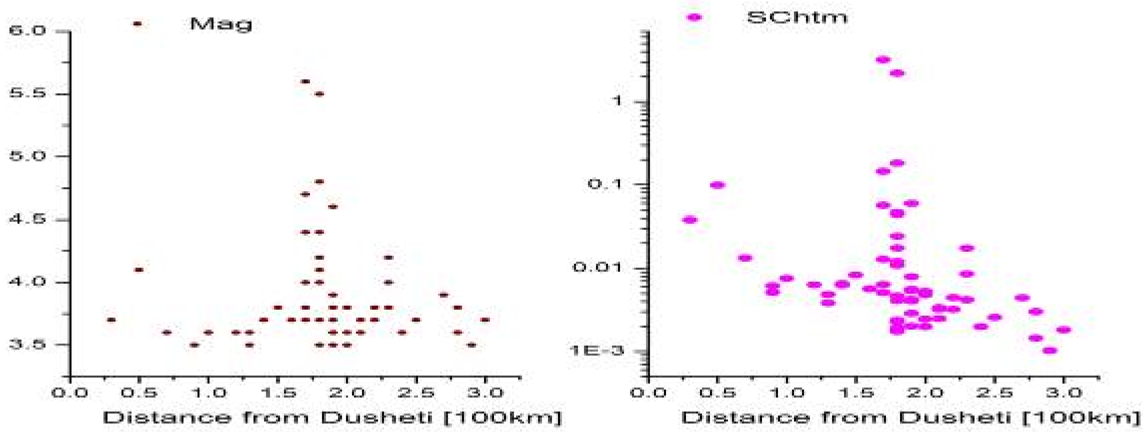


Fig. 3. The distribution of SChtM and Magnitude (>3.5) on distances for all occurred earthquakes in the region

The comparison of the distribution in the Fig3 and Fig.4 can give some presentation for distance and magnitude sensibility of the geomagnetic approach.

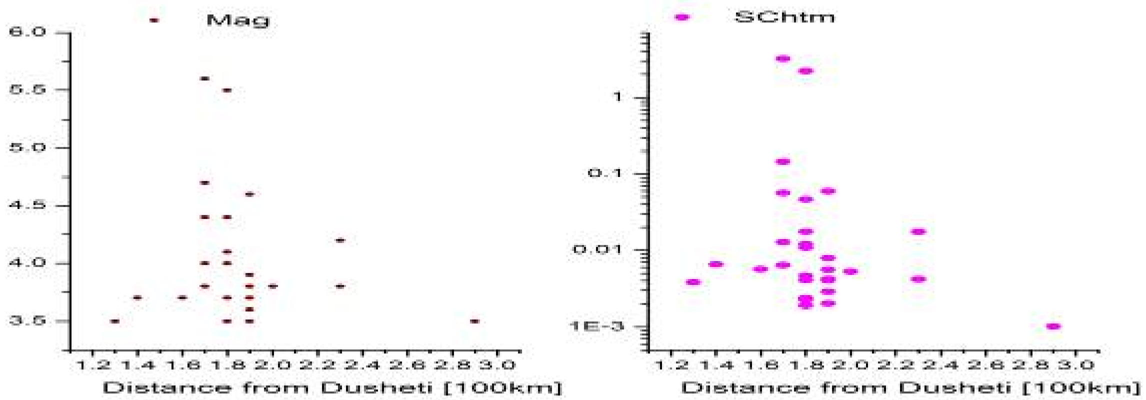


Fig. 4. The distribution of SChtM and Magnitude (>3.5) on distances for predicted earthquakes

4. Analysis

The next Table contains the monitoring data for Dusheti and its analysis, described above, which illustrate that the geomagnetic quake is regional reliable earthquake precursor. The columns present: the number of signals preceding the incoming tidal extreme data, information for the tidal minimum (1) or maximum (2), the time of tidal extreme, the time of occurred earthquake, latitude [degree], longitude [degree], depth [km], magnitude, distance from monitoring point [in 100 km], the value of function SChtM [J/km2], the difference between the time of tidal exstreme and the time of occurred earthquake [in days]. The table consists a data for the earthquake with magnitude grater then 3.5

Number of Signals	Tidal min,max	Signal Time	Tidal Min,Max time	Eq Time	Lat	Long	Depth [km]	Mag	Dist[100km]	Schtm	Time difference(day)
	1	29.12.2011	12/31/2011 9:10	1/2/2012 1:08	42.7	43.41	10	3.6	1.3	0.005	2
		29.12.2011	12/31/2011 9:10	1/2/2012 5:49	44.42	45.74	10	3.6	2.8	0.001	2
	2	3.01.2012	1/8/2012 13:09	1/5/2012 9:01	42.46	43.82	20	3.5	0.9	0.005	-3
		3.01.2012	1/8/2012 13:09	1/5/2012 14:17	41.92	45.9	5	3.6	1	0.008	-3
		3.01.2012	1/8/2012 13:09	1/6/2012 3:13	40.81	42.6	7	3.8	2.2	0.004	-2
			1/15/2012 10:00	1/12/2012 3:37	43.19	46.76	10	3.7	2.1	0.003	-3
			1/15/2012 10:00	1/13/2012 14:10	39.97	42.42	15	3.7	3	0.002	-2
	1	12.01.2012	1/15/2012 10:00	1/15/2012 0:11	42.54	42.93	2	3.7	1.6	0.006	-0
			1/29/2012 9:25	2/1/2012 4:28	43.79	42.81	5	3.7	2.5	0.003	3
			2/6/2012 12:48	2/2/2012 12:37	42.86	46.79	2	3.5	2	0.002	-4
	2	30.01.2012	2/6/2012 12:48	2/3/2012 9:11	42.77	43.36	10	3.7	1.4	0.006	-3
3	2	24.02.2012	3/8/2012 11:27	3/11/2012 8:41	41.63	46.79	20	4.4	1.8	0.044	3
	2	27.02.2012	3/8/2012 11:27	3/11/2012 23:18	40.84	42.74	4	3.6	2.1	0.002	3
2	1	12.03.2012	3/16/2012 11:19	3/16/2012 13:25	43.64	43.44	10	3.7	2.1	0.003	0
	1	15.03.2012	3/16/2012 11:19	3/16/2012 19:55	42.66	46.87	10	3.8	1.9	0.005	0
			3/16/2012 11:19	3/18/2012 6:59	41.62	44.08	2	3.6	0.7	0.013	2
1	2	22.03.2012	3/22/2012 10:57	3/22/2012 9:11	42.67	41.91	2	3.6	2.4	0.002	-0
			3/22/2012 10:57	3/25/2012 10:03	43.4	46.34	10	3.6	2	0.002	3
			3/22/2012 10:57	3/25/2012 14:50	39.95	42.97	7	3.9	2.7	0.004	3
2	1	24.03.2012	3/31/2012 11:32	3/31/2012 16:49	43.42	45.92	5	3.7	1.9	0.004	0
			4/8/2012 10:40	4/5/2012 18:14	43.31	44.9	10	3.8	1.5	0.008	-3
1	2	5.04.2012	4/8/2012 10:40	4/8/2012 20:28	43.56	44.54	10	3.8	1.7	0.006	0
1	2	10.04.2012	4/15/2012 11:41	4/14/2012 3:13	39.47	43.95	2	3.5	2.9	0.001	-1
1	1	23.04.2012	4/22/2012 10:35	4/23/2012 15:50	42.3	45.21	2	4.1	0.5	0.099	1
2	2	3.05.2012	5/6/2012 10:36	5/7/2012 4:40	41.5	46.67	10	5.6	1.7	3.191	1
			5/6/2012 10:36	5/7/2012 5:08	41.5	46.75	10	4	1.8	0.012	1
			5/6/2012 10:36	5/7/2012 5:38	41.5	46.67	8	4.7	1.7	0.145	1
			5/6/2012 10:36	5/7/2012 5:40	41.37	46.52	4	4.4	1.7	0.056	1
			5/6/2012 10:36	5/7/2012 8:27	41.53	46.79	2	3.5	1.8	0.002	1
			5/6/2012 10:36	5/7/2012 8:36	41.54	46.82	2	4.1	1.8	0.018	1
			5/6/2012 10:36	5/7/2012 14:15	41.62	46.76	10	5.5	1.8	2.196	1
			5/6/2012 10:36	5/7/2012 14:36	41.51	46.69	8	4	1.7	0.013	1
			5/6/2012 10:36	5/7/2012 14:51	41.47	46.71	2	3.7	1.8	0.005	1
			5/6/2012 10:36	5/7/2012 16:58	41.51	46.8	10	4.4	1.8	0.046	1
			5/6/2012 10:36	5/7/2012 17:04	41.48	46.85	10	3.9	1.9	0.008	1
			5/6/2012 10:36	5/7/2012 17:08	41.46	46.81	10	3.7	1.9	0.004	1
			5/6/2012 10:36	5/7/2012 17:49	41.51	46.83	10	3.6	1.9	0.003	1
			5/6/2012 10:36	5/7/2012 18:49	41.54	46.88	10	3.8	1.9	0.006	1

			5/6/2012 10:36	5/8/2012 0:06	41.52	46.96	10	3.8	2	0.005	2
			5/6/2012 10:36	5/9/2012 6:24	39.87	42.97	5	3.8	2.8	0.003	3
1	1	8.05.2012	5/13/2012 13:06	5/12/2012 18:00	41.5	46.7	2	3.5	1.8	0.002	-1
			5/13/2012 13:06	5/12/2012 21:10	41.54	46.67	11	3.8	1.7	0.006	-1
1	1	9.05.2012	5/13/2012 13:06	5/14/2012 9:58	41.18	47.19	2	4.2	2.3	0.017	1
			5/13/2012 13:06	5/14/2012 15:50	41.19	47.23	6	3.8	2.3	0.004	1
			5/13/2012 13:06	5/15/2012 4:54	41.54	46.81	5	4.2	1.8	0.024	2
			5/13/2012 13:06	5/15/2012 5:17	41.56	46.63	2	3.7	1.7	0.005	2
			5/21/2012 10:38	5/18/2012 10:04	41.19	47.1	5	3.7	2.2	0.003	-3
			5/21/2012 10:38	5/18/2012 14:46	41.69	46.89	10	4.8	1.8	0.181	-3
1	2	16.05.2012	5/21/2012 10:38	5/19/2012 2:01	41.47	46.78	20	3.5	1.8	0.002	-2
			5/21/2012 10:38	5/20/2012 23:07	41	43.93	2	3.5	1.3	0.004	-0
1	2	18.05.2012	5/21/2012 10:38	5/23/2012 7:50	41.47	46.8	10	3.7	1.8	0.004	2
			5/21/2012 10:38	5/24/2012 2:22	42.83	46.6	33	3.5	1.8	0.002	3
1	1	22.05.2012	5/29/2012 13:29	5/28/2012 7:51	42.07	47.52	2	3.8	2.3	0.004	-1
1	1	23.05.2012	5/29/2012 13:29	5/29/2012 22:45	43.31	46.29	2	3.5	1.9	0.002	0
1	2	31.05.2012	6/4/2012 10:37	6/2/2012 0:32	43.32	46.2	60	4.6	1.9	0.059	-2
			6/4/2012 10:37	6/3/2012 9:07	42.82	46.01	5	3.7	1.4	0.007	-1
			6/4/2012 10:37	6/5/2012 16:29	41.45	46.75	20	4	1.8	0.011	1
			6/19/2012 10:33	6/16/2012 1:32	41.5	43.48	2	3.6	1.2	0.006	-3
			6/19/2012 10:33	6/16/2012 6:33	43.33	46.39	15	3.8	2	0.005	-3
			6/19/2012 10:33	6/16/2012 16:29	41.74	44.49	2	3.7	0.3	0.038	-3
			6/19/2012 10:33	6/22/2012 15:04	42.1	45.82	2	3.5	0.9	0.006	3
1	1	25.06.2012	6/26/2012 13:32	6/25/2012 20:05	41.21	47.21	5	4	2.3	0.009	-1

At the next figures are presented the samples of material work-up for 25.03-27.06_ 2012 Dusheti data. From up to down are presented the curve of tidal gravitational potential, density of earthquake energy (Schtm), earthquake's distribution at the same period, values of SigD and its standard deviation.

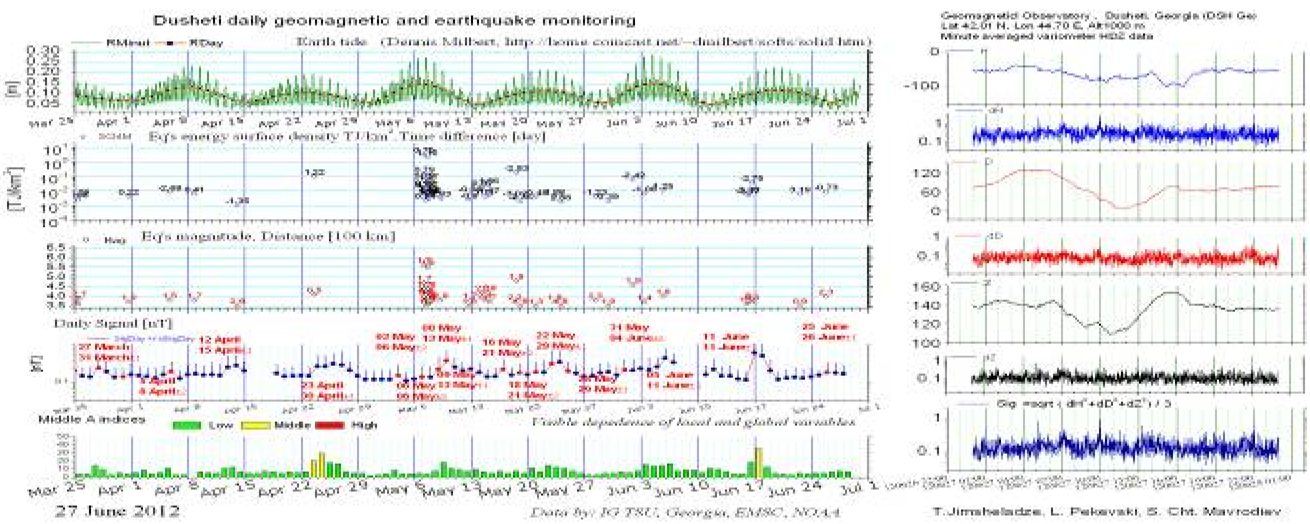


Fig.5. The reliability of the time window prediction for the incoming earthquake.

At Dusheti station, during the period of January-June 2012, there was revealed important disturbance before 7.05.2012 earthquake, Mag 7.5, epicenter Azerbaijan, which is located from Dusheti in 170km. The disturbance was detected 4 days earlier before earthquake. The disturbance was recorded as before earthquake in Azerbaijan as its aftershocks period.

Fig.6. Presents the comparison of the number of all occurred and predicted earthquakes For Dusheti. Fig6 Presents the map graphic for earthquakes with magnitude grater then 4 predicted simultaneously from Dusheti measurement.

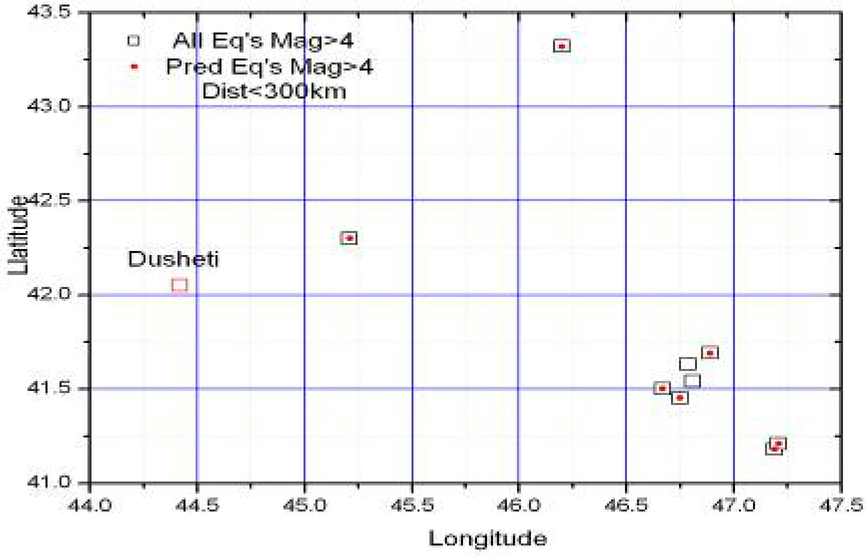


Fig.6 Map graphic for earthquakes with magnitude grater then 4 predicted simultaneously from Dusheti measurement.

It is clear from the picture that among 9 earthquakes for Mag>4; 7 of them were fixed by us.

It is obvious that the occurred in the predicted time period earthquake with maximum value of function SChtM (proportional to the Richter energy density in the monitoring point) is the predicted earthquake. But sometimes there are more than one geomagnetic signals in one day or some in different days. It is not possible to perform unique interpretation and to choose the predicted earthquakes between some of them with less values of energy density. The solution of this problem can be given by the analysis of the vector geomagnetic monitoring data in at least 3 points, which will permit to start solving the inverse problem for estimation the coordinates of geomagnetic quake source as function of geomagnetic quake. The numbering of powers of freedom for estimation the epicenter, depth, magnitude and intensity (maximum values of accelerator vector and its dangerous frequencies) and the number of possible earthquake precursors show that the nonlinear system of inverse problem will be over determinate.

5. Conclusion

The correlations between the local geomagnetic quake and incoming earthquakes, which occur in the time window defined from tidal minimum (± 1 day) or maximum (± 2 days) of the Earth tidal gravitational potential are tested statistically. The distribution of the time difference between predicted and occurred events is going to be Gaussian with the increasing of the statistics.

The presented results can be interpreted as a first reliable approach for solving the “when” earthquakes prediction problem by using geomagnetic data.

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ВАРИЯЦИИ ГЕОМАГНИТНОГО ПОЛЯ НА ДУШЕТСКОЙ ОБСЕРВАТОРИЙ СВЯЗАНИЕ СЕЙСМОАКТИВНОСТЮ В ВОСТОЧНОЙ ГРУЗИИ

(Январь - Июнь 1012)

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Резюме

Геомагнитные аномалий перед землетрясениями были зафиксированы многими авторами, но надо отметить что большинство из них не удовлетворяет строгие критерии. Этот метод прогноза землетрясений базируется на корреляции между землетрясениями, геомагнитными аномалиями и наступающими максимумами (или минимумами) приливными вариациями гравитационного поля. Геомагнитное отклонение определяется как отклонения в поле средних значений стандартного отклонения измеряемых минимум 2.5 раз в секунду. Окно вероятности совпадения во времени событий ровняется +- 1 дню для приливно –отливного минимума и +- 2 дня для приливно –отливного максимума. Статистическая достоверность геомагнитных предшественников, зафиксированные Душетской обсерваторий, еще раз подтверждаются данными распределение разницы между прошедшими и спрогнозированными землетрясениями для периода Январь- Июнь 2012

აღმოსავლეთ საქართველოს ტერიტორიის სეისმოაქტიურობასთან დაკავშირებული დუშეთის ობსერვატორიაზე დაფიქსირებული გეომაგნიტური ველის ვარიაციები

(იანვარი - ივნისი 1012)

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რეზიუმე

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