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Hydrodynamic and geomagnetic anomalies related with preparation of earthquakes in Caucasus

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Abstract

During July 2016 - September 2016 several hydrodynamic and geomagnetic anomalies were observed on the multiparametrical monitoring network located on the territory of Georgia. Data were recorded minutely and receiving in real time. Data were analyzed by the special program. In order to exclude the influence of geological factors, the data from various stations were calibraited by the common value of tidal variations. Were analyzed variation and reaction of parameters to the earthquake preparation process, the value of stress field before and after earthquake was calculated as well.

Introduction

Observation of spatial and temporal variability of earth crust's stress-deformation gives a possibility to create some modern methodology for earthquake prediction. In order to monitore the pre and post earthquake anomalies, considering the interaction between hydrodinamic, geophysical and other geodeformation processes (earthquakes, slow tectonic proceses, technogenic and etc), the data from July 2016 till September 2016 have been analyzed by the special program.

Data analysis

Multiparametric data (water level, atmosphere pressure, temperature, geomagnetic variation etc) were recorded with a minute frequency, in the deep boreholes located on the territory of Georgia. Observations were carried out using the specialized equipment providing measurement of deformation up to 10^{-8} degrees (1-2). In order to exclude the influence of geological factors, the data from various stations were rated against the common value of tidal variations (3-4). Variation and reaction of parameters to earthquake preparation process (5-9) were analyzed. The value of stress field by hydrodynamical parameters (10-11) and the stress field variations during preparation of several earthquake processes on the territory of Caucasus were calculated and analyzed:

Earthquake in Akhalkalaki area -21.07.2016 Mag-4.3

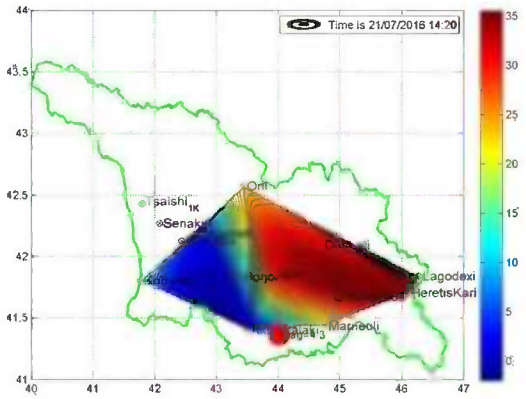
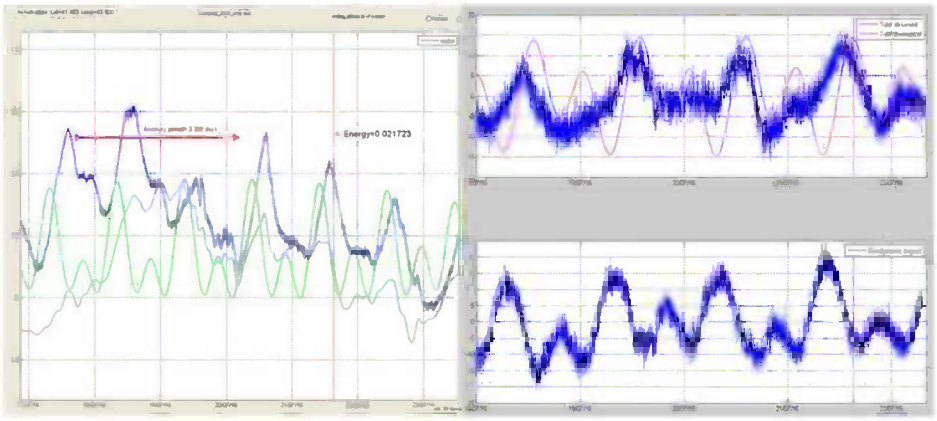


Fig.1.

Hydrogeodeformational field picture on the moment of 21 July 2016 earthquake. The field was created by the trended water level value

Anomaly was revealed on Akhalkalaki station before 21 July 2016 earthquake, 2 days earlier and continued 1day long. The earthquake was in 42km distance from the station.

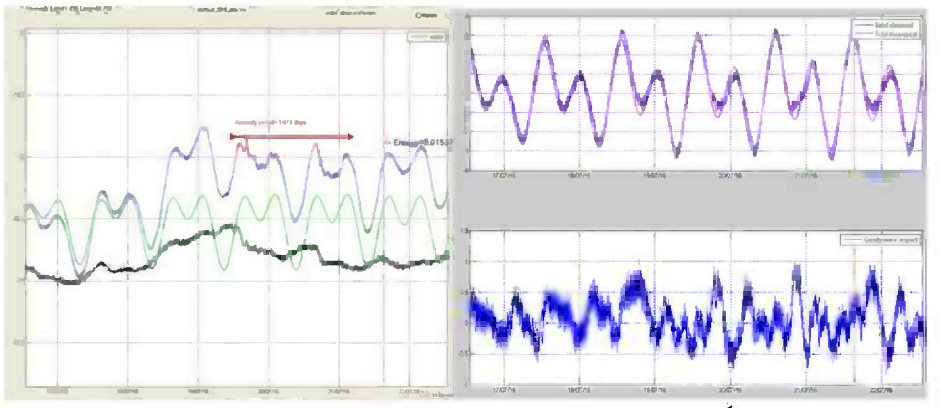


a b

Fig. 2

a- Origin of water level, atmospheric pressure and tidal variations at the Akhalkalaki borehole. Vertical line marks an earthquake moment. On abscise axis time is in hours. b- Speed factor of variations water level and earth tidal and the difference between them.

Anomaly was recorded at Marneuli station, as well.

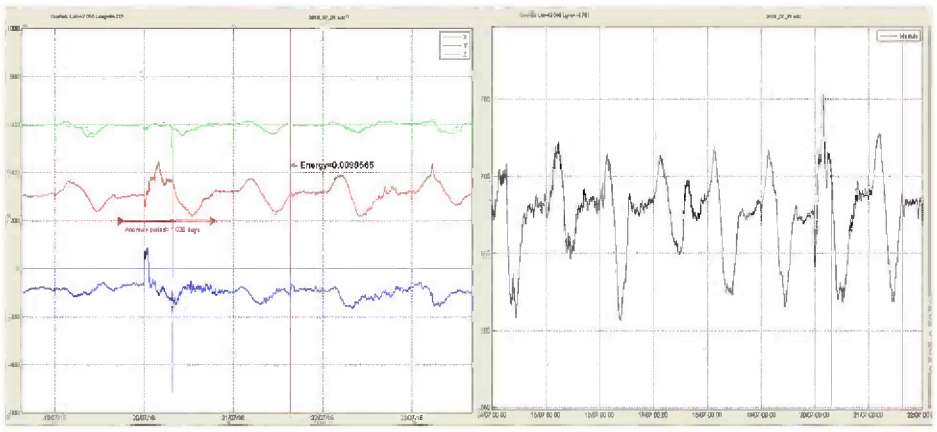


a b

Fig. 3.
a- Water level, atmospheric pressure and tidal variations at the Marneuli borehole (cm). Vertical line marks an earthquake. On abscise axis time is in hours. b- Speed factor of variations water level and earth tidal and the difference between them.

Anomaly of behavior of water level is revealed 2 days earlier before 21.07.2016 earthquake, 62 km from station.

Anomaly was observed in Dusheti geomagnetic observatory 1 day earlier before event of 21 July 2016. The Earthquake occurred in 99 km from a station.



a b

Fig. 4
a- Variations of x,y,z components of the magnetic field. b- Variation of calculated module value.

Earthquake in Kobuleti area-28_07_2016, Mag-3,6.

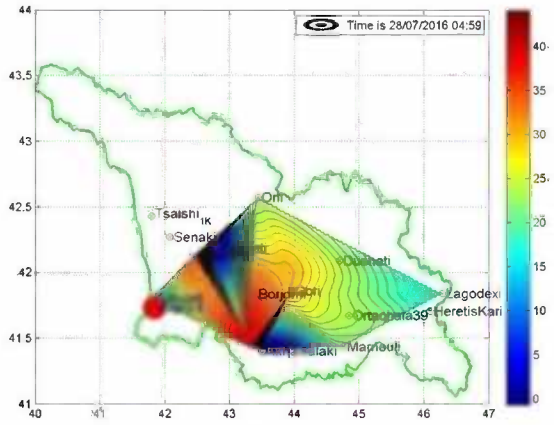
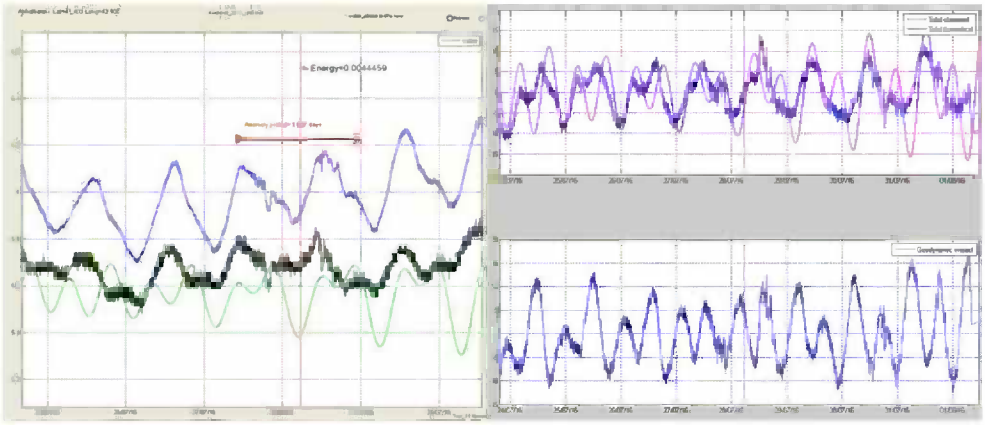


Fig. 5.

Hydrogeodeformational field picture on the moment of 28 July 2016 earthquake. The field was built for the value of trended water level.

Anomaly was observed from the Akhalkalaki station before 28 july 2016 few hours earlier and was continuing also during earthquake and after earthquake period. Earthquake happened in 142 km far from the station.



a b

Fig. 6

a - Water level, atmospheric pressure and tidal variations at the Akhalkalaki borehole. Vertical line marks an earthquake. On abscise axis time is in hours. b- Speed factor of variations water level and earth tidal and the difference between them.

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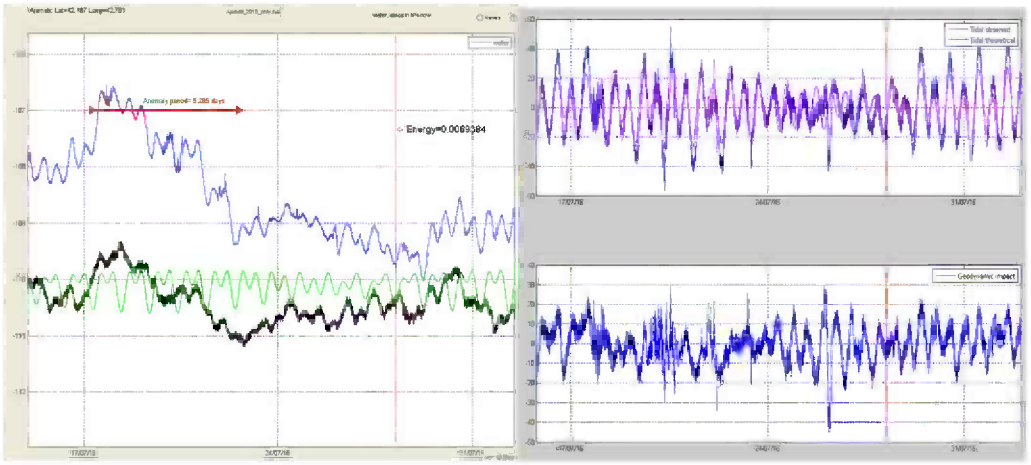
Anomalies were observed before the earthquake of Kobuleti, as well as on the Ajamenti station, also.



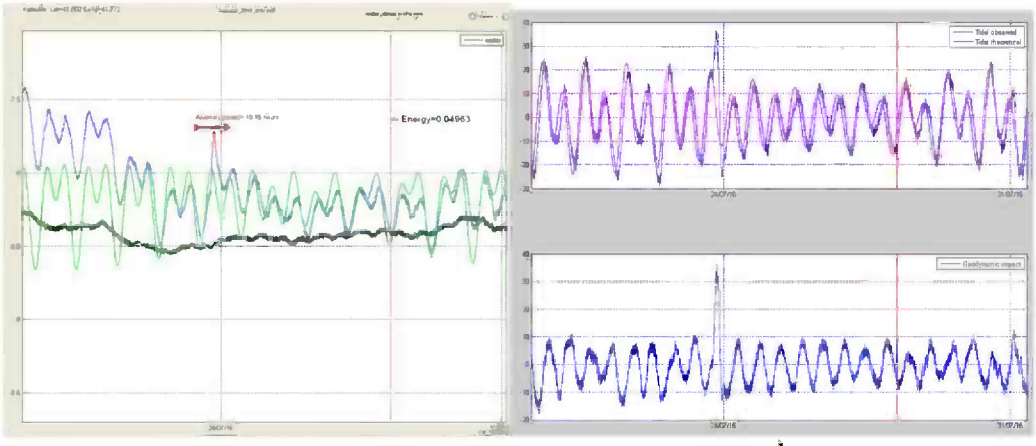
a b

Fig. 7

a - Water level, atmospheric pressure and tidal variations on the Ajameti borehole (cm). Vertical line marks an earthquake. On abscise axis time is in hours. b- Speed factor of variations water level and earth tidal and the difference between them.

At Ajameti station anomaly behavior was 9-10 days earlier before the earthquake. Earthquake epicenter was located in 93 km far from the station.

At Kobuleti station anomaly was observed 4 days earlier before the earthquake. Increasing water level and at the same time falling can be seen on the graph. Derangement continued for 2 days before the earthquake and the variation of water level got his regular face after 2 days. Earthquake epicenter was 9 km away from Kobuleti station.

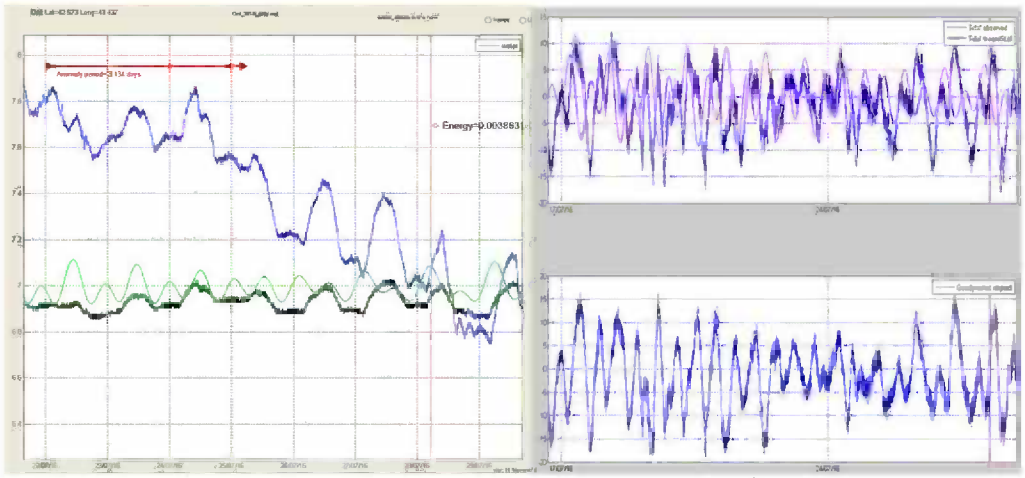


a b

Fig. 8.

a - Water level, atmospheric pressure and tidal variations on the Kobuleti borehole (cm). Vertical line marks an earthquake. On abscise axis time is in hours. b- Speed factor of variations water level and earth tidal and the difference between them.

Anomaly can be seen at Oni station, before 8 days earlier earthquake, as well as at on Ajameti station, water level drop was observed. The Epicenter of the 28 July earthquake occurred 161 km away from Oni station.

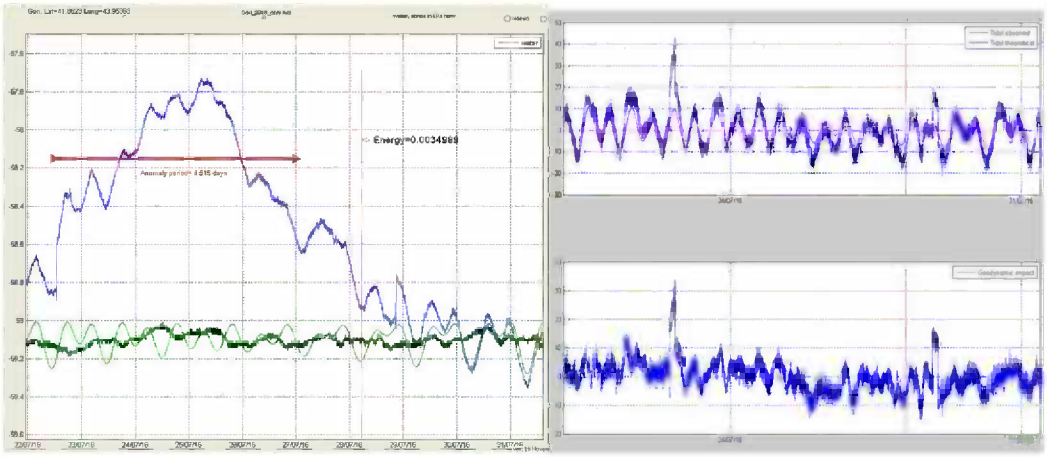


a b

Fig. 9.

a- Water level, atmospheric pressure and tidal variations at the Oni borehole (cm). The vertical line marks an earthquake. On abscise axis time is in hours. b- Speed factor of variations water level and earth tidal and the difference between them.

At Gori station water level drop also was observed. 6 days earlier before the earthquake water level increased. This process continued for 2 days and then began to drop down. Earthquake occurred 175 km away from Gori station

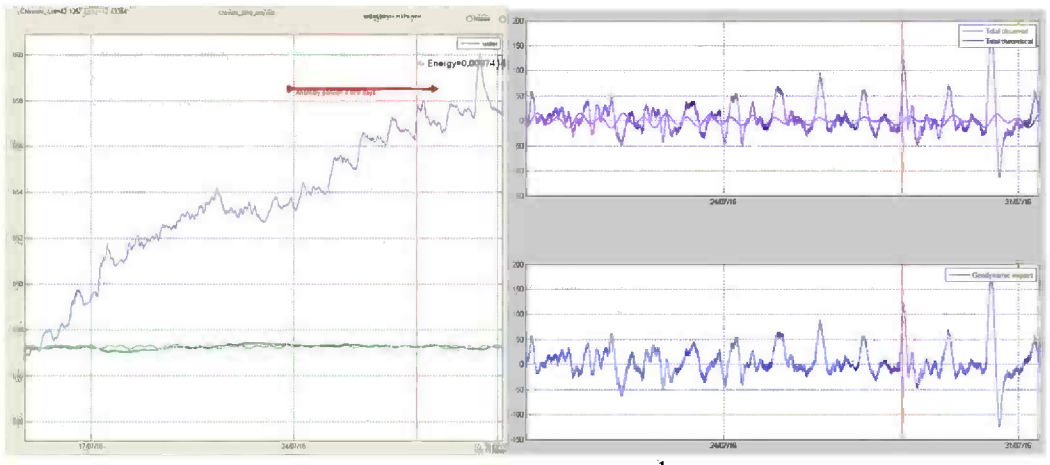


a b

Fig. 10.

a- Water level, atmospheric pressure and tidal variations on the Gori borehole. The vertical line marks an earthquake. On abscise axis time is in hours. b- Speed factor of variations water level and earth tidal and the difference between them.

The level started rising before Kobuleti earthquake on Chkvishi station, 4 days earlier before the earthquake. The epicenter was 65 km away from Chkvishi station.

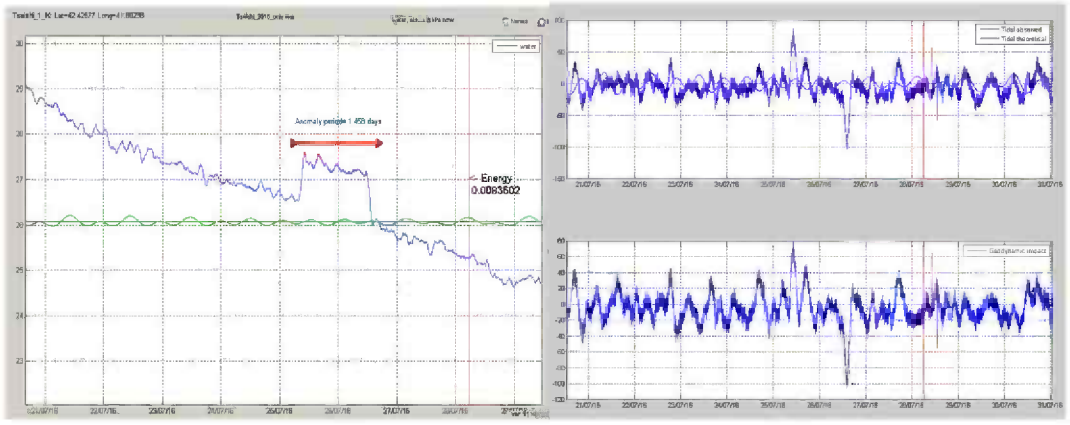


a b

Fig. 11.

a - Water level, atmospheric pressure and tidal variations at the Chkvishii borehole (cm). The vertical line marks an earthquake. On abscise axis time is in hours. b- Speed factor of variations water level and earth tidal and the difference between them.

As we can see on the graph, on 28 July before the earthquake, anomaly was recorded at Tsaishi station, 2-3 days earlier before the earthquake. Epicenter was 77 km away from the station.

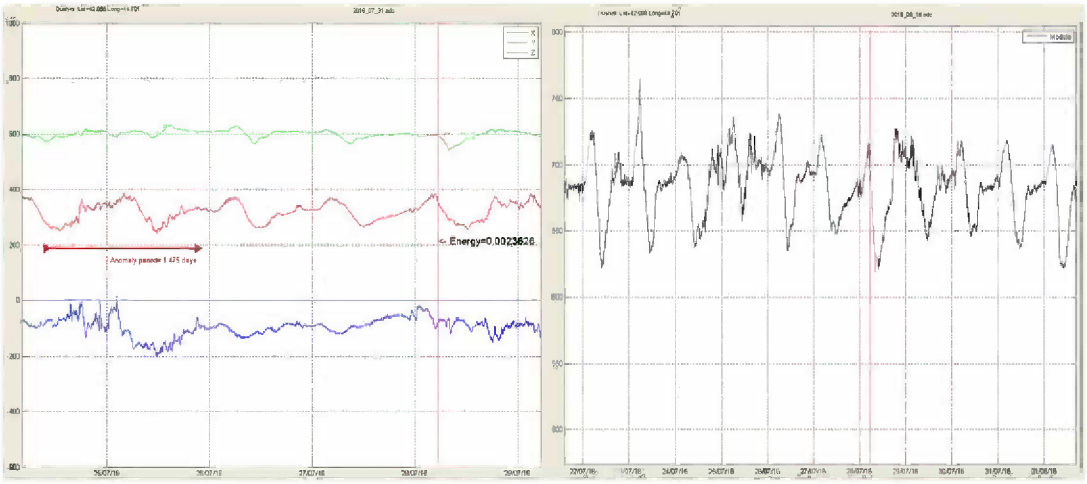


a b

Fig. 12.

a- Water level, atmospheric pressure and tidal variations on the Tsaishi borehole (cm). The vertical line marks an earthquake. On abscise axis time is in hours. b- Speed factor of variations water level and earth tidal and the difference between them.

Anomaly was observed at Dusheti geomagnetic observatory 3 days earlier before the earthquake and continues for 2 days after the earthquake. The earthquake occurred 240 km away from station.



a b

Fig. 13.
a-Variation of x,y,z components of the magnetic field. b- Variation of the module value

Earthquake near Akhalkalaki- 04.08.2016, Mag-3.1

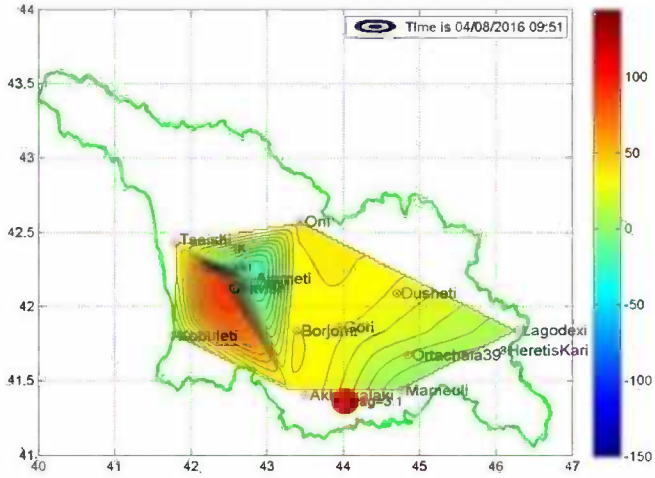
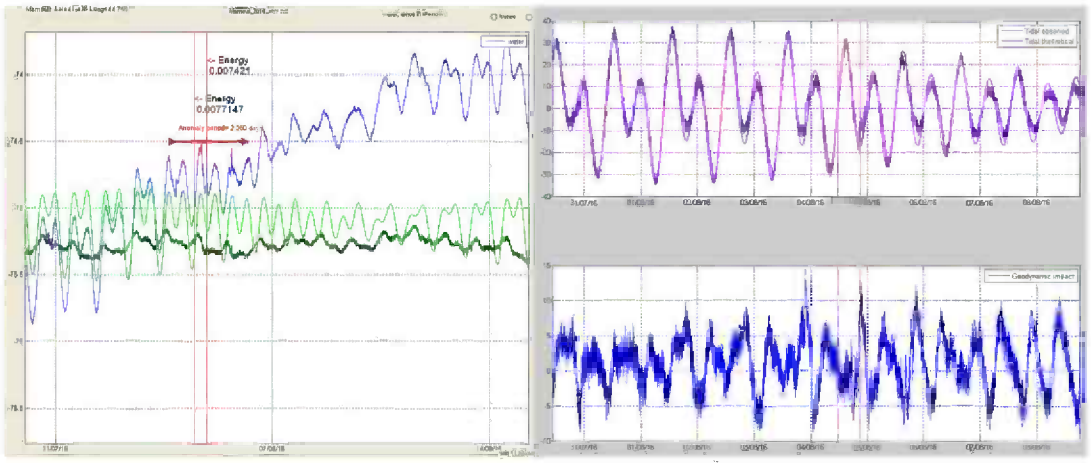


Fig. 14.
Hydrogeodeformational field value observed during the 4 August, 2016 earthquake. The field was created by the value of trended water level.

At the Marneuli station we observed anomaly on 4 August between the earthquake and its aftershock, it was also observed for 1 day after the earthquake. Earthquake occurred 60 km away from the station.

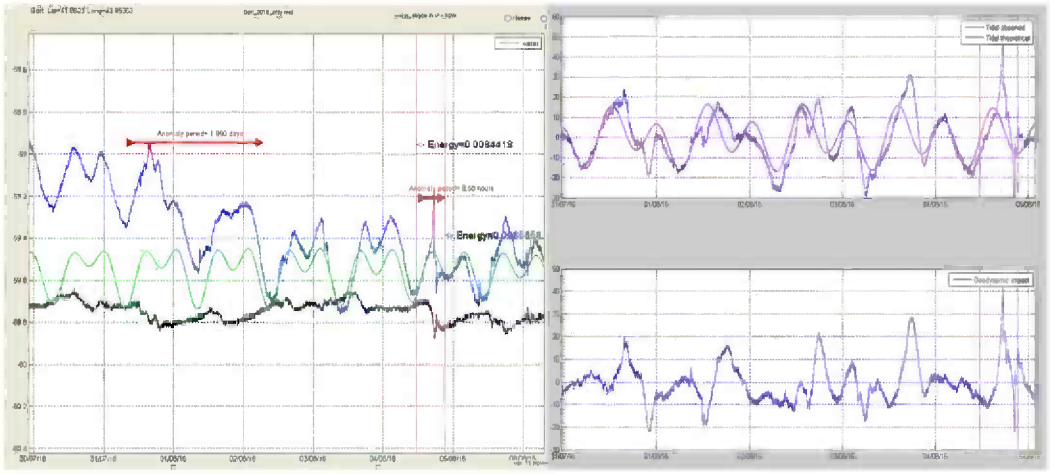


a b

Fig. 15

a- Water level, atmospheric pressure and tidal variations on the Marneuli borehole (cm). The vertical line marks an earthquake. On abscise axis time is in hours. b- Speed factor of variations water level and earth tidal and the difference between them.

At the Gori station, like the one at Marneuli station, anomaly was observed on 4 August before the earthquake and its aftershock. Gori station is in 51 km from the Epicenter.

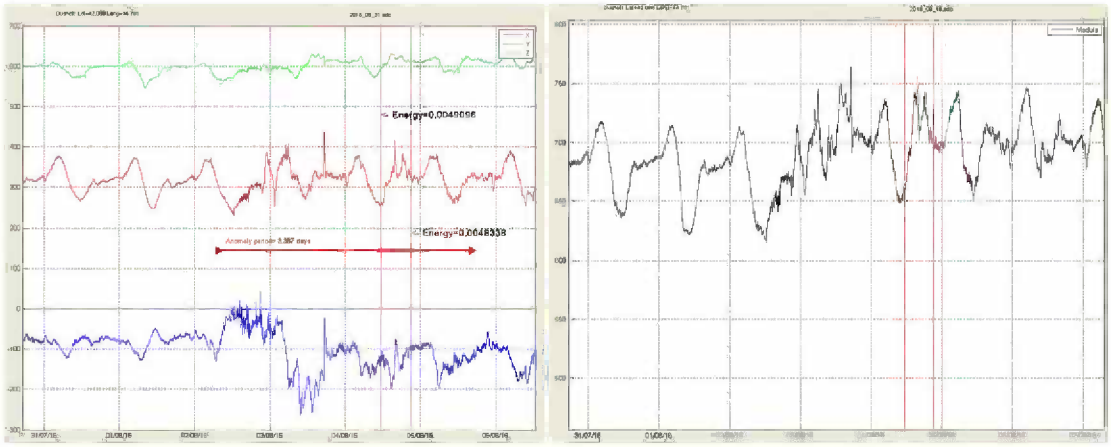


a b

Fig. 16

a- Water level, atmospheric pressure and tidal variations, Gori borehole (cm). The vertical line marks an earthquake. On abscise axis time is in hours. b- Speed factor of variations water level and earth tidal and the difference between them.

Anomaly was observed at Dusheti geomagnetic observatory, starting from 4 August 2016, 2- days prior to the earthquake. The earthquake occurred in 98 km from the station. The anomaly continued for 2 days after the earthquake.



a b

Fig. 17.
a-Variation of x,y z components of the magnetic field. b- Variation of the module value.

Earthquake in Ninotsminda area-15.08.2015, Mag-3.6

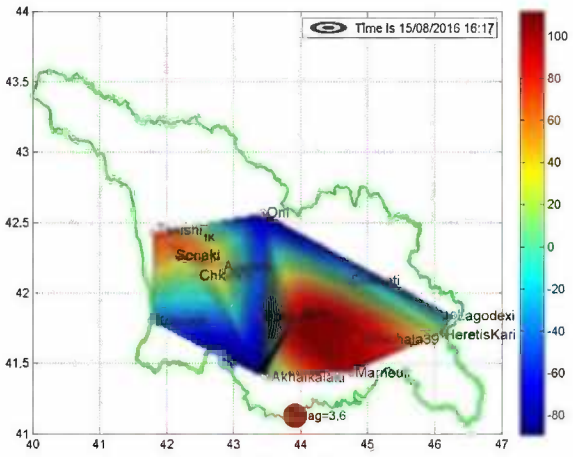
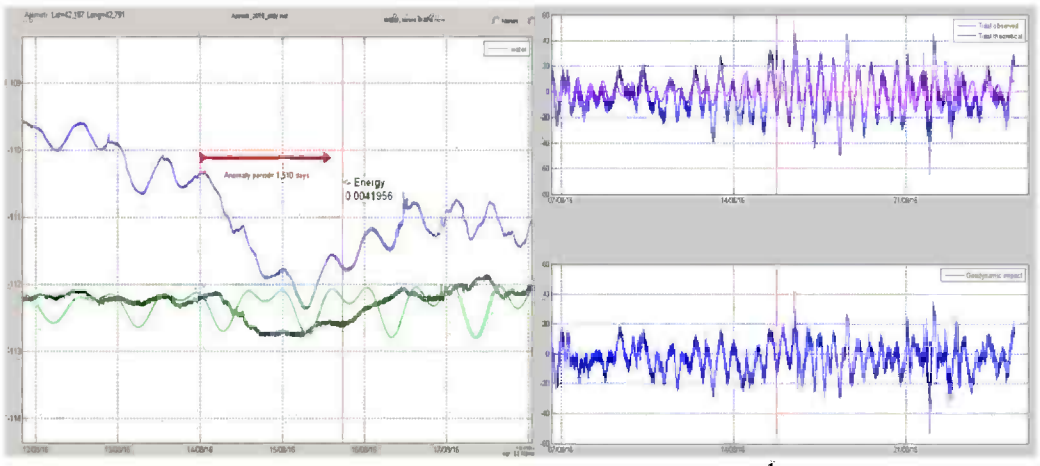


Fig. 18.
Hydrogeodeformational field value during the 15 August 2016 earthquake. The field was plotted for water level trended values.

Anomaly was observed at Ajameti station, on 15 August 2016, before the earthquake. The station is in 150 km from the epicenter of the earthquake. 3-4 days earlier before the earthquake the water level dropped by 40 cm. 1 day earlier before the earthquake we observed sudden rise of the water level by 20 cm. The stressed condition remained after the earthquake as wall.

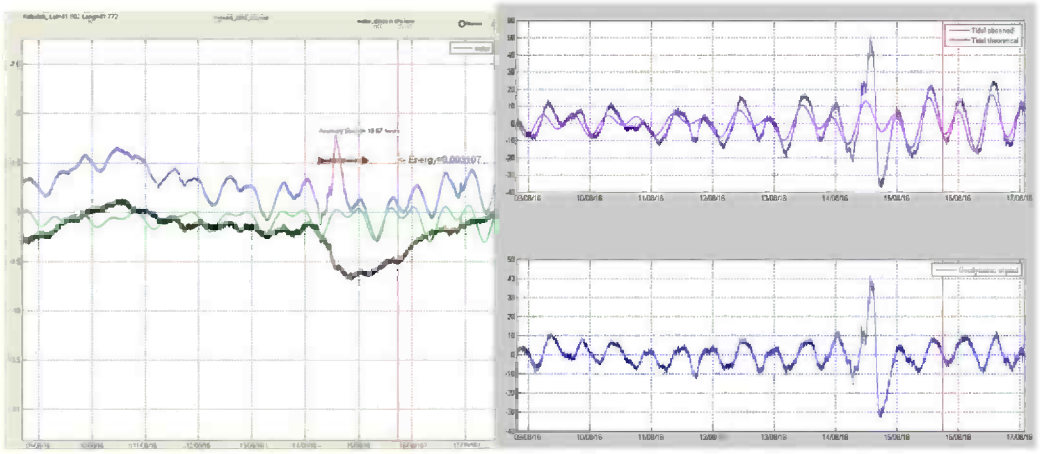


a b

Fig. 19.

a- Water level, atmospheric pressure and tidal variations, Ajameti borehole (cm). The vertical line marks an earthquake. On abscise axis time is in hours. b- Speed factor of variations water level and earth tidal and the difference between them..

In Kobuleti, which is 193 km away from the epicenter, we observed an anomaly 2 days prior to the earthquake.

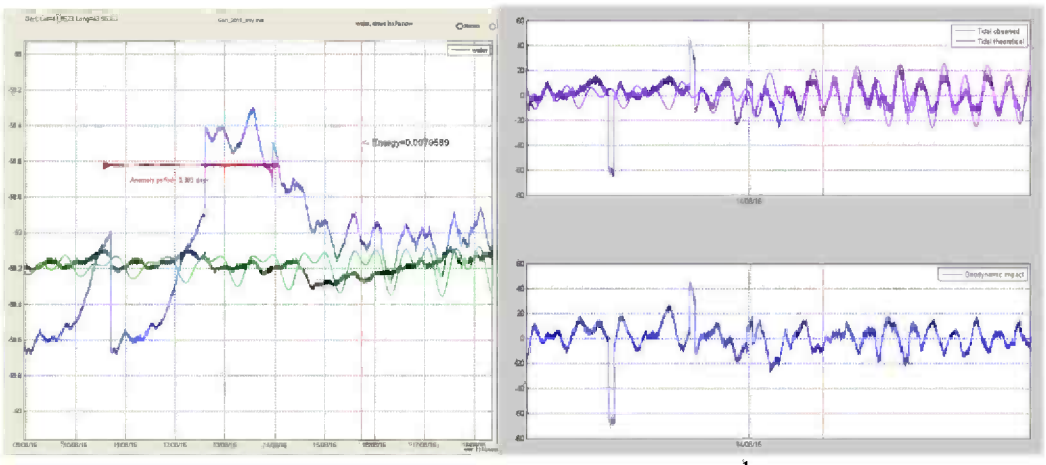


a b

Fig. 20

a- Water level, atmospheric pressure and tidal variations at Kobuleti borehole (cm). The vertical line marks an earthquake. On abscise axis time is in hours. b- Speed factor of variations water level and earth tidal and the difference between them.

The anomaly observed 4-5 days prior to the before earthquake can be seen in the plot. The epicenter was 81 km away from Gori station.

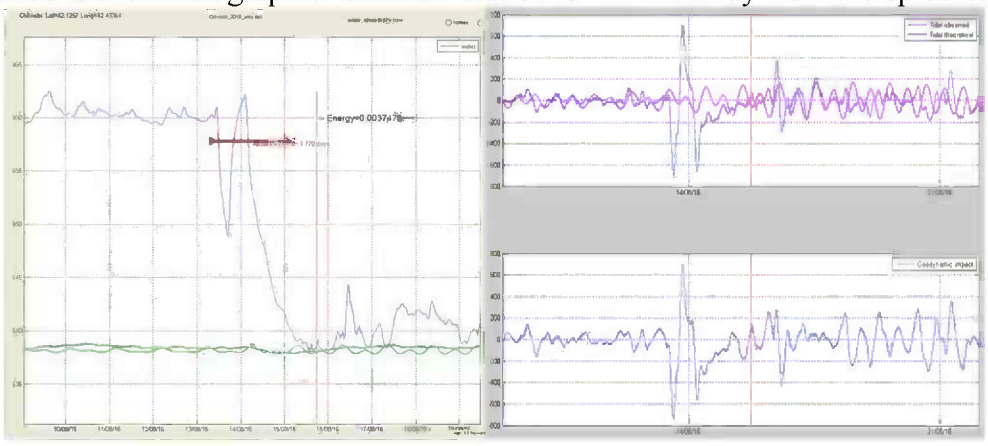


a b

Fig. 21

a - Water level, atmospheric pressure and tidal variations, Gori borehole (cm). The vertical line marks an earthquake. On abscise axis time is in hours. b- Speed factor of variations water level and earth tidal and the difference between them.

At Chkvishi station anomaly was observed 2days prior to the earthquake. The duration of the anomalous period is shown on graphic. Chkvishi station is 165 km away from the epicenter.

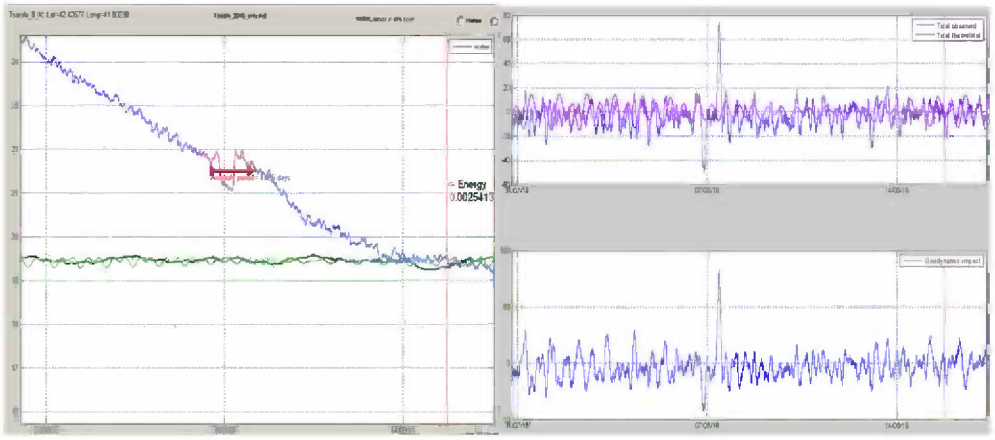


a b

Fig. 22

a- Water level, atmospheric pressure and tidal variations at Chkvishi borehole (cm). The vertical line marks an earthquake. On abscise axis time is in hours. b- Speed factor of variations water level and earth tidal and the difference between them.

At Tsaishi station the anomaly was observed a week prior to the earthquake. Borehole is out flowing and is located 227 km away from the epicenter.



a b

Fig. 23

a - Water level, atmospheric pressure and tidal variations on the Tsaishi borehole (cm). The vertical line marks an earthquake. On abscise axis time is in hours. b- Speed factor of variations water level and earth tidal and the difference between them.

Earthquake in the Gagra region- 02.09.2016 Mag=4

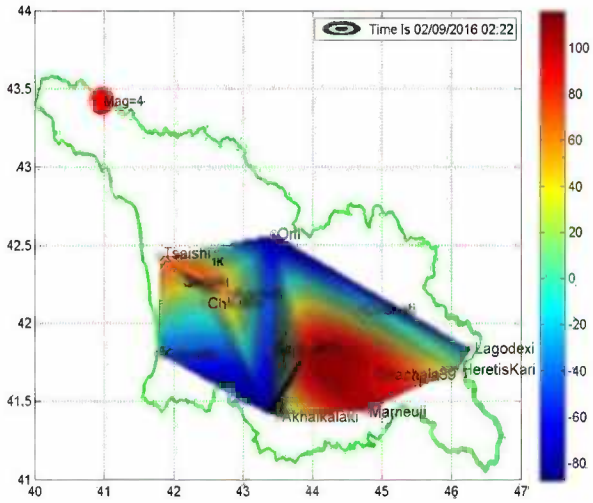
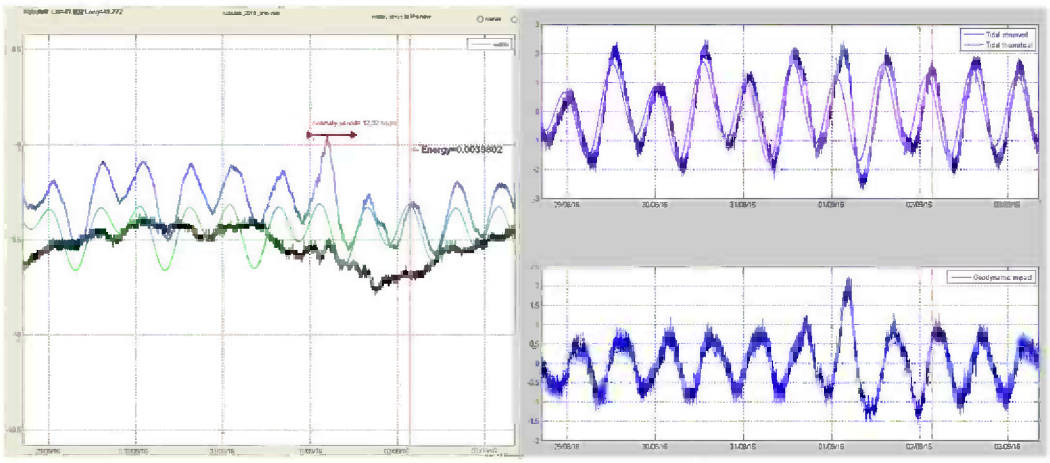


Fig. 24

Hydrogeodeformational field value during the 02 September 2016 earthquake. The field was built for the water level trended values

2 days prior to the 2 September earthquake we observed the anomaly at Kobuleti station. Kobuleti station is 191km away from the epicenter.

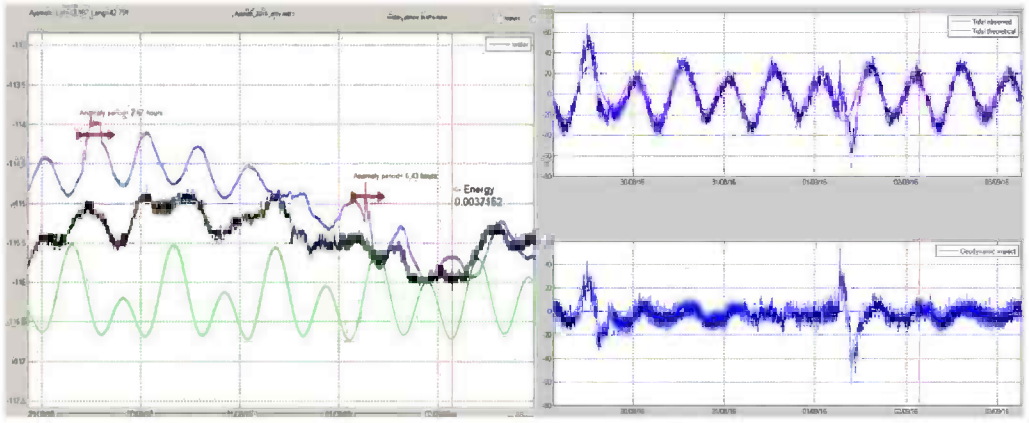


a b

Fig. 25

a- Water level, atmospheric pressure and tidal variations at Kobuleti borehole (cm). The vertical line marks an earthquake. On abscise axis time is in hours. b- Their variations speed graphics and the difference.

We observed anomaly at Ajameti station 1 day prior to the earthquake- water level remained dropped after the earthquake as well.



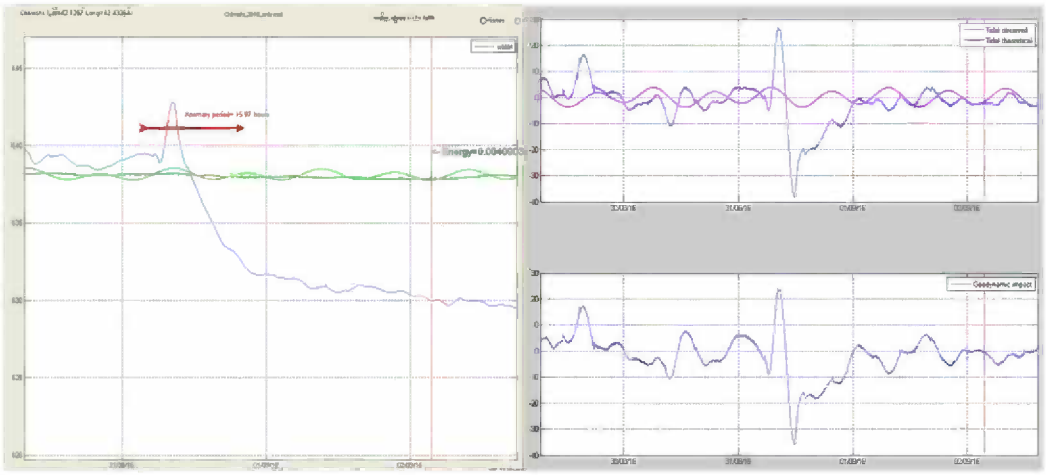
a b

Fig.

Fig. 26

a- Water level, atmospheric pressure and tidal variations at Ajameti borehole. The vertical line marks an earthquake. On abscise axis time is in hours. b- Speed factor of variations water level and earth tidal and the difference between them.

Anomaly was also observed at Chvishi station before the earthquake on 2 September, where like the one in Ajameti, the water level dropped and maintained the level for some time after the earthquake. Chkvishi borehole is 187 km away from epicenter.



a b

Fig. 27

a - Water level, atmospheric pressure and tidal variations at Chkvishi borehole (cm). The vertical line marks an earthquake. On abscise axis time is in hours. b- Speed factor of variations water level and earth tidal and the difference between them.

Earthquake occurred on the North-West territory of Azerbaijan- 07.09.2016, Mag=4.4

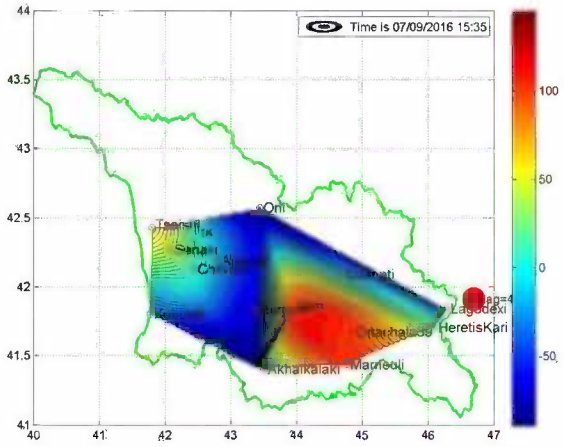
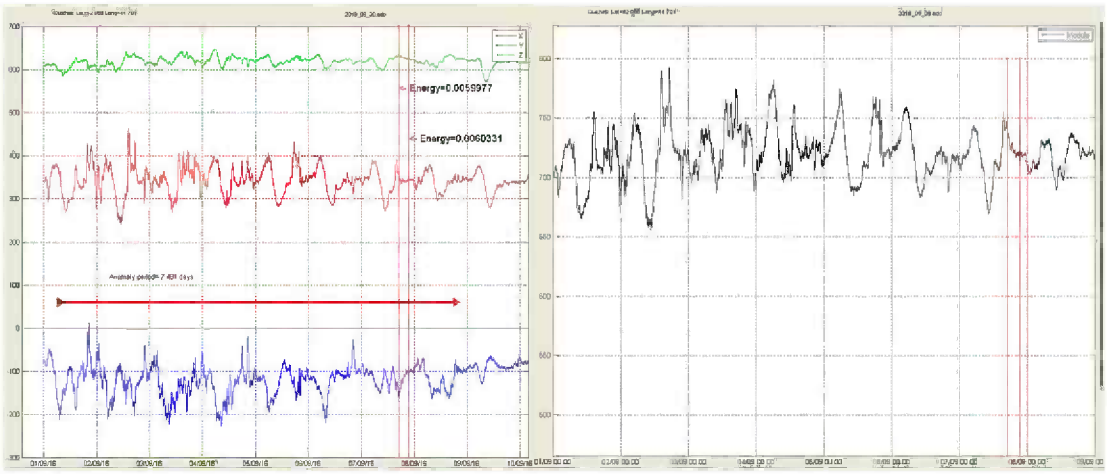


Fig. 28.

Hydrogeodeformational field value during the 07 September 2016 earthquake. The field was built for the trended water level values.

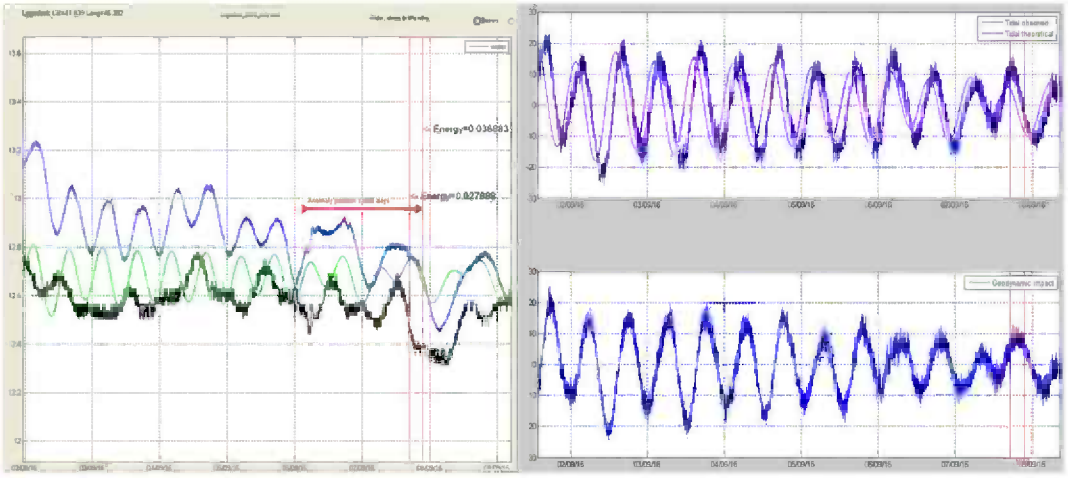
Anomaly was also observed at Dusheti Geomagnetic Observatory, a week prior to the 7 September 2016 earthquake and continued for 6 days. The earthquake occurred in 165 km from the station. The second earthquake in the graph is an aftershock.



a b

Fig. 29.
a-Variation of x,y,z components of the magnetic field. b- Variation of the module value.

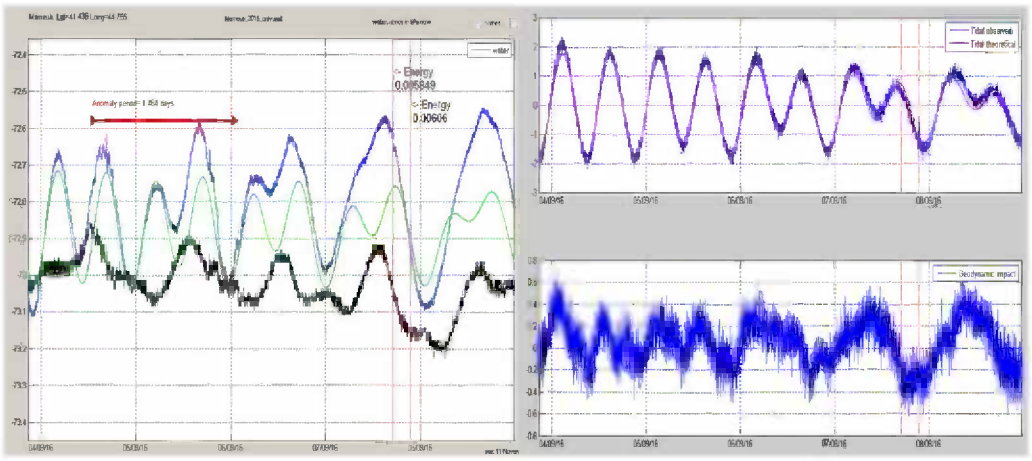
Lagodekhi station is in 35 km from the epicenter. As we can see the graph, the anomaly is observed 2 days prior to the 7 September earthquake.



a b

Fig. 30.
a - Water level, atmospheric pressure and tidal variations at Lagodekhi borehole (cm). The vertical line marks an earthquake. On abscise axis time is in hours. b- Speed factor of variations water level and earth tidal and the difference between them.

At Marneuli station, which is 169 km away from the epicenter, the anomaly was observed 2 days prior to the earthquake and lasted during the earthquake as well.

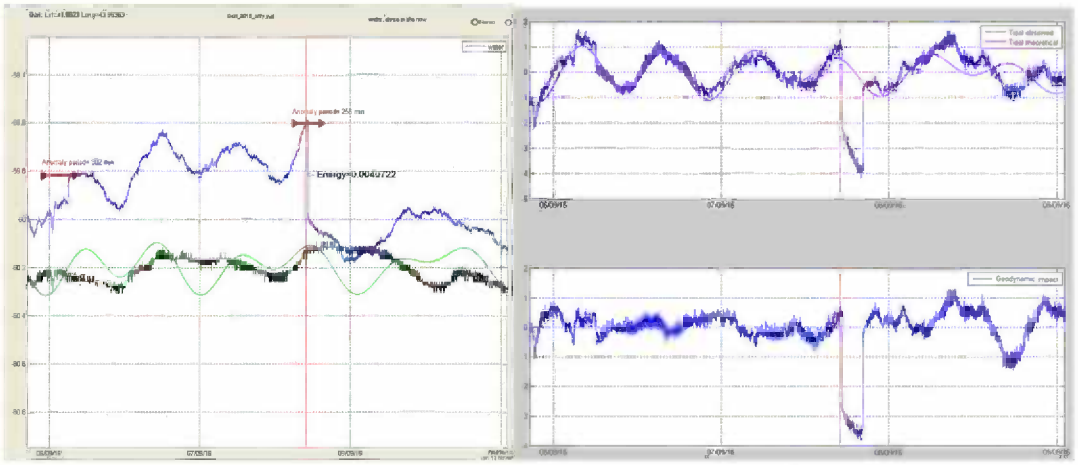


a b

Fig. 31.

a - Water level, atmospheric pressure and tidal variations at Marneuli borehole (cm). The vertical line marks an earthquake. On abscise axis time is in hours. b- Speed factor of variations water level and earth tidal and the difference between them.

Anomaly was also observed 2 days prior to the earthquake at Gori station. Here like in Marneuli, conditions lasted after the earthquake as well. Gori station is 226 km away from the 7 September earthquake epicenter.

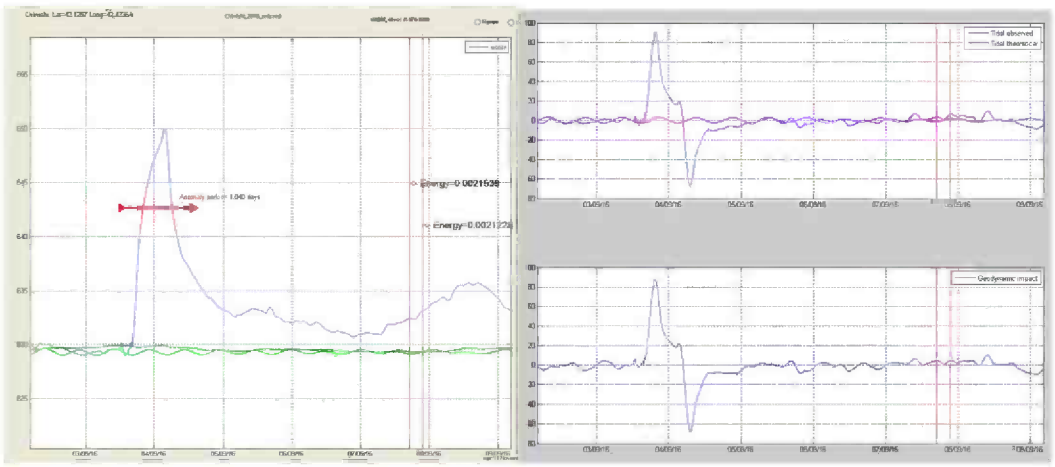


a b

Fig. 32

a - Water level, atmospheric pressure and tidal variations at Gori borehole (cm). The vertical line marks an earthquake. On abscise axis time is in hours. b- Speed factor of variations water level and earth tidal and the difference between them.

4 days prior to the earthquake an anomaly was observed near Chkvishi borehole. Here a typical picture of Chkvishi station is shown before the earthquake expressed in sharp changing of the level. Chkvishi station is away 352 km from the earthquake epicenter, which occurred on 7 September 2016.



a b

Fig. 33

a - Water level, atmospheric pressure and tidal variations at Chkvishi borehole (cm). The vertical line marks an earthquake. On abscise axis time is in hours. b- Speed factor of variations water level and earth tidal and the difference between them.

Conclusions

The results show that variations in hydrodynamic and geomagnetic parameters are caused by the earth stress. During normal period it change according tidal variation and has "background" value. "Anomalous" variations during preparation period of the seismic event demonstrated change above "background" value, as indicator of tectonic activity. Earthquakes with Magnitude 3-5, occurred during the observed time period on the territory of Caucasus. Character of "anomalies" depended on energy of earthquakes. Period of "anomalies" varied between 2-5 days and the distance of influence changed between 200-500 km from the epicenter.

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ჰიდროდინამიკური და გეომაგნიტიკური ანომალიები დაკავშირებული კავკასიის მიწისძვრებთან

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რეზიუმე

2016 წლის ივლისი-სექტემბრის პერიოდში, საქართველოს ტერიტორიაზე განლაგებულ მულტიპარამეტრულ სამონიტორინგო ქსელზე დაფიქსირდა მრავალი ჰიდროდინამიკური და გეომაგნიტური ანომალია. მონაცემები იზომებოდა ყოველ წუთში და იკრიბებოდა

რეალური დროის მონაკვეთში. მონაცემები მუშავდებოდა სპეციალური პროგრამის მეშვეობით. გეოლოგიური ფაქტორების გავლენის გამოსარიცხათ სხვადასხვა სადგურების მონაცემები კალიბრებოდა მიმოქცევითი ვარიაციებით. გაანალიზდა პარამეტრების ვარიაციები და რეაქციები მიწისძვრის მომზადების პროცესზე და ასევე მიწისძვრის წინ დაძაბულობის ველის რეალური სიდიდეები.

Гидродинамические и геомагнитные аномалии, связанные с землетрясениями Кавказа

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Резюме

В период с июля 2016 по сентябрь 2016 был зафиксирован ряд гидродинамических и геомагнитных аномалий при мультипараметрических наблюдениях на мониторинговой сети, расположенной на территории Грузии. Данные записывались ежеминутно и собирались в режиме реального времени. Они были проанализированы с помощью специальной программы. С тем, чтобы исключить влияние геологических факторов, данные с различных станций были откалиброваны с помощью значений приливных вариаций. Осуществлен анализ вариаций и реакция параметра на процесс подготовки землетрясения, а также вычислены значения напряженного поля земли до и после землетрясения.