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MANIFESTATION FEATURES OF LANDSLIDE PROCESS AROUND THE MINGACHEVIR RESERVOIR (2014)

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ABSTRACT. The landslide incident was recorded around the Mingachevir water basin on August 27, 2014. The landslide process occurred in the Boz mountain range mainly on its north-east slopes. The boundary of the slip plane and the active area directed South West - North East of Boz mountain slopes exposed to landslide were determined in this zone. Studies have shown that the depth of the slip plane is different in the separate fields of this area and it changes between 6 to 88 meters.

Introduction

Widespread of the mobility (movement) of soil masses on the sides of the Mingachevir reservoir is related to the loss of equilibrium as a result of variability of the physical and mechanical features of rocks and abrasive activities of reservoir waters. The land mass is divided into three groups when considering the causes of the stability disturbance of them: external influences increased of the loading activities and the decrease of the resistance forces of land against displacement. The external impact that causes the occurrence of landslide around Mingachevir reservoir is the abrasive activity that destroys the natural support of the soil masses located in the slopes of the reservoir water. Talking about the increased performance of the loading, it should be noted that, the reason of possible displacements may also be the increase of soil mass as a result of the absorption of atmospheric water. Resistance to displacement and reduction of pulling forces are conditioned by changes of resistance forces and attachment to friction. The intensive process of rocks erosion (the collapse of rocks by wind) of Mingachevir reservoir slopes sharply reduced the volume of displacement characteristics and it creates favorable conditions for occurrence of landslide. The reasons listed above that creation of soil masses displacement from the slopes of the reservoir and the complex of physical-mechanical features of different genetic type allow to study the condition of transition to unstable situation of soil masses rocks that formation of reservoir sides and occurrence the landslides.

The landslide incident was recorded around the Mingachevir reservoir on August 27, 2014. The seismological, engineer-seismology, gravimetric, magnetometric, geodynamic studies were conducted with the aim of detailed research of sliding processes.

Mingachevir reservoir and adjacent areas like other regions of Azerbaijan are characterized by seismic activity. Even though the strong earthquakes were recorded a little far from the water basin but directly medium strong seismic shocks had occurred in the area of reservoir [New Catalog 1977; Catalog 1980-2014]. (Fig.1).

Seismic activity in this area is related to tectonic faults formatting the tectonics of the areas.

The Mingachevir reservoir is located on the western edge of the Middle Kura Depression. From the north, this zone is separated by the Ajichay-Alat depth fault from the Vandam anticlinorium that is the south structure of Greater Caucasus. From the southern part, the zone is surrounded by the Kura depth fault (Fig. 2).

From the east and west sides, the zone is surrounded to anticaucasus direction by Sharur-Zaqatala and Arpa-Samur depth faults and Ganjachay transverse fault breaking off the basin and then going through it (Shikhalibeyli, 1996).

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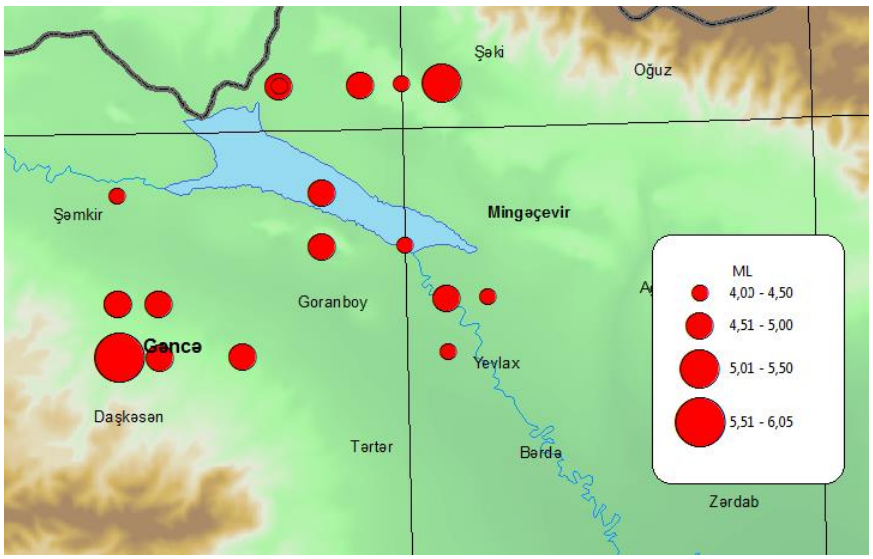

Figure 1. The maps of earthquakes epicenters with a magnitude of ≥ 4.0 tha occurred near the Mingachevir reservoir over the 1900-2018 years

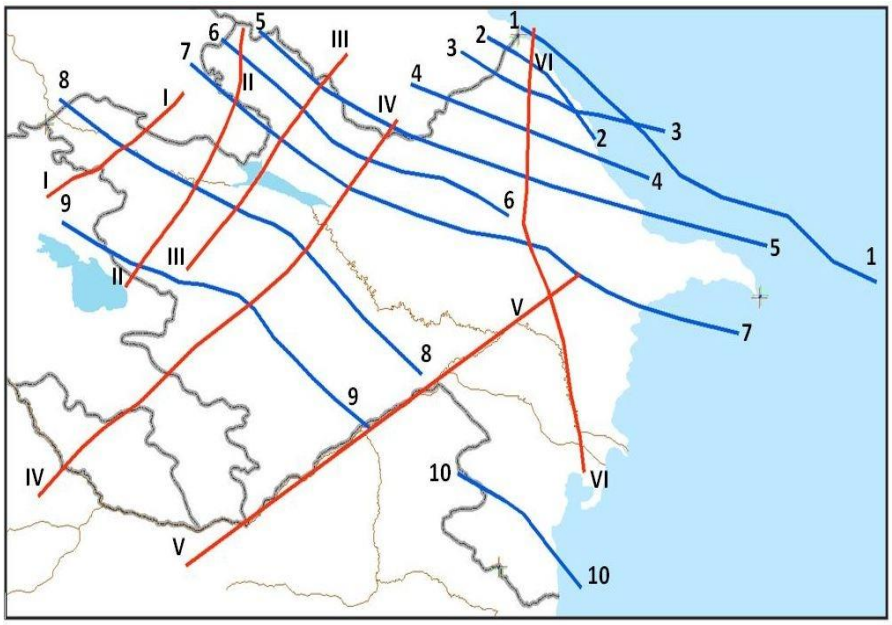

Figure 2. The map of tectonic faults of Azerbaijan area

1-1 Makhachkala – Turkmenbashi
2-2 Khudat – Gilazi
3-3 Akhtı-Nugadi-Gilazi
4-4 Siyezen
5-5 Qaynar-Zengi
6-6 Vandam
7-7 Ajıchay-Alat
8-8 Kura
9-9 Lesser Caucasus
10-10 Talish

I-I Gazakh-Siqnakh
II-II Sharur-Zagatala
III-III Ganjachay
IV-IV Arpa-Samur
V-V Palmir-Absheron
VI-VI West-Caspian

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Seismological researches have been carried out in the sliding area due to extensive research of the sliding incident. Seismic observation data of seismic stations operating in the territory of the Azerbaijan Republic shows that 19 weak earthquakes (ml-06-2.5) around Mingachevir reservoir were recorded during the period of 03.07-10.12.2014 years (Fig.3).

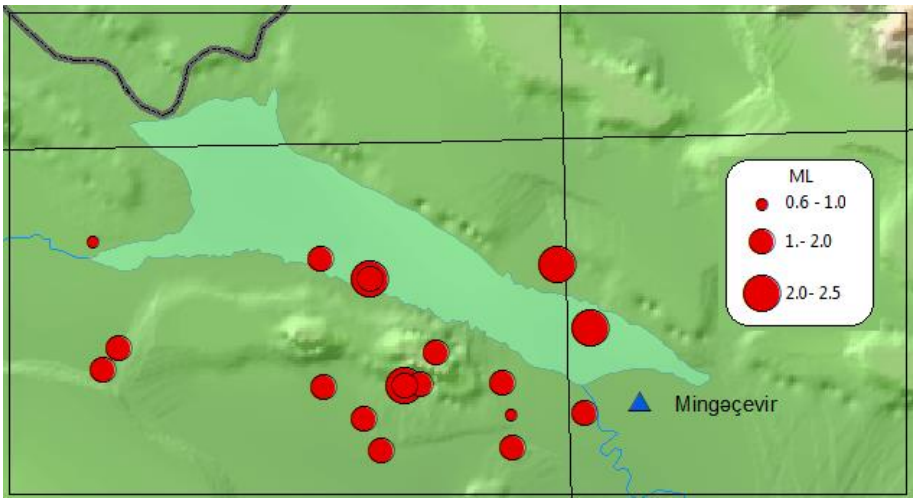

Figure 3. The epicenters of earthquakes that have been occurred around Mingachevir reservoir during the period 03.07-10.12.2014 years.

Analysis of earthquake records at Mingachevir seismic stations shows that the sliding process was started in early July. Thus, the records of landslides vibrations differ from earthquakes that had been recorded on the stations.

Additionally, 3 mobile seismic stations were installed around the area covered by the sliding process in order to follow the process more closely on August 29 (Fig.4) and the registration of numerous sliding processes that occurred in this area had been continued.

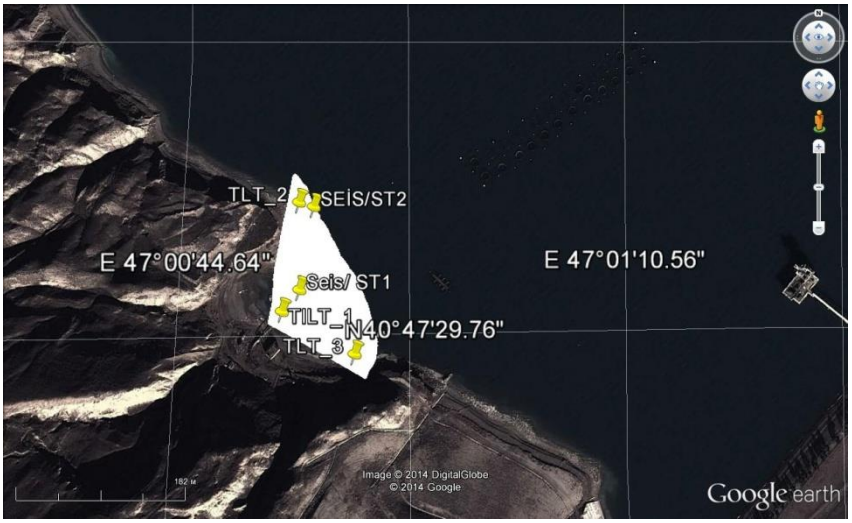

Figure 4. The location scheme of mobile seismic stations (GURALP) around the Mingachevir reservoir

Totally 80 landslides have been recorded in this area. The durability of sliding processes (vibrations) lasted 7-12 seconds. Carrying out construction works, traffic flows and etc. near the landslide area can create resonance effects here. In this regard, the analyses of the amplitude-frequency parameters of the vibration in the sliding zone (A,f) had been carried out. The registration of

vibrations was recorded in different weather conditions, during the production of equipment and transportation. The analysis of vibration records shows that rocks vibrations created by natural and artificial sources (transportation, construction and etc.) in the sliding area are separated from each other by frequency spectrum (Fig.5,6)

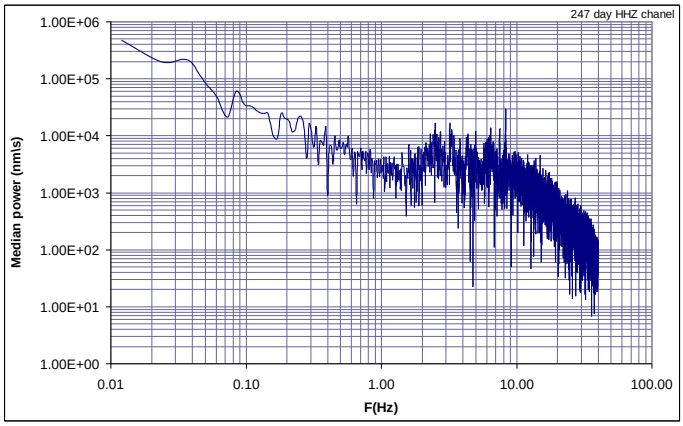

Figure 5. Vibration spectrum received on HH channel at ST1 mobile station on September 4.

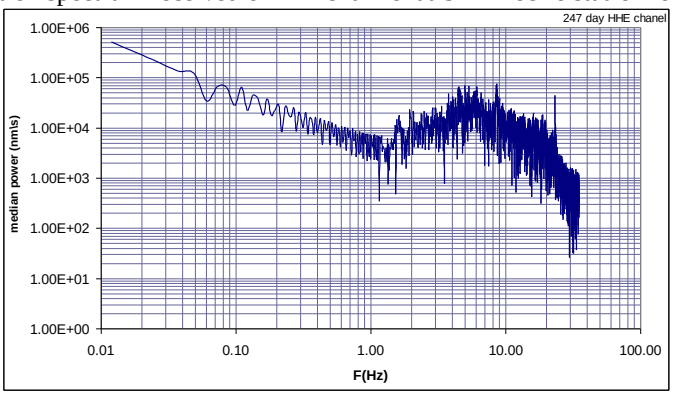

Figure 6. Vibration spectrum received on HHE channel at ST1 mobile station on September 4.

Distribution of transverse v_s waves on depth along the seismic profile 1,2,2a,3 and 4 (Fig.7) had been studied in the area. Seismic records had been collected from motorboats that going on the river, vehicles moving through nearby areas and other impacts according to each profile. Profiles are associated with a geological exploration well BN0.1-1 drilled at depth of 100 m. in the area.

The profile numbered 1 extends to north-south in the field of research (Fig.8). In this profile, there were mainly 3 wave reflective layers on depth. The first layer consists of fine-grained sand, dusty sand ground and the second layer consists of moist clay and fine-grained sand ground and the third consists of clay ground.

The profile numbered 2 extends to the north-west – south-east in the research area, mainly 3 seismic wave reflective layers were recorded by depth. The first layer consists of fine-grained sand, dusty sand ground and the second layer consists of moist clay and fine-grained sand ground and the third consists of clay ground.

Seismic section installed on other profiles that mentioned above and correlation of well data allows us to say that moist clay ground and friction plane are located at the depths of 6 to 88 meters in separate parts of research areas.

High precision gravimetric researches were conducted by three profiles with gravity force measurement method in the region where the sliding process was being in the slope of Mingachevir Boz mountain.

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Two of the gravimetric profiles cut tectonic faults off but the third one was set parallel to them.

Variations of gravity force change from 0.81 to 7.228 mGal in the I profile and from 0.076 to 5.326 mGal in the II profile. Intensive changes are observed that in the gravity force measurements at the 2 and 3 stations I profile and 6 and 7 stations in II profiles and this reflects in itself the incompatibility of the gravity force valuation in the measurements (Fig.10)

Figure 7. The location scheme of the seismic profiles in the area

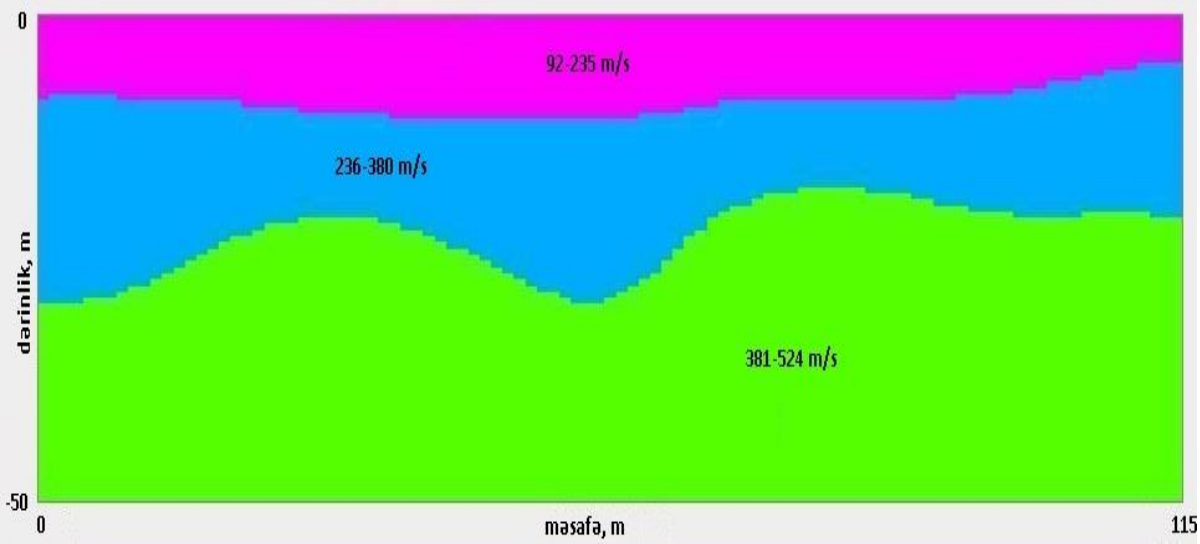

Figure 8. 2-dimensional speed model of Vs transverse wave for the seismic profile numbered 1

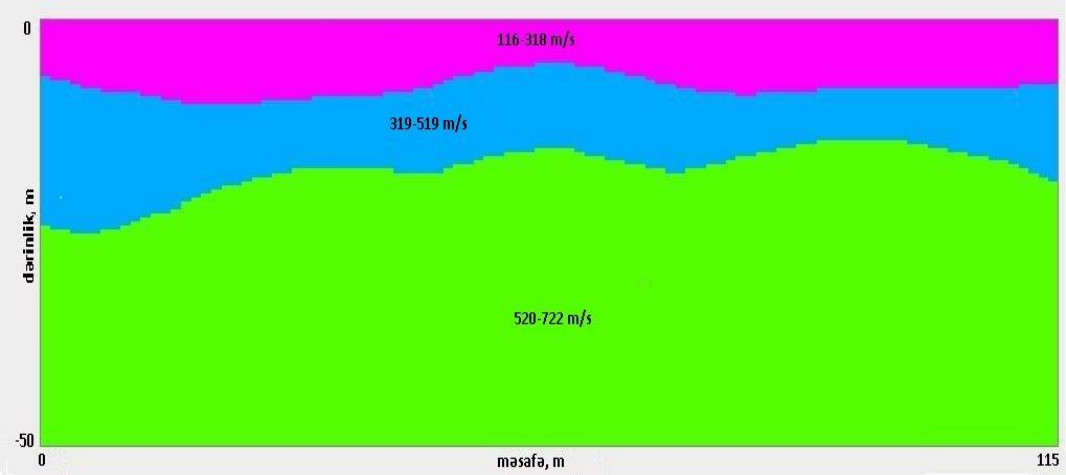

Figure 9. 2-dimensional speed model of Vs transverse wave by the seismic profile numbered 2

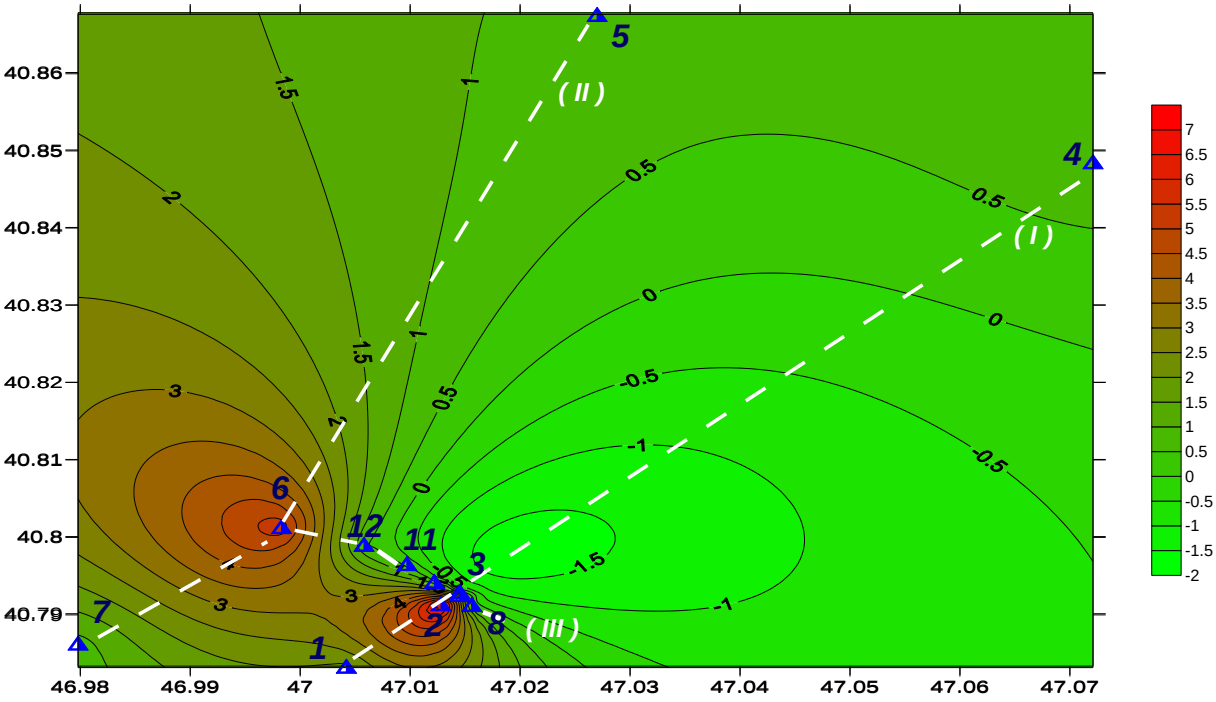

Figure10. The isoanomas map of gravity forces in 2D format

There is a sharp decline in gravity force during crossing time from 2 numbered station to 3 numbered station in I profile and this decline shows that, there is a slip plane in this area (Fig.10, 11).

The analogical situation is observed in the II profile during the crossing time from 6 numbered station to 5 numbered stations. Here, there is a sharp incompatibility of the gravity force value.

Thus, it can be assumed that the boundary of the slip plane extends from 2 numbered stations in the I profile to the 6 numbered stations II profile.

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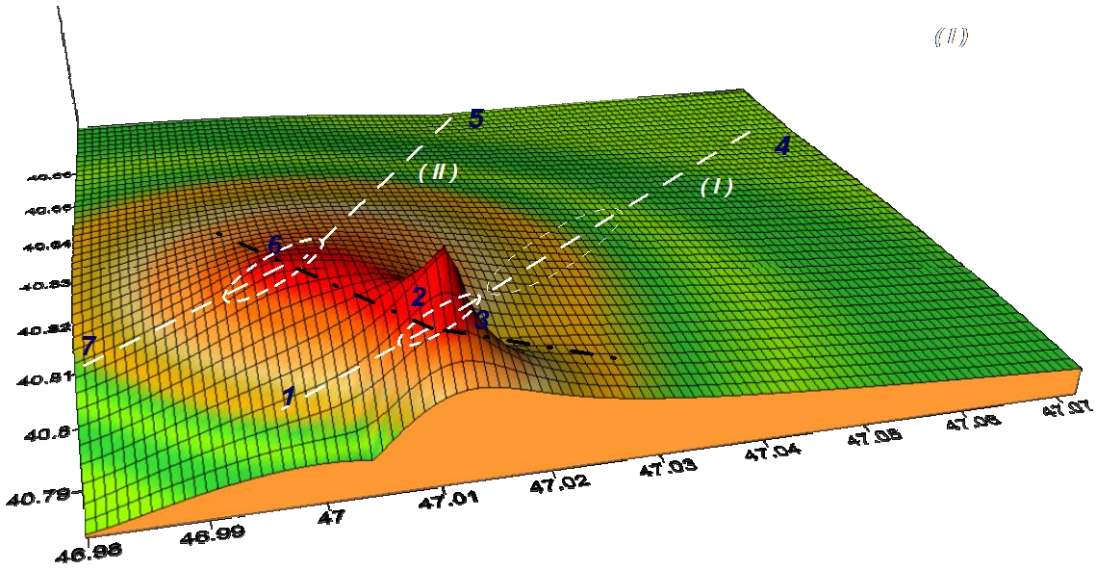

Figure11. The map of isoanomas in gravity force in 3D format

It should be noted that, gravimetric researches along I and II profiles indicate that the geodynamic movements are pointing to the occurrence of sliding process at a depth of 52 meters.

Magneto metric studies had been conducted on five profiles (P1-P1, P2-P2, P3-P3, P4-P4, P5-P5) (Fig.12) in the south – south-eastern part of Mingachevir reservoir. The initial analyses of the increase of geomagnetic tension gradient on these profiles allow allocating a zone that is in the tension-deformation situation in the south of the water basin, geological environment north of Mingachevir. This tension-deformation situation come into sight in the high rise in gradient of geomagnetic tension area complicated by the sharp decrease (minimally) of the gradient increase.

A-A line separating the opposite directions of the ΔT gradient shows that, the fracture zone where the sliding process occurs by impact the gravitational forces of the masses is formed. The geological environment along the P4-P4 and P5-P5 is very calm and here no anomalous geological-tectonic movements are observed (Fig.13,14).

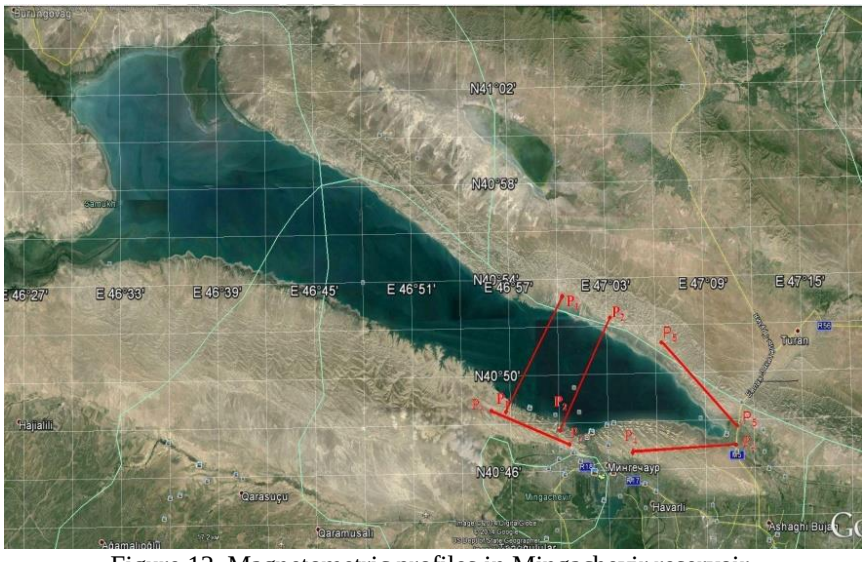

Figure 12. Magnetometric profiles in Mingachevir reservoir.

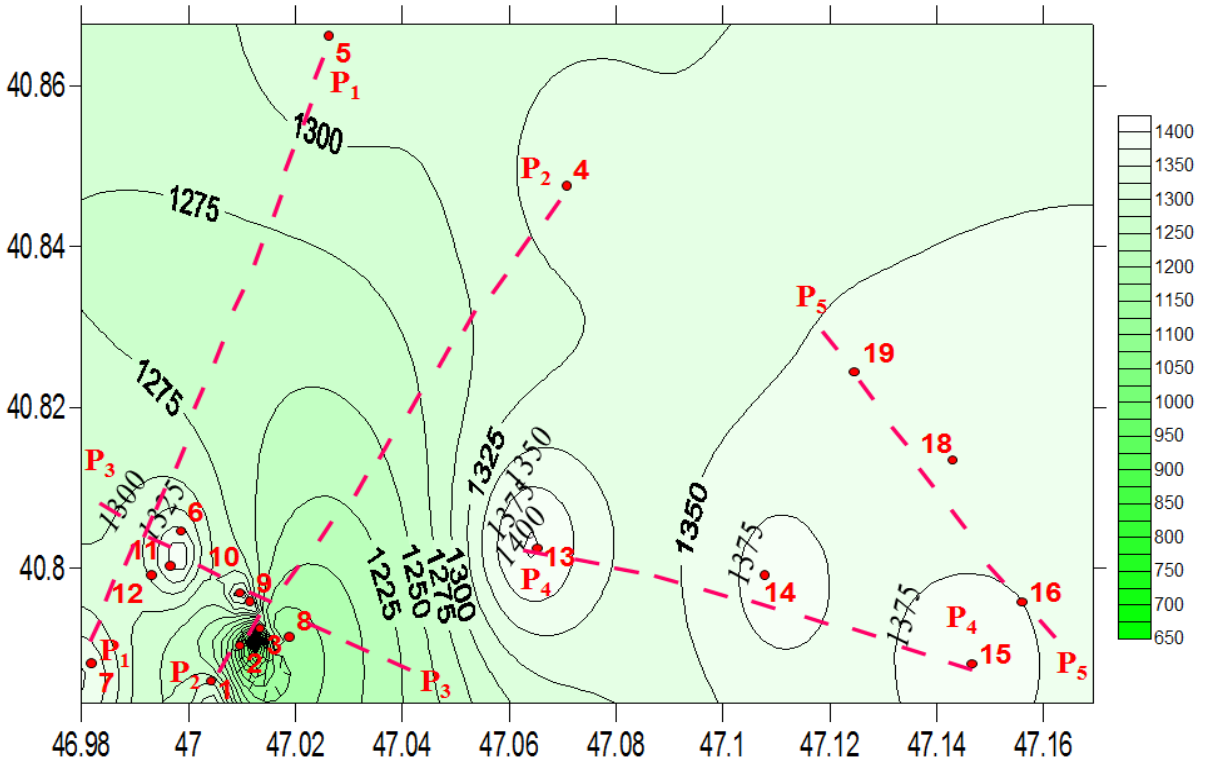

Figure 13. Map of distribution of ΔT gradient tension of geodynamic field in the 2D format in the Mingachevir reservoir.

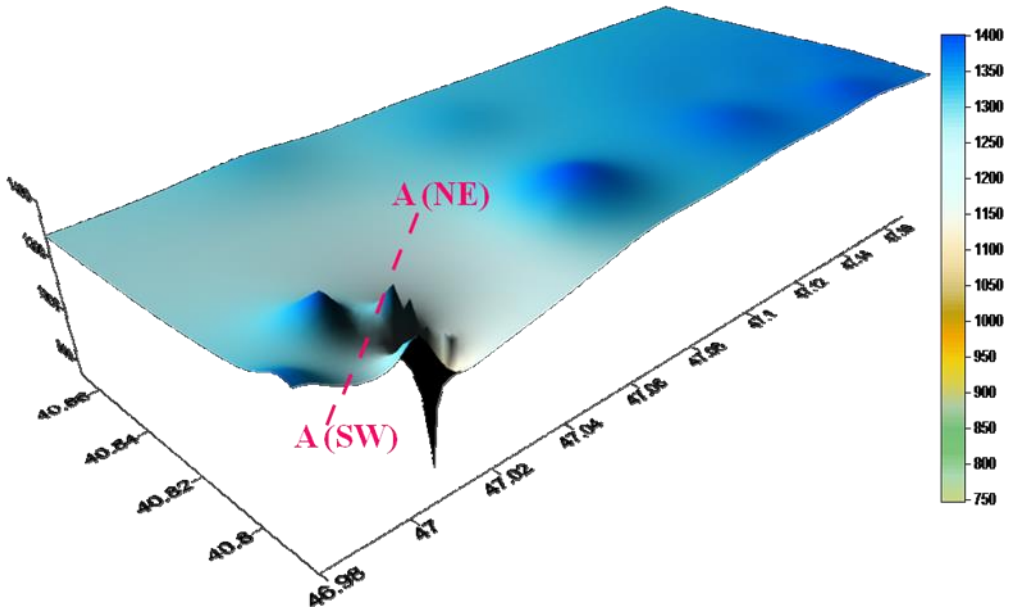

Figure 14. Map of distribution of ΔT gradient tension of geodynamic field in the 3D format in the Mingachevir reservoir (29.08.2014).

Repeating magneto metric measurements have shown that, there is a tension in the geological environment on the profile P3-P3. A-A line directed North East- South West is a zone in the environment where gravity sliding processes are likely to occur.

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Two temporary GPS (Trimble NetR9 branded) stations had been installed in the research zone to monitor the dynamics of horizontal movements in the area (Fig.15).

Figure15. The location scheme of GPS stations

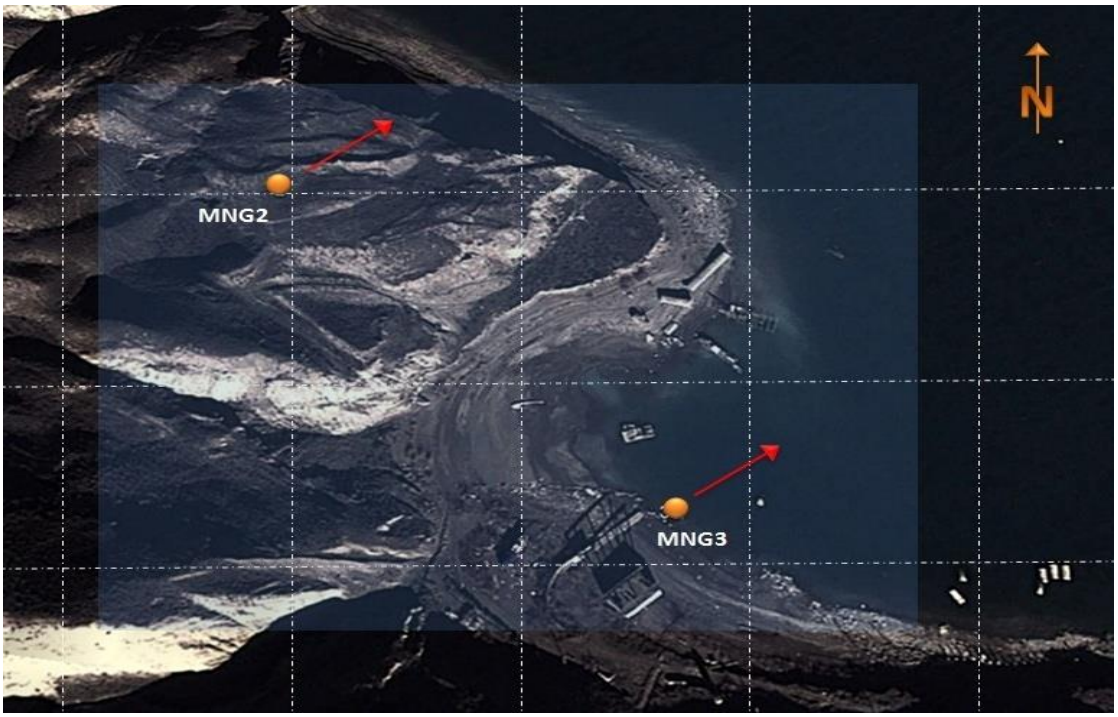

Figure16. The map of directions of horizontal displacements at GPS stations.

Analysis of initial data shows that the horizontal movements generally inclined to North East direction (Fig.16). However, in the early days, movement was recorded in the 1 mm S-SW direction but later, it was observed that the movement was gradually moving towards the North-North East direction. Throughout the recent movements, the maximum value of horizontal displacement was 3 mm.

During the next 12 days, the general tendency of sliding movement was in the direction of North-North East. The landslide in size 3-7 mm had been recorded in the South-South Western direction during the first days of the observation and then up to 5 mm in the direction of North-North East.

The data analysis obtained during research period at another station indicated that the sliding movements directed to the North-North East direction. In early days, even if the sliding that directed South-South West in size 1,0-1,5 mm had been observed, later movements directed to North-North East in size 2 mm had been recorded.

Analysis of data received from stations over the next 3 months showed that there were intermittent displacements in the direction of North East- South West (Fig.17). Up until the end of the observation, the movements directed South East were dominated. During the observations in October horizontal displacement was recorded in size 1,0-1,5 mm directed to North East- South West. In subsequent days, the values of horizontal displacement gradually decreased to 0.9-1.2 mm and the direction inclined to North-North-East direction. In December, the displacement dimensions were in size 0.5 mm.

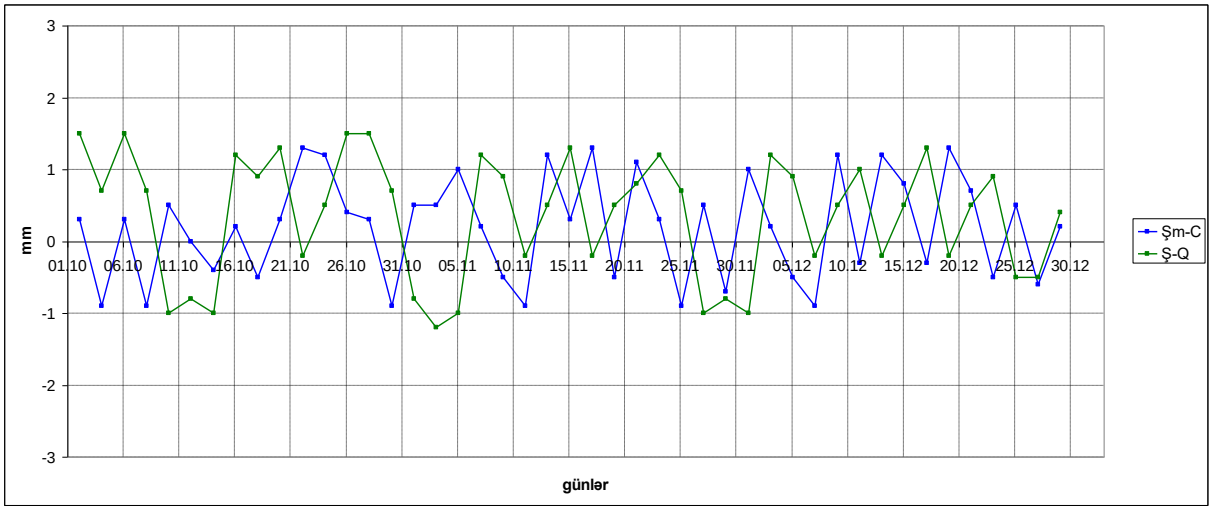

Figure17. The values of horizontal displacements directed to North South and East West received on 01.10-26.12.2014 at GPS station.

In order to investigate the deformation processes in the research area '701D' branded slope-measuring devices (tilt meters) were placed in three areas. These tilt meters were installed in triangular form to avoid the occurrence of random deformation cases. Two of them were installed in the sliding zone and the third one (POINT) was installed out of the zone.

The received initial data indicates that the vertical movements of amplitude in size 1-2 mm were in this area.

Conclusion

The following results have been obtained on the basis of seismological, engineer-seismological, and geophysical (gravimetric, magnetometric) and geodynamic (GPS and Tilt meter) researches:

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- The analysis of the vibration records at Mingachevir seismic stations (frequency spectrum) caused by sliding processes shows that the sliding process has begun in early July.
- The studies show that the depth of landslide flatness was different in separate areas of research field and it ranged between 6 to 88 meters.
- Horizontal movements in the sloping zone during the first days were directed to the North East but gradually moved to the North –North East direction then the general tendency of sliding movements has changed in the direction of North-North East. In the area, intermittent displacements have been recorded in the direction of North East- South West.
- Vertical movements in size of 1-2 mm amplitude were observed in the sliding area. The southern side at the foot of the hill has been exposed to collapse. As a result of vertical movements, in the area, the surface bending had occurred.

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