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CURRENT CRUSTAL DEFORMATION WITHIN THE AZERBAIJAN TERRITORY

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ABSTRACT. Based on the results of the GPS measurements the crustal deformation of the Azerbaijan territory was studied by the method of Shen et. al. (1996). Velocity vectors obtained from Azerbaijan, Iranian, Georgian and Armenian GPS networks for the 1998-2012 years are used in order to estimate the dilatation rates. It is found that contraction was observed in the Greater Caucasus, Gobustan, the Kura depression, Nakhchivan AR. Maximum strain rates (about 200 × 10-9/year) were observed in the area between KHID (Khidirly) and SHIK (Shikhlar) points, and the contraction axes sharply changes its direction here and is oriented in SW-NE direction (in the South of Gobustan and Northern part of the Lesser Kura structural zone).

There is the appearance of zones where the deformation is practically absent (the dilatation rate less than 5 × 10-9/year), alongside with the areas of contraction at the strain field. These zones are the Pre-Caspian-Guba region (ANIX, SAMU) and the northern part of Gobustan (or eastern part of Zagatala-Govdag structural zone). In these zones extensions are almost compensated by contractions. There is a correlation between epicenters of strong earthquakes and gradient zones of the deformation field.

Keywords: GPS, crustal deformation, collision zone, earthquake, seismic, magnitude, strain field

1. INTRODUCTION

The Azerbaijan territory is located at the active collision zone of two continent - African and Eurasian [6, 7]. The continuous "intrusion" of the Arabian plate through Eurasia, causes lithosphere shortening along the Main Caucasian Thrust (MCT), which spreads in NW direction and horizontal displacement of the lithosphere from the collision zone of right lateral strike-slip fault [1, 2, 4, 6, 8]. These regional tectonic processes, being the reason of crustal deformations cause earthquakes, which are historically recorded all over the Caucasian territory.

The GPS observation data, which conducted in Azerbaijan and surrounding territories, allow evaluating current surface displacements and related crustal deformations. The observed movements allow to identify zones of the fast strain accumulation, which are interpreted as a result of deep slip along the fault, which is located at the varying depths of the Earth`s crust.

GPS measurements

The GPS network of Azerbaijan was established by the Institute of Geology and Geophysics of the Azerbaijan National Academy of Sciences in collaboration with the Massachusetts Institute of Technology [1, 2, 8]. The network established during the period of 1998-2012 and the measurements were carried out 3-6 times at most times. Currently, there are 22 observation points in the territory, 3 of which are continuously operated by the GPS stations (Baku, Sheki and Neftchala).

The GPS data were processed and the errors were evaluated by the Massachusetts Institute of Technology using GAMIT/GLOBK program

[3, 5]. As a processing result, the average from the observed speed interval of component-displacement was determined for each point. Thus based on the GPS data for the time interval of 1998 - 2012 the initial data for the evaluation of deformation rates, including the field of velocity vectors are derived. The error of determining the velocity is mainly less than 0.6 mm/year and allows to determine convergence quite accurately across the Caucasus Mountain System (i.e. error is 5% from full rate of the convergence).

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On a wide scale the velocity field of the GPS observations clearly illustrates the movement of the Earth`s crust surface in N-NE direction in the Azerbaijan territory and adjacent regions of the Lesser Caucasus relative to Eurasia. The feature of the velocity field it is the speed decreasing, which have the most clearly defined at the observation points located perpendicular to the MCT (i.e. between KURD and MEDR, and BILE and SHIK). The GPS observation points along the MCT shows the speed decreasing. The N-NE motion of the Earth`s surface is interpreted as one of the reasons of strain accumulation on this thrust. In addition, there is a tendency of horizontal motion within the Kura depression and the Lesser Caucasus, where speeds are increasing from the West to the East along the mountain range.

Dilatation rate analysis

Since the deformation of the Earth`s crust may be considered as continuous and can be treated with changeable shape and volume of the body, so the each point of the Earth`s crust and its surface will correspond in time to the strain tensor, which is related to this point. It is important to note that, the analyses of the horizontal components of current Earth`s surface motions only allows to evaluate the surface deformation – the state of deformation, where one of the main deformation components is constant. The strain distribution for the studied area calculated by the Shen method is shown in the Fig.1 [9, 10, 11]. Black lines show the direction of contraction axes, white lines show the direction of extension axes. The analysis of Fig.1 provides possibility to understand, that even though the contraction is dominant regime, the deformation of the Earth`s crust within the Azerbaijan territory distributed unequally.

The contraction was observed in the Greater Caucasus, Gobustan, the Kura depression, the Nakhchivan AR. The contraction axes show that the Earth`s crust shortening in the Greater Caucasus region occurs in N-NE direction, and in Shamakhy area (MEDR) it is nearly submeridional. The maximum strain rates (about 200 × 10-9/year) were observed in area between KHID (Khidirly) and SHIK (Shikhlar) points, and the contraction axes sharply changes its direction and is oriented in SW-NE direction (in the South of Gobustan and Northern part of the Lesser Kura structural zone) here. At the Salyan, Bilasuvar and Neftchala areas the contraction axes sharply changes the direction also.

It can be seen from the Fig.1, that along with the areas of contraction at the strain field, there are appearance of zones, where the deformation is practically absent (the dilatation rate less than 5×10^{-9}/year). These zones are the Pre-Caspian-Guba region (ANIX, SAMU) and the Northern part of Gobustan (or Eastern part of the Zagatala-Govdag structural zone). In these zones extensions are almost compensated by contractions.

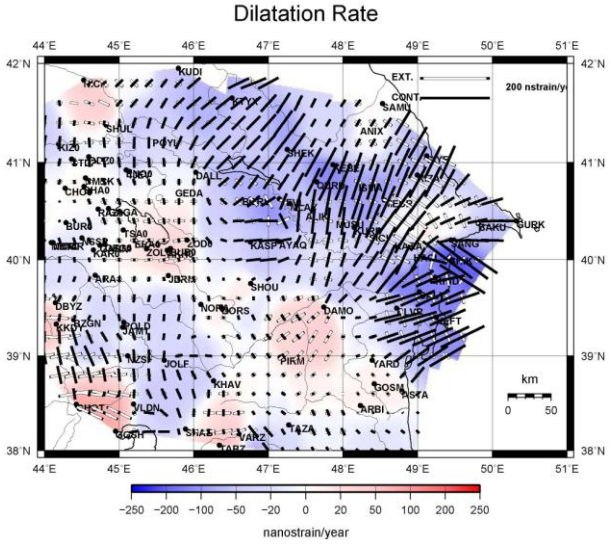

Figure 1. Distribution of contraction/extension axes and the field of dilatation rates derived from GPS data. The solid black lines – contraction axes, white lines – extension axes (nanostrain – 10^{-9}).

The extension was observed in the Lesser Caucasus: Gadabey (GADA), Shusha (SHOU) regions and in the zone which is located between DAMO and PIRM observation points. At these zones dilatation rate reaches

up to 100 × 10-9/year. The revealed heterogeneous feature of strain field in the region allows admitting the block model structure of the region, which is close to reality. A similar conclusion about the block structure was revealed for other regions. In order to solve the problem of identifying the boundaries of microplates it is necessary to increase the number of the continuous GPS observation stations.

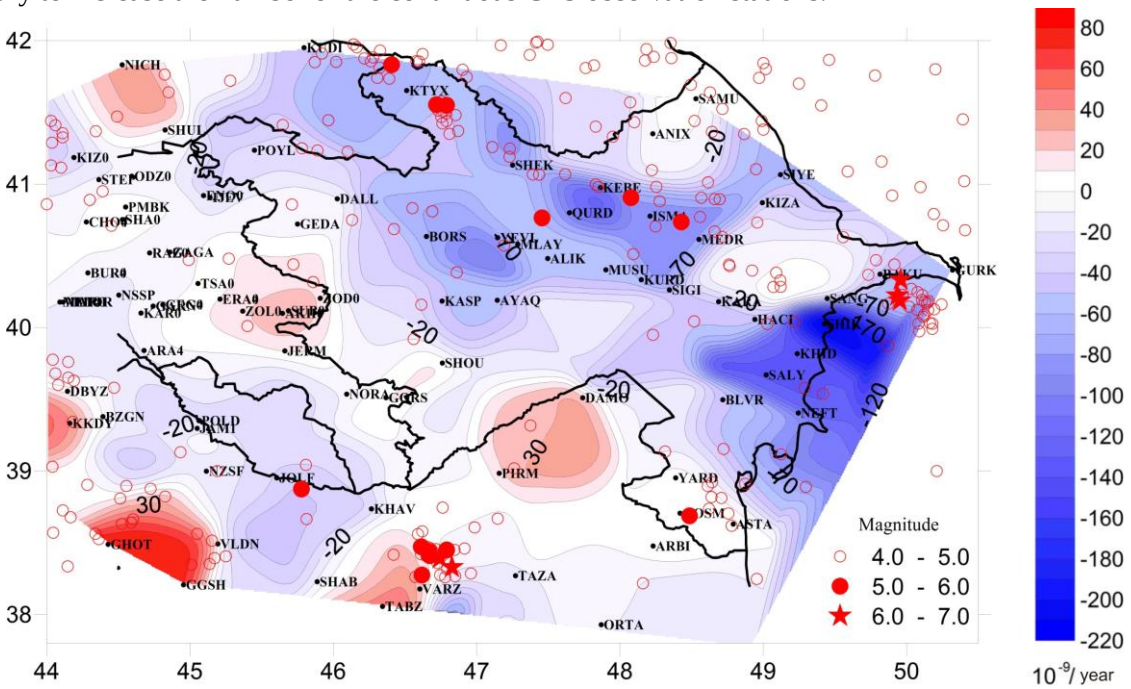

Figure 2. Distribution of earthquake epicenters with magnitude M≥4 occurred during 1998-2012 and dilatation rate field.

The Fig. 2 represents the distribution of earthquake epicenters with magnitude M≥4 occurred during 1998-2012 on a background map of the dilatation rate distribution.

The distribution of epicenters have been plotted by using the materials of the Republican Seismological Service Center of the Azerbaijan National Academy of Sciences; the Geophysical Service of the Russian Academy of Sciences and the open information of the international seismological centers such as EMSC and IRIS also.

It can be seen from the figure that the epicenters of strong earthquakes (M≥5) are in gradient zones of the deformation field.

Conclusion

The revealed heterogeneous feature of strain field in the studied territory allows to admit the block model structure of the region, which is close to reality. A similar conclusion about the block structure was revealed for the other regions. In order to solve the problem of identifying the boundaries of microplates it is necessary to increase the number of the continuous GPS observation stations.

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