ASSESSMENT OF MODERN GEODYNAMICS OF AZERBAIJAN BY GPS MEASUREMENT DATA

G.J.Yetirmishli[1], I.E. Kazimov[1], A.F.Kazimova[1]

Introduction

From the standpoint of plate tectonics, the existence of any lithospheric plate gives rise to certain geological processes at its borders. The nature of these processes, first of all, depends on the type of interaction with neighboring plates, in other words, on the type of interplate boundary. In turn, the type of interaction between the plates is determined by the directions and velocities of their movements, that is, their kinematics. Over time, the kinematics of lithospheric plates were determined using paleomagnetic, paleoclimatic, geological, geomorphological, seismological research methods that record the effects of plate interactions and their movements. Over the past decades, space geodesy methods have been actively developed, which make it possible to determine the location of objects on the Earth's surface with high accuracy. Changes in the position of such objects in time tell us about their kinematic characteristics. GPS satellite positioning system, at the moment, is the most developed among such systems. It has the necessary resolution for the quantitative assessment of a wide range of geological processes and, including, to identify the processes themselves. The use of satellite geodesy methods made it possible for a new approach to determine the motion parameters of lithospheric plates. Based on the results of GPS measurements, employees of the Massachusetts Institute of Technology built new models of instant kinematics of Mediterranean and Caucasian region plates (Fig. 1 a, b).

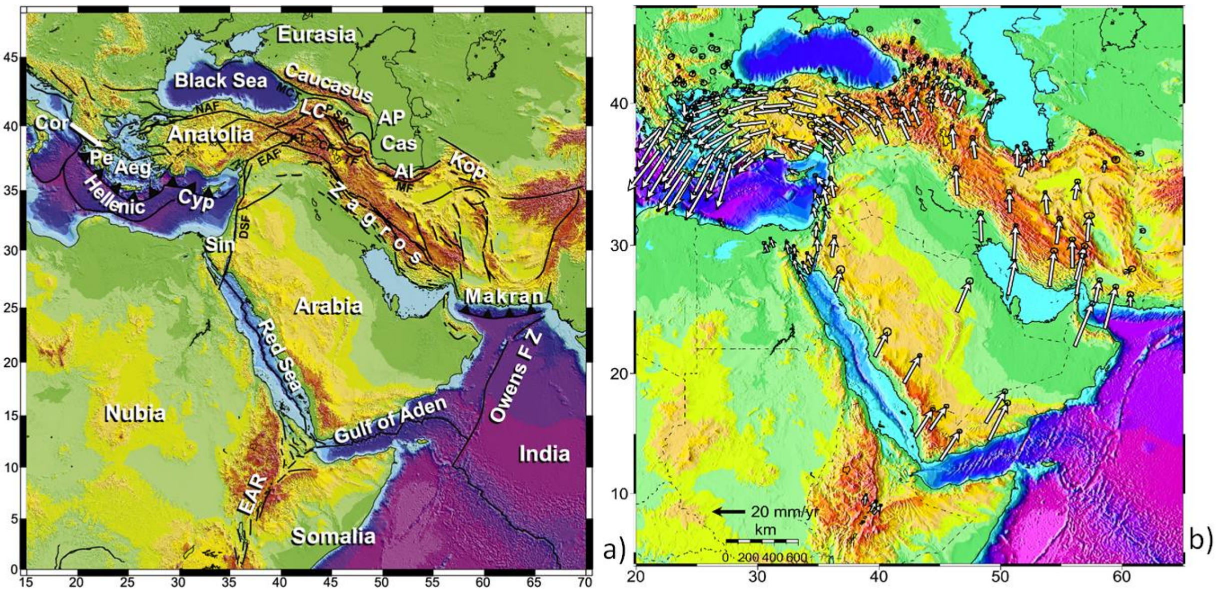

Figure 1a. Simplified topographic/bathymetric (SRTM30 PLUS; http://topex.ucsd.edu/WWW_html/srtm30_plus.html) and tectonic map of the study area, including the zone of interaction of the Nubian, Somalian, Arabian, and Eurasian plates. Abbreviations are North Anatolian fault (NAF), East Anatolian fault (EAF), Dead Sea fault (DSF), Mosha fault (MF), Pembak-Sevan-Sunik fault (PSSF), Tabriz fault (TF), Chalderan fault (CF), Gulf of Corinth (Cor), Peloponnesus (Pe), Aegean (Aeg), Lesser Caucasus (LC), Cyprus trench (Cyp), Karliova Triple junction (KT), Sinai (Sin), Caspian Sea (Cas), Main Caucasus Thrust (MCT), East African rift (EAR), Kopet Dag (Kop), Apsheron Peninsula (AP), Alborz Mountains (Al).[7]

Figure 1b. Map showing decimated GPS velocities relative to Eurasia determined in this study. For clarity, we plot 1s velocity uncertainties (see Table S1 for a complete tabulation of the velocities determined in this study). [7]

As you know, Azerbaijan is part of the Alpine-Himalayan mountain belt, formed in the Cenozoic on the southern edge of the East European platform as a result of a collision between the Eurasian and Arabian plates, which over the past five million years has experienced a rapid rise.

[1] Republican Seismic Survey Center of Azerbaijan National Academy of Sciences

The advance of the Arabian (also called Arab) plate to the north is partially offset by the displacement of the Anatolian block to the west. The tectonics of this vast region are mainly determined by the collision of the Arabian and African plates with the Eurasian plate. Models based on the global analysis of data on the movement of various plates show that, relative to the Eurasian plate, the Arabian plate moves in the north-north-west direction at a speed of about 18-25 mm / year (averaged over the past 3 million years). The African plate moves north with a lower speed of 10 mm / year, which causes a left-side shift along the zone of the Dead Sea faults. The advancement of the Arabian Plate to the north is also responsible for the formation of the Zagros mountain structure, the formation of the high plateaus of Eastern Turkey and the growth of the mountain structures of the Lesser and Greater Caucasus [3, 7].

The aim of our research was to calculate the velocities of modern horizontal displacements of individual tectonic blocks throughout the republic and to analyze their influence on strong earthquakes that occurred in 2017 and 2018.

Methods of studying horizontal modern movements of the surface of the Earth's crust

The study of modern movements and deformations occurring in the massif requires the monitoring mode of high-precision geodetic measurements of the displacements of the benchmarks of specially equipped observation stations - geodynamic ranges [1].

In the past few years, in our Center (RSSC), along with traditional geodetic observations, methods of satellite geodesy have been used. The combination of traditional ground-based and satellite measurements allows us to quite successfully solve the tasks. Due to its high performance, satellite technologies made it possible to obtain information on deformations of the Earth's surface at bases from a few meters to several tens of kilometers with high frequency, which was difficult using traditional measurement methods and, very important, to ensure the safety and efficiency of mining. To carry out satellite geodetic measurements, 24 GPS-receivers of the geodetic class from Trimble were used [2,4].

Thus, in the study of geodynamic processes using GPS technologies, two spatio-temporal modes are mainly used for a one-time redefinition of the initial coordinates of points of geodetic networks, and displacements of the reference values of deformations [5].

The data obtained as a result of experimental work on the current stress-strain state of the Earth's crust and the patterns of its change in time, on the one hand, provide new fundamental knowledge about the nature of the natural deformation processes that occur in the upper part of the Earth's crust and the effect on the formation of a stress state.

Azerbaijan's geodynamics assessment based on GPS measurements for 2017-2018 years

In recent years, Azerbaijan has been characterized by active seismic activity, in which the accumulated tension in the collision zone is released. In general, the seismic activity of the territory of the republic in 2017 varies in the range of 0.2-0.6. As in previous years, the maximum values were noted in the Gabala, Shabran and Shamakhi-Ismayilli districts (A = 1.0-2.0). However, it should be noted that the seismic activity of the Kura Depression in the Saatli and Agdam regions has increased. On May 11 at 07:24:19 in the Saatli region there was an earthquake with a magnitude of 5.3 and felt up to 4-3 points. On November 15, local time, 23:48:02 in the region of Agdam, an earthquake occurred with ml = 5.7 felt up to 6 points. The area of constant released tension, where in the absence of strong earthquakes many weak ones occur - the Talysh region, as in previous years, is characterized by maximum seismic activity (A = 1.6-2.0) [8].

In 2018, 16 tangible earthquakes with Ml = 3.2–5.5 occurred in the study area. Two significant earthquakes with Ml> 5.0 were recorded, which were felt at the epicenter with intensities of 5 and 6 points. Increased seismicity was observed in the Talysh mountain region, where there were 6 tangible earthquakes with Ml = 3.4 - 5.0, which were felt at the epicenter with an intensity of 3 to 5.5 points.

Based on said above, we analyzed the data of GPS stations for 2017-2018 years. The velocity estimates are based on the analysis of the time series of GPS station coordinates calculated from the primary data, which are sets of phase and code measurements at two frequencies lasting 24 hours with a recording interval of 15 s.

Thus, horizontal speed maps were constructed according to the data of the geodetic network of GPS stations in Azerbaijan for 2017 and 2018 years. (Fig. 2,3). As the analysis of the velocity distribution shows, the average values of the velocities of horizontal displacements of points to the north and east are not constant, and the processes of shortening the surface of the Earth's crust in the study region are also not constant. In addition, strong tangible earthquakes that occurred during these periods were plotted on the map. As can be seen in the Figure 2, the maximum values of the horizontal movements of individual blocks are characterized by increased seismic activity.

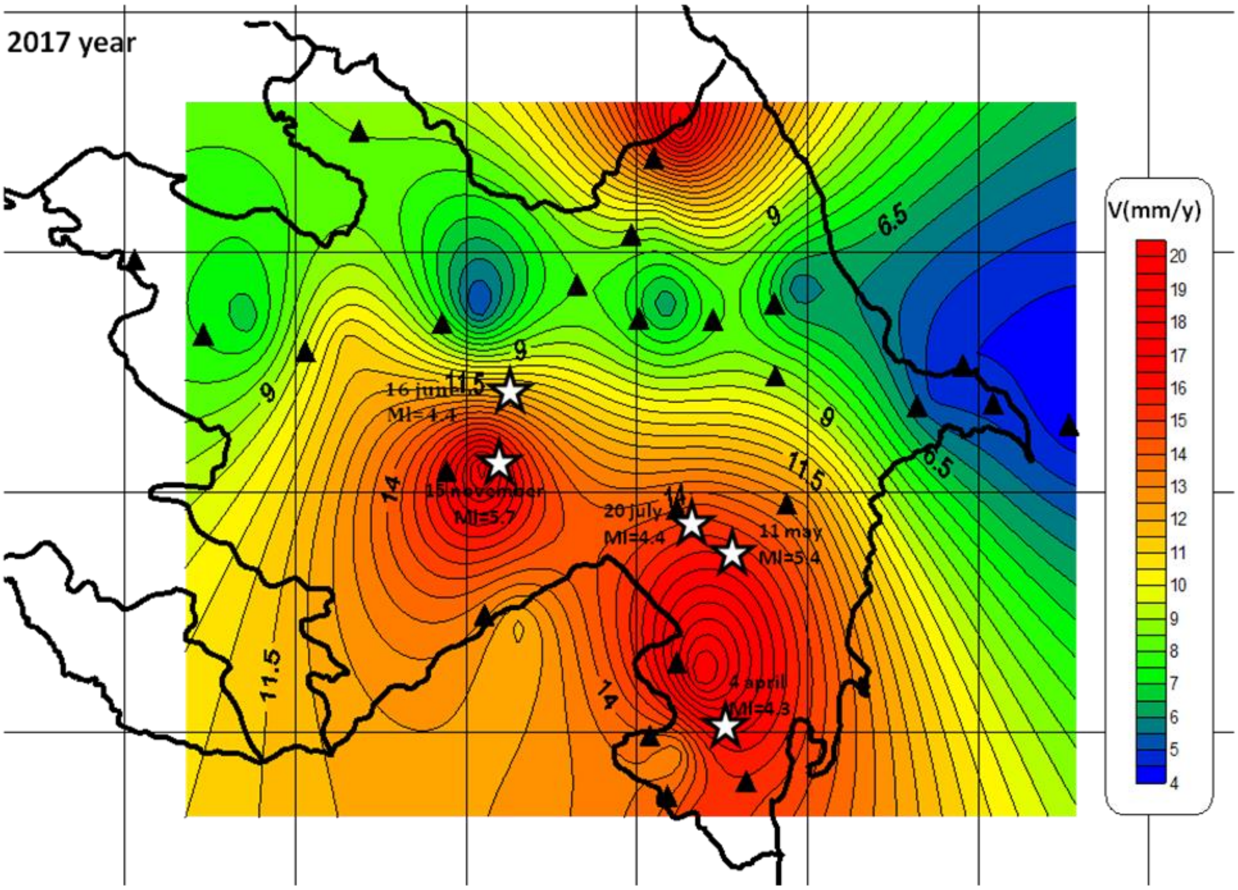

Figure 2. Velocities of horizontal movements of the Earth's crust surface according to the data of the geodetic network of GPS stations in Azerbaijan in 2017

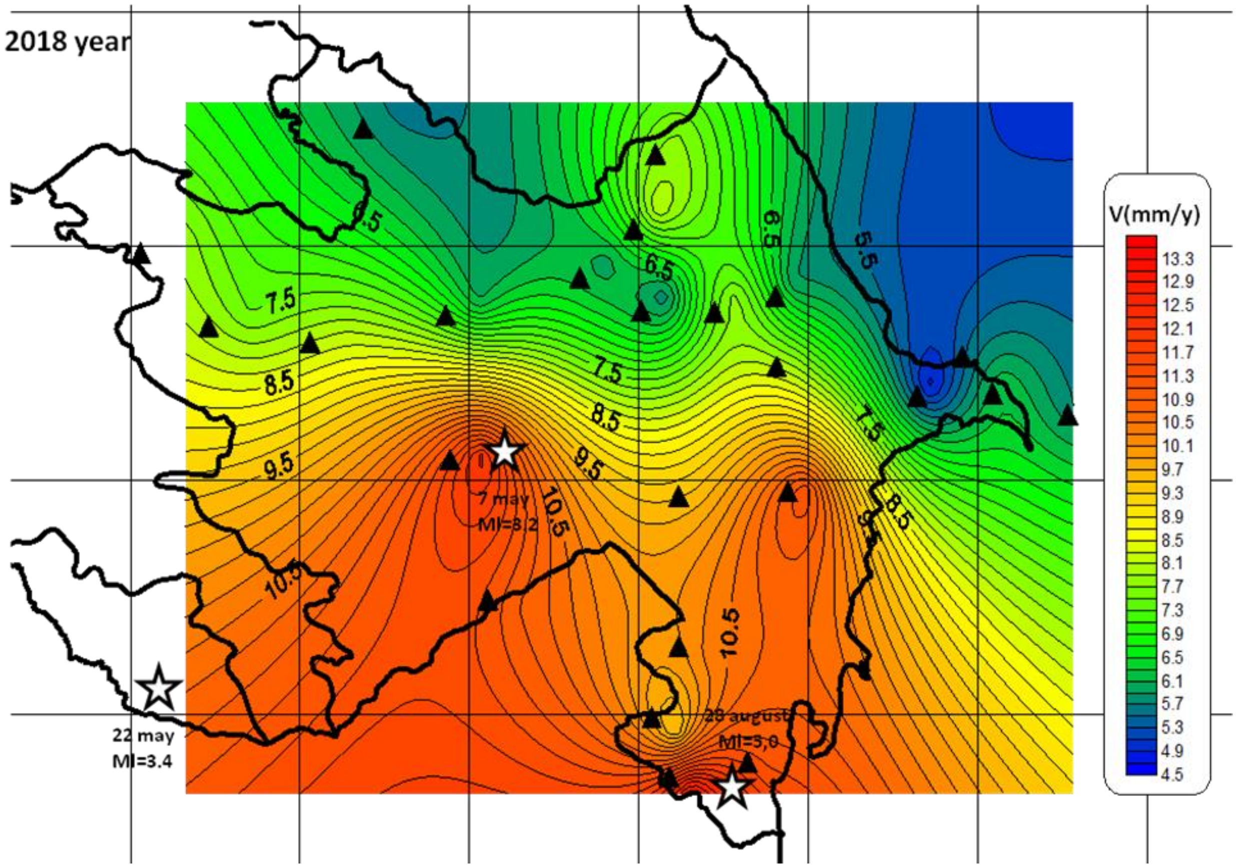

Figure 3. Velocities of horizontal movements of the Earth's crust surface according to the data of the geodetic network of GPS stations of Azerbaijan for 2018

Detected increase in velocity in 2017-2018 years at Lerik, Lankaran, Jalilabad, Agdam and Saatli stations (Fig. 4), compared with other years, is the most significant feature of the velocity field in the study region. On the comparative velocity chart between 2017 and 2018 years (Fig. 4) a direct proportional dependence is observed. In addition, over the course of these two years, the speed value at Gusar station has noticeably decreased.

In conclusion, it should be noted that the use of modern methods of traditional and satellite geodesy for observing the process of movement of the Earth's surface allows us to conduct research at a qualitatively higher level. The results of the studies, as well as the GPS measurement data, can be used to determine the kinematics of lithospheric plates, identify and clarify their boundaries, in the zone of influence of which are located sources of strongest earthquakes, to highlight the main fault systems and the most seismically dangerous zones, to track the progress of the change of stress-strain state of the environment and the accumulation of elastic deformations in the zones of such faults.

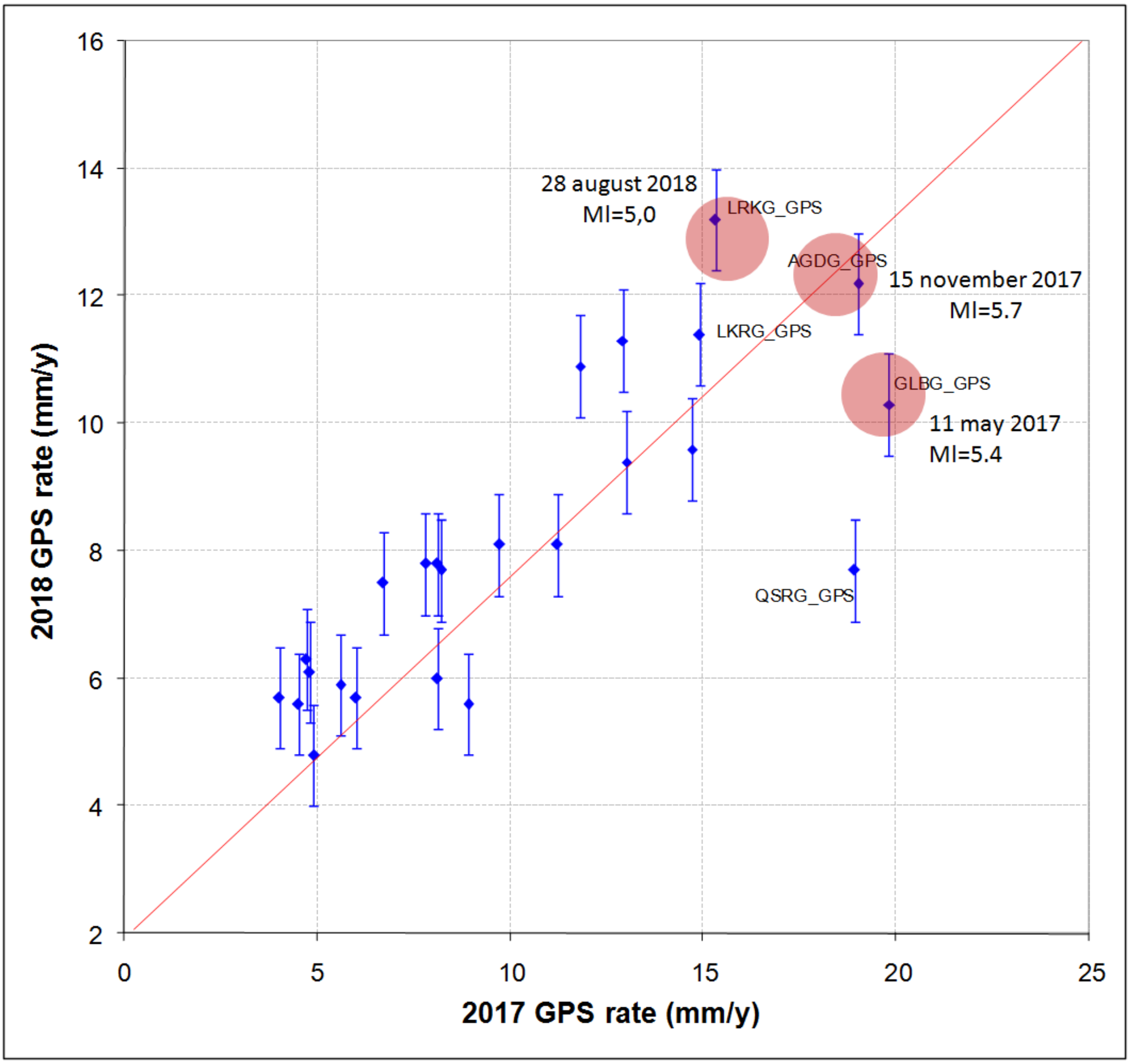

Figure 4. Comparative graph of the velocities of horizontal movements of the surface of the Earth's crust for the period 2017 – 2018 years

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