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STUDY OF GNSS SITE DISPLACEMENTS IN THE KASHKADARYA REGION OF UZBEKISTAN

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----------ABSTRACT----------

The paper presents the results of processing data from a network of permanent stations of the Global Navigation Satellite System (GNSS) of Kashadarya region for the period 2023-2024. The kinematic aspect of movement was considered, in station velocity relative to the reference system, and an assessment of local tectonic movements of the area was made. The Gamit/Globk program was used to estimate the coordinates and velocities of sites relative to ITRF2014 (The International Terrestrial Reference System) . The average value of horizontal velocities relative to ITRF2014 was 27 mm/yr. The obtained local rates relative to Eurasia ranged from -1 to 4.6 mm/g. The results of the obtained horizontal velocities confirmed their tectonic origin and can be used to assess the stress-strain state of the region.

KEYWORDS: *GNSS, horizontal movement, seismicity, CORS, GAMIT/GLOBK, RINEX, ITRF2014 .*

1. INTRODUCTION

The territory of Kashkadarya region is located in the southwestern Tien Shan and it is an integral part of the suture zone between the Eurasian and Indian plates. According to modern concepts, the study area is located in the transition zone of the Turan plate to the Tien Shan orogen. Kashkadarya region has a complex geological structure. Tevelev et al., when studying the southwestern Gissar, found that fold-and-thrust deformations predominate in the study area [1]. Abdullaev et al., when studying the territory, discovered numerous gas and oil fields. D.A. Tashkhodjaev et al. (1999), when studying oil and gas bearing regions of Uzbekistan, determined modern vertical displacements of the earth's crust and found that the uplift of the earth's surface in the southeastern part of the Karshi steppe and the settlements of Talimarjan, Chardzhou is from 0 to 8 mm/year. Vertical movements at the Karshi points are 2 mm/year; Guzar up to 3 mm, Shurtan field up to 4 mm/year. Horizontal movements of GNSS (Global Navigation Satellite System) sites of this territory relative to Eurasia are from 3 to 11 mm/year [2].

If we consider the seismicity of the territory, according to the earthquake catalog of the Republican Center for Seismic Prognostic Monitoring of the Ministry of Emergency Situations of the Republic of Uzbekistan for recent years, the Kashkadarya region is a seismically active region (Figure. 1).

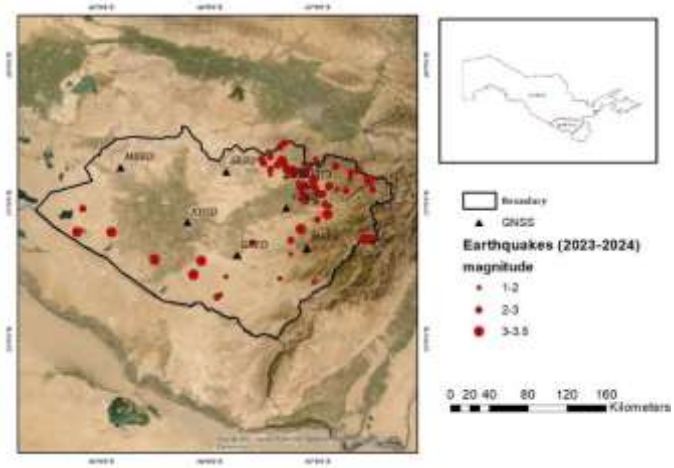


Figure. 1. Seismicity of the Kashkadarya region

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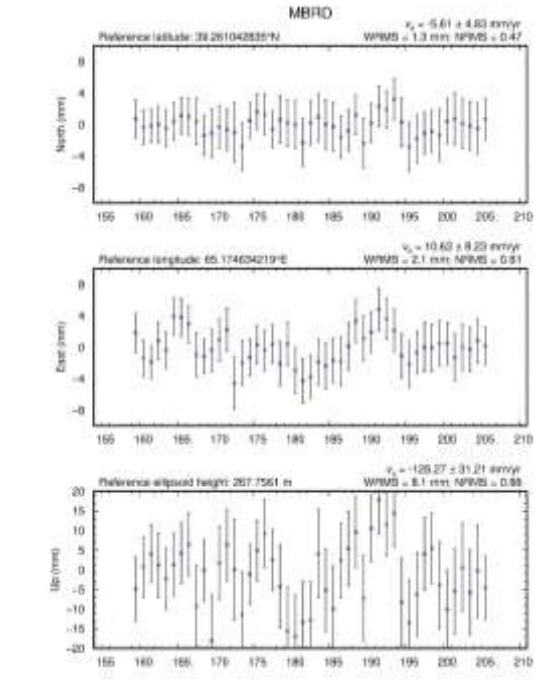
The magnitude of earthquakes ranges from 1 to 3.5 mb. The seismicity of the territory is caused by the continental collision of the Eurasian and Indian plates, as a result, of the subduction of the Indian plate under the Eurasian [3]. Such large-scale processes in the mantle provoke powerful movements in the earth's crust both above the hypocenter and at significant distances from the epicenter. Examples of such earthquakes include the Kamashi earthquake of April 20, 2000 with a magnitude of M = 5.3. One of the advantages of daily GNSS measurements is the quantitative assessment of the parameters of geodynamic movements. So today, it is actual to use GNSS measurements to monitor the movements of tectonic plates of the earth's crust, and deformations in the places where these plates interact, which will allow us to assess the readiness of the geological environment for a seismic event. The aim of this work is to determine the horizontal and vertical velocities of GNSS sites in the Kashkadarya region.

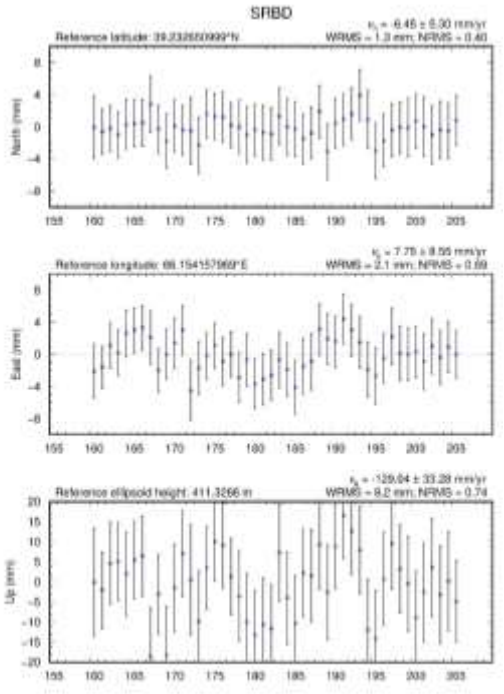
2. DATA AND METHOD

For processing, 8 points of the continuously operating reference stations (CORS) of the republic were selected for the period 2023-2024, having a continuous series of measurements KRSD, MBRD, SRBD, GUZD, KIT3, KITG, YKBD, MADK.

The GNSS sites data were processed in the GAMIT/GLOBK software, which is one of several well-known programs for processing high-precision geodetic data. The package includes a set of programs for calculating daily station positions, estimating atmospheric delays, resolving phase ambiguities, and orbital parameters. Detailed information on the methods for processing GNSS phase measurements using the GAMIT/GLOBK software for estimating station positions and velocities is given in [5–7]. The processing included preparing satellite orbits, adjusting clocks, calculating apriori coordinate values, RINEX (Receiver Independent Exchange Format) files, and estimating velocities. The main criteria for assessing the accuracy of the data obtained are checking that all measurements are included in the processing and that the models meet the specified accuracy. The Kalman filter included in the GLOBK software package was used to calculate the station coordinates.

The 21 international GNSS stations were included in the processing (atru artu badg bjfs chum hyde iisc kaza krvt lhaz kost pol2 podg shao seme tash tala tehn urum kmtr sumk), for obtaining a stable solution of coordinates and velocities and accurately reference regional measurements to the international reference coordinate system ITRF2014 (International Terrestrial Reference Frame). The main output parameters are daily values of displacements in the south-north (SN), west-east (WE) and vertical (Up) directions in the ITRF2014 coordinate reference system, as well as their time series and velocity vectors of displacements in the same directions. The generated time series for CORS stations are presented in figure 2.





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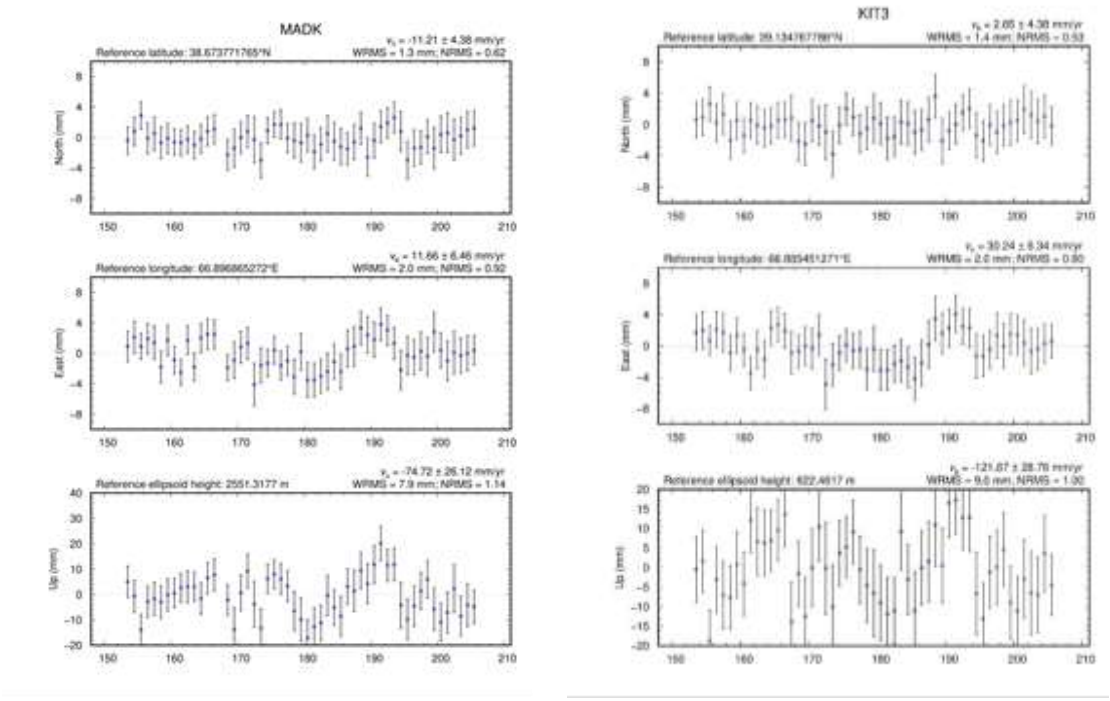


Figure 2. The Time Series for CORS stations.

The evaluation of the obtained station coordinates showed that the normalized root mean square (NRMS) values are close to 1 in all three components, and the weighted root mean square (WRMS) has a value of 0.4-1.4 mm vertically and 0.7-4.1 mm horizontally. As can be seen from the time series graphs, the normalized root mean square (NRMS) error is also close to 1. Therefore, we can conclude that all the necessary criteria for assessing the accuracy of both the measurements themselves and their processing performed in the GAMIT/GLOBK program are met and meet the requirements of the program developers [7].

Two aspects of the region's crustal movement were considered. First, we considered the kinematic aspect of the reference frame itself, i.e. the velocities of the sites and their relation to the plate motion. The results are presented as velocity vectors relative to the ITRF 2014 system, obtained using annual combinations of daily GNSS data. The average value of the station motion relative to the ITRF in this case it was 27 mm/year (Fig. 3).



Figure 3. Horizontal velocities of GNSS stations relative to ITRF 2014

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Secondly, an assessment of the tectonic local movements of the region was made. The velocity vectors relative to Eurasia were from -1 to 4.6 mm/yr and showed instability of the region with a reliability level of 95% (Fig. 4).

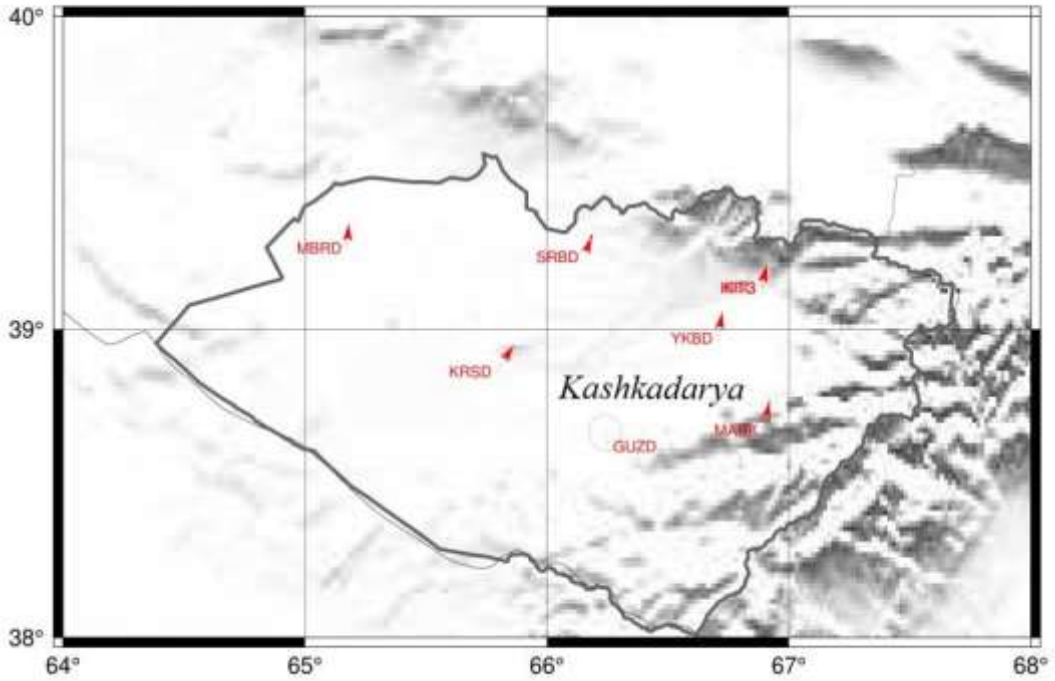


Figure 4. Local velocities of GNSS stations relative to the Eurasian plate

3. CONCLUSIONS

In this paper, new data on modern kinematics of sites of Kashkadarya region were obtained. Vectors of horizontal velocities of GNSS sites are directed to the north-east with the speed of 27 mm/year. The results of the received values and directions of velocities confirmed their tectonic origin. The obtained values of horizontal velocities of sites can be used for estimation of stress-strain state of the region.

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