Long-term monitoring of recent crustal movements in the region of Southwestern Bulgaria. Results from 2022

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Abstract. This article examines the study of modern crustal movements in the region of southwestern Bulgaria, a geologically and seismically active region with the presence of numerous fault structures. The main method of obtaining deformation information is by using GNSS measurements. The monitoring of geodynamic processes in the area has been going on for more than 25 years. GNSS data obtained from periodic campaign measurements between 1997 and 2022 are processed and analyzed to obtain the deformation accumulation result in southwestern Bulgaria. As a result of long-term measurements, more and more accurate and reliable results are obtained for the velocities of the points. A certain relationship has been established between the modern movements of the Earth’s crust, seismic events and tectonic structures. This extensive movement of southern Bulgaria and northern Greece is also confirmed. The results can be used for a detailed geodynamic and geological study of the active fault structures in the area.

Keywords: geodynamics, GNSS, recent crustal movements.

Introduction

GNSS technology is especially important in the study of modern tectonics and geodynamics because it provides quantitative estimates of recent crustal movements. Geodynamic processes of endogenous (earthquakes and modern movements of the earth’s crust) and exogenous origin – natural and man-made (landslides, abrasion, erosion, subsidence, collapses, collapses, etc.) can be dangerous. Their destructive impact on buildings, engineering facilities and disturbances in the resilience of the earth’s crust causes enormous economic, environmental, social and other damage, and often takes human lives. GNSS monitoring of the geodynamic processes in Southwestern Bulgaria continues more than 25 years. To study the modern movements of the Earth’s crust, a geodynamic network was built during the period 1996–1997 covering the region around Sofia and southwestern Bulgaria. The network covers the main tectonic structures in the area. The points of network are stabilized to provide high-precision GNSS measurements, and the results of the measurement processing are used to determine the coordinates and velocities of the points, calculate the active strain in the area and long-term monitoring of crustal movements.

Evaluation of previous results

The first GNSS measurements of the Sofia Geodynamic Network were made in 1997. Full measurement of the entire network with processing and analysis of the results were performed only in two epochs 1997 and 2000. Due to the short period between measurements, when plotted with 95% con-
Confidence ellipses, the velocities of 93% of points fall within the bounds of the error ellipses. (Kotzev et al., 2001; 2006). After conducting long-term monitoring and receiving the results of the measurements in 2020 and 2021 more and more accurate and reliable results are obtained for the velocities of the points. When plotted with 95% confidence ellipses, the velocities of all stations are outside of the bounds of the ellipses (Dimitrov, Nakov 2020, 2021, 2022).

Results from 2022 measurements
In the summer of 2022, we measured the next epoch at 9 network points (Fig. 1). These points now have at least four measurement epochs over a pe-
period of 25 years. The results for their velocities in general confirm the previous results. However, with much better accuracy and reliability. Their errors are now less than 0.1 mm/year. Also, the network was extended by measuring the point VARB located in the north of the area (Fig. 1). All velocities are in a southern direction. They are in the limits of 1.2 mm/year up to slightly over 3 mm/year, almost reaching 4 mm/year in the southernmost part of the region.

Interpretation

The new results for station VARB fill a gap in the entire network and provide a significant input for the interpretation of the regional geodynamics. The results for station VARB, located in the northwest part of the region, confirm and clearly show that the deformation in this locality occurs at much lower rates than the remaining part of the network. Combined with the velocities to southern laying stations the results point to the Sofia area (graben) being the main locality of an increasing extension, southern of the Balkan Range. The contrasting results between VARB and DOB1/SATO (in the southernmost part), differing at almost 3 mm/y, define the scale of extension across Western Bulgaria. This result is probably also significant for the central part of the Balkan Peninsula. The relatively low velocities of SOFI, KRAL, VERI, VETR confirm the existence of an intermediate zone of relatively lower deformation from the north around the Rila-Rhodope Mountains.

The newly obtained results for stations ZEME, CARV, DELA, together with previous results for station DSEC suggest the activity of a fault zone with NW-SE trend, limiting them from NE laying stations laying stations KRAL, BOSN, PLA1.

The velocities of all stations tend to increase from north (point VARB), passing through an intermediate locality (between Sofia and Kyustendil-Pazardhik), clearly increasing in the southernmost part of the country (around Gotse Delchev).

Conclusions

The newly acquired velocities from three campaigns 1997, 2000, 2020 and 2021 years, complemented with the new results from 2022, confirm that the general tendency of movement of the stations in the region of Central West Bulgaria is in the south direction with respect to stable Eurasia. In a general way, the velocities tend to increase from north to south. This pattern is in agreement with the extensive movement of Southern Bulgaria and northern Greece. The new results provide much better accuracy, reliability and local details. The obtained results show that the measurements may confirm previous results in area with missing data but provide also new more accurate data at a local level.

The results also show the necessity of continuous long-term observations, significantly increasing the accuracy at regional and local scale. As a next step, the measurements should be focused on local nets around suggested active structures in aim to establish the rate of local deformation.

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References

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