PRELIMINARY RESULTS FROM REASSESSMENT OF THE RECENT VERTICAL MOVEMENTS OF THE EARTH'S CRUST IN BULGARIA

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Several maps depict the recent vertical movements of the Earth's crust in Bulgaria's territory [1, 2, 3, 4]. According to Kanev and Mladenovski [2], almost the whole territory of Bulgaria is rising. The magnitude of the uplifts is mainly 1-2 mm/y. The supreme uplift velocities, with values exceeding 4 mm/y, are in the Pirin mountain and the Kotel-Omurtag part of the Balkan /Stara Planina/. The sinking areas are the South-Middle Rhodopes and the Strandja–Sakar mountains, where the drop speeds of the Earth's crust are up to -3 mm/y. The standard errors of the estimated vertical velocities are not given in the publication [2].

Contrary to Kanev and Mladenovski, Gospodinov et al. [3] estimate that the whole territory of Bulgaria is sinking. According to the authors, the values of the velocities are mainly in the range -1 ÷ -2 mm/y. The maximum fall of -3.4 mm/year is in the Lom depression, located in the southwest part of the Moesian Platform. The standard errors of the determined velocities are 0.7 mm/year on average.

A different picture of the tectonic motions in the territory of Bulgaria is presented by Belyashki [1]. According to [1], the velocities are predominantly in the range from 0 to -2 mm/y. The velocities between -2 mm/year and -3.5 mm/year are in the Lom depression and the Western Forebalkan. The mountains Pirin, Rila, and Central Rhodopes are rising by 1-2 mm/y. A similar rise is also detected in the Lodugorie-Dobrudzha Swell and the Strandzha mountain. The standard errors of the obtained velocities vary from 0.1 mm/year in Eastern Bulgaria to 1 mm/year in Western Bulgaria.

Another estimation of the recent vertical movements of the Earth's crust in Bulgaria is given by Spiridonov and Georgiev in their study [4]. According to the authors, the Lom depression is sinking by -2.5 mm/year. The central area of the Bulgarian Moesian Plain is rising by approximately 1 mm per year. The Western Forebalkan and the Balkan are sinking approximately -1 mm/year, but the Central Balkan is rising by 2 mm/year. The rates of rise for the Rila, Pirin, Rhodopes, and Sakar are 2 mm/year, 4 mm/year, 3.5 mm/year, and 1.5 mm/year, respectively. The authors did not give standard errors of the mentioned vertical velocities. As they remarked, there is no geomorphological logic between the presented vertical velocities and the known active faults in the territory of Bulgaria. Moreover, the South-Moesian fault [7, 8] is not detected in their investigation.

What is in common between the discussed vertical velocities in the studies [1, 2, 3, 4] is:

- They are based on the adjustments of the precise levelling data from three different epochs. In the study [2], the data from the First and the Second Levelling of Bulgaria were used. In the studies [1, 3], the data from the First and the Third Levelling of Bulgaria were used. In the study [4], all available levelling data were analysed.
- The adjustments of the levelling networks used the mean of both measurements of line elevations, which is the supreme systematic error considering levelling data processing [5].

- The adjustments were performed without minimising the standard errors of the adjusted benchmark heights [6].

As a result, using the same data, different results were obtained, and these results do not correspond with the active tectonic faults in Bulgaria [4, 7, 8].

To yield independent results considering the recent vertical movements of the Earth's crust in Bulgaria, we applied a different estimation approach.

We used the data from the Second and Third Levelling of Bulgaria. We applied 3^n independent adjustments of both networks to select those measured line elevations that minimise the loop errors in the networks [5]. We also applied Inverse Distance Weighting iterative adjustments [6] with a power parameter equal to 6. As a result, the standard errors of the adjusted benchmark heights in both networks, those of the Second Levelling /1953-1957/ and the First Phase of the Third Levelling /1975-1980/, are between 2 mm and 4 mm. Thus, the standard errors of the vertical velocities are on average 0.17 mm/year. The recalculated vertical velocities are shown in Fig.1.

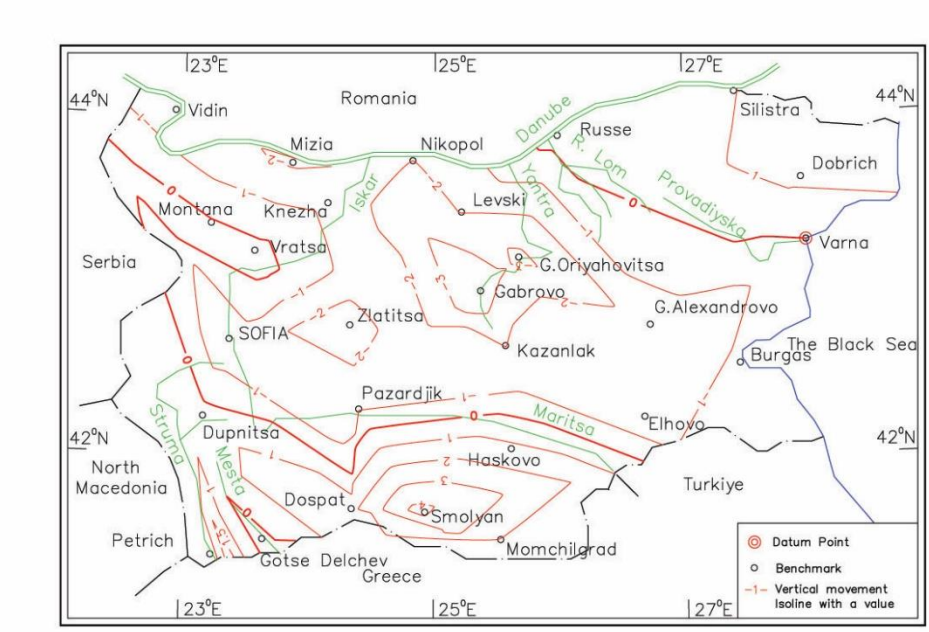

Fig. 1. The new map of the recent vertical movements of the Earth's crust in Bulgaria

According to Fig.1, the territory of Bulgaria, considering the signs of the yielded vertical velocities of the Earth's crust, can be divided into five parts.

The first one is the Eastern part of the Lodugorie-Dobrudzha Swell. This part of Bulgaria is rising by 1 mm/year. The boundary, that is to say, the velocity zero line, starts from the Varna Bay, passes along the rivers Pomoriyska, Beli Lom and Rusenski Lom. Thus, this zero line is very close to the Intramoesian Fault sketched by Fig.2 in [8] and coincides with a group of active faults given in this sketch.

The second part includes the rest of the Moesian Platform, the Forebalkan, the part of the Balkan located East of the Iskar River, the Tracian Plain, and the Strandzha-Sakar massifs. All this territory is sinking by 1-2 mm/year. The only exception is the area along the Yantra river between the towns of Gabrovo and Gorna Oriyahovitsa, where the velocities of sinking are up to -3.5 mm/year. This sinking is likely a logical result of the intensive seismic activities in this place [8, Fig.11]. Our results confirm the sinking of the Lom depression by 1.5-2.5 mm/year.

The south boundary of the second part is the Maritsa fault, extending between the mountains Vitosha and Rila, following the boundary between the Kraishte and Sredna Gora, according to Gabarov's geomorphological zonation of Bulgaria [7, Fig.2]. South of this line, which is an agglomerate of important neotectonic faults [7, Fig.7], is located the third tectonic part in Bulgaria, which is rising by 1-2 mm/year. The supreme rise of +4.3mm/year we registered in the area of Smolyan town, which is close to the highest Rhodopes' peak – Golyam Perelik. Other rises more significant than 3 mm/year we yielded in Madan / 3.5 mm/year /, and Zlatograd / 3.2 mm/year /. Considering the Pirin Mountain, we found that the territory of Papas Chayr passage is rising by 1.7 mm/year. The area of Kroupnik town, which is famous for extensive seismic activity, is rising by 1.4 mm/year.

The only zone south of the Maritsa fault and its extension between the Kraishte and Sredna Gora [7, Fig.7], where we registered sinking, is the area of the Mesta River fault. According to our calculations, the area around Gotse Delchev is sinking by 0.5 mm/year.

The last fifth zone is the Western part of the Stara Planina, located west of the Iskar River. This zone is surrounded by the Forebalkan fault in the North [8, Fig.2], the Iskar River fault in the East, and the boundary between the Forebalkan and the Stara Planina in the South [7, Fig.4, Fig.8]. The registered rise between Belogradchik and the Prevala passage is approximately 0.8 mm/year, which is higher than the standard errors of the velocity multiplied by three.

In conclusion, we can say that the velocities of the vertical movements of the Earth's crust in Bulgaria are between ±2 mm/year, except for the area of the Yantra River gouge meanders and the peak of Golyam Perelik. All boundaries between the zones with positive and negative velocities follow well-known active faults.

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