SEISMOTECTONIC DANGER FOR THREE CULTURAL MONUMENTS IN SOFIA CITY (BULGARIA)

Margarita Matova

Geological Institute, Bulgarian Academy of Sciences, Sofia 1113, Bulgaria; e-mail: m_matova@geology.bas.bg

Key words: Sofia graben, active faults and blocks, seismicity, cultural monuments

Introduction

Sofia graben is a recent active structure. It is situated in the western part of the seismic mobile Srednogorie structural unit. Sofia City, the capital of Bulgaria, is located in the northern, middle and southern parts of the graben.

Sofia City has numerous historical cultural monuments. The Dragalevtsi (14th century), the Kremikovtsi (14th century) and the Seslavtsi (17th century) monasteries represent a part of our national cultural heritage. The monasteries were built on the faulted peripheries of the Sofia graben, where the seismicity is significant.

Seismotectonic situation

Sofia graben is a Late Alpine structure, which developed mainly during the Neogene-Quaternary. The graben has a general NW-SE direction. Numerous faults with longitudinal, transversal or oblique directions cut the graben (Fig. 1).

The longitudinal Vitosha fault zone (NW-SE) represents the southern boundary of the graben. It is situated in the contact zone of the graben with the surrounding Viskyar, Lyulin, Vitosha, Plana and Lozen block-horsts. Manifestations of slope processes and several mineral water springs are related to the Vitosha fault zone as well.

The Negushevo fault zone (NW-SE) is also longitudinal one, but it is exposed in the northern contact zone of the Sofia graben. The Chepan, the Sofia Mountain and the Murgash block-horsts are located to the N of the graben. Local slope processes mark this contact zone.

Numerous transversal faults with NE-SW, several ones with N-S and E-W direction cut the graben and the adjacent horsts (Fig. 1). There are faults and fault crossings that are related to inner graben mineral water springs.

Fault displacements, slope processes and the specific spacial distribution of thermal springs are characteristic for Sofia graben and its surrounding. They indicate the recent graben mobility (Fig. 1).

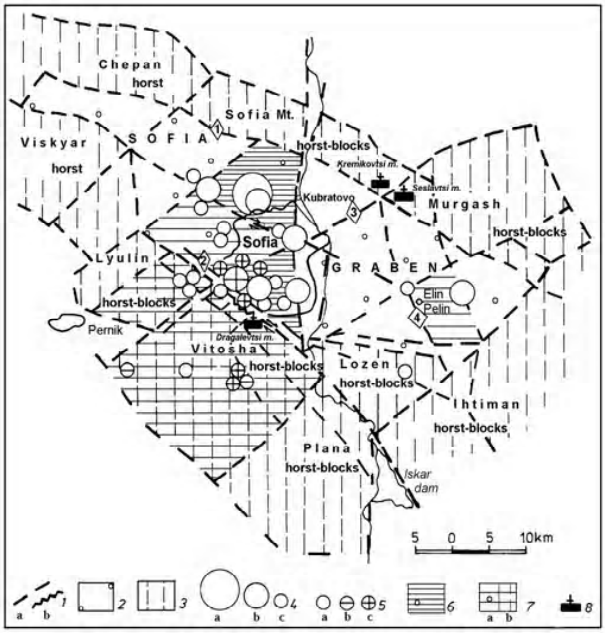

Fig. 1. Epicentres of earthquakes with M=4.0-6.5 in blocks of the Sofia graben and the surrounding horsts
1 – block boundary: a – faults (1 - Negushevo fault zone, 2 - Vitosha fault zone, 3 - Chepintsi fault, 4 - Elin Pelin fault), b – activated fault's segment during the 1858 Sofia earthquake; 2 – Sofia graben-block, 3 – surrounding horst-block, 4 – epicentres with: a – M=6.0-6.5, b – M=5.0-5.9, c – M=4.0-4.9; 5 – hypocentre depths in km: a – up to 10, b – 11-20 m, c – 21-30; 6 – block with relatively high activity, 7 – blocks with relatively moderate activity: a – of the graben, b – of the horst; 8 – monastery.

The intensive tectonic movements of the faults and the blocks are with vertical and horizontal components in the studied territory. The movements provoke continued block fragmentation. The continuous structural deformation causes seismic events. The earthquakes are with different magnitudes (Fig. 1).

The seismicity of the territory is considerable (Fig. 1). The seismic events take place in the crust, generally at a depth of about 10 km. The number of earthquakes is significant. They are weak and moderate seismic events. The 1858 Sofia earthquake

with magnitude of M=6.5 (Solakov et al., 2001) is of great importance for Sofia graben. The 1917 Sofia earthquake (M=5.1) is the last local earthquake that provoked considerable damages.

The geodetic information about the investigated territory is limited. The data from the geodetic measurements show the contemporary prolongation of the vertical block displacements in the area of Sofia graben and adjacent horsts. Sofia graben is subsiding and the adjacent horsts are uplifting. The geodetic measurements in the southern part of the graben indicate various tendencies of vertical movements (Dimitrov et al., 2001). The graben participates in a subsidence with values of 0.6±0.2 mm/a. There is an uplift of the Vitosha horst with values of 1.3±0.2 mm/a.

In the young Sofia graben the recent movements, including the seismic ones, create problems for the society, the geological environment and the cultural heritage.

Several cultural monuments in dangerous seismotectonic situation

Sofia region is one of the regions in Bulgaria with numerous and important mediaeval cultural monuments (Prashkov et al., 1992). It is know that the Bulgarian King Ivan Alexander (1331-1371) aided the building of 14 monasteries in Sofia region. The Dragalevtsi and Kremikovtsi monasteries were part of them while Seslavtsi monastery was built later.

The Dragalevtsi (Fig. 2), Kremikovtsi (Fig. 3) and Seslavtsi (Fig. 4) monasteries were built or reconstructed several times during the periods before, during and after the Ottoman domination. Their foundation was related mainly to the increase of the economic potential and the natural culture of the population in Sofia region. A lot of data for the reconstructions of the monasteries have been registered. Various causes provoked the reconstructions. One of them was the episodic deformation of Sofia graben and the surrounding horsts are a result of seismic activity.

Fig. 2. Dragalevtsi monastery

Fig. 3. Kremikovtsi monastery

Fig. 4. Seslavtsi monastery

The Dragalevtsi monastery (14th century) was built in the southern periphery of Sofia graben. It was placed on a high and significantly inclined slope of the Vitosha Mt. Horst. The monastery is near the crossing of the Chepintsi and the Vitosha faults, also near the seismically activated fragment of the Vitosha fault zone during the 1858 Sofia earthquake (Fig. 1). It had an important role for the culture, the education and the liberation of the country. The monastery (Fig. 2) is among the national cultural heritage from the Second Bulgarian Kingdom (1187-1396). The Dragalevtsi monastery was reconstructed after the 1917 Sofia earthquakes.

The Kremikovtsi monastery (14th century) is situated in the lower part of the southern slope of the Balkan Mt. It is on the contact of the northern periphery of Sofia graben with the adjacent Sofia Mountain horst. The monastery is very near to the crossing of the Chepintsi, Negushevo and Elin Pelin faults (Fig. 1). The Kremikovtsi monastery (Fig. 3) is important for the

national history. It was reconstructed after the 1553-1558 and the 1818-1858 Sofia earthquakes.

The Seslavtsi monastery (17th century) is located in the lower part of the considerably inclined southern slope of the Balkan Mt. It is again in the northern periphery of Sofia graben, more correctly in the contact zone of the graben with the adjacent horsts. The monastery is in close vicinity to the crossing of the Chepintsi, Negushevo and Elin Pelin faults (Fig. 1). The monastery (Fig. 4) is a heritage from the period of the Ottoman domination (1396-1878). The construction of the monastery during the17th century shows the high increase of the economic potential and the cultural interest of the population of Seslavtsi Village and Sofia region (Prashkov et al., 1992). The Seslavtsi monastery was reconstructed after the Sofia earthquakes of 1818 and 1858.

Conclusions

The three monasteries are among the representative constructions that were created during the Bulgarian Middle Age in Sofia area. They are located along the faulted contacts of Sofia graben with the surrounding horsts. The monasteries are situated in close vicinity with two of the fault crossings. The Dragalevtsi monastery is near the crossing of two faults, the Kremikovtsi and Seslavtsi monasteries – near the crossing of 3 faults (Fig. 1).

The studied cultural monuments are located in blocks with considerable tectonic activity. These blocks are in the northern and the southern horst boundaries of Sofia graben. Many earthquakes epicentres have been registered along the graben boundaries. The epicentres show local concentration near fault crossings.

The studied three cultural monuments were built in mobile blocks and near active faults. There are several concentrations of earthquake epicentres near the monasteries. The tectonic situation and the recent seismicity of the territory of Sofia City create considerable seismotectonic danger for the studied three monuments. The Seslavtsi monastery is strongly damaged now. It needs special reconstruction activities.

The seismotectonic danger in the areas of the monasteries is considerable. In the investigated monuments seismically induced damages were noted in the past. Analogous damages in them in the future are not excluded as well.

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СЕИЗМОТЕКТОНСКА ОПАСНОСТ ЗА ТРИ ПАМЕТНИКА НА КУЛТУРАТА В СОФИЯ (БЪЛГАРИЯ)

Маргарита Матова

Софийският грабен е съвременна активна структура. Той се намира в западната част на сеизмично мобилната Средногорска структурна единица. Град София заема северна, средна и южна част на грабена. Градът има множество исторически паметници. Драгалевският (XIV в.), Кремиковският (XIV в.) и Сеславският (XVII в.) манастир представляват част от националното ни културно наследство. Те бележат порасналите икономически възможности и културни интереси на населението в Софийския район през Средновековието.

И трите манастира са построени върху разломени периферни зони на Софийския грабен. В тези зони е налице значително блоково раздробяване, а и сеизмичните прояви не са рядко явление (фиг. 1). Самият Софийски грабен е късноалпийска структура с главно развитие през неоген-кватернера. Множество надлъжни, напречни и коси разломи пресичат грабена и обграждащите го хорстове. Надлъжната Витошка разломна зона от южната окрайнина на грабена бележи контактната му зона с прилежащите Вискярски, Люлински, Витошки,

Плански и Лозенски блок-хорстове. Прояви на склонови процеси и някои минерални извори са свързани с Витошката разломна зона. Негушевският разлом е също надлъжен, но лежи в северната контактна зона на грабена. Чепанският, Софийският малопланински, Мургашкият блок-хорстове намират място северно от Софийския грабен. Локални изяви на склонови процеси маркират и тази разломна зона. Редица разломи със СИ-ЮЗ, С-Ю и И-З посока пресичат грабена и прилежащите към него хорстове. Някои разломи и разломни пресечки са във връзка с минерални извори и лежат вътре в пределите на Софийския грабен. Вертикални и хоризонтални разломни движения, склонови процеси и специфичното пространственото разпределение на минералните извори указват за съвременната подвижност на грабена.

Земетръсните прояви в изследваната територия са значителни. Софийското земетресение от 1858 г. с M=6.5 (Solakov et al., 2001) представлява максималната им документирана изява. Последното местно земетресение, причинило значителни повреди, е това от 1917 г. Неговата магнитуда е M=5.1.

В Софийския грабен съвременните движения, вкл. сеизмичните, създават проблеми за обществото, геоложката околна следа и културното ни наследство.

Старинните Драгалевски, Кремиковски и Сеславски манастир са построени и реконструирани преди, по време и след периода на турското владичество. Някои от реконструкциите им са предизвикани от сеизмични движения. Драгалевският манастир е върху доста стръмния северен склон на Витошкия хорст и в близост с пресечка на активни разломи. Той е бил реконструиран след Софийското земетресение от 1917 г. Кремиковският манастир е в южния склон на хорста на Софийска Мала планина и отново е много близко до кръстовище на активни разломи. Той е реконструиран след Софийските земетресения от 1553-1558 г. и след тези от 1818 г. и 1858 г. Сеславският манастир е в южния стръмен склон на Мургашкия хорст и до споменатото за Кремиковския манастир разломно кръстовище. Манастирът е бил реконструиран след земетресенията от 1818 г. и 1858 г.

Трите манастира са разположени в територии със значителна сеизмотектонска активност. Те са в близост със пресечки на разломи и лежат в често включващи се в сеизмични движения блокове. Около тях е налице концентрация на епицентри на земетресения. Сеизмотектонската опасност е значителна. По паметниците е имало сеизмични щети в миналото. Очакват се такива и в бъдеще.