



## Geological hazard for several cultural monuments in Albania and Bulgaria

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### Introduction

The both Balkan countries possess a great number of cultural monuments. The monuments mark the long-term development of the civilization in the SE Europe. The cultural monuments have national and world significance. A number of monuments take part in territories with considerable faulting and intensive recent processes. The latter include block fragmentation, seismic events, landslides, rockfalls etc. The studied monuments are situated in localities with increasing geological hazard.

### Cultural monuments and their studies

The both countries possess cultural monuments from the Thracian and Illyrian periods, from the ancient Greek and Roman colonization of the Balkan Peninsula, from the creation of the Byzantine Empire and its influence in the surrounding territory, from the development of the Albanian and the Bulgarian States. Only small part of them is a subject of the research.

The monuments are of great significance for the cultural tourism in Albania and Bulgaria. They have importance for the cultural history of the Balkan Peninsula. They need various studies. The participation of the geologists and the architects in the research is of importance for the assessment of the natural and the man-made situation. Moreover, these investigations support the enlargements of the geological knowledge. The common research of geologists and architects is applied for the scientifically based protection of the cultural heritage. Our accent is put on the geological analyses.

### Albanian monuments — subjects of geological studies

The geological studies are made in a great number of ancient and mediaeval monuments. Two of them take part on the Adriatic coast of Albania. They are

the Amphitheater in the town of Durres (1<sup>st</sup>–4<sup>th</sup> centuries A.D.) in the Middle Albanian coast and the Lead Mosque of the town of Shkodra (18<sup>th</sup> century) in the Northern Albanian coast. The investigated monuments are in sites with different coastal relief. The Amphitheater of Durres lies on a hilly part of the coast. The Lead Mosque is constructed in a low plain of the coast.

### Albanian cultural monuments and their geological investigations

The Amphitheater of Durres was created in 98–117. It is one representative construction on the coast. The Amphitheater is a heritage from the Roman period. It represents an asymmetrically high construction. Its forms depend from the configuration of the hill. The western part of the Amphitheater is higher than the eastern one. The walls of the constructions are solid and very thick. The Amphitheater proposes seats for 15000–20000 persons. During 391 occurred the cruelest spectacles in it. During the 16<sup>th</sup> century Skenderberg visited this monument. Several centuries the Amphitheater was buried. In 1966 the archaeologists discovered the Amphitheater. Now it is included in the tourists' cultural program. The Amphitheater is opened for visitors. Numerous tourists visit it.

The Amphitheater is placed in a segment of the contact of the Adria Plate with the Euro-Asian Plate. Many longitudinal (NW-SE) faults and some (NE-SW) ones cut the Adriatic coast. In the Durres area the longitudinal faults are better represented. The 345 Durres earthquake caused destructions in the locality. The 1926 Durres earthquake (M=6.2) provoked also destructive effects. The Amphitheater was built on Pliocene siltstone deposits. It received a number of fractures. The fractures are concentrated mainly in the western part of the construction. They cut the basement as well. In the western part of the Amphitheater the configuration of the hill per-



Fig. 1. The fractured Roman Amphitheater of Durres (1<sup>st</sup>—4<sup>th</sup> centuries A.D.)



Fig. 2. The subsided and flooded Lead Mosque of Shkodra (18<sup>th</sup> century)

mits the development of slope processes, mainly landslides. The main deformation of the Amphitheater is as a result of the faults, seismic events and the activation of the slope processes (fig. 1). Now the construction is partially subsided as a result of earthquakes and landslides.

The Lead Mosque of the town of Shkodra (18<sup>th</sup> century A.D.) is situated on the Northern Albanian Adriatic coast. The construction was very representative and heavy (fig. 2). It is in close vicinity with the Adriatic Sea, the Drin River, the big Shkodra Lake and the Albanian Alps. Now the Mosque is subsided and partially flooded (fig. 2). The Mosque could not be used.

The site for the Lead Mosque is not well selected from the geological point of view. The Mosque is built on Quaternary alluvium. It is situated in a sector of the Albanian coast where the transversal faults are the most respectable. The local subsidence is a result of the significant activity of the Shkodra fault

zone (NE-SW) and several local earthquakes (fig. 2). A lot of destructive earthquakes are registered in the area. The local 1905 Shkodra earthquake ( $M=6.6$ ) and the regional one, the 1979 Albanian-Montenegro border area earthquake ( $M=6.9$ ) are among them. These seismic events caused damages in the territory of the town of Shkodra, including the Lead Mosque, and the adjacent territory.

### Geological interest for several Bulgarian monuments

The studies are made mainly in the territory of the Sofia City and the SW Bulgaria. There are a lot of old monuments with a great significance for the Bulgarian, Balkan and world history and culture in the Sofia region and in the SW Bulgaria. Now, three monuments will be the subject of study and interpretation. They include ancient and generally mediaeval monuments. The studies are made in the St. Sofia Church (6<sup>th</sup> century A.D.), the Boyana Church (11<sup>th</sup> century A.D.) and the Rila Monastery (10<sup>th</sup> century A.D.).

### Geological investigations of Bulgarian monuments

The Bulgarian experts make investigations for the geological conditions in the areas of St. Sofia Church (6<sup>th</sup> century A.D.) and the Boyana Church (11<sup>th</sup> century). The both monuments are placed in the recent active Sofia graben (Matova, 2001). The first church was built in the central part of the graben and the second — in its southern periphery. The both monuments are placed near a fault structure. The Boyana Church is near a sector of the Vitosha fault zone that was strongly activated during 1858 Sofia earthquake ( $M=6.5$ ). The Rila monastery (10<sup>th</sup> century) is situated in a complex block structure with the same name. This structure participated in numerous local and regional seismic events, including the destructive 1904 Kroupnik earthquake ( $M=7.8$ ). The three investigated monuments (fig. 3) are placed in territories where the seismic intensity could reach up to IX degree in 1000 years according the Code for Engineering Construction in Seismic Active Regions (1997).

St. Sofia Church (6<sup>th</sup> century A.D.) is a very representative construction with high historical value. In the 14<sup>th</sup> century it gave the name of the City. Only during the Turkish domination the church was transformed in a mosque. The 1858 Sofia earthquake provoked the correction of this transformation.

St. Sofia Church is in middle part of the Sofia complex graben. The graben has Neogene-Quaternary evolution and supplementary block fragmentation. It is in a territory with high seismic hazard (fig. 3). During 1858 Sofia earthquake ( $M=6.5$ ) the seismic deformation of the graben was the most impressive (Solakov et al., 2001). It destroyed one of the mosque

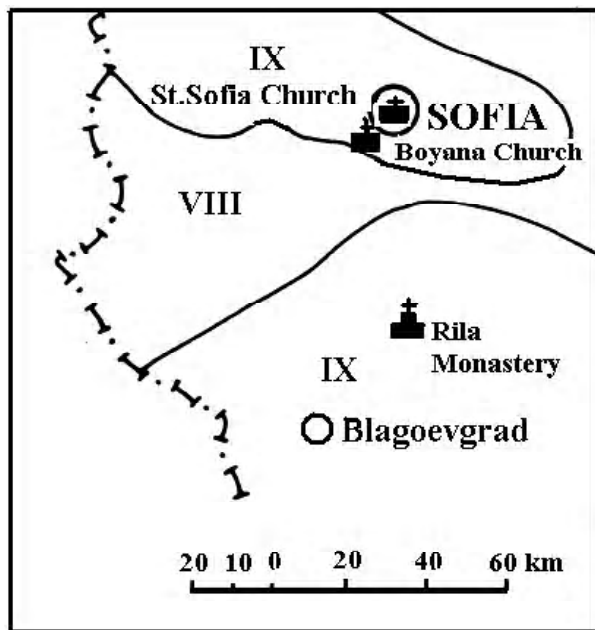


Fig. 3. Possible seismic effects in the studied Bulgarian monuments during 1000 years period (Code for Engineering Constructions in Seismic Active Areas, 1997)

minarets and killed persons. After the seismic event the transformed in mosque church was abandoned. At the beginning of the 20<sup>th</sup> century it was restored again in an Eastern Orthodox Christian Church. The destruction effects in the St. Sofia Church are related to the faulting and the block fragmentation of the Sofia graben as well as to the seismic activity of the graben territory (fig. 3).

The Boyana Church (11<sup>th</sup> century A.D.) is a monument with high significance for the country. During 11<sup>th</sup> century it was a church in one of the numerous strongholds in the Sofia region. During 13<sup>th</sup> and 17<sup>th</sup> centuries the church was enlarged and significantly reconstructed. During 11<sup>th</sup>, 13<sup>th</sup> and 19<sup>th</sup> centuries the church was painted. The painting of the church from the 13<sup>th</sup> century represents the beginning of the Renaissance development in the country. The murals of the Boyana Church are estimated like a new realistic living stream in the Byzantine liturgical canons. They include new humanistic tendencies in the mediaeval arts and relations with the contemporary life of the Bulgarians (Hristova, 1994).

The Boyana church was built in the Vitosha fault zone. The fault zone is recent active structure with considerable seismicity (fig. 3). Moreover, the church takes part at the foot of the northern steep slope of the Vitosha horst. It is a territory of intensive proluvial-deluvial fans development and local manifestations of slope processes. The church lies on one of these fans. There are manifestations of landslides and rockfalls along the steep mountain slope. The position of the church in a territory with intensive

recent dynamics and unstable basement is the reason for its numerous reconstructions.

The Rila Monastery (10<sup>th</sup> century A.D.) is situated in the highest Mountain of the Balkan Peninsula. It is the most respected monastery with respect to the power and population. The monastery receives numerous donations. It possesses a rich museum with documents for its long-term development. The construction and reconstruction activities of the monastery are numerous (Bozhilov et al., 1997). Only the Tower of Hrelyo (14<sup>th</sup> century) has not any transformations. During the Turkish domination the Monastery was the most important centre for the education, the cultural development and the diplomatic relations of Bulgaria.

The Rila Monastery was constructed in seismic hazardous region (fig. 3). There, the local earthquakes are numerous and the regional seismic events rich  $M > 7.0$ . The 1904 Kroupnik earthquake provoked partial destructions in the monastery. The construction is placed on the Quaternary sediments of the Rila River terrace. Its basements were put in the alluvial and proluvial coarse sediments, also in cultural layers. The alluvial and the proluvial sediments include intercalations of plastic clays. The monastery is situated in very close vicinity with the steep slope of Rila Mountain. The adjacent mountain slope and the lithology of the Quaternary layers permit the development of slope processes. The seismological data for the region, the local steep mountain slope and the unstable terrigenous sediments with plastic intercalations in the monastery basement cause the increase of geological vulnerability of the locality. The regional seismicity and the local slope processes create constant hazard for the monastery.

## Conclusions

Numerous geological processes (mainly tectonic and gravity movements, earthquakes) in the areas of the cultural monuments need studies. The recent bilateral Project of the Bulgarian and the Albanian Academies of Sciences "Geological danger for cultural monuments in the regions of Tirana-Shkodra (Albania) and of Sofia (Bulgaria)" supports this research. The investigated processes create hazardous situation for a part of the monuments. The geological research contributes the works related to the protection of the cultural heritage.

The studies of the cultural monuments propose very interesting information for the effects of different geological processes to the constructions. They give also data for the reaction of various elements of the monuments during the natural events.

The both kinds of information are based on the occurred events, but they have a potential to be introduced in the geological prognoses. These kinds of information contribute to reduce the geological vulnerability of the cultural monuments. They could be applied in the activities for the conservation and the protection of the cultural monuments.

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## Геоложка опасност за няколко културни паметници в Албания и България

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**Резюме.** Двете Балкански страни притежават голямо количество културни паметници. Паметниците бележат продължителното развитие на цивилизацията в ЮИ Европа. Културните паметници са с национално и световно значение. Част от паметниците (Римският амфитеатър на Дурес, Оловната джамия на Шкодра в Албания, църквата „Св. София“, Боянската черква и Рил-

ският манастир в България) са в територии със значително разломяване и интензивно протичащи съвременни процеси. Съвременните процеси включват главно блоково раздробяване на територията, сеизмични явления, свлачища и срутища. Изследваните паметници са разположени в локалитети с нарастваща геоложка опасност.