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GEOENVIRONMENTAL PROBLEMS FOR THE WORLD CULTURAL HERITAGE IN NORTH-EAST BULGARIA

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ABSTRACT. The geoenvironmental conditions in North-East Bulgaria are various. They are a result of continuous development in a sector of the Eurasian Plate periphery where the geological processes occur intensively. The national cultural heritage in NE Bulgaria is rich. It includes mainly pre-Thracian, Thracian, Greek, Roman and Bulgarian monuments and their relicts. There are three very representative monuments in this part of the country. They are the included in the List of UNESCO for monuments with world importance. They are the Madara Horseman, the rock-hewn Monasteries of Ivanovo and the Thracian tomb of Sveshtari. The cited monuments of the world cultural heritage are in territories with argued or supposed geological dangers. The knowledge for the geological conditions of the three significant monuments is of importance for their protection.

Introduction

Bulgaria has numerous recent active structural units and one relatively stable one – the southern part of the Moesian Platform. The NE Bulgaria is a part of the Moesian Platform and is partially in the Transitional zone between the Platform and the Fore-Balkan structural zone. To the East and South NE Bulgaria is surrounded by active structural units of the Black Sea Depression and the Balkan folded system. They create real and potential danger in the relatively stable territory of the Moesian Platform.

The Bulgarians have very long and rich history in Asia and Europe. Traces of numerous civilizations are to be founding Bulgaria and they have an impact in our culture. When the Bulgarians settled in the Balkan Peninsula they met the resistance and the help of a great number of people with different origin, including these from the powerful Byzantine Empire. The Bulgarians also found highly educated people in the territory of the Peninsula. The Bulgarian culture is a result of the specific interrelation of numerous achievements in the Asian and the European continents.

Geological data

Bulgaria is situated in a limited sector of the Southern periphery of Eurasian Plate. This sector is a part of the contact zone of Eurasian and African plates. It is a place of collision of both plates. The contact position of Bulgaria is the cause for its significant geological heterogeneity and its intensive geodynamic development. The territory is fragmented to large number of blocks (Fig. 1).

The main structural units in Bulgaria show recent activity. In general, they are finally formed during the Alpine period – in the Neozoic. The geological mobility of the different structural zones varies in wide intervals. The block fragmented structural units participate in contemporaneous horizontal and vertical block movements but with specific intensity (Fig. 1).

The tectonic movements are limited in the Northern part of the country where is the relatively stable Moesian Platform. There, the most important development of faulting and folding occurred before the beginning of the Mesozoic. The Alpine folding and the faulting in the neighbour active structural units provoke several small deformations in the territory of the Moesian Platform. The deformations are limited in their spatial distribution and intensity of manifestations. In these conditions the Neozoic deformation events in the Moesian Platform represent a surprise. The Platform deformations are expressed generally in the faulting, the fracturing and rarely in locally distributed folding. The tectonic movements in the Southern surrounding of the Moesian Platform, where the Transitional zone is situated, are not very considerable as well. The conditions are almost similar to the conditions in the Platform.

The Moesian Platform and the Transitional zone are cut by faults and photolineaments. They are with longitudinal, transverse and oblique orientations. The faults and the photolineaments limit blocks with particular participation in the vertical and the horizontal movements (Fig. 1).

The Moesian Platform and the Transitional Zone are covered by sediments where the unconsolidated rocks are dominant ones. In them the loess and the clay layers are well represented. A part of the layers is in inclined position as a result of the relief peculiarities and the tectonic movements.

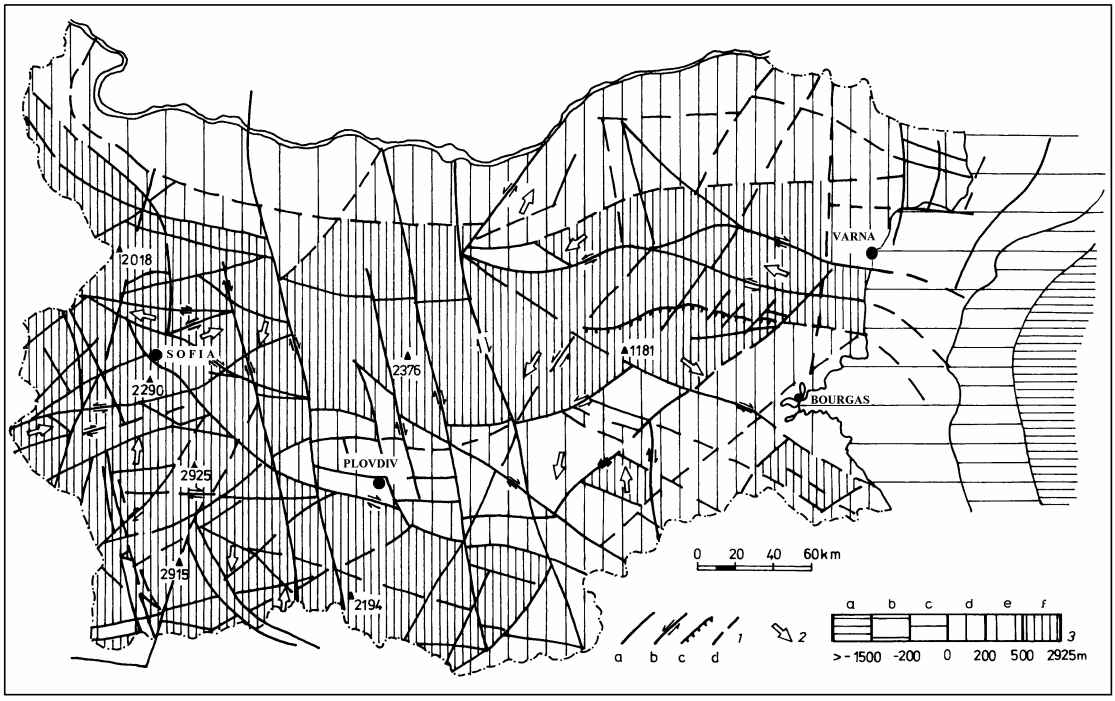

Fig. 1. Scheme for the general block fragmentation and the horizontal and vertical block movements in Bulgaria: 1 – fault and photolineament: a – well noted fault and photolineament, b – strike-slip fault, c – reverse fault and nappe lines, d – unsurely noted fault and photolineament, 2 – direction of horizontal block movement, 3 – vertical movements in indicated intervals of height

Geoenvironmental problems

The Moesian Platform and the Transitional zone represent vulnerable territory for various recent geological events. Most of the recent geological phenomena is of natural origin (Matova, 2000). The occurred dangerous geological phenomena are numerous. The earthquakes and the slope processes create the biggest danger for the NE Bulgaria. The faulting, the fracturing, the karstification, the weathering and the erosion have additional importance for the increase of geological vulnerability of the studied area. *The local earthquakes* occur without fixed frequency. Their epicentres are distributed irregularly over NE Bulgaria (Fig. 2). The earthquakes are very often weak, sometimes – moderate and rarely – strong. There are historical and contemporary strong seismic manifestations with epicentres in the studied NE Bulgaria. The earthquakes provoke directly or indirectly destructive effects and human losses.

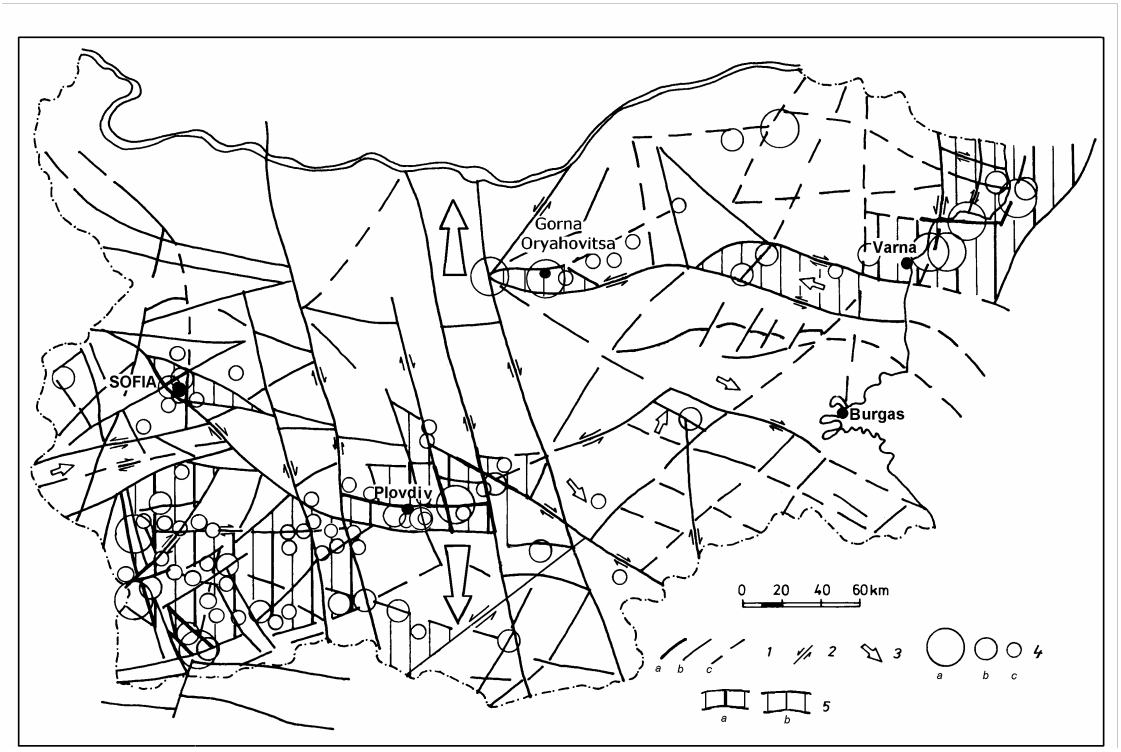

Fig. 2. Earthquake epicentre distribution in the country: 1 – fault and photolineament, a – very well noted one, b – well noted one, c - unsurely noted one; 2 – strike-slip fault; 3 – direction of horizontal block movement; 4 – earthquake with following magnitudes M, a – M≥7.0, b – M=5.0-6.9, c – M=3.0-4.9; 5 – blocks with significant concentration of epicentres, a – with biggest one, b – with big one

The regional seismicity has also great significance for NE Bulgaria. The earthquakes in the Black Sea and in the surrounding countries cause important seismic impact and sometimes destructive effects. Mainly the strong and often repeated intermediate deep earthquakes in Vrancea region (Romania) provoke considerable danger of changing the geoenvironment and the social life in the NE Bulgaria. The seismic events in the Black Sea and in the Marmara area (Turkey) cause different destructive influence. A number of local and regional earthquakes are related to losses of human lives, of personal and state constructions, of destructions in the cultural monuments and of changes in the geological environment. Finally they induce considerable financial losses of the state.

The slope processes are also well manifested in NE Bulgaria. They take place mainly along the Black Sea coast and the adjacent peripheries of the hills, mountains and plateaus. The rock characteristics, the slope inclination, the recent dynamics and the climatic conditions are among the most significant factors that provoke the appearance or the frequent mobilization of landslides, rockfalls and earthflows. Numerous manifestations of the slope processes are also cause for human losses, for the almost non-stop reconstructions of the transport systems (Fig. 3), for destroyed houses, monuments etc. They create crucial financial losses because the occurrences of the cited phenomena are frequent and in a number of localities. In a lot of cases the landslides, rockfalls and earthflows take place along the Black Sea coast. They need special studies and good reconstruction works

Fig. 3. Landslide in the surrounding of Varna City that destroyed the highway between the City and the resort Golden Sands

The faulting, the fracturing, the weathering, the erosion and the karst phenomena provoke considerable changes in the rock characteristics. They change the volume, the form and the density of the rock massifs and blocks. They create new ways for the water penetration in deep levels of the rock monoliths. They cause changes in the mechanic, physic, chemical and geological characteristics of the rocks. The faulting, the fracturing, the weathering, the erosion and the karst phenomena of the rocks provoke the decrease of the primary block stability. Very often they are related to manifestations of destruction in the inner parts of rock massifs or in their peripheries. In several cases the man-made constructions, including the monuments, are partially or totally destroyed.

Technogenic complications for the geoenvironment

A limited part of the geological phenomena have technogenic or combined geological-technogenic origin. The technogenic or the combined geological-technogenic manifestations represent man-induced phenomena. In the man-induced phenomena the human participation reaches different degrees.

The technogenic impact of our society over the crust is considerable and its influence increases. Its effects must be taken in account as well. Various collective activities provoke significant changes in the superficial part of the crust. These activities include various works in the mines, the artificial lakes for the power stations and the metallurgical works, the tunnels, the underground transport systems etc. Sometimes individual actions in different regions provoke supplementary changes in the geoenvironment. For example, numerous small summer houses are built in areas with interdiction for construction. Sometimes these houses have no officially approved plans and they do not possess any draining system. In above cited cases the social and the individual works cause geoenvironmental problems. The negative effects of these man-made problems are manifested in short- or long time periods. They change the geoenvironment. They have possibilities to provoke destructive consequences in the technogenic cover of the country, including the monuments with national and world significance.

World heritage monuments and the geological dangers for them

"Madara Horseman" rock bas-relief

The monument (IX c.) is situated to the South of Madara village and in the surrounding of the town of Shumen. Several most important events from the Bulgarian history on the Balkan Peninsula are symbolically expressed in the rock bas-relief. Short historic notes are included in the monument. The notes explain the symbolic figures on the monuments with information for several events with successful Bulgarian participation. These events confirm the importance of the Bulgarian State on the Balkan Peninsula. They represent very important help to the Byzantine Empire by the Bulgarian Kings and State. The Madara Horseman rock monument is the first highly representative monument in the country (Fig. 4). A significant peculiarity of the Madara Horseman rock monument is that it combines cultural traditions of Asia and Europe. The obtained synthesis of cultures of two continents causes the appearance of the first rock bas-relief monument in Europe. Now Bulgaria and Europe are proud of them.

The Madara Horseman bas-relief is cut in the Transitional zone – in the NW periphery of the Madara Plateau. The monument is situated on a steep rock slope. It is visible from the ancient capital of Bulgaria – the town of Pliska. The monument is cut into a relatively monolithic block of Upper Cretaceous sandy limestone. In this block there is a reduced quantity of fractures. In the long-time history of the monument the constant geological processes provoke partial destructive effects. Slowly manifested weathering, erosion, slope processes and karstification, and also rapidly occurring faulting, fracturing and earthquakes have influence over the Madara Horseman.

Fig. 5. The "Madara Horseman" rock bas-relief (IX century)

The distance from the epicentre of the 1892 intermediate deep Dulovo earthquake (M 7.3) is about 60 km, the same from the 1901 Shabla earthquake (M 7.2) – 160 km and the distance from the many time repeated strong intermediate deep Vrancea earthquakes (M≥7.0) – 280 km. All of the mentioned processes are related to progressively increased changes of the surface of the bas-relief. Several very dangerous for the monument stability slices are developed behind the surface of the bas relief. Their appearance is a result of the slope processes or combination of slope processes and weathering, the erosion and the karstification, but also the faulting, the fracturing and earthquakes (Matova, Frangov, 2001).

Now, as a result of weathering and erosion, the figures of the bas relief have smaller depth. The inscriptions for the historical events could be very difficultly to read. Two long vertical fractures cross the monument surface. The faulting, the fracturing and sometimes the earthquakes create very serious problems for the protection of the monument. The fracture displacement of the rock monument is a subject of more than 15 years monitoring research of Czech-Bulgarian team of experts. The displacement measurements are made on the basis of 3-D gauges of the extensometer TM-71 that is a Czech production. The values of the displacements are registered regularly. The monitoring data shows that the normally demonstrated fracture movements are of value 1-5 mm/y. The abnormal and extreme values of the displacements are established only as a result of earthquake events. The 1999 Izmit (Turkey) earthquake (M=7.4) and its aftershocks provoked the most representative values of 1-5 cm/y fracture displacements (Matova et al., 2001). The weathering, the erosion and the karstification destroy the monument slowly and without stops. The faulting, the fracturing and the earthquakes provoke very rapid deformations of the Madara Horseman bas-relief.

Ivanovo rock-hewn Monasteries

The Ivanovo rock-hewn Monasteries (XIII-XIV c) are situated at 20 km to the South of Rousse City. The monuments are on the slopes of the Beli Lom River (Fig. 6). The Ivanovo rock Monasteries are cut into the middle part of vertical slope above the river valley. Their position is about 30 m above the slope foot. The monasteries are placed between the first,the second and the third capital of the Bulgarian State, respectively between the first two capitals of Pliska and Preslav to the SE, and the third capital, the town of Veliko Tarnovo to the SW. The monasteries represent part of the so called "Bulgarian rock Aton" in NE Bulgaria. The Ivanovo Monasteries include various and very interesting constructions that are decorated by magnificent murals. They are among the significant masterpieces with which the period of Renaissance was marked in the Mediaeval Bulgaria.

The monasterieses are created in calcareous massifs of the Moesian Platform. They are in the Lower Cretaceous limestone of the Rousse formation. The Rousse formation is of Hauterivian-Aptian age. The Aptian sediments are mostly distributed in the locality of the Ivanovo Monasterieses. The limestone is mainly organogenic, including biomorphic, detritic, orbitolinic and oolithic variations. The cementation of the sediments is moderate. The silicificated limestone are rarely represented. Certain very thin layers of sand-gravel sediments are observed only locally. The thickness of the formation is usually of several hundreds meters. The limestone is with karst manifestations. The karst niches, cavities and caves are very well represented. They are used for the creation of the attractive rock monasterieses.

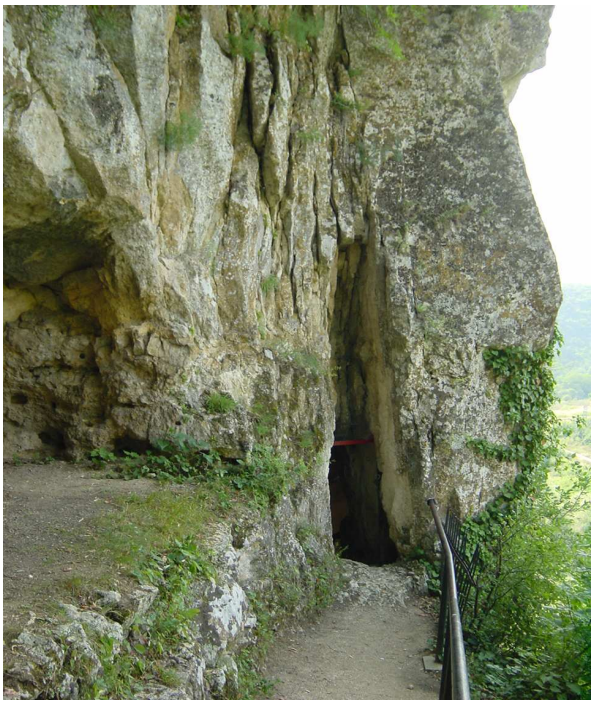

Fig. 6. The slope with one of Ivanovo monuments

The Ivanovo rock monasterieses are situated in a relatively moderately deformed region of the Moesian Platform. Photolineaments and faults with NE-SW and NNW-SSW directions (Matova, Gočev, 1977; Katskov et al., 1985) are well represented in the surrounding of the locality. Fractures with the above mentioned fault orientation, also with subequatorial direction cut the rocks of the monasteries.

The Ivanovo Monasteries support the influence of strong regional earthquakes. Numerous and periodically repeated Vrancea intermediately deep earthquakes (Romania) with magnitude M≥7 have the epicentres in a distance of 210-240 km from the investigated monuments (Brankov, 1983). The epicentre of the 1892 Dulovo intermediate-depth earthquake (M=7.3) is at a distance of 100 km from the investigated locality. The strong crust earthquakes, the 1901 Shabla one

(M=7.2) and the 1913 Gorna Oryahovitsa one (M=7.0), which epicentres are respectively at distance of 210 and 70 km, are also dangerous for the monuments (Grigorova, Grigorov, 1964). The regional seismicity is related to various destructive effects in the Ivanovo Monasteries. During the XIX and XX c. the local earthquakes are of magnitude M<5.0. Their influence on the locality of Ivanovo rock Monasteries is very limited. The seismic movements, mainly the strong ones, provoke slope processes. The rockfalls are among the well represented manifestations in the locality.

The lithological and the tectonic characteristics of the locality create problems for the protection of the monuments. The monasteries are placed in the moderately cemented limestone, that are attacked by weathering, erosion and karst processes. The monuments are situated in block fragmented territory. They are in a locality with very big influence of periodical and frequent manifestations of seismic activity in the Vrancea region to the NNE and of the rare and strong seismic movements in the Shabla-Varna area to the ESE and of the Gorna Oryahovitsa foyers to the SSW.

Thracian Sveshtari tombs

The Thracian Sveshtari tombs (V c. BC) are situated in the vicinity of the Sveshtari village (Razgrad District). The tombs are built in a plain territory that is cut by dry valleys. The tombs represent stone-masonry constructions covered by artificially placed terrestrial embankment. These ancient constructions are very representative and with very attractive sculptural decorations.

Fig. 7. Thracian Sveshtari tomb

The Thracian tombs manifest the presence of a very high Thracian culture in the Balkan Peninsula. Here the art achievements show also influence of the Greek civilization. The monuments are placed in the Moesian Platform. The local rocks are represented by Lower Cretaceous limestone and Quaternary loess. The limestone is fractured and karstified. The Quaternary loess is the basement of the tombs. It is important to underline that the rock basement of the monuments includes rock layers of contrast density, stability and wave resistance.

The earthquakes create the most significant danger for the Sveshtari Thracian tombs. The tombs are at 20 km from the epicentre of the 1892 Dulovo earthquake (M 7.3), at 150 km from the epicentre of 1901 Shabla earthquake (M 7.0) and at 180 km from epicentres of the frequently activated Vrancea foyers. The seismic impact is very serious for the monument. In these conditions the strong earthquakes of the Vrancea region have significant role for the instability of the tombs and their destruction. Now the stone funeral chambers, the sculptures in the chambers, the passages and the entrances are fractured and deformed. The destructions are with various intensities. In several places there are total destructions. The damages in the monuments could be related mainly to the manifestations of the local and the regional seismicity.

Conclusions

The studied monuments provide important information for the development of various highly developed civilizations in the Balkan Peninsula. Several civilizations existed before the settlement of the Bulgarians in the Balkan lands. Others of them are evaluated together with the Bulgarian participation or they are as a direct result of Bulgarian influence. The cultural heritage is rich, instructive and attractive. The geoenvironmental conditions of the studied monuments are different. In most of the cases, especially for the Madara Horseman bas-relief and the Ivanovo rock-hewn Monasteries, the weathering, the erosion and the karstification in a combination with earthquake danger create the main problems for their protection. In other cases, in particular, the Sveshtary Thracian Tombs, the seismic influence is mainly related to the monument destructions. The geoenvironmental knowledge is very significant for the different activities related to the safety of the historical monuments that are world and national cultural heritage.

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