

Geocological problems and hazards of the Bobovdol coal mine (Bulgaria)

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The Bobov Dol coal mines are situated in the Bobov Dol graben (SW Bulgaria). The coal is produced in 5 underground and one open-pit mine. The graben is a part of the Kyustendil-Saparevo kettle group. The Bobov Dol graben was formed in its contemporary shape during the Quaternary between the Konyavo mountain, the Gola-glava heights and the Pogled mountain. It was separated from the Saparevo kettle by the Razmetanitsa horst. The average altitude is 830 m. The graben is drained by the Bobov Dol, Babinska, Razmetanitsa and other smaller rivers that mouth in the Dzherman river. All the settlements situated in the area (Bobov Dol, Babino, Golyama Foucha, Mlamolovo, etc.) represent an indivisible part of the Bobov Dol coal basin in an economic-geographical aspect.

The relief is hilly, incised by deep steep ravines. The greater part of the territory of the Bobov Dol graben has actual slopes of the topographic surface of up to 10°. Terrains with slope values exceeding 35° are observed too (the contemporary erosion incisions, the landslide regions, the close to the faults regions and the contact areas to the mountain morphostructures). The values of the vertical relief dismembering are 100-200 m/km² and the erosion dismembering is within the range of 1.5 to 2.0 km/km². The relief of the Bobov Dol kettle was formed on Palaeogene sediments. It is represented by Plio-Pleistocene levels and terraces (100-200 m), a river-terrace complex (0.50-5 m, 8-12 m, 22-25 m, 30-35 m, 44-50 m, 55-60 m), as well as by gravitation (landslides, rock-falls), erosion (surface and linear), complex and technogenic forms. The development of the relief and its dynamics depended on the geological-

tectonic development during the Neogene, the Quaternary and the contemporary stage and on the technogenic activities. It was formed as a negative tectonic structure as a result of the Late Alpine extension, when it was filled with continental molasses of Oligocene - Lower Miocene age. The continental molasses were folded during the Middle Miocene due to bilateral compression. The Quaternary stage was characterised by a radical change and varying conditions of compression and extension in the different parts of the graben. As a result, its contemporary outlook was formed. The total value of the Quaternary vertical tectonic movements was 120-150 m for the kettle area and more than 200-250 m - for the peripheral parts. Earthquakes with intensity of 7th degree had been established in the investigated region.

The relief in the Bobov Dol graben is strongly anthropogenised as a result of the mining activities. The large contrasts between the sections with a relatively preserved primary relief and these affected by the mining operations, as well as the complex geological-tectonic circumstances, are the reason for the instability of the morphodynamic processes.

The erosion, gravitation, tectonic and accumulative processes are the most intensive from the related to the mining activities ones. Ravines and gullies represent the erosion processes in a different phase of development. The depth of contemporary erosion incision exceeds 40 m. The landslide and landslide/rock-fall processes and phenomena are of considerable importance for the region and its surroundings. They are of tectonic and erosion-tectonic type. The landslides along the left bank

of the Grebikal river are of the erosion-tectonic type and are related with the stage development of the relief. The landslides near the Bobov Dol railway station are of the same type but they were formed at the Holocene-Pleistocene boundary. Many of the landslides in the investigated region occurred during the Middle Pleistocene when two landslide terraces were formed. The mentioned processes are extremely dangerous during the performance of the mining activities. One of the most disastrous operation accidents in Bulgaria with human losses happened here during the last years due to underestimation of the specific stressed state of the massifs. They have complexly formed sliding surfaces. Due to the complex geological circumstances and favourable geological environment, these surfaces are situated in the Quaternary at the contact between the Quaternary and Palaeogene sediments, in the spaces between the single formations or in the coal horizons. The sliding surfaces are between 6 and 20 m in most of the cases. Most of the old landslides were technogenically activated as a result of the mining operations (surface and underground ones) and the construction of communication networks.

The territory of the Bobov Dol coalmine basin is characterised by a strong anthropogenic impact. For this reason the primary relief has a strongly changed outlook. Construction (architectural), embankment, excavation and other surface and underground types of complexes have been developed. The concentration of human and technical potential has led to the increased areas with residential, communication and industrial structures. This caused the hampered and ceased development of the natural morphostructural and morphosculptural processes and phenomena.

The natural hydrological and hydrogeological connections were disturbed (in the form of enhanced erosion, slope terraces, etc.) due to the mining activities. The dense ravine-gully

system is dry almost all the year round. The module of the constant river outflow is 2-6 dm³/s/km², the turbidity is between 500 and 3000 g/m³, the water hardness - 8.4-12.6 German degrees and the mineralisation - 300-400 mg/dm³. The landslides have additionally interrupted the aquifer levels, so that no constant underground outflow could be created. The unstable hydrological connections make the mining activities more complicated and cause many operation accidents in the mines. The soils and air in the mining region and its surroundings are considerably polluted. The vegetation and the soils are not only polluted but are significantly altered too.

The Bobov Dol graben has a markedly resource outlook with a negative balance between the natural and the technogenic impact factors. The performed complex assessment of the natural and technogenic environmental disturbances shows that the investigated territory is an "average favourable" one with respect to ecologically conformable life. It is also an "average favourable" one for carrying out construction and mining work, i.e. additional measures should be applied in it on terrains of average engineering complexity. According to the accepted strategy for the development of coal mining in Bulgaria, the gradual closure of most of the mines and the intensive development of the mine "Babino" with an output of about 2 million t/a is envisaged. The complicated natural and technogenic circumstances, the dangerous operation accidents with human losses and the liquidation of some of the mines, created conditions of social-economic stress in the region. Regardless of the mine closure, additional activities should be performed for the safety of the terrains since considerable subsidence and collapse events are observed. The development of territorial-arrangement plans and social-economic strategies is necessary in order to recover the terrains and to remove the social stresses.