

GEOLOGICAL, CLIMATE AND ANTHROPOGENIC PREREQUISITE FOR PROCEEDING OF EROSION PROCESSES ON THE TERRITORY OF MADZHAROVO CALDERA

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Abstract

The combination of the climate elements, the lithological characteristics and the active mining activities in the vicinity of Madzharovo are prerequisites for intensive denudation processes. As a result, material from the adjacent territories is periodically exported and part of them are transported to the lowest part of the caldera - the valley of Arda River.

Measures are needed to improve the state of the partial catchments of the Arda river, which will gradually reduce the amount of solid outflow to Ivailovgrad dam.

Keywords: Madzharovo, climate, erosion, disturbed terrains, embankment, alluvium

1. INTRODUCTION

The erosion is a complicated natural phenomenon, which activity requires appropriate combination of geology, topography, climate and anthropological factors.

On the area of Madzharovo caldera (Eastern Rhodopes, downer part of Arda river.) the interconnection between them creates a prerequisite for intensive erosion, often accompanied by processes of land collapse.

The climate in the area is defined as a combination between trans-continental and trans- Mediterranean (semi-Mediterranean climate). The precipitation is with autumn-winter maximum. Typical for the region are torrents rainfalls. They are extremely dangerous, especially when they coincide with periods of snow melting. In these cases, the hydrographic network focuses water masses with huge kinetic energy causing extreme erosion.

Depending on their origin and minerology, the rocks which build the walls of the caldera have different denudation resistance. As a result, a varied and highly intersected relief was formed in the area. Andesites and Riolites strongly stand out against the background of the surrounding terrain due to their harder substrate and contribute to the specific morphogenetic appearance of the area. After mechanical disintegration they form basically colluvial-scrree wreaths or loops from rock deposits. The sedimentary rocks - paleogene tuffs, tuffs, sandstones and marls - are highly resistant to erosion. They are easily crushed and transported, the end result of which is the accumulation of their bed on the Arda river.

The exploitation of valuable resources in the region has left a significant mark in the contemporary appearance of the area. It was related to closed (shaft) development of minerals. From the earth's skulls are retrieved and delivered to the surface new for the landscape materials and minerals, slightly weathered and mostly low nutrient. The formed embankments have large slopes. No measures for stabilization and biological recultivation have been carried out on them. As a result, they remain a source of large amounts of alluvium in Arda River.

2. MATERIALS AND METHODS

2.1. Object

Madzharovo (41.633260, 25.860350) is the main settlement falling within the range of the Madzharovo caldera (Arda's suburb of the East Rhodopes region) [1]. The caldera is situated in the middle stream of Arda river, east of the Studen Kladenets dam and west of the Ivaylovgrad dam. Its area is about 117 km². The main river artery is Arda River. From west to south and east to its tangent Topolovska River

and Oludere river which rounding the caldera from the north and northeast. They are characterized by an undeveloped river network, as for the most part of the year they are dry gullies. To them descend shallow and undeveloped gullies with typical torrential character. The river network in the southern part of the area is represented by Gurgendare river - the right tributary of Arda River.

2.2. Methods

There are multiple gullies and embankments on the area of the Madzharovo caldera which are source of a large amount of sediments to Arda River. It was made an overview of the available information related to the problem. The area has been a subject of investigations by many authors, focusing mainly on the lithological characteristics and region's specific climate. The present appearance of the Madzharovo caldera is also influenced by the active mining activity in the recent past.

2.2.1. Geological-morphological features of the territory

The present appearance of Madzharovo dome morphological structure territory is a result of long and complex geological development. The major part of the Rhodopian crystalline plinth within the range of Arda valley is with Paleozoic age and its base is result of Hercic orogenesis [2]. The earliest stages of the geological history of Eastern Rhodopes are difficult to explain because the metamorphic plinth of the massif is covered with Paleogene marine sediments and the associated to them formations [3]. In the morphology of these lands are preserved elements of an old relief, connected with the old tectonic stages of the development of the main morpho-structural units.

Long-term research in the eastern part of the Rhodopean mountain allowed the separation of a group of large relief forms with almost isometric shapes and a dome configuration showing high conformation to the volcanic structures formed through the Oligocene. Here are Strumniridska, Madzharovska, Spahyevska, Iranatepenska and Lozenska volcanogenic dome morphostructures [4]. During this period in parallel with the construction of volcanic positive forms accumulates abundant sediment superstructure, which at the end of the period acquires a dominant importance. During the later alpine stage of the descending development of the region, the sub-aquatic and continental relief is formed, differentiating in separate distinct positive volcanic structures and accumulative relief [5].

During the Neogene - Quaternary stage the East Rhodopean syncline has experienced epirogenic rise. The sudden change in development trends - from downer to upper direction, make a conditions for destruction of the volcanogenic relief and its defossilization. Thus, self-contained large forms of relief are separate – volcanogenic domed morphostructures with relict character, passively reflected in the contemporary relief. They are complex of orographic and geo-structural units closely connected to the last stages of the geological and historical development of these lands. From a morphological point of view, the volcanogenic morphostructures represent a combination of primary structural elements of the relief with a complex of morpho-sculptural elements, related to completely different stages of the late-alpine and neogenequaternere evolution of the East-Rhodope massif.

Madzharovo volcanogenic morphostructure is formed by the activation of a volcanic center for a relatively short period of time. Its development ends before the beginning of the upper Oligocene, as evidenced by the roof character of the sedimentary and volcanogenic rocks that fossilized it. The effusive expression was much more powerful than the explosive, with the result that the lithology involved mainly powerful spills that formed the vast shelters of Laitites and Andesites. There are many places where the volcanic materials are mixed with marls, limestone, sandstone and conglomerates.

In Neogene and Quaternary begins the formation of the present river-valley network and its cyclical digging. As a result of the selective denudation started the defossilization of the volcanic structure. At the same time the valley of Arda River started to dig. The specific of lithological characteristics determine the formation of a typical erosion caldera - valley, erosion lowering with rounded shapes in central parts of volcanic shields. The shaping of the erosion caldera was carried out under specific conditions after a long period of time after the final construction of the volcanic structure. The caldera lowering was made by a transit river and not by streams formed as a result of their primary placement within the range of volcanic shields [5].

2.2.2. Climate

Climate is an important factor for any natural-territorial complex. Its elements and their changes have a significant effect on the degree of erosion.

For the territory of Madzharovska caldera, representative climate information is provided by the weather stations in the towns of Ivaylovgrad and Krumovgrad [6; 7].

The studied area is part of the Eastern Rhodopes Mountain, where the climate impact of the Mediterranean is strongly expressed. It occurs mainly through the Mediterranean cyclones, which cross the Aegean Sea to the Marmara and Black Seas. Cyclonic activity is most pronounced during the cold months and therefore the Mediterranean climate impact over the area is better expressed during the transition seasons and winter than in the summer.

The relatively small height of the Eastern Balkan Mountains (Stara Planina Mountain) and that of the hills in Southeastern Bulgaria, as well as the wide openness of the Eastern Rhodopes from the north, make it possible to feel the influence of the cold continental air masses during some winters.

In terms of climatic zoning, the site falls into the Continental-Mediterranean climatic region, the South-Bulgarian climate suburb and the climatic region of the East Rhodope River valleys. These areas are considered to be the northernmost parts of the Mediterranean subtropical area and are characterized by much milder, rich in precipitation winter and warm, dry summers [8].

Specific for the rivers flowing through the territory of the Eastern Rhodopes and in particular through the territory of Madzharovska caldera are river springs. They increase the amount of runoff, activate erosion-accumulative processes and cause destructive floods.

This leads to rapid changes in the appearance of the affected landscapes and causes considerable damage to farms: "Because of the abundant winter rains here and the warm Aegean winds, the waters of the fast-falling snow and the torrential rains have often merged. Then there are dangerous mud streams that carry various materials, including a large blockade "[9].

Here, probably, the authors have in mind the formation of the saliva (mud-stone) streams. Besides their devastating effect, they greatly increase the turbidity of the Arda River, sometimes reaching 4000 - 5000 g/m³, which is one of the highest values for the country.

According to the same authors, in this case, not only the Arda River, but also all its smaller tributaries, are emerging: "Sometimes they form dangerous drainage waves, which as water thresholds and walls suddenly fall off the bare hillsides. Their destructive power is increased especially by the hasty rock material on the deforested slopes of the mountain. Then the level of the Arda river waters rises sharply, and the depth of the river in some places reaches 10 meters.

This is already a terrible water force that destroys bridges and houses, rocks huge trees, takes away various objects, takes victims. "The most characteristic of these parts of the Rhodope Mountains and respectively of the studied region are the rainy-snow floods. Their repeatability is established between 1,0 - 3,0 cases per year and maximum instantaneous water - up to 500-800 l/s per 1 km² [10].

2.2.3. Anthropogenic activity

Madzharovo volcanogenic dome morphostructure is interesting area because of its mineralogy and the genesis of materials. Its detailed examination in petrographic, mineral-geochemical and structural terms gave some authors basis for promoting the perception of its vertical and horizontal zonality. Gerelchev [11; 12], expresses the idea about a complex caldera development of Madzharovo volcano which reflected also in the zone of ores mineralization, which mainly looks horizontally concentric on the present erosion cut.

These studies have been made in connection with one of the most important final products of intensive magmatism in the region - its oreing. A lot of researchers define the area as a geological phenomenon. The following stages of mineralization have been identified: propylite, quartz-pyrit-chalcopryrite, quartz-hematite-chlorite, quartz-sulfide, quartz-halide-sulphosolene, carbonate, phosphate and zeolite [13]. Quartz-sulfide and quartz-chalcedone-sulphosolous stages are most varied about the mineral

composition. The first being the carrier of the bulk of sulphides of industrial interest. It is observed in most of the fields of the ore field and it is the most powerful expression of lead-zinc mineralization in the area.

When these resources are removed from the bowels on the Earth's surface, they fall into an unusual environment. Delayed chemical processes which are characteristic for the rocks in depth sharply modify the character on the surface and often accompanied by the formation of removable compounds which are toxic to a vegetation [14]. In the places where these materials have had a direct contact with natural - territory complexes by embankment or sputtering, the direction and speed of chemical processes occurring in the landscapes have changed. As a result of this and the existing infrastructure for the ore activities was created an unusual environment disequilibrium.

3. RESULTS

In terms of air temperatures, most characteristic of the surveyed area, the coldest month is January, with the average temperature being positive - of 1.3 ° C. In the spring months, air temperatures are rising rapidly. The second half of May features a summer character. The summers are relatively hot, the warmest being July and August, when the average air temperatures are above 23 ° C (Table 1, Table 2).

Autumn is warm, September still having a summer character. In October, average temperatures decrease more significantly. This is a typical autumn month, but average monthly air temperatures are higher than the same for most of the country. The month of November is characterized by a more sensitive cold and can be categorized as a late-autumn month [15].

Table 1. Average monthly air temperature (° C), relative humidity (%) and rainfall (mm) for Ivaylovgrad

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
t °C	1,4	3,6	6,4	12,1	16,9	20,5	23,5	23,5	19,2	13,9	8,9	4,1
%	83	78	74	67	67	64	58	55	61	72	81	84
mm	80	60	60	56	62	61	34	23	38	69	78	90

Table 2. Average monthly air temperature (° C), relative humidity (%) and rainfall (mm) for Krumovgrad

	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
t °C	1,3	3,6	6,5	12,2	17	20,8	23,7	23,4	19,1	13,4	8,7	4,2
%	80	76	74	69	69	65	59	58	65	75	80	81
mm	83	67	64	60	66	64	37	24	38	73	84	101

The precipitation regime has two maximums and two minimums (Figure 1, Figure 2).

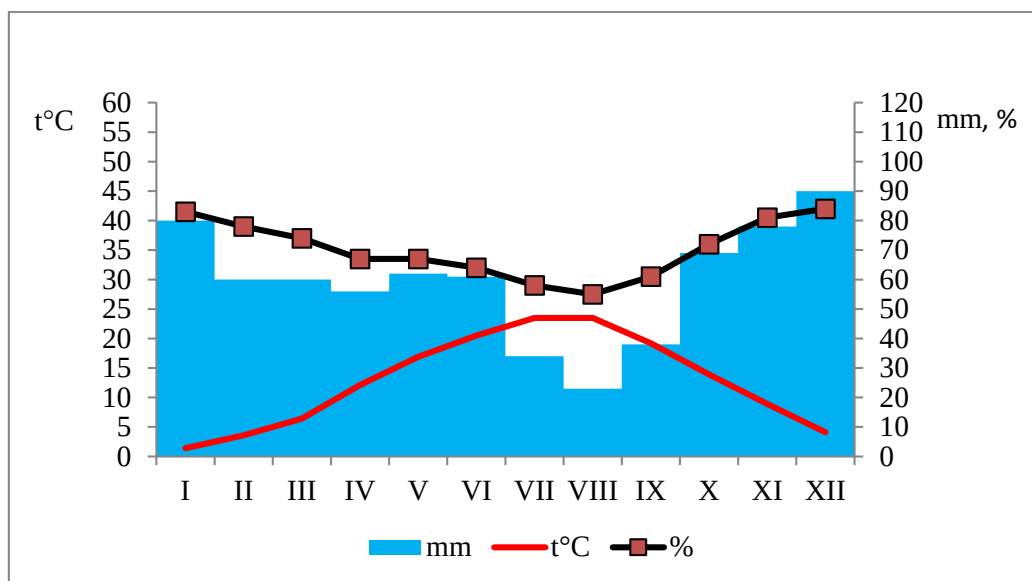


Figure 1. Climate diagram of Walter for the region of Ivaylovgrad

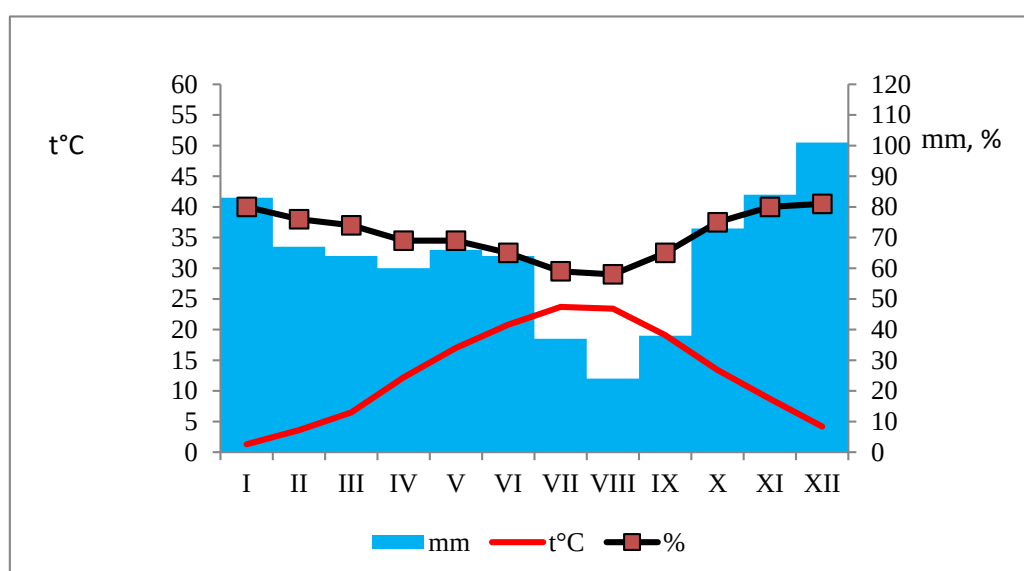


Figure 2. Climate diagram of Walter for the region of Krumovgrad

The climate diagrams present drought periods covering the months of July, August and the first half of September (Figure 1, Figure 2). This is one of the most characteristic features of the climate in the region, with an average of over two droughts occurring during the summer season, each with a duration of about 20 days [3; 16].

4. DISCUSSION

The heterogeneous, diverse, heavily folded and crushed geological base, the deeply leeward rocks, the large inclines and the climatic characteristics are a prerequisite for the variety of denudation processes and the complexity of the horizontal structure.

Depending on their origin and mineral composition, the ores have different denudation resistance. They leave various products resulting of their destruction. Andesites and rhyolites are characterized by

prismatic destruction. After their mechanical disintegration, they form wreath-shaped screes and trails of rock accumulations.

The Paleogene sandstones, tuffs and marls are unstable to denudation and they are exposed to an accelerated erosion.

As a result of the alternation of layers of magma and sediments was formed a varied and heavily intersected terrain with active erosion and collapsing processes. They are intensified by large slopes, deforested areas and torrential rainfalls.

The main maximum rainfall is in December (reflection of the Mediterranean climate) and the secondary maximum - in May (reflection of the continental climate).

The main minimum is in August, and the secondary minimum in April. The amplitude of the large (Mediterranean) precipitation wave is 2 to 4 times greater than the amplitude of the small (continental) precipitation wave due to the tangible Mediterranean climate impact [3; 16].

The active cyclonic activity during the cold months is the reason for the increase of precipitation, which in the most part has a frontal character. Often the rainfall is torrential, with a falling rainfall of 80-100 mm over day.

As part of the Eastern Rhodopes Mountains, heavy snowfall is rare and the snow cover is short-lived. Rare are the cases when the snow cover remains for 5-6 days. However, such cases may be repeated several times during the winter, as the melting of snow is usually going too fast [15].

The active mining activity in the past has led to significant changes in the Caldera. In the form of embankments, huge quantities of materials are deposited, which in most cases are without technical or biological recultivation. The inclines are about 100%, the slopes are unstable and there is no natural placement of vegetation. This is a prerequisite, combined with the presence of torrential rainfall, typical for the region, that these anthropogenic landscapes become the source of a large amount of sediment to the main water stream - the Arda River.

Attempts have been made to stabilize a small part of the embankments through series of transverse structures of natural materials. In spite of their small durability, they have managed to give the terrain a stepped profile, alternating sections of smaller length and slope. There is grassing on them.

In order to safely remove the drainage into one of the embankments a drainage ditch is built. Its cross-section is less than the maximum water flow that has led to spillage of the water outside. The ditch is totally destroyed. The terrain around it has a broken structure. The erosion has reached 1.0-1.5 meters below the level of the facility.

5. CONCLUSIONS

Climate determinants of the studied area are semi-Mediterranean climatic conditions. Their specific features largely determine the dynamics of erosion. Characteristic of the area are the heavy rains with clearly expressed autumn-winter maximum, as a result of which in the partial water catchments torrential streams are often formed.

A lot of processes, related to the selective denudation of the volcanic structure, have a trace of the Caldera's present appearance. The area of the morphostructure is characterized by high and inaccessible rock complexes, alternating with deep decreases, lot of collapses and areas with active erosion.

The anthropogenic activities have left a permanent trace of the natural-territorial complexes. With an aim to achieve ecological balance on the slopes and in the hydrographic system of Arda River it is necessary to carry out hydro technical anti-erosion measures, which goal will be to reduce the amount of solid outflow to the river.

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