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Mountain lakes in National Park 'Sutjeska' – Evolutionary self-development

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Abstract

Sutjeska National Park, besides the eponymous river and its valley, includes mountain morphostructures of Zelengora, Volujak and Maglic, situated in southeastern Bosnia and Herzegovina. These morphostructural units are also known as morphological region of southeast part of the Bosnian highlands or also as 'Roof of Dinarids', as popularly called in the geographical literature. This morphological highland on a mountain Maglic is the highest point in Bosnia and Herzegovina (2386 m). Mountain Zelengora vault over 1000 m above sea level, with its highest peaks above 2000 m.

At the morphological vault of Zelengora there are 8 lakes (Orlovacko, Stirinsko, Kotlanicko, Donje Bare, Gornje Bare, Bijelo, Crno and Kladopoljsko Lake) which have polygenetic origin with dominant karst, glacial and fluvial-denundation impacts. Evolution of the lake basin has a natural self-development character, which can be monitored by so called 'jezerina' that explains the parched lake basin. It is a consequence of the dual natural processes that work simultaneously on the disappearance of lacustrine stability. Natural fluvial detritus entering the inflow zone so it uplifts lake bed. Due to this reasons there are many examples of decreasing the volumes of the lakes. By the regressive erosion of river lake, river bed has been continually deepened and occupies more lake water that finally leads to the drying of the lake. This is particularly pronounced in lakes Gornje i Donje Bare (Upper and Lower Ponds). Besides the natural, in the basin of Zelengora there are examples of creating artificial reservoirs named after the owners of these lakes. Self-development of evolution of lake basin on Zelengora are affected by the special protection regime because they belong to the National Park of Sutjeska.

Keywords

Nationaln park 'Sutjeska', lakes, Zelengora, lake genesis, lake evolution, fluvial detritus, regresive erosion, lake drying, reservoirs.

Introduction

Zelengora seizes the southeastern Bosnian highlands between two large river basins: Neretva, on the southeast and Drina in the east and northeast. Considering the morphostructural and other physical-geographical characteristics of the mountains, Zelengora makes one quite unique orographic unity with Lelija and Tovarnica. This morphostructure is distinguished by sharp separated crossings in the north, while the southern parts of Zelengora between Dumos, Kalelija and Lelija are consisting of karst plateau with valleys, deep valleys and dry scattered paleovalleys.

These orographic morphostructures are made of tectonic and orographic vault elevated in the terciary. They are vertically dissected with the surface watercourses of the Drina river basin in the northeast. Zelengora borders with the Sutjeska valley in the southeast and east towards Maglic and Volujak mountains. In the southeast, towards the Treskavica mountain, Zelengora borders with the valley of the river Ljuta. The largest part of Zelengora mountain belongs to the National Park (NP) 'Sutjeska'.

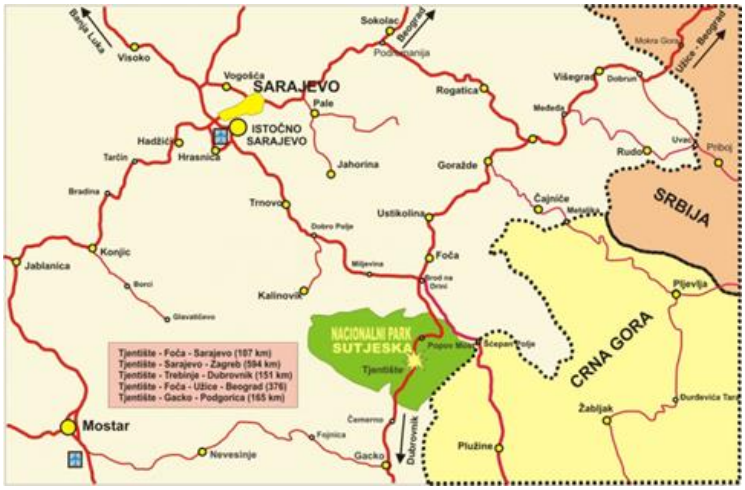

Figure 1: The traffic-geographical position of the National Park 'Sutjeska' Source: http://www.npsutjeska.info/?page_id=66 (accessed: 08/05/2017)

The NP was named after the river Sutjeska, the right tributary of Drina, which drains the waters of Zelengora from its western and southwestern morphological facade. National Park 'Sutjeska' is the oldest NP in Bosnia and Herzegovina. The Parliament and the Government of Bosnia and Herzegovina passed the law on proclamation in 1952. and with the decision of the National Institute for the Protection of Monuments of Bosnia and Herzegovina the NP is placed under the protection of monuments of culture and natural values in 1954. on an area of 175 km² (MIHIĆ 1978). Within the NP there is a forested district Perucica, which was placed under the state protection as a nature reserve. Inside the Perucica there is an magnificent waterfall Skakavac, 81 m high. The development of the NP in the past was largely based on historical events from the Second World War (TEMIMOVIĆ et al 2015). In this area, at Tjentiste, a memorial in which the mortal remains of 3301 partisans were buried was built. A monumental monument and memorial house of the Battle of Sutjeska are located near the memorial. National Park 'Sutjeska' is included in IUCN, an international list of national parks (SPAHIĆ et al. 2014).

Physicalogeographic position of mountain lakes in the National Park of Sutjeska

Zelengora is a mountain that contains the highest number of mountain lakes in the Bosnian-Herzegovinian Dinarides. In an area where surface waters end in the karst underground, these lakes are representing a special hydrographic oasis of clean and clear waters, which mountaineers popularly call 'mountain eyes' (TEMIMOVIĆ et al. 2015). There are eight of them: Kotlanicko, Stirinsko, Orlovacko, Crno (Black), Bijelo (White), Donje Bare, Gornje Bare, Kladopoljsko lake. There is also an artificial lake called Jugovo lake. All these lakes are morphostructally belonging to the eroded-corroded scalp of paleozoic antiform shale and mesozoic limestone with features of reverse pulling. There is a complex of metamorphic crystalline rocks with a carbonate roof drawn over a flysch complex, located in the Neretva valley, in the southwest. The geological superposition defines that secondary permeable limestone and dolomite of ansian floor are lying over the clastite. This phenomenon acts as a hydrological isolator. At the contact of these hydrogeologic members, water sources, hot springs of limited capacity and at the same time sinks can often be found (PERICA 2008).

The basin of Kotlanicko lake was formed at the contact of ladin and anisian floors, and the basin of Orlovacko lake at the contact of the lower trias deposits and the ladin floor. These almost identical geological and hydrogeological relations also occur in the basins of Crno, Bijelo, Kladopoljsko, Gornje Bare and Donje Bare lakes. Zelengora with other mountains of Dinaric system makes a natural barrier to maritime influences from the south and continental influences from the north. Through Zelengora, which is gradually falling towards the north, and stepwise to the south, there is an abundantly exchange of warm and cold air masses. Its southern parts are the windiest in the Adriatic's air flow and receive a higher amount of precipitation compared to the northern or continental parts.
The climate diagram data show that the average rainfall peaks on the windy and non-windy sides do not appear in the same months. This phenomenon is conditioned by the position of Zelengora, where both maritime and continental influences are strongly expressed. Precipitation are almost evenly distributed throughout the year. Snowfall starts in mid-October, dissolve at the end of May, and the snow in the sinkholes and deep valleys not before the beginning of June. The more months retention of snow is a consequence of a very low temperature during the cold season of the year. According to the data of the climate diagram, the continuity of negative temperatures is noted from December to March. Considering this continuity of low temperatures, Zelengora in the thermal regime can be divided into two annual periods: cooler which starts from November and lasts until March and a warm period from June to October (SPAHIĆ 2001).

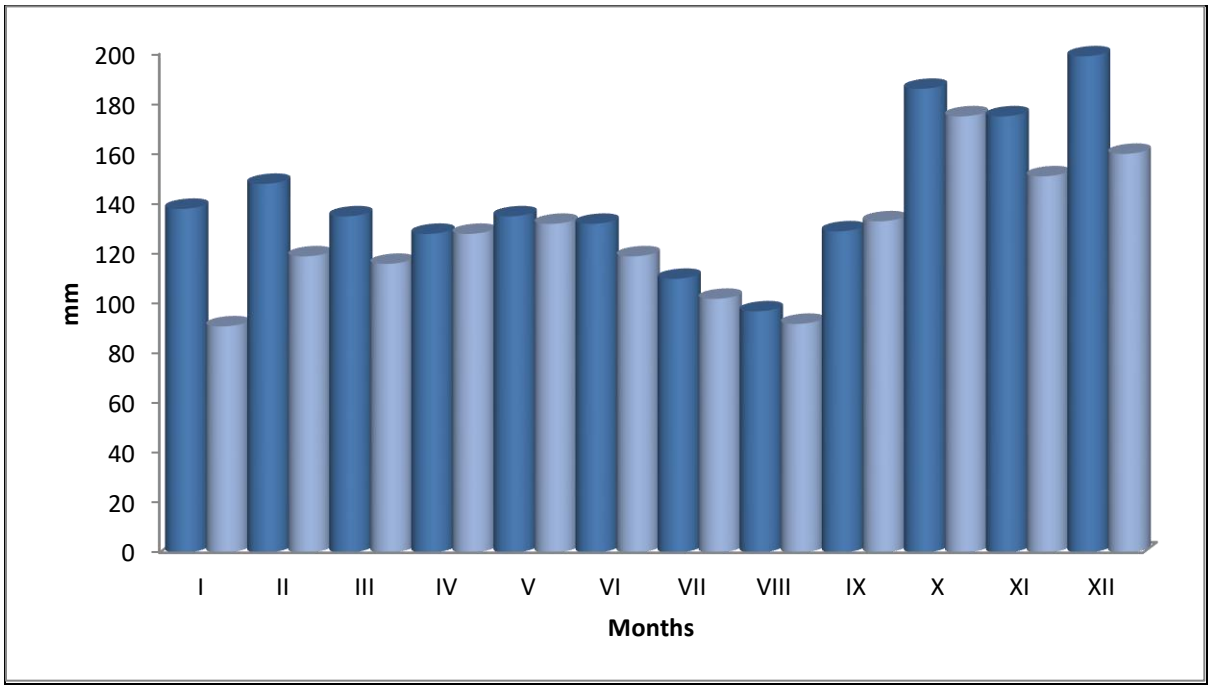

Figure 2: Diagram of precipitation on the south part-windy side (darker columns) and on the north part-non windy side (brighter columns) of Zelengora Mountain. Source: SPAHIĆ, 2001

According to the altitude belt, Zelengora belongs to the forest belt, and its highest peaks make the transition from the subalpine beech and distorted pine into the grassy floor. Except of lake basins of Orlovacko, Crno, Bijelo and Donje Bare lake in wich the beech-fir forest dominate, other lake basins have no forest biocenosis. They are obviously devastated in a favor of pasture.

Discussion – genesis and evolution of lake basins of Zelengora Lakes

Genetic phase of the development of lake basins

Lake basins were mainly formed in the area of paleozoic shales and mesozoic limestone with characteristic of reverse pulling. In them, massive and conglomerated carstic and watertight limestone of aniscinian period lean on the lower trias waterproof deposits of verfen, represented by clastic layer of liscuit shales, sandstones and quartz sandstone. Besides that, some lake basins, such as the Kotlanicko lake basin, were formed in a lithologic waterproof ladinic series: limestone with cherts, clays, tuffs, sandstones, diabase and spilite, to which the anisian floor is attached, whose contact is accomplished through a minor tectonic fault on the island side of the lake. Around most of Zelengora lakes the processes of gravitational collapse and dropping has been developed. This detritus is transported by canals and ends at the bottom of the lake basins through deluvial cones. Cones are most often grown together in deluvial deposits and conglomerates. Canals in the lake basins of the lake Gornje Bare below the Ugljesin peak, lake Orlovacko beneath Orlovac peak and Bijelo lake in the foothills of Orlovaca mountain, most commonly serve as an avalanche canal during the winter.

The indirectly lake basins are sprinkled by valleys that end in the direct lake basins. With their morphology they look like karstified waves, what the previous researchers often led to the conclusion of complete development of glacial processes. These valleys are sprinkled by caps and heads, which were later splited by deep sinkholes. Karstified sinkholes and dry valleys end in the bottom of the lake basin. Based on the morphological form of dry valleys, it can be concluded that the karstification occurred in the posttectonic phase of development. The lake basins are usually the lowest floors in the valley system and lie in the contact hydrological layer, this is why the karstification is kept at the level of that contact (SPAHIĆ 2001). The islands of the Zelengora lakes have a fluvio-denudational character and their harmonization is directed towards the sinking zone. Most of the lake basins have been created as a consequence of karst-corrosion processes, this is why karst processes have a special place in the morphogenesis of lake basins.

In current geographical literature, it is generally accepted that almost all lakes in Bosnia and Herzegovina have a natural origin. It was assumed that the higher mountain lakes are glacial, and the lower of fluvioglacial origin. Earlier researchers have completely ignored the impact of karst-corrosion, karst-contact and tectonic, fluvial and other physical factors, as well the human impact on the formation of mountain lakes. There is no doubt that Zelengora lakes are tectonic predisposed. They contain overprecipitaded sandy and clay-mud deposits that are eroded, transported and accumulated along the lake area. These masses are represented by renzini, rankerers, reddish limestone soils and black fores humus. Each lake has one or two proluvial-accumulation plane along to the lake, mainly on the tributary side of the lake, and often laterally in relation to the lake's water flow or the sinking zone. Upstream of the tributary areas, there are deep valleys and dry valleys, from which with the help of water during the rainy period the eroded masses are transferred into the lake.

From indirect lake basins, colluvial, proluvial, deluvial and defluctual depositions or their combinations are directed to the mountain lake basins. Lake coasts are usually formed in deposits of different genetic affiliations or are in the parent substrate. The coasts are most often built of colluvial, deluvial, eluvial and defluctual deposits. Flood deposits have the form of abrasion-lacustrine plane (SPAHIĆ 1988). The karst-corrosion characteristics of the lake coast are expressed in the contact zones of carbonate and clastite, especially around the sink of the water. Mountain lakes in Bosnia and Herzegovina are younger than the holocen. Since the surroundings of the lake basins have no peatland, the previously stated claim confirms that they belong to younger lake forms dating back to the period of upper subatlantics (SPAHIĆ 1988).

The evolutionary phase of the development of lake basins

The development of lake basin can be closely linked to the recent development of fluvial and karst processes. The karst processes lower the lower karst erosion base, which is evident on the island sides of all laks of Zelengora. On the island sides of some lakes, such as Stirinsko, Kotlanicko and Donje Bare, there are limestone sections where the karst openings at different levels can be found. This represents the succession of lowering of the lower karst erosion base. Its level and the capacity of the karstic crack caused the level of the lakes. Today's level of the lakes is at the level of the karst sinking (SPAHIĆ 2001). The evolution of the lake basins has a natural self-development character, which can be explained by the name ‘jezerina’ and means a dried lake basin. It is a consequence of a dual natural process that simultaneously acts on the disappearance of lake stability. The natural inflow of the fluvial detritus from the water flow zone raised the lake bottom, what reduced the volume of the lake. On the other hand, the drainage of the water from the lake deepens the river bed of the water drainage system, what ultimately leads to loss of water and the lake dries up in the end. All these phases are accompanied by an increased production of swamp vegetation. All together initially leads to the transformation of the lake into a swamp, and then to its complete disappearance. Almost all lakes in Zelengora are in some phase of evolutionary disappearance, and this phenomenon is particularly pronounced at lake Donje and Gornje Bare.
Thus, the disappearance of lake basins can occur naturally without the participation of the human factor, which is becoming more and more current today. Self-development of natural processes and phenomena takes place without a human impact. An example of this are the final stages of existence of lake basins in protected conditions like those in the NP ‘Sutjeska’.

Figure 3: Gornje Bare lake (right on the picture). Next to it is a basin of a dry lake, which has no hydrological function. It is a natural evolutionary sequence without the influence of a human factor

Conclusion

The evolution of the lake basins has a natural self-development character, although in all other circumstances, outside of NP it would be attributed to an anthropogenic negative factor. The self-development of lake basins is a consequence of simultaneous action of the natural and anthropogenic process on its disappearance. The most often are karst processes of lake basins disappearance, they occur in the drainage zones of the lake basin. They are caused by the expansion of drainage system and by lowering the lower karst erosion base through which a lot of lake water flows out. The second most frequent disappearance process is the fluvial, in which large amounts of eroded deposits enter the drainage system, and by the rise of the lake bottom the lake becomes shallow. Through backward pulling of the drainage system it is getting more and more cut into the bottom. This increases the flow out of the water from the lake. In conclusion, the lakes of the explored area are increasingly covered by aquatic vegetation, and because of this, they are transformed into wetland hydrological facilities.

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