СПИСАНИЕ НА БЪЛГАРСКОТО ГЕОЛОГИЧЕСКО ДРУЖЕСТВО, год. 80, кн. 3, 2019, с. 215–217
REVIEW OF THE BULGARIAN GEOLOGICAL SOCIETY, vol. 80, part 3, 2019, p. 215–217

Национална конференция с международно участие „ГЕОНАУКИ 2019“
National Conference with international participation "GEOSCIENCES 2019"

The catastrophic decrease of Prespa Lake level – result of natural or anthropogenic reason?

Природна или антропогенна е причината за катастрофалното понижаване на нивото на Преспанското езеро?

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Keywords: karst aquifers, Prespa Lake, environmental impact, climatic changes, Albania.

Introduction

In South-eastern Albania, in bordering area with North Macedonia and Greece, Prespa and Ohrid Lakes constitute a common hydraulic system. Prespa Lake has no surface flow and the outflow of the lake is realized only through karst underground conduits into Ohrid Lake. During some decades Prespa Lake has suffered extremely worrying water level decline of about 8.5 m, which is seriously influenced by natural climatic changes as well as by uncontrolled anthropogenic impact. As a result of insufficient scientific collaboration the hydrology and hydrogeology of this wide and complicated watershed is not fully investigated. This paper will try to shortly analyze the problem and should bring some important field observation helping the discussion.

Geology

Mali Thate-Galichitsa Mountain consists mainly of Upper Triassic–Lower Jurassic massive limestone with highest peak 2287 m above sea level (Fig. 1). During the Pliocene–Quaternary the study area embraced strong and progressive general uplifting, while the depression areas suffered mainly subsidence and partially uplifting (Aliaj, 2012). Most significant result of this tectonic style is the formation of big Mali Thate-Galichica Mountain horst. On both sides of the horst big graben structures are placed: Prespa Lake graben to the east, and Ohrid Lake and Korcha plain grabens to the west. Some regional faults with N-S orientation are developed along the eastern and western edges of Mali Thate-Galichitsa horst. The Pliocene deposits represented by clay, sandstone and conglomerate fill most of the bottom of Prespa Lake and some small outcrops are developed along the lakeside.

Hydrogeology

Main hydrogeological features of the area are shown on Fig. 1. The elevation and the surface of Ohrid Lake are respectively 694 m asl and 348 km^2, while those of Prespa Lake are respectively 849 m asl and 274 km^2. Small Prespa Lake surface is 47.4 km^2 and the water level is 1 to 3 m higher than that of Big Prespa and a natural sandy dam with a sluice gate separates them. Ohrid and Prespa Lakes are separated by the karst massive of Mali Thate-Galichica Mountain characterised by dense presence of karst phenomena like karst plateaus, dead valleys, sinkholes and caves. As the Prespa Lake water level is about 155 m higher than that of Ohrid Lake, big karst water quantities flow through Mali Thate-Galichitsa karst massive to the Ohrid lakeside recharging many karst springs in the bordering area between Albania and North Macedonia. Main water recharges are the big springs of St. Naum average discharge 7.5 m^3/s and that of Tushemisht with 2.5 m^3/s. There are also two other groups of springs, Biljana near Ohrid with an average discharge between 1 and 2 m^3/s and a group of springs, with total discharge of about 0.5 m^3/s, issues in Devoll River Valley in Albanian territory, near the villages Golloborda, Manchurisht and Proger, in Devoll River Valley (Fig. 1).

Some investigations conducted with environmental isotope techniques supported by IAEA–Vienna have demonstrated that Tushemisht Spring at about 52–54%, and St. Naum Spring at about 42–46% are recharged by Prespa Lake (Anovski et al., 1991; Eftimi, Zoto, 1997; Kolaneci, 2003; Matzinger at al., 2006).

However, the most significant and curious karst phenomenon of the area is Zaver swallow hole, which is located in Prespa lakeside between Small

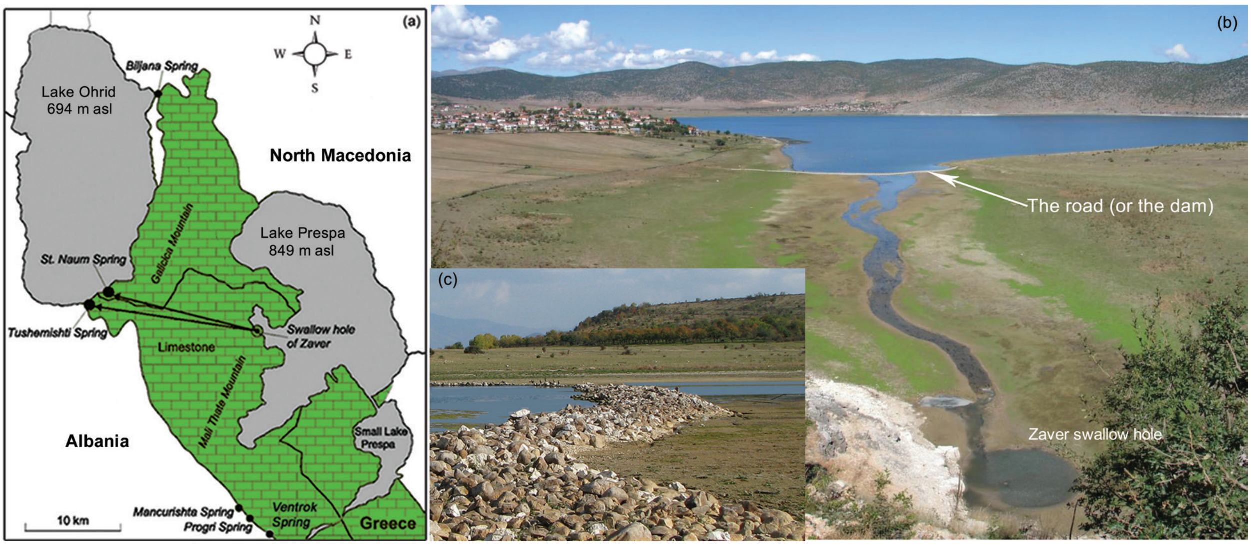

Fig. 1. *a*, recharge of Lake Ohrid Lake from Lake Prespa. The black arrows show the proven underground connection; *b*, Zaver swallow hole, where the Lake Prespa waters disappear to re-emerge at the Lake Ohrid coastal line; *c*, detail of road (or dam) of Zaver swallow hole at the lowest historical level during 2002–2005.

Gorica and Gollomboch villages (in Albanian territory), where an intensive loss of the lake water into the karst basin could be seen (Fig. 1). Taking into consideration the difference of water levels in both lakes of 155 m in average and the distance of 17 km between the two lakes in the direction Zaver swallow hole – Tushemisht and St. Naum, the maximum hydraulic gradient of karst water flow is 0.0091.

Catastrophic decrease of Prespa Lake level

Lake Prespa is an important natural, ecological and economical water resource in a region suffering water shortage. According to Kolaneci (2003) during the period 1963–2002 Prespa lake level is lowered 8.79 m, with a decreasing level trend of 21.7 cm/year, while the decreasing trend of the precipitation for the same period is 7.8 mm (Fig. 1). According to Popovska and Bonacci (2007) during the period 1951–2000 Prespa Lake level is lowered 7.79 m, with the decreasing trend of 10.9 cm/year, and the precipitation decreasing trend, for the same period, of 3.16 mm/year. Both investigations take into consideration different time periods.

Many balance calculations of Prespa-Ohrid basin performed by different authors and institutions of three neighboring countries result in big discrepancies (Pano, 1984; Kolaneci, 2003; Popovska, Bonacci, 2007). This is the result of missing collaboration and coordination regarding exchange of documentations between the three countries and systematic measurements of important water points (springs, rivers etc) as well as regarding the measurements of the climatic elements at high elevation areas of the karst basin and lack of data of snow fall and evaporation. Mostly, the conclusions of the investigators about the Prespa Lake level decline are based only on the data of "own country". In the specialized technical literature (Hollis, Stevenson, 1997; Kolaneci, 2003; Matzinger at al., 2006; Popovska, Bonacci, 2007) different opinions are expressed about the Prespa Lake level decrease which could be summarized as (a) geological (tectonic and karst widening of underground channels connecting both lakes), (b) anthropogenic (intensive use of lake water for irrigation) and (c) less recognized climate changes.

The widening of the tectonic-karst pathways transmitting the water from Prespa Lake to Ohrid Lake presuppose at least the increase of the discharge of the big karst springs of Tushemisht and St Naum, which is not supported by some non systematic measurements of the discharge of the springs.

The anthropogenic impact on Prespa Lake level is related to the increased use of the Prespa Lake water for irrigation or for other purposes. Often the increased use of Prespa Lake is related mainly to the "intensive" use of the lake Small Prespa for irrigation in Albanian territory. In 1976 the Devoll River in Albanian territory was diverted to flow to Small Prespa Lake and during the period 1976–1996 the River input was about 30–70 million m^3/year with the intention to be used for irrigation of Korça plain during the summer. As the constructed sedimentation basins of Devoll River didn't functioned normally about 40 000 m^3, of fine grained sediments are deposited every year in Small Prespa Lake, which in total reach about 800 000 m^3. The huge quantities of sediments changed completely the littoral zone and in the Albanian territory the beautiful Small Prespa was transformed into a wetland making impossible to further host the Devoll River water. It is obvious that the lake water used for irrigation cannot be the reason for the decrease of Big Prespa Lake level. The maximal volume of Prespa Lake in 1961 was 4.23 km^3 which has so far decreased by about 1.1 km^3 (Popovska, Bonacci, 2007). The used for irrigation water quantity is relatively small comparing with the total volume of Big Prespa Lake and moreover the used for irrigation water mostly was supplied by Devoll River belonging to another watershed.

Another anthropogenic impact on the decline of Prespa Lake level could be also the use of lake water for the massive irrigation of Resen plain located north to the Lake in the territory of North Macedonia, or the use of Small Prespa water for irrigation in Greek territory but no published data exist about these activities.

Zaver swallow hole as a testimony of the climatic changes

For a better understanding of the climate changes let us describe in more detail the Zaver swallow hole (Fig. 1) This is the biggest and most important swallow hole where the water of Prespa Lake disappears to reappear in the big karst springs along the Ohrid lakeside. The configuration of Zaver swallow hole at high water level is like an prolongation of the lake about 600 m in length finishing in a natural vertical Upper Triasic limestone wall about 25 m high of Mali Thate Mountain. At the foot of the limestone wall is located Zaver swallow hole and a big cave not yet well investigated is developed close to it. In the memory of the local people is transmitted the description of a "road" connecting two sides of the Lake prolongation finishing to Zaver swallow hole but no one has seen it untill the years 2002–2005. At this time interval the Lake reached the lowest known level of about 844.5 m asl and the road emerged with all its mystery. The road is about 200 m long; it is constructed like a dam whose carriage way is in average about 2.5 to 3.0 m wide, while its height varies from about 0.5 m in both extremes of the road to about 3 m in the central, deepest part of the water flowing to Zaver swallow hole. The road is constructed with stones of different dimensions, from about 15–20 cm to big blocks more than 70–80 cm thrown without order and actually no signs of any former pavement could be seen on the road. The used building stones are taken from the local sandstone-conglomerate Pliocene deposits outcropping along the lakeside near Zaver swallow hole and consist of igneous, metamorphic and carbonate rocks (Fig. 1c).

The presence of the road suggests some questions. When and why is constructed this "road"? Is there an ancient "road" or an ancient "dam"? Why it was necessary to construct this "road"? About the time of the construction of the road there is no any testimony; the local people say that "the road is very old and no one knows when it was constructed". The stone road is shorter and more convenient compared with the former existing road passing on limestone rocks and quite near to Zaver swallow hole. At the actual situation the stone road is not convenient and is not used by the local population. The water level on both sides of the road is different; the level of the Prespa Lake is about 0.8 m higher that of flowing water to Zaver swallow hole. Maybe the road is a dam constructed to keep Lake level at higher elevation so important for the fishing activity of the local people.

The construction of such a road (or dam) is justified only if for a long time (at least some tens of years or more) in the past Lake Prespa level has suffered by climatic shortages similar to the actual ones. An important investigation undertaken to explain the past climatic variability determining the sediment isotope and geochemical record from Lake Prespa over the Last Glacial cycle found very low lake levels occured around 1000 years ago and a rapid reversal is established in the last 500 years (Leng et al., 2013). This period could be the age of the road of Zaver swallow hole as well.

Conclusions

The existence of the ancient road of Zaver swallow hole testifies that the main reason of the catastrophic decline of Prespa Lake water level are the permanent cyclic climate shortages on which nowadays overlap seriously the dangerous anthropogenic impacts as well.

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