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# STUDY ON THE RELATIONSHIP BEETWEN THE WATER LEVEL OF THE PRESPA LAKE AND IT'S VOLUME

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## SYNOPSIS

According to an existing hypothesis [1], water from the Prespa Lake, which is shared by the three neighbouring countries, is drained through the Galichica and Dry mountains into Ohrid Lake.Several Projects (Supported by IAEA, NATO, EU, UNESCO and others) in the past and present, were/or are dealing with the determination the water balance and the protection of Prespa and Ohrid Lakes with special attention to the explanation of the decresaing of the Prespa Lake water level. Determination of the relationship between the Water level of the Prespa Lake and its surface, conducting to the evaluation of the Volume of the Prespa Lake, is an important parameter for the study of the water pollution of the Prespa Lake at all. A computer program in C++ language, was created, offering a calculation of the Volume of Prespa Lake by entering only the actual value of its water level.

## INTRODUCTION

Three lakes: Ohrid, Big Prespa and Small Prespa are on the borders between Albania, FYR of Macedonia and Greece, see Fig.1-2. Galichica and Dry mountains (with an intensive carstification) separate the lakes. According to an existing hypothesis (Cvijic, 1906), water from the Prespa Lake, which is shared by the three neighbouring countries, is drained through the Galichica and Dry mountains into Ohrid

Lake. Field research conducted first by Anovski and collaborators [2] and latter by other scientists [3] confirmed this hypothesis.

The Lakes Big Prespa (272 km2) and Small Prespa (47.4 km2) are at 847,68 m a.s.l.(referent level) and are linked by a small channel with a sluice that separates the two lakes (See Fig 3-4, taken at different time, showing even absence of the water in the channel, close to the gate, resulted from the decreasing of the water level in the Small Prespa Lake ,on the right side of the Gate at the Photos). In the past, periodical oscillations of the lake's level were in the range of one to three metres, depending on the amount of precipitations in the season. After the mid 80's, a steady decrease of the water level has been recorded that disturbs the ecological balance of the Lake and the watershed area resulting in serious consequences for the fishing and tourist industry in the Trans-boundary Prespa Region. In addition to this, the industrial activities as well as the overuse of the herbicides in agriculture activities raised the problem of pollution of the water in the Prespa Lake.

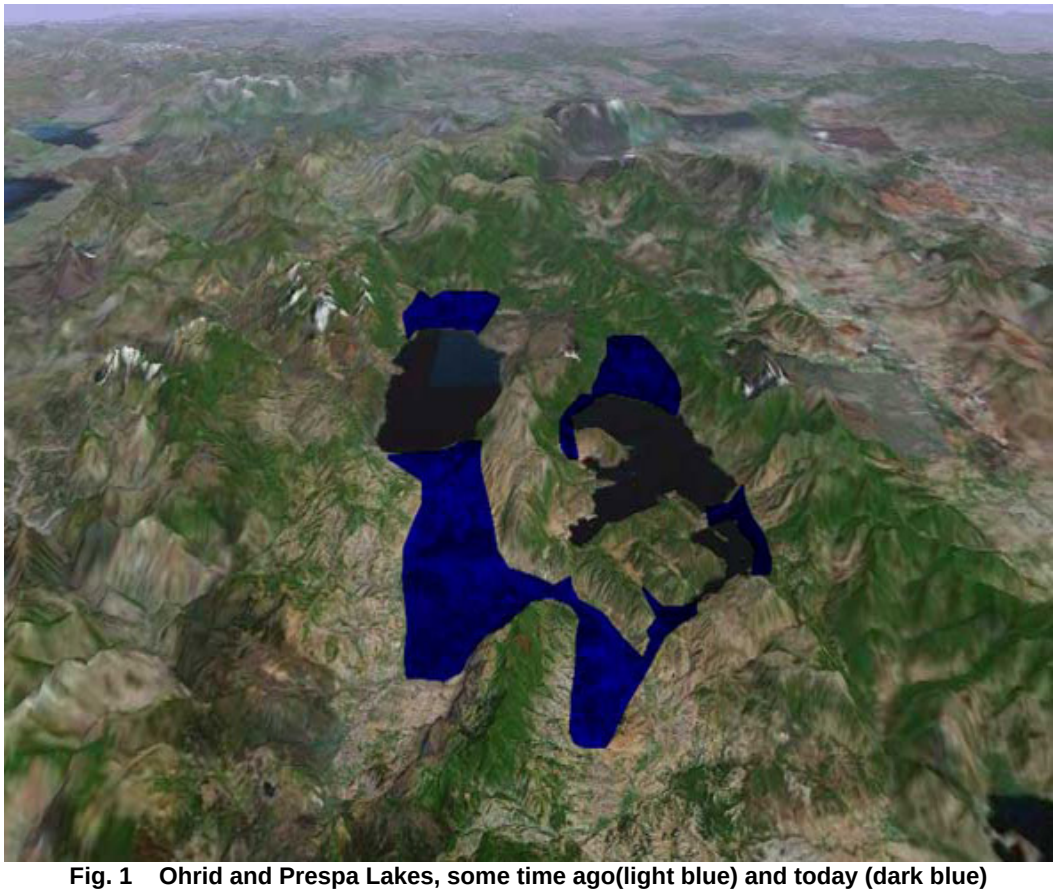

**Fig. 1 Ohrid and Prespa Lakes, some time ago(light blue) and today (dark blue)**

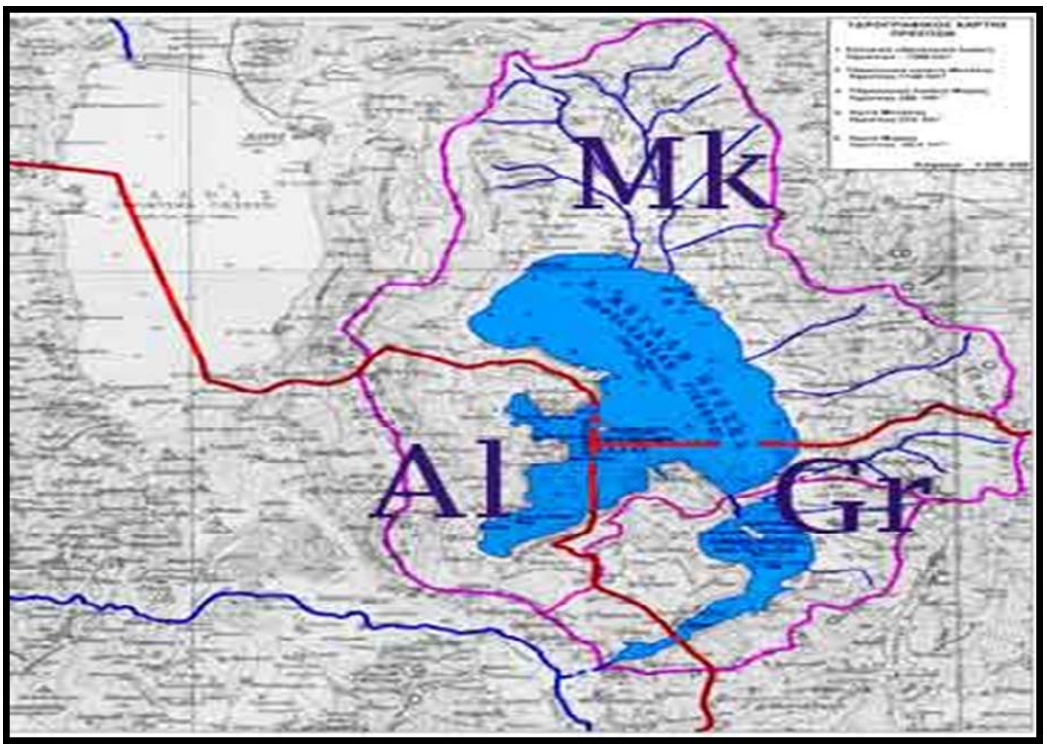


**Fig.2 Prespa Lake Water shared by the three neighbouring , AL, GR and MK Countries (Al-Albania, GR-Greece and MK –FYR of Macedonia)**

The Prespa Lake that is examined, constitutes areas of high ecological importance in addition to their use, because of their beauty, as recreational places. On the other hand they are sites of economic significance as they are associated with agricultural, industrial and other activities because of the use of their water and their fisheries potential. For all of the above factors the lakes and their surrounding is a field of particular interest.

Several projects(financially supported by IAEA,NATO, EU, UNESCO and other Institutions) that were or are under way, had or have to provide a link between the results acquired in the past and the present. Though in the recent years a joint research programme between the three border countries has been conducted, the cause for this water-level drop is still not known, mainly because the data collected has not been processed in a systematic way and some of the state-of-the-art computer simulation tools have not been used in the previous studies. The modelling part will help to calculate the Lake's water budget, based on the surface river inflow, precipitations, spring discharges, evaporations and treatment of other hydrometeorological parameters and isotope data.

**Fig. 3. Gate of the Channel conecting the two Lakes, Big Prespa and Small Prespa, on the route v. Ag. Germanos-v. Psarades, GREECE (Photo: T.Anovski, taken on the 17.04.2006)**

**Fig. 4. Gate of the Channel conecting the two Lakes, Big Prespa and Small Prespa**

**(Photo: T.Anovski, taken on the 26.11.2007)**

The novel aspects of the current projects relate to the way to deal with water resources in karstic regions under the influence of the changing weather patterns. A full evaluation of the data available in the previous years (Environmental Isotope Distribution, Quality control determination, Depth profiling, Water balance etc), combined with the data collected for the duration of the current projects are being used to estimate the implications on a complex system like the Prespa Lake where parameters like sinkholes, precipitation and evaporation, water inflow through rivers and streams and water use in agriculture must be taken into account. The research is advancing the scientific basis in this area, which will find its application in the future related research worldwide, as well.

Current Projects will help the further scientific and technologic development of the participating neighbouring countries as well. These projects are offering to Albania and FYR of Macedonia as a less developed countries the chance to acquire the needed equipment and know-how in order to use them efficiently in the field of interest. In addition to this, a training programme has been established for young scientists.

During the years 2000 and 2001 charting and profiling of the bottom of the Big Prespa Lake were carried out [4]. The results (the evaluation of which, because of many colected field data, still is not ended) showed two characteristic trenches-like structures on the lake's bed, (See Fig. 5). One of the trenches is 7 km long, 0.9 km wide and 35 m deep on average, while the other one is 12 km long, 1.5 km wide and

23 m deep on average. The southern part of the Lake showed unexpected structure of the lake's bottom with sharp faults indicating strong tectonic movements. In the eastern part of the lake a large sedimentation area was identified, where several rivers inflow the lake.

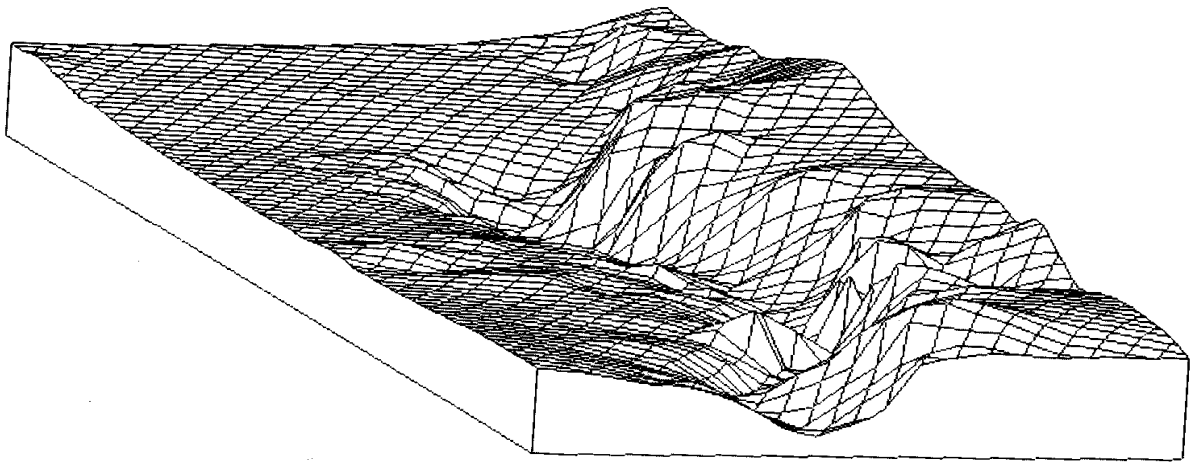

**Fig. 5 Depth Profile : Stenje –Golem Grad**

As, to date there was no efficient way of estimating the volume of water in the Lake as function of the water level, it has been one of our focused point. The data from the charting and profiling have to be used for creating a three-dimensional representation of the Lake's bed, offering on that way a possibility for more precise quantification of the water in the lake as a function of it's the water level.

## PERFORMED RESEARCH ACTIVITIES

The main objective of the performed research was to determine the relationship between the Water level of the Prespa Lake and its surface, conducting to the evaluation of the Volume of the Prespa Lake, an important parameter for the study of the water pollution of the Prespa Lake at all.

As the final evaluation of the previous charting and profiling performed within the IAEA (International Atomic Energy Agency) was not still ended, its further processing in order an accurate three-dimensional representation of the bottom of the lake to be obtained, was needed. In this sense, further estimation of the surface of the Lake corresponding to a certain range of depth [5] was an esential issue in determination the relationship among the water level of the Lake and its Volume.

Based on the results of these activities a computer program in C++ language, was created, offering a calculation of the Volume of Prespa Lake by entering only the actual value of its water level.

The underground inflow/outflow is more likely to have significant contribution towards the level decrease in the Lakes, and could be that the water sinks on the bottom of the Big Prespa Lake have widened in recent years.

Locations of spots where sediment deposits do not exist indicating a possible water sinking pathways were analysed, using the three dimensional representation of the Lake's bed.

## RESULTS AND DISCUSSION

As a rezult of the performed field work within the Ohrid-Prespa Region, location of the most significant sinkholes on the Prespa Lake, Coastline and it's bottom was determined. It seems that the Locality of Zavir is one of the dominant Location where the water is sinking into the Galichica carstic masif, reaching latter a serie of Springs, located on the South-Eastern Coast line of the Ohrid Lake, see Fig.6. Although some evaluation of the earlier collected data which includes the previous measurements, done in the join work still are not ended, durring the realization of this research, thanks to the colleagues from IGME, completition of the bottom profilling of the Macro Prespa Lake with unification of the data has been achieved. The morphology of the Prespa Lake's bed with higher density has been received and shown on the Fig.7.


**Fig. 6 Map of the Prespa Lake with alocated characteristic Points of interest**

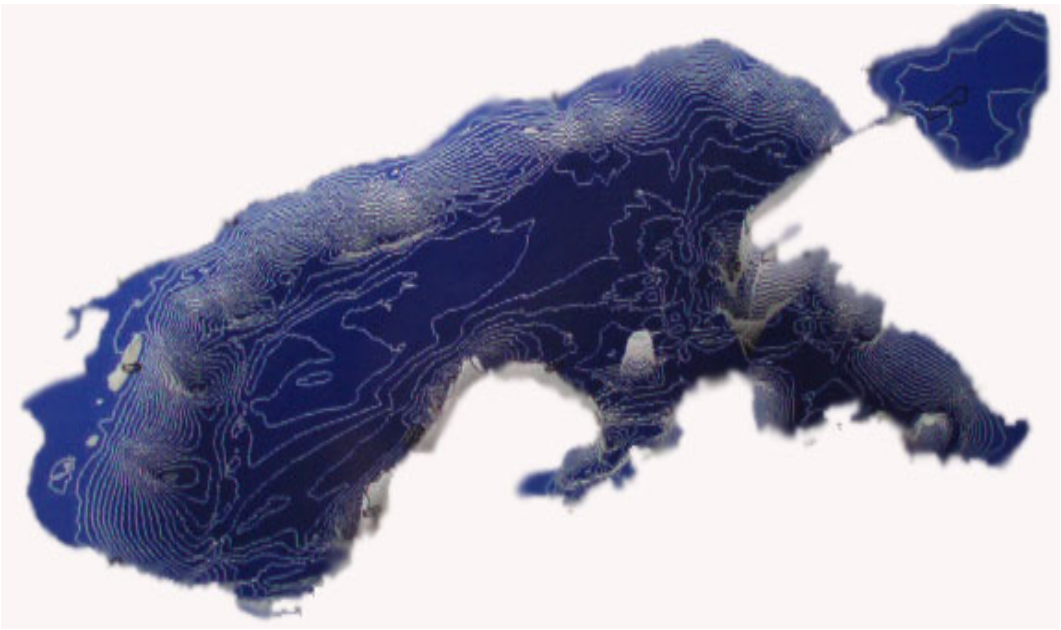

**Fig. 7. Morphology of Prespa Lake's bed**

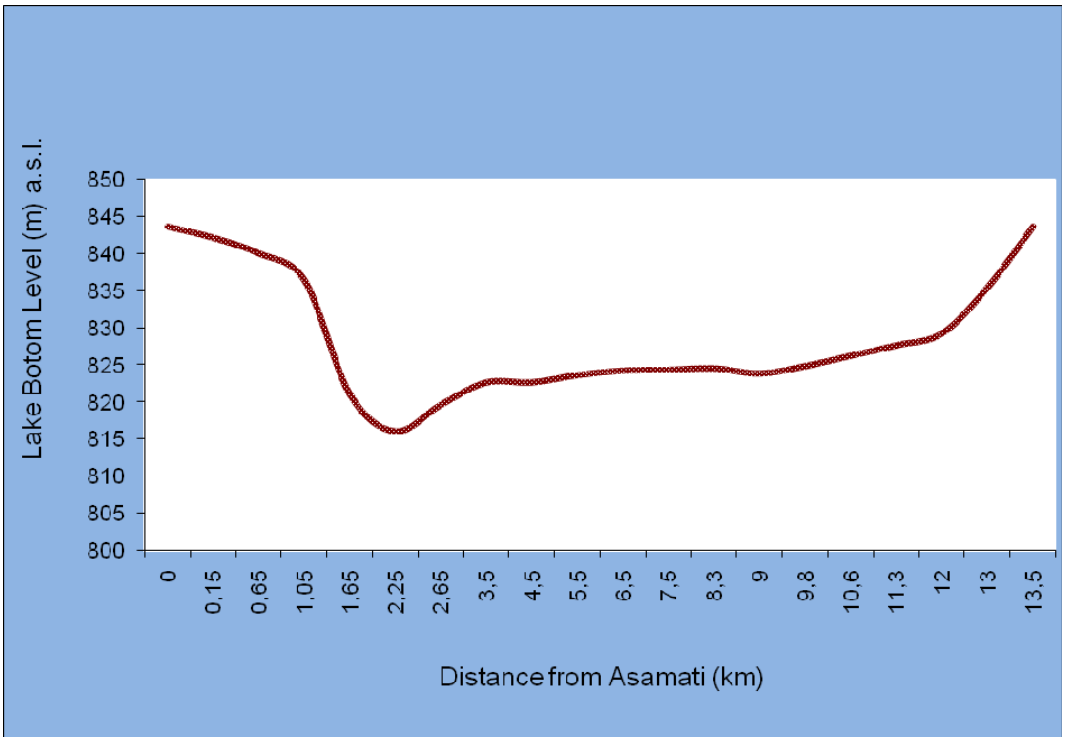


**Fig.8 Cross section of the depth profile of Prespa Lake among Asamati and Stenje villages for the water level 843.60 (m) a.s.l.**

In addition to this, a serie of control depth measurments on the Profile v.Asamati-v.Stenje, shown on Fig.6, have been performed, the results of which are shown on Fig.8

**Assessment Of The Volume Of The Prespa Lake Water**

On the basis of performed depth profiling activities (for water level of the Lake = 844,58 m.a.s.l), the following differential surfaces, each corresponding to the certain depth range, have been estimated see Tab.1 and related partial volumes were calculated, the sum of which represents the total volume of the Lake to be equal to 3,73 x109 m3 .

| Depth range (m) | Estimated corresponding Surface area ($km^2$) |
|---|---|
| 0 – 10 | 61,11 |
| 10 – 20 | 196,43 |
| 20 – 30 | 16,96 |
| 30 – 50 | 1,96 |

**TABLE – 1 Estimated corresponding surface area as a function of the depth (for water level of the Lake = 844,58 m.a.s.l)**

Appart from the Satellite Images taken in the past(see Tab.2), determination of the surface area of the Prespa Lake for measured corresponding water level has been evaluated [6],

| Big Prespa Lake Dates of observation/sources | Water level (m a.s.l.) | Estimated Surface ($km^2$) |
|---|---|---|
| Summer 1978 / Landsat MSS | 848,56 | 276,00 |
| Summer 1988/ Landsat TM | 848,39 | 273,70 |
| Summer 2000/ Landsat ETM | 845,77 | 265,26 |
| *Difference for the covered period (1978-2000)* | *3,54* | *10,74* |

**TABLE – 2 Estimated surface of the prespa lake as a function of it's water level**

On the basis of these figures (for the Surface area of the Prespa Lake and corresponding Depth, i.e. water Level of the Lake) the following exponential relationship, Lake Surface (Y) as a Function of Depth,

$$Y = 0.00366 * 1.01^X,$$

where,

a = 0.00365059647

b = 1.01332072

Correlation (R) = 0.9892194165

R-sq = 97.78328499%

s = 1.190691353

has been defined, enabling us to determine the surface area of the Prespa Lake for a certain water level.

Now, calculating the Volume of Prespa Lake for certain referent level (for example: for water level of 847,68 m a.s.l., calculated corresponding volume is 4,55x109m3) and by using adequate own computer program in c++ program language, we are able to estimate the volume of the available Prespa Lake water (from the ecological point of view, this is an important parameter for further study of the capacity of the Protected Prespa Lake ecosystem) knowing only its water level, i.e. for Water level of Prespa Lake equal to: 850.68m a.s.l., the following parameters are calculating by the applied computer program:

- Corresponding Surface Area of the Prespa Lake is : 2.830 x 108 m2
- Corresponding Volume of water of the Prespa Lake is: 5,38x109m3
- Prespa Lake water level difference compairing to the referent level of 847. 68 m a.s.l. is: h=3 m
- Prespa Lake Surface Area difference related to the referent level is: 1,1 x 107 m2
- Prespa Lake water Volume difference related to the referent level is : 8.3 x 108 m3.

## CONCLUSIONS

On the basis of the performed researches, related to the determination of the relationship between the water level and the volume of the Prespa Lake the following conclusions might be drown:

- Close cooperation among various research teams in the neighbouring countries sharing the waters from the Prespa nd Ohrid Lakes, like it was in the past as well as at present (since 1997 up to present, we have cooperate on several join Projects with colleagues from Tirana-Albania and Athens and Kozani from Greece), shows to be a very efficient way of conducting complementary projects in the Region.
- On the Bottom of the Prespa Lake there are at least two parallel trenches with a

Nord-South lieing direction.

- Absence of muddy material on the Bottom of the Lake with the highest depth speaks for existing of more intensive water courses.
- Applied methodology for calculating the Volume of the Prespa Lake water has been shown as an efficient tool for sustainable management of the International Prespa Lake waters.

**ACKNOWLEDGEMENT**

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