International Conference
and Field Seminar

Karst Without Boundaries

P R O C E E D I N G S

Edited by
N. Kukurić, Z. Stevanović, N. Krešić

11-15 June 2014
Trebinje (Bosnia & Herzegovina)
Dubrovnik (Croatia)

DIKTAS

Protection and Sustainable Use of the Dinaric Karst Transboundary Aquifer System

Publishers:
GRAFOKOMERC AD Trebinje
DIKTAS Project (Protection and Sustainable Use of the Dinaric Karst Transboundary Aquifer System)

For the publishers:
Zdravko Kašiković, GRAFOKOMERC AD Trebinje
Neno Kukurić, DIKTAS Project Manager

Editors:
Neno Kukurić, Zoran Stevanović, Neven Krešić

Technical preparation:
Vedran Furtula

English proofreading:
Natalija Miličević

Circulation:
300 copies

Front page:
Zalomka River (photo Ž. Zubac)

Printed by:
PRINT PLAST S.P. Trebinje

CIP - Каталогизација у публикацији
Народна и универзитетска библиотека
Републике Српске, Бања Лука

556.3(082)

INTERNATIONAL Conference and Field Seminar "Karst Without Boundaries" (2014 ; Trebinje, Dubrovnik)
Proceedings / International Conference and Field Seminar "Karst Without Boundaries", 11-15 June 2014, Trebinje (Bosnia & Herzegovina), Dubrovnik (Croatia) ; edited by N. Kukurić, Z. Stevanović, N. Krešić. - Trebinje : Grafokomerc, 2014 (Trebinje : Print plast). - 431 str. : ilustr. ; 30 cm

Tiraž 300. - Abstracts. - Registar.

ISBN 978-99938-52-58-2

1. DIKTAS (Trebinje)

COBISS.RS-ID 4308248

International Conference
and Field Seminar

Karst Without Boundaries

In partnership of

In collaboration with

Other supporting partners and organizations

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TRANSBOUNDARY KARST AND KARST AQUIFERS IN WEST STARA PLANINA MTS – CHARACTERISTICS AND PROBLEMS

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Abstract: The West Stara Planina Mountains are situated on the territories of two countries – Serbia and Bulgaria. The karstification is developed mainly in two carbonate complexes: Triassic and Upper-Jurassic while in western extension, in Vidlič Mt., karstified Cretaceous carbonate rocks are prevailing. The complicate geologic and tectonic conditions are the reason for the disclosure of carbonate rocks in long strips, oriented east-west. They formed a typical mountain karst with wide distribution of classical karstic landforms. The region is thus characterized by dolines, poljes, blind valleys. In the study area there are some hundreds of caves in both countries, many of them well explored. Due to the relatively low air temperatures, high rainfalls and relatively flat parts of the area with a lot of negative karst landforms, the conditions for extensive infiltration of precipitations and abundant groundwater reserves are created. The drainage is taking place over numerous large karst springs. Most of these are overflow sources while some of them drain the deeper saturated zones. Their discharge regime thus varies in very wide ranges from relatively constant to highly changeable. Some of springs are tapped and used for potable water supply as in case of Pirot, Dimitrovgrad (Serbia) or Svoge (Bulgaria). The majority of the karst springs have relatively clear catchment areas and are not subject to transboundary discharge. Till now it has been unclear as to the water movement between the two countries in a small area near the boundary, where the direction of the sink river water is unknown. The common water balance of the border territories of Serbia and Bulgaria needs more hydrological, hydrogeological and climatic data, field survey and water tracings.

Key Words: Karst, karst aquifers, West Stara Planina (Balkan), Serbia, Bulgaria

INTRODUCTION

The Balkan Mountain (*Stara planina*) is a mountain range in the eastern part of the Balkan Peninsula and represent a part of the Alp-Himalayan chain. Its western part is located on the territory of Bulgaria and Serbia, which to a large extent, especially in the past makes difficult common survey. During the recent years, the joint research of Serbian and Bulgarian scientists, including the areas of geology, geomorphology and hydrogeology was significantly activated. One of the most interesting and topical problems is to unify the research for cross-border areas to solve the problems of karst aquifers and karst waters distribution, having an important ecological and practical significance, as well.

PRECONDITIONS FOR DEVELOPMENT OF KARST AND KARST WATERS

The object of study is part of the Western Balkan Mountains where karstified rocks are continuously distributed throughout the territories of the two countries. Such areas are located south of the main ridge of the mountain, between the Toplodol River (in Serbia) and Iskar River (in Bulgaria) (Fig. 1). The southern boundary of the studied area is marked by rivers

draining the surface and underground waters of this part of West Stara Planina – Nishava River in Serbia and Elovitsa and Blato Rivers in Bulgaria. The total surface of the transboundary region is about 2000 km^2.

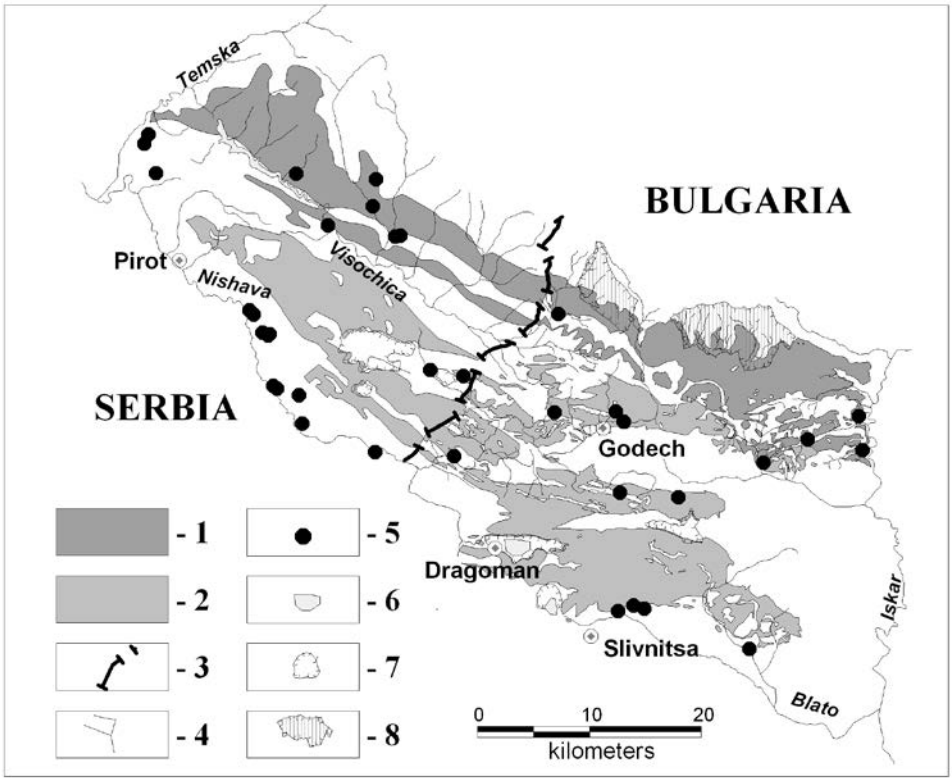

Fig. 1. Sketch map of West Stara Planina Mountains. 1 - Karstified rocks (northern zone); 2 - Karstified rocks (southern zone); 3 – State boundary; 4 - Rivers; 5 - Main springs; 6 - Lakes; 7 - Poljes; 8 - Blind valleys.

The landscape is typically mountainous. The highest parts - between 1300 and 2015 m.a.s.l. (peak of Kom) are on the main ridge of Stara Planina. South of the main ridge and parallel to it follow a series of ridges and valleys. The lowest parts, from about 300 to 700 m.a.s.l., are located along the southern border. The relief determine various climatic conditions. The annual average air temperature amended from 3.4 to more than 10º C according to the altitude. The annual rainfall of about 600 blows to up 1100 mm (Koleva, Peneva, 1990).

The formation of karst and karst aquifers depends mainly on the geological conditions. They have been studied by several researchers and the results are summarized in geological maps scaled 1:100000: map sheet **Pirot** (Geol Survey Serbia, 1970) and map sheet Berkovitsa (Haidutov, Dimitrova, 1992). Between the two sheets have some discrepancies in the geological boundaries and rock outcrops of different age and lithology. To solve these problems in recent years launched a joint Serbian-Bulgarian research project (Tchoumatchenco et al., 2011a, b).

The karst and karst aquifers are formed in Triassic limestone and dolomite and Upper Jurassic and Lower Cretaceous limestone. Their outcrops and spatial distribution are associated with the complex tectonic structure in the area. In N-S direction, within the two countries are separated two zones (Figure 1). In the first zone, covering the northern, higher parts of the mountain , the two carbonate complexes build a monoclinal structures dipping to south and are separated by non-karstic Lower - Middle Jurassic rocks. To the south it is bordered by Lower Triassic sandstones and Paleozoic rocks in the higher parts of the

mountains. The southern boundary is a thrust belt of east-west direction passing through the study region.

The second southern zone is characterized by more complex block structure due to a series of horst and graben structures also oriented east-west. The complicate tectonics reflects on the landscape of this zone: series of linearly oriented in the same direction depressions separated by ridges.

The river network also has an important impact on the karst and karst waters. The formed typical mountain rivers in the higher parts of the area running to the south, some of them (mainly on the territory of Bulgaria) completely lost their riverflow entering the carbonate complexes. Some of the rivers cross the limestone and dolomite in the first zone and flow periodically after rainfall: for example Gintsi River, the upper reaches of the Visochka (Visočica) River, and the upper reaches of its right tributaries in Serbia (Rosomačka, Jelovička). The rivers Visočica and Nishava represent the major drainage arteries of the second (southern) zone and Iskar River drains only the eastern part of the northern zone. Several rivers as Iskrets and Blato in Bulgaria begin from large karst springs. The western boundary of the area - Temska River has almost no connection with karst.

KARST AND KARST LANDFORMS

About 60% of the total area of the Western Balkans is occupied by karstified rocks. From morphological point of view the karst is mostly naked, mountain type with widespread surface karst landforms. On the territory of Bulgaria and eastern parts of Serbia the surface karst forms are described by Radev (1915) and Petrovic (1974), respectively. Karst studies in some sections of the border are performed by other authors (Petrovic, 1974; Benderev, 1989; Zlatkova, 2006; Mihaylova et al. 2008;). The intensity of karst processes is different in the northern and southern zones of the studied area. In the northern zone there are widespread karrenfelds, dolines and uvalas. Important role play, especially on the territory of Bulgaria, the significant blind valleys. Compared to the southern zone, a large number of caves and pot holes are established here; for instance over 184 in Bulgaria. There is a wide distribution of caves which morphology is determined by the monoclonal dipping to south of the layers of carbonate rocks and representing old or active ponors of surface water. There are caves, representing active and temporary springs as well (Vodnata Cave, Krivata Cave, Dushnika Cave, etc.). Most of the deepest and longest caves in theWest Balkans are located in this zone (Table 1).

Tabele1: The longest and the deepest caves in the studied area

№	Cave	Country	Zone	Length (m)	Depth (m)
1	Balabanova Dupka	Bulgaria	Northern	4800	80
2	Vetrena dupka	Serbia	Southern	4150	>50
3	Tizoin	Bulgaria	Northern	3599	320
4	Vodnata Cave	Bulgaria	Northern	3264	85
5	Katsite Cave	Bulgaria	Northern	2560	205
6	El Saguaro	Bulgaria	Northern	2217	135
7	Golyamata Temnota	Bulgaria	Southern	2100	106
8	Krivata Cave	Bulgaria	Northern	1500	75
9	Velika Pecina	Serbia	Northern	1440	>50
10	Dushnika Cave	Bulgaria	Northern	827	27
11	Kozarskata Cave	Bulgaria	Northern	709	12

12	Temnata Dupka	Bulgaria	Southern	493	95
13	Golema dupka ponor	Serbia	Southern	480	>50
14	Malata Balabanova	Bulgaria	Northern	400	125
15	Granicharskata Cave	Bulgaria	Northern	344	72
16	Malkoto Saguaro Cave	Bulgaria	Northern	338	44
17	Vladikina plocha	Serbia	Northern	300	20
18	Kolkina Dupka Cave	Bulgaria	Northern	68	236
19	Peshterica pothole	Serbia	Southern	0	155

The karst distribution in the southern zone varies in the different areas, depending on the specific geomorphological and hydrogeological conditions. There is both naked karst and sections covered with a thick soil layers. The distribution of uvalas and dolines is different - there are both areas with significant dolines density (for example 164 dolines on the flattened ridge part of Tri Ushi Ridge in Bulgaria on area of 35 km^2) and areas with relatively low levels of karstification. Typical for the zone are the large karst poljes: Rayanovsko, Dragomansko and Aldomirovsko poljes in Bulgaria, and Odorovacko in Serbia. According to the polje classification scheme of Gams (1994), the poljes in the Bulgarian part are of overflow type. In Dragomansko and Aldomirovsko poljes are form permanent marshes.

The number of the caves in this zone is much lower - about 60 in Bulgarian part. Most of the caves are small - up to 100 m long and 25 m deep. The exceptions are Vetrena dupka in Serbia (4150 m), and Golyamata Temnota Cave (2100 m) and Temnata Dupka Cave (493 m) in Bulgaria. The late two are active ponor caves.

KARST WATERS

The data on the karst aquifers and waters in the studied area are summarized separately for Bulgaria (Antonov, 1963; Antonov, Danchev, 1980) and Serbia (Stevanovic, 1994).

The karst aquifer recharge is primarily from rainfall. The rainfall quantity increases from south to north, due to larger values and the reduction of the evapotranspiration in the higher parts of the mountains. In the northern zone an important component of the water balance is temporary and permanent influation of surface rivers descending from the main ridge of Stara Planina. Influation of surface water occurs in the southern part but to a lesser degree. These are mainly flows passing through karst poljes. The general direction of groundwater movement is from north to south, to the lowest parts of the landscape. The exception is only in the most eastern part of the region, where part of the karst water is directed to the Iskar River.

The northern zone is characterized by predominantly movement of groundwater in isolated channels and only in the most southern parts can be formed small saturated areas. Due to the block structure of the southern zone, much more favorable preconditions for saturated zones formation in the different blocks can be found. This zone is largest in the lowest parts of the region where the Neogene terrigenous (mostly clay) sediments filling Sofia graben and Pirot basin and create conditions for accumulation of groundwater.

The drainage is performed by springs, groundwater extraction and subterranean flows into lateral permeable intergranular aquifers. There are both, small gravity springs of small local catchment areas with low flow rates and typical ascending karst springs with high flows. In the northern zone springs with relatively constant high flows are often found. Of interest, are the larger drainage areas where there is a concentration of several springs draining different

hydrodynamic zones: for example Krupac in Serbia and Opitsvet - Bezden in Bulgaria. In these areas are both springs draining the upper part of the saturated zone with highly variable flow and springs on relatively lower elevations with less varying flow rates. Characteristic is the presence of ascending springs with higher temperatures - 19-22º C draining areas with deep circulation.

TRANSBOUNDARY PROBLEMS

The specific geomorhological, geological and hydrogeological conditions greatly reduces the areas where can be found transboundary impacts near the state border. In the northern zone, it is possible that water transfers from Komshtitsa River to Kamenicka River (Fig. 2) but this must be proven by detailed hydrometric measurements and tracing experiments.

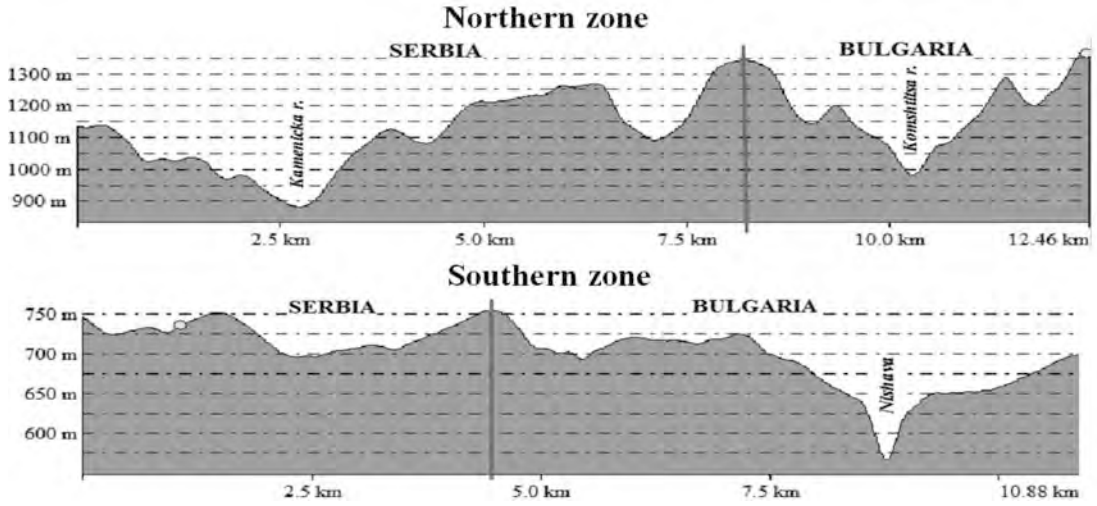

Fig.2. Schematic profile of transboundary areas in the northern and southern zones

In the southern zone the main drainage artery is Nishava River but probable influence of transboundary impact is minimal due to the small catchment areas, absence of a significant river recharge into the area and the lower level of karstification.

For a more complete elucidation of the possible cross-border relationships a number of obstacles exist because of limited access in the past due to pre-existing border regime and the varying degrees of available information. The main difficulties are related to:

1. Discordance of some geological boundaries and distribution of rock formations on the both sides of the state border;
2. Absence of mode observations of the rivers and springs near the border;
3. Difficult access to comparable hydrological and meteorological data.

CONCLUSION

The preliminary analysis of the existing information indicates that the karst region in the studied area is common and that the passing of karst water from one state to another is probable to a small extent. Therefore the continuation of the joint research between Serbian and Bulgarian hydrogeologists and karst scientists is necessary. The common water balance of the border territories of Serbia and Bulgaria needs more hydrological, hydrogeological and climatic data, field survey and water tracings.

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