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Original scientific paper

EPIGENETIC VALLEYS IN THE TIKVES BASIN IN THE REPUBLIC OF MACEDONIA

Kole Pavlov[1]
Ace Milenkovski
Gjorgi Pavlovski
Ivan Radevski

Abstract
The epigenetic valleys as part of the fluvial relief are of special geomorphologic significance. As ostensibly anomalous phenomena, they mirror the inconsistent fluvial relief, i.e. a phase of adjustment of longitudinal profiles of rivers. The subject of research in this paper involved some forms of the fluvial relief in the drainage basin of the Vardar River, in the Tikves Basin, which had some predispositions to be classified as an epigenetic valleys. The necessary geological-and-lithological and morphological parameters have shown that specific segments in the river valleys in Tikves are distinguished by special physiognomy, lithology and genesis, which correspond to epigenetic valleys and gorges. Thus arguments indicated in total ten created epigenetic valleys and gorges on the level of the Tikves Basin. Seven epigenetic occurrences were formed below the neogene level, whereas three of them were formed above the neogene level.

Keywords: epigenetic valley, epigenetic gorge, epigenetic incision, river relief.

Jel Classification: Q5

INTRODUCTION

Epigenetic valleys are a part of the inconsistent fluvial relief, and are used in the Balkans as the benchmark for establishing the height limit between the abrasive and fluvial relief (Zeremski 1965). The term ‘epigenetic’ refers to the secondary nature of the bedrock gorges, which occur after the formation of the original gorge (Kothyari et al. 2013; Ouimet et al. 2008). These are forms created from the lateral displacement of bedrocks during episodes of alluvial sedimentation with partitions of alluvial material that force the river to incise down into solid rocks in the form of a “canyon” rather than exhume its own paleovalley (Ouimet et al. 2008). The epigenetic gorges are also called: bypass valleys, or modern slot canyons. They have narrow, scalped steep-sided valleys.

[1] **Kole Pavlov**, PhD, Professor, **Ace Milenkovski**, PhD, Full Professor, University of Tourism and Management, Skopje; **Gjorgi Pavlovski**, PhD, Professor, Goce Delcev University, Stip; **Ivan Radevski**, PhD, Full Professor, Faculty of Natural sciences and Mathematics, Skopje, Macedonia.

At first sight, the epigenetic gorges are anomalies in the fluvial relief since they are cut into an elevation of resistant rocks in the surroundings of which there is lower ground built of softer rocks. The key question in the geneaology of the epigenetic valleys is why the rivers incised the gorge in more solid rocks rather than into deposited softer sediments in the immediate surroundings, which seemed easier to be eroded and where actually there were lower topographic positions? Accordingly, one of the conceptual models for formation of epigenetic valleys (gorges) is displacement of the riverbed resulting from the burying of the paleovalley with sediments or due to the side pressure of the water and the deposited alluvial flow material from the tributaries (Lazarevic 1975). The second concept of the genesis of epigenetic valleys attributes an active role to the tectonic dynamism that predisposes accelerated and exclusively deep erosion of valley sections located on elevation. Therefore, in literature, the epigenetic narrowings (gorges) refer to composite valleys formed by local tectonic faulting in the longitudinal profile of rivers that predispose sequences of erosive widening and sequences of pronounced deep dissection. The basic conditions for differentiating the epigenetic gorges are: lithological (existence of resistant rocks at the top) and morphological (existence of soft soil position lower in comparison with the upper edges of the gorge, incised in the resistant rocks (Petrovic 1953, 1977). Generally, studying the epigenetic valleys has an enormous scientific meaning. Actually, epigenetic valleys are preferred in geomorphology as the relevant indicator for determining the height of the central-lake plains of neogene lakes all over the Balkans. In fact, they have also been taken into consideration for determining the level of the central-lake plains of the Pliocene lakes in Macedonia through which subsequently, in Quaternary, a new network of rivers was formed (Manakovic 1960, 1968). The whole research process was initiated by several established fluvial landforms in Tikves Basin characterized by physiognomy of the epigenetic gorges that have no geographical nor geomorphological explication published any data yet. So, the main objectives in the study were some sequences from the valleys of the rivers in the Tikves Basin. The main task was to determine which of them according to visual clues, really possess character of epigenetic gorge, ie epigenetic built. The second task was to perform an altitude correlation with the plane of neogene lake in Tikves Basin and see if epigenetic valleys correspond to its height, like in some previous conclusions about the wider territory of the Balkans. The research activities through field survey related with other necessary methods turned out that in the area there are ten, so far undiscovered epigenetic gorges and river incissions. Their genesis is purely epigenetic. This statement was derived from all considered geomorphological, geological and genetic indications in the study. It also turned out that altitude of some epigenetic gorges genetically correspond to the level of neoge lake in the area while some epigenetic incissions lay above that level and are formed independently on the dwindling neogene lake in the Tikves Basin.

STUDY AREA

Geographically, the Tikves Basin encompasses the middle drainage basin area of the river Vardar in the central and the south parts of the Republic of Macedonia (fig. 1). It is located between $41^{0}05'30''$ - $41^{0}43'38''$ **N** and $21^{0}47'$ - $22^{0}19'$ **E**. The wavelike Tikves Basin in its natural boundaries, covers 2060.54 km^2, measured by the watershed line that accounts for 8% of the territory of the Republic of Macedonia (Pavlovski 1993;

Pavlov 2011). Tectonically, the Tikves Basin has a tectonic rift structure that completely belongs to the Vardar zone (Arsovski 1997; Kolcakovski 2008).

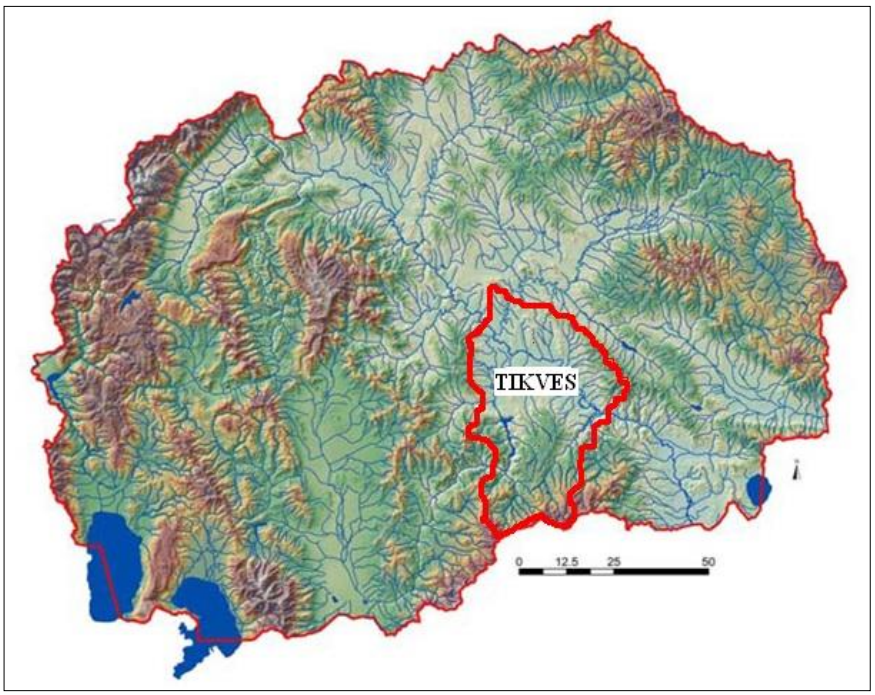

Figure 1. Tikves location in the Republic of Macedonia

METHODS AND DESIGN

Methods that were used for the recognition and genealogical explication of the epigenetic valleys as a geomorphologic phenomenon in Tikves were as follows. Primarily in the hypothetical stage were used topographic maps with large-scale (1: 25,000 and 1: 50,000) owned by the Institute of Geography at Faculty of Natural Sciences and Mathematics in Skopje for the initial detection of landforms which could be epigenetic valleys. The visual effect was further enhanced through observations of river gorges and incised sequences possessing indications of epigenetic valleys using the software package Google Earth.

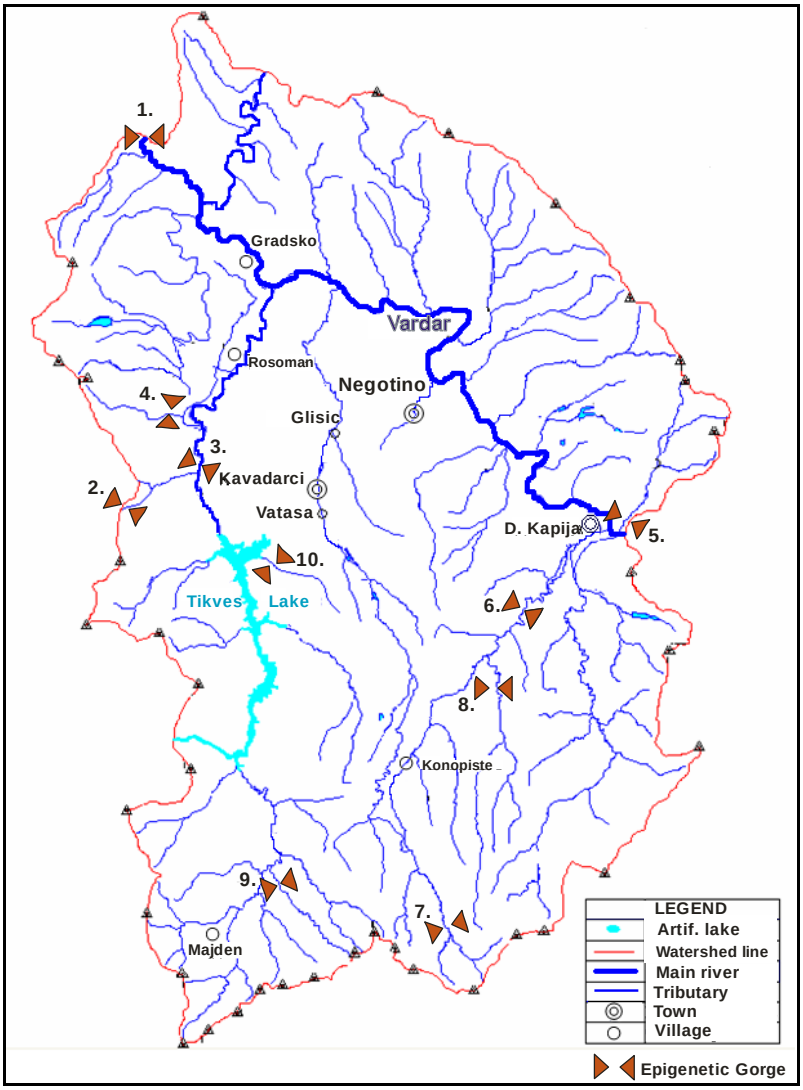

Figure 2. Spatial distribution of epigenetic valleys in the net of River Vardar in Tikves Basin

This software package using the three-dimensional animations refer to the requirements for observation the objects from different sides and different heights. Also it allows capturing the effect of lowering the topographical area near ravines as the basic feature of epigenetic valleys. After being in this way dozens of indicative epigenetic narrows and gorges were found whereas their validation required usage of methods of field survey and analyze of geological map. Field observations considering by the vastness of the examined area was conducted in several phases in the period 2009–2012. Field research in comparison with data from geological maps utilized from the Faculty of Mining and Geology in Stip and Geological Institute in Skopje beside visual had to

give lithological confirmation of epigenetic valleys. Geological maps were in large scale (1: 100,000). With the assistance of these methods definitely the existence of lithological softer surface in vicinity of 10 valleys carved into a solid rocks was confirmed which is actually the main feature of epigenetic valley. Conducting outdoor object observing was necessary for evolutionary explanation of epigenetic valleys in the area and also for clarification of their genesis. The spatial distribution of determined ten epigenetic gorges in Tikves Basin were eventually marked to the electronic map. The map was made using AutoCAD 2008 and Surfer 8 on basis of topographic map in scale 1: 100,000. Also the basis of a topographic map with a scale of 1: 50,000 were utilized to create schemes of epigenetic gorges. Those schemes refers to cross profiles of the epigenetic gorges exposed on their exits. In its creation the engraving and shading appropriate for lithological expression objects on geological maps were used.

RESULTS AND DISCUSSION

The **Zgropole Gorge** (41^0 38’ 48’’ **N**; 21^0 52’ 33’’ **E**) has been determined as the entry point of the Vardar River into the Tikves Basin (point 1, fig. 2) on the elevation of 142 meters (Pavlov, 2011). It is epigenetically incised in a partition composed of Palaeozoic shales placed transversely in relation to the river flow, which is by itself a geostructural continuity of the Klepa Massif to the west with a relatively complex lithological composition. It is incised by the Vardar River with spur-like ridges, creating 40 meter high steep hill slopes on the right side of the valley. The upper edges of the valley in the gorge are elevated 230 meters on the left and 170 meters on the right side. When qualifying of the Zgropole Gorge as an epigenetic gorge is involved, there are all lithological and morphological conditions for its undoubted determination. Actually, there are resistant rocks at the top, consisting of Palaeozoic shales that are radially scalped and are fully impressive on the right bank of the Vardar (fig. 3; 4). A topographically lowered land built from flysch formation originating from the Eocene epoch is located in the immediate vicinity, on the left bank of the Vardar (Stojanova and Petrov 2008). This is the very point that meets another condition of epigenetic valleys as an "ostensible anomaly" in the fluvial landscape, which seemingly indicates to the paradoxical incision of the Vardar through more resistant rocks instead of circumventing them and cutting through softer and lower soil in the immediate surroundings to the left (175 meters). Explanation for the existing phenomenon is in the tectonic and erosive events occurring in Early Quaternary. At that time, with the formation of the Vardar River network in the Middle Povardarie area, in the newly formed basins with powerful Neogene sediments, their quick evacuation and uncovering of layers at the bottom occurred (Arsovski 1991; Pavlov and Pavlovski 2013). In that campaign, a forced process of deep incision of more resistant Palaeozoic shales, which were at the top at that time, occurred concurrently with expressed lateral exhumation and lowering of the soil composed of soft Neogene sediments in the surroundings, which initially pinched the flow of the Vardar. After the final moulding of the gorge with subsequent fluvial denudation processes, additional lowering of the surroundings on the flysch-built left side of the Vardar occurred. Such a process of lowering of the right side lagged behind as a logical outcome given the geological composition of the more resistant rocks (fig. 3; 4).

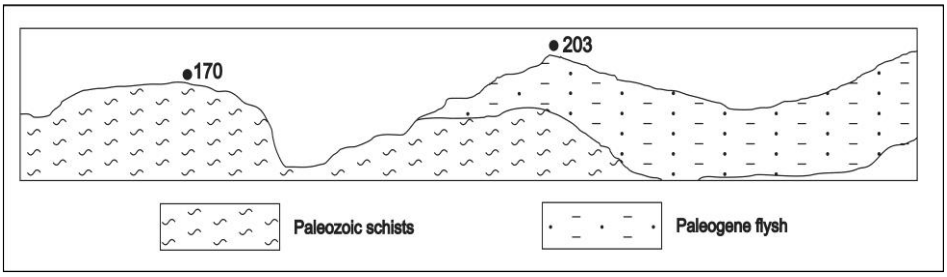

Figure 3. Sheme of epigenetic Zgropole Gorge of Vardar River into the Tikves Basin

Figure 4. Satellite image of the Zgropole Gorge at the entrance of the Vardar River into the Tikves Basin

The **Drenovo Gorge** on the Rajec River (41^0 26' 10'' **N**; 21^0 52' 15'' **E**) represents a natural communication gateway between the adjacent Tikves and Rajec regions. It is epigenetically incised between Skrka (582) to the north and Devol (441) to the south (point 2, fig. 2). The valley is actually a gorge that intersects the Skrka Hill with spur-like ridges, the range of which stretches in a northwest-southeast position (fig. 5). The upper edges of the valley are on the elevation of 477 meters on the left and 325 meters on the right side so that cut-outs of 240 and 90 meters respectively are rising above the Rajec River. Indications on behalf of the epigenetic description of the Drenovo Gorge are undoubted. Thus, the top layer contains resistant rocks of massive limestone of which the Skrka Hill is built, and they are radially incised on the bank of the River Rajec in the west-east direction. On the right (south) bank of the Rajec River, there is a topographically lowered ground built of Pliocene-Quaternary sedimentations. It is in fact a saddle (270) between Skrka and Devol, which nowadays seems as the most logical point to cross the Rajec from the Rajec region to Tikves, circumventing the Skrka Hill, which is built of more resistant rocks. Instead of the Rajec diverting in the south-east direction around the Skrka Hill to the north, during the adjustment of its longitudinal profile in the Early Pleistocene, it was first pinched into the limestone of Skrka, and concurrently to the lateral erosion and evacuation of the Neogene sediments on the southern side, it made the lowering of the ground (fig. 5; 6).

Figure 5. Satellite image of the Drenovo Gorge at the entrance of the Rajec River into the Tikves Basin

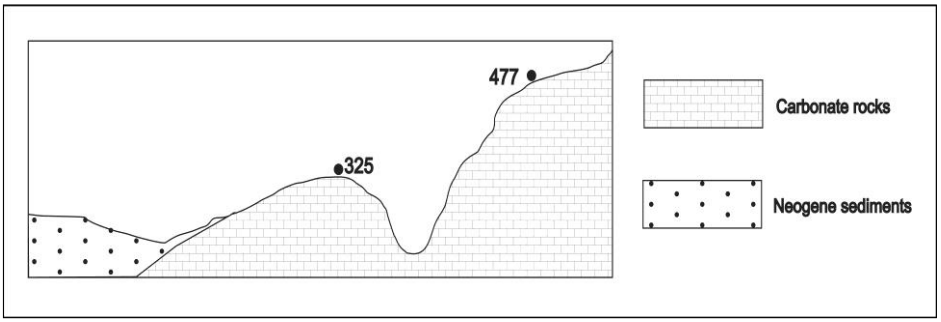

Figure 6. Sheme of epigenetic Drenovo Gorge of Rajec River

The **epigenetic gorge of the Crna Reka** river (41^0 27' 50'' **N**; 21^0 50' 21'' **E**) to the south of the village of Trstenik, is incised in a laterally placed partition of the Palaeozoic shales which is truly scalpted, especially on the right bank of the Crna Reka, with normal (canyon) bedrock walls up to 30 meters high (fig. 7; 8). The epigenetic gorge is 0.6 km long with the upper edges of the valley rising up to 90 meters on the left and 110 meters on the right bank of the Crna Reka (point 3, fig. 2). Arguing on behalf of the epigenetic nature of this gorge, it is sufficient to emphasise the resistant rocks at the top made of Palaeozoic shales as the lithological structure of the Makarija partition, which are radially incised by the Crna Reka. This is the only anticlinal structure in the Crna Reka basin in Tikves, which obstructs the water flow and around which lower grounds with softer layers from Pliocene and Quaternary stretch as plains. An attitude that logically imposes itself concerning the genesis of the Crna Reka epigenetic gorge is that during the Early Pleistocene refraction and lowering of the central-lake plain occurred in Tikves, from the elevation of 620 meters in the Pliocene, to a lower elevation by 400-430 meters in the Pleistocene (Pavlovski 1993; Pavlov 2011). This is supported by the lowest preserved abrasive area near the village of Drenovo, at the elevation of 390-430 meters. A partition of resistant palaeogenic shales where the epigenetic gorge is located nowadays spread across Tikves in the general direction, south-north, which followed the course of the Crna Reka which adjusted its longitudinal profile in the Pleistocene amid regressive erosion. The topographically lowered ground that occurred with the concurrent evacuation of the neogene sediments around the gorge is most evident 1 km to the west. That ablaut,

through which the Gradsko-Drenovo road passes, seems the most logical location for bridging of the course of the Crna Reka in the north-west direction on the line of the village of Sivec - village Kamen Dol than getting through the higher and lithologically more resistant ground to the north-east (fig. 7; 8).

Figure 7. Satellite image of Epigenetic gorge of Crna Reka River nearby village of Trstenic

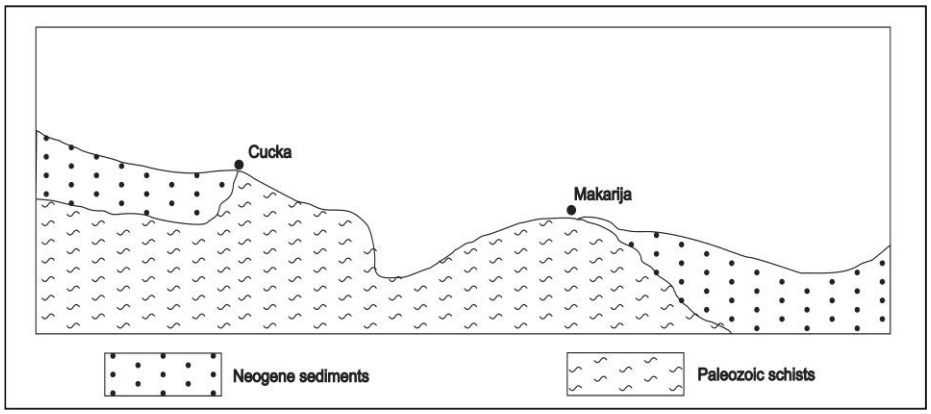

Figure 8. Sheme of epigenetically scalped gorge of Crna Reka River nearby village of Trstenic

The **epigenetic gorge of the Kamenodol Stream** (41^0 28' 30'' **N**; 21^0 53' 14'' **E**) is incised in Suvi Prisoj (421), to the west of the village of Kamen Dol (point 4, fig. 2). The Kamenodolski, i.e. Vodenicki Potok springs under Ruen (946) and is distinguished with a relatively unadjusted longitudinal profile. Actually, in the upper course, it is characterised with small average drop of the riverbed, moving through the relatively preserved and levelled abrasive area where the Mrzen-Oraovec settlement is located. In the middle course, before its average river drop intensifying suddenly 1 km upstream of the village of Kamen Dol, the river comes across an ascendingly set oasis of Paleozoic schists and marble at Suvi Prisoj, which it cuts epigenetically in the west-east direction (Pavlov and Pavlovski 2013). The upper edges of the formed dome-like epigenetic valley are located at 421 meters on the south (right) bank and 450 meters on the north (left) bank, rising above the riverbed more than 80 meters (fig. 9; 10). Besides the barrier of resistant rock at the top, which the Kamendol Stream has cut through, both

sides of the valley feature lowered relief areas built of softer neogene sediments leaning towards the village of Debriste to the south and the village of Sirkovo to the north (fig. 9). In order to provide plastic explication of the formation of the epigenetic gorge, it can be said that the main events were closely related to the adjustment of the longitudinal profile of the Kamendol Stream towards the Crna Reka basin as a local erosive basis, which tended to sink in the Pleistocene. The rivers to the left going downstream from Vetersko, Ruen and Klepa eroded intensively the soft neogene sediments towards depression of the Crna Reka. In such conditions, the Kamendol Stream managed to squeeze between resistant rocks of Suvi Prisoj, in the surroundings of which the fluvial denudation processes led to evident lowering of the topographic surface. It is also necessary to mention, on behalf of the "anomaly" attribute of this gorge, that in the initial phase of the genesis of the epigenetic incision, the stream could deviate to the south-east down a lower path to the Debriste gullies.

Figure 9. Satellite image of epigenetic incision of Kamendol Stream nearby village of Kamen Dol

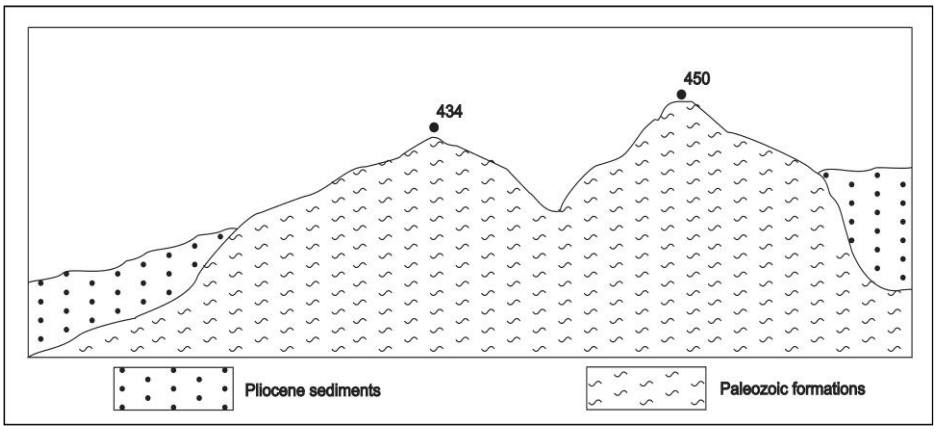

Figure 10. Sheme of epigenetic incision of Kamendol Stream through oasis of shists and marbles

The **epigenetic gorge of the Iberliska Reka** (41^0 24’ 26’’ **N**; 22^0 15’ 37’’ **E**) is the most striking and a school example of a dome-like epigenetic valley in Tikves (point 5, fig. 2). It springs at the altitude of 1,000 meters. The confluence to the Vardar River is near the entry to the Demir Kapija Gorge at the elevation of 94 meters. The total

descending of the river is 896 meters, and the average one is 70 ‰. One kilometre before the confluence to the Vardar, it made an epigenetic valley with the canyon form and steep cuts on the sides of the valley whose width is reduced to the width of the riverbed, more than 200 m high (fig. 11). The specific of this epigenetic valley is that in the middle catchment basin, sequences with small uplands (in form of saddles) are observable as part of the Demir Kapija - Gevgelija gabbro-diabase massif, along the watershed, especially in the south, on the left bank of the Iberliska Reka, which seem to be the most natural place on the way towards the Vardar as the final destination. Opposite that hypothetical south-west direction, downstream from the village of Celevac, the river running to the west penetrated in form of a canyon through a dome of powerful Jurassic limestone. A lowered ground in the direct catchment area of the Vardar consisting of soft alluvial deposits is perceivable in the near proximity of the epigenetic valley, to the north and the south of the upper edges of the valley (fig. 11; 12). According to the morphological features, it is most likely that at the time of the genesis of the epigenetic valley, the Iberliska Reka, when adjusting its longitudinal profile, followed in parallel the penetration of the Vardar through the limestone entry to Demir Kapija Gorge in the early Pleistocene. Visible lower positions in the south section of the watershed line of the Iberliska Reka were the result of subsequent fluvial denudation evacuation, most likely of soft neogene sediments. Lowering of the south part of the watershed line is in line with the general slope of the ground (inclined to the south) dictated by the main river (Vardar), which is a known feature of epigenetic valleys of small rivers before their confluence (Zeremski 1965).

Figure 11. Satellite image of epigenetic gorge incision of Iberliska Reka in front its entry to the Vardar River

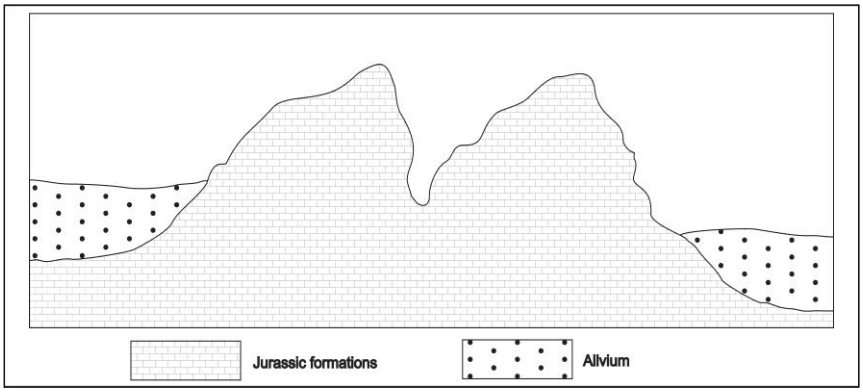

Figure 12. Sheme of epigenetic gorge of Iberliska Reka through a Jurassic limestones

The **Barovska Gorge** of the Bosava River (41^0 21’ 30’’ **N**; 22^0 10’ 56’’ **E)** is the longest epigenetic gorge in Tikves stretching in a 8 km strip downstream from the village of Barovo (point 6, fig. 2). It is epigenetically slotted in a belt of Jurassic complex of: shales, marls, and diabases between Krivi Dabec (501) to the north-west (on the left bank) and a nameless elevation (500) to the south-east (on the right bank) in the bed of the Bosava (fig. 13; 14). Given the complex geological-morphological picture of the surrounding area, on the edge of the Kozuf-Vitacevo volcanic area, it is generally an edge-located epigenetic valley with upper rims on the left valley side rising 240 meters above the river bed. This makes it exceptionally inaccessible, so that the local Barovo-Besvica road leads down a trough surrounding it from the left (Radovanovic 1924; Pavlov and Pavlovski 2013). That trough between Krivi Dabec (501) to the east and Cuka (665) to the west is a topographic depression of softer and younger sediments (Pliocene – Quaternary) in the bottom layer through which the Bosava should drive its valley instead of incising "anomalistically” in the resistant Jurassic complex, in the upper layer of the present-day valley sides (fig. 13; 14). Tangible evidence of the genealogical explication goes back to the time of the Early Quaternary. Then, the Bosava river flow, with a high level of erosion, incised deeply in the volcanic sediments of the Kozuf-Vitacevo volcanic area, which are totally eroded to the level of the previously deposited neogene sediments down the Konopiste settlement (660). The lateral compression of volcanic Quaternary sediments pinched and forced the Bosava river flow to cut deep through the Jurassic complex downstream Barovo only for them to be later exhumed with fluvial denudation processes to the level of the older of them, neogene sediments, to the west of the gorge. Such a process of the lowering of the right bank logically lagged behind as a consequence of the geological composition where more resistant rocks with gabbro-diabase composition participate (fig. 13; 14).

Figure 13. Satellite image of epigenetic Barovska Gorge of Bosava River downstream from the village of Barovo

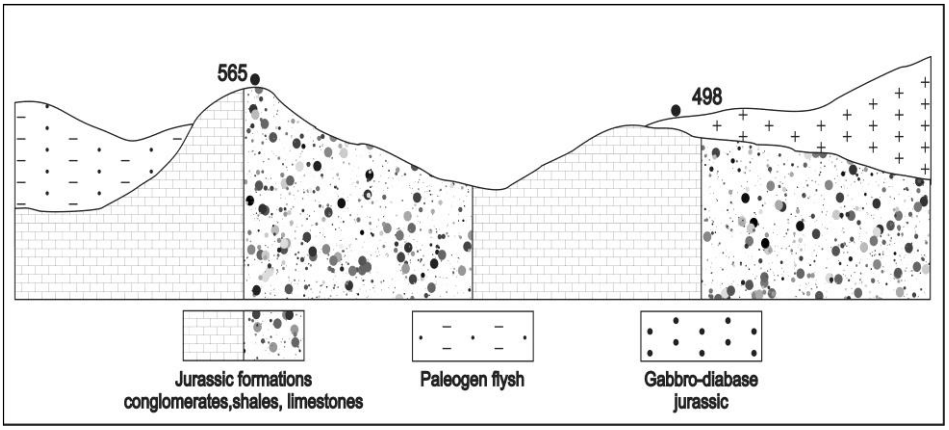

Figure 14. Sheme of epigenetic gorge of epigenetic Barovska Gorge of Bosava River

An **epigenetic gorge on the Bosava River** (41^0 11’ 12’’ **N**; 22^0 06’ 36’’ **E)** has been recognized in the upper flow under the slopes of Kozuf (point 7, fig. 2). It is 3 km long and is cut epigenetically into an “island” of Senonian limestone surrounded with volcanogenic sediment creations in form of andesite towers from the west and the east (Ostrec, Cvrstec, Duduca) and tuffs from the north. It demonstrates atypical characteristics compared to the other epigenetic valleys in Tikves and elsewhere, because the upper edges of the valley are elevated higher than the central lake plain at the time of the Pliocene lacustrine phase, unlike lithological and morphological characteristics that rather indicatively justify its epigenetic description. Although they are rarer, they are still differentiated and known in some geomorphologic research (Zeremski 1955). It is cut-in between Ostrec (1520) to the west (to the left from the the Bosava River) and elevation of 1368 to the east (to the right from the Bosava River). The upper edges on the right valley side rise steeply over the riverbed to 350 m (fig. 15). The top layer consists of karstified limestone of Senonian and andesite towers (on the left bank of the Bosava) whereas at the bottom, to the right of the riverbed, softer volcanic sediments that show lower topographic positions are found (fig. 15; 16). All indications for genetic explanation lead to that during the Early Quaternary the Bosava

River flow, in its upper section, evacuated the non-stratified pyroclastic material of the volcanic Kozuf-Vitacevo area with noticeable regressive erosion, and the configuration of the andesite towers directed the river flow to exhumation and incision in the pre-covered Senonian limestone (fig. 15; 16). Given the geology of the terrain, the process of topographic lowering of the right bank where softer Quaternary sediment took part continued further whereas it lagged behind on the left bank (fig. 13; 14).

Figure 15. Satellite image of epigenetic gorge of Bosava River upstream from the village of Konopiste

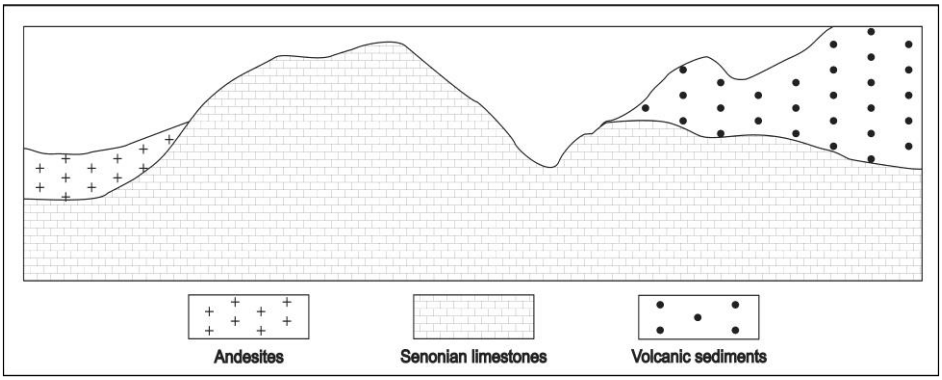

Figure 16. Sheme of epigenetic gorge of Bosava River upstream from the village of Konopiste

The **epigenetic gorge** (41^0 18’ 10’’ **N**; 22^0 09’ 45’’ **E**) **of the Bohulska Reka** (the right tributary of the Bosava River) is cut-into down the village of Bohula between Kalugjerica (762) to the west (on the left bank) and Usevica (822) to the east (on the right bank) of the river 6 km in length (point 8, fig. 2). Morphologically, the Bohulska Reka basin is dissected into a high abrasive area (more than 900 m) which the flattened parts of Gatenovo along the east part of the watershed and ‘Rziste along the west part of the watershed bear witness to as remnants (fig. 17). The Quaternary volcanic sediment is present in the upper catchment area, and Pliocene-Quaternary sediment of sand, gravel and clay in the middle one. In the lower flow, before the average river drop increases to 6 km upstream of the confluence into the Bosava, the river comes across a longitudinally positioned Jurassic formation of: shales, marls and diabases, which the epigenetic path cut through (fig. 17; 18). The upper edges of the formed dome epigenetic valley overlook the riverbed at 170 m (on the left) and 230 m (on the

right). Around the barrier of more resistant Jurassic rocks in the top layer which the Bohulska Reka has cut through, topographically lowered areas in the relief are located on both sides of the valley, built of softer neogene sands and gravel, which lean to the west towards the Bosava catchment area and the east, towards the Dosnica catchment area (fig. 17; 18). A significant point in the formation of the epigenetic gorge was the alignment of the longitudinal profile of the Bohulska Reka, which was delayed compared to the recipient Bosava as the local erosive basis, which had cut deep in an accelerated pace in the Pleistocene, predisposing the conditions for canyon slots in its tributaries on the sections before their confluences. In such conditions the Bohulska Reka, by inertia, squeezed itself between the resistant Jurassic rocks, which clutched the riverbed between Kalugjerica and Usevica, although nowadays, there is some lowering in form of a saddle to the west of the watershed where the river could deviate towards north-west and down a lower path towards the Bosava Reka, whose route follows the local Bohula-Cemersko road. Lowering in the west part of the watershed line corresponds to the general decline of the terrain, which is imposed by the valley of the recipient Bosava.

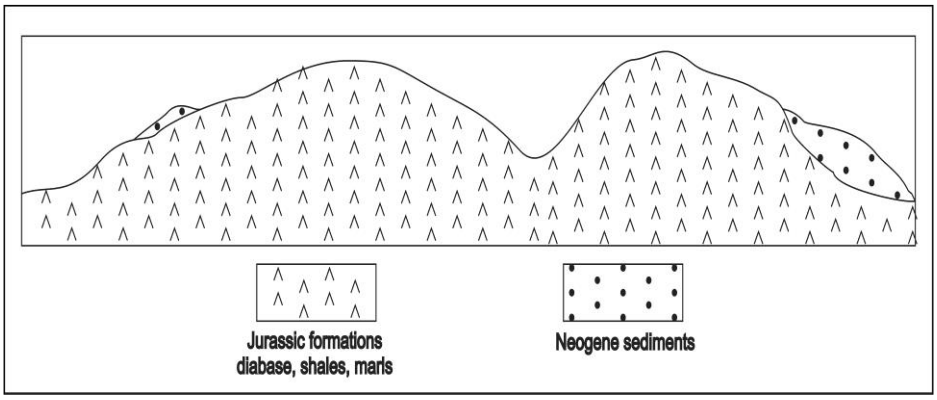

Figure 17. Sheme of epigenetic gorge of Bohulska Reka nearby the village of Bohula

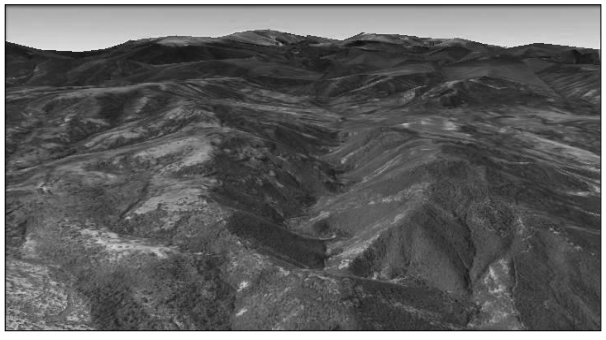

Figure 18. Satellite image of epigenetic gorge of Bohulska Reka nearby the village of Bohula

The **epigenetic incision of the Topli Dol** (41^0 11' 45'' **N**; 21^0 58' 49'' **E)** before the confluence into the Blasnica River is another example of a dome-like epigenetic valley of rivers in Tikves Basin (point 9, fig. 2). The Topli Dol is the right tributary of the Blasnica, which drains the waste water from the 'Rzanovo mine, and its confluence is 2.5 km to the northwest of the mine. The catchment basin belongs to the Kozuf area of early volcanism, actually to the metalliferous polymetallic area of Alshaar (Boev and Lepitkova 1991). The epigenetic section was created in a belt of Triassic terrigenous carbonate formations 1 km upstream the confluence between the 753 meter elevation on the north and 754 metre elevation on the left banks of the Topli Dol (fig. 19). The upper edges of the valley sides rise 200 metres above the riverbed. However the first visual impression speaks against the Topli Dol Gorge as an epigenetic phenomenon, a complex approach *de facto* confirms the necessary morphological and lithological conditions. Actually, a limestone series is visible in the top layer, and clay shales and Pliocene Quaternary layers are bared to the right (north) of the bottom left (south) side. Topographic lowering is visible on both sides, and two typical lower positions, as more favourable segments for the bridging of the river towards the recipient, are visible on the north side of the watershed line (fig. 19; 20). More remarkable lowering to the north of the watershed is in correlation with the general declining of the ground which was predisposed by the recipient, in the south north direction. Evolution of the epigenetic gorge of the Topli Dol started in the early Quaternary when the river started to initiate the fluvial relief on volcanogenic sediments that covered the Triassic limestone, which the lower part of the present-day river is constructed of. The volcanic sedimentation resulting from neo-volcanic activities was evacuated very soon because of the large drop of the river profile which, after all, was is a part of a large faulting structure, or the Polog-Rzanovo cliff where thermal sources were found (Arsovski 1997). An important link that fits complementarily in the time of the canyonic scalping in the Topli Dol valley is the fact that all right tributaries of the Crna Reka (of the first and the second line) on the Mariovo to Tikves section, have unadjusted longitudinal profiles with expressed depth slots and waterfalls at their confluences. A reason for that is their lagging behind in comparison to the Crna Reka, as a recipient, which deep-incised its valley faster than the tributaries. Those conditions made forced cut-crossing of the dome of limestone in front of the confluence, and nowadays it is an obstacle, instead of being bypassed, had its exhumation been even during the coverage with the pyroclastic material.

Figure 19. Satellite image of epigenetic incision of Topli Dol in front its entry to Blasnica River

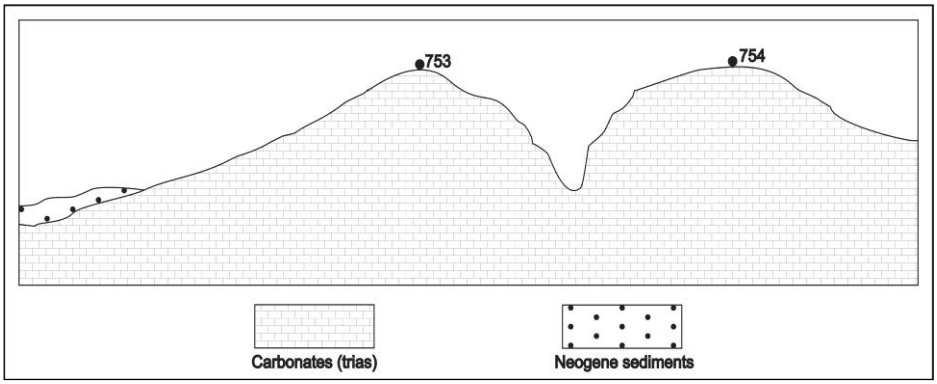

Figure 20. Sheme of epigenetic incision of Topli Dol in front its entry to Blasnica River

An epigenetic valley is determined in the lower part of the **Dabniska Reka** (41^0 23' 23'' **N**; 21^0 58' 29'' **E)**. Actually, it is located in a bay that is a product of the submerging of its confluence in Lake Tikves (point 10, fig. 2). Downstream from the village of Resava, in the 0.7 km length, a waterflow is epigenetically slotted in a dome-like "oasis" of Jurassic diabases surrounded with neogenetic sands and clays to the north, south and east sides (fig. 21; 22). The upper edges of the valley along the epigenetic section rise to the elevation of 366 meters on the right (north) side and 348 meters on the left (south) side, or up to 100 meters above the level of the riverbed (fig. 21; 22). The lithological and morphological configuration is fully explicit, or it is about a valley segment with a roof of resistant diabases and a bottom of soft Pliocene sediments in the surroundings, which are actually topographic lowering (fig. 21; 22). The evolutionary course of the epigenetic gorge started during the early Quaternary and was genetically closely related to the development of their recipient, Crna Reka. Then, the flow of the Dabniska Reka, descending from the area of Vitacevo with expressed regressive erosion, evacuated the non-stratified and stratified and pyroclasic material of the volcanic area of Vitacevo, which most likely covered almost the whole present-day catchment area. Later, they were fully eroded in the middle and the lower part of the basin and eliminated to the level of previously deposited Pliocene soft sediments of sand and clays (Pavlov and Pavlovski 2013). A question arises why the river did not bypass the resistant barrier of diabases and headed through the lowered and flattened part of the north side of the watershed moving from Resavsko Pole towards Brusansko Pole when adjusting to the longitudinal profile of Pleistocene, if it had already discovered and "treaded" on the soft Pliocene underlay. The answer can be sought in the morphogenetic evolution of the Crna Reka. It deep incised-in very fast, and the lagging of the tributary Dabniska Reka in that respect, resulted in deep exerted slotting into resistant diabase rocks of the epigenetic segment in the lower flow. The fact that the expressed lowering in the northern part of the watershed of the Dabniska Reka corresponded to the slope of the catchment basin of the Crna Reka in the same directon also speak on behalf of this conclusion.

Figure 21. Satellite image of epigenetic incision of Dabniska Reka in front its submerged confluence

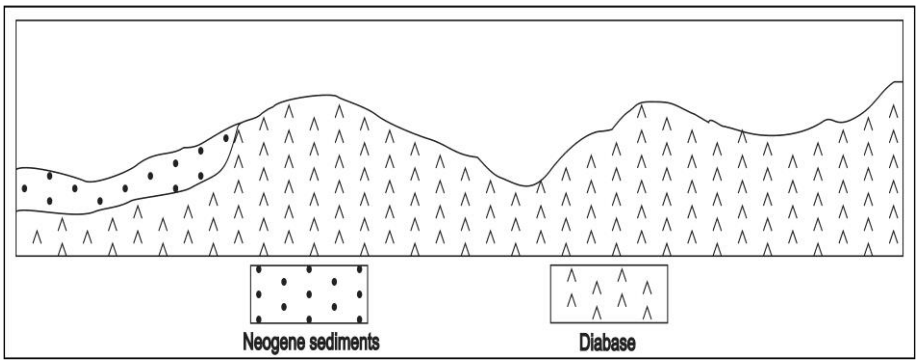

Figure 22. Satellite image of epigenetic incision of Dabniska Reka into oasis of Jurassic diabase

CONCLUSION

As ostensibly anomalous phenomena, epigenetic gorges mirror the inconsistent fluvial relief, i.e. a phase of adjustment of longitudinal profiles of rivers. A number of terrain-recognised, symptomatic segments of river valleys in Tikves were in their preliminary phase, and were only hypothetically set as the subject of further examination. The necessary geological-and-lithological and morphological arguments defined later, indicated in total ten created epigenetic valleys and gorges in the Vardar catchment area on the level of the Tikves Basin, as follows: Zgropole Gorge, Bizevic Gorge (the Crna Reka), Barovo Gorge (the Bosava), epigenetic valleys (the rivers of Bosava, Rajec, Bohulska Reka, Iberliska Reka, Dabniska Reka, Kamen Dol, and Topli Dol). The summary conclusion for all of them can be reduced to the following. The epigenetic gorges and slots in the river valleys in Tikves are striking examples of a fully justified morphological and geological basis. They were created during the early Pleistocene after a Pliocene lake had subsided into the Tikves depression with the formation of a post-lake river network across the central lake plain at 600 to 620 meters. Seven epigenetic occurrences were formed below the neogene level, with the erosion and denudation of neogene lake sedimentation, whereas three of them were formed above the neogene level, with the evacuation of volcanogenic sediments in the Kozuf-Vitacevo volcanic area (the Bohulska Reka, the Bosava in its upper flow, the Topli Dol). Six of them were formed in

the end, lower flow of tributaries, upstream their confluences, whose incising was initiated by abrupt deep lowering of the beds of their recipients. Such epigenetic valleys are: the Iberliska Reka, Barovska Gorge on the Bosava, the Bohulska Reka, Dabniska Reka, Kamen Dol, and Topli Dol rivers. With five epigenetic valleys, topographic descending of the watershed of tributaries is more expressed on the side inclined in the direction of the recipient's valley inclination (the Iberliska Reka, Topli Dol, Bohulska Reka, Dabniska Reka and Kamen Dol). The epigenetic valleys of the rivers in Tikves cannot be used as an adequate benchmark for detection of a height boundary between the abrasive and fluvial relief in relation to their vertical disposition that occurs at low elevations below 200 (Zgropole Gorge) up to elevations of 1300 meters (the Bosava), having in mind that the height of the neogene was determined at the altitude of 600-620 meters on the basis of fossilised volcanic tuff over the neogene sediments of the Vitacevo plateau.

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