Scientific Annals, School of Geology, Aristotle University of Thessaloniki Proceedings of the XIX CBGA Congress, Thessaloniki, Greece	Special volume 99	475-482	Thessaloniki 2010

GEOMORPHOLOGICAL CHARACTERISTICS OF KRATOVO-ZLETOVO PALAEOVOLCANIC AREA

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Abstract: Kratovo-Zletovo palaeovolcanic area is known as one of the largest in the F.Y.R. Macedonia and wider, covering a total of 970.1 km^2. A huge amount of pyroclastic material is expelled here, with an average depth of about 700 m (Arsovski, 1997). According to Serafimovski (1993), Arsovski (1997) etc., volcanic activity in Kratovo-Zletovo area started to the end of Eocene or lower Oligocene, and with some pauses last up to lower Pliocene. In that period, volcanic activity successively was moved from north-east to south-west (Boev and Yanev, 2001), with changes in volcanic intensity (violent eruption followed by expel of pyroclastic material; with silent phases followed by lava flows). The volcanism in the region was generally caused by deep sub-meridian dislocations, activated by Paleogene east-west extension. To the end of Miocene, volcanic activity is reestablished by longitudinal neotectonic dislocations, started with younger north-south extension. Geomorphologically, in Kratovo-Zletovo area there are about 20 volcanic cones and calderas, highly eroded by post-volcanic fluvial-denudation processes. Only Plavitsa cone (1297 m) and Lesnovo cone (1167 m) are better preserved, as well as their calderas on the top (Milevski, 2005). These two volcanic centers, together with Uvo-Bukovets cones, Zdravchi Kamen, Zhivalevo and other volcanic necks, belongs to the older volcanic phases, while younger centers are located in the south and west part of palaeovolcanic area (Crni Vrv (1115 m), Preslap (1117 m) and Rajcani (867 m) cones with some remnants of calderas). After finishing of the volcanic activity, due to strong erosion, volcanic forms subdue significant morphologic modifications. Today, on the remnants of palaeovolcanic cones, there are many fluvial, denudation landforms and even fossil coastal terraces. For that reason, the recent nature of Kratovo-Zletovo palaeovolcanic landscape is polygenetic.

Key words: Kratovo-Zletovo area, palaeovolcanic landscape, erosion, denudation

1. Introduction

The most remarkable palaeovolcanic area in the F.Y.R. Macedonia and one of the most characteristic on the Balkan Peninsula is Kratovo-Zletovo area. It is located in the north-east part of the country (Fig. 1), between Kozjak Mountain on north, Osogovo Mountain on east, Bregalnitsa valley on south and Ovche Pole basin on west, occupying 970.1 km^2. The palaeovolcanic area is extended from Zegljane village on NW to Krupishte village and Kocani on SE, in length of 55 km and average width of 15-20 km. This NW-SE direction is matching with deep dislocation (fault) line which separate Serbo-Macedonian tectonic unit on the east from Vardar unit on the west. The main volcanic centers are in the central and south part of the area, around Kratovo, Probishtip and Zletovo, were largest cones and calderas still exist in landscape. However, several centers are north of these (Dudarova Korija, Kaludjerica), and few are on south (Preslap, Rajchani). Except such large structures (cones and calderas), there are many smaller landforms, directly or indirectly related to previous like volcanic rocks shaped by weathering, earth pyramids, characteristic valleys, gullies and even badlands in tuffs.

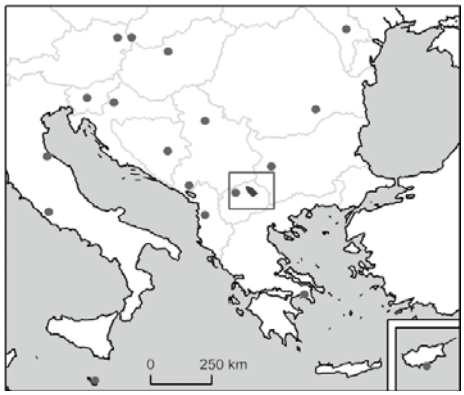

Fig. 1, Location map of Kratovo-Zletovo palaeovolcanic area.

The first geological and geomorphological knowledge of palaeovolcanic relief of this area dating from the late XIX and early XX-th century. Thus, Bouèe (1940) and give its opinion on the geological structure of the area and present data about the mining in the Kratovo area. A little later Cvijic on several occasions between 1902 and 1906, make detailed geological and geomorphological studies in the Kratovo-Zletovo area. In this, particular attention devoted to the determined palaeovolcanic forms and their later destruction. After World War II, because of commercial use of significant ore (Pb-Zn) deposits, comprehensive geological studies of the Kratovo-Zletovo area carried out. The results of these studies have been published in dozens of papers. In some of them, aside of geologic research, some geomorphological data's were presented, especially in the works of Markovic (1971), Stojanovic (1986), Serafimovski (1993), Dumurdzanov et al. (2004) and others.

2. Methodological approach

For detailed geomorphological study of Kratovo-Zletovo area, several methods were used. First of all, former geological research and data's (bibliography, geologic maps) are considered to introduce with views of geotectonic settings of Kratovo-Zletovo area, then the driving causes and timeline for tectonic and volcanic activities. With field research and GPS tools, some landforms are identified, recorded, precisely located and analyzed. In identification and interpretation of larger palaeovolcanic structures, satellite imagery (Landsat ETM+; Google Earth) as well as DEM (3"SRTM) of this area is used, which also were used for morphometry analysis.

3. Preconditions for the emergence of the volcanic landscape in the area

The appearance of the volcanism in Kratovo-Zletovo area is in close connection with the development of Cenozoic extension tectonics in the southern Balkan Peninsula. After a period of old-Alpine compression and collision of more megablocks, in South-Balkan-Aegean area N-S extension (relaxation) mode of development started. This mode is characterized with radial tectonic movements which created a grabens and horsts, due thinning, stretching and cracking of the Earth's crust (Mantovani et al., 2002). In the F.Y.R. Macedonia (in the southern Balkan Peninsula to the Aegean Arc), two phases of extension appear: the first at the end of Paleogene and the second from the middle Miocene until today. During the first east-west extension phase, more dislocations in northwest-southeast direction were activated (Dumurdzanov et al., 2004). That is the intersection of these dislocation lines with local fault lines where volcanic centers are created. Parallel with the appearance of volcanic activities, according to Graf (2001) and Zagorchev (1995), in-depth granitic intrusion is created under Osogovo and Ruen block which conditioned their tectonic rise. Paleogene (Eocene-Oligocene) volcanism in the above area is characterized by a discharge of acid to intermediary lava: andesite, dacite, quartz-latites, ignimbrites and others (Boev and Yanev, 2001). Younger, north-south extension started in the middle Miocene and lasts until today. It is expressed by the formation of young (neotectonic) fault structures with opposite (longitudinal) direction (Kjustendil-Debar fault; Kochani fault). At their intersection with the old fault lines, were reactivated old or new volcanic centers was formed. Interestingly explanation for Neogene magmatism have Petkovski (1998), by whom it is due to extrusion of magma through fault lines because of sinking of the surrounding grabens. Magma that could not come to the surface is intruded under Osogovo block that caused his rise. Stratigraphy and K-Ar dating of volcanic rocks, indicate that in the Kratovo-Zletovo area, volcanic activity began in the Oligocene, i.e. 32-29 million years ago (Boev and Yanev, 2001). Active volcanism with some interruptions, lasted almost 25 million years, and finally ended in the early Pliocene. For this period, volcanic areas of east parts of the region gradually move towards the south-west. The presence of acid to intermediate volcanic rocks: andesite dacite, and their tuffs and breccias, indicates violent-type eruptions, so that despite outbursts of lava has dropped a considerable amount of pyroclastic material. Taken as a whole, volcanic activity was of mixed type; calm eruptions with lava flows, occasionally changed with violent explosions and disposal of pyroclastic material. Volcanic phenomena were mainly of continental type, with the middle Miocene to Pliocene have emerged phases of accumulation and consolidation of material from eruptions in the surrounding Neogene lakes.

4. Basic morphological features of the palaeovolcanic landscape in Kratovo-Zletovo area

Today, from the former turbulent volcanic activity in the Kratovo-Zletovo volcanic area, remained a

little well-preserved morphological remnants. These are mostly highly modified and eroded volcanic cones, and much less remains of craters in the form of calderas. According to Cvijic (1906), volcanic cones between Zletovo and Kocani are arranged in series and between Kratovo and Zletovo, they are deployed in groups. If the terrain is analyzed in detail, it will realize that these cones represent: a) real volcano cones which are mainly from strato-type; b) pseudo-eruptive cones uplifted by intruding the magma near the surface; c) volcanic necks which because of faster erosion of the surrounded erodible terrain obtained cone-shaped form and d) conic hills shaped by fluvial-denudation processes.

Morphologically better expressed volcanic cones in the area are: Plavitsa (1297 m), Crni Vrv (115 m), Uvo (1472 m), Lesnovo (Ilin Vrv, 1127 m), Kunovska Chuka (1347 m) etc. Their relative height to the surrounding terrain is 200-400 m, and diameter at the base is 1-3 km. They are dominantly of strato-type, with the lava layers (andesitic-dacitic lava and ignimbrites) interchanged with pyroclastic material (tuffs, breccias). Laterally, smaller cones often appear as a secondary or parasite cone. Thus, only around Plavitsa there are 7 parasitic cones with relative height from 50 to 150 m: Kundinska Chuka (817 m), Marchinska Chuka (1044 m), Kala (798 m), Gradiste (995 cm), Ushi (1205 m), Baba (908 m) and Gro (1023 m). Several parasitic cones are present around volcanic centers: Uvo, Lesnovo, Crni Vrv, Preslap and others. Parasitic cone are often younger than the main cone, suggesting more phases of volcanic activity. Between main and parasite cone small passes are created, remnants of broken down "inter-colline" (Cvijic, 1906) or inter-cone depressions. After cessation of volcanic activity they predisposed formation of short rivers. In the inter-cone depression between Plavitsa (1297 m) and Kundinska Chuka (817 m), small Kundino Lake is formed by erosion of tuffs surrounded by harder rocks.

Due to continuous fluvial-denudation processes and young tectonic movements in the area, volcanic cones are significantly lowered, eroded and reduced, so it is not possible to reconstruct their initial shape and height. Particularly devastated are peaks where the crater was located. Alongside, cones are incised by river valleys which radially spread-out towards the foot. For the intensity (speed) the destruction of volcanic cones in the area can hardly speak, because the long-term process that affected a number of factors and variables. Certain studies in Europe and worldwide (Karátson, 1996; Thouret, 1999; Ramsey, 2003), show that the average reductions of fossil cones are approximately 20-40 m / million yr. At this intensity of destruction arises that in initial period, volcanic cone at Kratovo-Zletovo area were significantly higher, about 300-600 m.

It is interesting that some volcanic cones in post-volcanic period not only reduced, but increase its relative height, but now due to intense incision of the nearby river valleys. Thus, relative height of the cone Kunovska Chuka (1347 m) above the valley-bottom of the Zletovska River is 600-700 m, and above highest (Pleistocene) river terrace the relative height is only 400 m.

From the previous follows that upon the termination of volcanic activity today, volcanic cones are significantly modified, mainly due to erosion processes and also with tectonic movements. Such palaeovolcanic cones that are much changed by erosion-denudation processes are actually polygenetic.

Regardless of poor preservation, palaeovolcanic cones are important landscape feature in the Kratovo-Zletovo area. Unlike the cones, most craters are completely destroyed. In this area can be identified the remains of five craters in the form of erosive calderas. Well preserved is caldera on the top of Lesnovo cone and less is preserved calderas of Rajchani, Crni Vrv, Shtalkovica (Preslap) and Plavitsa cone. According to Markovic (1971), palaeovolcanic forms north of Lesnovo are poorly preserved because they are older. In our opinion, the good preservation of Lesnovo caldera is because of dense dacite lava flows and arranged necks that slow-down fluvial-denudation processes. Also, it is possible that lower cones and calderas in upper Miocene to Pliocene were covered with lacustrine sediments which later (in Quaternary) are exhumed. On that way, some period of time they were protected from erosive processes. Thus, between Lesnovo and Plavitsa cone now runs a belt of Miocene lake sediments covering older palaeovolcanic relief to a height of 900 m.

5. Morphological characteristics of larger palaeovolcanic centers in Kratovo-Zletovo area

As already mentioned, typical palaeovolcanic landscape which is better preserved is found in the central and south part of Kratovo-Zletovo area. In the northern part-on the west side of Kozjak

Mountain, there are number of conic hills and necks, from Kokino and Zhegljane village on north to the Stratsin, 10 km on southeast. But morphological reconstruction on these centers is very difficult because they are largely destroyed especially by fluvial erosion and denudation. Northernmost, near Kokino village, characteristic neck called Tatichev Kamen (1013 m) composed by andesitic lava and columnar (prismatic) emission, remarkably rise in the landscape. This neck together with Visoka (878 m) on south, probably belong to the large volcanic center near village Bajlovtse on east, which is highly altered by erosion of river Petroshnitsa. According to Karajovanovic and Hristov (1972), large masses of tuffs up to 400 m depth, suggest that eruptions in this area were explosive and very violent, especially toward the end of Miocene and beginning of Pliocene. Some remnants of volcanic cones and calderas appear in south direction i.e. in south side of Kozjak Mountain, toward Stratsin village. Thus, Vitlich (1073 m) and Nepci (938 m) are remarkable cones with about 350 m of relative altitude. Vitlich cone with near ridges on the NE (toward Drenok village) has semicircular shape of caldera, heavily eroded by Vetunitsa river from the east side. Here, large masses of lava and pyroclastic material are expelled. In vicinity there are small parasitic cones like ideally shaped Luda Mogila (673 m) and others. South of Vitlich up to the Stratsin pass, andesitic rocks are much flattened, with occurrences of small denudation hollows and caverns on the surface, called lithotelmes.

Near the village Ketenovo, on several hills from both sides of Kriva River, traces of flowing andesitic lava are notable. That is the result of volcanic activity of nearby hot spots Vidim (825 m) and Kaludjeritsa (791 m) from the right (north) side of the Kriva River and Ramni Rid (757 m) from left (south) side. Typical volcanic cone do not exist, only several necks on the mentioned hills. However, according to the arch-shaped remnants around, probably Kriva River was deeply incised and destroyed large volcanic cone with crater in the middle. Here the volcanic activity was the explosive type, so it formed small lava outbursts, surrounded by thick, extensive deposits of tuffs, which extend to the northeast Ilin Rid (574 m) near the village Opila. There are several parasitic cones also, like Ostrovitsa (641 m), Pobien Chovek, etc.

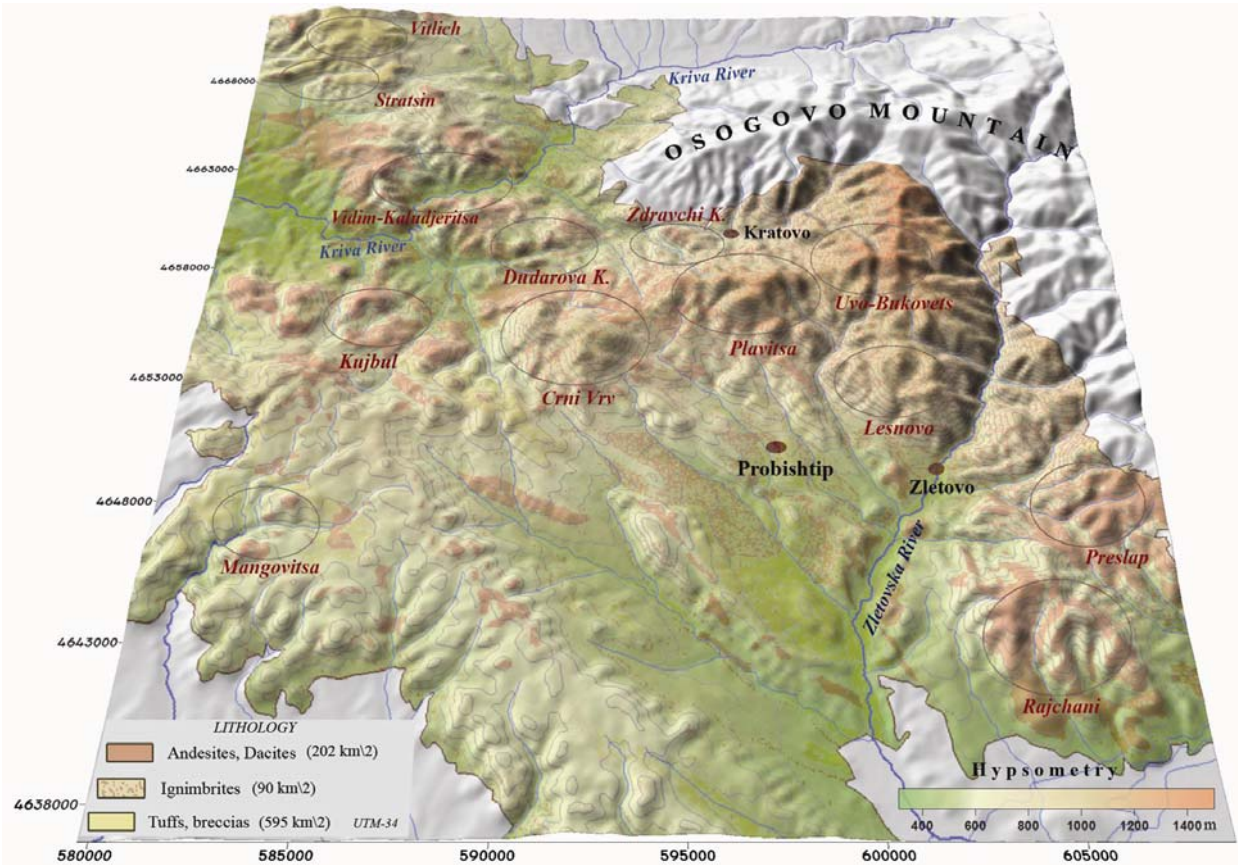

Fig. 2. Map of the most significant volcanic centers in Kratovo-Zletovo palaeovolcanic area (explanation in the text).

Taken as a whole, this volcanic center occupies large area of 25 km^2, and with surrounded pyroclastic material almost 60 km^2. According to the stratigraphic position and type of rocks, volcanic activity here belongs to the Oligocene-Miocene phase. It is interesting that on the right valley side of Kriva River, near village Kuklica, significant occurrence of earth pyramids exist. These forms (about 120 "stone dolls") were created by differential weathering and pluvial erosion of the tuffs with andesitic blocks inside (Milevski, 2000).

In south direction is volcanic center Dudarova Korija (768 m) with some semicircular caldera-like remnants on the west side, and several parasitic cones in vicinity (Zivalevski Rid, 723 m; Borovik, 664 m; Gradishte, 639 m). Because of augite-biotite andesitic lavas, this structure which is significantly eroded by Petroshnitsa River, is considered to belong to younger (Miocene-Pliocene) phases of volcanism (Serafimovski, 1993). Similar characteristics and dimensions has palaeovolcanic center Kujbul, 5 km west of Dudarova Korija, identified by Markovic (1971).

On the left valley side of the Kratovo River, 2 km west of Kratovo, rising remarkable andesitic neck Zdravchi Kamen (844 m) with columnar emission. Laterally are thick deposits of tuffs which are quite eroded by fluvial-denudation processes. On the eastern side, Zdravci Kamen is deeply cut by the Kratovo River, and on west by the short Shlegovo River. As a result of that and due to selective erosion, this structure highly rise in the landscape and give the look of well preserved volcanic cone with relative height of 300 m. With weathering of andesitic rocks, interesting denudation forms like columnar rocks, needle rocks, shallow hollows etc. are created. In the highest part of the neck, remains of Pliocene coastal terrace of 780-800 m are preserved.

In the vicinity of Kratovo the remains of more palaeovolcanic forms can be observed. Cvijic (1906) believes that the city Kratovo itself lies in a volcanic crater, which was cut in the middle with Tabachka (Kratovo) River. However, detailed analysis of elevation and geology do not go in favor of this assumption. Our opinion is that such morphology of the terrain around Kratovo, in the form of a circular depression, is actually the result of selective erosion of the Kratovo River and its tributaries, which intercepted the northeastern part of the complex Plavica center. Thus, the Kratovo River morphologically separated volcanic centers north of Kratovo from Uvo-Bukovets to the southeast and Plavitsa to the southwest.

With field research, along the right valley side of the Kratovo River (upstream of Kratovo) traces of flowing lava in the southern direction are observed. Probable center of volcanic activity here is a structure Dlaboki Del, north of Kratovo, in which are located several necks (Peshtar 1113 m, Kratovski Rid 1108 m and Kamen 994 m). Such arch morphology, probably is the secondary segment of Plavitsa or Uvo-Bukovets structure, which has very similar characteristics and meets the older volcanism.

Among Kratovo and Probistip is remarkable palaeovolcanic center, Plavitsa (1297 m). From the south side, this volcanic cone rises about 400-500 m over the Neogene lacustrine terrace (780-800 m), and the diameter is 3-4 km. Around the major cone, concentrically went up 7 smaller parasitic cones high 50 to 150 m. The slopes of Plavitsa have noticeable traces of the flowing lava, and that especially in the south and southeast direction. According to presence of lava and large amount of pyroclastic material, there are probably interchanged stages of silent and explosive eruptions, and the cone is of strato-type. The higher part of Plavitsa (above 1000 m) has a semi-circular shape and looks like quite destroyed caldera, particularly on the west and north side. However, concentric outbursts of dacitic-andesitic lava, reflect the contours of caldera and suggest a possible volcanic center. According to the position of surrounding ignimbrites, probably here volcanism began in Oligocene i.e. in the first phase. Andesites and tuffs originating from surrounding parasitic cones (Marchinska, cones near Shlegovo and Prikovci), with upper Miocene or lower Pliocene age as mixed or partially penetrate the Miocene lake sediments south of Plavitsa. This means that during the lake stage were strong volcanic activity.

Only 3 km west of Plavitsa is one also very remarkable volcanic structure Crni Vrv, with volcanic cone in the center (1115 m), connected with ridge to Gradishte (1009 m) on NW. According to Markovic (1971), this structure is remnant of caldera eroded on north side, while Serafimovski (1993) mean that south and west sides are destroyed by faults with NW-SE and NE-SW directions, whereas north side is better preserved. However, together with near parasitic centers (cones and necks), entire structure covers 50 km^2, thus one of the biggest in the area. Abundance of tuffs

implies explosive eruptions, with maximum in upper Miocene or early Pliocene.

East of Plavitsa (4 km), above the village Blizanci there are two cones: Bukovec (1423 m) on west and Uvo (1472 m) to the east. They are mutually far only 1 km and are separated by a shallow saddle, caused by a fault in the direction NNE-SSW. Cones have very symmetrical appearance, and their relative height is about 250 m (Fig. 3). Here the volcanic activity is represented mainly by lava outbursts of dacites (dacite ignimbrites). The whole structure Uvo-Bukovets with several parasitic cones around, stretches over an area of 10 km^2, and lava-pyroclastic material is distributed in an area of 35 km^2. Age of this structure is probably Oligocene.

Fig. 3. Volcanic cones Uvo (right) and Bukovets (left) with smaller cones in front.

At a distance of 3.5 km northeast of the volcanic center Uvo-Bukovec, west of the village Mushkovo, rising palaeovolcanic cone Golem Rid (1532 m), with the relative height of 200 m. According to Serafimovski (1993), it is a parasitic center associated with the activity of the Uvo center, although on the position and morphology, Golem Rid could be considered as a separate volcanic center. West of Golem Rid are several small parasitic cones (Valanovec, Potes, etc.), about 50 m high and indicate several phases of volcanism in this area.

About 5 km southwest of Plavitsa, near the village Lesnovo, is one of the best preserved structures in Kratovo-Zletovo palaeovolcanic area and wider. The entire structure with an area of 12 km^2 resembles volcanic cone with a diameter of 4 km. The cone has steep sides and over the surrounding landscape rises up to 400 m. It is particularly well expressed on the south and southwest side. From the east side, Lesnovo cone was cut by Zletovska River and from the west by Dobrevska River. Actually, the cone from several sides is incised by shallow valleys which Cvijic (1906) calls as circum-crater valleys. On top of Lesnovo cone, there has been impressive, well preserved caldera with a diameter of 1.5 km and depth in the middle of 150 to 200 m. Around the caldera center, circularly are located 7-8 conic hills i.e. volcanic necks. Most remarkable of them is Ilin Krst (1127 m) on north, which was probably a major volcanic center where largest amount of lava and pyroclastic material expel. On the southern and eastern side appear 3 other necks: St. Troica (1012 m), Nusheva Chuka (1025 m) and Gumichki Rid (1048 m).

Lesnovo caldera is morphologically well expressed, except on southwest and northeast side, where it is cut with Lesnovo stream. It should be noted that the initial appearance of the crater was considerably different, if we note that the structure belongs to the older volcanism in the area. It derives from the age of dacitic lava (dacitic ignimbrites) which according to Serafimovski (1993) is Oligocene. Also, on the southern side of the Lesnovo cone, younger Pliocene-coastal terrace of 900 m and 780-800 m are incised, therefore, the structure is certainly pre-Pliocene. If you take into account the aforementioned values for average reductions of andesitic-dacitic strato-volcanic cones of about 20-40 m per million years (Karátson, 1996; Thouret, 1999), it is clear that in the initial period, Lesnovo cone was at least 200-400 m higher. Indeed, the Lesnovo caldera has polygenetic character because for its contemporary shape, great importance had subsequent erosion processes.

With field research, on the Lesnovo cone are seen traces of the radial flow of lava, especially in the southern direction. Dacitic lavas today are exposed to selective erosion with numerous small denudation forms (stones, hollows, footprints, etc.). On certain incisions along the road Dobrevo-Lesnovo, can be noted that dacitic lavas lie on tuffs, suggesting that Lesnovo cone represent a strato-volcanic structure.

In the southeast end of the Kratovo-Zletovo area, several palaeovolcanic cones are registered that the omitted material belonging to the younger stages of volcanic activity. Characteristic residues of caldera are recognized north and northwest of the village Pantelej. Here in poly-phases volcanic activ-

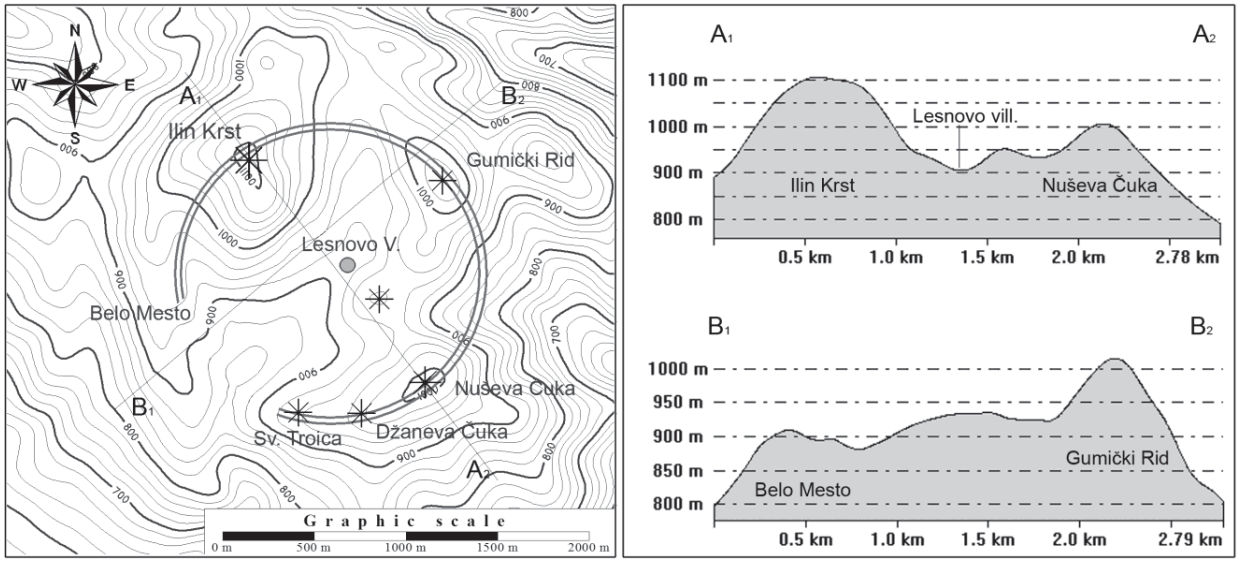

Fig. 4. Drawings and sections of the main crater (caldera) Lesnovo and secondary centers.

ity, a major center of Preslap (1117 m) is formed, and several parasitic centers: Iliica (859 m), Spasovica (851 m), Pantelejska Chuka (825 m) and others. The caldera ring itself, is hard to morphologically reconstruct, because it is pretty much eroded. Better is seen on the north side and south side was eroded by Koselska River (tributary Shtalkovitsa River). According to the preserved remains, caldera had a diameter of about 2.5 km. Volcanic activity of this structure was largely calm, with outbursts of large masses of young andesites, which flow traces can be noticed in southern direction, towards the villages Pantelej and Rajchani. Occasionally emerged stronger (explosive) eruption, for which testify deposits of andesitic tuffs, accumulated on land and in water environment (stratified). The volcanic activity was the upper-Miocene or lower Pliocene in age.

Southernmost, morphologically better expressed volcanic structure and the youngest in the area stretching west of Kochani, and cover an area of about 25 km^2. Today from the former cone with impressive dimensions two calderas remains, external and internal, both better preserved from the northern side. Pyroclastic material is presented with breccias and to a lesser extent with andesitic tuffs mostly deposed in water environment. Their status and composition suggest lower-Pliocene volcanic activity. However, large calderas with vast pyroclastic material are evidence of powerful eruptions in this area. Around Rajchani calderas has been observed several lower hills, which are small parasitic cone. These are: Sv. Gjorgji (570 m), Golak (559 m) from the southern side; Bakovo (596 m) above the village Tripatanci on west and others.

Fig. 5. West ridge of the Lesnovo caldera, incised by Lesnovo stream.

Remnants of volcanic center are also evident on the west side of Kratovo-Zletovo area, on the mountain Mangovitsa. Three andesitic cones: Mangovitsa (741 m), Golem Osoj (734 m) and Glozhje (655 m) and several smaller are arranged on such way that resemble caldera about 2 km in width, heavily eroded by Mavrovitsa (Kiselitsa) River. Here, large amount of pyroclastic material are expelled on about 50 km^2, showing explosive volcanic activity. After intensive volcanism in Pliocene, these structures are gradually destructed with many occurrences of denudation landforms today (earth pyramids, columnar and mushroom rocks, balls etc.).

6. Conclusion

In the paper are analyzed larger palaeovolcanic landforms in Kratovo-Zletovo represented by about 20 volcanic cones and several calderas. Besides these, many smaller landforms are observed, usually associated with the lava flow, accumulation of pyroclastic material and its erosion. There are many pseudo caves, volcanic bombs, stone blocks, columnar rocks and blocks, hollows, caverns and rills in horizontal andesites, as well as rills, gullies, earth pyramids and even badlands in tuffs as sites of excess erosion.

Imposes the conclusion that, taking into account the age of volcanic activity, palaeovolcanic forms are still well preserved. According to the study of Ramsey (2003), the initial stage to the stage in which today's palaeovolcanic forms in the field (according to its classification, it is the third of five stages), in areas with drier, continental climate, usually spends a period of 3 million years. This is significantly less compared to the aforementioned 5-30 million years ago how really wonderful. In the future remains to be explored whether Neogene palaeovolcanic forms were covered with lake sediments and protected from erosion or the intensity of erosion and tectonic destruction was weaker than expected.

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