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Petrography of the Granodiorite massive of Torkuz (Gashi Zone)

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***Abstract*—In Albania the Gashi zone is landed in the northest limits of Albania, in the north of the Shkoder-Peje lineament, in Dinaride followed by the Durmitori zone. The region is differed from the other areas by clear geological features. This is clearly expressed at the borders with the Alps area, which are almost completely matched to the tectonic overweight limit. Intrusive acid rocks and granodiritic meso-acids form the mass of Torkuz which continues outside the state border, in the direction of Rugova. These granodiritic rocks lie north-east and south-west cross the geological structures of Dinarides wich represents the direction of the foliation of this metamorfic mass. Since the fact that this mass interrupts the other rocks, is thought to be the youngest among them.This intrusion has exerted dynamic and thermal activity on the surrounding rocks that has enabled the recrystallization of quartz and feldspar minerals.The aim of this study is to observe the changes in the petro-grafic aspect of the whole mass, and this is the reason the për këtë qëllim the sampling was carried out almost dispersed across the whole massive. This study has as a second aim of observing the secondary minerals as apatiti and zircon, which will allow further studies according the termal history of this mass.**

Keywords—Granodiorite, Gashi Zone, ricrystallisation, metamophisation, mineralization.

I. The Geological Setting, Tectonics and Mineralisation of Gashi Zone

Gashi zone extends to the northern border of Albania, north of the transversal Shkoder-Peje. It also extends in the Montenegro and Kosovo territory, reaching Serbia further north followed by the Durmitori Zone [7]. South of the Shkoder-Peje transversal, the Gashi Zone can be paralleled with Hajmeli subzone of the Mirdita Zone and with the Alps zone in S dhe SW. This zone can be differentiated from the other zones by the clear geological and geomorphologic features [4]. This is clearly noticed in the border with the Alps zone, which are fully compatible with the thrust tectonic border.
The oldest formations in the Gashi zone are Silurian-Devonian sedimentary-volcanogenic formations, initially evidenced by [3] which are transgressively covered with an angular unconformity by the reddish conglomerate-sandstone formation of lower Permo-Triassic [14]. Meanwhile the acidic intrusive and medium acidic granodiorite rocks form the Torkuz massive extends abroad the state in direction of Rugova. In 1982, [12] qualified the granodiorite massive of Torkuzi as being located in the border between the schist formations of C-P and effusive-sedimentary formations of J3, with an unconformity setting.
These granodiorite rocks strike north east and south west, which is transverse the geological structures of the Dinarides. This intrusion has other outcrops that intersect different rocks in the form of apophyses, which are linked with the mineralisation in the contacts of different rock types as well as in their inner part. This formation (with a thickness of 1800÷2000m, among which 200÷300m are gabbro), extends from Markofça, Torkuzi till Doberdol and further in direction of Kosovo. The Torkuz massive consists of gabbro and granodiorite, with gradual transition, where the granodiorites have a widespread occurrence while the gabbro has limited spreading (in Doberdol). It has a clear intrusive relation with the sedimentary-volcanogenic formation of Çeremi, especially with its lower carbonate-schist pack, whereas it has a nearly cold relation with the volcanogenic–sedimentary formation of Rupe-Sylbices, from times to time tectonic as well [11], unlike [12] thoughts, that plutonic massive apophyses are met inside the effusive-sedimentary series as well as in the zone near the contact. These two formations with which the gabro-granodioritic formation is touched, are defined as conodon formation time and consequently this lineage belongs to the age D2 - C-P, [9] while the method of isotopes and bigotions in this formation shows up the absolute Amizian age (T21), this age is determined in two samples taken in the peak of Torkuz and the other in the same granite, in Decan (Kosovo).

This intrusion has applied remarkable dynamic and thermal activity over the surrounding rocks. These changes are represented by quartzization, chlorization, carbonization, dolomization, and less by feldsparization and albitization. This massive is believed to be younger in age due to the fact that it interrupts other rocks. Its age according to an age determined with the K-Ar method, is given as 75 Ma years (Cr_2).

II. Tectonics and General Structures of the Region

As for the tectonic part, Gashi region represents a major regional tectonic thrust where the flysch deposits are tectonically settled above the T3 limestone of the Alps zone. Such breeding relationships with the above characteristics are met also in the eastern part, where the Mirdita area formations overlap the volcanogenic-sedimentary formations of the Gashi region. The gabro of Torkuz shows a Nord-West subgroup (in Markofce-Balçine-Lugu i Vocit) and Nord and Nord-West (in Koshotice and Doberdol), a structure which is somewhat complicated at the stretching as well as downward from the structure of the second order. In addition of the idea of accepting them as a separate unit, there are authors [2] that support the hypothesis that the Gashi region is linked with the Korabi area, or others [12], whom link them partially to the Durmitori zone and partly to the Mirdita area. Our geologist-stratigraphic data [10] support the idea of it as a separate unit and as the southern continuation of the Durmitor area. Regardless, the Gashi Region forms the Paleozoic basement of Gashi Zone, while the Vermoshi Region forms its mesosphere cover. In the Nord-East extension of Gashi Zone, we note that Durmitor Zone is not only its continuation but also the largest unit of Dinarides (Figure 1. [10)

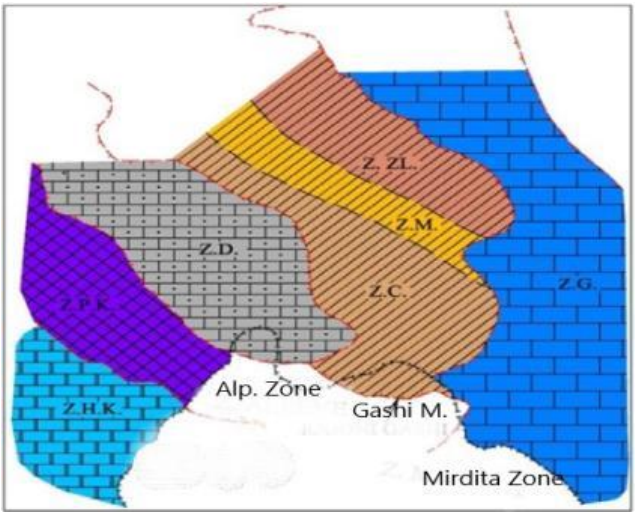


Figure 1. Some structural and facial areas of Dinarides according to Jean Paul Rampnaux**.**

Legend**:**

- Upper Karst Zone, (Z.H.K.);
- Parakarstike Zone, (Z.P.K.);
- Durmitor Zone, (Z.D.);
- Cetina, Mihajlovic and Zlatar Zones, (Z.C, Z.M, and Z.ZL.);
- Zone of Golies, (Z.G.).

According to [13] the rock formations of the Gashi Region are divided into two series: schist series as a continuation of the Durmitor zone and the effusive series as a continuation of Mirdita area, where in the middle of these two series, relies with discrepancy the granodiorite massif of the Mosaic Trouza with myocene age (N1).

In 1974, [14] it is said that sedimentary-effusive and effuzive-sedimentary formations are established in accordance with the agreement, the granodioritic mass (Pz). In 1982 [12] it is considered that the age of the granodioritic mass is J-Cr, and it is incompatible with the above formations that are in touch with it, while the andesite of the province Gashi is given as a sub-volcanic form that often represents a direct continuity with granodiorites.

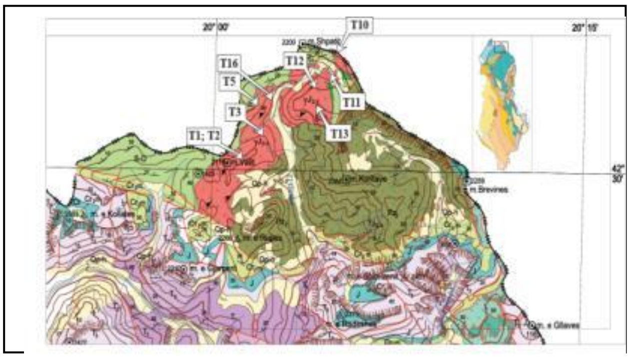
In 1982 [5] for the geological map scale 1:200,000 and in 1984, [6] for the tectonic map scale of Albanides 1:200,000, in the Gashi Region, the mass of Granodioritic is accepted as Cr1. In the framework of the complex surveying works in the scale 1:10,000, in the years1986-1990 [10], this granodioric mass is rated as D2-P1. Whereas in the framework, in 2011 it was firstly dated the Plutonik-Trokuz-Deçan mass of the Absolute Anisian Ages (T21), with the method of isotopes U-Pb in the zircons of two granite samples, one in Troika and one in Deçan, [8].

As mentioned before the magmatic formation is tectonically settled above the flysch. If seen in general as a region, it appear intensively folded and fragmented, this might have come as a result of towards pushing of the formations caused by the intrusions, being unable to outbreak them due to the great thickness. The conglomerate schist series is a highly complicated folded structure itself. If seen in general, the region presents a big anticline with an axe striking NW-SE with a twisted shape similar to the letter S. Its general strike complies with the Dinaride structure. Besides the folding, there is also notable tectonic faulting especially in the vicinity of the thrust of these deposits with the flysch. The mineralisation is mainly related to the faulting of the first group (NW-SW) and not with the regional ones.

III. Field Work, Sampling and the Studing Method

Several days of field work have been performed in the framework of the petrography study of the Torkuzi granodioritic massif. The field work consisted in field observations related to the own structure of the massive, as well as its relations with the surrounding rock masses. It has been attempted to make observations and sampling of the most representative parts along the entire stretch of the massive in the NE-SW direction and transversal in NW-SE direction. One of the objectives of this study during the work performed for the observation of the petrography thin sections is also the careful evidence of the presence of the secondary minerals like apatite and zircon, which are minerals with a very low content in the rock and their presence makes possible the dating with different thermal-chronologic methods.

Figure 2. Shows the geological map of the region and the location of the samples taken for study.



Fi ıe
Geological map of Albania scale 1-200 000 (ISPGJ-IGJN, 2003)

The methods followed for analysing the collected samples are; the cutting, glazing, sticking in the glass, reducing the thickness, fine glazing till the sample is ready for the petrographyc study.

IV. Study Results

The presentation of the petrography study results is thought to be done from the NE edge of the massive (at the state border line between Republic of Albania and Kosovo; sample T10) to Doberdol, at the western edge of the massive in direction of Cerem village (sample T1 and T2). In the following parts we will present the site observation data as well as the petrologic description of each sample.

Sample T10, is taken near the state border line of Albania. The grandodiorite here seems to be metamorphosed with visible foliation planes striking NE-SW and dip direction N-W.

Figure 3: View of the location of sample T10 collection, in Kosovo territory, in the crests extends the state border.

It has the following mineralogical composition: Quartz 45%, feldspar (mostly plagioclase) around 40%, amphibole partly transformed into mica and chlorite 10%, opaque minerals 3-4%, secondary minerals like apatite and zircon less than 1%. The rock has undergone to deformations which can be evidenced by the quartz deformation which has undergone ricrystallisation in the form of microcrystals, especially in the foliation planes. Plagioclases are deformed as well. The better part of the plagioclase is sericitized and the amphibolites are transformed into biotite and few muscovite. These changes show that the rock may have undergone a metamorphism of the green schist facies.

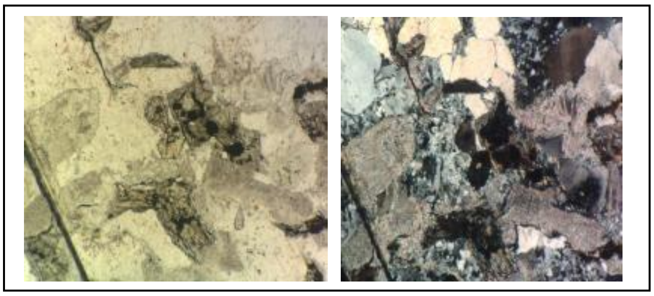
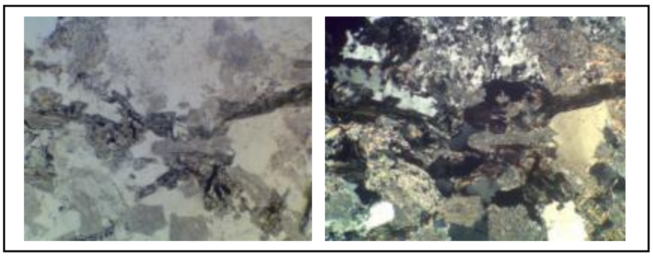


Figure 4: Picture of T10 thin section; a) with natural light b) with polarized light.

Sample T11

Thin section number T11 has similarities with sample T10; both samples demonstrate a less developed foliation compared to sample T3. It has a granular texture and the foliation planes are well developed along the amphibolites and mica minerals. The presence of zircon and apatite is distinguished.

Mineralogical content: Quartz nearly 45% is represented by big minerals and micro crystals which due to the deformation are formed from the ricrystallisation of the big crystals. There is around 35% plagioclase content, which is completely sericiticed (changed), while the amphibolite is partially transformed in mica. It is noticeable that there is a



very small percentage of biotite and muscovite.
Secondary minerals, apatite (Zr_2SiO_4) and zircon ($Ca_5(P_3O_2)_3(OH,Cl)$) are less than 1%.

Figure 5: Photo of T11 thin section; a) with natural light b) with polarized light. Minerals of quartz, feldspar (sericitized), amphibolites and their relics mica and chlorite, can be seen in the photo.

Sample T12

The Torkuz massive granodiorites in general are altered and fragmented into blocks which due to the very steep relief have moved down the slopes of Doberdoli Mountains. The sampling of the bedrock is very important in order to obtain correct information regarding the distribution of the deformation along all the structure of the rock massive.

Figure 7: Photo of T13 thin section, zoomed several times. Foliation planes from feldspar and quartz crystal deformation are clearly noticed.

Mineralogical content of thin section T12: Quartz around 45%, plagioclase around 35%, amphibolite which is transformed in biotite, the last is partly transformed into chlorite. Pyroxene relics are noticed in this thin section as well. The quartz phenocrystals belong to the first stage of the rock formation, while the microcrystals are a product of its ricrystallisation. The plagioclase is completely sericitized. Secondary minerals are represented by apatite and zircon.

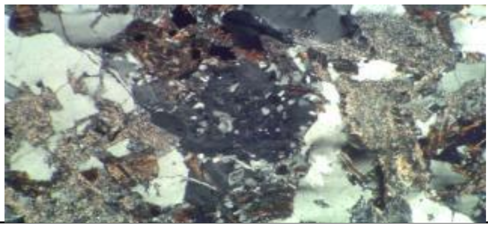


Figure III-5: Photo of T12 thin section; with polarized light. Content: quartz, plagioclase (completely sericitized) amphibolites relics, mica, chlorite.

Sample T13

It has a blasto porphyry texture. The foliation has a NE-SW direction, as formerly mentiond are denoted along the deformation of the mica and amphibolites, the plagioclases and quartz ricrystallisation.

Mineralogical content: Quartz content around 40%. Plagioclase content around 40% which is completely sericitized (altered), the amphibolite is partly transformed into mica and chlorite. The secondary minerals in this thin section are present as apatite and zircon. There are opaque minerals as well.

Figure 6: Sampling location of T13, with regular foliation planes which belong to the first stage of deformation (S1) and fault deformation planes which belong to the second stage (S2).

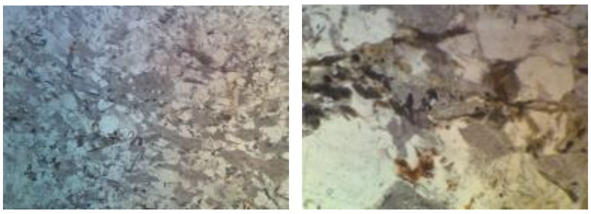


Figure 8: Photo of T13 thin section, zoom 32X. The arrows show the apatite mineral (with normal and polarized light).

Sample T16

It has a granular porphyritic texture. The foliation has a NE-SW direction, and the deformation rate is relatively high. The plagioclase is completely sericitized. The quartz is ricrystallized within the foliation planes with a micro granular texture. There are no traces of either amphibolites or pyroxene, probably they are completely transformed in biotite and part of the biotite is transformed into chlorite.

Mineralogical content: Quartz content is approximately 45%, where the quartz is represented by big crystals and micro crystals (ricrystallisation), plagioclase content is around 35% which is completely sericitized (changed) while the aphibolite is as well partly transformed into mica. It is noticed that there is a small percentage of biotite and muscovite. Apatite and zircon are noted as secondary minerals. There are opaque minerals as well. Sample T16 and T15 are the samples which show greater deformation rate compared to other samples, as shown in the figure below.

Sample T3

Here the rock is metamorphised, has a blasto porphyry texture with developed foliation, which is well formed along the completely sericitized feldspar minerals and along the mica. Both these minerals are very elongated and the foliation plane is created. Between the two. The quartz is highly deformed between these planes as well. The quartz has a micro granular texture as a result of the deformation.

Mineralogical content: Quartz approximately 45%, plagioclase approximately 30%, amphibolites seem to be transformed into mica, biotite and muscovite approximately 5%. There is a small percentage of chlorite. There are opaque minerals which are Iron-Titan oxides. There are secondary minerals as well like apatite and zircon.

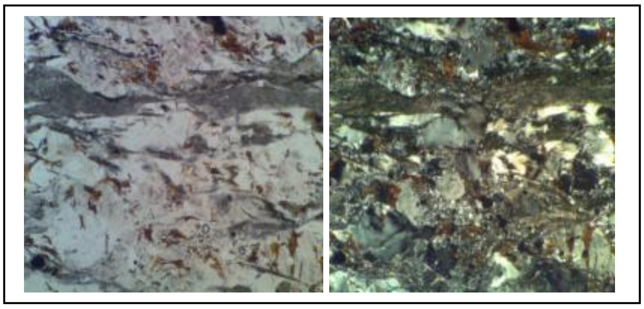


Figure 9: Photo of T16 thin section, zoom 32X. Beside the well developed foliation, in this sample it is also noted later crenulations deformation (with natural and polarized light).

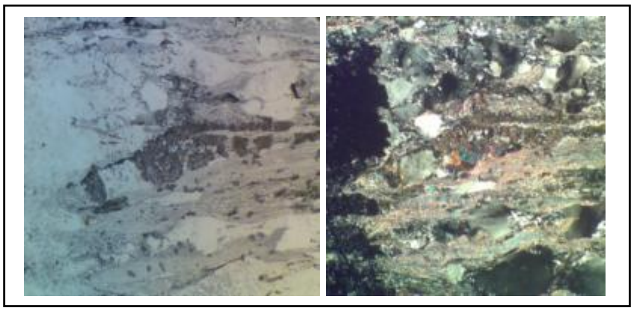


Figure 10: Photo of T15 thin section, zoom 32X. Highly deformed rock, the only thin section where it is noted the presence of clynopiroxene (with natural and polarized light).

CONCLUSIONS

The granodioritic massive of Torkuzi is a massive that has over passed several deformation stages which are notable in all its stretch. The foliation, which in the previous studies has been described as a failure direction, has a strike direction NE-SW almost along all the massive length and a dip angle of approximately 40° to the NS. This type of direction is transversal with the direction of the alpine deformation of the Albanides, this induces that the Gashi zone, has probably over passed earlier deformation stages. Along all the massive stretch the following principal primary mineral stages have been recorded: Quartz, plagioclase, little potassium feldspar, amphibolites, pyroxene (little amount), secondary phase minerals like apatite, zircon and Fe-Ti oxides, which cannot be determined in permeation light. The mineral stages related to the massive metamophisation, as a result of primary minerals transformation are: Quartz, biotite, muscovite, chlorite, sericite, calcite etc. This study points out the existence of a difference related to the rate of deformation of the massive, which is higher near the contacts with the surrounding rocks and less emphasized within the massive. It is not possible to say if this kind of difference comes as a result of the deformation of the contact with the surrounding rocks during the massive formation. This phenomenon would result in a foliation that changes the direction around the massive, a fact that has not been observed in this study.

The earliest magmatism known up to now in the Gashi area belongs to the S-D and is represented by volcanic rocks intertwined with rocks of sedimentary origin in the sedimentary-effusive formation of Cerem. This S-D magmatism should be seen as the first and only magmatic phase for a relatively long time. Thus, the second phase of magmatism in this zone is represented by a nucleus plutonic acidic of the Age of Carbonate (329.6 ± 2.1 Ma) in Junik (Kosovo), which is supposed to represent the Paleozoic basement of Gashi Zone (Durmitor).
In the regional framework, recognizing the granitic of Junik as a representative of the basement of the Gashi Zone (Durmitor), we can see the presence of an unidentified Carbonite continent to date in our territory.
The Triptych Massive Granitites, from the isotopic dating in two tests, with U-Pb method in zircons, have an absolute age of 242.2 ± 1.5 and 244.5 ± 1.5 M, therefore they are formed in the middle Triassic, (T2-Anizian).
From this study, in the regional framework, we see the presence of a plutonic acid magmatism, in addition to the already known Triassic volcanism in the territory of Albania. This plutonium magmatism must be very widespread because according to the same method of the granites of Fierze, it results to 247.3 ± 3.1 ma. It should be noted that in the Dinarides is evidenced the Triassic magmatism, both plutonic and volcanic.

The apatite and zircon minerals, which are necessary for the dating with the absolute age, have been observed in all the studied thin sections. This fact fulfills one of the objectives of this study that the presence of these minerals allows the accurate determination of the thermo history of all the massive.

Further detailed studies will be necessary regarding the massive kinematics and other formations like schists. These studies can be performed in more advanced stages.

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