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Petrographic and geochemical characteristics of rocks in the Drenas region, Kosovo

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Abstract

Purpose. The paper purpose is to provide complete identification of rock types and the geochemical characteristics in the Drenas region. The authors seek to determine the discontinuity or continuity of all inter-formational boundaries to accurately delineate them in the field and fully reflect on a 1:25000 scale map. In addition, they reveal the nature of the contact between rock types, giving its detailed description and geochemical characteristics.

Methods. Geological study is focused on the following facts: complete identification of all rock types on the basis of studying their samples, preparation of thin sections for petrographic study, chemical and geochemical analysis. The methods applied for geochemical analysis use the MinPet software. This software, used for mineral chemistry, is programmed to process and recalculate the results of major-element analysis according to the most common normative calculation schemes. This software is used in scientific works for constructing diagrams of rock calcification and geochemical interpretations according to the components of $Na_2O + K_2O/SiO_2$, as well as rare earth elements according to the component $SiO_2/Zr/TiO_2$. The exploration field trips have been conducted to identify and describe areas of mineral outcrop.

Findings. Based on the study of geochemical analysis and the petrographic description of mineral outcrops, as well as examination under a microscope, different types of rocks have been identified. Based on these types, the origin, age and spread of these rocks in this region have been determined.

Originality. The originality of the study is in the use of the analysis results obtained in the AcmelLabs Laboratory, Vancouver, Canada, for major elements, rare earth elements and trace elements, which are shown in the diagrams presented in this paper.

Practical implications. The geochemical analysis leads to the conclusion that the studied area has Ni-mineralization, which is important for the development of mining sector, as well as for the community while preserving the environment and applying an adequate method of exploiting the area.

Keywords: *petrographic properties, thin section, geochemical analysis, Drenas region*

1. Introduction

The Republic of Kosovo is situated in the central part of the Balkan Peninsula. It borders Albania to the southwest, Montenegro to the west, Serbia to the north and east of North Macedonia to the southeast. The territory extends within the longitudes N41050'58" and 43 015'42", and within the latitudes E200 01'30" and 21048'02". Kosovo covers an area of 10908 km^2 [1]. It is characterized by an average altitude of 800 m above sea level, but has significant changes in relief and morphology of the area (Fig. 1).

The studied area is located on the territory of the Drenas Municipality. The municipality of Drenas is located in the center of Kosovo, between the Çyçavica mountains in the east and the Drenica valley in the northwest. The administrative center is the Drenas Municipality, located 20 km west of Prishtina and 24 km south of Mitrovica. The studied area covers part of the Drenica basin, located between the Kosovo basin in the east and the Dukagjini basin in the west. The Drenica basin is about 30 km long, and the width varies no more than 10 km. This area belongs to the Vardar Zone.

The term Vardar Zone was introduced [2] after the name of the Vardar River. Based on differences in its Cretaceous sedimentation history [3], the Vardar Zone has been subdivided into three NNW-SSE trending units (Almopias, Paikon and Peonias). The studies have revealed the present division of the Vardar Zone into the following five units (from W to E): the Almopias Unit; the Paikon Unit; the Guevguelije Unit; the Stip Axios Massif; the Circum Rhodope Belt [4] (Fig. 2). The Vardar Zone (also referred to as the Vardar-Axios Zone) represents the eastern Hellenic and Dinaric ophiolite belt and comprises the MORB-type oceanic crust (Triassic to Jurassic), as well as Palaeozoic and Mesozoic sediments [5], as equivalent to the Verrucano Permo-Triassic formation, which is quite widespread in the present Mediterranean region.

The boundary of these geotectonic units is marked by a fault, covered with Neogene sediments [6]. The present structure of the Dinaric and Hellenic is the result of Mesozoic to Cainozoic orogeny, related to the ongoing convergence between the Apulian and European plates (Fig. 2).

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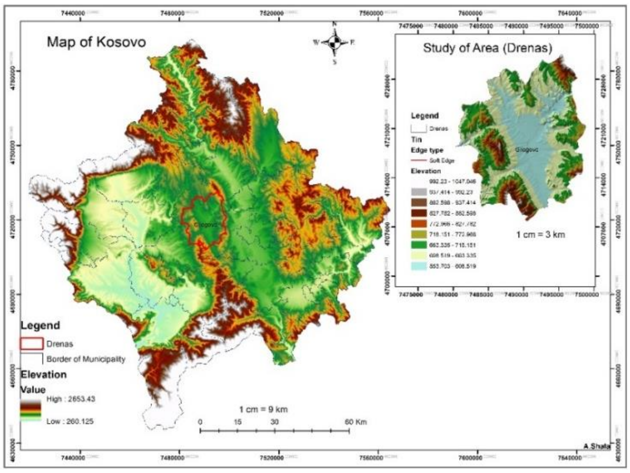

Figure 1. Map of Kosovo – the Drenas region under study

The present subdivision of the Dinaric-Hellenic into NNW-SSE trending zones (Fig. 2.) is related to the structural-geological and sedimentological investigations [3].

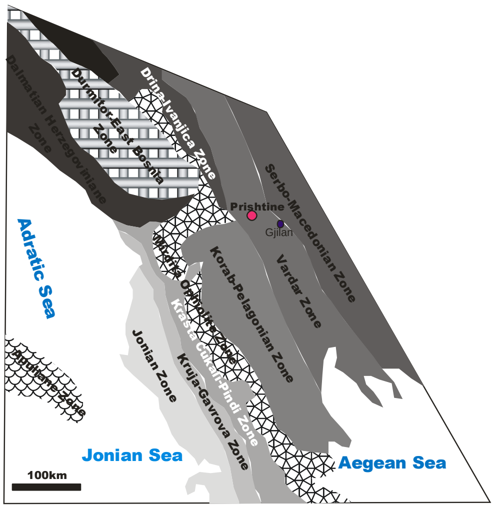

Figure 2. Geological setting of the Drenas region in the per-Alpine Balkan belts

The Apulian platform forms the foreland of the Hellenic orogen, which is outcropped on the islands (e.g. Paxos) located to the west of the Greek mainland. The Hellenic hinterland is represented by the crystalline Serbian – Macedonian and Rhodope Massifs (Fig. 2). The western vergent nappe system of the Hellenic orogen comprises the following major tectonic units (from W to E) (Fig. 2).

The Serbian – Macedonian and the Rhodope massif are composed predominately of crystalline rocks and are considered as a continental slope and rise during Jurassic and Cretaceous periods [7]. According to Alpine evolution, the Hellenic orogen is dominated by four distinct orogenic cycles, each accompanied by folding, nappe transfer, and regional metamorphism. The presence of an additional orogenic cycle during the Late Cretaceous period is assumed in the work [2]. During the preparatory period, archival and geological materials have been studied and published. During this period, the main problems have been identified and preliminary legends have been compiled. The reconnaissance of the area was carried out in groups, while problems related to lithological-formational, structural and metallogenic aspects were discussed directly in the field. In the context of this paper, the following facts have been highlighted:

1. For the first time, serpentinites have been identified that originate from the metamorphism of basal harcbugites with millionic and porphyroclastic texture at low temperatures, indicating lithospheric deformations during the final stage of the Vardar Ocean.

2. The nickel iron deposits in the Drenica basin are the result of the laterization process of ultrabasic rocks exposed to continental conditions about 5 million years ago. This is evidenced by the Lower Pliocene sediments located on the nickel iron crust disintegration in Çikatovo.

3. In the northeast corner, the ophiolitic melange has been identified, structurally located on the ophiolite of Vardar.

4. A conglomerate sandstone series with quartzite lenses, up to tens of meters in size, is structurally located at the base of the Permo-Triassic formation. This formation is supposed to be the Permo-Triassic formation, located with stratigraphic and structural inconsistencies on Paleozoic formation, as equivalent to the Verrucano Permo-Triassic formation, which is quite widespread in modern Mediterranean region.

In the studied area, igneous rocks have been identified only in blocks in the supra-ophioltic melange that occurs in the northeastern corner of this area. The results of the analysis of major elements, trace elements and rare earth elements have been processed using the geochemical-petrological MinPet software. The interpretation of the data is also comparable to data from neighboring regions.

2. Geological setting

Map of the studied Drenas region, composed according to the following lithostratigraphic units (Fig. 3).

Neogene – Quaternary:

– Lower Pliocene deposits (N2n7) transgressively occurring on the Paleozoic, Triassic, ultrabasic, Upper Cretaceous formations and on lateritic core of Ni-silicate. The sedimentary series is represented mainly by clays, sands, gravel, and less often by conglomerates and limestones. The thickness does not exceed 50 m [6];

– Middle Pliocene-Upper Quaternary (N2n8, N9-Q). The Middle-Upper Pliocene deposits have almost the same lithology as the Lower Pliocene, except for faunistic changes. While the oldest Quaternary formations in the Drenas region are of Pleistocene age and are represented by lacustrine sediments and river terraces;

– Pliocene formations also include laterites with nickel-silicate mineralizations, having serpentinites at their base and covered by Pliocene deposits. It is already known that the age of these laterites is equal to the age of the covering sediments.

Cretaceous (K):

– Cretaceous formations are represented by Lower Turonian (K2k2) sandy massive limestones with rudists (K2k2) up to 80 m thick [6]. The Lower Turonian deposits of Çikatovë are composed of massive light-gray limestones, yellow and ash-gray, very well crystallized, with numerous fracture sets filled with calcite and oriented in different directions. Compared with sediments of this age occur in neighboring areas. Hence, perhaps, it follows that the Lower Turonian is not complete and only its bottom is present, or even only the Upper Cenomanian.

Jurassic(J):

– The Middle Jurassic (J2), supra-ophiolitic "melange" (J2), previously called as volcanogenic-sedimentary formation or diabase – chert complex, shows that its basement blocks of gabbro, serpentinite and diabase are in a matrix represented by meta-sandstones, shale clay etc;

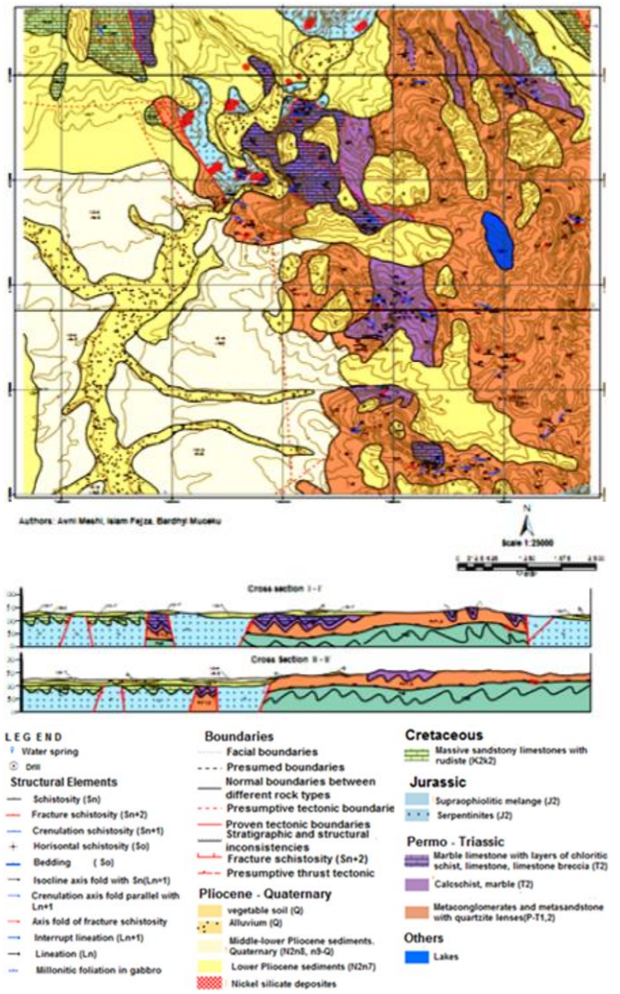

Figure 3. Geological map and cross-section of the studied area

– Serpentinites (J2) often show an intensives chistosity, which is parallel to shistosity Sn measured in Triassic and Cretaceous facies [6]. They are composed mainly of intergrowths of serpentinites, where serpentines of the antigone and crysotil type are accompanied by small inclusions of secondary magnesite, large deformed grains of bastitite and chromite. They are followed by laterites and Pliocene deposits. Serpentinites are exposed to transformation into harzburgites from basal peridotites with porphyroclastic to millonittic texture, low temperature and deformed under lithospheric conditions.

Permo-Triassic (P-T):

– Permo–Triassic formations are represented by Permian and Lower-Middle Triassic sub-formations, composed of metaconglomerates, meta-sandstones, quartzite lenses and shales in the lower part of the section, and then meta-sandstones;

– Upper Triassic sub-formation is represented by calcschists in the lower part of the section and marly limestones intercalated with green schists in the upper part.

3. Materials and methods

Fieldwork is focused on:

– identifying all types of rocks present in the studied area;

– sampling of all types of rocks for thin section preparation, chemical analysis and geochemical analysis;

Laboratory studies:

– preparing of thin section for microscopic examination;

– chemical analysis of all types of rocks, including rare earth elements and trace elements;

– geochemical analysis.

Thin sections are prepared in the laboratory of the Faculty of Geology and Mining, Polytechnic University of Tirana, Albania. Chemical analysis of major elements, trace elements and rare earth elements is performed at AcmelLabs Laboratory, Vancouver, Canada. The petrographic properties and geochemical analysis of the rock types in the studied area are described.

In total, 106 samples have been taken to conduct the geochemical analyses and study the petrographic properties of rocks in the studied area, but the descriptions of the most representative samples are given below.

Data analysis. The methods applied for geochemical analysis use the MinPet software. This software, used for mineral chemistry, is programmed to process and recalculate the results of major-element analysis according to the most common normative calculation schemes. This software is used in scientific works for constructing diagrams of rock calcification and geochemical interpretations according to the components of $Na_2O + K_2O/SiO_2$, as well as rare earth elements according to the component $SiO_2/Zr/TiO_2$. In addition, using the MinPet software, it is possible to see on the diagrams whether subalkaline igneous rocks have an intermediate calc-alkaline-tholeiite nature. Also, in the diagrams, igneous rocks are mainly found if they are in the volcanic field of island arches. This software can be used to enter a result after receiving chemical analysis results from a laboratory.

4. Results and discussion

Samples have been taken in the field to perform chemical-geochemical analysis and characterization of representative rocks in this region. The chemical analysis has been performed in the laboratory AcmelLabs Laboratory, Vancouver, Canada. The petrographic analysis has been conducted in the laboratory of the Faculty of Geology and Mining, Polytechnic University of Tirana, Albania.

The results of geochemical and petrographic analysis of some types of rocks in the studied region are briefly presented below.

4.1. Petrographic description

The mineralogical composition and structure of rocks are tested for Petrographic characteristics using petrography microscope preparations. Figures 4-10 show samples 1-7 in polarized light.

(a) (b)

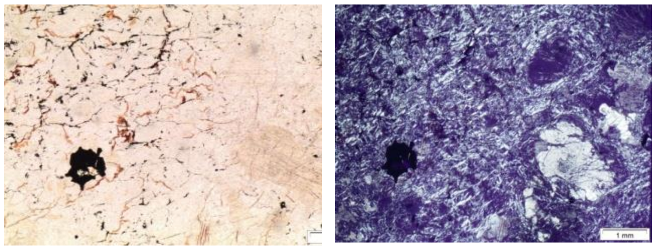

Figure 4. Sample 1: (a) PPL (30x); (b) CPL (30x)

Serpentinized Harcburgite with traces of orthopyroxene, while olivine is all altered by serpentine. The rock has a low content of iron oxides.

Gabbro with a granular texture, the size of which varies from 1 to several mm. The rock is relatively fresh, in terms of mineralogical composition it consists mainly of clinopyroxene and plagioclase.

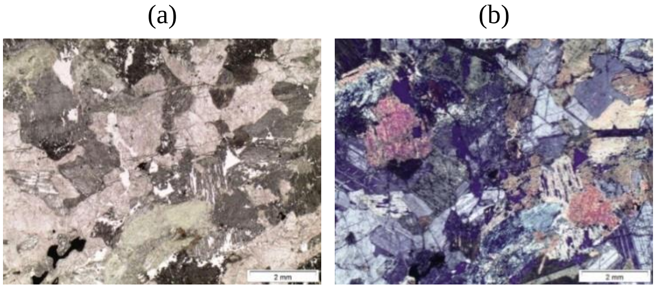

Figure 5. Sample 2: (a) PPL (30x); (b) CPL (30x)

Pyroxene is relatively altered and, to a lesser extent, plagioclase is transformed into sericite. There is very little presence of olivine and opaque minerals.

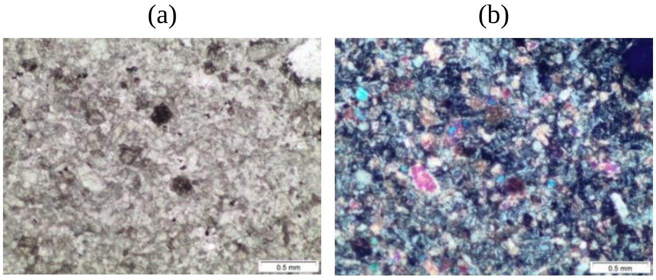

Figure 6. Sample 3: (a) PPL (30x); (b) CPL (30x)

Diabase with a microcrystalline texture, the size of which varies from 0.1 to 0.5 mm. The mineralogical composition is mainly represented by pyroxene formed earlier and plagioclase crystallized later.

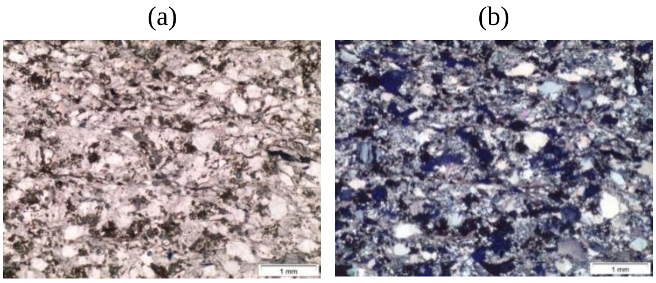

Figure 7. Sample 4: (a) PPL (30x); (b) CPL (30x)

Metasandstone with a high content of quartz, which in most of the rock is recrystallized into microcrystals. The rock is represented by very good foliation, along which mica minerals are developed.

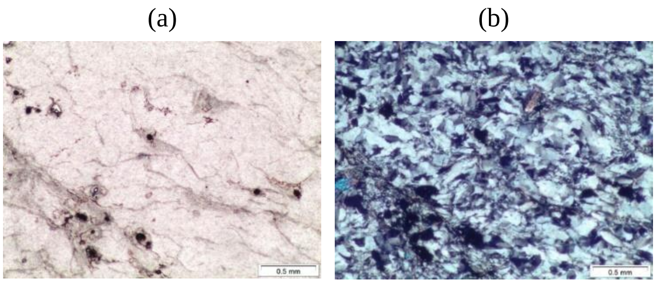

Figure 8. Sample 5: (a) PPL (30x); (b) CPL (30x)

Metasandstones (quartzites) are completely converted into quartz minerals, consisting of more than 80% of quartz microcrystals ranging in size from 0.01 to 0.3 mm, all recrystallized with very little mica.

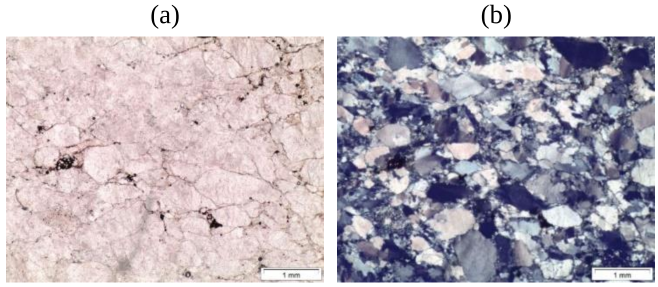

Figure 9. Sample 6: (a) PPL (30x); (b) CPL (30x)

Quartzite with a composition almost exclusively of quartz, with a granule size with a bimodal distribution: granules ranging from 0.5 to 1 mm; and another microcrystalline population smaller than 0.1 mm in size and formed from a matrix of fully recrystallized sandstone.

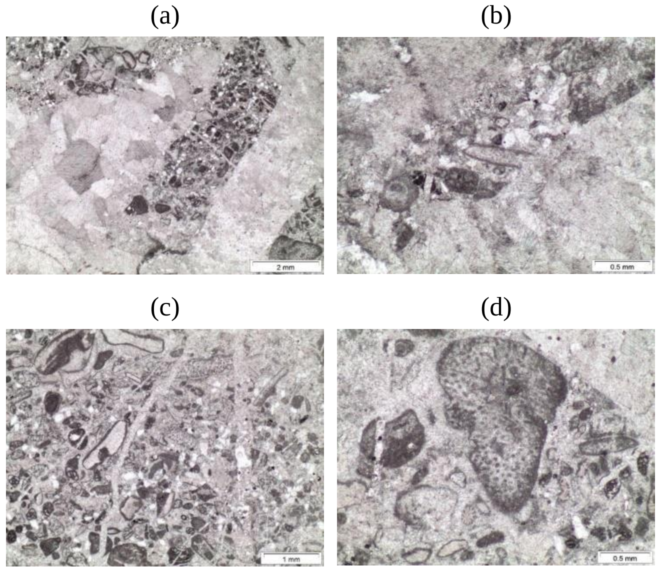

Figure 10. Sample 7: (a) Bioclastic grainstone with calcium-filled veins with dacycladal algae, small bentonic foraminifera and echinodermal fragments; (b) Aeolisaccus sp.; (c) Bioclastic grainstone with dacycladal algae and small miliolides (Textularides); (d) Salpingoporella sp. (PPL-25x)

The Petrographic characteristics and geochemical characteristics of the rocks in the Drenas region are divided into several groups: 1. Harzburgite. 2. Gabbro. 3. Diabase. 4. Metasandstone. 5. Sandstone. 6. Quartzite. 7. Grainstone with Calcium. Samples are taken in the exploration area. The mineralogical composition and structure of rocks are tested for Petrographic characteristics using petrography microscope preparations. Figures 4-10 show the samples 1-7 in PPL and CPL.

4.2. Geochemical data

The results of the analyses of major elements, rare earth elements and trace elements, conducted in the Laboratory AcmelLabs, Vancouver, Canada, are presented below in the form of diagrams (Figs. 11-14).

Classification of rocks based on the diagram Na_2O + K_2O/SiO_2 is shown in Figure 12. This diagram shows the magmatic rock classification. Five samples fall into the basaltic rock field, while one sample falls into the dacitic rock field. All magmatic rocks of Drenas region fall into the subalkaline rock field.

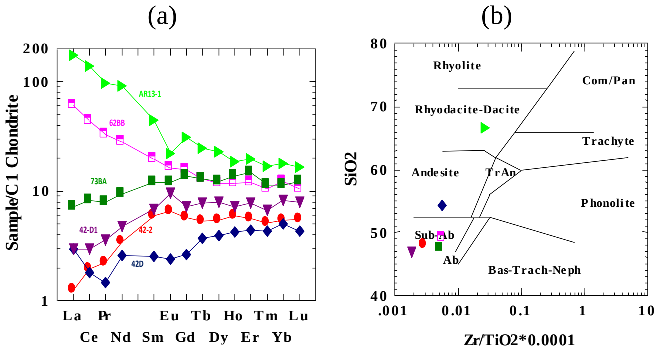

Figure 11. Diagrams of: (a) Normalization diagram of REE content in basalt rocks depending on their content in Chondrite; (b) the magmatic rocks are of the basalt type

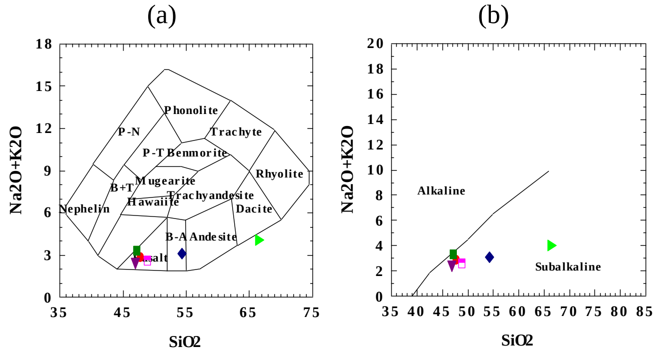

Figure 12. Diagrams of: (a) classification of rocks based on the diagram $Na_2O + K_2O/SiO_2$; (b) alkaline and subalkaline rocks $Na_2O + K_2O/SiO_2$

In the A-F-M diagram, subalkaline igneous rocks have an intermediate calc-alkaline-toleithic nature (Fig. 13).

Diagram V-Ti/1000 and Diagram Ti/10-Zr-Sr/2 are shown in Figure 14. Magmatic rocks fall mainly into the volcanic field of the island arches. Even in this diagram, the analyzed igneous rocks fall into the basalt field of island arches.

In the studied region, igneous rocks are found only in blocks in the supra-ophioltic melange, which occurs in the northeastern corner of this region. Processing of the analysis results of major elements, trace elements and rare earth elements is performed using the geochemical-petrological MinPet software. The data interpretation is also compared with the data from the neighboring regions.

From the diagram in Figure 11, the normalization of REE (rare earth elements) content in comparison with Chondrit can be seen. There are two groups of igneous rocks: the first group, which includes four samples, represents a fraction of REE expressed in relative impoverishment of rare light earth elements compared to rare medium and heavy earth elements.

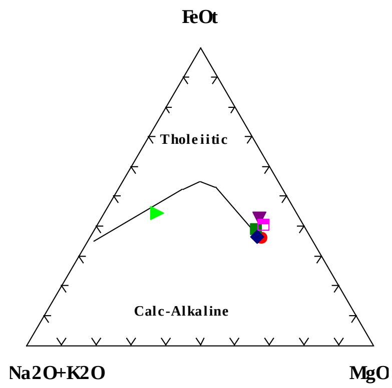

Figure 13. The A-F-M diagram of the subalkaline igneous rocks

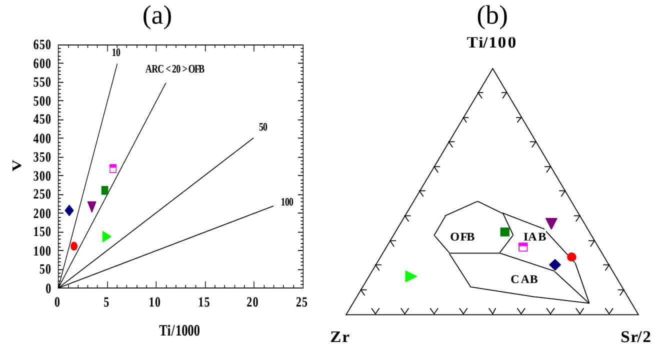

Figure 14. Diagrams: (a) V-Ti/1000; (b) Ti/100-Zr-Sr/2

The opposite occurs with two samples AR13-1 and 62BB (Fig. 11), in which the rare light earth elements are enriched compared to rare medium and heavy earth elements. This change in REE fractionation clearly distinguishes these two groups of magmatic rocks, crystallized respectively from two magmas in equilibrium with two mantle sources, which differ from each other not in the degree of partial melting (close contents of rare earth, light, medium and heavy elements), but in that one source partly is exposed to some metasomatism (enrichment with rare light earth elements) before undergoing partial melting, which would have yield the second group of igneous rocks.

5. Conclusions

The studied area is located in Drenas region – the central part of Kosovo, and belongs to the Vardar Zone. The term Vardar Zone was introduced after the name of the Vardar River in the Republic of Northern Macedonia [7].

From a scientific point of view, for the first time the following has been identified: evidence of serpentinites resulting from the metamorphism of basal harzburgites with myllonitic and porphyroclastic texture at low temperatures, which indicates deformations of the lithosphere during the final phase of the Vardar Ocean; evidence in the northeastern corner of the ophiolitic melange, which is structurally located on the ophiolites of the Vardar zone. The conglomerate sandstone series with quartzite lenses, all up to tens of meters, are structurally located along the formation of the Permo-Triassic ages. We assume that the Permo-Triassic formation has stratigraphic and structural inconsistencies over the Paleozoic formations, equivalent to the Verrucano Permo-Triassic formation, which is quite widespread in the present Mediterranean region.

Based on the petrographic analysis, the following structural units can be distinguished from bottom to top in the study area:

– the lower structural stage formed by Permo-Triassic meta-sedimentary deposits;

– ophiolites and supraophiolitic tectonic "melange" of the Middle Jurassic settled with obduction on the continental platform during the Upper Jurassic-Lower Cretaceous;

– upper Cenomanian – Lower Turonian transgression;

– tertiary transgression forming the last structural stage.

In the studied region, igneous rocks occur only in blocks in the supra-ophioltic melange found in the northeastern corner of this region. Processing of the analysis results of major elements, trace elements and rare earth elements has been performed using the geochemical-petrological MinPet software. The data interpretation has also been compared with the data from the neighboring regions.

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Петрографо-геохімічна характеристика гірських порід регіону Дренас, Косово

І. Фейза, А. Шала, Ф. Кутловці, А. Тмава

Мета. Забезпечення повної ідентифікації особливостей типів гірських порід і геохімічних характеристик у регіоні Дренас для визначення розривності або цілісності усіх міжпластових меж та окреслення їх у родовищі для повного відображення на карті масштабу 1:25000.

Методика. Геологічні дослідження зосереджені на таких фактах: повна ідентифікація всіх типів гірських порід на основі вивчення їх зразків, підготовка тонких розрізів для петрографічного дослідження, хімічний та геохімічний аналізи. У методах геохімічного аналізу використовується програмне забезпечення MinPet, яке застосовується для хімії мінералів, запрограмовано на обробку та перерахунок результатів аналізу основних елементів за найпоширенішими нормативними схемами розрахунку. Розвідувальні польові виїзди були проведені з метою виявлення та опису ділянок відслонення корисних копалин на поверхні.

Результати. Виявлено різні типи гірських порід на підставі дослідження геохімічного аналізу та петрографічного опису виходів корисних копалин, а також дослідження під мікроскопом. За петрографічними та геохімічними характеристиками породи району Дренас діляться на кілька груп: Гарцбургіти, Габро, Діабаз, Метапісковик, Пісковик, Кварцит і Зернистий камінь із кальцієм. Встановлено вік і поширення цих порід у даному регіоні на основі їх виявлення і походження. Отримано та оброблено результати аналізу петрогенних, розсіяних та рідкоземельних елементів із використанням геохіміко-петрологічної програми MinPet.

Наукова новизна. Для умов регіону Дренас досліджено характер зміни геохімічних, петрографічних та мінералогічних особливостей виявлених типів гірських порід для подальшої можливості їх видобування.

Практична значимість. Проведений геохімічний аналіз дозволяє зробити висновок про наявність на території дослідження Ni-мінералізації, що має важливе значення для розвитку гірничодобувної промисловості, а також для населення при збереженні довкілля та застосуванні адекватного методу експлуатації території.

Ключові слова: *петрографічні властивості, тонкий розріз, геохімічний аналіз, район Дренас*