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Geology and characteristics of petrographic rocks in the region of Trepça, Kosovo

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Abstract

Purpose. The purpose of this paper is to accomplish a thorough identification of rock types occurring within the Mitrovica region by describing in detail all encountered varieties. The authors aim to determine the discontinuity or continuity of all inter-formational boundaries, crucial for accurate delineation on the ground and complete reflection on a 1:25000 scale map. Additionally, the objective is to identify the nature of contact between rock types and provide a detailed their description.

Methods. Field exploration in the Mitrovica region was conducted for several months. Rock identification involved detailed sampling and petrographic analysis, including thin section preparation of magmatic rocks. The method included sample preparation, polarized light source interactions with minerals and observation of optical properties. Key properties observed are birefringence, interference colors, extinction angles, identification and analysis.

Findings. Based on the study of stratigraphic units and geological descriptions of mineral outcrop areas, various types of rocks through petrographic microscope preparation, as well as chemical and geochemical analyses, have been differentiated. The Mitrovica area encompasses the following lithostratigraphic units: harzburgite, gabbro, diabase, metasandstone, sandstone, quartzite and grainstone with calcium (Aeolisaccus sp.; Bioclastic grainstone with dacycladal algae and small milliolides; Salpin-goporella sp.).

Originality. The originality of the research lies in employing an optical microscope for the precise identification of rocks. Through the re-search carried out in the study area, we obtained a comprehensive petrographic description of mineral composition, texture, and mineralization, facilitating the assessment of the area exploitation potential.

Practical implications. The petrographic exploration yielded the conclusion that the Pb-Zn mineralization is present in the study area, which is a sig-nificant finding for the advancement of the mining sector and the local community, provided that environmental preservation measures are upheld and responsible methods of area exploitation are implemented.

Keywords: *Mitrovica zone, mineralogical composition, petrography microscope preparation, tectonics*

1. Introduction

Petrography, the detailed study of rocks at the microscopic level, plays a crucial role in understanding the geological structure, mineral contacts and natural resource potential of a region [1], [2]. In Kosovo, petrographic research on rocks is essential for various purposes, including exploration of mineral resources, understanding the geological evolution of the region, and assessing the suitability of rocks for construction materials [3], [4].

Kosovo, situated in the Balkans, is known for its complex geological history, which includes various tectonic events and geological processes. Petrographic studies of rocks in Kosovo are aimed at revealing this geological units and potential resources by examining the mineral composition, texture, and structure of rocks found in the region. Moreover, petrographic analysis provides valuable insights into the economic potential of the Kosovo rocks [5]. By studying the petrographic characteristics of rocks, researchers can identify potential mineral deposits, as well as assess the quality of construction materials and the suitability of rocks for various industrial purposes. Therefore, petrographic research on rocks in Kosovo is crucial for both scientific understanding and economic development, making it an important area of study for geologists and researchers interested in the geological and economic aspects of the region [6], [7].

By its geographical position, the Republic of Kosovo is located in the central part of the Balkan Peninsula. It borders Serbia to the north and east, North Macedonia to the southeast, Albania to the southwest, and Montenegro to the west. The Republic of Kosovo has an area of 10908 km^2. The territory lies within longitudes 41°50′58″ and 43°15′42″ and within the latitudes 20°01′30″ and 21°48′02″ [8], [9].

The study area is located in the northeastern part of the city of Mitrovicë and bounded by the village of Bajgore to the east by; by the village of Zaberrxhe to the north; by the villages of Vllahija and Boletini in the west; and by the village of Mazhiq to the south. Its southwestern corner borders the first tunnel of the Mitrovic-Bajgore road (Fig. 1) [9].

Almost the entire studied region is characterized by hilly-mountainous relief, with the development of small residential

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centres (neighbourhoods) of villages: Mazhik, Bajgorë, Bare, Vidishić, Melenicë, Zaberrxë, Magherë, Batahir, Zijaqë, Vllahi, Zhazhë, Boletin , Rahovë (Fig. 1) [9].

The municipality of South Mitrovica is an administrative unit in the northern part of Kosovo. The municipality of Mitrovica is located on the plain between the rivers Ibër, Sitnica and Lushte, as well as on the slopes of the surrounding hills. The city of Mitrovica is one of the seven largest centers in Kosovo, with 79890 inhabitants in the municipality of South Mitrovica, according to 2022 statistics.

The study area covers the part of Mitrovica located between the Iber, Stinica and Lushta rivers and is 18 km from Mitrovica to the village of Bajgora in the northeast of Mitrovica. This area belongs to the Vardar Zone [10]-[12].

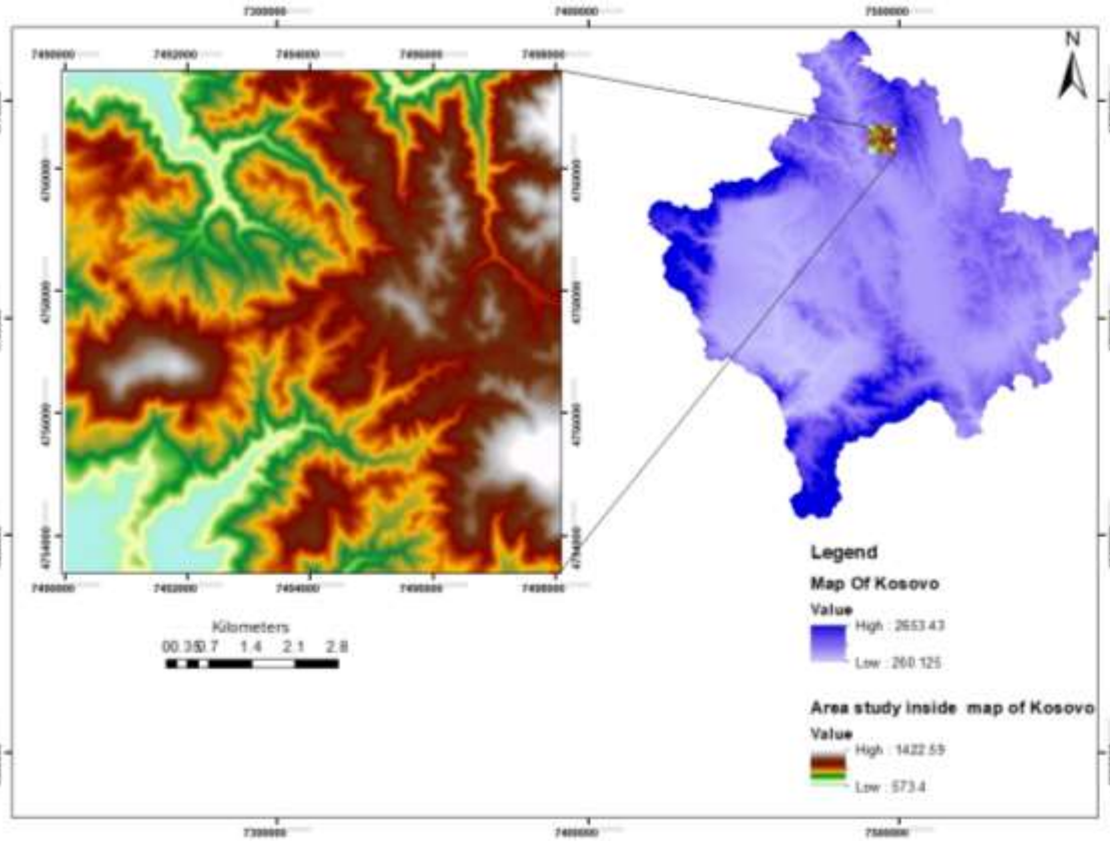

Figure 1. Location of the study area, Trepça mine (A. Shala)

The Vardar Zone, named after the Vardar River, is an important geological region in Kosovo. Based on differences in its Cretaceous sedimentation history, it is divided into three NNW-SSE trending units: the Almopias, the Paikon, and the Peonias units. However, recent studies have subdivided the Vardar Zone into five units from west to east [9]: the Almopias Unit, the Paikon Unit, the Guevguelije Unit, the Stip Axios Massif, and the Circum Rhodope Belt.

The Vardar Zone, also known as the Vardar-Axios Zone, constitutes the eastern Hellenic and Dinaric ophiolite belt. It comprises MORB-type oceanic crust dating from the Triassic to Jurassic periods, as well as Palaeozoic and Mesozoic sediments. The Verrucano Permo-Triassic Formation, widespread in the Mediterranean region, is equivalent to the Palaeozoic and Mesozoic sediments found in the Vardar Zone [9].

The boundary between these geotectonic units is marked by a fault covered by Neogene sediments. The current structure of the Dinaric and Hellenic regions is the result of Mesozoic to Cenozoic orogeny, which is related to the ongoing convergence between the Apulian and European plates.

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. 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. In the northeast corner, the ophiolitic melange, structurally located on the ophiolite of Vardar, has been identified. 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 study 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 [12], [13].

1.1. Stratigraphy

Quaternary (Q). In the study area, quaternary deposits occupy an area of about 15% and are composed of Deluvions (vegetable land) of the Holocene (Q_2d) and Holocene alluvium (Q_2a).

Deluvions (vegetable land) of the Holocene (Q_2d). Deluvions (vegetable soil) of the Holocene age occupy a considerable area, making it difficult to trace the contacts of the lithological types constituting the study area, their stratigraphic correlation, as well as to assess the thickness of the geological formations. In this perspective, the study area is a region with difficult conditions for geologic-structural survey [11], [12]. Deluvions are composed of vegetal soil with pieces of basalt, peridotite, gabbro, metasediments, quartz-latite, volcanic bombs, etc., ranging in size from a few millimeters to several tens of centimeters [10]-[12].

Alluvium of the Holocene (Q_2a). Alluviums are deposits of the upper flow of the Trepça River. They are composed of gravel, sand, clay, and less frequently rounded poplars. Usually, they contain underground water [9], [14].

1.2. Shallow volcanic-sedimentary and plutonic complex of the Upper Oligocene (E3e9)

The shallow volcanic-sedimentary and plutonic complex associated with the upper Oligocene magmatism occupies approximately 50% of the Trepça Plateau surface, spreading mainly in its central and southern parts. This complex is composed of:

– pyroclastic deposits of the Upper Oligocene (E_3e_9);

– sedimentary deposits (argillites, sandstones, and conglomerates) of the Upper Oligocene (E_3e_9);

– Dajka, volcanic flow, and latite sediments of the Upper Oligocene (E_3e_9);

– Trachytes of the Upper Oligocene (E_3e_9);

– Chatian pyroclastic deposits (E_3e_9).

Pyroclastic deposits overlie sedimentary deposits (Fig. 2) of the same volcanic-sedimentary complex of the Upper Oligocene (Chatian) [10], [11], [15]. However, cases are not excluded when these deposits, especially on their periphery, are located with structural and stratigraphic inconsistencies on metasediments of the upper Paleozoic, Triassic, and ophiolitic complexes (serpentinite, gabbro, basalts, and upper-ophiolitic melange) of the middle Jurassic, as well as on the flysch of the Senonian. They are composed of subhorizontal beds with an average direction of 80°S10°, where 83% of them have a direction of 75°S15° [12].

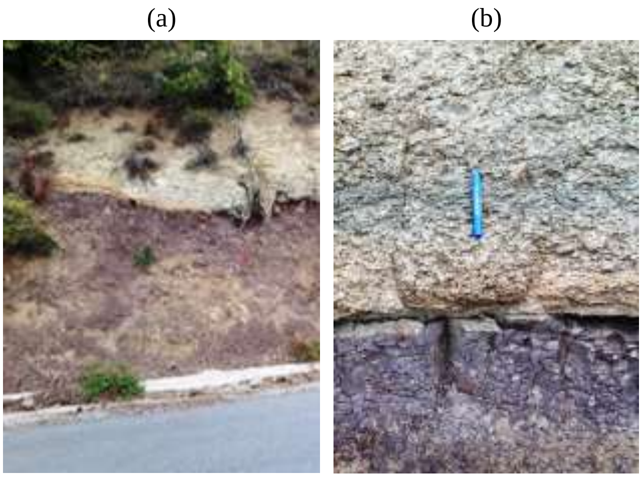

***Figure 2.** Area studied in the River Trepça: (a) normal occurrence of white-colored pyroclastic deposits over purple-colored sedimentary deposits; (b) details of this*

We assign them to the Upper Oligocene (Chatian) age, assuming that they are contemporaneous with the latite dykes that supplied these deposits. Layers in pyroclastic deposits (Fig. 3a) are the result of alternating layers based on granulometry of particles, pieces, and phenocrysts encountered in them. It is on the basis of this granulometry and based on the existing classifications of these deposits that we distinguish the following [10], [11], [15]:

– ten-centimeter volcanic bombs with phenocrysts consisting mainly of feldspar, biotite, etc. (Fig. 3b), with ring construction (Fig. 3c) and volcanic breccias from centimeter to tens of centimeters (Fig. 3d);

– coarse-size lapilla and fine-size lapilla;

– tufts, which occur in a limited extent in this tablet and in which enclaves of metasomatized green schists have been found during their transportation by magma rising from the depth towards the surface.

It is not correct to name them by chemical composition, as impurities are often found in fragmentary volcanic material.

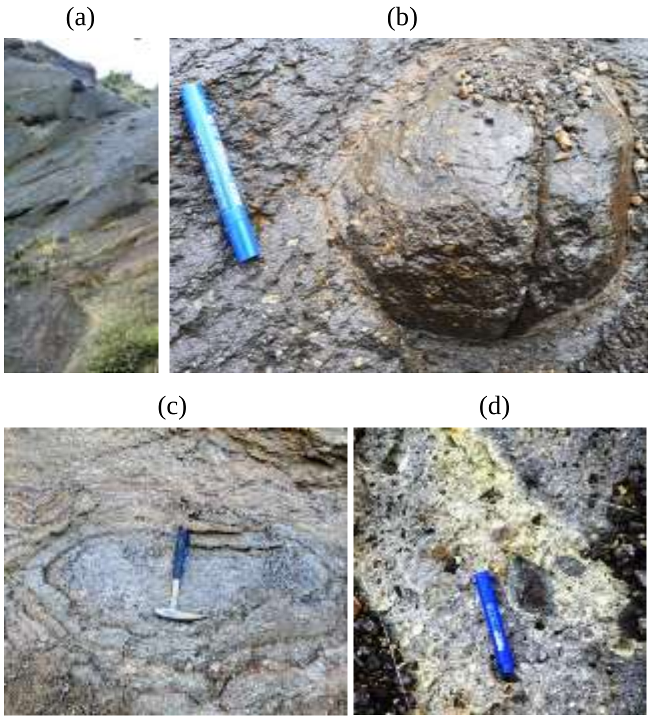

***Figure 3.** Samples taken in the Rashan: (a) beds of pyroclastic deposits; (b) volcanic bombs with feldspar phenocrysts; (c) generational construction of volcanic bombs; (d) volcanic breccia*

1.3. Sedimentary deposits (argillites, sandstones, and conglomerates) from the Upper Oligocene (E3e9)

Sedimentary deposits (argillites, sandstones and conglomerates) of the Upper Oligocene (E3e9) only occur at some limited outcrops (Fig. 4 and 5), right at the boundary between pyroclastic deposits and Paleozoic-Mesozoic rocks [16], [17].

Upper Cretaceous (K_2). In the most northwestern corner of the studied region, the upper Cretaceous is present in a very limited area and is represented by silic deposits of the upper Senonian [14], [18].

Upper Senonian Flysch (K_2k4-6). The deposits of the upper Cretaceous are composed of flysch of the upper Senonian (K_2k4-6), that is, Santonian (K_2k4), Campanian (K_2k5), and Maastrichtian (K_2k6).

(a)

(b)

Figure 4. Samples taken in the Mazhiq: (a) harzburgite enclave in pyroclastic deposits; (b) metasediment enclaves in pyroclastic deposits

(a) (b)

(c)

Figure 5. Samples taken in the Cernush: (a) gray to sky-blue argillites located below the white pyroclastic sediments; (b) latite silt in gray argillite; (c) sky-grey argillite with pieces of Triassic limestone

In the Trepça Plateau, they are presented as a tectonic slice within the middle-upper Jurassic upper-ophiolitic sedimentary mélange [10], [11].

Jurassic (J). In the Trepça study area, the Jurassic is represented by:

– melange upper-phiolitic sedimentary of the Middle-Upper Jurassic (J_2);

– basalts of the Middle Jurassic (J_2);

– gabbro, gabbrodiabase and amphibolic gabro of the Middle Jurassic (J_2);

– serpentinized peridotites of the Middle Jurassic (J_2).

Triassic (T). Triassic is represented by:

– schists and phyllites of the Middle Triassic (T_2);

– metabasalts and basalts of the Middle Triassic (T_2);

– metaranos, quartzites, phyllites and graphitic-sericitic schists of the Lower Triassic (T_1);

– metabasalts and basalts of the Lower Triassic (T_1).

During our fieldwork in the studied region, a considerable number of samples (over 100) were taken, for which petrographic description was performed. The petrographic description was conducted using an optical microscope with a polarizer and analyzer, with a magnification of 10 to 100 times. Based on this description, the studied samples can be divided into the following main groups: harzburgite, gabbro and amphibolic gabbro, basalt (mainly altered), diabase (also altered), latite, andesite, trachyte, etc. Map of the studied region, composed according to the following lithostratigraphic units, is shown in Figure 6.

1.4. Research purpose

The purpose of this paper is to comprehensively identify and describe the different rock types present in the Mitrovica region, determining the discontinuity or continuity of interformational boundaries, which is essential for accurate delineation of geological features on 1:25000 scale maps. Additionally, the research aims to identify the nature of contact between rock types and provide a detailed their description.

The importance of this research that accurate identification and description of the rock types in the area is fundamental to understanding its geological history and formation processes. Also, the findings of this research can have practical implications, especially in the mining sector. The identification of Pb-Zn mineralization in the study area suggests potential economic opportunities for mining activities.

2. Materials and methods

Fieldwork aims to identify all types of rocks present in the study area and to sample all rock types to prepare thin sections. Laboratory research focuses on preparing a thin section for microscopic examination.

A total of 22 rock samples have been taken. Several unaltered rocks were collected from fresh surface outcrops to determine the nature of the original rocks. Characteristics such as grain size, mineralogy, color, freshness or alteration of samples were described in the field. The mineralogy and textures of 22 thin sections were studied using a polarizing microscope.

Major elements from fifteen unaltered samples were determined using X-Ray Fluorescence Spectrometry (XRF). The samples were collected from different geological formations across Kosovo, including the Trepça region. Measurement data of petrographic rock characteristics were obtained between June 2021 and June 2022 using measurement techniques.

Petrographic Analysis: Thin sections of rock samples were prepared and examined under a polarizing microscope (scope microscope) to determine the mineral content, texture and rock structure.

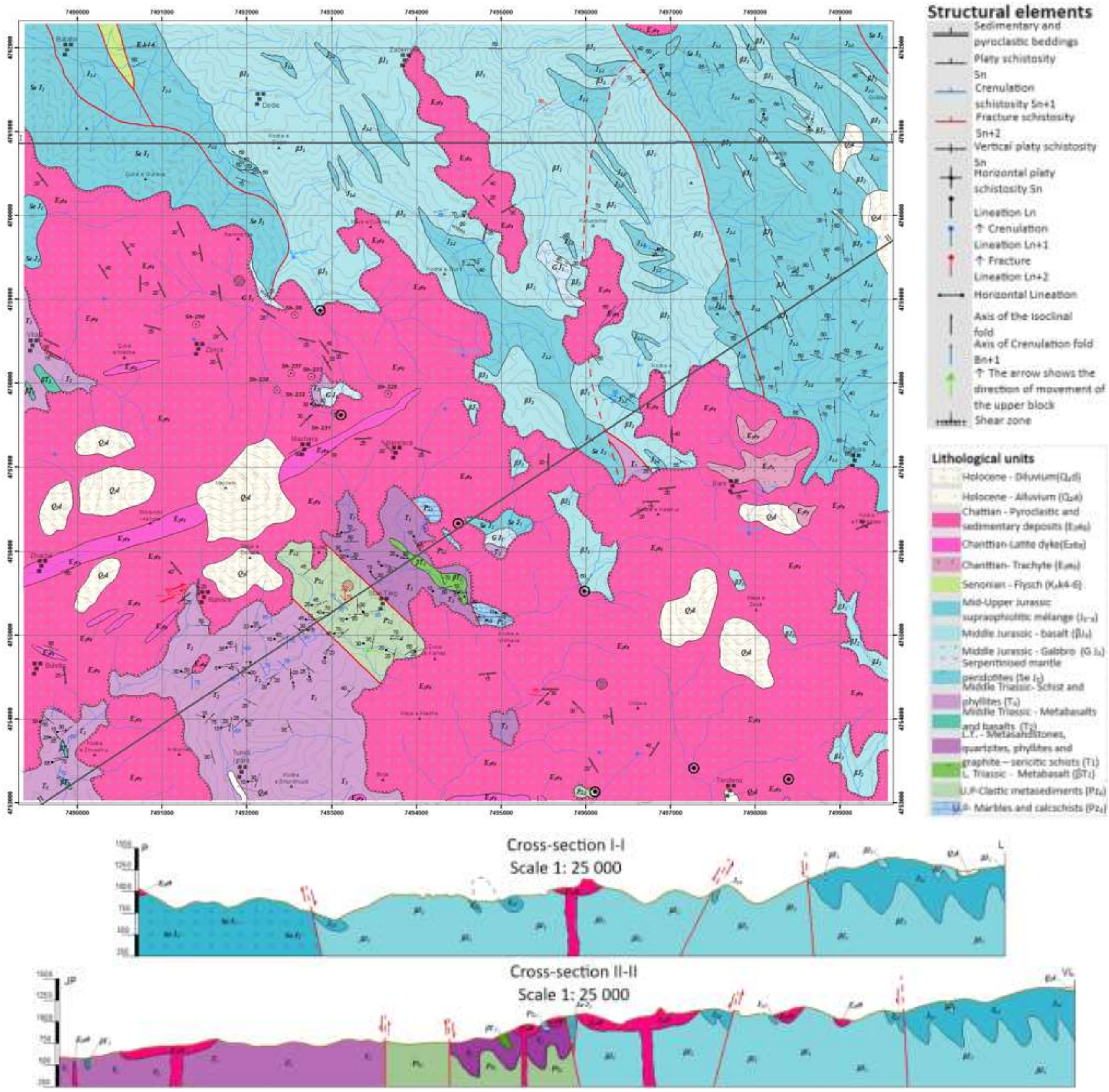

Figure 6. Geological map and cross section of the study area

Here is an overview of the method and its application:

1. Sample preparation. Thin sections of rock samples are prepared by cutting and grinding to a thickness of about 30 micrometers. These thin sections are then mounted on glass slides and polished to make them translucent.

2. Polarized light source. The prepared thin section is placed on a polarizing microscope stand. Polarized light is generated by passing light through a polarizer aligned with a second polarizer, called an analyzer, which is set perpendicular to the first.

3. Interactions with minerals. When polarized light passes through the thin section, it interacts with minerals in the rock. Different minerals have different optical properties, causing them to interact differently with polarized light.

4. Observation of optical properties. By observing the behavior of polarized light as it passes through minerals, petrographers can identify and characterize the minerals present in a rock sample.

Key properties observed include birefringence, interference colors, extinction angles and identification and analysis. The difference in refractive index between different crystallographic directions in a mineral. Colors are observed when light waves interfere as they pass through a mineral with birefringence. The angle at which the mineral grain darkens (disappears) when rotated under crossed polars. We use observed optical properties to identify minerals and interpret the rock texture, structure, and history.

Petrographic microscopes often have additional features such as a rotating stand to measure mineral grain orientations in a rock sample. Polarized light microscopy is widely used in petrology for detailed analysis of rocks and minerals at the microscopic level. It provides valuable information for understanding the mineralogical composition, texture, and geological history of rocks.

Samples collected in the field were analyzed to characterize representative rocks in the region. Petrographic analysis was carried out in the laboratory of the Faculty of Geology and Mining, Polytechnic University of Tirana, Albania.

3. Results and discussion

In this section we summarize the results of the petrographic analysis for some rock types found in the studied region. In the Trepça region, petrographic characteristics and geochemical characteristics of rocks are divided into several groups:

– harzburgite;
– gabbro;
– diabase;
– metasandstone;
– sandstone;
– quartzite;
– grainstone with calcium.

Also, there are some fossils in rocks (Aeolisaccus sp.; Bioclastic grainstone with dacycladal algae and small miliolides; Salpin-goporella sp.).

3.1. Petrographic description

The mineralogical composition and structure of rocks are tested for petrographic characteristics using petrography microscope preparations. Figures 7-24 show samples 1-18 in polarized light.

(a) (b)

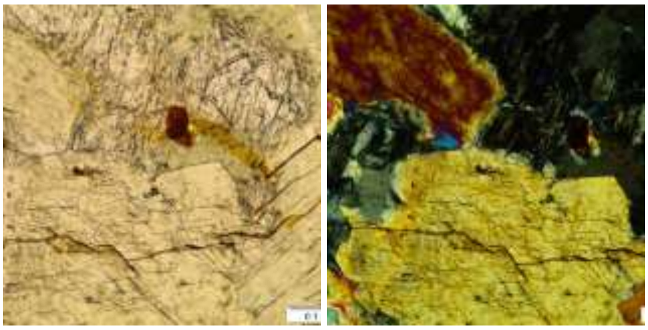

Figure 7. Sample 1 (A-348) under polarized light: (a) without analyzation; (b) with analyzation (magnified 25×)

Amphibolite is a metamorphic rock that may have originated from a gabbro, where all the pyroxene crystals were converted into amphibole. It typically contains amphibole minerals such as hornblende and sometimes actinolite. In addition to amphibole, amphibolite often contains plagioclase feldspar, which is usually completely altered, showing recrystallization or replacement textures. This alteration process transforms the original plagioclase into minerals such as epidote, chlorite, or albite.

(a) (b)

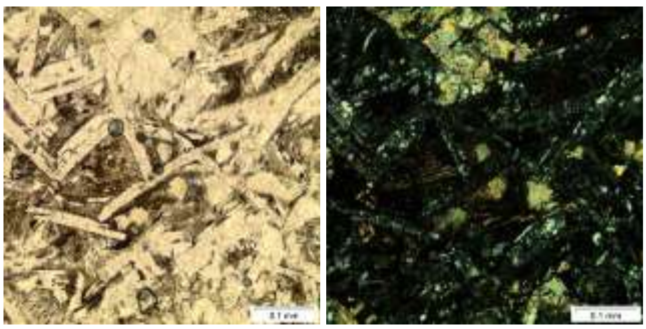

Figure 8. Sample 2 (A-348) under polarized light: (a) without analyzation; (b) with analyzation (magnified 100×)

The highly altered basalt has a skeletal structure with completely sericitized plagioclase crystals. There are relics of pyroxene, probably converted to actinolite. The rock also contains calcite, epidote, and chlorite, of which calcite predominates. Amygdaloidal cavities are filled with secondary minerals, predominantly calcium-containing minerals. This alteration assemblage suggests a history of hydrothermal alteration and metamorphism that transformed the original basalt into a calcite-rich, highly altered rock.

(a) (b)

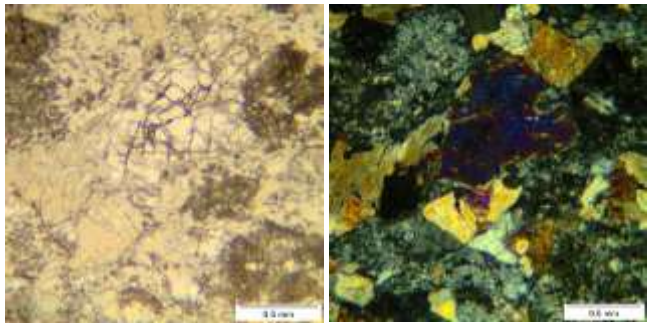

Figure 9. Sample 3 (A-348) under polarized light: (a) without analyzation; (b) with analyzation (magnified 100×)

The gabbro sample shows extensive alteration, with plagioclase completely sericitized. Olivine is serpentinized, and clinopyroxene is partially altered to a fibrous mineral, probably anthophyllite. The rock is predominantly composed of altered plagioclase with relics of olivine. This assemblage indicates a history of hydrothermal alteration, possibly related to metamorphic processes. The presence of serpentinized olivine and fibrous clinopyroxene suggests a secondary mineral assemblage formed under low-grade metamorphic conditions.

(a) (b)

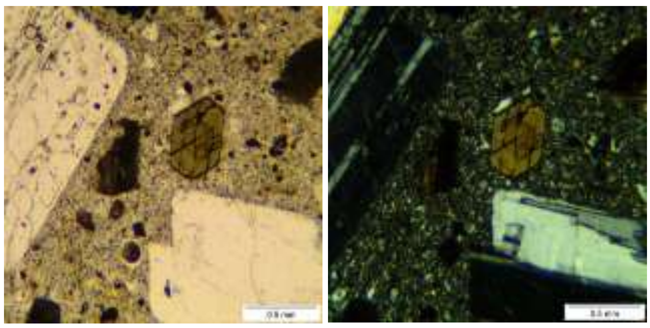

Figure 10. Sample 4 (A-348) under polarized light: (a) without analyzation; (b) with analyzation (magnified 100×)

The volcanic rock is predominantly andesite, characterized by phenocrystals of sodic plagioclase and amphibole. Plagioclase phenocrysts range from albite to oligoclase in composition. Sanidine, although present in smaller quantities, is also observed. Secondary minerals include opaque minerals, sphene and small amounts of apatite. This mineral assemblage suggests an intermediate composition of volcanic rock formed in a subduction zone.

The rock is identified as trachy-andesite or latite, characterized by plagioclase phenocrystals and sanidine. Amphibole, although present, is mostly altered and appears as colored minerals. Secondary minerals include opaque minerals, sphene, apatite, and minor amount of zircon.

(a) (b)

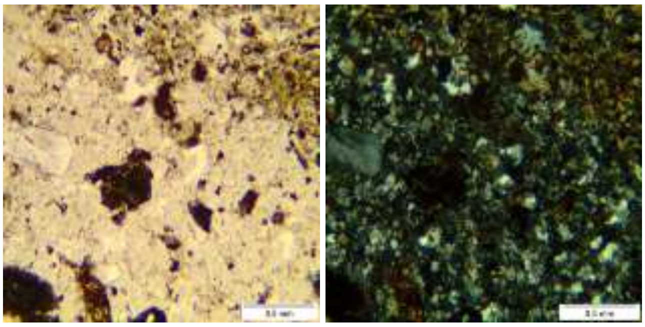

***Figure 11.** Sample 5 (A-348) under polarized light: (a) without analyzation; (b) with analyzation (magnified 100×)*

The rock shows significant alteration with minerals sericitized and extensively calcitized. The abundance of apatite and the presence of zircon suggest a complex history involving magma differentiation and subsequent alteration processes.

(a) (b)

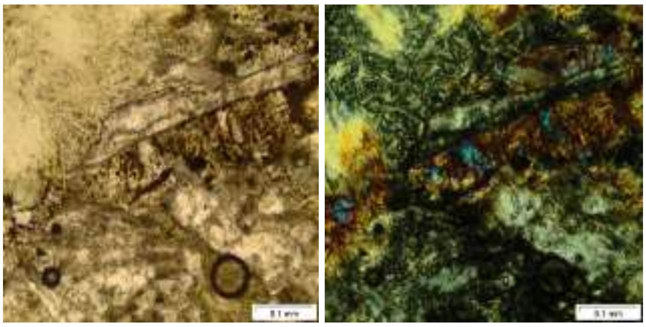

***Figure 12.** Sample 6 (A-348) under polarized light: (a) without analyzation; (b) with analyzation (magnified 100×)*

The rock is an olivine-rich igneous rock or altered clinopyroxene, characterized by a poikilitic texture. Olivine is extensively serpentinized, forming antigorite, while the pyroxene has transformed into a fibrous mineral, possibly actinolite or anthophyllite. This alteration assemblage suggests a history of hydrothermal alteration, possibly related to metamorphism or metasomatism. The presence of poikilitic texture indicates that the mineral grains are enclosed in larger crystals, indicating a complex crystallization history.

(a) (b)

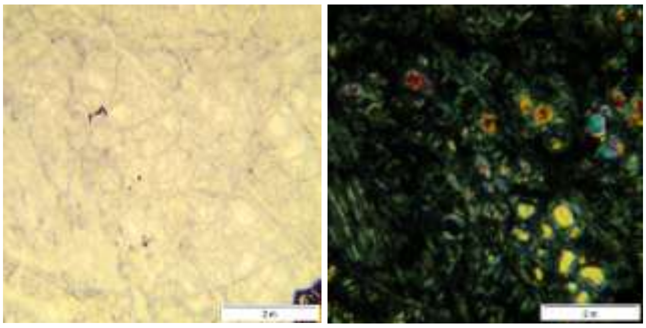

***Figure 13.** Sample 7 (A-348) under polarized light: (a) without analyzation; (b) with analyzation (magnified 100×)*

The ultrabasic rock is identified as harzburgite, consisting mainly of olivine and orthopyroxene, with lesser amounts of opaque minerals. Olivine is the dominant mineral, constituting approximately 90% of the rock, and is almost entirely serpentinized. Orthopyroxene is also present, but is almost completely altered. Within the orthopyroxene crystals, actinolite and talc minerals are observed, indicating extensive alteration. This mineralogical assemblage suggests a history of hydrothermal alteration, probably related to metamorphic processes, which transformed the original ultrabasic rock into a serpentinized harzburgite.

(a) (b)

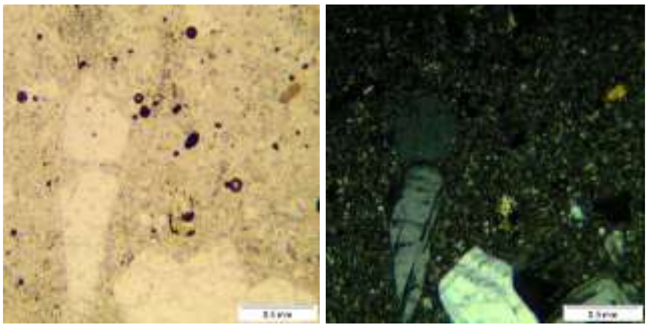

***Figure 14.** Sample 8 (A-348) under polarized light: (a) without analyzation; (b) with analyzation (magnified 100×)*

The rock is identified as quartz latite, characterized by phenocrystals of plagioclase and potassium feldspar, with relic of biotite and volcanic glass minerals. Quartz content is less than 10%. Secondary minerals include opaque minerals, sphene, and apatite. The presence of both plagioclase and potassium feldspar indicates an intermediate composition of volcanic rock. The occurrence of quartz, albeit in minor amounts, suggests the presence of silica-rich magma. This mineralogical assemblage suggests a volcanic origin followed by low-grade metamorphism.

(a) (b)

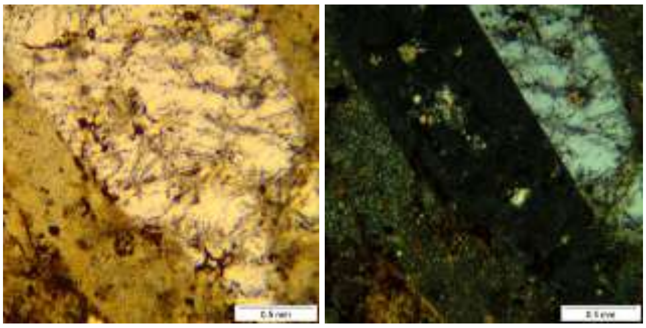

***Figure 15.** Sample 9 (A-348) under polarized light: (a) without analyzation; (b) with analyzation (magnified 100×)*

Volcanic rock with phenocrystals containing sericitized and potassium feldspars minerals are (mainly sanidine), colored minerals are (mainly amphibole) altered, and two or three quartz minerals. Secondary minerals contain many opaque minerals, apatite and some zircon. The rock is more like trachyte than quartz latite. The rock is altered, and the mineral content is sericitized and calcitized.

The highly altered volcanic rock is identified as trachyandesite (quartz latite), characterized by phenocrystals of potassium feldspars (orthoclase, sanidine) and sericitized plagioclase. Most minerals have been extensively altered to form sericite and epidote, while only two to three quartz crystals are observed, possibly formed at a later stage.

(a) (b)

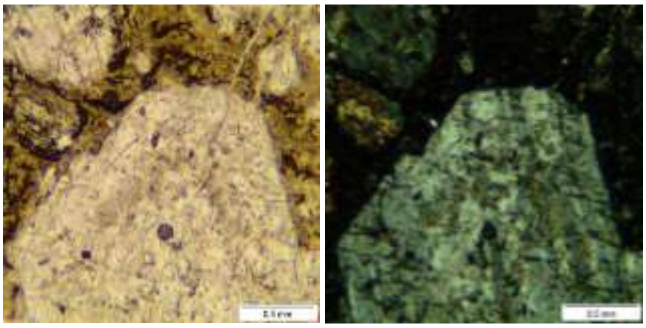

Figure 16. Sample 10 (A-348) under polarized light: (a) without analyzation; (b) with analyzation (magnified 100×)

Secondary minerals include opaque minerals and apatite. This mineralogical assemblage suggests a history of hydrothermal alteration, probably related to low-grade metamorphism that transformed the original volcanic rock into a highly altered trachy-andesite.

(a) (b)

Figure 17. Sample 11 (A-348) under polarized light: (a) without analyzation; (b) with analyzation (magnified 100×)

The rock is identified as a metasandstone characterized by higher content of quartz, feldspar and mica minerals. Despite the schistosity, the rock has not transformed into micaschist or quartzite. This indicates a low-grade metamorphic process, probably resulting from regional metamorphism. Metasandstone retains its original mineralogy, with quartz, feldspar, and mica remaining despite the development of schistosity. This suggests a metamorphic origin from a sandstone precursor.

(a) (b)

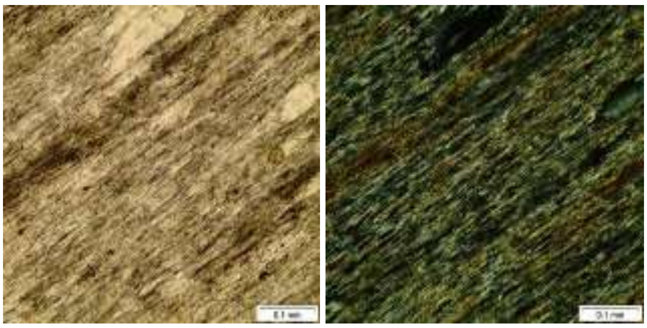

Figure 18. Sample 12 (A-348) under polarized light: (a) without analyzation; (b) with analyzation (magnified 100×)

The highly deformed rock is identified as ultramylonitic micaschist, characterized by intense deformation resulting in an ultramylonite structure. It contains microcrystals of quartz, mica, chlorite, and other minerals. The ultramylonitic texture indicates extremely ductile deformation, probably associated with intense tectonic forces such as shearing or faulting. The presence of mica, quartz, and chlorite suggests a metamorphic origin, with the original mineralogy preserved despite strong deformation.

(a) (b)

Figure 19. Sample 13 (A-348) under polarized light: (a) without analyzation; (b) with analyzation (magnified 100×)

The rock is identified as calc-schist, a metamorphic rock primarily composed of recrystallized calcite and other minerals. It exhibits a schistose texture with a foliation defined by the alignment of platy minerals such as mica, chlorite, and talc. The presence of calcite indicates a metamorphic origin from a precursor limestone or dolostone. Calc-schists often form in low-grade metamorphic environments, with the original sedimentary textures and structures partially or completely obliterated by metamorphic processes.

(a) (b)

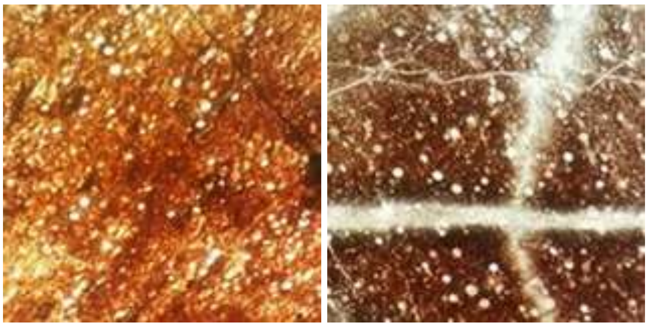

Figure 20. Sample 14 (A-348) under polarized light: (a) without analyzation; (b) with analyzation (magnified 100×)

The rock is identified as Middle Jurassic radiolarite (J2), characterized by its distinctive fine-grained texture and the presence of rare, thin fissures. Recrystallization is observed in some parts of the rock, indicating a history of metamorphism. Radiolarites are sedimentary rocks formed by the accumulation of microscopic skeletal remains of radiolarians, a type of marine plankton. The Middle Jurassic age (J2) suggests that these radiolarites were deposited during the Jurassic Period, approximately 174-163 million years ago, and then underwent metamorphism, resulting in recrystallization.

The rock is identified as brecciated radiolarite of Middle Jurassic (J2). It has a brecciated texture characterized by angular fragments of radiolarian-rich rock embedded in a fine-grained matrix.

(a) (b)

Figure 21. Sample 15 (A-348) under polarized light: (a) without analyzation; (b) with analyzation (magnified 100×)

This brecciation indicates that the rock has undergone fragmentation and subsequent cementation, possibly due to tectonic activity. The Middle Jurassic age (J2) indicates that these brecciated radiolarites were formed during the Jurassic Period, approximately 174-163 million years ago, in a marine environment rich in radiolarians.

(a) (b)

Figure 22. Sample 16 (A-348) under polarized light: (a) without analyzation; (b) with analyzation (magnified 100×)

Wackestone with sponge spicules is a sedimentary rock showcases a fine-grained texture interspersed with fossilized sponge spicules. These spicules, once part of ancient marine sponges, add a distinctive pattern to the rock composition. This formation offers insights into past marine ecosystems, highlighting the role of sponges in ancient seas.

(a) (b)

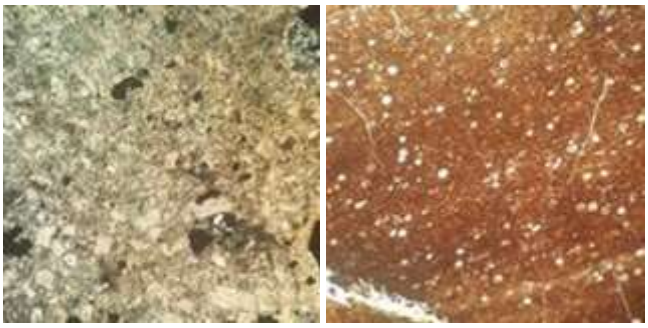

Figure 23. Sample 17 (A-348) under polarized light: (a) without analyzation; (b) with analyzation (magnified 100×)

This wackestone sample showcases a fine-grained texture peppered with fossilized radiolarians and occasional pelagic foraminifera. The intricate structures of radiolarians, microorganisms with intricate silica skeletons, provide a delicate beauty to the rock composition. Rare remnants of pelagic foraminifera are interspersed among them, further enriching the specimen with paleontological significance. Petrographic analysis of this sample provides insights into ancient marine environments, shedding light on past oceanic conditions and ecological dynamics. This wackestone serves as a valuable record of prehistoric marine life, offering a glimpse into the biodiversity of ancient seas.

(a) (b)

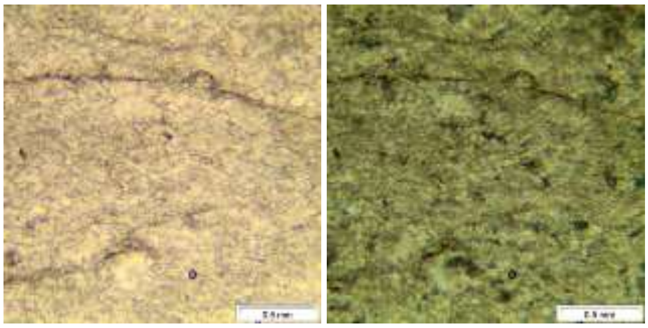

Figure 24. Sample 18 (A-348) under polarized light: (a) without analyzation; (b) with analyzation (magnified 100×)

This marble sample is a metamorphic rock primarily composed of recrystallized calcite or dolomite minerals, giving it a characteristic crystalline texture. Under petrographic examination, its granular structure reveals interlocking calcite grains formed through the metamorphism of limestone or dolostone. The presence of distinctive veining or foliation may indicate secondary mineralization processes. Petrographic analysis of marble provides valuable insights into its mineral composition, texture and the geological processes that led to its formation.

4. Conclusions

The geological survey of the Mitrovica region has provided new data on lithochronostratigraphy, structural deformation, metamorphism and other geological aspects. Utilizing petrographic microscope preparation, we have identified structural deformation, tectonics and metamorphism, particularly focusing on mineral resources in the area.

In the Mitrovica region, lithostratigraphic units include harzburgite, gabbro, diabase, metasandstone, sandstone, quartzite and grainstone with calcium (Aeolisaccus sp.; Bioclastic grainstone with dacycladal algae and small milliolides; Salpin-goporella sp.).

After petrographic analysis of magmatic rocks in the exploration area, we have identified gabbro, diabase and harzburgite, along with Pb-Zn mineralization, as there is a huge mining operation in Kosovo in this area (Trepça mining). These lithological units were confirmed using petrographic microscope preparation and with field observations of structural elements.

Tectonically, the area exhibits thrusting in three directions. The first thrust direction is characterized by inverse type of SW-NE direction, with a horizontal movement component. This tectonic deformation played a significant role in the structural evolution of the Mitrovica region, influencing the distribution and deformation of lithological units and mineralization.

Overall, an integrated approach involving petrographic analysis, field observations and structural analysis has provided valuable insights into the geological evolution of the Mitrovica region, shedding light on its tectonic history, magmatic activity and mineralization processes. These findings are crucial to understanding the geological framework and resource potential of the area, as well as the economic development of our country of Kosovo.

Author contributions

Conceptualization: ASH, IF; Data curation: ASH, IF; Investigation: ASH, IF; Methodology: ASH, IF; Project administration: IF; Resources: IF; Software: ASH; Supervision: IF; Validation: ASH; Visualization: ASH, IF; Writing – original draft: ASH; Writing – review & editing: ASH, IF. All authors have read and agreed to the published version of the manuscript.

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Conflicts of interests

The authors declare no conflict of interest.

Data availability statement

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

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Геологія та характеристики петрографічних порід у регіоні Трепча, Косово

А. Шала, І. Фейза

Мета. Ретельна ідентифікація типів гірських порід та характеру контакту між ними, що зустрічаються в регіоні Митровиця, шляхом докладного петрографічного опису всіх різновидів. Визначення переривчастості чи безперервності всіх міжформаційних кордонів, що має вирішальне значення для точного розмежування на місцевості та повного відображення на карті масштабу 1:25000.

Методика. Польові дослідження в регіоні Митровиця проводилися кілька місяців. Ідентифікація гірських порід включала детальний відбір проб та петрографічний аналіз, у тому числі підготовку шліфів магматичних порід. Метод включав підготовку зразків, взаємодію джерел поляризованого світла з мінералами та спостереження за оптичними властивостями. Ключовими властивостями, що спостерігаються, є подвійне променезаломлення, інтерференційні кольори, кути згасання, ідентифікація та аналіз.

Результати. Диференційовано різноманітні типи гірських порід на основі вивчення стратиграфічних одиниць і геологічного опису ділянок відслонень корисних копалин петрографічними й мікроскопічними методами, а також хімічних і геохімічних аналізів. Визначено, що регіон Митровиця включає наступні літостратиграфічні одиниці: гарцбургіт, габро, діабаз, метапісковик, пісковик, кварцит і грейнстоун з кальцієм (вид Aeolisaccus; біокластичний грейнстоун з дацикладними водоростями та дрібними міліолідами; вид Salpin-goporella).

Наукова новизна. Отримано вичерпний петрографічний опис мінерального складу, текстури та мінералізації гірських порід, що дало змогу оцінити потенціал території Митровиця, яка експлуатується.

Практична значимість. Підтверджена наявність на досліджуваній території свинцево-цинкової мінералізації, що є важливим фактом для розвитку гірничодобувного сектору та місцевої громади за умови дотримання заходів щодо охорони навколишнього середовища та відповідальних методів використання території.

Ключові слова: *зона Митровиці, мінералогічний склад, петрографічна мікроскопічна підготовка, тектоніка*

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