Faculty of Natural and Technical Sciences, University "Goce Delčev"-Štip, R. Macedonia with a grant from the CEI-ES Know How Programme organize

CEI
CENTRAL EUROPEAN INITIATIVE
CEI Know-how Exchange Programme (KEP)

1st INTERNATIONAL WORKSHOP ON THE PROJECT

Environmental Impact assessment of the Kozuf metallogenic district in southern Macedonia in relation to groundwater resources, surface waters, soils and socio-economic consequences (ENIGMA)

PROCEEDINGS

Edited by:
T. Serafimovski & B. Boev

Kavadarci, 10th October 2013

Faculty of Natural and Technical Sciences, University "Goce Delčev"-Štip, R. Macedonia with a grant from the CEI-ES Know How Programme organize

1st INTERNATIONAL WORKSHOP
ON THE PROJECT

Environmental Impact assessment of the Kozuf metallogenic district in southern Macedonia in relation to groundwater resources, surface waters, soils and socio-economic consequences (ENIGMA)

PROCEEDINGS

Edited by:
T. Serafimovski & B. Boev
Kavadarci, 10th October 2013

Organizing Committee:

Prof. D-r Todor Serafimovski, *President*
Faculty of Natural and Technical Sciences, University "Goce Delčev"-Štip, R. Macedonia

Prof. D-r Saša Mitrev
Rector of the University "Goce Delčev"-Štip, R. Macedonia

Prof. D-r Blažo Boev
Faculty of Natural and Technical Sciences, University "Goce Delčev"-Štip, R. Macedonia

D-r Josef Šimek
GIS-GEOINDUSTRY, s.r.o. ("GISGEO"), Czech Republic

Prof. D-r Violeta Stefanova
Faculty of Natural and Technical Sciences, University "Goce Delčev"-Štip, R. Macedonia

Doc. D-r Goran Tasev
Faculty of Natural and Technical Sciences, University "Goce Delčev"-Štip, R. Macedonia

M. Sc. Ivan Boev
Teaching Center-Kavadarci, University "Goce Delčev"-Štip, R. Macedonia

Scientific Committee:

Prof. D-r Todor Serafimovski, *President*
Faculty of Natural and Technical Sciences, University "Goce Delčev"-Štip, R. Macedonia

D-r Josef Šimek
GIS-GEOINDUSTRY, s.r.o. ("GISGEO"), Czech Republic

Prof. D-r Blažo Boev
Faculty of Natural and Technical Sciences, University "Goce Delčev"-Štip, R. Macedonia

Prof. D-r Nikola Dumurdžanov
Faculty of Natural and Technical Sciences, University "Goce Delčev"-Štip, R. Macedonia

Prof. D-r Trajče Stafilov
Institute of Chemistry, Faculty of Science, Sts. Cyril and Methodius University, R. Macedonia

Prof. D-r Orce Spasovski
Faculty of Natural and Technical Sciences, University "Goce Delčev"-Štip, R. Macedonia

Language: English for presentations and papers

THE GEOLOGY AND GEOTECTONIC SETTING OF THE KOZUF MOUNTAIN AREA (R. MACEDONIA)

Nikola Dumurdzanov[1], Gose Petrov[2], Violeta Stojanova[2]

[1] *V.S. Bato 75/3-18, 1 000 Skopje, R. of Macedonia, nikola_dumo@hotmail.com,*

[2] *Faculty of Natural and Technical Sciences, "Goce Delcev" University, Stip, R. of Macedonia,*

Abstract

The area of Kozuf Mountain widespread in the south of the Republic of Macedonia, in the central and the western part of Vardar zone. This area is a section of the mountain chain of E-W direction Kozuf - Nidze (Kajmakcalan)-Starkov Grob. It's a young mountain chain formed in Uppermost Miocene-Pliocene- Quaternary time, as a result of neotectonic vertical movements and volcanic activity. Many traces of the geological, tectonic, magmatic and metamorphic processes which occurred in the Vardar zone also are presented in area of Kozuf Mountain with relicts of rock complexes and tectonic structures of Proterozoic, Paleozoic, Mesozoic and Cenozoic age (fig.1).

Key words: Kozuf mountain area, geological structure, tectonics

Introduction

Kozuf mountainous area extends to about 130 km^2 in the southern part of the Republic of Macedonia and a small part goes to the south of the territory of the Republic of Greece. To the east is limited by the Vardar valley, to the west with mountain Kozjak and north with Tikvesh valley. Geomorphological belongs to mountain range Kozuf - Kozjak - Nidze (Kajmakachalan) - Starkov Grob with east - west extension, limited to the north with young Neogene depressions (ridges) Tikves - Mariovo and Pelagonian, and to the south with the ridges Gevgelia - Evzoni Almopias and Vegoritis (Meglen and ridge Ostrovski) in Greece. Kozuf Mountain is young and its formation begins in Upper Miocene, and maximal elevation was in Pliocene, as a result of neotectonic vertical elevations of terrains and strong volcanic activity that las from the Upper Miocene to the beginning of Quaternary.

Geology and tectonic

Kozuf area geotectonically belongs to the Vardar Zone and on its area are preserved many traces of polyphase geological tectonic development. Preserved are many relics of rock complexes from Prekambrian and Paleozoic age, of Mezozoic sediments and Jurrasic oceanic crust and from Kenozoic age. The principal lithological characteristics of the area and vicinity are shown in the interpreters for basic geological maps-sheets Kozuf (Pendzerkovski et al., 1970), Kavadarci (Hristov et al., 1973) and Vitoliste and Kajmakcalan (Dumurdzanov et al., 1981).

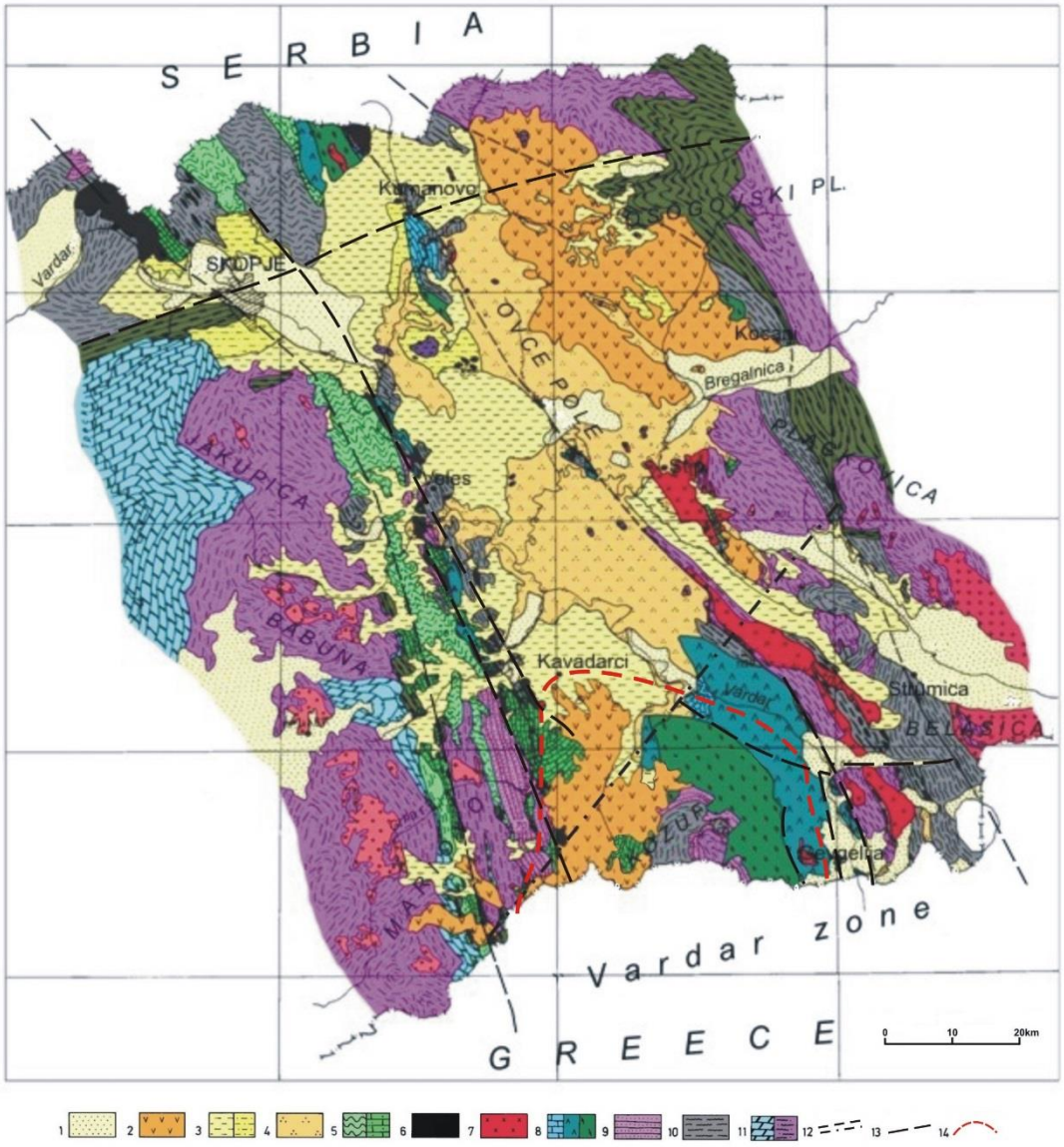

Fig. 1: Geological map of the Vardar zone

Legend: 1 – Pliocene - Quaternary deposits; 2 – Pyroclastic and volcanic rocks; 3 – Mio-Pliocene deposits; 4 – Eocene flysh; 5 – Albian-Cenomanian-Turonian deposits; 6 – Jurassic ultrabasic rocks; 7 – Jurassic granite; 8 – Jurassic ophiolite (gabbro, massive basalts and pillow lavas, flysh and limestones); 9 – Triassic deposits; 10 – Paleozoic low metamorphic rocks; 11 – Proterozoic; 12 – faulte and thrust, 13 – boundary of Vardar zone; 14 – approximate boundary of Kozuf area.

Lithological composition

PROTEROZOIC

The oldest rocks in the Kozuf area belong to Proterozoic complex in the tectonic block Mala Rupa (Fig. 1). The block is partially deformed brahisinkline and litostratigraphic can be fully correlated with the litostratigraphy of Pelagonian crystaline massiv (further Pelagon). In the structure, in the deepest parts are discovered biotite and porphiroblastic

gneisses, which to upper levels moves into muscovite gneisses and amphibole - biotite schists (upper zone of the Pelagon litostratigraphy), and they into micashistsi rich in albite. Over them are developed albite gneisses and cipollino marbles and on the top are dolomite and calcite marbles that belong to mixed and marble series of the Pelagon.

PALEOZOIC

Paleozoic is presented by the lithological zone of low metamorphic Lower Paleozoic rocks with thickness up to 1500 m. Upper level of the lithological zone is uncovered, in which are super - positional located: at the bottom are metaryolites, metatufts and quartzite, above are phylitic sericite - chlorite shale, which turn into carbonate shale and these into thicker mass of marbleized limestone and marble. The age of the complex is assumed to correlate with other phenomena of Paleozoic in Vardar zone.

MEZOZOIC

Mesozoic is represented by Triassic continental sediments, with Jurassic rocks of ocean type of earth's crust, and ultrabasic rocks and granitoides and Albian Cenomanian and Turronian sediments.

TRIASSIC

Triassic sediments are continental type and are presented with mass thick 500-600 m that transgressively lay above the Proterozoic and Paleozoic complex of rocks, and it is in tectonic position with Jurassic ophyolites. It begins with basal terrigene sediments (violet conglomerates, sandstones, clayey schists, quartz breccia) with thickness of about 100 - 150 m, that turn into mass of bank and massive calcite and dolomite limestone, locally marbleized with thickness up to 450 m.

JURASSIC

Since the formation of the Vardar Zone, in the early Paleozoic, on its area, took place a gradual process of thinning of continental crust and in the Lower Jurassic process is completed with fully melting and the formation of oceanic type of crust. According petrologic composition, chemical and geochemical characteristics of different lithological types, ophyolite crust in the Vardar zone is very similar to ophyolites from the crust of the Red Sea (Ivanov et al., 1987). From the later decomposed oceanic crust in the Vardar Zone, the largest relic is ophyolite massif Demir Kapija-Gevgelia with length and width 50x25 km, most of which belongs to the eastern regions of Kozuf Mt. The massif which generally has inverse to the southwest, sinking slightly toward NW, individual units in it have dip angle of 25^{o} toward SE. To the east through massif are addicted crystalline and Jurassic granites of range Serta-Plaus-Gradeski mountain and toward west, the massif is overlay through Paleozoic and Triassic and partly is covered with Pliocene - Quaternary pyroclastic material.

Ophiolites form the massif were first mentioned by Kossmat (1924), the petrographic data for some parts presents Tider (1939), and extensive knowledge obtained through Ba-

sic Geological Map and interpreters for sheets Kozuf (Pendzherkovski et al. 1970), Kavadarci (Hristov and et al.,1973) and Vitoliste and Kajmakcalan (Dumurdzhanov et al.,1981).

Detailed litostratigraphic, petrographic, chemical and geochemical examinations were made by Ivanov et al (1987) and Dumurdzanov et al (1990).

Magmatic level

Lithological zone of gabbro and associated plutonites, thick 4 - 5 km, composed of clinopyroxene gabbro with shifts in pyroxene - olivine gabbro and rare in troctolites, with local appearance of ultramafic cumulates (serpentinized dunites and verlites). Toward the upper levels of the zone, gabbro gradually turns into amphibolite gabbro, and uppermost dominated gabbro with locally turn into diorite and quartz - diorite. As vein differenciates occur gabbro - pegmatite, biotite - quartz aplite, albite - granite - porphyre and quartz - diorites. In all levels of the mass appear dykes of epidotized basalts.

Dyke sheeted complex with thickness of 200 - 300 m, and maximum to 500 m (river Konjska) is developed between the amphibole gabbro and lithological zone of massive basalts. It is represented by dykes of basalt, dolerite and gabbro composition.

Lithological zone of massive basalts is developed over the vein complex, with mass thick 2 km, composed of fine grained type of basalts, with ophite and intersertal structure and fully crystalized glassy mass, strongly altered, and in the upper levels strong spilitized.

Lithological zone of pillow basalts was continuously developed over the massive basalts. Today, locally is present and its thickness rich up to 1500 m. separate pillows, sometimes long to 2 m, present intensively spilitized basalts, with expressed albitization, amphibolization, epidotization and zeolitization, with mandolic structure.

Spilite - keratphyre lithological zone composed of spilite, keratophyre, quartz - keratophyre, rarely rhyolite and andesite. Spilite appears over the upmost levels of the pillow basalts.

Pelagic level

Spilite - chert lithological zone represents a gradual transition between magmatic and pelagic level. The massif is developed with 200 m thickness through spilite - keratophyre level, mostly composed of slate, alevrolites, conglomerates, sandstone, cherts - quartzite, carbonate sandstone with intraserial layers of spilites and rarely keratophyres.

Flysch lithological zone concordantly lies through spilite - chert formation and locally, lies directly through pillow lavas. The thick mass to about 300 m zone is built of breccia - conglomerates, sandstone, alevrolites, slate, marly limestone and rarely cherts and limestone olistolites who improperly shifting vertically and horizontally. Levels in the upper zone has flyschoidal to typical flysch character, where the right rhythms shifting sequence of layers of sandstone, alevrolites, slate and less marly limestone with confirmed upper Titonian fossils (Hristov et al., 1965).

Carbonate lithological zone represents the final phase in formation of the pelagic level of the Vardar oceanic crust. The 300 m thick zone concordantly lies over the flysch and it

is composed of clayey and marly slim plates of limestone with interstratification of slate and fine grained conglomerates, which in the upper levels move into bank limestone with intercalations of cherts and marls, and they into massive limestone (Hristov et al., 1965).

Ultrabasic rocks

Besides smaller occurrences of dunites and verlites as cumulates in gabbroidal mass in the ophyolite massif Demir kapija - Gevgelia in Kozuf area along deep faults and thrust structures appear larger tectonic placed masses and small bodies of strongly serpentinized dunites and harzburgite. Appearances of ultrabasic rocks are the most present in the western part of the area and further west, to peeled block Elen - Kozjak (Elen schupe, Kossmat, 1924), where the terrain is segmented into a number of shells in western inversion. Along these structures numerous bodies often deployed a chain. According to geological data, chemical and geochemical composition, these are tectonic ultrabasic rocks, flowing out of the earth's crust during the opening of the crust and later collision processes in the Vardar zone. From view of today's position, it can be concluded that massive tectonic imprint of ultrabasic rocks was during young Cimmerian compression (late Jurassic - beginning of Cretaceous) which conditioned strongly folding and peeling of the older complexes and protrusion of ultrabasic rocks and after a hiatus has followed.

Ultrabasic rocks exposed to continental conditions were affected with processes of laterization from which later, with the Albian Cenomanian - Turonian transgerssion were created deposits of redeposited Ni, Co, Fe ores (Rzanovo - Nikodin - Groot). The second very important phase is tectonic intrusion and placement of ultrabasic rocks that were taken out during the Subhercynian compression (before Senonian) and such masses are carriers of chromium ore. Later, appeared new phases of displacement of ultrabasic rocks and their placement in other lithological media, along deep faults and peels (connected with Laramie and Pyrenean orogenic phase - collision).

Jurassic granites

Jurrasic granites are represented with one smaller mass of granite - monzonite near the village Gurnicet, and other smaller bodies that intruded in the gabbros and diabases of Demir Kapija - Gevgelija. Gurnicet granite - monzonite intrusion toward south, in Greece, sterch into larger mass (Phanos granites) for which is determined apsolute age of 156 ± 6 Ma (Borsi et al, 1966, Spray et al 1984). Pearce et al (1984) granitoide rocks in the Vardar zone considered as type of collision granites.

Cretaceous

Cretaceous sediments occur in the western areas of the mountain Kozuf, where most of the mass is covered with pyroclastic and effusive material from Neogene volcanism, and toward east, is in tectonic contact with Paleozoic with deep fault along which occur tectonic ultrabasic rocks. More masses of Cretaceous sediments occur in the western peripheral areas, moving into areas of Kozjak mountain, where are pulled on the

Triassic sediments along shells marked by tectonic ultrabasic rocks and on the east side are covered with Neogene pyroclastic material. Cretaceous sedimentary mass, thick to about 2000 m has brachi - syncline form with axis orientation N - S. It is built from three superpozitional lithological zones: lithological zone of basal conglomerates and sandstone with intercalary of slate and limestone.

CENOZOIC

Cenozoic epoch in the Kozuf area is presented with Paleogenic sea sediments, Miocene - Pliocene sediments and volcanic rocks and Quaternary sediments.

Paleogene

Paleogene sediments occur on the northwest side of the Kozuf area, near Demir Kapija and toward south. Those are peripheral parts of Tikves Paleogene basin where over Jurrasic ophyolites transgressively lay basal conglomerates, and on some places where the contact is tectonic, Paleogene flysch is directly over the Jurassic ophyiolites. Tikves basin is thick over 3000 m and stratigraphic column is presented with several super - positional terrigenous lithological zones which can be generalized in three main: lithological zone of basal conglomerates, sandstones and slate; lower flysch zone of coarse terrigenous material and upper fpysch zone which end can be presented with marly limestone and limestone. The rich fossil fauna of clams, snails, corals, numulites, urchins, mikroforaminifers etc. is determined upper Eocene age of the sediments.

Neogene

Neogene sediments

On the western and northwestern parts of the Kozuf area are developed Neogene freshwater sediments and products of Neogene intermediary to acid volcanism. Formation of these rocks is connected with neotectonic development of the terrains in the Vardar zone and wider. In these areas and in the whole central Balkan at the end of lower and the beginning of medium Miocene started stage of differential vertical movements when terrain were dislocated in subsided blocks (grabens) and rising blocks (horsts). From the horst were formed today's mountains and mountain massifs, and from the ridges were formed freshwater basins with accumulation of thick masses of terrigenous layers and coal seams. In the same time, in the Kozuf area and Mariovo (Nidze), at the end of Miocene and in Pliocene was activated strong volcanism.

According the lithostratigraphy, paleontological data, age of volcanism and tectonic studies, Dumurdzanov et al. (2004) determined poly - phase formation of Neogene - Quaternary basins in Macedonia and were separated five cycles: I cycle - Badenian - start of upper Sarmat, II cycle - upper Sarmat - meot, III cycle - upper Meot - Pontian (Turolien), IV cycle - Pliocene,V cycle - Pleistocene.

Every cycle presented phase of formation of new ridges and freshwater lakes with accumulation of sediments or extension of existing or recovering the lakes after previous hiatus.

Tikvesh graben begins its formation in the II cycle and there were accumulated freshwater sediments up to the beginning of Quaternary, and in the Upper Miocene and Pliocene was accumulated volcanic material. In the basin was accumulated 600 - 700 m thick Miocene - Pliocene series separated into three super - positional formations.

The lowest is composed with 3 units. The first (lowest) is unit of basal conglomerates-gravel, sands, alevrolites, brown clays and many colors clay. Medium unit is coal-bearing-marl, thick about 100 m and composed of grey clays, coal clay, coal layers, marl. In the coal layers are determined *Ilyocypris* and *Hungarocypris*, with probable upper Miocene age. Upper unit is composed of sands, alevrolites, alevrolite clays in which are determined *Hipparion mathewei, H. probscideum, H. verae* (Forsten&Garevski, 1989) of Turonian age.

The medium is volcanic - sedimentary, developed through upper Miocene unit. It is divided into levels of Miocene age with tuffites, layer of diatomite with fossils of *Aulacoseira italica (Ehr.) Sim and associated species Cocconeis, Pinnularia, Gomphonem, Navicula,* and type *Fragilaria nitida Herib* (Ognjanova-Rumenova et al., 2008). Over them are developed agglomerates, sands, then over them is calcareous tuffs with Pliocene *Planorbis corneus, Lymneus cf. stagnalis, Lymneus cf. (Gulinaria) treger, Bythinia tentaculata*. At the top again are developed agglomerates.

Upper formation is presented by breccia - conglomerates of volcanic material, agglomerates, tuffs, volcanic breccia and locally travertine of Pliocene - Pleistocene age.

Neogene volcanites

Kozuf mountain area is characterized by volcanic origin of the highest areas. The wide expanse of volcanic material occurs in composition from andesite, latites and quartz - latites, with rare occurrences of basalts in the form of sub - volcanic bodies and intrusion masses, building the highest peaks of the mountain (Zelenbreg 2166, Dudica, Momina Cuka etc.) and with pyroclastic material. According occurrences of fossil diatomite (Ognjanova-Rumenova N., Dumurdzanov N., 2008) in sedimentary sequences in the upper Miocene of Tikves basin, volcanism stated in uppermost Miocene. According rich Pliocene diatomite fossil flora in Mariovo basin and Vitacevo, volcanism was very active in the Pliocene. Ognjanova - Rumenova N., Dumurdzanov N., (2008) in Mariovo confirmed that above the thick mass (over 100 m) of gravels and sands of Pliocene age is developed horizon in which exchange layers of tuffs, psammites and diatomite with the most characteristic type *Tertiarius macedonicus* and massive occurences of *Stephanodiscus careonensis* Ehr and *S. carconensis var. pussilus* Grun., *Fragelaria – F. brevistratiata* Grun., *F. construens* (Exp.) Grun., and *Epithemia turgida (*Ehr.) Kutz that presents diatomite flora that confirm Pliocene age of diatomite and volcanic material on these terrains.

The same is confirmed with isotope ages with K/Ar method of Kolios et al.,1980, from 4 ± 0,2 - 1.8 Ma for volcanites of Kajmakcalan and Boev, 1988, from 6.50 ± 2 - 1.8 ± 0.1 Ma for Kozuf's volcanites.

Quarternary

In the Kozuf area, Quaternary formations are represented by pyroclastic material developed in the western areas of the mountain in mass of which is given Pliocene-Pleistocene age. Also, quite prevalent are proluvial sediments on the eastern slopes of the mountain, toward Gevgelija valley and alluvial sediments in the valley of the Vardar.

Geotectonic position and structure of the Kozuf Mountain area

Kozuf mountain area is located in the southern central and western parts of the Vardar zone. As a tectonic unit, Vardar zone is separated and presented on the "Geological - tectonic map of Dinarides and a part of Karpato - Balkanides" from F. Kossmat (1924). In the further period the zone was studied from many scientists - geologists, Dimitrijevic M. (1974), Karamata S. (1974), Arsovski et al (1984), Ivanov T. et al (1987), Dumurdzanov et al. (1990), which from the tectonic point of view gave plate tectonic models according which Vardar zone is considered as a rift zone, subduction zone, zone of faulting, peeling and overlapping and zone of tectonic mélange. The same today is considered as ophyolitic structure (rift), or geotectonic unit that separates Dinarides on the west, from Serbian-Macedonian massif, Rodopes and karpato - Balkanides from east. With length over 1000 km is assumed that it begins north of Belgrade, where stretches toward south formation of throughs Serbia and Central Macedonia, where its width of 60-80 km are clearly marked, and then proceeds to Solun Gulf where bent eastward and becomes ophyolitic Izmir-Ankara zone.

Vardar zone as lineament commenced to form since the beginning of old Paleozoic. Its formation starts with breaking of Precambrian crystalline crust and formation of Pelagonian central massif and smaller blocks entering the Vardar Zone and Marina Rupa and Elen Kozjak shell and Serbo-Macedonian central massif and smaller blocks Buchimski and Serta-Plaush-Gradeski mountains to the east. Between the two central ridges began to create sinked space in which started to intrude the Tetis Sea and where throughout Paleozoic was done accumulation of terrigenous -carbonate sediments with products of basic and acidic volcanism. Old Paleozoic geosyncline space finished with tectonic and metamorphic processes and then performed hiatus with erosion of the land, which lasted until the early Triassic.

In the Triassic period in central and partly western part of the Vardar zone is formed trough in which was accumulated to about 550-600 m thick mass of continental sediments of reddish and purple basal conglomerates, sandstones and slate and dolomite and calcite limestone with intercalary of cherts.

In the Jurassic, in the radically altered geological conditions of the area of the Vardar Zone, formed rift zone, i.e. narrow ocean like the Red Sea, with a complete development of ocean crust.

After closing the oceanic crust, the upper Jurassic - Lower Cretaceous, with subduction, generally eastward under the continental crust of the Serbian - Macedonian massif, in the further development of the area of the zone and beyond, have changed several times the mode of compression with mode of extension, with the same orientation east - west. Such a direction of compression and extension conditioned and orientation of Paleozoic, Mesozoic and Paleogene rock complexes, faults and faulting blocks and axes of the folded structures in dinar direction NNW - SSE to N - S.

In the late Jurassic - Lower Cretaceous, subduction ends with young Cimmerian compression (collision phase) accompanied by strong folding, faulting, breaking, peeling and dynamo - metamorphic changes of Paleozoic and Triassic complex and Jurassic oceanic crust. Compression caused protrusion of tectonic ultrabasic masses stored in the

form of continuous belt or a chain deployed lens - shaped bodies along deep faults and regional peels.

During the regime of extension in Albian Cenomanian - Turonian and Senonian period in Vardar zone formed astounded troughs where was performed mainly marine accumulation of coarser terrigenous factions, locally and in the form of wild flysch, rarely carbonates, and in Senonian accumulated complex mainly with flysch character.

In Paleocene started a new period of compression (collision), expressed with very strong Laramie orogeny phase, with which were covered terrains out of the Vardar Zone. This phase is manifested by strong folding of Cretaceous sediment mass and refolding of older complexes, faulting and peeling of all complexes, and protrusion of ultrabasic rocks along regional ruptures.

After the Paleocene compression and hiatus in upper Eocene again started phase of extension and formation of трогови in direction north - south along which comes sea transgression on the terrain of the Vardar zone and Serbian - Macedonian massif, where was deposited terrigenous material in form of flyschoid and flysch.

During the upper Oligocene and lower Miocene, in compression mode, took place Pyrenean phase and phase of Sava. And during these phases is retained segmentation direction of the field and its peeling and overlaping toward WSW. At the same time in this period is activated and strong intermediate volcanism, particularly pronounced in the border of the Vardar Zone with Serbian - Macedonian massif and within the massif.

Neotectonic development

After compression in the phase of Sava and flattening the terrains in the lower Miocene, at the end of lower Miocene - beginning of middle Miocene in strong extension, started a period of intense neotectonic differential movements that caught the Balkan Peninsula. The result was segmentation of terrain blocks of rise, from which with the further movements occurred today's mountains, and the subsidence of blocks (grabens) which become freshwater sedimentation basins of Neogene and Quaternary sediments. With these processes have been intensified existing volcanism (Eastern Macedonia) and Kozuf -Kajmakcalan area was activated a new volcanic activity.

The larger part of the processes of the geotectonic development of the Vardar zone left traces in the internal structure of the Kozuf mountain area.

Neotectonic stage is very important in formation of the present shape and the relief of the Kozuf area. Namely, in the upper Miocene commenced creating of the grabens Tikvesh, Mariovo, Pelagonian north of the area, and on the south (in Greece) the grabens Gevgelija – Evzoni, Almopias and Vegoritis. Between two grabens systems was formed elevated block (horst) in which as a chain are placed, from east to west, mountains Kozuf - Kozjak - Nidze - Starkov Grob. The tendency of rise continued until the present day, and rising and shaping the highest relief of Kozuf area was assisted by volcanic activity initiated at the end of the upper Miocene, and mainly took place in the Pliocene and lasted until the beginning of the Quarter.

References

Boev B., 1988: Petrologic, geochemical and volcanologic characteristics of volcanic rocks of the Kozuf Mountain. Doctor theses, RGF Stip.

Bebien J. and Gagny C., 1980: Differencition des magmas ophiolites. L'exempledu cortegede de Guevgueli. In: A. Panayiotou (Ed.), Ophiolites, Proc. Int. Ophiolite Symp. Cyprus 1979, p. 351-359.

Borsi S., Ferrara G., Mercier J., 1966: Mesures d'age par la methode Rb/Sr des des granites filonien de Kapathodor. Referati VI Savetovanja geologa SFRJ, deo II, p. 5 Ohrid.

Dimitrijevic M., 1974: The Dinarides: A model based on the global tectonics. Metallogeny and concepts of the geotectonic development of Yugoslavia, Belgrade, p. 147-178.

Dumurdzanov N., Hristov S., Ivanova V., Pavlovski B., 1981: Explanatory note of the General Geological Map of SFRJ, Sheet Vitoliste and Kajmakcalan, scale 1:00 000. Skopje, R.Macedonia.

Dumurdzanov N., Petrov G., 1992: Lithostratigraphic characteristics of the ophiolite complex Demir Kapija – Gevgelija (Macedonia). Geologica Macedonica, T6, No 1, pp. 49-60.

Dumurdzanov N., Serafimovski T., Burchfiel B.C., 2004: Evolution of the Neogene-Pleistoc. Basins of Macedonia. Geological Soc. of America, DMC001, p.1-XX.

Dumurdzanov N., Serafimovski T., Burchfiel B.C., 2005: Cenozoic tectonics of Macedonia and its relation to the South Balkan extensional regime. Geosphere, August 2005, v.1. no.1, p.1-22. Geol. Society of America. N.1, 49-60, Stip.

Hristov S., Karajovanovic M., Strackov M., 1973 : Explanatory note of the General Geolog. Map of SFRJ. Sheet Kavadarci, scale 1:100 000. Skopje, R. Macedonia.

Ivanov T., Misar Z., Bowes D.R., Dudek A., Dumurdzanov N., Jaros J., Jelinek E., Pacesova M., 1987: The Demir Kapija-Gevgelija ophiolite massif. Macedonia, Yugos. Ofioliti, 1987, Bologna, Italia.

Karamata S., 1974: The geological evolution of the area of Yugoslavia: The nature and movements of plates and importance of these properties and processes for matallogeny. Metallogeny and concepts of the geotectonic development of Yugoslavia, Belgrade, p.109-118.

Kolios N., Inocenti F., Maneti P., Peccerillo, Giuliani O., 1980: The Pliocene volcanism of the Voras Mts.

Kossmat F., 1924: Geologie der zentralen Balkan Halbinsel. Die Kriegschauplatze 1914-19. Geologisch dargestel. Berlin.

Ognjanova-Rumenova N., Dumurdzanov N., 2008: Biostratigraphy and paleoecology of the sweet water deposites of Macedonia on the bases of the Neogene Diatoms. The I Geological Congress of R. of Macedonia. P. 5-20, Ohrid.

Pendzerkovski J., Rakicevic T., Ivanovski T., Gjuzelkovski D., 1970: Explanatory note of the General Geological Map of SFRJ. Sheet Kozuf, scale 1:100 000. Skopje, R. Macedonia.

Petrov G., 2002: Geotectonic evolution of the Vardar Zone with special references to the Alpine orogeny. Doctor theses. RGF, Stip.

Spray J.G., Rex D.C. and Roddick J.C., 1984: Age constraints on the igneous and metamorph. Evolution of the Hellenic-Dinaric ophiolites. Spec. Publuc. Geol. Soc. London, 17.

Tajder M., 1939: Physiographic, genesis and composition of the various reprocessing stages of the gabbroide massif Dren-Boula, southern Serbia. Yugoslav Academy of Sciences and Arts, 263:1-54.