



**PANCARDI 2001**

**II.**  
**ABSTRACTS**



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# Petrology of the Demir Kapija – Gevgelija ophiolite complex

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The Demir Kapija – Gevgelija ophiolite complex is the largest part of the ancient Vardar oceanic crust preserved and situated in the central subzone of the Vardar zone. The complex has a NW-SE strike dipping towards northwest. In the territory of the Republic of Macedonia it is 50 km long and 25 km wide. The complex extends further south in the territory of neighbouring Greece where it is known as Gevgelli series. The northwest portion of the complex situated in Macedonia is covered by Upper Eocene – Pliocene layers of the Tikves valley. Towards southeast it is covered, in part, by Pliocene – Quaternary layers extending further south to the territory of northern Greece.

Investigations carried out so far on the geology, tectonics and lithostratigraphy of the ophiolite complex determined the following geologic structure:

- a formation of gabbros and accompanying plutons,
- a vein complex,
- a formation of massive basalts,
- a formation of spilitized pillow basalts,
- a spilite-keratophyre level,
- a basalt chert formation,
- a flysch formation
- a tinitic carbonate formation.

This paper deals particularly with the magmatic members of the complex.

## 1. A formation of gabbros and accompanying plutons

The gabbroic formation is composed predominantly of fine-grained and medium-grained clinopyroxene gabbros, rarely of olivine gabbros, pyroxene gabbros with olivine, troctolites and amphibole gabbros and quite rare are serpentized dunites and hornblende peridotites as well as dikes of basalts, gabbropegmatites, aplites, granite-porphry and quartzdiorites. This fan of various types of intrusive and vein type rocks is a result of the magmatic differentiation and the processes of amphibolitization.

Pyroxene gabbros are developed mainly in the western part of the gabbroic mass and are found as fine-grained and medium-grained varieties of gabbroic to subophitic composition. They consist mainly of plagioclases (labrador-bytownite) and clinopyroxene, rarely secondary amphibole, magnetite etc.

Cleavage and lamellar twinning were noticed in plagioclases. They are classified as bytownite based on their microscopic characteristics.

Pyroxenes occur as alioform grains with frequent occurrences of uralitization along the rims. Prismatic cleavage is rare. They are normal twins and seldom occur as individual crystals. Mutual inclusions of plagioclase and pyroxene minerals lead to the conclusion that the two minerals developed contemporaneously. A characteristic feature of this mineral assemblage is that it consists only of plagioclase and diallage with no visible olivine presence. In addition to the occurrence of quite fresh gabbro, metamorphose of minerals can be seen in the thin section as saussuritization. Uralitization is quite noticeable and advanced in the cases where primary pyroxene (diallage) is completely replaced by secondary uralite.

The amphiboles present in the rocks are a result of transformation of pyroxenes.

Olivine gabbros are developed mainly in the eastern part of the gabbroic mass. They are medium-grained dark green rocks made up of bytownite, olivine, seldom clinopyroxene as well as secondary hornblende and subordinate magnetite. Olivine content is variable and in some parts it is more abundant

so that gabbros grade into troctolites, whereas in the parts where olivine is less abundant gabbros grade into pyroxene gabbros with olivine.

Olivine gabbros are of typical gabbroic structures. They are medium-grained and based on their degree of idiomorphism they can be classified as panidiomorphic grained gabbros. Plagioclases occur as fairly fresh minerals and comprise the dominant rock mass. Plagioclase grains are isometric in shape.

Diallage occurs as alotriomorphic individual grains whose prismatic cleavage is not exhibited. Most commonly they are individual grains and are seldom found as normal twins. Olivine is fairly common mineral occurring in variable quantities in the rocks. In cases where it is more abundant olivine gabbro grades into troctolite. There are cases of increased content of pyroxene at the expense of olivine in which the rock changes to pyroxene gabbro.

Olivine grains occur as xenomorphic forms which are relatively fresh with occasional visible transgression to serpentine. Kelyphite rims with pleochroic reddish hypersthene or diallage (sometimes amphibole) can occasionally be seen around olivine grains. Olivine grains become smaller in size, the slightly greenish actinolite being more common. Fractured olivine gabbros sometimes contain biotite as well as brown or green hornblende.

The diallage and plagioclase relationship is an evidence of the contemporaneous crystallization that took place after olivine crystallization.

Troctolites occur as red grey rocks along with olivine gabbros as a typical troctolite structure. They are composed of olivine, subordinate serpentine, rarely clinopyroxene and magnetite. Troctolite occasionally grades into melanotroctolite.

Ultrabasics are present as tectonically forced masses along fault structures or occur along with troctolites. They are present as serpentized dunites, amphibolized peridotites as well as wehrlites. They are made up of hornblende, serpentine, actinolite, olivine and accessory magnetite.

Wehrlite is predominantly made up of serpentized olivine, serpentine, diallage with subordinate minerals such as amphibole, hypersthene, chlorite, plagioclase, uvarowite and large quantities of magnetite.

Due to serpentization of ferromagnesian minerals, the primary composition has almost been lost. The remaining unchanged minerals are linked in a typically serpentine net.

Olivine grains are characterized by alotriomorphic shapes (of 1 mm in size) being totally serpentized in numerous magnetite veins that comprise the prevailing rock mass. Thin rims made up of randomly arranged fine crystals of diallage and amphibole comprising specific cephalite structure are also noticeable.

The thin section exhibits round olivine grains related to the diallage that are either present or enclosed in it. The round shapes are related to the magmatic history. Due to their conspicuous transformation to serpentine the remaining fresh olivine grains are characterized by pronounced high relief.

Diallage is less common than olivine and occurs as large individual grains always enclosing olivine grains. Prismatic cleavage, which is characteristic of them, is slightly exhibited in pyroxene grains.

Rhombic pyroxene (hypersthene), which is in genetic relationship to diallage, can sometimes be found in association with it.

Primary amphibole is present as actinolite occurring as fan-like aggregates or small flakes round olivine grains.

Secondary fibrous amphibole always occurs along diallage rims. Chlorite is found as large accumulations and is characterized by indigo blue interference colour.

Plagioclases belonging to the bytownite group are either rare or absent in the rock. Uvarowite occurs as small green grains especially in amphibolic accumulations, but like amphiboles, chlorite and plagioclases it is less common in the rock.

Magnetite grains are included in olivine minerals being, no doubt, the product of primary magmatic crystallization, not the secondary which would develop due to olivine serpentization. In actual fact, the magnetite veinlets define the manner of later serpentization.

Amphibolic gabbro occurs due to the general process of amphibolization of pyroxene and olivine gabbros with clear tendency of increase in the process of amphibolization starting from the upper levels of the complex. Amphibolic gabbros are often heavily tectonized to fractured. They are composed of zonal plagioclases, their central parts being made up of basic bytownite and the rims being more acid and composed of andesine. Quartz occurs in heavily tectonized kinds where gabbros grade into quartzdiorite. In addition to plagioclases, the gabbros also contain amphibole (hornblende) as well as variable quantities of clinopyroxene, magnetite, sphene, quartz, biotite, epidote, zoisite and chlorite.

Vein rocks occur in different levels in the gabbroic mass. They are found as gabbropegmatites, basalts, aplites, granite porphyry and quartzdiorites. Aplites are composed of quartz, andesine, biotite and secondary epidote, zoisite, magnetite as well as accessory apatite and albite. Graniteporphyries

are made up of albite-oligoclase, quartz, magnetite, epidote, hornblende, chlorite and apatite, whereas gabbropegmatites are made up of labrador, clinopyroxene, hornblende, chlorite and epidote. Basalts are made up of labrador-andesine, clinopyroxene, epidote, chlorite, hornblende, clinozoisite, seldom calcite and sulphides.

A vein complex occurs in the contact parts of the gabbroic formation and the formation of massive basalts as a well developed 200 to 300 (maximum 500 ) meters zone made up of basalt-dolerite dikes and segmented gabbro masses. The mineralogical composition is similar to the massive basalts and gabbroic mass.

Massive basalts are found in the central and eastern portions of the ophiolite complex. They are present as fine-grained ophiolite and intersertal composition with occasional occurrences of entire recrystallization of the glass groundmass. They are altered rocks in which feldspars are heavily albitized. Basic plagioclases occur as relic kinds (labrador-bytownite), whereas albite- oligoclase-andesine are present as plagioclases. Femic minerals as found as augite, hornblende, secondary chlorite, epidote, magnetite, apatite.

Serpentinized pillow basalts occur uninterruptedly across the massive basalts. Pillow shapes of variable sizes, sometimes reaching 2 meters in size, are heavily spilitized basalts with pronounced albitization, amphibolitization, epidotization and zeolitization. They are of typical amygdaloidal structure made up of plagioclases (albite-oligoclase), augite, glass mass, amphiboles, chlorite, epidote, clacite, magnetite, zeolites and titanite.

Spilite-keratophyre level occurs in the top most portions of the formation of basaltic pillow lavas. It is present as a concentration of dikes and outpourings of keratophyre masses, quartzkeratophyres, rhyolites and seldom andesites which form keratophyre level together with spilitized basalts. These acid differentiates occur as pink to red, grey-green to grey-white rocks with micro porphyritic to porphyritic structure composed of altered feldspatic mass with relics of plagioclase (oligoclase-albite), K-feldspar, also chlorite, quartz, epidote, seldom crystals of hornblende, chloritized biotite and calcite.

All petrologic members in the ophiolite complex with relatively small degree of alteration have been investigated in terms of their chemistry. The present study of minerals included plagioclases, olivines, pyroxenes, amphiboles, serpentines, magnetites and chromite.

# Orogenic Tertiary magmatism on the Macedonian Dinarides: a Review

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Widespread Tertiary magmatism of orogenic signature developed on the Macedonian part of the Dinarides, essentially in the Serbo-Macedonian massif and in the Vardar zone (KARAMATA et al., 1992). Orogenic magmatic rocks (predominantly volcanic) are presented in 5 areas (from east to west): the Osogovo-Besna Kobila, Kratovo-Zletovo, Bučim-Borov Dol, Dojran and Kožuf. The age of the volcanic occurrences decreases in the same direction: from Priabonian-Early Oligocene (32.56-29.47 Ma) in the first area, Early Oligocene (from 33.5±0.5-0.6 to 29±2 Ma)-Miocene (16 Ma) in Kratovo-Zletovo, Early-Late Oligocene in Bučim-Borov Dol (from 29.0±3.0 to 24.7±2.0 Ma) to Late Miocene-Late Pliocene (from 6.5±0.2 to 1.8±0.1 Ma) in Kožuf.

The Osogovo-Besna Kobila area contains only acid volcanics (trachydacites to dacites), mainly as subvolcanic to hypabyssal dykes. They have collision-related characteristics with high Rb content. Latites, andesites to dacites and their pyroclastites (mainly ignimbrites) predominate in the Kratovo-Zletovo area (STOJANOV & SERAFIMOVSKI, 1990), but one monzonite pluton (30,5±0,5 Ma) also is found. Only the rocks of the shoshonite series (from latites to trachyrhyolites) are presented in Bučim-Borov Dol area. The latites and trachytes form necks, lava flows and subvolcanic bodies. Dojran area contains some small trachyte and rhyolites domes and dykes. The Kožuf area (BOEV et al., 1997) contains only one volcanic massif, composed of lavas and various types of pyroclastic rocks (mainly debris and pyroclastic flow). The volcanic rocks form two series: shoshonitic (high-Mg shoshonites, latites, high-Ti latites to trachytes, trachydacites) and andesitic (low-K andesites and high-Fe rhyolites). This area seems to be the most complex of the Macedonian Tertiary magmatic areas.

Magmatic rocks of the Kratovo-Zletovo, Bučim-Borov Dol and Kožuf areas have subduction-related volcanic arc signature with very low Nb content. Probably they are related to Late Tertiary Aegean subduction. The subduction process in the Miocene and Pliocene moved to the south and southwest probably due to the extension in the North Aegean region causing migration of volcanic activity in Macedonia in the same direction - from Kratovo-Zletovo to Kožuf area.

Important ore fields are located in all magmatic areas (except for Dojran area): mineralizations of Pb-Zn in Osogovo-Besna Kobila and in Kratovo-Zletovo, of Cu in Bučim-Borov Dol and of Au-Sb-As-Tl-Pb-Zn in Kožuf.

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# Petrological characteristics of the crossite schists of the Susica site, Inner Dinarides, the Republic of Macedonia

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The aim of this paper is to present the investigations carried out on the crossite schists of the Susica site located south-east of the town of Gostivar in the western part of the Republic of Macedonia (Fig. 1).

The Susica site is located in the north-eastern part of the Western Macedonian zone (WMZ) in the contact parts of the Pelagonian massif. According to the geotectonic regional setting the Western Macedonian zone is distinguished as a separate geotectonic zone within the Inner Dinarides (ARSOVSKI, 1996).

The Western Macedonian zone is made up mainly of Early Paleozoic metamorphic rocks and Late Paleozoic orogene granitoids with rare occurrence of Mesozoic rocks present as terrigenous and carbonate sediments and Triassic, Jurassic and Cretaceous magmatites as well as Neogene-Quaternary sediments (DUMURDJANOV, 1987-1988).

The wider vicinity of the Susica site is made up of Paleozoic metamorphic rocks, Mesozoic sediments and igneous rocks, Tertiary and Quaternary sedimentary rocks.

The Paleozoic metamorphic rocks are present as sericite-quartz schists, carbonate schists and marbleised limestones, metadiabases, carbonate and various albitised (mainly) greenschists, quartzite grey-white marbles, dolomite marbles, phyllitoids, graphite-quartz-sericite schists, quartz-muscovite schists and metasandstones. Crossite schist occur in the series of metadiabases, carbonate and various albitised, mainly, greenschists.

Crossite schists are fine-grained rocks of grey to slightly greenish-grey colour. Their schistose texture is poorly pronounced. Their structure is porphyroblastic - lepidoblastic. They are made up of small laminated aggregates and individual sheets of 50 to 55% white mica (phengite) and of 45 to 50% acicular elongated crystals of alkali amphibole (crossite) that lie as porphyroblasts in the phengite ground mass. Quartz also occurs in individual grains.

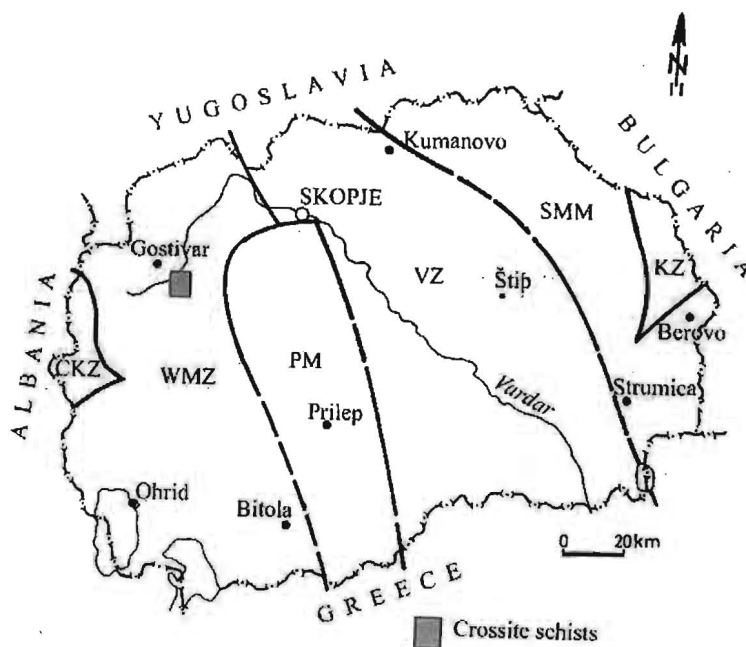


Fig. 1. Geotectonic map of the Republic of Macedonia and the position of the crossite schists. (ARSOVSKI, 1996). WMZ - Western Macedonian zone, PM - Pelagonian massif, VZ - Vardar zone, SMM - Serbo-Macedonian massif, CKZ - Cukali - Krasta zone, KZ - Kraistide zone



According to the classification of (LEAKE, 1978) alkali amphiboles are crossite in composition. The potassium white mica belongs to the muscovite-celadonite series called phengite (GREASER & NIGGLI, 1967).

Chemical analyses of macro and some microelements indicate that the protolith of crossite schists originates from trachyandesites, which contaminated with some microelements from the continental crusts during intrusion into the earth's crust.

P-T conditions of metamorphism were determined based on the chemical composition of crossite and phengite as major metamorphic minerals. The degree of metamorphism indicates that this mineral association formed during the major metamorphic phase and corresponds to the facies of blue schists. The P of 7-9 Kb and T of 400-420°C obtained are close to those that correspond to the subfacies of epidote blueschists (EVANS, 1987, 1989, 1990), or high T segment of the facies of blueschists.

The spatial distribution of the crossite schists in the contact parts between the Western Macedonian zone and the Pelagonian massif or the contact between the two large geotectonic units indicates that they originate from the areas of collision compression at the boundary between these geostructural units.

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