FACULTY OF MINING AND GEOLOGY ŠTIP

SYMPOSIUM - ANNUAL MEETING

PROCEEDING

MAGMATISM, METAMORPHISM AND METALLOGENY OF THE VARDAR ZONE AND SERBO-MACEDONIAN MASSIF

PLATE TECTONIC ASPECTS OF ALPINE METALLOGENY IN THE CARPATHO-BALKAN REGION

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Alpine Plutono-Magmatism and Metamorphism in the South-Eastern Parts of the Vardar Zone and the Serbo-Macedonian Massif

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Abstract

Intense magmatic activity and high temperature metamorphism took place in the subduction zone of the ophiolite complex in the south-eastern parts of the Vardar zone beneath the continental crust of the Serbo-Macedonian massif in the territory of the Republic of Macedonia and northern Greece to Chalkidiki during the Alpine period.

The zone is characterized by charriage relationships of north-east dipping of formations present as Paleozoic, Mesozoic and Upper Eocene rocks. The presence of a diabase cherts formation of regional strike determined between Skopska Crna Gora and Chakidiki in the eastern parts of the Vardar zone is important.

The presence of regional high temperature metamorphism, particularly manifested south-southeast of the town of Stip was determined. Uplift of blocks and discovery of the Stip granites (plutonic bodies) developed by melting of rocks of the earth's crust less than 10 km in depth with halos of medium to high temperature migmatites and in low pressure conditions. To the south the zone extends over Mount Gradeski - Plaus and via Valandovo and Bogdanci continues further to the territory of Greece to the Peonias zone. The zone is tens of kilometers wide.

Geologic - Structural Data

The Serbo-Macedonian massif is a metamorphic complex composed of granitoid intrusions. The rocks were affected by regional dynamo metamorphism mostly of Barovian type, local contact metamorphic alteration caused by later granite intrusions along some tectonic structures. From north -east to south-west it overthrusts a Paleozoic meta volcano-sedimentary series that can be seen on the Strumica - Dojran strike length where a series of metarhyolites and metapyroclasts tectonically overlies Paleozoic rocks of north-east dip. The tectonic border is of regional north-western strike towards Strumica - Radovis as well as north-west (Fig. 1).

The Dojran Paleozoic series tectonically overlies the low metamorphosed Jurassic volcanogenic sedimentary series of north-west strike and north-east dip. Weakly metamorphosed basic rocks of serpentinites, gabbros and diabases can be found along the tectonic border between the Ravrov mine, the village of Sobri - Dub close to the border with Greece.

All geological units mentioned are separated by charriage parallel structures of north-west strike and north-east dip, or south-west vergence. They tectonically overthrust the ophiolite structure over a narrow zone of Paleogene flysch sediments as narrow trench of north-west strike indicating that the charriage structures developed during post Upper Eocene period. The south-west border of flysch sediments transgressively overlies a ten kilometers wide zone of metamorphites and magmatites of north-west - south-east strike via the villages Stojakovo - Bodanci and Valandovo.

The metamorphic rocks in the zone are of Abakuma type metamorphism developed in medium to high temperature and low pressure conditions.

Magmatic intrusions into the metamorphic complex are of polyphase development and are related to the Alpine tectonic movements. They are composed of monzonite-diorites, granodiorites-quartz-monzonites and granosyenites and leucocratic granites as well as dikes and load magmatic rocks such as diabases, keratophyre-quartz-keratophyre and rhyolites.

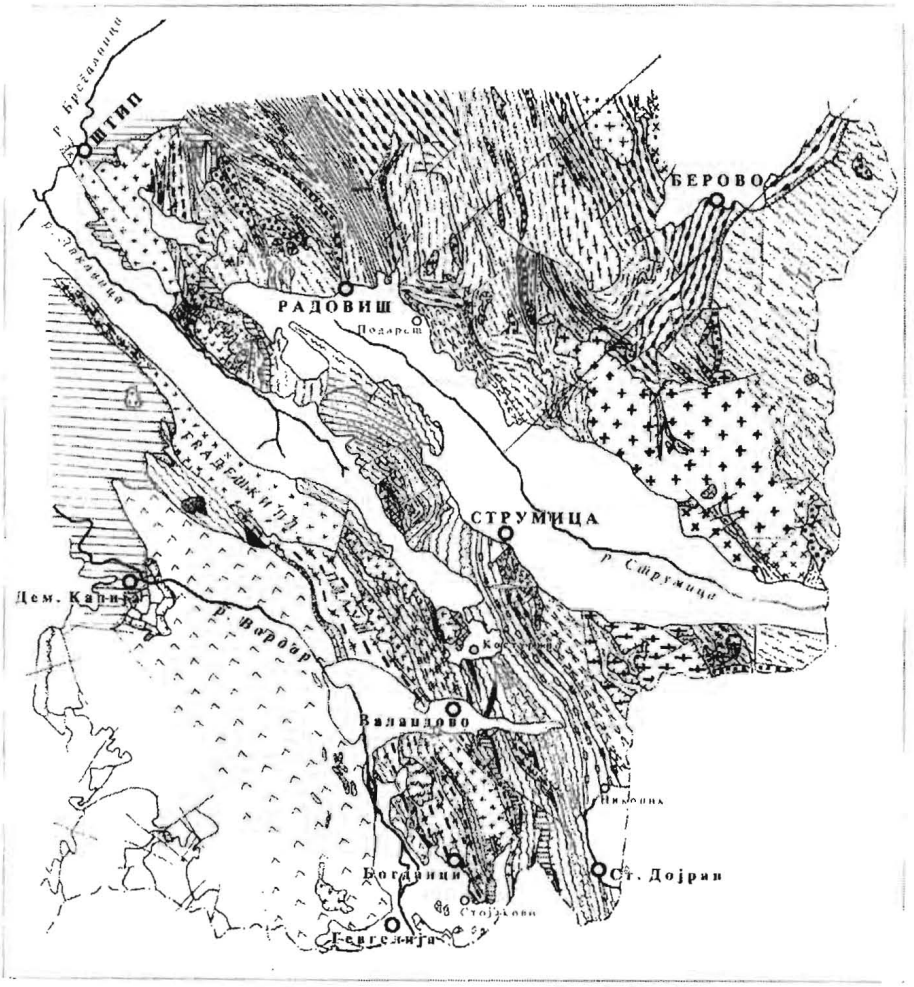
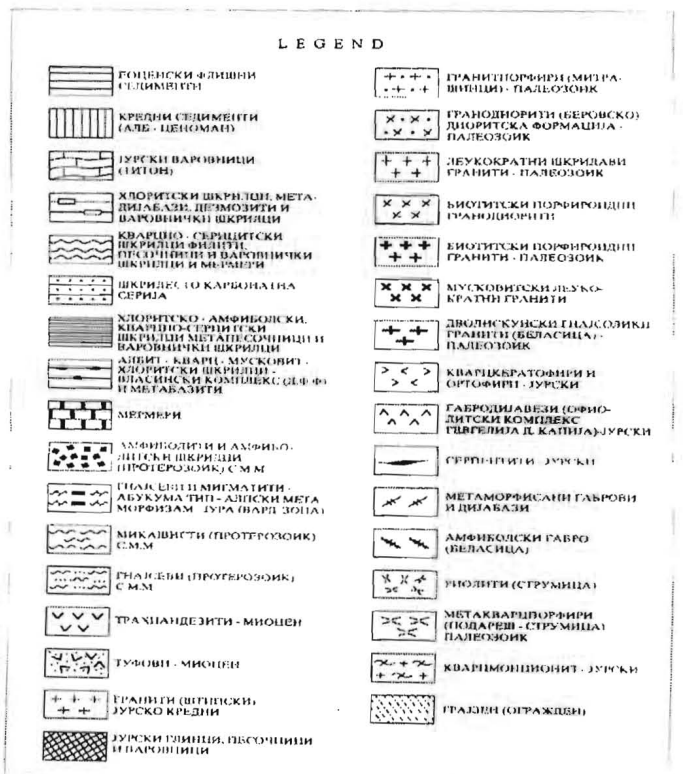


Fig. 1. Part of basic geological map of Republic of Macedonia



The south-west border of the metamorphic complex is tectonic with the Gevgelija - Demir Kapija ophiolite complex.

The south-east parts of the Vardar zone, between Lake Dojran and Gevgelija extends to north-west - southeast. It extends to Chalkidiki in northern Greece known as Peonias or Circum - Rodope (Perirodope). It continues uninterrupted to Stip in north-west, buries further on beneath Eocene sediments and the Zletovo-Kratovo volcanic complex and appears further on in the eastern slopes of Skopska Crna Gora between the villages of Matejce and Lojane.

The zone is characterized by charriage structure with parallel ophiolite belts (serpentinites) as narrow elongated zones of NW - SE extension and north-east dip. The presence of diabase chert formation is determined in the zone.

Complex of Metamorphic Rocks

Abakuma type metamorphic rocks are determined in several places in the zone described, particularly south of Stip, where vertical movements uncovered deeper portions of the crust in which granitic magma (Stip granites, table 1) formed by total or partial melting of rocks. This resulted in development of migmatites/metamorphic rocks in medium to high temperature and relatively low pressure conditions of regional scale. They are encountered south-east of Stip within the Stip granite massif, in the bordering parts with the Bucim block near the village of Sasavarlija, determined by Dumurdzanov N. as sillimanite-cordierite gneisses. A belt of contact metamorphic rocks is traced to the River Madenska and south-east of the river course.

Metamorphic rocks of this type are discovered in a 20 km wide and 7 km long area between Valandovo, near the villages of Bogranci and Stojakovo to the Gevgelija - Demir Kapija ophiolite complex.

Most of the rocks of this metamorphic complex originate from pelitic clayey sedimentary rocks, silstone and psamites, and zones of rocks of porphyroblastic texture (most likely gneiss-granites) can also be found.

They metamorphosed in medium temperatures of 600^0 C and pressures of 4 kb conditions in shallow parts of the earth`s crust. Cordieritic-sillimanite schists, gneisses as well as pyroxene-amphibolitic schists were formed. In places where carbonaceous rocks were present they transformed into marbles of high temperature metamorphic minerals such as olivine and pyroxene, garnets, wallostonite, vesuvianite, scapolite etc.

Table 1: Chemical composition of individual types of granitoids of the vicinity of Stip

	8	9	9a	St-2	G-1	G-2	G-3
SiO2	68.70	67.30	68.60	70.80	68.80	68.40	68.90
TiO2	0.33	0.36	0.36	0.33	0.72	0.68	0.79
Al2O3	15.15	15.35	14.82	14.43	14.00	14.60	14.40
Fe2O3	4.20	4.56	4.05	3.29	1.20	0.90	1.40
FeO					3.80	2.50	2.20
MnO	0.07	0.08	0.07	0.06	0.25	0.24	0.27
MgO	1.91	1.47	1.57	1.05	1.80	1.80	2.20
CaO	1.49	1.22	1.58	1.23	1.90	2.20	2.00
Na2O	3.46	5.06	4.32	4.07	2.30	2.50	2.10
K2O	3.35	2.98	2.47	3.31	3.00	3.60	3.10
P2O5	0.09	0.10	0.10	0.06	0.21	0.23	0.20
H2O	0.14	0.21	0.14	0.20	2.10	1.90	2.70
LOI	0.84	1.05	2.08	1.16			

Granitoid formation

The rocks of this formation are composed of elongated magmatic bodies of NNW - SSE strike, along fault ruptures particularly along the east margin of the Vardar zone (Lojane - Stip - Serta - Gradeska Planina - Plaus - Furka), seldom in the Vardar zone itself (Gradec - Grunicet). These magmatic bodies are forced into the Precambrian complex, the rocks of the Veles series of Paleozoic as well as the Mesozoic volcanogene sedimentary formation and the Dren granodiabase massif.

The formation is composed of component parts such as monzonitic granites with transitions into granodiorites or granites.

The shorter granitic phase which is characterized by intrusions into old granites is present as leucocratic granites. Generally speaking, though the mineralogical composition and chemistry are similar, the most acidic varieties tend to occur more to the south (poorer in biotite and richer in quartz). Locally, due to assimilation of surrounding rocks, granodiorites of the formation grade into dioritic or syenitic varieties (e.g. near Lojane and Stip) or into granodiorites with occurrence of hornblende.

The mineralogical composition of the granitoids is uniform: quartz, K-feldspar (orthocalse, seldom microcline), plagioclases of some 25-35 % anorthite or albite in leucocratic varieties), biotite and seldom muscovite. Accessory component parts are rare (fig. 2).

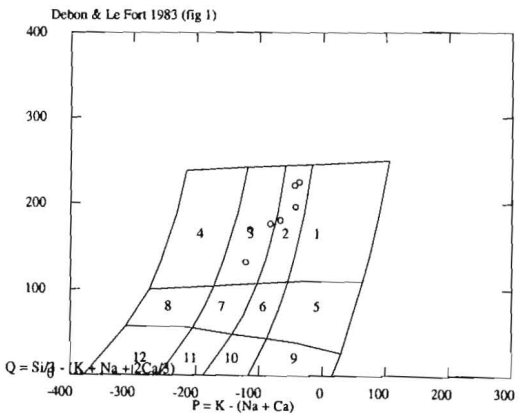


Fig. 2 Classification of granitoid rocks of the vicinity of Stip

The chemistry of these (unaltered with assimilation granitoids) consists of granites to granodiorites with prevalence of potassium over sodium and low calcium content (from ppm rarely to 3%).

Internal differentiation, besides changes due to assimilation of surrounding rocks, was very poor. Pegmatites and aplites, as accompanying rocks, are very rare.

Quartzmonzonitic, granodioritic and granitic rocks in the formation are intensely cataclysed, commonly as magmatic sericitized and post-magmatic clayey altered (plagioclases in particular).

A characteristic of these magmatites is heating of surrounding rocks and penetration of fluids, rich in alkalis, into surrounding rocks.

This contact metamorphism has all the characteristics of sizable intense migmatization. Wide belts of biotite-cordierite (sillimanite)-andalusitic gneisses, amphibolic-pyroxenic schists to gneisses or similar developed in this manner. It is important that this type of metamorphism is connected to the eastern belt of these granitoids, whereas the western belt, Dren and partially Lojane are characterized by fairly weaker metamorphism than the surrounding rocks.

These magmas formed by melting of granite gneissous zones of the continental crust at low melting temperatures. Their intrusion and consolidation took place with intense thermal run along fault zones at medium depth level. Strong migmatization of surrounding rocks at such levels was possible due to the intense thermal run.

The consolidation period of these magmatites, according to isotope analyses, was the end of Jurassic and the beginning of Cretaceous that is consistent with data obtained in the terrane: the Gradec and Grunicet intrude Jurasic basites, and these granites are encountered as alluvia (the Stip granites) in Albian-Cenomanian conglomerates (near Mocarnik and the village of Goracino). Based on poorly exhibited primary orientation of constituent parts, it can be inferred that the intrusion was pre-tectonic. Later, tectonic events made possible the intersecting of the south portions, which were elevated due to compression. The erosion level of these granitoids in the northern and western parts is shallower, but deeper in the southern and eastern parts due to these events.

Several samples of this granitoid complex are gathered and analyzed in detail. The results are shown in the text.

Conclusion

The granitoids of the Vardar zone are situated in the eastern subzone in a belt extending from the village of Lojane in the north via Kumanovo - Stip - Serta - Gradeski Planini - Furka to the south. In the south part it strikes from the central Vardar subzone to the village Grunicet - Fanos (Greece).

The granitoids intrude Precambrian and old Paleozoic rocks and magmatic members of ocean crust of the Vardar zone (gabbros and basalts), but occur as material in basal conglomerates of transgressive Albian-Cenomanian age.

Such contacts and isotope ages (162±3 Ma) obtained for the granitoids of our territory and Greece (Fanos) determine them as Medium to Upper Jurassic, and that the most acidic relic differentiates intruded during Lower Cretaceous, as well.

However, the chemistry of granitoids points to connection with processes of formation of ocean crust of the Vardar zone. Namely, it is assumed that after opening of the ocean crust in

Lower Jurassic, the crust opened until the end of Dogger and the process of heating by single sided subduction towards NE. In Upper Jurassic collision process took place and lasted to Lower Cretaceous.

Granitoid magmatism that commenced at the end of subduction processes manifested during the collision process (in Upper Jurassic and Lower Cretaceous). The chemistry of the granitoids places them in the Batcher+Batcher diagram in the field of the sym-collision granitoids with transitions to mantle type material (Fig. 3).

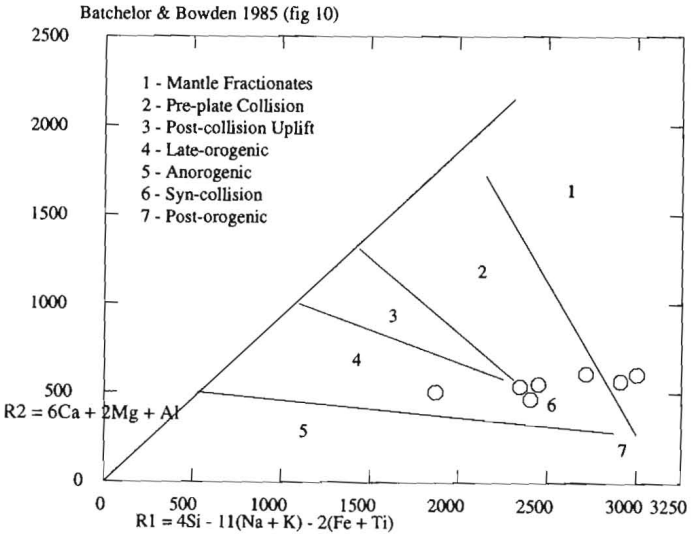


Fig. 3. Relationship between magmatism and geotectonic processes

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