

ГЕОЛОШКИ АНАЛИ БАЛКАНСКОГА ПОЛУОСТРВА ANNALES GÉOLOGIQUES DE LA PÉNINSULE BALKANIQUE	66 (2004–2005)	63–71	БЕОГРАД, ДЕЦЕМБАР 2005 BELGRADE, DECEMBER 2005
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Volcanogenic Turonian and epiclastics of Senonian in the Timok Magmatic Complex between Bor and the Tupižnica Mountain (eastern Serbia)

MIODRAG ĐORĐEVIĆ

Abstract. In the light of the findings presented in this paper, among the volcanic products of the Upper Cretaceous, referred to as “the first volcanic phase” (DROVENIK, 1961), two lithostratigraphic units can be singled out within the Timok Magmatic Complex (TMC):

– The lower one, consisting of volcanogenic, subaerial, dominantly hornblende andesite volcanoclastic, formed on land, and less abundant volcanic and sub-volcanic-hypoabyssal rocks. It is the main source of sulfide mineralization in Bor. It was formed before the Upper Turonian and consists of hornblende andesite and occasionally low biotite. Minor constituents are biotite-hornblende dacite and some andesite and dacite materials containing augite in addition to hornblende and biotite.

– The upper one, from the Upper Turonian period when the volcanic activity of the region had ended, is marine deposited and epiclastic. Intercalated with Senonian marls, it is composed of land deposited Turonian volcanogenic material of all generations. Fresh material mostly consisting of hornblende andesite volcanoclastics prevails in it. Fresh epiclastics include ore mineral epiclasts. Epiclastics composed of epiclasts of hydrothermally altered rocks were observed which also include ore epiclasts. The ore epiclasts originate from copper ore.

The boundary between the volcanogenic Turonian and the epiclastic deposits is a well-recognized unconformity. Table 1 in the text summarizes the main characteristics of the Turonian volcanogenic rocks, primarily those of volcanoclastics, as well as those of epiclastic deposits.

Key words: Turonian volcanism, Senonian epiclastics, mineralization, Bor, eastern Serbia.

Апстракт. У Тимочком магматском комплексу (ТМК) међу горњокредним вулканогеним творевинама познатим као “прва вулканска фаза” (DROVENIK, 1961), према сазнањима приказаним у овом раду, могу се издвојити две литостратиграфске јединице.

– Доња, вулканогена, субаерска, претежно хорнбленда андезитска вулканокластична, настала на копну уз мање учешће лавичних и субвулканско-хипоабисалних стена. Она је извор сулфидне минерализације у Бору. Формирана је пре горњег турона. Поред хорнбленда андезитског материјала где се понегде појављује мало биотита, ретко се проналазе и биотит-хорнбленда дацити, још ређе андезитски и дацитски материјал који поред хорнбленде и биотита садржи аугит.

– Горња, настала после горњег турона, када се вулканска активност на том простору завршила. Она је у мору таложена, епикластична, интеркалисана сенонским лапорцима. Изграђена је од разараног туронског, са копна наложеног вулканогеног материјала свих генерација. Преовлађује свежи материјал из вулканокластита хорнбленда андезитског састава. У свежим епикластитима појављују се рудни епикласти. Уочени су такође епикластити изграђени од епикласта хидротермално измењених стена где се такође виде рудни епикласти. Рудни епикласти су пореклом од бакрових руда.

Граница између вулканогеног турона и епикластичних наслага је добро препознатљива дискорданција. На табели 1 у прилогу текста приказана су најважнија својства туронских вулканогених творевина, првенствено вулканокластита и упоредо са тим, својства епикластичних наслага.

Кључне речи: туронски вулканизам, сенонски епикластити, минерализација, Бор, источна Србија.

Introduction

The explored area extends between Bor in the north and the northern flanks of the Tupižnica Mountain in

the south. Jurassic and Lower Cretaceous limestones of the Sto Mt. and a large area composed of Neogene sediments form its eastern boundary. The Brestovac–Tupižnica dislocation separates the explored area from Se-

nonian volcanogenic products in the west. Urban settlements within the investigation perimeter are Bor, Brestovac, Metovnica, Nikoličevo, and Gamzigrad. The main river is the Crni Timok (Fig.1).

and then later "Timazit" and, as he believed, it contained a special kind of hornblende which he designated as "Gamsigradit". The hornblende andesite with low biotite from the locations of Gamzigrad, Kopita, Zve-

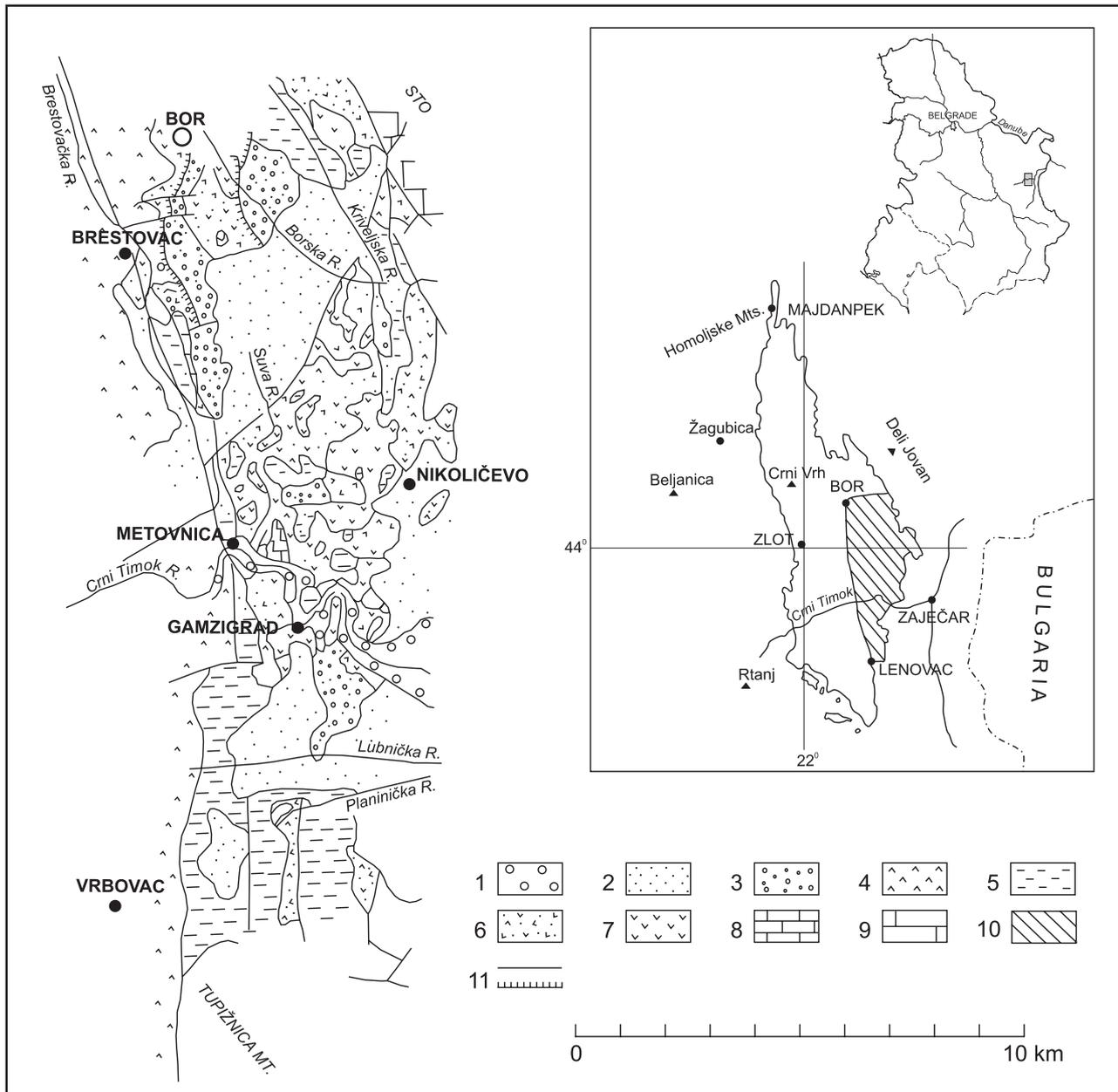


Fig. 1. Schematic geological map of the southern part of Timok Magmatic Complex between Bor and Tupižnica Mountain, East Serbia (after ĐORĐEVIĆ & BANJEŠEVIĆ, 1996b). 1. Quaternary; 2. Neogene; 3. Bor Conglomerates and Sandstones (Maastriichtian); 4. Senonian volcanoclastics and volcanic rocks; 5. Upper Turonian and Senonian sediments; 6. Epiclastics; 7. Turonian volcanoclastics and volcanic rocks; 8. Lower Cretaceous and Cenomanian; 9. Jurassic; 10. Explored area; 11. Faults.

The area is made up of dominantly hornblende andesite and Senonian sedimentary rocks (Fig.1)

BREITHAUPT (1860, 1861) was among the first geologists to suggest the presence of hornblende andesite rocks, initially named "Timozit" after the Timok River

zdan, Brestovac and Bor were described by ŽUJOVIĆ (1900) and noticed near Metovnica by ILIĆ (1905, 1909). The rocks are interbedded with Upper Cretaceous sediments (ANTULA, 1909), and their Senonian age was proposed by PETKOVIĆ (1908). Copper-mineralization of

Bor in hornblende andesites was reported in detail by LAZAREVIĆ (1909, 1912).

Subsequent investigations started only after the Second World War. The designation "Bor Type" for hornblende andesite in the Bor area (CLAR, 1946) remained only as a notation. After exploring Bor and its wider surroundings, DROVENIK & DROVENIK (1956) and CISSARZ (1956) gave their interpretations of the age and the origin of the ore mineralization in Bor and TMC in general. Another interpretation of the volcanism and ore mineralization history was given in an important paper by MARIĆ (1957) of the Bor area andesite material.

More extensive geological investigations began in 1956 and gave an insight into pyroclastics as the prevailing element of the TMC composition (ANTONIJEVIĆ, 1961). A conclusion was drawn that within the three-phase Upper Cretaceous, dominantly submarine volcanism (DROVENIK, 1961; DROVENIK *et al.*, 1962) when the formation of the TMC occurred, the eastern part of the Complex belongs to "the first volcanic phase" and consists mainly of pyroclastics of hornblende andesite composition with some biotite, sometimes minor augite, as well as intercalated Senonian marls. The volcanism was dated as Turonian/Senonian before Maastrichtian. Also, the intruded plutonic rocks were believed to be Laramian, bearers of ore mineralization in the TMC and Bor. The Basic Geological Map of the SFR Yugoslavia, the Sheets of Bor (ANTONIJEVIĆ *et al.*, 1976; KALENIĆ *et al.*, 1976) and Zaječar (VESELINOVIĆ *et al.*, 1975a, 1975b), which presents the development of the volcanism in the light of such notions, can be regarded as the conclusion of this phase of the explorations.

Since then, many articles have been published (JANKOVIĆ, 1990; JANKOVIĆ *et al.*, 1980, 1981, 2002; KARAMATA, 1974; KARAMATA & ĐORĐEVIĆ, 1980; KARAMATA *et al.*, 1983, 2002; MILOVANOVIĆ, 1980; MIŠKOVIĆ, 1989, 1995) on the geology of the TMC and the wider area and various other issues: from the origin of magma in the Carpatho-Balkanides to the integrity of the volcanogenic and subvolcanic-hypoabyssal processes to hydrothermal alterations and the occurrence of mineralization. During the same period three PhD and a number of MSc theses were also written (mostly unpublished), as well as studies mainly about the Bor ore deposits, which are all to be found in professional holdings.

The explorations performed for a geological map on the scale 1:50.000, which started in this area in 1980, relied on the unquestionably vast amount of existing data. Some of the investigation results were published (ĐORĐEVIĆ, 1989, 1994; ĐORĐEVIĆ & JANJIĆ, 1990; ĐORĐEVIĆ & BANJEŠEVIĆ, 1996a, 1996b, 1997; ĐORĐEVIĆ *et al.*, 1994, 1996; BANJEŠEVIĆ, 1993; BANJEŠEVIĆ *et al.*, 2001) and the findings of this paper are based on them.

The products of the "First volcanic phase"

Field works for the Geological Map scale 1:50 000, revealed that among the products of "the first volcanic

phase" (DROVENIK, 1961), two lithostratigraphic units could be singled out:

Volcanogenic Turonian, mainly composed of hornblende andesite, subaerial, projected land deposited volcanoclastics accompanied with identical rocks of lava level, pyroclastic flows, and, as the youngest, materially similar subvolcanic-hypoabyssal rocks, hydrothermally altered rocks, and sulfide Cu-ore mineralization.

Marine deposited epiclastic sediments, intercalated with Senonian marls. They are composed of andesite clasts, which originated from the products of Turonian volcanism products, formed after the Turonian volcanic activity had ceased.

The largest part of the mapped area of "the first volcanic phase" (DROVENIK, 1961) consists of epiclastics and Senonian silt marl. From the 63 km² of the map designated volcanogenic Turonian and epiclastics, the former covers only 18 km², i.e. less than 30%.

The volcanogenic Turonian and Senonian epiclastic deposits are overlain by Bor conglomerates and sandstones and their formation marks the end of the TMC as a marine environment and an environment in which magmatic processes had evolved (ĐORĐEVIĆ *et al.*, 1994). The presented schematic geological map shows the distribution of volcanogenic Turonian and Senonian epiclastic deposits between Bor and the Tupižnica Mountain.

Turonian volcanism products

Almost 95% of the Turonian volcanogenic products are volcanoclastic materials. Projected land deposited, unsorted or poorly sorted material of volcanic agglomerates and agglomerate lapilli, as well as tuff cement mostly forming as a matrix between coarse clasts prevail to a large extent. The volcanoclastics come from the ejecta of homogeneous structure material, whereas amygdaloidal material was not observed. There are clasts from pyroclastic flows, infrequent clasts of subvolcanic consolidated andesites, dacites, and clasts of hydrothermally altered rocks. Minor andesite and dacite veins, small occurrences of subvolcanic-hypoabyssal consolidated rocks and minor pyroclastic flows are the seldom-observed products of the Turonian volcanic activity.

The clastic material mainly consists of hornblende andesite, which often contains some biotite, and in some parts, especially the older levels, minor augite. Plagioclase in the Turonian volcanogenic products is mainly andesine (45%–48% an) or medium acidic labradorite. The hornblende is frequently conspicuously coarse, often longer than 1 cm. It generally corresponds to common hornblende, or locally – in the older pyroclastic levels, to basaltic hornblende. Dacite material shows quartz phenocrysts, usually in a few grains.

Pyroxene hornblende andesite, biotite-pyroxene hornblende andesite and pyroxene hornblende dacite occur only in few veins of the lava level. The pyroxene mainly occurs as augite.

Table 1. Characteristics of Turonian volcanic rocks and Senonian epiclastics of the TMC south of Bor (ĐORĐEVIĆ, 1994; partially adapted).

Material characteristics	Turonian Volcanic Rocks, mostly volcanoclastics	Senonian Epiclastics
Volcanic rocks composition	Dominantly hornblende andesite, some dacites.	No volcanic activity.
Composition	Dominantly volcanoclasts of fresh rocks: lava, pyroclastic flows; some hydrothermally altered subvolcanic, hornfels, basement rocks.	Same as in column 2 plus subvolcanic rocks, hypoabyssal, hydrothermally altered, silicified rocks (secondary quartzite), Cu-ore massive, porphyric and cementing.
Enclaves	Semilamprophyric, crystalline schist.	Crystalline schist not found.
Non-volcanic material	Synchronously deposited non-volcanic material not observed.	Synchronously deposited Senonian marl and sandstone; minor well rounded pebbles of Cenomanian sediments.
Clast texture in magmatic rocks	Porphyric, some hyaloporphyric, groundmass microcrystalline, hypocrySTALLINE, hyalopilitic; tuffaceous pyroclastic, dust and lapilli pyroclastic flows.	Same as in column 2 plus porphyric and porphyroid sub-volcanic and granular textures, altered rocks of volcanic, sub-volcanic and hypoabyssal levels.
Texture of volcanoclastic and epiclastic rock mass; Matrix	Pyroclastic texture: tightly cemented clasts into compact rock (in fresh rocks). Contact binder.	Distinct contact-cemented clasts, basal cement is zeolite, argillaceous carbonate material, chlorite.
Structure of volcanoclastic and epiclastic rock mass	Massive, homogeneous, agglomerate, lapillic, not-arranged, some visible irregular bedding in lithological stratification, seldom mechanical discontinuity.	Massive, thick-bedded, platy/flow sheets, discontinuous to locally visible or continuous; mechanically irregular, infrequently planar 'bedding without beds', like schistosity, lamination, gradation.
Granulometric composition	Agglomerate-lapilli-tuff grades, prevailing clast sizes smaller than 10 cm, rarely larger than 20 cm. Tuff component mainly groundmass.	Similar to volcanoclastics. Not characteristic.
Sorting	Poorly sorted to unsorted, some sorted.	Poorly sorted or sorted, some unsorted. Not characteristic.
Roundness class	Subangular to subrounded, angular.	Subangular to subrounded, rounded, some angular. Not characteristic.
Clast and pebble orientation	Not observed, possible in allochthonous material.	Sporadically visible in epiclastic breccias, more frequently in epiclastic psammite and epiclastic siltstone.
Depositional environment	Land. Material deposited in aquatic environment not observed.	Shallow marine environment.
Mode of deposition	Subaerial fall deposits. Terrestrial pyroclastic flow.	Short transport over rugged volcanic landscape.
Thickness	Little known. More than 1000 m in major structures. Original thickness likely two to three times as much.	From one to hundreds of meters. Largely unknown.
Time of formation	Before Upper Turonian or possibly in Upper Cenomanian.	From Upper Turonian, Lower Senonian to Lower Maastrichtian.
Rock and mineral alterations	At subvolcanic-hypoabyssal level: biotitization (biotite, K-feldspar, plagioclase, quartz, ore minerals); uralitization; low-temperature alterations: epidote, albite, chlorite, quartz, etc. Porphyry deposit of the Borska River. At volcanic level: silicification, pyritization, argillization, silicified rocks (secondary quartzite), chloritization, zeolitization, etc., massive Cu-ore and massive pyrite bodies of Bor, Cu-ore veins in a quarry by the Brestovac Brook.	Lack of alteration associated with Turonian magmatism. Sedimentary and diagenetic zeolite, carbonate, quartz, chlorite, argillaceous substance. Mineral ores: scattered ore pebbles, massive Cu-ore blocks in Novo Okno ore deposit (uncovered).

Dacite, in which biotite occurs with hornblende is dominant among subvolcanic consolidated rocks. Hypoabyssal rocks are equivalent to fine- to small-grained porphyroid diorite or quartz diorite.

The source magmas are calc-alkaline, silica-saturated (from 54% to almost 65% SiO₂), in which Na₂O is always higher than K₂O, and cumulative alkalis are in equal proportion with CaO.

Table 1 gives the most important characteristics of the volcanogenic materials.

Formation of the products of Turonian volcanism

Volcanogenic products were formed in the central structures of Bor and Metovnica. Minor occurrences of volcanogenic products, possibly parts of a smaller structure, were found south of the Lubnička River. These volcanic structures were destroyed or reshaped before the Upper Turonian, and they can be recognized only by some elements.

The Bor structure had the most complete formation. It contains all the products of the Turonian volcanic activities. The present assessment, based on the composition of the andesite volcanoclastic materials and in comparison with present-day volcanoes of a similar composition, the Bor volcano must have been high, possibly more than 3000 meters, and the broad area of its activity was almost 20 km wide. The western part of the Bor volcanic structure was down-thrown along the Brestovac fault and covered with Senonian volcanic products. In its eastern part, it was detached after Maastrichtian by the Bor reversed fault. It was at this time that the Bor conglomerates and sandstones came underneath the Bor ore area. East of the peripheral parts of the Bor structure, epiclastics and Senonian marlstones occur. Subsequently, it was covered with Bor conglomerates and sandstones. The Bor volcanogenic products are exposed on a very small area.

The volcanic activity of this type of volcano commences with the emission of large amounts of juvenile material, as well as of some basement rock fragments from under the volcano and it is deposited in the deepest parts, from where it is distributed during a subsequent volcanic action. These products have not been found in the Bor area.

The next stage, which begins once the volcano chamber is wide open, is developed in the Bor structure. Projected juvenile rocks are ejected together with the material of the preceding eruptive activities, rarely the basement rock (enclaves of crystalline schist) and some clasts of shallow-consolidated veins and hydrothermally altered rocks. The outflow material and pyroclasts sporadically contain enclaves of semilamprophyre with a mineral composition qualitatively identical to the rock. Clasts of Mesozoic sedimentary rocks, which are visible in the bedrock of the Metovnica–Nikoličevo

volcanic structure, have not been noted here. Volcanic activity was followed by a few minor pyroclastic flows that are visible in the pyroclastics SE of Bor. The occurrence of clasts from pyroclastic flows suggests that this kind of eruptive activity was present.

Volcanic activity ends with the last stage. During the emission of the eruptive material to the surface, in the deeper parts of the volcano, subvolcanic consolidated volcanites and hypoabyssal plutonic rocks close the vents on the peripheral part of the volcano. The most important moment occurred only after sufficient energy for the final volcanogenic processes had been accumulated inside the volcano. It is possible that the high pyroclastic cone of Bor was destroyed in this stage and the massive juvenile material was emitted. The volcano vent expanded, but pyroclastic fallback, wall-rock fragmentation and slide closed it. The tectonic alterations of the shape of the volcano could have occurred at this moment. The main mass of the emitted juvenile material in the Bor area is probably represented by the wide-spread volcanoclastics of hornblende andesites in which the hornblende is coarse. The hornblende grains in most cases do not show opacitization, which indicates an abrupt pressure drop, probably resulting from strong eruptions. The age of two hornblende grains from pyroclastics in a mine haulage level determined by K/Ar method to be 89±3.6 Ma (BANJEŠEVIĆ *et al.*, 2001).

The volcano energy was exhausted, but emanations from the depth formed massive sulfide ore minerals in the shallow part of the vent, while in the deeper, closed parts, the very fine-grained porphyroid quartz diorite of the Borska River was formed, which bore porphyritic copper mineralization.

The pyroclastic material which surrounded the massive ore in the vent transformed into silicified rocks ("secondary quartzite" in Russian terminology), which contain corundum, andalusite and diasporite adjacent to the ore body in the depth which changes gradually into silicified rocks with pyrophyllite, kaolinite, etc., further from the ore body at shallower depths (KARAMATA *et al.*, 1983). In the oxidation zone at the surface, siliceous rocks of brecciated texture were formed by pseudo-morphosis of volcanoclastics containing aluminum minerals, mainly argillaceous, and sulphates, as well as a notable amount of iron oxide. Contours of destroyed phenocrystal grains from andesite volcanoclasts are occasionally seen.

Subvolcanic consolidated biotite-hornblende dacites of the Bor volcano are visible in the surface as a minor vein in pyroclastics south of the Bor open pit mine. In the village of Brestovac it is possible to see, in the places where the top is mostly eroded, that deposited epiclastic sediments overlie biotite-hornblende dacites. Biotite-hornblende andesites were observed in boreholes drilled in the Brestovačka River. Here also the uppermost part is eroded since slightly hydrothermally altered andesites, with some pyrite impregnations, are overlain by unaltered epiclastic deposits. Biotite-horn-

blende dacites of the Brestovačka River contain numerous enclaves of semi-lamprophyre.

Destruction of the Turonian volcanism products and Epiclastics Formation

Tectonic events of the late Turonian and the early Senonian caused major changes in the region. The entire TMC area was submerged and transformed into a marine basin. The volcanic Turonian, which probably had a much greater distribution than is known, was overlain by epiclastic deposits and Senonian marl-sand sediments. This process continued to the Maastrichtian when the marine environment of the TMC vanished and the volcanic activity ceased.

The western flank of the Bor volcanic structure is recognized in the Brestovačka River west of the Brestovac–Tupižnica dislocation. It is overlain by epiclastics under the earliest Senonian volcanogenic products.

Deposition of epiclastics began in the late Upper Turonian and ended in the Lower Senonian (Oštrej, the Lenovačka River, Lenovac). In the areas of Gamzigrad and Metovnica it continued to the Middle Senonian, and near Brestovac to the Lower Maastrichtian. All epiclastic levels from the Upper Turonian/Lower Senonian to the Lower Maastrichtian include layers of marl, silt, sandstone and calcarenite, as well as sometimes, for example at the Srečko Brook near Brestovac, cement-like reddish marl mud with Senonian microfauna can be observed between epiclasts. The epiclastics were mainly deposited over the volcanogenic Turonian, but also over the Lower Cretaceous limestones and Cenomanian sediments.

The epiclastics were marine deposited, filling the uneven volcanic sea floor. The material was transported from the land over short distances, which is indicated by the subangular to subrounded, rarely rounded pebbles mostly equivalent to breccia or conglomerated breccia.

One of the most notable textural characteristic of the epiclastics is their bedding. The rocks are commonly massive or thick-bedded, less frequently bedded or platy, and schist-like bedded. The clasts are uniform in size through the thickness of the layer. Grading and lamination are less common. In some occurrences, coarse clasts are oriented and elongated minerals are parallelly arranged.

The epiclastics vary in thickness from one to hundreds of meters, but the actual thickness is only locally known. The epiclastic thickness is best known in Brestovac where they were studied in several boreholes. In a cutting of the Brestovac–Metovnica road SE of the village, epiclastic conglomerated breccia with clasts of massive Bor copper ore is only one meter thick over the volcanogenic Turonian, while in boreholes drilled in 1988 near a cutting, they vary from 180 m to 250 m. Some hundred meters to the south, the thickness of the epiclastics is estimated at more than 450 meters after the analysis of current borehole records.

Composition of the Epiclastic deposits

The epiclastics consist of clasts of Turonian volcanogenic rocks – volcaniclastic products, pyroclastic flows, lava material, pyritized or silicified rocks (secondary quartzite), kaolinized, sericitized, chloritized, epidotized, prehnitized rocks, metamorphic andesites and sediments (pyroxene hornfels), very fine- and fine-grained porphyroid diorite and quartz diorite, very fine-grained grandiorite, pebbles of Cenomanian sediments and ferruginous concretions.

The ore fragments are represented as clasts of porphyritic copper ores, massive Bor ores, copper ores from the cementation zone, and more or less pyritized rocks. They are most abundant near Metovnica and Brestovac, as well as in the narrower area of Bor.

It is possible to single out among the epiclastics the following:

- Epiclastic breccias and agglomeratic breccias in the fresh material of the various eruptions, with some clasts of structurally different subvolcanic rocks and a variety of hydrothermally altered rocks. These are the most widespread epiclastics.

- Epiclastic breccias and agglomeratic breccias of hydrothermally altered rocks with a lower degree of fresh eruption material, subvolcanic and hypoabyssal;

- Epiclastic psammites and silty material of fresh rocks produced by various eruptive activities, with the seldom occurrence of subvolcanic material and hydrothermally altered rocks. This material shows laminae of salic and femic minerals, as well as laminae with a large amount of clay, marl and carbonate mud;

- Most importantly, epiclastics with a large number of ore clasts, with many clasts of altered rocks, as well as clasts of fresh volcanic material.

Epiclastic Occurrences in Bor and Metovnica

The Bor volcano is the best example of how the products of Turonian volcanic activity disintegrated and formed epiclastic deposits.

The newest products of the Bor volcano, i.e. the ore minerals in the Bor open pit, were in an advanced stage of erosion before the deposition of visible epiclastics. The massive ore body of Čoka Dulkan, near the Weifert Mine, is overlain by an almost one hundred meter thick, unaltered epiclastic deposit of hornblende andesite and dacite materials, intercalated with Senonian sediments, which were believed to be pyroclastics with “Bor Pelite” layers and as such they were illustrated by a photo from 1957 (DROVENIK, 1968). However, the photo (Fig. 6) proves that the marine deposited sediments over the massive Bor ores, since unaltered, must have been younger than the ore mineralization occurrences. In addition to some massive ore, are also altered volcanogenic products, silicified (secondary quartzite) with kaolinite, pyrophyllite, alunite, diaspor, and possibly corundum

and other hydrothermal minerals, which were eroded before the epiclastic deposition in this area and which are absent above the ore body, such as those present around the Tilva Roš ore body between the height points +134 m and -78 m (KARAMATA *et al.*, 1983).

SPASOV *et al.* (1972) gave interesting information about the higher parts of the Bor deposit of the Tilva Roš (heights from +190 m to +195 m). To quote: "In Tilva Roš, the largest ore body of the Bor copper deposit, ore breccias cemented with tuffogene cement occur after the clasts were broken off the basic ore body". Later the authors mention that above the impregnation ore vein of Tilva Roš there is "a 50 cm layer that disturbs the continuous precipitation of mineral sulfides in the Tilva Roš body ... and the previously described effect disappears at the contact with this layer".

My interpretation is that "the ore breccias cemented with tuffogene cement" and "the 50 cm layer" represent Senonian epiclastic deposits with ore epiclasts that were deposited over the Tilva Roš ore body, the highest parts of which had been eroded. This is clearly an erosive unconformity.

If the above stated on Tilva Roš (SPASOV *et al.*, 1972) is disputed by DROVENIK (1973), then the already uncovered ore body in Novo Okno gives convincing evidence that the Bor orefield was disintegrated in the Senonian during the formation of the epiclastic deposit. Ore mineral clasts, in fact epiclasts of the massive Bor ore blocks, together with the epiclasts of Turonian altered and fresh andesite rocks, were carried and deposited in the marine environment consisting of epiclasts interbedded with Senonian marls. The material was most probably transported down the steep slopes from the primary source as debris or talus. A possible structural deformation of the Turonian volcanogenic and ore products should also be considered. Therefore, the environment, the Novo Okno ore body, can not be volcanogenic in any way, nor could the ore blocks have been torn off by the destruction of the primary ore body in the Bor area during volcanic eruptions as proposed by MIŠKOVIĆ (1989, 1995) and DROVENIK (1993).

Ore epiclasts along with hornblende andesite epiclasts were noticed during our explorations on Rukjavica, south of Bor, and in Brestovac on the left bank of the Brestovačka River at a Brestovac–Metovnica road cutting. Moreover, they have been known for more than hundred years as ore mineral clasts in andesite material on the banks of the Suva and Brestovačka Rivers in the village of Metovnica.

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Резиме

Вулканогени турон и сенонски епикластити у тимочком магматском комплексу између Бора и планине Тупижнице (источна Србија)

Творевине "прве вулканске фазе" (DROVENIK, 1961, DROVENIK *et al.*, 1962) у јужном делу тимочког

магматског комплекса (ТМК) у доњем делу одговарају вулканогеном турону изграђеном од андезитских пројекционих вулканокластита, а у горњем преко турона дискордантно наталоженим епикластичним седиментима сенона. Туронски вулканогени ниво јасно се разликује од епикластичних наслага сенона.

Главне вулканогене структуре су борска и николичевско-метовничка.

Туронски вулканокластичан материјал, субаерски пројектован, таложен на копну, углавном хорнбленда андезитског састава и ретко дацитског, најчешће садржи редак биотит. Подређен је материјал где се уз хорнбленду и биотит појављује аугит. Ове стене састоје се од класта еруптивног порекла, врло ретких класта субвулканске консолидације, ретких класта хидротермално измењених стена и изузетно ретких класта из подлоге вулкана. Продукти вулканизма су још ретки пирокластични токови, жице вулканског нивоа, субвулкански андезити и дацити, хипобаисални плутонити. То је ниво са сулфидним бакровим рудама.

Епикластити су стварани од горњег турона - доњег сенона до мастрихта у морској средини која се појављује услед тоњења читавог ТМК. При томе се западно од брестовачко-тупијжничке дислокације морско дно више продубљује и почиње сенонска вулканска активност. У подручју изграђеном од епикластита нису нађени продукти вулканизма. У епикластитима се појављују интеркалације сенонских лапораца. У епикластите је преталожен материјал вулканогеног турона, претежно непромењених, затим хидротермално измењених стена, свежих и измењених стена субвулканско-хипобаисалног нивоа из еродованих дубљих делова вулкана. Затим се јављају епикласти сулфидних руда бакра – масивних руда борског типа, порфирских руда, руда из цементационе зоне. На табели 1 дата су својства туронског вулканогеног материјала и епикластичних наслага.

Граница вулканогеног бакром оруђеног турона и епикластичног сенона је јасна ерозиона дискорданција што се најверљивије види у борском лежишту. Дебљина епикластита, састав епикластичног материјала и смер приноса из вулканогеног турона су основна питања упућена будућим истраживачима.