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UPPER CRETACEOUS TRACHYDACITES SOUTH OF BELGRADE - A CONTRIBUTION FOR THE KNOWLEDGE OF THE ANDESITIC VOLCANISM IN THE NORTHERN PART OF THE VARDAR ZONE COMPOSITE TERRANE

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ABSTRACT

Volcanic rocks are abundant as clasts in Senonian sediments south of Belgrade, as well as at the north in the Karadjordjevo formation in Southeastern Bačka and in the Central Banat. These rocks are known in the literature as andesites, but because of the size of grains and mostly high alteration they were not studied yet. An outcrop of andesitic debris-flow deposit interlayered into these sediments was found south of Belgrade and studied. The field and petrographic study reveal a submarine slump of the volcani(epi)clastic debris predominately composed of holo- to hypocrystalline porphyritic volcanic fragments within the fine-grained volcanogenic and marly matrix. Volcanic rocks display a high sodic alkaline character corresponding to trachydacites, respectively to benmoreites and sodic trachytes while their trace element ratios indicate VA (volcanic arc) affinity. These rocks represent members of the Senonian volcanic activity in the central part of the Vardar zone, i.e. in its northernmost exposed part of the Kopaonik block and ridge unit. Given the abundant occurrences of andesitic clasts in the Senonian Karadjordjevo formation in the base of the Neogene of the Pannonian basin further at north, the existence of a Senonian volcanism related to the subduction and the closure of the western branch of the Vardar ocean became more evident.

Keywords: debris-flow, trachydacite, pebbles, volcanic arc, Vardar zone, subduction, suture zone, Upper Cretaceous, Belgrade, Backa-Banat, Northern Serbia

INTRODUCTION AND GEOLOGICAL SETTING

The Vardar zone composite terrane is considered here in the sense of KARAMATA et al. (1994, 1996/1997, 1998), without the later introduced Jadar block (as a different terrane), embracing relics of the Main oceanic basin at the East (VZM) and the Western belt (WB), with the Kopaonik block and ridge unit (KBR) between. The Western belt of the Vardar zone composite terrane represents the relic of an oceanic back-arc basin originated in the Upper Triassic, between the detached Kopaonik block and ridge unit, at the East, and the main part of the Drina–Ivanjica terrane, at the West (*Fig.1*). The remnants of this belt are represented by an olistostrome deposited in the trench and now occurring over the area of collision. The olistostrome contains fragments of greywackes and basaltic rocks (of MORB and IAB type), lens-shaped bodies of Triassic and Jurassic limestones and cherts, as well as fragments of Upper Cretaceous limestones. Campanian limestones were found also as inclusions in the basalts (near Krupanj) or as interlayers

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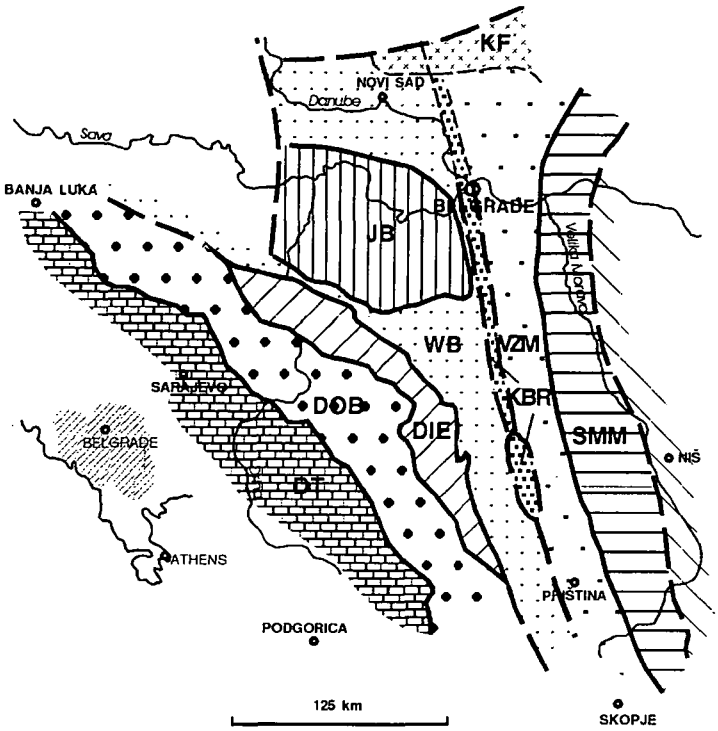

Fig. 1. – The Vardar zone composite terrane and the position of the studied volcaniclastic rocks (after KARAMATA, et al., 1996/97, 1998).
EXPLANATIONS: VZM – Main oceanic belt of the Vardar zone composite terrane, WB – Western belt of the Vardar zone composite terrane; KBR – Kopaonik block and ridge, KF – Karadjordjevo formation, extension beneath the Neogene cover, SMM – Serbian-Macedonian mass composite terrane, DIE – Drina-Ivanjica element/terrane, JB – Jadar block, DOB – Dinaridic ophiolite belt, DT – Dinaridic trunck.

between the pillow lava flows (northern flanks of Kozara Mt.). At the East of the Western belt, south of Belgrade, in the northern continuation of the Kopaonik block and ridge unit, Turonian-Senonian sandy-marly-clayish sediments occur. Within their highest levels abundant clasts of volcanic rocks (fine to middle grains) have been observed (MARKOVIC et al., 1984/85). Similar sediments of the same age, which contain frequent volcanic clasts, locally up to 80 % of the well core, have been reported as members of the Upper Senonian Karadjordjevo formation in the northernmost continuation of the Kopaonik block and ridge unit in the Pre-Neogene basement of the Pannonian basin (CANOVIC and KEMENCI, 1988). These grains are small and mosty altered, thus unconvenient for study, and according to their mineral composition they were named »andesites«. Some years ago, in the uppermost levels of those Turonian-Senonian sediments, situated south of Belgrade, a section with such »andesitic« fragments (up to 30 cm in diameter) was found. Being unaltered or only stightly altered these rocks were suitable for detailed determination of their character and for providing additional data on the evolution of the Western oceanic belt of the Vardar zone during Upper Cretaceous.

PETROGRAPHY OF THE VOLCANOCLASTICS

Volcanic conglomerates of andesitic appearance were found south of Belgrade (10–15 km) and briefly described about 15 years ago (MARKOVIC, et al., 1984/85, TERZIC and KARAMATA, 1968 – unpublished report). They are situated within a Turonian (?)–Senonian sedimentary series composed predominantly of greywackes, shales and marls, more precisely within its highest, andesitic clasts bearing levels, probabaly of Campanian age. These rocks are exposed in a new outcrop (oriented WNW-ESE), in a mainly covered area, as a 20 m long and up to 7 m high unit. This unit can be divided into three levels – the lowermost and the uppermost levels built of marls and sandstones, and the middle level predominantly composed of conglomerates with abundant volcanogenic fragments. The contact in the base of the conglomeratic level with underlying sedimentary rocks is sharp.

The middle level is an about 3 m thick section of volcaniclastic deposits, built of well rounded (in lower parts) to subrounded (in higher parts) andesite-like and rare sedimentary rock fragments enclosed by a fine-grained volcanic to mixed volcanic + marly matrix. Fragments of volcanic origin make from almost total mass to 60-80 % (vol) of all clasts. Coarse detrital material is moderately sorted, it highly predominates giving rise to pronounced closed framework of the deposit. Within some levels of the middle unit appear to be thin (up to 80 cm long) sandstone lenses. This level probably represents a submarine slump from an andesitic high.

The volcanic pebbles (up to 30 cm in diameter) are porphyritic rocks of various colour (pink, red, grey to black or green). The phenocrysts are represented by andesine (32-41% an), biotite and hornblende (chloritized), and in some samples rare augite. The hypo– to holocrystalline groundmass consists of plagioclase, K-feldspar and quartz microlites. Apatite, magnetite (?) and very rare zircon are the main accessories. Secondary chlorite, calcite, sericite and clay minerals are ubiquitous and often very abundant. Some volcanic fragments have a completely calcitized groundmass with almost invisible plagioclase microlites.

TABLE 1

Trace element contents of the studied trachydacites

Sample No	Zr (ppm)	Nb (ppm)	Y (ppm)	Sr (ppm)	Rb (ppm)	Ba (ppm)
1. BR2/8	217	14	19	332	13	2696
2. BR2/9	229	17	22	473	17	4763
3. BR2/10	238	15	30	520	30	969
4. BR2/11	242	17	22	558	29	4218
5. BR2/12	229	15	28	379	26	2169
6. BR2/13	242	19	28	605	31	4042
7. BR2/14	282	19	25	296	9	540
8. BR2/15	318	16	26	407	24	3082
9. BR2/16	253	17	23	461	19	1330
10. BR2/17	265	15	21	375	16	928
11. BR2/18	238	18	23	501	20	1420
12. BR2/19	300	17	21	318	20	1047
13. BR2/20	228	18	21	467	17	2356
14. BR2/21	241	15	23	472	21	3240
15. BR2/22	141	11	22	521	26	1334
16. BR2/23	215	15	21	433	17	2167
17. BR2/24	237	17	24	294	28	5232
18. BR2/25	300	16	22	291	23	1161

ROCK CHEMISTRY

The studied volcanic rocks are characterized by SiO_2 content ranging from 55 to 64%, mostly between 61 and 63% and with relatively high Na_2O (6.00 to 8.50 %) and low to medium K_2O (1.30 to 2.90. %) content. Only some highly altered rocks are poorer in-silica. According to LE BAS et al., (1986) these rocks correspond to sodic types and belong to trachydacites/benmoreites and sodic trachytes (*Fig.2*).

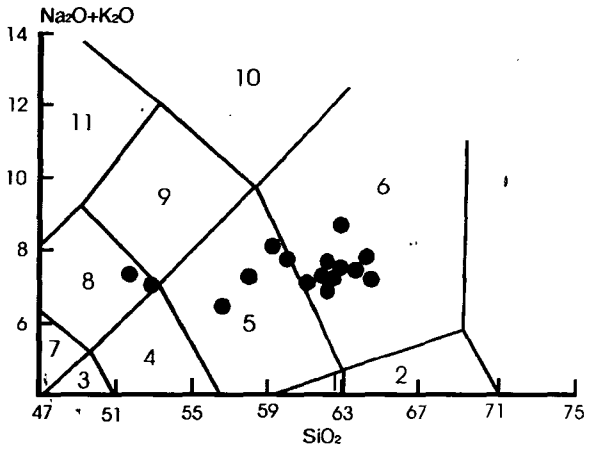

Fig. 2. – Total Alkali vs Silica diagram (after LE BAS et al., 1986): dots represent the trachydacitic rocks from the surrounding of Belgrade. EXPLANATIONS: 1 – andesite; 2 – dacite; 3 – trachybasalt; 4 – basaltic trachyandesite; 5 – trachyandesite; 6 – trachyte (q<20%) or trachydacite (q>20%); 7 – tephrite (ol<10%) or basanite (ol>10%); 8 – phonotephrite; 9 – tephriphonolite; 10 – phonolite; 11 – foidite

The contents of some characteristic trace elements (analyzed by XRF in the Laboratory of the IGEM of the Russian Academy of Sciences, Moscow, anal. T. MARCHENKO), presented in table 1, are without any significant variance. Even the rock alteration does not influence their contents, not only of the elements which are believed to behave immobile (Nb, Y and Zr), but of Sr and Rb, as well. However, Ba contents show considerable variations that could be measured by tens order of magnitude (540-5232 ppm)

In order to define the geological setting of origin of these rocks the discrimination diagrams for granitic rocks elaborated by PEARCE et al. (1984) were used. These diagrams consider the granitic rocks of the "Volcanic arc" belts, as well as those of the "Within plate" and "Collision" granites, comprising the rocks with more than 56 % SiO_2, and can be used for the determination of the geological setting of their volcanic equivalents, too. The studied volcanic rocks of the surrounding of Belgrade do meet the required criteria. According to the Nb/Y and Rb/Y+Nb (*Fig. 3 a,b*) discrimintion diagrams the studied rocks display volcanic arc affinity, while the Rb/SiO_2 (*Fig. 3 c*) ratios plot into the VAG+ WPG field and the Y/SiO_2 ratios (*Fig. 3 d*) into the VAG + COLG + ORG field. Since these trachydacites are situated within the Vardar zone, i.e. in a suture zone, the WPG character is excluded, and the COLG and ORG affinities are not likely because of the Rb/Y+Nb and Nb/Y ratios. According to the presented chemical characteristics these rocks belong to a volcanic arc granitic association, i.e. they are

related to subduction processes. Somewhat lower Rb contents than could be expected for the subduction related rocks might have been the consequence of biotite fractionation.

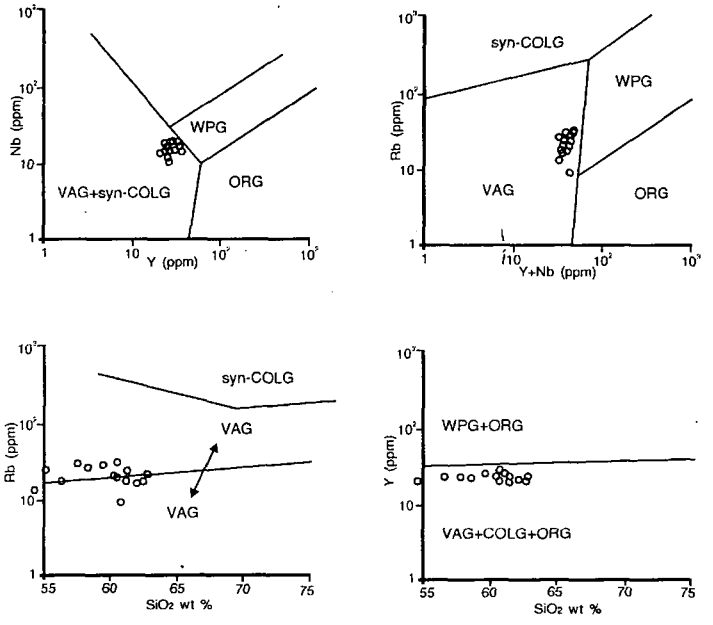

Fig. 3. – Nb – Y (a), Rb – Nb+Y (b), Rb – SiO2 (c) and Y – SiO2 (d) discrimination diagrams (after PEARCE et al., 1984).
EXPLANATIONS: Dots represent the trachydacitic rocks of the surrounding of Belgrade: VAG – Volcanic arc granites; WPG – Within plate granites; ORG – Ocean ridge granites; COLG – Collision granites; syn-COLG – Syn–collision granites.

CONCLUSION

The trachydacitic volcano(epi)clastic debris-flow of submarine slump features, close to the southern suburb of Belgrade, indicates the existence of a subduction related volcanism in this area during Senonian. The presence of small volcanic (andesitic, after MARKOVIC et al., 1984/85 or trachydacitic) clasts within (probably Upper) Senonian graywackes in the vicinity of Belgrade and of andesite and trachyte clasts (after CANOVIC and KEMENCI, 1988) in the Senonian, Campanian to Pre-Late Maastrichtian, Karadjordjevo formation in Central Banat and southern Backa in the basement of the Neogene deposits of the Pannonian basin, as the northernmost continuation of the Kopaonik block and ridge unit, represent further evidence for the existence of a significant volcanism in this area during Upper Cretaceous. The area of the volcanism was situated at the East of the Western belt (formerly an oceanic basin) of the Vardar zone. That fact further illuminates the problem of closure of the western branch of the Vardar zone. The age of oceanic basalts which include Campanian limestones near Krupanj and contain Campanian sandy limestone interlayers at the northern flanks of

Kozara Mt. in western Bosnia, together with the volcanic-arc geochemical features of the trachydacitic rocks near Belgrade, as well as the position of the subduction related volcanism, indicate that the Western (oceanic) basin of the Vardar ocean terminated by an eastward oriented subduction during Senonian. The overstep sequence is (Late) Maastrichtian flysch. By the subduction and collision processes, as well as by the later horizontal movements of the blocks, a primarily distal trench melange and a volcanic arc, related to subduction, approached to each other.

These new results date the closure of the western branch, i.e. the last existing of the northern parts of the Vardar zone in the Senonian, most probably in Upper Campanian or Early Maastrichtian .

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