

Spilite from Kamešnica, Mt. Kalnik, NW Croatia

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Keywords: spilites, Mt. Kalnik, hydrothermal alteration, Cretaceous volcanism

Ključne riječi: spiliti, Kalnik, hidrotermalna izmjena, kređni vulkanizam

The results of microscopic and chemical investigation of spilites from the upper coarse of the stream Kamešnica and from its tributary Kalnički potok on Mt. Kalnik (north-western Croatia) have been described. Spilites are a result of postmagmatic hydrothermal alteration of the basic effusive rocks. They are of Upper Cretaceous age.

Opisani su rezultati mikroskopskog i kemijskog istraživanja spilita iz gornjeg toka Kamešnice i iz Kalničkog potoka na Kalniku u sjeverozapadnoj Hrvatskoj. Spiliti su nastali postmagmatskim hidrotermalnim izmjenama bazičnih efuzivnih stijena i gornjokredne su starosti.

1. INTRODUCTION

The present study deals with a number of spilite outcrops found in the northern part of the Kalnik range. These outcrops are located about 1.5 to 2 km north of Kalnička greda in the upper coarse of the stream Kamešnica and its right tributary Kalnički potok. Sampling locations of the ten selected and investigated samples are presented in Fig. 1.

clastic sediments with diabase and spilite in Kamešnica are added by ŠIMUNIĆ & ŠIMUNIĆ (1979). The area of Kamešnica was mapped as a zone of basic effusive rocks comprising of diabase, spilitised diabase and spilite (ŠIMUNIĆ et al., 1982). The results of detailed microscopic and chemical analyses of eruptive rocks from this area were presented by VRKLJAN (1989).

3. SUMMARY OF GEOLOGY AND FIELD RELATIONSHIP

The sediments which host the spilites in the upper coarse of Kamešnica are described (ŠIMUNIĆ & ŠIMUNIĆ, 1979, ŠIMUNIĆ, 1983) as those of heterogeneous petrographic composition, comprising of sandstone, shale, marl, chert, limestone, silicified limestone and tuff. The sequence hosts disparately arranged allochthonous blocks and fragments of dolomite, limestone and sandstone of Triassic, Jurassic and Cretaceous age. The sequence contains eruptive rocks, and the limestone fossil data indicate an Albian - Upper Cretaceous age of this complex.

The spilite outcrops are mainly small, their size is up to a few meters. A site of a small quarry is the largest exposed outcrop of spilite, about 80 m wide and located upstream from the mouth of the Drenovčak on the right bank of Kamešnica (Pl. I, Fig. 1). The eruptives are intensely weathered, with altered and crumbly surfaces. The dense vegetation and the humus layer cover the edges of the outcrops.

4. RESULTS AND DISCUSSION

The region of the upper coarse of Kamešnica was sampled with 30 samples out of which 10 were analysed in detail both microscopically and chemically.

The rocks are of green and gray nuance with uneven impregnations of a red-violet pigment, and have uneven,

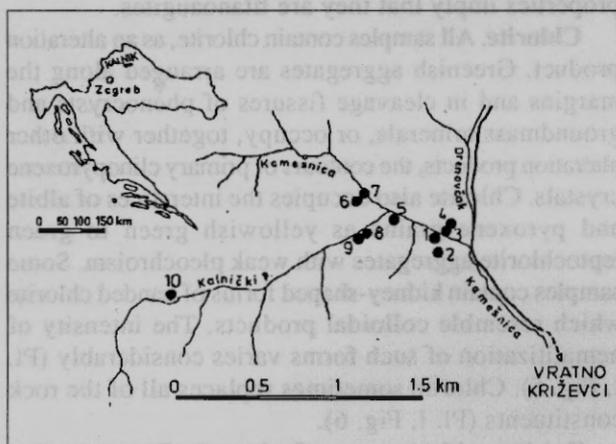


Fig. 1. The position of Kalnik and sampling locations.
Slika 1. Položaj Kalnika i mjesta uzimanja uzoraka

2. PREVIOUS INVESTIGATIONS

Occurrence of exposed sections of diabase rock in the stream of Kamešnica was first mentioned by WOLF (1861-62). Microscopic analyses of diabase occurrences from Kamešnica were presented by KIŠPATIĆ (1913). Apart from the weathered diabase, in the stream he found olivine diabase and olivine gabbro pebbles. The position of weathered diabase outcrops was confirmed by POLJAK (1914, 1942). He observed that the exposed diabase extruded on the contact between Oligocene and Cretaceous sediments. Well exposed Upper Cretaceous

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step-like or weak shelly fracture. They are clearly aphanitic. Irregular veinlets ranging from very thin to about 6 mm thick are common.

4.1. INDIVIDUAL MINERALS

The analysed rocks have quite uniform mineral composition with distinct differences in abundance, size, number and disposition of the constituents. All samples contain albite, clinopyroxene, chlorite and the minerals of the zoisite-epidote group. A majority of the samples contain calcite, magnetite, hematite and titanite. Minerals such as quartz, ilmenite, sericite (illite?), zeolite, prehnite, pyrite, pumpellyite and clay minerals occurred only in a few samples.

Albite. Only in several porphyritic rocks is albite present as phenocrysts and in the groundmass. Sample 7 contains numerous albite phenocrysts, mainly in clusters (Pl. I, Fig. 2), while some samples contain only rare phenocryst clusters.

The phenocrysts are usually subhedral. The largest of these have dimensions of about 0.8 x 0.5 mm, and are commonly simple twins or polysynthetic twins. Some grains show symmetrical extinction angles $< 5^\circ$. The grains contain inclusions of chlorite, calcite, minerals of the zoisite-epidote group, and sporadically clay minerals.

The main constituent of the porphyritic rock groundmass is also albite. The largest sections are 0.5 mm long and 0.06 mm wide. The polysynthetic twins are usually of the albite law. They are arranged like the plagioclases in the diabase (Pl. I, Fig. 3). Lath-shaped and acicular sections aligned bundly and fan-like occur in some samples (Pl. I, Fig. 4). A subparallel arrangement in some samples indicates a trachytic texture. Groundmass albites contain frequently inclusions of chlorite, minerals of the zoisite-epidote group, calcite or still very small undetermined colourless to greenish inclusions. Rarely, they contain inclusions of sericite (illite?) and prehnite. The inclusions sometimes cover the whole surface of the section, while elsewhere margins or central parts, and sometimes occur along cleavage fissures.

The size of albite crystals in rocks of aphyric texture varies in each individual sample. The dimensions of the largest sections are 1.45 x 0.97 mm. By means of the theodolitic microscope measurements chemical compositions of three grains from one sample were determined. It varies from 5 to 10 % an. The measured angle $2V$ is positive. Albites of aphyric rocks are very similar to those of porphyritic texture, but the former contain also inclusions of pumpellyite and titanite with leucoxene.

All the sections of albites at the contact with Canada balsam have at least one refractive index less than that of the balsam.

Clinopyroxene. Only two samples contain preserved phenocrysts of clinopyroxene mainly as rare four-sided sections of a light-skinpink colour. Some samples sporadically contain only their small relict fragments,

while other samples retained only euhedral and subhedral contours of either individual or clustered phenocrysts. Various in size, the largest are 0.7 x 0.5 mm. The largest isometric sections are about 0.5 mm in diameter. Their most common replacement products are chlorite, zoisite-epidote group of minerals, calcite and sporadically hematite.

Groundmass pyroxenes in samples with porphyritic texture occur as fine isometric sections with diameters up to 0.06 mm or as short prismatic sections up to 0.56 x 0.05 mm. In some samples relict fragments of clinopyroxenes are observed, and in sample 1 only their contours containing secondary minerals are preserved. A few samples contain skeletal clinopyroxenes with shapes that give the appearance of a spinifex texture. They have pink-brown colour with very weak pleochroism. The pyroxenes are cracked, and often have irregular extinction, and in sample 6 they show "hourglass structure". Replacement products are: epidote-zoisite, chlorite, calcite and hematite. Some rims are opacitized.

Apart from the already mentioned alteration products, clinopyroxenes in aphyric rock samples contain titanite, partly altered to leucoxene. Hematitized magnetite and comby, poorly hematitized ilmenite were also observed. Optical properties of clinopyroxenes in one sample were determined by means of the theodolitic microscope. The measured extinction angle $Z:c$ which ranges from 45 to 52° and $+2V$ from 50 to 53° and other observed properties imply that they are titanogaugites.

Chlorite. All samples contain chlorite, as an alteration product. Greenish aggregates are arranged along the margins and in cleavage fissures of phenocrysts and groundmass minerals, or occupy, together with other alteration products, the contours of primary clinopyroxene crystals. Chlorite also occupies the interstices of albite and pyroxene grains as yellowish green to green lepto-chlorite aggregates with weak pleochroism. Some samples contain kidney-shaped forms of banded chlorite which resemble colloidal products. The intensity of hematitization of such forms varies considerably (Pl. I, Fig. 5). Chlorite sometimes replaces all of the rock constituents (Pl. I, Fig. 6).

Zoisite-epidote group of minerals. Determination of epidote as a replacement product of clinopyroxene or as a mineral that occupies vesicles was possible only in some cases. Most samples contain numerous fine-grained aggregates of colourless to greenish minerals with high refraction indexes and low to bright interference colours. These probably belong to zoisite-epidote group of minerals.

Calcite is present in almost all investigated rock samples. It is one of the alteration products of original minerals, and in places almost completely fills the contours of original clinopyroxenes. Sporadically, just like chlorite, it replaces all of the rock constituents.

Magnetite. In most samples magnetite occurs either on rims and in fissures of altered and opacitized clinopyroxenes or as subhedral and anhedral grains of

various size unevenly dispersed over the whole sample section. It is abundant in sample 3.

Hematite. Magnetite is commonly partly altered to hematite, and in most rock samples these minerals occur together. In some samples hematite is also an alteration product of comby ilmenite. Sporadically uneven impregnations of hematite are present in spaces between albites and clinopyroxenes.

Titanite. A majority of samples contain titanite as an alteration product of clinopyroxene. Sometimes it is partly altered to leucoxene.

Quartz. Few samples contain quartz either in the groundmass of porphyritic rocks, or in interstices of albites and clinopyroxenes in aphyric rocks.

Ilmenite. Comby and skeletal crystal shapes and only rarely irregular sections of ilmenite occur in a few samples mainly in contours of previous clinopyroxenes together with chlorite, magnetite and titanite. Usually it is partly altered to leucoxene.

Sericite (illite?). Some samples contain alteration products of original plagioclase which resemble sericite and illite.

Zeolite. A small quantity of zeolite occurs in one sample in the space between essential minerals. By means of optical investigation it was not possible to determine the type of zeolite and separation due to small quantities was also impracticable.

Pyrite is observed in two samples as rare, fine, weakly hematitized grains. In sample 7 the larger impregnations are present on the margins of a thin fissure.

Prehnite, pumpellyite and clay minerals occur rare in company with other alteration products as inclusions in the albites.

The numerous amygdules and veinlets are of various size, shape, number and composition. Chlorite is their usual constituent. Some contain only chlorite while others in addition contain calcite, quartz, epidote and zeolite. In some amygdules chlorite occurs on their margins (Pl. II, Fig. 1), and in others in their central parts. The walls of the amygdules filled with epidote are surrounded by a narrower or wider zone consisting of an opaque aggregate (Pl. II, Fig. 2). The similar zone about 0.5 mm wide surrounds some vesicles filled with calcite of irregular extinction (Pl. II, Fig. 3). This zone contains finely dispersed leucoxene, iron oxides and very fine vesicles about 1.3-0.4 mm in diameter filled with calcite, chlorite and epidote. Quartz and zeolite fill scarce vesicles and veinlets. Hematite occurs rarely in veinlets as impregnations together with colloidal chlorite. Titanite occurs in veinlets also rarely.

Some samples contain, together with the above mentioned minerals, numerous micro to cryptocrystalline colourless to greenish arborescent aggregates and fan-like and dendritic aggregates, whose determination was not possible (Pl. II, Fig. 4).

4.2. STRUCTURAL AND TEXTURAL VARIETIES

In the investigated area of a relatively small surface

and short distance between outcrops a number of structural and textural varieties are observed.

A smaller number of samples display an homogeneous structure. The amygdaloid structure prevails.

The rocks of homogeneous structure are porphyritic and show a relict intergranular-intersertal to hyalophitic groundmass texture. The rocks of amygdaloidal structure occur both as porphyritic and aphyric varieties. Porphyritic rocks have various groundmass texture: relict intergranular-intersertal to hyalophitic, coarse arborescent with poorly expressed properties of a pilotaxitic, and a fine arborescent. Aphyric rocks have relict intergranular to intersertal texture with more or less expressed features of a hyalophitic texture. One sample has a relict hyalopilitic texture with barely noticeable characteristics of a relict intersertal texture.

In most porphyritic samples the texture is glomeroporphyritic.

4.3. CHEMICAL COMPOSITION AND CLASSIFICATION

Bulk rock chemical composition of 10 spillite samples and the calculated CIPW norms are presented in Table 1. The chemical composition is characterized by high abundances of Na and Al and low abundances or even absence of K. The high content of Na in relation to primary basalt is related to secondary albite enrichment of all samples due to spilitization. High Al is the result of its association with numerous secondary chlorites. According to MERRIMAN et al. (1986) K-feldspar

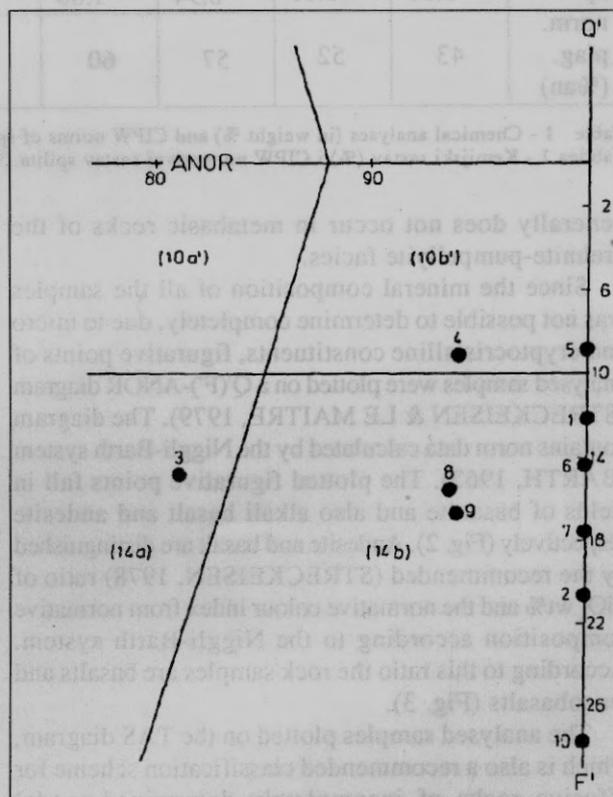


Fig. 2. Q'(F)-ANOR diagram after STRECKEISEN & LE MAITRE (1979).
Slika 2. Q'(F)-ANOR dijagram (STRECKEISEN & LE MAITRE, 1979).

	1	2	3	4	5	6	7	8	9	10
SiO ₂	40.81	41.18	44.02	42.72	49.12	47.01	44.62	45.65	44.87	44.13
TiO ₂	2.50	1.73	1.91	2.10	1.59	1.70	1.41	1.94	1.94	0.89
Al ₂ O ₃	17.82	18.42	15.66	18.92	18.21	15.59	16.43	14.28	18.09	15.05
Fe ₂ O ₃	2.65	2.99	4.60	2.89	2.61	3.47	3.25	2.88	4.61	2.84
FeO	5.79	4.63	2.51	5.31	6.32	7.23	7.94	4.57	3.52	5.53
MnO	0.18	0.16	0.10	0.18	0.12	0.12	0.16	0.08	0.16	0.13
MgO	12.70	9.76	4.29	9.99	5.33	5.94	6.57	5.06	9.96	8.77
CaO	4.61	8.45	13.87	7.04	6.41	9.51	10.78	12.31	4.50	11.46
Na ₂ O	4.58	4.56	4.33	4.07	6.17	5.25	4.30	4.40	6.20	4.38
K ₂ O	0.00	0.00	0.82	0.36	0.00	0.00	0.00	0.22	0.24	0.00
P ₂ O ₅	0.44	0.40	0.37	0.42	0.14	0.37	0.11	0.39	0.25	0.03
H ₂ O ⁺	4.81	4.50	4.53	4.73	3.80	2.89	3.21	4.06	4.40	3.71
H ₂ O ⁻	1.37	0.79	0.55	0.87	0.58	0.52	0.36	0.59	0.84	1.24
CO ₂	2.54	3.11	2.87	0.79	0.00	0.18	0.95	4.16	1.14	2.19
Σ	100.80	100.68	100.43	100.39	100.40	99.78	100.09	100.59	100.72	100.35
C	3.06	-	-	-	-	-	-	-	-	-
or	-	-	5.28	2.22	-	-	-	1.45	1.50	-
ab	29.87	19.39	16.87	25.68	43.65	31.75	21.17	25.62	35.79	16.14
an	22.24	32.25	22.52	34.36	22.85	19.68	26.66	20.18	22.05	22.94
ne	6.53	12.13	12.30	5.91	5.79	7.81	9.14	8.07	10.71	12.78
di	-	8.46	25.06	0.13	7.61	21.98	23.29	34.87	0.11	30.27
wo	-	-	7.25	-	-	-	-	-	-	-
ol	28.03	18.59	-	22.04	12.70	9.35	11.74	0.33	18.45	11.58
mt	4.18	4.71	3.06	4.45	3.94	5.24	4.94	4.55	6.59	4.43
hm	-	-	2.86	-	-	-	-	-	0.35	-
il	5.17	3.56	3.94	4.24	3.13	3.36	2.81	4.12	3.92	1.81
ap	1.01	1.01	0.94	1.08	0.37	0.91	0.27	1.01	0.60	0.07
norm. plag. (%an)	43	52	57	60	34	38	56	44	38	59

Table 1 - Chemical analyses (in weight %) and CIPW norms of spilites
 Tablica 1 - Kemijski sastav (%) i CIPW normativni sastav spilita (%)

generally does not occur in metabasic rocks of the prehnite-pumpellyite facies.

Since the mineral composition of all the samples was not possible to determine completely, due to micro and cryptocrystalline constituents, figurative points of analysed samples were plotted on a Q'(F)-ANOR diagram (STRECKEISEN & LE MAITRE, 1979). The diagram contains norm data calculated by the Niggli-Barth system (BARTH, 1962). The plotted figurative points fall in fields of basanite and also alkali basalt and andesite respectively (Fig. 2). Andesite and basalt are distinguished by the recommended (STRECKEISEN, 1978) ratio of SiO₂ wt% and the normative colour index from normative composition according to the Niggli-Barth system. According to this ratio the rock samples are basalts and leucobasalts (Fig. 3).

The analysed samples plotted on the TAS diagram, which is also a recommended classification scheme for effusive rocks of incompletely determined modal composition (LE BAS et al., 1986), fall into the fields of basic rocks (Fig. 4).

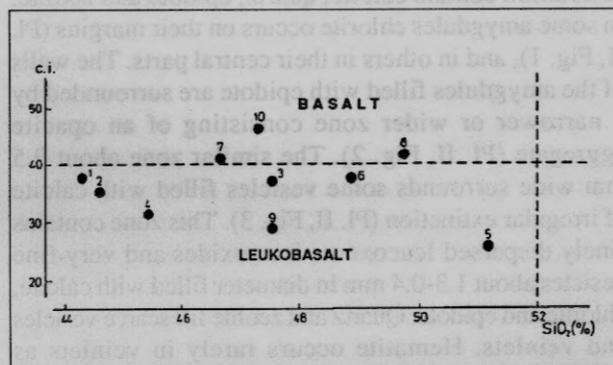


Fig. 3. c.i. - SiO₂ diagram after STRECKEISEN (1978).
 Slika 3. c.i. - SiO₂ dijagram (STRECKEISEN, 1978.).

On the basis of mineral constituents and their relationships, structure, texture, chemical composition and the presented diagrams, all the rocks can be classified as spilite.

4.4. GENESIS

The present mineral composition and chemistry of the investigated rocks are a result of intensive

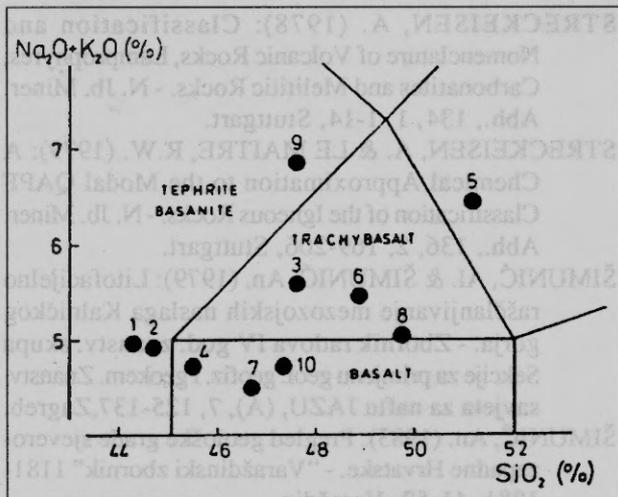


Fig. 4. TAS diagram after LE BAS et al. (1968).
Slika 4. TAS dijagram (LE BAS et al., 1968).

postmagmatic hydrothermal alteration, notably spilitization. Since alteration has affected all rocks the character of the initial magma cannot be determined.

On the $\text{SiO}_2 - (\text{Na}_2\text{O} - \text{K}_2\text{O})$ diagram (KUNO, 1968) and the ne-ol-di-hy-Q diagram (YODER & TILLEY, 1962) figurative points of the analysed samples plot in

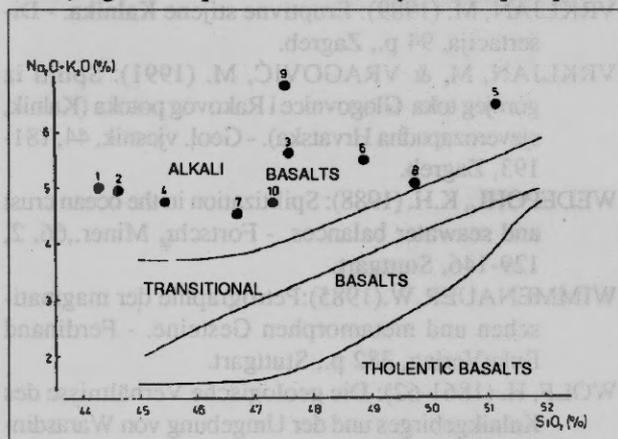


Fig. 5. $\text{SiO}_2 - (\text{Na}_2\text{O} + \text{K}_2\text{O})$ diagram after KUNO (1968).
Slika 5. $\text{SiO}_2 - (\text{Na}_2\text{O} + \text{K}_2\text{O})$ dijagram (KUNO, 1968).

the fields of alkali basalt (Fig. 5) and alkali olivine basalt (Fig. 6) respectively. This is due to the high Na resulting from spilitization, intensive chloritization and removal of excess Si.

The prevailing amygdaloidal structure implies an expansion of gasses and vapour from lava extrusions on or near the surface. Also rapid crystallization is implied by dominating relict microdiabase textures, sometimes with arborescent shapes, such as skeletal pyroxene of spinifex texture. This features suggest quick solidification of magma due to rapid cooling (WIMMENAUER, 1985).

Variation of textures on a relatively short distance infers to various positions of cooling inside the magmatic bodies.

Distinct pillow structures (Pl. II, Fig. 5) imply submarine lava extrusions. During such extrusions sea water can penetrate into the contraction cracks and cause spilitization (WEDEPOHL, 1988). However, some

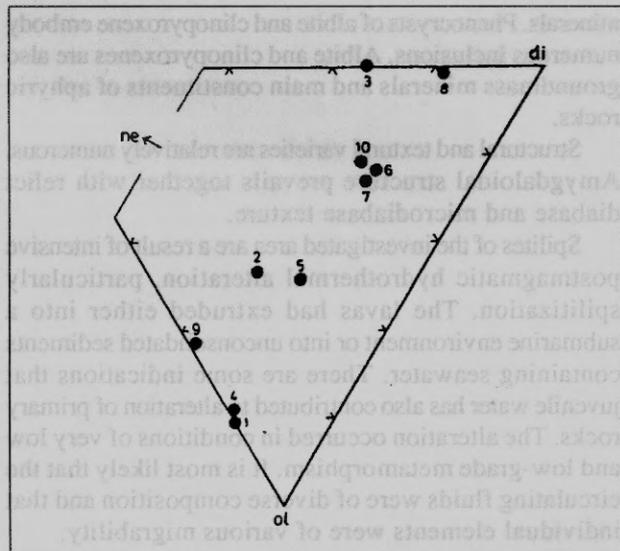


Fig. 6. ne-ol-di-hy-Q diagram after YODER & TILLEY (1962).
Slika 6. ne-ol-di-hy-Q dijagram (YODER & TILLEY, 1962).

outcrops exhibit no pillow structures, no contraction cracks, suggesting an assumption that unconsolidated sediments, into which basalt intruded, contain seawater, a source of Na for spilitization. Juvenile water could have also caused spilitization by imbuing the rocks and reacting with primary basalt minerals and engendering their alteration.

Beside spilitization, other hydrothermal alterations were observed, suggesting a variable composition of circulating solutions and migrability of individual elements. The alteration occurred in conditions of very low to low-grade metamorphism. Depletion of K in submarine basalts is interpreted by WEDEPOHL (1988) as an alteration of basalt in an open system at temperatures exceeding 150° .

Direct contact of eruptive with surrounding sediments was not observed in the investigated area. Sediments that embody the investigated spilites are Upper Cretaceous in age (ŠIMUNIĆ & ŠIMUNIĆ, 1979, ŠIMUNIĆ, 1983). Spilites from the area of the upper coarse of Kamešnica are analogous in mineral composition, structure, texture and even chemical composition to spilites of other parts of Kalnik (VRKLJAN, 1988, 1989, VRKLJAN & VRAGOVIĆ, 1991), for which an Upper Cretaceous age is presumed. Thus an extension of this age to the investigated spilites is possible.

5. CONCLUSION

The spilites from the upper coarse of Kamešnica, together with sediments of heterogeneous petrographic composition, compose a heterogeneous complex of Upper Cretaceous age.

All the samples contain albite (5 - 10% an), clinopyroxene (titanoaugite), chlorite and minerals of the zoisite-epidote group. Most samples include also calcite, magnetite, hematite and titanite. Other minerals, present according to quantity, are quartz, ilmenite, sericite (illite?), zeolite, prehnite, pyrite, pumpellyite and clay

minerals. Phenocrysts of albite and clinopyroxene embody numerous inclusions. Albite and clinopyroxenes are also groundmass minerals and main constituents of aphyric rocks.

Structural and textural varieties are relatively numerous. Amygdaloidal structure prevails together with relict diabase and microdiabase texture.

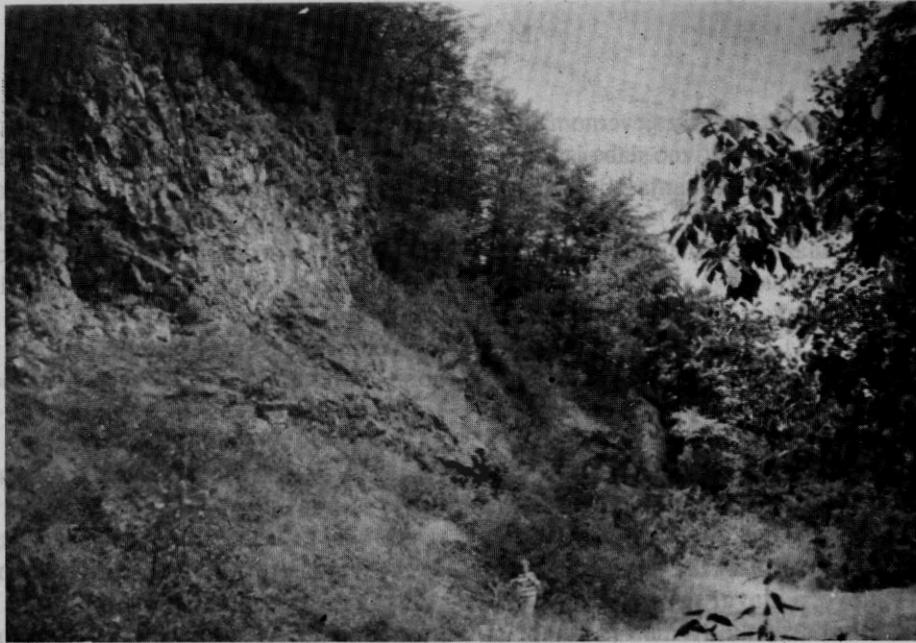
Spilites of the investigated area are a result of intensive postmagmatic hydrothermal alteration, particularly spilitization. The lavas had extruded either into a submarine environment or into unconsolidated sediments containing seawater. There are some indications that juvenile water has also contributed to alteration of primary rocks. The alteration occurred in conditions of very low and low-grade metamorphism. It is most likely that the circulating fluids were of diverse composition and that individual elements were of various migrability.

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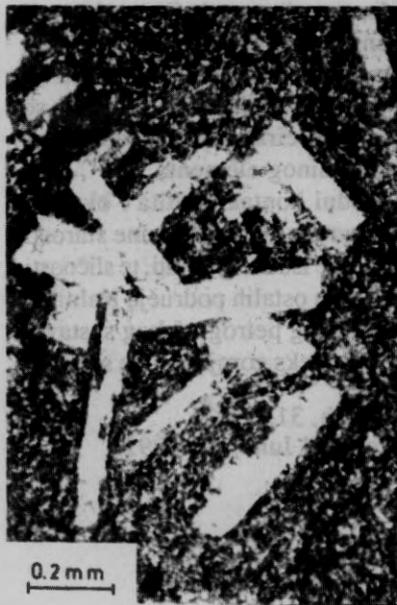
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PLATE - TABLA 1

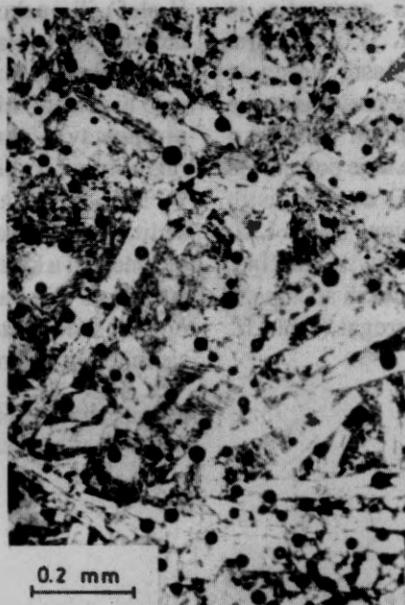
1. Outcrop of spilite, Kamešnica.
Izdanak spilita, Kamešnica.
2. Albite phenocrysts in clusters, N (sample 7).
Nakupine fenokristala albita, N (uzorak 7).
3. Relict diabase texture, N (sample 3).
Reliktna dijabazna struktura, N (uzorak 3).
4. Bundly and fan-like albites, N.
Svežnjasti i lepezasti agregati albita, N.
5. Chlorite of colloidal shape impregnated with hematite, N.
Klorit koloidalnog oblika impregniran hematitom, N.
6. Chlorite replaces all of the rock constituents, N+ (sample 3).
Klorit potiskuje sve sastojke stijene, N+ (uzorak 3).



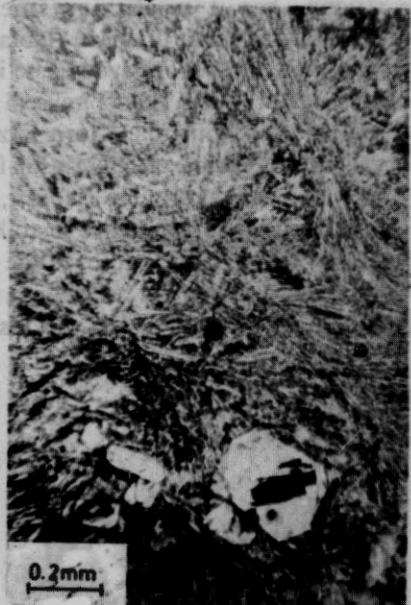
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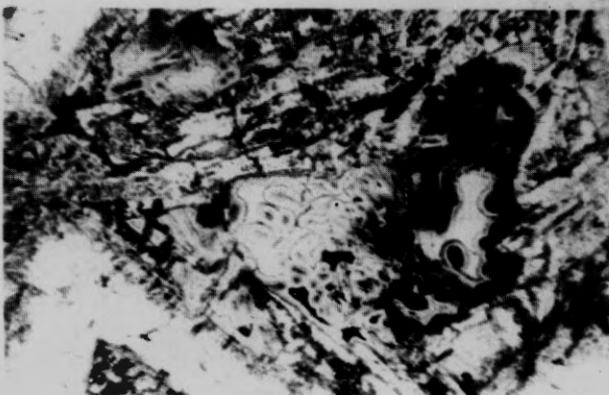
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5



6

Spiliti iz gornjeg toka Kamešnice, Kalnik, SZ Hrvatska

M. Vrkljan

Spiliti iz gornjeg toka Kamešnice na sjevernom dijelu Kalničkog gorja bili su do sada relativno slabo istraženi. Na sl. 1. naznačena su mjesta uzimanja 10 detaljnije istraženih uzoraka.

Eruptivne stijene se nalaze u sedimentnim naslagama heterogenog petrografskog sastava starosti alb-gornja kreda. Najveći izdanak je lokacija nekadašnjeg manjeg kamenoloma (tabla I, sl. 1).

Svi uzorci sadrže albit, klinopiroksen, klorit i minerale iz grupe coisita i epidota. Većina uzoraka sadrži kalcit, magnetit, hematit i titanit. Ostali minerali, po zastupljenosti, su kvarc, ilmenit, sericit (ilit?), zeolit, prehnit, pirit, pumpeliit i minerali glina. Fenokristali su zastupljeni albitom (tabla I, sl. 2) i klinopiroksenom, a sadrže brojne uklopke. Albit i klinopiroksen nalaze se i kao minerali osnove, a glavni su sastojci i afirnih stijena. Teodolitnomikroskopski utvrđen je kemizam albита (5 - 10% an), a klinopiroksen je determiniran kao slabotitanski augit. Raspored albита u osnovi porfirnih stijena, kao i u afirnim stijenama ponegdje je karakterističan za dijabaze (tabla I, sl. 3), a u nekim uzorcima albiti tvore svežnjaste i lepezaste agregate (tabla I, sl. 4). Albiti i klinopirokseni sadrže brojne uklopke sekundarnih minerala. Klorit je zastupljen obilno i u različitim oblicima, od bubrežastih forma koje podsjećaju na koloidalne tvorevine (tabla I, sl. 5) do lističastih agregata koji potiskuju sve sastojke stijena (tabla I, sl. 6). Mnogobrojne mandule i žilice različite su veličine, oblika, zastupljenosti i sastava, a oko nekih se zapaža uža ili šira rub koji sadrži opacitski agregat (tabla II,

sl. 1-3). Osim navedenih minerala u nekim se uzorcima zapažaju obilni mikro do kriptokristalasti bezbojni i zelenkasti arborescentni sastojci, te lepezaste i dentritične tvorevine, koje je teško prepoznati (tabla II, sl. 4).

Teksturno-strukturni varijeteti su relativno brojni. Prevladava amigdaloidna tekstura, te reliktna dijabazna i mikrodijabazna struktura.

Kemijski sastav istraženih uzoraka spilita i njihov normativni sastav po CIPW sustavu navedeni su u tablici 1. Figurativne točke unijete su u Q' (F') - ANOR, SiO₂-c.i. i TAS dijagrame koji su prikazani na sl. 2-4.

Karakter ishodne magme ne može se utvrditi, a na dijagramima SiO₂-(Na₂O+K₂O) i ne-ol-di-hy-Q figurativne točke nalaze se u poljima alkalijskih bazalta (sl. 5) odnosno alkalijskih olivinskih bazalta (sl. 6).

Spiliti istraženog područja rezultat su intenzivnih postmagmatskih hidrotermalnih izmjena, osobito spilitizacije. Lave su se izljevale submarinski, na što ukazuju mjestimice lijepo izražene pillow-strukture (tabla II, sl. 5), ili u nekonsolidirane sedimente koji su sadržavali morsku vodu. Na izmjenju primarnih stijena utjecale su i juvenilne vode. Stijene su izmijenjene u uvjetima od vrlo niskog do niskog stupnja metamorfoze, a može se pretpostaviti različiti sastav cirkulirajućih otopina i različita migrabilnost pojedinog elementa.

Nije zapažen neposredni kontakt spilita i okolnih sedimenta. Na osnovi utvrđene gornjokredne starosti sedimenta u kojima se nalaze istraženi spiliti, te sličnosti istraženih stijena sa spilitima ostalih područja Kalnika, oni, uz sedimente heterogenog petrografskog sastava, sačinjavaju heterogeni kompleks gornjokredne starosti.

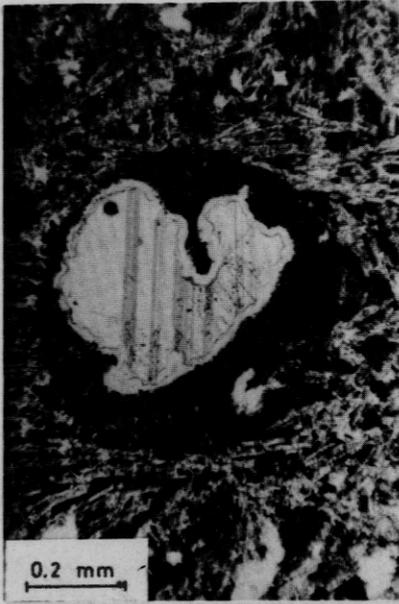
Manuscript received March, 31. 1992.

Revised manuscript accepted June, 29. 1992.

PLATE -TABLA II

1. Chlorite on the margin of an amygdule, N (sample 2).
Klorit na rubu mandule, N (uzorak 2).
2. An amygdule filled with epidote and surrounded by an opacite aggregate, N.
Mandula ispunjena epidotom i okružena opacitskim agregatom, N.
3. An opacite aggregate near the boundary of a vesicle filled with calcite, N.
Opacitski agregat uz rub mandule ispunjene kalcitom, N.
4. Microlites of albite and arborescent constituents of a rock, N (sample 5).
Mikroliti albита i arborescentni sastojci stijene, N (uzorak 5).
5. Spilite of pillow structure, Kamešnica.
Kuglasto lučenje spilita, Kamešnica.

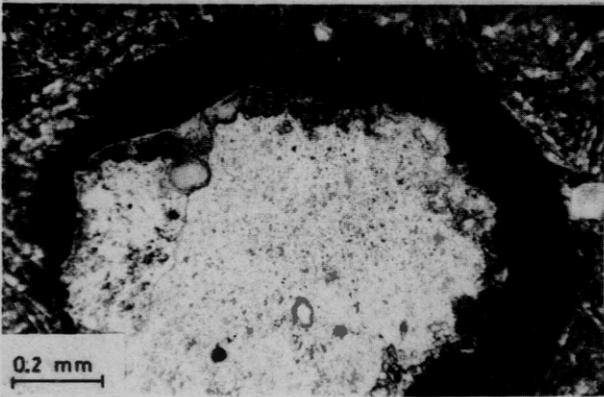
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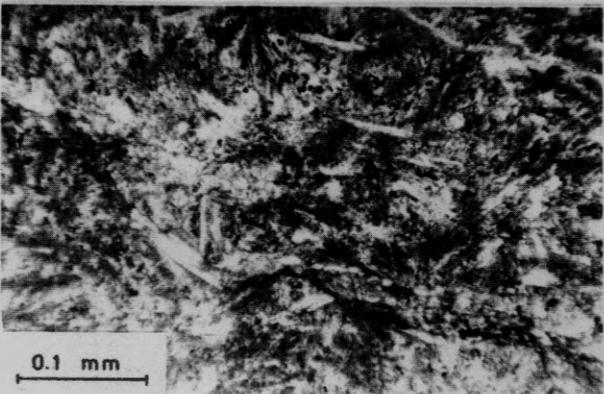
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