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RADIOMETRIC DATING OF MESOZOIC BASIC ERUPTIVE ROCKS OF THE KRÍŽNA NAPPE IN THE NW PART OF THE LOW TATRA

(Tabs. 1—2, Fig. 1)

Abstract: The Mesozoic of the Central West Carpathians is generally poor in occurrences of volcanics. The Krížna nappe is one of the units where basic effusive rocks-basalts accompanied by volcanoclastics are present in the Cretaceous. Basalts with olivine, augite and amphibole of analogous character from vein bodies cutting Middle and/or Upper Triassic carbonates of the same unit.

Radiometric ages of 106 — 116 m. y. for vein bodies in the Middle and/or Upper Triassic are identical with the geological position of the effusive bodies in the Lower Cretaceous. All occurrences are products of the Lower Cretaceous volcanism.

Резюме: Мезозойская система центральных Западных Карпат в общем бедная местонахождениями вулканитов. Крижнянский покров является одной среди единиц в которой в меловой системе находятся основные эффузивные базальты, которые сопутсвуют вулканические кластика. Приблизительный характер базальтов с оливином, аугитом и амфиболом имеют жильные тела пробивающие карбонаты среднего или также верхнего триаса той самой единицы.

Радиометрическое датирование 106—116 мил. лет в согласии для жильных тел в среднем и в верхнем триасе и для вызвержных тел в самой нижней меловой системе. Тоже на основе того все местонахождения жильных тел в триасе крижнянского покрова находятся в связи с нижнемеловым вулканизмом.

Position of vein bodies in the Middle Triassic of the Krížna nappe

Basic eruptive rocks in Neocomian marly limestones of the so called Lower Subtatric (Krížna) nappe were mentioned first by J. Koutek (1930) as basic lavas (augitites) and tuffs. With more detailed investigation of the Mesozoic of NW part of the Low Tatra we have found new occurrence of basic rocks. They are eruptive rocks in Middle to Upper Triassic dolomites of the Krížna nappe and are found east of elev. p. Salatín 1630 (situation point 783) and near Salatínka (situation point 237 b). At both localities relatively thin (12-10 m) bodies of eruptive rocks of orientation transversal to bedding occur. Thickness of dolomites in the site of exposures of eruptives is about 450 m. The bodies of eruptive rocks are of straight course and elongated shape, attaing up to 100 m of observed length at exposure. East of elev. p. Salatín the eruptive rocks fill up a crosscut-shaped groove of dislocation origin of several metres thickness. The contact-thermic effects of the bodies on dolomites are very weak. In the body near Salatínka locally pyrite mineralization with intensive limonitization is observed at the contact with dolomites. The dolomites in proximity of the bodies are pure dolomitic bio-

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micrites without volcanoclastic material. In thin sections from dolomites the following frequency of microfacial elements was found: organic remains 10/18, lamellibranchs-brachiopods? 4/18, gastropods 5/18, ostracodes 4/18, crinoid stems 4/18, foraminifers 2/18, brachiopods 7/18, cyanophyceans 1/18, filaments 1/18, calcified sponge spicules 1/18. Mineral elements — intraclasts 1/18, authigenic quartz 3/18, brown colloid 3/18, pyrite more than 0,02 mm 3/18, laminated structures 2/18, chalcedony quartzine 1/18 birds-eyes 1/18, microstylolites 1/18. Fauna has not been known from dolomites so far — H. Wolf (1867) mentioned *Coenothyris vulgaris* (Schlotheim, 1822) from light-grey limestones incorporated in dolomites. They are, however, Rhaetian limestones

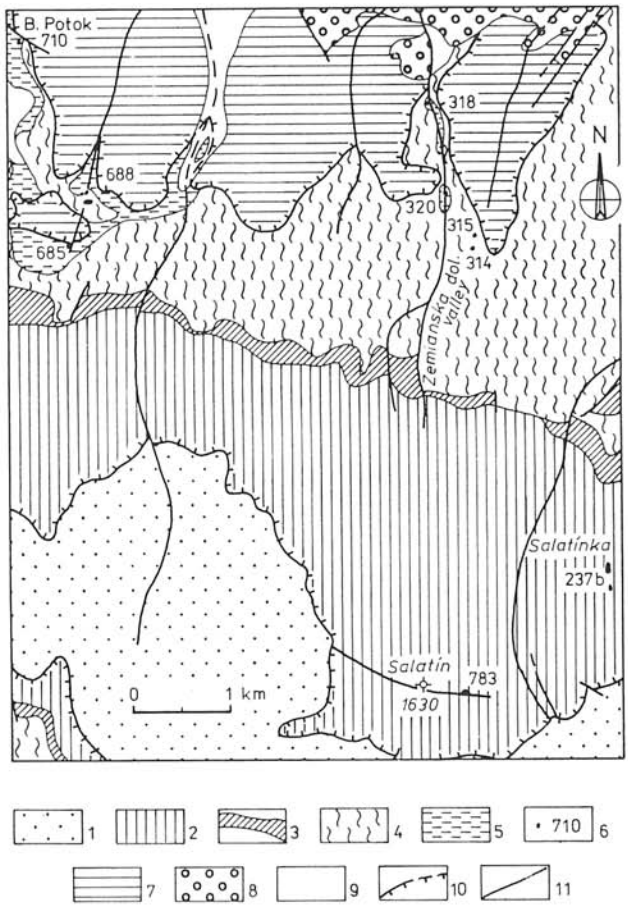

Fig. 1. Envelope group of Červená Magura (Lower Triassic — Lower Cenomanian); Križna nappe: 2. Gutenstein limestone and Ramsau dolomites (Middle Triassic); 3. Carpathian Keuper, Kössen beds, Gresten beds, Adneth limestones, radiolarites (Norian-Jurassic); 4. Marly limestones and marls (Tithonian-Hauterivian); 5. Sandy limestones and marls (Barremian — Lower Albian); 6. Basic eruptive rocks (Albian); 7. Choč nappe (Middle — Upper Triassic); 8. Paleogene of the Liptovská kotlina depression; 9. Quaternary; 10. Overthrust lines of nappes; 11. Faults.

with brachiopods, occurring at the southern slope of Červený Grúň (1180). Dasycladaceae in dolomites with basic bodies were found at the eastern slope of Salatín — *Diplopora annulata, Diplopora annulata* var. *dolomitica.* The mentioned diplopores approximately from the central part of dolomites point to Lower Ladinian. So far we have no paleontological evidence of the lower part of dolomites reaching even the Anisian from our territory. From the Carnian overlier of the Lunz beds it may be concluded that they range also in the Upper Ladinian or Carnian overlying the Lunz beds.

Petrographic characterization of eruptive rocks in Triassic dolomites

Eruptive rocks in dolomites of the Krížna nappe are of green, greyishblack to blackishgreen colour. The structure of rocks is medium — grained or fine-grained with megascopically observed phenocrysts of plagioclases and dark minerals. More rarely veinlets of calcite and epidote are observed. The texture is predominantly porphyritic. The prevailing groundmass is poikilitic with mutual overgrowing of amphiboles, amphiboles and plagioclases, then micro-grained, ophitic, vitrophyric and vitric.

Mineral composition: olivine is present in form of phenocrysts also in groundmass. It is idiomorphic and hypidiomorphic. It is chloritized and opacitized, at places also serpentinized.

Hornblende is preserved in form of phenocrysts rarely only. It is of prismatic habit and then up to 3 mm long. Besides that it is also in groundmass. Colouring to brown with distinct pleochroism predominates. Extinction γ/C to 28°. From alterations chloritization, epidotization, scarcely prehnitization predominate.

Augite is preserved in groundmass only. It was subjected to more intense alterations than amphibole. Chloritization and epidotization, limonitization predominate and serpentinization is more rare.

Plagioclases are highly decomposed, only in relict parts intergrowths according to albite law are observed. By methods of the symmetrical zone basicity An_{36}—An_{55} was establisched. From alterations albitization and sericitization predominate. After plagioclases are often pseudomorphs of epidote — zoisite, rarely also clacite is present.

Secondary minerals: chlorite, epidote, calcite formed mainly by alteration of dark minerals. More rarely also serpentine and prehnite are present. With alteration of feldspars mainly sericite formed.

Akcesory minerals: Apatite in forms of small idiomorphic grains and acicular titanite. Ore minerals: limonitized grains of pyrite and magnetite, which formed mainly by alteration of olivine.

In petrographic and chemical composition the above described basic eruptive rocks in position of veins in Middle Triassic dolomites of the Krížna nappe are similar to basalts occurring as effusive rocks in the Lower Cretaceous of the same tectonic unit.

Position of effusive bodies in the Neocomian of the Krížna nappe

They were described by J. Koutek (1930) as products of subaqueous volcanism. With more detailed study of the area, on the contrary to original

data, a much wider extent of basic bodies in Lower Cretaceous rocks of the Krížna nappe was established. Basic rocks form bodies of lenticular, elliptical to circular shape, which are piercing the surrounding environment i.e. Neocomian marly limestones in form of discordant veins and besides that, occur amidst this sequence as shallow — subsurface sills and interjacent bodies (Zemianska dolina valley). The content of glauconite and phosphate grains in Barremian to Lower Albian sandy glauconite limestoned points to a more shallow-water environment. The volcanoclastic material was described by J. Koutek (1930) from the stream-bed of the Zemiansky potok brook as concordantly lying layer in the Barremian to Lower Albian sequence. There are litho-crystalloclastic tuffs and tuffites cemented with white to greyishwhite carbonate. In the only one outcrop the rocks resemble hyaloclastite lavas of similar character as described by D. Hovorka — M. Sýkora (1980), M. Sýkora (1975) form the Veľká Fatra Mts. and A. Kullmanová — J. Vozár (1980) form the Lower Albian of the Krížna nappe near Bošáca and Beckov. The stratigraphic range of the sequence with basic volcanics is Barremian to Lower Albian. The lower boundary of the Barremian is indirectly indicated by the Upper Hauterivian subzone-*Pseudothurmannia angulicostata* and *Barremites difficilis* from the Lower Barremian. The assemblage of the Upper Barremian is characterized by the foraminifer species *Hedbergella infracretacea* GLAESNER. *Clavihedbergella subcretacea* TAPPAN and cephalopod *Barremites* cf. *strettostoma* UHL.. The Aptian is represented by benthic species of the genus *Lenticulina, Discorbis wassoeviczi* DJAFF. et AGALAROVA, *Pleurostomella obtusa* BERTHELIN and *Anomalina (Gavelinella) cf. rudis* REUSS. In the Clansajan to Lower Albian *Hedbergella roberti* GANDOLFI, *Haplophragmoides nonioninoides* REUSS, *Thalmanninella ticinensis* GANDOLFI and from cephalopods *Hoplites* sp. *predominate.*

Petrographic characterization of eruptive rocks in Neocomian limestones

The rocks are prevailingly of green colour with various shades of blackish-green to brownishgreen and greyishgreen. They distintegrate mostly irregularly. In marginal parts of the effusive bodies they are highly brecciated, similar to hyaloclastites. In sills the structure is fine-porphyritic with fine-grained groundmass. Amygdoloidal-porous structure was observed mainly in the marginal parts of veins but especially in all effusive bodies. The pores are filled up with secondary minerals, their cross-section is circular, ellipsoidal, rarely lobate. The colour of mineral filling of pores is white, greyishwhite. The size of amygdales is 2 mm, rarely up to 4 mm. Grain size of groundmass is less than 0,4 mm in all described structures, only seldom in the relatively coarser-grained groundmass up to 0,8 mm. The phenocrysts of plagioclases, amphiboles and olivine in the porphyritic variety are 0,6—1 4 mm in size. They reach rarely up to 3 mm. Besides the mentioned minerals epidote, calcite and chlorite may be observed megascopically, Brecciated rocks of hyaloclastite character are observed in marginal parts of effusive bodies. They are of greyisgreen colour. The fragments are exclusively formed by chloritized mass. Very often they are connected with one another,

of irregular delimitation. The groundmass, filling up the spaces between them, is carbonate, often recrystallized. This type genetically mostly resembles hyaloclastites originated by transport of lava into a relatively cooler water environment with carbonate sedimentation. Here sudden cooling and fragmentation of lava took place, the free spaces were filled up with carbonate, with which lava reacted. A similar character of hyaloclastite lavas was described by D. Hovorka — M. Sýkora (1979) and A. Kullmanová — J. Vozár (1980).

In vein bodies the texture of groundmass is predominantly poikilitic with characteristic mutual intergrowth of amphiboles or amphiboles and plagioclases. In effusive forms the texture is poikilophitic, micro-ophitic, vitric, porphyritic. Only locally vitroporphyritic texture is predominating in the porphyritic variety.

Mineral composition: olivine is represented in form of idiomorphic and hypidiomorphic phenocrysts. It is hemmed by limonite, frequent is its alteration into magnetite (opacitization). The most intense alteration of olivine is chloritization and serpentinization. The products of both alterations form pseudomorphs after olivine.

Hornblende is preserved in form of phenocrysts also in the groundmass. As phenocrysts of prismatic habit they often attain the size up to 3 mm. From alterations bleaching, chloritization and limonitization may be identified.

Augite is present in form of phenocrysts in the groundmass. It forms individuals of various orientation. It is coloured brownish, brownishgreen, with weak pleochroism. It is intensely chloritized, limonitized and epidotized.

Plagioclases are mostly intensely altered, only in relict parts basicity An_{36}—An_{54} may be found. Plagioclases are in form of decomposed phenocrysts but mainly in groundmass. They form laths which are often overgrowing, in some places poikilitic intergrowth with amphibole is to be seen. Only locally clusters of large individuals of plagioclases (up to 3 mm) were observed, which are even 80 % altered (albitization and sericitization). More rarely epidote and calcite formed with their alteration.

The groundmass is vitreous, highly chloritized, also limonitized. In the groundmass only sporadically individuals of highly chloritized biotite or pseudomorphs of chlorite and limonite after biotite occur. From secondary minerals chlorite and calcite are predominating in the filling of amygdales and veinlets.

Ore minerals: magnetite, limonite, pyrite and chalcopyrite. Besides that titanite was observed and J. Koutek (1930) mentioned also titanomagnetite. In accessory amount short-prismatic apatite was found.

On the basis of the above mentioned knowledge we hold the opinion that the studied eruptive rocks form shallow-subsurface vein fillings and effusive bodies in Neocomian limestones. On the basis of the occurrence in the Krížna nappe at the NW slopes of the Low Tatra their age is Lower to Middle Cretaceous. We ascribe a Lower Albian age to analogous products of volcanism in the Krížna nappe in the Považský Inovec Mts. according to micropaleontological data of A. Kullmanová — J. Vozár (180). In their general character the rocks belong to basalts with a distinct content of oli-

vine or amphibole and augite, however, the grade of alteration of these dark minerals in many samples renders a more detailed study as well as a more precise determination of modal composition difficult.

Results of geochronological investigation

From basic eruptive rocks occurring in form of veins in the Middle Triassic we used samples from the material of A. Bujnovský for geochronological investigations. They are two samples from basic bodies piercing Middle or Upper Triassic dolomites of the Krížna nappe in the dolomite complex of Salatín 1440 m — eastern ridge (sample No. 783/70) and near Salatínka (sample No 237 b). In both samples are augites and amphiboles relatively well preserved, mostly 0,5 — 3,0 mm in size. The samples selected from the whole collection of the study material did not contain amygdales and showed a lower degree of calcification only.

From basic eruptive rocks occurring in Neocomian marly limestones of the Krížna nappe we had samples from the Zemianská dolina valley, east of elev. p. 754 (sample No 315/69) and from the eastern surroundings of Biely Potok, about 50 m west of elev. p. 601,8 (sample No 710) from the Barremian — Lower Albian sequence. The first of them represents an amygdaloidal type. In both are augite as well as amphibole phenocrysts, also groundmass affected by intense alterations. Regarding to the state of preservation of minerals and limited amounts of the material of samples it was not possible to obtain un- or only slightly altered amphiboles or augites in sufficient amount. For the reasons mentioned they do not represent a material suitable for radiometric dating.

In order to get a certain picture of the age of both groups of basic rocks under the given conditions from Triassic dolomites and Neocomian marls — as well as of their relations, we have chosen this approach:

We dated radiometrically basic rocks from Triassic dolomites mainly according to pure concentrates (augite, amphibole) as well as according to whole rocks samples.

Neocomian and Barremian to Lower Albian rocks was possible to date on whole rock samples only.

1. Eruptive rocks from the Triassic

№	analysed part	K (%)	$^{40}A/10^{-6}Nccmg^{-1}$	t (10^6y.)
783(158)	augite-amphibole	0,913±0,05	4,2577±0,0140	116,2±6,5
783(102)	whole rock	2,836±0,03	7,6221±0,2172	67,9±2,6
237b(157)	augite-amphibole	1,053±0,014	4,4753±0,0156	106,2±1,7
237b(114)	whole rock	3,034±0,04	9,6498±0,1423	80,0±2,2

2. Eruptive rocks from the Cretaceous

№	analysed part	K (%)	$^{40}A/10^{-6}Nccmg^{-1}$	t (10^6y.)
315(109)	whole rock	2,009±0,05	5,7670±0,1335	72,4±3,4
710(115)	whole rock	0,173±0,02	0,5528±0,0140	80,4±11,1

Table 1

Chemical analyses of basic eruptive rocks

	Effusive rocks in the Barremian Lower Albian			Vein rocks in the Middle Triassic		
No	314	315	320	237 b	783	710
SiO_2	26,43	41,40	43,34	43,0	41,64	41,20
TiO_2	1,62	2,05	2,68	2,0	2,90	2,60
Al_2O_3	11,98	14,42	13,51	15,68	14,05	13,31
Fe_2O_3	2,20	5,60	3,42	5,20	6,39	2,02
FeO	5,74	6,76	7,09	7,18	5,85	8,53
MnO	0,11	0,16	0,14	0,14	0,10	0,10
MgO	6,18	11,56	10,85	5,77	8,31	14,09
CaO	22,75	11,27	9,81	10,86	8,97	4,65
Na_2O	1,50	0,90	1,61	1,96	2,30	1,19
K_2O	1,20	1,00	1,95	2,64	3,35	1,05
H_2O^-	0,34	0,64	0,74	0,12	0,34	0,58
H_2O	4,33	4,74	4,10	5,41	4,76	9,96
CO_2	15,60	st.		st.	st.	
P_2O_5	st.	st.	0,42	0,04	0,52	0,37
	99,98	100,5	99,66	100,00	99,48	99,65

Table 2

Modal composition of eruptive rocks in %

	Barremian—Lower Albian	Veins in the Middle Triassic	
No	313	315	237 b
olivine	10,0	6,0	18,0
amphiboles	12,0	6,0	12,0
augite	5,0	4,0	8,0
biotite	2,0	<1,0	<1,0
plagioclases	28,0	42,0	20,0
chlorite	15,0	22,0	22,0
epidote	8,0	8,0	10,0
calcite	9,5	7,0	6,0
ore minerals	3,0	5,0	3,0
accessory minerals	0,5	<0,5	1,0
vitrecous mass	7,0		

In valuation of the obtained data it is necessary to set out from the state of preservation of the samples investigated and their retentivity for argon. In this regard suitable material is represented by high purity concentrates of amphibole, augite — which are characterized by a very strong bond of

argon. Besides samples 783 and 237b they were only weakly affected by later, superimposed alterations.

Therefore we may consider radiometric ages of 106,2±1,7 and 116,2±6,5 as very close to actual ages of penetration of eruptives through Triassic complexes of the Krížna nappe.

These radiometric ages essentially corespond to geological ages of the second group of rocks in Neocomian, Barremian-Albian sequences as supposed by J. Koutek (1930) and A. Bujnovský (1971). It is probable also from correlations with the occurrences in the Váh valley (Bošáca-Beckov) where A. Kullmanová — J. Vozár (1980) proved a Lower Albian age also on the basis of paleontological remnants.

This is also evident from geochronological dating carried out on whole rock samples. The lowering of these ages is a consequence of superimosed processes as well as of the fact that in these samples potassium minerals from groundmass (glass), with low retentivity of argon, were essentially manifested.

It was possible to demonstrate by radiometric dating that rocks from the complex of Middle Triassic dolomites do not represent products of particular volcanism of Triassic age. They are younger and connected with Cretaceous volcanic activity in the original sedimentation area of the Krížná nappe.

Conclusions

The basic eruptive rocks in the Mesozoic of the Krížna nappe at the NW slopes of the Low Tatra occur in Middle Triassic dolomites as dykes and as silly interjacent intrusions; also as effusive bodies of small thickness accompanied by volcano-clastics in the Lower Cretaceous. On the basis of geological and petrographic studies it was possible to admit a genetic and chronological coincidence of both types of occurrences, vein and effusive. Relationship of the occurrences is also indicated by the data about the co-magmatic character of vein bodies in the Middle Triassic and of vein or effusive bodies in the Lower Cretaceous. Although in the paper by A. Kullmanová — J. Vozár (1980) from other region (Považský Inovec Mts.) but equal tectonic unit (Krížna nappe) on the basis of fossils unambiguously a Lower Albian age of effusive and volcano-clastic rocks of similar characret is mentioned, nevertheless, in the Low Tatra such a concrete dating was missing. By means of radiometric dating (J. Kantor) it was possible to prove the coincidence of the age of vein bodies in the Middle Triassic and of vein or effusive bodies in the Lower Cretaceous.

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