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THE POSITION AND PETROCHEMISTRY OF THE RHYOLITE IN THE RUDABÁNYA MTS. (NE HUNGARY)

SZAKMÁNY GYÖRGY*—MÁTHÉ ZOLTÁN**—RÉTI ZSOLT***

Dept. of Petrology and Geochemistry L. Eötvös University,
Mecsek Ore Mining Enterprise, Hungarian Geological Survey

ABSTRACT

The work was focussed to the position-origin and petrology of the rhyolite in the Rudabánya Mts. Our basic intention aimed to make exact determinations of the feldspars; their structure and chemical composition by electron microscope as well as electron microprobe analyses. According to these results the original rock-forming feldspars were sanidines and the minor plagioclase have been transformed to albite, by the effect of secondary sodium-metasomatism. Besides this transformation the rhyolite suffered silicification and carbonatisation. The relation and position of the Jurassic black shale and the intercalated rhyolite blocks, have also been analysed in detail. The methods were the following: trace element geochemistry (B, Li), vitrinite reflectance and macro- and microscopic analysis. All these data show, that the not completely cooled rhyolite entered to the unconsolidated Middle Jurassic sediments, so its age is probably the same or perhaps a little younger than that of these sediments.

INTRODUCTION

Vienna school geologists — the first surveyors of the area — determined the material of the small hillock on the flank of the Dunna hill, as a melaphire (FOETTERLE 1868, 1869, WOLF 1869). Firstly KOCH A. (1904) determined this rock as a metarhyolite (quartz porphyry) as the product of the coeval eruption with the sedimentation of the Lower Triassic (Werfenian shales). According to later studies of BALOGH K.—PANTÓ G. (1949) these rhyolites are younger than the Szepes-Gömör porphyries, and they dated the shales and the volcanism to the Ladinian stage. According to JUHÁSZ Á. (1964) all the chemically and mineralogically slightly varying rhyolites of the Rudabánya Mountains have the same origin, and represent a long time span of acid volcanism.

The latest research conducted by the Hungarian Geological Survey from 1979 to 1985 revaluating the structural position and determining radiolarians in the black shales, dated the rhyolites to the Middle Jurassic (GRILL *et al.* 1984).

Rhyolite outcrops in the Rudabánya Mts. *(Fig. 1)* are as follows:

1. Szalonna-Perkupa roadcut (Geol. Basic Section). This section is an olistostroma (KOVÁCS S. 1987), containing olistolites, (boulders and cobbles of limestone, sandstones and rhyolite in black shale of Jurassic age.)
2. Telekes valley — On the slope SE of the hunting box (vadászház) — There is a 150 m long outcrop of rhyolite in black shale environment.

* H-1088 Budapest, Muzeum krt. 4/A.
** H-7673 Kővágószőlős
*** H-1143 Budapest, Népstadion Népstadion u. 14.

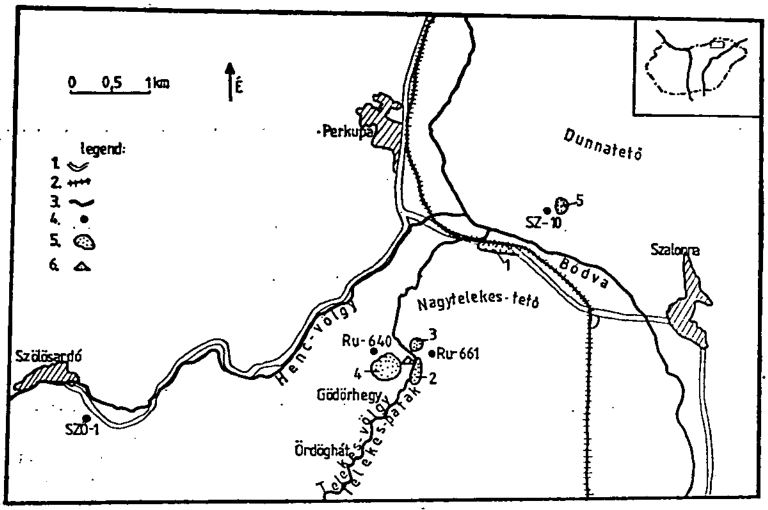

Fig. 1. Rhyolitic rocks in the Rudabánya Mts. 1=road, 2=railroad, 3=creek, 4=borehole, 5= =outcrop, 6=Vadászház (hunting box)

3. Southern side of the Balázs peak, — in black shale.
4. NW-from hunting box on the hillside the rhyolite crops out in some artificial research trenches.
5. On the southern slope of the Dunna hill crops out a rhyolite body.

Besides the outcrops boreholes cored the rhyolite: Szalonna—10, Rudabánya—640 and 661. The Szőlősardó—1 penetrated greyish-green rhyodacitic tuff between 464.2—464.9 m — in BALOGH K.—KOVÁCS S. (1981).

MINERALOGY OF THE RHYOLITE

On the surface the color of the relatively fresh samples is greyish-green to light green. The weathered rhyolites of outcrops No. 5 are yellow. The core samples are generally fresh, with greyish color. The texture is dominantly porphyric, with macroscopically two minerals determinable (quartz and feldspar). The length of the elongated feldspars frequently is exceeding 1 cm. Their color is dominantly pink, but some samples (Dunna hill, Szalonna—10) have white feldspars, too.

The lathy feldspars and the 0.5 cm patchy quartz crystals are surrounded mostly by chlorite mass in this porphyric rock. On the surface the rock is well fragmented. The cracks are refilled up with dark green chlorite. The massive, thick (1—10 cm) quartz veins also filled up with pyrite. The siderite pseudomorphs filled with limonite. The pseudomorphs had probably been formed by the migration of secondary solutions, which oxidized the pyrite and siderite. The veins infiltrate the surrounding black shale, too.

OPTICAL MICROSCOPY

With this method the following minerals were determined: quartz, feldspar, biotite, accessories (zircon, apatite) and secondary minerals (calcite, chlorite, sericite, clay-minerals and hematite). The euhedral quartz crystals are dominating with triangular, quadrangular and hexagonal shape. Some quartz crystals are broken, and the fragments are pulled away to some millimeters and also suffered superficial resorptioп (Fig. 2). The reaction rim around them consist of microcrystalline quartz, calcite, albite, sericite, chlorite (Fig. 3.). The devitrified glass and the calcite frequently appear inside large quartz crystals. This way, it is evident that the quartz phenocrysts are first generation rock forming high temperature dihexaedric crystals. The biotite is low quantity constituent, which dominantly has elongated habit of crooked platy forms. Strongly alterated to bauerite or kaolinite. Frequently has zircon inclusions. The first determinations of the feldspar were contradictory. JUHÁSZ Á. (1964) determined to orthoclase, and mentioned sanidine, too. GATTER I. (1976) determined

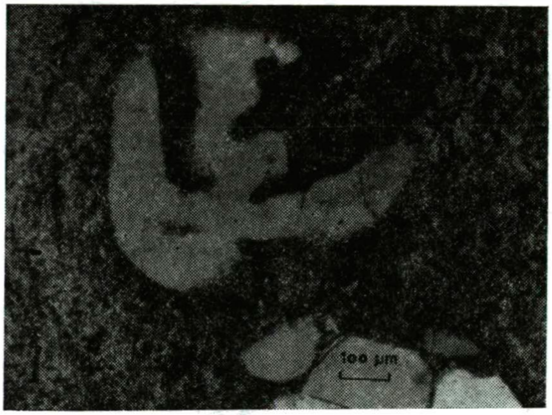

Fig. 2. Resorbed quartz from Szalonna—10 borehole (66.0): magn. 100X Crossed polarizers

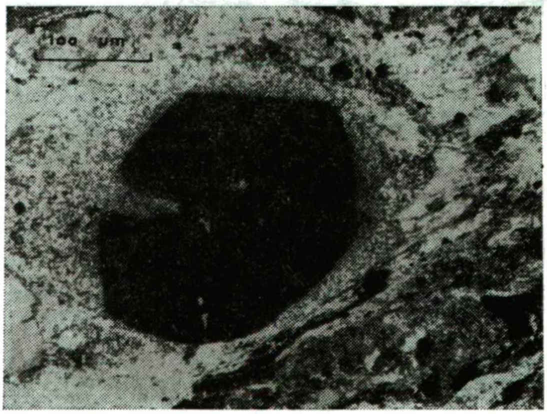

Fig. 3. Resorbed fine grain quartz surrounded by sericite, chlorite reaction rim-from Szalonna—10 borehole (31.8 m): magn. 40X. Crossed polarizers

anorthoclase by universal stage. ÁRKAI P.—KOVÁCS S. (1986) determined low albite from the same rock by X-ray diffractometry. Searching for exact data (besides traditional microscopy) Transmission Electron Microscope (I. DÓDONY) and Electron Microprobe Analysis (K. GÁL—SOLYMOS) were also used.

In thin sections two different feldspar generations were distinguished: (1) The first original volcanic generations are sanidine and plagioclase. (2) The secondary albites appearing in veins. The first generation euhedral, subhedral crystals have generally platy and rarely lathy habites. A great part of the crystals are broken and some places these fragments are dispersed to 1—2 mm distance. The resorption is also dominant, as well as the cluster forming of the wealded feldspars. These feldspars were determined by microscope to sanidine. These biaxal, optically (—) crystals have maximum 2V of 15—20°, and form Karlsbad twins *(Fig. 4)*. Rarely they also form hour-glass twins *(Fig. 5)*. The secondary calcite and albite veins, are frequent in the feldspars. On the less altered part mosaic (domenic) structure exists, too *(Fig. 4)*. About 5% of the plagioclase formed during the first (volcanic) crystallization

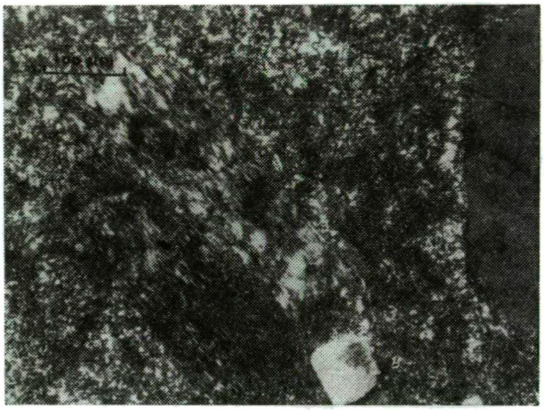

Fig. 4. Carlsbade twinned feldspar from Vadászház NW outcrop: magn. 65X Crossed polarizers

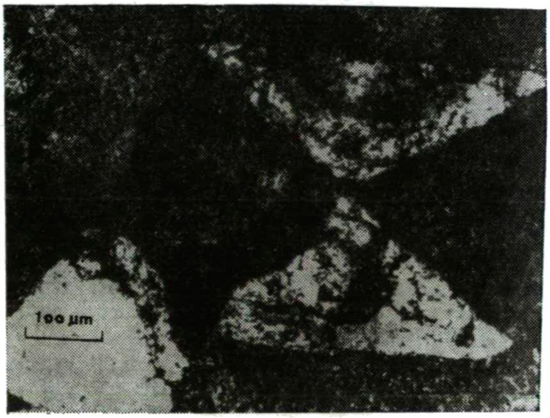

Fig. 5. Hour-glass structure feldspar from Szalonna—10 borehole (66.8 m): magn. 65X Crossed polarizers

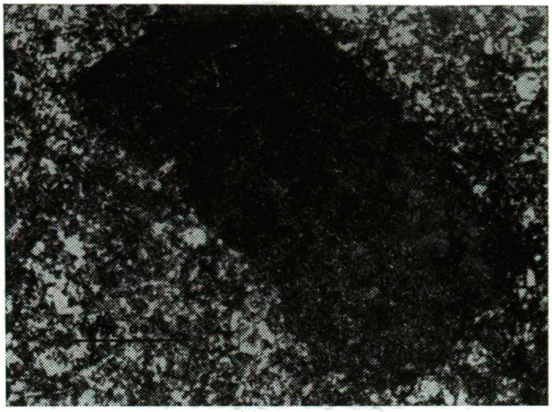

Fig. 6. Strongly altered feldspar, Vadászház NW outcrop: magn. 40X Crossed polarizers

phase. This original feldspars are already altered, and only some twinned crystal remains can be found by optical microscope. According to their optical character, albite-oligoclase were determined *(Fig. 6)*.

The more exact method (TEM) shows, that these domenic feldspars don't form twins, neither show intermingling. In this way the mosaic structure is neither the result of twinning, nor intermingling. For getting exact chemistry of the feldspars, Electron Microprobe Analyses were carried our on a couple of feldspar grains. Using this method the Si, K, Na and Ca were measured. All the feldspars are rich in Na. Potassium appears just in the narrow cracks. The Ca is definitely low. The wt% of the mean oxides are the following:

SiO_2	Al_2O_3	CaO	Na_2O	K_2O
68.7	19.2	0.13	11.9	0.07

The calculated feldspar is 99.05% albite, 0.59% K-feldspar, 0.36% anortite.

This way it is clear, that the feldspars of the meta-rhyolite are dominantly low temperature albites (pseudomorphs) and a few original plagioclase grains still exist. It shows that the rhyolite suffered Na-metasomatism, formed the second generation of albites, stable in low grade metamorphic condition.

The albite one way enmeshes the feldspars and the porphyric quartz crystals and also forms clusters in the mass and inside some feldspar crystals. It also forms reaction rims around quartz crystals. Generally the secondary albite forms clean platy crystals. The albite veins frequently infiltrate the nearby black shale, too.

The high sodium content of 6.6 wt% Na_2O is much more then the average for the calc-alkaline rhyolites; it is suggesting certain sodium metasomatism, too. The Na-rich solutions exhanged the potassium content of the sanidine to sodium, and this way it transformed to albite. A considerable portion of the K probably remained in the volcanite and formed sericite (K_2O=0.73—4.64 wt%).

The CaO content is generally low (1.5 wt%), only the secondary calcite veins elevates it in some samples. It shows that the original basic plagioclase content was low, so the plagioclase was nearly pure albite.

The few accessory minerals are zircon, apatite and opaques. The zircon appears with the opaques as scattered crystals in the mass, and as inclusion in the feldspars

TABLE 1

Chemical analyses of rhyolitic rocks of the Rudabánya-Mts (wt %)

Sample	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	$-H_2O$	$+H_2O$	SO_3	CO_2	total
1	68.45	0.08	11.09	0.45	1.16	—	3.02	2.24	3.15	4.64	—	0.79	3.92	0.09	—	99.08
2	75.91	0.08	10.76	0.45	1.16	—	1.20	0.84	5.65	1.61	—	0.38	1.63	0.16	—	99.83
3	71.05	0.07	12.65	0.80	0.72	—	1.01	0.56	5.81	4.35	—	0.27	1.63	0.29	—	99.21
4	77.45	0.08	10.73	0.50	0.87	—	0.21	1.02	6.61	0.73	—	0.25	0.73	0.13	—	99.31
5	73.32	0.15	12.78	0.62	1.30	—	2.41	0.58	3.07	2.07	—	0.59	2.56	0.10	—	99.55
6	65.61	0.51	16.80	0.50	1.74	—	3.78	0.58	3.19	3.01	—	0.51	3.79	0.10	—	100.12
7	66.34	0.20	17.27	0.40	1.74	—	3.25	1.17	2.95	2.52	—	0.72	3.59	0.23	—	100.38
8	59.47	0.65	16.23	0.57	4.28	—	3.04	2.92	2.98	3.04	—	0.50	4.33	0.08	1.54	99.63
9	45.73	0.24	14.67	0.27	4.35	—	3.04	11.99	2.26	3.37	—	0.32	3.87	0.12	9.36	99.59
10	64.55	0.11	15.73	0.04	2.32	—	2.52	2.92	3.03	2.23	—	0.44	4.22	0.13	1.58	99.82
11	71.49	0.20	13.77	0.15	2.46	—	2.94	0.87	2.39	2.27	—	0.32	3.15	0.23	0.14	100.38
6R	71.02	0.22	15.42	1.21	1.06	0.01	1.06	0.85	2.62	3.27	0.17	0.70	2.62	—	0.50	100.73
7R	77.91	0.18	12.22	0.70	0.60	0.01	0.57	0.23	2.91	2.12	0.05	0.54	1.52	—	—	99.56
13R	79.45	0.15	11.23	0.69	0.57	0.01	0.44	0.30	3.29	0.96	0.05	0.56	1.93	—	—	99.63
14R	83.26	0.17	5.83	0.84	0.22	0.01	0.35	0.36	4.93	1.48	0.07	0.36	1.32	—	—	99.20

Analyses: 1—11: Laboratory of OFKFV, Komló
6R, 7R, 13R, 14R: L. Hoffmann, Department of Petrology and Geochemistry, Eötvös Univ., Budapest
1. Sz—10 5.25—5.40 m; 2. Sz—10 15.50—15.60 m; 3. Sz—10 25.10—25.20 m; 4. Sz—10 35.50—35.60 m; 5. Sz—10 45.00—45.10 m; 6. Sz—10 55.50—55.60 m; 7. Sz—10 65.80—65.90 m; 8. Sz—10 70.40—70.50 m; 9. Sz—10 87.80—87.90 m; 10. Sz—10 123.20—123.30 m; 11. Sz—10 130.00—130.10 m
6R; 13R; Telekes-valley, on the slope SE of the hunting box.
7R; Telekes-valley, on the slope SE of the hunting box; near of the contact of the shale.
14R; Telekes-valley, NW from hunting box on the hillside.

and biotites. Two different generations of the zircon exist (GATTER, 1976). The first is short tetragonal pyramidic, and the second is elongated ditetragonal dipyramidic crystals.

In accordance with the low opaque (magnetite, ilmenite) mineral content, the TiO_2, Fe_2O_3 and FeO are lower than the rhyolite mean (Table 1).

Two kinds of apatite have been distinguished by microscope. The first one exists in the rhyolite outcroping NW of the Vadászház and it is found together with zircon and opaques in sericitic patches, and is optically tipical apatite. The other type of apatite existing in small quantity in all samples but it is abundant in the Sz—10 4R sample which had been determined by X-ray diffractometry as fluor-apatite. It will be discussed later in detail, in a separate paper.

The basic material of the rhyolite is devitrified glass containing the other components: sericite, chlorite, calcite and patches of clay minerals.

As a result of secondary silicification the quartz veins are frequent. Reflecting this secondary process some samples have extremely high silica content (SiO_2= =83 wt%) (Table 1). A part of the chlorite has probably been formed by the effect of silicic solutions from the groundmass, and the other is a secondary product derived from the mafic minerals.

The original texture of the rhyolite had been vitrophyric. Devitrification of the groundmass as well as the chloritisation and sericitisation transformed the original texture to spherulitic-felsitic one.

STUDY OF THE RHYOLITE-SHALE CONTACT

The precise age of the rhyolite and black shale is still not to be determined. The Telekes valley and Bódva pass black shale series (containing the bodies of rhyolite) was dated to Jurassic. According to the determined Unuma echinatus radiolarian zone the age of the shale is Middle Jurassic (GRILL—KOZUR 1986). In this way the age of the black shale is exact, however, that of the rhyolite is not. Two alternatives were raised recently: (1) Coeval formation of the rhyolite and the black shale (GRILL *et al.* 1984). (2) According to KOVÁCS (1987) the Perkupa-Szalonna roadcut (Telekes oldal) outcrop represents an olistostroma with sandstone and rhyolite olistoliths in the Jurassic shale. In such a case the age of the rhyolite can be Middle to Upper Triassic.

Macroscopic observations

In the Sz—10 borehole the rhyolite and the black shale alternate. At the contact these rock-types are mixing. The quartz and the calcite veins infiltrate both rock types. As the exocontact zone of the rhyolite the shale in also silicified. The veins of the shale entered the cracks of the volcanite. This kind of contact appears twice in the cores at 66.8 m the whitish-grey shale, and at 121.4 the black shale are mixing with the rhyolite. Similar phenomena can be found in Rudabánya—640 and Rb—661 boreholes, too.

In the outcrop "Vadászház SE" at the contact a 1 cm thin dark hard fragile contact rock band can be found. Leaving the contact at 1.5 cm a spotted shale, at 4 cm a dark gray shale and between 4 and 10 cm a confusedly bedded yellowish rock are found. Thickness of the exocontact does not exceed 10 cm.

Microscopy

The contacts are generally very sharp in thin sections but some places micro-interfingering and mixing of the two different rocks are visible *(Fig. 7, 8, 9)*.

On the sharp contact the phenocrysts (quartz, feldspar) are touching the shale. On these places are not contact alterations at all. There are plenty of veins in microscopic dimensions on contact surfaces. The mineral content of these veins is characteristic, as the center is filled with calcspars and the vein walls are covered by chlorite and albite. The chlorite shows a light green pleochroism with irregular brown or blue interference colour *(Fig. 10)*. Near the contact small fragments of rhyolite can frequently be found among the shreds of the shale *(Fig. 7, 8, 9)*. On these spots (between the shale and rhyolite) chlorite and calcite vein as well a sericite stripes are found. There has not been found thermal contact index minerals, just all the material is darker near the contact, and sericite is more abundant. There is a sedimen-

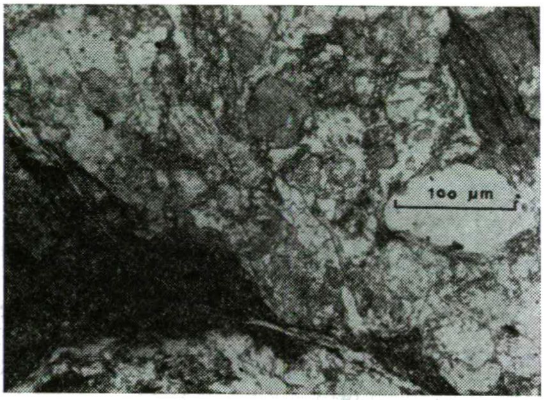

Fig. 7. Rock mixing at the rhyolite-shale contact from Szalonna—10 borehole (66.8 m): magn. 40X Crossed polarizers

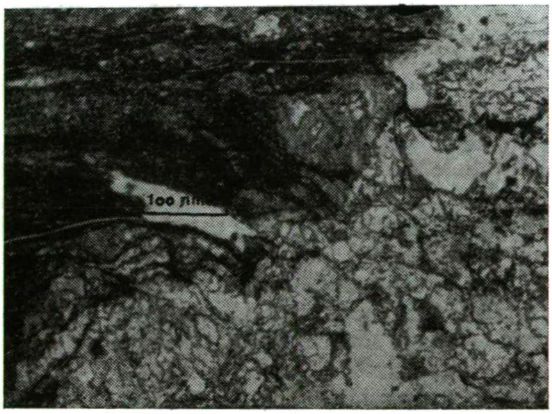

Fig. 8. Contact of rhyolite and shale from Szalonna—10 borehole (66.8 m): magn. 60X Crossed polarizers

tary inhomogeneity also, close to the contact. The chlorite and albite veins are continuing on the other side of the rock. The albite appears not only in veins, but also in flakes and in druses. So, this way it is evident that the Na-metasomatism affected not only the rhyolite but the shale, too.

The characteristic minerals are fine grained quartz forming fine layers, muscovite, biotite, feldspar, zircon, opaques and a few tourmaline. On the rhyolite side of the contact zone the minerals are the same as were mentioned earlier. Thin black shale fragments also appear in the rhyolite either as isolated patches, or as vein-like forms that are connected to the main body of the shale. There is always a chlorite enrichment around them. Near this shreds the volcanite shows its original texture and structure and there are no marks of any tectonic fragmentation. It is best shown by the fact, that the porphyric minerals are the same on the contact and far from it.

Accordingly, tectonic dislocation between these two consolidated rock body is considered to be impossible. A single change is noticed in the groundmass of the

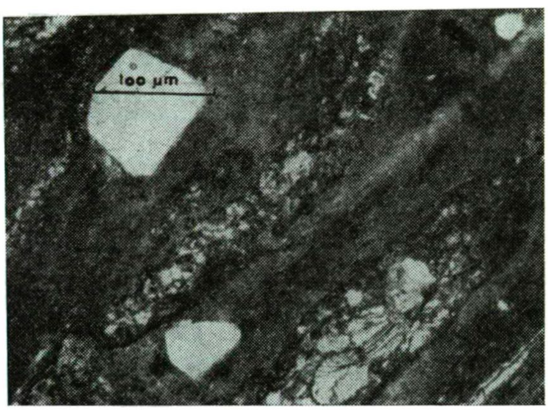

Fig. 9. Alteration of rhyolite and shale zones at the contact from Szalonna—10 borehole (66.8 m): magn. 40X one polarizer

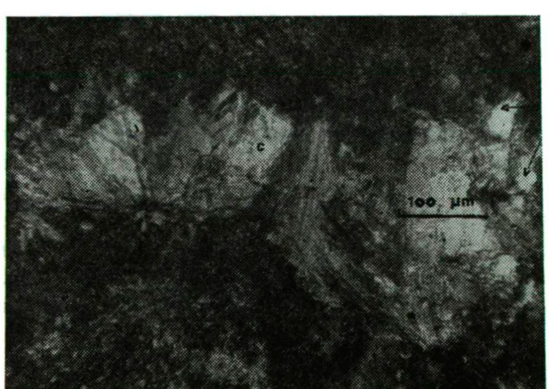

Fig. 10. Calcite (c), albite (a), chlorite (chl)-filled vein on the contact from Szalonna—10 borehole (121.4 m): magn. 160X Crossed polarizers

rhyolite, namely, it has more sericite and chlorite near the contact than far from it. In the light of these data the interpretation of the contact remained ambigous, so other type of analyses had been necessary (Trace element geochemistry and vitrinite reflectance).

Trace element geochemistry

The B and Li content were analysed by sensitive OES in the supposed thermal contacts, since these elements migrating to the direction of the heat source are perfect indicators of the thermal effects. This analysis was carried out on the „Vadászház outcrop" samples and borehole Szalonna—10, 121.4 m core sample (Table II.).

TABLE 2

The B and Li content in the shale and the rhyolite near the contact (ppm)

	Distance from the contact	B (1.)	Li (1.)	B (2.)	Li (2.)
	background	80	80	—	—
Shale ↑	20 cm	60	75	—	—
Shale	10 cm	95	75	—	—
Shale	4 cm	80	105	—	—
Shale	2 cm	75	110	125	90
Shale	1 cm	75	85	130	80
	contact	220	80	130	80
	contact	35	105	85	110
rhyolite	1 cm	40	105	80	90
rhyolite	2 cm	20	110	75	85
rhyolite	4 cm	40	110	—	—
rhyolite	8 cm	25	85	—	—
rhyolite	20 cm	50	110	—	—
rhyolite ↓	40 cm	35	85	—	—
	background	60	80	—	—

1. Vadászház SE — outcrop on the hillside
2. Szalonna—10 borehole (121.4 m)
Analyser: Mrs. VIGH. MÁFI spectroscopic laboratory.

Analysing the contact of the rhyolite and the shale, the B content in the volcanite is constant (40 ppm), and 220 ppm in the shale, which is dropping immediately at the contact to one third (B=75 ppm) within 1.5 cm and there is no any significant difference farther. The Li content remains constant around the contact, and it is the same (110—130 ppm) in the surface and the core samples. In case of the Sz—10 core the heat effect was definitely less, so the Li content in the contact is the same, and the B is slightly higher than the average of the rhyolite and the sediment.

Concludingly, on the basis of trace element enrichment pattern a typical thermal contact can not be defined. Probably they were not any appropriate pressure conditions for the pyrometamorphic recristallisation (open system).

Determination of R_{max}, R_{min} and R_{random} was carried out in MTA Geochemical Lab. by Z. A. HORVÁTH at 548 nm wavelenght in oil immersion using a reflection prism series of standards of the Bitumenous Coal Research Inc.... The samples are collected from the Sz—10/e borehole (121.4 m) and from the outcrop SE of Vadászház.

The samples contain 1—10 μm sized coal granules which are in relation to the original organic content of the sediment. Besides these, allochtonous graphite scales with pyrite are also abundant. In the Sz—10/e sample 16 granules were measured by this method.

The mean reflection is (R_{random})=4.745%, the standard deviation is (S_x)=0.133. From the surface exposure 28 granules were measured: (R_{random}=4.565%, S_x=0.178).

Interpretation of the data

In the metamorphic petrological study of the Aggtelek—Rudabánya and Slovakian Karst mountains by ÁRKAI P.—KOVÁCS S. (1986), correlations between the results of petrological data of very-low grade metamorphic rocks and conodont studies as well as carbonate microfacies analyses were carried out. According to their studies, these Jurassic shales suffered only diagenetic effects (250 °C), near to the conditions of the very-low grade regional metamorphism. Mean value of the illite crystallinity (IC) of <2 μm fraction shows a diagenetic transition alteration just below the anchi zonal metamorphism.

The R_{random} — values for the samples SE from Vadászház (Telekes oldal) are as follows:

$$R_{random}(\%) = \frac{\bar{x}}{S_x} = \frac{4.533}{(0.432)} \quad \text{mean of 13 anal.}$$

$$\frac{\bar{x}}{S_x} = \frac{4.630}{(0.144)} \quad \text{mean of 30 anal.}$$

Contrary the IC results according to ÁRKAI and KOVÁCS (1986) these values are fitting to the anchi metamorphic zone. The higher R values can probably be explained by short time heat effect.

Comparing these high R_{random} values with that of the contact [X/S_x=4.745/0.133 and X/S_x=4.565/0.178], those it can be seen that are even higher. In this case we could also explain it with this short time thermal effect.

Summarising the results of vitrinit reflectance measurements, and the B and Li geochemistry, we found that a sharp rhyolite-shale thermal contact could not be proved, but according to these data the partly cooled rhyolite lava entered the Jurassic unconsolidated sediment, so these materials were partially mixed. It can be studied best on the core samples of the Szalonna—10 borehole (Fig. 7). This way the partially cooled lava coudn't produce a real contact effect. Consequently, this rhyolite is a result of a Jurassic or a little younger volcanism.

REFERENCES

ÁRKAI, P.—KOVÁCS, S. (1986): Diagenesis and Regional Metamorphism of the Mesozoic of Aggtelek—Rudabánya Mountains (Northeast Hungary) — Acta Geol. Hung. 29, 349—373.

BALOGH, K.—KOVÁCS, S. (1981): A Szőlősardó 1. sz. fúrás. (The Triassic Sequence of the borehole Szőlősardó 1. (N Hungary). Ann. Rep. of Hung. Geol. Inst. of 1981. 39—63. (in Hungarian with English abstract).

BALOGH, K.—PANTÓ, G. (1952): A Rudabányai-hegység földtana. (La géologie de la montagne de Rudabánya). Ann. Rep. of Hung. Geol. Inst. of 1949. 135—154. (in Hungarian with French abstract).

FOETTERLE (1868): Das Gebiet zwischen Forró, Nagy-Ida, Torna, etc. Verhandl. d. K. K. geol. Reichsanst. **276**.

FOETTERLE (1869): Vorlage der geologischen Detailkarte der Umgebung von Torna und Szendrő. — Verhandl. d. K. K. geol. Reichsanst. **147**.

GATTER, I. (1976): A Rudabányától ÉÉK-re levő Telekesi-völgy kalkopirit, hematit, mangánérc indikációinak ásványtani vizsgálata. (Mineralogical investigation of the chalcopyrite, hematite and manganese ore mineral indications in the Telekes-valley, NNE of Rudabánya, Hungary). M. Sc. thesis. Library of Dept. Petrol. Geochem. of Univ. Loránd Eötvös, Budapest. Manuscript (in Hungarian).

GRILL, J.—KOVÁCS, S.—LESS, GY.—RÉTI, ZS.—RÓTH, L.—SZENTPÉTERI, I. (1984): Az Aggtelek—Rudabányai-hegység földtani felépítése és fejlődéstörténete. (Geological constitution and history of evolution of the Aggtelek—Rudabánya Range). Földt. Kutatás. **XXVII 4**, 49—56. (in Hungarian with English abstract).

GRILL, J.—KOZUR, H. (1986): The first evidence of the Unuma echinatus Radiolarian zone in the Rudabánya Mts (Northern Hungary). Geol. Paläont. Mitt. Innsbruck. **13**, 239—275.

JUHÁSZ, Á. (1964): A Rudabányai-hegység kvarcporfir kőzeteinek összehasonlító vizsgálata. (Examen comparatif des roches de porphyre quartzifère de la montagne de Rudabánya.) — Földt. Közl. **94**, 3, 321—326. (in Hungarian with French abstract).

KOCH, A. (1904): A Rudabányai-Szent-Andrási hegyvonulat geológiai viszonyai. (Geology of the Rudabánya-Szent András Mountains, Hungary). Mat. und Naturwissenschaft. Anzeiger **22**, 132—145. (in Hungarian).

KOVÁCS, S. (1987): Olisztosztrómák és egyéb, víz alatti, gravitációs tömegszállítással kapcsolatos üledékek az északmagyarországi paleo-mezozoikumban, I—II. (Olisthostromes other deposits connected to subaqueous mass-gravity transport in the Nort-Hungarian Paleo-Mesozoic I—II.). — Földt. Közl. **117**, 61—69 and 101—119. (in Hungarian with English abstract).

PÁLFY, M. (1924): A Rudabányai-hegység geológiai viszonyai és vasérctelepei. (Geology and iron ore deposits of the Rudabánya Mountains, Hungary.) Ann. Inst. Geol. Publ. Hung. **XXVI**, **2**, 1—24. (in Hungarian).

WOLF, H. (1869): Das Kohlenvorkommen bei Somodi und das Eisensteinvorkommen bei Rákó im Tornaer Comitate — Verhandl. d. K. K. geol. Reichsanst. Jahrg. **217**.

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