Acta Mineralogica-Petrographica, Szeged, XXXIII, 81—90, 1992

ON THE PYROXENE ANDESITES FROM THE TOKAJ MOUNTAINS AREA (NE HUNGARY)

N. SAAD*

Geology Dept., Fac. Education, Ain Shams Univ.

P. RÓZSA**

Mineralogy and Geology Dept., Kossuth Lajos University

ABSTRACT

This paper deals with the geochemistry of the pyroxene andesite in selected three localities from the Tokaj Mountains, North East Hungary. Major elements for twenty two samples are reported and discussed to conclude the chemical characteristics of these andesites.

The distribution and behaviour of the trace elements in the representative examined andesites from the three localities were studied. The implications of the data for the origin of andesites are discussed.

INTRODUCTION

The Tokaj Mountains include two geologically independent units. One of them is the Vilyvitány Block. The other is the Szerencs Hill country (Inselberg).

The relatively large middle part of the Tokaj Mountains between the Bózsva and Szerencs brooks is still a genuine highland in the north, while the southern part is getting narrower and lower with a characteristically protruding outpost Mountain Kopasz at the town of Tokaj.

Among the members of the so-called Inner Carpathian volcanic belt in the territory of Hungary, the Tokaj Mountains have the most varied types of rocks. In addition to the "acidic" pyroxene anndesite, rhyolite and rhyolitic tuff (forming the main mass of the mountains), dacites and the so-called "true" pyroxene andesite cover large areas.

The majority of the pyroxene andesite can be found in two large and many small areas in the southeastern part of the mountains (*Fig. 1.*). In addition to the areas marked in *Fig. 1*, the rocks of Mulató Hill near Erdőbénye Village is signed as pyroxene andesite on the geological map of the Tokaj Mountains, but its rock has to named dacite (KULCSÁR et al. 1971; RÓZSA 1987).

The rocks of the three areas, Kopasz Hill near Tállya Village, Szokolya-Párkány Hill near Erdőbénye Village, Várhegy and its environs near Bodrogszegi Village and three samples from boreholes (Bsz.1, M.23, Eb.165) were studied.

* Cairo, Egypt
**H—4010 Debrecen, P.O.Box. 4, Hungary

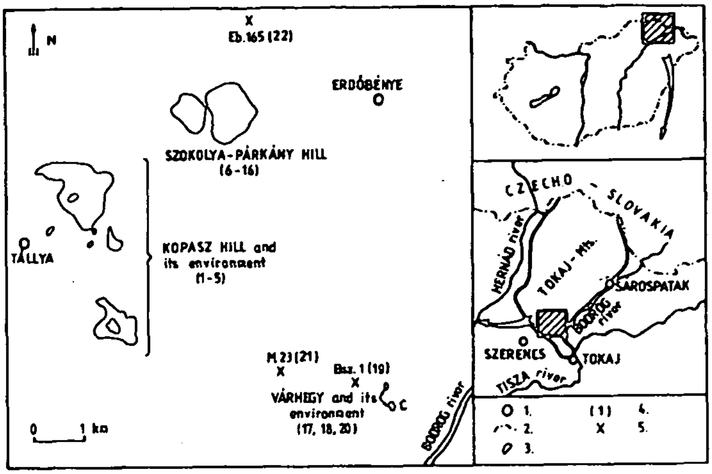

Fig. 1. Sketch map of the investigated area. 1) Settlement; 2) State boundary; 3) "True" pyroxene andesite; 4) Number of analysis and 5) Borehole.

PETROGRAPHY

Among the rocks of the three territories, the Szokolya-Párkány Hill near Erdőbénye Village is the most interesting one. This hill was formed by central volcanic eruptions (JUGOVICS 1965). The groundmass (<10 μm) form about 40 % of the rock, whereas the grains between 10—1000 μm and >1 mm represent 55 and 5 % respectively. The plagioclase feldspars are the most common phenocrysts with a composition ranging from An_{70} to An_{78}. The mafic minerals are represented by augite, less amount of hypersthene and olivine. The latter forms about 1-2 % of the whole rock with a composition ranging from Fo_{86} to Fa_{14} (PANTÓ,1970).

The rock of Kopasz Hill near Tállya Village has a relatively low quantity of the groundmass (approx. 20 %) due to its subvolcanic origin. The most abundant phenocrysts are plagioclase feldspars. The mafic minerals are represented by augite and hypersthene. Very rare small olivine grains could also be found. The texture of the rock is microholocrystalline porphyritic.

In the small cavities of the rock, several secondary minerals occur (e.g. calcite, dolomite, siderite, barite).

The andesite of Várhegy and its environs is also product of volcanic activity. The amount of the groundmass is about 40 % of the whole rock. The most abundant phenocrysts are plagioclase feldspars. The mafic minerals are represented also by both augite and hyperstene.

CHEMICAL CHARACTERISTICS

Major Elements Composition

The major element analyses of the samples from the investigated area are listed in Table 1. Table 2 shows these data recalculated on a H_2O and CO_2 free basis. In calculations, these values were used.

TABLE 1.

Major element analyses of the investigated rocks

	KOPASZ hill near TÁLLYA village					SZOKOLYA-PÁRKÁNY hill near ERDŐBÉNYE village											VÁRHEGY and its environment near BODROGSZEGI village				M. 23	Eb. 165
	1[a]	2[a]	3[a]	4[a]	5[b]	6[a]	7[a]	8[a]	9[a]	10[a]	11[a]	12[a]	13[a]	14[a]	15[a]	16[b]	17[c]	18[c]	19[c]	20[b]	21[a]	22[a]
SiO_2	57.06	57.53	56.71	58.36	55.87	55.50	54.56	55.65	54.34	54.86	56.58	52.80	53.79	53.58	53.74	55.40	53.07	54.74	54.10	53.29	54.67	57.06
TiO_2	1.20	1.18	1.22	0.95	1.16	0.63	0.38	0.81	0.47	1.02	0.40	0.45	0.42	1.06	1.18	0.80	1.27	1.21	1.50	1.25	0.90	0.73
Al_2O_3	18.52	17.31	18.39	15.82	17.46	18.96	18.23	17.00	17.33	16.31	18.79	19.21	18.57	17.23	16.76	18.12	18.80	18.39	16.50	17.84	19.34	15.57
Fe_2O_3	0.26	0.67	1.16	1.64	1.12	1.80	0.55	1.99	1.99	2.11	0.38	2.79	1.58	2.03	2.96	0.96	5.92	3.41	1.36	2.79	1.60	3.15
FeO	5.80	5.72	5.85	4.35	5.65	4.54	5.55	4.32	4.16	5.20	5.36	4.17	4.63	5.38	4.72	5.39	3.03	4.42	7.20	5.08	4.94	4.45
MnO	0.21	0.05	0.16	0.09	0.14	0.19	0.13	0.34	0.17	0.41	0.20	0.20	0.17	0.10	0.10	0.13	0.18	0.15	—	0.14	0.09	0.10
MgO	2.07	3.51	2.79	3.22	2.88	5.22	5.97	5.15	5.23	4.18	4.32	6.19	5.58	6.97	6.77	5.29	2.67	3.90	2.97	4.23	2.28	4.78
CaO	6.64	6.00	6.71	7.58	6.99	8.27	10.80	7.53	8.26	9.89	8.85	8.95	8.90	9.77	9.78	8.73	7.91	8.10	8.04	9.09	8.43	8.14
Na_2O	3.46	3.30	2.55	2.38	3.17	2.36	2.18	2.44	2.34	2.56	2.40	2.41	2.04	2.36	2.39	2.73	2.86	3.05	3.14	3.30	3.18	1.99
K_2O	1.93	2.18	2.04	0.68	2.50	1.45	1.24	1.85	1.78	1.32	1.49	1.32	1.35	1.20	1.12	1.97	1.33	1.37	1.12	1.56	1.60	1.43
P_2O_5	0.23	0.25	0.26	0.13	0.29	0.15	0.10	0.71	0.13	0.10	0.13	0.15	0.18	0.25	0.25	0.20	0.23	0.22	—	0.23	0.24	0.12
CO_2	1.34	0.62	1.00	1.98		—	—	—	0.19	0.08	—	0.06	—	0.17	0.21		—	—	—		1.14	0.04
$+H_2O$	1.35	1.92	1.83	2.23	2.16	1.18	0.70	1.27	2.47	1.24	0.81	1.40	2.35	0.42	0.35	0.65	2.22	1.13	1.15	0.96	0.88	1.20
$-H_2O$	0.24	0.12	0.12	0.25		0.30	0.17	1.06	1.61	0.37	0.25	0.45	0.76	0.27	0.23		0.61	0.41	3.40		0.72	1.04
Σ	100.31	100.36	100.79	99.66	99.39	100.55	100.56	100.12	100.47	99.65	99.96	100.55	100.32	100.79	100.56	100.37	100.10	100.50	100.48	99.76	100.01	99.80

a/ data from GYARMATI (1977) b/ new analysis; collector: RÓZSA P., analyst: NAZIH ALY SAAD c/ data from RÓZSA-BARTA (1986)

TABLE 2.

Major element contents of the investigated rocks recalculated on a H_2O and CO_2 free basis

	KOPASZ hill near TÁLLYA village					SZOKOLYA-PÁRKÁNY hill near ERDŐBÉNYE village											VÁRHEGY and its environment near BODROGSZEGI village				M. 23	Eb. 165
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
SiO_2	58.60	58.88	57.96	61.30	57.46	56.02	54.73	56.91	56.49	56.00	57.21	53.53	55.33	53.62	53.86	55.56	54.56	55.32	56.40	53.94	56.21	58.51
TiO_2	1.23	1.21	1.25	1.00	1.19	0.64	0.38	0.83	0.49	1.04	0.40	0.46	0.43	1.06	1.18	0.80	1.31	1.22	1.56	1.27	0.93	0.75
Al_2O_3	19.02	17.72	18.80	16.62	17.96	19.14	18.29	17.38	18.01	16.65	19.00	19.47	19.10	17.24	16.80	18.17	19.33	18.58	17.20	18.06	19.88	15.97
Fe_2O_3	0.27	0.69	1.18	1.72	1.15	1.82	0.55	2.03	2.07	2.15	0.38	2.83	1.63	2.03	2.97	0.96	6.09	3.45	1.42	2.82	1.64	3.23
FeO	5.96	5.85	5.98	4.57	5.81	4.58	5.57	4.42	4.32	5.31	5.42	4.23	4.76	5.38	4.73	5.41	3.11	4.47	7.50	5.14	5.08	4.56
MnO	0.21	0.05	0.16	0.10	0.15	0.19	0.13	0.35	0.18	0.42	0.20	0.20	0.17	0.10	0.10	0.13	0.18	0.15	—	0.14	0.09	0.10
MgO	2.12	3.59	2.85	3.38	2.96	5.27	5.99	5.27	5.44	4.27	4.37	6.28	5.74	6.98	6.79	5.30	2.74	3.94	3.10	4.28	2.34	4.90
CaO	6.82	6.14	6.86	7.96	7.19	8.35	10.83	7.70	8.59	10.10	8.95	9.07	9.16	9.78	9.80	8.75	8.13	8.19	8.38	9.29	8.67	8.35
Na_2O	3.55	3.38	2.61	2.50	3.26	2.38	2.19	2.49	2.43	2.61	2.43	2.44	2.10	2.36	2.40	2.74	2.94	3.08	3.27	3.34	3.27	2.04
K_2O	1.98	2.23	2.08	0.71	2.57	1.46	1.24	1.89	1.85	1.35	1.51	1.34	1.39	1.20	1.12	1.98	1.37	1.38	1.17	1.58	1.64	1.47
P_2O_5	0.24	0.26	0.27	0.14	0.30	0.15	0.10	0.73	0.13	0.10	0.13	0.15	0.19	0.25	0.25	0.20	0.24	0.22	—	0.23	0.25	0.12
Σ	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

The data show that the andesite of Kopasz Hill has the highest SiO_2 content, followed by the andesite of Szokolya-Párkány Hill and Várhegy and its environs respectively. The highest TiO_2 and iron contents are in the andesite of Várhegy and its environs. Corresponding mineral composition, the andesite of Szokolya-Párkány Hill has the highest MgO. In accordance with the SiO_2 content, rocks of Szokolya-Párkány Hill and Várhegy and its environs have a higher CaO content than that of Kopasz Hill, whereas alkalis have a reversed distribution.

The foregoing mentioned trends are clearly shown in the FMA diagrams (*Fig. 2*); the points of the three areas clearly separated from each other, only one point of Szokolya-Párkány Hill and another one of Kopasz Hill fall into different field (iron-rich field). In the CNK diagram (*Fig. 3*) grouping of the points by the three areas is obvious.These tendencies are shown together by the F-M diagram (*Fig. 4*) of SIMPSON (1954). The andesite of Szokolya-Párkány Hill has the lowest M and F values because of its high MgO and CaO contents, whereas the andesite

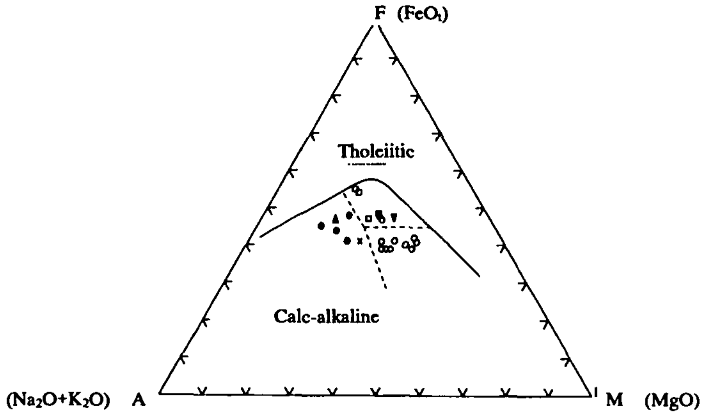

Fig. 2. FMA diagram of the studied samples.
Symbols: ● Kopasz Hill,○Szokolya-Párkány Hill, □Várhegy and its environment, ▲ M. 23 borehole, ▼ Eb. 165 borehole and X average of the acidic andesite.
FeO_t = total iron as FeO.

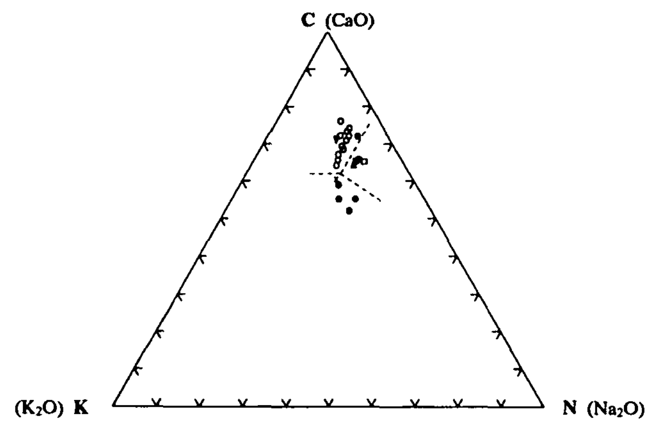

Fig. 3. CNK diagram of the studied samples; symbols as in *Fig. 2*.

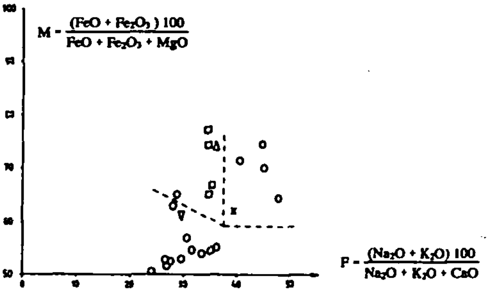

Fig. 4. F-M diagram of the studied samples; symbols as in *Fig. 2.*

of Kopasz Hill has highest M and F values because of the relatively low quantities of MgO and CaO. In the case of the points of Várhegy and its environs, M values are similar to that of Kopasz Hill and F values are similar to that of Szokolya-Párkány Hill. The numerical values of the MgO/FeO_t ratios of Kopasz Hill and Várhegy and its environs are similar to each other and lower then that of Szokolya-Párkány Hill (*Fig. 5*). However, the points of the three areas are well distinct.

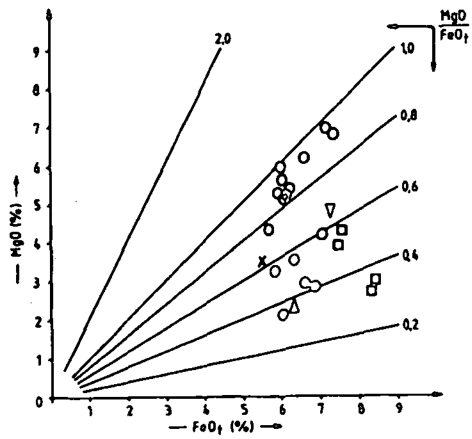

Fig. 5. MgO vs. FeO_t diagram of the studied samples; symbols as in *Fig. 2.*
FeO_t = total iron as FeO.

On the basis of the CaO/Alk ratios (*Fig. 6*), the points of Kopasz Hill are well separated from the other two groups. On the other hand, and on the basis of the Na_2O/K_2O ratios the separation of the three groups can be distinctly seen (*Fig. 7*).

It is noteworthy that the average point of the so-called "acidic" andesite is close to the points of Kopasz Hill in each diagram.

Classification and Nomenclature

Recently, there are two nomenclature diagrams accepted by IUGS for the classification of igneous rocks. The QAPF diagram (STRECKEISEN 1980) and the so-called TAS diagram (LE BAS *et al.* 1986) which distinguishes the volcanic rocks on the basis of their silica and alkalis contents. In our case, the latter was applicable because the groundmass of the rocks can reach about 40 % and these rocks do not contain either quartz or feldspathoids, therefore the location of all point could be found on the AP line on the QAPF diagram (diagram not shown here). It can be

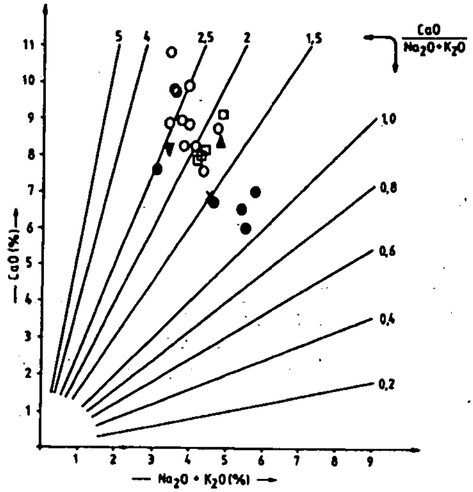

Fig. 6. CaO vs Alk. diagram of the studied samples; symbols as in *Fig. 2.*

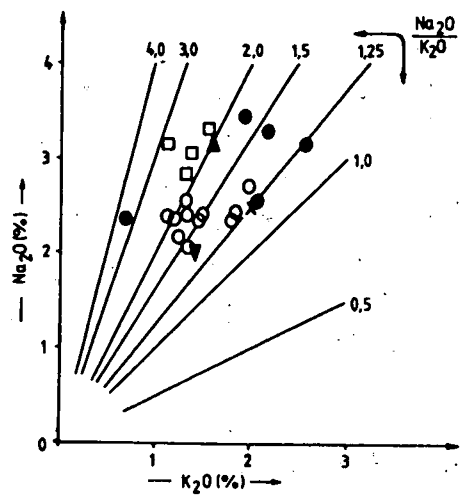

Fig. 7. Na_2O vs K_2O diagram of the studied samples; symbols as in *Fig. 2.*

seen from Figure 8 that each sample of Várhegy and Szokolya-Párkány Hill is classified as basaltic andesite, except sample 11, while that of Kopasz Hill fall into the andesitic field. These results are confirmed by the classification of TAYLOR *et al.* (1981) as shown in *Fig. 9*, where the same results have been obtained.

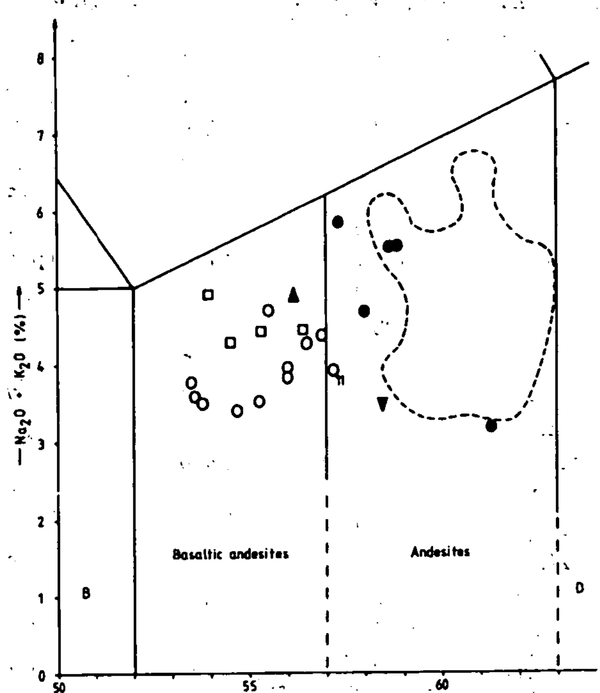

Fig. 8. Classification of the investigated volcanic rocks according to LE BAS *et al.* (1986); symbols as in *Fig. 2.*

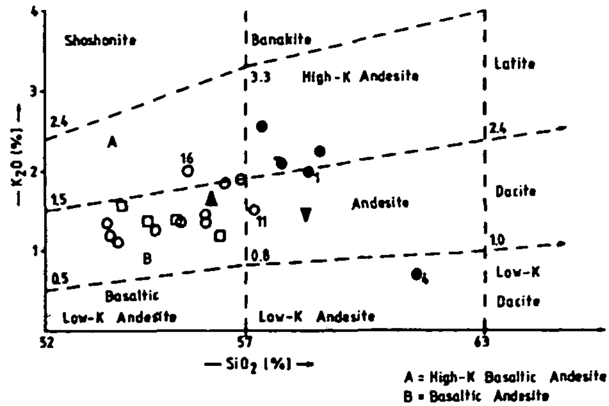

Fig. 9. Classification of the investigated volcanic rocks according to their K_2O content as suggested by TAYLOR *et al.* (1981); symbols as in *Fig. 2.*

Trace Elements Chemistry

15 trace elements were determined in the samples in question by ARL-34000-ISC emission spectrometer equipment (Utrecht, Holland).

The trace element analyses of representative samples from the three hills together with the average trace elements in andesite of TAYLOR *et al.* (1969) are listed in Table 3.

TABLE 3.
Trace element concentrations of the representative samples of the investigated andesitic rocks

	1	2	3	*
Sr	379.8	314.6	324.1	385.0
Ba	463.0	378.2	252.6	270.0
Ce	42.5	46.6	40.7	24.0
Sn	<2.6	<2.5	<2.7	0.8
Mo	<0.7	<0.6	<0.7	1.1
Zr	143.8	183.7	150.7	110.0
Li	17.4	9.7	14.8	—
Cu	21.1	20.2	15.2	54.0
Zn	71.6	78.2	76.2	—
Pb	<10.0	<9.7	<10.4	6.7
Co	18.3	16.3	22.9	24.0
V	148.0	147.8	176.9	175.0
Ni	18.1	10.4	20.6	18.0
Cr	58.3	16.2	68.1	56.0
Y	24.9	32.9	30.9	21.0
Ba/Sr	1.20	1.20	0.80	0.70
V/Ni	8.20	14.20	8.60	9.70
Ni/Co	0.99	0.64	0.90	0.75

1. Erdőbénye, Szokolya-Párkány Hill. 2. Tállya, Kopasz Hill, Quarry.
3. Bodrogszegi, Várhegy. * Average andesite of TAYLOR *et al.* (1969).
all concentration in ppm.

The compatible trace elements Co, Ni, Cr which are generally incorporated in ferromagnesian minerals and generally decrease with increasing differentation, show higher concentration values in the pyroxene andesite of Várhegy and decrease toward the Kopasz andesite through the andesite of Szokolya-Párkány Hill, and this is true if we compare these concentration with their major elements content in the foregoing FMA diagram and these values (Table 2) are in agreement with the average values of TAYLOR *et al.* (1969), though V, Cu, Zn and Y content show narrow range of variation in the three hills.

Zr content, on the other hand, varies highly and shows the highest concentration value in the andesite of Kopasz Hill (183.7 ppm) and this value is higher than the average value (110 ppm) given by TAYLOR *et al.* (op. cit).

The distribution of Ba and Sr in the examined andesite indicates that Ba is more abundant than Sr in Szokolya-Párkány and Kopasz Hill. The highest concentration of Ba and Sr is recorded in Szokolya-Párkány andesite and represented by 436 and 379 ppm respectively due to the high value of K_2O and CaO.

The examined andesite is characterized by low abundance of cobalt and nickel, and high abundance of vanadium. Ni/Co ratios for the three localities are less than one, and V/Ni ratios show the reverse relationship as being greater than 8.

The low values of Ni and Cr of the three localities perclude the derivation of andesites by mixing between basaltic magma and acidic material. According to TAYLOR *et al.* (1969), the high V/Ni ratios perclude the derivation of calk-alkaline andesites from alkali or tholeiitic basalts by crystal fractionation at low pressure. Since under these conditions, vanadium will be depleted in the residual magma as well as nickel. The high vanadium contents also perclude the operation of the mechanism proposed by OSBORN (1962) to account for the lack of iron enrichment in calk-alkaline rocks. On the other hand, the Ni/Co ratios of examined andesite increase with increasing K_2O or SiO_2. The decrease of Ni/Co ratios with the increasing K_2O or SiO_2 is considered as an evidence that andesitic rocks were derived by fractional crystallization from basic magma (TAYLOR *et al.* 1969).

Accordingly, it can be concluded from the behaviour of the trace elements and their ratios in the three localities (low contents of Ni, Cr, low Ni/Co ratios (<1) and high V contents) that the examined andesites represent derivatives of primary andesitic magma.

MAGMA TYPES AND TECTONIC IMPLICATION

The AFM diagram (IRVINE and BARAGAR 1971) has widely used to differentiate between tholeiitic and calk-alkaline magmas (*Fig.* 2). From this figure the examined andesites display a clear calk-alkaline affinity.

PEARCE *et al.* (1977) have proposed a FeO_t, MgO, Al_2O_3 triangular diagram to relate the chemical composition of basic and intermediate rocks with their tectonic environment. These authors screened out the alkaline rocks in order to improve their relationship with the tectonic environment. *Fig. 10* shows such a plot for the analysed samples. A clear tendency for the orogenic and spreading center island environments, can be seen from the plot.

According to the diagram after PEARCE (1980) and as shown in *Fig. 11*, the examined rocks located in the island arc basalt field.

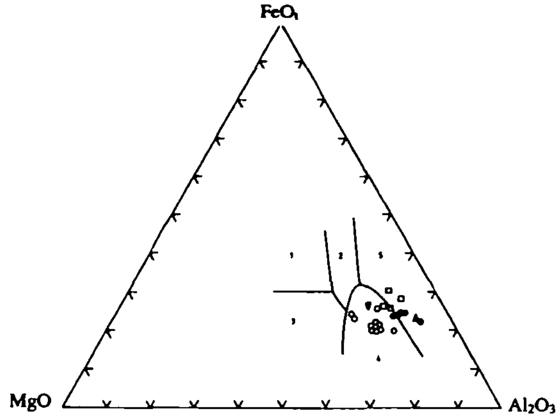

Fig. 10. Rock analyses plotted on the FeO$_t$-MgO.Al$_2$O$_3$ diagram. The fields numbered 1-5 are: 1) ocean island 2) continental 3) ocean ridge and floor, 4) and 5) orogenic and spreading center island respectively; symbols as in *Fig. 2.*FeO$_t$ = total iron as FeO

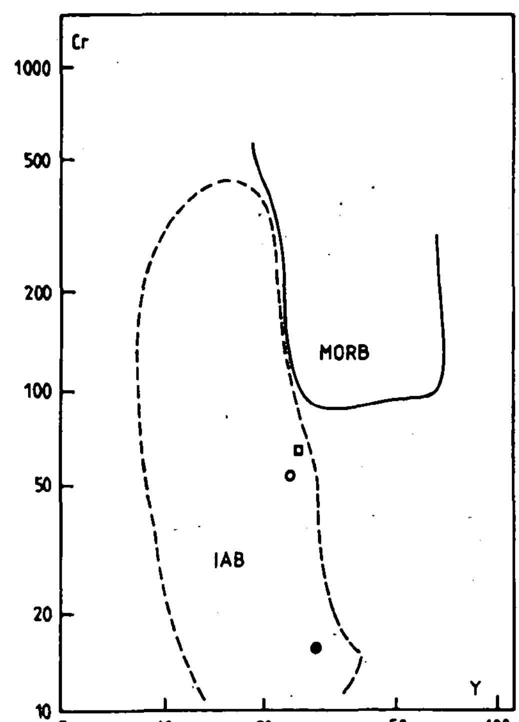

Fig. 11. Cr vs Y diagram (after PEARCE 1980) MORB = solid ballon, and IAB = dashed ballon, indicate fields of mid-ocean ridge basalts and island-arc basalts respectively; symbols as in *Fig. 2.*

CONCLUSION

On the basis of the studies on the so-called "true" pyroxene andesite from southern part of Tokaj Mountains, the following can be concluded:

(1) On the basis of the recommendation of TAS diagram accepted by IUGS, the name "basaltic andesite" should be used instead of the name "true" andesite. Rocks of Szokolya-Párkány Hill and Várhegy and its environs have to be arranged into this group. "True" andesite of Kopasz Hill, however, together with "acidic" andesite, has to named simply as andesite.

(2) Classificational differences are incident to the chemical compositional differences of the rocks. It is characteristic that basaltic andesite of Szokolya-Párkány Hill and Várhegy and its environs have lower total alkalis compared to the iron and MgO content and have higher CaO content than andesite of Kopasz Hill. Because of their CaO content, the basaltic andesite samples have relatively low F indices. The close connection between "acidic" andesite and the andesite of the Kopasz Hill is proved by the fact that the average point of "acidic" andesite is close to the points of andesite of Kopasz Hill in each diagram.

(3) Although both rocks of Szokolya-Párkány Hill and that of Várhegy and its environs should be named basaltic andesite, there is a definite difference between their major elements composition besides the well known difference between their mineral assemblages. The olivine-bearing basaltic andesite of Szokolya-Párkány Hill has slightly lower Na_2O and iron content than the basaltic andesite of Várhegy and its environs. In accordance with this fact, the basaltic andesite of Várhegy and its environs have lower MgO/FeO_t ratio and M index. Consequently, it seem to reasonable to subdivide the basaltic andesite of the Tokaj Mountains into two groups: (1) the less differentiated "Szokolya"-type and (2) the more differentiated "Várhegy"-type. The petrochemical differences of the two groups are as follows:

TABLE 4

	FeO_t	MgO	Na_2O	MgO/FeO_t	M-index
Szokolya-type:	<7	>4	<2.7	>0.6	<68
Várhegy-type:	>7	<4	>2.7	<0.6	>68

Sample of Eb. 165 borehole has to be named andesite, rock of the M. 23 borehole is basaltic andesite and belongs to "Várhegy"-type.

From the trace elements and their ratios, it is obvious that the investigated andesites represent derivatives of primary andesitic magma.

It was found that the three areas under consideration have mainly calk-alkaline affinity, indicating an island arc tectonic setting.

REFERENCES

GYARMATI, P. (1977): A Tokaji hegység intermedier vulkanizmusa (Intermedier volcanism of Tokaj Mountains) Annal. of Hung. Geol. Survey. LVII. (In Hungarian).

IRVINE, T. N. and BARAGAR, W. R. A. (1971): A guide to the chemical classification of the common volcanic rocks. Canad. J. Earth Sci. 8, 523—548.

JUGOVICS, L. (1965): Az erdőbényei Szokolya-hegy andezitjének kőzettani-kőzetmechanikai viszonyai és kőterületének készletszámítása (Petrographic and rock-mechanical relations as well as stock-calculation of rock-mass of the Szokolya Hill located near Erdőbénye). Manuscript, Hung. Geol. Survey. (In Hungarian).

KULCSÁR, L. and BARTA, I. (1971): Kőzettani vizsgálatok az erdőbényei Mulató-hegy Barnamáj lakkolitján (Petrographic investigations carried out on the Barnamáj laccolite of the Mulató Hill near Erdőbénye). Acta Geogr. Geol. Meteor. Debrecen. **15—16**, 39—72.
LE BAS, M. J., LE MAITRE, R. W., STRECKEISEN, A. and ZANETTIN, B. (1986): A chemical classification of volcanic rocks based on the total alcali-silica diagram. J. Petrol. 27, 3, 745—750.
OSBORN, E. F. (1962): Reaction series for subalkaline igneous rocks based on different oxygen pressure conditions. Am. Mineral., **47**, 211—226.
PANTÓ, GY. (1970): Tokaji-hegységi kőzetminták elektronmikroszonda vizsgálata (Electron-microprobe analysis of rock samples originated from the Tokaj Mts.). Manuscript. Hung. Geol. Survey.
PEARCE, T. T., GORMAN, B. E. and BIRKETT, T. C. (1977): The relationship between major element chemistry and tectonic environment of basic and intermediate volcanic rocks. Earth Planet. Sci. Lett. **36**, 121—132.
PEARCE, J. A. (1980): Geochemical evidences for the genesis and setting of lavas from Tethyan ophiolites. Proc. Int. Ophiolite Symp., Nicosis, Cyprus, Geol. Surv. (1979), 261—272.
RÓZSA, P. and BARTA, I. (1986): A bodrogszegi Cigányhegy és környéke intermedier vulkanitjai (Intermedier volcanics of Cigányhegy and its surroundings near Bodrogszegi). Acta. Geog. Geol. Meteor. Debrecen, **23**, 63—78.
RÓZSA, P. (1987): On the petrogenesis of pyroxene dacite in the southern part of the Tokaj Mountains (NE Hungary). Geol. Zbornik — Geol. Carpathica. **38**, 1, 43—54.
SIMPSON, E. S. W. (1954): On the graphical representation of differentation trends in igneous rocks. Geol. Mag. **91**, 238—244.
STRECKEISEN, A. (1980): Classification and nomenclature of volcanic rocks, lamprophyres, carbonatites and melilitic rocks. Geol. Rundschau. **69**, 194—207.
TAYLOR, S. R., CAPP, A. C. and GRAHAM, A. L. (1969): Trace element abundance in andesites. II. Saipan, Bougainville and Fiji. Contr. Mineral. and Petrol. **23**, 1—26.
TAYLOR, S. R., ARCULUS, R., PERFIT, M. R. and JOHNSON, R. W. (1981): Island arc basalts, pp. 193-213. *In:* Basaltic volcanism on the terrestrial planets (Basaltic Volcanism study project), Pergamon Press, New York, 1286 p.

Manuscript received, 7 September, 1992