Acta Mineralogica-Petrographica, Szeged, XXIV/2, 235—244, 1980

PETROLOGICAL AND GEOCHEMICAL CHARACTER OF THE BÁR BASALT, BARANYA COUNTY, SOUTH HUNGARY

T. SZEDERKÉNYI

SUMMARY

Based on exploration carried out by deep-drillings near Bár village a small maar-like volcano covering by Quaternary loess and characterized by a sole eruption is proved. Producing a fairly well determinable thin volcanic sequence this eruption is represented by a very thin tuffaceous sheet on the base of the volcanic succession and a scoria member and a porous, sometimes churned rarely compact basaltic lava mass. The basalt is classified as a leucite basanite turning into analcitebearing basanite at the margins and at some places of the porous inner sections of the volcanic body. Being a conspicuous petrologic difference between Pannonian basalts of Hungary and Bár alkaline rocks, the latter is regarded as an independent volcanic event of the great Pannonian volcanism of Hungary.

INTRODUCTION

On the flood-area of the Danube River near Bár village *(Fig. 1)* a few cubic meters of boulders of a basaltic rock were mapped and ranged into Lower Cretaceous alkaline diabase association of the Mecsek Mountains by T. SZEDERKÉNYI [1962, 1964]. A. KASZAP [1963] presumed a certain connection between volcanism of Bár and Popovác Hill (Yugoslav side of Baranya County) which latter is represented by andesito-basalt and penetrated the Late Miocene (Sarmatian) deposits according to L. LÓCZY JR. [1914]. Based on a petrographic description by I. VICZIÁN [1965] these volcanic rocks located near Bár may be considered as analcite basalts which are is a close genetic connection with Hungarian Pannonian basalts.

After detailed geophysical measuring (geoelectrical sounding and geomagnetic measurements) three deep-drillings were deepened to prove the existence of the basaltic mass below Quarternary loess sheet and to determine its geological setting.

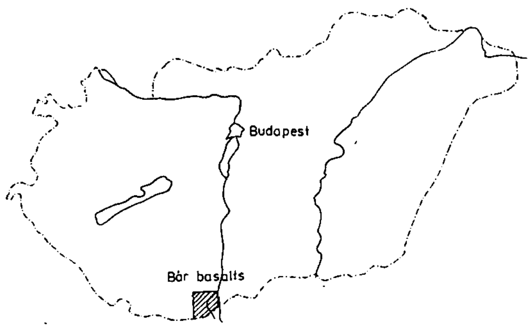

Fig. 1. Location map of Bár basalt.

As it was mentioned previously, our geological knowledge related to Bár basalt was confined to the boulders exclusively. After realizaticn of the geophysical and deep-drilling research plan made T. SZEDERKÉNYI [1970] the reality of a basalt boy was proved. Having about 0,5 km² extension it forms and elongated magnetic field arranged to NW — SE directions.

Based on the data of the deep-drillings their stratigraphic columns differ from each other. One of them (Bár No. 4) had penetrated not only the volcanic body and underlying fauna-free, probably Quaternary deposits, but deeply invaded to the Lower Pannonian fauna-bearing layers; another bore-hole (Bár No. 5) did to the volcanic body and stopped in the underlying red clay; and finally the third one (Bár No. 6.) crossing 54 m thick basalt section stopped within it.

Prior to the lava-flow a weak eruption had taken place which prduced a small amount of agglomerates and tuffs having less than 20 cm thickness. A very characteristic contact zone represented by a 1,0 m thick "natural brick" material originating from a mixture of tuffs and clays and loose basaltic debris, formed by thermal effect of the lava-flow is also recorded. Belonging to the so-called *scoria* formation this rock-type has not been detected in Hungary so far.

The Pre-Tertiary bedrocks lying below the basalt body have not been explored yet and may be ranged into Middle Jurassic or Triassic. Finally a notice is taken about the age of the red clay member underlying the volcanic mass, and is ranged into Lower Quaternary by GY. HŐNIG [1971]: this classification had been made merely on the basis of lithostratigraphic observations and considerations, however, in the lack of biostratigraphic proofs it is only conditionally acceptable. A conspicuous petrological difference between the Pannonian and Bár basalts supports an idea of different age of Pannonian and Bár basalts and that of underlying formations.

PETROGRAPHIC CHARACTERIZATION OF THE BASALT

A fairly big portion of the explored basaltic rocks resembles macroscopically to the outcropped basalt. There is an exact description about the latter by I. VICZIÁN [1965]. Recognizing the special mineralogical composition of the rock (iddingsitic olivine, augite, plagioclase, analcite, etc.) he classified it as an analcite basalt. Origine of the analcite was assigned as a primary magmatic process related to the formation of plagioclases.

The fresh basaltic rock-material produced by deep drillings has a general grey colour with a dark shade at the compact parts and a lighter one at the miarolitic and churned sections. Vertical distribution and dimensions of the vesicles, miarolitic holes and churned parts of the rock-columns show a considerable variability. Rhytmic alteration of the vesicle-bearing and vesicle-free sections gives a "layered" character to the volcanites. The elongated vesicles are usually without any filling material, or they are encrusted by no more than one mm thick layer of zeolite, analcite and/or calcite crystals. The length of longitudinal axes of the holes are from a few mm up to 2—3 cm.

Perfectly compact vesicle-free parts are rather scarce in the basalt column and occur only in the deepest sections explored by Bár No. 6 deep-drilling. Parallel with the disappearance of vesicles from the basalt, grain size of the rock-forming minerals increases suddenly giving a dolerite-like look.

The Bár basalt microscopically shows a nearly general vitrophyric texture with the exception of the coarse-grained vesicle-free parts having a granophyric one. Euhedral porphyritic augite, leucite, plagioclase (An_{40}—An_{65}), analcite and olivine crystals are embedded into a glassy or sometimes microcrystalline matrix *(Fig. 2* and *3)*. All olivine therein have an iddingsite frame. Characteristic accessory minerals as tiny apatite and xenotime crystals, ilmenite and magnetite euhedrons moreover amphibole and biotite vrecks are also recorded.

Contrary to the outcropped basalt examined by I. Viczián [1965] the subsurface one shows an appreciable leucite enrichment at the expense of the analcite. Leucíte-free (analcite-bearing) rocks can be found only in the outcrop, but analcite-free (leucite-bearing) ones only at the inner part of the volcanic body exclusively. First of all the coarse grained basalt contains leucitohedron-shaped leucite crystals in rock forming quantity *(Fig. 3)*. In the strongly porous and churned basalt samples

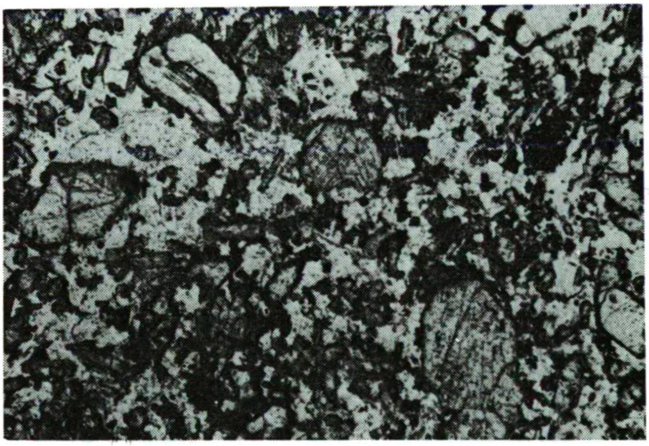

Fig. 2. Pyroxene and iddingsitic olivine crystals, interstitial plagioclase (white) and metallic particles (black). //N, 68x. Bár No. 6. 47,10 m.

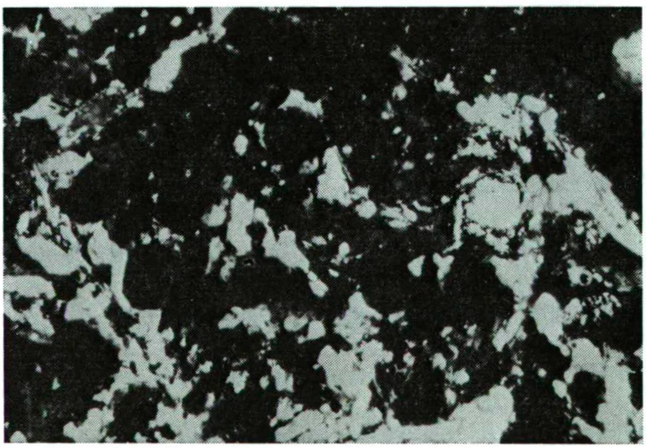

Fig. 3. Leucite euhedrons (black), intersititial plagioclase (white). +N, 125x.

4

(originated from either the inner or marginal parts) of the body the leucite are partly or perfectly substituted by analcite. It is proving that the analcites are secondary minerals which derived from leucite (and perhaps nepheline) and the frequency depends above all on the porosity and permeability of the basaltic rocks. The existence and disribution of leucite are proved by not only thin sections, but X-ray investigations, too.

CHEMICAL COMPOSITION AND TRACE ELEMENT DISTRIBUTION OF THE BÁR BASALT

The basalt varieties of the studied rock-mass bear a great resemblance to each other in chemical composition (Table 1). Compared with that of average of "normal" basalts [F. TURNER and J. VERHOOGEN, 1960] there are, however, some considerable

TABLE 1

Chemical composition and C. I. P. W. norms of South Transdanubian basalts

Components Vol. %	Popovac Hill	Bár From outcrop		Bár-6 66,7 m	Bár-6 55,0 m	Bár-6 47,10 m	Bár-5 48,30 m
SiO_2	54,24	48,05	48,70	46,63	49,99	50,03	49,76
TiO_2	1,26	1,18	1,13	2,00	1,90	2,00	1,90
Al_2O_3	18,13	14,38	14,37	14,05	14,78	13,48	13,48
Fe_2O_3	2,69	5.17	6,47	1,25	3,65	3,55	3,77
FeO	4,24	4,02	3,14	6,52	4,66	2,87	2,72
MnO	Ny	0,14	0,15	0,10	0,10	0,06	0,08
MgO	4,95	8,24	6,92	7,86	6,71	7,31	7,11
CaO	6,17	8,79	7,35	7,65	5,84	5,42	5,29
Na_2O	3,88	3,24	4,55	2,95	3,76	2,32	4,50
K_2O	1,24	4,27	1,99	5,97	5,50	8,20	4,20
H_2O^+	2,48	1,17	3,55	1,34	0,64	0,79	3,42
H_2O^-	2,48	0,38	1,11	0,59	0,13	0,23	0,11
P_2O_5	0,24	0,75	0,80	1,40	1,34	1,40	1,42
SO_3	0	0	0	0,12	0,13	0,16	0,08
CO_2	Ny	0	0,11	0,78	0	0,09	0,26
Total:	99,52	99,78	100,34	98,44	99,25	98,00	98,00
Anal.:	MAURITZ, B.	SOHA, I.		BÍRÓ, J., SÜTŐ, Z.		BÍRÓ, J., SÜTŐ, Z.	
qz		—	—	—	—	—	—
or		22,5	23,0	24,3	23,9	28,2	23,4
ab		2,0	—	—	—	—	2,0
an		15,3	15,7	13,1	12,0	10,2	14,7
lc		15,0	13,7	19,8	18,8	23,4	15,8
ne		5,3	7,8	3,7	6,7	2,5	7,7
Ca_2SiO_4		—	—	—	—	—	—
$CaSiO_3$		14,0	15,2	13,2	12,8	10,7	9,6
$MgSiO_3$		7,3	6,3	6,6	6,3	7,1	6,8
$FeSiO_3$		4,3	5,2	3,3	3,2	2,9	3,5
Mg_2SiO_4		3,3	1,6	2,5	2,2	3,1	2,9
Fe_2SiO_4		3,2	3,1	2,4	2,3	2,0	2,5
mt		3,1	3,0	2,9	2,8	2,6	2,7
il		3,6	2,5	3,5	3,4	3,2	3,4
ap		2,0	2,3	4,0	3,9	4,1	4,6
cc		—	—	—	—	—	—
Total:		100,9	99,4	99,3	98,3	100,0	99,6
M		40,8	39,2	38,4	36,9	36,6	36,0
Pyroxens		25,6	26,7	23,1	22,3	20,7	19,9
Olivines		6,5	4,7	4,9	4,5	6,0	5,4
Feldspathoids		20,3	21,5	23,5	25,5	25,9	23,5

differences between them. The most significant anomalies are: (1) a generally low CaO content; (2) a markedly high K_2O and P_2O_5 content; (3) a considerable excess of K_2O in contrast to Na_2O; and finally (4) a fairly high amount of total alkalies.

Semiquantitative spectrochemical analysis for 30 elements made by PGS quartz spectrography were carried out from three characteristic rock samples of the Bár basalt. Furthermore, quantitative measurements of some immobile elements as Ce, Ga, Nb, Sc, Zr, Y were also made (Table 2) which are suitable to determine of the origin and developement of basaltic magma. Comparing these data with the average trace element content of basaltic rocks given by T. TUREKIAN, K. WEDEPOHL [1971] a conspicuous divergence can be found in the trace element distribution. Double amounts of Be, Ce and Y content are characteristic for the Bár basalt samples. According to K. WEDEPOHL [1971] extreme high values of Y (more than 0,1%) Zr, La, Be and Ce are typical of basalts derived from secondary differentiation of acidic magmas.

TABLE 2

Trace element content of Bár basalt

	Semi-quantitative			Quantitative		
	Bár-6 66,7 m	Bár-6 55,0 m	Bár-5 48,30 m	Bár-6 66,7 m	Bár-6 55,0 m	Bár-5 48,30 m
Ag	2,5	2,5	2,5			
As	—	—	—			
B	—	—	—			
Ba	2000	2000	2000			
Be	25	25	25			
Bi	—	—	—			
Ce	not examined			615	655	853
Cd	—	—	—			
Cr	100	100	100			
Co	10	10	10			
Cu	50	50	50			
Ga	100	125	100	138	199	158
Ge	—	—	—			
In	—	—	—			
La	100	100	250			
Mn	1000	1000	1000			
Mo	—	—	—			
Nb	40	40	25	84	—	77
Ni	100	100	100			
Pb	50	50	100			
Sb	—	—	—			
Sc	50	50	50	65	52	44
Sn	1	1	1			
Sr	2000	2000	2000			
Te	—	—	—			
V	1000	1000	1000			
W	—	—	—			
Zn	—	—	50			
Zr	600	700	1000	621	621	1080
Y	175	500	750	1378	1155	1575

Analysed by: KÁDAS, M.

An attempt to use the amount of immobile trace elements for classification of basalts by methods developed by J. PEARCE, J. CANN [1973] and R. SMITH [1976] and P. FLOYD, J. WINCHESTER [1978] was made. But due to their exterme high values this attempt was unsuccessful.

PETROLOGY OF BÁR BASALT

By way of introduction it seems necessary to explain the interpretation of some petrological concepts related to basalts.

F. CHAYES [1966] has counted basalts with quartz in the norm as "subalkaline" (i. e. tholeiitic) and those with nepheline in the norms as "alkaline" (alkaline-olivine basalts).

A. MIYASHIRO [1975] had classified the volcanic rock-series of the Earth-crust into two main groups: (1) alkaline, and (2) nonalkaline ones. The latter may be subdivided into tholeiitic and calc-alkaline series. The most important characteristics of alkaline rocks are regarded as (1) peralkaline composition (i. e. $Na_2O+K_2O>$ $>Al_2O_3$ in molecular ratio) leading to the formation of alkaline pyroxenes and/or amphiboles, and (2) silica undersaturation producing feldspathoids: e. g. $(Na_2O+K_2O)>SiO_2$. Well, the Bár basalt satisfies these criteria so it can really be qualified as an alkaline basalt.

It is known that in a large-scale alkaline volcanic association a normative nepheline content is very low in general. If the alkaline rocks originated from primary alkaline magma or by contamination of sub-alkaline magmas, the nepheline content is higher. But nepheline and hyperstene minerals are very sensitive to secondary changes mainly of oxidation so it is almost sure that under conditions of oxidation characteristic in the Bár basalt, they could not remain at all. In the light of these observations the real nepheline content of this rock should be changed probably into analcite perfectly.

For a distinction between alkaline and nonalkaline volcanic series and presentation of the place of the Bár basalt within them, a HARKER's-type variation diagram [1909] serves which is modified by G. A. MACDONALD, T. KATSURA [1964] and A. MIYASHIRO [1975]. Alkaline character of the Bár basalt seems to be evident *(Fig. 4)*.

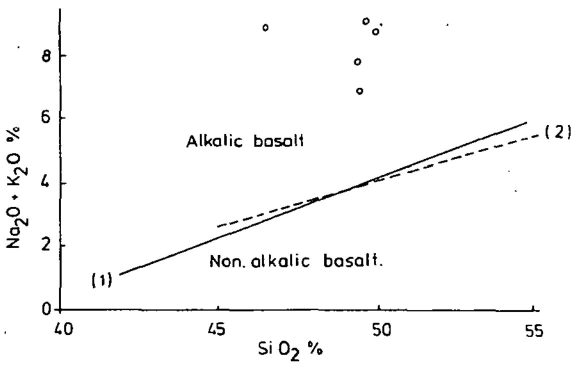

Fig. 4. Alkali-silica variation diagram. The curve (1) means the boundary between the alkalic and tholeiitic basalt in Hawaii [MACDONALD, G. A., KATSURA, 1964].

Place of the Bár basalt in the system of alkaline rocks made by A. STRECKEISEN [1980] is marked out by *Fig. 5.* Applying C. I. P. W. norms for an APF diagram, the projections of the rock samples get both on the field of No. 12 and No. 13, i. e. between phonolites and basanites in a close contact with the field of the latter. The high normative potassium feldspar content shows a trachybasaltic strain.

In the TRÖGER's-system [E. TRÖGER, 1935] the Bár basalt should be as leucite basanite having an extreme low CaO content. (Despite of the low portion of CaO

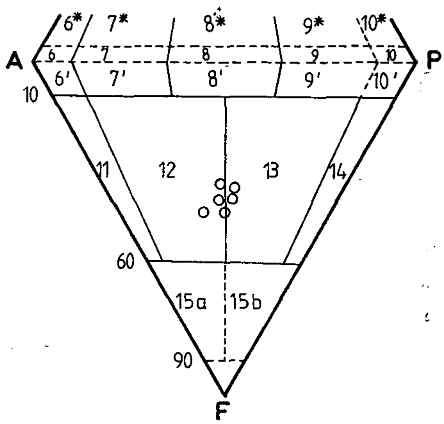

Fig. 5. Place of the Bár basalt samples in the STRECKEISEN's [1967] system.

a rather high olivine content helps to range this rock into the leucite basanite category.) in TURNER and VERHOOGEN's classification [1960] this basalt belongs to the leucite basanite type of a potassium-rich trachybasalt-leucite basalt association.

Due to the before-mentioned reasons there is no doubt about priority of leucite contrary to analcite is the term of the rock. But the importance of the analcite is also unquestionable among rock forming minerals in some parts of the basalt body. Therefore, our proposal for an exact name of the Bár basalt is *analcitic leucite basanite.*

PLACE OF THE BÁR BASALT VOLCANISM IN THE YOUNG BASALT VOLCANISM OF HUNGARY

Formerly a close genetical connection was supposed between Pannonian and Bár basalt volcanisms [I. VICZIÁN, 1965]. Having a great number of (232) analyses of Pannonian basalts [L. JUGOVICS, 1974)] there is a fairly good possibility to check this hypothesis. A variation diagram of total alkalines and SiO_2 *(Fig. 6)* and another one of K_2O—Na_2O *(Fig. 7)* clearly show an appreciable geochemical divergence between Pannonian and Bár basalts. Further on there are some other remarkable differences among the bulk composition of both basalt groups (Table 3).

Considering all the geological, petrological and geochemical characteristics, it seems that the idea of close genetical connection between Pannonian and Bár volcanisms is ready for revision. Regarding the genetical connection between Popovac — Hill (Yugoslavia) andesitic-basalt and Bár basalt based on sole datum for the andesitic-basalt is proved to be unfounded [B. MAURITZ, 1920 and A. KASZAP, 1963].

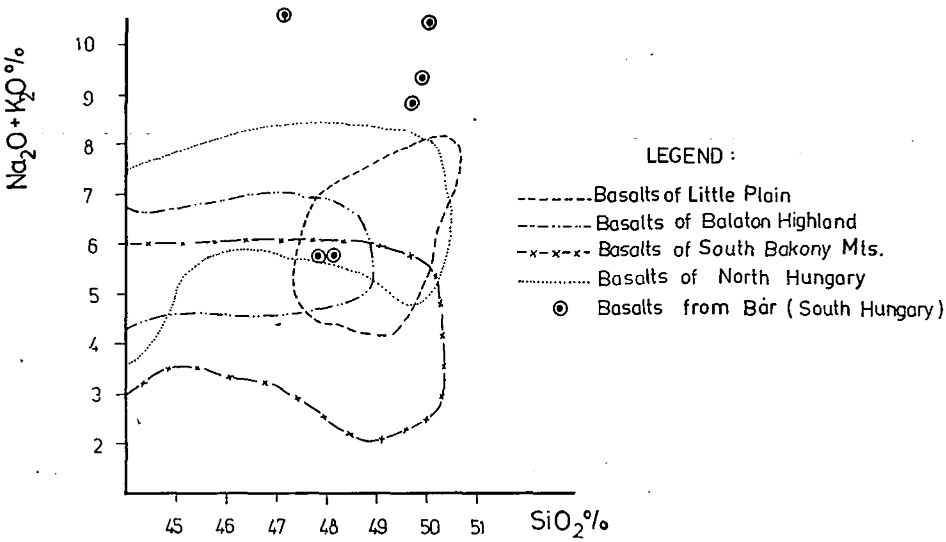

Fig. 6. (K_2O+Na_2O)—SiO_2 variation diagram of Cenozoic basalts of Hungary.

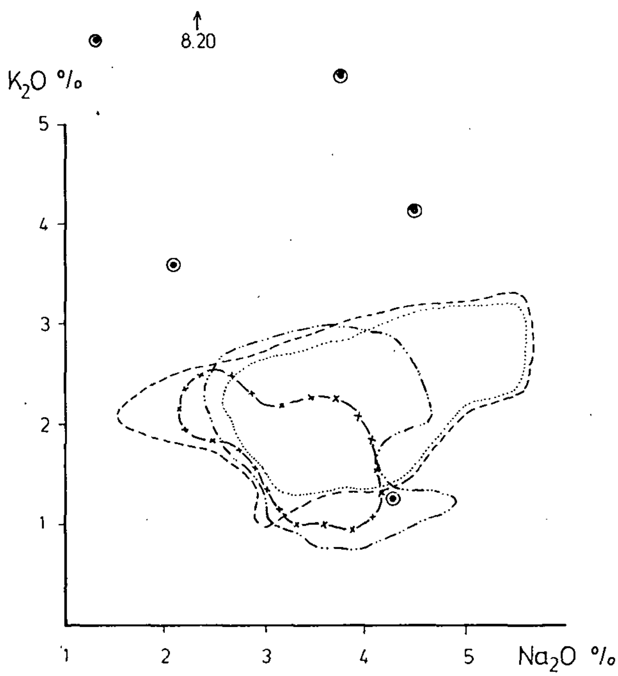

Fig. 7. K_2O—Na_2O variation diagram of Cenozoic basalts of Hungary. Legend: same as *Fig. 6.*

TABLE 3

Remarkable chemical differences between young Hungarian basalts

Average in vol. %	Bár basalt (6 samples)	Pannonian basalts (232 samples)
Al_2O_3	14,09	16,60
CaO	6,71	9,70
K_2O	5,02	2,02
P_2O_5	1,20	0,62
Na_2O/K_2O	3,55/5,02	3,51/2,02

REFERENCES

CHAYES, F. [1966]: Alkaline and subalkaline basalts. Amer. J. of Sci., **264**, 128—145.

DEER, W. A., HOWIE, R. A., ZUSMANN, M. A. [1965]: Rock Forming Minerals. Longmans, London.

FLOYD, P. A., WINCHESTER, J. A. [1978]: Identification and discrimination of altered and metamorphosed volcanic rocks using immobile elements. Chem. Geol., **21**, 291—306.

HARKER, A. [1909]: The natural history of igneous rocks. Macmillan, New York. (Reprinted 1965. Hafner, New York).

HŐNIG, GY. [1971]: Jelentés a K-baranyai Bár község mellett 1971-ben végzett bazaltkutatásról (Report about basalt prospecting carried out near Bár, E-Baranya, in 1971) Manuscript, Hung. Geol. Survey, Budapest.

JUGOVICS, L. [1974]: A magyarországi bazaltok kémiai jellege. (Chemical character of basalts of Hungary) Annual Rep. of Hung. Geol. Survey from 1974 Year, 431—470.

KASZAP, A. [1963]: A dél-baranyai mezozóos szigetrögök. (Mesozoic island-hills of South Baranya.) Földt. Közl., **93**, 440—450.

KUNO, H. [1966]: Lateral variation of basalt magma-types accross continental margins and island arcs. Bull. Volcanology **29**, 195—222.

LÓCZY, L. JR. [1914]: A Báni hegység (Baranya) geológiai viszonyai. (Geology of Bán Mountains, Baranya County.) Annual Rep. of Hung. Roy. Geol. Survey from 1913 Year, 353—360.

MACDONALD, G. A., KATSURA, T. [1964]: Chemical composition of Hawaiian lavas. J. Petr., **5**, 82—133.

MAURITZ, B. [1920]: A Báni hegység bazalt-szerű kőzetei. (Basalt-like rocks of Bán Mountains.) Mat. Term. Tud. Ért., **37**, 62—65.

MIYASHIRO, A. [1975]: Volcanic rock series and tectonic setting. Annual Rev. Earth Planet. Sci. Letters **3**, 251—269.

MIYASHIRO, A. [1978]: Nature of alkalic rock series. Contrib. Miner. Petr., **66**, 91—104.

PEARCE, J., CANN, J. R. [1973]: Tectonic setting of basic volcanic rocks determined using trace element analyses. Earth Planet. Sci. Letters **12**, 290—300.

SMITH, R. E. [1976]: Comments on the use of Ti, Zr, Y, Sr, K, P, and Nb in classification of basaltic magmas. Earth Planet. Sci. Letters **32**, 120—144.

STRECKEISEN, A. [1967]: Classification and nomenclature of igneous rocks. N. Jahrb. Miner. Abh., **107**, 144—240.

SZEDERKÉNYI, T. [1962]: A II. sz. Kutatócsoport 1962 évi jelentése a Bátaszék környéki kutatásokról. (Annual Rep. of Expedition No. 2 about investigations of surroundings of Bátaszék in 1962 year.) Mecsek Ore Mining Co., Pécs, Manuscript.

SZEDERKÉNYI, T. [1964]: A baranyai dunamenti mezozoos szigetrögök földtani viszonyai. (Geology of Mesozoic island-hills along Danube River, Baranya County.) Földt. Közl., **94**, 448—452.

SZEDERKÉNYI, T. [1970]: Javaslat a bári bazalt komplex földtani kutatására bányanyitás céljából. (Proposal on geological prospecting of Bár basalt for opencast exploitation.) Manuscript, Central Geol. Office, Budapest.

TRÖGER, W. E. [1935]: Spezielle Petrographie der Eruptivgesteine. Verlag der Deutsch. Miner. Gesell. e. V., Berlin.

TUREKIAN, K. K., WEDEPOHL, K. H. [1961]: Distribution of the elements in some major units of the Eart's crust. Bull. Soc. Geol. Amer., **72**, 175—191.

TURNER. F. J., VERHOOGEN, J. [1960]: Igneous and Metamorphic Petrology. McGraw-Hill, New York, Toronto, London, Sydney.
WEDEPOHL, K. H. [1971]: Handbook of Geochemistry. Vol. 1. Springer — Verlag Berlin, Heidelberg, New York.

Manuscript received, July 10, 1980.

DR. TIBOR SZEDERKÉNYI
Institute of Mineralogy,
Geochemistry and Petrography
Attila József University
H-6722 Szeged, Egyetem u. 2—6.
Hungary