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ON THE PETROGENESIS OF PYROXENE DACITE IN THE SOUTHERN PART OF THE TOKAJ MOUNTAINS (NE HUNGARY)

(Figs. 6, Pl. 1, Tab. 1)

Abstract: The Tokaj Mts. are the most north-eastern members of the range called Inner Carpathian Volcanic Belt in the territory of Hungary. This mountain range is the one, in which dacitic rocks are widely spread besides acidic pyroxene andesite and rhyolite. This work deals with the petrogenetical investigation of the 3 largest territories of pyroxene dacite in the southern part of the Tokaj Mts. On the basis of former and recent investigations it can be established that differentiation, assimilation and magma-mixing also had a role in the evolution of this rock. These processes are of different importance at the different territories. The most important process in the rock evolution of Mulató Hill — Barnamáj laccolith was assimilation, of Cigány Hill: differentiation and of the Tokaj-Nagyhegy: magma-mixing.

Резюме: Токайские горы — это самая северовосточная часть внутрикарпатского вулканического хребта в Венгрии. Эти горы являются единственными, в которых кроме кислого пироксенандезита и риолита широко распространен и дацит. Эта работа занимается петрогенетическим исследованием трех больших происхождений пироксендацита южной части Токайских гор. На основе прежних и настоящих исследований можно установить, что при формировании пород ассимиляция и дифференциация и перемешивание магмы играли важную роль. Эти процессы на различных территориях имеют различное значение. Важную роль играет ассоциация в случае лакколита в горах Мулатохедь — Барнамай, дифференциация в случае Цигань-хедь и перемешивание магмы в горе Токай-Надьхедь.

Introduction

The Tokaj Mts. represent the easternmost range in Hungary of the so-called „Inner Carpathian Volcanic Belt", which is unique among the Hungarian volcanic mountains in two respects. On the one hand, contrary to the caldera structure of the other volcanic mountains — in this region we can count with the presence of many smaller volcanic centres, on the other hand here, in addition to pyroxene andesite, various rhyolites and dacites are very frequent, and even olivine basalt also occurs.

The dacites of the mountains can be geographically divided into two (northern and southern) groups. Out of the two regions, the dacites of the southern part are seemingly more uniform, since the geological map indicates the occurence here of pyroxene dacite only, whereas in the northern area pyroxene amphibole- and biotite-amphibole-dacite can also be found.

The dacites of the southern part are essentially concentrated in three areas: the largest one (~ 17.5 km^2) is that of Tokaj-Nagyhegy rising in the southern

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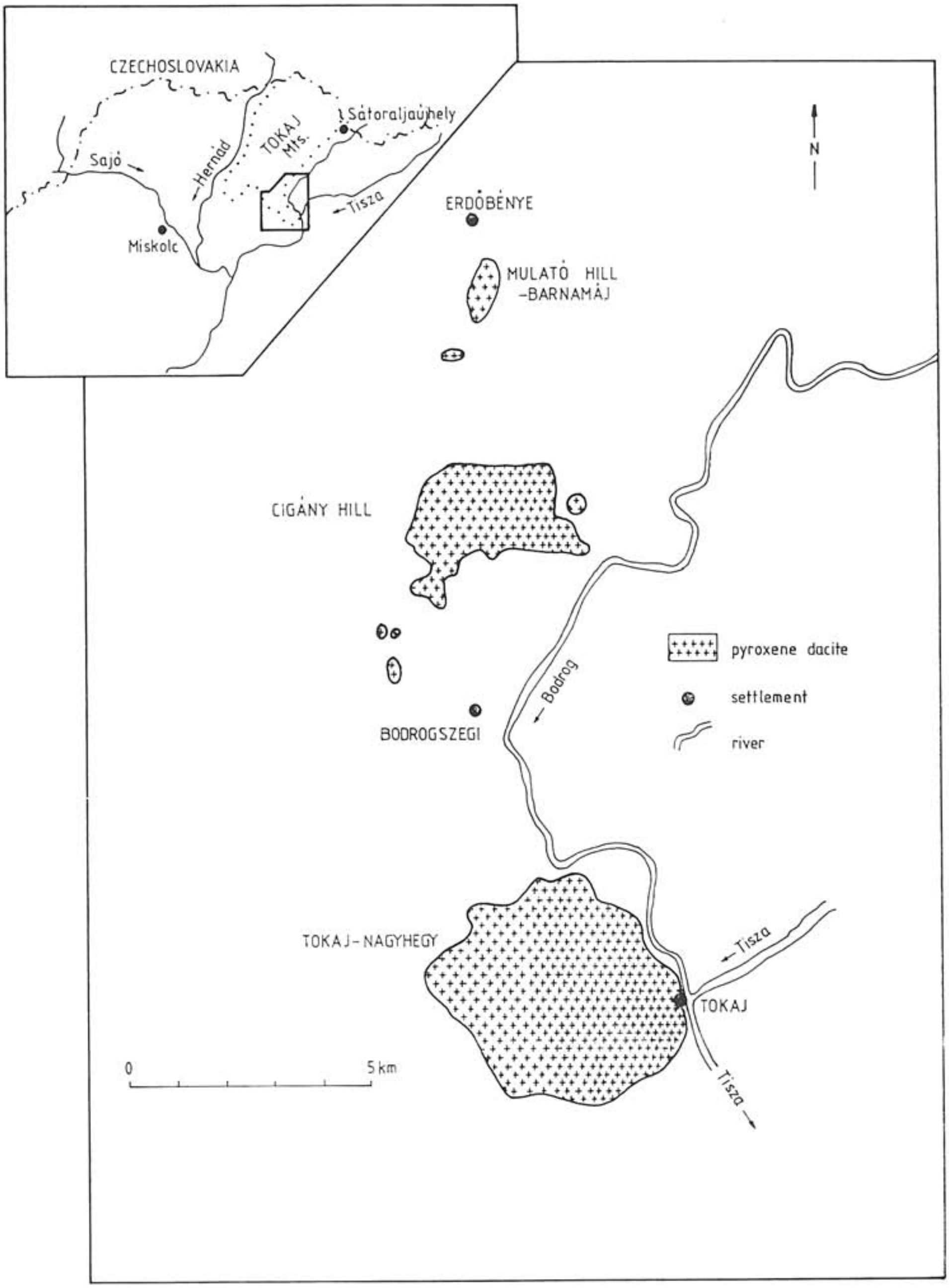


Fig. 1. Geographical situation of dacite occurrences in the southern part of Tokaj Mts.

end of the range, about one third in size (~ 6 km²) is Cigány Hill and its environs, the smallest area is the laccolith of Mulató Hill — Barnamáj, near the village Erdőbénye (~ 0.5 km²) (Fig. 1). As to the denomination of the rocks there was no uniform agreement in the past. The name dacite was first applied to denote the rock of Tokaj-Nagyhegy and Cigány Hill by Gyarmati (1961), Mulató Hill — Barnamáj is denoted on the geological maps as andesite, even at present. The problem was caused by the fact that the mineral composition of these rocks is close to andesite, in addition — because of the large amount of groundmass with microscopically undeterminable composition — the question cannot be cleared up even by the help of the internationally adopted Streckeisen diagram, either. On the grounds of the recently introduced TAS diagram, which is based on chemical composition, the term dacite must be accepted (Fig. 2) for the rock of Tokaj-Nagyhegy as well, even if one part of

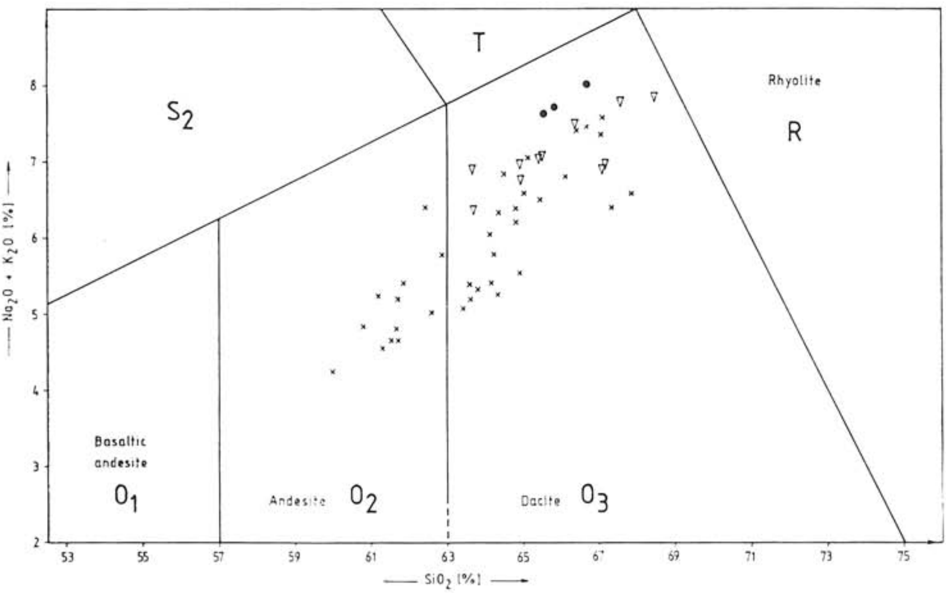


Fig. 2. Rock analyses plotted on the TAS diagram.
Symbols: ×Tokaj-Nagyhegy, ▽ Cigány Hill, ● Mulató Hill — Barnamáj.

the chemical analyses refer this rock into the andesitic field.

In the following, on the basis of the petrographic characteristics and the evaluation of the major element content, an attempt will be made at drawing the petrogenetic conclusions.

Tokaj-Nagyhegy

Although it is possible to distinguish several variants of the pyroxene dacite of Tokaj-Nagyhegy, the identical character of the texture and mineral compo-

Table 1

Average chemical composition of the pyroxene dacitic rock types from the southern part of Tokaj Mts.

occurrence	Tokaj—Nagy hegy		Cigány Hill I. type		Cigány Hill II. type		Mulató Hill—Barnamáj	
area (km^2)	17.5		6.0				0.5	
number of analyses	35		5		6		3	
area/No. of anal.	0.5		0.5				0.2	
		a.d.		a.d.		a.d.		a.d.
SiO_2	63.95	1.67	64.56	0.68	67.04	0.74	66.03	0.44
TiO_2	0.62	0.10	0.74	0.06	0.74	0.10	0.58	0.05
Al_2O_3	16.53	0.62	16.70	0.36	17.72	0.87	16.20	0.23
Fe_2O_3	2.42	0.60	3.12	1.01	2.68	0.49	2.09	0.77
FeO	2.86	0.63	2.88	0.94	0.49	0.12	2.93	0.28
(FeO_t)	(5.04)	(0.54)	(5.68)	(0.21)	(2.90)	(0.35)	(4.81)	(0.72)
MnO	0.14	0.03	0.11	0.03	0.05	0.03	0.07	0.02
MgO	2.14	0.70	1.27	0.33	0.15	0.06	0.53	0.11
CaO	5.28	0.95	3.56	0.45	3.50	0.56	3.61	0.02
Na_2O	2.90	0.34	3.92	0.87	3.94	0.21	4.29	0.04
K_2O	2.96	0.50	2.89	1.04	3.39	0.21	3.49	0.17
P_2O_5	0.20	0.03	0.25	0.03	0.30	0.09	0.18	0.01
Σ	100.00		100.00		100.00		100.00	
MgO FeO_t	0.11—0.65		0.15—0.30		0.00—0.08		0.10—0.12	

Note: Analyses were recalculated water and CO_2 free to 100 %.

sition of the rock is obvious (Rózsa — Kozák, 1982). A groundmass of lower than 10 μm grain size constitutes 65—70 % of the rock. Out of its phenocrystals the most frequent ones are plagioclase feldspars. Inclusions of groundmass are characteristic of the larger crystals, and it is noteworthy that the inclusions are surrounded by an intact edge often showing strong zonality. György Pantó performed, by microprobe, on a zonal crystal determination along the line, which proved the reverse, slightly oscillating zonality of the crystal (in Gyarmati, 1977). As to their composition, the core corresponds to labradorite, the more basic zones to bytownite. In much smaller quantities resorbed sanidine can also be found. Occurring as coloured constituents are hypersthene and augite. Out of the pyroxene dacites in the southern part of the mountains this is the only rock that contains quartz crystals. It is striking that they are strongly resorbed and do not occur in the grain-size below 100 μm. From weathered dacite whole crystals could be separated, on some of them the dihexahedric form can be clearly detected. Very characteristic are the usually rounded, porous, diorite-porphyric inclusions with more basic composition, occurring in dacite. They are holocrystalline in texture, predominant

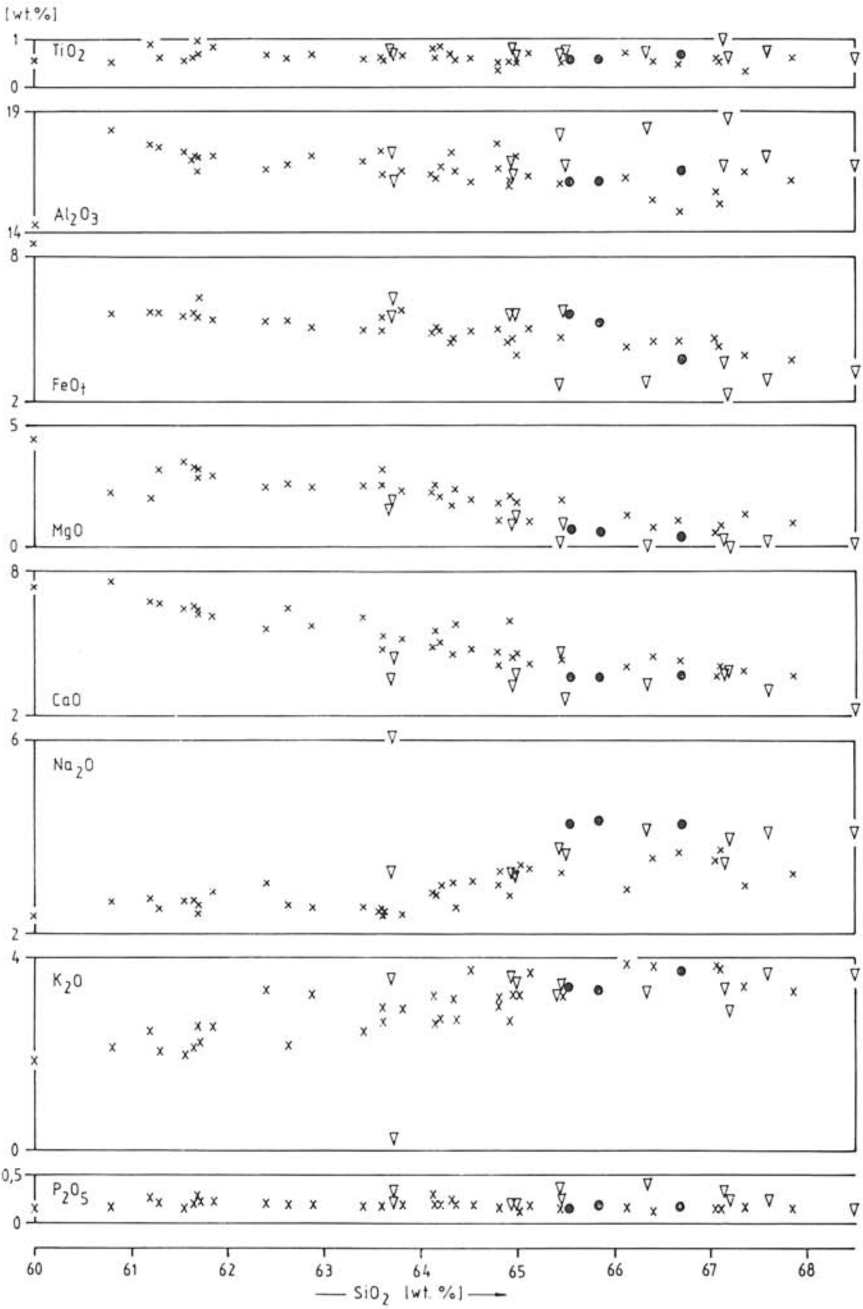


Fig. 3. Variational diagram of the analyses of pyroxene dacite from the southern part of Tokaj Mts. Analyses were recalculated water and CO_2 free to 100 %.
Symbols: × Tokaj-Nagyhegy, ▽ Cigány Hill, ● Mulató Hill — Barnamáj.

among the phenocrystals is plagioclase and, occurring as coloured minerals are hypersthene and augite. The composition of their phenocrystals is es-

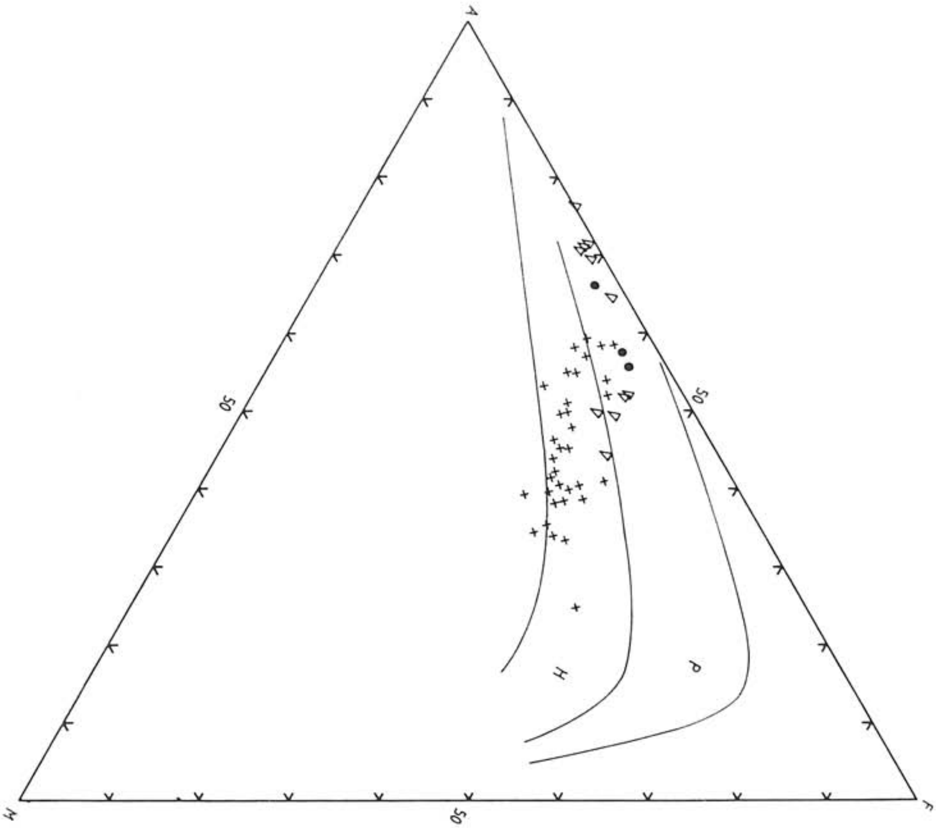


Fig. 4. Rock analyses plotted on the FMA diagram.
Symbols: P — K u n o's (1969) pigeonitic rocks series. H — K u n o's (1969) hypersthenic rocks series. ×Tokaj-Nagyhegy, ▽ Cigány Hill, ● Mulató Hill-Barnamáj.

sentially identical with that of the independent phenocrystals of dacite.

Contrary to the relative uniformity of mineral composition, the chemical composition of the rock falls within a wide range. Especially striking is the fluctuation of the SiO_2 value (Tab. 1, Fig. 3). This is probably due to the inhomogeneous distribution of the dioriteporphyric inclusions of millimetre order of grain-size, and quartz. Accordingly, there is a wide scattering of the points of analyses both on the S i m p s o n F/M diagram (Fig. 5) and in the AFM triangle (Fig. 4). It is remarkable that in the latter the vast majority of points fall within the field of the K u n o's (1969) hypersthenic rock series.

Cigány Hill

Contrary to the previous occurence, the dacite of Cigány Hill can not at all be regarded as a homogeneous rock. On the grounds of mineral composition and the texture of the rock, two main groups can be distinguished, within which several variants can be found (Rózsa — Barta, 1986). One is a type with texture transitional between pilotaxitic and hyalopilitic, with 63—66 % of the groundmass below 10 μm. Among the phenocrystals plagioclase is predominant, the amount of coloured minerals is 15—20 %. The latter can be highly varied: the great majority is pyroxene (mainly hypersthene, in subordinate quantities augite), there occur rarely amphibole, very rarely Fe-rich olivine (Rózsa — Barta, 1986). The texture of the other type is hyalopilitic and the groundmass below 10 μm grain size amounts to 74—80 %, and among the phenocrystals the proportion of coloured minerals remains below 10 %. Among the coloured minerals predominantly pyroxenes (overwhelmingly hypersthene) can be found. The decisive majority of feldspars, in this region too, is constituted by plagioclase. It is valid for both types that in the feldspars ground-

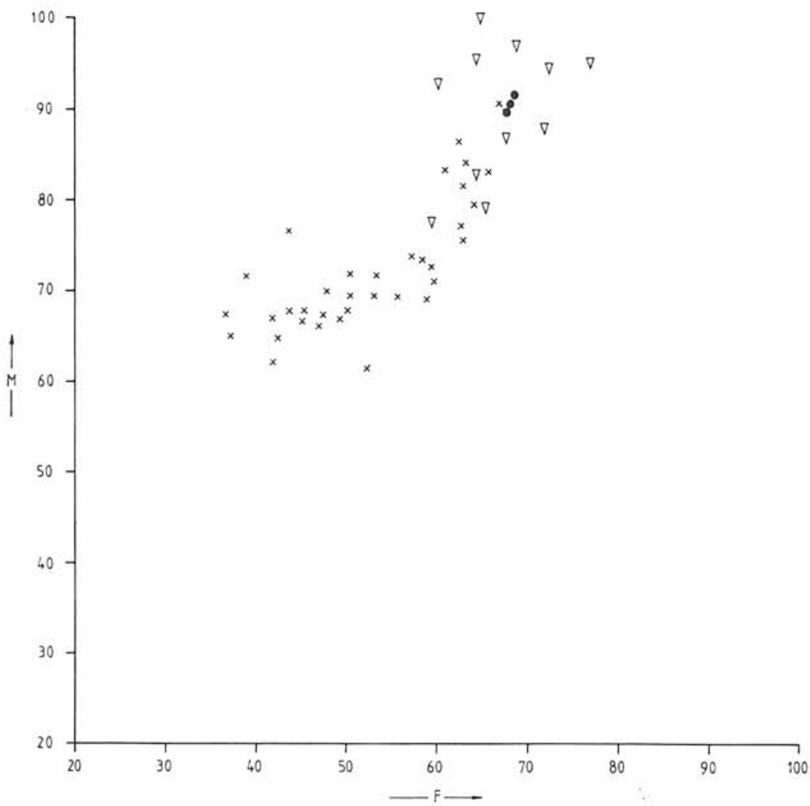


Fig. 5. Rock analyses plotted on the Simpson's F/M diagram.
Symbols: × Tokaj-Nagyhegy, △ Cigány Hill, ● Mulató Hill — Barnamáj.

mass inclusions are scarce, there are hardly any diorite-porphyric inclusions, and no amount of quartz worth mentioning is contained even in the most acidic variant of the rock.

The SiO_2 content of the dacite of Cigány Hill ranges between 63.7—68.5 %. Characteristic are the relatively high Na_2O, K_2O and the relatively low CaO and MgO values. The two main types of rock can be clearly distinguished in the basis of their chemical compositions. The SiO_2 content of the first is 63.7—65.5 % that of the second 65.5—68.5 %. There is a considerable difference in the FeO_t and MgO content, as well as in the MgO/FeO_t ratio (Tab. 1, Fig. 6). The analytical values comprise both in the Simpson F/M and the AFM diagrams a relatively wide field. The former already indicates their differentiation whereas, in the latter the two rock types can be well distinguished.

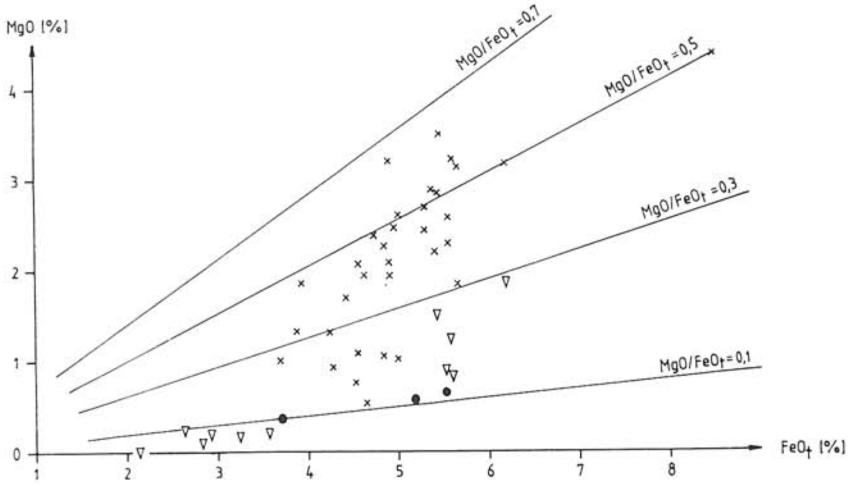


Fig. 6. MgO versus FeO_{total} for rock analyses.
Symbols: × Tokaj-Nagyhegy, ▽ Cigány Hill, ● Mulató Hill — Barnamáj.

Mulató Hill — Barnamáj

The rock, which is — due to transvaporisational and postvolcanic effects — macroscopically varied in its appearrance, turns out to be homogeneous in mineral composition. In agreement with its laccolithic character, its texture is microholocrystalline, predominant both in the groundmass and among the phenocrystals are the fresh plagioclase feldspars. Occuring as coloured minerals are augite and Fe-rich olivine (Kulcsár — Barta, 1971). They occur in subordinate amounts, mostly accumulated in clumps. The augite is, in general, intact, sometimes it is surrounded with a pigeonite rim, the majority of olivine is decomposed.

As to the chemical composition of the rock, no wide variety is found. It is, however, noteworthy that olivine can be found in a rock with 65 % SiO_2 content.

In the Simpson F/M diagram (Fig. 5) the analyses converge almost on a single point, and show strong differentiation, they are, on the other hand, much better separated in the AFM triangle (Fig. 4). It should be noted that in both cases they show similarity to the rocks of Cigány Hill.

Petrogenetic conclusions

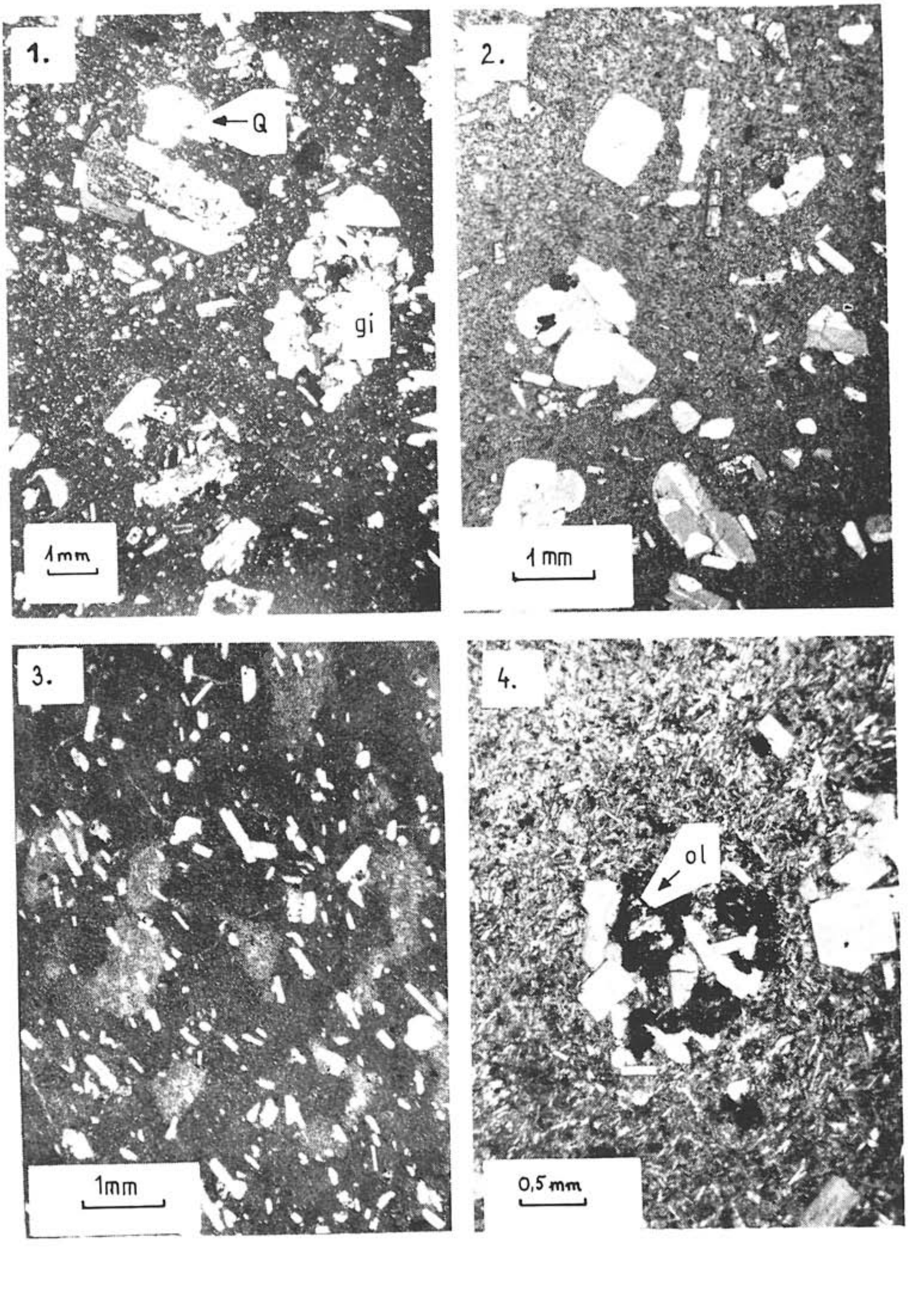
When discussing the genetics of pyroxene dacite, earlier researchers emphasize the importance of contamination and the close relationship with acidic pyroxene andesite. In the opinion of Gyarmati (1977) the main role is played by Sial contamination in several phases, involving a higher degree of acidification. G. Pantó (in Bóczán et al., 1966) stressed that the eruption centres of pyroxene dacite show differing individual traits, which result from the depth, environment and degree of acidification. This also means that each centre of eruption must be examined individually so that generalized conclusions can be drawn on the genetics of pyroxene dacites.

On the basis of the foregoing it can be established that in the southern part of the Tokaj Mts. the rocks summarized under the name "pyroxene dacite" are not uniform formations. This is verified by the differences in mineral composition of the rocks from various localities, which cannot be simply exlained by the view that these rocks can be ones from different stages of a sequence of differentiation, nor by the one that contaminations of different degrees have taken place. We think that in the evolution of pyroxene dacite several processes participated jointly, although in different degrees according to the localities.

As an initial step to our hypothesis on the petrogenesis of the rocks, we adopt the view of Gyarmati (1977) who says that the origin magma must have been close to basic pyroxene andesite (SiO_2 content: 53—54 %). This magma, due partly to contamination, partly to differentiation, became acidic and assumed the composition (SiO_2: round 58 %) corresponding to acidic pyroxene andesite. Then, in the case of Tokaj-Nagyhegy, magma-mixing played the chief role (Rózsa — Kozák, 1985) as is shown by a number of observations. The groundmass inclusions in the plagioclases show such characteristic features that are common when more basic and more acidic materials are mixed (Kuno, 1950; Eichelberger, 1978). The appearance of reverse zonality has been correlated — among other things — with magma-mixing (Lofgren, 1980). The dihexahedric structure makes the magmatic origin of quartz undoubted, contrary to several reports (e.g. Lengyel, 1924) which described it as a mineral coming from sedimentar rock. The evolution of porous, rounded dioriteporphyric inclusions can also be related with the filling up of an acidic reservoir of magma with a more basic material (Eichelberger, 1980). The decisive majority of analyses falls within the hypersthene field of the AFM diagram. In the above process in Kuno's opinion a role is played, in addition to differentiation, by assimilation, too, which, in a wider sense, involves magma mixing as well. The uniformity of mineral composition refers to the advancement of mixing, whereas the wide scattering of the analyses to a smaller or greater inhomogeneity.

In the case of the rock of Cigány Hill the main role, besides assimilation, was played by differentiation, since the differences manifested in the mineral and

Plate 1



chemical compositions of the rock types cannot be simply attributed to different degrees of assimilation (Rózsa — Barta, 1986). From the fact that alien rock inclusions or minerals originating in these (e.g. quartz) cannot be found even in the most acidic type of dacite, one can conclude on the significance of differentiation and the antecedence of the contamination. The position of the analyses in the F/M diagram also indicates a high degree of differentiation, whereas in the AFM diagram the two main rock types identified on the grounds of textural and mineral compositional differences, are clearly distinguished. In this diagram the points of the analysis essentially fall within the pigeonitic field. In connection with this sequence of rocks Kuno (1950) emphasized the importance of differentiation.

The laccolith of Mulató Hill — Barnamáj, although this is the smallest body of rock out of the three, can be regarded as the least settled question. L. Kulcsár, who cleared up the petrographic conditions of the rock, on account of the mineral composition not "fitting" with the acidity of the rock emphasized the importance of rhyolite assimilation taking place in the depth (Kulcsár — Barta, 1971). This statement is to be accepted with the remark that its confirmation needs further examinations.

From those said above it follows that the pyroxene dacites in the southern part of the Tokaj Mts. represent a really highly varied group of rocks, the common denomination of which is only justified by their macroscopic similarity and the convenience for everyday routine work. Their variety is due to the complex process of their evolution, and to the circumstance that the most obvious change was caused by a different process in every individual case.

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Plate 1

Fig. 1. Textural photo of pyroxene dacite from Tokaj-Nagyhegy. X N. Q — quartz, gi — glomeroporphyric inclusion.
Fig. 2. Textural photo of I. type of pyroxene dacite from Cigány Hill. 1 N.
Fig. 3. Textural photo of II. type of pyroxene dacite from Cigány Hill. 1 N.
Fig. 4. Textural photo of pyroxene dacite accessory with olivine from Mulató Hill — Barnamáj. 1 N. ol — olivine.

REFERENCES

BÓCZÁN B. et al., 1966: Magyarázó Magyarország földtani térképsorozatához. M-34-XXXIV. Sátoraljaújhely. Budapest, 84 pp.
EICHELBERGER, J. C., 1978: Andesites in island arcs and continental margins: relationship to crustal evolution. Bull. Volcanol., 41, 4, pp. 480—500.
EICHELBERGER, J. C., 1980: Vesiculation of mafic magma during replenishment of silicic magma reservoirs. Nature (London), 288, 5790, pp. 446—450.
GYARMATI, P., 1961: Vulkáni kőzetminősítés problematikája tokaji-hegységi példákon. Földt. Közl. (Budapest), 91, pp. 374—381.
GYARMATI, P., 1977: A Tokaji-hegység intermedier vulkanizmusa. Magyar Állami Földtani Intézet Évkönyve, LVIII. Budapest, pp. 85—87.
KULCSÁR, L. — BARTA, I., 1971: Kőzettani vizsgálatok az erdőbényei Mulatóhegy--Barnamáj lakkolitján. Acta Geogr. Geol. Met. (Debrecen), 15—16, pp. 39—72.
KUNO, H., 1950: Petrology of Hakone Volcano and the adjacent areas, Japan. Bull. Geol. Soc. Amer. (New York), 61, 2, pp. 957—1020.
KUNO, H., 1969: Andesite in time and space. International upper mantle project scientific report, 16. Proc. andesite conf., pp. 13—21.
LENGYEL, E., 1924: Ujabb adatok a Tokaji-Nagyhegy petrogenetikájához. Földt. Közl. (Budapest), 54, pp. 64—71.
LOFGREN, G., 1980: Experimental studies on the dynamic crystallization of silicate melts. In: Hargraves, R. B. ed.: Physics of magmatic processs. Princeton University Press.
RÓZSA, P. BARTA, I., 1986: A bodrogszegi Cigány-hegy és környéke intermedier vulkanitjai. Acta Geogr. Geol. Met. (Debrecen), in press.
RÓZSA, P. — KOZÁK, M., 1982: A Tokaji-Nagyhegy dácittipusai. Acta Geogr. Geol. Met. (Deberecen), 20, pp. 191—215
RÓZSA, P. — KOZÁK, M., 1985: Petrogenetic problems of mixed rocks of Tokaj Mountains. Manuscript, Debrecen.

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