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PETROLOGICAL INVESTIGATION OF LEUCOCRATIC ANDESITE ON THE BASIS OF CHEMICAL COMPOSITION OF INDIVIDUAL COMPONENTS AND OF THE WHOLE ROCK ON VERTICAL CROSS SECTIONS OF LAVA STREAMS

(Fig. 1—18)

Abstract: The presented paper includes two andesite streams with a low content of mafic minerals. The principal rock-forming component are basic plagioclases and insignificant contents of pyroxenes. On the basis of chemical analyses of the rock and analyses of minerals carried out by the microprobe petrological relations of crystallization of phenocrysts and groundmass as well as changes in chemical composition of the rock are considered. The mineral-petrographic composition shows that typical leucoandesites are concerned.

Резюме: В предлагаемой статье авторы анализируют два андезитовых потока с низким содержанием мафических минералов. Главными породообразующими минералами являются основные плагиоклазы и небольшое содержание пироксенов. На основании химических анализов пород и анализа минералов электронной микрозондой авторы разбирают проблему петрохимических соотношений кристаллизации фенокристаллов и основной массы, как и изменений в химизме пород. На основании минералогическо-петрографического состава изучаемые породы были определены как типичные лейкократовые андезиты.

Introduction

At the southern slopes of the Štiavnické pohorie Mts. several streams of dark-grey to black andesite are found. The streams are relativaly well preserved, their extension can be traced at the distance of several hundreds of metres in some places. The mode of occurrence of these andesites is different from typical pyroxene andesites, which build up the major part of neovolcanic complexes.

Their particular sculpturing led many authors in the past to distinguish them from the complex of pyroxene andesites and to underline their particular character by giving various names. M. Kuthan (1963) in the explanatory notes to map sheet Nitra distinguishes them as vitrophyric andesites (Bohunice type). K. Karolus (1967) called analogous andesites from the area of the Pohronský Inovec Mts. as leucocratic for their low content of the mafic component.

The subject of this study are two andesite streams from borehole LEK-2 near the community Žemberovce.

In the profile of borehole LEK-2 (Fig. 1) below the overburden of loam and clays (1) is found a clayey-sedimentary complex with intercalations of tuffites and diatomaceans (2). In the underlier of this complex are two andesite streams (3),

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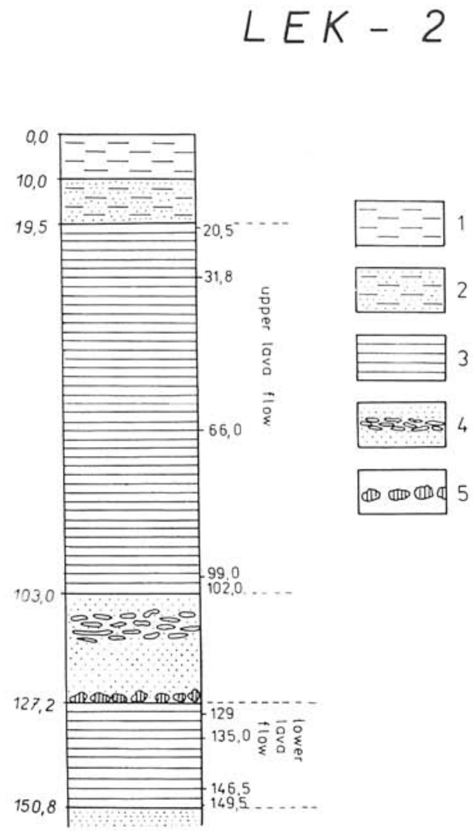

Fig. 1. Profile of borehole LEK-2.

greyishblack, of pitch habit, separated from each other by an about 24 m thick layer of sandy, also pumiceous tuffs of Brhlovisko type (4), (5) (Fig. 2 and 3). Both andesite streams have many common properties, which make them interesting and suitable for a detailed petrological study. The upper lava stream is 83,9 m thick; the lower one 23,6 m only. The upper stream was investigated in detail at five sections, the lower at four sections. In the mentioned sections petrographic composition of rock, development of groundmass and porphyric components, their per cent amounts were traced. In these sections also chemical composition of rock, chemical composition of porphyric phenocrysts of plagioclases, pyroxenes, microlites of plagioclases and accessory magnetites or titanomagnetites were traced.

I. Petrographic composition of rock

Megascopic characterization of lava streams

In both streams andesite is dark-grey, at the surface of the streams and at the base highly porous, of pitch habit. Its texture is distinctly porphyric with vitreous groundmass. This fundamental characteristic changes slightly within the observed profiles. Especially variable are the size of porphyric phenocrysts and their amount, therefore also total appearance of the rock is changing; from the vitreous rock at the surface and at the base of streams becomes gradually a conspicuously porphyric rock.

Microscopic characterization of groundmass development

Megascopic properties are the reflection of microscopic development, which is not equal within all the cross sections of both andesite streams. Most distinctly is changing groundmass development, its per cent amount and porosity.

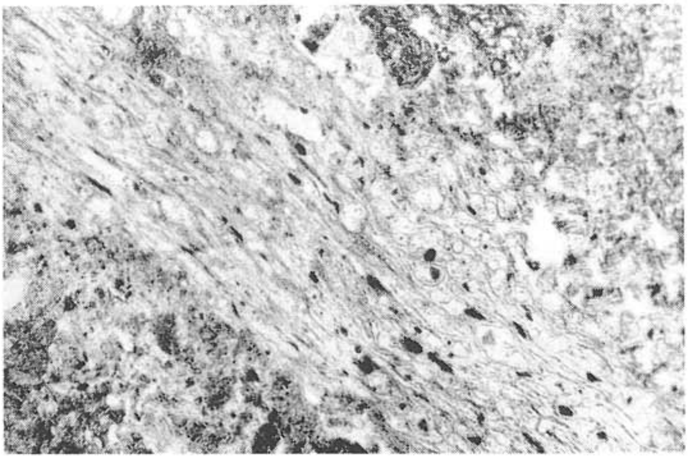

Fig. 2. Detail from layer of pumiceous tuffs. In the middle is a highly fluidal, vesicular pumice, slightly compressed by diagenesis. Nicols //, magnif. 43 ×. Photo by Martančík.

Development of groundmass in both streams analogously passed through several stages, from the hyalopilitic to microlitic. Hyalopilitic development dominates in both streams in the upper as well as basal part. The hyalopilitic groundmass is formed by thin microlites of plagioclases, which are partly fluidally ordered. Among them is brown glass, in this vitreous mass are small isometric grains of magnetite (Figs. 4, 5, 6, 9).

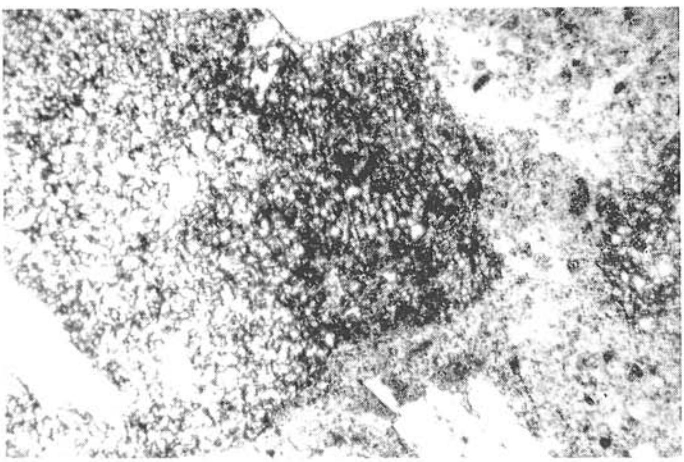

Fig. 3. Between the andesite streams is a layer of synvolcanic tuffs. In the ashy cementing mass are found crystalloclasts of plagioclases among highly vesicular fragments of leucocratic andesites (darker porous parts). Nicols //, magnif. 23 ×. Photo by Martančík.

Fig. 4. 31,8 m. Porphyritic texture of leucocratic andesite from the upper stream in section 31,8 m. Characteristic in having large phenocrysts of plagioclases with many inclusions of mesostasis, from the cluster of pyroxenes and oxides (in the corner is twinned augite). The groundmass is hyalopilitic, inhomogeneous, Nicols //, magnif. 23 ×. Photo by Martančík.

Towards the centre of stream, of the upper as well as lower one, the amount of microlites increases and then gradually the vitreous substance disappears, development is getting microlitic. The microlites are densely ordered, partly flow around the phenocrysts (Figs. 7, 8). The spaces between the microlites

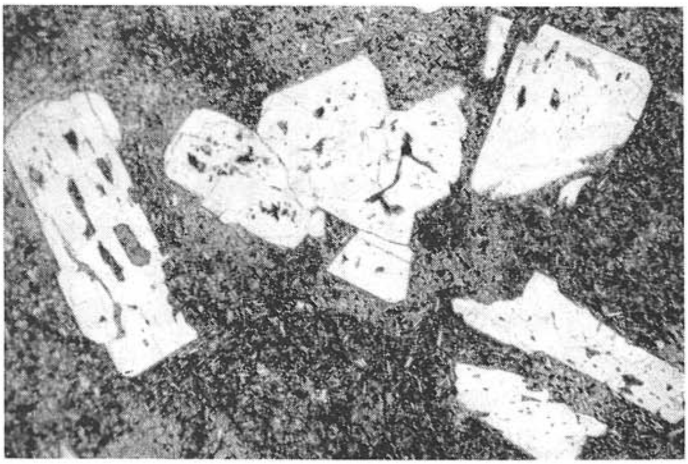

Fig. 5. Texture of groundmass from leucocratic andesite from 31,8 m is distinctly inhomogeous. The inhomogeneity is caused by differentiation of the hyalopilitic groundmass into two parts; the lighter-coloured vitreous and darker, in which the vitreous mass is recrystallized into fibers and forms some imperfect spherulites among microlites of plagioclases. The plagioclase microlites are passing from one substance to other. Nicols //, magnif. 23 ×. Photo by Martančík.

Fig. 6. Detail of groundmass texture from section 66 m from the upper stream. The microlites in the hyalopilitic groundmass flow around phenocrysts of plagioclases. The plagioclases contain many inclusions of mesostasis. Nicols //, magnif. 43 ×. Photo by Martančík

are filled in with fine grained magnetite and minutely crystallized pyroxene (augite?). The change of groundmass development from hyalopilitic to microlitic at the top as well as at the base of the stream can be traced in a section of about 5 metres.

In the groundmass of the upper as well as lower stream we see porosity. At the top of the stream the pores are rather round (Fig. 10), elongated, bordered or also filled up with a brownish-greenish fibrous opalous mass (Figs. 11 and 12).

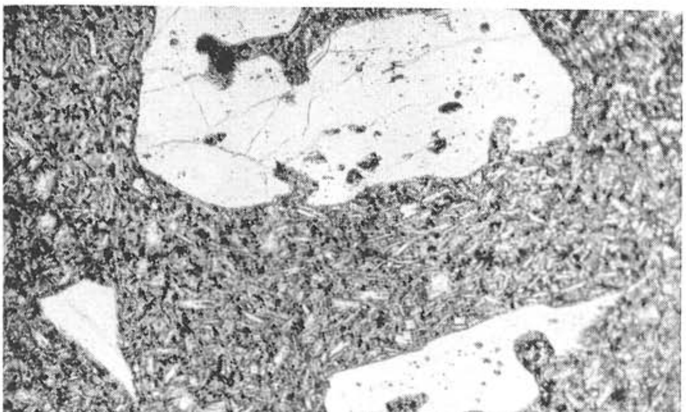

Fig. 7. Detail of microlitic groundmass from section 99 m with imperfectly developed phenocrysts of plagioclases, having numerous embayments and small inclusions from crystallized groundmass. Nicols //, magnif. 43 ×. Photo by Martančík.

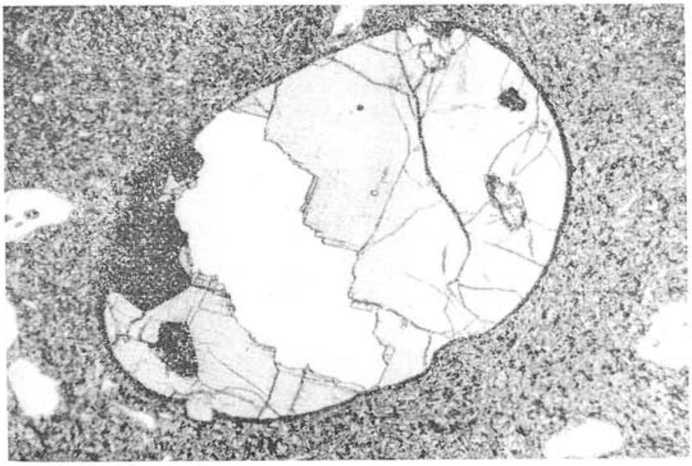

Fig. 8. Partly melted porphyric phenocrysts of augite from section 99 m. The rims of augite are melted probably due to the reaction of groundmass, therefore a reaction border is visible around the phenocryst. Nicols //, magnif. 23 ×. Photo by Martančík.

For determination of per cent amount of the groundmass and porphyric phenocrysts planimetric analyses were carried out from certain sections.

The planimetric analyses were made on Leitz's calculator. Calculated was the surface of the whole thin section, 3 cm^3 minimum. From the calculated values some interesting facts result (Fig. 12 and Tab. 1).

Above all there is a different ratio groundmass: porphyric phenocrysts, in the upper stream about 75 : 25 and in the lower stream about 64 : 36. Different is also the ratio plagioclases-pyroxenes, which in the upper stream is approxi-

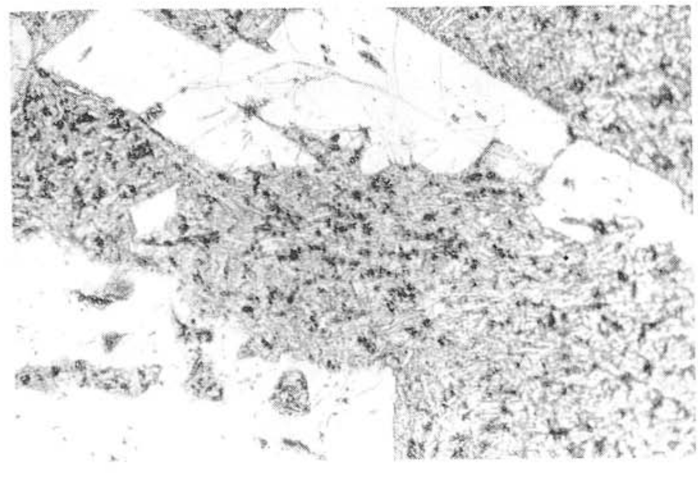

Fig. 9. In section 102 m among weakly fluidally directed microlite laths of groundmass glass appears. The phenocrysts of plagioclases are skeletal, with numerous embayments, imperfectly developed. Nicols //, magnif. 43 ×. Photo by Martančík.

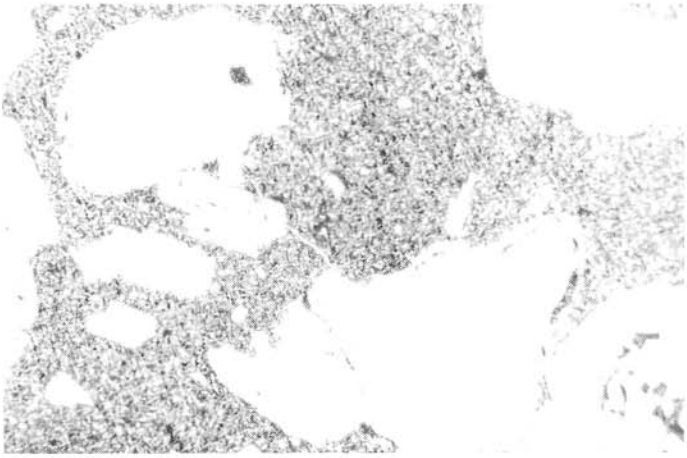

Fig. 10. Section 129 m representing the upper part of the lower stream. Characterized by a highly vesicular structure, with small phenocrysts of plagioclases. Vesicularity is formed by large, almost round pores. The groundmass is hyalopilitic, between the microlites is brown glass. Nicols , magnif. 23 ×. Photo by Martančík.

mately 24 % : 1 %, in the lower one 34 % : 2 %. As a consequence of these different ratios the lower stream has a smaller share of groundmass than the upper one. Porosity of the groundmass is observed in both streams at the top of stream (13.62—12.11 % pores). At the base porosity is developed in the lower stream only (10.86 %). Due to porosity the volume of groundmass is adequately smaller at the top and base of the stream.

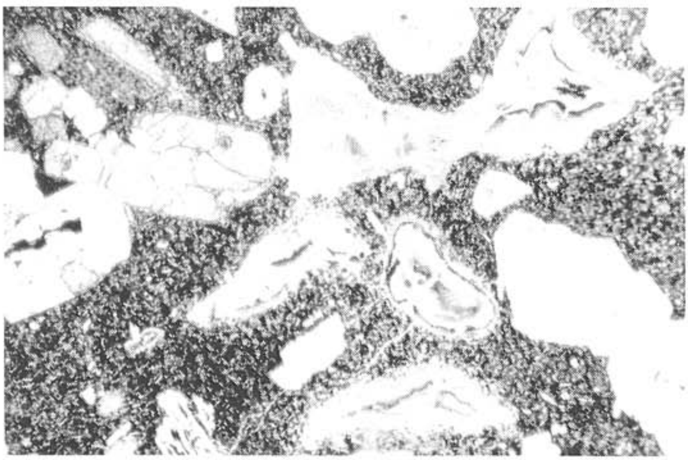

Fig. 11. Basal part of the lower lava stream (section 149.5 m), highly vesicular. The pores are of elongated shapes. They are filled up with various colloids of greenish, rusty-brown-greenish colours. The rock has weak fluidal arrangement. Nicols , magnif. 23 ×. Photo by Martančík.

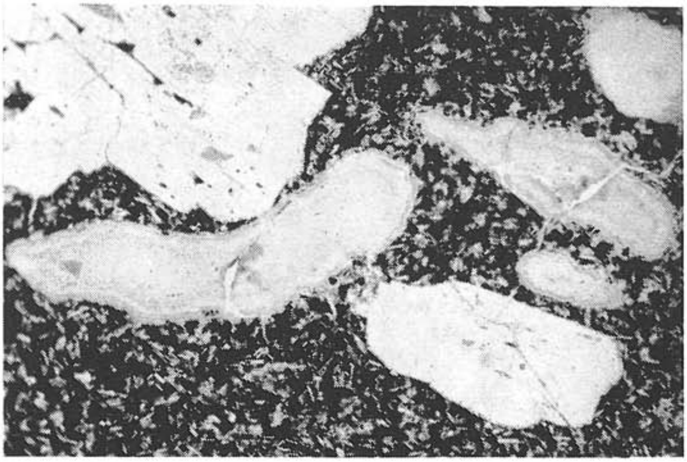

Fig. 12. Detail of groundmass from the basal part of the lower stream (section 149,5 m); among fluidally ordered phenocrysts are pores of elongated shapes with partial zonal filling. The microlites in the brown, vitreous groundmass are minute, thin, imperfectly developed. Nicols //, magnif. 43 ×. Photo by Martančík.

Investigation of plagioclases

In both andesite streams the dominant part of porphyric phenocrysts are plagioclases. At the top and near the base of streams they are of imperfect, hypidiomorphic, often even skeletal development (Fig. 9). The individuals have uneven rims, canals filled up with vitreous mesostasis of groundmass. Frequent are large inclusions of mesostasis (Figs. 4 and 5). Characteristic of this andesite type is that plagioclases have many inclusions but, nevertheless, their dimensions are lesser towards the stream middle. Distinct is also the zonality of plagioclase phenocrysts (Fig. 3). The zonality together with imperfect to skeletal development and resorption of many mesostasis particles indicate a rapid crystallization under rapidly changing pt conditions.

Table 1

	Depth	Matrix	Plag.	Pores	Pyrox. Hy. Aug.	Magnetite ilmenite	
1.	20,5	58,49	27,60	13,62	—	0,29	upper stream
2.	31,8	76,75	19,79	0,83	0,98—0,51	1,14	
3.	66,0	73,58	25,67	—	0,62 —	0,13	
4.	99,0	75,51	22,68	—	0,08—1,34	0,39	
5.	102,0	75,07	24,00	—	0,06—0,50	0,37	
6.	129,0	54,77	31,55	12,21	1,47 —	—	lower stream
7.	135,0	64,13	34,05	0,50	1,20—0,12	—	
8.	146,0	62,80	34,60	—	2,29—0,31	—	
9.	149,5	54,77	33,76	10,86	0,61 —	—	

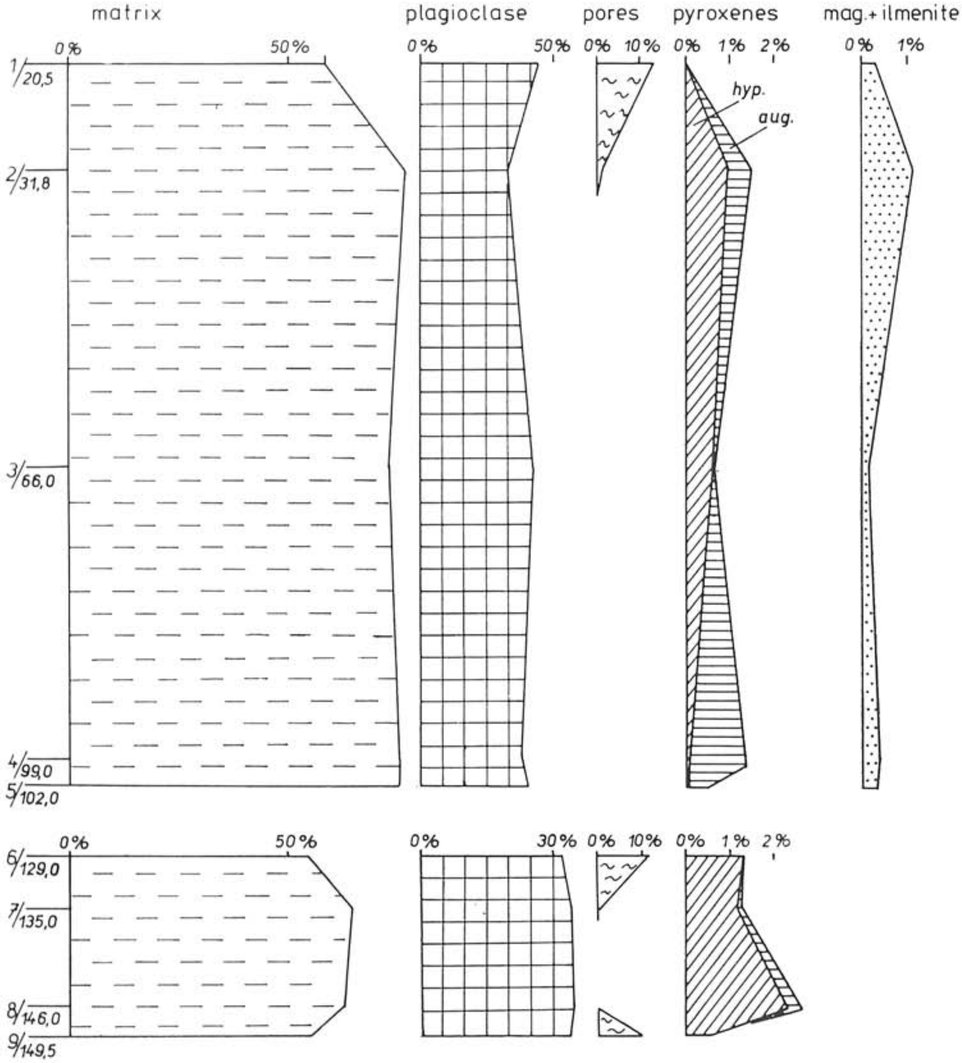

Fig. 13. Graphical representation of modal contents ZH-PV.

Basicity of plagioclase phenocrysts according to the symmetric zone is in the frame of bytownite An_{70}. At Fedorov's desk, according to the diagram of Nikitin, various An values were measured, 60, 66, 72 to 80 with n_x 1,565, in their frame also corresponding to basicity labradorite — bytownite.

Basicity of plagioclases we traced also by X-ray microanalyser JEOL-5. In the traced sections at several individuals the content of Na-Ca, or Na_2O-CaO was established by point analysis and commonly the content of SiO_2 and Al_2O_3 was determined. None of the analysed grains contained K_2O. The results of the point analysis are summarized in the graph in Fig. 14. In this graph the contents of CaO correspond to the more acid half of bytownite, seldom to the boundary labradorite-bytownite. Among these point analyses unambiguously no difference in plagioclase phenocrysts of the lower and upper stream is evident. Certain indications of more acid plagioclases are from the upper stream, especialy at the upper margin. The lower stream has more acid plagioclases at the base.

The recalculation of some analyses to An-Ab shows the following relations:
An % 73,0; 75,7; 78,0; 79,8;
Ab % 27,0; 24,3; 22,0; 20,2.

Beside plagioclase phenocrysts, the rock contains in the groundmass also microlites of plagioclases. We have analysed them by X-ray microanalyser too. As expected, this second generation of plagioclases is more acid than porphyric phenocrysts of plagioclase. SiO_2 contents in both streams vary 52,46 % — 56,82 %. Al_2O_3 contents 25,92 % — 29,6 %, CaO 8,16 — 11,11 % and Na_2O 3,17 — 6,52 %. To these contents correspond also the calculated values of An-Ab:
An % 54,7; 53,3; 42,5; 67,9; 70,9; 59,5; 58,6; 63,3;
Ab % 45,3; 46,7; 57,5; 32,1; 29,1; 40,5; 41,4; 34,7.

According to these values they are andesines in sporadical cases. The majority of microlites are from the labradorite group, the more acid half. More basic members An 60 are in the minority.

According to the works of Bowen (1913) crystallization of plagioclases with basicity of anorthite took place at high temperatures around 1550 °C. In our case when porphyric plagioclases are relatively basical we must suppose that their crystallization temperature was considerably high, only somewhat lower than at anorthites, however, surely not sinking below 1450 °C, at which temperature plagioclases of composition $An_{50}Ab_{50}$ crystallize. In that interval of temperature probably crystallization of microlites of the groundmass was taking place. Crystallization of the melt with the already crystallized solid phase (porphyric phenocrysts), with further cooling, gave rise to only more acid plagioclases with a short time of crystallization (small microlites) and was terminated by sudden cooling of crystallizing solution into a vitreous mass among the already existing solid phases.

Investigation of pyroxenes

The low contents of porphyric mafic minerals are a characteristic feature of these leucocratic andesites. Their contents are variable, within the range of 0—2,5 %. The individuals present are mostly small. From the planimetric analyses of andesites of both streams it is evident that the lower lava stream is richer in pyroxenes, augites form only an insignificant proportion of pyroxenes. The upper stream, on the contrary, mainly in the lower half, is richer in augites (Fig. 8). Pyroxenes are almost absent at the surface of the lava stream. In the upper half bronzite-hypersthene is more abundant than augite. They are usually idiomorphic, sometimes forming clusters of hypersthene-augite or also magnetite intergrowth (Fig. 15). Hypersthenes have little distinct pleochroism, = yellowish-green, = greyish-green. In augites pleochroism is little distinct and in greenish shades. The angles 2 V of rhombic pyroxenes are within the limits of so called magnesium hypersthenes (53°; 56°; 60°) with prevailing component $Mg_2(Si_2O_6)$ from 54—58 to 66 % and a smaller portion of $Fe_2(Si_2O_6)$ from 34—42

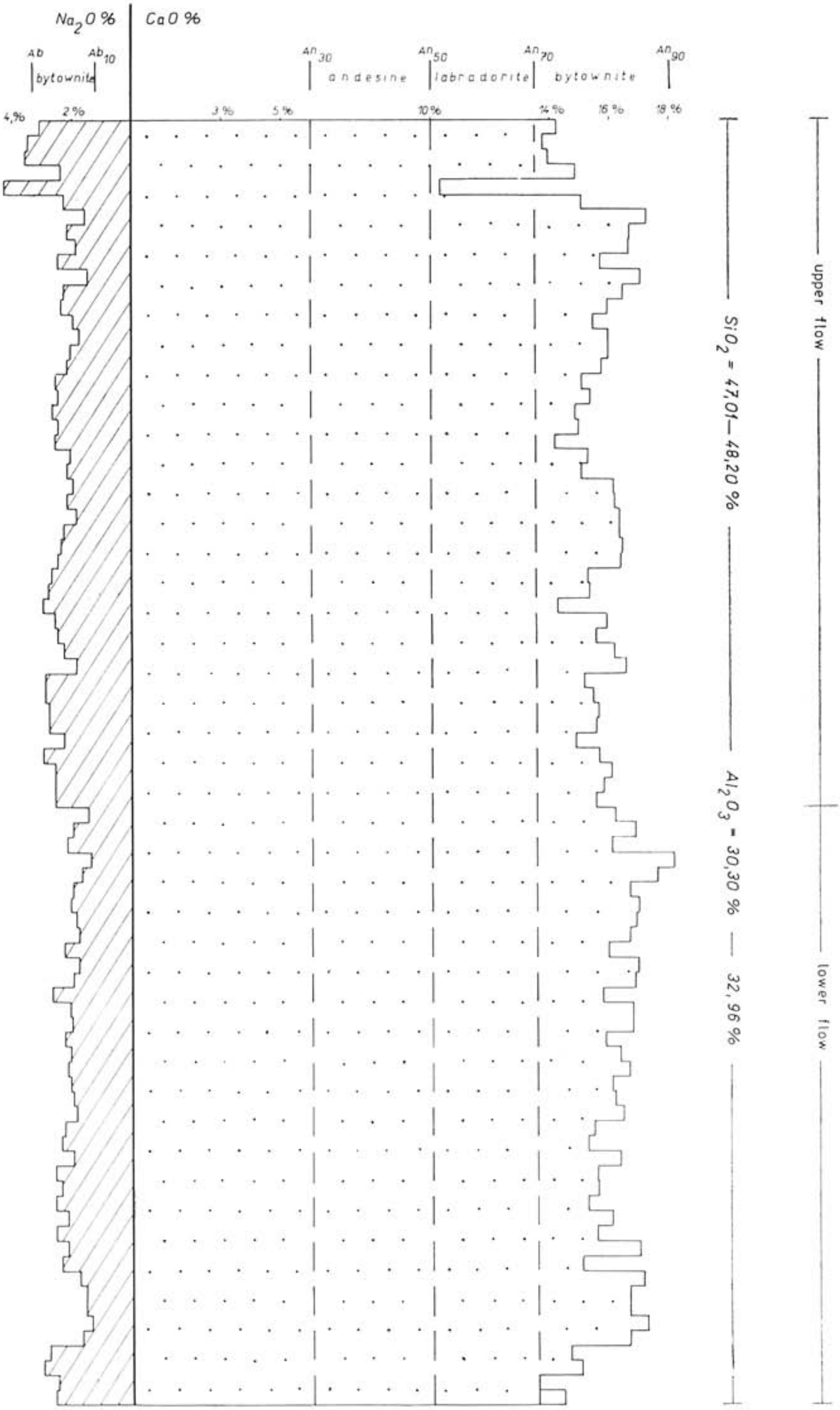

Fig. 14. Graph Na_2O CaO in plagioclases.

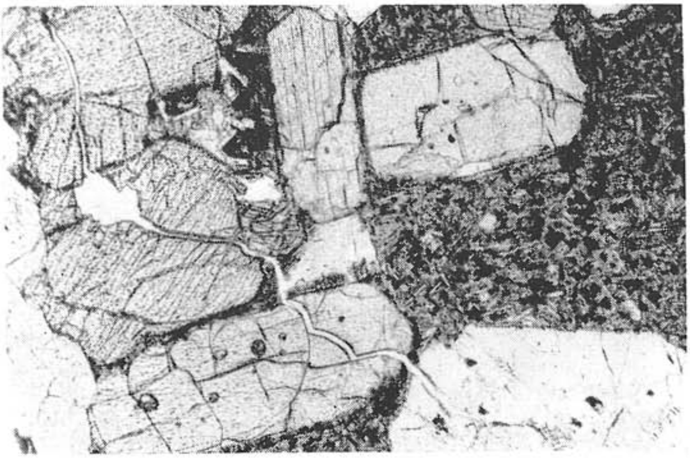

Fig. 15. Cluster of ortho- and clinopyroxenes in section 146,5 m. The pyroxenes are idiomorphic with a very weak reaction zone. The groundmass is hyalopilitic, with a large of amount of acicular microlites. It contains a large amount of small magnetites-ilmenites. Nicols //, magnif. 43 ×. Photo by Martančík.

to 46 % (according to Poldewaart, 1947). Refractive indices are according to the diagram of Kennedy (1947) $n_x = 1{,}695$; $n_y = 1{,}705$; $n_z = 1{,}71$.

The chemical analyses of several grains of orthopyroxenes also indicate high MgO contents, 22,85—24,55 % and also low contents of FeO 13,62—15,86 %. From the representation of both these important components is evident that in the studied streams of leucocratic andesite are present magnesium hypersthenes poor in ferrosilite component with transition into bronzites. The angles 2 V of bronzites are 80 to 74 with refractive indices according to the diagram of Tröger (1950) and Kennedy (1947), $n_x = 1{,}672$; $n_y = 1{,}68$ and $n_z = 1{,}685$. In augites is a similar trend in chemical composition. Several analyses on Fe-Mg-Ca show that its FeO contents are low (max. 7,59 %) and MgO contents relatively high. The analyses of some pyroxenes by the microprobe are presented in Tab. 2.

From the present pyroxenes we may conclude that in the course of crystallization two short phases of pyroxene crystallization took place, of orthopyroxenes-bronzite-hypersthene and augite. On the basis of investigation under the microscope and their succession we suppose, that first crystallized Mg-rich bronzites and hypersthenes and before crystallization of rhombic pyroxenes with a larger content of ferrosilite component could started, the turning point was reached and monoclinic pyroxene, augite crystallized. Some cases of mutual intergrowth of hypersthene and augite also show the possibility of contemporaneuous crystallization of both pyroxenes, as also mentioned by the authors W. A. Deer — R. A. Howie — J. Zussman (1965, vol. II). On the basis of the results of measurement on individual pyroxenes by the microprobe it may be supposed that in our case two independent but very near crystallization phases of both pyroxenes took place, which are represented by orthopyroxenes with a low content of Ca and augite with a high content of Mg component,

Table 2

	Bronzite		Bronzite		Augite	
SiO_2	56,06 %		50,5 %		52,40 %	
TiO_2	0,36		0,30		tr.	
Al_2O_3	1,46		1,19		2,99	
FeO	19,09		13,62		7,59	
MnO	tr.		tr.		tr.	
MgO	24,55		26,86		17,36	
CaO	1,53		1,37		19,76	
	100,25		93,85		100,10	
Si	1,949	2,00	1,937	2,001	1,924	2,00
Al	0,051		0,055		0,076	
Al	0,011		—		0,052	
Ti	0,011		0,009	2,02	—	2,012
Fe^{2}	0,584	2,01	0,435		0,234	
Mg	1,344		1,534		0,950	
Ca	0,059		0,056		0,776	

both are characterized by lacking ferrosilite component. The turn in crystallization of hypersthenes was probably induced by the change in temperature of the crystallizing solution. Already in hypersthenes are represented 0.059–0.056 atoms of Ca, which can enter the lattice of magnesium pyroxenes with temperature sinking to 700 ° C (H e s s, 1952).

Investigation of accessory minerals

Accessory grains were observed only in thin sections, where they often show themselves as octahedral grains or grains with uncertain delimitation. Some of them were analysed by microprobe for Fe and Ti contents. The results are summarized in Tab. 3.

The analyses make clear that among the accessories are represented three kinds of minerals, ilmenite and magnetite with higher contents of TiO_2. Ilmenite was found at the base of the lower stream. It represents one of the first products

Table 3

	Magnetite with higher contents of TiO_2					Magnetite					Ilmenite
FeO	36,41	27,29	40,65	39,91	61,24	56,74	64,35	63,48	60,59	58,92	52,71
TiO_2	46,54	34,86	47,54	44,87	19,35	18,68	16,70	16,46	21,35	22,50	47,34
Sum	82,95	62,15	87,99	84,78	80,59	75,42	81,05	79,94	81,94	80,42	99,05
	upper stream					lower stream					

Table 4
Silicate analyses of leucoandesites from borehole LEK-2

Depth in m	20,5	31,8	66,0	99,0	102,1	129,0	136,5	146,5	149,5
SiO_2	54,40	57,21	57,43	56,32	56,35	55,95	54,60	54,31	55,01
TiO_2	0,62	0,68	0,64	0,62	0,58	0,68	0,62	0,62	0,68
Al_2O_3	19,49	18,33	19,41	19,84	19,47	19,42	20,50	20,63	18,75
Fe_2O_3	6,15	5,27	4,47	2,73	1,98	1,22	2,25	1,14	4,47
FeO	0,65	0,29	1,01	2,77	3,59	3,44	3,67	4,47	1,65
MnO	0,16	0,01	0,004	0,14	0,10	0,06	0,10	0,11	0,04
MgO	0,60	1,31	1,11	1,61	1,26	1,81	1,86	2,32	1,51
CaO	7,29	8,55	8,27	8,51	8,88	10,23	8,55	8,97	9,25
Na_2O	2,02	2,24	1,98	2,99	3,42	1,82	2,94	2,84	1,60
K_2O	1,58	1,78	1,48	1,87	1,96	1,44	1,68	1,68	1,12
P_2O_5	0,20	0,25	0,11	0,10	0,24	0,23	0,11	0,09	0,20
H_2O^-	1,98	0,84	0,68	0,16	1,58	0,24	0,81	0,20	1,58
H_2O^+	3,88	1,80	2,26	1,96	0,11	2,50	2,58	2,14	2,60
SO_3	0,80	1,28	0,95	—	—	0,83	—	—	1,30
Sum	99,82	99,84	99,80	99,62	99,52	99,86	100,31	99,52	99,76
Zavaricki s parameters:									
a	7,73	8,30	7,36	10,09	11,05	6,68	9,81	9,60	5,93
	10,25	9,36	10,89	9,35	8,44	11,08	10,26	10,34	11,31
b	9,94	9,81	7,82	10,46	11,00	10,92	10,72	11,69	10,61
s	72,08	72,53	73,93	70,10	69,41	71,32	69,21	68,37	72,15
a′	19,05	—	—	—	—	—	—	—	—
c′	—	21,54	4,90	18,44	29,33	25,00	11,27	14,10	14,71
f′	69,05	53,85	68,63	53,19	50,00	43,75	56,34	49,36	58,09
m′	11,90	24,61	26,47	28,37	20,67	31,25	32,39	36,54	27,20
n	65,31	65,45	66,67	70,59	72,37	65,91	72,31	71,88	68,42
t	0,86	0,94	0,83	0,85	0,85	0,96	0,87	0,88	0,97
	60,32	50,77	54,90	24,11	16,00	9,72	19,72	8,97	41,18
Q	18,45	19,10	22,25	10,67	8,08	18,20	8,54	7,20	21,13
a/c	0,75	0,89	0,68	1,08	1,32	0,60	0,96	0,93	0,52
Class	2	2	2	3	3	2	3	3	2
Group	6	6	6	10	10	6	10	10	6

of magma crystallization and is very often in association with rhombic pyroxenes. Mostly spread among accessory grains is magnetite, which is also most abundant in the groundmass of andesites. Buddington et al. (1955) suppose that the majority of magnetites with titanium content and magnetite-ilmenites form at magmatic temperatures at the same time with silicate phases.

II. Chemical composition of lava streams

The chemical analyses are from the same parts of streams, in which also planimetric analyses were carried out (Tab. 4 and Fig. 16). The purpose of these chemical analyses was mainly to find out relations between chemical and mineral composition. Already mere graphical representation of some oxides reveals dependence on the present minerals.

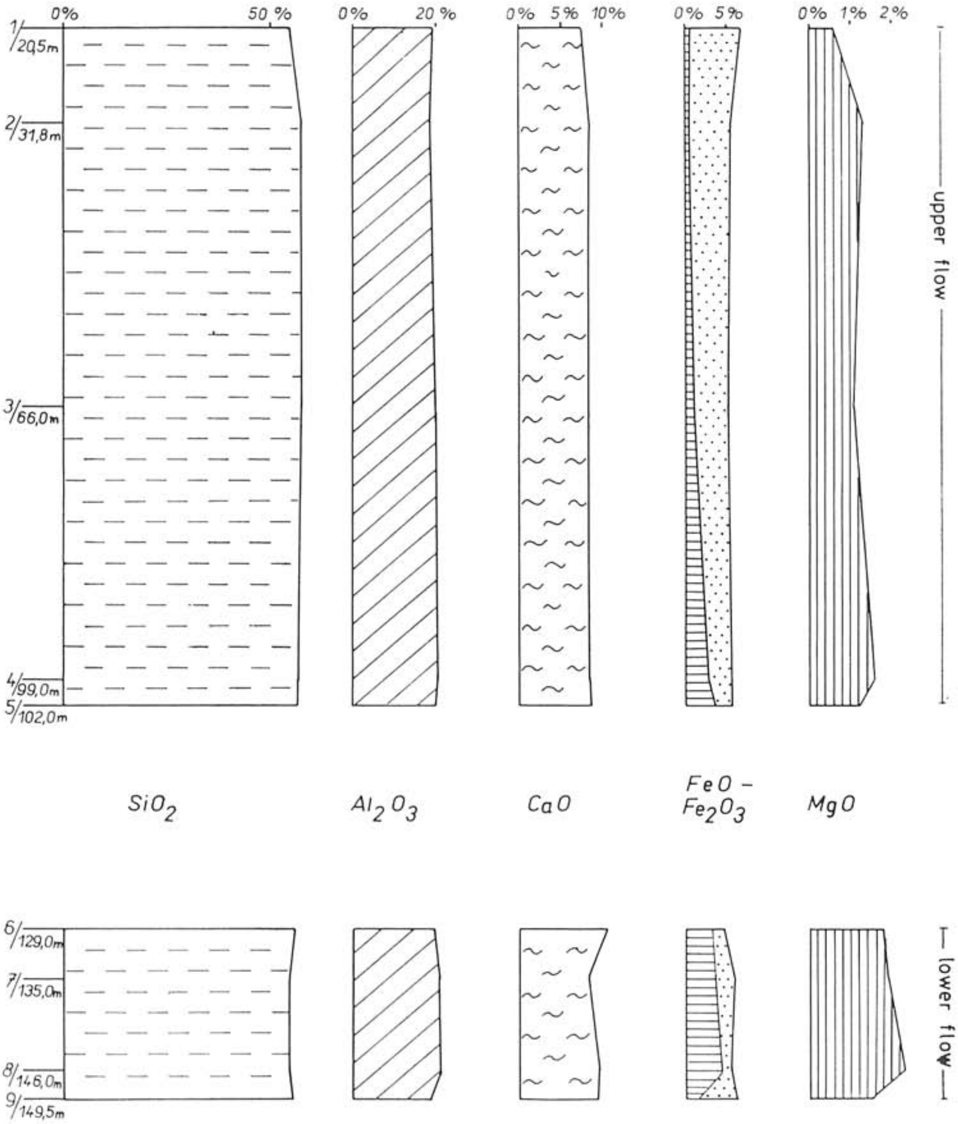

Fig. 16. Graph of oxides from chemical analysis.

According to Zavaricki's parameters (Tab. 4 and Fig. 17) both lava streams differ from each other also in their chemical composition. On the whole they may be characterized in a way that the lower stream is somewhat more basical than the upper one. The higher acidity of the upper streams is shown by the parameter of free quartz Q within the range 8,08–22,25 (average 15,71) and by parameter b within the range 7,82–11 (average 9,8). The more basic character of the lower stream is confirmed by parameter Q within the

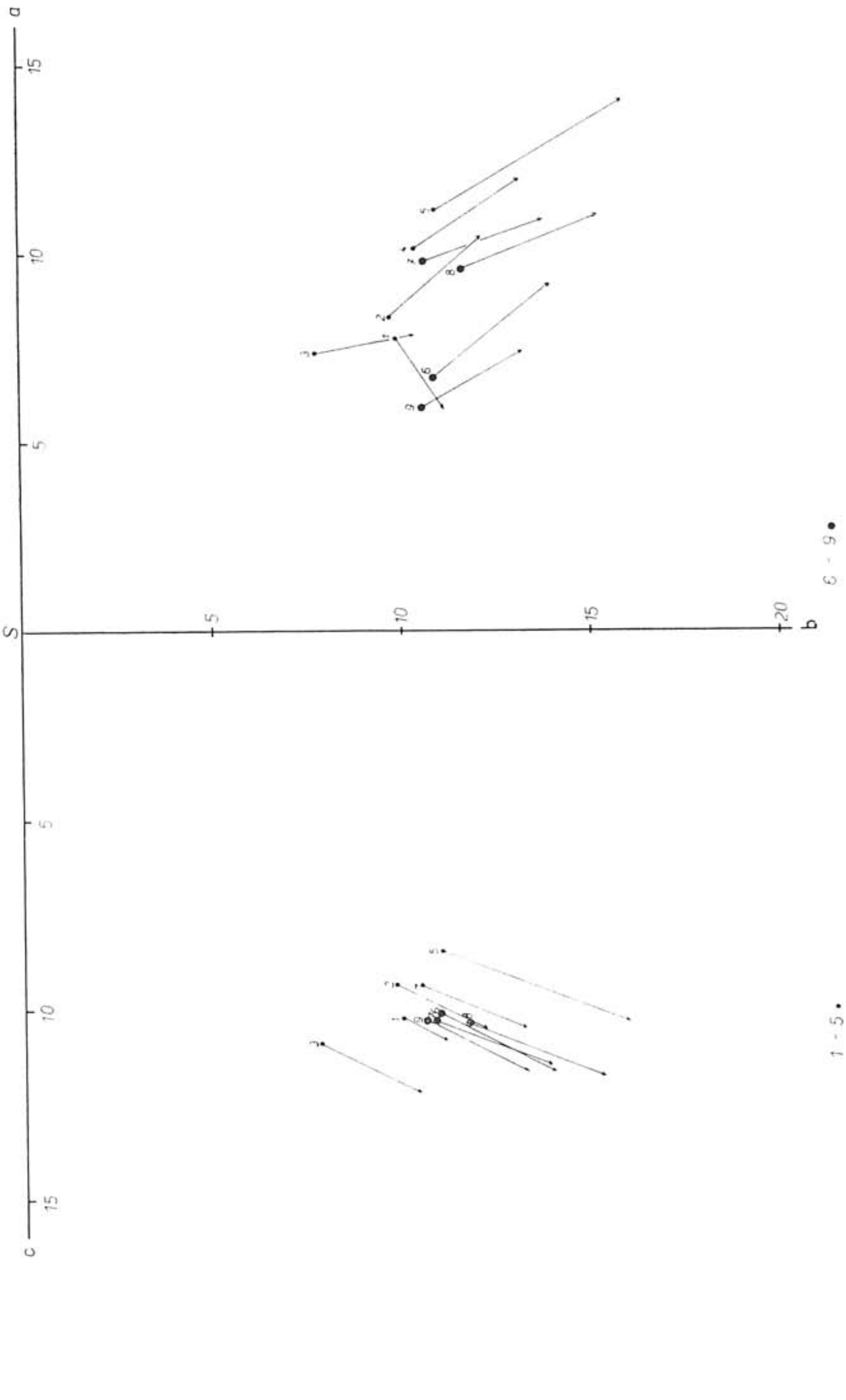

Fig. 17. Zavaricki's parameters.

range 7,20—21,13 (average 13,8) and by parameter b within the range 10,61—11,69 (average 11). Alkalinity of both streams is generally very scattered and variable. They differ, however, from each other only very little in the upper stream being in general a little more alkalic than the lower one (the upper stream varies within the limits $7{,}36 < a < 11{,}05$; the lower stream varies within the range $5{,}93 < a < 9{,}81$). On the contrary, anorthite component of the upper stream, following chemical composition, is also very scattered ($8{,}44 < c < 10{,}89$) whilst in the lower stream it is reduced to the narrow extent $10{,}26 < c < 11{,}31$.

Femic mineral components, beside one case, are characterized by the content of diopside (parameter c'), mostly varying in the range $11{,}27 < c' < 29{,}33$ (only in analyse 3 $c' = 4{,}9$). Analyse 1 instead of diopside component is oversaturated with aluminium ($a' = 19{,}09$). Remarkably different ratios in both streams display Fe and Mg components. The upper stream is characterized by the range $50\,0 < f' < 69{,}05$ and $11{,}9 < m' < 28{,}37$. The lower stream displays ranges $43{,}75 < f' < 58{,}09$ and $27{,}2$ $m' < 36{,}54$. The ferrous component in the upper stream is prevailingly also higher than in the lower one.

In Zavaricki's chemical classification scheme a part of andesites is oversaturated with SiO_2, very poor in alkalies (analyses 1, 2, 3, 6, 9) and a part is only slightly oversaturated with SiO_2, also very poor in alkalies (analyses 4, 5, 7, 8).

Resulting from correlation of the chemical composition and individual stages of the effusive process are to a small extent the questions of acidity but mainly alkalinity. According to the component of free quartz (Q) most acid in the lower stream is the basal brecciated part (depth 149,5 m; analyse 9). Andesite with gradually proceeding effusive activity is getting markedly poorer in free quartz (Q) whilst termination of the effusion in the upper part shows conspicuous enrichment in SiO_2. The quite acid volcanic activity commenced poor in alkalies, the middle parts are essentially richer in alkalies which decrease again. Plagioclase component does not adequately indicate alkalinity, only very insignificantly and as naturally in reversed tendency. The upper andesite stream, on the contrary to the lower one, displays inversed tendency. Its basal part contains very low Q components, which are enormously growing twice with the gradual increase of lava masses. The effusion terminates with a slighter decrease of Q than in the middle of the lava column. Alkalinity of the free streams was very high at the beginning of the effusion, to the middle of the stream it decreased rapidly and towards the surface increased moderately again. Dependence of acidity and alkalinity is completely opposite and in a reversed order appears also the whole cycle in contrast to the lower stream. Plagioclase component in the upper stream is reciprocal to alkalinity.

Evaluation of spectral analyses of trace elements

Differences in material composition of the two streams of leucocratic andesite were recorded very sensitively also in quantitative spectral analyses on some siderophyllic (Cr, Cu, V) and lithophyllic elements (Zr, Sr, Ba). The analyses were carried out by J. Cubinek and L. Tomanóczy in the laboratories of the Dionýz Štúr Institute of Geology.

The contents are plotted in the graph in Fig. 18. The dispersion of analysed elements in the lower and upper stream is summarized in Tab. 5.

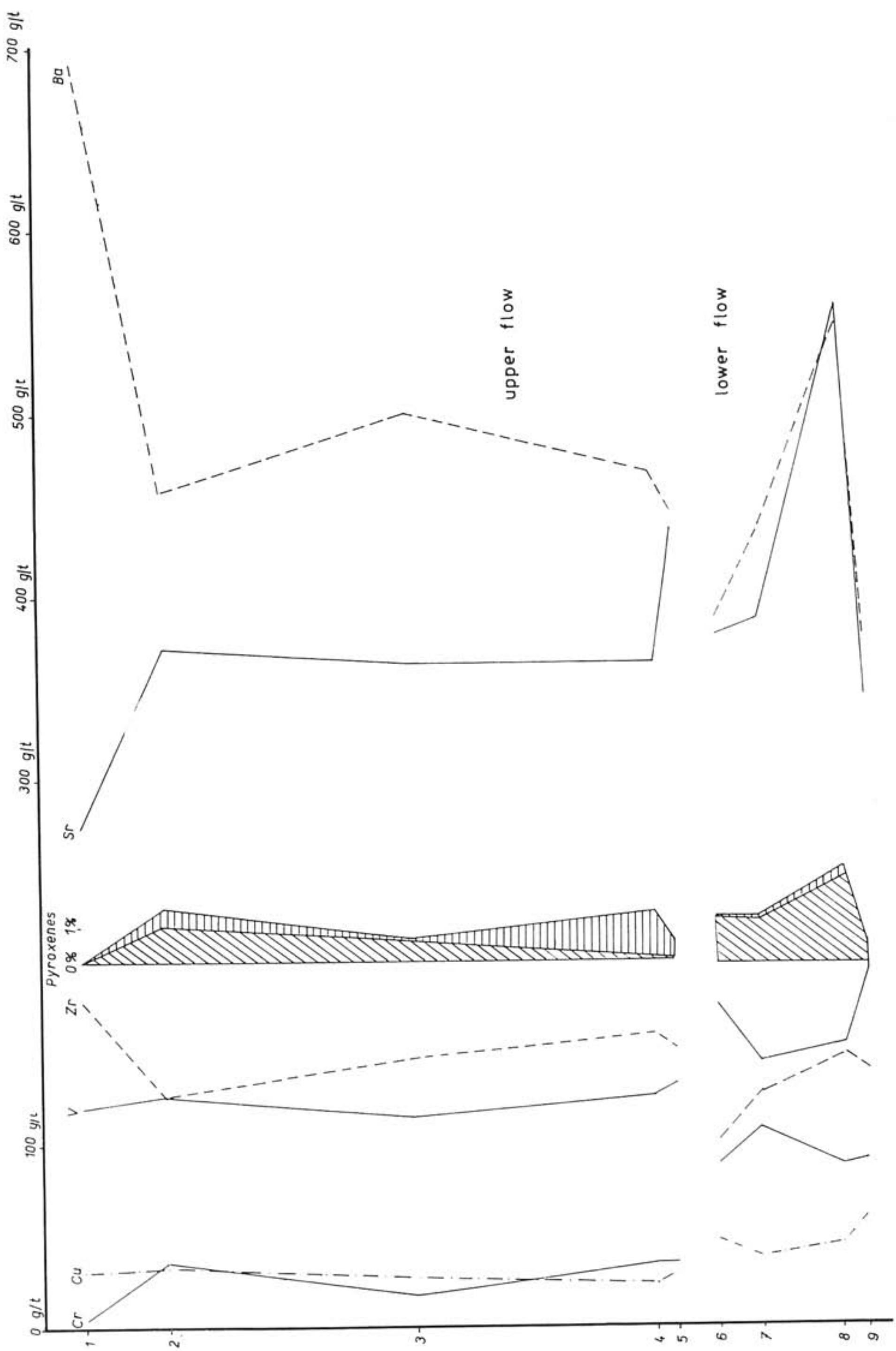

Fig. 18. Graph of trace elements contents.

The graphs in Fig. 6 and the values in Tab. 5 make clear several dependences between the trace elements and mineral composition of both elements. In the graph (Fig. 6) among the contents of trace elements are plotted modal contents of pyroxenes, rhombic and monoclinic. In the upper stream the contents of siderophyllic elements Cr, Cu, V are directly dependent on the content of femic minerals. In the lower stream this dependence is unclear and very probably influenced also by other factors or by the presence of small amounts of magnetite in the groundmass, in which, as known, are the highest concentrations of Cr, V and Cu (D. M. Schaw 1964). Zr contents are bound to augite and plagioclase. In our case Zr contents even ideally follow the contents of augites in the upper as well as lower stream of leucocratic andesites.

Table 5

	Lower stream	Upper stream
Cr	89—110	10— 35
Cu	38— 60	22— 32
V	145—200	115—132
Zr	102—151	126—178
Sr	347—562	275—437
Ba	380—550	447—692

Lithophyllic elements Sr and Ba are directly bound to Ca contents in plagioclases although it is not excluded that Ba is bound to alkalies in the groundmass.

Conclusions

In the case of these two streams of leucocratic andesites from one locality we are witness that the course of crystallization itself and processes of differentiation are the determining factor of petrographical and chemical composition of these investigated leucocratic andesites. The differences in the mineral content are given by the position in the lava body. Material composition of the lower and upper stream results from differentiation processes, on the basis of which quite regularly the lower stream appears to be more basic. Closing it should be noted that even such an equal type of rocks as the group of leucocratic andesites has its variation scales and its composition depends on the position in the lava stream as well as on that whether it is a member of the commencing or later product of effusion.

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