AN AREAL, QUANTITATIVE, CHEMICAL STUDY OF THE GRANITES OF THE VELENCE HILLS, HUNGARY

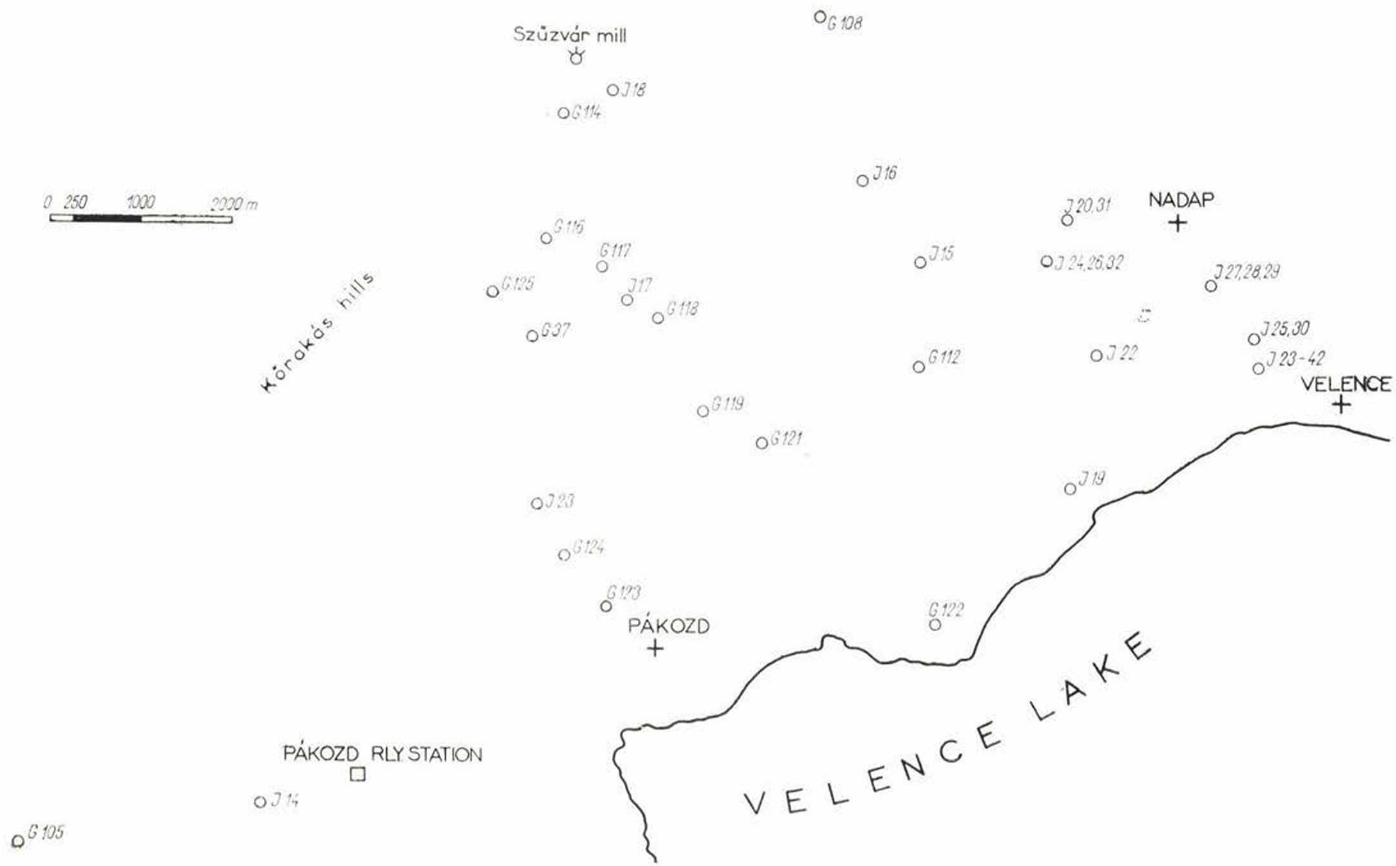
N. W. GOKHALE

(Geology Department, Eötvös Loránd University, Budapest)
(Received on 23. II. 1965)
(With 10 sketches and 3 diagrams)

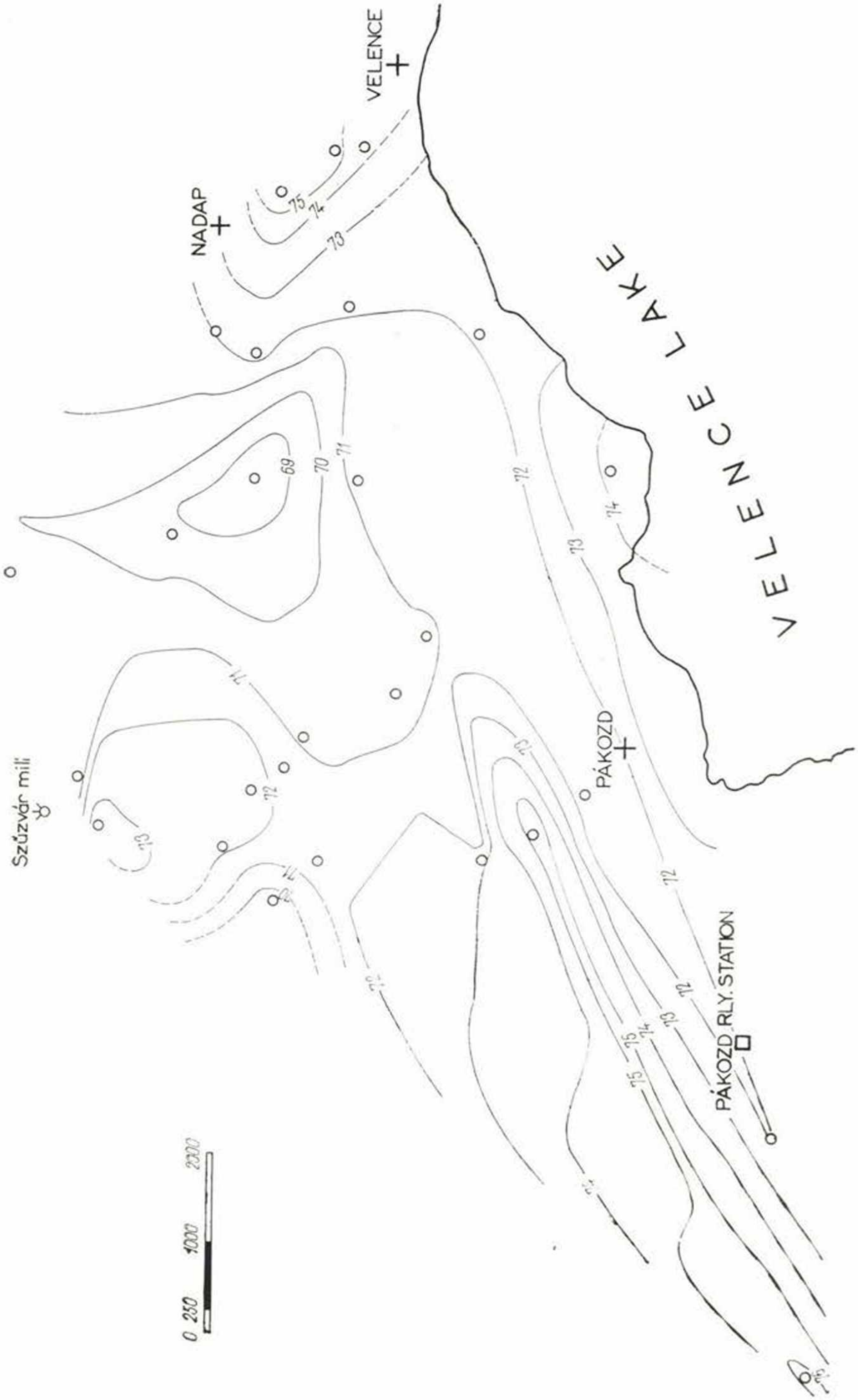
SUMMARY

Based on chemical analyses of 26 granitic rocks from the Velence hills, the areal distribution of the various oxides is studied with the help of isopleth maps. This indicates that the content of SiO_2 and that of K_2O in the rocks decreases from the periphery of the region towards the central parts, whereas that of the remaining oxides increases towards the central parts. The wt. percentage of Al_2O_3, Fe_2O_3, FeO, MgO, CaO, Na_2O and K_2O is plotted against that of SiO_2. These graphs show that with an increase in the wt. percentage of SiO_2 that of Al_2O_3, Fe_2O_3, FeO, MgO CaO and Na_2O decreases, whereas that of K_2O increases. These graphs agree remarkably well with those drawn by Hattori for the granitic rocks of Japan. The granites of Velence hills are rich in SiO_2, Al_2O_3 and K_2O but poor in CaO, S, Al, F (Osann) and $Fe_2O_3 + FeO$, MgO, $Na_2O + K_2O$ triangular variation diagrams disclose that syenites, quartz-diorites and granodio rites are not present. The author in his earlier paper dealing with the modal analyses of the granitic rocks of the Velence hills, has shown that these rocks are rich in orthoclase and that syenites, granodiorites and monzonites are absent. The present study strengthens this conclusion.

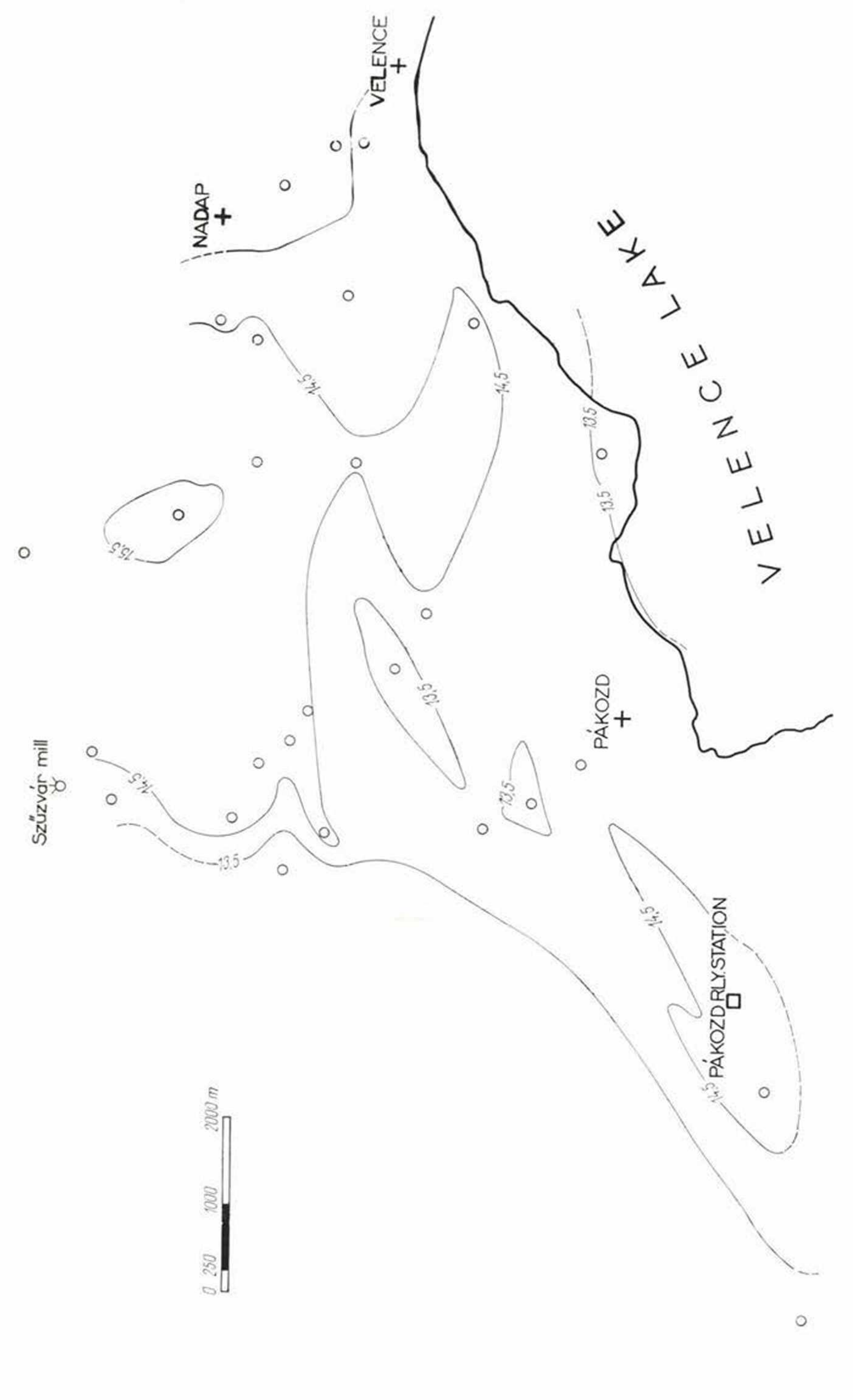
26 granite samples were chemically analysed. Out of these 13 are new and the remaining are taken from Jantsky (1957). Map no. 1 shows the sites of the samples. For most of the chemical analyses, corresponding modal analyses are also available. In Table 1. are set out the wt. percentages of the important oxides. The areal variation of the oxides enumerated in table 1. is studied by constructing isopleth maps. Map no. 2 shows the distribution of SiO_2. The wt. percentage of this oxide ranges between 68 and 76. Rocks with high silica content are located in the region between Nadap and Velence villages (75%), in the region of Lake Velence (74%), in an elongated zone in the southwestern region of the area with 76% (these are the granites that are richest in silica) and finally in the area near the Szűzvár mill (73%). Relatively silica-poor granites are met with in the region of Kőrakás Hill (69%) and in the region between the Szűzvár mill and Nadap village (68%). The variation is quite sudden in the SW parts of the area whereas it is gradual elsewhere. It is interesting to note that the silica percentage decreases from the periphery inwards. However, on the northern border of the area under study, the behaviour of this oxide i.e., whether the content increases or decreases, is not known.



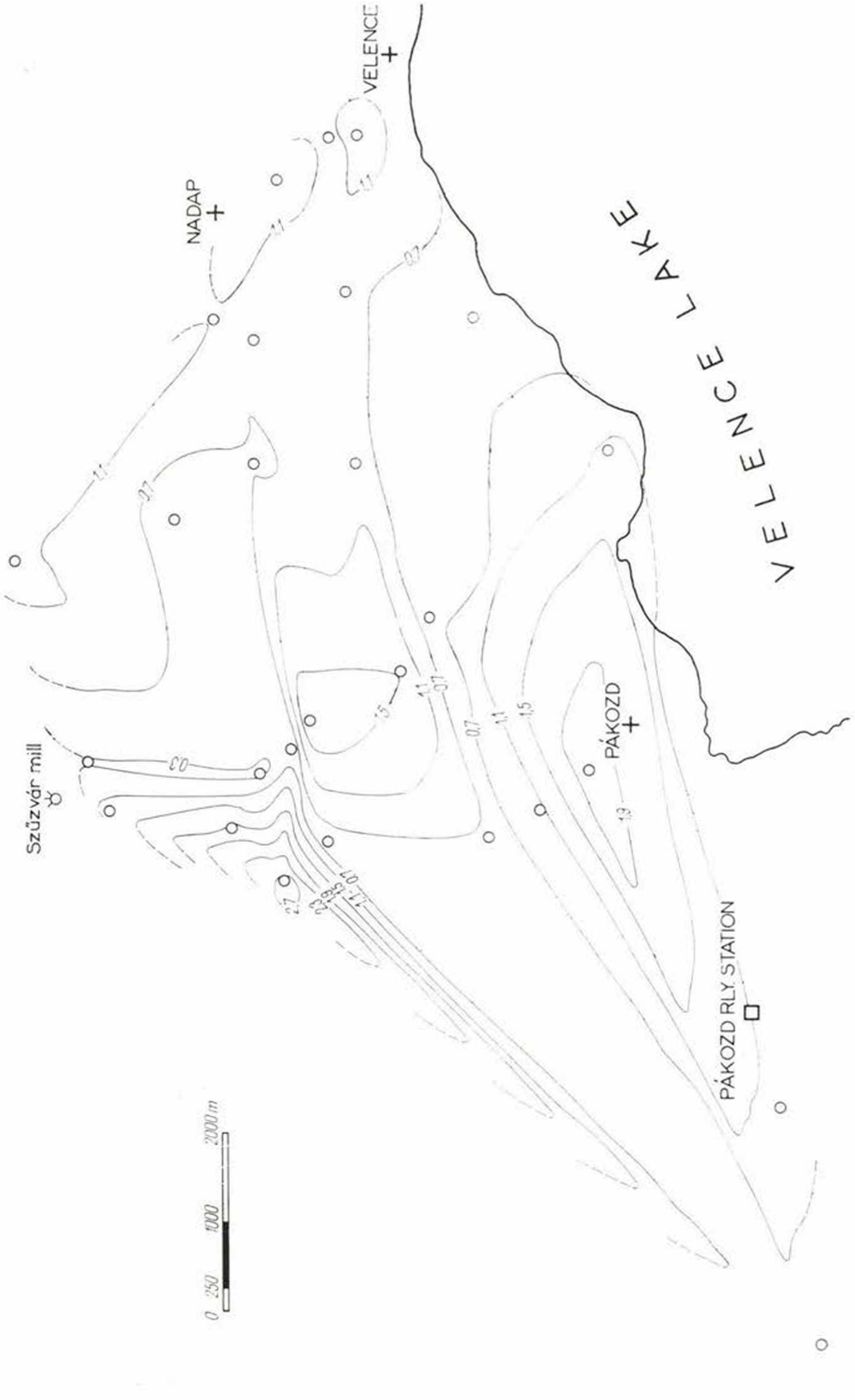
Map No. 1. ites of rock samples. The letters "G" and "J" represent the author's and Jantsky's rock collection respectively. (Granites of the Velence hills, Hungary)



Map No. 2. Areal distribution of SiO_2 (in wt. percents) in the granites of the Velence hills, Hungary



Map No. 3. Areal distribution of Al_2O_3 (in wt. percents) in the granites of the Velence hills, Hungary



Map No. 4. Areal distribution of Fe_2O_3 (in wt. percents) in the granites of the Velence hills, Hungary

Table 1.

SiO_2	Al_2O_3	Fe_2O_3	FeO	MgO	CaO	Na_2O	K_2O
71,68	14,52	0,47	2,13	0,87	1,40	3,10	4,31
72,80	14,70	1,52	0,41	0,30	0,91	2,94	4,32
72,98	15,48	0,29	0,17	0,12	0,52	3,80	4,42
70,21	14,57	1,74	1,66	1,44	2,09	3,34	4,43
70,65	13,14	1,50	1,67	1,95	1,92	3,26	4,80
70,92	14,49	0,51	1,96	0,45	2,16	3,35	3,76
74,25	13,39	1,11	0,56	0,30	0,63	3,18	5,84
71,03	14,40	2,15	0,62	0,82	1,39	2,64	5,74
75,22	13,36	1,01	0,52	0,20	0,97	3,17	4,90
76,14	13,28	0,32	0,17	0,17	0,35	3,06	5,15
70,68	15,35	1,32	0,31	0,62	0,52	3,10	5,44
71,22	14,57	0,91	1,53	0,52	1,78	3,27	4,35
73,41	14,37	0,81	0,26	0,17	0,83	3,35	4,35
72,01	14,95	0,97	2,01	0,39	2,11	2,93	3,88
68,51	15,31	0,65	2,87	0,77	2,37	3,06	4,04
69,35	15,74	0,52	2,64	0,68	2,38	3,64	4,00
71,45	14,62	0,32	2,44	0,49	1,62	3,46	4,45
70,48	14,51	0,27	2,41	0,56	1,92	3,56	4,47
72,04	14,67	0,32	1,55	0,40	0,91	3,79	4,77
72,05	14,47	1,08	1,07	0,06	0,33	2,36	5,58
72,05	13,99	0,79	1,42	0,12	0,97	3,42	5,16
72,96	13,61	0,62	1,77	0,26	0,87	3,19	4,69
72,47	14,57	0,80	1,32	0,09	0,26	2,33	5,97
75,04	13,09	1,05	0,88	0,11	0,66	2,36	4,59
75,78	13,16	1,26	0,38	0 09	0,30	2,14	5,57
74,27	13,84	1,32	0,27	0,07	0,21	2,62	5,35

The author has shown in an earlier paper, that the content of modal quartz also diminishes from the periphery inwards. The rocks with the lowest quartz content are met with on the Kőrakás Hill and also in the more or less central parts of the area. The silica distribution is also similar and hence the earlier observation, that relatively silica/quartz poor rocks are met with in the central parts of the area, is thus strengthened.

Map No. 3 shows the distribution of alumina. The content varies between 13.09 and 15.74%. Rocks rich in alumina are noticed at two places – one near Pákozd railway station (14.95%) and the other in the area lying between Szűzvár mill and Nadap village (15.74%). The rise in the content of this oxide though slight, it is still from the periphery inwards.

Map No. 4 shows the distribution of Fe_2O_3. It varies between 0,27% and 2,75%. The areal distribution is rather regular. Zones stretching in a NE-SW direction are noticeable. The richest zone (2,75%) is noticed on the westernmost part of the area. Progressing due SE, the content rapidly diminishes, then it rises again in the central part of the area (1,75%). The latter zone is ill-defined and the isopleths do not stretch in a NE-SW direction. To the SE of this zone, the Fe_2O_3 content again diminishes for a stretch and then rises again to form the last iron-rich zone (2,15%), which is situated on the southern border of the area. This is located near Pákozd village. The Fe_2O_3 content diminishes towards the periphery of the region under study.

Map No. 5 shows the distribution of FeO. It varies between 0,17% and 2,87%. The distribution is quite simple. Rocks rich in this oxide are located in the region lying to the west of Nadap village (2,87%) and in the vicinity of the Szűzvár mill (2,41%). The isopleths are vaguely elongated in a NE-SW direction. The content of this oxide diminishes towards the periphery of the region with the exception of the Szűzvár mill area, where the content is seen to rise.

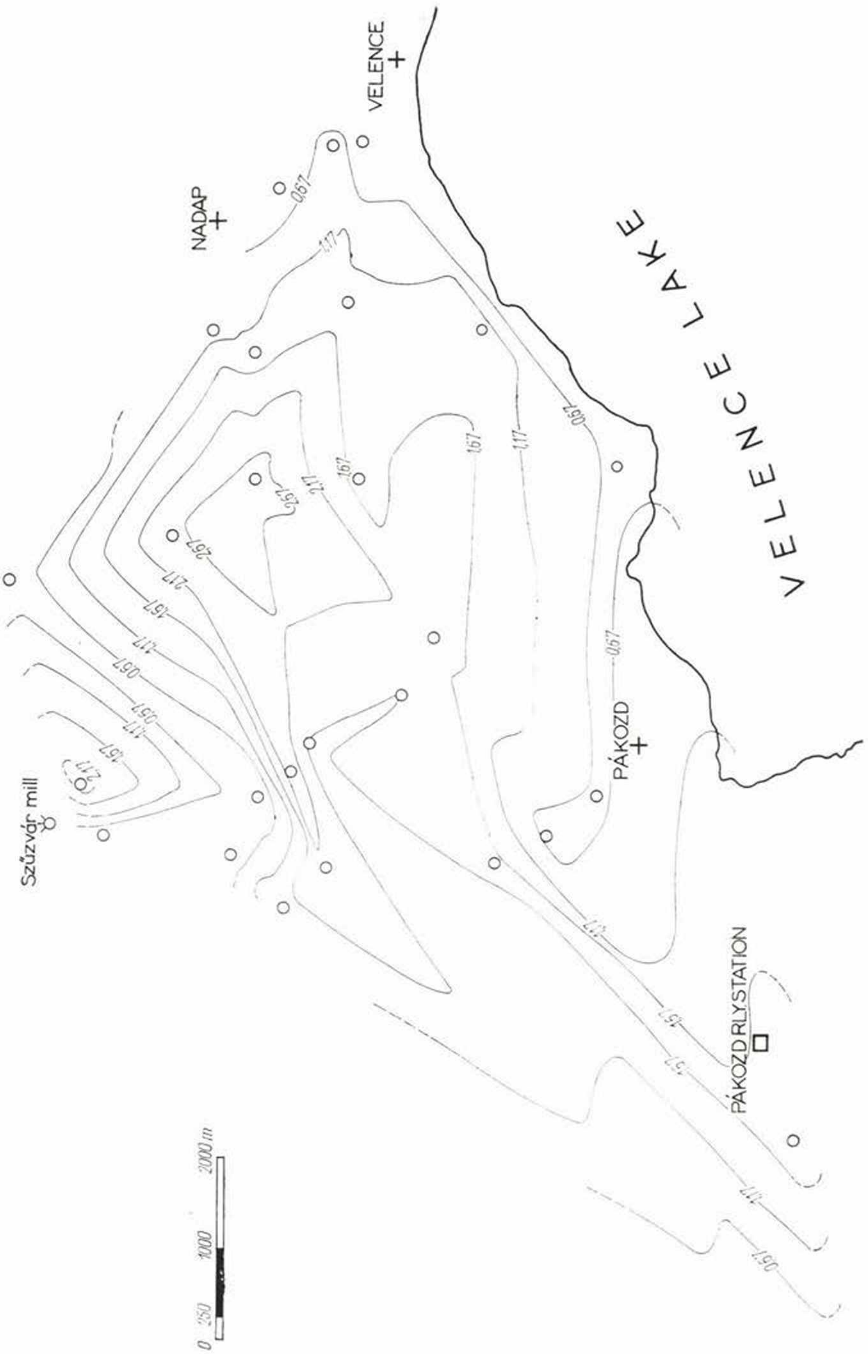
Map. No. 6 shows the distribution of the MgO content of the rocks. It varies between 0,06% and 1,95%. The isopleths are again stretched in a NE-SW direction. Rocks with maximum MgO content (1,95%) are located in the central parts of the area. On the western part of the area, once again rocks rich in MgO (1,57%) are found. Immediately NW of Pákozd village the MgO content slightly rises (0,82%). However towards the periphery of the region the content diminishes once again.

Map No. 7 shows the distribution of the CaO content of the rocks. It varies between 0,26% and 2,38%. Rocks with maximum CaO content (2,38%) are found to the west of Nadap village. The content rapidly decreases towards the NE, while in the other directions it decreases gradually. The content of CaO slightly increases (2,16%) to the north of Pákozd village. To the immediate west of the Pákozd railway station, it once again increases (2,11%) and the increase is quite sudden. In general the CaO content decreases towards the periphery of the region with the exception of the area near the Pákozd railway station, where it is seen to rise.

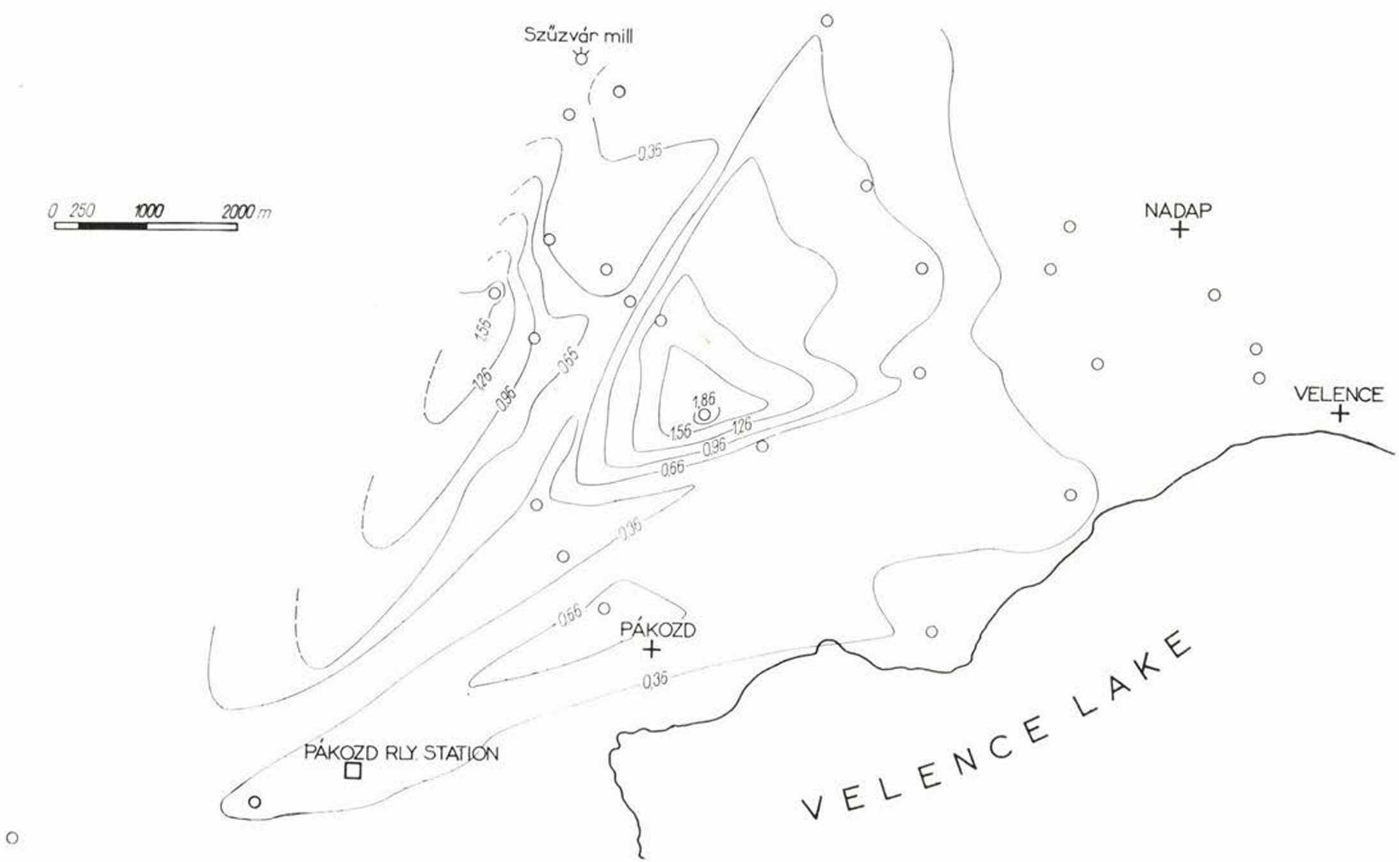
The distribution of Na_2O is shown on map No. 8. Its variation, between 2,14% and 3,8%, is rather slight. Rocks rich in soda are located at three places: 1. Immediately NW of Pákozd village (2,64%), 2. in the region between Velence and Pákozd villages (3,79%) and 3. to the south of the Szűzvár mill (3,8%). The variation is gradual. In general the content of soda diminishes towards the periphery of the region.

Map No. 9 shows the areal distribution of the K_2O content of the rocks. It varies between 3,76% and 5,97%. Rocks richest in K_2O content (5,97%) are noticed immediately west of Nadap village. Rocks rich in K_2O are encountered in the area around Lake Velence (5,84%), in the SW corner of the area (5,15%) and in the area to the west of Velence village (5,35%). Rocks poor in K_2O (3,76%) are met with in the central part of the area and also in the area immediately to the west of the Pákozd railway station (3,88%). The K_2O content rapidly increases towards the Lake Velence region, towards the NE and eastern part of the region under study. The increase on the western border of the area is not rapid, yet the content is seen to rise towards the periphery of the region. Thus it may be said that with the exception of the region of the Pákozd railway station, the K_2O content of the rocks decreases towards the central parts of the area.

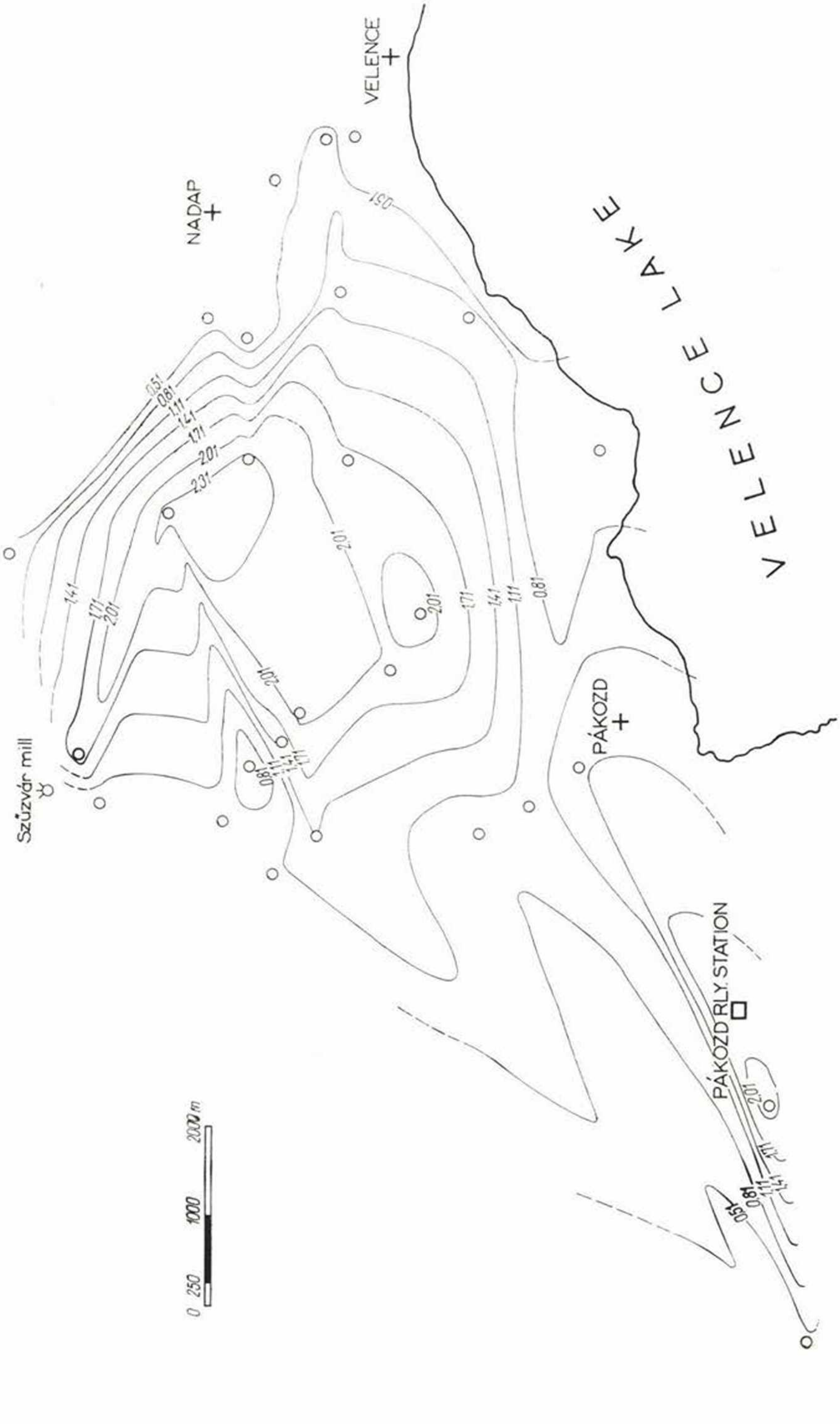
Thus it is seen from the areal distribution maps drawn for the various oxides that the SiO_2 content and the K_2O content of the rocks decreases towards the central parts of the area. In the case of the rest of the oxides the content increases towards the central parts of the region. Of course these statements are true only in a general way, for in the case of one or two oxides there are exceptions. But these exceptions do not much offset the general statements made in respect of the areal distribution of the various oxides.



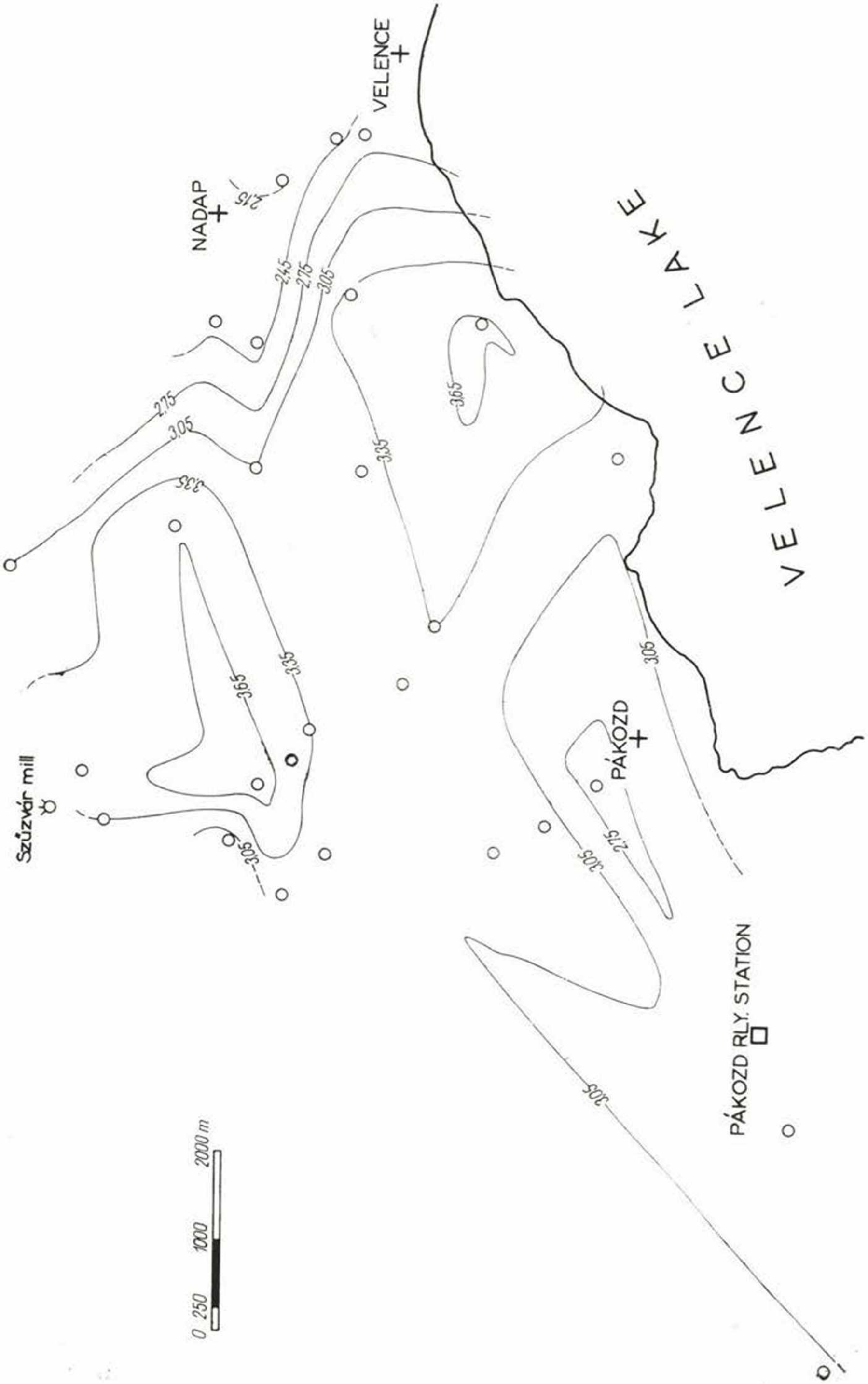
Map No. 5. Areal distribution of FeO (in wt. percents) in the granites of the Velence hills, Hungary



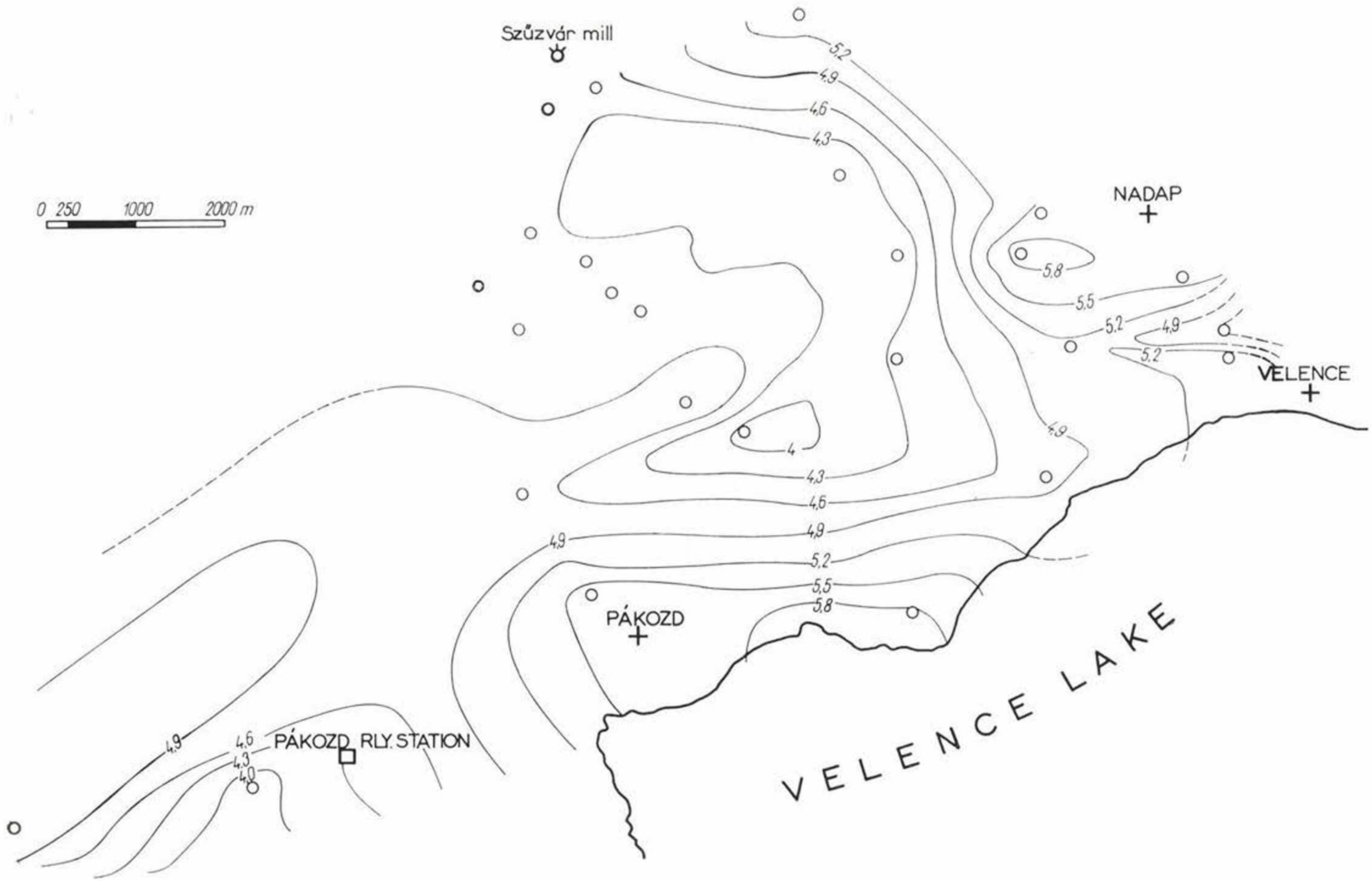
Map No. 6. Areal distribution of MgO (in wt. percents) in the granites of the Velence hills, Hungary



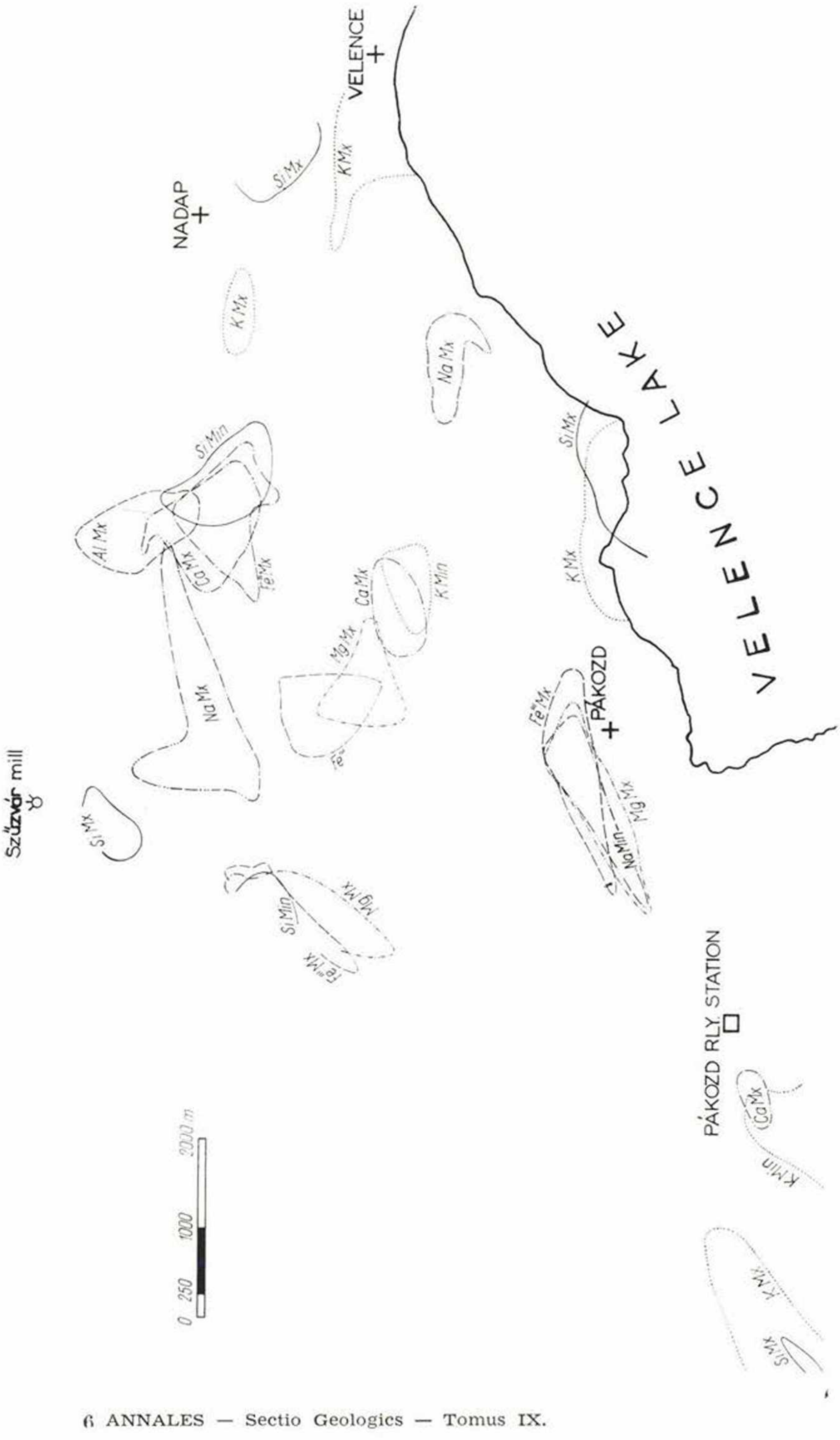
Map No. 7. Areal distribution of CaO (in wt. percents) in the granites of the Velence hills, Hungary



Map No. 8. Areal distribution of Na_2O (in wt. percents) in the granites of the Velence hills, Hungary



Map No. 9. Areal distribution of K_2O (in wt. percents) in the granites of the Velence hills, Hungary



Map No. 10. Superposition of zones of maximum and minimum values for the various oxides in the granites of the Velence hills, Hungary

SiMx	SiO_2 maximum	Fe'' Mx	Fe_2O_3 maximum	Fe'' Min	FeO minimum	NaMx	Na_2O maximum
SiMin	SiO_2 minimum	Fe''' Min	Fe_2O_3 minimum	MgMx	MgO maximum	NaMin	Na_2O minimum
AlMx	Al_2O_3 maximum	Fe'' Mx	FeO maximum	MgMin	MgO minimum	KMx	K_2O maximum
AlMin	Al_2O_3 minimum					KMin	K_2O minimum

Map No. 10 shows the location of the sites of maximum and minimum values of the individual oxides treated above. This helps to visualise the inter-relation between the various oxides i.e., their co-variance or contra-variance.

It helps to see whether the sites of maximum and minimum values for the various oxides are irregularly spread over the region or whether they coincide. This map reveals the following features:

1. The sites of the silica and K_2O maximum coincide. Near Nadap and Velence villages, the two sites do not actually coincide but lie close to each other. Near the Szűzvár mill, only an SiO_2-maximum is seen, without a corresponding maximum of K_2O.

2. The SiO_2 minimum is located not exactly at the central parts of the area yet it cannot be said that it is on the periphery of the region. The zone of minimum SiO_2 on the western side of the area is an exception. It should be remembered that granites extend further to the west of this point, but the rock here is so much altered that it is fit neither for chemical nor for modal analysis. But the feature to be noted is that the K_2O minimum and SiO_2 minimum are located towards the central part of the area.

3. The sites of maximum content of Al_2O_3, CaO, MgO, Fe_2O_3 and FeO are seen to coincide with each other. Further the maximum is located more or less in the central parts of the area. Exceptions are seen on the western side of the area, in the area immediately NW of Pákozd village, in the Szűzvár mill area and in the area to the west of the Pákozd railway station. Even there the Fe_2O_3 and MgO maximum are seen to coincide with each other.

4. The behaviour of Na_2O is not clear. It is not seen to belong to any one of the group of oxides mentioned above.

5. SiO_2 and K_2O decrease together towards the central parts of the area whereas in the case of the remaining oxides the value increases towards the centre. In other words, where the SiO_2 and K_2O content increases, the content of the remaining oxides decreases and vice versa.

The inter-relation between the various oxides has also been studied with the help of graphs. The wt. percentage of the various oxides is plotted against that of SiO_2 (diagram 1). The graphs for Al_2O_3, FeO, MgO, CaO clearly show that these oxides decrease with an increase in the silica content. In the case of Fe_2O_3 and Na_2O this relation is not quite obvious as the points are scattered. Still the content of these two oxides is seen to fall off with the increase in silica.

In the case of K_2O, however the content increases with an increasing silica content. In this graph, too, the points are much scattered and the relation is not readily appreciable. The graphs drawn for the various oxides of the granites of the Velence hills are seen to agree well with those drawn by Hattori (1960) for the granitic rocks of Japan.

In Table 2 are set out the ratios of K_2O+Na_2O, MgO and Fe_2O_3+FeO. On the basis of these data, a triangular variation diagram (diagram 2) is drawn after Schneiderhöhn (1957). It is seen that the most frequent rock types are aplitic granite and granite. Granites approaching pegmatite in composition are present, but these are not frequent. Syenites, granodiorites and quartz-diorites are totally absent. This conclusion was arrived at by the author also in an earlier paper (in press).

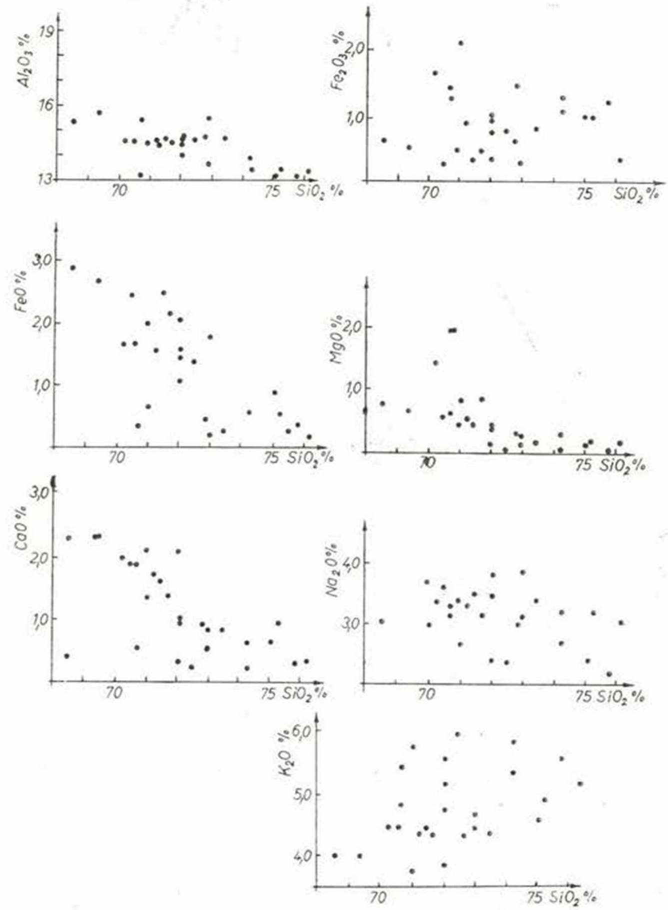


Diagram No. 1. Wt. percents of Al_2O_3, Fe_2O_3, FeO, MgO, CaO, Na_2O and K_2O vs. weight percents of SiO_2

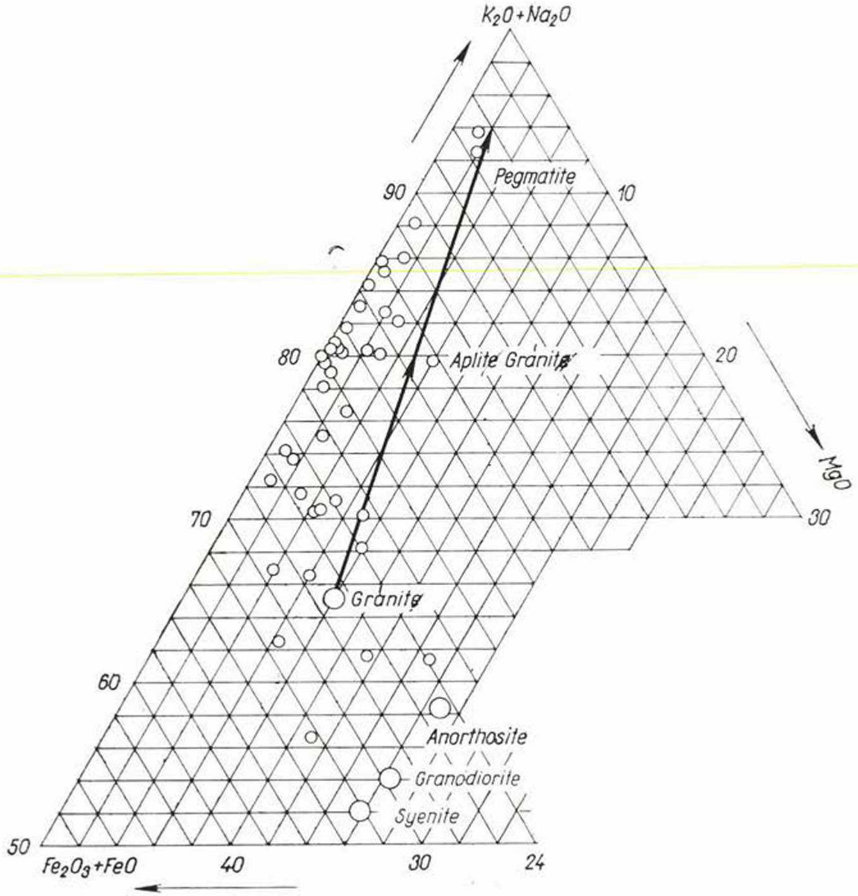


Diagram No. 2. Variation diagram (in part) after Schneiderhöhn. Small circles represent the analyses of granites of the Velence hills, Hungary

Similar results are obtained by plotting the Osann values on the S, Al, F triangular diagram. Table 3. sets out the S, Al, F data for the granitic rocks of the Velence hills. The diagram (diagram 3) shows that only granites are present in the area under discussion. It is also seen that the points are not at all scattered. This perhaps means that the magma did not undergo any differentiation, or perhaps differentiation occurred deeper down and the magma merely rose to the present position and crystallised.

Osann has classified the igneous rocks on the basis of the S, Al, F values. According to his classification in the present area, 9 analyses out of the total of 39, belong to the siliceous alk-lime granites, 2 belong to granite proper and the remaining lie between these two varieties. For them there is no name in the Osann's classification. All the same, it is seen that quartz-diorites, granodiorites are not present as the S, Al, F values do not even approach the Osann values necessary for these rocks.

Table 2

Fe_2O_3+FeO	Na_2O+K_2O	MgO	Fe_2O_3+FeO	Na_2O+K_2O	MgO
23,00	72,00	5,00	20,00	79,00	1,00
12,00	86,00	2,00	22,50	75,00	2,50
15,50	82,50	2,00	19,00	80,00	1,00
5,00	93,50	1,50	18,50	80,50	1,00
24,50	71,50	4,50	21,00	78,00	1,00
5,50	92,50	2,00	26,50	72,50	1,00
20,50	76,50	3,00	12,50	86,00	1,50
24,00	68,00	8,00	11,00	88,00	1,00
15,00	79,00	6,00	25,00	73,50	1,50
15,00	82,00	3,00	25,00	74,00	1,00
27,00	61,50	11,50	20,00	79,50	0,50
24,00	61,00	15,00	13,80	85,90	0,30
23,00	70,00	7,00	16,54	81,18	2,28
32,00	56,50	11,50	14,50	84,80	0,70
29,00	67,00	4,00	17,60	81,90	0,50
31,00	62,50	6,50	20,15	79,55	0,30
27,50	66,50	6,00	18,66	81,04	0,30
25,00	70,50	4,50	13,36	85,85	0,79
24,00	71,00	5,00	17,59	81,53	0,88
17,00	80,00	3,00	17,69	81,58	0,73
20,00	80,00	0,00	16,16	83,83	0,81
25,50	71,50	3,00			

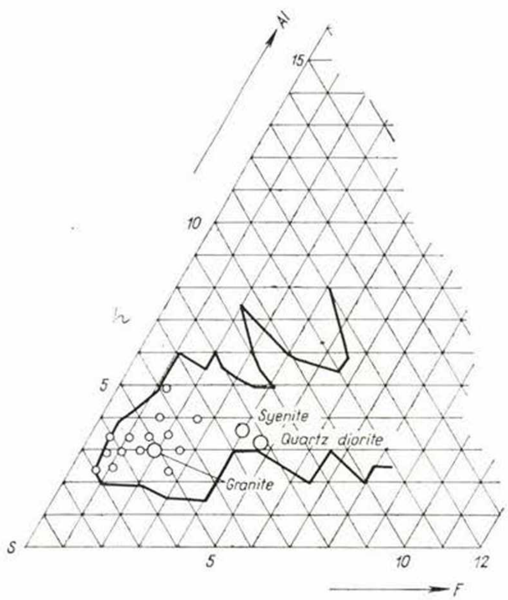


Diagram No. 3. Variation diagram (in part) after Osann. Small circles represent the analyses of granites of Velence hilis. Hungary.

Table 3.
Osann values

No. of analyses	S	Al	F	Osann's classification
9	26,0	3,0	1,0	siliceous alk-lime granite
9	26,5	3,0	0,5	
4	25,0	3,0	2,0	
3	26,5	2,5	1,0	
3	27,0	2,5	0,5	
3	26,0	3,5	0,5	
2	25,5	3,0	1,5	
1	24,5	3,5	2,0	
1	25,0	3,5	1,5	
1	25,5	3,5	1,0	
1	25,0	2,5	2,5	
2	24,5	3,0	2,5	granite

CONCLUSIONS

The study reveals that:

1. The content of Al_2O_3, Fe_2O_3, FeO, MgO, CaO and Na_2O increases towards the central parts of the area.

2. The content of SiO_2 and that of K_2O decreases towards the central parts of the area.

3. Where the SiO_2 content increases, the content of Al_2O_3, Fe_2O_3, FeO, MgO, CaO and Na_2O decreases. Only the content of K_2O increases with an increase in the SiO_2 content.

4. The rocks are rich in SiO_2, K_2O and Al_2O_3 but poor in CaO.

5. Only granites are present and quartz diorites, granodiorites and syenites are absent.

6. The magma either did not undergo differentiation, or the differentiation occurred in a greater depth and it was only some time after that the granitic magma rose to its present position.

7. The Velence hill granites are rich in K_2O and may be called potassic granites.

REFERENCES

1. Gokhale, N. W. (1965): A velencei-hegységi gránit kvantitatív ásványtani vizsgálata (in press).
2. Hattori, H. and others (1960): On chemical composition of granitic rocks of Japan, *Report, 21st Int. Geol. Cong.* pp. 40 – 46.
3. Jantsky, B. (1957): A Velencei-hegység földtana, *Geologica Hungarica*, Series geologica, **10**.
4. Johannsen, A. (1931): A descriptive petrography of the igneous rocks Vol. I. Univ. Chicago press, Illinois.
5. Schneiderhöhn, H. (1958): Die Erzlagerstätten der Erde, Band I p. 45, Gustav Fischer Verlag, Stuttgart.