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AN ATTEMPT FOR DISTINCTION OF AMPHIBOLITES BASED ON STATISTICAL ANALYSIS OF THEIR BULK COMPOSITION

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ABSTRACT

Distinction between different amphibolite types usually is solvable by great number of discrimination diagrams based on chemical composition and trace element content. Using mathematical statistics (cluster analysis as well as hypothesis analysis) another method is presented in this paper This attempt proves a fairly good fitness of these statistical methods for the distinction of amphibolites.

INTRODUCTION

Due to their uniform mineralogical-petrographic and petrochemical characteristics as well as lithostratigraphic position, a distinction of different amphibolites of South Transdanubia and Great Hungarian Plain is very difficult. Having essential importance for the correlation, these amphibolite intercalations (lenses or beds) of thick and monotonous gneiss-mica-schist complexes, similarly to that of marble beds require an emphasized attention of the researchers.

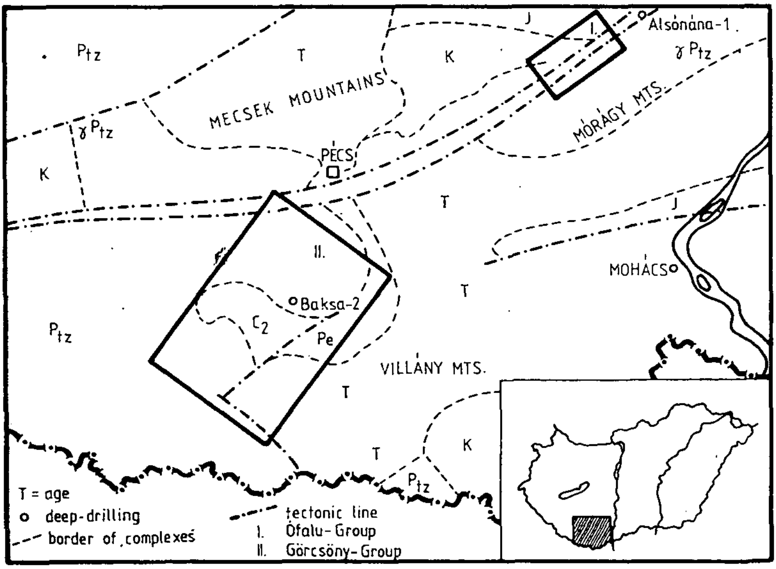


Fig. 1. Locality of the investigated complexes

The aim of this attempt is to develop a mathematical method for the evaluation which renders the long and sometimes gloomy graphical works (discrimination diagrams) shorter and makes it more understable. This attempt is based on numerous bulk composition data gained from amphibolites of South Transdanubian Görcsöny- and Ófalu Groups which has already been evaluated and interpreted by a traditional petrological method [SZEDERKÉNYI, 1982].

REVIEW OF THE INVESTIGATED COMPLEXES

Metamorphics belonging to the crystalline groundfloor of Southeast Transdanubia *(Fig. 1)* are subdivided into two groups lithostratigraphically: (1) Görcsöny Group and (2) Ófalu Group [SZEDERKÉNYI, 1977], see *Fig. 1.* Both groups contain numerous amphibolite intercalations and show certain diversities in their lithology and metamorphic development as well as geochemistry, too. Their most important characteristics are as follows:

1. The *Görcsöny Group* is located on the southern foreground of Western Mecsek Mts. and consists of a well-developed sequence of Barrow-type metamorphics containing zones from chlorite up to sillimanite (and migmatization) with a well detected progressivity from SW to NE. Its characteristic rock-types are: chlorite schist, biotite-muscovite schists and gneisses with or without garnet, staurolite, kyanite, sillimanite minerals corresponding to the Barrovian zonality and amphibolite and actinolite schist intercalations as well as marble and/or dolomitic marble lenses together with calc-silicate rocks having regional polymetamorphic origin.
2. The *Ófalu Group* joints to the northern margin of the Mórágy granite mass. Its members form a strongly sheared and diaphtorized crystalline schist sequence which is developed by a greenschist-amphibolite grade of regional metamorphism and a considerable shearing. Its most important rock-types are: metagraywacke with basic and intermedier tuffs and lavas, chlorite schists, siliceous shales with chert, sericitized phyllonitic rocks, actinolite schists and amphibolite beds as well as a rather thick (30—70 m) crystalline limestone member having chlorite schist intercalations. Several parts of this strongly sheared and tectonically dissected sequence show a weak melting phenomenon connected with the shearing [SZEDERKÉNYI, 1974].

METHODS OF STATISTICAL ANALYSIS

Requirements of the applied analytical technique are:

— to give a real genetical arrangement of samples by means of their geochemical features,

— to describe several geochemical connections among the genetical units obtained,

— to point out some genetical differences and similarities among these groups.

In the first step of this statistical work several possibilities of different grouping phrough the bulk chemical analysis of the amphibolites and their geological interpretation are examined. In the second step a mathematical modelling of applied cetrotectonic interpretations is attempted. The applied mathematical process is a combination of multiple hierarchical classification and hypothesis analysis as well as torrelation one, which is suitable for drawing several geological-geochemica inferences of particular importance for the geology of crystalline complexes of South Transdanubia and Great Hungarian Plain. For a better petrological interpretation

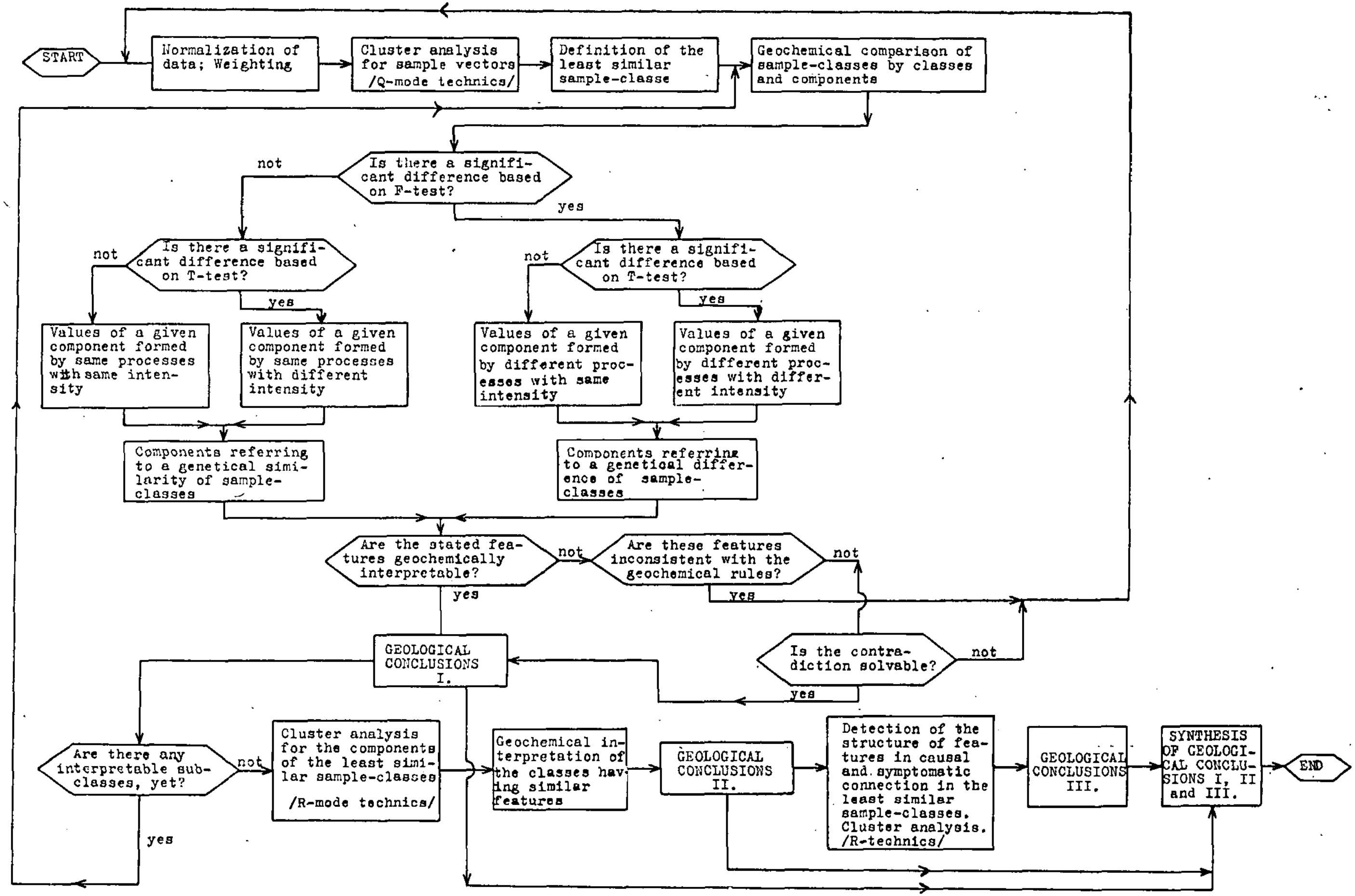


Fig. 2. Flow sheet of the examination applied

TABLE 1

Chemical composition (calculated on volatile-free basis)
of the Ófalu Group amphibolites as well as Görcsöny Group ones

No. of samples	Components											
	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	L.O.I.
Görcsöny Group												
V_1	47.64	2.56	14.22	1.14	10.17	0.08	5.35	11.71	3.19	2.05	1.26	2.98
V_2	47.89	2.55	13.95	1.60	10.46	0.11	5.23	10.69	3.19	1.80	1.38	2.73
V_3	47.13	1.19	14.58	0.35	12.24	0.22	6.10	10.49	3.08	1.50	1.48	2.48
V_4	48.62	2.05	14.89	0.35	12.05	0.18	5.22	9.57	3.59	1.23	0.23	2.36
V_5	45.98	3.07	12.88	1.30	12.63	0.17	8.24	11.58	2.56	0.91	0.39	2.29
V_6	47.49	2.87	14.83	0.52	12.21	0.16	6.35	9.22	3.43	1.37	0.29	2.42
V_7	49.57	2.72	15.76	1.52	10.08	0.16	6.76	9.15	2.15	1.70	0.25	2.44
V_8	47.31	2.82	13.77	1.18	11.11	0.10	6.50	11.32	2.92	1.20	1.09	2.38
V_9	50.57	3.33	15.14	0.58	12.03	0.16	4.20	10.14	2.07	1.02	0.27	2.36
V_{10}	46.47	3.23	14.57	0.99	10.67	0.21	7.42	10.97	2.60	1.31	1.16	2.87
V_{11}	48.39	2.88	13.98	1.29	9.50	0.21	6.53	9.42	2.80	2.18	1.02	1.53
V_{12}	46.61	3.13	14.23	0.98	11.29	0.26	7.36	10.35	2.63	1.39	1.13	2.13
V_{13}	50.34	3.01	14.42	1.20	9.04	0.16	7.10	9.45	1.30	3.23	0.89	2.11
V_{14}	47.65	3.00	14.45	0.54	10.64	0.18	7.54	10.40	2.83	1.16	1.05	2.40
Ófalu Group												
V_{15}	51.85	1.56	13.88	3.94	6.88	0.19	6.49	10.40	4.11	0.78	0.16	3.78
V_{16}	47.93	1.27	15.48	1.02	12.80	0.17	7.38	11.02	2.34	0.31	0.22	4.17
V_{17}	50.64	1.67	13.87	2.67	5.17	0.26	8.21	8.92	3.24	3.39	0.37	4.34
V_{18}	51.47	1.88	13.42	3.13	10.74	0.18	8.17	0.57	2.48	0.99	0.19	4.03
V_{19}	52.73	2.49	14.27	3.41	8.27	0.82	5.92	7.69	4.35	0.53	0.24	2.11
V_{20}	51.27	2.44	15.59	4.24	8.47	0.23	4.92	9.80	2.89	0.34	0.46	2.62
V_{21}	48.39	2.01	13.52	2.92	9.66	0.95	6,98	12.42	2.24	1.03	0.22	3.77
V_{22}	50.24	0.68	15.99	3.16	7.73	0.25	8.80	9.60	2.78	0.70	0.33	3.05

TABLE 1

Source of the investigated samples

(continued)

No. of the samples			
V_1	Baksa No. 2. drilling,	108,6 m	T. SZEDERKÉNYI [1982]
V_2	Baksa No. 2 drilling,	118,0 m	
V_3	Baksa No. 2 drilling,	127.0 m	
V_1	Baksa No. 2 drilling,	108,6 m	
V_2	Baksa No. 2 drilling,	118.0 m	
V_3	Baksa No. 2 drilling,	127.0 m	
V_4	Baksa No. 2 drilling,	825.0 m	
V_5	Baksa No. 2 drilling,	845.3 m	
V_6	Baksa No. 2 drilling,	856,9 m	
V_7	Baksa No. 2 drilling,	1065.1 m	
V_8	Baksa No. 2 drilling,	152,6 m	
V_9	Téseny No. 1 1 drilling,	169.2 m	
V_{10}	Téseny No. 1 drilling,	172.5 m	
V_{11}	Gyód No. 3 drilling,	130.0 m	
V_{12}	Gyód No. 3 drilling,	147.0 m	
V_{13}	Gyód No. 4 drilling,	75.2 m	
V_{14}	Okorág No. 1 drilling	1178.5 m	
V_{15}	Bátaapáti, Kövespatak		B. JANTSKY [1979]
V_{16}	Alsónána No. 1 drilling,	102.3 m	B. JANTSKY [1979]
V_{17}	Ófalu, Sheep-fold Valley		T. SZEDERKÉNYI [1982]
V_{18}	Ófalu, Goldgrund		
V_1	Ófalu, Studer Valley		
V_{20}	Bátaapáti, Kövespatak		M. A. F. GHONEIM., T. SZEDERKÉNYI [1977]
V_{21}	Erdősmecske, village		
V_{22}	Erdősmecske, village		

of the results obtained in close connection with the geological considerations, a few quantitative checking points are enclosed into the mathematical process (see *Fig. 2)*.

In the first step of the analysis, each sample is represented by 12 dimensional vectors derived from the chemical components (Table 1) belonging to the given sample (more exactly: each value of all parameters is divided with the standard deviation of the given parameter. This methods liquidates the mistakes derived from the differences of the order magnitude. The classifying algorithm has been carried out this rescaled sample). A classification of the points of the sample-space is carried out by group average method of cluster analysis [MICHENER, 1958]. A vectorial distance is regarded as a similarity parameter. Results of the analysis are displayed on a dendogram or dendograph *(Fig. 3)*. At the interpretation of dendograms it is important to consider that the horizontal lines having different similarity parameters and drawn in different heights on the graph, correspond to different hierarchy of the sample classes. (As synonyms of the sample class concept, the "cluster class" and "group", or "genetical unit" expressions are also used in this paper.) Consequently, according to their contents, only the sample classes having same similarity level can be set against with each other. Including a lower similarity level as well as a higher one of a sample class, the first one (the lower level) can be characterized as a special case of the second one (the higher level).

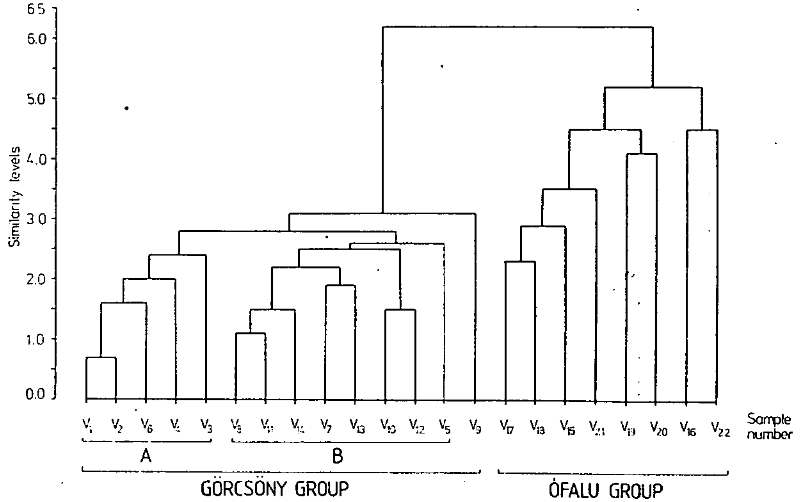


Fig. 3. Dendograph of the Görcsöny Group amphibolites as well as Ófalu Group ones

Since the cluster classes obtained are originated from the grouping of different sample-vectors, every cluster expresses some kind of genetical relationship of the samples contained by it. Theoretically, each different cluster represents several rock-types of heterogenous origin, or of the same origin showing the results of heterogenous geochemical events during their genesis. Consequently, degree of similarity of the obtained statistical sample classes appears as an image of some kind of genetical relationships of the examined rock-samples. The sample classes linked in the highest similarity level of a dendogram, represent a group of the most important rock-

TABLE 2

Averages ($\bar{x}$) and related standard deviation values (s) of the chemical components of the Ófalu Group amphibolites as well as Görcsöny Group ones

Group	No. of samples	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	L. O. I.	
Görcsöny Group	14	1.392	0.553	0.681	0.425	1.112	0.049	1.112	0.871	0.601	0.603	0.460	0.351	s
Ófalu-Group	8	1.666	0.601	1.023	0.974	2.356	0.315	1.303	3.610	0.796	0.999	0.103	0.801	
Görcsöny Group	14	47.976	2.744	14.405	0.967	11.009	0.168	6.421	10.319	2.739	1.575	0.849	2.391	$\bar{x}$, wt%
Ófalu Group	8	50.565	1.750	14.503	3.061	8.715	0.381	7.109	8.803	3.054	1.009	0.274	3.484	

genetical units. The sample classes are defined only up to the similarity level as far as they have still a precise geological-petrological content (see *Fig. 3)*.

A geochemical comparison of the opposed cluster classes is carried out by hypothesis analysis of the parameters obtained *(Fig. 2)*. The aim of this comparison is to select several components which suffered different effects during their formation in the opposed sample classes. This operation carried out by the sequence of so called "F-test" and "T-test"; the type of T-test depends on the result of F-one *(Fig. 2)*. If on a fixed level of significancy the result of the F-test demonstrates appreciable differences in the values of the standard deviation (with a certain reservation) it can be inferred on some qualitative differences in the geochemical events during the rock genesis. A significant deviation of the mean-values shown by the T-test suggests quantitative differences in the events [NAGY, 1969]. *Fig. 2* [after NAGY, 1969] also presents some geological interpretations belonging to different variational possibilities. Geochemical components which can characterize several cluster classes *(Figs.* 3, 7, 10, 11) are granted by this figure. At the same time, a geochemical interpretability of the obtained results also gives a checking-point for the series. Geological conclusions are originated from here *(Fig. 2)*.

After the definition of all geologically interpretable sample classes, the next task is to describe each group. It can be carried out by the revelation of the particular relationships of the chemical components. Firstly, the related component-groups are determined in the sample classes by the "R-test" of cluster analysis. The strength of dependence between the chemical components is measured by the correlation coefficient, and the hierarchic classification is made again by the "group-average method" *(Figs. 4, 5)*. Since in this algorithm the causal relations and/or symptomatic ones are reflected in a hidden-way, a structure of relations existing between parameters is developed by the so called "ramifying linkage method" [TYRON, 1939; CATTEL, 1944; GEIGER, 1982]. Further on, these structures will be regarded as geochemical (correlation) profiles *(Fig. 6)*. The correlatable features are signed by a straight line on *Fig. 6*. The number being close to this line expresses a value of a correlation and its sign gives a direction for this correlation. The geochemica

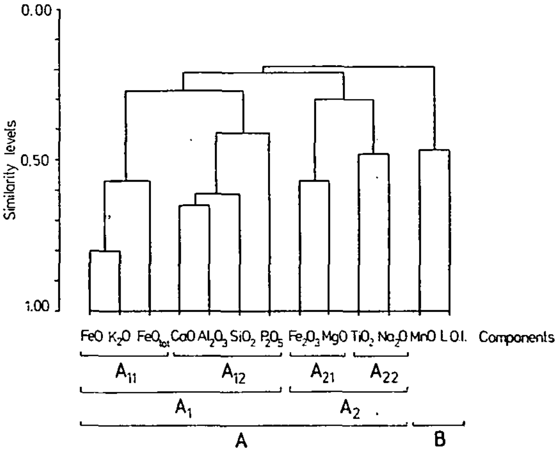


Fig. 4. Dendograph of the Görcsöny Group amphibolites based on the correlation coefficients existing between chemical components

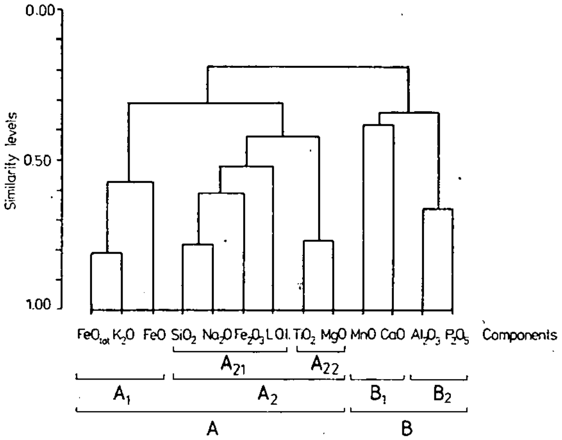


Fig. 5. Dendograph of the Ófalu Group amphibolites based on the correlation coefficients existing between chemical components

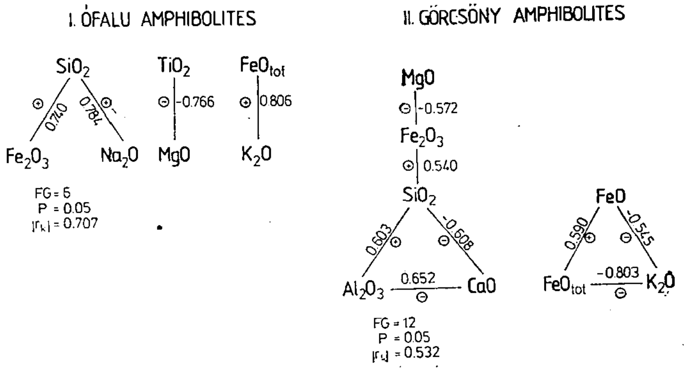


Fig. 6. Geochemical correlation profiles of the Ófalu Group amphibolites (I) as well as Görcsöny Group ones (II).
Legend: FG = numbers of degree of the freedoms
P = level of the significancy
(r_k) = critical value of the correlation coefficient

interpretation related to several genetical units of the rock samples is given by the evaluation of the geochemical correlation profile, as well as similar groups of the components. Moreover, the correlation profile is also suitable for the realization of different geological conclusions obtained from the second and third levels of *Fig. 2.*

Chemical components showing the same evolution within a genetical unit are also selected. The obtained results offer numerous useful complementary information for the analysis of the progress of development. The way of this process is the F-test and T-one of the hypothesis analysis.

Finally, a complete analysis of series of the geochemical data is completed by the synthesis of several geological conclusions obtained from the first, second and third levels in *Fig. 2.*

INTERPRETATION OF THE RESULTS

One of the most important results of the cluster analysis is a perfect separation of the samples of Görcsöny and Ófalu amphibolites based on the similarity level No. 6,4 of the dendogram *Fig. 3* (which is calculated and compiled by chemical analyses in Table 1). Consequently, amphibolites originated from both groups have a fairly divergent evolution. This separation can be interpreted as different origin, or site, or a possibly another premetamorphic and/or metamorphic history, etc.

The separated cluster-class of the Görcsöny Group in the *Fig. 3* shows a further division possibility into two subclasses (named A and B) on the similarity level No: 2, 6. A sample signed V_9 may be regarded as a supplementary class of the Görcsöny Group, but being a single element it should rather be considered as a variation. Due to its little sample-number a similar subdivision cannot be made in the Ófalu Group.

According to the hypothesis analysis of the mean values andstandard deviations, it is obvious that the Al_2O_3, MgO, Na_2O K_2O, SiO_2 TiO_2 componeots mathematically show the same evolution but the Fe_2O_3, FeO, P_2O_5 MnO, CaO, and the "loss of ignition (L. O. I.)" parameters are formed by different ones in the amphibolites of the Ófalu and Görcsöny Groups *(Fig. 7)*. The components derived in the sameway, are suitable for a further differentiation based on their T-test. Morevoer, the *Fig. 7* shows a perfect genetical identity (i.e. same evolution and same intensity) in the features of the Al_2O_3, MgO, Na_2O and K_2O. But in spite of the same evolution, the SiO_2 content of the Görcsöny amphibolites is significantly lower, and the TiO_2 content is significantly higher than that of Ófalu ones. Fe_2O_3, FeO, P_2O_5 and L.O.I. components represent a total genetical difference between both groups (divergent evolution characterized by different intensity). But, the values of MnO and CaO were formed by divergent processes with the same intensity. After all, the most important geochemical differences between Ófalu and Görcsöny amphibolites are given by the formation of Fe_2O_3, FeO, P_2O_5 and L.O.I. parameters. The caracteristic and extreme high P_2O_5 content of the Görcsöny amphibolites suggest magmatically and essentia difference in the parent rocks of both amphibolite groups.

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	L.O.I.
F - test	●	●	●				●		●	●		
t - test			●			●	●	●	●	●		

Fig. 7. Hypothesis analysis of the chemical components of the Ófalu Group amphibolites as wel as Görcsöny Group ones.

Legend: ● no significant difference pointed out in the development of the investigated features on significancy level P=0.05 (F-test) and in the medium intensity of the process produced by the investigated features (T-test).

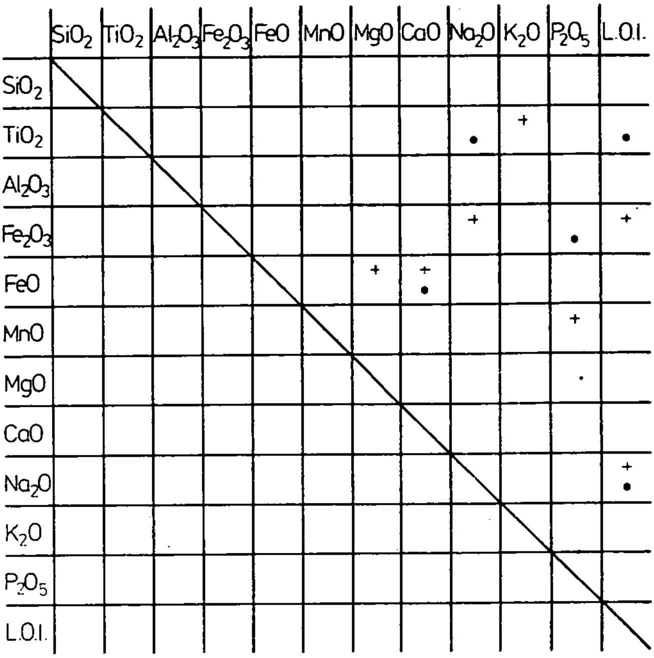
Further differences can be traced by results of cluster analysis, too. A dendograph drawn on the basis of the chemical components of Görcsöny amphibolites *(Fig. 4)* shows a bipartition among them as it is mentioned before (subclasses A and B). The B subclass is represented by MnO and L.O.I. components (where the correlation coefficient is smaller between them than the critical but still acceptable value: see *Fig. 4* B and *Fig. 6* II). All other components belong to the A subclass. A similar bipartition can be observed on the graph of the Ófalu amphibolites *(Fig. 5)*. The A subclass is determined by MnO, CaO and Al_2O_3, but all other chemical components to the subclass B. Common features of both graphs (*Fig. 4* and *Fig. 5*) are: (1) further differentiation occurs only in the subclasses A, (2) FeO, FeO_{tot} and K_2O establish the same members in both A subclasses.

Geochemical correlation profiles of both amphibolite groups show fairly sharper genetical differences between them than the dendographs do. *Fig. 6* shows four no-correlatable systems in the Ófalu amphibolites. MnO, CaO and L.O.I. data (from 13 components) have no significant correlation either with each other, or with other components. In the Görcsöny amphibolites (*Fig. 6* II) the parameters TiO_2, MnO, Na_2O, P_2O_5 and L.O.I. show the same picture. Geochemical (correlation) profile of these amphibolites contains two no-correlatable systems with three mutually acting components: Al_2O_3—CaO—SiO_2 triad influenced by Fe_2O_3 through the SiO_2, as well as the FeO — FeO_{tot} — K_2O one.

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	L.O.I.
SiO_2			+	+	+ ●		+ ●	●		+		
TiO_2			+ ●	+ ●		+		●	+ ●	+ ●	●	+ ●
Al_2O_3				+			+	●	+ ●	+ ●	●	+
Fe_2O_3							+		+ ●	+ ●	●	+ ●
FeO							+ ●	●	+	+		+
MnO								+				
MgO								●	+	+		+
CaO									●	●		
Na_2O										+ ●	●	+
K_2O											●	+
P_2O_5												●
L.O.I.												

Fig. 8. Result of the F-test hypothesis analysis of the Ófalu Group amphibolites as well as Görcsöny Group ones based on chemical data.
Legend: + no significant difference pointed out in the development of both variables on the significancy level $P=0.05$ in the Ófalu Group amphibolites
● The same for the Görcsöny Group amphibolite

In *Figs. 8* and *9* a paired hypothesis analysis of the examined parameters of both groups are presented. Based on the results of this operation, several component-pairs having a common origin are pointed out. These pairs in the Görcsöny amphibolites are: TiO_2 — K_2O, Fe_2O_3 — Na_2O, Fe_2O_3 — L.O.I., FeO — MgO and Na_2O — L.O.I. pairs in the Ófalu amphibolites. The rock-evolutional interpretation of these pairs is rather complicated and in many cases uncertain. Triads having the same origin are much more interpretable. E. g. in the Ófalu amphibolites an Fe_2O_3 — Na_2O — L.O.I. system exists as a triad showing the same origin, but such a triad is missing from the Görcsöny amphibolites.



	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	L.O.I.
SiO_2												
TiO_2									•	+		•
Al_2O_3												
Fe_2O_3									+		•	+
FeO							+	+ •				
MnO											+	
MgO											·	
CaO												
Na_2O												+ •
K_2O												
P_2O_5												
L.O.I.												

Fig. 9. Result of the T-test hypothesis analysis of the Ófalu Group amphibolites as well as Görcsöny Group ones based on chemical data.
Legend: The same as that of *Fig. 7.*

This feature of the Ófalu amphibolites follows partly from the spilitic character of their parent-rocks and partly from the effect of a considerable shearing and diaphtoresis. The lack of this character from the Görcsöny amphibolites can be explained by non-spilitic parent-rocks and the absence of shearing. A further difference between two amphibolite groups appears in the individual behaviour of MnO in the Görcsöny Group, as well as in a similarly unique evolution of P_2O_5 in the Ófalu Group contributing to the confirmation of the main result of the cluster analysis, namely: the Görcsöny and Ófalu Groups have different origin.

Due to a higher rock-sample number, the Görcsöny amphibolites are suitable for a further detailed analysis. According to a comparative hypothesis analysis of its subclasses A and B (originated from the dendogram in *Fig. 3*) show conspicuous differences between them. Thus, the mean-values of TiO_2, MgO and Na_2O are significantly higher in the B subclass than that of in A one (Table 3). Precursors of these amphibolites represent the most mafic parent-rock types of the pre-metamorf sequence. Otherwise, according to their parameters, each sample of the Görcsöny amphibolites can be regarded homogeneous in the evolutional point of view *(Fig. 10)*. Simultaneously, it means fairly constant evolutional circumstances within this group (i.e. the same magmatype and same grade of metamorphism, etc.). Some small but observable differences existing between them can be attributed to a varying grade of epidotizational effect of the aplitic veins wich dissect all the mass of the Görcsöny Group.

Figs. 11 and *12* show some results of the paired hypothesis analysis carried out between the parameters of subclasses A and B of the Görcsöny amphibolites. The

TABLE 3

Averages ($\bar{x}$) and related standard deviation values (s) calculated from the chemical data of the Görcsöny Group amphibolites (subclasses A and B) based on cluster analysis

Group	No. of samples	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	L.O.I.	
Görcsöny Group A class	5	0.56	0.66	0.40	0.56	1.02	0.06	0.53	0.98	0.21	0.33	0.62	0.26	s
Görcsöny Group B class	8	1.54	0.17	0.81	0.29	1.12	0.05	0.59	0.92	0.53	0.75	0.35	0.38	
Görcsöny Group A class	5	47.75	2.24	14.49	0.79	11.43	0.15	5.65	10.34	2.30	1.59	0.93	2.59	$\bar{x}$ wt%
Görcsöny Group B class	8	47.79	2.98	14.26	1.13	10.62	0.18	7.18	10.33	2.47	1.64	0.87	2.27	

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	L.O.I.
F-test	•	•	•	•	•	•	•	•	•	•	•	•
t-test	•		•	•	•	•		•		•	•	•

Fig. 10. Hypothesis analysis of the chemical components of the Görcsöny Group amphibolites (subclasses A and B).
Legend: The same as that of *Fig. 7.*

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	L.O.I.
SiO_2		•	+ •	•	+ •		•	+ •		•	•	•
TiO_2			•	+ •	•		•	•		•	•	
Al_2O_3				•	+		+ •	+ •	+ •	+ •	•	•
Fe_2O_3					•		•	•	+	•	+ •	+ •
FeO							+ •	+ •		+	•	
MnO												
MgO								+ •	+ •	+ •	+ •	+ •
CaO									+	+	•	
Na_2O										+ •	+	+ •
K_2O											•	•
P_2O_5												+ •
L.O.I.												

Fig. 11. Hypothesis analysis of the chemical components of the Görcsöny Group amphibolites (subclasses A and B); F-test.
Legend: ● no significant difference pointed out in the development of both variables on the significancy level P=0.05 in the subclass A.
\+ The same in the subclass B.

component pairs of the subclasse A are: TiO_2 — K_2O, Fe_2O_3 — P_2O_5 and K_2O — P_2O_5. Apart from the TiO_2 — K_2O pair, the Fe_2O_3 — K_2O — P_2O_5 triad also suggest the same origin. It is rather difficult to give an acceptable explanation for the behaviour of K_2O in the presented relations. Its close contact with some immobile components can be reflected on a special alkaline basalt origin of amphibolites belonging to the subclass A. Moreover, these amphibolite samples are collected from a definite lithostratigraphic unit of the Görcsöny Group. The connected component pairs of the subclass B are: Fe_2O_3 — P_2O_5, FeO — CaO and Na_2O — L.O.I. The last of them signs a weak Na metasomatism produced by greenschist grade of retrograde metamorphism. These rock-samples belong to another lithostratigraphic unit of the Görcsöny Group and mineralogically consist mainly of actinolite-hornblende mixture and subordinate chlorite and epidote.

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	L.O.I.
SiO_2												
TiO_2										●		●
Al_2O_3												
Fe_2O_3						●				+ ●	+ ●	
FeO								+ ●				
MnO												
MgO												
CaO												
Na_2O												+
K_2O											●	+
P_2O_5												
L.O.I.											●	

Fig. 12. Hypothesis analysis of the chemical components of the Görcsöny Group amphibolites (subclasses A and B); T-test.
Legend: ● no significant difference pointed out in the medium tendencies of the processes produced both variables on the significancy level P=0.05 in the subclass A.
+ The same in the subclass B.

Finally, *Figs. 13* and *14* show a comatative hypothesis analysis of subclasses A and B of the Görcsöny amphibolites together with the Ófalu ones according to every component of their bulk composition. A difference between both subclasses A of the Görcsöny as well as Ófalu amphibolites is recognized in their P_2O_5 evolution. Differences between B classes are manifested by TiO_2, MnO and CaO components.

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	L.O.I.
F-test	●	●	●	●	●	●	●	●	●	●		●
t-test		●	●			●		●	●	●		

Fig. 13. Hypothesis analysis of the chemical components of the Görcsöny Group amphibolites subclass A as well as the Ófalu amphibolites.
Legend: The same as that of *Fig. 7.*

	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	L.O.I.
F-test	●		●	●	●		●		●	●	●	●
t-test			●		●	●	●	●	●	●		

Fig. 14. Hypothesis analysis of the chemical components of the Görcsöny Group amphibolites subclass B as well as Ófalu Group amphibolites.
Legend: The same as that of *Fig. 7.*

These results also comfirm the genetical diversities existing between Görcsöny and Ófalu amphibolites which formerly were already pointed out by discrimination diagrams [Szederkényi, 1982] and now by cluster analysis, respectively.

CONCLUSIONS

The most important result of this attempt is the demonstration of fitness of hypothesis analysis together with cluster one for the distinction of amphibolites based on their bulk composition. Comparing the results of this operation to that of discriminant diagrams of the same rock-samples [Szederkényi, 1982] the statistical methods applied can give more remarkable pictures about similarities or differences existing among the rock-samples and can offer a more exact and well computerizable method for the distinction. Explanation of the differences obtained by such a statistical analyses still requires further considerations and conciliations with the experiences of "classical" petrochemical as well as petrotectonic interpretations. It is important to take into consideration that these statistical methods are founded on an enlargement of the differences existing between the same chemical components of the samples examined. Therefore these methods strictly require correct chemical data.

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