GEOLOGICKÝ ZBORNÍK — GEOLOGICA CARPATHICA 31, 1—2, BRATISLAVA, JUNE 1980, PP 3—26

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PETROCHEMICAL CORRELATION OF GRANITOIDS OF THE BOHEMIAN MASSIF AND THE WEST CARPATHIANS.

(Figs. 10, Tab. 1)

Abstract: Differences and analogies in the chemistry of the plutonic bodies in the Bohemian Massif and Alpine West Carpathian belt are analyzed. West Carpathian plutonic rocks are chemically closer to pre-Variscan granitoids of the Bohemian Massif than to typical Bohemian Variscan plutonic rocks (in spite of the fact that the West Carpathian plutonic rocks are generally considered to be of Variscan age).

Резюме: Анализованы разницы и аналогии в химии плутонических тел в Чешском Массиве и в поясе Альпийских Западных Карпат. Плутонические породы Западных Карпат химически более близкие доварийским гранитоидам Чешского Массива как к типичным Чешским Варийским плутоническим породам (во преки того, что вообще считают Западно-Карпатские плутонические породы как принадлежащие к Варийскому возрасту).

Introduction

The geological unit neighbouring with the Bohemian Massif is the Czechoslovak part of Alpine mountain chain the so-called West Carpathians. While in the Bohemian Massif a substantial part of plutonic rocks forms the core of the Variscan orogen, the plutonic rocks of West Carpathians represent old cores within belt mountain ranges of the Alpine orogene. They belong to a complex of rocks forming the original basement of Mesozoic sediments which have been tectonically reworked to a variable degree. The characteristics of plutonic rocks of the Bohemian Massif have been described in many detailed papers (for example Cloos, 1925, Klomínský, 1969, Vejnar et al., 1969, 1973) and regional studies (Sattran — Klomínský, 1970; Štemprok — Škvor, 1974; Bernard — Klomínský, 1975; Klomínský — Dudek, 1978; Palivcová et al., 1978). The plutonic rocks of the West Carpathians have been the subject of a number of regional studies (Cambel — Valach, 1956; Ončáková, 1960; Krist, 1960, 1979; Gorek, 1959). A lot of informations about these rocks has been published in notes to the geological maps 1:200 000 and their tectonic position has been correlated with that of the other Carpathian plutonic rocks (Mahel', 1978). The only comparison of the plutonic rocks of the Bohemian Massif and those of the West Carpathians was made by Vachtl (1947).

The aim of this study is to examine to what extent the plutonic rocks of the West Carpathians and the Bohemian Massif are similar as far as their composition is concerned.

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Fig. 1. Plutonic bodies of the Bohemian Massif and the West Carpathians Plutonic rocks of the Bohemian Massif: A — Krušné hory Mts. pluton, B — West Bohemian pluton, C — Central Bohemian pluton, D — Lužice Mts. pluton, E — Čistá—Jesenice pluton, F — Krkonoše—Jizera Mts. pluton, G — Železné hory Mts. pluton, H — Moldanubian pluton, I — Brno pluton, J — Dyje pluton.
Plutonic rocks of West Carpathians: K — The group of plutonic rocks of Malé Karpaty Mts., Inovec and Suchý — Malá Magura, L — The group of plutonic rocks of Malá Fatra and High Tatras, M — The group of plutonic rocks of Tribeč and Low Tatras, N — The area of Veporides and Čierna hora, O — The area of Gemeride granites.

However the amount of data accumulated in both regions is not equivalent. Plutonic rocks of the Bohemian Massif are represented in this study by a set of 1200 chemical analyses collected mostly from published works. The plutonic rocks of the West Carpathian system are characterized by a set of about 100 new chemical analyses from representative granitoid bodies; older analyses (Hovorka, 1972) were not included. Both sets of chemical analyses are represented in table 1. by arithmetic means of chemical composition of individual bodies and massifs of the Bohemian Massif and the West Carpathians. The set of the correlated plutonites covers granitoid rocks forming typical intrusions with corresponding geological structures and contacts. The mafic rocks of separate bodies have not been included.

Regional distribution of plutonic bodies

Plutonic rocks occupy on Czechoslovak territory an area exceeding 20 000 kilometers (Fig. 1). Their outcorps, including those in the basement of younger formations occupy over 15.000 sq.km in the Bohemian Massif and 6.000 sq. kilometers in West Carpathians, i.e nearly 20% of the Czech part of the Bohemian Massif and 12 % of the West Carpathian System.

The individual plutonic bodies outcrop at the surface as parts of geological units, called plutons* (Fig. 1).

The extent of individual plutons was defined according to „The proposal of the regionally-geological classification of the Bohemian Massif" (Svoboda 1976); in the region of the West Carpathians the outlines of plutons follow the traditional tectonic divisions.

Schematic boundaries of the main plutons in the Bohemian Massif and the plutonic bodies of the West Carpathians are given in Fig. 1.

Typological classification of plutonic bodies

For the purposes of comparison of plutonic bodies in the Bohemian Massif and West Carpathians the granitoids are classified here according to the composition (Klomínský, Dudek, 1978) into the following groups:

1. leucogranites (aplitic granites)
2. two-mica and biotite granites (adamellites and leucocratic granodiorites)
3. biotite ± amphibole granodiorites

* The term „pluton" used here is synonymous with „igneous complex".


Čierná Hora Intrusion
Vysoké Tatry Massif
Kohút Massif
Hrončok Intrusion
Sinec Intrusion
Ďumbier Massif
Lubochňa Massif
Malá Fatra Massif
Vepor Massif
Lieskovec Intrusion
Hornomoravský Úval Massif
Suchý Mogura Intrusion
Tribeč Massif
Inovec Intrusion
Modrá Massif
Bratislava Massif
Brno Massif
Skorošice Body
Šumperk Massif
Nový Hrádek Massif
Olešnice Massif
Litice Granite
Nasavrky Massif
Krkonoše-Jizera Massif
Sázava Tonalite
Říčany Massif
Rumburk Granite
Tanvald Granite
Neratovice Komplex
Fláje Massif
Čistá Jesenice Massif
Karlovy Vary Massif
Bohutín Stock
Smrčiny Massif
Bor Massif
Čistá Massif
Rozvadov Massif
Kladruby Massif
Babylon Massif
Štěnovice Massif
Stod Massif
Blatná Granodior.
Červená Granodiorite
Čertovo Břemeno Massif
Rastenberg Granite
Marginal Granite
Weinsberg Granite
Freistadt Granodiorite
Tábor Massif
Eisgarn Granite
Všeradov Granite
Moldanubian Massif
Jihlava Massif
Třebíč Massif

4. tonalites and biolite-amphibole granodiorites
5. durbachites (in the Bohemian Massif only)
6. diorites and gabbros associated with granitoids (in the Bohemian Massif only)

The classification of the bodies and massifs into the above mentioned petrographic groups is shown schematically in Fig. 1.

The age of the plutonic rocks

The age of the granitoids in the Bohemian Massif and the West Carpathians is poorly understood. For most individual plutonic bodies concrete data about the geological age of the country rocks (biostratigraphical data) are lacking and that is why most of them have been classified according to the data of radiometric analyses (Bernard—Klomínský, 1973). However, due to Variscan reactivation of the Bohemian Massif and younger reconstruction of the West Carpathian basement, these data often indicate only the age of the last metamorphism.

In the Bohemian Massif we can distinguish a group of Variscan and a group of pre-Variscan plutonic rocks in accordance with the geochronological analyses and occasional geological criteria (Klomínský—Dudek, 1976).

The differences in approach to the time classification of plutonites of the Bohemian Massif are due to a relatively long interval between their origin and final consolidation after emplacement. While the interpretation of Chaloupský (1975) treats the time classification of plutonites from the point of view of their origin, Klomínský—Dudek (1978) consider their age according to the time of their consolidation after emplacement in the shallow zones of the Earth's crust. For the latter mode of interpretation of the age of plutonites there are more concrete geological and radiometrical data.

In the Carpathian system, the geological and most geochronological data indicate the presence of Variscan plutonic rocks, even though the age classification of the number of bodies is not unequivocal (Schönlaube—Scharbert, 1978). In the Carpathians there are also younger, so-called Neoid Gemeride granitoids, which are not developed in the Bohemian Massif. Their very short age, however, has not been verified by new radiometric analyses (Kantor et al., 1979; Kovach et al., 1979). One of the geological proofs of the Paleozoic age of the plutonic rocks of West Carpathians is the contact metamorphism of the Harmonia series (Malé Karpaty, Mts.). According to the biostratigraphical data the series is Devonian to Carboniferous in age (Cambel—Čorná, 1974; Čorná, 1971). The radiometric analyses of the plutonic rocks of the West Carpathians (K/Ar, Rb/Sr, U—Th/Pb methods) agree with the geological proofs of their age. From the survey of radiometric analyses of plutonic rocks (Cambel et al., 1979) it follows that the granitic plutonism is the main source of progressive metamorphism of country rocks.

The plutonic rocks of the Bohemian Massif

In spite of different interpretations of the age of individual plutonic bodies in the Bohemian Massif (Bernard—Klomínský, 1975; Chaloupský, 1975), the classification to Variscan and pre-Variscan plutonites has generally been accepted. On the surface of the Bohemian Massif and in the basement of its sedimentary cover (Upper Carboniferous to Quaternary) Variscan plutonic rocks are most common. They occupy about 19 % of the total surface, while only 7—10 % are formed by older granitoids.

Variscan plutonism

The intermediate rocks of the Central Bohemian pluton, the Železné hory Mts. pluton and some individual bodies of West Bohemian pluton belong to the oldest intrusive phase of the Variscan plutonic activity (Sattran — Klomínský, 1970). According to Palivcová and Šťovíčková (1968) most of them belong to massifs outcropping typically along the boundaries of blocks of unequal geological development. These plutons cause contact metamorphism of Lower Carboniferous and older sediments (Wierzchowski, 1976). The Devonian to Carboniferous (360 mil. years) ages of these intrusions agree with the isotopic data (Klomínský — Dudek, 1978; Bernard — Klomínský, 1975).

Petrographically, tonalites and amphibole-biotite granodiorites are the most common types. They have an increased bazicity, and contain basites and ultrabasites. They represent a characteristic gabbro—diorite—granodiorite formation in the sense of Kuznecov (1964). According to Steinocher (1969) these plutonic rocks can be classified into Niggli's group of magmas of the calc-alkaline (Pacific) province.

The plutonic complex of the central zone is rimmed by a ring of younger granite bodies, that outcrop at the surface mostly along the margin of the Bohemian Massif. These granites (called the plutonic complex of the marginal zone) include the Krušné hory Mts. and Krkonoše—Jizera Mts. plutons (plus the Strzegom and Strzelin massifs in Poland in the North and the Moldanubian pluton in the South and West. Most of these massifs and bodies consist of biotite granites to biotite granodiorites and two-mica granites; they are often porphyritic. Amphibole is uncommon. Most two-mica granites are rich in Al--minerals, such as andalusite ± cordierite and topaz. After Palivcová and Šťovíčková (1968) the plutons of marginal zone mostly belong to typical intra-block intrusions. The plutonic rocks cause contact metamorphism of country rocks including Upper Carboniferous or Permian (Zoubek — Škvor, 1963). The Upper Carboniferous — Westhalian (300 mil. years) ages of intrusions again agree with the isotopic data (Klomínský — Dudek, 1978).

Thermal effects of individual bodies in the marginal zone complex on the country rocks vary. In the sense of White et al., 1974 we can distinguish intrusions with a regional aureole (Moldanubian pluton), granites with a contact aureole (a part of the Krušné hory Mts. pluton, Krkonoše—Jizera Mts. pluton) and subvolcanic intrusions (a part of the Krušné hory Mts. pluton), which evidently intrude into their own volcanic products (the little Cínovec Massif) — see also Raguin, 1957.

The granitoids and syenitoids called "durbachites" are characteristic rocks of the Moldanubian area of the Bohemian Massif. They form separate bodies and massifs grouped into two zones bordering the Central Moldanubian pluton. Regionally they belong to the Moldanubian and Central Bohemian plutons.

Among durbachites prevail granites, granodiorites and syenites rich in amphibole and biotite (known as Rastenberg and Čertovo břemeno type). The geologically older biotite-pyroxene melasyenites (Tábor and Jihlava Massifs) are commonly grouped together with the durbachites.

The durbachites are usually considered to be older than the calc-alkaline series, but recently younger age has been proposed (Holub — Žežulková, 1978).

Pre—Variscan plutonic rocks

Orthogneiss bodies in the Moldanubian crystalline complex are believed to be the oldest primary magmatic rocks of the Bohemian Massif (early Cadomian granitoids after Chaloupský, 1975). Most of these rocks are metamorphosed, originally autochthonous or para-autochthonous granites (exceptions see Fediuk, 1976). By their composition, they differ from typical intrusive bodies that penetrated into the uppermost parts of the Earth's crust, (for example Variscan or some pre-Variscan plutons). The most widespread types are two-mica or biotite granitic rocks, that may represent the roots of old plutons. The orthogneisses could have changed their original mode and composition due to younger metamorphic processes and therefore, were not included in the present study.

Within the Bohemian Massif a number of distinctly intrusive granitoid bodies has been exposed, which are also classified with the group of pre-Variscan plutonic rocks. However, since there are no geological data about their ages some of them are considered to be the old ones only according to wider regional relations. Radiometric data (mainly the K/Ar method) indicate higher ages for a number of these bodies; for others, there is no dating so far or the results are at variance with the geological assumptions.

Pre-Variscan plutonic rocks crop out in regions of the Bohemian Massif with no or little Variscan plutonism. They cause contact metamorphism of the surrounding sediments whose age reaches up to Upper Proterozoic. In some places the pre-Variscan plutonic rocks are intruded by Variscan ones of intermadiate or acid composition (Čistá Massif, stocks Stolpen and Königshain). Occasional pebbles of the pre-Variscan plutonic rocks have been found in the Lower Ordovician (the Rumburk granite). In the area of the Brno pluton Devonian overlies the eroded plutonic rocks. The geologically inferred age of the intrusion (Lower Cambrian, 500—600 mil, years) agrees with isotope dating (Klomínský — Dudek, 1978).

According to White's et. al. (1974) classification, the Cadomian plutonic rocks of the Bohemian Massif belong the group of intrusions of contact aureoles. Their zones of contact metamorphism (the Čistá—Jesenice pluton) are superimposed on regional metamorphism of Upper Proterozoic of the Barrandian zone. In the case of the Lužice and Čistá—Jesenice plutons, whose erosian level is shallow (tabular) bodies with sharp discordant contacts are exposed. Petrographicaly biotite granodiorites and granites are the most significant types. In addition to these rocks, abundant leucotonalites occur in the Brno and Dyje plutons. Both plutons form a substantial part of the basement of the Carpathian fore-deep. The position of both plutons at the margin of the old block of the Bohemian Massif is comparable to the geotectonical position of the Variscan Central Bohemian pluton.

Plutonic rocks of the West Carpathians

Granitoids of the West Carpathians form cores of individual mountains together with highly metamorphosed rocks. Most of the latter are products of periplutonic contact metamorphism of the schist complex (Cambel, 1976). In some cases also synorogenic migmatites are present, which, according to radiometric dating, are also the products of Variscan granitic plutonism. However, according to some authors Variscan granitoids crop out on the contact with pre-Cambrian highly metamorphosed schists (Kamenický, J. 1967; Kamenický L., 1973; Máška — Zoubek, 1961). Individual mountain cores in the West Carpathians may be looked upon as a segmented granite—gneiss basement. Crystalline schist and granitic rocks are tectonically affected to a various extent. On the basis of petrographical and petrochemical variability it is not possible to differentiate between granitoids of individual mountains; the granitoids of West Carpathians in general can be considered to be a relatively uniform complex of similar magmatic rocks; individual mountains consist of various types of granitoids in different amounts. In the West Carpathians, the core mountains are separated by younger depressions filled with Paleogene flysh and Neogene formations. Mesozoic rocks overlie the crystalline complex, especially in the North and North—West. The crystalline schists are usually present in the cores only in small amounts; they represent supracrustal material that took on the form of relics due to the erosion of schists overlying the intrusive granitoids.

From Fig. 1 it follows that granitoid rocks occur in belts. The outer granitoid zone includes granitoid complexes of the Malé Karpaty, Mts., Inovec, Suchý, Malá Magura, Malá Fatra, Vysoké Tatry Mts. and Branisko, and the inner of core mountains consists of the system of Nízke Tatry, Žiar, Veľká Fatra and Tribeč.

South of the region of the Tatride crystalline complex lies the zone of Veporides, which represents a less segmented and almost continuous complex of crystalline schist and granitoids. The inner tectonical structure of this complex is rather complicated. The rocks are affected by strong Alpine diaphtoresis and dynamometamorphism. Numerous cases of migmatization and ultrametamorphism of sediments with the appearance of palingenic granitoids can be found; the latter form sheets or subautochthonous intrusions, and in contrast to the granitoids of core mountain ranges, are emplaced near the zone of autochthonous migmatites where they originated. The southern part of the Vepor granite gneiss complex, the so called Kohút zone, is strongly influenced by Neiod, resp. by late-Variscan (Permian) or granite magmatism. This younger magmatism is known to have caused the release of argon from the overlying rocks. Therefore, the K/Ar dating yields a wrong age of about 90 mil. years for the whole region of southern Veporides. Future research should help to determine the distrbution of younger granitoids in the basement of the old crystalline complexes.

In terms of granite plutonism, the West Carpathians crystalline complex can be divided into two subregions: (i) the region of Tatrides and Veporides with numerous granites and ultrametamorphic series and (ii) the region of Gemerides, where the main phase of Variscan plutonism was not intensive at all. In the Tatrides and Veporides granite-gneiss complexes predominate and the erosion cut relatively deep into the lower parts of crystalline zone, while in the zone of the Spišskogemerské Rudohorie Mts. prevails the phyllitic schist series accompanied by numerous representatives of Palaeozoic, acid or basic volcanics. No periplutonic metamorphism of schists took place here during the Variscan orogeny, except in marginal parts of the Gemerides. Progressive regional metamorphism was lower in intensity, being caused by late-Variscan magmatic processes or by Neoid Gemer granites.

The number of petrographic types varies characteristically in individual mountain ranges (Fig. 1). So far we have not succeeded in solving the succession and mutual relations of individual granitoid types. It is not clear, whether they are separate intrusions or gradual transitions, or whether two--mica and leucocratic rocks are a product of differentiation or the result of autometamorphic processes. As much as there was not carried out the evaluation of the individual granitoid complexes from the point of formational analysis, it appears, that one episode of Variscan granite plutonism is involved, (unless we take into consideration the young Variscan or Neoid intrusive types). Pre-Variscan granitoids have not been verified. Radiometric dating of granitoids of the Western Carpathians and migmatites and metamorphic rocks genetically associated with them, yields ages between 280—340 mil. years, while the late-Variscan (Permian) granitoids reach the age of 250—280 mil. years. According to the latest data of Kovách et al., 1979, the age of the part of Gemer granitoids determined by the Rb/Sr method is 250 ± 20 mil. years. According to Kantor et al. (1979 — in print) who used the K/Ar method on muscovite ages of 222 — 261 mil. years hold for Gemer granites from the region of Hnilec and Podsúlová.

Petrochemical correlation of the plutonic rocks of the Bohemian Massif and West Carpathians.

Chemical composition of individual plutonic massifs and bodies of the areas compared is represented by mean analyses of the main rock types in Table 1. The chemical trends of plutonic rocks and variability of the main petrographic types are expressed by the Niggli's differentiation diagram (Figs. 2—5) and in the AFM, Q—Or—Ab diagrams (Figs. 6, 7).

In all the figures mentioned plutonic rocks of the Bohemian Massif are represented by average compositions of the main rock types (two-mica granites, biotite granites, biotite granites to granodiorites and amphibole-biotite granodiorites to tonalites), while those of the West Carpathians are represented by individual analyses of the characteristic rocks' types.

Niggli's values (al, alk, fm and c) in Figs. 2, 3, 4, 5) indicate the extent and the main tendency of differentiation in both complexes.

From Fig. 5 it follows that plutonic rocks of the Bohemian Massif differ from those of the West Carpathians by a generally greater extent of differentiation series. However, the trend lines of plutonic rocks of the West Carpathians reach farther into the field of the most acid differenciates. Variscan plutonic rocks of the Bohemian Massif are distinguished by the steepest trend of *fm* and *al* values. The isofaly point (the point of intersection of *al* and *fm* line) corresponds to $si = 220$. The trends of Niggli's values for pre-Variscan plutonic rocks of the Bohemian Massif and those of the West Car-

Table 1

Average chemical composition of plutonic rocks of the Bohemian Massif and West Carpathians

	A											B					
	Smrčiny M.		Karlovy Vary M.		Fláje M.	Cínovec M.	Telnice M.	Čistá M.	Štěnovice M.	Stod M.		Kladruby M.		Sedmihoří S.	Bor M.		Babylon M.
Rock type	3	4	4	3	4	3	4	4	5	5	4	4	4	4	4	5	4
	1	2	3	4	5	6	7	8	9	10	11		13	14	15	16	17
SiO_2	71,71	67,66	71,52	73,22	69,54	73,36	69,93	69,76	68,57	59,74	75,37	72,25	73,59	73,07	72,27	56,75	72,31
TiO_2	0,21	0,33	0,39	0,12	0,43	0,08	0,37	0,27	0,41	1,45	0,15	0,23	0,20	0,13	0,17	0,99	0,13
Al_2O_3	14,51	15,07	13,86	13,71	14,97	13,55	14,26	15,91	15,94	15,59	13,07	13,83	13,27	14,05	14,30	17,93	13,79
Fe_2O_3	0,52	1,22	0,57	0,57	0,63	0,64	0,77	0,80	0,88	1,65	1,02	0,97	0,94	0,94	0,65	0,82	0,93
FeO	0,94	1.93	1,57	1,50	1,53	0,73	1,94	1,04	1,55	6,01	0,88	1,89	1,66	0,93	1,28	5,76	1,32
MnO	0,14	0,06	0,05	0,05	0,04	0,09	0,04	0,04	0,04	0,11	0,01	0,04	0,05	0,03	0,03	0,10	0,03
MgO	0,44	0,80	0,76	0,28	0,96	0,13	1,26	0,59	0,94	1,72	0,18	0,60	0,45	0,35	0,26	2,67	0,38
CaO	0,75	1,90	1,37	0,72	1,69	0,52	1,91	2,66	3,00	4,82	1,21	2,31	1,67	0,80	0,99	4,46	1,25
Na_2O	3,74	3,55	3,03	3,04	3,39	3,58	3,60	5,33	4,98	4,31	4,03	3,53	3,66	3,63	3,58	3,82	4,14
K_2O	5,21	5,53	5,01	4,81	4,21	4,83	4,20	2,51	2,58	2,17	3,47	2,74	3,44	4,64	5,23	4,24	4,03
P_2O_5	0,31	0,28	0,21	0,26	0,23	0,01	0,15	0,14	0,15	0,23	0,03	0,11	0,06	0,20	0,26	0,42	0,13
H_2O+	1,28	1,04	0,89	1,30	1,74	1,48	1,07	0,48	0,54	1,53	0,23	0,77	0,67	0,70	0,70	1,52	0,91
H_2O-								0,07	0,13	0,22	0,13	0,12	0,17	—	0,08	0,17	0,23
N	4	1	27	64	3	21	1	4	6	3	3	2	3	5	10	10	5
K_2O/Na_2O	1,39	1,56	1,65	1,58	1,24	1,35	1,17	0,47	0,52	0,50	0,86	0,77	0,94	1,27	1,46	1,11	0,97
$Al/[Na+K+(Ca/2)]$	1.04	1.04	1.06	1.11	1.24	1.04	1.10	1.20	1.21	1.22	1.09	1.27	1.13	1.08	1.03	1.19	1.06
$100 \cdot Fe^{3+}/(Fe^{2+}+Fe^{3+})$	33.03	36.32	27.81	25.64	26.99	52.94	26.47	40.88	34.06	16.01	51.08	31.63	28.73	47.45	31.25	11.31	18.25

For explanation of symbols A — O see Fig. 1. 2 — leucogranites 3 — two-mica granites, 4 — biotite granites and granodiorites, 5 — amphibole-biotite granodiorites and tonalites, 6 — durbachites. — type, M. — massif, S. — Stack, 6. — granite, To — tonalite.

	C															
	leuco-G.	Jevany T.	Říčany T.	Marginal T.	Požáry T.	Těchnice T.	Sedlčany T.	Klatovy T.	Blatná T.	Červená T.	Sázava T.	Bohatín S.	Benešov T.		Čertovo Břemeno T.	Tábor T.
Rock type	2	2	4	4	4	5	4	5	4—5	5	5	5	6	4	6	6
	18	19	20	21	22	23	24	25	26	27	28	29	31	32	33	34
SiO_2	72.46	72.54	69.64	70.77	71.18	65.58	66.10	66.01	65.58	62.00	60.80	59.75	58.95	67.91	61.39	57.30
TiO_2	0.20	0.20	0.35	0.30	0.25	0.45	0.47	0.59	0.57	0.68	0.58	0.70	0.72	0.40	0.81	0.92
Al_2O_3	13.95	14.03	15.24	13.40	14.51	15.43	14.47	14.53	15.35	15.71	15.72	15.52	15.23	14.94	13.85	13.18
Fe_2O_3	0.54	0.36	0.72	1.00	0.95	0.81	1.15	1.42	0.95	0.88	1.90	1.46	0.94	0.79	1.16	1.28
FeO	1.07	0.97	1.48	2.08	2.22	3.00	2.55	3.42	3.08	3.88	4.35	5.65	4.75	2.39	3.87	5.25
MnO	0.03	0.12	0.05	0.06	0.08	0.07	0.07	0.07	0.07	0.11	0.12	0.11	0.13	0.06	0.11	0.11
MgO	0.55	0.60	1.42	1.15	0.82	0.62	2.54	1.88	1.91	3.18	3.06	3.59	3.67	0.51	4.51	6.61
CaO	1.23	1.16	1.43	1.96	3.22	3.83	2.43	3.18	3.39	4.00	5.17	5.41	4.85	2.46	3.16	4.41
Na_2O	3.94	4.01	3.50	3.74	3.61	3.16	2.84	4.10	3.57	3.33	3.30	2.43	3.02	3.55	2.67	2.61
K_2O	4.94	4.69	5.40	4.41	2.38	4.36	5.76	3.86	3.81	4.01	3.04	3.05	4.11	4.21	6.27	6.12
P_2O_5	0.12	0.10	0.35	0.13	0.13	0.25	0.36	0.17	0.21	0.30	0.25	0.01	0.55	0.18	0.59	0.58
H_2O+	0.50	0.59	0.43	0.72	0.52	0.87	0.90	0.63	0.81	1.10	0.91	2.51	1.70	1.05	1.11	0.77
H_2O-	0.14	—	0.27	0.17	0.10	0.10	0.14	0.20	0.11	0.09	0.16	0.17	0.21	0.14	0.26	—
N	32	11	16	15	9	6	10	12	20	13	39	1	5		25	41
K_2O/Na_2O	1.25	1.17	1.54	1.18	0.66	1.38	2.03	0.94	1.07	1.20	0.92	1.26	1.36	1.19	2.35	2.34
Al/[Na+K+ +(Ca/2)]	0.89	1.01	1.06	0.99	1.32	1.09	0.98	1.04	1.15	1.15	1.20	1.31	1.09	1.12	0.88	0.81
$100 \times Fe^{3+}/(Fe^{2+}+Fe^{3+})$	31.40	25.00	30.30	30.30	27.73	19.44	28.88	27.20	21.64	16.85	28.14	18.89	15.01	22.92	21.26	17.94

	D					E		F					G			
	Rumburk G.		Lužnice G.	Zavidov G.	basic rocks	Krkonoše G.	Tanvald G.	Krušné hory Mts.		Jizera-orthgneiss		Čistá-Jesenice	Nasavrky M.		Litice G.	Bial To.
Rock type	4	4	4	4	1	4	3	3	4	3	4	4	4	5	4	5
	35	36	37	38	39	40	41	69	70	71	72	73	42	43	45	46
SiO_2	75.35	70.37	66.56	66.45	70.32	72.02	74.66	72.81	69.33	74.56	73.04	72.48	71.58	63.03	70.10	56.20
TiO_2	0.13	0.41	0.69	0.64	0.42	0.41	0.08	0.27	0.60	0.15	0.38	0.28	0.18	0.64	0.35	0.84
Al_2O_3	12.93	14.56	15.56	15.84	14.90	13.89	14.39	13.72	14.39	13.34	13.16	13.67	13.97	16.22	15.39	18.04
Fe_2O_3	0.54	0.52	1.04	1.46	0.63	0.69	0.36	0.53	0.85	1.00	1.16	0.63	1.85	1.16	1.14	2.77
FeO	0.99	2.44	3.45	3.09	2.36	1.62	0.74	1.51	2.84	0.97	1.54	1.96	1.69	3.78	1.15	3.91
MnO	0.02	0.03	0.07	0.04	0.11	0.06	0.08	0.03	0.02	0.01	0.02	0.04	0.06	0.12	0.04	0.22
MgO	0.28	0.93	1.42	1.62	1.19	0.67	0.11	0.86	1.48	0.41	0.47	0.70	0.57	2.37	0.67	3.31
CaO	0.50	1.60	2.86	1.97	1.88	1.70	0.46	1.17	2.08	0.88	0.99	1.02	1.47	3.89	1.75	6.39
Na_2O	3.18	3.47	3.75	3.28	3.37	3.37	3.94	3.32	3.85	3.43	2.90	3.61	3.69	3.75	4.54	4.17
K_2O	4.67	4.28	3.37	3.87	3.53	4.54	4.19	4.76	3.65	3.89	4.90	4.38	4.09	3.63	4.24	3.14
P_2O_5	0.24	0.35	0.14	0.16	0.07	0.11	0.12	0.33	0.13	0.19	0.20	0.10	0.07	0.25	0.15	0.32
H_2O+	0.78	0.58	1.18	1.59		0.74	0.82	0.97	1.00	0.94	0.99	0.95	0.57	0.56	0.85	1.20
H_2O-	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
N	11	3	20	16	3	42	3	10	5	9	5	9	6	12	4	2
K_2O/Na_2O	1.47	1.23	0.90	1.18	1.05	1.35	1.06	1.43	0.95	1.13	1.69	1.21	1.11	0.97	0.93	0.75
$Al/[Na+K+(Ca/2)]$	1.01	1.14	1.24	1.31	1.29	1.09	1.15	1.13	1.14	1.15	1.06	1.08	1.11	1.19	1.08	1.19
$100 \times Fe^{3+}/(Fe^{2+}+Fe^{3+})$	33.33	16.00	21.24	29.91	19.30	27.75	30.49	24.03	21.15	48.28	40.50	22.45	49.62	21.66	47.02	38.91

	G		H								I		J		
	Zderaz G.	Chvaletice G.	Eisgarn T.	Rozvadov M.	Freistadt T.	Weinsberg T.	Třebíč M.		Jihlava M.	Rastenberg T.	Brno		Dyje		
Rock type	4	4	4	3	4	4	6	4	6	6	4	5	4	4	5
	47	48	55	56	57	58	59	60	61	62	63	64	66	67	68
SiO_2	71.02	74.01	73.01	74.31	69.08	67.22	56.89	69.96	59.87	60.54	72.70	64.37	73.33	72.06	58.56
TiO_2	0.45	0.20	0.22	0.10	0.39	0.67	1.10	0.58	0.72	0.79	0.16	0.53	0.35	0.43	1.32
Al_2O_3	14.49	12.75	14.45	13.54	15.44	15.05	14.88	14.98	14.12	13.68	14.33	17.19	14.30	15.12	18.79
Fe_2O_3	1.09	2.14	0.52	0.42	0.86	1.23	1.45	0.90	1.78	1.40	1.24	1.89	0.47	0.29	1.41
FeO	0.91	0.73	0.89	0.74	1.66	2.93	4.46	1.31	4.24	4.20	1.53	2.13	1.46	1.59	4.09
MnO	0.02	0.06	0.02	0.01	0.03	0.03	0.08	0.03	0.15	0.11	0.05	0.08	0.03	0.04	0.09
MgO	1.18	0.48	0.20	0.24	0.90	1.08	6.07	0.68	5.14	4.48	0.56	1.60	0.41	0.59	2.02
CaO	2.18	1.35	1.01	0.53	2.81	2.04	4.16	1.69	4.01	3.11	2.65	3.29	1.70	2.00	5.02
Na_2O	3.69	3.46	3.12	3.26	0.01	3.21	2.52	3.97	3.09	2.71	3.71	4.61	2.92	4.09	3.75
K_2O	3.09	4.49	4.93	4.78	3.78	5.21	5.42	4.82	5.35	6.53	3.31	2.47	3.66	2.97	2.65
P_2O_5	0.07	0.05	0.26	0.26	4.01	0.29	0.53	0.26	0.52	0.70	0.23	0.28	0.15	0.07	0.23
H_2O+	0.48	0.50	0.37	0.94	0.09	0.72	1.04	0.36	0.44	0.13	0.83	1.55	1.23	0.82	1.80
H_2O-	—	—	—	0.07	0.76	—	—	—	0.34	—	—	—	—	—	—
N	5	1	63	2	4	17	4	1	6	7	8	8	2	3	3
K_2O/Na_2O	0.84	1.30	1.58	1.47	37.80	1.62	2.15	1.21	1.73	2.41	0.89	0.54	1.24	0.73	0.71
$Al/[Na+K+ +(Ca/2)]$	1.26	0.99	1.13	1.08	1.96	1.07	1.00	1.04	0.91	0.84	1.17	1.36	1.30	1.28	1.46
$100 . Fe^{3+}/ /(Fe^{2+}+Fe^{3+})$	52.05	72.68	34.29	33.72	31.75	27.48	22.65	38.41	27.43	23.16	42.23	44.44	22.60	13.99	23.80

	K								L						M		
	Malé Karpaty Massif				Inovec-Massif		Suchý-M. Magura Massif		Malá Fatra Massif		Vysoké Tatry — Branisko Massif				Tribeč Massif		
Rock type	2	3	4	5	2	3	2	3	4	5	2	3	4	5	2	3	5
	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92
SiO_2	74.25	72.16	70.84	66.67	74.33	73.89	73.16	73.24	69.33	68.05	72.87	73.44	70.61	69.58	75.93	75.95	62.60
TiO_2	0.20	0.31	0.39	0.71	0.19	0.20	0.10	0.28	0.48	0.57	0.10	0.35	0.37	0.37	0.21	0.23	0.82
Al_2O_3	13.64	14.86	15.23	16.54	12.79	13.80	13.56	13.81	14.93	15.59	14.22	14.28	14.87	14.72	13.00	13.31	14.89
Fe_2O_3	1.23	0.63	0.17	1.26	1.24	1.19	2.22	1.69	1.68	0.77	0.60	1.28	1.38	1.92	1.24	0.79	4.45
FeO	0.70	1.32	1.97	2.01	0.28	0.50	0.84	0.27	1.69	2.76	1.08	0.90	2.32	1.81	0.50	1.18	2.66
MnO	0.05	0.05	0.02	0.07	0.02	0.04	0.07	0.04	0.05	0.08	0.03	0.03	0.04	0.05	0.02	0.03	0.12
MgO	0.40	1.44	0.66	1.51	0.46	0.47	0.21	0.49	0.67	1.11	0.52	1.00	0.94	0.79	0.47	0.28	2.10
CaO	0.78	1.42	2.12	2.68	0.84	1.43	0.72	1.48	3.39	3.39	0.75	0.79	2.75	3.38	0.46	0.81	3.73
Na_2O	3.18	3.96	3.74	4.40	5.35	4.00	4.68	3.75	3.98	4.17	3.36	3.77	3.77	4.40	4.70	3.90	4.36
K_2O	4.06	3.61	3.90	2.85	3.79	3.18	3.28	3.47	2.64	2.07	5.32	2.88	2.74	1.96	2.87	2.92	2.56
P_2O_5	0.16	0.14	0.14	0.15	0.10	0.11	0.16	0.22	0.18	0.21	0.13	0.06	0.10	0.15	0.02	0.00	0.33
H_2O +	1.31	0.64	0.59	1.26	0.70	0.92	0.82	0.22	0.90	0.99	0.76	1.14	0.80	0.86	0.68	0.52	1.60
H_2O —	0.07	0.04	0.04	0.06	0.05	0.09	0.11	0.08	0.08	0.07	0.10	0.06	0.09	0.06	0.03	0.04	0.07
N	3	5	1	1	2	3	1	2	3	2	1	1	9	1	2	1	1
K_2O/Na_2O	1.28	0.91	1.04	0.65	0.71	0.80	0.70	0.93	0.66	0.50	1.58	0.76	0.73	0.46	0.61	0.75	0.59
$Al/[Na+K+(Ca/2)]$	1.20	1.22	1.19	1.32	1.91	1.19	1.11	1.18	1.24	1.36	1.04	1.38	1.30	1.27	1.13	1.25	1.17
$100 \times Fe^{3+}/(Fe^{2+}+Fe^{3+})$	61.43	30.14	7.27	36.07	79.82	68.03	70.45	84.89	47.17	20.15	33.33	56,25	34.78	48.91	69.05	37.41	60.15

	M							N						O		
	Velká Fatra Massif			Nízke Tatry Massif				Vepor Massif				Čierna Hora Massif		Gemer Massif		
Rock type	2	3	4	2	3	4	5	2	3	4	5	4	5	2	3	4
	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108
SiO_2	74.89	74.07	64.81	74.46	72.23	70.13	67.45	74.27	71.40	71.64	65.53	68.78	64.50	75.62	74.50	75.11
TiO_2	0.14	0.26	0.89	0.09	0.23	0.45	0.56	0.24	0.36	0.42	0.84	0.47	0.98	0.12	0.23	0.21
M_2O_3	11.16	14.54	16.27	13.54	14.07	14.18	15.16	13.38	13.70	14.11	15.46	14.59	15.53	12.49	12.16	12.40
Fe_2O_3	1.81	0.75	2.93	1.03	1.16	1.52	3.75	1.08	1.86	1.63	3.25	2.59	3.99	1.36	1.86	1.82
FeO	0.89	0.65	1.71	0.11	1.21	1.51	0.14	0.54	1.06	0.98	1.45	0.81	1.55	0.95	1.39	0.27
MnO	0.02	0.03	0,05	0.02	0.06	0.06	0.05	0.03	0.04	0.04	0.07	0.07	0.06	0.05	0.06	0.03
MgO	1.31	0.28	1.60	0.43	0.65	1.08	1.56	0.48	1.10	0.86	1.81	1.23	1.99	0.19	0.64	0.46
CaO	1.10	0.95	3.30	0.47	1.47	2.32	2.07	1.37	1.93	1.90	3.65	2.67	3.27	0.78	1.19	0.81
Na_2O	3.28	3.83	4.31	3.55	3.90	3.63	4.15	3.40	3.71	3.72	3.66	3.92	3.83	3.34	2.57	4.44
K_2O	4.50	3.62	2.65	5.00	3.82	3.77	2.50	4.38	3.65	3.44	2.36	3.34	2.07	4.36	4.28	2.76
P_2O_5	0.08	0.12	0.25	0.08	0.12	0.13	0.18	0.08	0.19	0.17	0.41	0.24	0.47	0.20	0.17	0.03
H_2O +	0.73	0.99	1.01	0.93	1.22	0.98	1.42	0.76	0.90	0.98	1.25	1.31	1.77	0.54	1.23	1.02
H_2O —	0.08	0.12	0.03	0.11	0.07	0.11	0.04	0.07	0.05	0.11	0.12	0.12	0.83	0.08	0.06	0.05
N	2	2	2	2	2	4	1	3	8	14	5	2	2	2	4	1
K_2O/Na_2O	1.37	0.96	0.61	1.41	0.98	1.04	0.60	1.29	0.98	0.92	0.64	0.85	0.54	1.31	1.67	0.62
Al [Na + K + + (Ca/2)]	0.89	1.24	1.30	1.03	1.12	1.12	1.35	1.06	1.12	1.18	1.36	1.16	1.43	1.03	1.09	1.11
$100 . Fe^{3+} / (Fe^{2+} + Fe^{3+})$	64.80	50.98	60.65	50.00	47.48	47.53	47.61	64.41	61.32	60.00	66.96	74.18	69.92	56.21	54.62	85.81

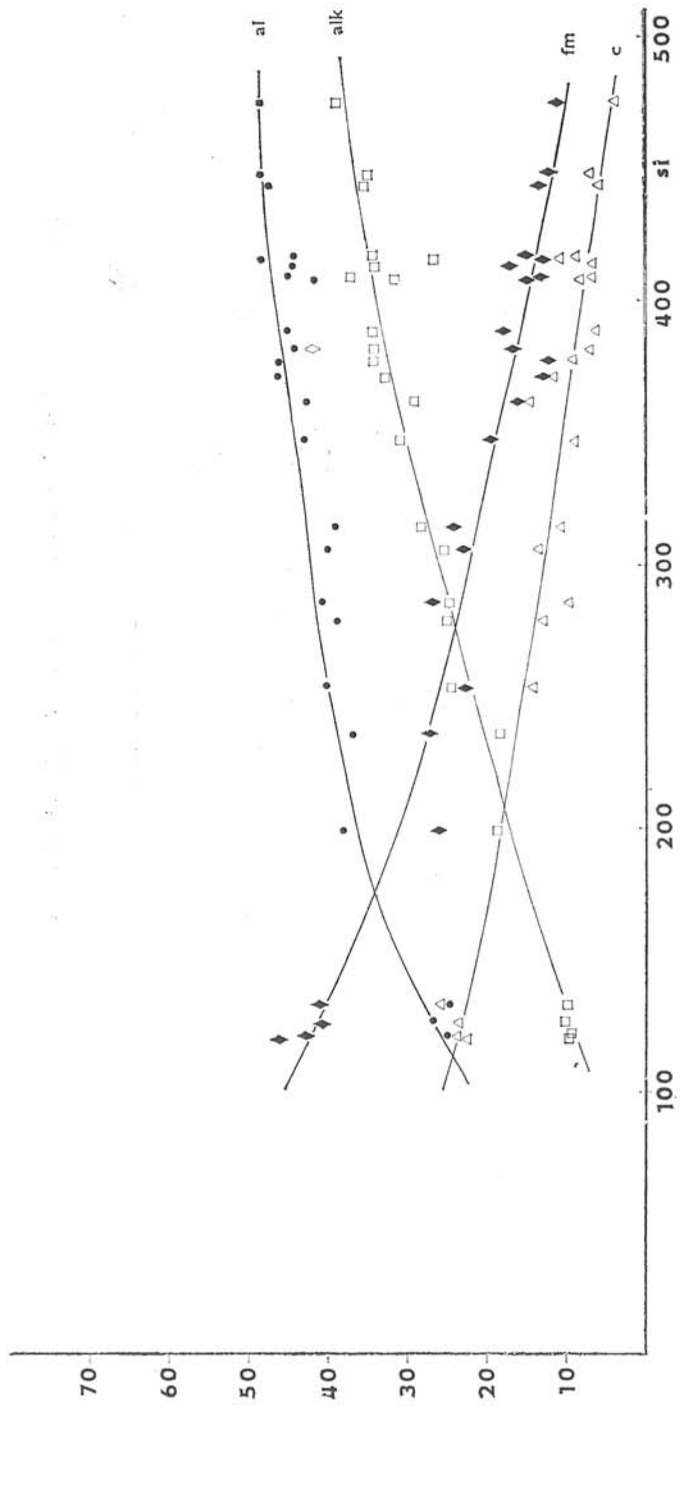

Fig. 2. Niggli's differentiation diagram of pre-Vari scan plutonic rocks of the Bohemian Massif.

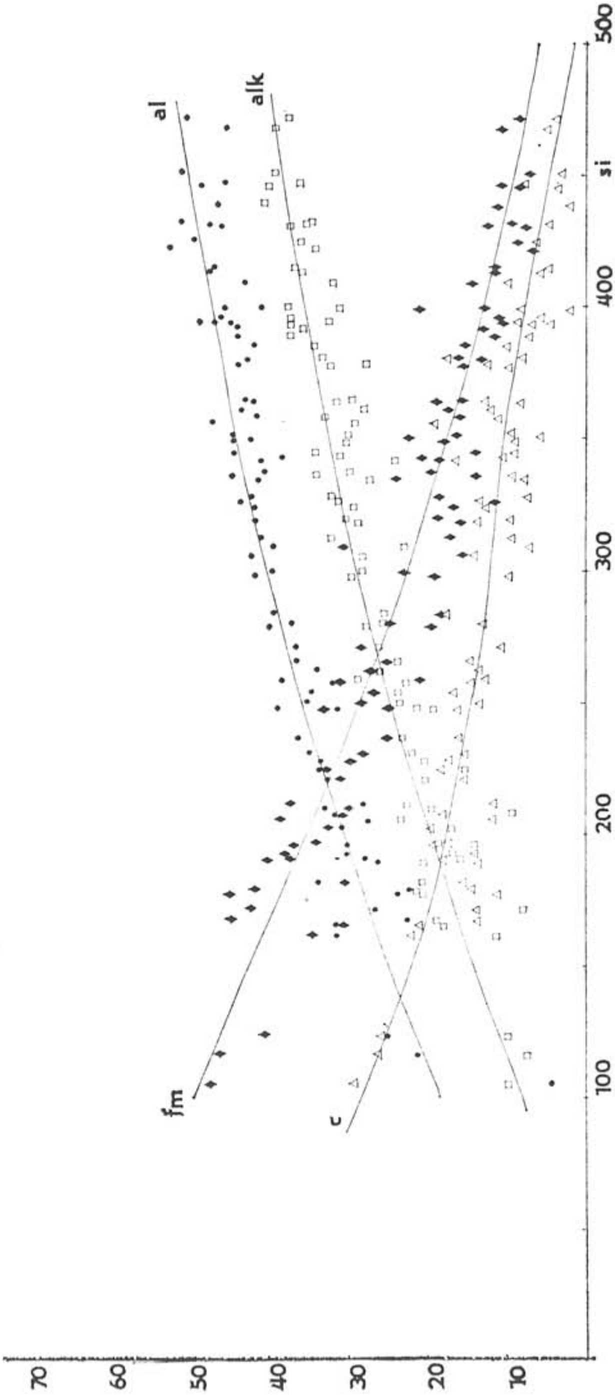

Fig. 3. Niggli's differentiatri diagram of Variscan plutonic rocks of the Bohemian Massif.

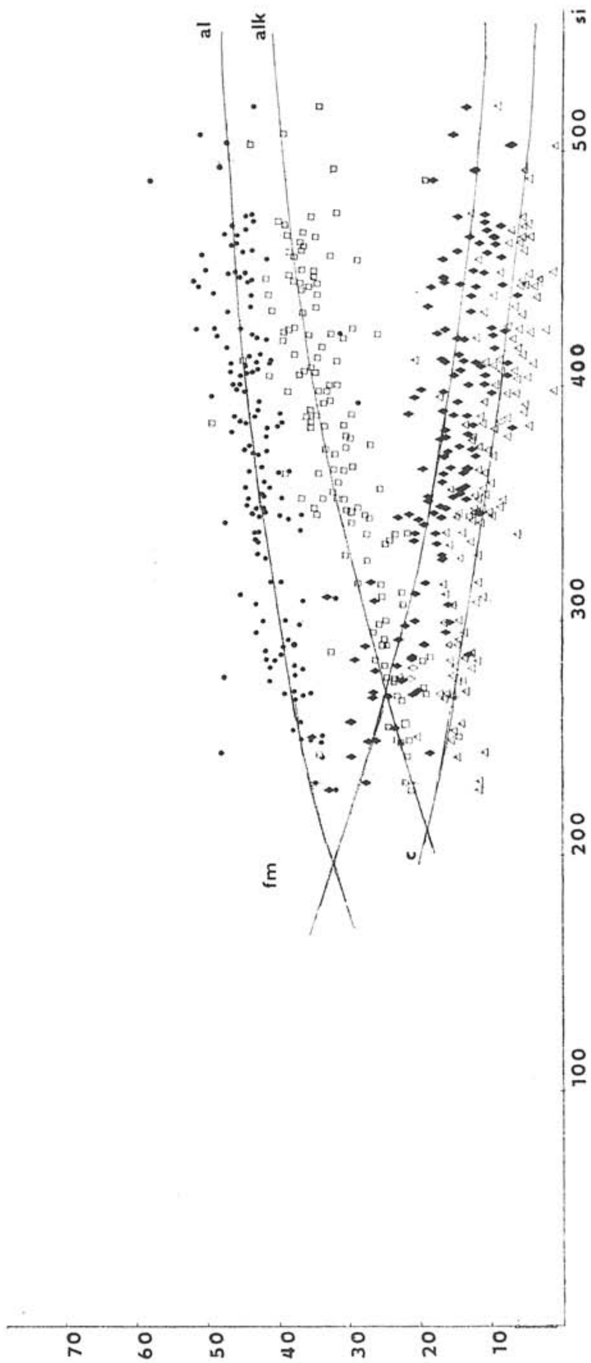

Fig. 4. Niggli's differentiation diagram of Variscan plutonic rocks of the West Carpathians.

pathians are nearly parallel (Fig. 5) and their isofaly points correspond to *si* = 170 and 200, respectively.

The variability of the main types of plutonic rocks of the Bohemian Massif and the position of their fields in AFM diagrams (Fig. 6) show the differences of petrochemical trends in the groups of Variscan and pre-Variscan granitoids (Klomínský — Dudek, 1976).

The overall development of Variscan plutonic rocks of the Bohemian Massif bears all signs of calc-alkaline chemistry. The conspicuous field of typical intrusive granites partly coincides with a distinctly smaller field of biotite granodiorites. The field of tonalites and associated diorites and gabbros is distinguished by a considerably wider extension. Klomínský — Dudek (1976) explained the discontinuities between the fields of granites-granodiori-

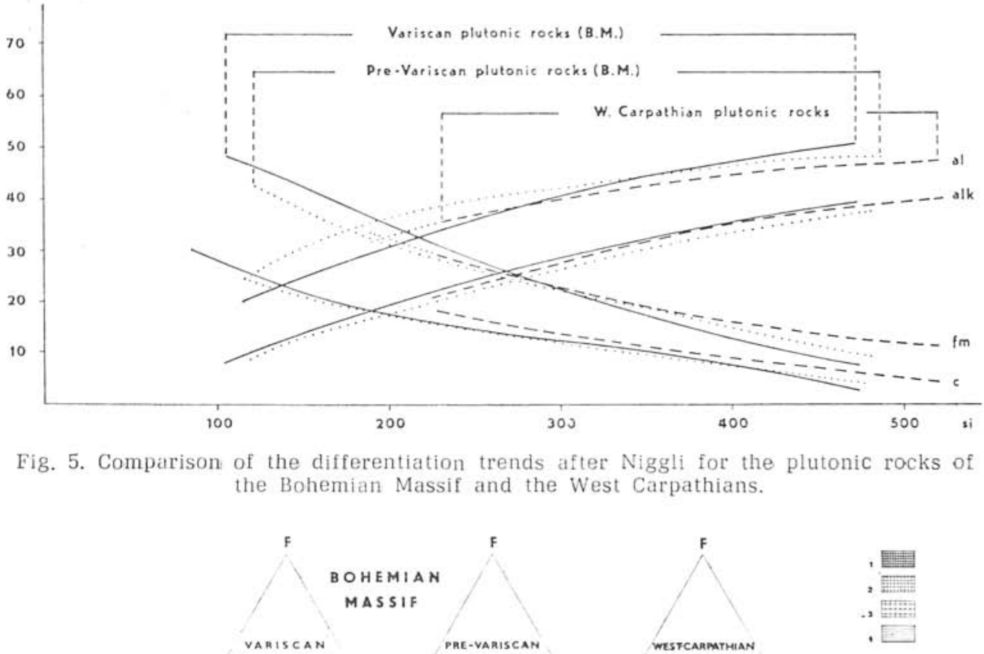

Fig. 5. Comparison of the differentiation trends after Niggli for the plutonic rocks of the Bohemian Massif and the West Carpathians.

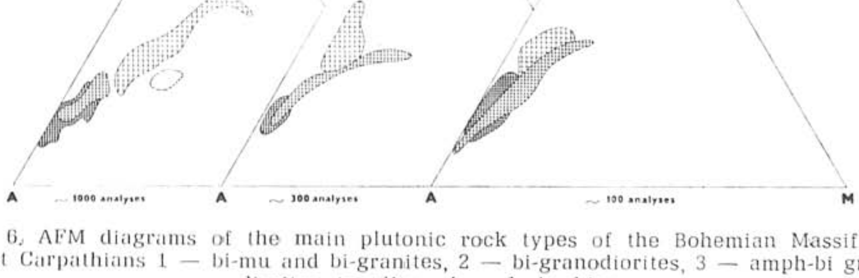

Fig. 6. AFM diagrams of the main plutonic rock types of the Bohemian Massif and West Carpathians 1 — bi-mu and bi-granites, 2 — bi-granodiorites, 3 — amph-bi granodiorites, tonalites, 4 — durbachites.

tes and tonalites as due to different ages and locations of these chemically different groups of Variscan plutonic rocks within the Bohemian Massif. Separate in the diagram lies the field of durbachitic rocks. Their isolated position reflects a different development deviating from the development of other Variscan granitoid rocks (Klomínský — Dudek, 1978; Tauson et al, 1977).

Among the pre-Variscan plutonic rocks of the Bohemian Massif we can observe a smaller dispersion of granites a conspicuously larger extent of

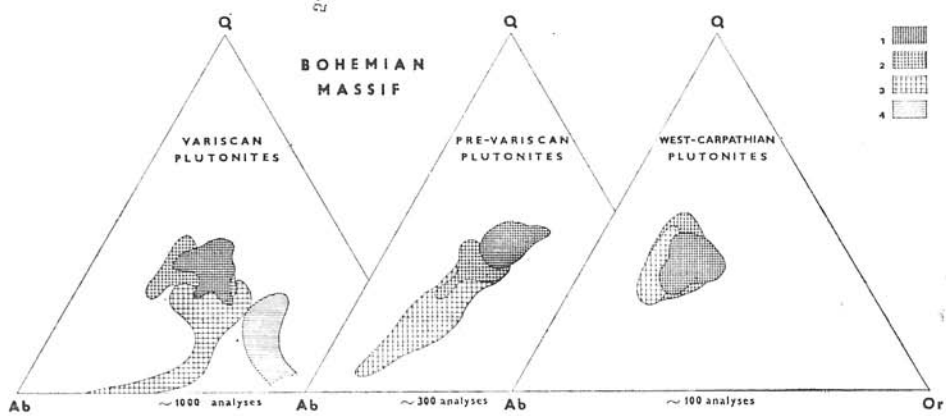

Fig. 7. Ab-Q-Or diagrams for normative mineral composition of the main plutonic rocks types of the Bohemian Massif and the West Carpathians, 1 — bi-mu and bi-granites, 2 — bi-granodiorites, 3 — amph-bi granodiorites, tonalites, 4 — durbachites.

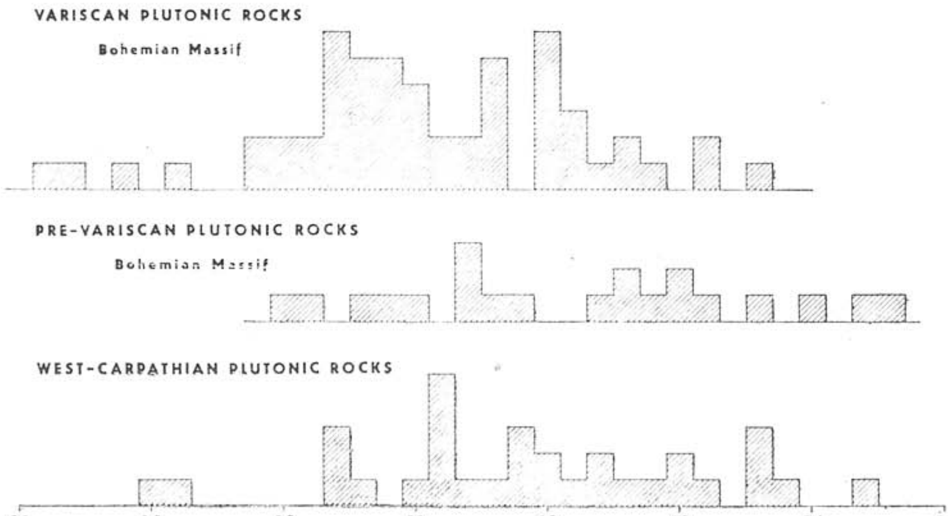

Fig. 8. Histograms of Al/(Na + K + (Ca/2)) ratio for plutonic rocks of the Bohemian Massif and the West Carpathians.

biotite granodiorites and a different position of the tonalite field, indicating an alkaline trend in the direction of the F pole.

The variability in the AFM diagram (Fig. 6) and the position of the fields of the main rock types of the West Carpathians are similar to those of pre-Variscan plutonic rocks of the Bohemian Massif. The considerable extent of biotite granodiorites, the identical position of tonalite fields and the generally steep gradient of the granito—granodiorite—tonalite series in the direction of the F pole are characteristic features common to both areas.

The histogram of the Al/Na+K+(Ca/2) ratio (Fig. 8) demonstrates a surplus of Al in both the pre-Variscan plutonic rocks of the Bohemian Massif and the granitoids of West Carpathians. Most pre-Variscan plutonic rocks of the Bohemian Massif plot above 1.1 value, which is considered by Chappell and White (1974) to be the chief parameter of the genetic classification of granitoids.

The oxidation ratio $100 \times Fe^{3+}/(Fe^{3+} + Fe^{2+})$ (Fig. 9) is a significant differentiation factor for the correlation of plutonic rocks of the Bohemian Massif and the West Carpathians. While this ratio is roughly identical for both Variscan and Pre-Variscan plutonic rocks (about 20—30), it is markedly higher for the plutonic rocks of the West Carpathians, attaining as much as 50—70. The higher degree of oxidation of the plutonic rocks of the West Carpathians is probably related to the intensive effects of Alpine dynamometamorphism.

The normative composition of felsic minerals (Fig. 7) of the Variscan plutonic rocks of the Bohemian Massif exhibits analogous coincidences and differences in the position of the fields of the main rock types as in the AFM diagram (Klomínský — Dudek), 1976).

An isolated field distinctly shifted to the Or corner belongs to the group of durbachites.

For the pre-Variscan plutonic rocks of the Bohemian Massif we can observe a different arrangement of fields corresponding to the main rock types and a linear trend to the albite corner indicating t significant role of albite molecule.

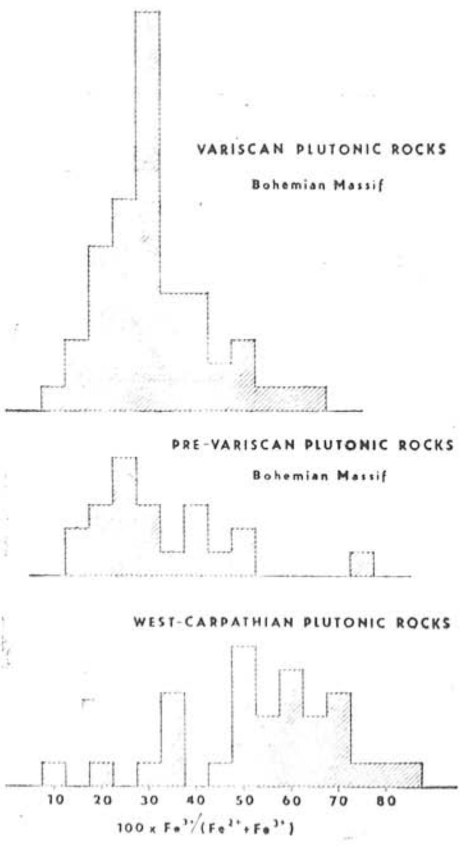

Fig. 9. Histograms of the oxidation degree of plutonic rocks of the Bohemian Massif and the West Carpathians.

Granitoids of the West Carpathians are distinguished from both groups of plutonic rocks of the Bohemian Massif, in the Q-Ab-Or diagrams (Fig. 7) by nearly total overlapping of all fields of the main rock types and thus by a relatively narrow dispersion in the composition of felsic minerals.

The ratio K_2O/Na_2O (Fig. 10) is another discriminating parameter in the correlation of plutonic rocks of the Bohemian Massif and the West Carpathians. Most analyses of plutonic rocks from the West Carpathians have a lower K_2O/Na_2O ratio than Variscan rocks of the Bohemian Massif. The K_2O/Na_2O ratio for the Pre-Variscan plutonic rocks of the Bohemian Massif is spread out and overlaps both, the field of Variscan plutonic rocks of the Bohemian Massif, as well as the field of granitoids of the West Carpathians (Fig. 10).

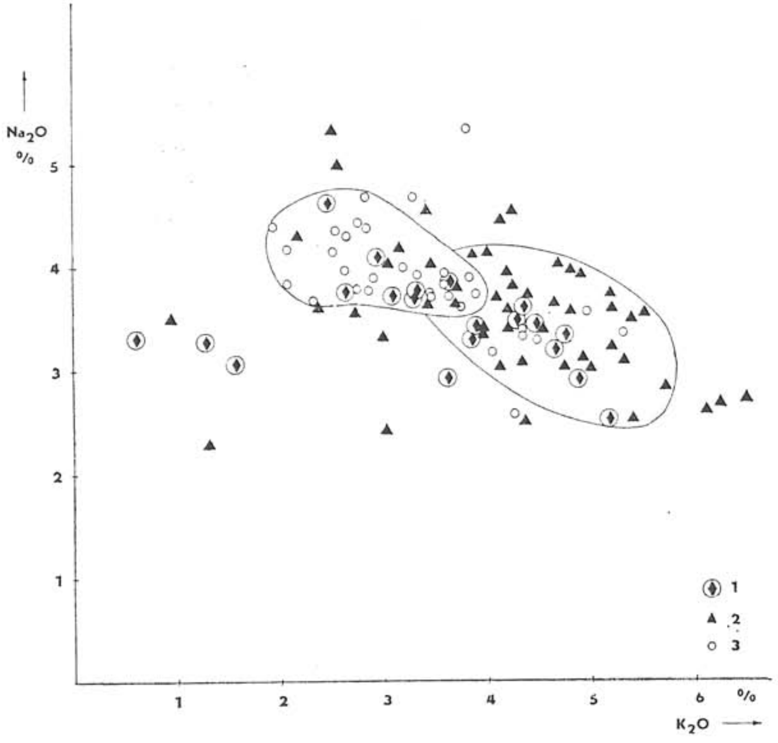

Fig. 10. The relation of Na_2O and K_2O in plutonic rocks of the Bohemian Massif and the West Carpathians.
1 — Prevariscan plutonic rocks of the Bohemian Massif, 2 — Variscan plutonic rocks of the Bohemian Massif, 3 — plutonic rocks of the West Carpathians.

Conclusions

1. At present there are few biostratigraphic limits on the age of the country rocks and numerous radiometric analyses indicating that plutonic rocks of the Bohemian Massif and West Carpathians are Variscan. Only several granitoids of the Bohemian Massif show geological proofs of pre-Variscan age. The so-called Neoid Gemer granites (West Carpathians) are a special

group which, according to recent radiometric analyses, should be of Permian age.

2. A comparison of petrographic characteristics of the main plutonic rock types of the Bohemian Massif and the West Carpathians shows some differences as well as similarities:

a) In both areas two-mica granites and biotite granodiorites are the dominant rock types. On the whole, however, the plutonic rocks of the West Carpathians are more leucocratic.

b) Petrographically, the plutonic rocks of the West Carpathians are monotonous and there are no durbachites. Neither it is true for the Bohemian Massif.

c) The tonalites of the West Carpathians are substantially more leucocratic than Variscan tonalites of the Bohemian Massif. The West Carpathian rocks are mostly biotite and rocks similar to tonalites (of the Central Bohemian plutonic types) which do not occur in the West Carpathians. Their petrographic and some chemical characterstics compare is similar to those of the pre-Variscan granitoids of the Bohemian Massif.

d) In agreement with the petrographic characteristics, the plutonic rocks of the West Carpathians have higher *si* values in Niggli's classification and a different point of isofaly; the latter lies between those of Variscan and pre-Variscan plutonic rocks of the Bohemian Massif.

e) In the petrochemical diagrams (AFM and Ab—Q—Or) there are differences in the position and field size of the bain petrographic types of plutonic rocks of the areas compared. For plutonic rocks of the West Carpathians overlapping elongation of the fields of Variscan plutonic rocks of the Bohemian Massif. In line with their more acid character, the tonalities of the West Carpathians show a higher F/M ratio than do the Variscan tonalites of the Bohemian Massif.

f) The Na_2O/K_2O ratio, which is distinctly higher in Carpathian plutonic rocks than in their Variscan equivalents of the Bohemian Massif, is an important discriminating value. The Na_2O/K_2O values for pre-Variscan plutonic rocks of the Bohemian Massif fall into fields of Carpathian and Variscan granitoids.

g) The evaluation of petrochemical parameters $(Al/(Na+K+Ca/2)$ and 100 $Fe^{3+}/(Fe^{2+} + Fe^{3+})$ of the plutonic rocks of the areas compared represent a potential basis for an interpretation of the origin of the parent material and the effects of superimposed processes in the sense of White et al., 1974.

h) The paper submitted is an example of the present state of the petrochemical research of the plutonic rocks of the Bohemian Massif and the West Carpathians. However, the data accumulated so far do not submit an analysis of genetical questions. In order to solve these problems, more petrological and geochemical research is necessary.

Translated by M. Kubínová.

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Reviewed by M. SUK Manuscript received September 12, 1979