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GEOLOGICAL CHARACTERIZATION OF THE VARISCAN AND PRE-VARISCAN IN HUNGARY

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ASTRACT

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Five pre-Permian megatectonic units can be distinguished in Hungary: a high-grade Precambrian crystalline complex, two Variscan greenschist-facies complexes, the amphibolite-facies complex of the Sopron massif, and the unmetamorphosed Palaeozoic. These five units are described. The Variscan orogeny has reactivated the older basement, which forms part of a number of median massifs. These can be traced towards Greece and Turkey.

In the present state of knowledge, the pre-Permian formations in Hungary can be assigned to five megatectonic units readily separable from one another both chronologically and spatially (Fig. 1). They are:
(1) The Baikalian and pre-Baikalian metamorphic crystalline complex of Precambrian age, known to occur in the Pannonian Median Mass to the southeast of the Zagreb-Tokaj Lineament-Rift Zone (Fig. 2).
(2) The spiš-Gemer-Balaton Highland metamorphic zone of greenschist facies represents the Variscan crystalline substratum of the Hungarian Central Mountains. Territorially, it is situated between the Zagreb-Tokaj Lineament and the lineament called the Rába Line. This certain Variscan zone begins with the Gemerides in the northeast, to continue then with the crystalline basement of the Balaton Highland and to pinch out, finally, between the Karawanken and the Pohorie Massif in the southeast.
(3) The Kőszeg-Velem phyllite-chlorite schist and carbonate (calc-phyllite) succession of greenschist facies, hitherto believed to be Variscan, extends from the Rába Lineament to the western frontier and can be traced, farther west, as the 'Altkristallin' of the upper east-Alpine, already on Austrian territory.
(4) The metamorphic complex in amphibolite facies called the Sopron Massif which has undergone a strong diaphtoresis.
(5) The Lower to Upper Palaeozoic (pre- to post-Variscan) non-metamorphic complex, the members of which overlie, in minor patches, the Precambrian of the median mass and the phyllite substratum of the Balaton Highland, respectively.

The interrelations of the five megatectonic units are illustrated by a geological section across the country (Fig. 3). Our knowledge of the above megatectonic complex can be summarized as follows:
(1) The crystalline rocks of the Pannonian Median Mass are only exposed in the Mecsek Crystalline Area and the so-called Zemplén Window, in the extreme north of the country. In the other areas to the south-east of the Zagreb-Tokaj Lineament it was block-faulted in Miocene time and thus subsided to different depth. It is now covered by a total of about 1000 m sediment of Helvetian, Tortonian (Carpathian-Badenian), Sarmatian, Pliocene and Pleistocene age. Drilling for oil has discovered throughout the study area one and the same crystalline substratum in amphibolite facies containing migmatitic and anatectic rocks. This characteristic Precambrian polymetamorphic complex has a geological evolution identical to that of the Serbian-Macedonian Median Mass, the

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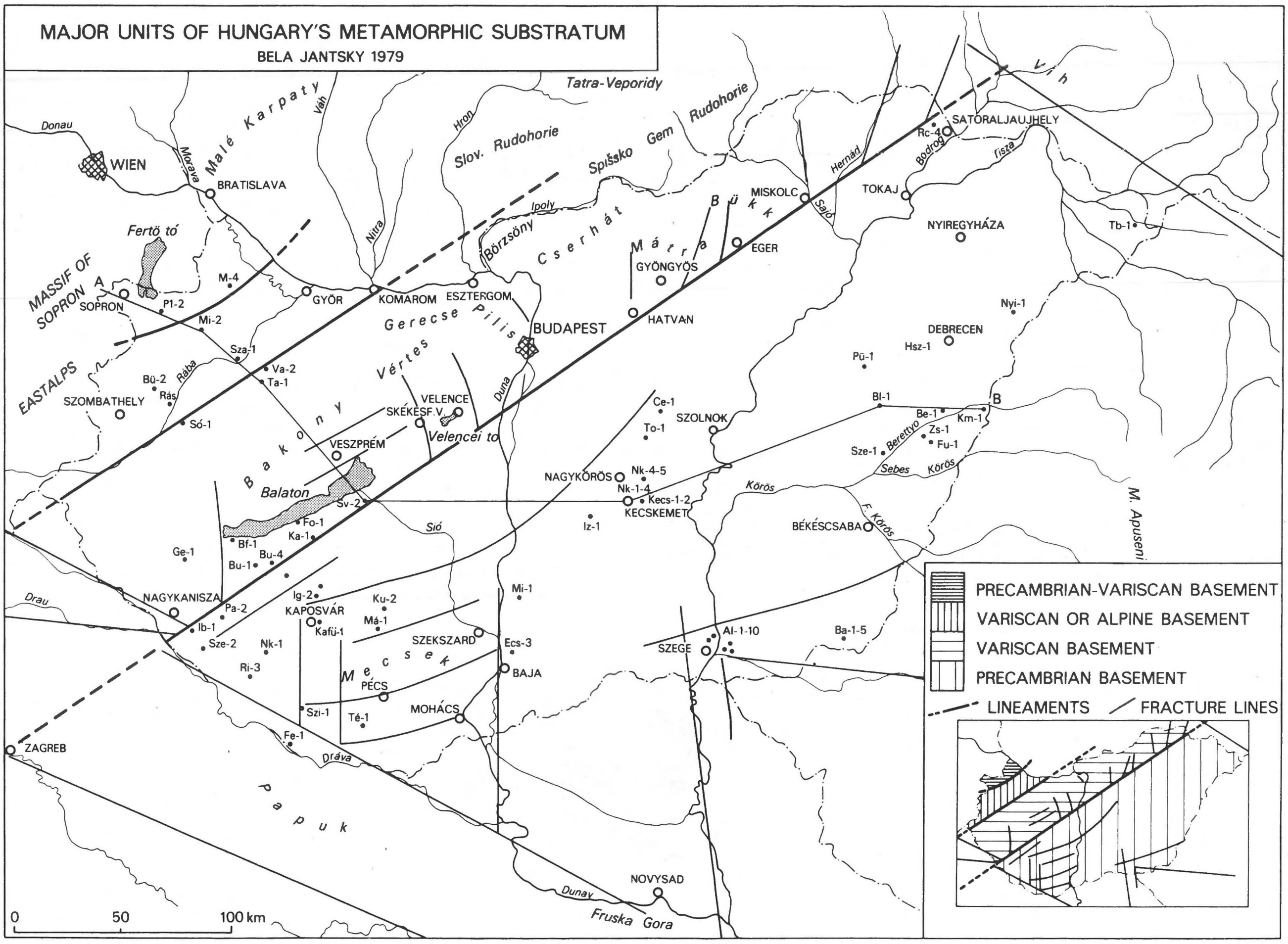

Fig. 1
Major units of the metamorphic substratum of Hungary (after Jantsky, 1979).

Rhodope Median Mass, the Muntii Apuseni Massif. Furthermore, it is very similar to the polymetamorphism of the Precambrian crystalline basement of the eastern and southern Carpathians (see references).

In Hungary the Phanerozoic sedimentary cover lying on the Precambrian basement was not affected by metamorphism. This means that during the Variscan orogeny this area was a consolidated massif, unlike the basement of similar age in the eastern and southern Carpathians characterized by Variscan magmatism and retrograde metamorphism of greenschist facies. In other words, these areas must have witnessed an reactivation in Variscan time. The Precambrian polymetamorphism of the median mass underwent the following geological evolution:

(1a) Carbonate-less eugeosynclinal sedimentation on a substratum of varying depth. The pelitic-psammitic sedimentary sequence has been pierced by basic (ophiolitic) eruptive rocks (Figs. 4-5).

(1b) Regional metamorphism of amphibolite facies of the above complex having attained the sillimanite, staurolite and cordierite isograds (Fig. 6).

(1c) Over the thermal axes the above regional metamorphism was superimposed by a high-grade metamorphism, leading to migmatization; formation of agmatites, diatexites and nebulitic-skialitic porphyroblastic granites was superimposed on the above mentioned metamorphics (Figs. 7-8). This metamorphism is believed to have been connected with the Karelian orogenic processes.

(1d) Then followed a denudation phase with local basin formation, followed in turn by miogeosynclinal sedimentation characterized by the predominance of carbonates, shales, marls, calcareous schists, limestones and dolomite, ankerite and iron-rich sediments.

(1e) In connection with the Assyntian folding (also referred to as Cadomian, Brioverian, Baikalian, Riphean and Vendian orogenies), this sedimentary sequence underwent a greenschists-facies metamorphism producing chlorite, sericite, albite, hornblende and calcite which provoked, at the same time, a retrograde metamorphism of the ancient, highly crystallized sequence.

(1f) This metamorphism was followed by a large-scale denivellation and block-faulting which led to the formation of

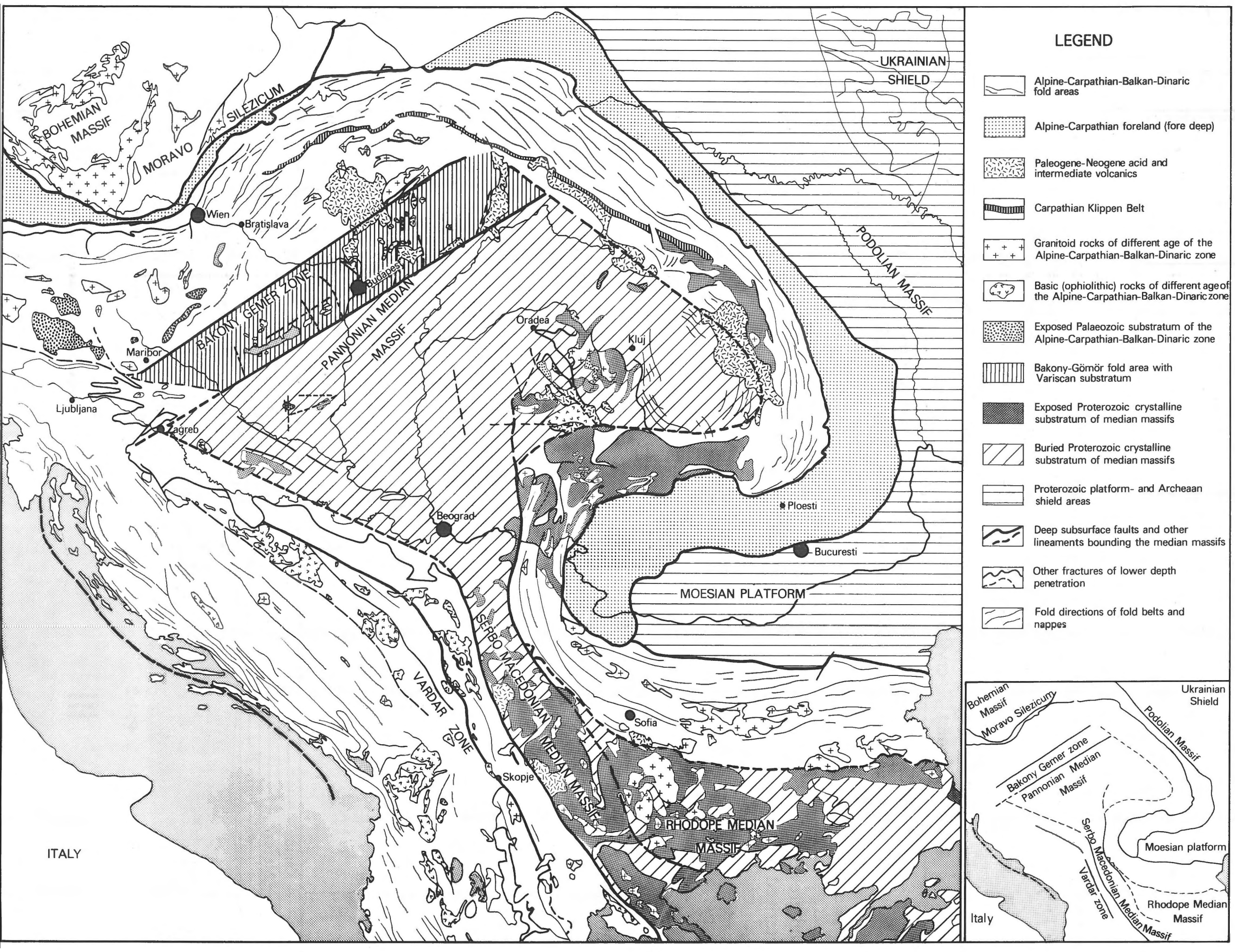

Fig. 2
Megatectonic situation of the Precambrian substratum of the Pannonian Median Mass (after Jantsky, 1979). The distance between the northern and the southern part of the map is some 1150 km.

new aulacogens, troughs and basins in which early Palaeozoic sediments were deposited, marking the beginning of the development and subsequent history of the Phanerozoic cover of the median and central massifs of the Proterozoic crystalline substratum.

(2) The crystalline basement of the Hungarian Highland Range (also called the Hungarian Central Mountains) is known in outcrops in the Szendrö Mountains as the mantle of the granite pluton of the Velence Mountains, and in several minor patches on the Balaton Highland (Fig. 1). It is also found in drillholes at Scécsény, Börzsöny, Székesfehérvár (to a depth of 1200 m), Ságvár, Balatonfenyves, Karád, Buzsák, Gelse, Pusztamogyoród and along the Rába Line. Its geological history is reconstructed in Table I.

The Cambro-Silurian sequence of the Hungarian Highland Range is evidenced by its microfauna, the Visean of the Carboniferous System by a rich macrofaunal record. In the Transdanubian Central Mountains forming a member of the Highland Range the Devonian is represented by bluish-grey crystalline limestones which have hitherto been found sterile.

The phyllite complex is chaotically folded, showing an unconformity with younger, non-metamorphic formations, of which fragments may be tectonically emplaced in the phyllites. Its strike direction corresponds to that of the Highland Range, the schistosity planes being locally perpendicular to the original sedimentary stratification. The vergence of the complex could not be determined.

The calc-phyllite-crystalline limestone sequence of the Szendrö Mountains, North Hungary, is assigned to the Devonian on the basis of faunistic data.

The Highland Range's Cambro-Silurian phyllite-greywacke sequence is cut by homogeneous biotite granite plutons with a contact-metamorphic mantle, in the Spiš-Gemer Metalliferous Mountains (Slovakia) and several other places (Velence Mountains, boreholes at Ságvár, Foyód-1 and Gelse-1, Hungary). These granite plutons are cut by a great number of granite porphyry and aplite dykes with a NE-SW strike. Postmagmatic granitoid dyke intrusions were followed

Table I
Geological history of the Hungarian Highland Range.

Sedimentation		Metamorphism	
Age	Type	Age	Products
Cambrian Silurian	Pelitic, psammitic, carbonate-less eugeosynclinal sedimentation with diabase and quartz-porphyry intrusions and interbedded tuff layers	Variscan (Bretonic)	Sericitic quartz-phyllite, meta-sandstone, chlorite-sericite schists, meta-greywackes, lyditoferous quartz schists with intercalated diabase, diabase-porphyritoid and tuffaceous porphyroid bodies
Devonian	Miogeosynclinal sedimentation of limestone, marl, dolomite, and siltstone	Varisacan (Bretonic)	Crystalline limestone and calcphyllite, ankeritic crystalline limestone
Carboni-ferous		Sudetic phase of Variscan orogeny	Granitic magmatism with strong postmagmatic vein activities, pneumatolytic, hydrothermal processes and ore mineralization
Carboni-ferous	Visean, white-streaked black limestone and grey shale sequence and conglomerates characterized by macrofauna		
Permian	Red Gröden Sandstone and quartz-porphyry volcanism		
Mesozoic	Complete Mesozoic represented by marine sedimentation Late Cretaceous denudation and bauxite formation		absent

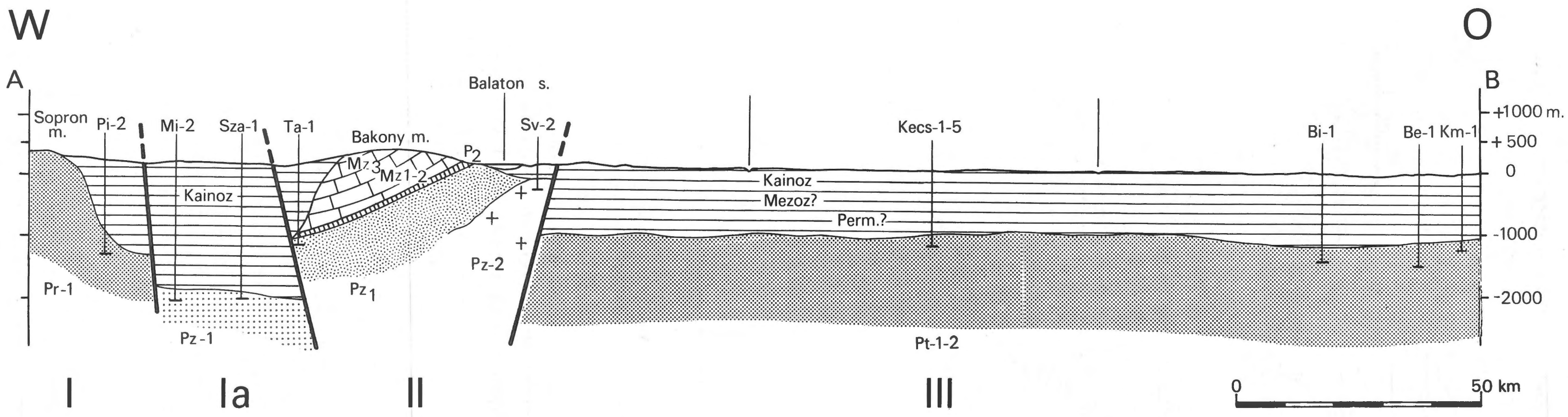

Fig. 3
Geological section across Hungary (after Jantsky, 1979).

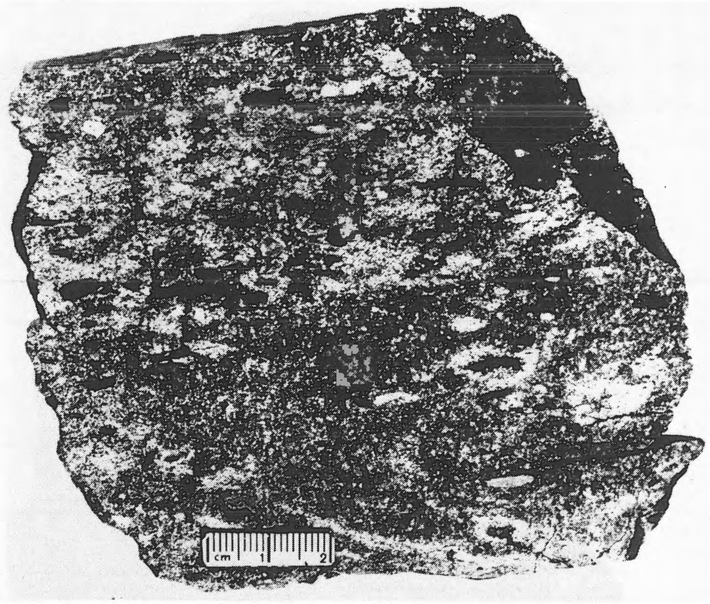

Fig. 4
Metaconglomerate (polished surface). Valley of Köves brook at Bátaapáti.

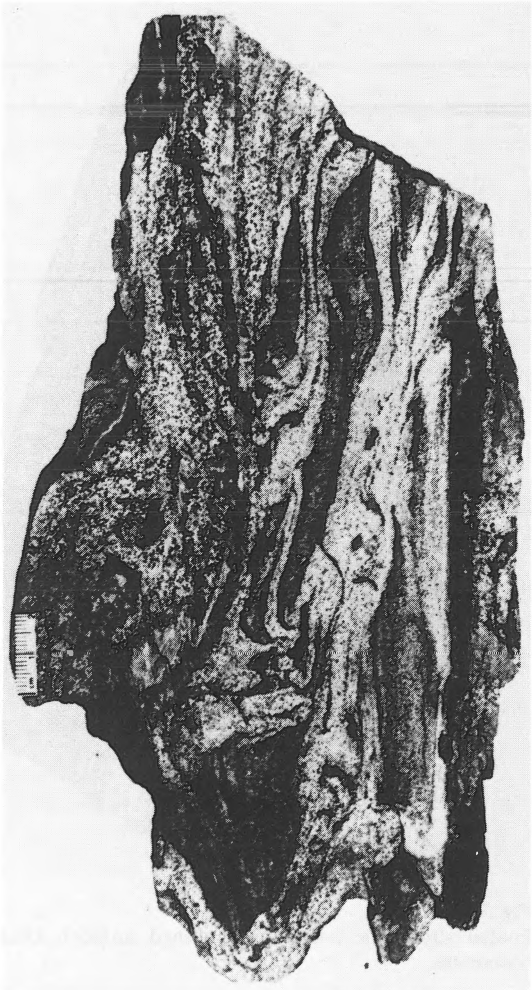

Fig. 5
Migmatite (sillimanite-biotitic paragneiss; polished surface). Lovászhetény, Mecsek Mountains.

Fig. 6
Staurolite-cordieritic paragneiss (crossed nicols). Mecsek Crystalline.

by pneumatolitic (with tourmaline), then by hydrothermal veins. The granite is only in three places intersected by thin and short kersantite veins.

Both the granite and its schist mantle are dissected by a dense system of faults. The same holds true for the entire crystalline basement. The system of fractures parallel and perpendicular to the two confining lineaments has resulted in the formation of a fault-block structure with Palaeozoic igneous rocks, followed by andesitic intrusions of Eocene age at the intersections of the faults. This seems to be responsible for the fact that almost all boreholes put down in this zone have cut across andesite intrusions. Rocks similar to the tonalites of the Pohorie Massif and the Karawanken were intersected by boreholes at Pusztamogyoród, Gelse and Balatonfenyves in the neighbourhood of Lake Balaton.

After Permian peneplanation, the study area became a marine sedimentary basin, where sedimentation lasted uninterrupted as long as Late Cretaceous time, then until the advent of Alpine orogenic movements that produced fault structures.

Fig. 7
Folded stromatitic migmatite (polished surface). Ofalu, Mecsek Mountains.

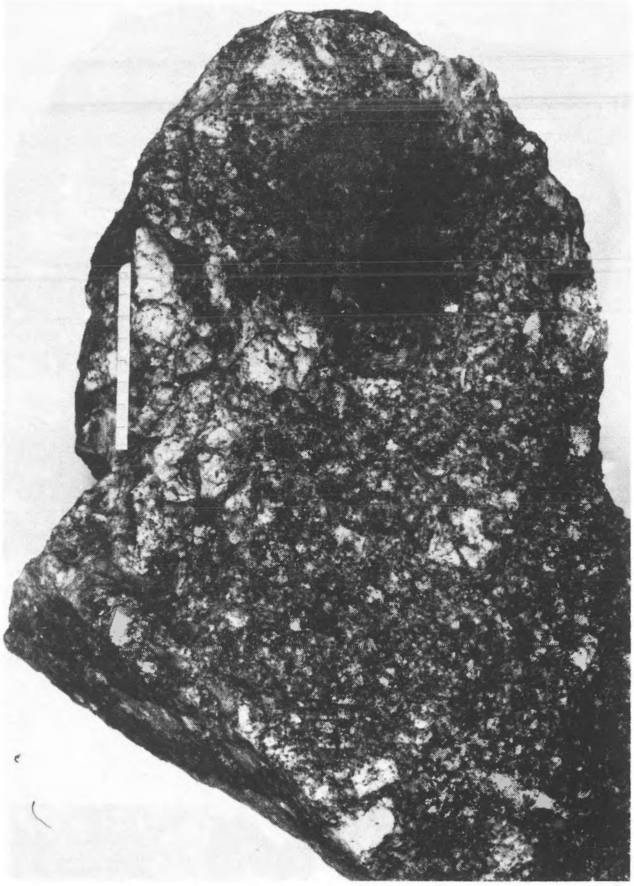

Fig. 8
Porphyroblastic nebulitic granite (polished surface). The nebulites are rimmed by microcline. Quarry at Erdösmecske. Mecsek Mountains.

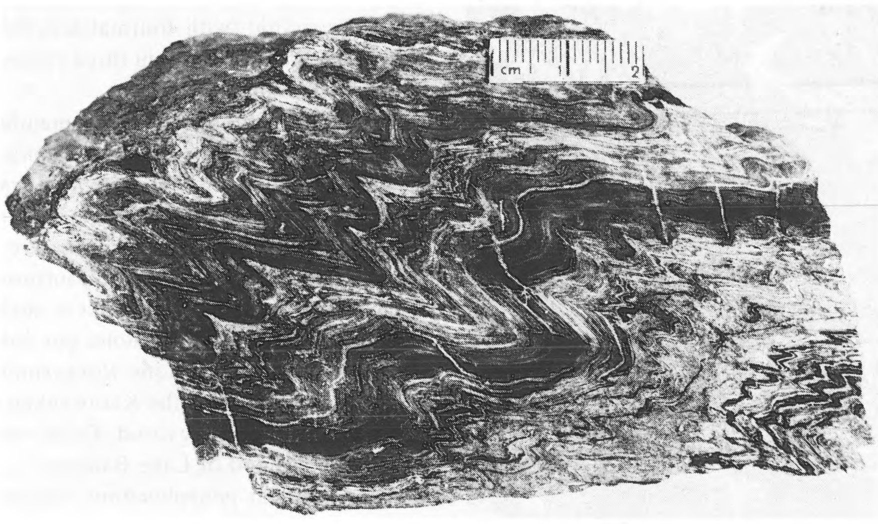

Fig. 9
Stromatitic migmatite affected by diaphtoresis (polished surface). The original leucosome-melanosome layers can still be recognized. Ofalu, Mecsek Mountains.

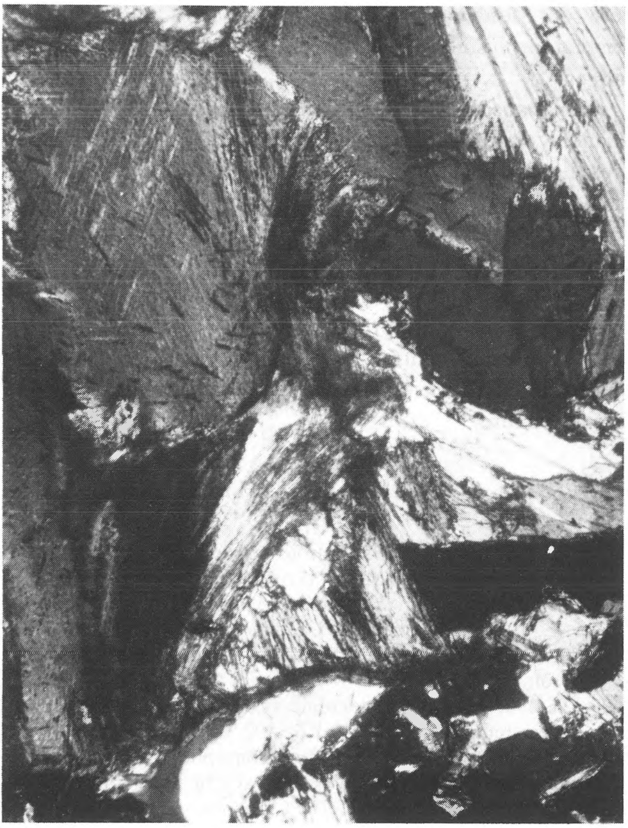

Fig. 10
Sillimanite-kyanite-biotitic paragneiss. Sopron-Ujbrennberg. Photograph: Kisházi.

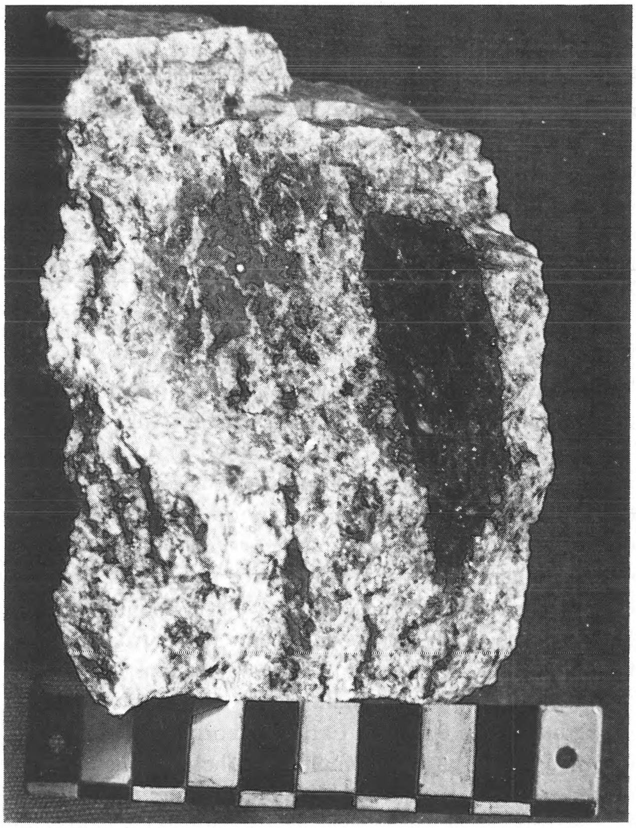

Fig. 11
Blastomylonitized granite with biotitic paragneiss xenoliths (polished surface). Várisi quarry, Sopron. Photograph: Kisházi.

(3) From the Rába Lineament up to the country's frontier in the west there is a carbonate-rich (limestone-dolomite-calc-phyllite) metamorphic sequence of similar greenschist-facies rocks. This complex is known as the Köszeg-Velem and Vashegy/Eisenberg/sequences. Well-foliated chlorite-sericite quartz-phyllites and calc-phyllites are known to occur in a number of exposures to the south of Köszeg. At Cák this sequence contains a coarse, dolomite-pebble conglomerate of about 5 m thickness.

The Köszeg-Velem sequence plunges gradually eastwards to considerable depths, its position on the attached map is shown by a number of boreholes that have uncovered it. It shows the following lithology: crystalline dolomite and limestone, sandy dolomitic schist, sericitic phyllite, calcphyllite, calcareous schist and chlorite schist.

In recent years some research workers on the Austrian side of the frontier have assigned this sequence, on the basis of fossil record, to the Mesozoic. At any rate, to be able to settle this question definitively, one will have to rely on Austrian results, as over the Hungarian sector no faunistic record of this kind is known to be available and the stratigraphic position of the sequence does not enable a decision about it. At any rate, it follows convincingly from the above considerations, that the eastern outposts of the Alps extend as far as the Rába Line.

(4) The Sopron Massif is made up of regional metamorphic and eventually ultrametamorphic (granitized) rocks of amphibolite facies carrying sillimanite, andalusite and kyanite. It seems to occur in the vicinity of Sopron, extending from the frontier eastwards (being traceable through boreholes Fertörákos-1-2, Mosonszentjános-1 and Pinye-1) as far as Kapuvár.

The rocks composing the massif are sillimanite-andalusite-kyanite-biotite paragneisses, two-mica paragneisses, kyanite-quartzites, and a sequence hitherto referred to as orthogneiss and granite-gneiss. The mineralogical composition of the rocks is characterized by the occassional presence of sillimanite, andalusite and kyanite, a feature related to variable pressure conditions (Figs. 10-11). The orthogneisses abound in dark, small-grained, well-foliated, biotite-rich paragneiss inclusions. These metamorphites and ultrametamorphites of amphibolite facies underwent a retrograde metamorphism of varying intensity during which leucophyllites, chloritoid-muscovite-phyllites, sericite-phyllonites and chlorite-schists were formed.

According to most recent literature, the original rocks of this fault-block are taken to be of Precambrian age. In accordance with this, the metamorphism could be of Cadomian or Variscan age, the retrograde metamorphism, in turn, may have been associated with the Variscan or Alpine orogenies. The abundance of paragneiss xenoliths and the large-scale homogenization of the gneiss suggest that this rock must once have been an intrusive granite. Accordingly, the biotite paragneiss xenoliths could be an early Proterozoic formation equivalent to the sillimanite-gneisses. These have been intruded by similar Variscan granites which acquired their schistose nature simultaneously with the regional greenschist facies metamorphism, whereas the sillimanite-bearing gneiss complex underwent a retrograde metamorphism.

In this case the age problems of the metamorphism of the Köszeg-Rechnitz Mountains have to be considered on the basis of their Alpine relations. Isotopic dating has hitherto not produced any reliable results, so a discussion will be omitted. The similar crystalline rocks of the Sopron Mountains may occur also in the Little Carpathians and the central massifs of the western Carpathians (Tatra-Veporides). The interpretation of geophysical (geomagnetic, gravimetric, palaeomagnetic) results cannot yet be considered to be completed.

(5) On the crystalline basement of the Pannonian Median Mass minor early Palaeozoic sedimentary troughs were formed. One of these is the Szalatnak-Alsómocsolád-Györe basin in the northern foreland of the Mecsek Mountains in which more than 500 m of Early Palaeozoic (Cambro-Silurian) sediments have accumulated. These formations are characterized by their non-metamorphic state; furthermore, in their topmost parts, by the presence of pebbles of granite-porphyry, which penetrates as dykes into the shale at the base of the sequence. A contact-metamorphosed hornfels zone of 3 to 5 cm width was formed at the margins of the 1 to 5 m thick dykes.

In some parts of the Danube-Tisza Interfluve and of the Transtibescian region (east of the Tisza river) non-metamorphic rocks, similar to the Lower Palaeozoic cut by borehole Szalatnak-3, have been explored by drillings for oil in recent years. This means that the last metamorphism in this region must have taken place at the end of the Late Proterozoic. Beside these, the Proterozoic basement gradually subsided in southerly direction so that a productive Carboniferous sedimentary basin could develop, of which the anthracite layers can be correlated with those of the productive Carboniferous of the Banat region.

The phyllite basement of the Balaton Highland, as already mentioned, witnessed a marine sedimentation in allegedly Visean times. The resulting white-streaked black limestones and grey shales did not undergo either regional or contact metamorphism. Consequently, both metamorphic processes must have taken place here in pre-Visean time.

Constituted by Precambrian rocks, the Pannonian Median Massif is the westernmost member of a chain of median massifs represented by the Serbian-Macedonian, the Rhodope, the Anatolian and the Iranian Median Massifs. Its mobile behaviour originated in early Palaeozoic times and it underwent folding and metamorphism during the Variscan orogeny. The above mentioned median massifs are wedged between Mesozoic mobile belts whose folding and slight remetamorphism are to be associated with the Alpine orogeny.

The consolidated median massifs responded to Phanerozoic orogenic movements by producing deep fractures, lineaments, which became channelways for the ascenst of magmatic products and thus created possibilities for the genesis of the rich ore deposits of the Alpine-Himalayan fold system.

Compilers of palinspastic maps of the Variscan mobile belt should seek to consider the location of the Precambrian median massifs, central massifs and platforms and their Palaeozoic-Variscan history, in order to arrive at a satisfactory picture.

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