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GEOLOGICAL EVOLUTION OF SOUTH TRANSDANUBIA (HUNGARY) IN PALEOZOIC TIME*

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SUMMARY

Accepting the opinion about Precambrian age of crystalline basement of South Transdanubia declared by B. JANTSKY [1974], the oldest Paleozoic formations of South Transdanubia can be placed into Ordovician-Silurian period [K. BALOGH, 1974]. Three Ordovician-Silurian rock types are recorded:

1. Strongly folded dark grey siliceous shales with basic tuffs and agglomerates covered by Lower Triassic red sandstones. This rock sequence is interrupted by Carboniferous (?) syenite-porphyric subvolcanic body with uncertain aureole. The unexplored underlying rocks are assumed to pertain to the Precambrian granite mass.
2. The second formation represents a single depositional cycle ranging from coarse grained deposits to limestone with products of ultrabasic and basic volcanism. It forms the oldest Paleozoic part of the so called "Mecsekalja Tectonic Belt" passed along they southern margin of the Mecsek Mountains. These rocks had been superincumbent in Pre-Carboniferous upon the Precambrian "Mórágy Granite Formation" and "Görcsöny Metamorphic Formation". At the beginning of the Variscan Orogeny they had wedged into the underlying Precambrian rocks by a considerable transcurrent faulting, and they suffered a tectonic metamorphism with a slight selective melting. After Pre-Upper Carboniferous denudation of these rocks have taken place the present geological setting.
3. The third formation is formed by ultramafic lava-filled conduits surrounded with Precambrian metamorphites and granites covered by Upper Pannonian and Permian deposits. Rock-material of these vents consists mostly of clinopyroxenites, serpentinites and associated derivatives.

The area affected by powerful movements from the end of the Silurian up to Upper Carboniferous. During this period had been the first manifestation of the Variscan Orogeny caused the wedging of the above mentioned second formation into the "Mecsekalja Tectonic Belt" by transcurrent faulting. It can be placed into Earliest Carboniferous (Bretonian Phase).

During Sudetic Phase a weak granitization had taken place produced microgranite intrusions, aplit veins, K metasomatism as well as presumed syenite-porphyrite near Szalatnak.

At the beginning of Upper Carboniferous the western part of the area formed a basin filled by continental Upper Carboniferous and Permian deposits. The Upper Carboniferous sequence measures more than 1000 m thickness near Téseny—Bogádmindszent covered by Upper Pannonian sediments. It contains some coal beds and coaly siltstone streaks with well determinable flora resembling to the Ruhrland one.

The Upper Carboniferous coal bearing sequence changes gradually into Permian variegated sandstones, siltstones and conglomerates of about 2500 m thickness. The Permian sedimentation was interrupted by an uplift (presumably with local importance) accompanied by a quartzporphyric lava flow attributed to Saalic Phase in Western Mecsek, and by another one in Villány Mts. ranging over the Upper Permian alternating with sandstones.

According to recent views the Upper Carboniferous — Permian sedimentation did not extend more than to so called "Villány—Szalatnak Deep Fracture Zone" in the Eastern direction and line of Drava river in Southern side. The basin of Upper Carboniferous and Permian are made of continental sediments (mainly fluviatile and fewer lacustrine) having a NW—SE general trend.

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At the end of Permian sedimentation a general sinking had taken place which produced a characteristic purplish-red basis conglomerate and sandstone mass due to Pfalz Phase. It is considered as a starting part of the mesozoic sedimentation all over Hungary.

It is important to notice that if the theory of Precambrian age of Görcsöny Metamorphic —, and Mórágy Granite Formations rules out, it will result certain transformation of history of South Transdanubian Old Paleozoic series.

INTRODUCTION

Geological knowledge of ours about Paleozoic of South Transdanubia shows a dissimilar view. The outcrops and not too deeply buried parts of Upper Paleozoic are investigated by boreholes during the uranium prospection and coal mining then a detailed and up to date geological map (scale 1:10.000) of the Mecsek Mts. edited by the Hungarian Geological Survey. Fundamental geological descriptions were recorded by J. BÖCKH [1876] and E. VADÁSZ [1935, 1953, 1960]. From the beginning of the last two decades A. BARABÁS and his coworkers have performed essential work first of all in respect to Permian of South-East Transdanubia.

Apart from several outcrops near Ófalu and Pécs, the Old Paleozoic rocks are covered by younger formations and they are studied mainly by deep drillings. Contrasting with Late Paleozoic, these rocks — according to present-day knowledge — do not contain ore minerals in remarkable quantity. Exploration of them could be regarded as random-like events (geophysical controll drillings and several oil prospecting wells drilled into several Upper Pannonian anticlines) giving isolated and uncertain data. So the geological examination, correlation and exact interpretation being in an initial stage all over the Transdanubia. There is only a comprehensive interpretation of Old Paleozoic in relation with Precambrian crystalline basement on one hand [B. JANTSKY, 1974] and stratigraphic, petrographic and geochemical evaluation [T. SZEDERKÉNYI, 1962, 1970, 1974] as a part of monographic elaboration, on the other hand.

Stratigraphy and chronology of Paleozoic formations were determined on the basis of different geological considerations without acceptable fossils. The stratigraphy is mostly lithostratigraphy with a fairly good accuracy in the South–East Transdanubian Paleozoic. The situation in this respect is much more unmaintainable in the Paleozoic of the area between Balaton lake and Mecsek Mts. Apart from few exceptions, the age of the groundfloor in this area — explored several boreholes — sometimes variously modified. E.g. Igal limestone affected a powerful alteration because of Helvetian and Tortonian volcanism (in the neighbourhood) it was in the first time described as Old Paleozoic, then changed into Carboniferous, lastly it is regarded as an Anisian limestone. Or limestone Karád–1 deep drilling, where — according to original documents — the Upper Carboniferous age was detected only in fragments of Miocene breccia. In spite of this fact the Hungarian geological literature is full of references to this Upper Carboniferous, moreover this datum is the cardinal point some paleogeographic and tectonic ideas referring to the Upper Carboniferous era.

It is an unfortunate fact that fundamental establishments, research conceptions, important paleogeographic conclusions as well as industrial investigations based on defective or uncertain data were born. After some unsuccessfulnesses it has arisen the necessity of a general revision connected with Old Paleozoic of South Transdanubia, mainly on demand of the petroleum and ore mining. This revision-work is in progress. Consequently this paper throws some lights on the geological evolution of the region in accordances with the new developed results and news.

Many of the data collected are not yet available in published form, being either uranium and oil company files and other places or awaiting publication, so that some of the opinions expressed here, may be modified in future.

GROUNDFLOOR OF PALEOZOIC OF SOUTH TRANSDANUBIA

(A review)

Crystalline rocks give the bedrock for Paleozoic or younger formations of South Transdanubia. They can be divided into two parts: metamorphites and granitoids. The latter occupies an elongated zone within metamorphites striking Northeast, from Szigetvár up to the centre of Great Hungarian Plain. This trend is generally characteristic in the Pannonian Mass except the metamorphic basement of Drava Basin where Northwest trend prevailes without granitoids [T. SZEDERKÉNYI, 1974]. The metamorphism is dated on Early Proterozoic due to the effect of Gottidic Orogeny and the age of granitisation assumed to be Late Proterozoic by B. JANTSKY [1974]. Without counterproof we accept this idea and found our Old Paleozoic classification on this statement.

EVENTS OF CALEDONIAN TECTONIC UNIT

There is no proof to the existence of Cambrian and Ordovician rocks on South Transdanubia. At present the oldest known Paleozoic formation is located Northeast Mecsek Mts. near Szalatnak, aged Silurian based on several badly preserved fossils [J. ORAVECZ, 1964]. It is possible that the unexplored introductory part of this group can be placed to Ordovician [K. BALOGH, 1974].

1. *Szalatnak Siliceous Shale Formation*

It is extended to about 300 km^2 area in Northeast Mecsek Mts. between Szekszárd and Dombóvár *(Fig. 1)* covered by Lower Triassic, Miocene or Upper Pannonian deposits. In the centre of this area the Formation was explored by six boreholes which produced a strongly folded sequence with tripartition which can be studied best of all in Szalatnak-3 borehole. Classification of the Formation:

a) *Upper Siliceous Shale Member.* Dark grey, sometimes black coloured siliceous shale beds alternating with light grey tuffite streaks of about 110 m thickness. On the uppermost part about 20 m thick reddish brown Premesozoic oxidation zone can be found.

b) *Agglomerate Member.* It consist mainly of diabase, andesite, porphyrite, diorite and granodiorite as well as metasandstone fragments embedded in dark grey coloured coarse grained tuffaceous sandstone matrix. It measures about 80 m thickness. The boundaries of the Member are not sharp.

c) *Lower Siliceous Shale Member.* Lithologically it is similar to the Upper Siliceous Shale Member. Certain difference can be observed between two units apart from stratigraphical position of theirs, namely a weak metamorphism in the lower member containing prehnite. The weak metamorphism with prehnite may be regarded as not a Barrow type, but it requires further studies.

Some badly preserved fossils were recorded in the black shale bands in the middle zone of the Member: e.g. *Monograptus* sp., *Hystricosphaeridae*, *Girvanella* and algae by J. ORAVECZ [1964] and M. SIDÓ [1969]. The Lower

Siliceous Shale Member measures about 205 m thickness in Szalatnak-3 borehole.

Precambrian granodiorite-like rock with large K-feldspar phenocrysts underlies the lowermost part of Szalatnak sequence [Gy. WEIN, 1966; GY. BUDA, 1972]. The age of the rock based on radioactive age determination (1100 m.y. by Á. KOVÁCH, [1967] but later it was rejuvenated). According to other authors a narrow contact zone is hidden by strongly fractured rocks between shales and underlying granitoids disturbed by diabasic sills of uncertain age [K. VÁRSZEGI, 1971; B. JANTSKY, 1974]. These authors changed the Precambrian age of the crystalline rocks into Carboniferous in general, and the granodiorite-like rock is considered as being a subvolcanic syenite-porphyr body (laccolite). On the basis of geological point of view, the latter opinion is not fully accepted because of the lack of decisive proofs. Regarding the first opinion of Precambrian age — in spite of more probability of its — it also requires further supports. A new borehole near Szalatnak-3 may gives realistic informations about the lowermost part of the Szalatnak sequence and it could solve the age problems of the Szalatnak Premesozoic formations.

2. *Ófalu Phyllitoide Group*

During the earliest manifestation of Variscan Orogeny an Old-Paleozoic metamorphic belt had wedged along the main axis of the granite range with more than 80 km length and 2–5 km width. Due to a considerable transcurrent faulting the wedged rocks as well as a narrow zone of the country rocks suffered a metamorphism and mylonitisation. The schistosity planes are generally parallel with the bedding planes; — the latter dips are about 330°/54°–80°.

The rocks of the Group are generally covered by Miocene and/or Upper Pannonian deposits except surroundings of Ófalu village (Eastern Mecsek Mts.) where they are outcroping in 5 km in length.

The Ófalu Phyllitoide Group under consideration represented originally a nearly complete single large depositional cycle with basic and ultrabasic volcanics. It can be divided into two formations based on development of theirs:

a) *Goldgrund Formation* can be found along the Goldgrund valley and in Eastern part of the Group. From NW to SE direction it consists of at least four members: a spilite-like metavolcanite, a phyllite an amphibolite and a marble one. M. A. E. GHANEM, L. BARANYAI [1969] were the first interpreters of this volcanism. The members of this Formation have not sharp boundaries between them but there are transitional zones in wich the beds of neighbouring members alternate with each-other. Several beds of some members occur each part of the Formation: e.g. tuff streaks (which in large quantities form the phyllite member) can be found as intercalations in all of members. The phyllite member contains yet great number of metagreywacke beds with characteristic siliceous matrix and appreciable K-feldspar content originated by a later K-metasomatism. The thickness of the Formation reaches 1300 m.

b) *Gründl Formation* forms the NW part of Ófalu Phyllitoide Group and named by Gründl valley in Western section of the investigated area. It measures of more than 200 m thickness, but the covered part of the Formation is possible larger. It consists mainly of basic metavolcanites and associated metasomatites. As a matter of fact, the members of this Formation are

particularly metasomatized metabasalts and mica schists according to M. GHONEIM'S observations.

The Ófalu Phyllitoide Group did not contain any fossils. Based on development and volcanic and metamorphic characters of its it can be dated into (Ordovician)–Silurian period. Based on common lithologic and volcanic character of this Group it seems to be identical with Szalatnak Siliceous Shale Formation and Diabase-Phyllitoide Formation of Balkan Mts. No contradicts of this state the almandine-amphibolite facies of Ófalu Phyllitoide Group as a highest metamorphic degree. The eugeosyncline origin of this Group is assumed by GHANEM–RAVASZ [1969].

3. *Western Mecsek Ultrabasite-Serpentinite Formation*

It consists of two elongated rock bodies of 5 km length and 0.8 km width, enclosed into Precambrian crystalline basement and covered by Permian and Upper Pannonian deposits. Fundamental description of the Formation carried out by T. SZEDERKÉNYI [1962, 1970, 1974].

a) *Helesfa serpentinites and associated rocks* are wedged into the axis of Western Mecsek Permian—Triassic brachianticline (deformed during Upper Cretaceous) in fairly perpendicular position enclosed by strongly sheared porphyroblastic granite (really "augen" mylonite). The latter belonged to the Mecsek Granite Formation. The Western part of this complex is covered by Upper Pannonian sandy deposits of about 100 m thickness, and the Eastern part by undisturbed Lower Permian red sandstones and conglomerates. According to geophysical data and results of two deep drillings, the serpentinite and associated metasomatites settled down as a diapir within a wide gap of the granite, uplifted the covering Upper Pannonian deposits and rolled out the granite country rocks.
Chemical and mineralogical composition of the serpentinite mass shows a rather homogeneous distribution within the body, apart from marginal parts of its which are framed by talc schist selwages. The parent rock of the serpentinite mass was first of all pyroxenite which transformed to serpentinite by shearing, produced lizardite and clinochrysotile composition [J. ERDÉLYI, 1971]. Microstructure of the rock is generally very strongly deformed "mesh" one.

b) *Gyód pyroxenite and associated metasomatites* are settled down in Barrow type metamorphites belonging to the foreground of Western Mecsek Mts. covered by 65 m thick Upper Pannonian conglomerates and sands. Dimension of the rock-mass are almost the same as Helesfa one has, and the position of it is perfectly perpendicular and parallel with the schistosity of Görcsöny metamorphites and it can be regarded as a neck. The main part of the body consists of pyroxenite and weakly serpentinized pyroxenite and serpentinite with laminar texture in all of them, due to lineation of the large clinopyroxenite crystalls oriented to boundaries of the rock body.
According to X-ray investigations, the composition of the pyroxenite are predominantly clinoenstatite and a smaller quantity of olivine, basic plagioclase and magnetite-chromite. The serpentinite consists of lizardite and a small amount of clinochrysotile as well as magnetite [J. ERDÉLYI, 1971]. The microstructure of the serpentinized rocks exhibits an undisturbed "mesh" structure without traces of any shearing or cataclasis. Consequently

it can not be expected diapiric or other type movements within the pyroxenite-serpentinite body.

Three types of altered ultramafic rock-bodies can be distinguished on South Transdanubia: serpentinite diapir at Helesfa, pyroxenite-serpentinite neck near Gyód and serpentinized ultrabasic sill (or lava flow) within Ófalu Phyllitoide Group. This ultrabasic volcanism seems to be of the same age, but in absence of radiometric age determination it can be only presumably placed into Silurian period. The age of the serpentinization can be expected to a very long era from the beginning of the last volcanic events up to present-day at Gyód, but it probably had finished in the Late Paleozoic at Helesfa and Ófalu.

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It seems that our knowledge about Old-Paleozoic of South Transdanubia is first of all restricted to the area of Sout–East Transdanubia, due to industrial (oil, coal and uranium) prospectings. The groundfloor of other parts of the region is covered by rather thick (2000–3000 m) Neogene deposits and therefore is largely unexplored. In the Drava Basin there are scattered data origined from oil prospecting boreholes proving a Barrow type metamorphic basement which sporadically is covered by Upper Carboniferous grey sandstones.

On the Northern side of the so called "Zágráb–Kulcs Lineament" [GY. WEIN, 1967] between Mecsek Mts. and Balaton lake we have unique uncertain occurrence of a slightly metamorphosed grey slate and limestone (Öreglak–1 drilling) which seems to be similar to the adequate members of Ófalu Phyllitoide Group. There are no fossils or else evidences to the real age of these rocks.

EVENTS OF VARISCAN TECTONIC UNIT

1. *Paleohercynian events*

Betveen Silurian and Upper Carboniferous there is no proof of existence of Devonian and Lower Carboniferous rocks in the basement of South Transdanubia, although near Szabadbattyán — in suggesting proximity of the region — can be found a Devonian crystalline limestone occurrence thrusting over the Visean shales and limestones [K. BALOGH, 1974]. It presumably is due to a powerful uplift and fracturing of the region accompanied by hypabissal magmatism produced microgranite and aplite weins as well as K-metasomatism in the older formations. Based on the large hyatus during the period of Early Hercynian movements, it can be assumed that the South Transdanubian region belonged to the "Red Continent". But in the depht very important events had been taking place. The area of Precambrian granites and related metamorphic rocks had suffered the first manifestations of Early Variscan movements (Breton phase) simultaneously with uplift, namely the before-mentioned wedging of Old-Paleozoic overlying rocks to the granite mass and large transcurrent faulting. These events were followed by a second granitization process which produced extremly acidic microgranite and aplite veins (Sudetic phase) intruded mainly to the wedged rocks of Ófalu Phyllitoide Group and Western Mecsek Ultrabasite-Serpentinite Formation.

Southward of the Balaton lake (in 10 km distance) there is another important appearance of the Lower Carboniferous phenomena. A narrow (about 3–4 km width) granite zone — covered by Neogene and Mesozoic rocks, explored a few

deep drillings — runs parallel with the Balaton lake and Mecsek Granite Formation. This granite belt extends to Velence Mts. and the Western border of Hungary. However, opposite to Precambrian granites it form intrusion similar to Velence Mts. granite mass [B. JANTSKY, 1974]. The age of the intrusion is placed to Sudetic phase of Hercynian Orogeny based on radioactive age determinations. The range of this narrow granite belt and the belonged country rocks form the core and axis of a long anticline structure which separates the area of South Transdanubia from Transdanubian Middle Mountains (Bakony etc.).

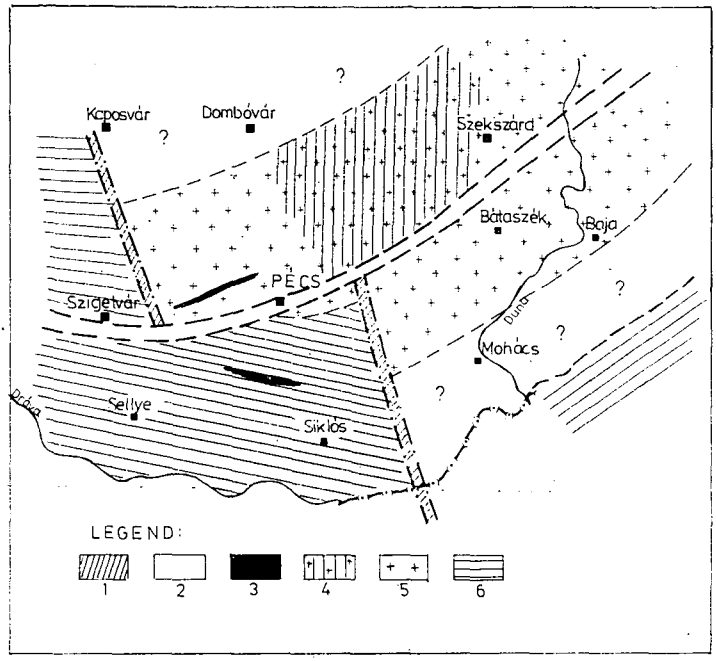

Fig. 1. Geological-tectonic sketch of South-East Transdanubia at the beginning of Late Paleozoic, by T. SZEDERKÉNYI, 1970. Legend: *1.* Precambrian(?) tectonic belt. *2.* Bretonian tectonic belt. *3.* Ultramafic rocks (volcanic vents). *4.* Silurian rocks underlying with granites. *5.* Granites, migmatites. *6.* Crystalline schists with effective strikes.

On the interanticlinal area (between Carboniferous and Precambrian granite range) a connecting link between Paleozoic sequences of Bükk Mts. and Dinaric region by so called "Igal trough" is imagined. There is no aim of this paper to discuss of this conception, but it should also be noted that it is based upon an unique uncertain datum of Karád–1 borehole. By all means the theoretical possibility of Lower Carboniferous sedimentation on the interanticlinal area and the existence of a Paleohercynian trough were rather improbable.

The *Fig. 1* illustrates a tectonic sketch map of South–East Transdanubia at the beginning of the Late Paleozoic after the effect of very first Variscan movements (transcurrent faulting). This aspect is characteristic of all South Transdanubia in this time and shows the connection between Pannonian Mass and a marginal portion of the crystalline basement of Dinaric Geosyncline. The Western part of the map

shows a NW–SE striking belonging to Dinaric type and the Eastern one with SW–NE strikes to the Pannonian type. The northernmost extension of Dinaric structural characteristics can be supposed up to the above-mentioned Lower Carboniferous intrusive granite range.

2. *Neohercynian events*

In contrast to the aforesaid Caledonian and Paleohercynian events, the Neohercynian ones are much more particularly investigated and elaborated, first of all in South–East Transdanubia due to uranium prospecting. There are satisfactory publications available concerning not only Permian of Mecsek Mts. but all over the Hungary. Therefore this chapter of the paper deals with the summary of different interpretations and tries to give some criticism about them in respect to the paleogeography.

It is a well known fact that there is a large scale — at least 4000 m thick — continental series in Mecsek and Villány Mts. put in Upper Carboniferous and Permian period. The study of idealized rock column *(Fig. 2)* reveals some impor-

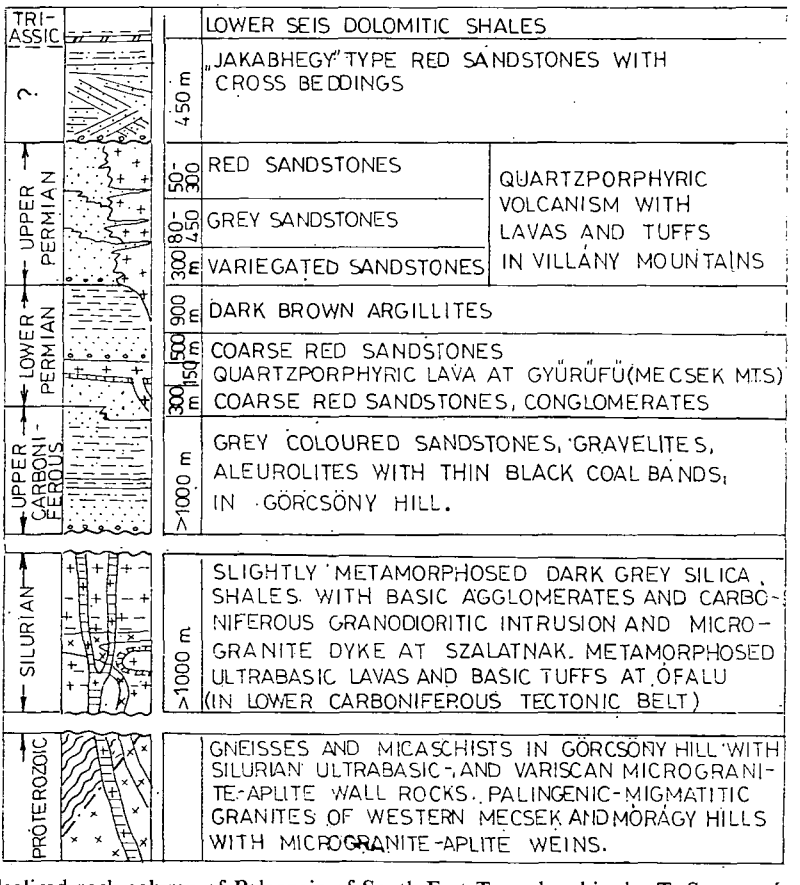

Fig. 2. Idealized rock-column of Paleozoic of South-East Transdanubia, by T. SZEDERKÉNYI, 1974

tant differences between Late Paleozoic of Mecsek and Villány Mts. First of all — according to present-day knowledge — the Carboniferous formation is missing from the sequence of the Mecsek Mts. and is lacking the Upper Permian quartz-porphyric volcanism in the Mecsek Mts. etc. Moreover lateral alterations of thicknesses of the Upper Permian members show a fairly big possibility of error in prediction to a larger distance. In spite of very big density of the data there are controversies about transport directions of the Upper Permian deposits: e.g. based on crossbedding evaluation, those can be originated from NW direction [J. SZABÓ, 1962], but according to the well-founded measurement on lateral alterations of the grain-size, — from the East [M. KASSAI, 1972]. It was not by chance of the first paleogeographic experiment — extended to all of Western Hungary — based on tectonic consideration referring to the Upper Carboniferous and Permian together starting from effectively observed and calculated data [M. KASSAI, 1970, 1972]. At first let us see the palaeogeographic sketch of Upper Permian of South-East Transdanubia by M. KASSAI [1970] *(Fig. 3)*. The estimated area can be divided into two parts by a large fracture zone showing marked NW–SE main directions; this is the so called "Villány–Szalatnak Deep Fracture Zone which is partly coincides

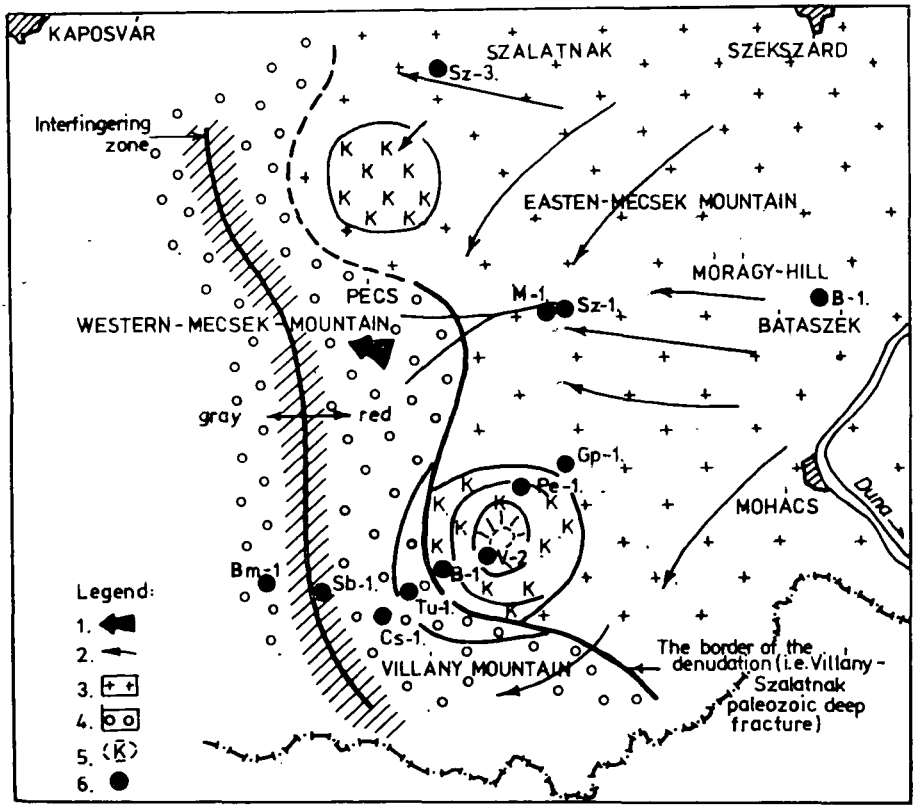

Fig. 3. A palaeogeographic sketch about Upper Permian, South-East Transdanubia by M. KASSAI, [1970]. Legend: *1.* Direction of sediment transport by statistical analysis. *2.* Main direction of deposit-movement on the denudation area. *3.* Denudation area. *4.* Trough. *5.* Quartz-porphyr volcanoes. *6.* Deep drilling.

with the dividing Precambrian (?) tectonic belt between Görcsöny metamorphites and Eastern Mecsek granites (see *Fig. 1*). On the Western side of the deep fracture zone there was a trough filled up with Upper Carboniferous and Permian deposits, and a denudation area on the opposite side with deposit-production for the trough. In the author's interpretation of this sketch, the border between basin and denudation area corresponds to the above-mentioned deep fracture zone, lived during Upper Carboniferous and Permian period, stamped by powerful quartz-porphyric volcanism in the Upper Permian. The lateral distribution of the grain-size and occurrence of an important interfingering zone in the Upper Permian sandstones, show an acceptability of this palaeogeographic picture, nevertheless it would be necessary to confirm it on a few cardinal places. M. KASSAI, [1972] considers this palaeogeographic model valid of Transdanubia in general, and he presents some very thought-provoking proofs to support his conception (see *Fig. 4*). The cardinal place to verify the validity of this idea is the area of supposed "Igal trough".

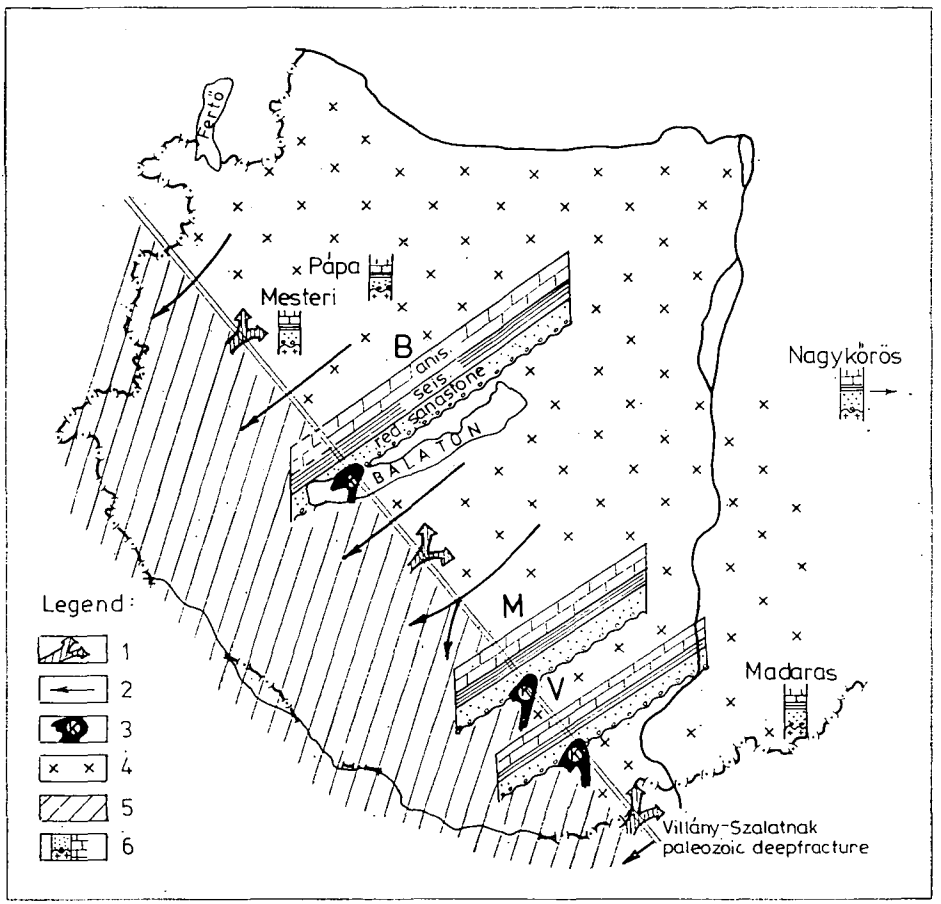

Fig. 4. A palaeogeographic sketch about at the end of Upper Permian of Transdanubia with some typical Lower Triassic profiles, — by M. KASSAI [1972]. Legend: *1.* Direction of Triassic transgression. *2.* Direction of sediment-movement at the end of Upper Permian. *3.* Quartz-porphyric volcanism (Permian). *4.* Area of denudation until end of Upper Permian with crystalline basement. *5.* Upper Permian — Permian trough. *6.* Deep borings.

In the introductory part of this paper the unacceptability of Karád–1 deep drilling was mentioned. The explored and examined rock-material does not belong to the basement. From the debris the Upper Carboniferous age was determined by L. MAJZON, [1966] based on foraminiferas. Apart from the unsuited rock samples of Karád–1 deep drilling, there is a serious failure concerning Upper Carboniferous microfauna of Hungary. Because of more and more species turning into precarious, it is necessary to re-evaluate the Hungarian Paleozoic microfauna. It is easy to see that first of all one ought to make order among obscure originated or misinterpreted data. After all one ought to drill a few boreholes on the cardinal points of the "Igal trough", because this is the key of both hypotheses.

A general sinking had taken place at the end of Permian period all over Hungary producing a typical crossbedded red sandstone formation (except Bükk Mts.) with ground conglomerate overlying the Paleozoic rocks, or crystalline basement. In diastrophic view this is the introductory formation of the Mesozoic sequence of Hungary. In spite of this general statement there are serious correlation problems between red sandstone of Balaton Highland and Mecsek Mts. which are waiting for a satisfying answer.

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