Acta Mineralogica-Petrographica, Szeged, XXXVII, 143–160, 1996

Project No. 276
Paleozoic geodynamic domains and their alpidic evolution in the Tethys

METAMORPHIC FORMATIONS AND THEIR CORRELATION IN THE HUNGARIAN PART OF TISIA MEGAUNIT (TISIA COMPOSITE TERRANE)

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ABSTRACT

Theory of Tisia as an isolated and rigid median-mass located into the inner region of Pannonian Basin originated from PRINZ (1914). After 65 years rise this idea partly defeated partly transformed. Nowadays the Tisia Megaunit is regarded as lihosphere fragment broken off the southern margin of Variscan Europe during the Jurassic (Bath) and after a compilated drifting and rotation it occupied the present tectonic position in the Miocene giving the basement complex – of East Slavonia (Croatia) – South Hungary–North Vojvodina (Yugoslavia) and West Transylvania (Romania). Crystallines and covering Late Paleozoic and Mesozoic overstep sequences show a rarely uniform lithology, lithostratigraphy and geological evolution. On the basis of these features both Pre-Mesozoic as well as Mesozoic sequences are ranged into numerous terranes and subterranes. Each one has tectonically determined boundaries and characteristic lithological-lithostratigraphic content and evolution.

The crystalline mass of Hungarian section of Tisia Megaunit is subdivided into three terranes and eight subterranes. All are represented by the same amount of lithostratigraphic units. This lithostratigraphic classification can be regarded as an experimental model which is reasonably suitable for correlation within the Megaunit and in all probablity it fulfils our expectations in the correlation with Variscan Europe.

INTRODUCTION

The first ideas of so-called "median mass" of the Carpathian system arose at the beginning of this century in the Hungarian (Austro-Hungarian) geology. Common feature of these hypotheses is assumption of an old /Paleozoic or older/ and rigid crystalline mass with "boot-stretcher" role; i.e. after an ancient mountain period and following breaking up and sinking, this mass is served as a core for uplifting of the Carpathians which practically surrounds and adheres it (PRINZ 1914, 1926; LÓCZY sen. 1918; KOBER 1921). This idea had obliged to suffer hard criticism from the birth until prevailing of up-to-date plate tectonic interpretations (SZEDERKÉNYI 1984), but it has not extincted perfectly until today. Its re-interpreted and refreshed variety incorporated the present evolutional picture of Alpine-Carpathian system.

What is the Tisia Megaunit today? A fragment which broke off the southern margin of Variscan Europe during the Jurassic and after a complicated drifting and rotation it occupied the present tectonic position in the Miocene, giving the basement formations of East Slavonia (Croatia), South Transdanubia (Hungary) and southern part of Great Plain

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(Hungary and Vojvodina) as well as West Transylvania /SZEDERKÉNYI 1974, 1984; KOVÁCS 1982, FÜLÖP 1994; KOVÁCS et al. 1996/.

TISIA MEGAUNIT AS A COMPOSITE TERRANE

Terrane is a crust-fragment (block) bordered by considerable fractures, lineaments or accretional complexes or (krypto) sutures. It is characterised by diverse evolution which differs from that of adjacent block(s) and based upon non-horizontal lithofacial changes, as well as stratigrapic-, paleontolological-, structural-, deformational-, e.t.c. inner continuity (after KEPPIE and DALLMEYER 1990 with a little modification). This principle offered basis for the Pre-Tertiary basement of Hungary to range into a terrane system (KOVÁCS et al. 1996) which was realised upon the following evoloutional background (FÜLÖP et al. 1987).

– Pre-Alpine (Pre-Variscan and Variscan) tectono-cycle
– Alpine (Tethyan) "geosynclinal" cycle
– Paleo-Alpine (Cretaceous) nappe movements
– Meso-Alpine (Paleogene-Early Miocene) strike-slip faulting
– Neo-Alpine (from Middle Miocene up to recent time) cycle with the formation of Pannonian Basin.

It is evident that the crystalline mass as a part of Variscan Europe formed during Carboniferous by accretion of earlier lithosphere-fragments (terranes and composite terranes) and broke up by Penninic rifting (Bath stage) and after a complicated drifting and rotation it joined to the Alpine Europe (BALLA 1986). Hence "Tisia Composite Terrane" designation terminologically refers to the Pre-Late Carboniferous (crystalline) mass only, while the " Tisia Terrane" name belongs to the Alpine stage of the Megaunit. The latter is bordered by Mid-Hungarian lineament (Zagreb-Kulcs line, WEIN 1969) as well as Save Moslavina -Sombor-Becej-Lipova lineament and Somes fracture zone.

Pre-Alpine terranes and sub-terranes of Tisia Composite Terrane (Tisia Megaunit) are as follows: *(Fig. 1.)*

Drava Terrane
- Babócsa Sub-terrane
- Baksa Sub-terrane

"Para-Autochton" Terrane
- Mecsek-North Plain Sub-terrane
- Middle Plain Sub-Terrane

Szeged-Békés-(Codru) Terrane
- Kelebia Sub-Terrane
- Tisza Sub-terrane
- Battonya Sub-terrane
- Sarkadkeresztúr Sub-terrane

"Outliers" (wedges, nappe-vrecks and remnants)
- Horváthertelend Unit (terrane)
- Szalatnak-Unit (terrane)
- Ófalu - Unit (terrane)
- Tázlár- Unit (terrane)
- Álmosd Unit (terrane)

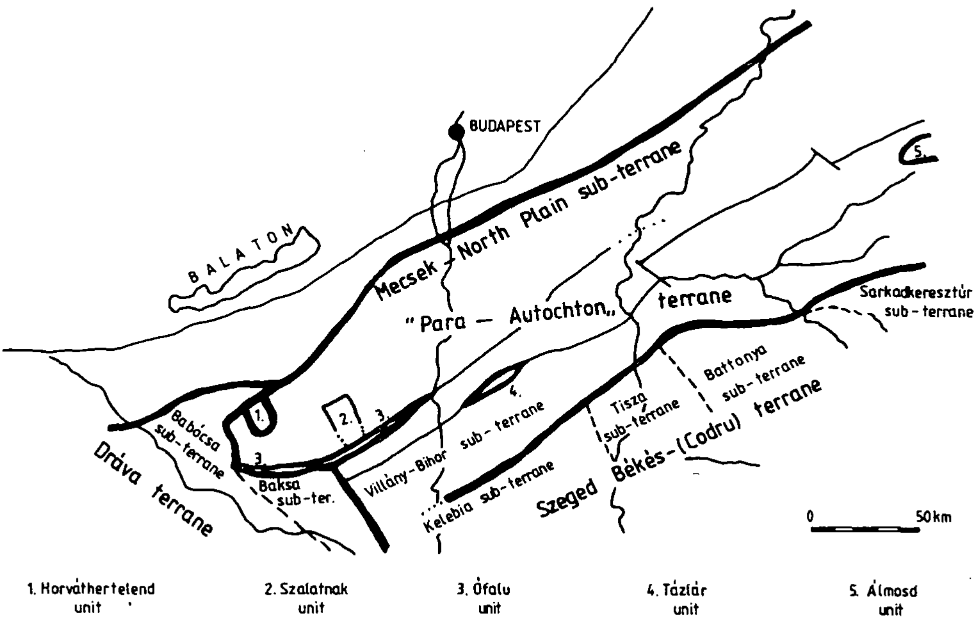

Fig. 1. Areal extension of units of Tisia Composite Terrane in Hungary.

As it appears from this list, besides terranes and sub-terranes several small units (nappe remnants, wedged bodies of larger tectonic zones) are also found in the Tisia Composite Terrane which show perfectly else lithological and metamorphic features. Really, they can also be regarded as terranes.

All terranes and sub-terranes have tectonically well-determined extensions and boundaries as well as characteristic lithostratigraphic columns and evolution. An acceptable lithostratigraphic classification of metamorphic bodies can be realised only if data with sufficient quality and quantity are available for the fulfilment of the following four requirements: (1) data for proving of pre-metamorphic rock-quality and facial characters, (2) data for determination of types and intensity of the metamorphic events, (3) data for the giving of succession of deformational events and their timing, (4) data for marking out of terranes and their subdivisions.

PROTOLITHS OF CRYSTALLINES OF TISIA COMPOSITE TERRANE

Protolith analysis was carried mainly out by geochemical methods using elements which retained their concentrations and ratios during the metamorphic process and metamorphic reactions had taken place more or less on isochemical way.

Prevailing rock association of Tisia crystallines is gneiss and mica-schist as well as related anatectic granitoids which derived mostly from greywacke-pelitic type sedimentary sequences (SZEDERKÉNYI 1984. *Fig 2)* with several m.-s thick mafic lava and/or tuff intercalations. These latter show tholeiitic basalt and tuff character in general (SZEDERKÉNYI 1983). Based on new geochemical data and up-to-date discriminating

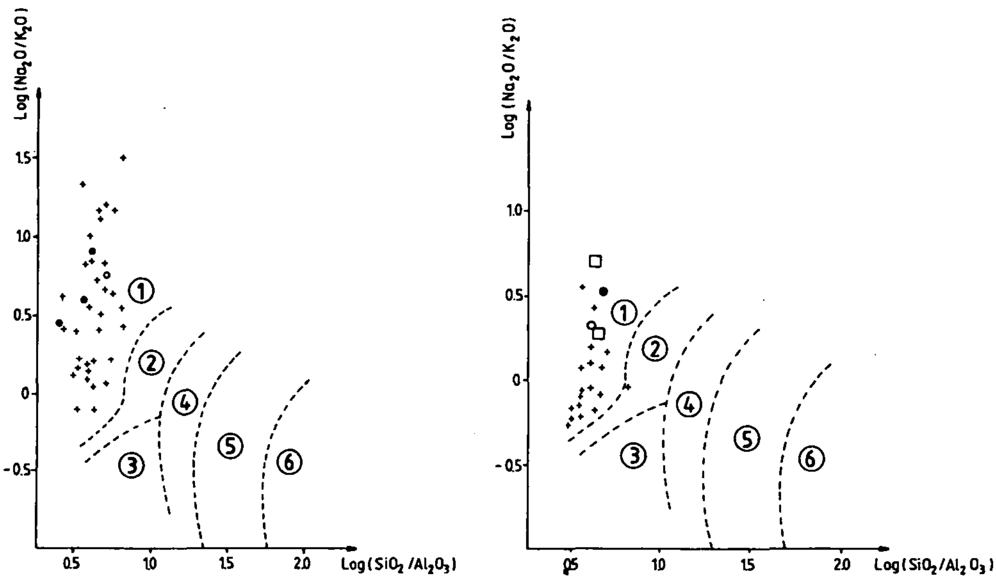

Fig.2. PETTIJOHN-POTTER-SIEVER (1972) diagram from the gneisses and micashists of Great Plain. Legend: 1. greywacke, 2. sub-greywacke, 3. arcose, 4. sub-arcose, 5. aleurolite, 6. Shale
Symbols represents different occurrence from every part of Great Plain.

methods these volcanics represent bac-arc basin tholeiite (T-MORB) origin (M. TÓTH 1995). In the rock-columns of South Transdanube and southern part of Great Plain some acidic tuff intercalations also occur showing a presumptive continental margin volcanic effect, too. Baksa-, as well as Tisza Sub-terranes also contain several m.-s thick carbonatic (marl, limestone, dolomite marl, dolomite) layers interbedding the psammitic-pelitic sediment column. No signs in any other terranes or sub-terranes are available of the existence of carbonatic layers or lenses.

METAMORPHISM

Apart from several "outliers" (nappe-vrecks and tectonic wedges) the metamorphic process comprised one or more progressive and several retrograde phases developed on the backgroud of single or sometimes two tectono-metamorphic characters of Tisia metamorphics plotted by *Fig.3*. Three characteristic fields are separated on the Miyashiro diagram: (1) High- pressure, approximately low-temperature metamorphism having P= 9,5-12 Kb. pressures and 12 °C/km thermal gradients. It settled in a few smaller covered occurrences extending along half-way line of "Para-autochton" Terrane (RAVASZ-BARANYAI 1969; M.TÓTH 1995). (2) Metamorphism characterised by medium-pressure and temperature (Barrow-type) deformation showing P= 4-6,5 Kb pressures and 24-27°C/km thermal gradients. This type is predominant in the "Para-autochton" Terrane but it can be detected on the whole area of Tisia Composite Terrane. (3) Low-pressure and high-temperature metamorphism characterised by P=2-3 Kb pressures and 70°C/km

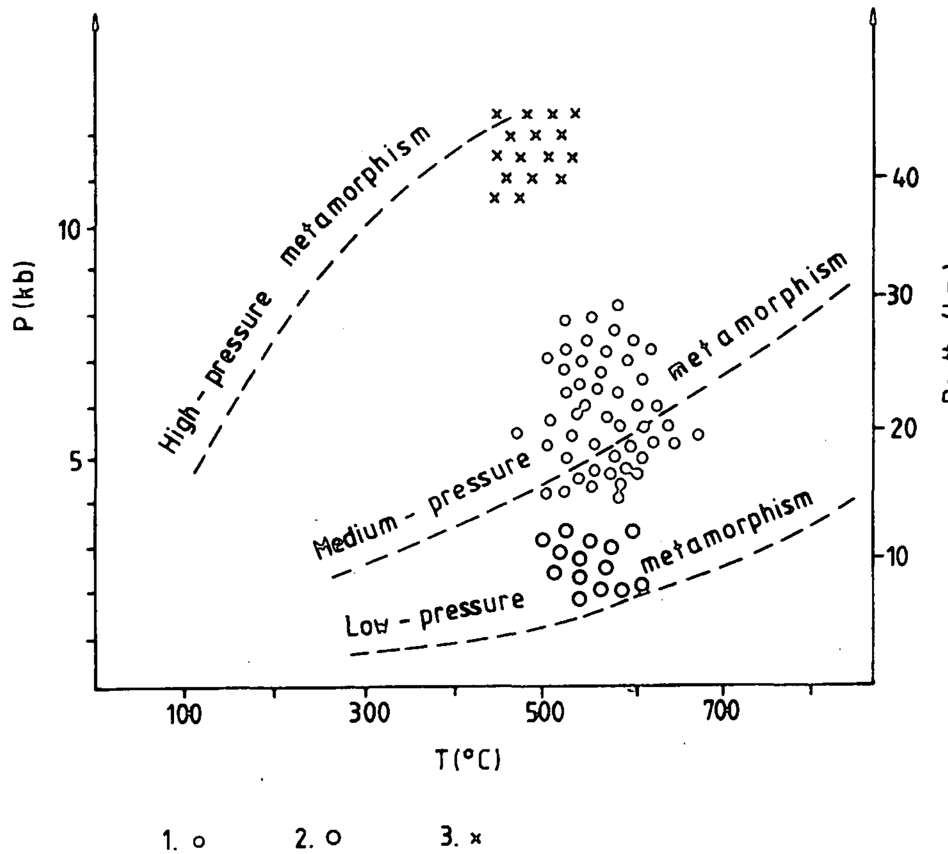

Fig.3. Pressure and temperature character of crystalline mass of Tisia Composite Terrane. Legend: /1/ Barrow-type crystalline schists, /2/. andalusite-bearing crystalline schists. /3/ high-pressure-low temperature eclogites.

thermal gradients overprinting the Barow-type metamorphic mass in the southern section of Tisia Composite Terrane {Drava Terrane and Szeged-Békés-(Codru) Terrane}.

A complete sequence of polymetamorphic deformations is shown by *Fig.4.* together with its every phasis, as follows:

1. This phasis of the polymetamorphism is corresponding to the previously-mentioned deformation No.1. on the Fig.3. which is detected about in a 10 Km-s wide zone located into the axial part of "Para-autochton" Terrane running near Szeghalom-Szarvas-Szank-Ófalu-Gyód traverse. It is represented by obduced ultramafic small bodies (SZEDERKÉNYI 1974; GHONEIM and SZEDERKÉNYI 1979; BALLA 1983) and low-temperature eclogites, amphibolites (RAVASZ-BARANYAI 1969; M.TÓTH 1995). This zone is assumed as a Pre-Variscan suture representing 400-440 Ma Rb/Sr ages (KOVÁCS et al. 1985).

2. Medium-pressure and temperature Barrow-type progressive metamorphic event corresponding to deformation No.2. in the Miyashiro diagram *(Fig. 3.)* as the very-first

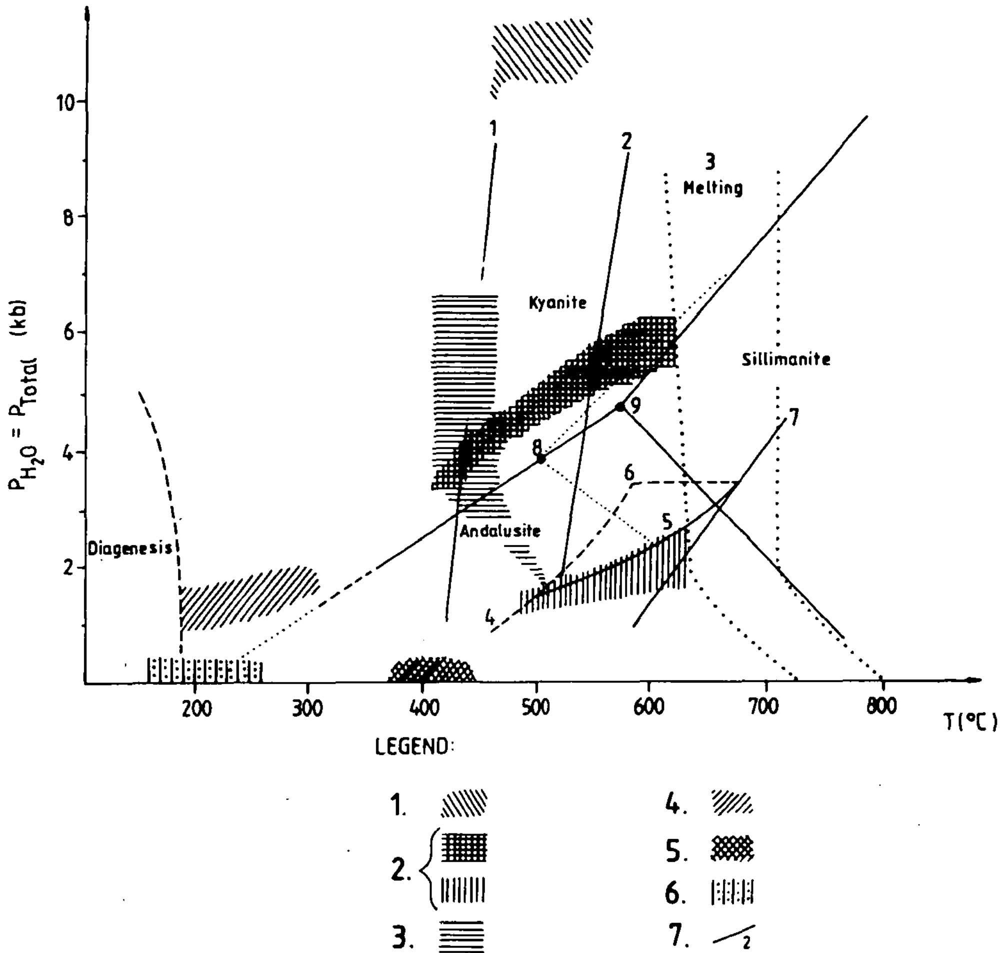

Fig.4. P-T diagram of metamorphic events of Tisia Composite Terrane. Legend: /1/ Pre-Variscan(?) high P.-metamorphism /2/ Variscan Barrow-type and high-T metamorphism, /3/ Variscan blastomylonitization, /4/ Alpine regional retrogression, /5/ Upper-Cretaceous contact metamorphism (Banatite), /6/ Lower Permian hydrothermal metasomatism (rhyolite), /7/ phasis boundaries of important mineral reactions, as follows: 1. stilpmomelane+muscovite out, biotite+muscovite in, 2. staurolite in, 3. melting, 4. chloritoide+quartz=Fe-cordierite+sillimanite $+H_2O$, 7. muscovite+quartz= Orthoclase+Al_2SiO_5+H_2O, 8. Al_2SiO_5 triple-point by Holdaway, 9. Al_2SiO_5 triple-point by Greenwood.

manifestation of Variscan metamorphism and at the same time it is the most powerful deformation in the metamorphic history of Tisia Composite Terrane characterised by 350-330 Ma Rb/Sr and K/Ar ages (KOVÁCH et al. 1985; SVINGOR and KOVÁCH 1981; BALOGH KAD. and ÁRVA-SÓS 1983).

3. Blastomylonitization and following low-pressure and high temperature event occurred in the metamorphics of southern part of Tisia Megaunit with 330-270 Ma Sr/Rb and K/Ar ages (SVINGOR and KOVÁCH 1981; KOVÁCH et al. 1985; BALOGH KAD. and ÁRVA-SÓS 1983/. It corresponds to deformation No. 3. in the Miyashiro diagram (*Fig.3.*).

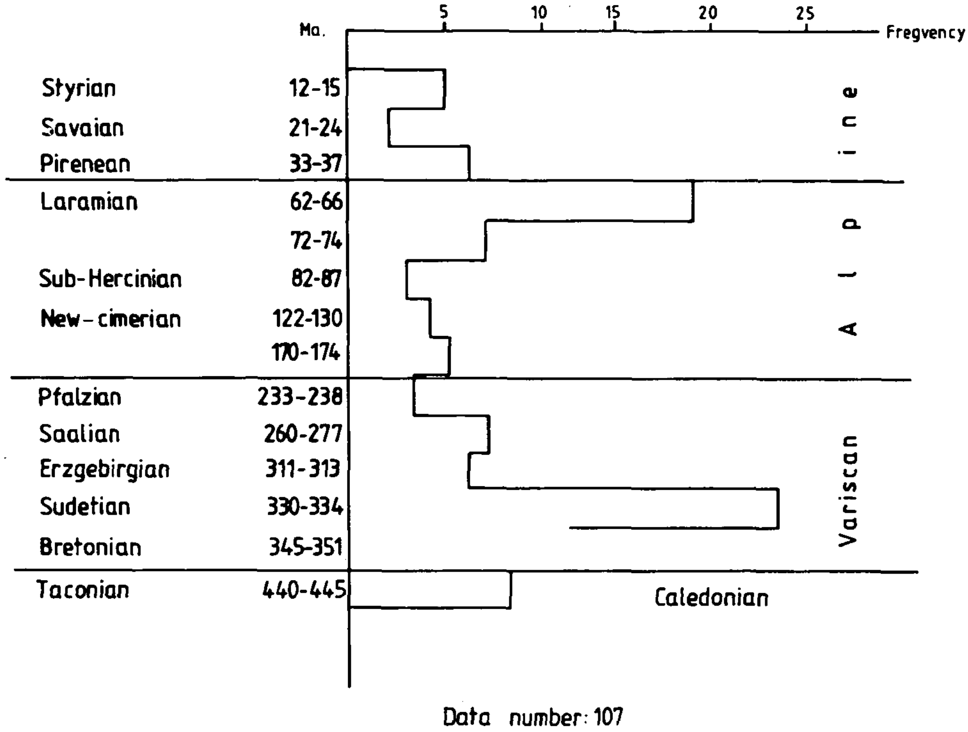

Fig.5. Frequency of isotopic ages of crystallines of Tisia Composite Terrane (SZEDERKÉNYI et al. 1991)

4. Pre-Upper Cretaceous retrogression succeed to Mesozoic in general due to the tensional tectonism.

5. Thermal /contact/ metamorphism concerning Late Cretaceous banatite intrusions found in the Szeged-Békés-(Codru)Terrane and characterised by 75-64 Ma (SZEDERKÉNYI 1984), (BALOGH KAD. and ÁRVA-SÓS 1983).

6. Hydrothermal metasomatism belonging to Lower Permian-Lower Pannonian subvolcanic-volcanic events found in the whole area of Tisia Composite Terrane.

This succession of metamorphic phases is also proved by the frequency diagram of absolute ages *(Fig. 5).*

ROCK-TYPES AND ASSOCIATIONS

Due to the above-mentioned deformation system, rocks of the pre-metamorphic idealised rock-column /reviewed in a previous chapter/ transformed into crystalline schists and in some places into granitoids. The *Fig. 6.* shows an idealised crystalline rock-association of Tisia Composite Terrane by two characteristic rock-columns. One of them (A) represents the "Para-autochton" and Drava Terranes, the other (B) does the Szeged-Békés-(Codru) Terrane and Baksa Sub-terrane. A common lithological feature of both

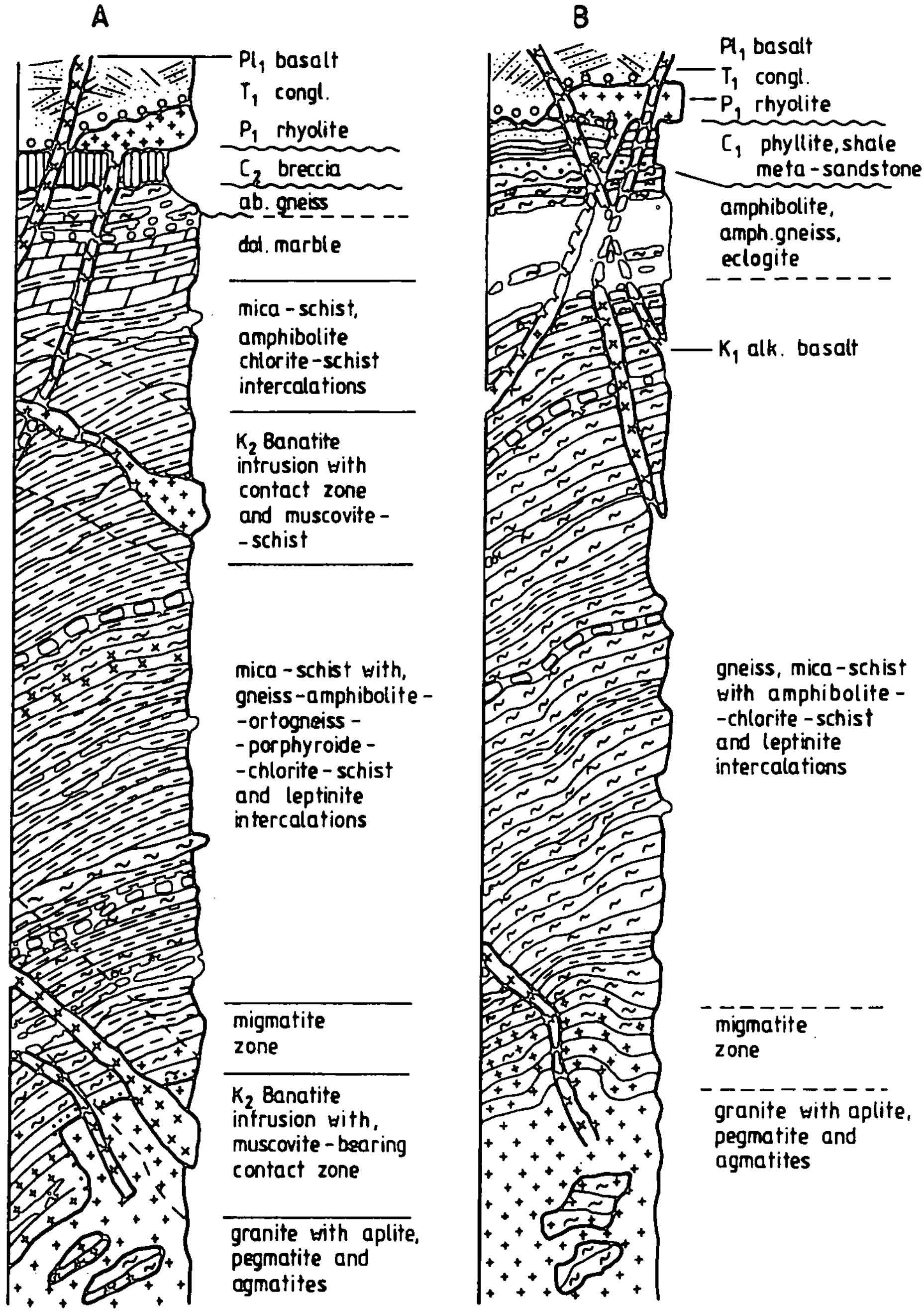

Fig. 6. Idealized rock-column of crystallines of Tisia Composite Terrane. "A" = Szeged-Békés-/Codru/ Terrane, "B"= Para-autochton" and Dráva Terranes

rock-columns can be seen namely existence of palingenetic granite in the lowermost parts of them containing crystalline schist xenolites and aplites and/or pregmatites. Without sharp boundaries 500-1600 m. thick folded migmatite zone covers the granitic bodies which goes into a folded and frequently sheared and /or mylonitized, sometimes fractured very-thick (several thousand m.) gneiss - mica-schist complex. Ratio between alternating gneiss - mica-schist rock-types shows a detectable lateral and vertical variety. So, smaller or larger lithostratigraphically separative gneiss or mica-schist-rich bodies (formation, maybe members) have been designated. Corresponding to the protolith character and metamorphic grade the gneiss - mica-schist complexes is interrupted by from several cm to a few m. thick amphibolite, chlorite-schist, leptinite, marble, dolomite-marble, calc-silicate gneiss intercalations which here and there can be groupped into larger lithostratigraphic units /members or rarely formations/, too.

All rock-units have detectable mineral parageneses with critical minerals and mineral associations as well as observable and determinable isograds and isoreaction-grads (SZEDERKÉNYI 1976, 1984). Difference between two idealised rock-columns is manifested by the existence or the lack of carbonatic rocks and in the frequency of amphibolite bands and finally, in the quality of younger volcanic dykes and subvolcanic intrustions.

TECTOGENESIS

Based on ages, succession of metamorphic events and related deformation characters as well as P-T conditions and existence of special "indicator rocks" (eclogites, blue-schists, ultramafics) the following global tectonic Paleozoic history may be determined in the crystallines of Hungarian part of Tisia Megaunit:

1. 440-400 Ma old (SVINGOR and KOVÁCH 1981) Caledonian event. Its signs are retained in a narrow (5-10 Km. broad) and weakly recovered belt only , located into the geometric axis of "Para-autochton" and Drava Terranes streching from Szeghalom (East Hungary) up to Görgeteg-Babócsa (South Transdanube) traverse. High-pressure low-temperature eclogites at Kőrösvidék (Szeghalom, M.TÓTH 1985) and SE Transdanube (GÖRCSÖNY, RAVASZ-BARANYAI 1969) or several obduced serpentinized ultramafic bodies (SZEDERKÉNYI 1974; GHONEIM and SZEDERKÉNYI 1979; BALLA 1983/ as well as several characteristic amphibolite xenolites enclaved into the northern margin of granite mass of Mórágy Hill (SE Transdanube) postulated a Caledonian suture.

2. 350-330 Ma old (SVINGOR and KOVÁCH 1981, KOVÁCH et al. 1985, BALOGH KAD. et al. 1983) Variscan collisional event can be regarded as culmination of Variscan orogenesis. During this period the accretion of Variscan Europe including the development of crystalline rock-types, associations and lithostratigraphic units were accompanied by mega-, macro- and micro-folding, shearing and blastomylonitization. Forming of palingenetic granite belts at the axial zones of synclinoria happened during the same period; although , the Late Variscan low-pressure and high-temperature effect (late orogenic heating up during 330-270 Ma. period) undoubtedly helped the granitization.

3. Fractures from the main orogenic event are unknown. However, after the granite genesis and before Upper Carboniferous sinking some important fracturing events had taken place, as follows:

– Nappes having unknown vergency. Their remnants are found as Horváthertelend and Szalatnak nappe-vrecks or outliers.

– NW-SE striking trancurrent fault bordering the Drava Terrane eastward,

– Stike-slip faults having ENE-WSW strike (oldest manifestation of so-called Mecsekalja Belt" as well as Baja-Tázlár-Túrkeve-Nyírábrány fracture) which close into itself Ófalu and Tázlár units as wedges.

Period taking from late Carboniferous up to Lower-Triassic is characterised mostly by epirogenetic movements controlled the evolution of Late Carboniferous and Permian sedimentation. Formations of this process exist as non-metamorphic "overstep" sequences settled mainly on the erosional surface of crystallines.

LITHOSTRATIGRAPHIC CLASSIFICATION AND CORRELATION

It is well-known that conventional stratigraphic methods are unusable in the metamorphic masses because the original signs are considerably or totally destroied and borders of metamorphic units generally cut the pre -metamorphic lihostratigraphic units and alloied them into a single metamorphic one. Acceptably defined smallest metamorphic lihostratigraphic unit which can be marked out with certainity is the formation. Its boundaries coincide to that of pre-metamorphic ones in the very-low and partly in the low-grade metamorphic mass so, criteria referring to the sedimentary lihostratigraphic system can be utilized here. Unfortunately, insignificant minority of rock- units of Tisia Composite Terrane can be classified by this method, only.

In the overwhelming majority of cases – as it was mentioned previously – (mainly medium-high-grade metamorphics) amalgamate a fairly big portion of earlier units. In this situation a new lithological content develops with new borders and new age which corresponds to the age of last heating. Therefore smallest and acceptable lithostratigraphic unit may be the complex. Idealized rock-columns presented by *Fig. 6.* give an appropriate example of metamorphic complexes. Based on an attempt (being at an advanced stage) the following lithostratigraphic units are realised by the Metamorphic Branch of Hungarian Stratigraphic Committee:

1. Ófalu Phyllite Formation

Meta-greywacke- phyllite- crystalline limestone and interbedded meta-basalt, actinolite-schist, prophyrite and prophyroide form a low-grade metamorphic sequence which is embedded as a wedge into the "Mecsekalja" Tectonic Belt with 40 km length and more than 2 km width. The weakly folded and tilted (sometimes perpedicular) rock-bands are strongly sheared in general, except a few siliceous shale and crystalline limestone intercalations. Silification these latter are attributed a marine volcanic activity running synchronously with the sedimentation. They preserved some uncertain plant-remnants and fossils (Conodont fragments). Carbonised plant-remnants are supporting tissue relics derived from botanically fairly well-developed plants (KEDVES and SZEDERKÉNYI 1996) so, age of the protoliths can be ranged about into Upper Silurian (not older) epoch. Strongest shearing took place at the northern margin of the formation and due to a considerable friction-heat and related potassium metasomatism a weak melting developed in it.

2. Ófalu Serpentinite Formation

Within the Ófalu Phyllite Formation near Ófalu a small (12 m wide and about 100 m long) nearly perpendicular serpentinite body is wedged into the meta-greywacke along fracture zones. It is interpreted as an obduced lower lithosphere remnant (BALLA 1983) and this grey-coloured rock-association shows a lherzolite origin (GHONEIM and SZEDERKÉNYI 1979).

3. Gyód Serpentinite Formation

It consists of two of same size occurrences which are regarded as two separated 5-6 km long and 600-700 m wide lithostratigraphic members: (1) Helesfa serpentinite and talc-schist association forms a nearly perpendicular lens-like body wedged into the Variscan granite along broad shearing zones filled by talc-rich metamorphics penetrated by numerous metasomatized aplite dikes not only in the shearing zones but in the serpentinite body, too. This latter consists of sheared and perfectly serpentinized harzburgite showing diapiric structure (SZEDERKÉNYI 1974, 1977). (2) The Gyód member occupies a perpendicular position at the northern margin of the Baksa Sub-terrane but whitin it. Its country-rocks are medium-grade crystalline schist belonging to the Baksa Complex. No traces of shearing are observable, thus the process of serpentinization is not so perfect as it is in the Helesfa serpentinites. In a central narrow plane a less serpentinized harzburgite zone is retained. According to BALLA (1983) both members of the Gyód Serpentinite Formation can be regarded as obduction wedges.

4. Görcsöny Eclogite Formation

A weakly investigated formation located into the Baksa Sub-terrane near its northern margin . It consists of retrograde "symplectite". Its size and extensions are unknown (RAVASZ-BARANYAI 1969). Based on analogies, it looks like to belong to high-pressure low-temperature eclogites written by M.TÓTH (1995) near Szeghalom (East Hungary).

5. Szalatnak Shale Formation

It is comprised by strongly and complicatedly folded two dark-grey shale occurrences separated from each-other: Szalatnak body can be found in the Eastern Mecsek Mts. and the Horváthertelend one is in Western Mecsek. (1) At the Szalatnak the rock-column is subdivided into three lithostratigraphic members, two shale ones and a 80 m thick basalt agglomerate member between them. More than 1500 m thick sequence is underlain by Mórágy Granite Formation. Thin siliceous shale stripes are characteristic in the shale members and several anthracite-like intercalations also occur mainly in the lower member containing characteristic Llandoverian Conodont fauna (KOZUR 1984) and Garptolite fragments (ORAVECZ 1964). Whole rock-mass suffered a very-low grade metamorphism (prehnite-quartz facies, SZEDERKÉNYI 1974) which turns into a low-grade one (ÁRKAI et al. 1996) in the lower part of the rock-column. This formation extends about on 200 km^2 area covered by Permian and/or Lower Triassic sandstones and it tectonically is regarded as a Late Variscan nappe-vreck having unknown vergency. During the Carboniferous (before the nappe movements) a small (about 1 km large) syenite-porphyry intrusion (Szalatnak Syenite-porphyry Formation) invaded into the lower member causing a fractured and hardly examined thin contact aureole in it. (2) Exactly the same shale and similar nappe-outlier can be found at the western frame of Mecsek Mts. covered by Badenian sediments near Horváthertelend, but it is not studied yet in detail..

6. Szalatnak Syenite-porphyry Formation

A small (about 1 km^2 large) hypabissal (nearly subvolcanic) intrusion of a grey, coarse-grained holocrystalline syenite-granodiorite body which caused a few m thick fractured contact aureole. Its Rb/Sr ages (SVINGOR and KOVÁCH 1981) show a Variscan late kinematic origin (328-310 Ma.). The geochemical character differs from that of Mórágy granite postulating an intrusion preceeded the Carboniferous nappe movements.

7. Babócsa Complex

It is bordered by Middle Hungarian Lineament NW-ward and NW-SE striking transcurrent fault located between "Para-autochton" and Drava Terranes as well as the fracture bordering the Villány Mts. westward. Southward this complex extends over Croatian area. Areal extension in the Hungarian side is larger than 1000 Km^2. It consists mostly of medium-grade gneiss with subordinate mica-schist and amphibolite intercalations, which latter is generally mylonitized. Its idealized rock-column is the same as *Fig. 6B*. Apart from an uncertain Caledonian datum (JANTSKY 1979) double Variscan metamorphic phases are recognised. The first one is represented by a Barrow-type deformation having P=6-9 Kb pressure and 17-27 °C/km thermal gradients, the second one is an andalusitic higher temperature {34°C/km thermal gradients} phasis (ÁRKAI 1984; TÖRÖK 1989). Overstep sequence above the crystallines is a Late Carboniferous molasse.

8. Baksa Complex

It gives the crystalline floor of Villány Mts. and its northern foreground up to the Mecsek Mts.. Its SW border is manifested in the fracturing zone which coincides with transcurrent fault located between "Para-autochton" and Drava (KASSAI 1977). Petrographically this complex consists of a weakly-folded migmatite - gneiss - mica-shist - marble - dolomite marble-calc-silicate gneiss association characterised by a remarkable isograde system showing zones and isograds from sillimanite up to chlorite with a south-west progressivity trend (SZEDERKÉNYI 1976). Its idealized rock-column is the same that of *Fig.6A*. (without banatites)

Thickness of this complex exceeds 10 km. Two 250 m and 25 m thick marble and dolomite marble members are characteristic in the sillimanite zone accompanied by fairly thick (23-30 m) amphibolite beds. Near Gyód locality an obduced (BALLA 1983) and partly serpentinized ultramafic body is wedged into this complex (Gyód Serpentinite Formation). North of this body a formerly mentioned single eclogite (now symplecite) occurrence (RAVASZ-BARANYAI 1969) as well as a characteristic high temperature overprinting with andalusite in the northern margin of the complex are found (LELKES-FELVÁRI and SASSI 1983) showing at least three phases of the polymetamorphism altogether. Upper Carboniferous (Vestphalian) coal-bearing molasse covers the Baksa Complex as overstep sequence.

9. Mórágy Complex

It consists of Mórágy -Kecskemét granite range and accompanied migmatite - gneiss - mica-schist flanks on its both sides. Its idealized rock-column is perfectly same that of *Fig. 6B*. Most characteristic part of the complex is the granite range itself. Forming a not-too broad axial stripe of an ENE-WSW striking synclinorium zone, the granite body forms an about 200 km long and 25-30 km broad continuons belt beginning at Szigetvár (South Trandanubia) and near Szolnok which disappears below the Upper Cretaceous-Paleogene flysch complex (JANTSKY 1979). It is composed petrographically by porphyroblastic granite-granodiorite mass with biotite and/or amphibole-rich xenolites. The latter show 440-400 Ma Rb/Sr ages (SVINGOR and KOVÁCH 1981; KOVÁCH et al. 1985) suggesting a Pre-Variscan (Caledonian?) deformation but it requires further confirmation. These granites are S-type mixed meta and peraluminous syn-collisional rocks (BUDA 1981, 1985, 1995). Forming wings of the synclinorium it is accompanied by crystalline schists showing typical polimetamorphism. In the first phase of Variscan deformation a Barrow-type event had taken place with P= 6-8 Kb pressure and 14-26 °C/km thermal gradients extending over whole area of Tisia Composite Terrane (SZEDERKÉNYI et al. 1991). In the second phase a low-pressure high-temperature retrogression was characteristic along the Mecsekalja Tectonic Belt and the eastern continuation of Mecsek Mts. (Vajta, LELKES-FELVÁRI et al. 1989) with late kinematic (322 Ma old) andalusites. Overstep sequences are Permian and/or Lower Triassic sandstones.

10. Tázlár Phyllite Formation

About 15 km long and 300 m wide double bodies are wedged into the gneisses of Mecsek -North Plain Sub-terrane by a NE-SW striking fault zone in the central area of the Danube-Tisza interfluve. Not more than 300 m thick greenish-grey coloured carbonate-phyllite with black graphitic phyllite stripes gives the rock-content of these bodies. Their age is uncertain; according to FÜLÖP (1994) it may be Early Palaeozoic or Early Carboniferous.

11. Kőrös Complex

It is comprised by crystallines of Middle Plain Sub-terrane and bordered by Baja-Túrkeve-Nyírábrány fracture zone northward, South-Hungarian Nappe Belt southward. Its eastern border is found somewhere at the Transylvanian Apuseni Mts. Its rock-column is perfectly same that of *Fig. 6B*. Similarly to the Mórágy Complex a more than 250 km long and narrow not continuous granite range (embedded into 15-20 km wide migmatite belt) forms axial zone of the complex. Within the range five 5-10 km wide and 15-25 km long granite bodies settled along the Jánoshalma-Jászszentlászló-Endrőd-Füzesgyarmat-Kőrösszegapáti traverse represented by S- and I-types porphyroblastic biotite granite-granodiorite rocks (BUDA 1985, 1995) which form at once synclinorium axis, too. Similarly to that of Mórágy Complex this granite-migmatite range is accompanied by medium-grade gneiss – mica-schists – amphibolite associations in both sides as flanks of an ENE-WSW striking synclinorium. Apart from the previously mentioned complexes, these crystallines show double-facial progressive metamorphism, only. The first is the Caledonian(?) phasis appearing along Szeghalom-Szarvas-Szank-Ófalu-Helesfa traverse in 5-10 km broad zone as a presumed suture. The second one is the Variscan Barrow-type deformation (medium-pressure and temperature P-T circumstances and 350-330 Ma isotope age). Phasis marked by andalusite is perfectly missing from the metamorphic history of Kőrös Complex.

12. Álmosd Formation

Low-grade chlorite schist-two mica-schist and graphite-bearing biotite schist association forms an Upper Cretaceous nappe outlier (on about 20 km^2 area) thrusting over the metamorphics of Kőrös Complex at the Romanian-Hungarian border. It has N-W vergency and it genetically is same as low-grade metamorphics of Szeged-Békés-(Codru)-Terrane i.e. South Hungarian Nappe Belt.

13. Kelebia Complex

It is the westernmost sub-unit of Szeged-Békés-(Codru) Terrane which is bordered by the nappe boundary west- and northward, Ásotthalom-Bordány sinking eastward. It extends over Yugoslavian area southward. Covered by Lower Permian rhyolitic and/or

Lower Triassic red-beds low-and medium-grade strongly-folded two-mica-schists sometimes chlorite schists form the metamorphic rock-mass in unknown thickness. The mentioned Barrow-type Variscan metamorphic phasis and contact zones of several small banatite intrusions and dykes near Kunbaja and Kelebia characterize the metamorphism. Its idealized rock-column is the same as *Fig. 5A.* without marble and variscan granitoids.

15. Tisza Complex

It is bordered by nappe boundary northward and the Ásotthalom-Bordány sinking westward and so-called "Makó trough" eastward. Southern border is found somewhere in the Yugoslavian Bačka area. Its idealised rock-column is presented on the *Fig. 6A.* A characteristic peculiarity is a 200 m thick marble-dolomite marble member near Kiskundorozsma (Szeged) as the single carbonatic rock-association in the crystalline basement of Great Plain. Besides these marbles a small deep- plutonic granite occurrence and related migmatites (near Deszk) as well as medium-grade slightly folded gneiss - mica-schist alternation are also typical in the whole South Hungarian Nappe Belt {Szeged-Békés-(Codru) Terrane}. 350-330 Ma old first Variscan (Barrow-type) phasis with P= 6-8 Kb pressure and 500-570°C temperature as well as 330-320 Ma old second Variscan phasis with blastomylonitization and third, late kinematic 320-315 Ma old high-temperature and low-pressure retrogression (P= 3-4 kb pressure and T= 580-600°C temperature) and finally Upper Cretaceous banatite magmatism and related contact metamorphism as main metamorphic events are characteristic. The latter is comprised by small elongated intrusions and relatively broad (400-600 m) accompained tourmaline-rich muscovite schist aureoles near Ferencszállás and Kiszombor with ENE-WSW strike (SZEDERKÉNYI 1984; SZEDERKÉNYI et al.1991). Overstep sequences are Lower Triassic red-beds.

16. Battonya Complex

In the Hungarian section it consists of 15–25 km long and 10–15 km wide body (stretching over Romania and Yugoslavia) represented mainly of by granite and a few associated migmatite and crystalline schists. Boundaries are Makó "Trough" westward, Békés Basin eastward and the nappe boundary nortward. Porphyroblastic orthoclase-biotite granite and associated enclaves give the predominant portion of deep-plutonic body. Beginning from Yugoslavian Bačka and finishing in the Transylvania Apuseni Mts. this granite similarly to the Mórágy Complex also form a more than 150 km long and not too broad continual range. Contrary the Mórágy mass the magma of this deep-plutonic granite body at Battonya-Mezőhegyes after an in situ melting moved a little upward as an intrusion during the phasis of Variscan late kinematic movement period (SZEPESHÁZY 1969; SZEDERKÉNYI 1984; KOVÁCH et al. 1985). All deformational and age data are the same that of Tisza Complex. Overstep sequence is the Lower Permian molasse.

17. Sarkadkeresztúr Complex

It is an isolated 15 km long and 5 km wide crystalline basement – high uplifting on the eastern side of Békés Basin having a W-E elongation it consists of light-grey diatexite and subordinately porphyroblastic orthoclase-biotite granite. In both side of the high they are accompanied by medium-grade gneiss - mica-shist - amphibolite association showing the same deformational and time characters that of Tisza Complex (SZEDERKÉNYI 1984).

18. and 19. Vilyvitány mica-schist and Füzérkajata Porphyroide Formations

Being apparently isolated from the main mass of the Tisia Composite Terrane (no boreholes in the basement of Upper Cretaceous-paleogene flysch-trough are available), so, the character of their deformation and isotopic ages as well as tectonic considerations and overstep sequences can show that these units may belong to the Tisia, but based on newer petrological and tectonic interpretations carried out by VOZÁROVÁ and VOZÁR (1987) they are ranged now into the Tatra-Vepor Unit of Western Carpathians.

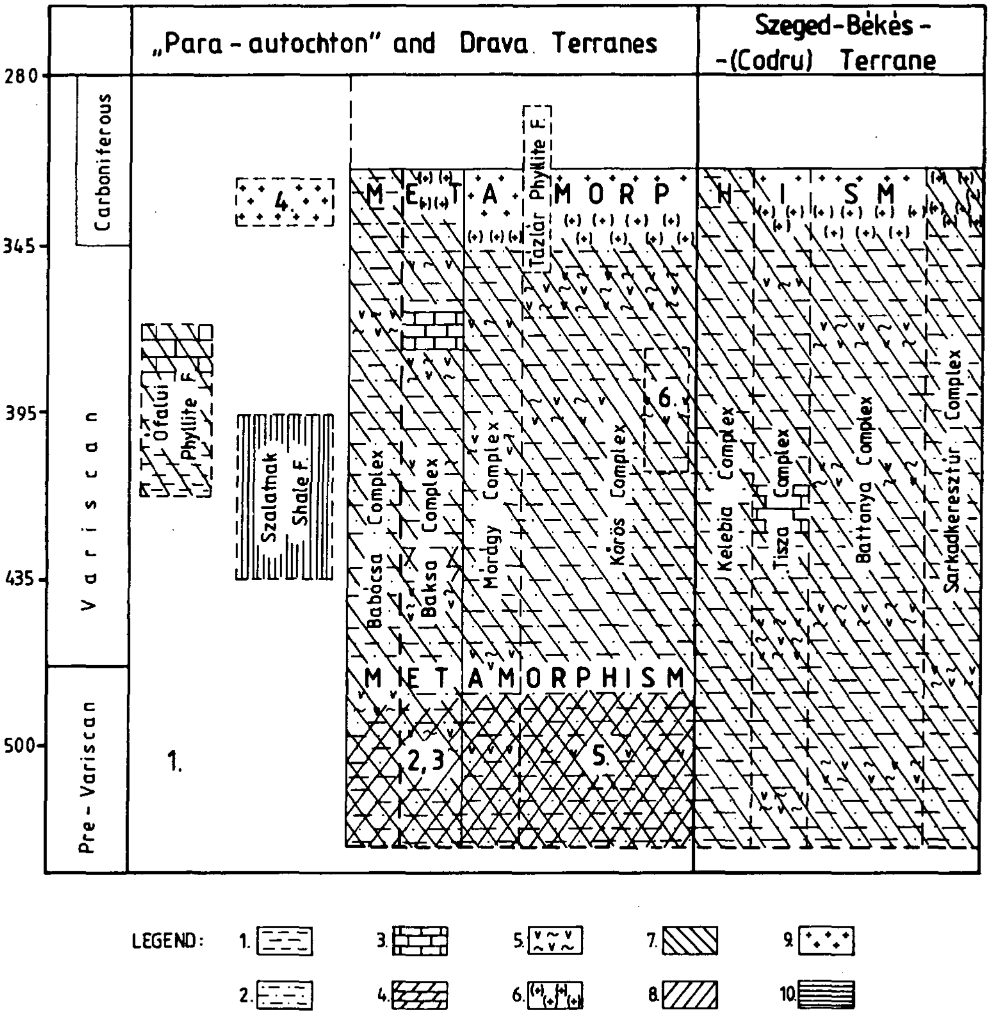

Fig. 7. Lithostratigraphic table of crystallines of Hungarian part of Tisia Composite Terrane. Legend: /1/= pelite, /2/ =greywacke, /3/= limestone, /4/= dolomite, /5/ basic lava, tuff, /6/= migmatite, /7/= Variscan deformation , /8/ Pre-Variscan deformation, /8/ granitoide intrusion, /10/ slate.

Lithostratigraphic table of complexes and formations are presented by *Fig.7* shows perpendicular and lateral relationships among the units of Tisia Composite Terrane. This table differs strongly from those ones which are compiled for sedimentary formations. Difference appears mainly in the block-like construction. Due to considerable burial, recovered, kown unit-borders are rather rare in our metamorphics and it causes serious difficulties in the recognition and delineation of heteropic units. Thus, the characters of lateral relationships can not be presented, moreover, inside a rock-column an authentic presentation of a succession is also not easy.

The lithostratigraphic table *(Fig.7)* tries to display together the quality of metamorphics and the tectono-metamorphic cycles in the time in continual rock-columns which are beginning at the age of protolith and finishing at the time of last progressive metamorphic event. It seems to be expedient to record the time scale of Earth history, too. The lithological content is presented by conventional signs and the metamorphism by shade-lines. The shade-lines can extended to the whole rock-column which means in this case that each rock of the rock-column suffered metamorphism. Age of metamorphic event can be red from the position of the "metamorphism" notice. The outliers (nappe remnants and tectonic wedges) are sitting in "empty space" in the lithostratigraphic table (because their parent-complexes are unknown), or in the rock column of receptor unit.

One sub-terrane in the lithostratigraphic table corresponds to one complex. Units of Drava- and "Para-autochton" Terranes occupy a relatively autochton situation compared to that of Szeged-Békés-(Codru) Terrane, i.e. they are "Para-autochtonous" and contrary the latter they collect themselves into an independent group isolated from the "nappe complexes and formations".

Lateral relationships of metamorphic lithostratigraphic units are clearly expressed in the global identity of protholits and metamorphic character as well as culminating time of metamorphic phases together with migmatization and palingenesis. Apart from the outliers some essential differences are existing between two main groups of lihostratigraphic table which are manifested in the follows:

– Pre-Variscan deformation can be detected in the para-autochtonous terranes, exclusively.

– Variscan late kinematic heating (andalusite mineralization) occurs first of all in the nappe units.

– Upper Cretaceous contact metamorphism in Hungarian area of Tisia Megaunit (belonging to the banatitic intrusions) occured in the nappe units, only.

ACKNOWLEDGEMENT

Many thanks to the National Scientific Fund (OTKA) for the financial support of this research-work.

REFERENCES

ÁRKAI, P. (1978): A Tázlára terület metamorfitjainak leírása. (Description of metamorphics of Tázlár Area.) Manuscript in Hungarian. Kézirat. MOL Adattár, Szolnok.

ÁRKAI, P., LANTAI, CS., LELKES-FELVÁRI, GY., NAGY, G. (1996): Biotite in a Paleozoic metagreywacke complex, Mecsek Mts, Hungary: conditions of Low-T metamorphism deduced from illite and chlorite crystallinity, coal rank, white mica geobarometric and microstructural data. Acta Geol. Hung. Budapest (in press).

BALLA, Z. (1982): Development of the Pannonian Basin basement trough the Cretaceous-Cenozoic collision: a new synthesis. Tectonophysics. **88**, 61-102.

BALLA, Z. (1983): A Dél-dunántúli ultrabázitok lemeztektonikai értelmezése. (Tectonic interpretation of South-Transdanubian ultramafics). In Hungarian . Földt. Közl. **113**, 39-56.

BALOGH, KAD., ÁRVA-SÓS , E., BUDA, GY. (1983): Chronology of granitoid and metamorphic rocks of Transdanubia (Hungary). Ann. Inst. Geol. Geofiz. **61**, 359-364. Bukarest.

CSONTOS, L. , NAGYMAROSI, A., HORVÁTH , F. KOVÁC M. (1992): Tertiary evolution of the intracarpathian area: a model. Tectonophysis **208**, 221-241.

FÜLÖP, J., DANK, V. et. al (1987): Magyarország földtani térképe a kainozoikum elhagyásával. M: 1:500.000. (Geological map of Hungary without Cenozoic. M:1:500.000) Hung. Geol. Survey. Budapest.

FÜLÖP, J. (1994): Magyarország Geológiája: Paleozoikum II. (Geology of Hungary: Palaeozoic II). Academia Kiadó, Budapest.

GHANEM, M.A.E., RAVASZ-BARANYAI, L. (1969): Petrographic study of the crystalline basement rocks, Mecsek Mts., Hungary. Acta Geol. Ac.Sci. Hung. **13**, 191-219.

JANTSKY, B. (1979): A mecseki gránitosodott alaphegység földtana. (Geology of granitized crystalline basement of Mecsek Mts.) Annales of Hung .Geol. Survey. **60**, 1-3 1-385.

KEPPIE, J.D., DALLMEYER, R.D. (1990): Introduction to terrane analysis and the tectonic map of Pre-Mesozoic terranes in Circum-Atlantic Phanerozoic orogens. Abst. Vol. IGCP Project 233 Meeting. 24-27. Göttingen

KOBER L. (1921): Bau der Erde. Wien.

KOVÁCH, Á., SVINGOR. É., SZEDERKÉNYI, T. (1985): Rb-Sr dating of basement rocks from the southern foreland of the Mecsek Mountains, Southern Transdanubia, Hungary. Acta Miner. Petr. Szeged. **XXVII**, 51-56.

KOVÁCS, S. (1982): Problems of the "Pannonian Median Massif" and the plate-tectonic concept. Geol. Rundschau. **71**, 617-638.

KOVÁCS, S., SZEDERKÉNYI T., ÁRKAI P., LELKES-FELVÁRI, GY., BUDA GY., NAGYMAROSI, A. (1996): Explanation to the terrane map of Hungary. Final Vol. of. Rep. of IGCP Project No. 276. Athens-Padova (In press)

KOZUR, H. (1994): Muellerisphaeria eine neue Ordung von Mikrofossilien umbekanuter systematischer stellung aus dem Silur und Unterdevon von Ungarn. Geol. Pal. Mitt. Innsbruck, **13**/16, 125-148.

LÓCZY, L. sen. (1918): Magyarország földtani szerkezete (A Magyar Szent Korona Országainak leírása) (Geological structure of Hungary. Description of Countries of Hungarian St. Crone). In Hungarian. Budapest.

M. TÓTH, T.: (1995): Retrograde eclogite in the crystalline basement of the Körös Unit, Hungary. Acta Miner. Petr. Szeged. **XXXVI**, 117-129.

ORAVECZ, J. (1964): Szilur képződmények Magyarországon (Silurian formations in Hungary) In Hungarian. Földt. Közlöny. **94**, 3-9.

PRINZ, GY. (1914): Magyarország Földrajza. A magyar föld és életjelenségeinek leírása.(Geography of Hungary Description of Hungarian and its life) In Hungarian, Budapest.

RAVASZ-BARANYAI, L. (1969): Eclogite from the Mecsek Mountains, Hungary. Acta Geol. Ac.Sci, Hung., **13**, 315-322.

SZEDERKÉNYI, T. (1974 a): Paleozoic magmatism and tectogenesis in Southeast Transdanubia, Hungary. Acta Geol. Ac Sci. Hung. **18**, 305-313.

SZEDERKÉNYI, T. (1974 b): A DK-dunántúli paleozoós képződmények ritkaelem kutatása. (Rare-element investigation of Paleozoic complexes of southeast Transdanubia) In Hungarian. PhD Theses. MTA Library. Budapest.

SZEDERKÉNYI, T. (1976): Barrow-type metamorphism in the crystalline basement of southern Transdanubia. Acta Geol. Hung. **13**, 27-34.

SZEDERKÉNYI, T.: (1977): Geological evolution of South Transdanubia (Hungary) in Paleozoic time. Acta Miner. Petr. Szeged, **XXIII**, 3-14.

SZEDERKÉNYI, T. (1983): Origin of amphibolites and metavolcanics of crystalline complexes of South Transdanubia, Hungary. Acta Geol. Hung. **26**, 103-136.

SZEDERKÉNYI, T. (1984): Az Alföld kristályos aljzata és földtani kapcsolatai. (Crystalline basement of the Great Plain and its geological connections). In Hungarian. Dr. Sc. Diss. MTA Library, Budapest.

SZEDERKÉNYI, T., ÁRKAI, P. , LELKES-FELVÁRI, GY. (1991): Crystalline groundfloor of the Great Hungarian Plain and South Transdanubia, Hungary. (In Geodynamic Evolution of the Pannonian Basin). Serb. Ac. of Sci. Arts.Ac.. Conferences **LXII**. Dept. of Nat. and Mat. Sci. **4**, 261-273. Belgrade.

SZEPESHÁZY, K. (1969): Kőzettani adatok a battonyai gránit ismeretéhez. (Petrographic data for the Battonya granite). In Hungarian. Ann. Rep. of Hungarian Geol. Survey from 1967, 227-266.

TÖRÖK, K. (1983): Fluid inclusion study of the gneiss from the borehole Nagyatád K-11, SW Transdanubia , Hungary. Acta Miner. Petr. Szeged. **XXX**, 115-126.

VOZÁROVÁ, A., VOZÁR, J. (1987): West Carpathian Late Paleozoic and its paleotectonic development. In: FLÜGEL, H.W. SASSI, F. P., GRECULA, P.: Pre-Variscan and Variscan Events in the Alpine Mediterranean Mountain Belts. 469-487. Bratislava.

Manuscript received 17 Aug. 1996