

## Polyphase evolution of the structure of the Aggtelek-Rudabánya Mountains (NE Hungary), the southernmost element of the Inner Western Carpathians - a review

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*Abstract:* The Aggtelek-Rudabánya Mts. is the southernmost element of the Inner Western Carpathians. Its Mesozoic sequences can be grouped into three series groups. Of these, the Silica series group (represented by deeper facies in the Rudabánya than in the Aggtelek Mts.) is non-metamorphosed, deposited on continental crust and forms the uppermost tectonic unit of the primary nappe structure, the Silica nappe system. The anchimetamorphic Meliata series group deposited on oceanic or intermediate crust. It can be found partly in the evaporitic basement of the Silica nappe system, partly between it and the underlying Torna series that is epimetamorphosed and deposited on continental crust. This series with its probable Paleozoic basement, the Hídvégardó and Uppony series, is the lowermost known element of the primary nappe structure. The structural evolution of the territory started in the Middle Anisian with rifting and then opening of the Meliata ocean between the Silicic and Tornaic depositional areas. The ocean subducted northward during the Jurassic and simultaneously obducted southward on top of the Tornaic crust. The Silica nappe system was formed after the collision by gravitational gliding to the S, having detached from its Paleozoic basement along thick plastic Upper Permian evaporites. In a later phase folding and imbrication were terminated in forming secondary klipps in about the Middle Cretaceous. The last main phase in the Oligo-Miocene was induced by the Bükk and Szendrő Mts. having approached far from SW. As a result, the Rudabánya Mts. were moved in three main segments from the southern vicinity of the Aggtelek Mts. to their eastern neighbourhood along sinistral strike-slips of the Darnó zone. Overthrusting of new secondary klipps and movements along complementary strike-slips of E-W direction (e.g. the Rožňava line) are also associated with this phase.

*Key-words:* Inner Western Carpathians, Aggtelek-Rudabánya Mts., nappe structure, structural evolution

### Introduction

After the intensive geological mapping in the first half of the 80-s supported by several boreholes, a new map of the Aggtelek-Rudabánya Mts. were issued (Less et al., 1988). New results are published in several papers (Árkai & Kovács, 1986; Grill, 1988, 1989; Grill et al., 1984; Hips, 1996; Kovács, 1984, 1986; Kovács et al. 1989; Less, 1998; Márton et al., 1989; Réti, 1985; Szentpétery, 1988, 1998). However, a general summary of these results on the structure and its evolution of this region in English is still missing. This paper tries to fill this gap.

### Structural overview

Despite of its small dimension, the Aggtelek-Rudabánya Mts. is geologically one of the most complex regions in Hungary. It can be subdivided into two parts, to the Aggtelek and to the Rudabánya Mts. The first one is clearly the continuation of the Slovak Karst Mts. However, their structures are cut along the Ragály-Szólóardó-Perkupa-Bódvarákó-Hídvégardó-Žarnov line, from the S and E of which one can find the Rudabánya Mts. The two units are separated by a complicated, generally sinistral strike-slip structure (see in detail later) of Oligo-Miocene

age (Szentpétery, 1988). This means that until the Late Oligocene the Rudabánya Mts. were located some tenth of km-s to the S of the Aggtelek Mts. that was relatively intact to the sinistral movements along the Darnó zone. In fact, the Rudabánya Mts. (whose rocks are still related to the Inner West Carpathians) are incorporated into this zone because SE of it already the Uppony and Szendrő Mts. follows whose Paleozoic rocks show already a Southern Alpine and Dinaric affinity, together with the Paleo-Mesozoic of the Bükk Mts. So, the SE margin of the Rudabánya Mts. is once again a sinistral strike-slip (its complicated structure see in Fig. 1) delimiting the entire Inner West Carpathians towards SE from the units of South Alpine and Dinaric origin.

In re-establishing the pre-Miocene structures (see in detail later), i.e. in pulling back the Rudabánya Mts. virtually to the SW into the southern continuation of the Aggtelek Mts. and the Slovak Karst, the obtained structure is still very complicated. It consists of (in order of superposition from upwards): 1) the neo-allochthonous klipps of Alsó-hegy (Dolny Vrch), Éles-tető and Derenk, covering 2) the folded and imbricated structures (of southern vergency in Hungary) of the mountains that are superpositioning 3) the primary nappe structure.

### Paleo-mesozoic sequences and their primary tectonic position

This reconstructed primary nappe structure is composed of three main tectonic units that are characterized by three different groups of rocks whose metamorphic degrees are also distinctively different (Árkai & Kovács, 1986). These units are called here as Silica, Meliata and Torna (Turňa) Units despite the enormous confusions accumulated into these names. The origin of these confusions is that the meaning of these terms is not unambiguously defined, therefore they are used in terms of both rock sequences (and also of their depositional areas) and tectonical units. However, they are recently so widely used and so deeply imprinted, that the introduction of each new name would create even more confusions. At the same time we feel that hammerable rock sequences are much more concrete than tectonical or paleogeographical units reconstructed on their basis, therefore, these three main units are characterized below on the basis of their rock sequences and their metamorphic degrees.

1. Non-metamorphosed Uppermost Permian, Triassic and Jurassic rocks deposited on continental crust are joined in the Silica series group. They form the upper tectonical unit of the primary nappe structure of the Aggtelek-Rudabánya Mts., the Silica nappe system, originally defined by Kozur & Mock (1973). This nappe system is mostly detached from its Paleozoic basement along the plastic Uppermost Permian/Lowermost Triassic Perkupa Evaporites. We interpret the older Carboniferous-Permian sequence of the Brusník brachianticline in Slovakia as the older Paleozoic basement of the Silica series group in agreement with Mello & Vozárová (1983) despite that they are later grouped by Vozárová & Vozár (1992) into the Torna (Turňa) series group and the Carboniferous (Turiec Formation) is correlated by them with the Szendrő and Bükk Paleozoic in Hungary (see also Vozárová, 1998). However, rhyodacitic volcanoclastic material (characteristic for the Turiec Formation) has never been found in the Carboniferous of the Szendrő and Bükk Mountains, therefore the palinspastic link of the Brusník development to the Southern Gemeric one (Vozárová, 1998) is more acceptable for us. In this case the Paleozoic basement of the Silica series group could be an external Southern Gemeric one that is mostly incorporated into a later collisional zone whose exhumed remnants (Jasov and Bučina formations) are recently exposed in the lower slice of the secondary Bôrka nappe (Mello et al., 1998). Due to the thick Uppermost Permian-Lowermost Triassic evaporitic layer, the Mesozoic cover (the Silica series group) could be detached from the Paleozoic basement and overthrust the collisional zone and could form in this way the later Silica nappe system. At the same time, some parts of the Paleozoic basement - locally not having had too thick evaporitic cover (like the ones represented in the Brusník anticline) - could join to the overthrust of the Silica series group and become part of the Silica nappe system.

The sequences of the Silica series group are partly different in the Aggtelek and Rudabánya Mts. In the first it is

called Aggtelek series whereas in the Rudabánya Mts. its name is Bódva series. Both they start uniformly with Permo-Triassic evaporitic to sandstone beds (= the "Haselgebirge" in the Eastern Alps), followed by shallow marine, terrigenous but ever more limy Lower Triassic (correlatable with the Werfen beds), then by shallow marine, Anisian platform carbonates (Gutenstein and Steinalm beds). After or without an intraplateform basinal event (Reifling and Schreyeralm Limestones) this carbonate platform survived in the Aggtelek series up to the Late Carnian (Wetterstein Limestone in the Aggtelek facies) or even up to the Norian (Dachstein Limestone in Drnava, Slovakia). However, some intraplateform basins could also survive the Late Ladinian to Carnian interval within the Wetterstein platform (Derenk Limestone in the Derenk facies).

Meanwhile, in the Bódva series no platform carbonates can be found starting from the Middle Anisian. This series is also a composite one: The Szőlősardó facies is characterized by the slope deposits of the Nádaska Limestone and by the relatively thick, terrigenous Szőlősardó Marl marking the Middle Carnian Raibl event. The Upper Anisian to Carnian of the Bódva facies s.s. is characterized mainly by basinal limestones (Bódvalenke Limestone) interfingering with under-CCD radiolarites (Szárhegy Radiolarite). After the very diverse Upper Anisian - Middle Carnian, the Upper Carnian and Norian of the Aggtelek and Bódva series became almost uniform: this interval is represented in both series by the same pelagic Hallstatt and/or Pötschen Limestones.

The Jurassic in Hungary is known only in the Bódva series (in the Aggtelek series it is supposed to be similar to the Jurassic of Bleskový prameň near Drnava): It has two developments (Grill, 1988): The Telekesoldal Complex lying upon the Triassic of the Bódva facies s.s. is built up by monotonous black shales then by rhyolitic wildflysch. However, the Triassic basement of the other development, the Telekesvölgy Complex is rather uncertain (partly because this complex can be found only in the Early Miocene shear zone between the Aggtelek and Rudabánya Mts.). In Fig. 2. an atypical Bódva type sequence without Hallstatt Limestone is shown (found in the vicinity of the cemetery of Hídvégárdó) that can be reconstructed also from the olistoliths of the lower, variegated marly part of the Jurassic Telekesvölgy Complex. Its upper part is composed of crinoideal marls and manganese shales.

The facial distribution of the Upper Anisian-Middle Carnian within the Silica series group (taking also into account that the Rudabánya Mts. together with the Bódva series lying on its top must be pulled back far to the S before the Miocene) indicates a general southward deepening in recent coordinates thus it could be much more easily the northern margin of an ocean (the "Meliata-Hallstatt ocean") than the southern one.

2. Anchimetamorphic (in average) Triassic and Jurassic rocks deposited on oceanic or thinned continental crust are grouped into the Meliata series group. Most of its sequences are tectonically dismembered and secondarily incorporated into the evaporitic basement of the Silica

nappe system as it is shown by several boreholes both in Hungary (boreholes Bódvarákó 4, Komjáti 11, Szögliget 4, Szín 1, the upper part of Tornakápolna 3) and in Slovakia (DRŽ-1 in Držkovce, VŠ-1 in Šankovce). At the same time some remnants could stay in their original position, just below the Silica nappe system (the Bódvarákó series in the Rudabánya Mts., the lower part of borehole Tornakápolna 3 and of Brusník BRU-1). This twofold superpositional character of the Meliata series group indicates that primarily, before the overthrusting of the Silica nappe system, the Meliata series group was in uppermost tectonic position. Due to its dismembered (and also olistolithic - see later) character and also due to its partly true, newly formed oceanic nature, practically nothing is known about its Paleozoic basement and very little about the Lower Triassic that is representing only in the Meliata MEL-1 borehole and resembling the Werfen facies.

Because of its outcropping, the Meliata series group is much less known than the Silica one. Three series can be distinguished. The Meliata series s.s. (which is understood here in its strictest sense, i.e. only the occurrences at the vicinity of Meliata, Držkovce and Čoltovo) is not known from Hungary. Recently it is thought to be an Upper Jurassic olistostrome with both Middle-Upper Triassic and Jurassic olistoliths (Mock et al., 1998). In the Triassic sequence that can be reconstructed from these olistoliths, basic magmatic rocks are subordinate, therefore this sequence is believed to be of intermediate crust. The newly formed, true oceanic crust of mostly Ladinian age is represented by the Tornakápolna series from whose dismembered serpentinites, gabbros, basalts and radiolarites a real MORB-type ophiolite (Bódva Valley Ophiolite) can be reconstructed (Réti, 1985). Red Ladinian radiolarites (Čoltovo Radiolarite) characteristic for the Meliata (s.s.) series and basalts belonging to the Tornakápolna series are interfingering in Čoltovo (Mello & Gaál, 1984), Jaklovce (Mock et al., 1998) and in the Darnó Hill in Hungary (Dosztály & Józsa, 1992), so the close relationship of these two series is unambiguous. The Bódvarákó series is the third among those ranged into the Meliata series group. It is outcropped in the core of an antiform in the northern part of the Rudabánya Mts. and located clearly under the Silica nappe system represented here by the Bódva series (Fig. 1). Its peculiarity is the complete lack of the Middle Anisian Steinalm Limestone between the shallow water Gutenstein Dolomite (the lowermost known member of the series) and the deepwater

(formed around the actual CCD) Bódvarákó Formation of Upper Anisian-Ladinian age. No evidence for the Upper Triassic in this sequence, the overlying Nyúlkerlápa beds are black shales with some olistoliths of unknown age. These beds are thought to be of Middle-Upper Jurassic age by their similarity to the Telekesoldal Complex and the Upper Jurassic Meliata shales. However, the Bódvarákó series is not a Jurassic olistostrome (like the Meliata s.s. series) because its Gutenstein Dolomite reserves a huge quantity of water as it is shown by the Bódvarákó 4. borehole.

3. Anchi- to epimetamorphic (bearing sometimes, however relatively high pressure - see Árkai & Kovács, 1986) Triassic rocks deposited on continental crust are grouped into the Torna (Turňa) series. Primarily it can be found always under the Silica series group (the Esztramos Hill NE of Bódvarákó, Zádielské Dvorniky in Slovakia), in the core of huge antiforms. Moreover, in our interpretation in the vicinity of Honce in Slovakia, on the northern slope of the Plešivec plateau, the original Torna-Meliata-Silica tectonic superpositional arrangement is preserved as well (see also geological profile 5-6 in Mello et al., 1996). Unlike the Meliata series group, the Torna series can never be found as tectonically dismembered blocks in the basal evaporitic layer of the Silica nappe system. This means for us that primarily the Torna series forms the lowest known tectonic unit of the Aggtelek-Rudabánya Mts. and also of the Slovak Karst to the S of the Rožňava line. However, most of the Slovak authors indicate the Torna series tectonically above the Meliata series. Their main argument is the borehole BRU-1 at Brusník (Vozárová & Vozár, 1992) where they range the upper complex into the Torna series superpositioning the lower complex belonging undoubtedly to the Meliata series. Based on this, they speak very often about Turňa nappe. However, the upper complex of this borehole is overlain by an Uppermost Permian to Anisian sequence identical with that of the Silica series group. The closest rocks, really belonging to the Torna series can only be found in Gemerské Teplice, 12 km to the NE of the borehole, but the continuity of the sequence in this distance cannot be judged at all (see Mello et al., 1996). As it was expressed earlier, in this borehole we see rather the superposition of the Silica nappe system on the Meliata series. Therefore, there are no evidences for the primary nappe position of Torna (Turňa) series thus the term of Torna nappe cannot be justified. However, as it is shown

Fig. 1. – Tectonic scheme of the Aggtelek-Rudabánya Mts. (after Less, 1998 with slight modifications)

1. Pannonian; 2. marine Oligocene/Miocene; 3. continental Lower Miocene. 4-5. Younger (Early Miocene) secondary nappes: 4. the Martonyi klipp built up by Torna series; 5. the Lászi klipp built up by Bódva series. 6-8. Older (Cretaceous) secondary nappes: 6. the Alsó-hegy klipp (Aggtelek and Derenk facies), 7. the Derenk klipp (Derenk facies); 8. the Éles-tető klipp (Aggtelek facies). 9-18. Rock sequences in the primary nappe structure: 9-13. Silica series group: 9. Aggtelek series. 10-13. Bódva series: 10. Szőlősgárdó facies, 11. Bódva facies, 12. Telekesvölgy series, 13. the Rudabánya-Martonyi ore complex (Lower Triassic to Lower Anisian of the Telekesvölgy facies?). 14-15. Meliata series group: 14. Bódvarákó series, 15. Tornakápolna series. 16. Torna series, 17. Hídvégárdó series, 18. Uppony series. Other signs: 19. primary nappe boundaries, 20. older secondary nappe boundaries, 21. younger secondary nappe boundaries, 22. tectonically reworked ophiolitic blocks, 23. older imbrications, outcropped and covered, 24. younger imbrications, outcropped and covered, 25. axis of antiforms/anticlines, 26. axis of synclines, 27. sinistral strike-slips, outcropped and covered, 28. dextral strike-slips, 29. faults in general, 30. non-tectonized geological boundaries, 31. number of strike-slips mentioned in the text.





in Fig. 1, this series secondarily can be overthrust but always onto less metamorphosed units. Of these, the Martonyi klip (thought to be Lower Miocene) will be discussed later. However, the age of superpositioning of the Torna series onto the less metamorphosed Hídvégdó Complex (deep diagenetic ?Carboniferous black shales and Permian evaporitic beds associated with grey marls, drilled in Hungary by the Hídvégdó 3 and in Slovakia by the Žarnov ŽAM-1 boreholes) cannot be judged. Maybe this complex forms the Carboniferous-Permian overlier of the archimorphic Uppony type Paleozoic that can be followed along the SE margin of the Rudabánya Mts. and they together can be supposed as the most probable Paleozoic basement of the Torna series.

The series itself contains only Triassic rocks, its Jurassic is eroded. The Lower Triassic is not known from Hungary and the Slovakian data are also rather uncertain: by judging from the description of Mello et al. (1997), the Paklan and Jelšava beds can be correlated with the Szin Marl of the Silica series group. The Middle-Upper Triassic is well known and rather uniform: its standard elements are the Middle Anisian Steinalm (Honce) formation, the Middle Carnian Tornaszentandrás Shale marking the Raibl event and the Upper Carnian to Middle Norian Pötschen Limestone. The Upper Anisian to Lower Carnian is more diverse: in Hungary a marginal and a "seamount" development can be distinguished: the former with distinctive terrigenous input (represented in the secondary Martonyi klip) and the latter with moderately deep basinal limestones in the Esztramos near Bódvarákó and at the vicinity of Hídvégdó and Becskeháza.

The sequence of the Torna series is very similar to that of the Szőlősdó facies of the Bódva series belonging to the Silica series group, and therefore (despite their strong metamorphic difference) they are united by Kozur (1991) into the South Rudabányaikum that was subdivided by the Meliata Ocean from the North Rudabányaikum represented by the Bódva facies of the Bódva series. However, the Bódva and Szőlősdó facies are clearly interfingering in the borehole of Rudabánya 690 (Szentpétery, 1998) and, therefore they could not be separated by an ocean. However, the similarity of the Szőlősdó facies and the Torna series can be explained by their symmetrical position related to the axis of an existing ocean as well. At the same time the different metamorphic history can be explained by their opposite position at the time of oceanic closure: the Szőlősdó facies remained unmetamorphosed because it occupied an upper plate position at the active margin while the Torna series as part of the passive margin came into a lower plate position and, therefore became metamorphosed.

### Structural evolution

#### Formation of the primary nappe structure

The Middle Triassic to Middle Cretaceous structural evolution of the territory is reconstructed on six palinspastic profiles in Fig. 3A-F. Depositional areas on them refer to the aforescribed series and their partial

facies. As it can be seen from the profiles the structural development is described as having started with a rifting in the Late Anisian then with forming of the oceanic crust of the Meliata Ocean that started subducting and simultaneously obducting in the Jurassic. This means that an additional depositional area within the Meliata Ocean has to be distinguished that later completely subducted. The arrangement of particular depositional areas has been already more or less explained before. Its two crucial points are the location of the Meliata Ocean in the southern neighbourhood of the depositional area of the Silica series group (further northern continental margin) having possessed an external southern Gemic continental crust on the one hand and the location of the Torna depositional area (with a supposed Uppony type continental crust) to the south of the ocean on the other.

This arrangement can quite well explain the completely different degree of metamorphism of the Silica and Torna series groups because during the subduction of the Meliatic oceanic and thinned continental crust the first of them located in an upper plate position (thus did not metamorphose) while the other came into a lower plate position and metamorphosed. This arrangement induces also the northward subduction of the Meliatic crust and simultaneously its southward obduction (forming in this way the Meliata nappe - Fig. 3C-D - that was later mostly eroded or tectonically reworked into the basement of the later Silica nappe system) as well as the primarily southward overthrusting of the Silica nappe system. The recently observable northvergent character of the exhumed suture zone of the Bórka nappe has been caused by secondary processes (Mello et al., 1998) and also the occurrence of the Silica nappe system N of the Rožňava line on the Gemicum and Veporikum (Stratená and Muráň nappes) can be explained by later processes (Plašienka, 1997). As it is written by Mello et al. (1998, p. 271): "An idea about the southern dip of the suture ... is generally accepted [mostly by Slovak authors], though without unambiguous evidence". Thus the alternative model shown in Fig. 3 with northward dipping suture can be a subject of discussion, too.

The third crucial point in our reconstruction is the connection of some Gemic granites with a Jurassic/Cretaceous cooling age (Kováč et al., 1986) with the Middle/Upper Jurassic rhyolites of the Telekesoldal Complex in the Bódva series and with the Late Jurassic to Early Cretaceous ore mineralization in both the northern Gemic domain (Rojkovič et al. 1993) and the Rudabánya ore complex (Baksa, 1986) containing sanidin of volcanic origin (Nagy, 1982). They are all located in rocks belonging to the northern continental margin. Rhyolites in the Telekesoldal complex bear an island-arc character (Máthé & Szakmány, 1990) and all this acidic magmatism can be connected with partial melting of the Gemic crust caused by the northward subduction of the "Meliata ocean". The accumulation of Gemic granites might lead to the thickening of continental crust then to its isostatic emersion with forming an embryonal anticline with a dip of 2-3°-s on its wings that was enough to initiate the detachment of the Uppermost Permian to Jurassic rocks from the older Paleozoic basement along the thick,

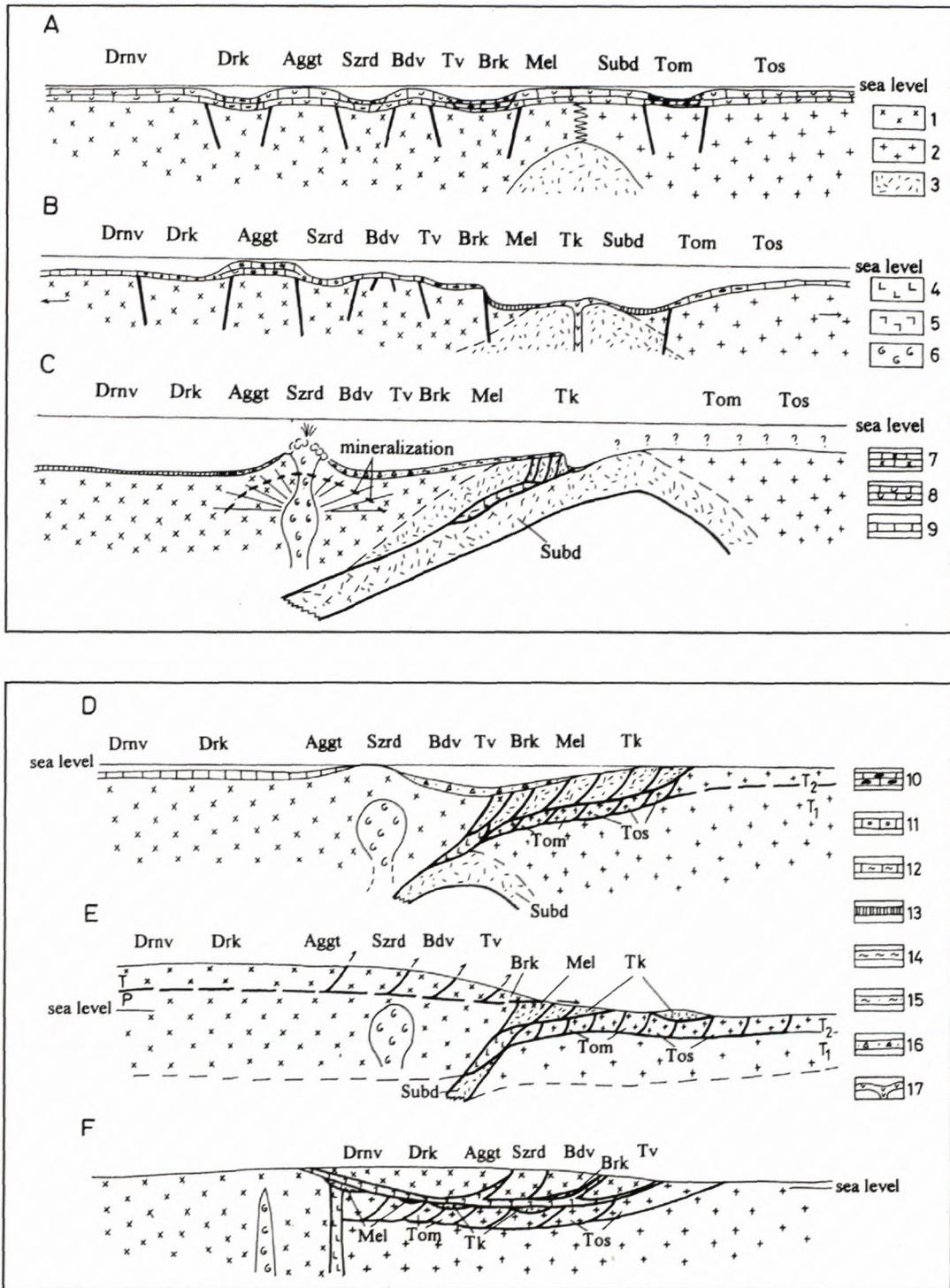


Fig. 3. – The process of forming of the primary nappe structure of the Aggtelek-Rudabánya Mts. and Slovak Karst during the Middle Triassic to Middle Cretaceous interval in a series of principal palinspastic profiles with no scale.

A: The last moment of the pre-rift stage in the Middle Anisian.

B: The oceanic stage in the Ladinian.

C: The process of subduction and simultaneous obduction in the Middle Jurassic.

D: The change of subduction/obduction to collision at the end of the Jurassic.

E: The beginning of overthrusting of the Silica nappe system in the Early Cretaceous.

F: The primary nappe system before starting the folding phase in the Middle Cretaceous.

Abbreviations for depositional areas (see also Fig. 2): Drnv: Drnava; Drk: Derenk; Aggt: Aggtelek; Szrd: Szőlőszárd; Bdv: Bódva; Tv: Telekesvölgy; Brk: Bódvarákó; Mel: Meliata (s.s.); Tk: Tornakápolna; Subd: Subducted; Tom: Torna, margin; Tos: Torna, seamount.

1. Extreme Southern Gemic crust, 2. Torna-Hídvégardó-Uppony type continental crust, 3. Meliatic oceanic crust, 4. glaucophanites, 5. the evaporitic basement of the Silica nappe system with tectonically reworked blocks of the Meliata series group, 6. Mesozoic granitoids, 7. reefal carbonates, 8. lagoonal carbonates, 9. red pelagic limestones, 10. grey cherty limestones, 11. limestones of slope facies, 12. marls, marly limestones, 13. radiolarites, 14. black shales, 15. sandy shales, 16. olistostromes, 17. basalts.

plastic evaporites (Fig. 3E). As a result, the detached Silica nappe system overthrust southward through the remnants of the Meliata nappe (mostly having reworked it) onto the Torna series and its Paleozoic basement, having formed in this way the primary nappe structure of the Aggtelek-Rudabánya Mts. (and also of the Inner West Carpathians). The different forms of acidic magmatism are also detached from each other: those located in Mesozoic rocks became overthrust while the others remained in the relative autochthon.

### The folding phase

Already the whole primary nappe structure was affected by the next main event of the structural evolution manifested in folding, imbrication and secondary nappe forming. The compression was of N-S direction (in recent co-ordinates, however an about 90° counter-clockwise rotation is detected by Márton et al., 1988) and first resulted probably in simple folds of great amplitude. These folds can be observed mainly in the Silica nappe system, however in the core of some antiforms (the Turňa valley window in Slovakia, the Esztramos and Bódvarákó windows in Hungary - the first in the Aggtelek while the second in the Rudabánya Mts.) deeper units of the primary nappe structure crop out, too. Southward from the axis of the Horný vrch (Felső-hegy) the vergency of these folds is ever more southern. Later, the continuing compression could be decompressed only in reverse faults of southern vergency (e.g. N of Szögliget, between Bódvaszilás and Silická Brezová or N of the Jósva valley, as well as several slices in the Rudabánya Mts.).

The formation of secondary nappes (klipps) of Derenk, the Alsó-hegy (Dolný vrch) and Éles-tető can be explained as the terminal movement of this folding event. These klipps are built up by wings and cores of synclines (of rocks belonging to the Aggtelek series) lying upon a huge anticline (Ménés valley anticline) in which thick evaporites of the same series crop out. In the course of forming this anticline, plastic evaporites could start to flow towards its core and then to form a huge diapiric dome that could thrust the neighbouring synclines aside, on top of each other. In the next stage the evaporitic dome could crop out in the surface and became free for rapid erosion. This latter could result in a deep depression onto which the blocks thrust away could slide back forming klipps in such a way.

During the Late Cretaceous to Middle Oligocene the territory was mostly a dry-land that was interrupted by a marine interval only in the Senonian as it is shown in Slovak territory (Mello & Salaj, 1982). This continental period is proven by resedimented bauxitic material found in some karstic holes near Aggtelek. Otherwise, this period is very poorly documented by rocks.

### The phase of lateral movements

The last main event of the structural evolution is linked with lateral displacements along the Darnó zone - as part of the movement of the whole ALCAPA terrane - beginning at the end of the Oligocene and spanning until about the end

of the Early Miocene. In this time the approaching Bükk and Szendrő Mts. - having started far from SW - mobilized those territories having lied that time still in the southern continuation of the Aggtelek Mountains. As a result these territories were dragged to north-eastern direction, to the eastern vicinity of the Aggtelek Mts., forming in this way the recent Rudabánya Mts. that are internally further subdivided by strike-slips of SSW-NNE direction of the Darnó zone. Three main segments can be distinguished from W to E, called Szőlősardó, Rudabánya-Tornaszent-andrás (further central) and Szuhogy-Becskeháza (further eastern) segments subdivided by strike-slips marked by 1 and 2 in Fig. 1. Before the lateral displacements these three segments followed each other from N to S that is shown also by the distribution of their Bódvaic facies in the Silica nappe system: the Szőlősardó segment bears the Szőlősardó facies, the Bódva facies can be found in the central segment while the Telekesvölgy facies (at the cemetery of Hídvégáró and in Žarnov) in the eastern segment.

However, their syntectonic Uppermost Oligocene to Lower Miocene facies are also different: two main depositional areas can be distinguished. Marine deposits with their coastal facies can be found in the southern margin of the Aggtelek Mts. and in the Szőlősardó and central segments of the Rudabánya Mts. (Bretka Limestone and Szécsény Schlier representing the Hungarian Paleogene Basin - see Báldi & Báldi-Beke, 1985), whereas in the eastern segment this time-span is represented by continental deposits (Szuhogy Conglomerate). Oligo-Miocene sediments with the configuration of their basins and their movements are described in detail by Szentpétery (1988).

According to the pre-Miocene distribution of the segments, the originally northernmost Szőlősardó segment arrived first at its recent place and hit against the Aggtelek Mts. on the line between Szőlősardó and S of Trizs. The stress caused by this (rather superficial) collision was decompressed in the Aggtelek Mts. by some N and NW vergent thrusts, one of which is shown in Fig. 1. to the NW of Tornakápolna.

At that time the central segment of the Rudabánya Mts. might have been still active and followed to have dragged towards NNE beside the Aggtelek Mts. along line 1 (in fact a shear zone) in Fig. 1. Simultaneously, some huge blocks were thrust aside, onto the neighbouring Aggtelek Mts., forming in this way the Lászi klipps (built up by Bódva facies) E of Szőlősardó. This central segment could hit against the Aggtelek Mts. in the vicinity of Bódvalenke (this zone is recently covered by Pannonian deposits). The energy of this collision could be worked off by plastic deformations in evaporitic rocks in the core of the joined Jósva- and Ménésvölgy anticlines between Bódvaszilás and Hídvégáró.

At the time of the consolidation of the central segment, the eastern segment of the Rudabánya Mts. (starting far from S and carrying already a continental Lower Miocene) was still active and followed to have dragged towards NE beside the central segment along line 2 in Fig. 1 that is in fact a shear zone from Rudabánya to N of Martonyi containing several subsegments. Huge blocks were thrust aside from this segment, too, onto the neighbouring central

segment, forming in this way the Martonyi klipp (built up by Torna series) between Martonyi and Tornaszentandrás. The emplacement of allochthonous bodies of the Torna series onto the Hídvégardó series in the Becskeháza area can also be related to these movements, however its mechanism cannot be explained in detail. The neighbouring territories of the eastern segment were also activated by its kinetic energy. A sinistral strike-slip of small amplitude between Martonyi and Bódvarákó can be observed in the central segment as well as NW vergent thrusts to the E of Bódvarákó. The eastern segment could hit against the Slovak Karst/Aggtelek Mts. in Slovak territory, between Turnianské Podhradie and Moldava nad Bodvou and was slowed down by ?Eocene to ?Oligocene deposits of the Šomodí Formation (Mello et al., 1997) and by evaporites in the core of the Turňa Valley anticline. An other effect of this slowing down was the westward movement of the northern part of the Aggtelek Mts./Slovak Karst mainly along two lines. One of them, the Ménes-völgy line is marked by 3 in Fig. 1. whereas the other one, the Rožňava line runs in Slovakia and in the Miglinc Valley contains Drienovec conglomerate of Miocene age in tectonically jammed position (personal observation).

The sinistral strike-slip in the Ménes-völgy was accompanied by complementary transtensive dextral movements (shown in Fig. 1) along which the already complicated structure of this territory (see at the description of secondary klipps in this zone) were split and the plastic evaporite of the tectonical foot-wall could be injected into the opened fissures.

However, in these movements along the Darnó zone, the Bükk and the Szendrő Mts. in its northern continuation (bordered from the Rudabánya Mts. by an other sinistral strike-slip covered by Pannonian) played the really active role. Unfortunately, the tectonical effects caused by their movements cannot be traced in detail because the crucial zones are covered by younger sediments.

At the time of consolidation of the territory in the Middle Miocene it became once again a dry-land. This period spanned until the Late Miocene when the Pannonian Lake ingressed into morphological depressions caused by erosion and brittle faults. These latter have also a younger generation that affected already the Pannonian deposits as well.

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