IGCP 572 field trip POST2
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LOWER AND MIDDLE TRIASSIC SUCCESSION IN AGGTELEK KARST

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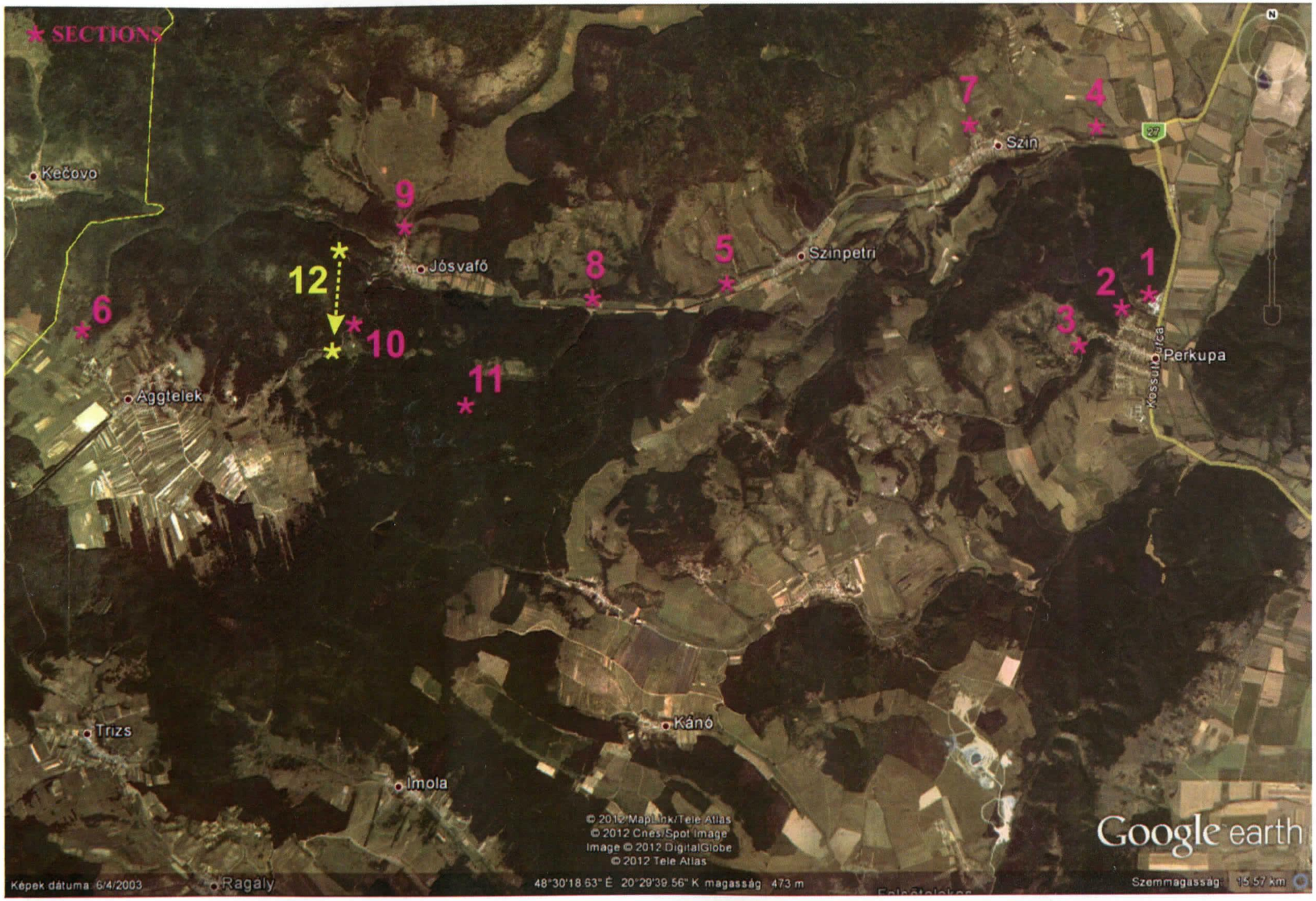
PERMIAN-TRIASSIC ECOSYSTEMS
IGCP572: Restoration of marine ecosystems following the Permian-Triassic mass extinction
LESSONS FOR THE PRESENT

MAGYARHONI FÖLDTANI TÁRSULAT – MENTE ET MALLEO – 1848

MAGYAR TUDOMÁNYOS AKADÉMIA 1825

MOL

AGGTELEKI NEMZETI PARK


* SECTIONS
Kečovo
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Jósvafő
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Aggtelek
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Szin
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Perkupa
Kossuth utca
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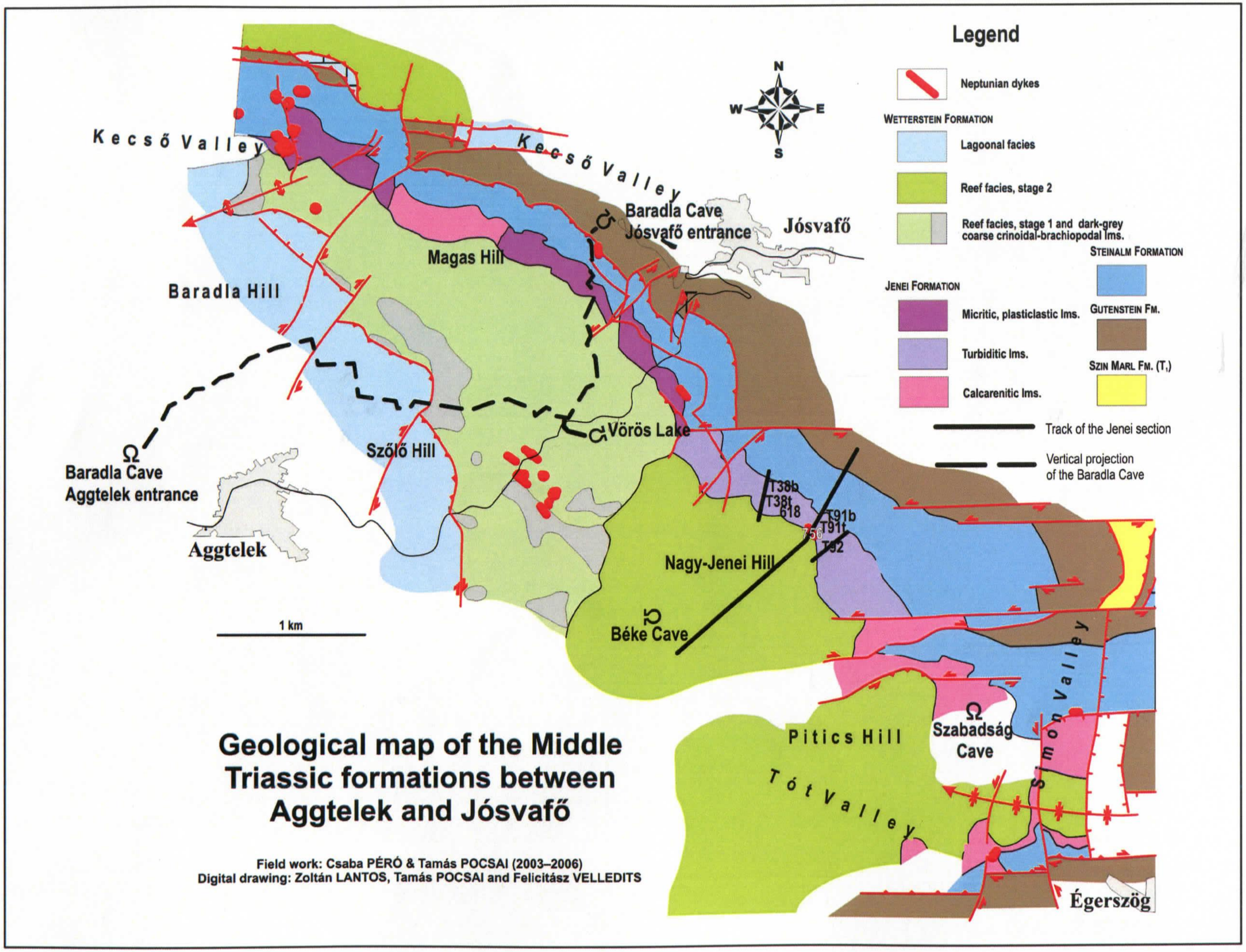
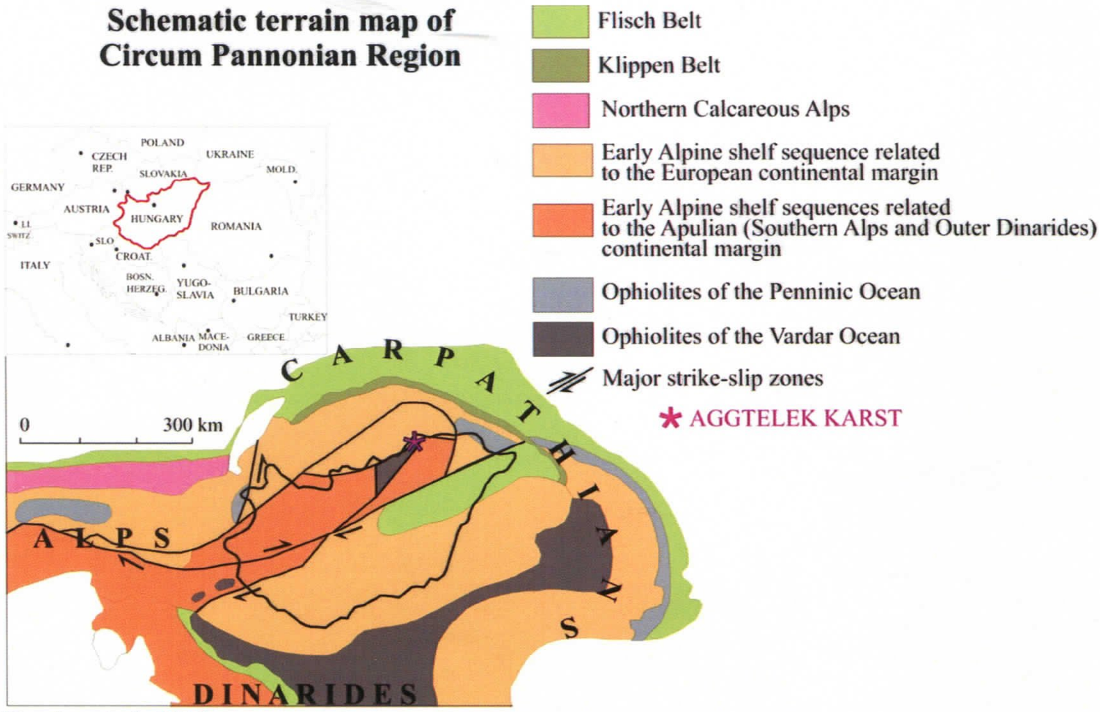
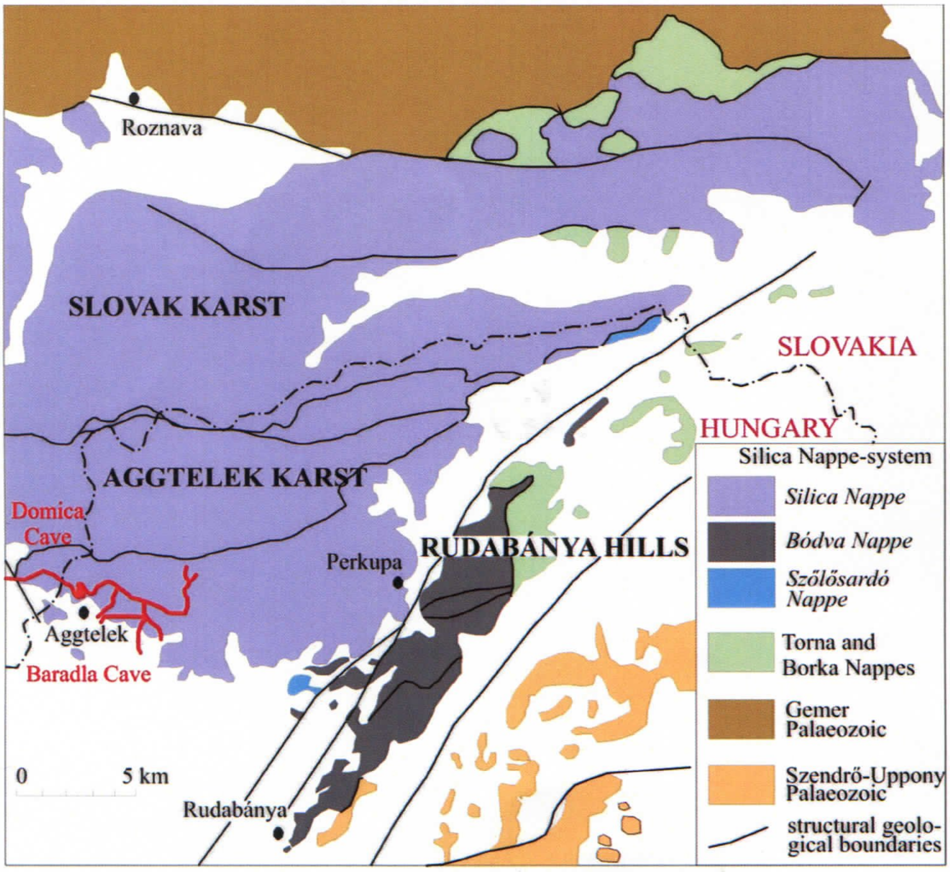
Google earth
Képek dátuma: 6/4/2003
Ragály
48°30'18.63" É 20°29'39.56" K magasság 473 m
Szemmagasság 15.57 km


Geological map of the Middle Triassic formations between Aggtelek and Jósvafő
Field work: Csaba PÉRÓ & Tamás POCSAI (2003–2006)
Digital drawing: Zoltán LANTOS, Tamás POCSAI and Felicitász VELLEDITS
Legend
Neptunian dykes
WETTERSTEIN FORMATION
Lagoonal facies
Reef facies, stage 2
Reef facies, stage 1 and dark-grey coarse crinoidal-brachiopodal lms.
STEINALM FORMATION
JENEI FORMATION
Micritic, plasticlastic lms.
Turbiditic lms.
Calcarenitic lms.
GUTENSTEIN FM.
SZIN MARL FM. (T_1)
Track of the Jenei section
Vertical projection of the Baradla Cave
N
S
W
E
1 km
Kecső Valley
Kecső Valley
Baradla Cave Jósvafő entrance
Jósvafő
Magas Hill
Baradla Hill
Vörös Lake
Baradla Cave Aggtelek entrance
Aggtelek
Szőlő Hill
T38b
T38t
618
T91b
T91t
750
T92
Nagy-Jenei Hill
Béke Cave
Pitics Hill
Szabadság Cave
Simon Valley
Tót Valley
Égerszög



Kovács et al. 2011.



Structural geological map of the South Gemer area (Less and Mello, eds, 2004).

Introduction

The field trip focus on the sedimentary and biota evolution in the course of Early and Middle Triassic following the end-Permian extinction event. The siliciclastic and carbonate rock succession exposed on the Aggtelek Karst provides an opportunity for better understanding of the scenario after the mass extinction; however, the bad exposure condition of the rocks is a great disadvantage. The recovery of the calcareous skeleton-secreting metazoan reef biota started only after a considerable gap.

Geological setting

The Aggtelek Karst constitutes a part of the southernmost unit in the Inner Western Carpathians. It is made up of the non-metamorphosed Silica Nappe, which extends across the Hungarian–Slovakian border through the Slovak Karst. The Silica Nappe was detached from its original basement. In the consequence of the subduction of the Neo-tethyan oceanic crust in the Late Jurassic, the series of the Silica began to thrust over from the pre-alpine basement on its own Permian–Lower Triassic evaporite base. During the overthrusting, the evaporitic base was strongly deformed and larger slabs of obducted ophiolites were imbricated inside the evaporite series forming an evaporitic mélange complex (Réti 1985).

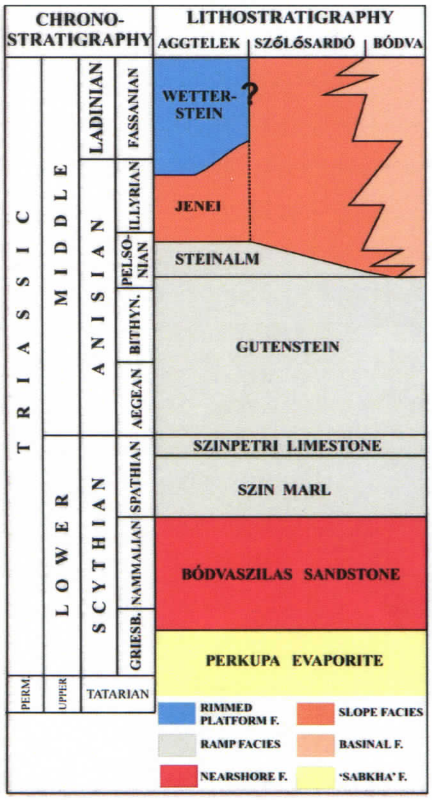
The formations of the Silica Nappe-system (including the Szőlősardó- and Bódva-Nappes) differ most sharply in their Ladinian–Middle Carnian formations that reflect intense block faulting and facies differentiation (Kovács, 1997): the Aggtelek facies is represented by platform succession, the Szőlősardó facies by slope and the Bódva facies by pelagic basin succession. The pre-rift formations are uniformly developed in all facies units; these are the Permian–Middle Anisian (Middle Triassic) shallow marine evaporite, siliciclastic and carbonate deposits. The first sponge–'*Tubiphytes*' reefs appeared already in the Late Anisian (Scholz 1972; Velledits et al., 2011; Senowbari-Darian et al., 2011), and were represented by 400–600 m thick massive limestone of Wetterstein Formation (terminology is used from the appearance of reef limestone). Reef building organisms include '*Tubiphytes*', calcareous sponges, corals and hydrozoans.

Lower Triassic stratigraphy

The Upper Permian–Lower Triassic sequence can be subdivided into four formations: the Perkupa Evaporite, Bódvaszilas Sandstone, Szin Marl and Szinpetri Limestone (Kovács et al. 1989; Hips 1996, 1998). The thickness of the Lower Triassic sequence is about 650–700 m, without the evaporate series.

- The **Perkupa Evaporite Formation** (*not visited*) consists dominantly of anhydrite and subordinately gypsum, dolomite, siltstone and shale. It is very poor in fossils, but it can be presumed that the age of the formation is Upper Permian and lowermost Scythian (Griesbachian) and, thus, the Permian–Triassic boundary is located in its upper part. Fossils are: *Triadispora* sporomorph association (Barabás-Stuhl, 1981) and foraminifers, such as *Cyclogyra*? *mahajeri–Rectocornuspira kalhori* and *Meandrospira pusilla*.
- The **Bódvaszilas Sandstone Formation** (Nammalian) consists of alternation of dominantly red sandstone, siltstone and shale. In its uppermost part, red oolite marker bed appears. Thickness of the formation is approximately 200–250 m. Despite the prevalence of rocks of

finer grain size in the lower part of the succession, and of rocks of coarser grain size in the upper one, markedly different members cannot be distinguished within the formation. The faunas of the two parts are different. Index fossils are *Claraia clarai*, *C. aurita* in the lower part and *Eumorphotis hinnitidea* and *Eumorphotis* sp. (cf. Broglio Loriga and Mirabella 1986), *E.* gr. *multiformis* in the upper part. Other fossils are: *Unionites canalensis*, *U. fassaensis*, *Neoschizodus ovatus*, *N.* cf. *laevigatus*, *Bakevellia* sp. and *Lingula tenuissima*. The sediments were deposited in the nearshore zone of the shelf.



Lithostratigraphic subdivision, not to scale (Kovács et al. 1989, Hips 1998, Velledits et al. 2011).

- The **Szin Marl Formation** is made up dominantly by grey silty limestone, and additionally, red or varicoloured oolite, grey crinoidal limestone, beige marl, red sandstone and siltstone also occur. The thickness of the formation is about 350 m. The upper Olenekian (Spathian) age is proved by *Tirolites cassianus, T. illyricus* and *T.* gr. *carniolicus.* Other fossils are as follows; foraminfers: *Glomospira–Glomospirella* association, *Meandrospira pusilla*, *Cyclogyra*? *mahajeri–Rectocornuspira kalhori*; gastropods: *Natiria costata*, *'Turbo' rectecostatus*, *Purpuroidea* (?) *minioi*, *Coelostilina werfensis*, *Holopella gracilior*, *Naticopsis gaillardati*, *Natica* sp.; bivalves: *Eumorphotis kittli*, *E. telleri*, *E. reticulata*, *E.* cf. *tenuistriata*, *Scythentolium tyrolicum*, *Costatoria costata*, *Avichlamys tellini*, *Unionites canalensis*, *U. fassaensis*, *Neoschizodus ovatus*, *N.* cf. *laevigatus*, *Bakevellia* sp., *Leptochondria albertii*, *Entolium discites*, *'Homomya'* sp.; ammonoidea: *Diaplococeras liccanum*, *Dinarites dalmatinus*, *Dalmatites morlaccus*; conodonts: *Hadrodontina–Elisonia–Parachirognatus* association; others: *Spirorbis phlyctaena* and echinoderm fragments. The sediments were deposited on a homoclinal ramp from the inner ramp zone down to the deep ramp areas.

- The **Szinpetri Limestone Formation** is composed dominantly of dark grey nodular, bioturbated limestone and subordinately of marl and clayey marl. Thickness of the formation is about 100 m. Based on *Stacheites* cf. *floweri* and *Eumorphotis* sp. its age is uppermost Olenekian (upper Spathian). Other fossils are as follows; foraminfers: *Glomospira sinensis, Meandrospira pusilla, Cyclogyra*? *mahajeri–Rectocornuspira kalhori*; gastropods: *Natiria costata, 'Turbo' rectecostatus*, bivalves: *Costatoria costata, Bakevellia* sp. and echinoderm fragments. The deposits were formed in deep ramp zone.

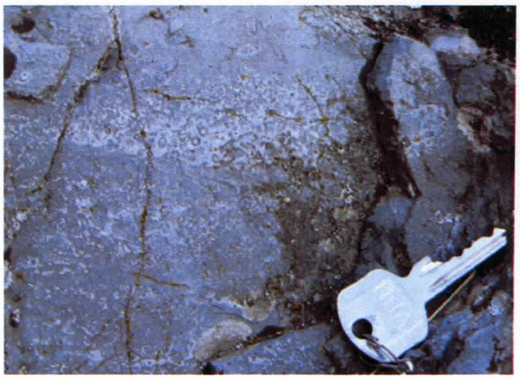
Middle Triassic stratigraphy

The Middle Triassic carbonate sequence is subdivided into several formations: Gutenstein Limestone, Steinalm Formation, Jenei Formation, Wetterstein Limestone (Kovács et al. 1989; Velledits et al. 2011).

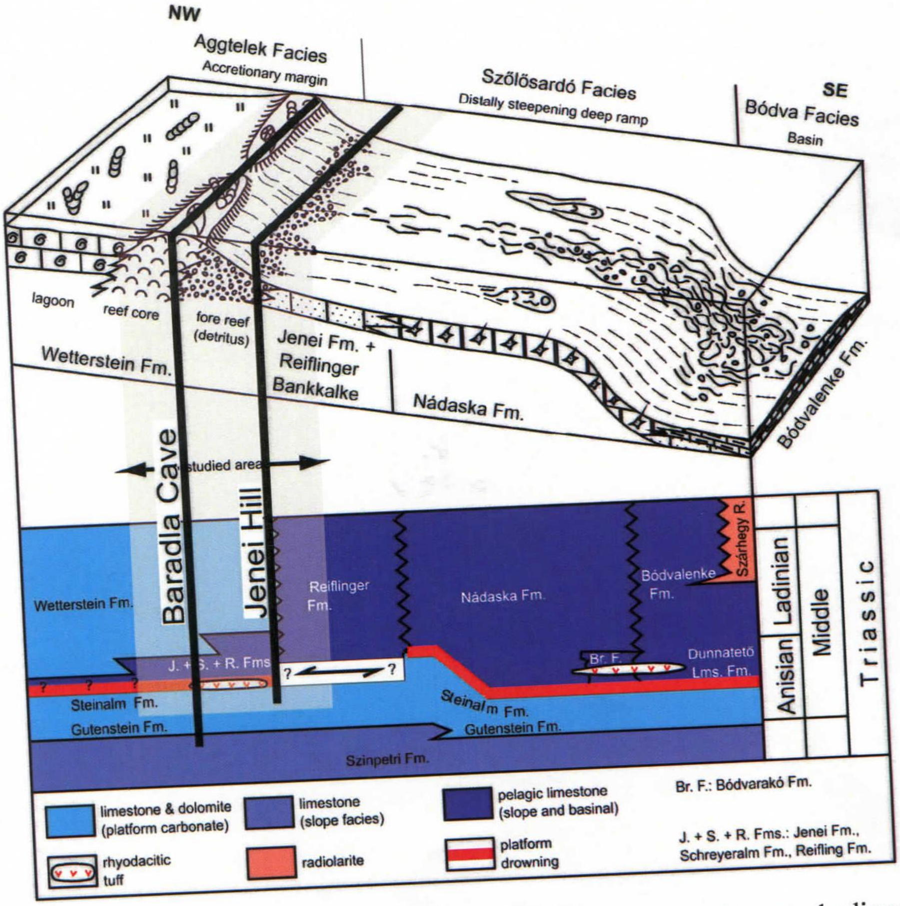
- The **Gutenstein Limestone** consists of dark grey to black dominantly micritic limestone and clayey dolomite that can be subdivided into two members: the lower Jósvafő Limestone and the upper Annaberg Limestone. The lower member is typified by dark grey mudstone with a few bioclastic packstone interlayers *c*. 300 m in thickness. It is extremely poor in fossils. Its uppermost beds contain foraminifera *Glomospira densa* (Pantić) that constrains Middle Triassic, the late Early Anisian age (cf. Rettori et al., 1994). The upper member is made up of black, dark or light grey various limestone and dolomite, 170 m in thickness. Six principal facies types were distinguished and most of them repeatedly occur (Hips, 2007). The observed fairly regular recurrence of the facies types suggests cyclic deposition. Each cycle exhibits a deepening- and shallowing-upward unit and their stacking pattern suggests a larger-scale shallowing-upward trend. The total absence of dasyclad algae and prevalence of microbes and sponges may have been controlled by extreme environmental conditions, i.e. hypersalinity. Foraminifers, thin bivalve shells, micro-gastropods, echinoderm fragments, ostracodes, spirorbid worms are present. The foraminifera association indicates the Pelsonian age of the member. The deposits of the lower part were formed below storm wave base in a restricted deep trough and succession of the upper part deposited in the inner ramp zone.

- The **Steinalm Formation** consists dominantly of light grey stromatolite, dasycladal packstone–grainstone, crinoidal limestone, oncoidal dolomite and massive dolomite, 150 m in thickness. Characteristic fossils are dasyclad alga, *Physoporella pauciforata, Diplopora hexaster, Oligoporella pilosa* and foraminifers *Meandrosipa dinarica* (Piros, 1986). The flora association refers Pelsonian age of this unit. The carbonates deposited in shallow subtidal and the connected peritidal zones. During the subaerial exposure dolomitization took place.

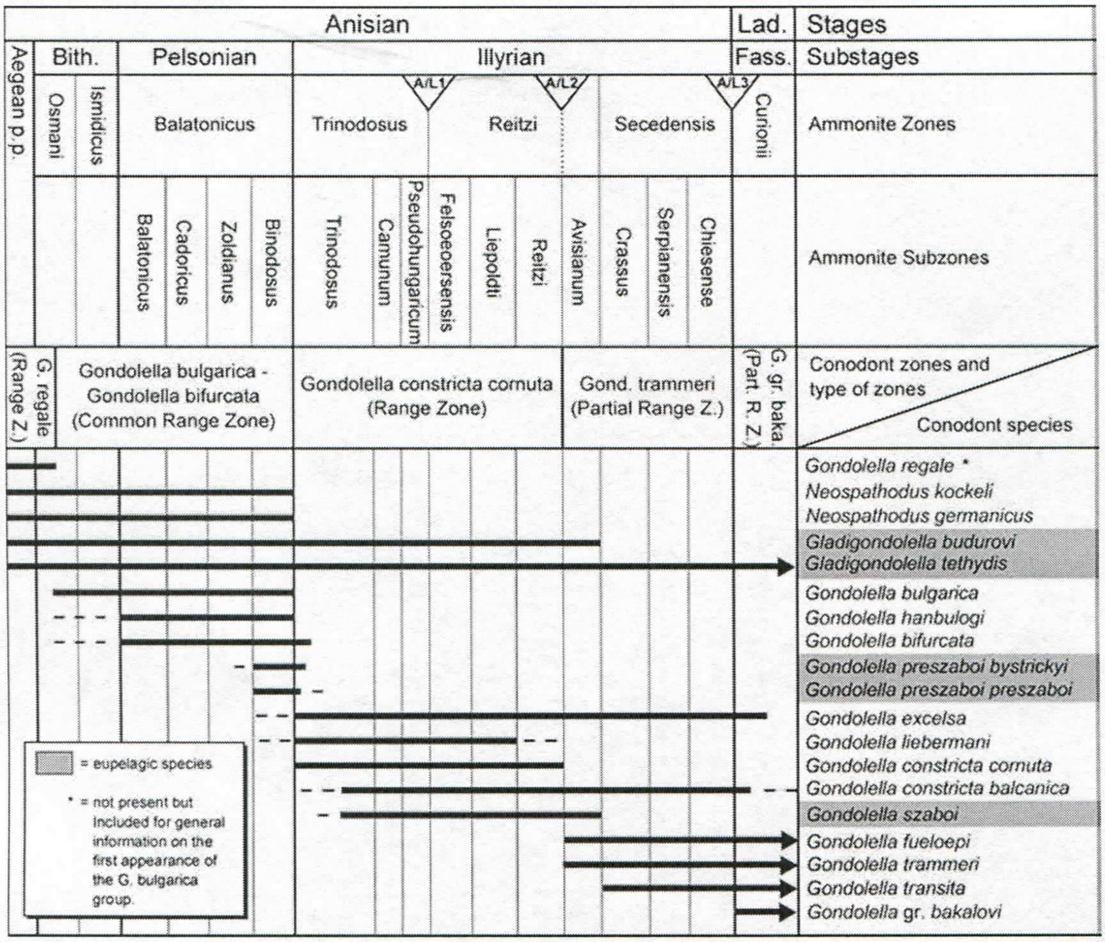
Typical weathered surface of the dasycladal limestone (Photo: O. Piros).



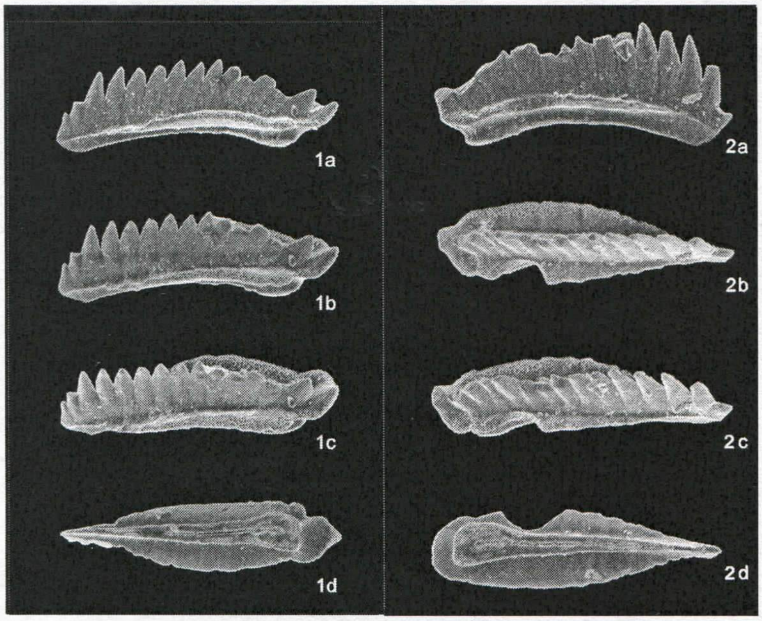
- The **Jenei Limestone** is typified by thick bedded, pink, reddish, sometimes greyish micritic limestone, rich in coquinas, which alternates with thick-bedded, fine calcarenitic limestone. Turbiditic calcarenite with platform detritus are more frequent upwards. Fossils are as follows: thin-shelled bivalves, brachiopods, conodonts, radiolaria, siliceous sponges, crinoid fragments, foraminifers and reef detritus. Thickness of the formation is approx. 40–80 m in the NW area and up to 140 m in the SE. In the NW (Baradla Cave section), the lowermost bed contains conodonts of Binodosus Subzone (Pelsonian, Middle Anisian): *Gondolella bulgarica, G. hanbulogi, G. bifurcata, G. preszaboi bystrycky, G. preszaboi preszaboi* and *G. bulgarica–G. excelsa* transitional forms. The upper beds contain conodonts from the Trinodosus–Reitzi Subzones (Illyrian, Upper Anisian): *Gondolella szaboi, G. excelsa, G. liebermani, Gladigondolella tethydis*. In the SE (Nagy-Jenei Hill section), the lowermost beds contain rich mixed conodont fauna of Binodosus–Trinodosus–Reitzi Subzones and the uppermost layer contains conodonts from the Curionii Zone (Fassanian, Lower Ladinian) *G. constricta* juv., *G. fueloepi, G. trammeri, G. 'transita/pseudolonga'* and *G.* gr. *bakalovi*. The sediments were deposited mainly on a distal slope, but reef detritus supply was abundant during the reef progradation that was deposited on the proximal slope, in front of the reefs.



Middle Triassic facies model (Kovács 1997, Velledits et al. 2011). Light grey shading indicates the study area.



Range chart of selected conodont species, compiled by Velledits et al. 2011.

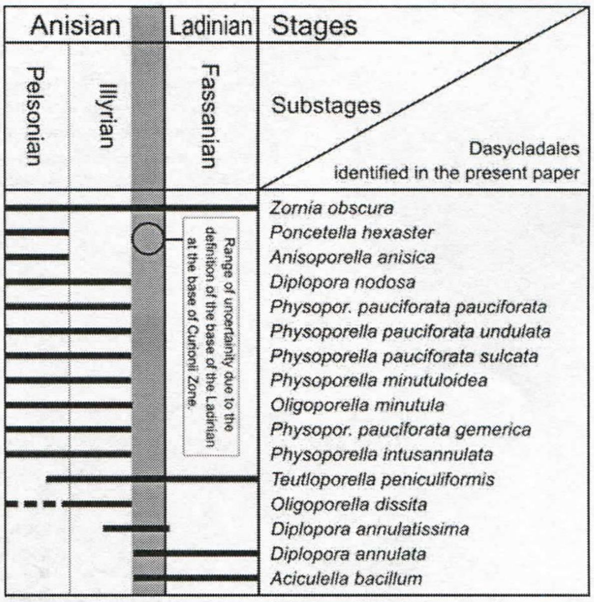


Conodonts from Baradla Cave. 1a–d. *Gondolella bulgarica*. Sub-adult ontogenetic stage, (ammonoid bed). a) lateral view, b) upper-lateral view, c) lateral-upper view, d) lower view. All 60x. 2 a–d: *Gondolella bystrickyi*. Medium ontogenetic stage, (ammonoid bed). a): lateral view, b) slightly lateral-upper view, c) lateral-upper view, d) lower view. All 60x (Velledits et al. 2011).

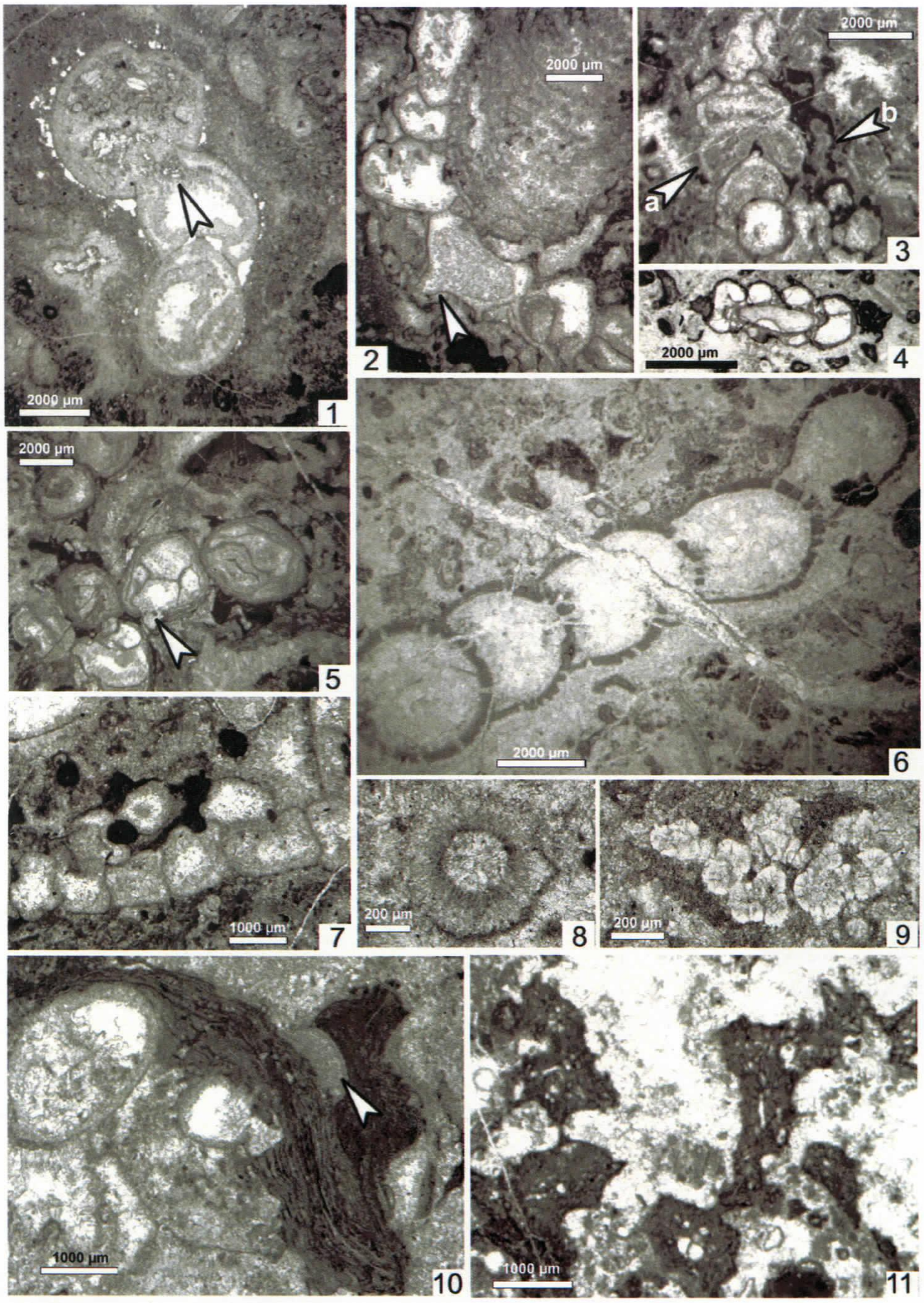
➢ The **Wetterstein Limestone** is typified by bedded or massive, light grey limestone and dolomite. Two stages of thick series of 'Tubiphytes'–calcareous sponge reefal deposits were distinguished (Scholz 1972, Kovács et al. 1989, Piros 2002; Velledits et al. 2011, Senowbari-Darian et al. 2011). The calcareous sponges, Sphinctozoans, were the main reef building organisms, such as *Celyphia zoldana, C. minima, Colospongia catenulata, Folicatena cautica, Olangocoelia otti, Solenolmia manon, Thaumastocoelia dolomitica, Vesicocaulis oenipontanus* and some microproblematica, like '*Tubiphytes*', *Ladinella porata, Radiomura cautica, Plexoramea cerebriformis, Baccanella floriformis, Bacinella ordinata,* occur as well. Corals were subordinate. Characteristic flora of inner platform–lagoonal facies includes *Diplopora annulata annulata, Aciculella bacillum, Zornia obscura* which indicates Upper Anisian (Illyrian)–Ladinian age (Bystricky 1986). The foraminifers are also typical in this facies, such as *Trochammina almtalensis*, *T. alpina*, *Earlandinita oberhauseri*, *Diplotremina astrofimbriata.*

Diplopora annul. annulata, Photo: O. Piros.

Oligoporella dissita, Photo: O. Piros.



Range chart of selected dasycladales species (modified after Piros 2002).



Reef building organisms. Porifera: 1. *Celyphia*? *minima*. Section through three chambers. Arrow shows the osculum at the top of the middle chamber. 2. *Celyphia?* sp. Arrow indicates the rimmed osculum cut in one chamber. 3. *Celyphia zoldana* (arrow a) is colonized by a specimen of *Colospongia* sp. (arrow b). 4. *Vesicocaulis oenipontanus*. This is the earliest sponge and occurs immediately above the radiolarite layer. 5. *Follicatena cautica*. Specimen exhibits vesicular filling skeleton within the chamber interiors. A sieve-like opening (cribribullum) is cut in the wall of the middle chamber (arrow). 6. *Celyphia zoldana*. The dark circles with a white point in the center are specimens of *Anisophytes aggtelekensis*. 7. *Colospongia catenulata catenulata*. Section through six chambers exhibiting the well-perforated chamber walls. Microproblematica: 8. *Radiomura cautica*. 9. *Baccanella floriformis*. 10. Sponge encrusted by *Aggtecella hungarica*. Arrow indicates an undetermined organism which colonized *Aggtecella* and is overgrown by *A. hungarica*. 11. '*Tubiphytes*' *multisiphonatus*. Cross-sections through several 'thalli' that are laterally connected (Velledits et al. 2011).

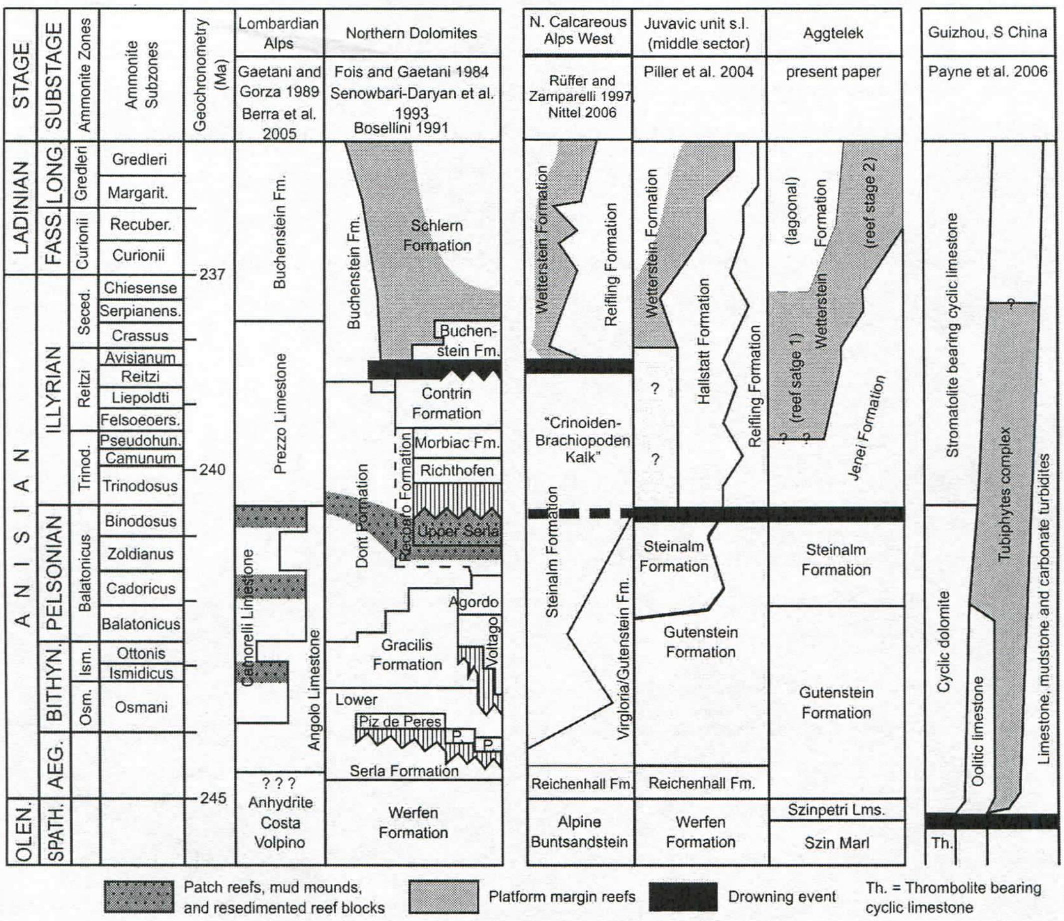
Details of reef deposits:
On the southern part of the Aggtelek Plateau, two Middle Triassic reef bodies can be found: stage 1: lower?–middle Illyrian, stage 2: upper Illyrian–Ladinian, which differ from each other in age, in geographical setting and slightly in fossil content. Both reef bodies are interpreted as platform margin reefs. From the middle Illyrian until the Early Ladinian, a heteropic basin can be traced in front of reef stage 1 while in the late Illyrian–Ladinian a lagoon existed behind reef stage 2. Both reef community consists mainly of segmented sponges (Sphinctozoans), calcimicrobes, bryozoans, gastropods and foraminifera. The fossils are characteristic of the Wetterstein-type reef communities, although several typical Wetterstein sphinctozoan taxa have not been found in the studied association, i.e. *Alpinothalamia bavarica, Uvanella irregularis, Stylothalamia dehmi, Cryptocoelia zitteli* and almost all species of *Vesicocaulis* except for *V. oenipontanus*.

The reef facies is characterised by two microfacies types. The first consists of bafflestone–bindstone with a micritic–pelmicritic matrix, in which reef-building organisms, sponges, microproblematicas, calcimicrobes, bryozoans, gastropods and foraminifers can be found. The reef-building organisms are sometimes coated by crusts of different origin. The stromatactis are filled by different generations of calcite cements. The second microfacies type is characterised by a sparry calcite cement with fossils (*'Tubiphytes'*, *Plexoramea cerebriformis*, echinodermata fragments with micritic envelopes, gastropods, bivalves, foraminifers, ostracodes, dasycladaleans and rarely segmented sponges), fossil fragments and intraclasts.

In the NW part of the studied area, the reef is 700 m thick and can be followed over a distance of 3.5 km on the edge of the platform next to the basin. The reef development (stage 1) starts with a crinoidal bedset, less than 80 m thick, which corresponds to the stabilisation stage. The reef development was twice interrupted by deeper water events resulting in dark-grey crinoidal–brachiopodal limestone. The conodonts (*Gondolella fueloepi, G. trammeri*) from the lower intercalation indicate an age interval the Avisianum Subzone–Secedensis Zone (end of the Illyrian). After the first deep water event, the reef recovered for a short time until it was finally terminated by a second deep water horizon, the age of which is unknown. Dasycladaleans are present only in reef stage 1. *Physoporella pauciforata sulcata* and *Ph. paucif. pauciforata* indicate Pelsonian–middle Illyrian age, whereas *Diplopora annulatissima* indicates middle Illyrian–base of Ladinian. Deep water intercalations with brachiopods and neptunian dykes were found only in reef stage 1. The basal portion of the lower crinoidal–brachiopodal unit is frequently cut by neptunian dykes, filled by red crinoidal limestone. The conodont faunas from the neptunian dykes prove the age Avisianum Subzone or younger (*Gondolella excelsa, G.* cf. *szaboi* and *G. trammeri*). We consider that the age of the dykes might be middle Illyrian (Avisianum Subzone), because the later stepping-in species like *Gondolella transita* or *G.* gr. *bakalovi* are missing. Reef stage 1 is overlain by upper Illyrian–earliest Fassanian lagoonal limestone (*Diplopora annulata* with *D. annnulatissima).*

Differently from this, in the SE part of the studied region, a basin existed (Jenei Formation) from the late Pelsonian (*G.* gr. *bulgarica*) until the early Ladinian *(G. transita/pseudolonga, G.* gr. *bakalovi).* During the late Illyrian–Early Ladinian the reef prograded to the SE, where the reef stage 2 was established. Its thickness is at least 550–590 m. Compared to reef stage 1 the reef cores are much larger and densely packed with reef-building organisms. The thick, coarse crinoidal bedset, forming the base of the reef stage 1, is absent here.

The evolution of the lower part of the reef is in accordance with the model of James (1983), who stated that the life of a reef basically consists of four stages. They recognised that for each stage another community dominates, and the reef building communities replace each other as time goes by. During the first stage the pioneer organisms, in our case the crinoids settle down. The roots or holdfasts of the crinoids bind and stabilise the substrate. In that way they prepare the ground for the settlement for the real reef building organism.



Well known selected reefs which appeared after the P/T extinction event. Correlation chart of the Olenekian–Early Ladinian formations from different parts of the Paleo-Tethys and Neo-Tethys Ocean. Dark grey shading with dots indicates small patch reefs, mud mounds and biostromes. Light grey shading indicates the platform margin reefs. A black line indicates the tectonic events preceding the formation of the extensive platform margin reefs while other parts of the former ramps subsided. This way vertical differences were created between platforms and basins, which were favourable for the formation of platform margin reefs (Velledits et al. 2011).

Overview of the reef recovery after the end Permian extinction event, and the place of the Aggtelek reef within this process

The end-Permian extinction event caused a sudden worldwide disappearance of reefs. The recovery of the reefs started only after a considerable gap. The subsequent Triassic reef ecosystem underwent a three-step development (Flügel 2002). The process started with microbial reefs in the Scythian (this stage is missing from the Aggtelek succession), and was followed by metazoan reefs. In the late Anisian–Carnian the metazoan reefs are represented by Wetterstein reefs and in the Norian–Rhaetian by the Dachstein reefs. Wetterstein reefs are characterised by the dominance of the segmented calcisponges (sphinctozoans). During the late Carnian–early Norian interval most of the fossils belonging to the Wetterstein reef community died out and new species belonging to the Dachstein reef community appeared. The Dachstein reefs are characterised by the dominance of corals (Riedel 1990; Flügel 2002; Velledits 2008).

The metazoan reef recovery started after a 4–6 million years gap (Lehrmann et al. 2002) following the P/Tr extinction event. Taking into consideration the extension, with respect to the life span of the Lower Triassic–Early Ladinian reefs two large categories can be distinguished.

1. Small reefs: such as patch reefs, biostromes, reef/mud-mounds. Small Anisian reefs are known from the Southern Alps and from the Dolomites (e.g. Fois and Gaetani 1984, Senowbari et al. 1993), Lombardy (Berra et al. 2005, Gaetani and Gorza 1989) and from the German Triassic (Szulc 2000). The diameter of these small reefs never exceeds 100 m and on average it is between 20 cm and some ten metres. The basement on which these small reefs were formed was never differentiated to any significant extent. They were mainly formed on the middle–lower part of the ramp. The lifetime of these small reefs was short and only episodic in geological terms.

2. Huge Late Olenekian–Early Ladinian platform margin reefs are known from SW China (Payne et al. 2006a,b), the Western Carpathians: Aggtelek Karst (Hungary; however, the Early Triassic stage is missing here), the Northern Calcareous Alps (Brandner and Resch 1981, Piller et al. 2004) and the Dolomites. In the Dolomites, after the Anisian/Pelsonian small reefs, large platform margin reefs appeared from the late Illyrian (Bosellini 1991, Flügel 2002). All these reefs were formed on platform margins, in the neighbourhood of deep basins. According to Payne et al. (2006) in South China there was a 400 m relief between the reef complex and the adjacent basin. Bosellini gives a 700–800 m maximum depth for the Buchenstein Formation. These reefs existed over longer periods, i.e. for a duration of several millions of years.

Extensive platform margin reefs appeared in three steps during the latest Olenekian–Anisian. 1. South China, 2. Western Carpathians–Eastern Alps, 3. Southern Alps. The differentiation of the basement obviously preceded the formation of the platform margin reefs. In China, this happened in the latest Olenekian (Payne et al. 2006), in the Western Carpathians–Northern Calcareous Alps in late Pelsonian (late Binodosus Subzone, Reifling event) and in the Dolomites in the Illyrian (Reitzi Zone, Brack and Muttoni 2000).

Connection between the opening of the Neo-Tethys Ocean and the Triassic reef recovery

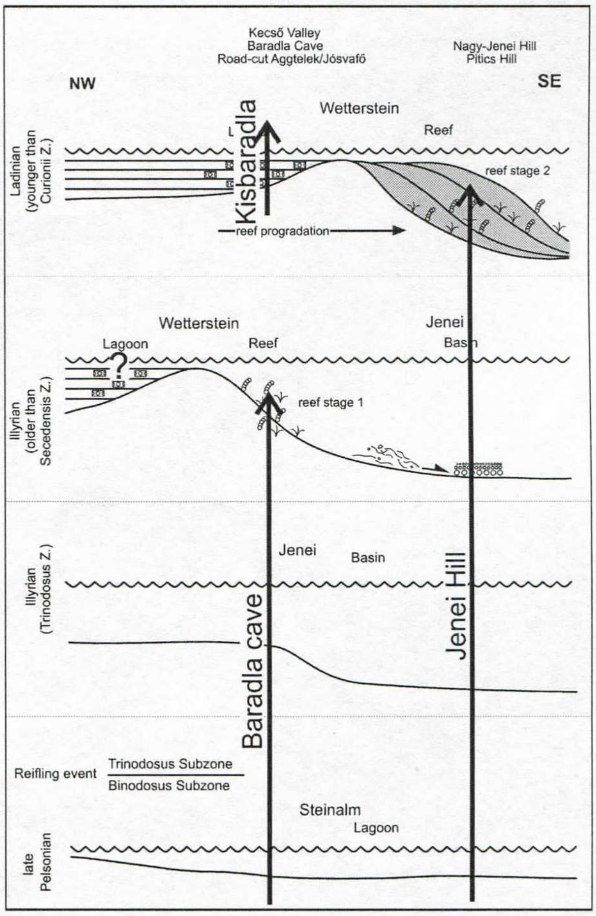
Already Flügel (2002) stated that there was a connection between the Lower–Middle Triassic reef recovery and the opening of the Neo-Tethys Ocean. Platform margin reefs appeared only after a considerable differentiation of the sea floor. The undifferentiated sea floor can be a credible explanation why in the Pelsonian only small patch reefs were formed on the middle–lower part of the ramp in the Dolomites and why the extended platforms in Lombardy were not colonised by a reef community. If we consider the time of the appearance of the large platform margin reefs on the northern shelf of the Neo-Tethys Ocean the statement of Flügel (op. cit.) seems to be true. On the Northern shelf of the opening Neo-tethys the large platform margin reefs appeared earlier on the East than on the West. This is most probably due to the successive opening of the Neo-Tethys Ocean which also propagated from east to west.

Advantages and disadvantages of the Aggelek reef

In Aggtelek area, the transition between the underlying unit (Jenei Formation) and the Aggtelek reef (Wetterstein Formation) is revealed in the subsurface in the Baradla Cave and on the surface in a road-cut section. Unfortunately the study of the transition is restricted by dripstone covering the cave wall and the rock is frequently recrystallised. Although well-preserved reef organisms can be observed on the weathered surface of the rock, but because of recrystallization the inner structure of the fossils can only rarely be observed. Continuous outcrops are also missing on the surface. Consequently the formation of the reef can be followed only roughly step-by-step. Despite these unfavourable conditions the reef has the great advantage that its exact age can be determined with the help of conodonts originating from the underlying and intercalating deep water limestone.

Evolution of the Aggtelek platform in the Middle Anisian–Early Ladinian

In the late Pelsonian, the uniform Steinalm Platform was drowned and dissected due to the Reifling event (Schlager & Schöllnberger 1974). A connection with the open sea was established, indicated by the appearance of gladigondolellid conodonts from the early Illyrian. Basins and highs were formed. In the NW part of the studied area, lower–middle? Illyrian basinal carbonates were followed by a platform margin reef (reef stage 1) developed on a morphological high. This is the oldest known Triassic platform margin reef within the Alpine–Carpathian region. The reef association is dominated by sphinctozoans and microproblematicas. The fossils are characteristic of the Wetterstein-type reef communities. Differently from this, in the SE part of the studied region, a basin existed from the late Pelsonian until the end of Illyrian. During the late Illyrian–Early Ladinian the reef prograded to the SE, where reef stage 2 was established. Meanwhile, on the NW part of the platform a lagoon was formed behind the reef. Synsedimentary tectonics were detected in the 1. Binodosus Subzone, 2. Trinodosus Zone, the most part of the Reitzi Zone, 3. Avisianum Subzone.

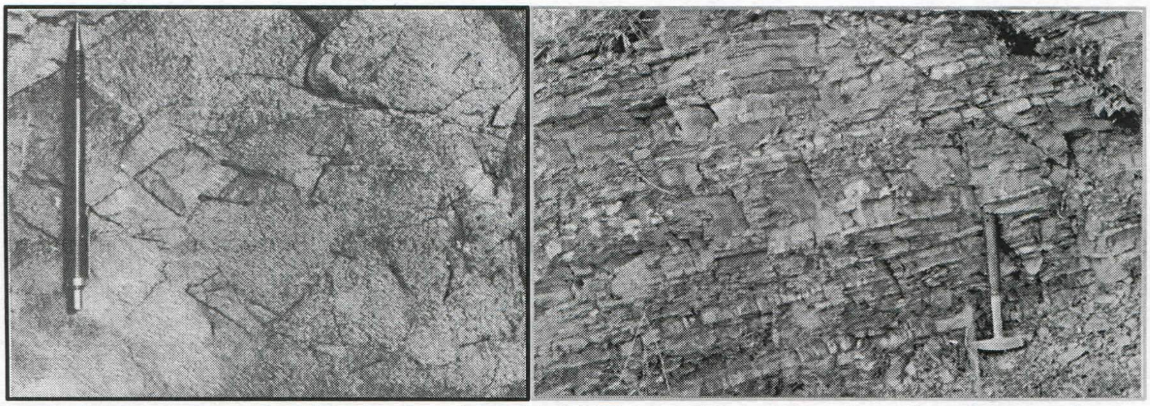


Schematic sketch of the evolution of the Aggtelek platform in the Middle Anisian–Early Ladinian. Arrows inditace outcrops to be visited during the field trip. In the late Pelsonian, the Steinalm Platform drowned and the basement was differentiated. In the studied area, a basin and a topographic high originated. Later in the middle Illyrian, to the NW on the edge of a morphological high a platform margin reef (reef facies, stage 1) developed. During the late Illyrian–early Ladinian the reef prograded into the Jenei Basin forming reef facies, stage 2. Meanwhile on the NW part of the platform behind reef facies, stage 2 a lagoon was formed. Note: the question mark in the Illyrian paleogeographic reconstruction indicates a facies (Wetterstein lagoon) which is not present in the studied area (Velledits et al. 2011).

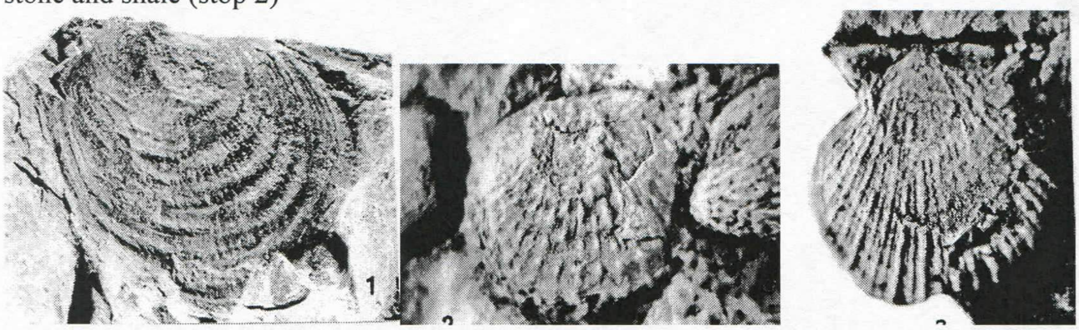
June 5, 2012.

Stop 1. Perkupa, abondant quarry

The lower part of the Bódvaszilas Formation is made up dominantly by the alternation of red and green micro-cross laminated sand-streaked siltstone, parallel laminated silt-streaked shale and shale occasionally with small pore-filling calcite as pseudomorphs after evaporite-aggregates. Bedding surfaces of shale are covered by desiccation polygons, that of the siltstone by wrinkle marks. Thin graded sandstone layers with erosional lower surfaces commonly form intercalations. In addition, thinner packages of cross-laminated fine sandstone, covered by ripple marks and thin clayey flasers, also occur. Bivalve coquinas in thin lenses are common and in certain horizons the finer deposits are densely penetrated by thin vertical U-shaped burrows. The sediments were deposited in the nearshore zone and on the related tidal flat. In this section, *Claraia* and other pelecypods can be collected.



A: Wrinkle marks on bedding surface (stop 1). **B**: Thin-bedded alternation of sandstone, silt-stone and shale (stop 2)



A: *Claraia clarai* (stop 1). **B**: *Eumorphotis hinnitidea* (stop 2). **C**: *E. multiformis* (stop 2).

Stop 2. Perkupa, near the cemetery

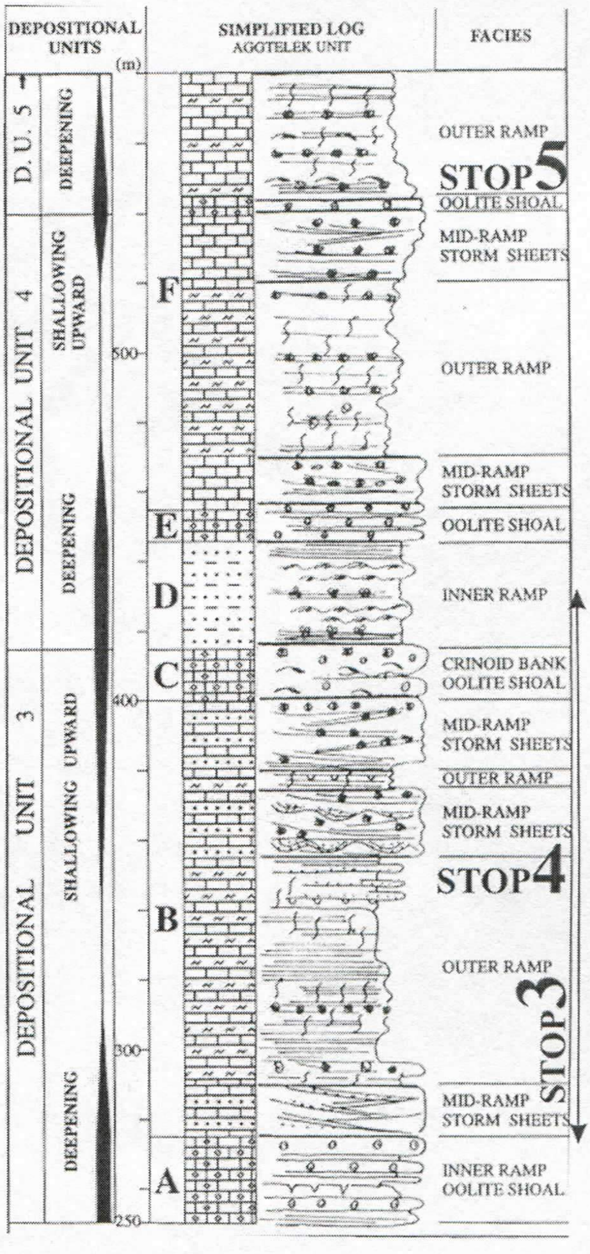
The upper part of the formation is characterized by alternation of brownish red planar laminated or hummocky cross-stratified sandstone, massive or parallel laminated siltstone and shale. The coarser deposits dominate, and the thicker the sandstone layers are, the thinner the siltsone and shale are between them. The thicker sandstone beds are sharp, flat based and massive, without showing any internal structure in their lower part. In the graded, upper part of the beds, silty sandstone and siltstone alternate in thin planar laminae. The thin bedded sandstone is graded. The thicker sandstone layers form ball-and-pillow structures. Bivalve coquinas form several thin horizons. Bioturbation is visible only in the finer sediments. The sediments were deposited is nearshore zone, whereas planar, hummocky cross-stratified and graded sandstone was formed as storm sheets and finer sediments were deposited from suspension after cessation of storms.

Ball-and-pillow structures indicate rapid storm-induced redeposition of relatively large amount of sand. Their formation can be connected to early diagenetic water escape processes, as suggested by Lowe (1975). In this section, *Eumorphotis* and other pelecypods can be collected.

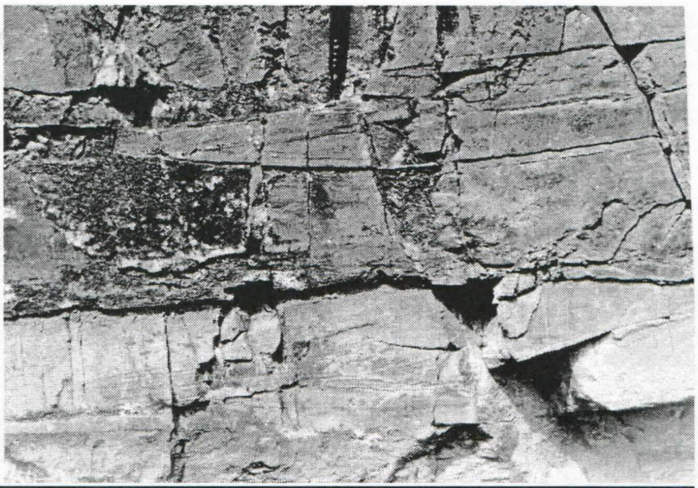
Stop 3. Perkupa, west

This section exposes the lower half of the Szin Marl in which four litho-units can be distinguished. Each litho-units is characterized by a typical association of rocks: A) grey oolite; B) crinoidal limestone, silty–sandy limestone, marl and siliciclastics; C) red oolite with blackened bivalve shells; D) red silicilcastics. A deepening- and shallowing-upward trend is exhibited in the succession by stacking patterns of the metre-scale cycles.

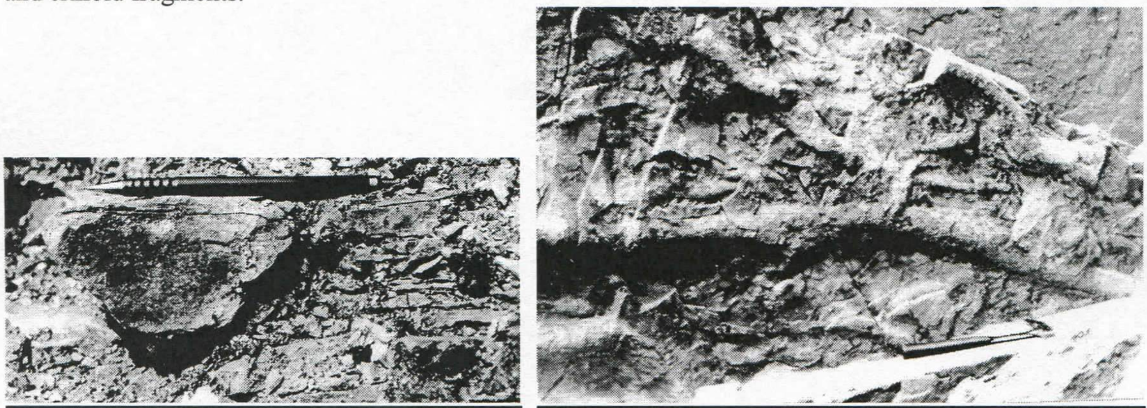
At the base of the section, oolite shoal cycles occur that are followed by mid-ramp storm sheet cycles, which are capped by more distal storm sheets upward. The cycles show thinning upward trend. Upsection, glauconitic, graded packstone–mudstone (distal storm layers), burrow-mottled mudstone and bioturbated marls (outer ramp facies) indicate the deeper water conditions below storm wave base. Ammonites, *Tirolites cassianus* and *Diaplococeras* sp. as well as small glauconite coated gastropods are relatively abundant in the deepest interval. Deepening was succeeded by shallowing as revealed by the rapid progradation of the storm sheets. It is indicated by increasing siliciclastic-influx and coarsening of detrital grains received on the mid-ramp. The succession is composed of less clearly defined, high-frequency cycles characterized by distal storm layers (at the lower part), and different type of amalgamated mid-ramp storm sheets (at the upper part), such as sandstone with ball-and-pillow structure and coarse crinoidal limestone. Gutter casts represent distal scour-and-fill marks of the storm at the base of silty limestone. Molluscs were found from different small outcrops, i.e. *Tirolites* cf. *illyricus*, *Dinarites dalmatinus*, *Eumorphotis kittli*, *E.* cf. *reticulata*, *E.* cf. *telleri*, *Bakevellia* sp., Aviculopectinidea, *Natiria costata*. The shallowing-upward succession is capped by oolite beds with abundant bivalve shells (*Neoschizodus ovatus*, *Costatoria costata*, *Scythentolium tyrolicum*). The lower part of the next sequence is represented by red siliciclastics.



Photomicrograph of distal storm layer
with, foraminifers, bivalves
and crinoid fragments.



HCS in sandstone (storm sheets; w: 40 cm).



Gutter casts: scour and infilling.

Stop 4. Szin, old mill quarry

The quarry exposes the shallowing-upward succession of the litho-unit B, in the lower half of the Szin Marl.

Stop 5. Jósva valley, between Szinpetri and Jósvafő

Small outcrops and a quarry expose a part of the upper half of the Szin Marl. The lithology is very similar to the lower half of the formation. In litho-unit F), oolite, crinoidal limestone, silty–sandy limestone and marl occur; however, the finer grained rocks dominate. Upsection from the varicoloured oolite (not exposed here), quick changes in vertical pattern of metre-scale cycles display a rapid deepening. Oolite shoal cycles are followed by storm sheet cycles. Upsection, the deposits were formed below storm wave base. The deepest part of the succession shows a gradual restriction and transition to the overlying formation along the nodular limestone occurrence.

Stop 6. Aggtelek, near to the camping (Kis-Baradla section)

The uppermost Anisian–Ladinian inner platform–lagoonal limestone is exposed here. The microfacies is bioclastic grainstone, and on the weathered surface of the beds, dasycladaleans, *Diplopora annulata annulata* can be observed. The absence of *D. annulatissima* may suggest its Ladinian age.

June 6.

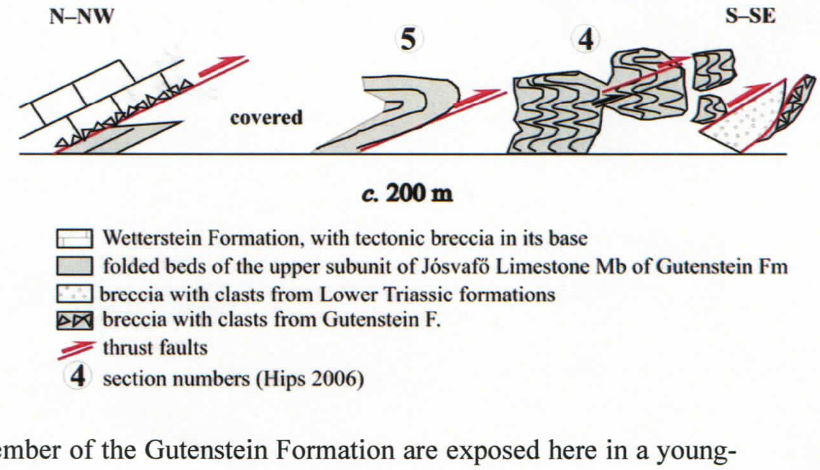
Stop 7. Szin, north

Rocks of the Szinpetri Limestone are exposed here which are highly folded especially in its upper part. The formation is characterized by platy, thin bedded, dark grey nodular limestone (mudstone and wackestone). The beds are strongly bioturbated, which gives them nodular habit or burrow-mottled appearance. The strong bioturbation overprints almost every original sedimentary structures. Nevertheless, gradation and parallel lamination have been preserved in the bioclastic limestone layers. Locally, bivalve coquinas consisting of *Costatoria costata* covers the bedding planes, and parallel gutter casts are abundant on the base of beds. Few ammonite specimens were found in some levels (*Stacheites* cf. *floweri* and *Dinarites dalmatinus*) and additionally *Eumorphotis* sp. bivalve also occur. Foraminifers, i.e. *Meandrospira pusilla* and *Cyclogyra*? *mahajeri–Rectocornuspira kalhori*, were determined from bioclastic beds. The dark colour of the rocks, their poor fossil content, low diversity benthos fauna and strong bioturbation all together refer the gradual restricted condition in the low-energy outer ramp environment.

Stop 8. Jósva valley, near to Jósvafő

According to the revised stratigraphy, the lowermost part of the lower member of the Gutenstein Limestone is exposed in this abundant small quarry. This unit is typified by thick bedded dark grey, laminated limestone (mudstone). The lamination is expressed by the alternation of lighter and darker streaks. Thin, graded crinoidal packestone (distal storm deposits) occur but they are quite rare and disappear upsection. Locally, bivalve coquinas with *Costatoria costata* occur on top of the beds. Frequency of slump structures may indicate incipient synsedimentary tectonic movements getting more intense. The finely laminated beds were formed in anoxic environment, where lamination most likely refers to the changing amount of the organic matter. The lamination is well preserved because of the lack of inbenthic organisms due to the anoxic bottom conditions.

Stop 9. Jósvafő, north



Highly folded beds of lower member of the Gutenstein Formation are exposed here in a young-on-older thrust fault zone. The succession of the second stage of this unit differs from the underlying beds in a lack of burrow-mottling. A monotonous series of massive, pure mudstone with common slump structures characterises this stage. Evaporite crystal moulds filled by calcite and lamination are subordinate. The microfacies exhibits alternations of micrite and detrital carbonate silt laminae or thin layers. Only foraminifer fragments, ostracodes and peloids occur extremely scarcely. The deposition of relatively thick, massive mudstone suggests a low-energy environment that was most probably below the storm wave-base. The general poverty of both benthic and nektonic fossils indicates unfavourable environmental conditions not only at the water/sediment interface but most likely also within the water-column of the shelf that may indicate density stratification of the seawater.

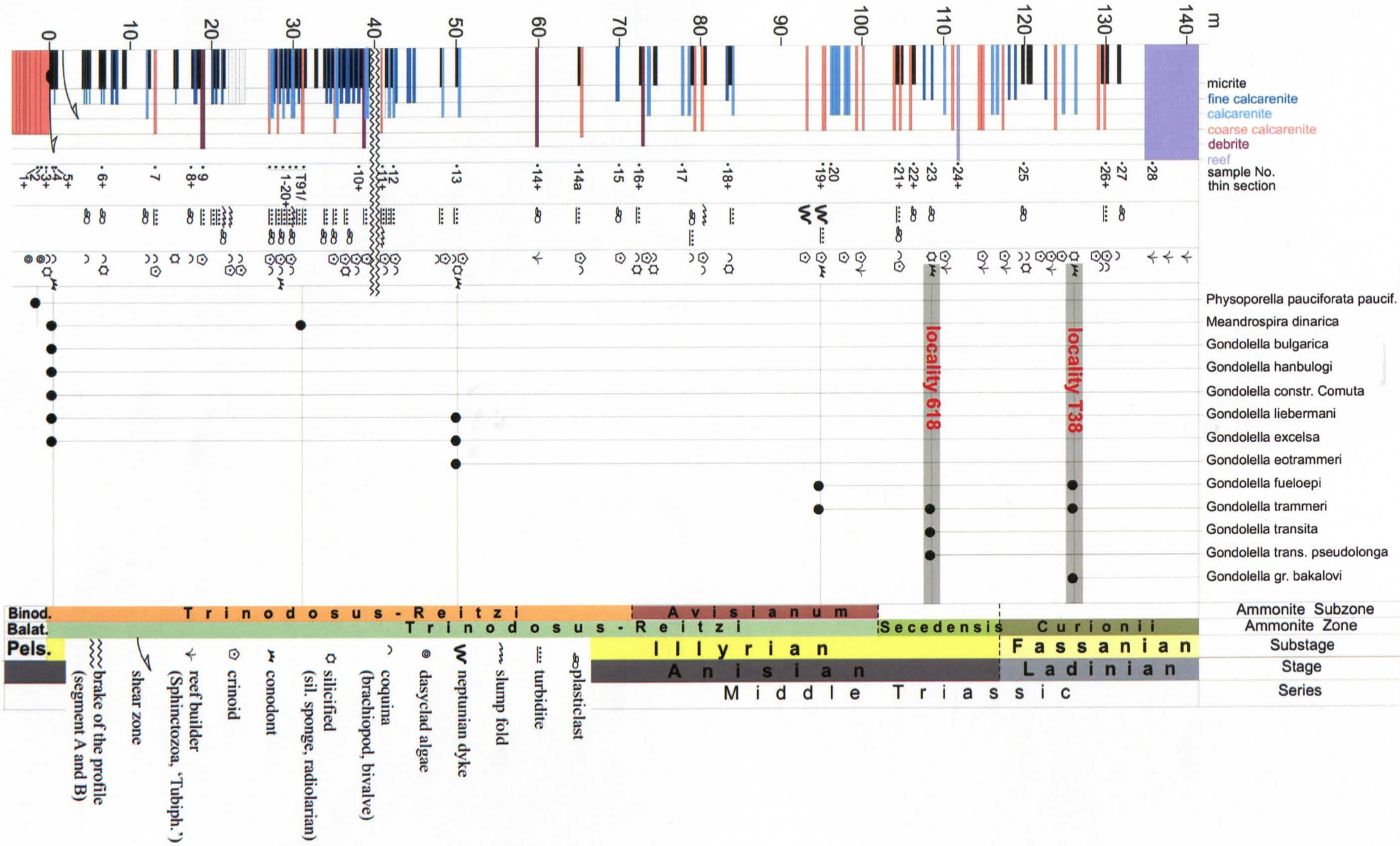
The rocks of the third stage, exposed in a recumbent fold, are represented by the uppermost part of the member. It is characterised by an increasing frequency of thin to thick intraclastic–bioclastic packstone interlayers between mudstone, upsection. The relatively thicker packstone beds were deposited on scoured, eroded surfaces and often show cross-bedding. They contain micritized intraclasts, foraminifers, micro-gastropods, spirorbid worms, echinoderm fragments and large amounts of peloids. Slump structures frequently deformed the mudstone beds, which constitute the bulk of this interval. Accumulation of resedimented shallow-marine debris in gradually increasing amounts indicates provenance from an adjoining carbonate sand source. Occurrence of large amount of bioclasts and non-skeletal carbonate sand grains, deposited in a slope facies, following a long-term, monotonous lime mud deposition suggests a shallow platform progradation and a significant change during late Early Anisian.

Stop 10. Red Lake neighbourhoods

Oncoidal grainstone layers represent the uppermost unit of the Steinalm Formation. On the basis of dasyclad alga and formanifers, Pelsonian age is proved.

Stop 11. Nagy-Jenei Hill NE, forest road from Red Lake

Along the forest road, the topmost beds of oncoidal limestone (Steinalm Fm) and, further away, grey, pinkish, calcarenitic limestone with coquinas (Jenei Fm) crop out. (1) In the bottom of the sinkhole, the lowermost thick beds are light grey, algal calcarenitic limestone (Steinalm Fm). (2) On the uneven top surface, reddish brown coquina-rich micritic limestone is deposited (Jenei Fm). (3) Upwards, grey, calcarenite dominates, with plasticlasts of pink micritic limestone. Mixed conodont fauna indicates the late Pelsonian–middle Illyrian. (4) Upsection, calcareous turbidite, rich in brachiopod-coquina and crinoid fragments, are prevailing. The lower member of the cycles contains graded bedded, coarse brachiopod coquina, fading out upwards. The dominantly crinoidal coarse calcarenite is gradually overlain by grey micritic limestone and then, pink micritic limestone that cap the cyclothems. At certain levels, cross-bedding, undulate bedding, slumps structures, or initial sedimentary brecciation (flaser bedded, nodular or brecciated limestone) can be observed. Conodonts indicate the higher middle Illyrian. (5) At the topmost part, the rate of the light grey calcarenite increases, well sorted coarse calcarenite of encrinitic limestone becomes dominant. Reef detritus (‘*Tubiphytes*’, Sphynctozoan fragments) appears repeatedly and *in situ* reef structure was discovered, too. At special levels, neptunian dykes occur, filled with rhythmically alternating red–pinkish micrite and grey coquina turbidite, furthermore with breccias of the host rocks. Conodonts indicate upwards at least the end of middle Illyrian, late Illyrian and Early Ladinian. At the top of the hill, sphinctozoan reef limestone (Wetterstein Fm., reef stage 2) occurs.



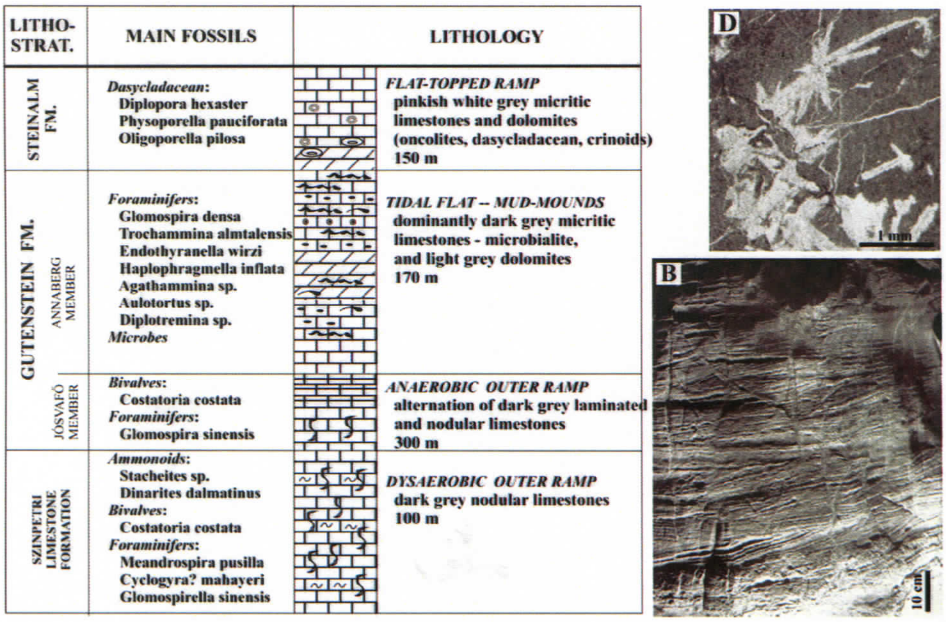
m
micrite
fine calcarenite
calcarenite
coarse calcarenite
debrite
reef
sample No.
thin section
Physoporella pauciforata paucif.
Meandrospira dinarica
Gondolella bulgarica
Gondolella hanbulogi
Gondolella constr. Comuta
Gondolella liebermani
Gondolella excelsa
Gondolella eotrammeri
Gondolella fueloepi
Gondolella trammeri
Gondolella transita
Gondolella trans. pseudolonga
Gondolella gr. bakalovi
locality 618
locality T38
Binod.
Balat.
Pels.
Trinodosus - Reitzi
Avisianum
Secedensis
Curionii
Illyrian
Fassanian
Anisian
Ladinian
Middle Triassic
Ammonite Subzone
Ammonite Zone
Substage
Stage
Series
brake of the profile (segment A and B)
shear zone
reef builder (Sphinctozoa, 'Tubiph.')
crinoid
conodont
silicified (sil. sponge, radiolarian)
coquina (brachiopod, bivalve)
dasyclad algae
neptunian dyke
slump fold
turbidite
plasticlast

June 7.

Stop 12. Baradla Cave, from Jósvafő to Red Lake

The upper member of the Gutenstein Formation is exposed from the entrance to the Giants' Hal, through the next halls, some characteristic beds of the Steinalm Formation, Jenei Formation and the reef facies of the Wetterstein Limestone are exposed where calcite does not cover the walls.

12/1, Labyrinth: The upper member of Gutenstein Formation is very variable in lithology and facies compared to the monotonous development of the lower units. Because of the limited observation potential in the cave section the true dimensions and geometry of the facies-types could not be determined, but most likely they have mosaic arrangement. Sponge–microbe mud-mounds and the associated facies are as follows from bottom to top: **1)** dark grey, tabular cross-laminated peloidal and bioclastic packstone–grainstone; subtidal mound-flanking debris facies; **2)** dark grey, thick-bedded, clotted micrite, as automicrite, with abundant bioclasts (boundstone); sponge–microbe mud-mounds that is recognised only by microfacies studies; **3)** light grey, parallel laminated or micro-cross-laminated, finely crystalline limestone and dolomite with evaporite pseudomorphs and tepee-derived breccias; peritidal facies.



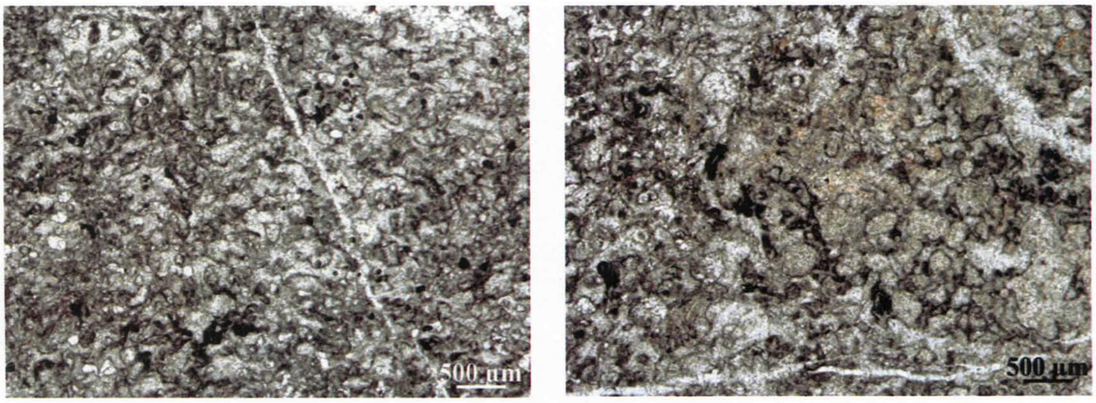
B: Cross-laminated peloidal limestone. **D**: Photomicrograph of dolomite with pseud. gypsum.

12/2, Fault's Hall: A shallowing-upward cycle top is represented by the following succession: **1)** a layer-cake facies succession of light grey, laminated or massive mudstone (oxidative peritidal facies) and dark grey, bioturbated, parallel or cross-laminated peloidal grainstone deposited on eroded surface (shallow subtidal mound-flanking debris facies); and **2)** light grey, thick-bedded dolomites with evaporite pseudomorphs and chert nodules (peritidal facies and pedogenic dolocretes). The deeper water facies of the next cycle is represented by dark grey, thick-bedded peloidal grainstone and automicrite–microspar (mound-flanking debris with small microbial knobs).

(→)

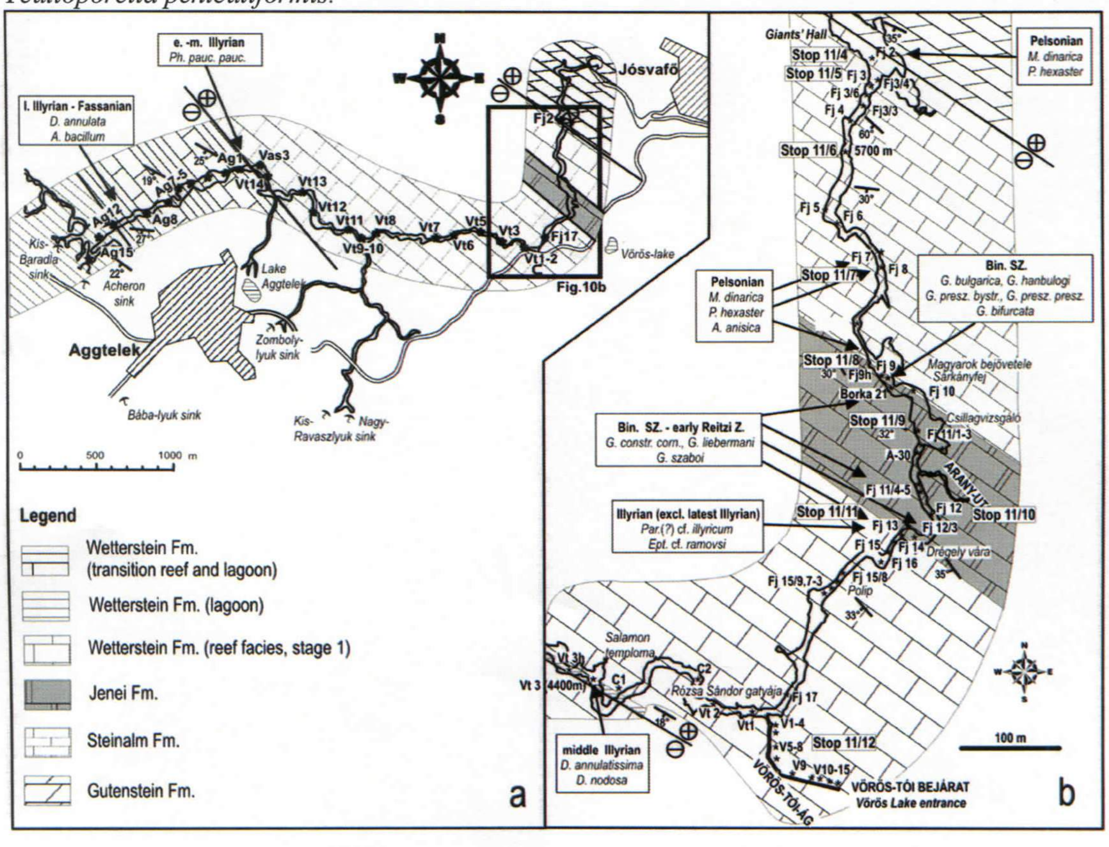
Baradla Cave map with the location of the most important samples and the stops during the field trip (**b**). Reef facies, stage 1 is above the Jenei Fm (early Illyrian) and below the lagoonal facies of the Wetterstein Formation (late Illyrian), (Velledits et al. 2011).

12/3, Black Hall: A deepening- and shallowing-upward cycle (continuously above the previous stops) is represented by from bottom to top: **1)** dark grey, peloidal grainstone, shallow subtidal flanking debris facies; **2)** light grey, cross-bedded oncoidal–ooidal grainstone, shallow subtidal sand-bank or sheet; **3)** light grey dolomite with evaporite pseudomorphs and chert nodules, peritidal facies and pedogenic dolocretes. The deepening part of the next unit is characterized by dark grey, peloidal grainstone and laminated clotted-micrite of microbial origin, shallow subtidal facies, deposited on a sharp surface.



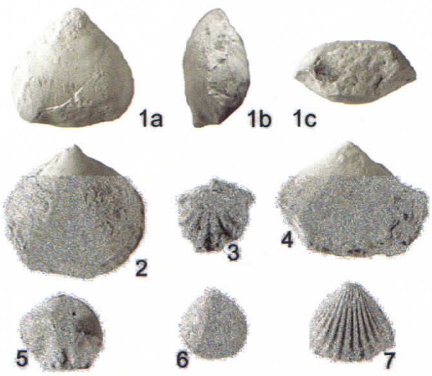
Photomicrographs of boundstone microfacies of microbial–sponge mud-mounds (Hips 2007).

12/4, Swallow hole after Giant's Hall: In the lofer beds of the Steinalm Limestone, two types of microfacies alternate: bioclastic limestone with dasyclad alge and microbial mat. The rich flora contains *Physoporella pauciforata pauciforata, Ph. paucif. undulata, Ph. dissita* and *Teutloporella peniculiformis*.



12/5, Neptunian dyke: The platform carbonates are dissected by numerous neptunian dykes that originate in the tectonically active periods. 16 samples gave ages: (1) latest Pelsonian (Binodosus Subzone), (2) early–middle Illyrian (Trinodosus Zone–most part of Reitzi Zone) and (3) uppermost middle Illyrian (Avisianum Subzone). Consequently these three periods refers to those which were tectonically active.
These neptunian dykes yielded conodonts from the Binodosus Subzone. In the insoluble residue of some neptunian dykes, with the age of Binodosus Subzone,we have found heavy minerals: orthopyroxene, magnetite, ilmenite. Orthopyroxene cannot be transported for a long distance. Consequently these heavy minerals yield coeval volcanic activity, which took place in the neighbourhood area.

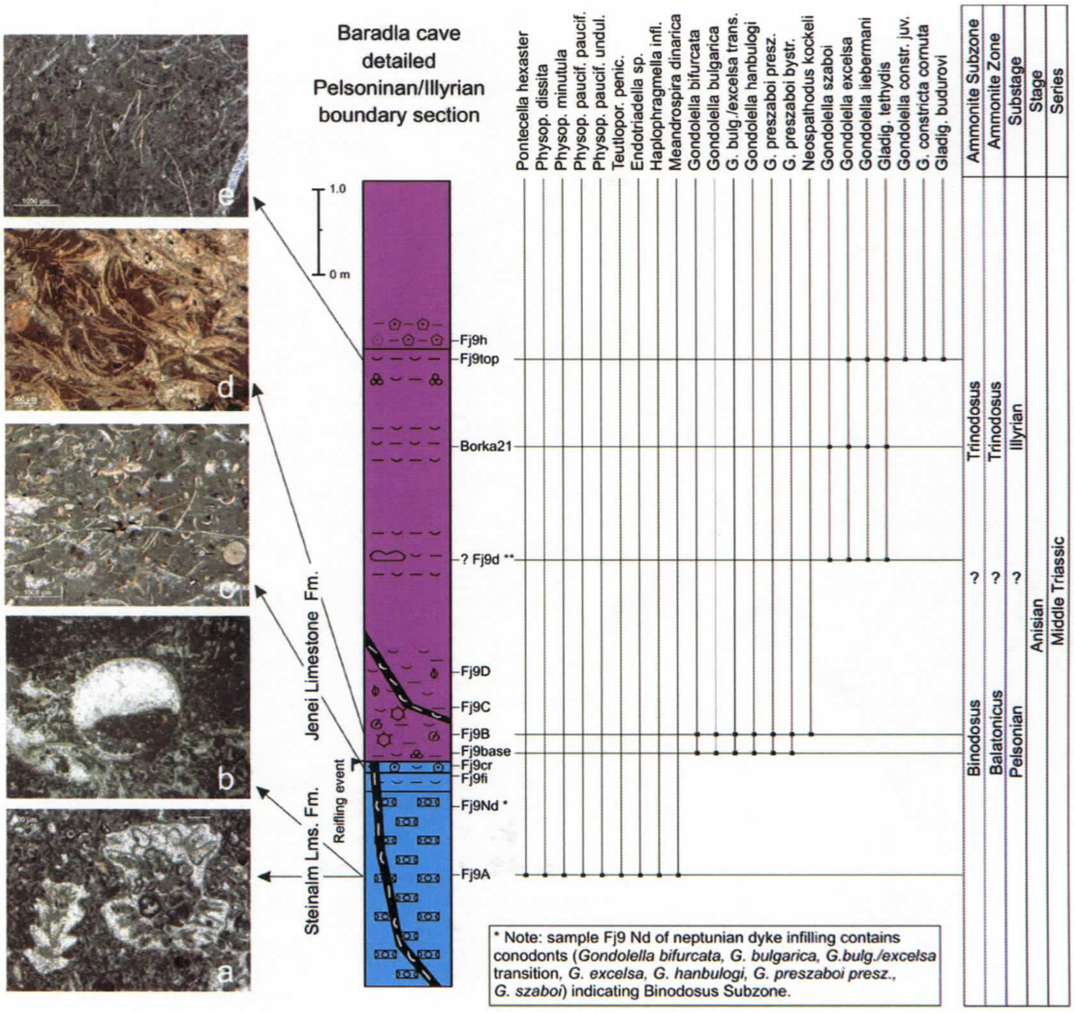
12/6, Red, brachiopod bearing blocks: This red limestone block was most probably fallen from the ceiling and represents a neptunian dyke. Brachiopods and conodonts were determined and in the insoluble residue we have found heavy minerals. The following brachiopods were determined: *Mentzelia mentzeli, Costirhynchopsis* cf. *mentzeli, Piarorhynchella trinodosi, Homoeorhynchia*? sp., *Volirhynchia* cf. *vivida, Norella* sp, *Austriellula?* sp., *Holcorhynchella*? sp, *Schwagerispira* cf. *mojsisovicsi, Schwagerispira* sp. The brachiopods are commonly fragmentary with single valves and appear size-sorted favouring predominantly small individuals. The rare articulated specimens are filled by sparry calcite, enclosed in a purple-red micritic matrix. These observations suggest transport and/or resedimentation, possibly representing a neptunian dyke filling. The assemblage is rich in small, smooth rhynchonellids [*Norella* (Figs 1,4), *Austriellula*?] that may characterize a relatively deep-water environment. Conodonts are: *Neospathodus kockeli, Gondolella bulgarica, G. hanbulogi, G. preszaboi bystryckyi, G. press. preszaboi*. The brachiopods give an Anisian–Lower Ladinian (Curionii Zone) age, whereas the conodonts restrict it to the Binodosus Subzone.



Brachiopods from sample Fj4. (5700 m from the Aggtelek entrance) Where multiple views of the same specimen are provided, 'a' denotes the dorsal, 'b' the lateral and 'c' the anterior view respectively. 1, 4. *Norella* sp., 2. *Mentzelia mentzeli*. Ventral valve. 3. *Volirhynchia* cf. *vivida*. 5. *Piarorhynchella trinodosi*. Dorsal valve. 6. *Holcorhynchella* ? sp. 7. *Schwagerispira* cf. *mojsisovicsi*, dorsal valve (Velledits et al. 2011).

12/7, Fallen Tree-trunk: Subtidal member of the Steinalm Limestone with rich dasycladalean association and foraminifers. The *Poncetella hexaster* and *Anisoporella anisica,* together with *Meandrospira dinarica* and *Glomospirella semiplana* limit this lithostratigraphic interval to the Pelsonian.

12/8, Dragon's Head: Base of the Jenei Limestone with ammonites. The peritidal sedimentation was terminated by a drowning event in the Late Pelsonian. The platform carbonates are followed by a deep water intercalation (Jenei Formation) rich in conodonts and ammonoids. The ammonite-bearing beds, which is the manifestation of the Reifling event (Schlager & Schöllnberger 1974) yielded two different conodont associations. In the lower part,the conodont association and the globose Ptychitids are characteristic for the upper part of Pelsonian Substage: Binodosus Subzone (pers. comm. of L. Krystyn). The upper part, contains species of the Trinodosus Zone. The apperance of the gladigondolellid conodonts refer to the connection with the open sea. The connection with the open sea is justified from this point onward.



Baradla Cave, detailed Pelsonian/Illyrian boundary section. A significant change is visible in the deposits between the Steinalm Fm. (a–b) and the Jenei Fm. (c–e):

a. Two dasycladaleans from the Steinalm Fm: *Physoporella pauciforata* var. *undulata* to the right, and *Oligoporella minutula* [=*Physoporella minutula*] to the left. b. The original filling of the gastropod shows a geopetal structure (lower part micrite, upper part sparite). Later the micrites were partly dissolved and filled with brownish filament wackestone (surrounded by dashed white line), infiltrated from above.

c. Filament–crinoidal packstone just below the base of the ammonoid layer.

d. Filament packstone from the lower part of the ammonoid layer.

e. Filament packstone with ostracods.

* Fj9Nd was taken from a neptunian dyke.

** Fj9d was collected from a fallen block originating from a higher level than Fj9D (Velledits et al. 2011).

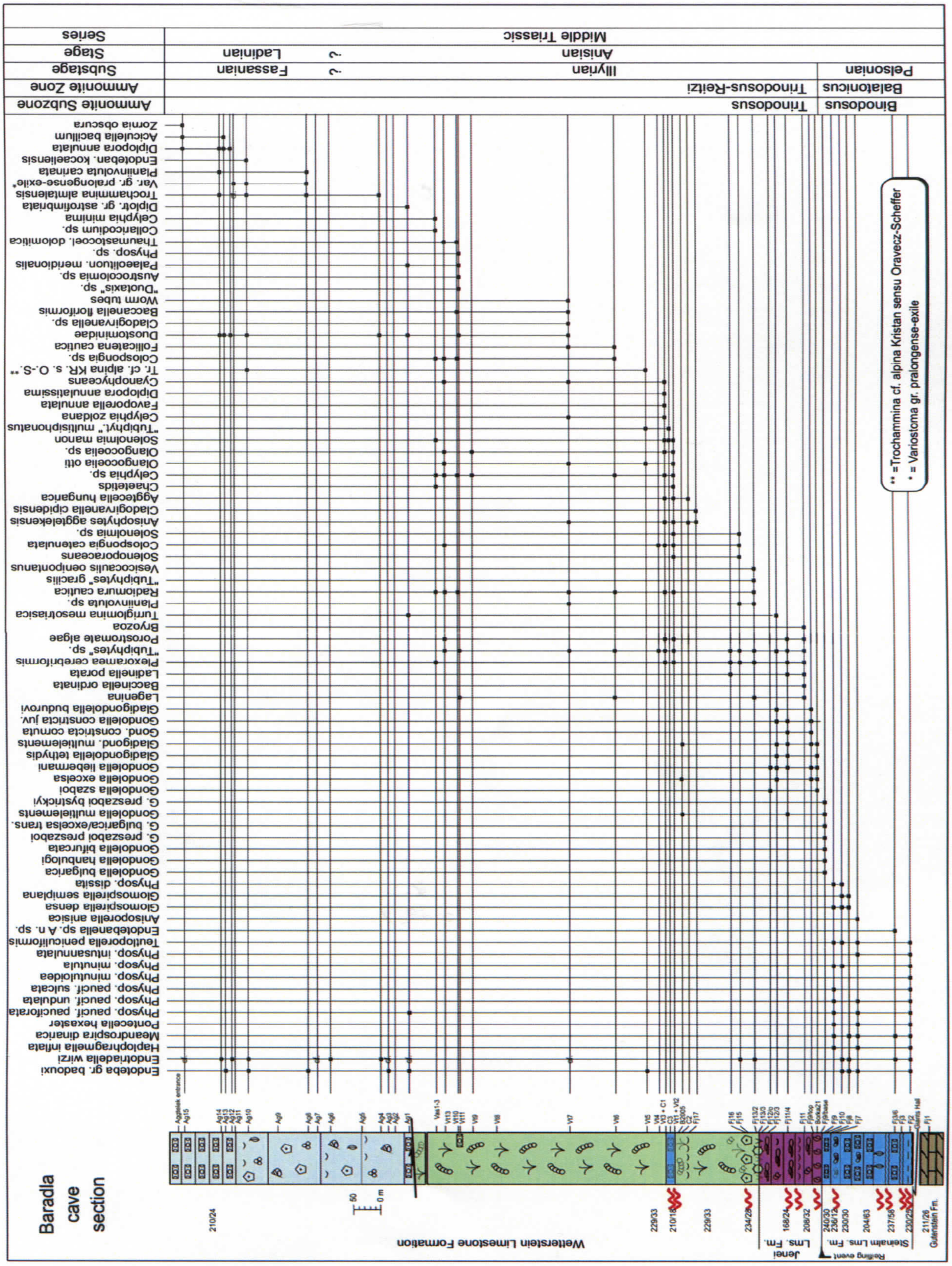
The drowning event can be detected all over the northern shelf of the Vardar ocean: West Carpathians, Northern Calcareous Apls: 'Reifling event' Schlager & Schnöllnberger (1974). Until this time a uniform ramp had existed, which was dissected by faults and the uniform basement was differentiated, consequently platforms and basins came into existence all over the northern shelf. The Reifling event differentiated the basement in Aggtelek as well. The uniform Steinalm platform was drowned and differentiated. Basins and highs were formed. In the NW part of the area lower - middle? Illyrian basinal carbonates were followed by a platform margin reef (reef stage 1) developed on a morphological high. Differently from this in the SE part of the studied region a basin existed from the late Pelsonian until the end of Illyrian. At the base of the deep water intercalation in the insoluble residue next to the conodonts orthopyroxene and magnetite appeared, which refer to coeval volcanic activity in the neighbourhood. Both the neptunian dykes and the heavy minerals refer to a very intensive tectonic activity.

This tectonic event played a fundamental role in the development of the reef:

Create morphology: As we know huge barrier reefs came into being on platform margins, which are in the neighbourhoods of steep slopes. These steep slopes are tectonically controlled (Scoffin 1987). In our case the Reifling event disrupted the basement: platforms and intraplatform basins were formed. The edge of a platform is a favourable place for the formation of a barrier reef. The cold, deep, nutrient-rich ocean waters are drawn up on a platform edge. They are heated and agitated by the wave action. The wave action drives off the CO_2 (carbodioxid) in that way promoting the calk ($CaCO_3$) precipitation. That's way lime production, both organic and inorganic is generally higher in this shallow tropical platform edges than anywhere else. That is the reason why the tropical platform edges are covered by barrier reefs, and vica versa huge barrier reefs develop on platform edges which are attached to steep slopes. It means they are tectonically performed. Of course adequate temperature and salinity are the prerequisites for the forming of a barrier reef as well.

Created depth: In the middle Triassic the calcareous sponges were the dominant reef builders. The sponge reefs existed down to 40-60 m deep. As we know the reef building corals live in symbiosis with zooxantellen, so they can exist only in peritidal environment. The sponges live alone. Their skeleton is full of pores. They can make a vacuum in their body, and they make the water circulate and in the meantime they filter the nutrients from the circulating water. Consequently they are independent from the wave action, that's why they live deeper than corals, sponges live 40–60m deep. The tectonic event, causing the drowning of the Steinalm platform, caused a considerable water depth, and in this way it created favourable conditions, first of all suitable depth to the sponges.

12/9, Turkish Town–Observatory–Castle of Drégely: Crossing the Jenei Limestone Formation, transition to the tuffitic layer. (**1**) Grey encrinitic limestone overlays the ammonite beds. (**2**) In some meters we turn to the left (NE), and opposite to Turkish Town we reach again the footwall Steinalm lagoonal beds, crowded with Dasycladaleans, similar as at Stop 12/6. (**3**) Under the Observatory, on the left (E) side we cross again the boundary of the Steinalm and Jenei Limestone, and return finally to the latter. Over our heads, we can again catch site again the overlying micritic limestone beds of the ammonitic horizon. (**4**) After a small bridge we step again to hangingwall, grey limestones follow rich in brachiopod coquinas and resedimented intraclasts. The plasticlastic appearence of the rock refers to that the intraclasts were soft when they resedimented. Several beds are rich in crinoid remnants. (**5**) Leaving the staircase to the Observatory, about thirty metres above the base of the Jenei Formation, the first resedimented reef-building organisms, Bryozoa, calcimicrobes and microproblematica (*Baccinella ordinata, Ladinella porata, Plexoramea cerebriformis)* appear in a micritic filament-rich matrix. This level is dissected by numerous neptunian dykes, containing mixed conodont fauna from the Binodosus–Avisianum Subzones. (**6**) About sixty-five m above the base of the Jenei Formation, a grey micritic limestone with pinkish spots ('plasticlasts') appears. From here the conodonts *Gondolella liebermani* and *G. constricta cornuta* refer to the early–middle Illyrian: Trinodosus Zone and most part of Reitzi Zone. In the same sample, resedimented *Ladinella, Plexorama, 'Tubiphytes',* calcimicrobes were found, too. The estimated stratigraphical thickness of the Jenei Limestone up to here is about 80 meters.



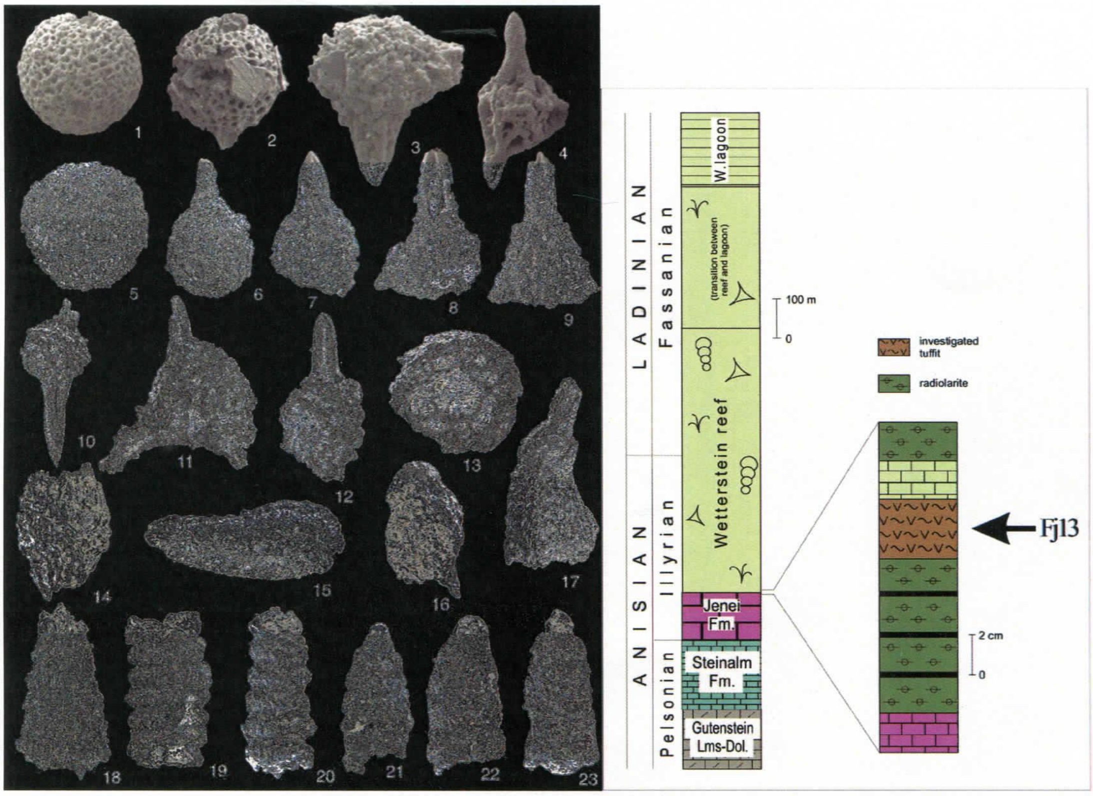
Baradla Cave section and fossils. Note: the Wetterstein Fm. (reef) represents reef facies, stage 1 (Velledits et al. 2011).

12/10, Castle of Drégely: The top of the Jenei Formation contains four radiolarite layers, each of which is 2 cm thick. The fourth radiolarite layer is covered by the 3-cm-thick acid (rhyolite) tuffite layer in which zircons were found. This is followed by a 2-cm-thick limestone layer, on the top of which a thin radiolarite layer appears again. The fifth radiolarite layer is followed by the Wetterstein reef limestone (stage 1). The first sponge appeared immediately above the fifth radiolarite layer (accordingly, the boundary between Jenei and Wetterstein Formations delineated between the top of the fifth radiolarite layer and the overlaying limestone). The most of the radiolarian species of the studied assemblage are known from the Illyrian (Paraceratites trinodosus Zone), late Illyrian or late Illyrian–Fassanian. It is also noteworthy that the late Illyrian and Fassanian species of the oertlispongid genera *Pseudoertlispongus*, *Oertlispongus* and *Baumgartneria*, almost ubiquitous at these stratigraphic levels, are completely lacking here. Consequently, the radiolarian assemblage is Illyrian in age. The absence of oertlispongid radiolarians excludes the late Illyrian. Although the known stratigraphic range of *Eptingium manfredi* is upper Illyrian to Fassanian, the appearance of secondary furrows took probably place in the lower Illyrian. *Pararuesticyrtium* (?) cf. *illyricum* (Fig. 19) may be also compared to *Pararuesticyrtium*? sp. illustrated by Ramovš & Goričan (1995) from middle Illyrian (previously 'upper Illyrian') *Neogondolella mesotriassica* conodont Zone. The age of the Radiolarian assemble is in accordance with the age determined by the conodonts *(Gondolella constricta* juv., *G. constr. cornuta, G. liebermanni, G. excelsa* and *Gladigondolella tethydis)* refer to the Trinodosus Zone–most part of Reitzi Zone. The X-ray diffraction of the tuffite revealed that the original rock could be an acidic vulcanite (rhyolite–rhyodacite–dacite), which originated either *in situ* through halmirolysis, or it was eroded from the continent nearby.

Zircons define an upper intercept age of 502 –23/+26 Ma, consequently the tuffite contains inherited zircons. Our section belongs to the rootless Silica Nappe-system, so the original basement the zircons originate from is unknown. The nearest volcanites of similar age are known from the Gelnica unit of the Gemericum (Vlachovo Formation) (Snopková & Snopko 1979). The Illyrian volcanic activity was most probably connected with the opening of the Vardar–Meliata branch of the Neo-Tethys Ocean. The Illyrian volcanic activity acted as a sampling tool and transported the euhedral basement zircons with an ash flow into the Aggtelek section.

12/11, After Apollo Hall: Crinoidal limestone. The tuffite/radiolarite level is overlain by crinoidal-dominated coarse-grained limestones. Well-preserved crinoid stems (1-1.5 cm in diameter) are frequent and whole chalices and autochtonous crinoids can be found between (Hagdorn & Velledits 2006). The first determinable sponge *(Vesicocaulis oenipontanus)* together with *Radiomura cautica* and *'Tubiphytes' gracilis* appear already above the topmost radiolarite layer. About 25 m higher in the section, other sponges (*Colospongia catenulata, Solenolmia* sp.) and microproblematica were found. Neptunian dykes are very frequent in this level. Higher up in the section, the reef-building organisms (Sphinctozoan and microproblematica) become more abundant, while the crinoids disappear.

Upsection, about 130 m higher, but still in the lower part of the reefal sequence, a horizon rich in *Diplopora nodosa* associated with *D. annulatissima* indicates a middle Illyrian age. Next to the dasycladaleans this level contains several sphinctozoans and '*Tubyphites*' sp., *Aggtecella hungarica,* bryozoa, brachiopoda and ostracoda.

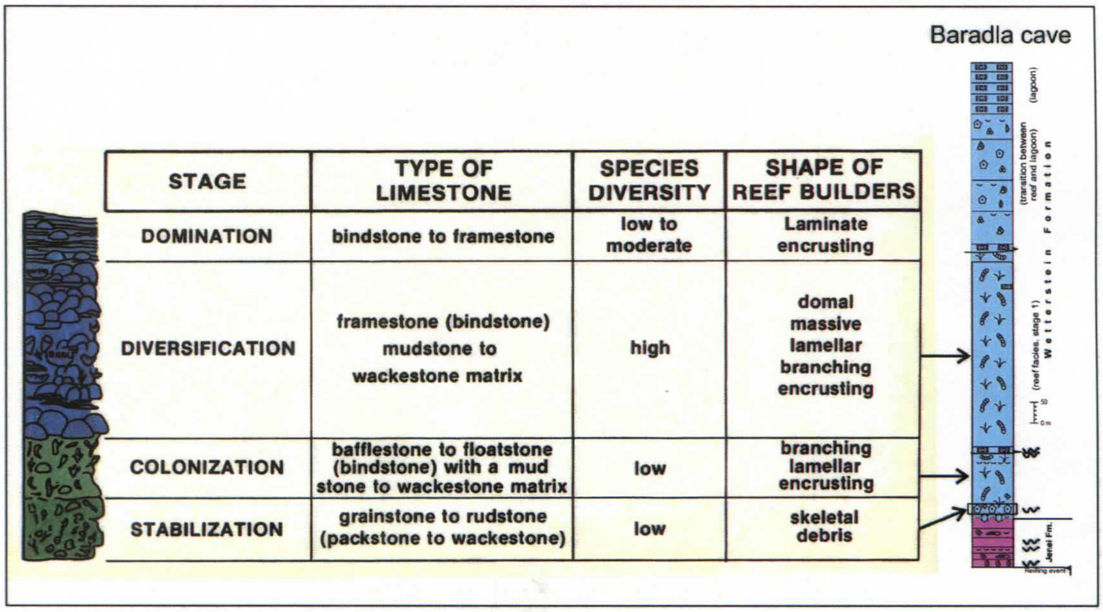


A **B**

(A): Radiolaria and Ostracoda; sample Fj13/3. 1. *Cenosphaera* gr. *andoi* x185, 2. Spumellarian, gen. et sp. indet. x185, 3. *Eptingium* gr. *manfredi* x275, 4. *Spongostephanidium* cf. *spongiosum* x275, 5. *Cenosphaera* gr. *andoi* x125, 6. *Monospongella* sp., x275, 7. *Eptingium* cf. *ramovsi* x185, 8. *Eptingium* gr. *manfredi* x185, 9. *Eptingium* gr. *manfredi* x185, 10. *Pseudostylosphaera* sp. A, x275, 11. *Eptingium* gr. *manfredi* x185, 12. *Pseudostylosphaera japonica* x185, 13. *Lobactinocapsa* cf. *ellipsoconcha* x185, 14. *Pseudostylosphaera* sp. B, x185, 15. Ostracod, gen. et sp. ind., x185, 16. *Deflandrecyrtiid,* gen. et sp. ind., x185, 17. *Spongosilicarmiger scabiturritus* x185, 18. Nassellarian, gen. et sp. ind., x154, 19. *Pararuesticyrtium* (?) cf. *illyricum* x185, 20. *Annulotriassocampe campanilis* x275, 21. *Pararuesticyrtium* ? sp., x275, 22. *Anisicyrtis* sp. 2, x275, 23. *Anisicyrtis* sp. 1, x185 (**c. half of the given sizes; note! the original size in** Velledits et al. 2011)
(B): Position of the tuffite layer and the radiolarite.

12/12, Staircase to Red Lake: Wetterstein Reef. In the wall, we can see nice reef structures and segmented sponges. Stromatactis is also very frequent. The reef facies is characterised by two microfacies types. (1) The first consists of bafflestone–bindstone with a micriticelmicritic matrix, in which reef-building organisms, sponges, microproblematicas, calcimicrobes, bryozoans, gastropods and foraminifers can be found. The reef-building organisms are sometimes coated by crusts of different origin. The stromatactis are filled by different generations of calcite cements. (2) The second one is characterised by a sparry calcite cement with fossils ('*Tubiphytes*', *Plexoramea cerebriformis*, echinodermata fragments with micritic envelopes, gastropods, bivalves, foraminifers, ostracodes, dasycladaleans and rarely by segmented sponges), fossil fragments and intraclasts. The reef community consists mainly of segmented sponges (Sphinctozoans: *Celyphia? minima*, *C. zoldana*, *Colospongia catenulata*, *Follicatena cautica*, *Olangocoelia otti*, *Solenolmia manon manon*, *Sollasia*? *baloghi*, *Thaumastocoelia dolomitica, Vesicocaulis oenipontanus*): and microproblematica (*Baccanella floriformis*, *Bacinella ordinata, Ladinella porata, Plexoramea cerebriformis, Radiomura cautica, 'Tubiphytes' gracilis, 'T'. multisiphonatus, 'T'.* sp.), calcimicrobes, bryozoans, gastropods and foraminifera. The fossils are characteristic of the Wetterstein-type reef communities, although several typical Wetterstein sphinctozoan taxa (*Alpinothalamia bavarica, Uvanella irregularis, Stylothalamia dehmi, Cryptocoelia zitteli and* all species of *Vesicocaulis* except for *V. oenipontanus*) have not been found in the studied association.

The reef stage 1 can be followed on the surface over a distance of 3.5 km. Thus we can conclude that it was a platform margin reef. Neptunian dykes which dissected the lower part of the reef are here totally absent. It is interesting to note, that neptunian dykes appear only in the lower 150 m of the reef. We can conclude that the birth of the reef took place during a tectonically active period, but the real flourishing of the reef occurred in a tectonically quiet period.



Comparison the Baradla Cave section with the James (1983) model.

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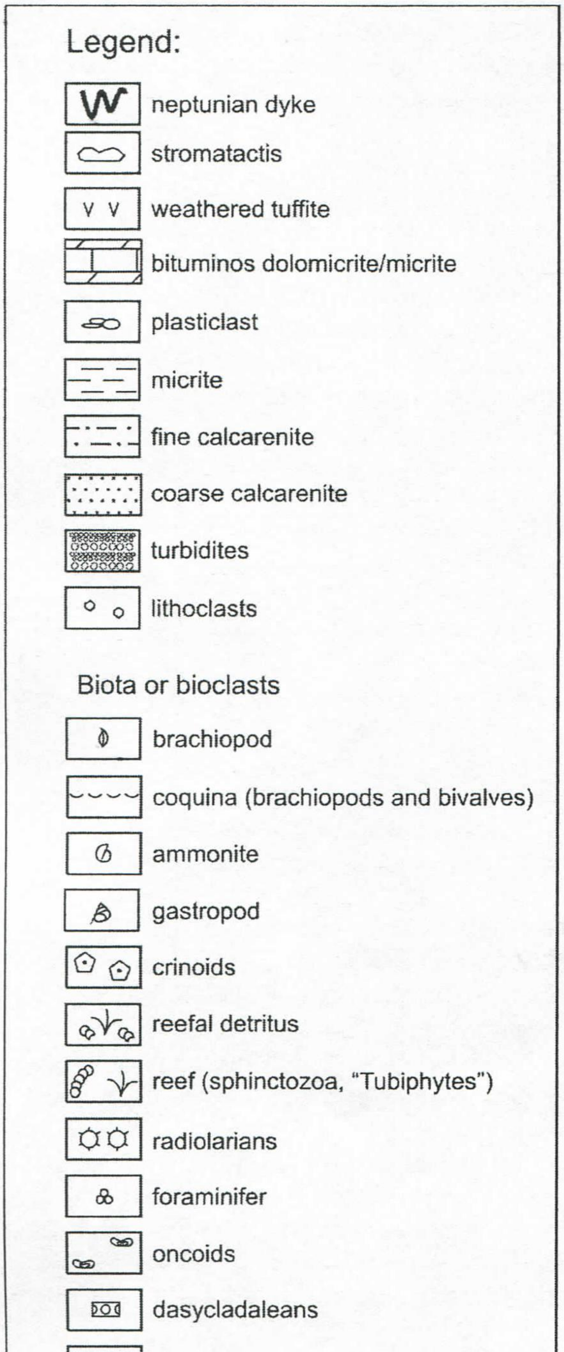

Legend for figures of Velledits et al. 2011.

RESEARCH OF THE ROMAN CATHOLIC CHURCH IN TORNASZENTANDRÁS

(Abstract) *Ilona Valter*

The Tornaszentandrás Church stands on a hill on the right side of the Bódva in North-Borsod. It is a small church directed toward east consisting of one nave and two identical semicircular shrines from the same period. The double shrine from the Roman Period is unique in Hungary. Beside the architectural interest attached to the building the bad technical state made renovation necessary. The archaelogical excavations and the research of the walls were made in 1971. The history of the building of the church is revealed from the comparison of the archaeological investigations, the historical sources and the data of the Canonica Visitation from the 18th519th cc.

The earliest part of the church is from the Roman Period: the two identical semicircular shrines with an arched break resting on pillars to provide transition. The nave of the Roman Period was square formed. The shrines were covered with halfdome vault, while the nave seems to have been covered with a simple domical vault, similar, probably, to the dome of the Castellana (Apulia, South-Italy) church. The ground level was lowered with half a metre in the Gothic period thus the base of the altar (or altars) could not be found in the twin apses. The small niches in the apses served for the storage of vessels needed for the ceremony. The southern semicircular niche was a sitting niche, while the one on the northern side was made for cibarium.

Only scattered Slavic population could be met on the upper flow of the Bódva at the end of the 12th c. The villages of the modern sense and the churches appeared only after the organisation of the bailiff system of Torna (1198). According to the archaeological excavations the graves of the early church are from a layer dated by sherds from the 13th-14th cc. The frescos of the Roman church were made at the very beginning of the 13th c. These unilateral data show that the Roman church with the double shrine, consecrated to St. Andrew the Apostle was built at the very beginning of the 13th c.

Churches with double shrine and one nave are to be found on the territory of the Carolingian Empire (Solhoffen, after 700, Reichenau-Mittelzell, an Abbey built about 816, Mendrisio 8th—9th cc, parish church, Mesocco 10th—11th cc. parish church etc.). This type is surviving on the territory of the Holy Roman Empire (Austria-Tirol, Salzburg, Meran) partly as parish church (Schönna at Meran), partly as castle chapel (Zenoburg, Aufenstein). In the Gothic period large miners' churches of two or more naves and two shrines are built on the same territory (Schwaz, Rattenberg, Hallstatt 15th—16th cc).

Endre II. married Gertrúd the daughter of the Istria marquis, the Meran earl, Andechsi Berthold between 1200 and 1203. Gertrúd presented large estates to her conpatriots and relatives accompanying her to our country. Her tutor, Adolf, the later Szepes Provost got an estate in Szepesség, belonging to the bailiff in Torna in 1209. The connection between the Szepesség and the village of Szentandrás both belonging to the bailiff of Torna is natural. This could cause the appearance of the double shrine church form in Hungary, being the usual form in Meran-Tirol.

The enlargement of the church can be dated, with the help of the archaeological excavations, the historical sources and the murals from the Anjou Period from the middle of the 14th c At that time the village belonged to the Bebek family. They added the present nave with two altars to the church. A gallery resting on pillars occupied the western side, while an outer ossarium was built to the southern wall. The gothic nave was painted by masters, who learnt painting in Italy.

The Turks burnt the village of Szentandrás in 1576. The population fled, the church had no owner for about 150 years. The roofless ruins of the church were rebuilt for the new population by András Zsillavy, parson of Bódvaszilas. The walls were repaired, tiled roof and tabular ceiling were built and three altars were placed inside. The popular baroque gallery of U form and the pulpit were made between 1789 and 1814.