

Middle Triassic crinoid remains from the Aggtelek platform (NE Hungary)

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With 8 figures

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Abstract: In the Middle Triassic Steinalm Limestone and Wetterstein formations from Aggtelek (NE-Hungary), crinoids are represented by isolated sclerites. The crinoid remains have been collected from neptunian dykes of the Steinalm Limestone Formation underlying the Wetterstein Formation and from the Wetterstein reef. The following crinoids have been found: 3 different Encrinidae gen. et sp. indet., *Silesiacrinus* (?) *cancellistriatus* (? Millericrinida), *Tollmannicrinus quinqueradiatus* (Holocrinidae), and 1 Isocrinidae gen. et sp. indet. Among the crinoids, unequivocal biostratigraphical index taxa have not been found. However, the conodonts *Gondolella praeszaboi praeszaboi* and *G. bulgarica* occurring together with *Tollmannicrinus quinqueradiatus* and *Silesiacrinus* (?) *cancellistriatus* indicate late Pelsonian to early Illyrian age of the neptunian dykes. In the reef, the 3 Encrinidae, the Isocrinidae and *Silesiacrinus* (?) *cancellistriatus* were found. The reef age can be determined between the upper Pelsonian Binodosus Subzone and the lower Ladinian Curionii Zone by *Gondolella bulgarica*, *G. hanbulogi*, *G. bifurcata*, and *G. praeszaboi bystrycky* from deep water intercalations underlying the Wetterstein reef, and by *Gondolella excelsa*, *G. fülöpi*, and *G. trammeri* occurring at the base of the overlying Wetterstein lagoon sediments. Although crinoids that were permanently attached to solid substrates by means of incrusting holdfasts are rather common, they did not substantially contribute to the reef frame, as encrinids and millericrinids did in small oyster/crinoid buildups of the germanotype Muschelkalk, which may be associated with corals and hexactinellid sponges in the Lower Muschelkalk of Upper Silesia. Obviously, in large reefs with a diverse fauna, crinoids could not establish themselves as active frame builders.

Zusammenfassung: In der mitteltriassischen Steinalm- und Wetterstein-Formation von Aggtelek (NE-Ungarn) fanden sich von Crinoiden nur isolierte Sklerite. Sie stammen aus Spaltenfüllungen der liegenden Steinalm-Formation und aus dem

Wetterstein-Riff. Die folgenden Taxa wurden bestimmt: 3 verschiedene Encrinidae gen. et sp. indet., *Silesiacrinus* (?) *cancellistriatus* (? Millericrinida), *Tollmannicrinus quinqueradiatus* (Holocrinidae), und 1 Isocrinidae gen. et sp. indet. Sichere biostratigraphische Indexformen sind nicht darunter. Allerdings zeigen die Conodonten *Gondolella praeszaboi praeszaboi* und *G. bulgarica*, die zusammen mit *Tollmannicrinus quinqueradiatus* und *Silesiacrinus* (?) *cancellistriatus* vorkommen, oberpelsonisches bis unterillyrisches Alter der Spaltenfüllungen an. Im Riff fanden sich die 3 Encrinidae, der unbestimmte Isocrinide und *Silesiacrinus* (?) *cancellistriatus*. Das Riff lässt sich zwischen die oberpelsonische Binodosus-Subzone und die unterladinische Curionii-Zone einstufen, und zwar anhand von *Gondolella bulgarica*, *G. hanbulogi*, *G. bifurcata* und *G. praeszaboi bystrycki* aus Tiefwassereinschaltungen unter dem Wettersteinriff und anhand von *Gondolella excelsa*, *G. fillöpi* und *G. trammeri* von der Basis der hangenden Wetterstein-Lagunensedimente. Obwohl Crinoiden, die mit Haftscheiben dauerhaft auf Festsubstrat siedelten, ziemlich häufig vorkommen, trugen sie nur unwesentlich zum Riffgerüst bei. In kleinen Austern/Crinoiden-Biohermen im germanotypen Muschelkalk, mit denen in Oberschlesien auch Korallen und hexactinellide Kieselschwämme assoziiert sein können, spielten Encriniden und Millericriniden dagegen eine erhebliche Rolle. Offenbar konnten sich die Crinoiden in großen Riffen mit diverser Fauna nicht als aktive Gerüstbildner etablieren.

Key words: Middle Triassic, Hungary, Aggtelek karst, Silica nappe, neptunian dyke, crinoids, paleoecology.

1. Introduction

In Mesozoic reefs, crinoids are not as diverse as in Paleozoic reefs where they reached the maximum abundance in their clade history and optimized their filtering success in their paleocommunities by occupying different tiers above the seafloor (AUSICH & BOTTJER 1985). However, only less than 10 My after their end-Permian almost-extinction, they had recovered and even contributed to framebuilding in small bioherms in the Anisian Germanic Muschelkalk. With their root calli they incrustated clusters of terquemiid oysters and provided hereby solid anchoring grounds for their larvae a few centimeters above the seafloor that protected their juveniles from being smothered by mud. These buildups have been reported from the Pelsonian and early Illyrian part of the Lower Muschelkalk (KLOTZ & LUKAS 1988, HAGDORN et al. 1999) and from the late Illyrian Upper Muschelkalk (HAGDORN 1978, HAGDORN & OCKERT 1993). Meanwhile, such oyster-crinoid buildups have also been found in the Pelsonian Recoaro Formation of

the Vicentinian ALPS (HAGDORN et al. 1999), in the Ladinian of Southern France and in the early Ladinian of the Balaton Highland (own observations, unpublished) and were obviously wide spread over the western Paleo-Tethys during this time interval.

With this background, any crinoid fauna occurring in Middle Triassic reefs deserves special interest not only from the viewpoint of early post-Paleozoic crinoid recovery and radiation, but also with respect of the ecological role stalked crinoids played in shallow waters before their retreat to the deep sea.

The end-Permian extinction event also caused the worldwide sudden disappearance of metazoan reefs. The P/T boundary is followed by a considerable gap of metazoan reefs (STANLEY 1988, 2001, VELLEDDITS 1999, FLÜGEL 2002, LEHRMAN et al. 2002). The Early Triassic (Induan-Olenekian) is characterised by microbial reefs which occur at several localities distributed over the world between 20° Northern and Southern paleolatitudes (WEIDLICH et al. 2003). The absence of metazoan reefs is explained by restricted conditions, such as anoxic and/or CO₂ rich water prevailing in outer-shelf to basinal settings during the Early Triassic (WEIDLICH et al. 2003, PRUSS & BOTTJER 2004).

According to our present knowledge, the earliest Triassic metazoan reef, situated in South China, has late Olenekian/Anisian age (LEHRMANN et al. 2002). Until now, Anisian metazoan reefs have been described only from South China, the Western Paleo-Tethys and from the German Triassic. For a detailed list of Anisian reefs see FLÜGEL (2002). Middle to late Pelsonian reefs are known from the Southern Alps, from the Dolomites (BECHSTÄDT & BRANDNER 1971, FOIS & GAETANI 1984, SENOWBARI-DARYAN et al. 1993) and from Lombardy (GAETANI & GORZA 1989). In the Pelsonian, reefs appeared on the southern shelf of the Vardar-Meliata branch of the Neo-Tethys. These small patch reefs are represented either as autochthonous or as resedimented reef talus blocks (SENOWBARI-DARYAN et al. 1993). From the germanotype Pelsonian/early Illyrian Triassic of Silesia (Lower Muschelkalk, Karchowice Formation) that was deposited close to the marine gates connecting the Germanic Basin with the Tethys, BODZIOCH (1997), HAGDORN et al. (1999), and SZULC (2002) described sponge-coral build-ups reaching 2 to 80 m in diameter. Crinoid-bivalve-bioherms of the same age that are widely distributed in several horizons of the Germanic Lower Muschelkalk are characterized by much lower diversity and by crinoid (encrinid) holdfasts as primary frame builders (KLOTZ & LUKAS 1988, HÜSSNER 1993, HAGDORN et al. 1999).

In contrast to these small buildups and resedimented boulders of the Southern Alps and Silesia that never reached more than a few tens of meters in lateral extension, in the Aggtelek area a well developed barrier reef occurs. The vertical section of this reef allows a step by step study of the reef

establishment. This Aggtelek reef bordered to the southern edge of the northern shelf of the opening Vardar-Meliata branch of the Neo-Tethys Ocean. In the neighborhood of the Aggtelek area it is possible to study various Triassic facies units (Fig. 1 b) from the reefs and platform fore slope, to the basin, and even remnants of oceanic crust (KOVÁCS 1982). A detailed investigation of the Aggtelek reef offers a unique opportunity to study the relations between the rifting of the Vardar-Meliata branch of the Neo-Tethys ocean and the process of reef establishment.

The aim of the present contribution is to describe the crinoid faunas of the well dated Aggtelek platform. During Triassic times, crinoids strongly radiated and had recovered by the end of the Triassic. Their radiation commenced in early Anisian and reached a first maximum during early Illyrian. In a second maximum, their diversity culminated in mid-Carnian times (HAGDORN 1998). Before the end of the Carnian, many crinoid clades, like the Encrinidae, the Traumatocrinidae, and the Holocrinidae, disappeared. This faunal turnover may have been triggered by a global climatic change towards more humid conditions that caused a decrease of plankton abundance (SIMMS & RUFFELL 1989). Isotope analyses of Triassic brachiopod shells indicate a 2 ‰ $\delta^{18}\text{O}$ increase within the uppermost Cordevolian and lower Julian (Carnian) of the Southern Alps (KORTE et al. 2005) that suggests either a distinct temperature decline or an increase in salinity, or their combination. Due to their rapid evolutionary radiation, crinoids can be used as biostratigraphic tools, especially in such formations where ammonoids or conodonts are lacking. Even isolated ossicles of many crinoids have diagnostic characters that make them useful index fossils. Exceeding from the Muschelkalk in Poland and Germany, a crinoid biozonation was established for the Anisian (HAGDORN & GLUCHOWSKI 1993) that could be transferred to the Muschelkalk of South Hungary (Mecsek Mountains) by HAGDORN et al. (1997).

2. Geological setting, stratigraphy, and fauna

The investigated reef forms a 1.8 km wide belt of NW/SE strike over a distance of about 7 km between Aggtelek, Jósvalő and Égerszög in the karstified Aggtelek Hills, NE Hungary. Two sections have been sampled for the present study: (1) Baradla cave, which belongs to the UNESCO World Natural Heritage of the Aggtelek-Slovak Karst, (2) road cut between the villages of Aggtelek and Jósvalő (Fig. 1c).

The Aggtelek Karst continues in Slovakia as Slovak Karst. The classical name for both areas is Gömör – Torna Karst. The Triassic platform formations building up the Aggtelek karst belong to the Silica Nappe which forms the uppermost nappe of the Inner West Carpathians (KOZUR & MOCK

1973). In Triassic times, both the West Carpathians and the Northern Calcareous Alps were situated on the northern shelf of the opening Vardar – Meliata branch of the Neo-Tethys (KOVÁCS 1982, TOLLMANN 1987, HAAS 2001). Its rifting strongly influenced the evolution of the region. Due to the lack of tectonic activity and of reef building organisms during the Early Triassic to Pelsonian times, a homoclinal ramp came into existence in the area (HIPS 2003).

The Alpine evolutionary cycle commenced in the Late Permian with a hypersaline lagoonal facies of thick anhydrites and red or green or black shales (Perkupa Evaporite Formation). This evaporitic complex containing tectonic slivers of magmatites of the oceanic basement (diabase, gabbro, serpentinite) forms the base of the Silica Nappe. According to RÉTI (1985, 1988) the fragments of the Middle Triassic (Ladinian) ophiolitic suite were tectonically incorporated into the evaporite complex during the nappe overthrusting. Most probably due to a climatic change, the Permian evaporitic sedimentation was followed by siliciclastic sediment deposition (Bódvaszilas Sandstone Formation, Szin Marl Formation) in the Early Triassic.

At the end of the Early Triassic, the input of fine grained siliciclasts became strongly reduced and carbonate deposition became dominant on the ramp (Szinpetri Formation). The lower 100-150 m of this formation is made up of grey, bioturbated, nodular limestones and marls (“vermicular” limestone similar to the Wellenkalk facies of the Germanic Muschelkalk). The Gutenstein Formation can be considered as the youngest deposit on the ramp. It is 450 m thick and consists of dark grey to black, bituminous, thin to thick bedded limestone and dolomite. From its upper part, HIPS (2003) described mudmounds of Pelsonian age dominated by cyanobacteria, calcimicrobes, and questionable *Tubiphytes* that colonized the sea floor in the deepest part of the subtidal zone forming microbial mats.

Due to the rifting in the Pelsonian, the fairly uniform ramp was dissected and three facies units evolved (Fig. 1 b, KOVÁCS et al. 1989): (1) the Aggtelek Unit existed as a platform till the late Carnian (Tuvalian) while the Aggtelek reef bordered the platform edge only until the Ladinian, (2) the Szőlősárdó Unit represents the slope between the platform, and (3) the deep basin (Bódvá Unit) which bordered the opening ocean. The latter unit can be correlated with the Hallstatt facies in the Northern Calcareous Alps.

The Aggtelek reef is underlain by the Gutenstein Formation, which has early Anisian age in this region. The name Gutenstein Limestone coined by HAUER (1853) was applied for these sediments as early as 1896 by the Austrian geologist FOETTERLE and by the Hungarian geologist SÓBÁNYI (in BALAOGH 1945). SCHRÉTER (1935) correlated the Gutenstein Dolomite with the Megyehegy Dolomite of the Balaton Highland. Based on brachiopods

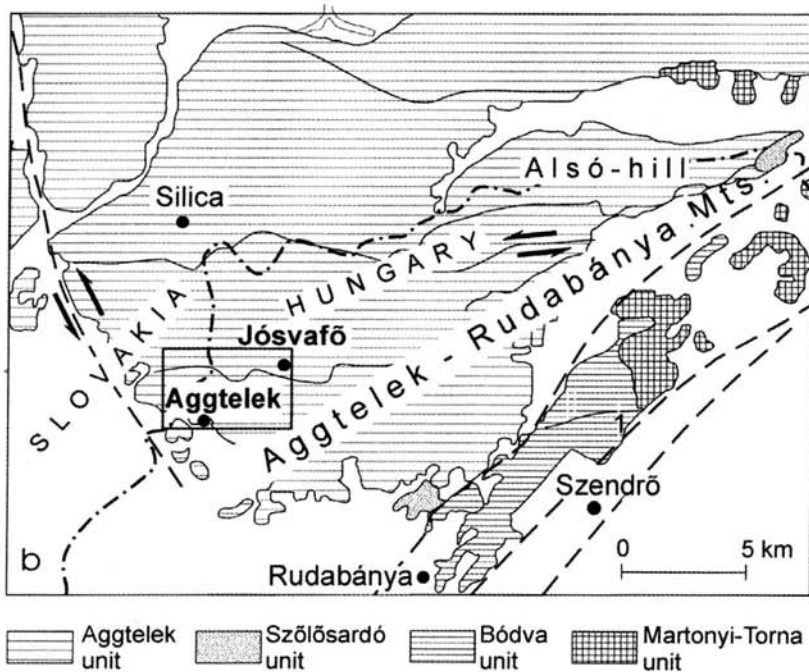
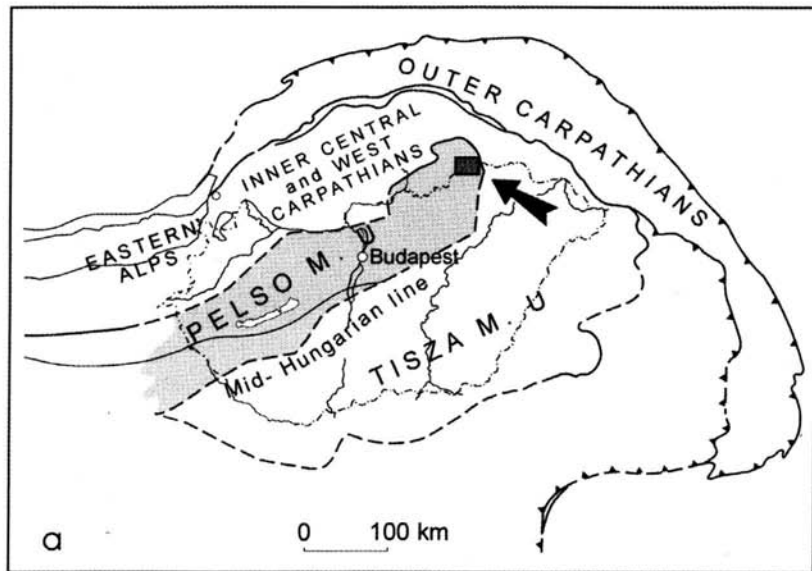


Fig. 1 (Legend see p. 379)

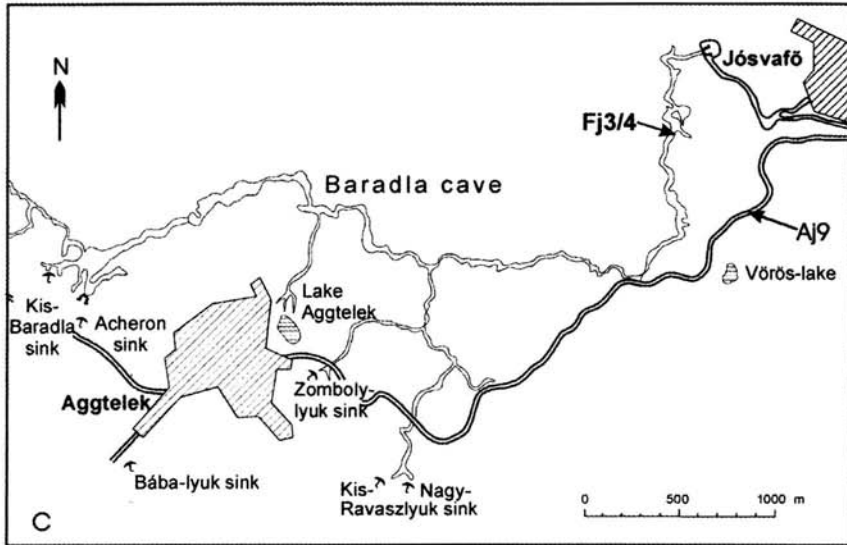


Fig. 1. **a** – Location of the studied area and major geological units of the Pannonian Basin. **b** – Tectonofacies (facies) units of the Silica nappe after the Middle Triassic differentiation of the basement. Simplified after LESS (1998). **c** – Location of the investigated fossil sites. FJ3/4: location of the investigated neptunian dyke in the Baradla Cave, AJ: Aggtelek / Jósvalfő roadcut.

and dasycladaceans, he divided the Anisian part of the limestone (today Steinalm Formation) from the Ladinian part (today Wetterstein Formation). However, he used the name Recoaro Limestone instead of Steinalm Limestone. BALOGH (1948) recognized the Northern Alpine affinity of the succession. When mapping during 1941-1943 between Plešivec, Szögliget, and Horný Vrch, he collected *Teutloporella herculea*, *T. nodosa*, and *Diploporella annulata* and assigned the host rock to the Wetterstein Limestone (BALOGH 1945, 1948).

The first paper focussing on the Aggtelek reef was presented by SCHOLZ (1972). He gave an overview of the diverse fauna and flora of the reef, described some reef building organisms, and determined its age by means

of the stratigraphical range of dasycladaceans. He considered the reef limestone coeval with the Steinalm Formation, consequently he regarded the age of the reef Pelsonian to middle Illyrian. SCHOLZ subdivided the 500 to 600 m thick reef complex into three main facies, (1) a central reef with colonial corals, hydrozoans and calcispongia, (2) a reef slope under heavy wave action with a paleocommunity of brachiopods, molluscs, and echinoderms, and (3) a more quiet water reef slope with echinoderms and molluscs. The reef was covered by dasycladacean bearing sediments.

MIHÁLY (1981) carefully studied echinoid spine and interambulacral material of the Aggtelek karst and reported 16 species among which 7 were new. Although Mihály recognized a definite similarity with echinoid faunas in the Ladinian/Carnian Cassian Formation of the Southern Alps, he assigned the echinoids to the Pelsonian to lower Illyrian. According to MIHÁLY the reef core is built up by two biofacies: (1) "calcareous-sponge-hydrozoan-coral", and (2) "echinoderm-brachiopod-mollusc" limestone.

At the same time, BORKA (1982) mapped the eastern part of the Aggtelek plateau and studied the lower and middle stages of the Baradla Cave in his unpublished diploma thesis. His careful field observations contributed to the knowledge of the platform evolution. He described the microfacies types of the Gutenstein and Steinalm Formations and figured their foraminifera faunas which were determined by BÉRCZI-MAKK. He was also the first to describe the Lofer cycles in the Steinalm Limestone, the ammonites from the cave, and the tuffite intercalation from the succession underlying the reef. He also reported neptunian dykes in the Steinalm Limestone. However, he interpreted them as channels cut through the reef core. Based on *Diplopora annulatissima* (det. by OLGA PIROS) found at 4400 m from the entrance of the Baradla cave near Jósvalő, he stated that the reef formation commenced in late Illyrian and continued in the Ladinian. In the 1980s the area was mapped by the Hungarian Geological Institute. The results are depicted in a geological map at scale 1:25000 (LESS et al. 1998). In her doctoral thesis, PIROS (1986) differentiated the Anisian (Steinalm) and Ladinian/Carnian (Wetterstein) limestones and subdivided the reef and the lagoonal facies of the Ladinian Wetterstein Limestone the age of which she determined by dasycladaceans. In the lagoonal facies she distinguished different Dasycladacean communities arranged in a lateral zonation that she called "horizontal Dasycladacean zones" (PIROS in KOVÁCS et al. 1989).

From 2002 onward a new project started to study the evolution of the Aggtelek Platform. In the course of this project, a more detailed mapping of the platform facies, the revision of the fauna and flora, and the reconstruction of the Anisian-Ladinian reef evolution is under study. Another objective is to answer the question how the rifting of the Vardar – Meliata oceanic branch of the Neo-Tethys controlled the evolution of the Aggtelek

Platform, i.e. how the rifting promoted the development of the Anisian/Ladinian reef on the Aggtelek Platform. In the frame of this project, SIMON (2003) has carried out paleontological and sedimentological investigations on the reef facies. In her diploma thesis she distinguished two types of reefs between Aggtelek and Égerszög. The first is made up by small sized Sphinctozoans without internal skeleton (*Olangocoelia*, *Celyphia*); the diversity of this reef community is low. The second type is built up mainly of larger Sphinctozoans with internal skeleton (*Colospongia*, *Vesicocaulis*, *Solenolmia*); the diversity of this reef community is higher.

3. Crinoids from the Aggtelek Platform and their bearing on stratigraphy

The crinoid samples from the Aggtelek reef comprise almost exclusively disarticulated columnals and pluricolumnals and a few brachials and cup elements. Some of them have already been figured by SCHOLZ (1972) and MIHÁLY (1981). Some longer crinoid stem fragments were found inside the Baradla cave. They cannot be removed from there and transferred into a paleontological collection. Since their long time preservation in the cave cannot be ensured, this material was not included into this paper. Echinoderm remains are quite common in the Aggtelek reef. Due to the influence of humic acids, rock surfaces are etched inside the caves and along joints of crushed rocks providing naturally etched echinoderm sclerites. All weathered rock surfaces at the fossil site along the roadcut between Aggtelek and Jósvalfó are flesh to rust coloured. There, specimens were collected by careful searching the weathered surfaces using a hand lens. Due to the solution process, the surfaces of the sclerites are more or less etched. Although the material base is rather poor, crinoids – like the echinoids, which have been described by MIHÁLY (1981) – form an important faunal element during reef development and may provide arguments for the determination of the age of the reefs. However, the number of specimens is far from being representative for a full description of the crinoid faunas.

In the Aggtelek reef, we have found crinoids in three levels, (1) in neptunian dykes of the Steinalm Limestone Formation underlying the Wetterstein Formation, together with conodonts and filaments, (2) at the base of the reef complex, (3) within the reef together with brachiopods, *Tubiphytes*, mollusks and other echinoderm sclerites (Fig. 2).

3.1. Crinoids from neptunian dykes

Neptunian dykes in the Baradla Cave yielded a small number of echinoderm sclerites (Fig. 2) among which a few (sample Fj. 3/4) can be attributed to

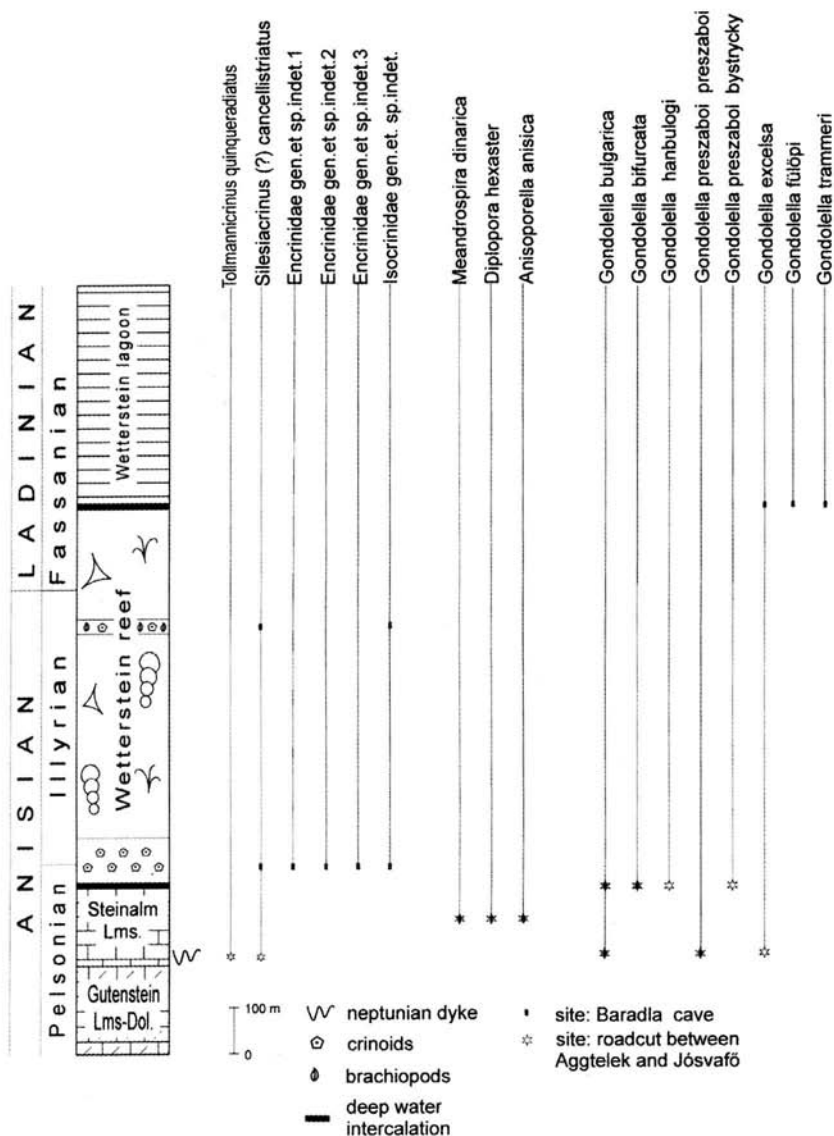


Fig. 2. Stratigraphical position of the crinoids and the stratigraphically important fossils. The stratigraphic column has been composed of the sections at Aggtelek/Jósvalfő roadcut and in Baradla Cave.

existing taxa, however not with certainty. This material was processed from the infill of the dyke by acetic acid according to the method of BECKMANN (1952), and MÜLLER (1962). The sclerite surfaces are visibly etched; however, some of the ossicles still show the echinoderm stereome.

Some of the columnals are related to *Tollmannicrinus quinqueradiatus*, a small crinoid that until now is known from isolated material exclusively. *T. quinqueradiatus* was originally described by BATHER (1909) from the early Carnian of Czerhát (= Cserhát, a district of Veszprém, Balaton Highland, Hungary) as *Entrochus quinqueradiatus* and has later been reported from the South Alpine Cassian Formation (ZARDINI 1976) and from late Ladinian limestones of Hallstatt facies in Saklibeli (Taurus Mountains, Turkey) by KRISTAN-TOLLMANN & KRYSZYN (1975) together with *T. saklibelensis* and some additional species. However, following BATHER (1909), she included both taxa into the parataxonomic genus *Entrochus*. Later, KRISTAN-TOLLMANN (1988) reported these crinoids from Anisian to Norian formations of many parts of the Tethys and Panthalassa realm ranging from the Northern Calcareous Alps to Timor and New Zealand. The late Anisian to Rhaetian material from New Zealand has been re-described and figured by EAGLE (2003). From this wide distribution KRISTAN-TOLLMANN (1988) concluded a Panthalassic E – W peri-equatorial current system in the western Tethys that existed during the Triassic. Finally, KLIKUSHIN (1992) established the genus *Tollmannicrinus* with *T. saklibelensis* as genotype and attributed it to family Holocrinidae, however, without knowledge of its cup and crown. *T. quinqueradiatus* is a very common crinoid in the Carnian Hanwang Formation in Central China (Sichuan; unpublished material including articulated cups in Muschelkalkmuseum Ingelfingen). This material gives evidence for inclusion of a small barrel shaped crinoid cup described by BATHER (1909: 56, pl. 5, figs. 123-126) from the Carnian of the Balaton Highland. BATHER attached this cup that combines holocrinid with encrinid and isocrinid characters to *Isocrinus scipio*, which is the most common crinoid at Czerhát, Veszprém.

Like the Turkish specimens, the columnals from the Aggtelek neptunian dykes are very small and do not exceed 1.5 mm (Fig. 4 a-e). Generally, the very small size of the crinoid columnals does not allow their unequivocal determination. For this reason, it cannot be excluded that the material also represents a juvenile *Holocrinus* or an isocrinid. A more detailed discussion has to be postponed until the well preserved Chinese Fauna will be described. *Tollmannicrinus* was a very small crinoid that did not grow higher than 20 cm and could therefore not substantially contribute to the reef debris. Moreover, its terminal stem is still unknown and it is an open question whether the stem ended in an enlarged cirriferous nodal as in KLIKUSHIN'S (1992) reconstruction, or in an encrinid-type holdfast that would have

persistently anchored the animal to hard substrate. As the references of *Tollmannicrinus* indicate Anisian to Rhaetian time, this crinoid genus does not deserve biostratigraphic value. This is also the case if the columnals are attributed to genus *Holocrinus*, which has an Olenekian to Ladinian range.

Two circular columnals with an articulation facet pattern of long crenulae can be attributed to *Silesiacrinus* (?) *cancellistriatus* (Fig. 4f), a taxon that does not deserve biostratigraphic value either. This taxon will be discussed below.

The conodonts processed from the neptunian dykes were determined by S. KOVÁCS (Fig. 2). They indicate Anisian age: *Gondolella bulgarica dominancia* (KOVÁCS 2003) in sample Fj3 is indicative for the Bithynian Osmani Biozone to the boundary of the Pelsonian Binodosus Subzone/Illyrian Trinodosus Zone. Sample Fj3/4 with the crinoid remains yielded *Gondolella praeszaboi praeszaboi* (KOVÁCS, PAPŠOVÁ & PERRI 1996), which is indicative for late Pelsonian/early Illyrian age. Fig. 3 gives an overview of conodont ranges and correlation with Anisian/Ladinian ammonoid biozonation.

3.2. Crinoids from the Aggtelek reefs

The bulk of the crinoid material was collected along the roadcut between Aggtelek and Jósvalfő (Figs. 5-8) from the base of the reef (facies 2 and 3 of SCHOLZ 1972). Here, echinoderm remains are quite abundant but still less than 5 % of the bioclasts (Fig. 5). Due to the humic acids, larger crinoid columnals are often incomplete or have strongly etched surfaces that do not allow determination.

Similarly to most other Middle Triassic shallow water benthic paleo-communities, the crinoid diversity is low compared to Paleozoic reefs. Two different types of attachment to the substrate are represented, (1) permanent and solid attachment by a discoid or incrusting holdfast that did not allow re-attachment when the stalk was broken (orders Encrinida and Millericrinida), and (2) attachment by cirri that enabled the animal to change its position by crawling on the seafloor and to get re-anchored when the stem was broken or actively shed at a preformed rupture point (order Isocrinida). According to HAGDORN (1983) and BAUMILLER & HAGDORN (1995), in family Holocrinidae preformed rupture surfaces at the lower facets of the nodals made sure that the stem always ended in a cirriferous nodal which took over the re-attachment of the animal. As no complete articulated skeletons have been found in Aggtelek, it remains an open question whether or not the crinoids specifically differed in stem lengths elevating their crowns to different tiers above the seafloor.

The largest columnals among the Aggtelek crinoids are encrinid. Unfortunately, most encrinid columnals are not diagnostic at species or genus level and have to be attributed to Encrinidae gen. et sp. indet. Nevertheless, the Aggtelek samples have not yielded proximal nodals with cirrus scars which would be diagnostic for Pelsonian/early Illyrian *Encrinus aculeatus* and *Chelocrinus* sp. (HAGDORN et al. 1996, HAGDORN & SCHULZ 1996). Moreover, columnals with extremely large height index that occur abundantly in the Pelsonian Felsőörs Formation and in the late Illyrian Vászoly Formation (Avisianum Subzone) of the Balaton Highland are not present either. Among the encrinid remains are some pluricolumnals (Fig. 6 a, c, d) from the mesial or distal stem that have very distinct epifacets which make the stem resembling a chain of beads (Encrinidae gen. et sp. indet. 1). This character has been observed in encrinids from the upper Ladinian Wettersteinkalk Formation of the Northern Calcareous Alps of Füssen, Bavaria (MHI 1867) and from the upper Ladinian Pachycardia Tuffite of the Seiser Alp in the Dolomites, Italy (ZARDINI 1976: pl. 3, figs. 41, 48; HAGDORN 1988, fig. 4, 3 a, b). However, from the poor material, the stratigraphical value of this character can not yet be estimated. This is also true for encrinid columnals with tuberculated latera that rarely occur in the Aggtelek/Jósvafő roadcut fauna (Fig. 6 e-g). Columnals with tuberculated latera have been described by ZARDINI (1976: pl. 2, figs. 4-11) from the South Alpine Cassian Formation as *Encrinus tuberculatus*, however, with an articular facet pattern of granulated loops resembling *Zardinicrinus granulatus*. Typical late Ladinian/early Carnian taxa like *Cassianocrinus varians* and *Zardinicrinus granulatus*, the columnals of which are diagnostic, are not present in the Aggtelek reef. Resulting from the encrinid data, the fauna from the Aggtelek/Jósvafő roadcut yielded neither typical Anisian nor typical late Ladinian/early Carnian elements.

Fig. 4. Crinoids from neptunian dykes in Baradla Cave (sample FJ 3/4). **a-e** – ? *Tollmannicrinus quinqueradiatus* (BATHER, 1909); **a** – circular distal columnal with long crenulae, Ø 1.3 mm, MÁFI Ech 2087; **b** – subcircular distal columnal with long crenulae, Ø 0.9 mm, MÁFI Ech 2089; **c** – basaltiform proximal columnal with short crenulae, Ø 1.2 mm, MÁFI Ech 2090; **d** – substellate proximal columnal with short crenulae, 1.2 mm, MÁFI Ech 2089; **e** – stellate proximal nodal, articulation facets poorly preserved, Ø 0.8 mm, MÁFI Ech 2087; **f** – *Silesiacrinus* (?) *cancellistriatus* (BATHER, 1909), columnal with small lumen and long crenulae with additional crenulae intercalating, Ø 1.4 mm, MÁFI Ech 2090.

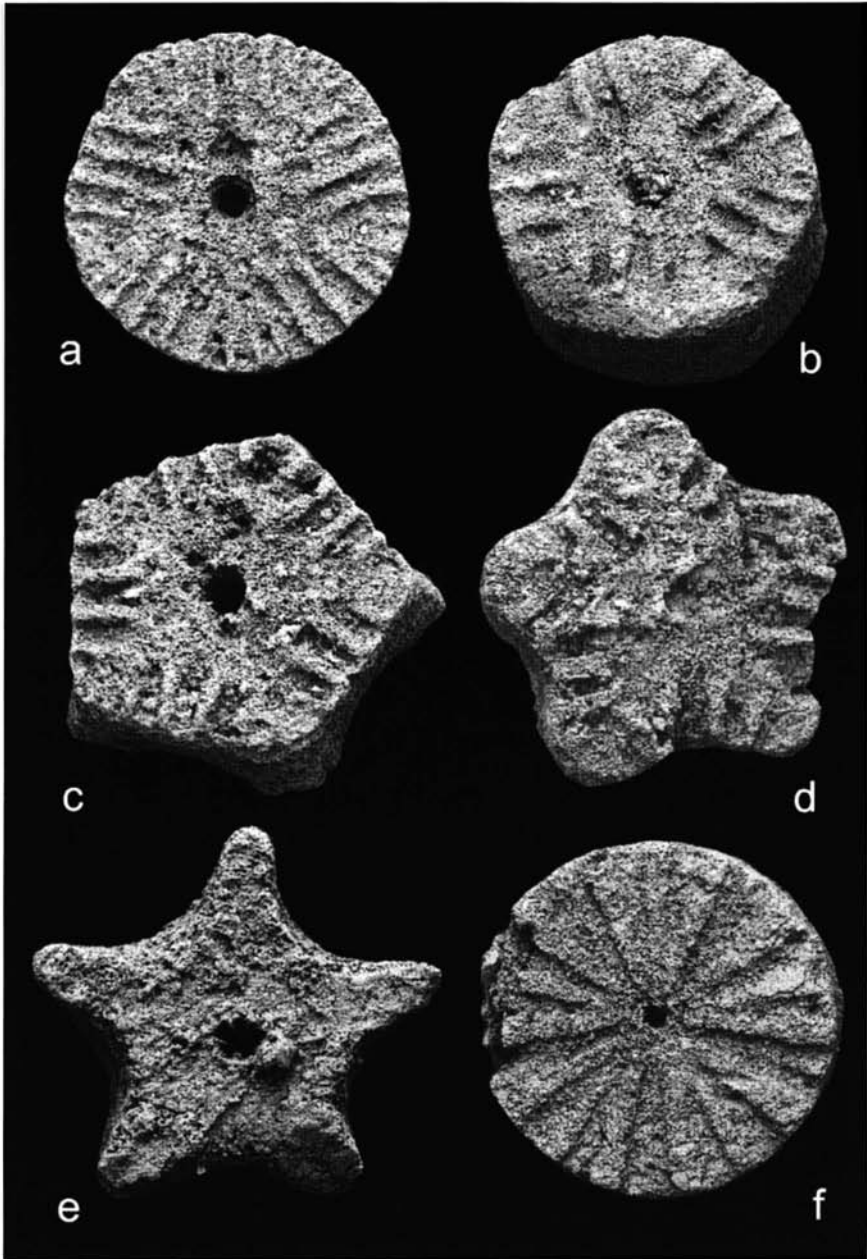


Fig. 4 (Legend see p. 386)

The Millericrinida is another group of crinoids that was attached by in-crusting holdfasts. The Triassic material included into this order comprises only columnals and some holdfasts (HAGDORN et al. 1996, Stiller 2000). Millericrinid columnals are low disc-shaped and have long crenulae that may bifurcate or be added by intercalation during growth. These characters are represented in several columnals and pluricolumnals from the Aggtelek roadcut fauna (Fig. 7a-h) and in two very small columnals from the neptunian dykes (Fig. 4f). From typical *Silesiacrinus silesiacus* that was widely distributed over the Western Paleo-Tethys during early Illyrian times (HAGDORN & GLUCHOWSKI 1993, HAGDORN et al. 1996, 1997) they differ in their narrow central canal, however specimens with narrow canal may occur within the variability of *S. silesiacus*. Such specimens have been found in the Steinalmkalk of Saalfelden (Salzburg, Austria; SCHNETZER 1934 and own collections). The articulation facet pattern with long bifurcating and intercalating crenulae is very common among crinoids with cylindrical columnals and was developed several times by convergency. Isolated columnals which were described by BATHER (1909) from the Carnian of the Balaton Highland as *Encrinus cancellistriatus* also represent this type, as well as columnals from the Norian/Rhaetian Hallstatt Limestone of the Steinbergkogel (Austria, Salzkammergut) in the collections of the Naturhistorisches Museum Wien (comp. BATHER 1909: 14, and own collections). *E. cancellistriatus* has also been reported from the Carnian Cassian Formation of the Seelandalpe (Dolomites, Italy, ZARDINI 1976, own collections). These columnals do therefore not deserve special stratigraphic value.

The order Isocrinida is represented by a small crinoid with circular to subcircular columnals and enlarged nodals with big cirrus scars (Fig. 8a-g). Due to the scarcity of well preserved specimens, it remains an open question whether the distal nodal articulation facets were symplectial, which would be indicative of holocrinid affinity and Anisian age, or synostiosial/cryptosynostiosial respectively, which would rather indicate isocrinid affinity and Ladinian or younger age. Among Triassic isocrinids, circular outline and big cirrus scars are diagnostic for genus *Singularocrinus* which has been reported from the Norian of former USSR (KLIKUSHIN 1982, 1992) and is also common in the Carnian Hanwang Formation of Central China (own collections). However, this genus is invalid because no holotype has been designated (in lit. communication, H. HESS, Basel, 11 May, 2005). The Aggtelek columnals do not reach the size of typical *Singularocrinus*. Much more important for stratigraphic calibration of the Aggtelek/Jósvafő roadcut crinoid palaeocommunity is the lack of typical Anisian holocrinids like the *Holocrinus acutangulus/Holocrinus dubius* chronokline (Bithynian to early Illyrian) and *Eckicrinus radiatus* (Pelsonian/early Illyrian) that are typical faunal elements in most western Tethys stenohaline benthic communities



Fig. 5. Rock surface etched by humic acids with crinoid remains. Width of picture 35 mm.

of this time span, e.g. Upper Silesia, the Mecsek Mountains and Balaton Highland (HAGDORN & GLUCHOWSKI 1993, HAGDORN et al. 1996, 1997). The Isocrinida fossil record from Aggtelek does not contain any unequivocal biostratigraphic index. Thus, the lack of *Holocrinus* and *Eckicrinus* can be explained by (1) a chronostratigraphic position later than early Illyrian, or (2) by unknown paleobiogeographical or paleoecological reasons.

3.3. Evidence for stratigraphic calibration based on other fossils

Foraminifera, dasycladaceans, and conodonts provide better tools for stratigraphic calibration of the Aggtelek reef (Fig. 2).

(a) In the neptunian dyke at the base of the Steinalm Limestone that yielded ? *Tollmannicrinus quinqueradiatus* and *Silesiacrinus* (?) *cancellistriatus*,

the conodonts *Gondolella bulgarica* and *G. preszaboi preszaboi* (det. by S. KOVACS) have been found. According to KOVACS (2003), *G. bulgarica* is indicative for the time interval between the Osmani Zone (Bithynian) and the boundary of the Binodosus Zone (Pelsonian)/Trinodosus Zone (Illyrian); *G. praeszaboi praeszaboi* is indicative for late Pelsonian/early Illyrian (Fig. 3). Thus, the conodonts give evidence for late Pelsonian/early Illyrian age of this neptunian dyke, which is not in contradiction with the crinoid data.

(b) For the Steinalm Limestone Formation underlying the Wetterstein reef, Pelsonian age is indicated by foraminifera *Meandrospira dinarica*, *Glomospirella semiplana* (det. by J. Blau), dasycladaceans *Diplopora hexaster*, *Anisoporella anisica*, *Physoporella pauciforata undulata*, *Physoporella pauciforata sulcata*, *Physoporella pauciforata pauciforata*, *Physoporella minutuloidea*, and *Physoporella minutula* (det. by O. PIROS). The conodonts *Gondolella bulgarica*, *G. hanbulogi*, *G. bifurcata*, and *G. praeszaboi bystrycky* were collected under the Wetterstein reef. They are indicative of the late Pelsonian Binodosus Zone (Fig. 3).

(c) The strata overlying the reef (a deep water intercalation) yielded *Gondolella excelsa*, *G. fueloepi*, *G. trammeri*. Their ranges allow a fairly exact calibration because *G. excelsa* disappears in the upper part of the Curionii Zone (BRACK et al. 2005) and *G. fueloepi* and *G. trammeri* appear at the base of the Avisianum Subzone. Thus, the age of the strata topping the reef is most probably between Avisianum Subzone and Curionii Zone.

According to these data, the formation of the Aggtelek reef is covering the time span between late Pelsonian (Binodosus Zone) and early Ladinian (Curionii Zone). Because the Anisian/Ladinian boundary has recently been fixed at the base of the Curionii Zone by decision of ICS, those parts of the Wetterstein reef that correspond to the Reitzi Zone and the Secedensis Zone are thus late Anisian in age (BRACK et al. 2005). Herewith, the Wetterstein reef crinoids of the present investigation must certainly be dated back to latest Anisian age.

The material figured in this paper is deposited in the collections of the Hungarian Geological Survey (Magyar Állami Földtani Intézet, MÁFI) and in the Muschelkalkmuseum Ingelfingen (MHI).

4. Systematic paleontology

Class	Crinoidea MILLER, 1821
Subclass	Articulata MILLER, 1821
Order	Encrinida MATSUMOTO, 1929 [nom. transl. HAGDORN, 1987]
Family	Encrinidae JAEKEL, 1918

Encrinidae gen. et sp. indet. 1

Fig. 6a-d

Material: A 10.0 mm long and 4.0 mm wide pluricolumnal MÁFI Ech 1974 (Fig. 6d); a 13.7 mm long and 2.5 mm wide pluricolumnal MHI 1801/1 (Fig. 6a); a 10 mm long and 6.4 mm wide distal pluricolumnal could also belong to this taxon, MHI 1801/1 (Fig. 6c).

Description: Medium sized encrinid with circular columnals. Latera convex, forming a distinct epifacet in mesial and distal stem. Thus, the articular facets are less wide than the entire columnal; pluricolumnals with undulated lateral outline, resembling a chain of beads. The suture line is coarsely crenulated in side view; crenulation multiradiate, culmina short. Proximal columnals or crown elements cannot be attributed with certainty.

Discussion: If the epifacet in the mesial and distal stem is a consistent character, this crinoid could represent a taxon of its own. However, the existing material is too poor for establishing a new species. At present, it cannot be decided either, whether the above mentioned columnals from the Cassian Formation in the Dolomites, Italy belong to the same crinoid.

Encrinidae gen. et sp. indet. 2

Fig. 6e-g

Material: A pluricolumnal with distinct tuberculation MÁFI Ech 1974 (Fig. 6g); a 6.2 mm long and 2.0 mm wide pluricolumnal MHI 1801/2 (Fig. 6f.); a 9.5 mm long and 3.9 mm wide pluricolumnal MHI 1801/3 (Fig. 6e).

Description: Small encrinid with circular columnals. Latera straight with irregularly distributed small tubercles. Crenulated suture line depressed, in side view hardly visible; multiradiate crenulation, culmina short. Proximal columnals or crown elements cannot be attributed with certainty.

Discussion: If the tuberculation on the columnal latera is a consistent character, this crinoid could also represent a separate taxon. The available material is too poor for establishing a new species. This crinoid differs from *Encrinus tuberculatus* ZARDINI, 1976 from the Cassian Formation in its very short multiradiate crenulae.

Encrinidae gen. et sp. indet. 3

Figs. 6c; 7i

Material: A 9.0 mm wide distal columnal with granulated perilumen MÁFI Ech 1974 (Fig. 7i); a 10.0 mm long and 6.4 mm wide distal pluricolumnal that could also belong to Encrinidae gen. et sp. indet. 1 MHI 1801/1 (Fig. 6c).

Description: Medium sized encrinid with cylindrical distal columnals with straight latera. Suture line depressed, in side view hardly visible; multiradiate

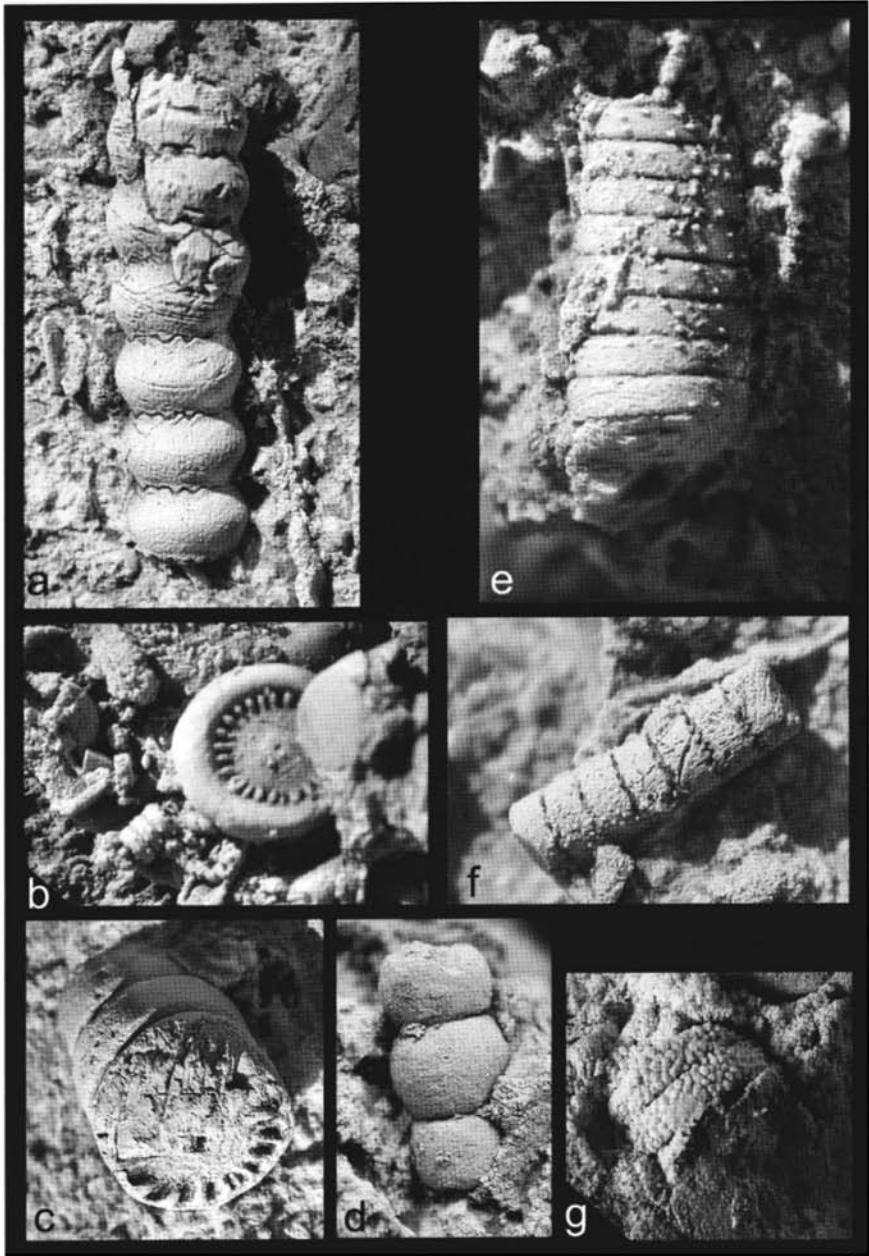


Fig. 6 (Legend see p. 393)

crenulation, culmina very short. Proximal columnals or crown elements cannot be attributed with certainty.

Discussion: These encrinid columnals are devoid of diagnostic characters and could not be attributed to any encrinid genus. The large nodals with inflated epifacet and rounded latera devoid of cirrus scars could belong to this indistinct encrinid, however as well to Encrinidae gen. et sp. indet. 1. A few discoid holdfasts are definitely encrinid but cannot be assigned to any encrinid genus or species.

Order Millericrinida SIEVERTS-DORECK in MOORE et al., 1952
 Family Bangtoupocrinidae STILLER, 2000
 Genus *Silesiacrinus* HAGDORN & GLUCHOWSKI, 1993

Silesiacrinus (?) *cancellistriatus* (BATHER, 1909) Fig. 7a-h

Material: 1 columnal from the neptunian dykes MÁFI Ech 2090 (Fig. 4f); a holdfast with 4 columnals attached MÁFI Ech 1976 (Fig. 7a, b); a distal columnal with very long culmina MÁFI Ech 1974 (Fig. 7c); a pluricolumnal from the proximal or mesial stem MÁFI Ech 1974 (Fig. 7d, e); a pluricolumnal from the proximal or mesial stem MÁFI Ech 1973 (Fig. 7f); a pluricolumnal of 5 columnalia from the proximal stem, MÁFI Ech 1974 (Fig. 7g, h).

Description: Medium sized crinoid. Columnals cylindrical, low to moderately high, with straight to slightly convex latera. Crenulation very fine, multiradiate. Culmina of proximal columnals moderately long, areola more or less wide, smooth. Distal columnals with very long, wedge shaped culmina, the longest starting from the lumen of the central canal; culmina smooth, or slightly granulated, or with a delicate longitudinal groove; culmina may bifurcate, additional culmina may be intercalated. Lumen of the central canal narrow, circular, no distinct spatia between columnals. These characters are also present in juvenile columnals smaller than 1.5 mm. Holdfast discoid. Other parts of this crinoid are not known.

Fig. 6. Encrinids from roadcut between Aggtelek and Jósvalő. **a-d** – Encrinidae gen. et sp. indet. 1. **a** – pluricolumnal from distal stem, 13.7 mm long, MHI 1801/11; **b** – proximal nodal, could also belong to Encrinidae gen. et sp. indet. 3, 6.1 mm wide, MHI 1801/7; **c** – pluricolumnal from distal stem, could also belong to Encrinidae gen. et sp. indet. 3, 10 mm long, MHI 1801/1; **d** – pluricolumnal, 10 mm long, MÁFI Ech 1974; **e-g** – Encrinidae gen. et sp. indet. 2. **e** – pluricolumnal 9.5 mm long, MHI 1801/3; **f** – pluricolumnal, 6.2 mm long, MHI 1801/2; **g** – pluricolumnal with distinct tuberculation MÁFI Ech 1974.

Discussion: This crinoid has been attributed to *Encrinus* by BATHER (1909). However, its multiradiate crenulation with very long, bifurcating and intercalated culmina resembles the articulation pattern of *Silesiacrinus* (*S. silesiacus* and *S. parvus*), which are considered early representatives of the Millericrinidae (HAGDORN et al. 1996, STILLER 2000). From these Anisian (early Illyrian) crinoids occurring in Europe and South-China respectively, *S. (?) cancellistriatus* differs in its simple narrow axial canal lacking lensoid intercolumnal spatia. However, the crenulation pattern is likely to be a simple basic pattern of multiradiate crenulation and could also have originated several times convergently among different crinoid lineages. Crinoid columnals assigned to *Silesiacrinus (?) cancellistriatus* have been reported from the Carnian of Balaton Highland (BATHER 1909), the Carnian Cassian Formation of the Seelandalpe (Dolomites, Italy; ZARDINI 1976, and own collections). Crinoid columnals with a similar articulation pattern have been described by JEKELIUS (1936) from the late Ladinian/early Carnian white reef limestone of Brasov (Romania). In the present paper, *Encrinus cancellistriatus* is attached to *Silesiacrinus* with reservation. *Entrochus ternio*, originally described by BATHER (1918) from the late Ladinian of New Zealand, has a very similar pattern of long bifurcating and intercalated culmina, however, its crenulation exceeds from a narrow areola (see also EAGLE 2003). This is also true for columnals of *Bangtoupocrinus* from the Anisian of SW-China, the latera of which are strongly ornamented with tubercles or spines (STILLER 2000).

Order Isocrinida SIEVERTS-DORECK, 1952
 Family Holocrinidae JAEKEL, 1918
 ? Genus *Tollmannicrinus* KLIKUSHIN, 1992

? *Tollmannicrinus quinqueradiatus* (BATHER, 1909)

Fig. 4 a-e

Material: 5 small columnals of 1.0-1.5 mm MÁFI Ech 2087, 2089, 2090. (Fig. 4a-e).

Fig. 7. *Silesiacrinus (?) cancellistriatus* (BATHER, 1909) from roadcut between Aggtelek and Jósvalfő. **a-b** – holdfast with 4 distal columnals attached, Ø of facet 10 mm, MÁFI Ech 1976; **c** – distal columnal with very long crenulae, Ø of facet 8 mm, MÁFI Ech 1974; **d-e** – proximal or mesial pluricolumnal, Ø of facet 5 mm, MÁFI Ech 1974; **f** – proximal or mesial pluricolumnal with smooth areola, Ø of facet 6 mm, MÁFI Ech 1973; **g-h** – proximal or mesial pluricolumnal, Ø of facet 5 mm, MÁFI Ech 1974; **i** – Encrinidae gen. et sp. indet. 3, columnal with granulated perilumen, Ø of facet 9 mm, MÁFI 1974.

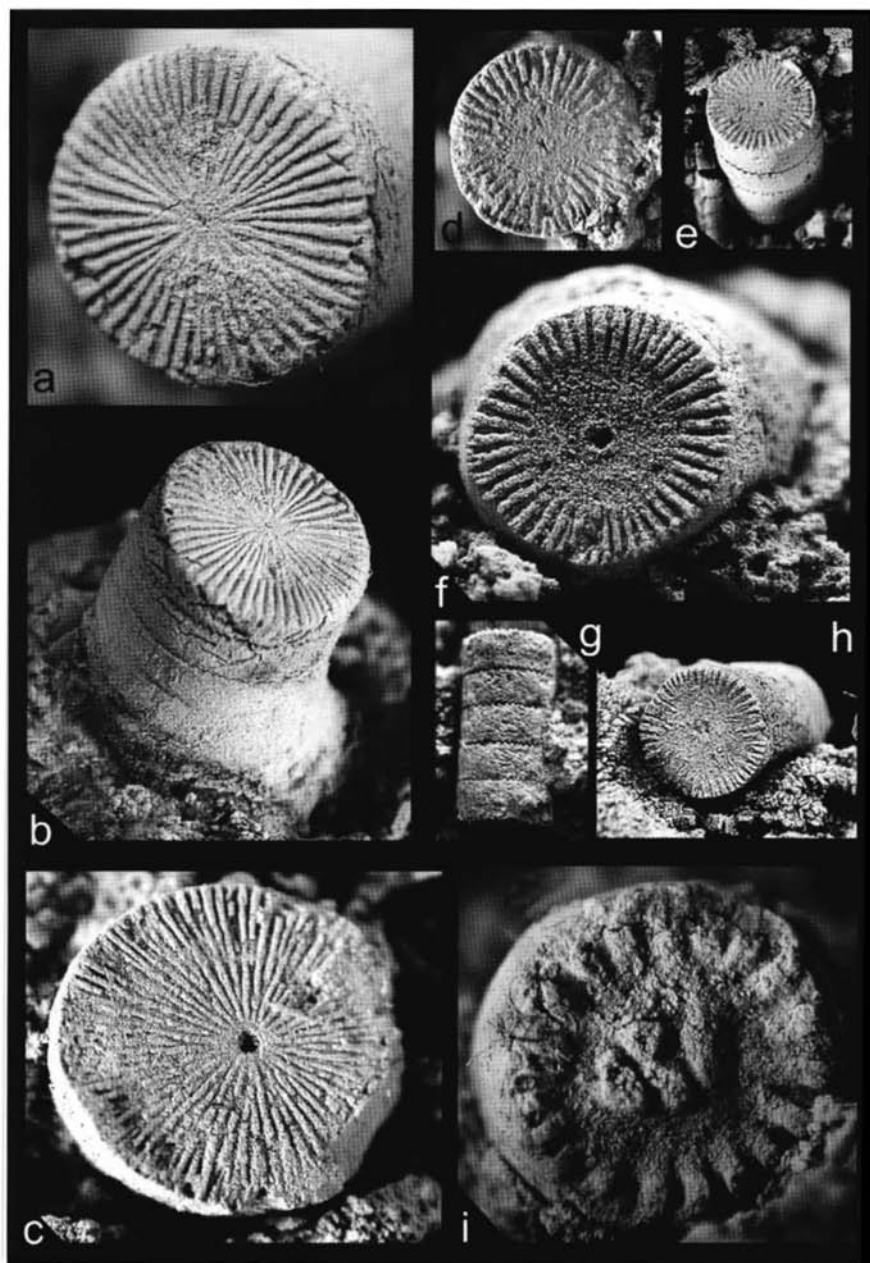


Fig. 7 (Legend see p. 394)

Description: Columnals small (1.0-1.5 mm), circular to pentalobate, with up to three short culmina in each radius; interradial crenulation with very short, oblique culmina. Lumen wide, circular or pentagonal. Latera straight.

Discussion: The Aggtelek material does not contain the typical barrel shaped columnals with circular articulation facets and five pairs of short culmina upon which BATHER (1909) based his parataxonomic species. However, the Aggtelek columnals are within the variety of this species that has been described by KRISTAN-TOLLMANN & KRYSZYN (1975) from the upper Ladinian of the Taurus Mountains (Turkey). The present material could also belong to a juvenile *Holocrinus* or an isocrinid. Nodals with cirrus sockets have not been found.

Family Isocrinidae GISLÉN, 1924

Isocrinidae gen. et sp. indet.

Fig. 8a-g

Material: A cup (only radial circle, basals not preserved MÁFI Ech 1964 (Fig. 8g); a pluricolumnal of 3 columnalia with a nodal at its distal end MÁFI Ech 1980 (Fig. 8c); a pluricolumnal of 7 columnalia with a nodal MÁFI Ech 1973 (Fig. 8e); an isolated nodal, MÁFI Ech 1974 III 26 H (Fig. 8f); a pluricolumnal of two inter nodals one of them with a poorly preserved articulation facet visible MÁFI Ech 1966 1/49 H (Fig. 8a, b).

Description: Small isocrinid with circular columnals and straight latera. Nodals slightly higher than internodals, with large cirrus scars directed upward; no cirrus grooves. The crenulation pattern of very short crenulae could not be clearly observed in any specimen. Suture line in side view not crenulated; no difference in suture lines of lower and upper nodal facets. Cup low cone shaped; basals large, visible in lateral view, in lateral contact with one another. Radials large, high, with trapezoidal aboral sides; radial facets directed obliquely upward, with deep aboral ligament grooves and distinct transverse ridge. Other parts not known.

Fig. 8. Isocrinidae gen. et sp. indet. from roadcut between Aggtelek and Jósaváő. **a-b** – pluricolumnal of two internodals, \emptyset of facet 4 mm, MÁFI Ech 1966; **c** – pluricolumnal of 7 columnalia with a nodal, length 6 mm, on the right a pluricolumnal of *Silesiacrinus* (?) *cancellistriatus*, MÁFI Ech 1974; **d** – pluricolumnal of 3 columnals with a nodal at its distal end, \emptyset of facet 3 mm, on the right smaller pluricolumnal, MÁFI Ech 1980; **e** – columnal, \emptyset of facet 3 mm, on the right a brachial, MÁFI 1973; **f** – nodal, \emptyset of facet 3 mm, MÁFI Ech 1973; **g** – radial circle, basals not preserved MÁFI Ech 1964, width of radial 8 mm, MÁFI 1964.

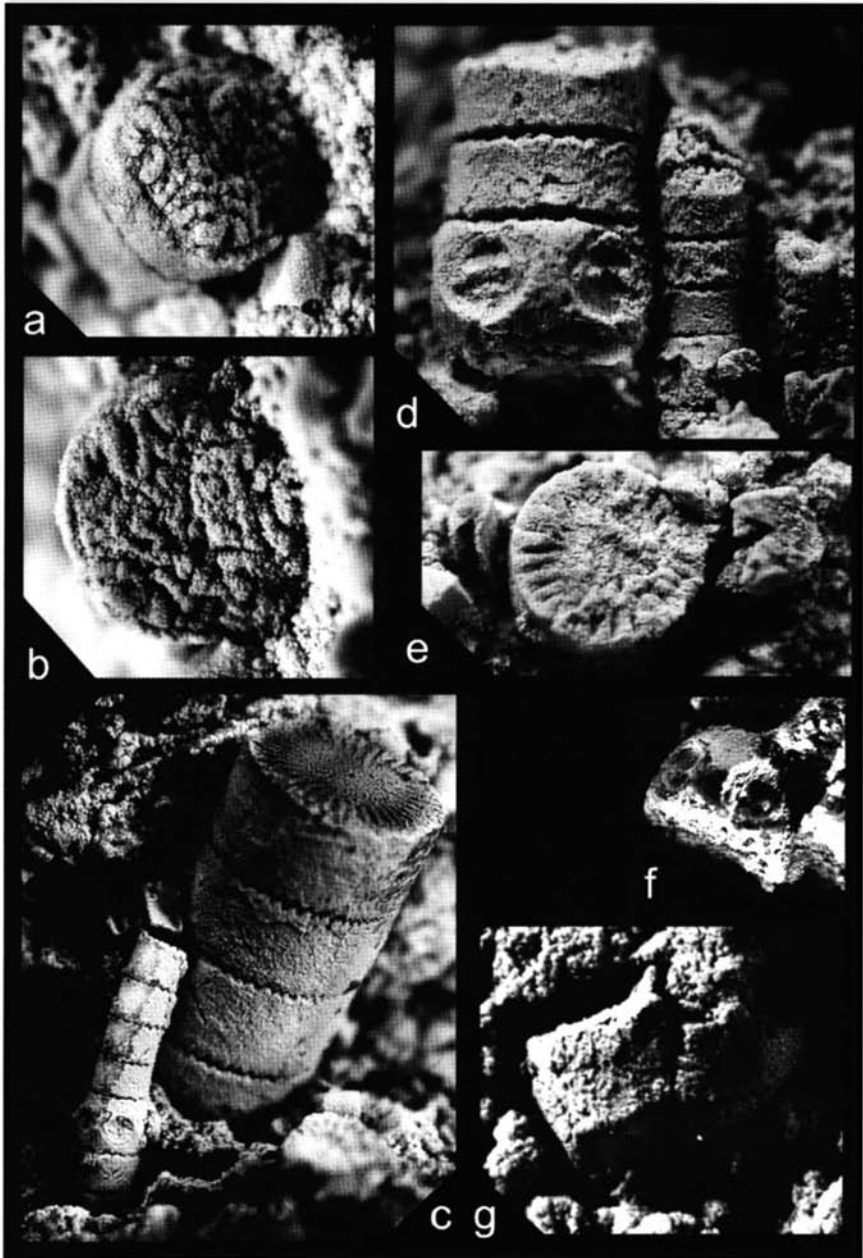


Fig. 8 (Legend see p. 396)

Discussion: The few and poorly preserved columnals do not allow a full description of this isocrinid. Its circular stem and the fairly large cirrus scars resemble the – probably invalid – Upper Triassic isocrinid genus *Singularocrinus* which has been described by KLIKUSHIN (1982) from Siberia and which is abundantly found in the Carnian of Central China (Sichuan, Hanwang Formation, unpublished). Like the Aggtelek isocrinid, the cup of *Singularocrinus* is low cone shaped with a convex base and has large basals that are visible in lateral view. It can be assumed that the Aggtelek isocrinid is a species of its own, but the material is not sufficient for establishing a new taxon.

5. The role of the crinoids in the Triassic reefs

Encrinid crinoids played an important role as frame builders in the small Pelsonian/Illyrian bioherms in the Muschelkalk and in other western Paleozoic Tethys areas. With their holdfasts incrusting clusters of oysters they substantially contributed to the vertical growth of the bioherms and provided solid anchoring ground above the sediment level for the following generations. Therefore, they belong to the oldest post-Paleozoic reefbuilding organisms, although the overall scale of their buildups remained small. Members of family Encrinidae reached their maximum size in late Illyrian times when *Encrinus liliiformis* grew up to 1.50 m. With their considerable biomass, they produced the “Trochitenkalk”, crinoidal limestones that may reach up to 16 m thickness in the Upper Muschelkalk of SW-Germany (HAGDORN & OCKERT 1993). In the much more diverse reefs of the Aggtelek type and in the late Ladinian/early Carnian coral/stromatoporoid/sponge reefs of the Northern Calcareous Alps and the Dolomites, encrinids played a very minor role and did not reach the size they once had in the Muschelkalk. These Carnian encrinids also had discoid or incrusting holdfasts, but they did not substantially contribute to the reef frame and their disarticulated skeletons do not substantially contribute to the reef talus sediments either. Thus, the Paleozoic shallow water sediment type “Trochitenkalk” disappeared with the beginning of the encrinid decline in the early Late Triassic. Later, only some Jurassic millericrinids produced larger amounts of skeletal debris that formed thin sheets of crinoidal limestones, e.g. in the North Alpine Lower Jurassic Hierlatz Formation.

The reason why crinoids as frame building organisms disappeared from Mesozoic metazoan reefs can be seen in the rise of the much more successful calcareous sponges and corals that dominated the diverse Late Triassic reefs, which grew up to a much larger scale. Finally, towards the end of the Mesozoic, stalked crinoids retreated to deep sea environments.

6. Conclusions

During the Triassic two major metazoan reef associations can be distinguished, the Wetterstein reefs (late Anisian to late Carnian) and the Dachstein reefs (late Carnian to Rhaetian) (FLÜGEL 2002). They differ in biotic composition of the dominating reef builders as well as in size and structures. Faunal and floral compositions easily allow differentiation of Wetterstein reefs and Dachstein reefs. However, it is much more difficult to give a more precise age determination within these two time intervals. This is especially true for the late Anisian/early Ladinian reefs because only a few reefs from this time span have become known until now. This is the main reason why early Ladinian crinoid faunas from the western Paleo-Tethys realm are not really well known.

Fortunately the age of the Aggtelek reef can be determined by means of conodonts from the underlying and overlying strata. Further evidence is given by foraminifera and dasycladaceans from the Steinalm Formation underlying the Wetterstein reef. Much less fortunately, the crinoid samples from the Aggtelek reef are too poor for detailed stratigraphic information. They only allow a few statements concerning a rather rough stratigraphic significance: (1) the presence of encrinids is indicative for an age older than mid Carnian, since this family was extinct before the end of the Carnian (HAGDORN 1995). (2) late Ladinian/early Carnian taxa with easily distinguishable columnals, e.g. the encrinids *Zardinicrinus granulosus* and *Cassianocrinus varians* and the isocrinids *Tyrolocrinus tyrolensis* and "*Iso-crinus*" *propinquus* which are common faunal elements in the South Alpine Cassian Formation are also absent. (3) On the other hand, the well known Pelsonian/early Illyrian species *Holocrinus dubius* and *Eckicrinus radiatus* and encrinids with cirriferous nodals which are widely dispersed in the German Muschelkalk, in the Mecsek Mountains and in the Pelsonian of Balaton Highland (HAGDORN & GLUCHOWSKI 1993, HAGDORN et al. 1997 and unpublished data) have not been found in the Aggtelek reef (4) MIHÁLY (1981) determined the diverse echinoid fauna from the Jósvalfő/Aggtelek roadcut as Pelsonian to early Illyrian. However, this fauna is rather similar to the late Ladinian/early Carnian Cassian Formation of the Dolomites (ZARDINI 1976) and to the late Ladinian/early Carnian white reef limestone of Braşov (Romania; JEKELIUS 1936). Club shaped spines of the "*Cidaris*" *dorsata* type that are present in the Aggtelek fauna have not yet been recorded from Anisian rocks.

Thus, the echinoids suggest an early Ladinian rather than an Anisan age of the Aggtelek reef. This calibration is neither contradictory to the crinoid data nor to the Ladinian conodonts found in the deep water intercalation topping the Aggtelek reef. In these considerations, the recent fixation of

the Anisian/Ladinian boundary at the base of the Curionii Zone has to be considered.

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