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Upper Jurassic ammonite biostratigraphy in the Gerecse and Pilis Mts. (Transdanubian Central Range, Hungary)

Felső jura ammonitesz biosztratigráfia a Gerecse és a Pilis hegységben

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(with 12 figures)

Abstract

The paper gives a preliminary review of the Upper Jurassic ammonite succession of the Gerecse Mts. and reports on a fossiliferous locality in the Pilis Mts. The latter is the easternmost Upper Jurassic outcrop of the Transdanubian Central Range.

The study is based on more than 3000 ammonites, collected from 11 localities, bed-by-bed, in most cases.

Generally the 1—3 m thick Upper Jurassic — lowermost Cretaceous succession of the red and pink nodular limestone rests on the "Middle Jurassic" radiolarite. In the case of the rather lacunose sequences the cherty formation is missing and also the Upper Jurassic beds are randomly represented.

The poorly documented Oxfordian is usually reduced to a fossiliferous bank within the radiolarite or above it. The fauna, including *Gregoryceras, Passendorferia, Euaspidoceras* seems to be rather uniform and represents the Middle Oxfordian Transversarium Zone. The single Pilis Mts. profile, yielding *Paraspidoceras, Euaspidoceras* and *Benetticeras,* probably indicates a similar level.

The little known Kimmeridgian is represented by nodular or massive limestone. The fauna is generally poorly preserved, insufficient for detailed subdivision. The Upper Kimmeridgian Beckeri Zone is the only level which is easy to demonstrate.

The Tithonian is the most complete and best documented part of the studied period. The whole succession of the Lower Tithonian (including the Hybonotum, Darwini, Semiforme, Fallauxi, and Ponti Zones) was recognised. The higher part of the Tithonian is generally poorly represented in the sections by ammonites.

Differences in lithofacies, way of preservation and, partly, the composition of the fauna, indicate a tectonically preformed, diversified palaeoenvironment for the Late Jurassic. Basin, structural high and seamount margin environments were distinguished, which controlled the sedimentation and probably also the ammonite distribution.

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The presence of certain important forms, and the character of the fauna indicates a strong relationship with the "Mediterranean", and on the other hand, with certain "Submediterranean" faunas.

Összefoglalás

A Dunántúli Középhegység ÉK-i felében, a sommásan csak „középső jura" radiolaritként emlegetett tűzköves sorozat felett 1—3 méter vastagságú karbonátos felső jura — legalsó kréta rétegsor van.

A Gerecsében vizsgált tíz szelvény (Szomód, Asszony-hegy, Szél-hegy akna, Szél-hegy kőfejtő, Paprét-árok, Margit-tető, Törökbükk, Tölgyhát, Ördöggát, Domoszló-tető) és az egyetlen pilisi lelőhely (Velka Skala) több mint 3000, legalább alrend szinten meghatározható ammoniteszt szolgáltatott.

A finomrétegtani értelemben hiányos, vagy erősen hiányos szelvények egymással jól párhuzamosíthatók, ill. egymást jól kiegészítik.

A makrofaunával igazolható oxfordit csak néhány réteg, vagy egyetlen masszív pad képviseli. A meglehetősen egyveretű fauna legfontosabb elemei a *Gregoryceras, Euaspidoceras, Paraspidoceras, Benetticeras* és a *Passendorferia* nemzetségek amelyek a középső oxfordi Transversarium Zónájának meglétét jelzik.

A szintén meglehetősen szegényesen dokumentált kimmeridgeiből egedül az emelet legfelső (Beckeri) zónája jelent biztosan, több szelvényből kimutatható szintet. Az emelet mélyebb részeiből csak kevés lelőhely szolgáltatott amúgy is rosszul értékelhető, szegényes faunát.

A tithon a rétegtanilag legteljesebben dokumentálható felső jura emelet Középhegységszerte, így a Gerecsében is. A Hybonotum, Semiforme, Fallauxi és Ponti Zónák több szelvényben, változatos faunával voltak igazolhatók. A Darwini Zóna és a felső tithon csak szegényesen, vagy egyáltalán nem mutatható ki a rétegsorokban.

Kőzettani, üledékföldtani, valamint az egyes rétegsorok ősmaradvány anyagának megtartásában és összetételében mutatkozó különbségek alapján egy K—Ny-i irányú, lejtő (?medence), hátság, medence típusú felső jura őskörnyezet vázolható fel a vizsgált területen.

A gerecsei malm alapvetően mediterrán jelleget tükröz, s így az Appenninek, a Déli Alpok és a Szubbétikum felső jurájával mutat szoros faunisztikai rokonságot. Mindemellett azonban pl. a Paprét-árki tithon jellegzetes „szubmediterrán" formákat is tartalmaz. E látszólagos kettősség — legalább is részben — a paleobiotópok meghatározta ökológiai tényezők különbözőségére vezethető vissza.

Key words: Upper Jurassic, biostratigraphy, Ammonoidea, Hungary

Introduction

The Gerecse and Pilis Mts. (Bakony unit, KÁZMÉR, 1986) are situated in the Transdanubian Central Range in Western Hungary. They are bordered by tectonically preformed trenches.

The main part of the hilly area is built up by Upper Triassic platform limestone. This is covered by pelagic Jurassic rocks.

The Hettangian—Bajocian part is usually less than 50 metres thick. It is represented by Ammonitico Rosso type limestone, except the Toarcian, which is in marly facies. Above it, there is some metres thick radiolarite. This is covered by a few metres of fossiliferous limestone.

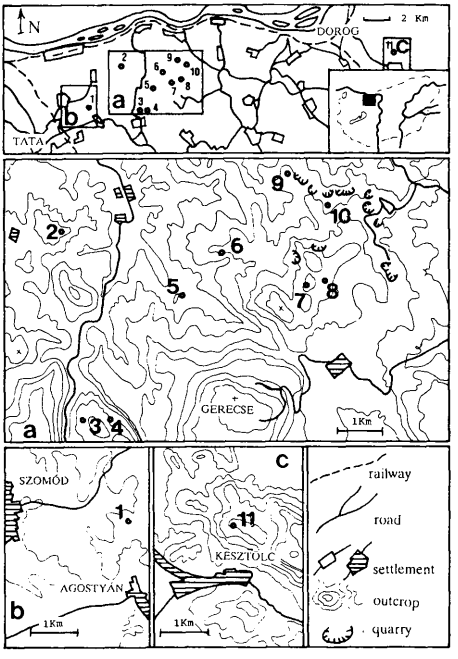

Fig. 1. Sketch map showing location of the studied profiles. **1.** Szomód, **2.** Asszony-hegy, **3.** Szél-hegy (quarry), **4.** Szél-hegy (shaft), **5.** Paprét, **6.** Margit-hegy, **7.** Törökbükk, **8.** Ördöggát, **9.** Domoszló, **10.** Tölgyhát, **11.** Velka Skala

1. ábra. A gerecsei felső jura szelvények helye.

The present paper gives a review of the ammonite succession of this Upper Jurassic series. Among the eleven examined profiles ten are situated in the Gerecse Mts. and only one lies in the Pilis area. The latter is the easternmost outcrop of the Jurassic rocks in the Central Range.

The study is based on a fauna collected recently, bed-by-bed. This material was completed by some old collections.

The fauna consists of about 3000 ammonites, determinable on suborder level at least. Many of the specimens were determined only tentatively and provisionally, so the present paper gives a preliminary evaluation only. The complete illustration of the fauna is a task of the future, and needs a monographic framework.

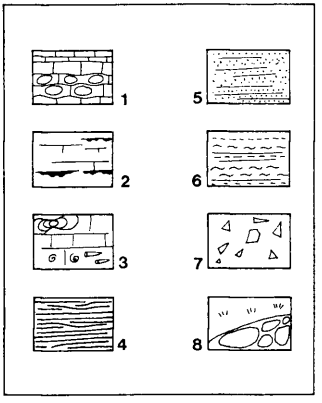

Fig. 2. Lithological key for the profiles. **1.** bedded, and/or nodular limestone, **2.** limestone with ferruginous crust, **3.** megafauna-rich limestone, **4.** radiolarite, **5.** sandstone, **6.** marl, with clayey intercalations, **7.** breccia, **8.** scree.

2. ábra. A szelvényeken használt kőzetjelek. 1. rétegzett és/vagy gumós mészkő, 2. mészkő vasas kéreggel, 3. megafaunában gazdag mészkő, 4. radiolarit, 5. homokkő, 6. márga, agyagos betelepülésekkel, 7. breccsa, 8. törmelék.

Previous studies

The first results on the Upper Jurassic biostratigraphy of the Gerecse Mts. were provided by K. HOFMANN in the 19th century. From the beginning of our century, many geologists have worked on the Jurassic of the area, but their special attention has been focused on the Lower and Middle Jurassic.

This is partly true in connection with Gyula and Gusztáv VIGH, father and son, although they had been working on the Upper Jurassic, too. They published many geological and palaeontological descriptions, geological maps and explanations. Detailed references are given in connection with the separate profiles.

From the very beginning the Gerecse research went on as part of the activities of the Hungarian Geological Survey. After the pioneer work of K. HOFMANN, and the VIGHs, the study of the Jurassic of the Gerecse renewed in the 1980s. The latest (mainly lithostratigraphic) works were done by J. KONDA. He was also the supervisor of the recently organized Upper Jurassic collecting activities.

The profiles

Gerecse Mts.

Szomód

The Szomód profile is situated in the western edge of the Gerecse Mts. between the villages of Szomód and Agostyán (Fig. 1). Unfortunately the area is a military zone and is difficult to visit.

The locality was mentioned by J. FÜLÖP (1958). The author indicated Lower and Upper Jurassic limestone, Hauterivian and Barremian sandstone from north of Agostyán.

The Upper Jurassic — Lower Cretaceous beds crop out on the margin of a forest, on the top of an old quarry. The deeper part of the quarry is built up by the succession of Liassic limestone and Middle Jurassic radiolarite.

The fossiliferous part of the 3 metre thick limestone formation above the radiolarite, was subdivided into 13 beds. The rock is a pink, crinoidal, brittle limestone with ferromanganese crusts in some levels. The stratification of the lower beds is not well defined, even the presence of slump structure is not excluded. Ammonites were found in a rather chaotic way in the limestone. The upper (Cretaceous) part of the sequence is well bedded, most of the fossils were parallel with the stratification. This was the only section, which yielded a rich Lower Cretaceous ammonite assemblage in calcareous facies in the Gerecse Mts.

There were more than 1000 ammonites, with different ways of preservation. Many of them were subsolved, difficult to determine. But some were beautifully preserved, with recrystallized shells.

According to the fossil material, a reduced Lower Tithonian and a somewhat more complete Berriasian was documented. The biostratigraphic data based on the ammonites (Fig. 3) were completed by the calpionellid data.

Unfortunately, the beds immediately overlying the radiolarite yielded no megafossils. The first layer, providing informative material was Bed 13. The well preserved specimens of *S. semiforme* and *H. verruciferum* documented the Semiforme Zone.

The overlying Bed 12 provided about 150 ammonites, but only one fragmentary specimen had an index value. The poorly preserved *S. fallauxi* indicated the presence of the Fallauxi Zone.

Bed 11 yielded no ammonites, while the next stratum — containing *V. volanense* — was ranged into the Ponti Zone already.

Beds 9—6, on the basis of the rich material of *Ptychophylloceras* and *Haploceras* genera, still represent the Tithonian. *Spiticeras* and some Simoceratidae indicate the uppermost part of the substage. It is noteworthy that the Upper Tithonian *Himalayites, Corongoceras* and *Protacanthodiscus* genera characteristic elsewhere, are lacking or rare in the Szomód section.

The uppermost five beds of the profile, with their diverse Berriasellidae and Spiticeratidae fauna were ranged already into the Lower Cretaceous. Many of the large *Spiticeras* were determined as *S. mutabile.* It is rather likely that Beds 3—1 represent the higher part of the substage.

Further study of the Lower Cretaceous part of the fossil material is planned.

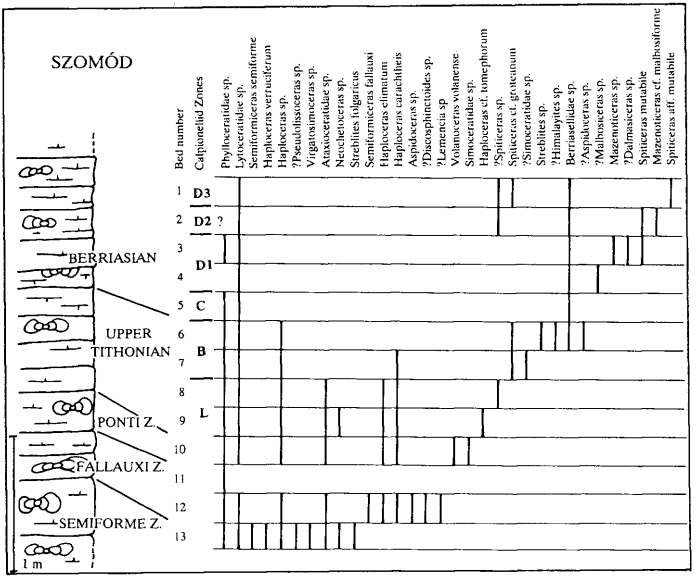

Fig. 3. Simplified stratigraphic column of the Szomód section with the indications of ammonite distribution. Micropalaeontological data (zones L—D) are given on the basis of the kind permission of J. KNAUER.
3. ábra. A szomódi szelvénye egyszerűsített rétegoszlopa, az ammoniteszek előfordulásával. A mikropaleontológiai adatok (L—D zónák) KNAUER J. szíves közlése nyomán.

Asszony-hegy

Jurassic rocks crop out on the top of an abandoned quarry (Fig. 4) on the south-eastern edge of Asszony-hegy (Fig. 1).

The Upper Jurassic beds of the poorly known outcrop were first mentioned by E. VADÁSZ (1913) and K. KULCSÁR (1913). Gy. VIGH (1920) described Lower Tithonian strata from the southern slope of the Asszony-hegy. According to Gy. VIGH (1943) and G. VIGH (1961) the Tithonian beds rest on Liassic rocks.

A. GALÁCZ (1986) reports that the Lower Jurassic rocks are covered by a bed belonging to the Bajocian Sauzei Zone. This is proved by the presence of *Kumatostephanus* sp. and *Emileia* sp. specimens. The overlying fauna contains Kimmeridgian forms.

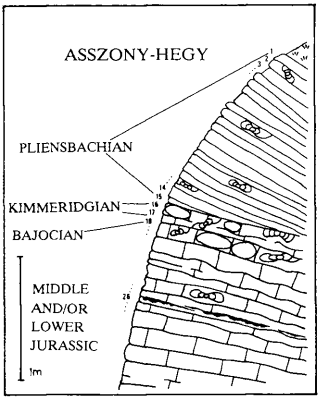

Fig. 4. Simplified section of the Asszony-hegy profile.
4. ábra. Az asszony-hegyi lelőhely egyszerűsített szelvénye.

The recent investigations (I. FŐZY and J. PÁLFY, 1992) were focused on the ammonite rich topmost part of the section (Fig. 4). It was shown that some Kimmeridgian layers rest above the Liassic and the lacunose Middle Jurassic. These layers contained fragmented, strongly subsolved ammonites. Bed 17 yielded: *Phylloceras serum, Phylloceras* sp., *Calliphylloceras* sp., *Lytoceras* sp., *Protetragonites* sp., *Taramelliceras* div. sp., *Aspidoceras* sp., *Orthaspidoceras* cf. *garibaldii,* Aspidoceratidae div. sp., *Nebrodites* div. sp., Ataxioceratidae div. sp. The rich, but poorly preserved fossils document level(s) from the middle part of the Kimmeridgian. The covering bed (No. 16) contained also fragments of phylloceratids, lytoceratids, aspidoceratids, ataxioceratids and a specimen of *Hybonoticeras pressulum,* a form chacarteristic for the uppermost Kimmeridgian Beckeri Zone.

The Tithonian strata are missing, but a block of Liassic (Pliensbachian) age (!) covers the succession. J. PÁLFY determined Lower Jurassic ammonites, including *Phylloceras, Juraphyllites, Audaxlytoceras* sp., *Harpophylloceras* cf. *eximium, Protogrammoceras, Fuciniceras* etc. from the block. The determination of the poor brachiopod fauna (including: *Phymatothyris cerasulum, Zeilleria*? sp.) of the same strata was made by A. VÖRÖS, and the results supported the Pliensbachian age.

Szél-hegy quarry

The Szél-hegy is situated in the vicinity of Tardosbánya, in the centre of the Gerecse Mts. (Fig. 1). Jurassic rocks rest on the edge of the hilltop.

The first mentioning of the Jurassic of the Szél-hegy is due to Gy. VIGH (1940). The author described not only Lower and Middle Jurassic beds, but also the debris of the lowermost Upper Jurassic chert and the layers bearing *Aspidoceras* cf. *uhlandi,*

characteristic for the (Middle) Kimmeridgian. The Tithonian strata were described also by E. JAKUCS-NEUBRANDT (1954), who published a detailed map of the territory, too. J. FÜLÖP (1958) mentioned the Tithonian as the underlying beds of the Lower Cretaceous. G. VIGH (1961) described a small patch of Oxfordian limestone, and proved the presence of Kimmeridgian and Tithonian by megafauna.

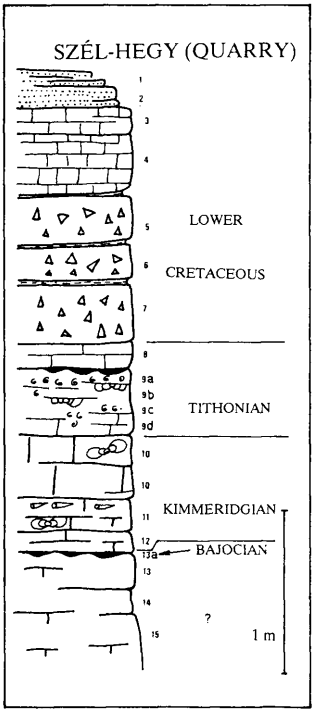

Fig. 5. Simplified section of the Szél-hegy quarry.
5. ábra. A szél-hegyi kőfejtő egyszerűsített szelvénye.

There are two separate outcrops in the Szél-hegy now, yielding two types of Upper Jurassic rocks, very different from each other.

One of the outcrops is a small abandoned quarry in the northern edge of the hill. Here the Upper Jurassic contains about a dozen of layers (Fig. 5), but ammonites are very rare and extremely poorly preserved. The succession starts with a massive bank, which yielded no megafossils. Above it, there is a hardground, followed by well-bedded

and more massive micritic limestone beds. In certain levels, accumulation of megafossils (mainly belemnites) and/or bioclasts is characteristic. The upper part of the profile, the so called Felsővadács Breccia, and the overlying sandstone beds belong to the Cretaceous.

The lacunose Upper Jurassic series below the Cretaceous breccia was recently studied by A. GALÁCZ (1986), who recorded Tithonian and Kimmeridgian ammonites. According to his report, the Kimmeridgian forms are mixed with some typical Bajocian ammonites. Recent investigations pointed out a strong condensation, which was the reason of the "mixing".

Middle Jurassic (Bajocian) elements (*Skirroceras* sp.) were only found in the condensed level (Bed 13/a) above the massive banks.

In the overlying bedded limestone Kimmeridgian aspidoceratids and also perisphinctids, resembling to the Ataxioceratidae fauna of the Beckeri Zone were found. In Bed 9 *Haploceras* sp. was found, suggesting Tithonian age already. Bed 8 yielded no megafossils. From the Bed 7 on, in the Lower Cretaceous breccia horizon ammonites are scarce, insufficient for detailed study.

The succession is extremely lacunose, not only the radiolarite, but most of the horizons of the Upper Jurassic are missing.

Szél-hegy shaft

The other type of the Upper Jurassic rocks of the Szél-hegy is coarse-grained limestone, or a poor sparite, called as "Tithonian Hierlatz" traditionally. The peculiar facies was reported by G. VIGH (1928) for the first time. There are only a few outcrops of this rock in the Gerecse Mts, and the section, described below yielded the best fauna of its type.

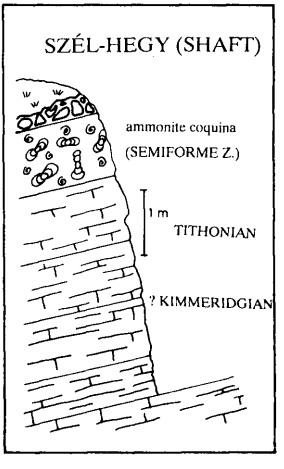

Fig. 6. Simplified section of the Szél-hegy shaft.
6. ábra. A szél-hegyi akna egyszerűsített szelvénye.

The profile (Fig. 6) can be found in a 5 m deep (artificial) shaft in the northwestern edge of the Szél-hegy. The lower beds are dark red micritic limestone with *Saccocoma.* Upwards in the sequence the limestones texture turns from fine- to coarse-grained, and its color from red to yellow and grey. The uppermost 70 cm of the profile is the ammonite-crinoid coquina referred to "Tithonian Hierlatz limestone" by the VIGHs. Many of the forms are small-sized, or fragmented. Although the fauna is described separately (FŐZY et al., in press.) it is worth listing the most important ammonites:

The section of the Szél-hegy shaft contains the following fauna:

Streblites folgaricus (OPP.)
Semiformiceras semiforme (OPP.)
Neochetoceras div. spp.
Cyrtosiceras collegialis (OPP.)
Pseudolissoceras planisculum (ZITT.)
Pseudolissoceras rasile (ZITT.)
Haploceras elimatum (OPP.)
Haploceras carachtheis (ZEUSCH.)
Haploceras verruciferum (ZITT.)
Anaspidoceras neoburgense (OPP.)
Pseudohimalayites steinmanni (HAUPT.)
Simocosmoceras adversum (OPP.)
Simocosmoceras simum Q(OPP.)
Volanoceras cf. *aesinense* (MGH.)
Subdichotomoceras pseudocolobrinus (KIL.)
Ataxioceratidae div. sp.

The fauna is characteristic for the Semiforme Zone of the Lower Tithonian. It is proved not only by the presence of the zonal index, but also the presence of *H. verruciferum, P. steinmanni, V. aesinense, Simocosmoceras* etc. Many of the listed ammonites are small-sized (but not dwarfed) and (or) rare. *Cyrtosiceras* e.g. was recorded until now from the type locality (Rogoznik) (K. ZITTEL, 1870 J. KUTEK and A. WIERZBOWSKI, 1986) and from fissure infillings from the Southern Alps (A. BENETTI et al., 1990).

The small *Simocosmoceras* and the peculiar *Pseudohimalayites* are also very rare forms. Besides ammonites, the Szél-hegy shaft yielded a relatively diverse brachiopod and bivalve fauna.

The composition of the megafauna, the way of the preservation, and also the rock is characteristic, and very different from the typical Upper Jurassic of the Gerecse Mts.

Paprét

The Jurassic section of the Paprét has been known since HOFMANN's time. The locality is situated on a slope of a ravine (Fig. 1).

The succession is built up of fossiliferous Middle Jurassic limestone with some metres of radiolarite on top. Above it there is a rather condensed Oxfordian-Tithonian succession. Because of the "lacunose character" of the rocks, the thickness varies, the Tithonian e.g. from 36 cm to 1 metre. The Upper Jurassic rocks are pink, purple and extremely hard limestone.

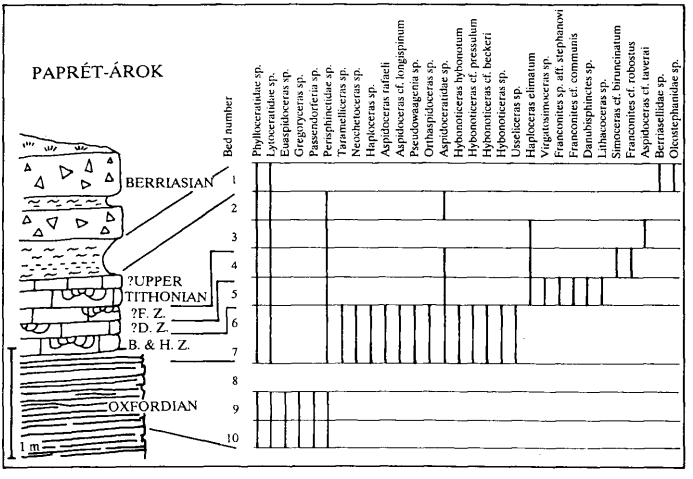

Fig. 7. Simplified section of the Paprét profile and the distribution of ammonites. **F. Z.** Fallauxi Z., **D. Z.** Darwini Zone, **B. & H. Z.** Beckeri & Hybonotum Zones.
7. ábra. A paprét i lelőhely eszerűsített szelvénye az ammonitesek előfordulásával. F. Z. Fallauxi Zóna, D. Z. Darwini Zóna, B. & H. Z. Beckeri és Hybonotum Zóna.

The first collecting by K. HOFMANN (1884) revealed a Tithonian fauna, including *"Haploceras Staszycii"*, *"Simoceras Volanense"* above the cherty formation and the *Stephanoceras*-bearing Middle Jurassic limestones.

The locality was also mentioned by J. STAFF (1905) already. He, as well as J. FÜLÖP (1958) focused his attention on the Lower Cretaceous (Berriasian) part of the section.

G. VIGH (1970, 1984) reported a 1 metre thick Upper Jurassic succession. The Oxfordian and Kimmeridgian strata are only mentioned, while the Tithonian is better documented. The Hybonotum Zone was recognizable without any doubt, and some Middle and Upper Tithonian forms were also described.

The place where G. VIGH collected his fauna was destroyed by the creek. The present study is based on a new gathering, which was carried out some ten metres from VIGH's profile. Here 10 layers, in less than 1 metre total thickness, were found above the radiolarite.

The material contains nearly 300 specimens. Some of them, however fragmented, are beautifully preserved, with recrystallised shell. Many ammonites are strongly subsolved and encrusted. The general picture of the fauna is given in Fig. 7.

Beds 9 and 10 furnished the following Middle Oxfordian faunula:

Holcophylloceras sp.
Gregoryceras sp.
Passendorferia sp.
Perisphinctidae div. sp.
Euaspidoceras sp.

There were no ammonites in the layer No. 8.

The Kimmeridgian/Tithonian boundary can be placed somewhere in the interval of Beds 7—6. Unfortunately the two layers were sampled together. The most important genus is the *Hybonoticeras*, including forms close to the *beckeri* and *hybonotum* groups. Aspidoceratids and perisphinctids are diverse.

Beds 5 and 4 include a rather condensed ammonite fauna: some of the perisphinctids, like the big-sized *Lithacoceras* suggest lowermost Tithonian age. *Franconites* could be characteristic for the Darwini Zone, while *S.* cf *biruncinatum* suggests already the Fallauxi Zone.

There were no diagnostic ammonites in Beds 3 and 2, but the appearance of the evolute *Aspidoceras* cf. *taverai* probably indicates the Upper Tithonian.

It is worth mentioning that on the ammonites from Beds 5—3 trace fossils were discovered. Borings, holes, worm tubes and grazing traces of different types were recognized.

Bed 1 yielded some very poorly preserved berriasellids and olcostephanids. On the basis of the characteristic changes of the fauna (and also the rock) this level was referred to the Lower Cretaceous (Berriasian).

It was interesting to see that the mentioned material of K. HOFMANN, G. VIGH and the present one, resulted three different biostratigraphic documentations. In the field the biostratigraphically documentable horizons are changing step-by-step. The thickness data also vary. All of these together with the sedimentological features of the rock, mean that the area was characterized by a episodic deposition and/or subsolution.

Margit-hegy

The Jurassic sequence of Margit-hegy is situated on the southern slope of the hill (Fig. 1). The succession was not studied in detail. The Upper Jurassic part of the profile rests on the thick series of Middle Jurassic limestone and radiolarite. There is an 80 cm thick nodular, pinkish fossiliferous bank in the upper part of the cherty formation which yielded the small Oxfordian fauna listed below:

Gregoryceras sp.
Passendorferia sp.
Perisphinctidae div. sp.
Euaspidoceras sp.

Above the radiolarite there are Ammonitico Rosso type limestone beds. During the collecting 9 strata were separated. The faunal spectrum is given in Fig. 8.

Beds 9—5 provided a rich fauna characteristic of the Lowermost Tithonian. Besides the numerous specimens of *H. hybonotum*, a diverse perisphinctid fauna was found. Bed 4 and 3 contained *Volanoceras aesinense*, diagnostic of the Semiforme Zone. It is difficult to prove, but the perisphinctids coming from the first bed also suggest the presence of the latter zone.

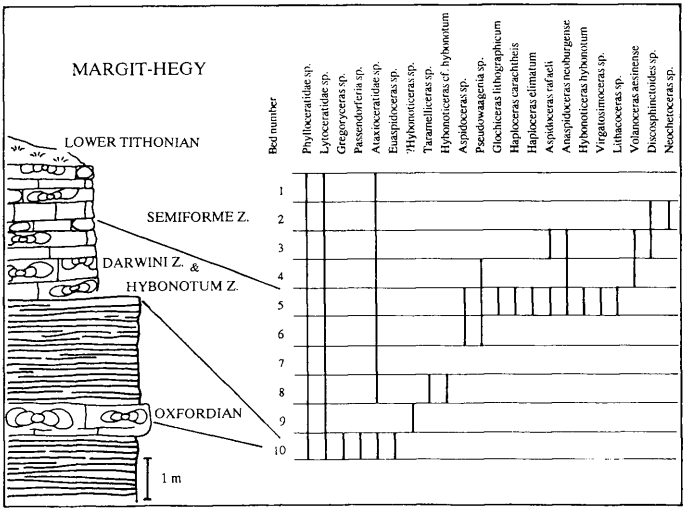

Fig. 8. Simplified section of the Margit-hegy profile and the distribution of ammonites.
8. ábra. A margit-hegyi lelőhely egyszerűsített szelvénye az ammoniteszek előfordulásával.

Above the discussed beds there is only debris. It is easy to imagine that the higher part of the section has been removed by erosion.

Although the sequence is rather incomplete in its present state, it seems to provide the most detailed data on the Hybonotum Zone of the Gerecse Mts.

Törökbükk

The Jurassic sequence of the Törökbükk (Fig. 1) is a relatively little known outcrop of the Gerecse. Liassic rocks were reported by K. KULCSÁR (1914). The first detailed description of the Upper Jurassic was given by Gy. VIGH (1940). According to VIGH, the Upper Jurassic is built up by the succession of Oxfordian limestone, *A. acanthicum* bearing red nodular limestone, Lower Tithonian limestone and 2—2.5 metres thick *diphya* limestone on the top. In a subsequent paper by G. VIGH (1969), the geologic profile of the neighboring area was given, and an Upper Tithonian *Micracanthoceras* sp. was reported.

The material described here came from a recently excavated shallow trench. The recognized 20 beds yielded a Tithonian — ?Lower Berriasian succession with ammonites (Fig. 9). Most of the ammonites (about 250 specimens) were deformed, strongly subsolved and poorly preserved. In spite of this, the rough biostratigraphic subdivision of the profile left little problem.

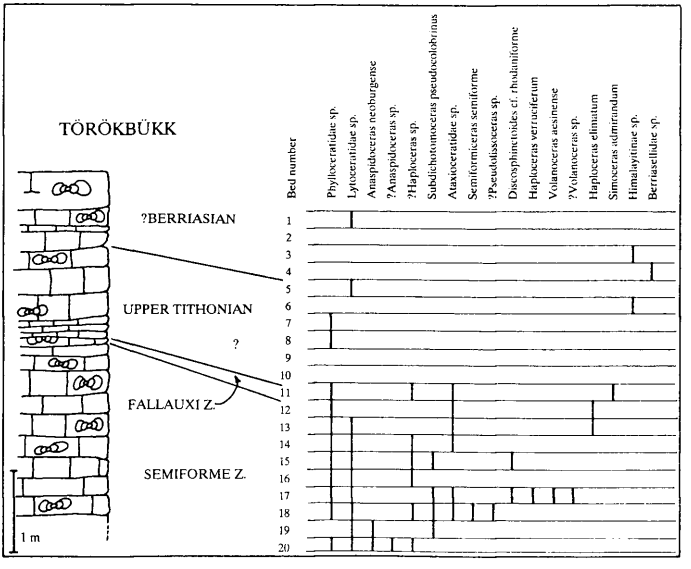

Fig. 9. Simplified stratigraphic column of the Törökbükk profile and the distribution of ammonites.
9. ábra. A törökbükki lelőhely egyszerűsített szelvénye az ammoniteszek előfordulásával.

Unfortunately the collections stopped before reaching the radiolarite. No information on the lowermost Tithonian and on the deeper horizons were obtained.

The lowermost two beds yielded *A. neoburgense* and *S. pseudocolobrinus,* but no diagnostic ammonite was found.

The bed above (18) contained *S. semiforme,* positively indicating the presence of the Semiforme Zone. Higher beds (up to 15) yielded further elements (including *H. verruciferum, V. aesinense* and *D.* cf. *rhodaniforme*) characteristic also of the Semiforme Zone.

Unfortunately Beds 14—12 contained only some long-ranging ammonites, but Bed 11 yielded *S. admirandum,* the index form of the second (Admirandum-Biruncinatum) subzone of the Fallauxi Zone. Thus, the deeper part of the zone (Richteri Subzone) is not documented in the succession.

Beds 10—5 were tentatively ranged into the Upper Tithonian on the basis of some poorly preserved fragments.

The uppermost beds yielded extremely subsolved Himalayitinae and Berriasellidae specimens, representing the Uppermost Tithonian and/or the Lowermost Berriasian.

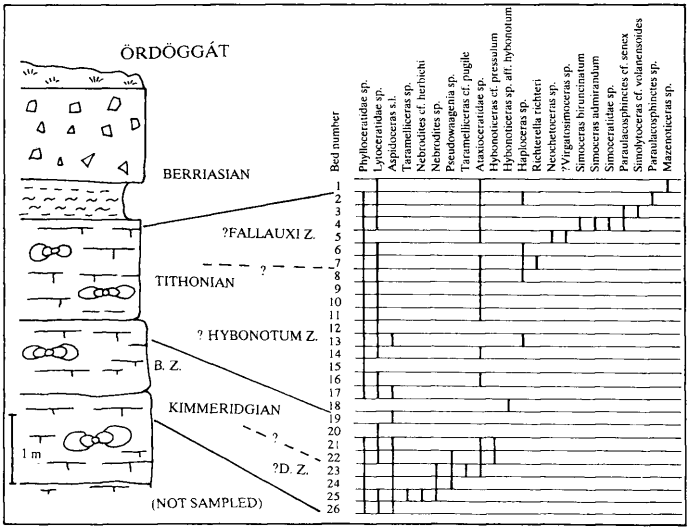

Fig. 10. Simplified section of Ördöggát profile and the distribution of ammonites. **B. Z.** Beckeri Zone, **D. Z.** Divisum Zone.

10. ábra. Az ördöggáti lelőhely egyszerűsített szelvénye az ammoniteszek előfordulásával. B. Z. Beckeri Zóna, D. Z. Divisum Zóna.

Ördöggát

The Ördöggát (or "Pócké") section is a relatively little known outcrop situated on the northern slope of the Gerecse (Fig. 1). The place was mentioned, and the profile of the neighbouring area was sketched by Gy. VIGH (1928). J. FÜLÖP (1958) published the section of the Ördöggát quarry, where Cretaceous marls were uarryed.

The Upper Jurassic rocks were studied in a small deep trench excavated in the continuation of a road cut. Below the Lower Cretaceous breccia there is a hard, compact Jurassic limestone. The facies is more or less nodular, the colour is light yellow on the top, and reddish on the bottom. Ammonites are scarce, and the fauna is not very well preserved. The number of specimens, determinable on suborder level is about 300. The faunal spectrum is given in Fig. 10.

Unfortunately the lowest part of the section was not sampled. Beds 26—23 yielded *Taramelliceras, Aspidoceras* and Nebrodites and were ranged into the Kimmeridgian. *H. pressulum,* diagnostic for the uppermost Kimmeridgian Beckeri Zone was found in Bed 22 and 21.

The extremely poorly preserved specimen determined as ?*H.* cf. *hybonotum* from Bed 18 indicated the lowermost Tithonian Hybonotum Zone.

The next 11 beds yielded no diagnostic ammonites, except poorly preserved perisphinctids, difficult to determine.

The following fix point in the biostratigraphy, the *Richterella richteri,* found in Bed 7, indicates the deeper part of the Fallauxi Zone. Simoceratids from Beds 4 and 3 belonging to the *biruncinatum-admirandum* group mark the higher horizon of the same zone.

The *Mazenoticeras*-bearing first bed belongs to the Berriasian.

The small fauna of the Ördöggát section seems to be more or less complete for the Upper Kimmeridgian and Lower Tithonian, but the Upper Tithonian is missing. Though many ammonite zones were not positively documented, on the basis of the thickness and lithological features of the section it is likely that the poor documentation is, — at least partly — due to the poor state of preservation.

Domoszló

The Domoszló is a forest-area in the Gerecse Mts. (Fig. 1). In a tectonically rather complicated environment, Jurassic limestones of different ages occur. The locality was mentioned by K. KULCSÁR (1913) who described Liassic limestone. The geological profile of the place was given by G. VIGH (1969). Above the "Bathonian—Callovian chert" a fossiliferous Oxfordian bank was indicated. Even some ammonites, including phylloceratids and *Gregoryceras toucasi* were listed.

The list of the ammonites, collected by the late G. VIGH contains the following taxa:

Holcophylloceras sp.
Phylloceras sp.
Gregoryceras cf. *fouquei*
Gregoryceras sp.
Perisphinctidae sp.
Euaspidoceras sp.

The material (42 specimens altogether) represents the biggest and best preserved Middle Oxfordian (Transversarium Zone) ammonite fauna from the Gerecse Mts.

Tölgyhát

The Tölgyhát quarry is situated in the northern edge of the Gerecse Mts. (Fig. 1), close to the village of Lábatlan.

This is one of the best known Jurassic localities of the Gerecse Mts. The first detailed description with a special focus on the Middle Jurassic part of the profile was given by Gy. VIGH (1940). Later G. VIGH (1961) published the geologic sketch of the quarry and the neighbouring valley.

The Upper Jurassic biostratigraphy of the Tölgyhát profile was already published (CECCA et al., 1993). In the quarry a rather complete Lower and Middle Jurassic can be found. Above the limestone series there is the radiolarite, about 2 metre in thickness. The covering topmost beds yielded the Middle Oxfordian faunula, very similar to those known from the previously mentioned profiles:

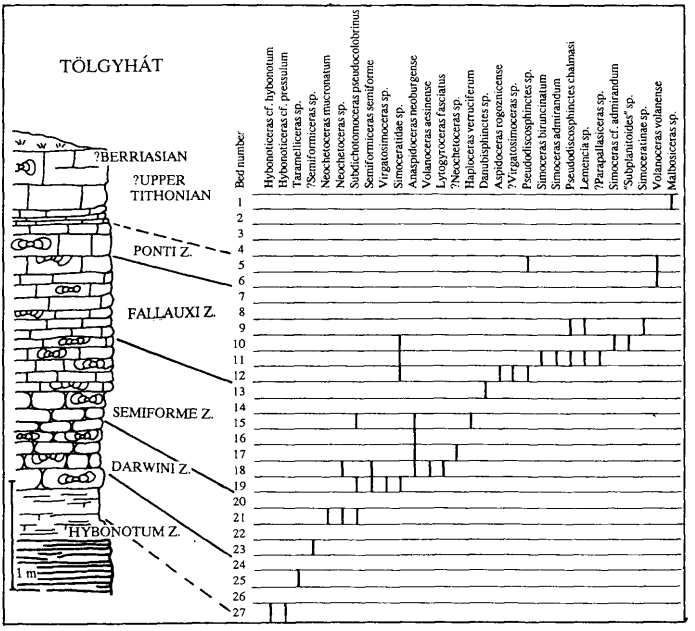

Fig. 11. Simplified section of the Tölgyhát profile and the distribution of ammonites. Phylloceratids and lytoceratids are not indicated.
11. ábra. A tölgyháti lelőhely egyszerűsített szelvénye az ammoniteszek előfordulásával, a phylloceratidák és a lytoceratidák elhagyásával.

Phylloceras sp.
Holcophylloceras sp.
Lytoceras sp.
Passendorferia div. sp.
Perisphinctidae div. sp.
Euaspidoceras sp.

The (Kimmeridgian) — Tithonian succession, described below, was sampled close to the old quarry in a ravine.

Here the 4 metre thick series was subdivided into 27 beds (Fig. 11). The radiolarite is situated at the base of a small valley. The first limestone layers are dark red and marly, then the rock becomes more and more nodular, Ammonitico Rosso type. Higher up in the sequence the limestone is pink to light, the nodularity is less expressed.

The fossils are poorly preserved. Many of the ammonites were indeterminable even on suborder level. In spite of this, on the basis of the gathered material (about 550

specimens determinable on suborder level) it was easy to outline a stratigraphic subdivision even on zonal level.

On the general composition of the fauna and on the stratigraphic range of the taxa, Figs. 11 and 12 give information.

Above the cherty rocks the first megafossil-bearing bed (27) yielded ammonites diagnostic for the uppermost Kimmeridgian and for the lowermost Tithonian. On the basis of some very characteristic forms (*H.* cf. *pressulum* and *H.* cf. *hybonotum*) the Beckeri and Hybonotum Zones were recognized. It means that the Kimmeridgian — Tithonian boundary can be drawn within bed 27.

Beds 26—24 yielded no diagnostic ammonites. The presence of the Darwini Zone can be tentatively proved by the appearance of *Semiformiceras*? sp. (Bed 23) and the characteristic tricarinate *N. mucronatum* (Bed 21).

Higher up from Bed 20 on, aspidoceratids are more common, *A. neoburgense* is typical.

A specimen, determined as *S. semiforme* (Bed 19) is a stable point in the succession. The appearance of the index form of the Semiforme Zone fits well with the occurrence of *V. aesinense* in Bed 18.

This bed also yielded an interesting fragment of a *Lytogyroceras* nucleus. It strongly resembles a *V. aesinense* nucleus, but differs from it by bigger size, and by a venter bearing a furrow. The latter suggest *Virgatosimoceras* origin. What is surprising is the stratigraphically "deep" occurrence of the specimen.

H. verruciferum is rare, only one specimen was gathered from the Bed 15.

Simoceratids from Bed 12 onwards indicate the Fallauxi Zone. The group is surprisingly diverse. Unfortunately a lot of them (especially specimens ranged into *Virgatosimoceras*) were problematic to determine at species level.

Big-sized perisphinctids, *P. chalmasi* are very common. Beds 6 and 5 contain *V. volanense* typical of the Ponti Zone.

The overlying beds (4—2) yielded no diagnostic fossils, so the presence of the Upper Tithonian in the section is not proved.

Bed 1 yielded *Malbosiceras* sp. and some small-sized Berriasellidae, so the top of the Tölgyhát profile was ranged into the Lowermost Berriasian.

Pilis Mts.

Velka Skala

The Velka Skala ("Great Cliff" if we translate the name given by the Slovaks living in the area), is situated in the Pilis Mts. The locality represents the easternmost outcrop of the Upper Jurassic in the Transdanubian Central Range (Fig. 1).

The first report on the Velka Skala was given by F. SCHAFARZIK (1884). Gy. VIGH (1913) indicated Kimmeridgian and Lower Tithonian ammonites collected from debris.

Some years ago a pit was opened in the vicinity of the sequence studied before. The recent collecting revealed an Oxfordian faunula found in one of the beds of the profile. The outcrop is strongly tectonized, even the stratigraphic position of the fossiliferous bank is uncertain. It is not clear, whether it is above or below the "Middle Jurassic" cherty formation.

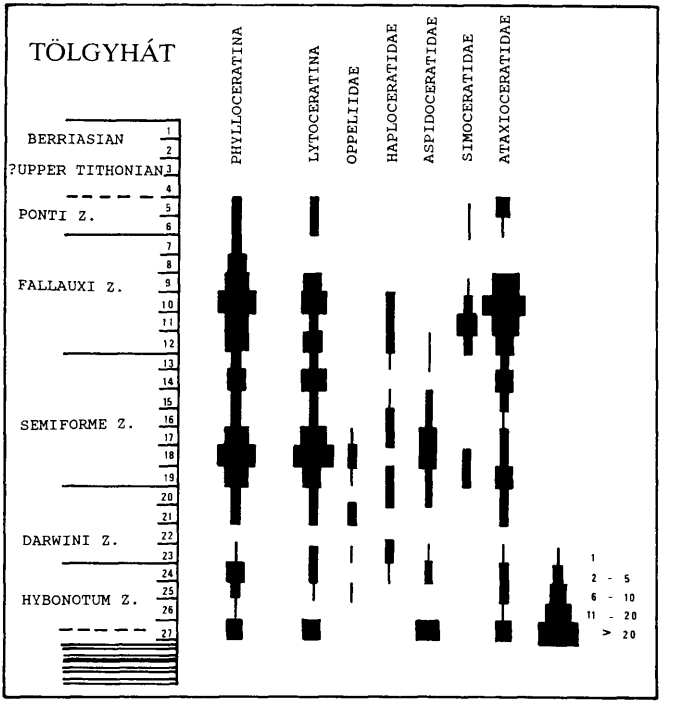

Fig. 12. Distribution of the total ammonite fauna for each family in the Lower Tithonian part of the Tölgyhát profile.

12. ábra. Az ammonitesz-fauna családonkénti megoszlása a Tölgyháti-kőfejtő alsó tithon rétegeiben.

The complete faunal list is as follows:

Phylloceras sp.
Holcophylloceras sp.
Lytoceras sp.
Paraspidoceras cf. *submerani* ZEISS
Euaspidoceras sp.
?*Euaspidoceras* sp.
Benetticeras cf. *benetti* CHECA
Aspidoceratinae sp.
Perisphinctidae sp.

On the basis of the relatively abundant aspidoceratid fauna the material was ranged into the Oxfordian.

The best preserved specimen is *P.* cf. *submerani.* This is the first report of the genus in the Central Range. On the inner whorls of the big-sized specimen the rare, strong, spatula-like tubercles are clearly visible.

B. benetti was described recently from Upper Oxfordian — Lower Kimmeridgian strata (CHECA, 1985). The Hungarian material (fragmentary, inflated aspidoceratids with completely smooth surface) was tentatively referred to this species.

The composition of the fauna probably indicates Middle or lower Upper Oxfordian age.

The ammonite succession

Oxfordian

As was documented above, the Oxfordian of the Gerecse Mts. is generally represented by cherty formations. The only fossiliferous level is usually an ammonitiferous bank situated on the top of the radiolarite or intercalated in its upper part. Thus to discuss the Oxfordian "succession" is rather theoretical. The fauna is similar (if not uniform) all over the Gerecse Mts. Besides the most common phylloceratids and lytoceratids *Euaspidoceras, Gregoryceras* and some perisphinctids, including *Passendorferia,* form the essential part of the fauna.

Oxfordian ammonites are very scarce all through the Transdanubian Central Range. The listed material is the most complete one known up to date.

The fauna probably indicates a narrow Middle Oxfordian interval, probably a part (or parts) of the Transversarium Zone.

The only Pilis Mts. outcrop yielded also *Paraspidoceras* and *Benetticeras* specimens, but no *Gregoryceras* was found.

Kimmeridgian

The Kimmeridgian ammonite fauna is also very incomplete and poorly known in the Gerecse Mts. In many sections the first ammonite-bearing beds above the radiolarite provided *Hybonoticeras* fauna, characteristic of the uppermost Kimmeridgian Beckeri Zone, or of the lowermost Tithonian.

The deeper part of the Kimmeridgian was documented in the Asszony-hegy and Ördöggát sections only. The first provided an extremely poorly preserved Middle Kimmeridgian fauna, insufficient for further study. The Ördöggát material was partly ranged into the Middle Kimmeridgian, too, on the basis of the *Nebrodites* fragments, *Taramelliceras* and the diverse aspidoceratids.

Tithonian

The Tithonian is the most complete and best documented part of the Upper Jurassic succession of the Gerecse Mts.. Especially the Lower Tithonian seems to be well represented. The succession of the Hybonotum, Darwini, Semiforme, Fallauxi and Ponti Zones is almost complete.

H. hybonotum was found in many localities. In the beds above, the genus *Semiformiceras* and simoceratids are the most useful index forms. Perisphinctids are abundant in certain levels, and some assemblages are similar to those illustrated by ZEISS (1968) and CECCA (1990) from the Submediterranean region. The *S. admirandum-biruncinatum* bearing horizon is, if it is documented, very characteristic.

The Upper Tithonian assemblages are generally rather incomplete. Himalayitids are rare. The Jurassic/Cretaceous boundary is generally not traceable by means of megafossils.

Late Jurassic facies and environment

According to the general picture outlined for the Jurassic of the whole Transdanubian Central Range (GALÁCZ and VÖRÖS, 1972; GALÁCZ et al., 1985) the Jurassic of the Gerecse Mts. is also characterized by a former uneven bottom topography.

Although there were local differences in the water depth at the beginning of the Late Jurassic, the area sank below the CCD. This is proved by the widespread cherty formation of Oxfordian age.

The intercalated Middle Oxfordian brecciated limestone bed (see also FÜLÖP, 1975) represents an episodic uplift characteristic of the discussed area, or an episodic fall of the CCD.

It is difficult to determine the exact time when the deposition of the siliceous mud ended. The radiolarite formation probably went on in the Early Kimmeridgian in many places. But from the Middle and especially from the Late Kimmeridgian the return of the carbonate environment is typical.

The Upper Jurassic carbonates, similar to the Lower and Middle Jurassic facies, reflect three different types of depositional environments.

The first is the basin, where the most complete and thickest, red, nodular, Ammonitico Rosso type limestone deposited. Typical examples are the Margit-hegy, Tölgyhát, Törökbükk and Ördöggát sections.

The second environmental type is the surface of probably elevated blocks, where strong currents resulted episodic sedimentation and generally thin succession. Hardground-like ferromanganese crust and sharply subsolved, differently bored ammonites characterize this type. The succession of the Paprét profile displays all these features. The rather incomplete succession of the Szél-hegy quarry, with the hardground-like surfaces is also regarded as a succession deposited on elevated blocks, or simply in an environment characterized by effective bottom currents.

The third type is the slope environment chracterized by gravity slides. The Asszony-hegy and the Szél-hegy shaft profiles were ranged into this type.

The complicate succession of the Asszony-hegy needs detailed evaluation. Here, above the thick Lower Jurassic series some Middle and Upper Jurassic is randomly represented. The overlying rock above the Kimmeridgian were ranged into the Liassic again. According to an explanation, the Lower Jurassic rock is repeated tectonically. In fact, beds immediately below the Liassic strata seems to be continuous under the Lower Jurassic block, which suggest a non-tectonical repetition. There is another explanation for the succession. According to this, the whole Middle and Upper Jurassic

series would be a fissure infilling in the Lower Jurassic rocks. Unfortunately, the way of preservation of the megafossils does not support this idea. Ammonites bear no ferromanganese crust, and they are neither size sorted. In the case of a fissure-infilling, it is also difficult to understand the accumulation of some megafossils (e.g. belemnites) in certain level.

Unfortunately, because of the poor preservation of the ammonites, coming from below, from the Liassic rocks, the exact age-relation between the lower and upper Liassic strata is unknown. In conclusion the thin and chaotic series of Asszony-hegy, with the Lower Jurassic block on the top, can be regarded as a scarp breccia.

The lumachella-like, size-sorted fossil material of the Szél-hegy section can be interpreted as a fine-grained debris of shells washed through by currents toward the basin area.

The Szomód section, with the chaotic, slump-like structure above the radiolarite, can be regarded as a distal gravity sliding.

Detailed sedimentological studies on the documented profiles are expected to refine the general idea for the Late Jurassic palaeoenvironment outlined above.

Palaeobiogeographic affinity of the megafauna

The rich material of the Upper Jurassic of the Gerecse Mts. is built up overwhelmingly by ammonites. Other cephalopods are extremely rare: besides the thousands of ammonites only some specimens of belemnites and only one nautiloid were found.

As far as the proportion of the non-cephalopod fauna is concerned, the Tölgyhát section offers a representative example: together with the hundreds of ammonites the section yielded some fragments of belemnites and one nautiloid specimen. Additionally 37 specimens of echinoids and a dozen brachiopods (mainly pygopids) were collected.

The composition of the ammonite fauna is characterized by the high percentage of the Phylloceratina and Lytoceratina suborders which indicate Mediterranean affinity. The biostratigraphicaly useful Ammonitina were subdivided into five families. This kind of diversity, as well as the appearance of *Semiformiceras, Volanoceras, Simoceras* etc. document also the Mediterranean character. It means, that the fauna has a strong similarity to those described e.g. from the Appennines (F. CECCA et al., 1990) and from the Subbetics (F. OLÓRIZ, 1978). On the other hand, especially from the point of view of the Early Tithonian perisphinctids, there are surprising similarities to those faunas published from Ardèche (F. CECCA, 1986) and South Germany (A. ZEISS, 1968), and which are regarded as Submediterranean traditionally.

The common appearance of the strictly Mediterranean and the Submediterranean ammonites in the same (small) tectonic unit, suggests probably palaeoecologic reasons. It means that the biogeographic distribution of the ammonites was complicated by local ecological factors.

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