

New data on the stratigraphy of the Lower Cretaceous of the Gerecse Mts. (Hungary) and the Lackbach section (Austria)

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This paper is dedicated to the memory of C. F. WEIDICH (7th Nov. 1952–10th Nov. 1992)

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Abstract: Biostratigraphic and lithostratigraphic studies have been made on four boreholes (Ago-styán Agt-2, Neszmély N-4, Tatabánya Ta-1472, Ta-1486) in the Gerecse Mts. and the Tatabánya basin in Hungary. The Lower Cretaceous succession of this area comprises the Neszmély Sandstone Formation (NSF, Barremian-Aptian), the Tata Limestone Formation (TLF, Aptian) and the Vértessomló Formation (VF, Lower and Middle Albian). In its stratotype, borehole N-4, the NSF was subdivided into four integrated ammonite and planktonic foraminifera zones from top to bottom: The *Ticinella bejaouensis* ivz – *Hedbergella gorbachikae* ivz (Late Aptian – ?Early Albian), the *Globigerinelloides algerianus* trz (early Late Aptian), the *Shackoina cabrii* trz – *Globigerinelloides blowi* ivz (Early and Mid Aptian), and the *Hedbergella sigali* ivz (Barremian). In the lower and middle part of the *Sh. cabrii* trz – *Gl. blowi* ivz the ammonites *Procheloniceras albrechtiaustriacae* HOH., *Pseudosaynella* ex gr. *matheronites* (D'ORBIGNY), and *Barremites difficilis* (D'ORBIGNY) indicate the Early Aptian *Deshayesites weissi* ammonite Zone. In the *H. sigali* ivz *Costidiscus recticostatus* (D'ORBIGNY) and *Spitidiscus vandeckii* (D'ORBIGNY) give evidence for a Barremian age. The NSF can be correlated with the upper part of the Bersek Marl and the Lábatlan Sandstone Formation at Bersek Hill on the basis of the ammonite successions.

Borehole Agt-2, the stratotype of the Lower and Middle Albian Vértessomló Formation, comprises the *T. bejaouensis* ivz; the *H. planispira* ivz; and the *T. primula* ivz. The overlying Köszörükőbánya Conglomerate Formation is of Albian-Cenomanian age, according to the occurrence of *Conicorbitalina conica*, *C. corbarica* and of *Favusella washitensis*.

A new ammonite assemblage collected from facies unit F of the Lackbach section of Austria (Northern Calcareous Alps) correlates with the Late Hauterivian *Pseudothurmannia ohmi* zone, including the lower *P. ohmi* and the upper *P. catulloi* subzones. The nannoplankton obtained from the matrix inside the ammonites indicates the middle part of the nannozone NC5.

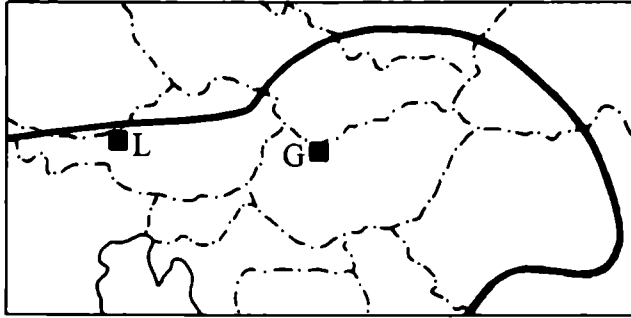
Keywords: Ammonites, Foraminifera, Nannoplankton, Upper Hauterivian, Aptian, Albian, Cenomanian, Hungary, Austria

1. INTRODUCTION

The Lower Cretaceous sedimentary succession of the Transdanubian Range (TR), including in its northern part the Gerecse Mts. and the Tatabánya basin in its SE foreland, was

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G – Gerecse L – Lackbach

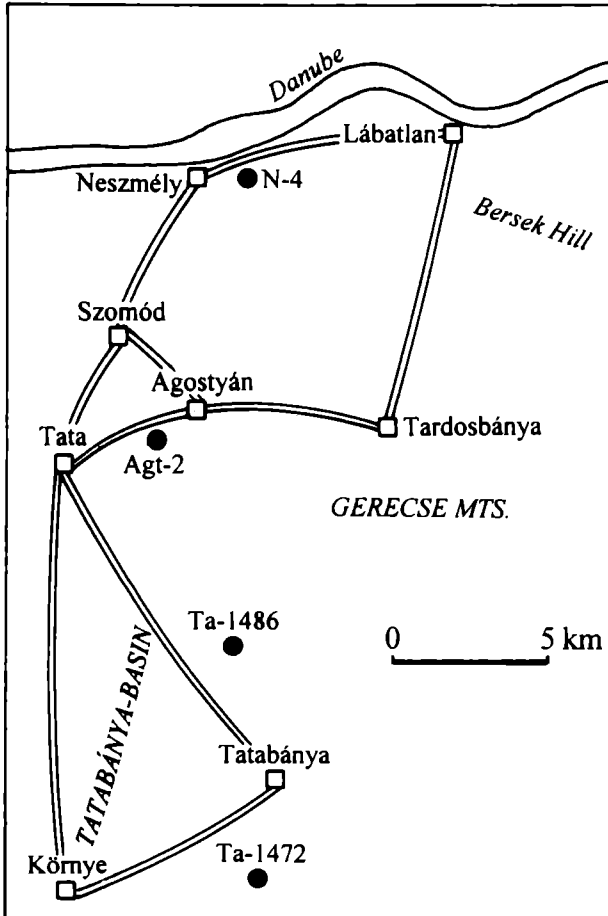


Fig. 1a: Sketchmap to show location of the Gerecse Mts. (G) and Lackbach (L) in Hungary and Austria respectively. b: Location of the Lower Cretaceous boreholes in the Gerecse Mts.: Agostyán Agt-2., Neszmély N-4, Tatabánya Ta-1472, Ta-1486.

deposited from Neocomian to Middle Cretaceous at the southern margin of the western Tethys (BALLA, 1981, 1988 ; KÁZMÉR & KOVÁCS, 1985). The TR with the Drauzug is a separate unit of the Alpine edifice between the Eastern and Southern Alps (KOVÁCS, 1983). The distribution of Permian and Paleogene facies zones of the TR can be fitted in between the Southern and Eastern Alps facies zones. Due to the northward motion of Apulia, a continental escape took place in an eastward direction following the Mesoalpine orogeny. The TR (or Bakony Unit) shifted about 450 km to the east from the Middle Eocene to the Early Miocene.

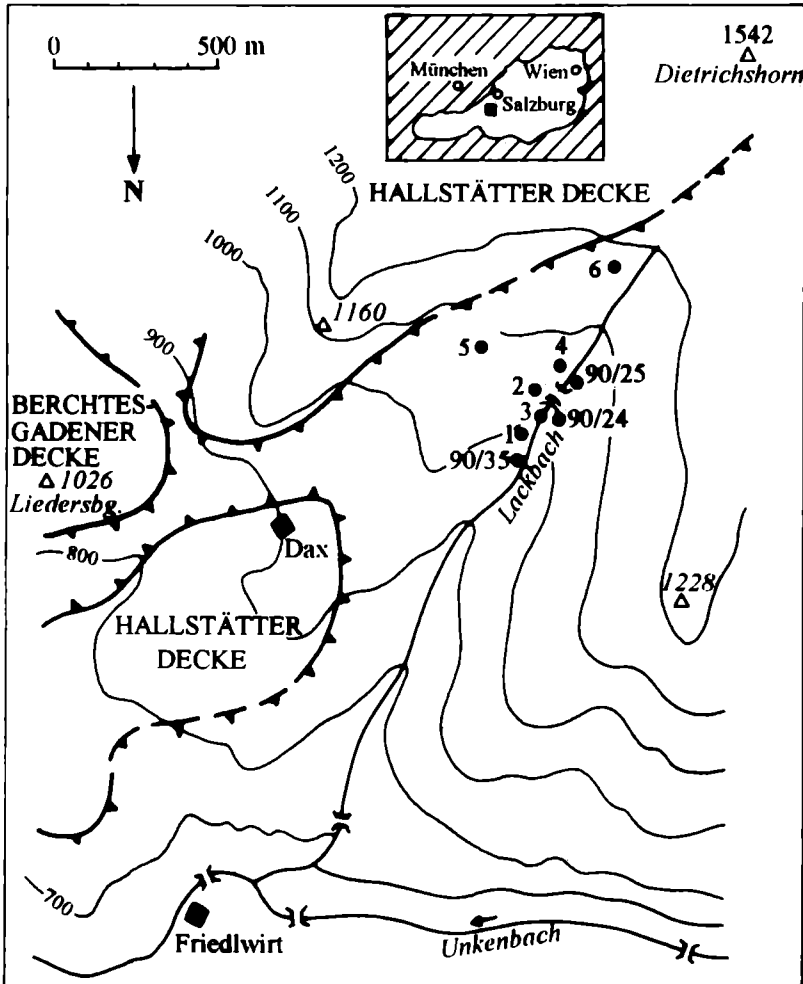


Fig. 2: Location of Lackbach section (Northern Calcareous Alps, Austria) after DARGA & WEIDICH (1986) with the sites of fossil finds: 1–6, collected by DARGA & WEIDICH (1986), LB 90/24–25 and LB 90/35 collected by LOBITZER & BODROGI in 1990.

In this paper we correlate the Lower Cretaceous formations of two boreholes from the Gerecse Mountains (Agt-2, N-4) and two boreholes from the Tatabánya basin (Ta-1472 and Ta-1486) (Fig. 1, 3) based on biostratigraphic and lithological data. We further compare these units with the coeval Late Hauterivian-Early Aptian Lackbach Beds (DARGA & WEIDICH, 1986), exposed in the Lackbach section of the Northern Calcareous Alps in Austria (Fig. 2, 4). A new latest Hauterivian ammonite fauna was found in facies unit F of this section.

2. STRATIGRAPHICAL SUBDIVISION OF LOWER CRETACEOUS SUCCESSIONS IN THE GERCSE MTS.

The Lower Cretaceous siliciclastic sediments of the Gerecse Mts. are overlain by a transgressive Eocene to Oligocene sequence. The contact between the Lower Cretaceous Neszmély Sandstone Formations (NSF) and the underlying pelagic Szentivánhegy Limestone Formation (Berriasian-Valanginian) is tectonic. The contact between the Vértessomló Formation and Triassic Dachstein Limestone is an erosional unconformity.

2.1. Lithostratigraphy

The predominantly massive, turbiditic sandstone sequences, earlier named Neszmély Beds (HANTKEN, 1868), are restricted to the western Gerecse Mts. and to the Tatabánya Basin. In the eastern Gerecse Mts. the NSF interfingers with the Lábatlan Sandstone Formation. The thickness is 381.50 m in the stratotype borehole Neszmély N-4 and ca. 50 m in the reference boreholes Tatabánya Ta-1472 and Ta-1486. This formation comprises mainly graded sandstones and conglomerates.

In borehole N-4 (845.80 to 427.40 m) dark grey marl and silt intercalations predominate. Matrix supported chert conglomerates, chert breccias and polymict conglomerates, as well as echinoderm-bearing allodapic limestone intercalations are common. The detrital fragments are mainly quartz and chert, but carbonates, opaque minerals, mainly chromite, weathered volcanites, volcanic glass and radiolarite detritus are present in considerable amounts, while feldspars and metamorphic rock fragments are subordinate. The pebbles of the conglomerate beds are predominantly quartz and chert, with subordinate quartzite, Triassic and Jurassic limestones, and intraformational marls. The conglomerate beds are on the average 0.1–0.3 m thick (maximum 3 m). In the upper part of the N-4 borehole section glauconite is common.

In borehole Ta-1472, the NSF, (495.10 to 548.50 m) comprises small- and fine-grained, variegated sandstone with varied pelite and carbonate content. It is characterized by intensive bioturbation, high organic matter content, and carbonaceous plant detritus. It is heavily tectonized. A characteristic feature is the lack of coarse sediments. In borehole Ta-1486, the NSF (184.40 to 230.90 m) consists mainly of fine- and medium-grained, compact, calcareous quartz sandstone. At the lower boundary of the formation there is a fault plane.

The macrofauna and -flora consists of fragmented, poorly preserved ammonites, crinoids and echinoids, with smaller numbers of aptychi, bivalves, gastropods, brachiopods, belemnites and worm tubes. In the allodapic limestones intercalations of poorly

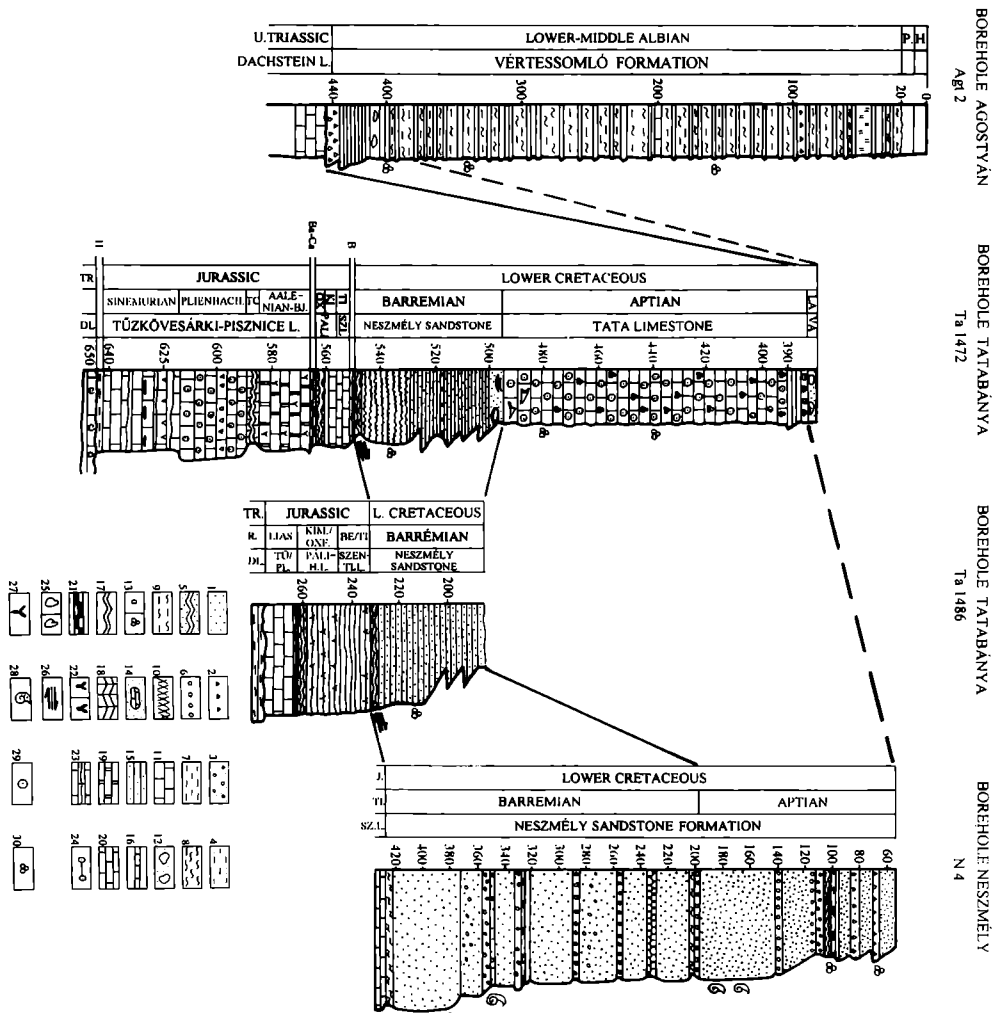


Fig. 3: Correlation of Lower Cretaceous borehole successions of Gerecse Mts. (Hungary).

Legend: lithological symbols (1–26) and fossil symbols (27–30): 1. sand; 2. authigenic breccia; 3. sandy gravel; 4. sandy clay; 5. faulted sandstone; 6. gravel; 7. clay; 8. marl; 9. clay-marl; 10. tectonised rock; 11. limestone; 12. siltite with pebbles; 13. planktonic foraminifera bearing limestone; 14. sandstone with limestone lenses and with nodules of limestone; 15. graded sandstone; 16. allodapic limestone; 17. folded rock; 18. nodular limestone; 19. white pelagic limestone; 20. red pelagic limestone; 21. radiolarite; 22. *Lombardia*-bearing limestone; 23. limestone with stylolithes; 24. oolith and ?stromatolite-bearing limestone; 25. Dachstein Limestone; 26. tectonic movements; 27. *Lombardia*; 28. ammonite; 29. crinoidea; 30. planktonic foraminifera.

preserved ammonite moulds are common and in the fine-grained beds carbonaceous plant remains are frequent. In the coarser beds drifted timber also occurs. The age is generally Barremian to Aptian in the studied boreholes.

2.1.2. *Tata Limestone Formation (TLF)*

The Tata Limestone Formation occurs in the Tatabánya Ta-1472 reference borehole (382.9 to 495.10 m) where it is 112.20 m thick, comprising grey, pale green, dark grey, hard, heavily fractured limestone and quartz sandstone with dark grey, finely stratified to microstratified clay, silt and fine sand interbeds. Glauconite appears as grains. The macrofauna consists of crinoids, echinoids and bivalves, with subordinate brachiopods and trace fossils. The formation passes gradually into the NSF and the VF. The stratotype area of the TLF is at Tata, Kálvária Hill (FÜLÖP, 1975). The age is generally Aptian.

2.1.3. *Vértessomló Formation (VF)*

FÜLÖP (1975) originally named this interval the "Vértessomló Siltstone Formation". We propose to change the name "Vértessomló Siltstone Formation" to "Vértessomló Formation", because in the stratotype section in borehole Agt-2 and in the reference sections, marl and clay marl predominate and siltstone intercalations are rare.

In the stratotype borehole Agostyán Agt-2 (23.3 to 440.80 m) its thickness is 417.5 m. The formation contains only two thin siltstone intervals (26.5 to 28.60 m and 393.90 to 394.30 m). The lower 50 m consists of extra- and intraformational breccias, which are overlain by a 70 m thick alternation of marls and sandstones, with intra- and extraformational breccias. The upper part displays an alternation of mainly marl and clay marl beds. The upper marl is finely stratified, laminated, probably graded. There are also laminae of fine-grained sandstone together with clays and clay marls. The formation is intensively tectonized. The extraclasts are mainly greyish white Triassic limestones, pink Jurassic limestones and cherts. In intraformational breccias, greyish-green, brownish-purple, strongly glauconitic limestone fragments become more and more frequent upwards. Crinoidal allodapic limestone intercalations containing syngedimentary breccias are common. The macrofauna consists of commonly small-sized ammonites, echinoids, bivalves, gastropods and crinoids. Brachiopods, belemnites and hydrozoans occur sporadically.

The VF occurred also at the top of the Cretaceous succession in borehole Tatabánya Ta-1472 (373.50 to 382.90 m) where it is 9.40 m thick. Variegated clay (yellowish brown, rusty brown), and grey siltite, devoid of carbonates, predominate.

2.2. **Biostratigraphy**

2.2.1. *Neszmély Sandstone Formation*

In the stratotype borehole Neszmély N-4 the ammonites were studied by HORVÁTH (1977, 1978a,b). BODROGI (1993, 1995), studied the planktonic and benthic foraminifers of the poor and unevenly distributed assemblages in the 37.00 to 442.00 m interval (101 washed residues, 80 thin sections; see Plate 1).

An integrated planktonic foraminifera – ammonite zonation has been established with reference to the zonal schemes of CARON (1985), ROBASZYNSKI & CARON (1995), CIOCCIONI & PREMOLI SILVA (1994), HOEDEMAEKER & COMPANY et al. (1993), HOEDEMAEKER (1995), HOEDEMAEKER & LEEREFELD (1995). With the exception of zones 2 and 4, only combined zones could be recognized:

1. *Ticinella bejaouensis* – *Hedbergella gorbachikae* zone (37–99 m), age: Late Aptian – ? Early Albian;
2. *Globigerinelloides algerianus* trz. (99–139 m); accompanying species are *Hedbergella trocoidea* (GANDOLFI), *Globigerinelloides ferroelensis* MOULLADE; age: early Late Aptian.
3. *Shackoina cabri* – *Globigerinelloides blowi* zone (139–198 m); age Early and Middle Aptian. *Procheloniceras albrechtiaustriae* UHLIG was found at 158 m, *Pseudosaynella* ex gr. *matheronites* (D'ORBIGNY) at 172–173 m, and *Barremites difficilis* (D'ORBIGNY) at 197 m. This ammonite succession indicates the Early Aptian *Deshayesites weissi* Zone (HOEDEMAEKER in HOEDEMAEKER & LEEREFELD, 1995). Its lower boundary has been drawn at 198 m, above the occurrence of *Costidiscus recticostatus* (D'ORBIGNY);
4. *Hedbergella sigali* zone (198.0–422.00 m); age: Barremian. Its upper boundary is defined by the occurrence of *Costidiscus recticostatus* (D'ORBIGNY), its lower boundary by the first occurrence of *H. sigali*, *H. delrioensis* (CARSEY), and *Claviedbergella eocretacea* (NEAGU). Higher, at 351 m, appears the long-ranging *Spitidiscus vandeckii* (D'ORBIGNY), the FO of which is in the Barremian, and *Costidiscus microcostatus* (D'ORBIGNY). Between 303 and 314 m benthic foraminifers and orbitolines have been found, testifying to the erosion of a Barremian carbonate platform: *Orbitolina* sp., *Orbitolinopsis* cf. *cuvillieri* MOULLADE, *Urgonina alpillensis* FOURY, *Falsurgonina* sp.

In the reference boreholes Ta-1472 (495.10 to 548.50 m; 151 thin sections) and Ta-1486 (184.40–229.0 m; 40 thin sections), the microfauna consists of foraminifera, radiolarians, cadosina, alcyonaria spicules and metazoa. The foraminifers are fairly well preserved. Crinoids are common, echinoids, bryozoans, bivalves, worm tubes and sponges are present. The calcareous algae are represented by detritus of Rhodophyta and *Archaeolithothamnium* sp.

In the boreholes Ta-1472 (495.10–547.5 m) and Ta-1486 (184.40–229.00 m) the entire sequence has been assigned to the *H. sigali* izv. Accompanying species are *H. similis* LONG., *H. delrioensis* (CARS.), *H. aptiana* (BETTENSTAEDT), *H. infracretacea* (GLAESNER) and *Claviedbergella eocretacea* (NEAGU).

2.2.2. Tata Limestone Formation

The fauna of the TLF in borehole Tatabánya Ta-1472 (383.5 to 494.85 m; 30 thin sections; see also BODROGI, 1993, 1995) is dominated by crinoids and echinoids, with subordinate brachiopods and bivalves. In some intervals sponge spicules are present in rock-forming quantities, foraminifera and radiolarians are moderately common to common. Preservation is good to moderate. The planktonic foraminiferal zonation indicates an Early to Late Aptian age (*Globigerinelloides algerianus* trz.: 368.5–413.5 m: lower part of the *Ticinella bejaouensis* izv and *Hedbergella gorbachikae* izv. Age: Late Aptian; 413.5–468.5 m. *Globigerinelloides algerianus* trz. Age: early Late Aptian; 468.5–495.1 m: *Shackoina cabrii* trz – *Globigerinelloides ferroelensis* izv – *Globigerinelloides blowi* izv. Age: Middle and Early Aptian).

2.2.3. Vértessomló Formation

SOLTZ (in FÜLÖP, 1975) assigned the oldest deposits of the "Vértessomló Siltstone Formation" to the *Leymeriella tardefurcata* ammonite Zone at Tata, where the accompanying species, *Leymeriella revili* JACOB, *Leymeriella romani* JACOB and *Kosmatella jacobii* WIEDMANN, occur in several boreholes (TVG 45, TVG-55, TVG-59). In the stratotype borehole Agostyán Agt-2 the badly preserved ammonite fauna was not studied, the planktonic and benthic foraminifera were studied by BODROGI (1993, 1995). The well preserved rich fauna of foraminifera consists of 157 species and 34 form that could be determined only at generic level. Accompanying fossils are radiolarians, calcispheres, gastropods, bivalves, ostracods, sponge spicules, echinoderms and sclerites of octocorals.

3 planktonic foraminiferal biozones could be distinguished:

1. *Ticinella primula ivz* (20 to 162 m); age: Middle Albian.
2. *Hedbergella planispira ivz* (162 m to 328 m); age: Early Albian.
3. *Ticinella bejaouensis ivz* (338 to 4230 m); age: latest Aptian – earliest Albian. However, in this borehole only the upper portion from the the lowermost Albian is present.

Based on benthic foraminifera, WEIDICH (1990) distinguished the *Osangularia* (*Planomalina*) *schloenbachi* – *Haplophragmoides nonioides* ivz (Late Aptian to the Early Albian) in the Northern Calcareous Alps. This zone can also be recognized in our material, comprising all three planktonic foraminifer zones. The benthic zone markers are present even in the last *T. primula*-bearing sample. All samples of the formation belong to the Early and Middle Albian; no new species appearing in the Late Albian-Cenomanian is present.

3. CORRELATION OF THE GERECSÉ BOREHOLES

We correlated the N-4 borehole succession (stratotype of the NSF) with the successions in reference boreholes Ta-1472 and Ta-1486. According to the biostratigraphic data, the coarse detrital Barremian part of the NSF can be correlated with the finer-grained deposits in boreholes Ta-1472 and Ta-1486. The bulk of the Barremian (198–351 m) is documented by means of ammonites, the lower part (351–427 m) by means of planktonic foraminifera. The upper boundary of the Barremian is indicated by *Costidiscus recticostatus* at 198 m, the Lower Barremian by *Spitidiscus vandeckii* at 351 m, and the earliest Early Barremian by the *H. sigali* ivz and its accompanying species (*Clavihedbergella eocretacea*, *Hedbergella delrioensis* and other species) in the 351–422 m interval.

In borehole N-4 the upper (Aptian) portion of the NSF (45.8–198 m) can be correlated with the time-equivalent Tata Limestone Formation in borehole Ta-1472 (382.9–495.10 m). The lower boundary of the Aptian is indicated in borehole N-4 by the Barremian ammonite *Costidiscus recticostatus* at 198 m, while the upper boundary is an erosion surface. Early Aptian is proven by the presence of *Procheloniceras albrechtiaustriacae* UHLIG at 158–158.80 m, Late Aptian by *Hedbergella trocoidea* GANDOLFI at 139 m, *Globigerinelloides algerianus* TEN DAM at 99–101 m and *Ticinella bejaouensis* SIGAL in the 90–45.8 m interval.

The youngest formation in borehole Ta-1472, the Vértessomló Formation, was correlated with the basal Lower Albian beds of borehole Agt-2. This is confirmed by the presence of *Hedbergella similis* and *Ticinella bejaouensis*, as well as by their position.

4. LACKBACH SECTION (NORTHERN CALCAREOUS ALPS, AUSTRIA)

4.1. Geographic position and geological setting

The Lackbach section is located at the northern margin of the Tirolicum, at the eastern rim of the Unken Syncline, 25 km WSW of the village of Unken (Salzburg province), on base map TK 50, map sheet Bad Reichenhall L.8342 (Fig. 2). The 2 km long section exposes Upper Jurassic and Lower Cretaceous rocks, with the Lower Cretaceous Lackbach Beds in its upper part (Fig. 4; see DARGA & WEIDICH, 1986). The upper portion of the Lackbach Beds is also exposed ENE of Dax, between the Hallstatt Nappe and the Berchtesgaden Nappe. The Lackbach Beds are underlain by the Tithonian Oberalm Beds and the Tithonian – Berriasian Schrambach Formation. The succession is tectonically truncated by Triassic and Jurassic rocks of the Hallstatt Nappe

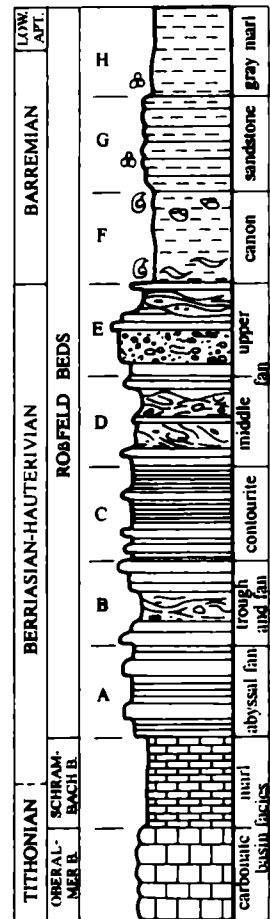


Fig. 4: The Lackbach section (Northern Calcareous Alps, Austria) modified from DARGA & WEIDICH (1986). Lackbach Beds of DARGA & WEIDICH (1986) are included into Roßfeld Beds. Legend for fossil symbols: see legend Fig. 3.

4.2. Facies zones and stratigraphic classification

The Lackbach Beds are a local lithostratigraphic unit, which corresponds broadly to the Rossfeld Formation developed elsewhere in the Tirolicum (DECKER et al., 1987). It consists of varied facies units (A-H, see Fig. 4) of a Berriasian-Early Aptian prograding submarine detritus fan (DARGA & WEIDICH, 1986). The lower portion of the LB (A-E) is of Late Berriasian-Hauterivian age, the upper portion (F-H) is of terminal Late Hauterivian – Barremian – Early Aptian age.

4.3 New latest Hauterivian ammonite fauna

A new ammonite fauna was collected from facies unit F of the Lackbach Beds at the three sites LB 90/24, LB 90/25 and LB 90/35 (Figure 2; see BODROGI, 2000). The ammonites are poorly to only moderately well preserved and were determined by HOEDEMAEKER (1995, manuscript: see Pls 2–3) as follows:

1. Site LB 90/24: *Neolissoceras* cf. *subgrasianum* (DRUSHCHITS)
2. Site LB 90/25: *Plesiospidiscus subdifficilis* (KARAKASCH)
3. Site LB 90/35: *Pseudothurmannia sarasini* SARKAR, *P. ex gr. simionescui* SARKAR, *P. ohmi* WINKLER, *P. cf. ohmi*, *P. cf. mortilleti* (PICTET & LORIOU), *Phylloceras thetys* (D'ORBIGNY), *Plesiospidiscus subdifficilis* (KARAKASCH), *Crioceratites* cf. *ibizensis* WIEDMANN, *C. aff. pseudothurmanni* (DIMITROVA)

The ammonite assemblage of Site LB 90/35 belongs to the latest Hauterivian *Pseudothurmannia angulicostata auctorum* Zone sensu HOEDEMAEKER et al. (1993). The zonal index species, *Pseudothurmannia angulicostata auctorum* is a junior synonym of *P. ohmi* WINKLER. This latter species is the index of the new *Pseudothurmannia ohmi* Zone, subdivided into two subzones, a lower subzone of *P. ohmi* and an upper subzone of *P. catulloi* (see HOEDEMAEKER & LEERFELD, 1995; HOEDEMAEKER, 1995).

There is a major ammonite turnover between these two subzones (HOEDEMAEKER, 1995). The fauna from Site LB 90/35 contains species restricted to one or other of the two subzones, in addition to species common to both, and one long-ranging species. *Plesiospidiscus subdifficilis*, *Crioceratites* cf. *ibizensis* and *C. aff. pseudothurmanni* indicate the *Pseudothurmannia ohmi* Subzone, *Pseudothurmannia sarasini* and *P. ex gr. simionescui* are restricted to the *Pseudothurmannia catulloi* Subzone, while *P. ohmi* and *P. mortilleti* could indicate either subzone. *Phylloceras thetys* ranges from the Berriasian to the Aptian.

At the two remaining sites, *Neolissoceras* cf. *subgrasianum* from Site LB 90/24 indicates the *P. ohmi* Subzone, as does *Plesiospidiscus subdifficilis* from Site LB 90/25.

The *Pseudothurmannia ohmi* [former *P. angulicostata auctorum*] Zone has been placed variously either in the Hauterivian or in the Barremian, or the two component subzones have been placed in the Hauterivian and Barremian respectively. It is of relevance to this paper that IMMEL (1987), in his study of the Lower Cretaceous ammonites of the Northern Calcareous Alps (including the Lackbach section), assigned the zone [which he proposed to rename the *mortilleti* Zone after the species *Crioceratites* (*Pseudothurmannia*) *mortilleti*] to the basal Barremian. The controversy was finally resolved at the Brussels Symposium (RAWSON, 1996), when it was formally recommended that the *P. angulicostata auctorum* Zone should mark the top of the Hauterivian.

The nanoplankton from the Lackbach sections gives a rather equivocal Late Hauterivian/Early Barremian date, but it is unclear whether or not the nanoplankton ranges have been recalibrated in the light of the Brussels recommendation. FOGARASI (1996) studied the nanoplankton obtained from the matrix of the ammonites *Neolissoceras subgrasianum* (LB 90/24), *Pseudothurmannia sarasini* and *Pseudothurmannia* cf. *ohmi* (LB 90/35). Two biostratigraphically important species have been found in the samples, indicating a level near the Hauterivian/Barremian boundary: *Assipetra* (*Rucinolithus*) *terebrodentarius* and *Calcicalathina oblongata*. The FO of the first species is in the uppermost Hauterivian, in the middle of zone NC5 (*Watznaeria oblonga*), while the LO of the second one is in the upper part of the same zone. Since both species are present in the samples, they indicate the middle part of the *Watznaeria oblonga* Zone and a Late Hauterivian/Early Barremian age.

These stratigraphical data can be compared with the ammonite assemblages (FÜLÖP, 1958; FÖZY, 1995) from the dark red sequence of the upper part of the Bersek Marl at Bersek Hill, Gerecse Mts. (section B2 of FOGARASI, 1996), where *Partschiceras* sp. aff. *winkleri* (UHLIG) and *Olcostephanus* sp. aff. *asterianus* (D'ORBIGNY) occur. An Early Barremian age is indicated by the species *Silesites vulpes* (COQUAND), *S. castellenaensis* and *Anahamulina hoheneggeri* (see FÖZY, 1995).

Also from facies unit F of the Lackbach succession (localities 2 and 3 in Figure 2), DARGA & WEIDICH (1986, p. 103, pl. 3) recorded a small ammonite fauna comprising *Phylloceras thetys*, *Barremites* cf. *difficilis* (D'ORBIGNY), *Crioceras* (*Pseudothurmannia*) *mortilleti* and *Karsteniceras beyrichi* (KARSTEN). This fauna indicated the *mortilleti* Zone (IMMEL, 1987), i.e. (sensu IMMEL) basal Barremian. *Pseudothurmannia mortilleti* suggests the Upper Hauterivian *P. ohmi* Zone, while *Barremites* cf. *difficilis* and *Karsteniceras beyrichi* suggest a Barremian age. Thus, this reported ammonite fauna may be mixed or reworked. From the overlying facies unit H, DARGA & WEIDICH (1986) recorded *Karsteniceras* sp and ?*Ptychoceras*, which they also attributed to the basal Barremian. The Early Barremian of this unit has been assigned to the *Hedbergella sigali* foraminiferal Zone, while the higher part of the unit ranges up to the Early Aptian *Globigerinelloides blowi* – *Hedbergella similis* zones (WEIDICH, 1990).

5. DISCUSSION AND CONCLUSIONS

New and updated biostratigraphic data on the Lower Cretaceous boreholes of the Gerecse area (N-4, Ta-1472, Ta-1486 and Agt-2) give a revised age interpretation. In the detrital Gerecse sequence, we have confirmed the Barremian age of the *Hedbergella sigali* IVZ (CARON, 1985 and ROBASZYNSKI & CARON, 1995) by the occurrence of the zonal index species together with *Clavihedbergella eocretacea*, *Hedbergella similis*, *H. delrioensis* and *Globigerinelloides blowi*.

In the Aptian portion of boreholes N-4 and Ta-1472 only combined planktonic foraminiferal zones could be distinguished, namely the *Globigerinelloides blowi* – *Shackoina cabri* (Early Aptian) and the *H. gorbachikae* – *T. bejaouensis* (Late Aptian) zones, with the only exception being the *Globigerinelloides algerianus* trz.

The 158–198 m interval of borehole N-4 we assigned to the Early Aptian *Deshayesites weissi* ammonite zone, on the basis of the occurrence of *Procheloniceras albrecht-*

tiaustriae UHLIG. The lower boundary of the zone is defined by the occurrence of *Costidiscus recticostatus*, its upper boundary by the occurrence of *P. albrechtiaustriae* and *Pseudosaynella* ex gr. *matheronites*.

In borehole Ta-1472 the Vértessomló Formation is only a few meters thick, but it can be correlated with the stratotype borehole Agt-2. In boreholes Ta-1369, Ta-1462, Ta-1495, as well as in boreholes Vst-6, Kö-24, O-1881, the VF is 40 to 100 m thick, while in borehole Agt-2 its thickness is 417.5 m. The Vértessomló Formation in all of the boreholes is of Early and Middle Albian age, and no *Rotalipora* are present even in its uppermost part.

The Tata Limestone Formation consists mainly of quartz sandstone in the northern area and in borehole Ta-472. It contains plenty of mafic minerals, weathering products of volcanites, locally radiolarite and detrital grains of pelagic calpionella-bearing Tithonian limestone, and involutina-bearing Malm platform carbonates. The formation belongs unequivocally to the Gerecse detrital sequence. Its redeposited material, rich in echinoderms, derives probably from an intraoceanic island arc (according to BALLA, 1981); its age is Aptian.

The terminal member of the Gerecse detrital Lower Cretaceous are the Köszörükőbánya Conglomerate (Albian-Cenomanian) and the Vértessomló Formation. Increasing number of palaeontological (BODROGI, 1993, 1995, 1999, 2000) and clay mineralogical data (VICZIÁN & KOVÁCS-PÁLFFY, 1997) seem to indicate that the Köszörükőbánya Conglomerate "Member" is in fact an independent formation, and not a member of the Lábatlan Sandstone Formation. It is assumed to be underlain by or to be a heterotopic facies of the Vértessomló Formation. The VF is of Early and Middle Albian age.

In the Lower Cretaceous Lackbach section, Northern Calcareous Alps, a new ammonite fauna is reported from facies unit F of DARGA & WEIDICH (1986). The ammonites give evidence for the Latest Hauterivian *Pseudothurmannia ohmi* Zone of HODEMAEKER (1995), the former *Pseudothurmannia angulicostata auctorum* Zone. Comparing the two Lower Cretaceous successions in the Gerecse Mts. and the Northern Calcareous Alps, the VF is of Early and Middle Albian age, while the terminal grey marl of the Lackbach beds is Early Aptian. The latter is covered by the Hallstatt Nappe, which might have been overthrust onto it not earlier than in the Early Aptian, during the Austroalpine tectonic phase (DARGA & WEIDICH, 1986). In the Transdanubian Range, including the Gerecse area, sedimentation continued longer than in the Lackbach area, and no subsequent nappe overthrusting took place.

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Plate 1

Lackbach section, fossil site LB 90/35, *Pseudothurmannia ohmi* Zone, age: latest Hauterivian
 Figs 1, 2: *Pseudothurmannia sarasini* SARKAR from the upper, *Pseudothurmannia catulloi* Subzone, magnification × 1

Fig. 3: *Pseudothurmannia* cf. *ohmi* WINKLER, magnification × 1.5

Fig. 4: *Pseudothurmannia ohmi* WINKLER, external mould, magnification × 2

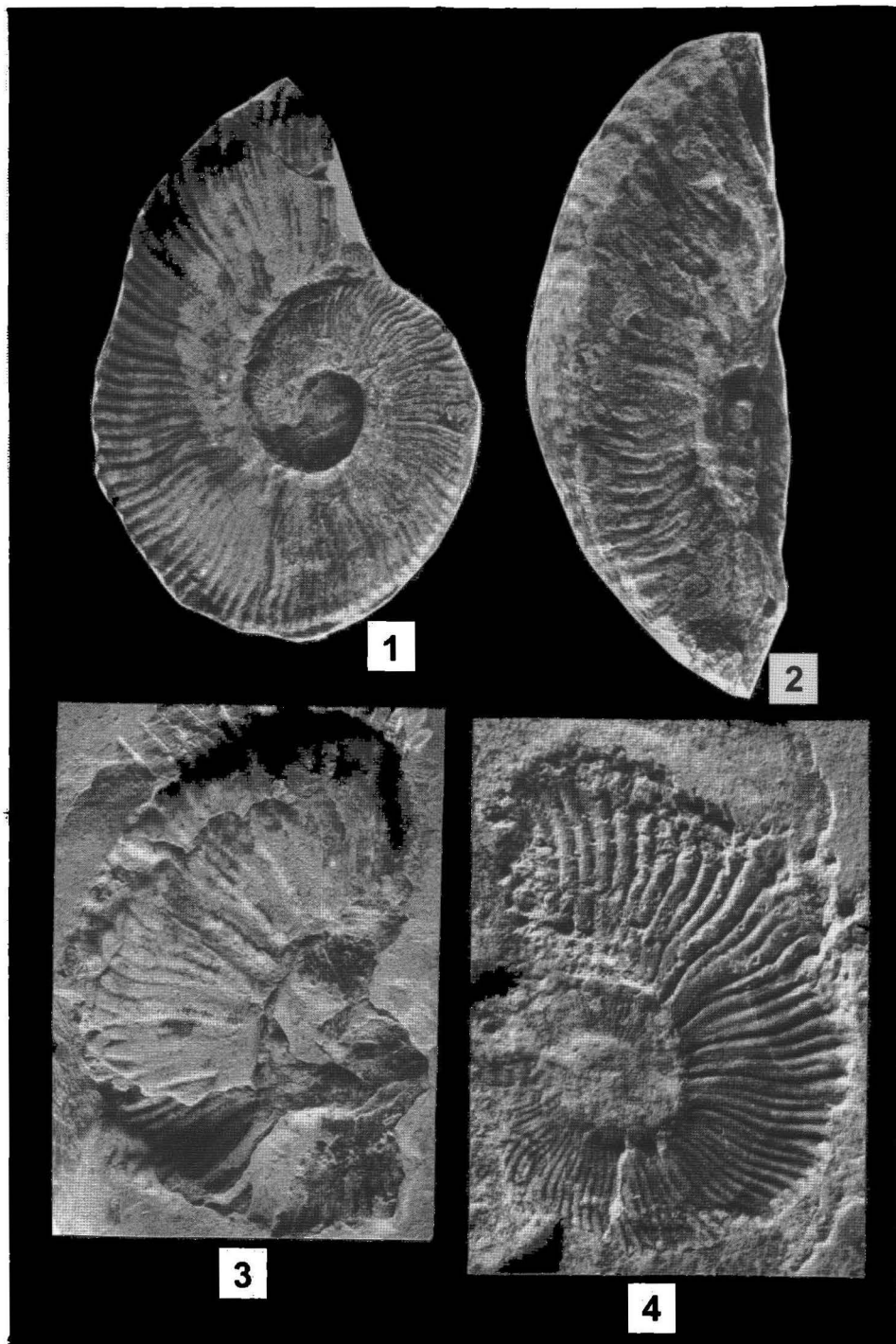


Plate 2

Lackbach section, fossil site LB 90/35, except fig. 6. *Pseudothurmannia ohmi* Zone, age: latest Hauterivian.

Fig. 1: *Pseudothurmannia subdifficilis* (KARAKAS), from the lower, *Pseudothurmannia ohmi* Subzone, magnification $\times 1$

Fig. 2: *Pseudothurmannia* ex gr. *simionescui* SARKAR, from the upper, *Pseudothurmannia catulloi* Subzone, magnification $\times 1$

Fig. 3: *Pseudothurmannia* cf. *ohmi* WINKLER, external mould, magnification $\times 2$

Fig. 4: *Plesiospidiscus subdifficilis* (KARAKAS), from the lower, *ohmi* Subzone, magnification $\times 1$

Fig. 5: *Pseudothurmannia* cf. *mortilleti* (PICTET & LORIOU), magnification $\times 1$

Fig. 6: *Neolissoceras* cf. *subgrasianum* (DRUSHCHITS), internal cast from fossil site LB 90/24, from the lower, *Pseudothurmannia ohmi* Subzone, magnification $\times 1$

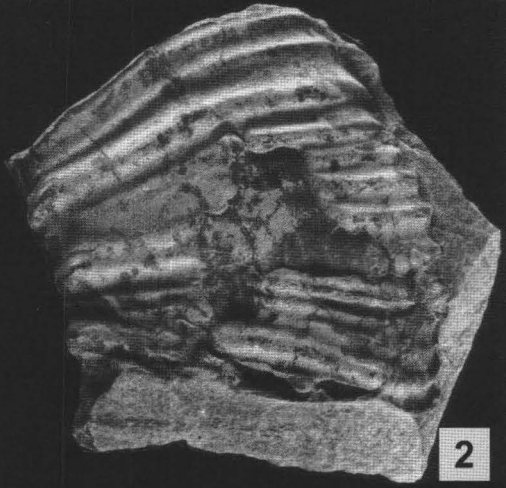


Plate 3

Borehole Neszmély N-4 (Gerecse, Hungary), except fig. 6, Neszmély Sandstone Formation

Fig. 1: *Costidiscus microcostatus* (D'ORBIGNY), 187 m, Late Barremian, magnification $\times 1$

Fig. 2: *Procheloniceras albrechtiaustriae* UHLIG from the *Deshayesites weissi* Zone, Late Aptian, magnification $\times 1$

Fig. 3: *Spitidiscus vandeckii* (D'ORBIGNY), 351 m, Late Barremian, magnification $\times 1$

Fig. 4: *Costidiscus recticostatus* (D'ORBIGNY), 198 m, Late Barremian, magnification $\times 1$

Fig. 5: *Clavihedbergella eocretacea* (NEAGU), 204.5 from borehole Tatabánya Ta-1486, magnification $\times 50$

Fig. 6: *Globigerinelloides algerianus* TEN DAM, 101 m, thin section, Late Aptian, magnification $\times 50$

