HANTKENIANA

Contributions of the Department of Palaeontology,
Eötvös University

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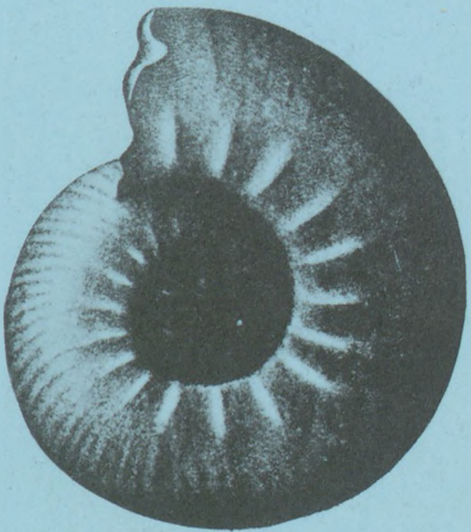
Barnabás GÉCZY Jubilee Volume



Budapest, 1995

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Frontispiece

Type specimen of *Erycites baconicus* HANTKEN in PRINZ, 1904, an ammonite species from the uppermost Toarcian (Lower Jurassic) of the Bakony Mts. as figured by HANTKEN in PRINZ (1904, Die Fauna der älteren Jurabildingen im nordöstlichen Bakony. – Mitteilungen aus dem Jahrbuche der Kgl. Ungarischen Geologischen Anstalt 15/1, 1–142, Pl. 16, fig. 2a.)

This volume is dedicated to

Professor Barnabás Géczy

on his 70th birthday

by his disciples and admirers

It is the first volume of the new series

Hantkeniana

named after the founding professor
of the Department of Palaeontology
at Budapest University

M. Hantken

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GÉCZY Jubilee Volume
Hantkeniana 1, 1–190 (1995) Budapest

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GÉCZY Jubilee Volume
Hantkeniana 1, 3–11 (1995) Budapest

Professor Barnabás Géczy: a bibliography of his works from 1951 to 1995

Miklós KÁZMÉR

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This bibliography has been compiled upon the occasion of the retirement of Barnabás Géczy, Professor of Palaeontology at Eötvös University, Budapest, at the age of seventy from... From what? He continues teaching, regularly publishes on his favourite topics of Jurassic ammonites, extinction, evolution and history of palaeontology, organizes postgraduate education and serves in committees on various aspects of the earth sciences.

The bibliography reflects his manifold interests in all aspects of fossil life, his commitment to fully publish his results, commitment for careful documentation of fossils before using them for far-reaching conclusions in biostratigraphy, evolution, palaeobiogeography, and plate tectonics.

His passion for teaching yielded a number of books covering all branches of palaeontology, which provide guidance and abundant factual information also for those, who were not so lucky to be able to attend his lectures. Few if any professors can boast with textbooks on palaeobotany and palaeozoology as well!

Books[1]

1954

Cyclolites (Anth.) tanulmányok. Studien über Cycloliten (Anth.). – Geologica Hungarica, series Palaeontologica 24, 180 p., 10 pls, 51 figs, Budapest.

1966

Ammonoides jurassiques de Csernye, Montagne Bakony, Hongrie. Part I. (Hammatoceratidae). – Geologica Hungarica, series Palaeontologica 34, 276 p., 126 figs, 44 pls, Budapest.

1967

Ammonoides jurassiques de Csernye, Montagne Bakony, Hongrie. Part II. (excl. Hammatoceratidae). – Geologica Hungarica, series Palaeontologica 35, 413 p., 249 figs, 65 pls, Budapest.

1970

Ősnövénytan. [Palaeobotany.] Egyetemi jegyzet. [Lecture note.] Tankönyvkiadó, Budapest, 284 p.

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[1] Foreign titles in (...) parentheses are the titles of the original abstracts. Titles in [...] brackets were translated by the bibliographer.

1972

Ősnövénytan. [Palaeobotany.] Egyetemi tankönyv. [University textbook.] Tankönyvkiadó, Budapest, 356 p.

1975

Ősállattan. Tematika a II. éves geológus hallgatók részére. [Palaeozoology. Course note for 2nd grade geology students.] Budapest, 105 p.

1976

Les Ammonitines du Carixien de la Montagne du Bakony. Akadémiai Kiadó, Budapest, 223 p., 138 figs, 39 pls.

1977

Őslénytan. [Palaeozoology.] Egyetemi jegyzet. [Lecture note.] Tankönyvkiadó, Budapest, 304 p., 162 figs.

1979

Biosztratigráfia. [Biostratigraphy.] Egyetemi jegyzet. [Lecture Note.] Budapest, 102 p., 34 figs.

Az eltűnt élet nyomában. [In search of the lost life.] Gondolat, Budapest, 128 p., 57 figs.

Ősállattan. [Palaeozoology.] Egyetemi jegyzet. [Lecture note.] Tankönyvkiadó Budapest, 454 p., 400 figs.

1980

A biokronológia és a biokronometria alapjai. [Principles of biochronometry and biochronology.] *In:* BALÁZS, Béla, FÉNYES, Imre, GÉCZY, Barnabás & HORVÁTH József: Mi az idő? [What is time?] Gondolat, Budapest, 111–167, 2 figs, 1 t.

1982

Az állatok törzsfejlődése. [Phyletic evolution of animals.] *In:* VIDA Gábor (szerk): Evolúció II, 111–172, 10 figs Natura, Budapest.

1983

Lamarck és Darwin. [Lamarck and Darwin.] Gyorsuló Idő, Magvető Kiadó, Budapest, 171 p.

1984

Őslénytan. [Palaeontology.] Tankönyvkiadó, Budapest, 474 p, 239 figs, 20 t.

1993

Ősállattan. Vertebrata Paleontologia. [Palaeozoology. Vertebrate Palaeontology.] Tankönyvkiadó, Budapest, 502 p.

Ősállattan. Invertebrata Paleontologia. [Palaeozoology. Invertebrate Palaeontology.] Tankönyvkiadó, Budapest, 595 p.

1994

Brief History of the Hungarian Palaeontology. – Annals of the History of Hungarian Geology, Special Issue 6, 68 p., Budapest.

1995

A magyar őslénytan története. [History of Palaeontology in Hungary.] Értekezések, emlékezések. Akadémiai Kiadó, Budapest (in press)

Papers

1951

Az 1950. évi magyarországi földrengések [Earthquakes in Hungary in 1950.] – Országos Földrengéskutató Intézet Kiadványai, Budapest, pp. 3–6.

1954

Adatok a sümegi Cyclolitesek ismeretéhez. [Contributions to the knowledge of the Cyclolites of Sümeg, Hungary.] – A Természettudományi Kar Évkönyve 1952–1953, 103–104, Budapest.

1957

Az Ammonites váz és lágytest viszonyáról. [On the shell and soft body of the Ammonites.] – Földtani Közlöny 87, 348–349, Budapest.

1958

A csernyei jura Cephalopodák mennyiségi értékelése. (Quantitative Auswertung jurassischer Cephalopoden von Csernye.) – Földtani Közlöny 88, 125–127, 2 figs, Budapest.

A Hexacoralliák törzsfejlődéséről. (Über die Stammesentwicklung der Hexacorallen.) – Földtani Közlöny 88, 464–466, 1 fig., 1 tab., Budapest.

1959

Über das Absterben und Einbettung der Ammoniten. – Annales Universitatis Scientiarum Budapestinensis de Rolando Eötvös nominatae, Sectio Geologica 2 (1958), 93–98, Budapest.

Sur les *Diploctenium* (Anth.) de Sümeg. – Acta Geologica Academiae Scientiarum Hungaricae 6, 195–208, 6 figs, 4 pls, Budapest.

Liparoceras (Hemiparinodiceras) urkuticum n. sg. n. sp. (Ceph.) a bakonyi középsőliászból. *Liparoceras (Hemiparinodiceras) urkuticum* n. sg. n. sp. (Ceph.) from the Middle Liassic of the Bakony Mountains, Transdanubia, Hungary. – Földtani Közlöny 89, 143–147, 2 figs, 1 pl., Budapest.

Az Ammonites-félék elhalásáról és beágyazódásáról. (On the decease and internment of Ammonites.) – Földtani Közlöny 89, 298–301, Budapest.

Tragophylloceras vadászi (LÓCZY 1915) emend. nov. aus der Klippenzone der NW Karpaten. – Geologické práce 1959, 183–186, 1 pl., Bratislava.

1960

Die zeitliche Verbreitung von *Paleotrix* in den jurassischen Schichten des nördlichen Bakonygebirges. – Annales Universitatis Scientiarum Budapestinensis de Rolando Eötvös nominatae, Sectio Geologica 3 (1959), 49–53, Budapest.

A Neoammonoideák életmódjáról. On the way of life of Neoammonoids. – Földtani Közlöny 90, 200–203, Budapest.

1961

Liász konferencia Franciaországban. [Liassic Conference in France.] – Földtani Közlöny 91, p. 81, Budapest.

A bakonycsernyei Tűzkövesárok jura rétegsora. The Jurassic sequence of the Tűzkövesárok at Bakonycsernye. – Annales Instituti Geologici Publici Hungarici 49/2, 393–443, 7 figs, 1 t., 7 pls, Budapest.

Die jurassische Schichtreihe des Tűzköves-Grabens von Bakonycsernye. – Annales Instituti Geologici Publici Hungarici 49/2, 507–567, 7 Abb., 7 Taf., Budapest.

Problèmes biostratigraphiques du Bakony septentrional. – Bureau de Recherches Géologiques et Miniéres, Mémoire 4, 1–7, 4 figs, Paris.

Cenoceras truncatus vadaszi n. ssp. (Ceph.) a Bakony hegység középsőliász rétegösszletéből. (*Cenoceras truncatus vadaszi* n. ssp. from the Middle Liassic complex of Bakony Mts.) – Földtani Közlöny 91, 325–337, 1 fig., Budapest.

1962

Cancellophycus et *Chondrites:* deux traces de vie du Dogger inférieur de la partie du N de la Montagne Bakony. – Annales Universitatis Scientiarum Budapestinensis de Rolando Eötvös nominatae, Sectio Geologica 5 (1961), 47–54, 1 pl., Budapest.

1963

A liász–dogger határ kérdéséhez. (Zur Frage der Lias–Dogger Grenze.) – Földtani Közlöny 93, 227–230, Budapest.

A jura időszak tagolási kérdései két kongresszus nyomán. [Subdivision of the Jurassic period after two congresses.] – Földtani Közlöny 93, p. 251, Budapest.

1964

Szint, életszint, időszint. (Zone, Biozone, Chronozone.) – Földtani Közlöny 94, 132–135, Budapest.

Zóna, biozóna, kronozóna. [Zone, biozone, chronozone.] – Őslénytani Viták 2, 1–7, Budapest.

Contribution au problème de la limite Lias/Dogger dans la Montagne Bakony. – Comptes Rendus et Mémoires Sci. Nat. Inst. Luxembourg.

Evolúciós folyamatok jura Ammonoideákon. [Evolutionary processes on Jurassic ammonoids.] – Őslénytani Viták 3, 21–26, 2 figs, Budapest.

Természettudományi Lexikon. Cnidaria és Cephalopoda címszóanyag. [Natural Sciences Lexicon, titles on Cnidaria and Cephalopoda.] Akadémia Kiadó, Budapest.

FÜLÖP József & GÉCZY Barna: Határozat a luxemburgi jura kollokvium javaslatainak tárgyában. [Decisions on the proposals of the Jurassic Colloquium in Luxembourg.] – Földtani Közlöny 94, 152–153, Budapest.

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Hammatoceraten und Eryciten (Ceph.) aus dem Oberlias von Úrkút. – Annales Universitatis Scientiarum Budapestinensis de Rolando Eötvös nominatae, Sectio Geologica 8 (1964), 17–34, 5 figs, 5 pls, Budapest.

Jura sztratotípusok. [Jurassic Stratotypes.] M. Áll. Földtani Intézet, Budapest, 14 p.

1966

Le problème de la limité Lias/Dogger en Hongrie. – Acta Geologica Academiae Scientiarum Hungaricae 10, 195–202, Budapest.

Csernyei jura Ammonoideák. [Jurassic Ammonoidea from Csernye.] – Doktori értekezés tézisei, Budapest, 11 p.

Pathologische jurassische Ammoniten aus dem Bakony-Gebirge. – Annales Universitatis Scientiarum Budapestinensis de Rolando Eötvös nominatae, Sectio Geologica 9 (1965), 31–40, 3 pls, Budapest.

Mediterrán jura fáciesvizsgálatok. [Studies on the Mediterranean Jurassic.] – M. Áll. Földtani Intézet, Budapest, 15 p.

Upper Liassic Dactylioceratids from Úrkút. – Acta Geologica Academiae Scientiarum Hungaricae 10, 427–443, 8 figs, 2 pls, Budapest.

Die Evolution des *Holcophylloceras ultramontanum* (Ammonoidea). – Vorträge Jahresversammlung, Paläontologische gesellschaft, Münster, 1966, pp. 13–14.

Ammoniták, ősi tengerek korjelző lábasfejűi. [Ammonites, age indicator cephalopods of ancient seas.] – Föld és Ég 1, 150–151, Budapest.

A *Holcophylloceras ultramontanum* ZITTEL fejlődésmenete. (Sur lévolution spécifique de l'espéce *Holcophylloceras ultramontanum* ZITTEL.) – Földtani Közlöny 96, 473–475, 1 fig., Budapest.

1967

Biozones et chronozones dans le Jurassique de Csernye. – Colloque Jurassique, Luxembourg (section Jur. Commission Mésozoïque méditerranéenne) Budapest, 1967, 1–23.

Upper Liassic Ammonites from Úrkút, Bakony Mountains, Transdanubia, Hungary. – Annales Universitatis Scientiarum Budapestinensis de Rolando Eötvös nominatae, Sectio Geologica 10 (1966), 115–160, 23 figs, 9 pls, Budapest.

Catacoeloceras tethysi n. sp. (Ceph.) from the Upper Liassic of Csernye. – Acta Geologica Academiae Scientiarum Hungaricae 11, 293–298, 7 figs, Budapest.

Csernyei jura biozónák és kronozónák. (Biozones and chronozones in the Jurassic of Csernye, Bakony Mts., Hungary.) – Földtani Közlöny 97, 167–176, Budapest.

Die Evolution des *Holcophylloceras ultramontanum* (ZITTEL) (Ceph.) – Paläontologische Zeitschrift 41, 230–232, 1 fig., Stuttgart.

Megemlékezés Telegdi-Roth Károlyról. [Memorial of K. Telegdi-Roth.] – Őslénytani Viták 9, 5–8.

Az Ammonoideák törzsfejlődésének vizsgálati módszerei. [Investigation methods on the phyletic evolution of ammonoids.] – Őslénytani Viták 10, 9–14, Budapest.

1968

II. Jura Kollokvium Luxemburgban. [The 2nd Jurassic Colloquium in Luxembourg.] – Földtani Közlöny 97, p. 472.

Rétegtani kérdések – jura kollokviumok tükrében. [Stratigraphic problems in the light of Jurassic Colloquia.] – MTA X. Osztály Közleményei 1, 381–383, Budapest.

FÜLÖP, J., BARNABÁS, K., BÖJTÖS-VARRÓK, K., CSEH-NÉMETH, J., GÉCZY, B., GIDAI, L., HÓDI, M., GÓCZÁN, F., JÁMBOR, Á., JUGOVICS, L., KNAUER, J., KÓKAY, J., KONDA, J., KOPEK, G., MAJOROS, Gy., MOLDVAY, L., ORAVECZ, J., SZABÓ, I., SZABÓ-DRUBINA, M. & VIGH, G.: Geology of the Transdanubian Central Mountains. – International Geological Congress, XXIIIrd Session, Prague. Guide to Excursion 39C. Akadémiai Kiadó, Budapest, 50 p., 27 figs.

Felsőliász Ammonoideák Úrkútról. (Ammonoides du Lias supérieur d'Úrkút.) – Földtani Közlöny 98, 218–226, 6 figs, Budapest.

Deformed Jurassic Ammonoids from Úrkút (Bakony Mountains, Transdanubia). – Annales Universitatis Scientiarum Budapestinensis de Rolando Eötvös nominatae, Sectio Geologica 11 (1967), 117–132, 6 figs, 8 pls, Budapest.

1969

Franciaországi tanulmányutam őslénytani tapasztalatai. [Palaeontological experiences of my study tour in France.] – Őslénytani Viták 12, 6–24, Budapest.

FÜLÖP, J., BARNABÁS, K., BÖJTÖSNÉ VARRÓK, K., CSEH-NÉMETH, J., GÉCZY, B., GIDAI, L., HÓDI, M., GÓCZÁN, F., JÁMBOR, Á., JUGOVICS, L., KNAUER, J., KÓKAY, J., KONDA, J., KOPEK, G., MAJOROS, Gy., MOLDVAY, L., NAGY, E., ORAVECZ, J., SZABÓ, I., SZABÓNÉ DRUBINA, M. & VIGH G.: Földtani kirándulás a Dunántúli-középhegységben. [Geological excursion in the Transdanubian Central Range.] – A Kárpát-Balkán Földtani Asszociáció,

IX. Kongresszusa, Budapest. Magyar Állami Földtani Intézet, Budapest, 60 p., 23 figs.

FÜLÖP, J., BARNABÁS, K., BÖJTÖSNÉ VARRÓK, K., CSEH-NÉMETH, J., GÉCZY, B., GIDAI, L., HÓDI, M., GÓCZÁN, F., JÁMBOR, Á., JUGOVICS, L., KNAUER, J., KÓKAY, J., KONDA, J., KOPEK, G., MAJOROS, Gy., MOLDVAY, L., NAGY, E., ORAVECZ, J., SZABÓ, I., SZABÓNÉ DRUBINA, M. & VIGH G.: Geology of the Transdanubian Central Mountains.] – Carpatho-Balkan Geological Association, IXth Congress, Budapest. Hungarian Geological Institute, Budapest, 47 p., 23 figs.

FÜLÖP, J., GÉCZY, B., KONDA, J. & NAGY, E.: Földtani kirándulás a Mecsek-hegységben, a Villányi-hegységben és a Dunántúli-középhegységben. [Geological excursion in the Mecsek and Villány Hills and in the Transdanubian Central Range.] – Mediterrán Jura Kollokvium, Budapest. Magyar Állami Földtani Intézet, Budapest, 68 p., 22 figs.

FÜLÖP, J., GÉCZY, B., KONDA, J. & NAGY, E.: [Geological excursion in the Mecsek and Villány Hills and in the Transdanubian Central Range.] – Mediterrán Jura Kollokvium, Budapest. Magyar Állami Földtani Intézet, Budapest, 68 p., 22 figs.

L'àge du banc à Ammonites du Villány. – M. Áll. Földtani Intézet, Mediterrán Jura Kollokvium, Budapest, 8 p.

Examen quantitatif des Ammonites liasiques de la Montagne Bakony. – M. Áll. Földtani Intézet, Mediterrán Jura Kollokvium, Budapest, 8 p.

A földtani oktatás reformja Franciaországban és Angliában. [The reform of geology education in France and England.] – Földtani Közlöny 99, 221–223, Budapest.

Franciaországi tanulmányút. [Study travel in France.] – Földtani Közlöny 99, 286–287, Budapest.

1970

A kericseri (Bakony hegység) pliensbachi rétegek biosztratigráfiai értékelése. (Biostratigraphische Auswertung der Pliensbach-Schichten von Kericser, Bakony Gebirge, Ungarn.) – Őslénytani Viták 14, 45–59, Budapest.

Pliensbachi Ammonites-zónák a Bakony-hegységben. Zone d'Ammonites pliensbachiennes dans la Montagne du Bakony. – Földtani Közlöny 100, 248–258, 2 figs, Budapest.

1971

The Pliensbachien of the Bakony Mountains. – Acta Geologica Academiae Scientiarum Hungaricae 15, 117–125, 1 fig., Budapest.

Jura. *In:* Tudományos eredmények a rétegtan területén. [Scientific results in stratigraphy.] MTA Földtani Tudományos Bizottság, Budapest, pp. 18–23.

Inauguration au Colloque du Jura Méditerranéen. – Annales Instituti Geologici Publici Hungarici 54/2, 9–11, Budapest.

L'age du banc à Ammonites du Villány. – Annales Instituti Geologici Publici Hungarici 54/2, 465–470, Budapest.

Examen quantitatif des Ammonoides liassiques de la Montagne Bakony. – Annales Instituti Geologici Publici Hungarici 54/2, 483–486, Budapest.

Az őslénytani rétegazonosítás alapjai. [Principles of palaeontological correlation.] – Őslénytani Viták 17, 3–13, Budapest.

Hozzászólás „A rétegtani terminológia és osztályozás kérdései" c. előadáshoz. [Discussion on the lecture Problems of stratigraphic terminology and classification.] – Őslénytani Viták 17, 55–56, Budapest.

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1972

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Szinemuri Ammonites-zónák a Bakony-hegységben. (Zones à Ammonites du Sinémurien dans la Montagne du Bakony.) – Földtani Közlöny 102, 1–11, Budapest.

Hozzászólás „A rétegtani korreláció és osztályozás módszerei" c. kollokvium vitájához. [Discussion at the colloquium "Methods of stratigraphic correlation and classification".] – Őslénytani Viták 19, 15–16, Budapest.

Hozzászólás „A tektonikai tagolás módszereiről" c. előadáshoz. [Discussion to the lecture "On the methods of tectonic subdivision".] – Általános Földtani Szemle 1, 39–40, Budapest.

Hozzászólás Szádeczky-Kardoss E. „A Kárpát-Dinarid-terület az új globális tektonika szemszögéből" c. akadémiai vitaindító előadásához. [Discussion on the lecture of

Szádeczky-Kardoss E.: The Carpathian-Dinaride region and the new global tectonics".] – MTA X. Osztály Közleményei 5, p. 153, Budapest.

A jura faunaprovinciák kialakulása és a mediterrán lemeztektonika. [Development of Jurassic faunal provinces and Mediterranean plate tectonics.] – MTA X. Osztály Közleményei 5, 297–311, Budapest.

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1973

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Geobiológia és paleoklimatológia. [Geobiology and palaeoclimatology.] – Geonómia és Bányászat 6, 206–207, Budapest.

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Stegena, L., Horváth, F. & Géczy, B.: Late Cenozoic evolution of the Pannonian Basin. – Abstracts of the First Meeting of European Geophysical Societies, p. 83, Zürich.

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1974

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Development of the Jurassic geochronologic scale

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(with 4 figures and 2 tables)

Abstract

A reliable geochronologic scale is necessary for many aspects of Jurassic research. Time scales are built from chronostratigraphically constrained isotopic dates. An overview of Jurassic time scales published between 1964 and 1994 demonstrates significant differences in the estimated ages of stage boundaries. Apart from the evolution and growth of the isotopic age database, most of the discrepancies can be explained by differing approaches to data selection, the handling of uncertainties, and procedures for boundary estimation and interpolation. A fundamental shortcoming of all Jurassic scales proposed to date remains the inadequate number of isotopic dates used. Current and future research needs to generate new data which can resolve the ambiguities of currently competing scales. Significant improvements are expected through the preferential use of precise and accurate U–Pb or ^{40}Ar–^{39}Ar dating of samples which are biochronologically constrained at the zonal level.

Key words: Jurassic, geochronology, time scale

Introduction

Time is a fundamental dimension of geologic processes and phenomena. Stratigraphers and geoscientists in general interested in the Jurassic (or any other geologic period) need a chronometrically calibrated chronostratigraphic scale which facilitates correlation of rocks and events dated by various methods. It is also necessary for measuring rates of geologic processes. Conclusions in a wide range of problems are affected by the accuracy and precision of the time scale used. For example, in an active margin setting the correlation of isotopically dated magmatic and metamorphic events with biochronologically dated sedimentary events depends on the reliability of time scale. Also, calculation of sedimentation rates, sedimentary cycle duration, purported periodicity in extinction and other phenomena, subsidence or uplift rates, plate velocity vectors, etc. needs accurate measurements of time, again dependent on the time scale.

The nomenclature of different kinds of time scales is extensively discussed by HARLAND (1978, see also HARLAND et al. 1990). The focus of this review is the calibration of the chronostratigraphic scale made up of standard subdivisions with the linear chronometric scales which uses Ma (million years) units. The resulting calibrated scale is termed the geochronologic scale, sometimes also referred to as the numeric or geologic time scale. Over the past 40 years the Jurassic chronostratigraphic scale has remained relatively stable except for the status of the Aalenian and the subdivisions of the latest Jurassic. Even at the zonal level of standard ammonite biochronology, refinements (e.g. COPE et al. 1980) since ARKELL's synthesis (1956) have been minor compared with developments in the field of isotopic dating and the emergence of new concepts and methods of time scale calibration.

Many geologic time scales have been published since BARRELL's (1917) first attempt at systematically estimating the ages of geologic system boundaries (including those of the Jurassic). The early scales (BARRELL 1917, HOLMES 1937, 1947, 1959, KULP 1961) were based on very limited numbers of isotopic dates and provided estimates for only the upper and lower boundaries of the period (Table 1). Beginning with HARLAND et al. (1964), the next generation of researchers attempted to assign numeric age estimates to stage boundaries based on a growing database of primarily K–Ar ages (e.g. VAN HINTE 1976, ARMSTRONG 1978), although some workers (e.g. LAMBERT 1971 and FITCH et al. 1974) rejected this approach as inappropriate given the available dataset. Modern time scales published between 1982 and 1994 (see Fig. 1) are based on a much larger, although still insufficient, isotopic

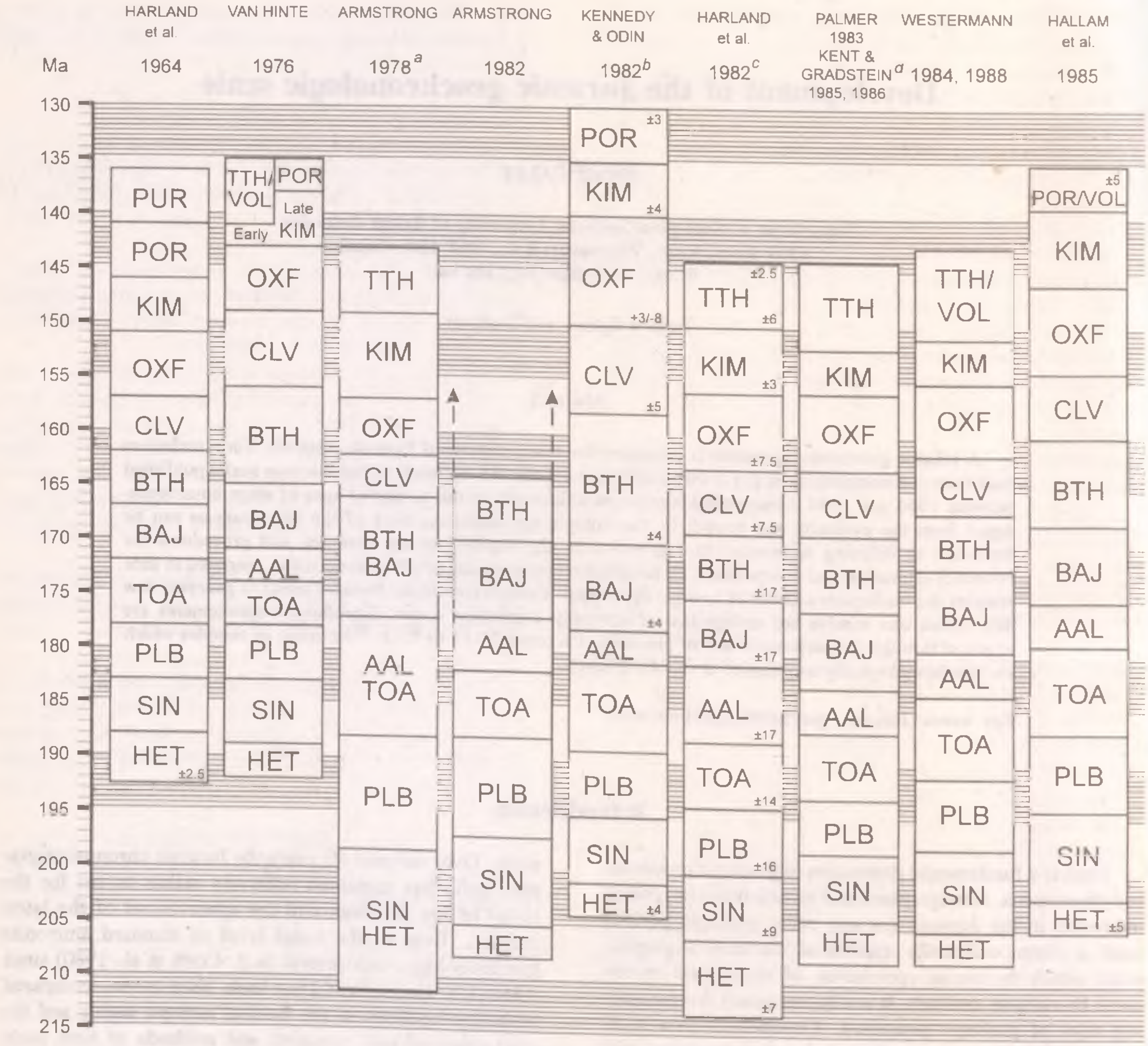
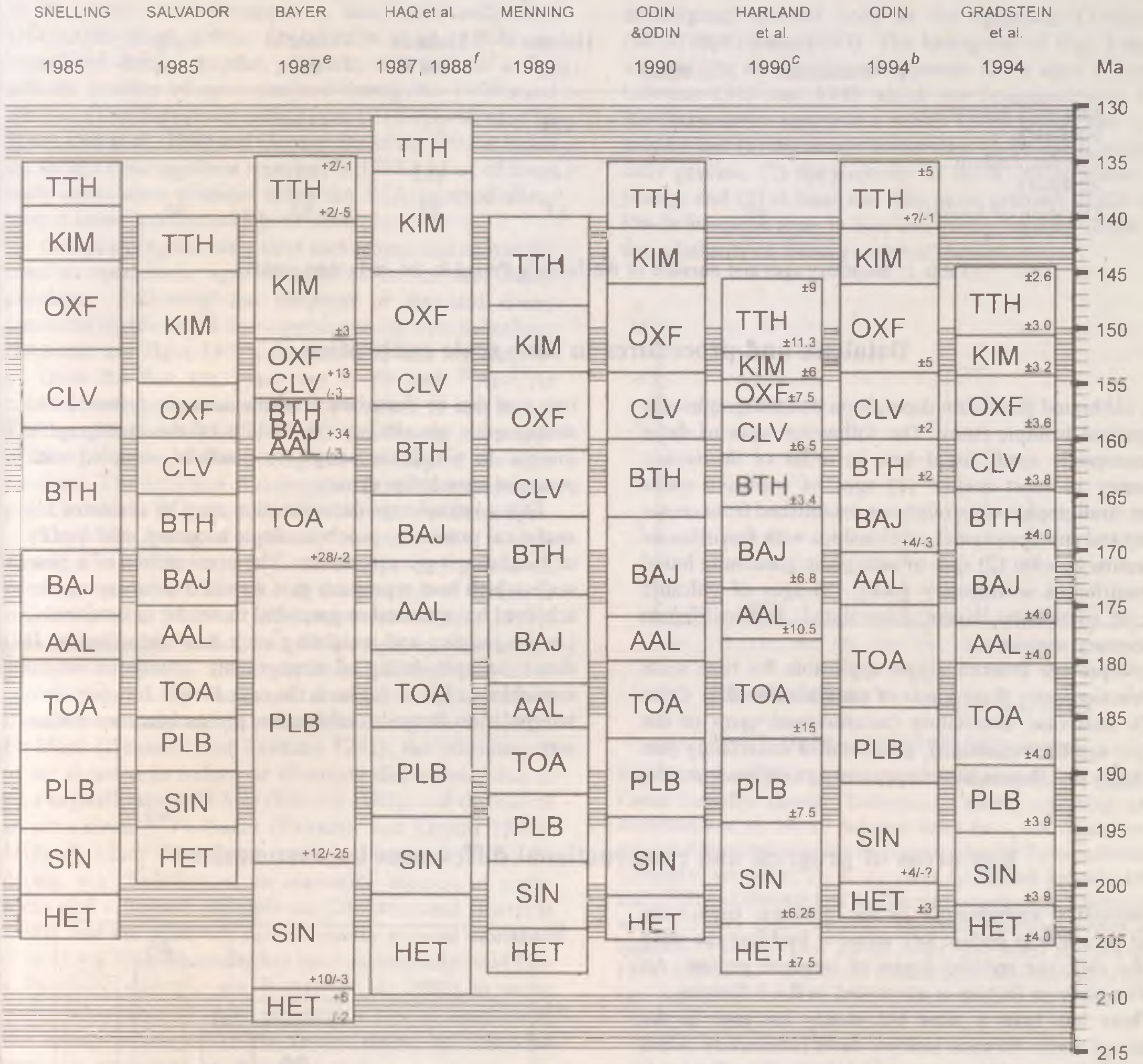


Fig. 1. Synopsis of the Jurassic part of time scales with assigned stage boundary ages.
[a] approximate readings from graph, no numeric value given in text
[b] no error limits given for interpolated ages
[c] ± errors given here are one half of quoted chronogram error range
[d] uncertainties not given in KENT and GRADSTEIN (1985, 1986), PALMER (1983) quotes the uncertainties given by HARLAND et al. (1982)
[e] boundary ages and 0.5s errors from Table 1 of BAYER (1987) note that his comparative time scale (Fig. 6A) proposes 209 ± 10 for Triassic/Jurassic and 138 ± 2 for Jurassic/Cretaceous boundary
[f] estimated average limits of uncertainty quoted in text ±3.5 Ma

age database which includes a slowly increasing proportion of ^{40}Ar–^{39}Ar and U–Pb ages. Many of these time scales introduce some kind of statistical treatment of accepted isotopic dates and express the uncertainties of boundary age estimates. Some of these time scales are extensively referred to in the recent geologic literature (especially HARLAND et al. 1982 superseded by HARLAND et al. 1990, PALMER 1983, and to a lesser extent KENNEDY and ODIN 1982, HAQ et al. 1987, 1988). Time scales which oversimplified the problem (SALVADOR 1985) or concentrated on the mathematical aspects only (CARR et al. 1984, BAYER 1987) did not gain widespread acceptance, nor did those based on reinterpretations of pre-existing datasets (e.g. WESTERMANN 1984, 1988, HALLAM et al. 1985, MENNING 1989). The Soviet time scales were not widely available and thus had relatively little impact in the western geoscience literature (e.g. AFANASYEV and ZYKOV 1975, AFANASYEV 1987). Omitted from my



treatment are compilations published only in a chart format which lack adequate explanatory notes or reproduce an earlier compilation (e.g. VAN EYSINGA 1975, COWIE and BASSETT 1989).

As illustrated in Fig. 1, the wide range of available time scales disagree significantly in their boundary estimates. Where uncertainties are quoted, they often exceed the duration of adjacent stages. The aims of this paper are to (1) provide some background regarding the construction of time scales; (2) review the historic development of Jurassic time scales; (3) present the variety of modern time scales and analyse their differences and limitations; and (4) discuss current and future avenues of research which may lead to improved accuracy. It is hoped that Jurassic stratigraphers will benefit from an increased awareness of the differences in the available time scales and will be more critical in their use.

	Barrell 1917 Minimum	Barrell 1917 Maximum	Holmes 1937	Holmes 1947	Holmes 1959	Kulp 1961
Jurassic/Cretaceous boundary	120	150	108	127	135±5	135
Triassic/Jurassic boundary	155	195	145	152	180±5	181
Duration of Jurassic	40		37	25	45	46

Table 1: Boundary ages and duration of the Jurassic Period in the early time scales.

Database and procedures in time scale calibration

A calibrated time scale depends on biostratigraphically constrained isotopic dates. The following types of dates are commonly used, listed here in order of decreasing frequency in most scales: (1) ages of intrusive rocks whose stratigraphic constraints are established from cross-cutting and superpositional relationships with fossiliferous sedimentary rocks; (2) ages of authigenic glauconite found in fossiliferous sedimentary rocks; (3) ages of volcanic flow or pyroclastic layers intercalated in fossiliferous sedimentary sequences.

Isotopic age determinations applicable for time scale construction carry three kinds of uncertainties (e.g. ODIN 1982): analytical uncertainty (measurement error of the isotopic age determination), geochemical uncertainty (the possibility that the measured apparent age differs from the true age due to disturbance of the isotopic system), and stratigraphic uncertainty (the width of the stratigraphic interval to which the sample is confined, coupled with potential correlation error).

Every isotopic age determination must be evaluated for analytical precision, geochronologic accuracy, and quality of biochronologic constraints. The construction of a time scale which best represents this screened database can be achieved by statistical or graphical methods, or intuitively, i.e. by judging and weighting each date individually. If direct isotopic dating of stratigraphic boundaries is not available, as has so far been the case for the Jurassic, then interpolation between calibration points becomes necessary.

Key areas of progress and constructional differences between scales

Successive amendments of the geologic time scale reflect progress in certain key areas of building the scale and the differing methodologies of research groups. An analysis of these factors is attempted in the following.

There has been a slow but steady increase in the number of useful Jurassic isotopic dates (commonly called "items" following HARLAND et al. 1964) (Fig. 2). ARMSTRONG (1978) pioneered a computer database for efficient management of large number of isotopic dates, a practice followed by subsequent workers who relied on comprehensive and original databases with the intention of mathematical treatment of dates (HARLAND et al. 1982, 1990, Gradstein et al. 1994).

Advances in isotopic dating

A succinct overview of progress in geochronometry can be found in ARMSTRONG (1991). Developments in this field were reflected in the time scales. The earliest scales (BARRELL 1917, HOLMES 1937, 1947) relied mostly on age determinations of uranium minerals. In the 1950's, the K–Ar method became available and for decades it was the most frequently used dating method. The databases used

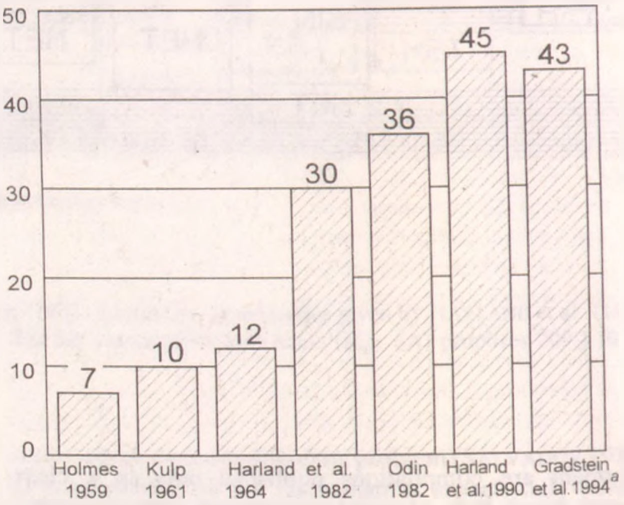


Fig. 2. The number of critical Jurassic dates used in some key time scales built on comprehensive isotopic databases.

[a] seven additional glauconite dates listed but not used in final calculations.

in the most recent attempts at time scale calibration (HARLAND et al. 1990, GRADSTEIN et al. 1994) accumulated during decades of work, and include a significant number of ages obtained during the 1960's and 1970's. (The historically oldest item (PTS76) still used by HARLAND et al. 1990 and GRADSTEIN et al. 1994 is based on an age determination reported in 1958.) Most of these early dates were obtained using the K–Ar method along with a lesser number of Rb–Sr analyses.

Complicating the early time scale compilations was the need to recalculate ages because of inconsistent decay constants. Following the adoption of standard decay constants by the IUGS Subcommission on Geochronology (STEIGER and Jäger 1977), this problem was resolved.

Over the last ten years the U–Pb and ^{40}Ar–^{39}Ar methods emerged as superior in precision to the K–Ar, Rb–Sr, and other methods. They also offer the advantage of interpretation of the geological meaning of the ages obtained. The detection of radiogenic daughter isotope loss greatly reduces the geochemical uncertainty of these ages.

The U–Pb dating of accessory minerals, most notably zircon, is one of the most accurate isotopic dating methods presently available. The closing temperature of zircon is estimated to be >800 C° (HEAMAN and PARRISH 1991), thus it retains the radiogenic Pb isotopes even in upper amphibolite grade metamorphism. Recent advances contributing to the increased accuracy of the method include new analytical procedures lowering the analytical Pb blank (HEAMAN and PARRISH 1991); the introduction of air abrasion to reduce or eliminate discordance due to post-crystallization Pb loss (KROGH 1982); and the use of an ultra-clean ^{205}Pb tracer (PARRISH and KROGH 1987). Minerals other than zircon can also be used for U–Pb dating, e.g. badelleyite, an accessory mineral in mafic rocks (for a Jurassic example see DUNNING and HODYCH 1990), and the relatively rare accessory mineral monazite (PARRISH 1990). Monazite has been successfully used (for a Paleozoic example see RODEN et al. 1990) in cases where inheritance of older xenocrystic zircon complicates the interpretation of U–Pb zircon dates, as inherited monazite appears to be extremely rare.

The ^{40}Ar–^{39}Ar dating technique was introduced in 1966 by MERRIHUE and TURNER, and its application became more widespread by the early 1970's (MCDOUGALL and HARRISON 1988). Nevertheless the HARLAND et al. (1990) time scale lists only three ^{40}Ar–^{39}Ar dates (as opposed to 30 conventional K–Ar ages) for the Jurassic. It is now well established that the age spectra generated by step-heating technique can be used to interpret the thermal history of rocks. Ar loss or gain can therefore be detected and a true cooling age can be inferred. Among the datable, common rock-forming minerals, hornblende has the highest closure temperature (>500 °C). The precision of ^{40}Ar–^{39}Ar technique approaches that of the U–Pb chronometer, attaining ±1–2 Ma for Jurassic samples in favourable circumstances.

As an example, dates obtained from the Guichon Creek batholith (British Columbia, Canada) are illustrated here. This intrusion is perhaps the most geochronometrically investigated igneous body in the Canadian Cordillera (MORTIMER et al. 1990). The histogram of Fig. 3 summarizes the distribution of apparent K–Ar ages reported between 1960 and 1979 which are compared with two Rb–Sr isochron ages and a recent U–Pb zircon age. It is evident that (1) the nearly concordant U–Pb age is analytically precise, (2) the majority of the K–Ar ages are too young, and (3) at least one (the more precise) of the two Rb–Sr isochron ages is also too young, casting doubt on the reliability of those geochronometers.

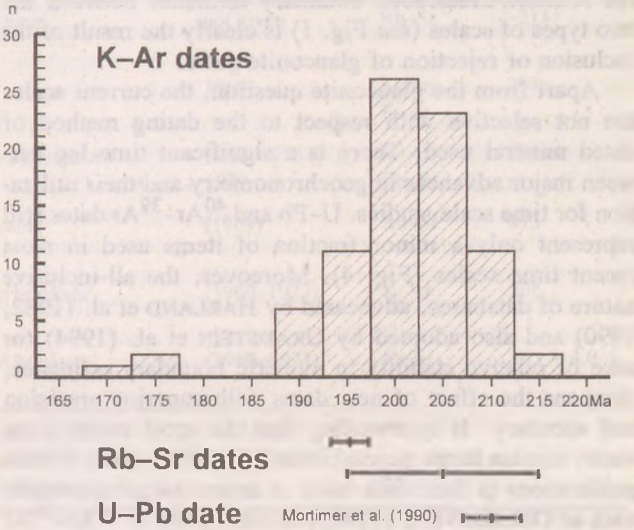


Fig. 3. Summary of geochronometric data from the Guichon Creek batholith (British Columbia, Canada) (modified after MORTIMER et al. 1990). Selected dates from this dataset were used in different time scales for constraining the Triassic/Jurassic boundary (see Table 2). K–Ar dates (published between 1960 and 1979, and unpublished data) are summarized on a histogram with a 5 Ma class interval, reported analytical errors are typically ±8 Ma. Two Rb–Sr dates (published in 1969 and 1979) and one U–Pb date are plotted with their respective error bar. Sources of data are listed in MORTIMER et al. (1990).

Selection of dates

It is clear from the criteria listed above that not every isotopic date is suitable for use in time scale calibration. LAMBERT (1971) pointed out that each Jurassic item quoted by HOWARTH (1964) and listed in HARLAND et al. (1964) can be criticized on one or more grounds. The greatest risk posed by minerals with low closure temperature is their susceptibility to loss of radiogenic daughter isotopes in post-crystallization geological processes. The result is a young apparent age which is hard to detect especially using the K–Ar method. It became apparent that glauconite ages often tend to be younger than their high-temperature counterparts (e.g. OBRADOVICH 1988). However, ODIN advocated the use of glauconite arguing that its geochemical behaviour can be independently evaluated (ODIN 1982). Glauconitic sediments are abundant in the European Jurassic and most glauconite dates are biochronologically tightly constrained (e.g. FISCHER and Gygi 1989), therefore their use in time scale studies is tempting. In the time scales of Kennedy and Odin (1982), Afanasyev and Zykov (1975), Haq et al. (1988), Odin and Odin (1990), and Odin (1994) glauconite ages dominate the Late Jurassic dataset. Other workers, however, gradually abandoned the use of glauconite ages. Harland et al. (1982) qualified some glauconite ages as too young and later treated them as minimum ages only (Harland et al. 1990). Gradstein et al. (1994) list glauconite ages but reject all of them for their final calculations. The 10 to 15 Ma discrepancy in the Jurassic/Cretaceous boundary estimates between the two types of scales (see Fig. 1) is clearly the result of the inclusion or rejection of glauconite dates.

Apart from the glauconite question, the current scales are not selective with respect to the dating method or dated mineral used. There is a significant time lag between major advances in geochronometry and their utilization for time scale studies. U–Pb and ^{40}Ar–^{39}Ar dates still represent only a minor fraction of items used in most recent time scales (Fig. 4). Moreover, the all-inclusive nature of databases, advocated by Harland et al. (1982, 1990) and also adopted by Gradstein et al. (1994) for sake of relative stability in numeric boundary estimates, dampens the effect of new dates with superior precision and accuracy. It is revealing that the most recent time scales contain items gleaned from late 1950's–early 1960's publications in their data suite. A more radical approach, such as Obradovich's (1993) exclusive use of ^{40}Ar–^{39}Ar ages with high analytical and stratigraphic precision for the Cretaceous time scale, has not yet been taken for the Jurassic.

The example of the Guichon Creek batholith can be used again to illustrate this point. Dates from this pluton have been used in time scales since the work of Holmes (1959), because the emplacement of the batholith is thought to be near the Triassic/Jurassic boundary. Successive attempts at dating the batholith, their representation in various time scales, and their effect on the placement of the Triassic/Jurassic boundary are listed in Table 2. It is notable that (1) the more recently obtained ages tend to be geologically older then previous ones; (2) some time scales (e.g. Gradstein et al. 1994 using sources published more than 20 years earlier) rely on outdated information; (3) the U–Pb age should be preferred over K–Ar or Rb–Sr ages. The last point has not been considered in any existing Jurassic time scale but it may indicate that K–Ar or Rb–Sr ages are best treated as minimum ages only.

The elimination of biochronologically well constrained glauconite dates increases the weight of ages from intrusive rocks whose stratigraphic position is often poorly bracketed although their isotopic age can be precise. Multi-phase intrusions, whose emplacement can span long intervals of time, are common in the geologic record. The large percentage of plutonic ages in the database of every time scale is accountable for the large uncertainties attached to stage boundary estimates. The listing of inconsistent interpretations of the stratigraphic constraints on the Guichon Creek batholith (Table 2) reveals the problems associated with intrusive bodies and their serious effect on boundary age estimates.

Errors and uncertainties in dates

The three main sources of uncertainties related to items used in time scale studies were mentioned above. Quantification of uncertainties in form of error limits is required if errors on mathematically derived boundary age estimates are to be rigorously calculated. Errors need to be taken into account even if an intuitive method is preferred when each date is individually evaluated and weighted.

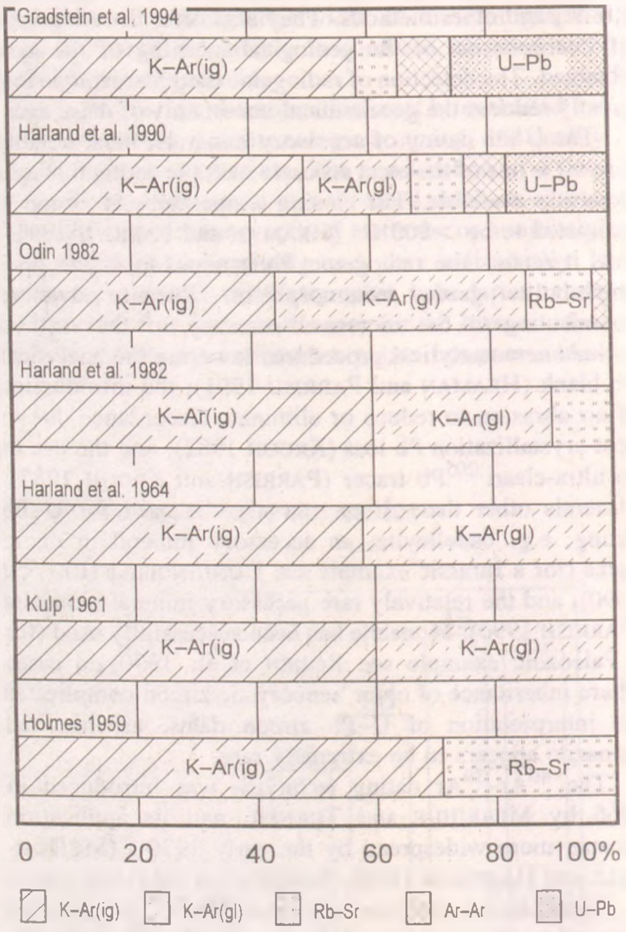


Fig. 4. Proportion of dates obtained by different isotopic methods used in some widely cited time scales. **gl** – glauconite age; **ig** – age determined on igneous mineral.

Any isotopic age determination is subject to analytical error. It is generally reported at 1σ (90% confidence) or 2σ (95% confidence) level. Although this is common practice now, many early dates used in even modern scales do not have published error limits.

The geochemical uncertainty, i.e. the possibility that the apparent age may deviate from the true age of the dated rock, cannot be quantified. It is dealt with at the

TIME SCALE	ITEM CODE[1]	QUOTED AGE	QUOTED CHRONOSTRATIC POSITION	PUBLICATION YEAR OF QUOTED SOURCE OF AGE[2]	METHOD[2]	TRIASSIC/ JURASSIC BOUNDARY ESTIMATE
Holmes 1959		180	Upper Triassic or Lower Jurassic	1959	K–Ar	180±5
Kulp 1961	62	181±5	post-Carnian, pre-Bajocian	1960	K–Ar	181
Harland et al. 1964	10 (Tozer & Hacker)	185, 186	Norian to Bajocian	1961	K–Ar	190–195
Harland & Francis 1971	366 (Lambert)	200±2	post-early Upper Triassic, pre-Middle Jurassic	1969	Rb–Sr	200?
Armstrong 1978	366 475	200±2 200±5	Carnian–Pliensbachian brackets	not given	Rb–Sr	~211[3]
Armstrong 1982		209 (oldest) 203 (mean)	post-Norian, Hettangian or older	1969	K–Ar K–Ar	208
Odin 1982 Kennedy & Odin 1982	NDS 177 (Armstrong)	205 (mean) 205±20	Late Norian to pre-Sinemurian	1967–1973 1979	K–Ar Rb–Sr	204±4
Harland et al. 1982	PTSS 366	195.77±2[4]	Carnian–Pliensbachian brackets	(1969)	Rb–Sr	213
Harland et al. 1990	NDS 177 (A366)	205±2.5	Norian–Hettangian brackets	(1969–1973)	K–Ar	208
Gradstein et al. 1994	284 (NDS 177)	205±2.5	Norian–Hettangian brackets	(1969–1973)	K–Ar	205.7±4.0
		210±3	post-Carnian (possibly post-Norian), pre-Pliensbachian (possibly pre-Sinemurian)	Mortimer et al. 1990[5]	U–Pb	

Table 2: Summary of dates obtained from the Guichon Creek batholith (British Columbia, Canada) and their role in successive time scales with reference to the Triassic/Jurassic boundary age estimate.

[1] Name of abstractor or reference to item used in previous time scales given in parentheses

[2] parentheses indicate that no direct source given but reference made to an item used in previous time scales

[3] approximate reading from graph, no numeric value given in text

[4] recalculated in HARLAND et al. (1982) using standard decay constants in STEIGER and JÄGER (1977)

[5] age not referred to in GRADSTEIN et al. 1994 or any other time scale

selection of acceptable isotopic dates when for example, glauconite ages are treated as minimum ages only (HARLAND et al. 1990) or rejected altogether as suspect (GRADSTEIN et al. 1994; see discussion above). As noted earlier, none of the Jurassic scales acknowledges that U–Pb and ^{40}Ar–^{39}Ar analyses can prove the closed system behaviour of the isotopic system, thereby minimizing the geochemical uncertainty.

The stratigraphic uncertainty also poses serious problems. Chronostratigraphic assignment of intrusive rocks is problematic and commonly even the tightest constraints leave an interval of several stages, as demonstrated above by the example of the Guichon Creek batholith (Table 2). Here the overlying sediments were dated as Early Jurassic based on the bivalve *Weyla* (FREBOLD and TIPPER 1969). The upper bracket of the batholith's emplacement was arbitrarily interpreted as Hettangian, Sinemurian, or Pliensbachian in different time scales, without due consideration to the Hettangian to Toarcian age range of *Weyla*. Although Late Pliensbachian ammonites were subsequently found as the oldest fossils in overlying sediments (TIPPER *in* MONGER and MCMILLAN 1984), this is not reflected in the time scales of Harland et al. (1990) and GRADSTEIN et al. (1994) which cite a Hettangian upper bracket.

Most authors are satisfied to accept the reported stage-level chronostratigraphic brackets of isotopic ages and they take them at face value implying that biochronologic correlation is free of error. Most biostratigraphers, however, would agree that chronologic correlation between stratigraphies of different fossil groups and separate biogeographic provinces is not straightforward. Only HARLAND et al. (1990) attempted to quantify this kind of chronostratigraphic uncertainty as "fossil error" by arbitrarily assigning an additional 2.5 Ma error to all Jurassic ages. As acknowledged by SMITH (1993), it is an incorrect overestimation of the uncertainty which was chosen only for simplicity and in lack of other available error estimation method. Another example from near the Triassic/Jurassic boundary further illustrates the difficulties faced. HODYCH and DUNNING (1992) obtained a U–Pb age from a basalt flow within the non-marine, Upper Triassic to Lower Jurassic Newark Supergroup in Nova Scotia. The Triassic/Jurassic boundary within the Newark

Supergroup is established not far below the dated basalt, based on palynology and vertebrate biostratigraphy. However, correlation with standard chronostratigraphy is debated (HALLAM 1990). Clearly, the usefulness of this analytically precise date depends on the estimation of the uncertainty involved in correlating non-marine faunas and floras with the standard ammonite zonation.

Boundary estimation and mathematical data manipulation

After building the dataset of acceptable isotopic dates, the stage and period boundary ages need to be estimated. With the "geochronologic approach" (ODIN 1994), the boundary ages are derived from intuitive judgement and weighting of each individual data point. As there are often conflicts between isotopic ages and their chronostratigraphic position, an element of subjectivity is introduced in resolving the disagreements. Pre-1982 time scales were all constructed in this manner, and ODIN's research group still favours this method (KENNEDY and ODIN 1982, ODIN and ODIN 1990, ODIN 1994).

With an increase in the number of dates used, the intuitive method becomes more difficult and the need arises for mathematical treatment of data. On the other hand, a large dataset is needed to statistically validate such procedures. ARMSTRONG (1978) graphically plotted all of the relevant dates accepted by him, thus provided a visual means of evaluating consistency and choosing the best fit for boundary ages. This was a step towards removing potential bias by using the dataset collectively.

There have been three mathematical methods applied to the boundary age estimation problem. The formulae and detailed descriptions are not reproduced herein, only the key features are discussed. HARLAND et al. (1982, 1990) used the chronogram method which was originally introduced by COX and DALRYMPLE (1967) to calculate the age of magnetic polarity reversals from the available isotopic dates. The boundary is approximated by an $E(t)$ error function which is calculated at regularly placed trial ages (for details see HARLAND et al. 1990, p. 106). In the calculation only the inconsistent dates are considered, i.e. those where the isotopic age and the trial age for stage boundary are in conflict given the known chronostratigraphic age of the sample. The standard deviation of the date is taken into account, therefore analytically precise ages are more heavily weighted regardless of their geochemical uncertainties. A chronogram is graphically produced by plotting E, the error function against t, the trial age. The ideal chronogram curve is parabolic and assumes its minimal value at the boundary age. The error range is established statistically non-rigorously as the time interval where $E \leq E_{\min} + 1$.

AGTERBERG (1988, 1994) noted that although the chronogram method does provide unbiased boundary age estimates, it does not use the dataset efficiently inasmuch as it excludes consistent dates which carry important information. He proposed using the maximum likelihood method which was shown to be superior to the chronogram method by obtaining boundary age estimates with lower error limits from the same data set. As with the chronogram method, the maximum likelihood method is also based on the assumptions that the true ages of samples are randomly distributed and their error distribution is normal. GRADSTEIN et al. (1994) used the maximum likelihood method and noted that it yielded significantly better results (i.e. smaller standard deviations) than the chronogram when the available data was sparse, such as for the Jurassic. It is, however, not fully documented whether in the case of small sample size the assumption of normal distribution of samples remains warranted. Furthermore, GRADSTEIN et al. (1994) ignore the chronostratigraphic error in their time scale construction, which is partly responsible for their smaller boundary age errors as compared with the HARLAND et al. (1990) scale.

CARR et al. (1984) also noted that a weakness of the chronogram method was that the consistent dates were ignored in the calculation. They proposed a linear regression model instead, based on the assumption that the relative stratigraphic position of isotopically dated samples can be expressed numerically and the plot of isotopic ages versus stratigraphic position is expected to be a straight line. A serious practical limitation to this method is that only the ages of stratigraphically precisely constrained samples can be used, not many of which are available in the Jurassic. In fact, CARR et al. (1984) were only able to calculate the boundary ages for the Jurassic period but not for its stages. Theoretically, the quantification of stratigraphic position requires the assumption of constant rate of the geological process used in the linearization. As it will be discussed below, most such assumptions are controversial.

Interpolation techniques

Whether using a statistical approach or intuitive evaluation of data for best fit, establishing a satisfactory boundary age requires a minimum number of good quality, consistent dates from both side of the boundary. Lacking adequate control for boundaries to be calibrated, estimates must be made by interpolation between some anchored calibration points using a linearizing operator based on a geologic process with assumed constant rate.

BARRELL (1917) had only one Tertiary and one Late Paleozoic isotopic date to calibrate the intervening Mesozoic. His approach, followed in the subsequent time scales of HOLMES including his last attempt (1959), was to use cumulative sediment thicknesses as a proxy for time. Although the underlying assumption of constant sedimentation rate cannot be defended, this method allows a crude estimate of relative duration of geologic periods. An attempt to revive the concept by SMITH (1993) suggests that a new look at this method taking into account recent research on measuring stratigraphic completeness (e.g. SADLER and STRAUSS 1990) could yield more sophisticated results.

For interpolation within a period, HARLAND et al. (1964, 1982) assumed equal duration of constituent stages. The influential HARLAND et al. (1982) scale used no Jurassic tie-points (i.e. all Jurassic stage boundary chronograms were rejected as having error ranges in excess of 5 Ma). Interpolation between the Anisian/Ladinian and Aptian/Albian tie points was used to determine all Jurassic stage boundaries. Chronostratigraphic subdivisions are based on faunal evolution but the usage of stages records historical developments and tradition in stratigraphy. It is therefore less unrealistic to assume an equal duration for biochronozones (ammonite zones for the Jurassic) in which case a constant rate of evolution is implied. This method was introduced by VAN HINTE (1976) and later followed by KENT and GRADSTEIN (1985, 1986, for Hettangian to Oxfordian only) and HARLAND et al. (1990). The latter scale used five tie-points for interpolation of Jurassic stages: the chronogram ages to define Norian/-Rhaetian, Hettangian/Sinemurian, and Oxfordian/Kimmeridgian boundaries which are supplemented by the mid-Bajocian and Tithonian/Berriasian pseudo-tie-points. WESTERMANN (1984, 1988) carried the argument further by developing the scaled equal subzone interpolation method which considers the ammonite subzone as a basic unit and scales the duration of a subzone at 0.75 of that of an undivided zone. His time scale is based on the re-apportion of Jurassic according to this method, using the period boundary ages proposed by PALMER (1983). (However, after scaling and rounding, the sum of WESTERMANN's (1984, fig. 1) stage durations exceeds the total duration of Jurassic in PALMER (1983) by 1.5 Ma.) HALLAM et al. (1985) also used a similar, subzone based interpolation scheme for their Jurassic time scale.

A fundamental criticism leveled against these methods is that the assumption of constant rate of evolution is unwarranted (e.g. HOUSE 1985). Direct isotopic dating of ammonite zones is not yet available for the Jurassic but Cretaceous dates of OBRADOVICH (1993) points to widely disparate zonal durations. A possible independent method of estimating zonal durations utilizes orbitally forced sedimentary cycles. HOUSE (1985) suggested that Milankovitch cycles could be demonstrated in the rhythmically-bedded lowermost Jurassic Blue Lias and the Upper Jurassic Kimmeridge Clay of England and the recognition of cycles could have chronostratigraphic application. SCHWARZACHER (1993) pointed out that HOUSE's (1985) calculations supporting cycle durations within the Milankovitch range first used ammonite zonal durations derived from the equal zone assumption, before the oversimplified counting of bed couplets was in turn used to provide arguments against the equal zone durations. Subsequent studies confirmed the presence of cycles in the Blue Lias utilizing sophisticated filtering and spectral analysis (WEEDON 1985, SMITH 1990). SMITH's (1990) dates, derived from the cyclostratigraphic correlation of three biostratigraphically well-controlled sections, are strongly suggestive of disparate ammonite zonal durations in the Hettangian and earliest Sinemurian. Based on the number of cycles represented, he found an order of magnitude difference between some zones, independent of the absolute cycle length. Similar disparity in ammonite zonal length was also suggested for the Cenomanian (Cretaceous) based on Milankovitch cycles studied by GALE (1990).

Lastly, another possible linearizing operator for interpolation is the width of sea-floor magnetic anomalies. The oldest known preserved oceanic crust is Callovian in age, therefore the post-Middle Jurassic geochronologic time scale can be calibrated using the magnetic polarity time scale. A thorough review of the topic can be found in HAILWOOD (1989). If a constant spreading rate is assumed, then the width of sea floor magnetic anomalies is proportional to the duration of the respective magnetochrons. The spacing of the Hawaiian sequence of oceanic magnetic lineations (LARSON and HILDE 1975) was used for Late Jurassic interpolation in the DNAG time scale (PALMER 1983, KENT and GRADSTEIN 1985, 1986) and by GRADSTEIN et al. (1994). It is interesting, although perhaps coincidental, that the proportions of Late Jurassic stages in these magnetochronologically interpolated time scales are remarkably similar to the proportions obtained by WESTERMANN (1984, 1988) using the equal scaled subzone method.

Cubic spline smoothing was proposed as an additional mathematical technique to improve interpolation (AGTERBERG 1988, 1994). The time scale of GRADSTEIN et al. (1994) uses this method which offers several advantages over the simple linear interpolation: it takes into account the standard error of tie-points, reduces the asymmetry of unit length on the two sides of tie-points, and reduces the uncertainty of intermediate boundaries, especially for stages with large error.

Despite the availability of these techniques, ODIN (1994 and references therein) argued against interpolation and used it only to complement his "geochronologic approach" when the lack of isotopic dates otherwise precluded the assignment of a boundary age (e.g. for his Sinemurian/Pliensbachian, Pliensbachian/Toarcian, Toarcian/Aalenian, and Oxfordian/Kimmeridgian boundaries).

Directions in current and future time scale research

The relatively poor quality of calibration in the Jurassic has been repeatedly pointed out by various time scale authors (e.g. HARLAND et al. 1990, GRADSTEIN et al. 1994, ODIN 1994). Its primary cause is the scarcity of adequate critical dates from this period. Therefore significant improvement of the Jurassic time scale cannot be achieved without new isotopic dates. Statistical data analysis and interpolation will be relegated to secondary importance as the pool of acceptable ages increases.

Recently the gap between the resolution of biochronology and isotopic dating has been closing with the advent of accurate and precise U–Pb and $^{40}Ar–^{39}Ar$ dates with uncertainties near ±1Ma, thus comparable with the average ammonite zonal duration (e.g. WESTERMANN 1984). It is expected that zonally constrained high-precision dates will become available, as it has been the case for the Cretaceous (OBRADOVICH 1993). Dating of volcanic layers intercalated with fossiliferous sediments should be given priority, since glauconite is generally rejected as an unreliable geochronometer yielding anomalously low ages (e.g. OBRADOVICH 1988) and plutonic rocks cannot generally have tight enough stratigraphic brackets required for zonal resolution. The U–Pb and $^{40}Ar–^{39}Ar$ dating methods yield superior analytical precision with the benefit of offering an internal checks for closed system behaviour. Their use reduces or eliminates the geochemical error, i.e. the apparent versus true age dilemma plaguing other dating methods. In this light the traditional time scale database needs to be re-evaluated and the bulk of old K–Ar and Rb–Sr ages replaced (rather than supplemented) by newly obtained U–Pb and $^{40}Ar–^{39}Ar$ ages.

Volcanosedimentary successions with the potential for stratigraphically well-constrained dateable horizons are scarce in Europe but known to exist abundantly in areas of Jurassic active margins, e.g. in the North American Cordillera and the Andes. Dedicated studies towards improving the Jurassic time scale are now underway in Canada (PÁLFY et al. 1995). A prerequisite for such projects is the development of regional ammonite zonal schemes outside Europe (e.g. HILLEBRANDT et al. 1992, SMITH et al. 1994). The increase in precision of intercontinental correlation will render isotopic age determinations from different parts of the world much more useful for calibration.

If chronostratigraphic age assignments are made at the zonal level, the need for an accurate representation of correlation uncertainty increases. Promising recent research in quantitative biostratigraphy (e.g. taxon range confidence intervals: STRAUSS and SADLER 1989, MARSHALL 1994) may be adapted and further developed to assess uncertainties of zonal correlation. Alternatively, a semi-quantitative uncertainty assessment may prove satisfactory, where expert judgement is used to numerically express the reliability of biochronologic correlation to the standard scheme.

Refinements in the Sr isotope reference curve for the Jurassic enable correlations comparable to the subzonal level of resolution at the steepest parts of the curve (JONES et al. 1994a, b). As an independent method, it can corroborate biochronologic correlation or substitute it where zonal fossils are not available to determine the chronostratigraphic age of radioisotopically dated samples.

Developments in cyclostratigraphic analysis appear promising for interpolation below the stage level when it remains necessary. Where the completeness of record and the orbital forcing of sedimentary cycles can be documented, relative zonal durations can be independently assessed.

Summary

The building blocks of geochronologic scales are isotopic dates of known chronostratigraphic age. Plutonic rocks are frequently dated isotopically but their chronostratigraphic position is difficult to establish and commonly poorly constrained. Glauconite, an authigenic mineral occurring in sedimentary rocks, can also be isotopically dated, but the apparent age is commonly anomalously low. The biochronologic age of the sampled horizon, however, can be very precisely known. Volcanosedimentary sequences provide opportunities for isotopic dating of samples from intercalated volcanic rocks. In many cases, fossils from adjacent sediments tightly bracket the chronostratigraphic age of the sample.

The database of critical age determinations has been growing gradually, allowing the estimation of Jurassic stage boundaries for the first time in 1964 (HARLAND et al. 1964). In the past 30 years numerous amendments were published, resulting in a perplexing array of time scales available for the Jurassic. The significant discrepancies of the proposed stage boundary ages and their quoted uncertainties (which often exceed the stage durations) may confuse time scale users, who cannot assume that the most recently published scale is necessarily the most reliable.

An obvious reason for repeated revisions of time scales is that new isotopic dates become available and technologic advances increase their analytical precision. Yet the differences between time scales cannot be explained by these factors alone. Divergent approaches regarding the selection of data, handling of uncertainties, procedures for boundary age estimation and interpolation all contribute to the disagreement among time scales.

Among the major modern works (published in 1982 or later), ODIN's successive time scales (KENNEDY and ODIN 1982, ODIN and ODIN 1990, ODIN 1994) represent the "geochronologic approach", whereby each date is individually evaluated, the boundary ages are intuitively selected to provide a subjective best fit for the dataset, uncertainties are assigned manually, and interpolation is used, if at all, only as a last resort where critical data are lacking. Glauconite ages, especially common for the Late Jurassic, are weighted heavily, resulting in younger boundary estimates than in most other scales.

HARLAND et al. (1982, 1990) treat glauconite dates as minimum ages but their database is conservative in preserving most items from previous compilations. All accepted dates are handled equally by using the chronogram method for calculating boundary ages and estimating their associated error range. Only the best constrained chronogram ages are accepted as tie-points, the inter-

vening stage boundaries are interpolated assuming equal duration of stages or zones.

The DNAG time scale (PALMER 1983, KENT and GRADSTEIN 1985, 1986) uses "hand-picked" tie-points and interpolation based on sea-floor magnetic anomalies for the KimmeridgianTithonian and the equal-zone-duration method for the older part of the Jurassic. GRADSTEIN et al. (1994) append the isotopic database of HARLAND et al. (1990) but reject the use of glauconite ages. The maximum likelihood method is used to obtain first estimates for stage boundaries, then cubic spline smoothing is employed to refine the interpolation results of equal-subzone-duration (for the Early and Middle Jurassic) and sea-floor magnetochronology (for the Late Jurassic) methods.

The framework of Jurassic isotopic ages is still too sparse for reliable and precise calibration. Existing scales do not reflect recent directions in geochronometry which increasingly employ the U–Pb and ^{40}Ar–^{39}Ar methods for precise and accurate dating. Perhaps the most promising approach to improve the Jurassic geochronologic scale is the construction of a scale from U–Pb and ^{40}Ar–^{39}Ar ages which are directly constrained at the zonal level.

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Early Pliensbachian foraminifera from Szentgál, Bakony Mountains (Hungary)

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(with 4 figures and Plates 1–4)

Abstract

Well-preserved and rich foraminifera fauna were set free by concentrated acetic acid from hard "Ammonitico Rosso" limestone of Bakony Mts. The studied section is well defined by ammonites, indicating the Early Pliensbachian age. Family Nodosariidae is the most abundant and the most diversified. *Lenticulina gottingensis* (BORNEMANN), *Involutina liassica* (JONES), *Trocholina granosa* FRENTZEN and *Ammodiscoides*? *clypeiformis* (FRENTZEN) are the dominant species. Most species are cosmopolitan in character and have wide stratigraphical distribution. Detailed systematic description of 46 benthic species, involving 5 new species are given.

Key words: Lower Jurassic, Foraminifera, Bakony Mts, Hungary, new species

Introduction

During the prestudy of Lower Jurassic foraminifers from Bakony Mts one of the best preserved and rich fauna was found on the Tűzköves Hill of Szentgál. The studied section is one of the classical Lower Jurassic localities. GÉCZY (1974) investigated it in detail and gave its stratigraphical subdivision. On the basis of ammonite fauna he established that these layers correspond to the lower part of the Carixian (Lower Pliensbachian) Jamesoni Zone and the basal Ibex Zone.

At this time the foraminifera of the Hungarian Lower Jurassic had received very little or no attention. The main reason was that the non-washable formations, as the indurated marls and limestones are predominant, from which it was impossible to free the microfossils by standard processing methods. The use of the concentrated acetic acid solution allowed the study of free microfauna from hard Ammonitico Rosso type rocks, too.

The aim of this paper is to give a detailed study of a rich foraminiferal fauna from a stratigraphically well determined layer.

Material and methods

The studied samples were collected from Layer 11 of the T–I section on the top of the Tűzköves Hill, Szentgál, Southern Bakony Mts (Fig. 1). On the basis of previous studies these layers seemed to be the most fossiliferous. The Lower Jurassic rocks of the Tűzköves Hill are well-known long ago. The lithological features were investigated by NOSZKY (1953), KONDA (1970) and MÉSZÁROS (1980). The most detailed lithological and stratigraphical subdivisions of the T–I section were given by GÉCZY (1974) (Fig. 2). Lower Pliensbachian layers are less than 2 m thick, thin-bedded, brownish-red limestones. The macrofauna contains ammonites, nautiloids and is relatively rich in brachiopods and bivalves. The specimens are often coated with ferromanganese crust. On the basis of ammonites the studied layer corresponds to Jamesoni Zone and the basal Ibex Zone (GÉCZY, 1974). The microfauna were represented by mainly foraminifers, less ostracods, echinoid spines and sponge spicules, moreover some embryonic bivalves, gastropods and brachiopods were found.

The sample of Layer 11 in T–I section weighed about a kilogram. The hard limestone was dissolved in concentrated acetic acid. A total of 687 specimens were extracted, distributed among 47 species including 5 new ones. Synonym lists, stratigraphical ranges and paleogeographical distributions of species are based only on publications which contain descriptions and/or figures of given forms. Abundance was studied both as percentage of the total foraminifera assemblage and as the number of their specimens in the sample.

Described foraminifers are housed in the micropalaeontological collection of the Department of Palaeontology, Eötvös University, Budapest.

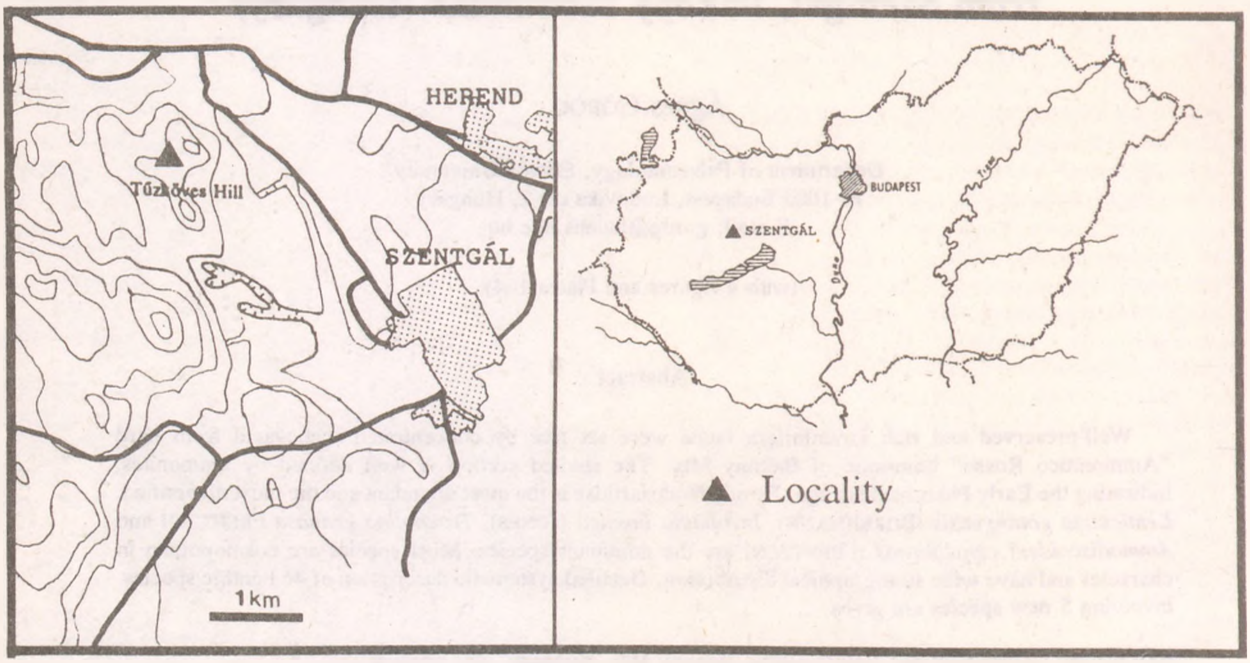

Fig. 1. Sketch map of the locality of studied section on the Tűzköves Hill, Bakony Mountains.

Lower Pliensbachian foraminifera fauna of Szentgál, Bakony Mts

The studied layer of of the T–I section, on the Tűzköves Hill, of Szentgál were rich in benthic foraminifera. The identified 20 genera (47 species) belong into 5 suborders: Textulariina, Involutinina, Miliolina, Lagenina and Rotaliina. The abundance and species number of characteristic taxa can be seen on Fig. 3.

Species of Lagenina, Involutinina and Textulariina are the most abundant (in this order), while the two other suborder are subordinate. More than 64% of the studied specimens belong to suborder Lagenina, moreover in it 11 genera and 38 species were identified, so this is the most diversified group. Within Lagenina the family Nodosariidae is the dominant and the family Ichthyolariidae play the second role, as the family Lagenidae and Polymorphinidea do not comprise 1% of the total assemblage. More than 50% of the studied specimens belong to family Nodosariidae. Genus Nodosaria is the most diversified genus, involving 11 genera and represents 16% of the total fauna. The most frequent species is *Nodosaria regularis* TERQUEM, 1862 (4.5%). Genus *Lenticulina* is represented by four species, but nearly 20 % of the studied specimens belong to these forms. The most frequent species of the assemblage is *Lenticulina gottingensis* (BORNEMANN, 1854) (13% of the total fauna).

Genus *Ichthyolaria* is relatively frequent, especially the characteristic Lower Jurassic forms namely *Ichthyolaria tenera* (BORNEMANN, 1854) and *Ichthyolaria testudinaria* (FRANKE, 1936) are abundant. Suborder Involutinina stands on second place in abundance (nearly 20%), but it is represented by two species only. *Involutina liassica* (JONES, 1853) is the second, *Trocholina granosa* FRENTZEN, 1941 is the third in frequence of specimens. Within subordo Textulariina *Ammodiscoides*? *clypeiformis* (FRENTZEN, 1941) (6%) and *Ammodiscus siliceus* (TERQUEM, 1862) (4.5%) are relatively abundant. Subordo Rotaliina is represented by a few specimens of *Reinholdella margarita* (TERQUEM, 1866b) and *Epistomina*? sp.. Only a broken *Ophthalmidium* specimen indicates the presence of Subordo Miliolina. Relatively in large number apperared the specimens of *"Placentula" pictonica* (BERTHELIN, 1879) (3,5%), which is taxonomically incertain.

Greater part of the species have wide stratigraphical distribution (Fig. 4). Most of them range from Hettangian to Pliensbachian. On the basis of literature there are no characteristic changes in foraminifera fauna at the Sinemurian–Pliensbachian boundary.

Detailed stratigraphical range and geographical distribution of each species are given in the systematic part.

Conclusion

Several papers on Lower Pliensbachian foraminifera fauna were published in the last 100 years (Issler 1908; Franke 1936; Bartenstein & Brand 1937; Frentzen 1941; Barnard, 1950; Pietrzenuk 1961; Rabitz 1963; Barbieri 1964; Pjatkova & Permjakova 1978; Exton and Gradstein 1984; Riegraf et al. 1984; Nocchi 1992). Inspite of this fact, because of the absence of detailed quantitative data from other age-equivalent localities the comparison with other foraminifera faunas is very difficult.

Generally speaking, that the most studied species have wide geographical distribution. The most characteristic Lower Jurassic species are cosmopolitan, e.g. *Involutina liassica* (Jones, 1853), *Ichthyolaria sulcata* (Bornemann, 1854), *Ichthyolaria tenera* (Bornemann, 1854), *Ichthyolaria testudinaria* (Franke, 1936), *Nodosaria dispar* Franke, 1936, *Nodosaria regularis* Terquem, 1862, *Berthelinella paradoxa* (Berthelin, 1879), *Lenticulina* gottingensis (Bornemann, 1854), *Marginulina prima* d'Orbigny, 1849. These species could be found in the sample of Tűzköves Hill.

The assemblage of Szentgál is attributed a late Sinemurian to early Pliensbachian age since they are in good agreement with other faunas of this age.

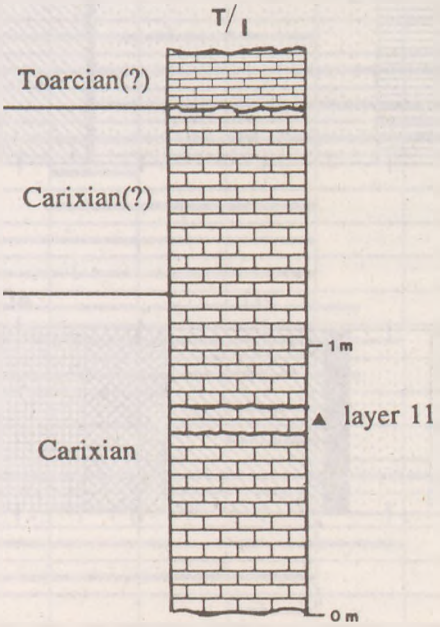

Fig. 2. Detailed section of T-I locality on the Tűzköves Hill (after Géczy, 1974).

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Systematic descriptions

After Loeblich & Tappan (1988).

Phylum Protista
Subphylum Sarcodina Schmarda, 1871
Classis Rhizopodea Von Siebold, 1845
Subclassis Lobosia Carpenter, 1861
Ordo Foraminiferida Eichwald, 1830
Subordo Textulariina Delage & Hérouard, 1894
Superfamily Ammodiscacea Reuss, 1862
Family Ammodiscidae Reuss, 1862
Subfamily Ammovolummininae Chernykh, 1967
Genus *Ammodiscoides* Cushman, 1909

Ammodiscoides? *clypeiformis* (Frentzen, 1941)
Pl. 1, Figs 1, 2.

1941 *Ammodiscoides clypeiformis* nov. spec.; Frentzen, p. 302, pl. 1, fig. 6.

1984 *Trocholina umbo* Frentzen, 1941; Riegraf et al., p. 689, pl. 7, figs 181–182.

Material. 42 specimens.

Description. Test very low cone, the about 5 times wider than high; periphery rounded; proloculus spherical, in the apex of spira; the second tubular chamber trochospirally coiled of 5 to 6 whorls, which can be seen only on the dorsal side; ventral side depressed; sutures indistinct; aperture is on the open end of the tube; wall finely agglutinated.

Remarks. Specimens of Szentgál show a very good resemblance to specimens of Frentzen.

Dimensions. Diameter: 0.13–0.32mm; thickness: 0.05--0.06mm.

Distribution. Germany (Karlsruhe): Upper Sinemurian; Morocco (DSDP): Sinemurian–Pliensbachian.

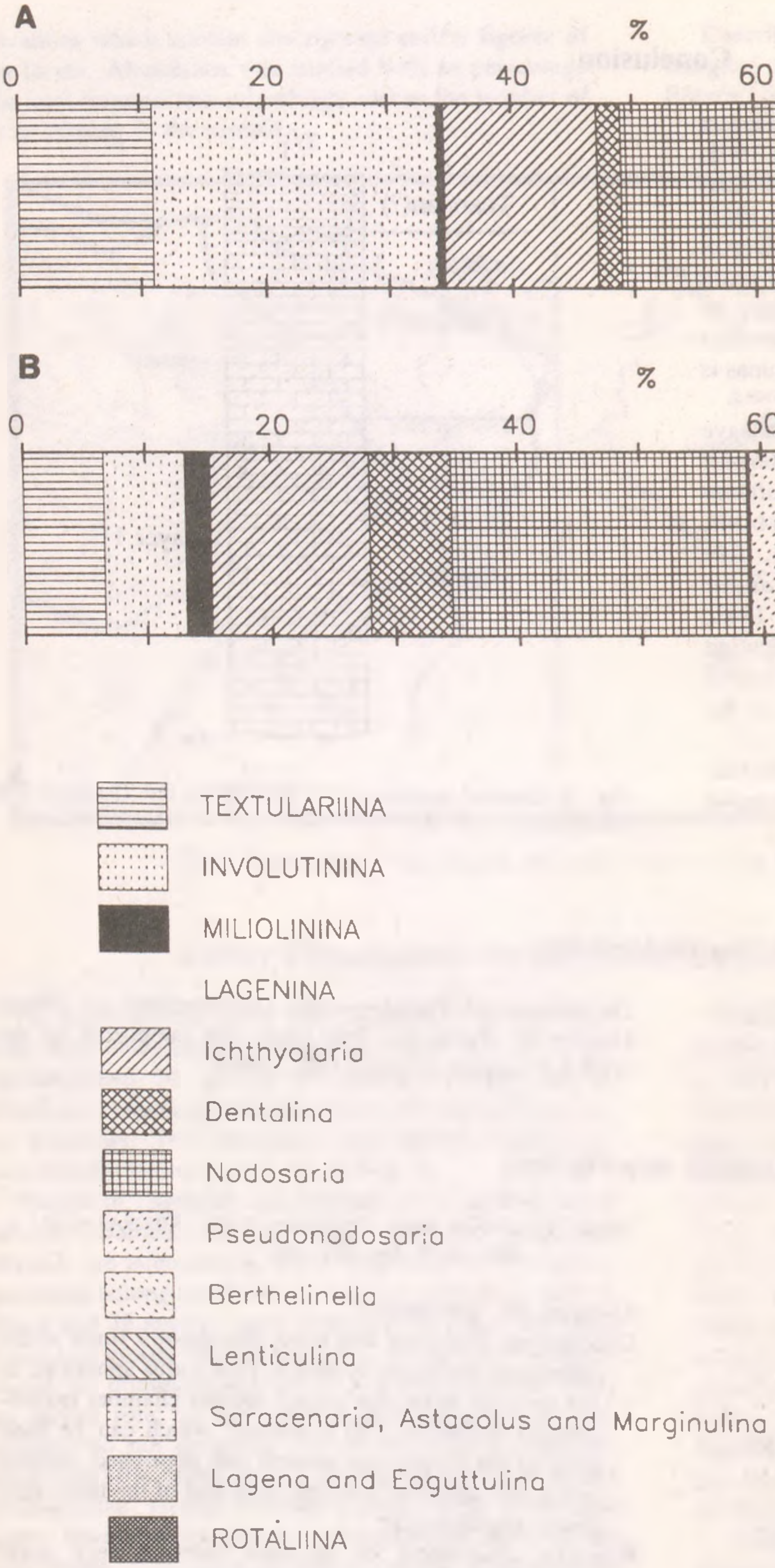

Fig. 3. A. Abundances of the characteristic taxa. Abundance is given in % of the total foraminiferal assemblage. B. Distribution of species number by characteristic taxa.

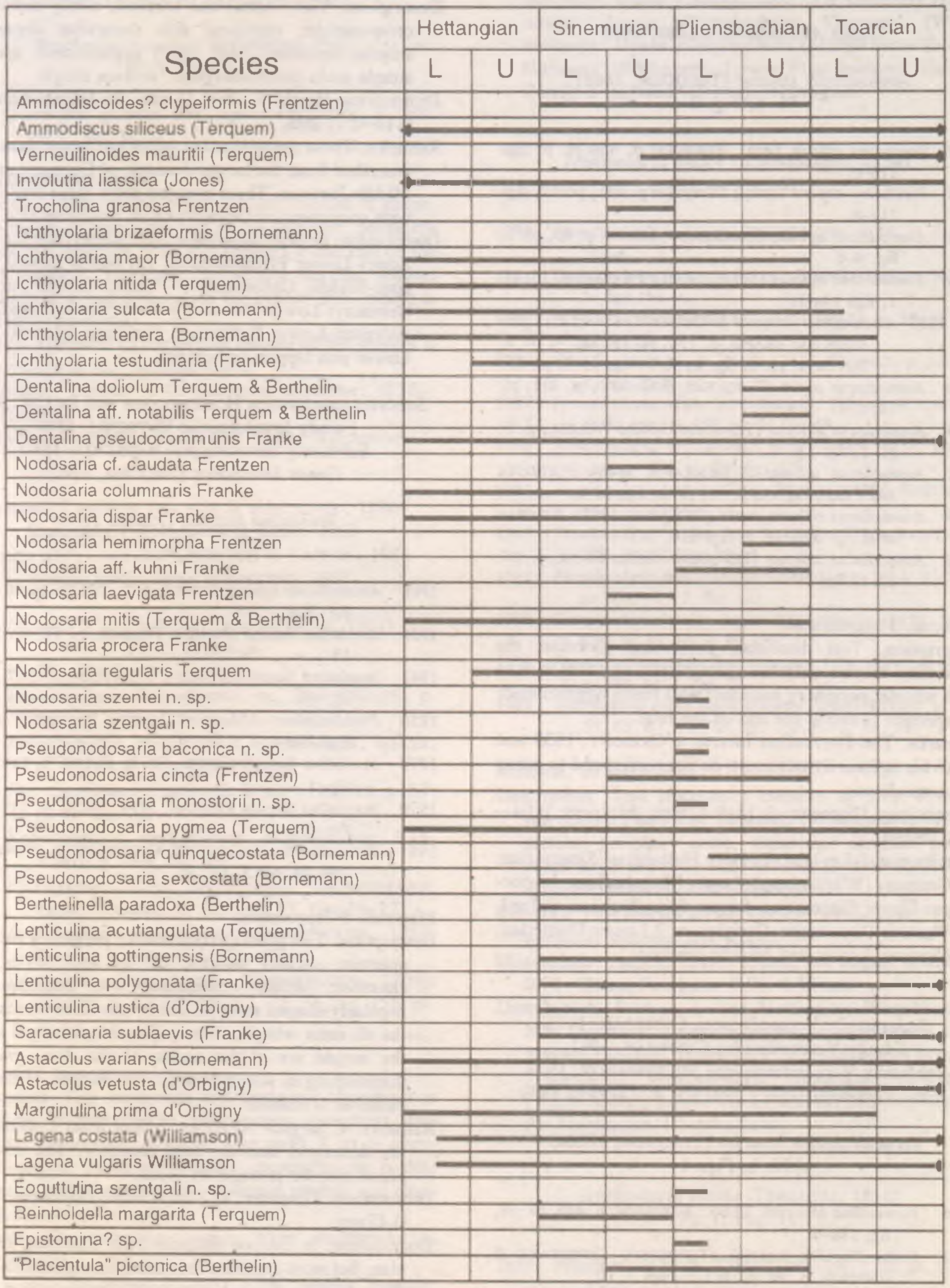

Fig. 4. Stratigraphic distribution of studied species

Genus *Ammodiscus* REUSS, 1862

Ammodiscus siliceus (TERQUEM, 1862)
Pl. 1, Fig. 3

1862 *Involutina silicea Terq.;* TERQUEM p. 450 pl. 6, figs 11a–b.
1863 *Involutina aspera* TERQ.; TERQUEM p. 221, pl. 10, figs 21a–b.
1908 *Ammodiscus infimus* STRICKLAND; ISSLER, p. 40, pl. 1, fig. 4–6.
1936 *Ammodiscus infimus* (STRICKLAND); FRANKE; p. 15, pl. 1, figs 14a–b.
pars 1937 *Ammodiscus incertus* (D'ORBIGNY, 1839); BARTENSTEIN and BRAND, p. 130, pl. 2B, fig. 4; pl. 3, figs 5a–c; pl. 4, fig. 4; pl. 5, figs 5a–b; pl. 8,
1950 *Ammodiscus asper* (TERQUEM); BARNARD, p. 351, pl. 1a, i, ii.
1968 *Ammodiscus siliceus* (TERQUEM, 1862); WELZEL, p. 5, pl. 1, fig. 11.
1978 *Ammodiscus infimus* (STRICKLAND, 1846); PJATKOVA and PERMJAKOVA, p. 16, pl. 2, figs 6a–c.
1984 *Ammodiscus siliceus asper* (TERQUEM, 1863); RIEGRAF et al., p. 679, pl. 4, figs 114, 117.
1988 *Ammodiscus siliceus* (TERQUEM, 1862); KOPIK, p. 26, pl. 1, fig. 1.

Material. 31 specimens.

Description. Test discoidal; proloculus globular; the second tubular chamber planispirally enrolled in 4 to 8 whorls; periphery rounded; wall finely agglutinated; aperture round at the end of the tube.

Remarks. The *Operculina incerta* D'ORBIGNY, 1839 and *Orbis infimus* STRICKLAND do not correspond to genus *Ammodiscus.*

Dimensions. Diameter: 0.14–0.42mm; thickness: 0.04–-0.08mm.

Distribution. S England (Dorset): Hettangian–Sinemurian; Germany (Württenberg): Lower Pliensbachian; Morocco: Upper Sinemurian–Lower Pliensbachian; Poland, Western Pomerania: Carixian or ? Lower Domerian; Ukraine: Lower and Middle Jurassic.

Superfamily Verneuilinacea CUSHMAN, 1911
Family Verneuilinidae CUSHMAN, 1911
Subfamily Verneuilinoidinae SULEYMANOV, 1973
Genus *Verneuilinoides* LOEBLICH & TAPPAN, 1949

Verneuilinoides mauritii (TERQUEM, 1866a)
Pl. 1, Fig. 4

1866 *Verneuilina Mauritii,* TERQ.; TERQUEM, p. 448, pl. 18, fig. 18a–b.
1981 *Verneuilinoides mauritii* (TERQUEM); COPESTAKE & JOHNSON, p. 90, pl. 6.1.1, Figs 5, 10.
1995 *Verneuilinoides mauritii* (TERQUEM, 1866); GÖRÖG, p. 31, pl. 2, fig. 3. cum. syn.

Material. 2 specimens.

Description. Test conical and triserial; nearly circular in cross-section; umbilical side somewhat depressed; sutures depressed; wall finely agglutinated; aperture simple arch, interiomarginal; surface rough.

Dimensions. Height: 0.18–0.23 mm; the largest diameter: 0.13–0.17 mm.

Remarks. These specimens are wider and lower than those described from the Lower Jurassic of Germany and the Middle Jurassic. These specims show large similarities with specimens of COPESTAKE & JOHNSON (1981).

Distribution. Britain: uppermost Sinemurian (Raricostatum Zone)–Lower Pliensbachian; E France: Lower Bajocian–Middle Oxfordian; S France: Lower Jurassic; Germany: Lower Jurassic; Poland (Extra-Carpathian): Aalenian–Lower Bathonian; Hungary (Mecsek Mts): Lower and Upper Bathonian.

Subordo Involutinina HOHENEGGER and PILLER, 1977
Family Involutinidae BÜTSCHLI, 1880
Subfamily Involutininae BÜTSCHLI, 1880
Genus *Involutina* TERQUEM, 1862

Involutina liassica (JONES, 1853)
Pl. 1. Fig. 5

1908 *Ammodiscus infimus* STRICKLAND; ISSLER, p. 40, pl. 1, fig. 7–8.
1936 *Involutina liasina* (JONES); FRANKE, p. 17, pl. 1, fig. 13.
1941 *Involutina liassica* (JONES); FRENTZEN, p. 307, pl. 1, fig. 14.
1950 *Problematina* cf. *liassica* (JONES); BARNARD, p. 378, figs 10a–c.
1970 *Involutina liassica* (JONES, 1853); FUCHS, p. 116, pl. 9, fig. 1.
1970 *Involutina turgida* KRISTAN, 1957; FUCHS, p. 116, pl. 9, fig. 6.
1981 *Involutina liassica* (JONES); COPESTAKE & JOHNSON, p. 100, pl. 6.1.5, fig. 9.

Material. 84 specimens.

Description. Test planispirally coiled; periphery rounded; aperture circular situated on the end of the final chamber; surface ornamented with numeruous irregularly-shaped short pillars or verrucae, which cover the all inner whorls; these pillars are arranged so that the largest are at the centre of the disc, gradually diminishing in size outwards; the surface of the final chamber is smooth.

Remarks. *I. turgida* KRISTAN differs from *I. liassica* in the destroyed smooth, final chamber. The ornamentation may be stronger or weak.

Dimensions. Diameter: 0.23–1.15mm; thickness: 0.09–-0.45mm.

Distribution. In Europe ranging from Rhaetian to Toarcian, but most common between Hettangian and Lower Pliensbachian. Lower Austria (Hernstein): Lowermost Jurassic; S England: Uppermost Pliensbachian; S Germany (Württenberg): Hettangian–Sinemurian.

Genus *Trocholina* PAALZOW, 1922

Trocholina granosa FRENTZEN, 1941
Pl. 1, Figs 6, 7

1941 *Trocholina granosa* nov. spec.; FRENTZEN, p. 304, pl. 1, fig. 11.

Material. 52 specimens.

Description. Test trochospirally coiled; conical in shape, the height is nearly the half of the diameter; periphery subacute; aperture oval and situated at the end of the last chamber, marginal. Spiral side smooth, sutures indistinct; a ring situated on the ventral side, which is filled by verrucae.

Remarks. The most characteristic feature of this species is the ring with the pustules inside.

Dimensions. Height: 0.16–0.36mm; diameter: 0.18–-0.51mm.

Distribution. Germany, Karlsruhe: Upper Sinemurian.

Subordo Lagenina DELAGE & HÉROUARD, 1896
Superfamily Robuloidacea REISS, 1963
Family Ichthyolariidae LOEBLICH & TAPPAN, 1986
Genus *Ichthyolaria* WEDEKIND, 1937

Ichthyolaria brizaeformis (BORNEMANN, 1854)
Pl. 1, Figs 8–9

1854 *Frondicularia brizaeformis* m.; BORNEMANN, p. 36, pl. 3, figs 17a–d, 18a–c, 20a–b.
1908 *Frondicularia brizaeformis* BORNEMANN; ISSLER, p. 57, pl. 3, figs 122–124.
1936 *Frondicularia brizaeformis* BORN.; FRANKE, p. 67, pl. 6, fig. 24.
1950 *Frondicularia brizaeformis* BORNEMANN; BARNARD, p. 369, fig. 7h.
1963 *Plectofrondicularia brizaeformis* (BORNEMANN, 1854); RABITZ, p. 215, pl. 17, figs 26–27.
1970 *Frondicularia brizaeformis* BORNEMANN, 1854; FUCHS, p. 89, pl. 5, fig. 15.
1985 *Ichtyolaria brizaeformis* (BORNEMANN, 1854); RUGET, p. 52, 59, 63, 67, 72, 76, fig. 15b; pl. 2, fig. 15;

Material. 7 specimens.

Description. Test lanceolate and flattened; rhomboid in outline; rhomboidal in cross-section; periphery subacute; proloculus globular; the next 3 to 6 chevron-shaped chambers rapidly increasing in width; sutures slightly depressed; aperture central and elongated; surface smooth.

Remarks. The test-shape varies from rhomboidal to broad-oval.

Dimensions. Height: 0.35–0.52 ; the largest breadth: 0.36–0.45mm; thickness: 0.09–0.13mm.

Distribution. Lower Austria (Hernstein): Lowermost Jurassic; France: Lower Hettangian–Pliensbachian; S Germany: Upper Pliensbachian; NW Germany (Hannover): Lower Pliensbachian; Germany (Württemberg): Upper Pliensbachian (Margaritatus Zone); Germany (Göttingen): Lower Pliensbachian (Davoei Zone); S England (Dorset): Hettangian.

Ichthyolaria major (BORNEMANN, 1854)
Pl. 1, Fig. 10

1854 *Frondicularia major* m.; BORNEMANN, p. 36, pl. 3, figs 21a–c.
1854 *Frondicularia intumescens* m.; BORNEMANN, p. 36, pl. 3, figs 19a–c.
1908 *Frondicularia carinata* BURBACH; ISSLER, p. 59, pl. fig. 127, 128.
1936 *Frondicularia major* BORN., 1854; FRANKE, p. 68, pl. 7, figs 2a–b.
1937 *Frondicularia major* BORNEMANN, 1854; BARTENSTEIN & BRAND, p. 155, pl. 5, fig. 68.
1959 *Frondicularia brizaeformis* BORNEMANN, 1854; DREXLER, p. 496, pl. 20, fig. 17.
1963 *Frondicularia major* elliptica BURBACH 1886; RABITZ, p. 208, pl. 17, fig. 19.
1963 *Frondicularia major lata* BURBACH 1886; RABITZ, p. 209, pl. 17, fig. 20.
1963 *Frondicularia major major* BORNEMANN 1854; RABITZ, p. 209, pl. 17, fig. 18.
1968 *Frondicularia major major* BORNEMANN, 1854; WELZEL, p. 37, pl. 2, fig. 20.
1984 *Frondicularia major* BORNEMANN, 1854; RIEGRAF et al., p. 684, pl. 1, fig. 21.
1985 *Ichthyolaria major* (BORNEMANN, 1854); RUGET, pl. 52, 59, 63, 67, 72, 76, fig. 15c; pl. 2, fig. 19

Material. 10 specimens.

Description. Test lanceolate, consists of 5 to 8 chevron-shaped chambers; flattened, rhomboidal in cross-section; periphery acute, sometimes carinate; proloculus large and spherical; sutures slightly depressed; aperture slit-like; surface smooth.

Remarks. This species differs from *F. nitida* TERQUEM its gradually widened test-shape.

Dimensions. Height:0.22–0.63mm; the largest diameter: 0.21–42mm; thickness: 0.06–0.13mm.

Distribution. France: Lower Hettangian–Pliensbachian; NW Germany: Lower Pliensbachian–Toarcian; Germany (Göttingen, Hannover): Pliensbachian; Germany (Thüringen, Württenberg): Hettangian; Germany (Württenberg): Lower Pliensbachian; Morocco (DSD-P): Sinemurian–Pliensbachian.

Ichthyolaria nitida (TERQUEM, 1858)
Pl. 1, Fig. 11

1858 Frondicularia nitida, TERQ.; TERQUEM, p. 32, pl. 1, fig 9 a–c.
pars 1908 Frondicularia nitida TERQUEM; ISSLER, p. 56, pl. 2, fig. 104–106, non 107–108.

1936 Frondicularia nitida TERQ.; FRANKE, p. 68, pl. 7, fig. 1, 3.
1937 Frondicularia nitida TERQUEM, 1858; BARTENSTEIN & BRAND, p. 155, pl. 2B, fig. 19; pl. 4, fig. 55; pl. 5, fig. 35.
1968 Frondicularia major nitida TERQUEM, 1858; WELZEL, p. 38, pl. 2, fig. 21.
1970 Frondicularia nitida TERQUEM, 1858; FUCHS, p. 89, pl. 5, fig. 10.
1985 Ichthyolaria nitida (TERQUEM, 1858); RUGET, p. 72, 76, 77, pl. 30, figs 1–3.

Material. 4 specimens.

Description. Test lanceolate, elongated; nearly parallel-sided; strongly flattened; periphery acute; 8 to 11 shevron-shaped chambers; sutures distinct, depressed; aperture slit-like and terminal; surface smooth.

Remarks. Most characteristic feauture of this species is the parallel-sided test-shape. Specimens of ISSLER (1908, pl. 2, figs 107–108) correspond to genus *Lingulina*.

Dimensions. Height: 0.39–0.50mm; the largest diameter: 0.18–0.28mm; thickness: 0.08–0.11mm.

Distribution. Lower Austria (Hernstein):Lowermost Jurassic; S France: Lower Jurassic; Central France (Etaules): Lower Pliensbachian; NW Germany: Hettangian–Upper Pliensbachian; Germany (Thüringen, Württenberg): Hettangian; Germany (Thüringen, Bayern, Württenberg): Lower Pliensbachian.

Ichthyolaria sulcata (BORNEMANN, 1854)

Pl. 2, Figs 1–2

1854 *Frondicularia sulcata* m.; BORNEMANN, p. 37, pl. 3, fig. 22a–c.
1908 *Frondicularia sulcata* BORNEMANN; ISSLER, p. 61, pl. 3, figs 140–142.
1936 *Frondicularia sulcata* BORN.; FRANKE, p. 71, pl. 7, fig. 8.
1937 *Frondicularia sulcata* BORNEMANN, 1854; BARTENSTEIN & BRAND, p. 158, pl. 1A, fig. 12; pl. 2A, figs 19a–b; pl. 2B, fig. 20; pl. 4, fig. 50.
1950 *Frondicularia sulcata* BORNEMANN; BARNARD, p. 369, fig. 7a, e, f.
1961 *Frondicularia sulcata* BORNEMANN 1854; PIETRZENIUK, p. 81, pl. 6, figs 5, 6.
1963 *Frondicularia bicostata sulcata* BORNEMANN, 1854; RABITZ, p. 213, pl. 17, fig. 22.
1968 *Frondicularia terquemi sulcata* BORNEMANN, 1854; WELZEL, p. 39, pl. 2, fig. 27.
1970 *Frondicularia sulcata* BORNEMANN, 1854; FUCHS, p. 90, pl. 5, fig. 3.
1981 *Ichthyolaria terquemi muelensis* RUGET & SIGAL; COPESTAKE & JOHNSON, p. 94, pl. 6.1.2., figs 12–13.
1985 *Ichtyolaria sulcata* (BORNEMANN); RUGET, 52, 59, 63, 67, 72, 77, 81, 86, 90–97, 118, 123–125, 128–129, 140, 142–143, 146, pl. 3, figs 2–4, 6–11, pl. 4, figs 4, 10–11; pl. 14, figs 1–8, 10–11; pl. 15, figs 7, 10–11; pl. 16, figs 1–13; pl. 17, figs 1–12; pl. 18, figs 1–7, 10, pl. 27, fig. 11; pl. 28, figs 1–3, 5–12, 16–17, 19.; pl. 29, figs 2, 9, 13; pl. 39, fig. 5; pl. 47, figs 1–3, 5–6, 8–9, 12–15.
1985 *Ichtyolaria muelensis* RUGET et SIGAL, 1970; RUGET, p. 52, 59, 63, 67, 72, 77, 93, 94, 95, 97, 118, 123–-126, 128–129, 140, 142–143, 146, pl. 18, figs 8–9; pl. 27, fig. 10; pl. 28, figs 13–14, 18, 20–21; pl. 29, fig. 4; pl. 47, figs 4, 7, 10–11.
1993 *Ichthyolaria sulcata* (BORNEMANN); HOHENEGGER, p. 250, pl. 1, fig. 1–5.

Material. 4 specimens.

Description. Test robust, lanceolate and elongated; strongly flattened; periphery acute or keeled except in the apertural region; proloculus rounded; the 4 to 8 chevron-shaped chambers slowly increasing in size; sutures indistinct and flush; aperture oval and terminal; surface ornamented with numerous strong and longitudial ribs, but on the macrospherical form the last chamber is smooth.

Remarks. Test-shape is similar with *I. terquemi* (D'ORBIGNY, 1850), differ in its surface ornamentation, because *I. terquemi* is smooth. Macrospheric forms have more higher ribs, thus ribs of microspheric forms are coarser.

RUGET (1985) and HOHENEGGER (1993) dealt with the morphological changes and stratigraphical ranges of this genus and species in detail.

Dimensions. Height: 0.34–0.65 mm; the largest diameter 0.21–0.32 mm; thickness: .10–0.13 mm.

Distribution. Lower Austria (Hernstein):Hettangian–Sinemurian; S England (Dorset): Lower Sinemurian and Upper Sinemurian (Raricostatum Zone)–Upper Toarcian; France: Lower Hettangian–lowermost Toarcian; NW Germany: Hettangian–Upper Pliensbachian; Germany (Apfelstädt, Stollenhalde am Grossen Seeberg): Upper Sinemurian); Germany (Halberstadt): Hettangian; Germany (Dobbertin) Upper Pliensbachian; Germany (Göttingen): Hettangian–Lower Pliensbachian (Davoei Zone); Germany (Wüttemberg): Lower Sinemurian–Pliensbachian.

Ichthyolaria tenera (BORNEMANN, 1854)

Pl. 2, Figs 3–5

1854 *Lingulina tenera* m.; BORNEMANN, p. 36, pl. 3, figs 24a–c.
1858 *Lingulina hexagona* TERQ.; TERQUEM, p. 594, pl. 1, figs 13a–c.
1858 *Lingulina tenera,* TERQ. (BORN. sp.); TERQUEM, p. 595, pl. 1, figs 14a–c.
1875 *Frondicularia pupa,* TERQ. et BERTH.; TERQUEM & BERTHELIN, p. 36, figs 1c, d.
1950 *Lingulina tenera* BORNEMANN; BARNARD, p. 365, figs 6a, c, f, g.
1936 *Lingulina tenera* BORN.; FRANKE, p. 64, pl. 6, fig. 18.
1937 *Frondicularia tenera tenera* (BORNEMANN, 1854); BARTENSTEIN & BRAND, p. 156, pl. 1A, fig. 11, 19; pl. 2A, figs 10a–c; pl. 2B, figs 18a–b; pl. 3, figs 25–26, pl. 5, figs 67a–b.

1941 *Lingulina tenera tenera* (BORNEMANN); FRENTZEN, p. 333, pl. 3, figs 18, 19.
1961 *Lingulina tenera tenera* BORNEMANN 1854; PIETRZENUK, p. 77, pl. 8, figs 1, 2.
1961 *Lingulina tenera carinata* NORVANG 1957; PIETRZENUK, p. 78, pl. 8, figs 7–9.
1963 *Lingulina tenera tenera* BORNEMANN 1854; RABITZ, p. 218, pl. 17, fig. 30.
1964 *Lingulina tenera* BORNEMANN; BARBIERI, p. 775, pl. 60, figs 8a–b.
1964 *Lingulina tenera prismatica* BARTENSTEIN & BRAND; BARBIERI, p. 775, pl. 60, figs 9a–b.
1968 *Lingulina tenera* BORNEMANN, 1854; WELZEL, p. 36, pl. 19, fig. 19, text-fig. 4.
1970 *Lingulina tenera tenera* BORNEMANN; FUCHS, p. 108, pl. 8, figs 1, 12, 15. 444
1984 *Lingulina tenera carinata* NORVANG, 1957; RIEGRAF et al., p. 688, pl. 7, fig. 180.
1985 *Lingulina tenuistriata* (NOERVANG, 1957); RUGET, p. 53, 54, 58, 59, 63, 67, 73, 143, pl. 5, figs 4–5.
1985 *Lingulina tenera* BORNEMANN, 1854; RUGET, p. 53, 54, 59, 63, 67, 73, 77, 85, 86, 143, 144, pl. 6, figs 1–3; pl. 19, fig. 5; pl. 31, figs 10–11, 13, 15; pl. 39, figs 2, 6.

Material. 30 specimens.

Description. Test elongate and compressed; hexagonal in cross-section; proloculus small and sharpened; later 5 to 10, chevron-shaped chamber slowly increasing in size; sutures distinct and more or less depressed; aperture oval and terminal; surface ornamented with 6 longitudinal, strong costae or broad and sharp rims.

Remarks. WELZEL (1968) dealt with the different subspecies of species L. tenera. The development of the surface ornamentataion strongly varies.

Dimensions. Height: 0.16–0.50mm; the largest diameter 0.14–0.36mm; thickness: 0.04–0.10mm.

Distribution. Lower Austria (Hernstein):Lowermost Jurassic; England: Upper Sinemurian–Lower Pliensbachian; France (Nancy): Upper Pliensbachian (Margaritataus Zone); France (after Ruget, 1985): Upper Sinemurian–Lower Toarcian; Germany (after Franke, 1936): Hettangian–Upper Pliensbachian; Germany (Göttingen, Eisenach): Lower Hettangian–Lower Pliensbachian; Germany (Võlpke, Apfelstädt, Stollenhalde am Grossen Seeberg, Eisenach): Upper Sinemurian); Germany (Dobbertin) Upper Pliensbachian. Morocco (DSDP): Sinemurian–Pliensbachian; Portugal (Coimbra): Lower Pliensbachian–lower part of the Upper Pliensbachian; Sicily: Pliensbachian–Lower Toarcian.

Widespread in Europe from Hettangian to lowermost Toarcian: Denmark, Sweden Germany, Portugal, Poland Italy, France (COPESTAKE at al. 1981.);

Ichthyolaria testudinaria (FRANKE, 1936)
Pl. 2, Fig. 6–7

936 *Lingulina testudinaria* n. sp.; FRANKE, p. 63, pl. 6, fig. 19.
1970 *Lingulina testudinaria* FRANKE, 1936; FUCHS, p. 109, pl. 8, fig. 19.
1981 *Lingulina testudinaria* FRANKE, 1936; COPESTAKE & JOHNSON, p. 96, pl. 6.1.3., figs 1–3.
non 1985 *Lingulina testudinaria* FRANKE, 1937; RUGET, p. 73, 77, 81, 84, 85, 86, 143, 144, pl. 40, figs 1–4.
non 1985 *Lingulina testudinaria* FRENTZEN; RUGET, p. , pl. 40, figs 5–6.

Material. 23 specimens.

Description. Test subtriangular, consists of 6 to 10 low chambers; strongly flattened and subrhomboidal in cross-section; periphery keeled; the first 4 to 5 chambers rapidly increasing in size, later ones nearly uniform in wide; sutures bordering with ribs; aperture is slit-shaped; surface ornamented with two longitudinal central ribs, which bordering a median sulcus.

Remarks. Most distinctive character of this species are the surface ornamentation, wich give a "trilobite-like" appearence. Specimens of RUGET (1985) have totally different surface ornamentation.

Dimensions. Height: 0.18–0.37mm; the largest diameter: 0.13–0.26mm; thickness: 0.09–0.13mm.

Distribution. Lower Austria (Hernstein):Lowermost Jurassic; England: Upper Sinemurian (Raricostatum Zone)–Lower Toarcian (Tenuicostatum Zone): Germany (Göttingen): Lower Pliensbachian.

Superfamily Nodosariacea EHRENBERG, 1838
Family Nodosariidae EHRENBERG, 1838
Subfamily Nodosariinae EHRENBERG, 1838
Genus *Dentalina* RISSO, 1826

Dentalina doliolum TERQUEM & BERTHELIN, 1875
Pl. 2, Fig. 8

1875 *Dentalina doliolum*, TERQ. et BERTH.; TERQUEM & BERTHELIN, p. 32, pl. 2, fig. 23.

Material. 3 specimens.

Description. Test short, consists of 2 chambers; the chambers nearly uniform in size; sutures indistinct flush; aperture small and round; surface ornamented with 12 to 14 longitudinal ribs, except the nearly flat area around the aperture.

Remarks. Specimens of Szentgál are very close to the original decription of TERQUEM & BERTHELIN (1875).

Dimensions. Height: 0.23–0.41mm; the largest diameter: 0.20–0.36mm.

Distribution. France (Nancy): Upper Pliensbachian (Margaritatus Zone).

Dentalina aff. *notabilis* TERQUEM & BERTHELIN, 1875
Pl. 2, Fig. 9

1875 *Dentalina notabilis*, TERQ. et BERTH.; TERQUEM & BERTHELIN, p. 31, pl. 2, fig. 19.

Material. 1 specimen.

Description. Test large, elongated egg-shaped; consists of 4 chambers; the first chamber strongly sharpened; sutures indistinct; aperture round and relative large and situated on the tapered end of the last chamber; surface ornamented 14 strong,longitudinal ribs.

Remarks. The test-shape of specimen from Szentgál is very similar to those of TERQUEM & BERTHELIN (1875), but the surface ornamentation seems stronger than of holotype.

Dimensions. Height: 0.73mm; the largest diameter: 0.29mm.

Distribution. France (Nancy): Upper Pliensbachian (Margaritatus Zone).

Dentalina pseudocommunis FRANKE, 1936
Pl. 2, Fig. 10

1908 *Dentalina communis* D'ORBIGNY; ISSLER, p. 62, pl.3, figs 143–145.
1936 *Dentalina pseudocommunis* n. sp.; FRANKE, p. 30, pl. 2, fig. 20a–b.
1961 *Dentalina pseudocommunis* FRANKE 1936; PIETRZENUK, p. 63, pl. 2, fig. 4.
1964 *Dentalina communis* D'ORBIGNY; BARBIERI, p. 752, pl. 57, figs 6a–b.
1970 *Dentalina communis* (ORBIGNY, 1826); FUCHS, p. 80, pl. 3, figs 12, 15.
1970 *Dentalina pseudocommunis* FRANKE, 1936; FUCHS, p. 84, pl. 4, figs 16–17.
1985 *Dentalina pseudocommunis* FRANKE, 1937; RUGET, p. 51, 59, 62, 67, 70, 71, 77, 85, 86, 88; pl. 2, fig. 10; pl. 13, fig. 5.
1995 *Dentalina pseudocommunis* FRANKE, 1936; GÖRÖG, p. 44, pl. 4, fig. 1. cum. syn

Material. 2 specimens.

Description: Test uniserial, elongated; circular to slightly oval in cross section; proloculus ovate; 6 to 7 chambers gradually increasing in size, giving slender, gently flaried outline; the height of chambers are usually larger than the wide; end of the last chamber narrowed; suture slightly oblique, usually indistinct at first, later depressed; aperture radial and terminal; surface smooth.

Dimensions. Height: 0.71–0.82 mm; the largest diameter: 0.29–0.37 mm.

Distribution. Lower Austria (Hernstein):Lowermost Jurassic; England: Hettangian–Kimmeridgian; France: Hettangian–Toarcian; NW Germany: Lower Jurassic-lower part of the Upper Jurassic; S Germany: Lower Jurassic; Upper Bajocian, Lower Oxfordian; Germany (Völpke, Apfelstädt, Stollenhalde am Grossen Seeberg): Upper Sinemurian); Germany (Dobbertin): Upper Pliensbacian; Hungary (Mecsek Mts): Bathonian; Poland: Lower Jurassic; Central Poland: Kimmeridgian; Switzerland: Oxfordian; Ukraine: Aalenian–Bajocian, Callovian.

Genus *Nodosaria* LAMARCK, 1812

Nodosaria cf. *caudata* FRENTZEN, 1941
Pl. 2, Fig. 11

1941 *Nodosaria caudata* nov. spec.; FRENTZEN, p. 317, pl. 2, fig. 22.

Material. 1 brokened specimen.

Description. Test elongated, slim; the 3 remained chambers are elongated; sutures slightly depressed; aperture is bordered with a rim and situated on the end of the long extension of the last elongated, egg-shaped chamber; surface smooth.

Remarks. The most characteristic features of this species is the shape of the aperture.

Dimensions. Height of the chambers: about 0.2mm; the largest diameter 0.125mm.

Distribution. Germany, Karlsruhe: Upper Sinemurian.

Nodosaria columnaris FRANKE, 1936
Pl. 2, Fig. 12

1908 *Nodosaria raphanistrum* LINNÉ; ISSLER, p. 53, pl. 2, figs 84, 85.
1936 *Nodosaria columnaris* n. sp.; FRANKE, p. 48, pl. 4, fig. 19a–b.
1937 *Nodosaria columnaris* FRANKE, 1936; BARTENSTEIN & BRAND, p. 146, pl. 3, fig. 24.
1950 *Nodosaria columnaris* FRANKE, 1936; BARNARD, p. 356, fig. 4e.
1961 *Nodosaria columnaris* FRANKE 1936; PIETRZENUK, p. 60, pl. 1, fig. 6.
1981 *Nodosaria byfieldensis* BARNARD, 1950b; COPESTAKE & JOHNSON, p. 97, pl. 6.1.2, fig. 6.1.3.
1985 *Nodosaria columnaris* FRANKE, 1936; RUGET, p. 61, 67, 69, 77, pl. 12, fig. 5; pl. 25, figs 10, 13, 19–20.

Material. 4 specimen.

Description. Test elongated, nearly parallel-sided, with 6 to 7 drum-shaped chambers; sutures nearly flush; aperture round and central; surface ornamented with 8 longitudinal, continuous ribs.

Remarks. Specimens from Szentgál very well correspond to type specimen of Franke.

Dimensions. Height: 0.73–0.96 mm; the largest diameter 0.20–0.24 mm.

Distribution. Britain: Lower and mid-Toarcian; France: Upper Sinemurian–Pliensbachian; Germany (Württenberg): Hettangian–mid-Toarcian; Germany (Göttingen): Lower Pliensbachian; Germany (Völpke, Apfelstädt, Stollenhalde am Grossen Seeberg): Upper Sinemurian); Portugal (Coimbra): Lower Pliensbachian (Davoei Zone).

Nodosaria dispar FRANKE, 1936
Pl. 2, Fig. 13

1908 *Nodosaria raphanistrum* LINNÉ: ISSLER, p. 53, pl. 2, figs 87–89.
1936 *Nodosaria dispar* n. sp.; FRANKE, p. 47, pl. 4, fig. 18.
1961 *Nodosaria dispar* FRANKE 1936; PIETRZENUK, p. 60, pl. 1, figs 2, 3.
1964 *Nodosaria dispar* FRANKE; BARBIERI, p. 748, pl. 56, fig. 16.
1970 *Nodosaria dispar* FRANKE, 1936; FUCHS, p. 76; pl. 2, fig. 8.

Material. 1 specimen.

Description. Test elongated, consists of 3 nearly globular chambers; first chamber apiculate; sutures depressed; aperture radial and elevated; surface covered by 8 to 10 costae.

Remarks. Specimen of Szentgál correspond to FRANKE, (1936, pl. 4, fig. 18c) and FUCHS (1970).

Dimensions. Height: 0.46mm; the largest diameter: 0.21mm.

Distribution. Lower Austria (Hernstein): Lowermost Jurassic; Germany (Württenberg): Hettangian–Upper Pliensbachian; Germany (Võlpke, Apfelstädt, Stollenhalde am Grossen Seeberg): Upper Sinemurian; Germany (Dobbertin): Upper Pliensbacian; Sicily: Sinemurian–Lower Pliensbachian.

Nodosaria hemimorpha FRENTZEN, 1941
Pl. 2, Figs 14–15

1941 *Nodosaria hemimorpha* nov. spec.; FRENTZEN, p. 318, pl. 2, figs 29, 30, 31.

Material. 17 specimens (10 rectangular and 7 quinquangular).

Description. Test elongated; the initial chamber piramidal and large; the next 4 to 8 chambers neraly uniform in size; sutures indistinct, sometimes slightly depressed; aperture radiate and situated on the extention of the last chamber; surface ornamented 4 to 5 straight costae.

Remarks. The test-shape of this species is very variable, it may be rectangular or quinquangular in cross-section. Sometimes the later chambers are smaller in diameter than the previous ones.

Dimensions. Height: 0.48–0.78mm; the largest diameter: 0.16–0.23mm.

Distribution. Germany (Karlsruhe): Upper Pliensbachian.

Nodosaria aff. *kuhni* FRANKE, 1936
Pl. 2, Fig. 16

1936 *Nodosaria kuhni* n. sp.; FRANKE, p. 46, pl. 4, fig. 13.

Material. 6 chambers.

Description. Chambers ovoid in shape; sutures strongly deepened; aperture small and round; surface ornamented with 8 longitudinal, upwards widened ribs, diminishing towards the aperture.

Remarks. These chambers are probably the last chambers of *N. kuhni*.

Dimensions. The largest diameter 0.25–0.29mm.

Distribution. Germany (Hannover): Upper Pliensbachian; Germany (Bayern): Lower Pliensbachian.

Nodosaria laevigata FRENTZEN, 1941
Pl. 2, Fig. 17

1941 *Nodosaria laevigata* nov. spec.; FRENTZEN, p. 319, pl. 2, figs 26–27.

Material. 4 specimens.

Description. Test elongated, pupa-shaped; the first chamber small and spherical; the next 5 to 7 chambers slowly increasing in wide, forming nearly parallel side of the test; chambers are somewhat wider than high; sutures indistinct, horizontal; aperture is on a small extension of the final chamber; wall smooth.

Remarks. The most characteristic features of this species are the pupa-shaped test and the indistinct sutures.

Dimensions. Height: 0.41–0.44mm; the largest diameter: 0. 17–0.19mm.

Distribution. Germany, Karlsruhe: Upper Sinemurian.

Nodosaria mitis (TERQUEM & BERTHELIN, 1875)
Pl. 2, Fig. 18

pars 1875 *Dentalina mitis,* TERQ. et BERTH. (n. sp); TERQUEM & BERTHELIN, p. 28, pl. 2, fig. 9 b, non 9a, c, d.
1908 *Nodosaria raphanistrum* LINNÉ; ISSLER, p. 53, pl. 2, fig. 86.
1936 *Nodosaria mitis* (TERQ. & BERTH.); FRANKE, p. 45, pl. 4, figs 10a–b.
1937 *Nodosaria mitis* (TERQUEM & BERTHELIN, 1875); BARTENSTEIN & BRAND, p. 145, pl. 2A, fig. 9; pl. 2B, fig. 13; pl. 3, fig. 18; pl. 4, fig. 36; pl. 5, fig. 24.
1961 *Nodosaria mitis* (TERQUEM & BERTHELIN, 1875); PIETRZENUK, p. 59, pl. 1, figs 7–8.

Material. 2 specimens.

Description. Test elongated, consists of 6 chambers; first chambers small and sharpened; the next 2 to 3 chambers rapidly increasing in size, later chambers nearly similar in size; sutures distinct depressed; aperture round and somewhat elevated; surface ornamented with 6 strong longitudinal costae.

Remarks. FRANKE (1936) described and figured specimens with 8 costae.

Dimensions. Height: 0.71–76mm; the largest diameter 0.24–0.26 mm.

Distribution. France (Nancy): Upper Pliensbachian (Margaritataus Zone); Germany (Hannover, Bayern): Upper Pliensbachian; Germany (Bayern): Lower Pliensbachian; Germany (Württenberg): Hettangian–Sinemurian; Germany (Völpke, Apfelstädt, Stollenhalde am Grossen Seeberg): Upper Sinemurian; Germany (Dobbertin): Upper Pliensbacian.

Nodosaria procera FRANKE, 1936
Pl. 2, Fig. 19

1936 *Nodosaria procera* n. sp.; FRANKE, pl. 51, pl. 5, fig. 3.
1937 *Nodosaria procera* FRANKE, 1936; BARTENSTEIN & BRAND, p. 146, pl. 3, figs 17a–c.
1985 *Nodosaria procera* FRANKE, 1936; RUGET, p. 61, 67, pl. 12, figs 12–13.

Material. 2 specimens

Description. Test uniserial, elongated; round in cross-section; proloculus large and spherical; 3 to 4 chambers, which are wider than high; sutures depressed and distinct; aperture small and round; surface ornamented by 10 to 12 longitudinal costae.

Remarks. Usually there are more costae on the younger chambers.

Dimensions. Height of chambers: 0.16–0.18mm; diameter of chambers: 0.18–0.20mm.

Distribution. Central France: Upper Sinemurian; Germany (Bayern): Lower Pliensbachian; NW Germany: Hettangian–Lower Pliensbachian.

Nodosaria regularis TERQUEM, 1862
Pl. 2, Fig. 10

1862 *Nodosaria regularis*, TERQ.; TERQUEM, p. 436, pl. 5, fig. 12.
1862 *Nodosaria nitida*, var., TERQ.; TERQUEM, p. 436, pl. 5, fig. 11.
1875 *Nodosaria simplex*, TERQ. et BERTH. (n. sp.); TERQUEM & BERTHELIN, p. 19, figs 18a–b.
1936 *Nodosaria regularis* TERQ.; FRANKE, p. 41, pl. 3, figs 19a–b.
1937 *Nodosaria regularis* TERQUEM, 1862; BARTENSTEIN and BRAND, p. 144, pl. 11A, figs 6a–b; pl. 15A, fig. 10.
1941 *Nodosaria regularis* TERQUEM; FRENTZEN, p. 323, pl. 2, figs 12–15.
1964 *Nodosaria regularis* TERQUEM; BARBIERI, p. 750, pl. 56, fig. 11.
?1968 *Nodosaria regularis regularis* TERQUEM, 1862; WELZEL, p. 10, pl. 1, fig. 16.
1970 *Nodosaria regularis* TERQUEM, 1862; FUCHS, p. 78, pl. 2, fig. 15.
1981 *Nodosaria regularis* subsp. A; COPESTAKE & JOHNSON, p. 98, pl. 6.1.4, fig. 3.
1984 *Nodosaria regularis* TERQUEM, 1862; RIEGRAF et al., p. 682, pl. 5, fig. 129.

Material. 31 chambers.

Description. Chambers globular, connected by short constricted neck; aperture produced on a neck; surface smooth.

Remarks. Specimen figured by WELZEL (1968) have pyriform chambers.

Dimensions. Diameter: 0.28–0.33mm.

Distribution. Lower Austria (Hernstein): lowermost Jurassic; Britain: Toarcian–Bathonian; France: Upper Pliensbachian (Margaritatus Zone); Germany (Karlsruhe): Upper Pliensbacian–uppermost Middle Jurassic; S Germany (Bayern, Württemberg): Upper–Toarcian; Morocco (DSDP): Pliensbachian ?; Sicily: Sinemurian.

Nodosaria szentei n. sp.
Pl. 3, Figs 1–3

Derivatio nominis: After István SZENTE, my kindly colleaque.

Locus typicus: 11 layers of T–I section on Tűzköves Hill, Szentgál, Bakony Mts, Hungary.

Stratum typicum: Lower Pliensbachian, Jamesoni–Ibex Zone.

Holotype: Plate 3, Figure 1.

Paratypes: Plate 3, Figure 2, 3.

Material. 5 specimens.

Diagnosis. Test is cucumber-shaped, sutures indistinct; aperture round at the tapered end of the last chamber, costae bifurcated at the latest chambers.

Description. Test elongated, more or less curved and robust; round in cross-section; 4 to 7 chambers are wider than high; sutures indistinct and flush; aperture round at the tapered end of the last chamber; surface ornamented with 10–12 longitudinal costae, which often bifurcated at the younger chambers.

Remarks. The most characteristic features of this species are the cucumber-shaped test, and the surface ornamentation. This species most resembles to *N. szentgali* n. sp., but the latter differs from *N. szentei* in its more slender and straight test-shape, large number of costae and the less tapered final chamber.

Dimensions. Height: 0.68–1.32mm; the largest diameter: 0.26–0.36 mm.

Nodosaria szentgali n. sp.
Pl. 3, Fig. 4

Derivatio nominis: After Szentgál, the type locality.

Locus typicus: 11 layers of T–I section on Tűzköves Hill, Szentgál, Bakony Mts, Hungary.

Stratum typicum: Lower Pliensbachian, Jamesoni-Ibex Zone.

Holotype: Plate 3, Figure 4.

Material. 10 specimens.

Diagnosis. Test is elongated and slim; sutures indistinct and flush; aperture round and terminal, covered by 11 to 14 longitudinal costae.

Description. Test elongated, slim and consists of 3 to 8 nearly uniform chambers; sutures indistinct and flush; aperture round and terminal; surface ornamented by 11 to 14 sharp longitudinal costae.

Remarks. The most distinctive features of this species are the slim test-shape and the indistinct and flush sutures. This species most resembles to *Nodosaria bambergensis* FRANKE, 1936, but differs from it in uniform chambers and flush sutures.

Dimensions. Height: 0.46–0.65mm; the largest diameter 0.20–0.23mm.

Genus *Pseudonodosaria* BOOMGAART, 1949

Pseudonodosaria baconica n. sp.
Pl. 3, Fig. 5

Derivatio nominis: After type locality, Bakony Mts.

Locus typicus: 11 layers of T–I section on Tűzköves Hill, Szentgál, Bakony Mts, Hungary.

Stratum typicum: Lower Pliensbachian, Jamesoni–Ibex Zone.

Holotype: Plate 3, Figure 5.

Material. 2 specimens.

Diagnosis. Test is spindle-shaped; sutures indistinct and flush; aperture round and terminal, the periphery of the last chamber is ornamented with dense and short grooves.

Description. Test spindle-shaped; periphery subacute; 3 to 4 chambers rapidly increasing in size; sutures indistinct and flush; aperture round and terminal; surface smooth except the periphery of the last chamber, which is ornamented with dense and short grooves.

Remarks. The most distinctive features of this species are the indistinct and flush sutures and the short grooves on the periphery. This species most resembles to *P. pygmea* (TERQUEM, 1866b), but differs from it in surface ornamentation.

Dimensions. Height: 0.32–0.35mm; the largest diameter 0.23–0.25mm.

Pseudonodosaria cincta (FRENTZEN, 1941)
Pl. 3, Fig. 6

1941 *Pseudoglandulina cincta* nov. spec.; FRENTZEN, p. 326, pl. 3, fig. 4.

Material. 24 specimens.

Description. Test large, elongated, rectilinear and consists of 5 to 8 chambers; the initial chamber small and rounded; the first 3 to 4 chambers are very broad and rapidly increasing in size, than the enlarging more slowly and less; the final chamber is onion-shaped; sutures straight and slightly depressed; along the sutures there are ring-like thickening; aperture radiate terminal; surface smooth.

Remarks. This species is most resembles to *Nodosaria annulifera* FRENTZEN, 1941, but differs from it in its lower chambers, which very quickly enlarging in wide.

Dimensions. Height: 0.31–0.56mm; the largest diameter: 0.22–0.28mm.

Distribution. Germany (Karlsruhe): Upper Sinemurian–uppermost Pliensbachian;

Pseudonodosaria monostorii n. sp.
Pl. 3, Fig. 7

Derivatio nominis: After Miklós MONOSTORI, my kindly colleaque.

Locus typicus: 11 layers of T–I section on Tűzköves Hill, Szentgál, Bakony Mts, Hungary.

Stratum typicum: Lower Pliensbachian, Jamesoni–Ibex Zone.

Holotype: Plate 3, Figure 7.

Material. 2 specimens.

Diagnosis. Test is egg-shaped; lower part of the chambersa ornamented with numerous short ribs; sutures distinct and depressed.

Description. Test elongated egg-shaped and consists of 5 chambers gradually increasing in size; sutures distinct and depressed; aperture round and terminal; lower part of the chamber ornamented with 8 to 12 short ribs.

Remarks. The most characteristic feature of this species is the surface ornamentation.

Dimensions. Height: 0.26–0.28mm; the largest diameter 0.14–0.16mm.

Pseudonodosaria pygmea (TERQUEM, 1866b)
Pl. 3, Fig. 8

1866b *Glandulina pygmea*, TERQ.; TERQUEM, p. 478, pl. 19, fig. 6.

1875 *Glandulina pygmea*, TERQ.; TERQUEM & BERTHELIN, p. 22, pl. 1, figs 23a–b.

1984 *Pseudonodosaria vulgata* (BORNEMANN, 1854); RIEGRAF et al., pl. 1, fig. 35.

Material. 4 specimens.

Description. Test elongated egg-shaped; proloculus rounded; 3 to 5 chambers gradually increasing in size; sutures indistinct and flush; aperture radiate; surface smooth.

Remarks. This species differs from *Pseudonodosaria vulgata* (BORNEMANN) in its flush and indistinct sutures.

Dimensions. Height: 0.41–0.62mm; the largest diameter: 0.27–0.35mm.

Distribution. S France: Sinemurian–Pliensbachian; Germany (Bayern): Pliensbachian; Germany (Württemberg): Hettangian, Toarcian; Morocco: Sinemurian–Pliensbachian.

Pseudonodosaria quinquecostata (BORNEMANN, 1854)
Pl. 3, Fig. 9

1854 *Glandulina quinquecostata* m.; BORNEMANN, p. 32, pl. 2, figs 6a, b.
1936 *Glandulina quinquecostata* BORN.; FRANKE, p. 58, pl. 5, fig. 25a–b, 26a–b.

Material. 4 specimens.

Description. Test egg-shaped consists of 3 to 4 chambers; quinquangular in cross-section; proloculus sharpened; aperture terminal, radiate and produced on a short neck; surface ornamented with 5 strong, rounded and longitudinal ribs.

Remarks. This species differs from *P. sexcostata* BORNEMANN in less, but broad and rounded ribs.

Dimensions. Height: 0.41–0.46; the largest diameter: 0.22–0.24mm. Distribution. Germany (Göttingen): Lower Pliensbachian (Davoei Zone); Germany (Bayern): Upper Pliensbachian.

Pseudonodosaria sexcostata (BORNEMANN, 1854)
Pl. 3, Fig. 10

1854 *Glandulina sexcostata* m.; BORNEMANN, p. 32, pl. 2, figs 7a–b.
1936 *Glandulina sexcostata* BORN.; FRANKE, p. 58, pl. 6, figs 1a–b, 2a–b.
1963 *Rectoglandulina sexcostata* (BORNEMANN 1854); RABITZ, p. 207, pl. 17, fig. 29.
1984 *Pseudonodosaria sexcostata* (BORNEMANN, 1854); RIEGRAF et al., p. 686, pl. 1, fig. 32.

Material. 5 specimens.

Description. Test spindle-shaped, consists of 3 chambers; first chamber apiculate; sutures indistinct, sometimes slightly depressed; aperture round and elevated; surface ornamented with 6 thin, sharp and longitudinal ribs.

Remarks. The most characteristic features of this species are the spindle-like test-shape and the six longitudinal ribs.

Dimensions. Height: 0.31–0.42mm; the largest diameter: 0.22–0.25mm.

Distribution. Germany (Göttingen): Lower Pliensbachian (Davoei Zone); Germany (Bayern): Upper Pliensbachian; Germany (Hannover): Lower Pliensbachian; Morocco: Sinemurian–Pliensbachian.

Subfamily Plectofrondiculariinae CUSHMAN, 1927.
Genus *Berthelinella* LOEBLICH & TAPPAN, 1957

Berthelinella paradoxa (BERTHELIN, 1879)
Pl. 3, Fig. 11

1908 *Frondicularia paradoxa* BERTHELIN; ISSLER, p. 57, pl. 3, figs 119–121.
1936 *Flabellina paradoxa* (BERTH.); FRANKE, p. 91, pl. 9, figs, 10–11.
1937 *Flabellina paradoxa* (BERTHELIN, 1879); BARTENSTEIN & BRAND, p. 168. pl. 4, figs 63a–e.
1961 *Berthelinella paradoxa* (BERTHELIN 1879); PIETRZENUK, p. 83, pl. 4, figs 14–15.
1970 *Berthelinella paradoxa* (BERTHELIN, 1879); FUCHS, p. 110, pl. 8, fig. 7.
1984 *Frondicularia paradoxa* BERTHELIN, 1879; RIEGRAF, pl. 684, pl. 6, figs 150–151.
1985 *Berthelinella paradoxa* (BERTHELIN, 1879); RUGET, p. 64, 67, 68, 144, pl. 21, figs 6, 8, 10; pl. 36, fig. 13.

Material. 6 specimens.

Description. Test elliptical, consists of 6 to 10 chambers; compressed and slightly deepened along the longitudinal axis; periphery subacute or acute; proloculus oval and followed by 2 or 3 pairs of biserially arranged chambers; later chambers uniserial and chevron-shaped; sutures slightly raised above the surface; aperture slit-like and terminal; surface smooth.

Remarks. The sutures can be more or less elevated.

Dimensions. Height: 0.43–0.55mm; the largest diameter: 0.31–0.40mm; thickness: 0.06–0.08 mm.

Distribution. Lower Austria (Hernstein): lowermost Jurassic; France (Nancy): Upper Sinemurian; NW Germany: Lower Pliensbachian; Germany (Württemberg): Hettangian–Lower Pliensbacian; Germany (Völpke): Upper Sinemurian; Germany (Dobbertin): Upper Pliensbachian; Portugal (Coimbra): Lower Pliensbachian (Jamesoni Zone); Morocco (DSDP): Sinemurian–Pliensbachian.

Subfamily Lenticulininae
CHAPMAN, PARR & COLLINS, 1934
Genus *Lenticulina* LAMARCK, 1804

Lenticulina acutiangulata (TERQUEM, 1863)
Pl. 3, Fig. 12

1863 *Robulina acutiangulata*, TERQ.; TERQUEM, p. 220, pl. 10, fig. 20, a; b. 1936. *Cristellaria (Lenticulina)* *acutiangulata* (TERQ.); FRANKE, p. 117, pl. 11, fig. 25.
1937 *Cristellaria (Lenticulina) acutiangulata* (TERQUEM, 1864); BARTENSTEIN & BRAND, p. 175, pl. 5, figs 52a–d.
1961 *Lenticulina (Lenticulina) acutiangulata* (TERQUEM 1864); PIETRZENUK, p. 63, pl. 5, figs 1a–b.
1968 *Lenticulina muensteri acutiangulata* (TERQUEM, 1863); Welzel, p. 43, pl. 2, fig. 29.
1975 *Lenticulina acutiangulata* (TERQUEM, 1864); JENDRYKA-FUGLEWICZ, p. 135, pl. 2, figs 4–6.

Material. 4 specimens.

Description. Test lenticular in shape; periphery keeled; 7 to 8 chambers on the last whorl; sutures distinct, flush and gently arcuate; aperture radiate, terminal and peripheral; surface smooth.

Remarks. JENDRYKA-FUGLEWICZ (1975) dealt with this species in detail. This species differs from *L. gottingensis* BORNEMANN only in its keeled periphery.

Dimensions. Diameter: 0.41–0.48mm.

Distribution. S France: Lower Pliensbachian (Davoei Zone); NW Germany: Pliensbachian; S Germany: Pliensbachian–Toarcian; Poland: Pliensbachian–Toarcian.

Lenticulina gottingensis (BORNEMANN, 1854)
Pl. 3, Fig. 13–14

1854 *Robulina Gottingensis* m.; BORNEMANN, p. 43, pl. 4, figs 40a, b; 41a–b.
1908 *Cristellaria rotulata* LAMARCK; ISSLER, p. 87, pl. 7, figs 311–315.
1936 *Cristellaria (Lenticulina) gottingensis* (BORNEMANN, 1854); FRANKE, p. 116, pl. 11, fig. 22a–b.
1937 *Cristellaria (Lenticulina) münsteri* (ROEMER); BARTENSTEIN & BRAND, p. 174, pl. 3, fig. 30, pl. 4, fig. 69.
1963 *Lenticulina gottingensis gottingensis* (BORNEMANN 1854); RABITZ, p. 202, pl. 16, fig. 4.
1975 *Lenticulina gottingensis* (BORNEMANN, 1854); JENDRYKA-FUGLEWICZ, p. 129, pl. 1; pl. 2, fig. 3; pl. 3, figs 1–4.
1984 *Lenticulina gottingensis* (BORNEMANN, 1854); RIEGRAF et al., p. 684, pl. 6, fig. 159.

Material. 94 specimens.

Description. Test planispiral, nearly round in outline, slightly biconvex; periphery acute; 7 to 9 chambers are on the final whorl; sutures distinct, flush, gently arcuate; aperture radiate, terminal and peripheral; surface smooth.

Remarks. JENDRYKA-FUGLEWICZ (1975) dealt with the variability of this species in detail.

Dimensions. Diameter: 0.23–0.73mm; thickness: 0.24--0.36mm. .

Distribution. Germany (Hannover, Gõttingen): Pliensbachian; Germany (Bayern): Upper Pliensbachian; Germany (Württemberg): Lower Pliensbachian, Upper Toarcian; Poland: Pliensbachian; Morocco (DSDP): Sinemurian–Pliensbachian.

Lenticulina polygonata (FRANKE, 1936)
Pl. 3, Fig. 15

1908 *Cristellaria rotulata* LAMARCK; ISSLER, p. 87, pl. 7, figs 316.
1936 *Cristellaria (Lenticulina) polygonata* n. sp.; FRANKE, p. 118, pl. 12, figs 1a–b; 2a–b.
1964 *Lenticulina polygonata* (FRANKE); BARBIERI, p. 758, pl. 57, fig. 13.
1968 *Lenticulina muensteri polygonata* (FRANKE, 1936); WELZEL, p. 42, pl. 2, fig. 38.
1975 *Lenticulina polygonata* (FRANKE, 1936); JENDRYKA--FUGLEWICZ, p. 136, pl. 2, figs 7–8.
1984 *Lenticulina polygonata* (FRANKE, 1936); RIEGRAF et al., p. 685, pl. 1, fig. 23.
pars 1985 *Lenticulina polygonata* (FRANKE, 1937) mg *Lenticulina;* RUGET, p. 64, 73, 77, 83, pl. 32, fig. 1, non 2.

Material. 16 specimens.

Description. Test planispirally coiled, biconvex; polygonal in outline; periphery acute; 7 to 10 chambers on the final whorl; sutures slightly deflected posteriorly and somewhat elevated; aperture radiate, terminal and peripheral; surface smooth.

Remarks. This species differs from *L. gottingensis* (BORNEMANN) in its polygonal outline and elevated, nearly straight sutures.

Dimensions. Diameter: 0.43–0.71mm; thickness: 0.16--0.24mm.

Distribution. Germany (Hannover, Thüringen): Pliensbachian; Germany (Bayern): Upper Toarcian; S Germany: Upper Pliensbachian; Morocco (DSDP): Sinemurian–Pliensbachian; Poland: Pliensbachian–Toarcian; Portugal (Coimbra): Lower Pliensbachian; Sicily: Upper Pliensbachian–Lower Bajocian.

Lenticulina rustica (D'ORBIGNY, 1849)
Pl. 3, Fig. 16

1849 *Cristellaria rustica, d'Orb.;* D'ORBIGNY, p. 242, Nr. 268.
1854 *Robulina nautiloides* m.; BORNEMANN, p. 43, pl. 4, figs 42a–b.
1858 *Cristellaria rustica* D'ORB.; TERQUEM, p. 623, pl. 3, fig. 19a, b.
1936 *Cristellaria (Lenticulina) rustica* (D'ORBIGNY, 1850); FRANKE, p. 115, pl. 11, figs 23a–b.
1963 *Lenticulina (Robulina) rustica* (D'ORBIGNY, 1849); RABITZ, p. 203, pl. 16, fig. 7.
1968 *Lenticulina muensteri rustica* (D'ORBIGNY, 1850); WELZEL, p. 42, pl. 2, fig. 31.

Material. 3 specimens.

Description. Test planispiral, flattened; periphery subacute; 8 to 10 chambers on the final whorl; inner part of the last 2 or 3 chambers do not reach the umbilicus; sutures distinct, slightly arcaute and deepened at the younger part of the test; umbilicus depressed; aperture radiate and peripheral; surface smooth.

Remarks. The most distinctive features of this species are the deepened umbilicus and the nearly parallel-sided test-shape.

Dimensions. The largest diameter: 0.42–0.48mm; thickness: 0.24–0.26mm.

Distribution. S France: Lower Jurassic; N Germany (Hannover): Upper Sinemurian–Upper Pliensbachian; Germany (Württemberg): Pliensbachian–Toarcian; Germany (Bayern): Upper Pliensbachian.

Genus *Saracenaria* DEFRANCE, 1824

Saracenaria sublaevis (FRANKE, 1936)
Pl. 4, Fig. 1

1936 *Cristellaria (Saracenaria) sublaevis* n. sp.; FRANKE, p. 98, pl. 9, figs 30–31.
1937 *Cristellaria (Saracenaria) sublaevis* FRANKE, 1936; BARTENSTEIN & BRAND, p. 170, pl. 5, figs 59a–b.
1961 *Saracenaria sublaevis* (FRANKE, 1936); PIETRZENUK, p. 69, pl. 5, figs 7a–b.
1968 *Saracenaria sublaevis sublaevis* (FRANKE, 1936); WELZEL, p. 49, pl. 2, fig. 51.
1978 *Saracenaria sublaevis* (FRANKE, 1936); PJATKOVA & PERMJAKOVA, p. 89, pl. 30, figs 4a–b.
1981 *Saracenaria sublaevis sublaevis* (FRANKE); COPESTAKE & JOHNSON, p. 98, pl. 6.1.4, fig. 6.
1985 *Lenticulina sublaevis* (FRANKE, 1936) mg *Saracenaria;* RUGET, p. 75, 76, 77, 86, pl. 36, fig. 11.

Material. 2 specimens.

Description. The coiled initial part consists of 4–5 chambers, which followed by an uncoiled portion of 3–4 chambers; nearly triangular in cross-section; periphery subangular; ventral surface slightly convex; aperture is situated on a protruding part of the last chamber; surface smooth.

Remarks. Specimens from Szentgál differ from specimens of FRANKE (1936) in more inflated last chamber.

Dimensions. Height: 0.37–0.41mm; the largest diameter: 0.21–23mm.

Distribution. Britain: Hettangian–Lower Toarcian; N Germany (Hannover): Hettangian; Germany (Dobbertin, Bayern, Württemberg): Upper Pliensbachian; S Germany: Upper Toarcian; Portugal (Murtade): Upper Pliensbachian–Toarcian; Ukraine: Oxfordian.

Subfamily Marginulininae WEDEKIND, 1937

Genus *Astacolus* DE MONTFORT, 1808

Astacolus varians (BORNEMANN, 1854)
Pl. 4, Figs 2–3

1854 *Cristellaria varians* m.; BORNEMANN, p. 41, pl. 4, fig. 32–34a–c.
1854 *Cristellaria granulata* m.; BORNEMANN, p. 41, pl. 4, fig. 36a, b.
1908 *Cristellaria varians* BORNEMANN; ISSLER, p. 86, pl. 6, fig. 306–310; pl. 7, figs 308, 310.
1963 *Lenticulina (Astacolus) varians* (BORNEMANN 1854); RABITZ, p. 203, pl. 16, figs 1–3, 6.
1968 *Lenticulina varians varians* (BORNEMANN, 1854); WELZEL, p. 43, pl. 2, figs 32–33.
1981 *Astacolus varians* (BORNEMANN, 1854); RIEGRAF et al., p. 683, pl. 6, fig. 169.
1995 *Astacolus varians* (BORNEMANN, 1854); GÖRÖG, p. 58, pl. 8, fig. 4. cum. syn.

Material. 25 specimens.

Description. Test planispiral, oval in outline, somewhat biconvex; periphery acute, sometimes keeled on the spiral part of the test; initial portion planispirally coiled, the final 1 or 2 chambers elongated and uncoiled; 7 to 10 chambers are on the last whorl; sutures distinct, flush, arcuate on the spiral portion, nearly straight on the uncoiled portion; aperture radiate, terminal and peripheral; surface smooth.

Dimensions. The largest diameter: 0.58–1.12 mm; thickness: 0.12–0.16 mm.

Remarks. According to WELZEL (1968, pl. 2, fig. 33) and JENDRYKA-FUGLEWICZ (1975) sutures sometimes elevated and thickened, like on Plate 4, fig. 3.

Distribution. England: Middle Callovian–Lower Oxfordian; NW Germany: upper part of the Lower Jurassic–Oxfordian; Germany (Göttingen): Upper Hettangian–Lower Pliensbachian (Davoei Zone); Germany (Völpke, Apfelstädt, Stollenhalde am Grossen Seeberg): Upper Sinemurian); Germany (Völpke, Halberstadt): Hettangian; Germany (Dobbertin): Upper Pliensbachian; Hungary (Mecsek Mts): Lower and lower part of the Middle Bathonian; Morocco (DSDP): Sinemurian–Pliensbacian; Poland: Lower Jurassic, Malm; Russia: Upper Bajocian; Ukraine: Upper Bajocian–Lower Bathonian, Lower Callovian.

Astacolus vetusta (D'ORBIGNY, 1849)
Pl. 4, Fig. 4

1849 *Cristellaria vetusta* D'ORB., 1849; D'ORBIGNY, p. 242, No. 267.
1858 *Cristellaria vetusta* TERQUEM; TERQUEM, p. 622, pl. 3, figs 17a–d.
1970 *Lenticulina (Vaginulinposis) vetusta* (ORBIGNY, 1850); FUCHS, p. 101, pl. 5, fig. 16.
1985 *Lenticulina vetusta* (D'ORBIGNY, 1849) mg *Marginulinopsis;* RUGET, p. 65, 67, 74, 77, 143; pl. 20, figs 8, 10, pl. 34, figs 2, 3, 5, 10, 12, 13.
1995 *Astacolus vetusta* (D'ORBIGNY, 1849); GÖRÖG, p. 59. pl. 8, fig. 5.

Material. 2 specimens.

Description. Test elongated; early portion coiled later uncoiled and rectilinear; periphery rounded; oval in cross-section; 4 to 6 coiled chambers rapidly increasing in size as added, the 5 uniserial ones nearly uniform in size; sutures distinct, oblique and arcaute; sutures slightly depressed on the coiled portion and depressed on the younger portion of the test; aperture radiate, at the dorsal angle; surface smooth.

Dimensions. Height: 0.51–0.62 mm; breadth of uncoiled portion: 0.17–0.19 mm; thickness: 0.11–0.13 mm.

Distribution. Lower Austria (Hernstein): lowermost Jurassic; France: Lower Sinemurian–Lower Pliensbachian; NW Germany: Lower Jurassic–Middle Jurassic; S Germany: Lower Jurassic–lower part of the Upper Jurassic; Hungary (Mecsek Mts): Bathonian; Central Poland: Kimmeridgian; S Poland: Bathonian;

Portugal (Coimbra): Lower Pliensbachian (Davoei Zone).

Genus *Marginulina* D'ORBIGNY, 1826

Marginulina prima D'ORBIGNY, 1849
Pl. 4, Figs 5–6

1849 *Marginulina prima*, D'ORB; D'ORBIGNY, p. 242, No. 262.
1858 *Marginulina prima*, D'ORB. var. *gibbosa* TERQ.; TERQUEM, p. 612, pl. 3, figs 5a–d.
1858 *Marginulina alata*, TERQ.; TERQUEM, p. 615, pl. 3, figs 9a–b.
1858 *Marginulina ornata*, TERQ.; TERQUEM, p. 616, pl. 3, figs 10a–c.
1863 *Marginulina burgundiae*, TERQ.; TERQUEM, p. 196, pl. 9, figs 3a–d.
1875 *Marginulina gibberula*, TERQ. et BERTH.; TERQUEM & BERTHELIN, p. 55, pl. 4, fig. 21a–b.
1908 *Marginulina burgundiae* TERQUEM; ISSLER, p. 67, pl. 4, figs 171–174.
1936 *Marginulina prima* D'ORB.; FRANKE, p. 76, pl. 8, fig. 1–7. 1936. *Marginulina burgundie* TERQ.; FRANKE, p. 78, pl. 8, fig. 8.
1936 *Dentalina insignis* n. sp.; FRANKE, p. 36, pl. 3, fig. 11a–b.
1937 *Marginulina prima* D'ORBIGNY; BARTENSTEIN & BRAND, p. 161, pl. pl. 2B, fig. 26; pl. 3, figs 39–40; pl. 4, figs 60a–b; pl. 5, figs 46a–b.
1937 *Marginulina burgundiae* TERQUEM; BARTENSTEIN & BRAND, p. 161, pl. 4, fig. 58.
1950 *Marginulina prima* D'ORBIGNY; BARNARD, p. 372, figs 5a–b, g.
1961 *Marginulina prima* D'ORBIGNY 1849; PIETRZENUK, p. 73, pl. 7, figs 1–9.
1964 *Marginulina prima* D'ORBIGNY; BARBIERI, p. 767, pl. 59, fig. 6.
1968 *Marginulina prima prima* D'ORBIGNY, 1850; WELZEL, p. 32, pl. 2, figs 10–12.
1970 *Marginulina prima* D'ORBIGNY, 1850; FUCHS, p. 101, pl. 6, fig. 10; pl. 8, fig. 9.
1981 *Marginulina prima* D'ORBIGNY, 1850; RIEGRAF, p. 685, pl. 6, figs 162–163.
1985 *Marginulina burgundiae* TERQUEM, 1863; RUGET, p. 58, 66, 67, 75, 77, pl. 21, fig. 3; pl. 37, figs 7, 15; pl. 38, figs 9, 20.
1985 *Marginulina prima* D'ORBIGNY, 1849; RUGET, p. 58, 66, 67, 75, 77, 84, 86, 143, 144, 146, pl. 21, figs 4–5; pl. 31, figs 16, 18; pl. 37, figs 5–6, 8, 10, 12–14, 16–18; pl. 38, figs 4, 10, 12–17, 19, 21, 23; pl.39, fig. 12.

Material. 8 specimens.

Description. Test elongated, usually slightly curved and consists of 5 to 8 chambers; round in cross-section; proloculus rounded, or sometimes somewhat sharpened; sutures flush or slightly depressed; aperture round, nearly central to peripheral and produced on a short neck; surface ornamented with 6 to 12 longitudinal costae.

Remarks. WELZEL (1968) dealt with trimorphizm of this species in detailed. Variability size of the proloculus, number of costae, deepening of sutures and the position of the aperture. Specimens from Szentgál have nearly flush sutures.

Dimensions. Height: 0.40–0.81mm; the largest diameter 0.20–0.35mm.

Distribution. Lower Austria (Hernstein): lowermost Jurassic; S England (Dorset): Lower Sinemurian; W Europe (according to RUGET, 1985): Upper Sinemurian–lowermost Toarcian; Central France: Upper Sinemurian–Upper Pliensbachian; S France: Lower Pliensbachian (Davoei Zone); S Germany: Upper Pliensbachian; Germany (Württemberg): Hettangian; N Germany: Upper Pliensbachian; NW Germany: Hettangian–Pliensbacian; Portugal (Coimbra): Lower Pliensbachian–Upper Pliensbachian (Margaritatus Zone); Morocco (DSDP): Sinemurian–Pliensbachian; Sicily: Lower Toarcian.

Family Lagenidae REUSS, 1862
Genus *Lagena* WALKER & JAKOB, 1798

Lagena costata (WILLIAMSON, 1858)
Pl. 4, Fig. 7

1858 *Entosolenia costata* (n. sp.); WILLIAMSON, p. 9, pl. 1, fig. 18.
1978 *Lagena costata* (WILLIAMSON, 1858); PJATKOVA & PERMJAKOVA, p. 45, pl. 13, fig. 11.

Material. 4 specimens.

Description. Test consists of a ovoid chamber; round in cross-section; aperture small, round and terminal; surface covered by 11 to 12 longitudinal ribs.

Remarks. The most distinctive features of this species is the surface ornamentation.

Dimensions. Height: 0.40–0.42mm; the largest diameter: 0.32–34mm.

Distribution. Lower Jurassic–Recent. SSSR: Lower Jurassic.

Lagena vulgaris WILLIAMSON, 1858
Pl. 4, Fig. 8

1858 *Lagena vulgaris typica* (n. ssp.); WILLIAMSON, p. 4, pl. 1, fig. 5, 5a.
1875 *Lagena vulgaris* WILLIAMSON; TERQUEM et BERTHELIN, p. 13, figs 6a–b.
1995 *Lagena vulgaris* WILLIAMSON, 1858; GÖRÖG, p. 67, pl. 9, fig. 10. cum. syn.

Material. 3 specimens.

Description. Test consists of a nearly globular chamber; round to oval in cross-section; aperture small round and protruding on short conical neck; surface smooth.

Dimensions. Diameter: 0.28–0.33mm.

Distribution. England: S France: Lower Jurassic–Middle Jurassic; Germany: upper part of the Lower Jurassic; Hungary (Mecsek Mts): Bathonian; S Poland: Bathonian.

Family Polymorphinidea D'ORBIGNY, 1839
Subfamily Polymorphininae D'ORBIGNY, 1839
Genus *Eoguttulina* CUSHMAN & OZAWA, 1930

Eoguttulina szentgali n. sp.
Pl. 4, Figs 8–9

Derivatio nominis: After Szentgál, the type locality.
Locus typicus: 11 layers of T–I section on Tűzköves Hill, Szentgál, Bakony Mts, Hungary.
Stratum typicum: Lower Pliensbachian, Jamesoni–Ibex Zone.
Holotype: Plate 4, Figure 9.
Paratype: Plate 4, Figure 10.
Material. 5 specimens.
Diagnosis. Test rhomboid in side-view and subtriangular in cross-section; aperture radial.
Description. Test rhomboid in side-view and subtriangular in cross-section; tapered at both ends; subtriangular in cross-section; periphery rounded; 3 or 4 chambers are visible; sutures indistinct, more or less depressed; aperture radial; surface smooth.
Remarks. This species differs from the other Jurassic species of genus *Eoguttulina* in very broad and squat test-shape.
Dimensions. Height: 0.37–0.41 mm; breadth: 0.32–0.34 mm; thickness: 0.19–0.23mm.

Subordo Rotaliina DELAGE & HÉROUARD, 1896
Superfamily Ceratobuliminacea CUSHMAN, 1927
Family Epistominidae WEDEKIND, 1937
Subfamily Reinholdellinae SEIGLIE & BERMÚDEZ, 1965
Genus *Reinholdella* BROTZEN, 1948

Reinholdella margarita (TERQUEM, 1866b)
Pl. 4, Figs 11–12

1866b *Rotalina margarita* TERQ.; TERQUEM, p. 522, pl. 22, figs 20–22.
1981 *Reinholdella margarita* (TERQUEM); COPESTAKE & JOHNSON, p. 102, pl. 6.1.5, fig. 13.

Material. 2 specimens.
Description. Test trochospiral, biconvex; periphery acute; Spiral side: 7 or 8 chambers on the final whorl; elevated spiral and septal sutures. Umbilical side: 5 to 6 chamber visible; sutures depressed; open and crater-like umbilicus; aperture interiomarginal. Surface smooth.
Remarks. The *R. macfadyeni* (TEN DAM) emend. HOFKER differs from this species in its less convex test-shape, less elevated sutures and closed umbilicus.
Dimensions. The largest diameter: 0.27–0.34mm; thickness: 0.12–0.16mm.
Distribution. Britain: Lower Sinemurian (Semicostatum Zone)–Upper Sinemurian (early Obtusum Zone); S France: lowermost Jurassic.

Family Epistominidae WEDEKIND, 1937
Genus *Epistomina* WEDEKIND, 1937

Epistomina? sp.
Pl. 4, Figs 13–14

Material. 4 specimens.
Description. Test low trochospiral, planoconvex; periphery rounded and sligtly lobulate; chambers gradually increasing in size; arrenged in 2 whorls on the spiral side; umbilicus flush; sutures slightly curved and somewhat depressed; aperture oval and peripheral, situated on the umbilical side; surface smooth.
Dimensions. The largest diameter: 0.25–0.41mm; thickness: 0.07–0.12 mm.

Foraminifera incertae sedis

"Placentula" pictonica (BERTHELIN, 1879)
Pl. 4, Figs 15–16

1981 *"Placentula" pictonica* (BERTHELIN); COPESTAKE & JOHNSON, p. 100, pl. 6.1.5, figs 2, 3.

Material. 24 specimens.
Description. Test low conical, trochospirally coiled, 4 to 6 chambers per whorl; periphery sharp. Dorsal side: sharp spiral line run along the chambers, giving a distinct step-like appearence in side view, there is a small apical depression; sutures indistinct. Ventral side: umbilicus flush or slightly convex, with numerous curved growth lines radiate from the umbilicus to the ventral side.
Remarks. Specimens of Szentgál show a very good resemblance to specimens of Copestake and Johnson (1981).
Dimensions. Height: 0.19–0.24mm; diameter: 0.23–0.31mm.
Distribution. Britain: Upper Sinemurian (Raricostatum Zone)–Upper Pliensbacian (Spinatum Zone).

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Plate 1

Fig. 1. *Ammodiscoides*? *clypeiformis* (FRENTZEN, 1941), spiral side. 200×
Fig. 2. *Ammodiscoides*? *clypeiformis* (FRENTZEN, 1941), umbilical side. 160×
Fig. 3. *Ammodiscus siliceus* (TERQUEM, 1862), side view. 80×
Fig. 4. *Verneuilinoides mauritii* (TERQUEM, 1866a), oblique umbilical view. 240×
Fig. 5. *Involutina liassica* (JONES, 1853), oblique side view. 160×
Fig. 6. *Trocholina granosa* FRENTZEN, 1941, umbilical side. 100×
Fig. 7. *Trocholina granosa* FRENTZEN, 1941, spiral side. 120×
Fig. 8. *Ichthyolaria brizaeformis* (BORNEMANN, 1854), side view. 110×
Fig. 9. *Ichthyolaria brizaeformis* (BORNEMANN, 1854), side view. 90×
Fig. 10. *Ichthyolaria major* (BORNEMANN, 1854), side view. 100×
Fig. 11. *Ichthyolaria nitida* (TERQUEM, 1858), side view. 100×

Plate 2

Fig. 1. *Ichthyolaria sulcata* (BORNEMANN, 1854), side view of a microspherical specimen. 90×
Fig. 2. *Ichthyolaria sulcata* (BORNEMANN, 1854), side view of a macrospherical specimen. 140×
Fig. 3. *Ichthyolaria tenera* (BORNEMANN, 1854), side view of a "tenera" type specimen 70×
Fig. 4. *Ichthyolaria tenera* (BORNEMANN, 1854), side view of a "pupa" type specimen. 100×
Fig. 5. *Ichthyolaria tenera* (BORNEMANN, 1854), side view of a "carinata" type specimen. 110×
Fig. 6. *Ichthyolaria testudinaria* (FRANKE, 1936), side view. 100×
Fig. 7. *Ichthyolaria testudinaria* (FRANKE, 1936), apertural view. 120×
Fig. 8. *Dentalina doliolum* TERQUEM & BERTHELIN, 1875, side view. 80×
Fig. 9. *Dentalina* aff. *notabilis* TERQUEM & BERTHELIN, 1875, side view. 70×
Fig. 10. *Dentalina pseudocommunis* FRANKE, 1936, side view. 70×
Fig. 11. *Nodosaria* cf. *caudata* FRENTZEN, 1941, sligthly oblique side view. 70×
Fig. 12. *Nodosaria columnaris* FRANKE, 1936, side view. 80×
Fig. 13. *Nodosaria dispar* FRANKE, 1936, side view. 110×
Fig. 14. *Nodosaria hemimorpha* FRENTZEN, 1941, slightly oblique view of a rectangular specimen. 75×
Fig. 15. *Nodosaria hemimorpha* FRENTZEN, 1941, side view of a quinquangular specimen. 90×
Fig. 16. *Nodosaria* aff. *kuhni* FRANKE, 1936, side view. 100×
Fig. 17. *Nodosaria laevigata* FRENTZEN, 1941, side view. 80×
Fig. 18. *Nodosaria mitis* (TERQUEM & BERTHELIN, 1875), side view. 40×
Fig. 19. *Nodosaria procera* FRANKE, 1936, slightly oblique view. 80×
Fig. 20. *Nodosaria regularis* TERQUEM, 1862, side view. 100×

Plate 3

Fig. 1. *Nodosaria szentei* n. sp., side view of the holotype. 75×
Fig. 2. *Nodosaria szentei* n. sp., side view of paratype. 110×
Fig. 3. *Nodosaria szentei* n. sp., side view of paratype. 50×
Fig. 4. *Nodosaria szentgali* n. sp., side view of the holotype 50×
Fig. 5. *Pseudonodosaria baconica* n. sp., side view of the holotype 140×
Fig. 6. *Pseudonodosaria cincta* (FRENTZEN, 1941), side view. 130×
Fig. 7. *Pseudonodosaria monostorii* n. sp., side view of the holotype 160×
Fig. 8. *Pseudonodosaria pygmea* (TERQUEM, 1866b), side view. 80×
Fig. 9. *Pseudonodosaria quinquecostata* (BORNEMANN, 1854), side view. 70×
Fig. 10. *Pseudonodosaria sexcostata* (BORNEMANN, 1854), side view. 100×
Fig. 11. *Berthelinella paradoxa* (BERTHELIN, 1879), side view. 85×
Fig. 12. *Lenticulina acutiangulata* (TERQUEM, 1863), side view. 75×
Fig. 13. *Lenticulina gottingensis* (BORNEMANN, 1854), slightly oblique view. 100×
Fig. 14. *Lenticulina gottingensis* (BORNEMANN, 1854), apertural view. 120×
Fig. 15. *Lenticulina polygonata* (FRANKE, 1936), slightly oblique view. 100×
Fig. 16. *Lenticulina rustica* (D'ORBIGNY, 1849), slightly oblique view. 130×

Plate 4

Fig. 1. *Saracenaria sublaevis* (FRANKE, 1936), slightly oblique view. 120×
Fig. 2. *Astacolus varians* (BORNEMANN, 1854), slightly oblique view. 115×
Fig. 3. *Astacolus varians* (BORNEMANN, 1854), side view. 100×
Fig. 4. *Astacolus vetusta* (D'ORBIGNY, 1849), side view. 80×
Fig. 5. *Marginulina prima* D'ORBIGNY, 1849, side view of "gibberula" type specimen. 80×
Fig. 6. *Marginulina prima* D'ORBIGNY, 1849, slightly oblique view. 90×
Fig. 7. *Lagena costata* (WILLIAMSON, 1858), side view. 65×
Fig. 8. *Lagena vulgaris* WILLIAMSON, 1858, side view. 60×
Fig. 9. *Eoguttulina szentgali* n. sp., side view of holotype. 120×
Fig. 10. *Eoguttulina szentgali* n. sp., apertural view of paratype. 150×
Fig. 11. *Reinholdella margarita* (TERQUEM, 1866b), slightly oblique view of the spiral side. 120×
Fig. 12. *Reinholdella margarita* (TERQUEM, 1866b), slightly oblique view of the umbilical side. 110×
Fig. 13. *Epistomina*? sp., spiral side. 150×
Fig. 14. *Epistomina*? sp., ventral side. 130×
Fig. 15. *"Placentula" pictonica* (BERTHELIN, 1879), spiral side. 160×
Fig. 16. *"Placentula" pictonica* (BERTHELIN, 1879), umbilical side. 170×

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Preliminary notes on Early and Middle Jurassic corals of the Bakony Mountains (Hungary)

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(with 9 figures and Plate 5)

Abstract

Hettangian, Pliensbachian and Bajocian corals were examined from 6 localities of the Bakony Mountains. All of the suborders existed in Early and Middle Jurassic are present in the 80 specimens. The determined 6 genera belong to 4 suborders. 88% of the fauna is derived from the Domerian formations, but the number of taxa are nearly equal in Carixian, Domerian and Bajocian. Four genera appeared earlier in the Bakony Mountains, than in other areas.

Seventy-seven specimens belong to solitary corals, and only 3 specimens are colonial. Two-third of the fauna is hermatypic at the Pliensbachian localities, but at the same time 80% of the specimens are ahermatypic in Bajocian. Fissures of seamounts and the edge of a seamount are represented at these localities. This means, that the top of the seamounts were not sinking below the depth of 100 m during the Pliensbachian, but it may have been below 100 m in Bajocian. The elongated morphotypes of corals stabilized themselves by root-like fixation, or the specimens had to be sunk in the loose sediments. Because the loose sediments were rare at the top of seamounts, the corals are sometimes overturned (scolecoid specimens).

Key words: Early Jurassic, Middle Jurassic, coral, Scleractinia, Bakony, Hungary, paleoecology

Introduction

The Jurassic fossils of the Transdanubian Central Range are examined in most detail perhaps in the Mediterranean region. Ammonites, brachiopods, gastropods and bivalves are studied for a long time up to the present. At the same time some fossil groups are in very neglected position. Corals belong to these groups, therefore data of Jurassic corals from Hungary are almost completely missing though they (mostly solitary but sometimes colonial) sporadically but regularly can be found in the Jurassic sediments of the Transdanubian Central Range, both in the Bakony and the Gerecse Mountains.

In spite of this fact only some data can be seen about Hungarian Jurassic corals in the literature. KOCH (1909) mentioned *Trochocyathus truncatus* ZITTEL from the Tithonian beds of Tata, Kálvária Hill. FÜLÖP et al. (1960) figured a section of a solitary coral from the Tithonian formations of Vértes Mountains (Mór, Csókahegy). The only one publication, which dealt with corals in detail is by KOLOSVÁRY (1954), who described 23 taxa (including a new genus, 4 new species and 2 new subspecies) from 7 localities.

Jurassic corals are similarly poorly known in the other areas of the Mediterranean region. There is a profuse literature on European reef-forming corals (mainly in the Upper Jurassic) but at the same time we have only sparse data about deeper-water ahermatypic solitary corals. Some solitary corals can be found in monographs of the last century, which essentially were written about other fossil groups. Some attempts were made on the examination of Jurassic (Bajocian, Kimmeridgian, Tithonian) corals in Italy in the last few decades (NICOSIA & PALLINI, 1977; MARIOTTI et al., 1979a–b).

The author was commissioned to examine the Jurassic corals within the framework of a scientific research program on Jurassic benthic fossils of the Transdanubian Central Range (OTKA No. T.4431, leader: János SZABÓ). The studied material consists of about 200 specimens (of this 80 specimens are from Early and Middle Jurassic), which are derived from the collections of the Hungarian Geological Survey, the Hungarian Natural History Museum and from the collections of some colleagues, who work on Jurassic fossils (I. FŐZY, J. SZABÓ, A. VÖRÖS, I. SZENTE, A. GALÁCZ). Unfortunately the type specimens of the new taxa described by KOLOSVÁRY (1954) and some other described specimens are missing from the collection of Hungarian Geological Survey.

The preliminary results of the examination of Early and Middle Jurassic corals of the Bakony Mountains are given in this article. For lack of adequate literature and previous experience on corals, the determinations are given at generic level, mainly on the basis of external morphological characters of the specimens. The correspondence with genera known from WELLS (1956) is sometimes uncertain. This fact permits the supposition that the examined material contains not only new species but probably new genera, too. Further examination is required to the exact and detailed description. Therefore this paper can be regarded as a preliminary report and it will be followed by other publications.

The importance of the fauna is increased by the fact that in most cases the corals were collected with ammonites, so the exact ages of the specimens are known.

Localities

The corals were collected from 6 localities of the Bakony Mountains (Fig. 1). The localities from north to south are the following.

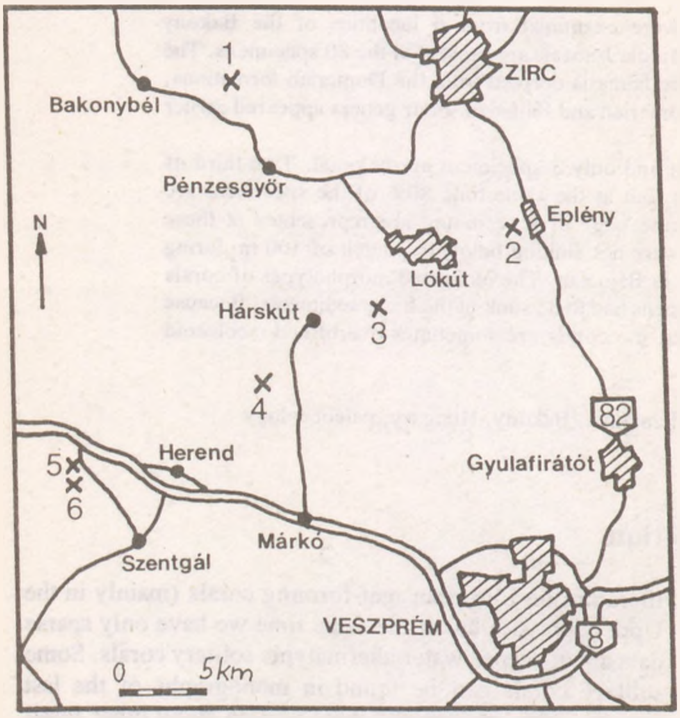

Fig. 1. Sketch-map of the localities of the studied corals in the Bakony Mountains.

Bakonybél, Somhegy

Somhegy Hill is situated east of the village Bakonybél, on the northern side of the Bakonybél–Pénzesgyőr road. The locality was described in detail by GALÁCZ (1976). The highly condensed sequence was deposited in a seamount area. Within the Hettangian Dachsteinkalk-type Kardosrét Limestone there is a 60 cm thick fissure, filled with reddish manganiferous limestone and yielding Bajocian fossils. The Liassic Limestone is overlain by red, nodular Bajocian limestone and Kimmeridgian limestone.

The studied 5 solitary corals were collected from the Bajocian fissure of the locality by J. SZABÓ. (Two solitary specimens are known from the Kimmeridgian limestone, but these are disregarded in the present paper).

Layer 1
Middle Bajocian, Humphriesianum Zone

Epistreptophyllum ? sp.

One poorly preserved specimen, with the following characteristic dimensions:

Height of the corallum (mm)	8
Minimum diameter (mm)	3
Maximum diameter (mm)	5
Basal angle	23°
Number of septa	(26)

Septa cannot be seen well because of the poor preservation, but the estimated number of septa is about 26. The surface of the specimen is nearly completely smooth, only some very weak growth lines are visible. Epitheca is developed, the calice is slightly sunk in. The form of the corallum is cylindrical (slightly trochoid). Some roof-like growth are at the bottom of the specimen.

Trochocyathus sp.
Fig. 2.2

Two specimens can be seen only in transverse sections. One of the sections is fragmentary. The diameter of the corallum is 5 mm, and there are 16 septa arranged in a semicircular arch with 5–6 pali in the central part of the section. Septa are slightly undulating. The other section is 4 mm in diameter and the number of septa is about 22. The form of the corallum is unknown.

Layer 3
Upper Bajocian, Subfurcatum–Garantiana Zones

Trochocyathus sp.
Text-fig. 2.3. and Plate 5, fig. 15.

Only one specimen with the following dimensions:

Height of the corallum (mm)	7.5
Minimum diameter (mm)	2.5
Maximum diameter (mm)	4.5
Basal angle	20°
Number of septa	22

There are about 8–10 pali at the central part of the section of the specimen. Weak growth lines and weak longitudinal costae can be seen on the surface of the theca. The form of the corallum is turbinate.

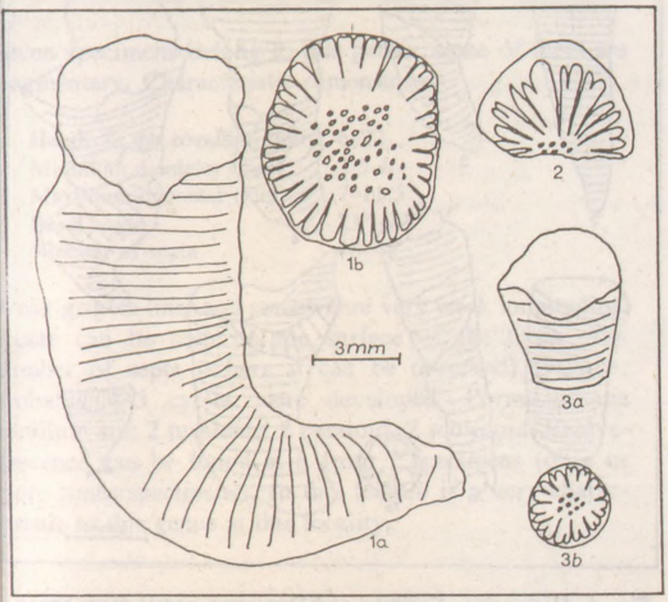

Fig. 2. Bajocian solitary corals from Bakonybél, Somhegy.
1.a: *Trochocyathus* sp.; Bed 6; scolecoid specimen; 1.b: transverse section
2: *Trochocyathus* sp.; Bed 1; transverse section
3.a: *Trochocyathus* sp.; Bed 3; turbinate specimen; 3.b: transverse section

Layer 6
Upper Bajocian, Subfurcatum–Garantiana Zones

Trochocyathus sp.
Text-fig. 2.1a–b and Plate 5, fig. 16

Dimensions of the single specimen:

Height of the corallum (mm)	19
Minimum diameter (mm)	5
Maximum diameter (mm)	7
Basal angle	22°
Number of septa	41

Large number (36–40) of pali are in the central part of the specimen. Strong growth lines and weak longitudinal costae are on the surface of the theca. The form of the corallum is scolecoid.

Eplény, Manganese Ore Mine

The former Manganese Ore Mine is situated about 300 m west from the village of Eplény, near to the Zirc–Veszprém road. The examined material is derived from the collection of the Hungarian Geological Survey. It was collected by M. SZABÓ-DRUBINA, I. SZABÓ and J. NOSZKY, Jr. from a submarine dyke in the northern part of the mine. The fissure can be found in the Rhaetian Dachstein Limestone or Hettangian Kardosrét Limestone. The formation is light red in colour, fine-grained but sometimes slightly crinoidal in texture. At some places manganese-oxide covers are in the limestone.

Benthic fossils are dominant in the megafauna. The age of the limestone is Domerian (Margaritatus Zone) (GÉCZY, pers.comm. *in:* SZABÓ, 1990). About 50 coral specimens belong to three genera, so this locality is fairly rich in specimen number but not too diverse in taxon number.

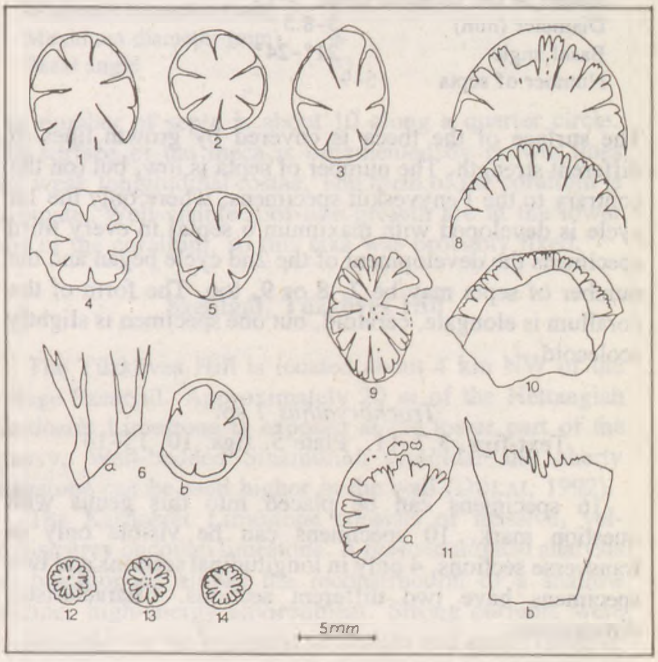

Fig. 3: Domerian corals from Eplény, Manganese Ore Mine.
1–5.: *Ceratocoenia* sp.; transverse sections
6.: *Ceratocoenia* sp.; a: longitudinal section; b: transverse section
7–9.: *Trochocyathus* sp.; transverse sections
10.: *Trochocyathus* sp.; transverse section with rejuvenescencion
11.: *Trochocyathus* sp.; a: transverse section; b: longitudinal section
12–14.: *Stylosmilia* sp.; transverse sections

Stylosmilia sp.
Text-figs. 3.12–14 and Plate 5, Fig. 12

Three specimens are placed into this genus. All of them can be seen only in transverse sections. Characteristic dimensions are the following:

Diameter (mm)	2.8–3
Number of septa	15–16

Strong styliform columella can be seen in sections. These specimens are fragments of a phaceloid colony. At some places the septa are well-visibly step out beyond the theca, so the surface of the corallum is probably costate.

Ceratocoenia sp.
Text-figs. 3.1–6, 4.2–3, Plate 5, figs. 5–9, 11

30 specimens (about two-third of the material) belong to this genus. From these, 22 can be seen only in transverse sections, one specimen has two different sections (a transverse and a longitudinal) and 7 specimens are fragmentary but three dimensional in preservation. Dimensions:

Height of the corallum (mm)	5–15
Diameter (mm)	3–8.5
Basal angle	21°–24°
Number of septa	5–9

The surface of the theca is covered by growth lines of different strength. The number of septa is low, but (on the contrary to the Fenyveskút specimens, where only the 1st cycle is developed with maximum 6 septa) in every third specimens the development of the 2nd cycle began and the number of septa may be 7, 8 or 9, too. The form of the corallum is elongate, ceratoid, but one specimen is slightly scolecoid.

Trochocyathus ? sp.
Text-figs. 3.7–11., Plate 5, figs. 10, 13–14

16 specimens can be placed into this genus with question mark. 10 specimens can be visible only in transverse sections, 4 only in longitudinal sections and two specimens have two different sections. Characteristic dimensions:

Height of the corallum (mm)	13–14
Diameter (mm)	5–12
Number of septa	(30–60)

Septa generally can be seen along a quarter- or semicircle arch, so these values are only estimated data. At one of the sections rejuvenescence is well-visible, when the corallum becomes thin, and after that increase to the original dimension. The form of the corallum is turbinate in the longitudinal sections.

Lókút, Fenyveskút

The locality is SW of the village Lókút at the northern foot of the Papod Hill, on the southern side of a ravine directed NW–SE. The ravine follows a paleotectonic zone, which rejuvenated several times. Limestone blocks of different size, lithology, colour and texture emerge from the soil. Rhaetian, Hettangian, Sinemurian, Domerian, Toarcian and Middle Bajocian limestones can be found in this melange (VÖRÖS, 1992). This association was interpreted as a megabreccia formed along the Papodalja line by repeated tectonic movements (GALÁCZ, 1988). About two dozens Domerian solitary corals were collected from this locality by A. GALÁCZ and A. VÖRÖS. The specimens belong to two genera.

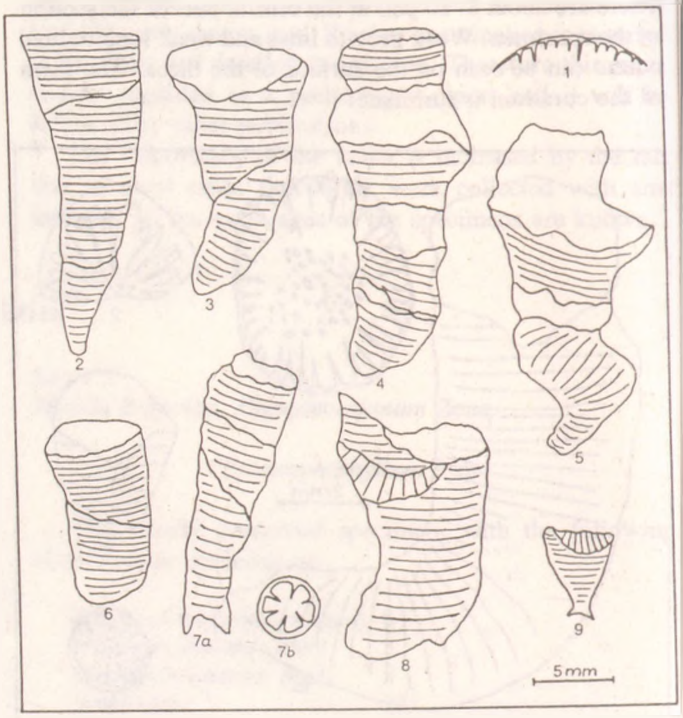

Fig. 4: Hettangian, Carixian and Domerian corals from Szentgál, Eplény, Lókút and Hárskút.

1.: Scleractinia gen. et sp. indet.; Szentgál, Tűzköves-hegy; Hettangian
2–3.: *Ceratocoenia* sp.; Eplény, Manganese Ore Mine; Domerian
4.: *Trochocyathus* sp.; Lókút, Fenyveskút; Domerian; rejuvenescenced specimen
5.: *Trochocyathus* sp.; Lókút, Fenyveskút; Domerian; scolecoid specimen
6.: *Ceratocoenia* sp.; Lókút, Fenyveskút; Domerian
7.: *Ceratocoenia* sp.; Lókút, Fenyveskút; Domerian; b: transverse section
8.: *Trochocyathus* sp.; Lókút, Fenyveskút; Domerian; rejuvenescenced specimen
9.: *Caryophyllia* ? sp.; Hárskút, Közöskút-ravine; Carixian

Ceratocoenia sp.
Text-figs. 4.6–7, Plate 5, fig. 4

15 specimens can be ranked to this genus, most of them are fragmentary. The characteristic dimensions are the following:

Height of the corallum (mm)	4–18
Minimum diameter (mm)	2–4(7)
Maximum diameter (mm)	3.5–6.5(9.5)
Basal angle	15°–22°
Number of septa	5–6

The surface of the theca is covered by growth lines different in strength. There are only a few (5–6) septa, only a single cycle was developed. The growth is uneven, slightly keeps bending. The form of this genus is elongate, ceratoid. One specimen is larger (7 and 9.5 mm in iameter) but it was placed here on the basis of the umber of the septa (6).

Trochocyathus sp.
Text-figs. 4.4–5, 8, Plate 5, figs. 1–3

even specimens belong to this genus, some of them are ragmentary. Characteristic dimensions:

Height of the corallum (mm)	6–22
Minimum diameter (mm)	2.5–8
Maximum diameter (mm)	7–11.5
Basal angle	23°–32°
Number of septa	40–48

/eak growth lines and somewhere very weak longitudinal ostae can be seen on the surface of the theca. The umber of septa (where it can be observed) is large, robably 4–5 cycles were developed. Forms of the orallum are: 2 turbinate, 3 ceratoid, 2 scolecoid. Rejuveescence can be found in 6 from 7 specimens (once or ore times/specimens), so this feature is a very characristic to this genus at this locality.

Hárskút, Közöskút Ravine

The Közöskút-ravine is about 2.5 km SW from the illage of Hárskút, directly next to the Borostyánhajag-Iill. The profile was described by GALÁCZ (1976, 1990). Iassive, light red (sometimes grey owing to manganese-xide) limestone rests on the rough surface and in the issures of Hettangian Kardosrét Limestone. This forhation is overlain by Toarcian and Middle Jurassic mestones.

The light red limestone contains some fossils. Three olitary corals are known from Bed 19 of this limestone, liensbachian (Ibex Zone) in age. Two specimens are rom the collection of Hungarian Geological Survey, the iird was got from the Paleontological Department of ötvös University.

Ceratocoenia? sp.
Plate 5, Fig. 17

The 16 mm high fragmentary specimen is 3 mm in iameter. Septa are unknown, because the corallum is ifilled with calcite spar. The surface of the theca is rnamented by concentric growth lines in different rength. At some places rejuvenescence are visible. The orm of the corallum is elongate, cylindrical, slightly eratoid.

Montlivaltia ? sp.
Plate 5, Fig. 18

One fragmentary specimen, of which the diameter is 1.5 mm and the number of septa is about 80. Only the pper part of the corallum can be observed on the surface of the limestone. The calice is convex (cupolate), the form of the corallum can not be seen, but probably trochoid or cylindrical.

Caryophyllia ? sp.
Text-fig. 4.9. and Plate 5, Fig. 19

One small-sized solitary specimen. The characteristic dimensions are the following:

Height of the corallum (mm)	5
Minimum diameter (mm)	1
Maximum diameter (mm)	4
Basal angle	43

The number of septa is about 10 along a quarter circle. The surface of the theca is ornamented by growth lines and weak longitudinal costae. The form of the corallum is turbinate. Well-visible roof-like growth are at the lower part of the corallum, so this taxa was probably fixed.

Szentgál, Tűzköves Hill

The Tűzköves Hill is located about 4 km NW of the village Szentgál. Approximately 20 m of the Hettangian Kardosrét Limestone is exposed at the lower part of the quarry. Well-bedded Sinemurian crinoidal and cherty limestone can be seen higher in the wall (DULAI, 1992).

The Kardosrét Limestone consists of massive, yellowish grey oncoidal limestone. A paleoecological analysis on brachiopods allows the reconstruction of a shallow marine, high-energy environment. Strong currents were responsible for the transport of ooliths and shells (DULAI, 1993). Ammonites are missing from the Kardosrét Limestone, the Hettangian age is based on brachiopods and lithological features.

Scleractinia gen. et sp. indet.
Text-fig. 4.1

Only one very fragmentary, unidentifiable section was collected by the author. Diameter is larger than 11 mm and 12 septa can be seen along a quarter circle. At least 3–4 cycles are developed.

Szentgál, Gombáspuszta

The sequence marked as Fg–II is situated at the northern foot of the Tűzköves-hegy, south of Gombáspuszta. Lower Pliensbachian thick-bedded, reddish crinoidal limestone can be found in the quarry. This formation is overlain by thinner-bedded brownish red limestone. This Carixian limestone contains lots of nodules of manganese-oxide, and some fossils. Middle and Upper Toarcian marl and limestone are in the upper part of the sequence and in some dykes (SZABÓ, 1990).

Montlivaltia ? sp.

One poorly preserved solitary coral was collected from the Carixian limestone by J. SZABÓ. The height of the specimen is 2 mm and the diameter is 6 mm. The number of septa is about 60. Columella cannot be seen on the fractured section. The surface of the corallum is black because of the manganese cover. The form of the corallum is probably tympanoid.

Systematic position of the determined genera

Order Scleractinia BOURNE,1900
Suborder Astrocoeniina VAUGHAN & WELLS, 1943
Family Stylinidae D'ORBIGNY, 1851
Subfamily Stylininae D'ORBIGNY, 1851
Genus *Stylosmilia* MILNE-EDWARDS, 1848

Suborder Fungiina VERRILL, 1856
Superfamily Agariciicae GRAY, 1847
Family Calamophylliidae VAUGHAN & WELLS, 1943
Genus *Epistreptophyllum* MILASCHEWITSCH, 1875

Suborder Faviina VAUGHAN & WELLS, 1943
Superfamily Stylophyllicae VOLZ, 1896
Family Amphiastreidae OGILVIE, 1896
Genus *Ceratocoenia* TOMES, 1884

Superfamily Faviicae GREGORY, 1900
Family Montlivaltiidae DIETRICH, 1926
Subfamily Montlivaltiinae DIETRICH, 1926
Genus *Montlivaltia* LAMOUROUX, 1821

Suborder Caryophylliina VAUGHAN & WELLS, 1943
Superfamily Caryophylliicae GRAY, 1847
Family Caryophylliidae GRAY, 1847
Subfamily Caryophylliinae GRAY, 1847
Genus *Caryophyllia* LAMARCK, 1801
Genus *Trochocyathus* MILNE-EDWARDS, 1848

The determined 6 genera belong to 4 suborders. From 5 suborders of order Scleractinia order the Dendrophylliina suborder appeared only in the Upper Cretaceous. This fact shows, that all of the existed suborders in Early and Middle Jurassic are present in the 80 specimens of the Bakony Mountains, but not equally. Suborder Faviina is represented by *Ceratocoenia* (46 specimens) and *Montlivaltia* (2) is forming 60% of the fauna, while *Caryophyllia* (1) and *Trochocyathus* (27) belonging to suborder Caryophylliina are present in 35%. In accordance with it the other two suborders are present in moderate number. *Stylosmilia* (3) belonging to Astrocoenia is 3.75% and *Epistreptophyllum* (1) belonging to Fungiina is 1.25% from the examined fauna (Fig. 5).

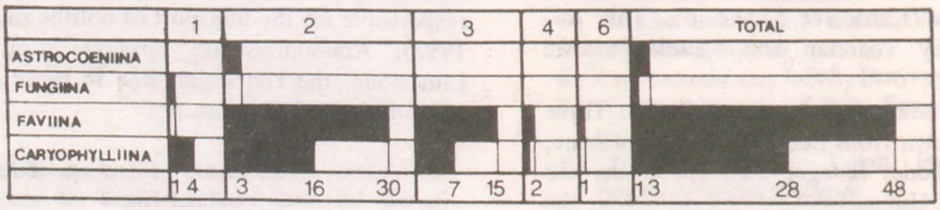

Fig. 5: Systematic composition of the coral fauna at the Early and Middle Jurassic localities of the Bakony Mountains.
1 – Bakonybél, Somhegy
2 – Eplény, Manganese Mine
3 – Lókút, Fenyveskút
4 – Hárskút, Közöskút-ravine
6 – Szentgál, Gombáspuszta

Stratigraphic distribution

Eighty-eight percent (71 specimens) of the studied fauna is derived from the Domerian beds. On the contrary we have only 1 specimen from Hettangian, 4 specimens from Carixian and 5 specimens from Bajocian formations. At this moment corals are unknown from Sinemurian, Toarcian, Aalenian, Bathonian and Callovian rocks of the Bakony Mountains (Fig. 6a).

At the same time these sharp differences cannot be seen during the investigation of the number of taxa. In spite of the large specimen number in the Domerian, the number of taxa is just as many as in the Carixian (3 taxa). In the same way 2 taxa are present by 5 specimens in the Bajocian (Fig. 6b). These facts show that larvae of the representatives of all the existed suborders arrived to the area of the Bakony Mountains, but the conditions were generally not favourable here for corals. The two Domerian localities (Eplény and Fenyveskút) are exceptional, where practically the same genera can be found in relatively greater number.

Making comparisons on the first appearence of determined genera between the Bakony Mountains and in global (based on WELLS, 1956), it can be seen, that except 2 genera (*Montlivaltia*, *Epistreptophyllum*) all the others appeared earlier in the Bakony Mountains, than in other areas (Fig. 7). This phenomena is also characteristic to other fossil groups (ammonites, brachiopods, gastropods etc.), i.e. some taxa appeared earlier in the Mediterranean region than in Northern Europe. At the same time at present it is possible, that during a detailed study, some of these taxa must be described as a new genus.

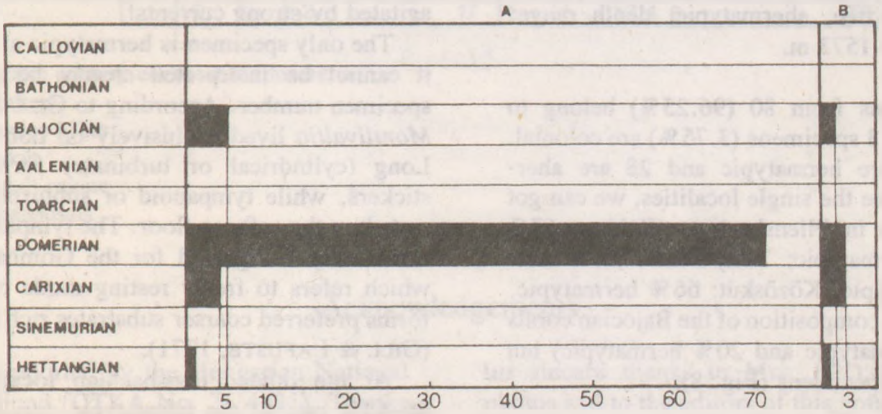

Fig. 6: Stratigraphic distribution of the studied corals.
A: number of specimens, **B**: number of taxa

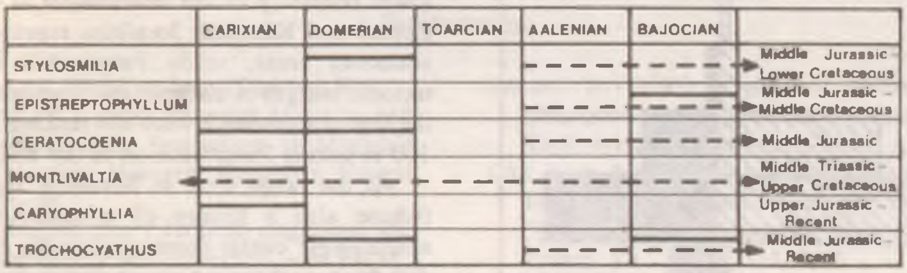

Fig. 7: Stratigraphic distribution of the determined Early and Middle Jurassic coral genera.
Continuous line: distribution in the Bakony Mts. (this paper). Broken line: global distribution (WELLS, 1956)

Paleoecology

All corals live in marine conditions and belong to the sessile epibenthos. Independently the taxonomically distinguished 5 suborders, ecologically the corals can be divided into two groups:

- hermatypic corals (zooxanthellae are present)
- ahermatypic corals (zooxanthellae are lacking)

In both groups solitary and colonial forms equally can be found. Zooxanthellae do photosynthesis, for this reason hermatypic corals can live in the upper, well-illuminated zone only (0–90 m). In this way hermatypic corals are excellent environment indicators. In addition to the depth, hermatypic corals give useful information about water-temperature, salinity, water-movement, sedimentation and substrate. Ahermatypic corals can live between quite wider limits down to 6000 metres, but mainly between 0 and 500 metres (WELLS, 1957).

According to WELLS (1956) the ecological characters and morphotypes of the determined genera are the following:

Stylosmilia	colonial, phaceloid, hermatypic
Epistreptophyllum	solitary, turbinate-cylindrical, hermatypic
Ceratocoenia	solitary, elongate, ceratoid or cylindrical, hermatypic
Montlivaltia	solitary, cupolate, trochoid to subcylindrical, hermatypic, usually free in ephebic stage. According to GALÁCZ & MONOSTORI(1992) *Montlivaltia* lives in shallow water, in

symbiose with zooxanthellae on the basis of recent analogies

Caryophyllia: solitary, turbinate to subcylindrical, fixed or free, ahermatypic, depth range: 0–2743 m

Trochocyathus: solitary, turbinate to ceratoid, fixed or free, ahermatypic, depth range: 32–1573 m.

Seventy-seven specimens from 80 (96.25%) belong to solitary corals and only 3 specimens (3.75%) are colonial. 52 specimens (65%) are hermatypic and 28 are ahermatypic (35%). If we see the single localities, we can got exactly the same rates in Pliensbachian (Eplény: 67% hermatypic, 33% ahermatypic; Fenyveskút: 68% hermatypic, 32% ahermatypic; Közöskút: 66% hermatypic, 34% ahermatypic). The composition of the Bajocian corals is different (80% ahermatypic and 20% hermatypic) but only on the basis of 5 specimens (Fig. 8).

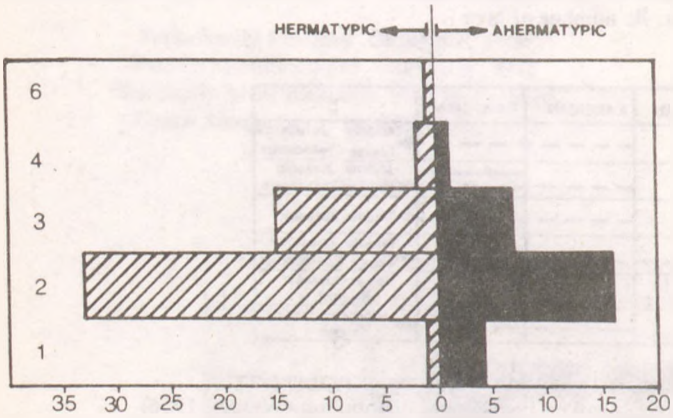

Fig. 8: Ratio of hermatypic and ahermatypic corals at the localities.
1 - Bakonybél, Somhegy
2 - Eplény, Manganese Ore Mine
3 - Lókút, Fenyveskút
4 - Hárskút, Közöskút-ravine
6 - Szentgál, Gombáspuszta

One part of the Scleractinia went down to the colder and deeper seas in the Jurassic and the recent deep-sea corals developed from these forms (GÉCZY, 1993). According to WELLS (1956) the first ahermatypic Scleractinian corals appeared in the Toarcian. On the other hand more than one-third of the coral fauna is ahermatypic in the Pliensbachian in the Bakony Mountains. (Moreover in the Jurassic corals of the Gerecse Mountains, which is not discussed in this work, the first ahermatypic coral came from Sinemurian formations.) The ahermatypic corals appearing in the Lower Jurassic presumably became more frequent in the Middle Jurassic and the coral fauna is mainly composed of ahermatypic forms at some Upper Jurassic localities.

The Hettangian Kardosrét Limestone was deposited in well-illuminated depths (it is proved by the large number of oncoids in this limestone) but the only indeterminable specimen suggests, that the depositional environment was unpleasant for settlement of corals. One of the preconditions of the settlement of the coral larvae is the immobile bottom in the sea. This requirement is not realized here, because the ooidal-oncoidal bottom was constantly agitated by strong currents.

The only specimen is hermatypic at Gombáspuszta but it cannot be interpreted clearly because of the small specimen number. According to GILL & LAFUSTE (1971) *Montlivaltia* lived exclusively on non-lithified substrate. Long (cylindrical or turbinate) forms were sediment stickers, while tympanoid or subturbinate forms simply rested on the soft sea floor. The tympanoid morphotype is uncertainly recognized for the Gombáspuszta specimen, which refers to freely resting mode of life. Tympanoid forms preferred coarser substrates rich in clasts and grains (GILL & LAFUSTE, 1971).

At the other Pliensbachian localities the observed 66-68% rate of the hermatypic corals suggests that the depositional environment was shallower than 100 m. The sizes of corals are generally small, the conditions probably were not very favourable, so depth may be near to the lower boundary of the distribution of hermatypic corals. Eplény and Közöskút localities represent the fissures of seamount areas, while Fenyveskút is situated at the tectonic margin of a seamount. This practically means that the top of seamounts were not sinking below the depth of 100 m during Pliensbachian in the Bakony Mountains.

At the same time at Somhegy during the Bajocian (where also a fissure of a seamount is represented) ahermatypic corals dominated in the fauna which means that the top of the seamount sank below 100 metres.

Solitary corals may be collected into groups on the basis of the shape of the corallum and the size of the attachment and resting area (WELLS, 1956; FÜRSICH et al.,1994). Five morphotypes were distinguished in the fauna of the Bakony Mountains, at that specimens where not only a section can be seen (Fig. 9). The most frequent type is ceratoid (23), relatively frequent the turbinate (6) and the scolecoid (4) types whereas cylindrical (2) and tympanoid (1) are rare. Nearly all types are elongated in shape and the attachment area are small. The small attachment area indicates that the larvae settled only on one particle or small fragments. The stabilization of the elongated corals required the fixation of the corallum (roof-like growth can be seen at some specimens) or the specimens had to be sunk in the loose sediments by the pointed basis of the corallum. However loose sediments were probably rare on the top of the seamounts, therefore the fixation was uncertain. The scolecoid morphotype, with worm-like irregular shape demonstrates this problem. These specimens were overturned by currents and because they were not able to stand up, the coral started to build itself to a new direction.

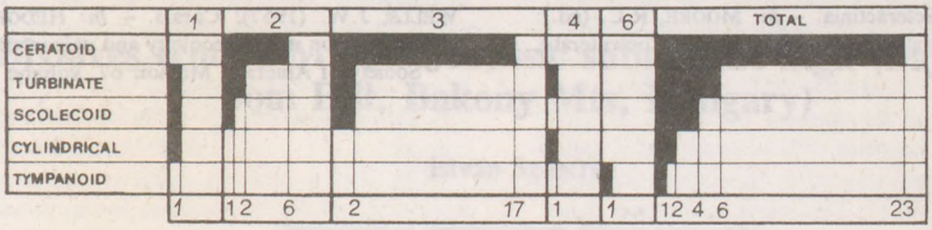

Fig. 9: Morphotypes of the solitary corals at the localities
1 – Bakonybél, Somhegy
2 – Eplény, Manganese Mine
3 – Lókút, Fenyveskút
4 – Hárskút, Közöskút-ravine
6 – Szentgál, Gombáspuszta

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Plate 5

Fig. 1. *Trochocyathus* sp.; Lókút, Fenyveskút; Domerian; rejuvenescenced specimen; 2×
Fig. 2. *Trochocyathus* sp.; Lókút, Fenyveskút; Domerian; rejuvenescenced specimen; 2×
Fig. 3. *Trochocyathus* sp.; Lókút, Fenyveskút; Domerian; rejuvenescenced specimen; 2×
Fig. 4. *Ceratocoenia* sp.; Lókút, Fenyveskút; Domerian; 2×
Fig. 5. *Ceratocoenia* sp.; Eplény; Domerian; 2×
Fig. 6. *Ceratocoenia* sp.; Eplény; Domerian; 2×
Fig. 7. *Ceratocoenia* sp.; Eplény; Domerian; longitudinal section; 2×
Fig. 8. *Ceratocoenia* sp.; Eplény; Domerian; transverse section; 2×
Fig. 9. *Ceratocoenia* sp.; Eplény; Domerian; transverse section; 2×
Fig. 10. *Trochocyathus* ? sp.; Eplény; Domerian; longitudinal section; 2×
Fig. 11. *Ceratocoenia* ? sp.; Eplény; Domerian; transverse section; 2×
Fig. 12. *Stylosmilia* sp.; Eplény; Domerian; transverse section; 2×
Fig. 13. *Trochocyathus* sp.; Eplény; Domerian; transverse section; 2×
Fig. 14. *Trochocyathus* sp.; Eplény; Domerian; transverse section with rejuvenescence; 2×
Fig. 15. *Trochocyathus* sp.; Bakonybél, Somhegy, Bed 3; Upper Bajocian; 2×
Fig. 16. *Trochocyathus* sp.; Bakonybél, Somhegy, Bed 6; scolecoid specimen; Upper Bajocian; 2×
Fig. 17. *Ceratocoenia* sp.; Hárskút, Közöskút-ravine; Carixian; 2×
Fig. 18. *Montlivaltia* ? sp.; Hárskút, Közöskút-ravine; Carixian; 2×
Fig. 19. *Caryophyllia* ? sp.; Hárskút, Közöskút-ravine; Carixian; 2×

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Bivalves from a Middle Jurassic submarine high (Bajocian, Som Hill, Bakony Mts, Hungary)

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(with 2 figures and Plate 6)

Abstract

Marine bivalves from a fissure filling of Upper Bajocian (Middle Jurassic) age are briefly described and figured. Palaeoecological analysis of the Som Hill assemblage as well as the similarity of its taxonomic composition to those of other, coeval faunas preserved in fissure-fillings suggest that a distinct bivalve assemblage populated fissures of some Mediterranean seamounts during the Middle Jurassic. Both in diversity and density, bivalves are subordinate to gastropods in the Som Hill fauna. The bivalve fauna is dominated by the epibyssal forms and consists of representatives of extinct genera except *Limopsis* and *Cuspidaria* s. l., which latter two are frequent in Recent deep-sea bivalve assemblages.

Key words: Middle Jurassic, Bajocian, Bivalvia, Bakony, Hungary, paleoecology

Introduction

Except some opportunistic and probably pseudoplanktonic forms such as *Bositra* (= "*Posidonia*" auctt.) and thin-shelled inoceramids, bivalves are not frequent elements in invertebrate faunas of the deeper-water Jurassic of the peri-Mediterranean region, where the macro-benthic asseblages are usually dominated by brachiopods. Bivalves other than those mentioned above have been especially rarely recorded from higher Middle Jurassic (Bajocian to Callovian) deposits, which represent times when considerably large areas provided hostile environmental conditions for benthic life. In most segments of the peri-Mediterranean region *Bositra*-bearing deep-water limestones, marls and radiolarites, – sediments probably deposited at the greatest water depth reached during the period –, represent these stages (see BAUMGARTNER 1986).

In contrast to the paucity in benthic molluscs of fossil assemblages in most of the typical Mediterranean Middle Jurassic environments, fillings of submarine fissures penetrated into submarine highs ("seamounts" or "guyots") yielded surprisingly rich bivalve and gastropod faunas (e. g. CONTI & FISCHER 1981, 1984; WENDT 1971). Such type of sediments have been known from the Jurassic of the Bakony Mts as well (e. g. VÖRÖS 1993). The most fossiliferous fissure-filling rocks of Middle Jurassic age are known from the Som Hill, from where the bivalves described below were collected.

Geological setting of the locality and previous studies on the fauna

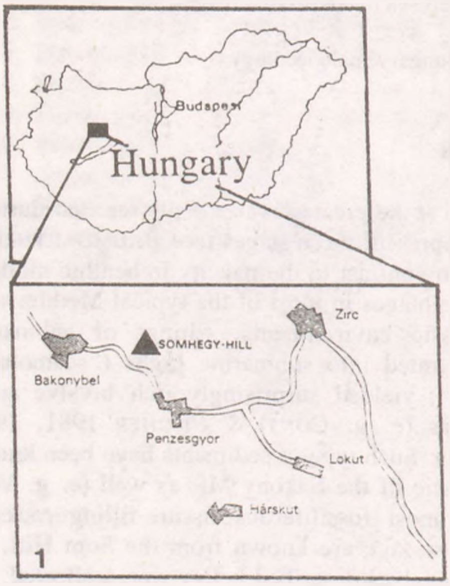
Jurassic sediments of the Bakony Mts were deposited on a passive continental margin, overlying segments of the drowned Upper Triassic carbonate platform (GALÁCZ et. al. 1985). Stratigraphical and facies analyses suggest a very marked bottom topography during most of Jurassic times. Submarine highs, their slopes, and inter-seamount basins were the main depositional environments, each of them characterized by distinct lithologies, stratigraphical features and fossil assemblages.

The Som Hill is an approx. 650 m high forest-covered hill near the village Bakonybél, west of the town Zirc, in the heart of the Bakonyerwald (Fig. 1). On the top of the hill an E-W striking trench and some natural outcrops expose the Jurassic rocks, which have been known since the last century (see KONDA 1970 and GALÁCZ 1976 for review). The exposure was made during the sixties, and was first sampled and studied by József KONDA, then Director of the Hungarian Geological Institute. Later János SZABÓ from the Hungarian Museum of Natural History enlarged the section, recognized the relationships between the rock bodies observable and made extensive bed-by-bed collections.

Szabó (1990) distinguished six beds of red, manganiferous, usually micritic limestone, in max. 2m cumulative thickness, below the uppermost two beds of the light yellow, oolithic Kardosrét Limestone (Lower Jurassic, most probably Hettangian) (Fig. 2). This latter rock forms the base of the section as well. The red limestones sandwiched between beds of much older rocks can be interpreted as infilling of a "horizontal" fissure ("S-Spalte") (Wendt 1971). The lower and upper three beds represents parts of the Bajocian Humphriesianum and Niortense Zones, respectively (Galácz 1985). Both Lower and Middle Jurassic rocks are penetrated by near vertical dykes ("Q-Spalten") of various ages. At the eastern end of the trench, above the uppermost two oolithic limestone banks, nodular "ammonitico rosso" limestone beds, representing the upper part of the Bajocian Humphriesianum Zone and lower part of the Parkinsoni Zone appear, in 160 cm thickness (Galácz 1985). The latter-mentioned Middle Jurassic rocks are conformably overlain by pink nodular limestones of Kimmeridgian (Upper Jurassic) age.

The lack of several stages (Sinemurian to Aalenian, Bathonian to Oxfordian) and especially that of radiolarite, which latter occurs in most of the Jurassic sections of the Bakony Mts, as well as reduced thicknesses and peculiar facies of the rocks indicate that the Som Hill was a submarine high during at least some periods of the Jurassic.

The fissure-infilling Bajocian rocks contain a well preserved and diverse mollusc fauna, characteristic of this type of environments (Wendt 1971). Fossils are usually coated with a thin layer of Fe-Mn-oxides and their cavities are filled with sparry calcite, which makes them rather fragile. The fossil assemblage is highly dominated by gastropods, which were described in a series of papers by Szabó (1979, 1980, 1981, 1982, 1983) and Conti & Szabó (1987). Stratigraphic evaluation of the abundant ammonites was given by Galácz (1976, 1985). Monostori (1995) described the ostracods. Foraminifers, annelids, solitary corals, scaphopods and echinoids also occur, but they have not been studied until now.



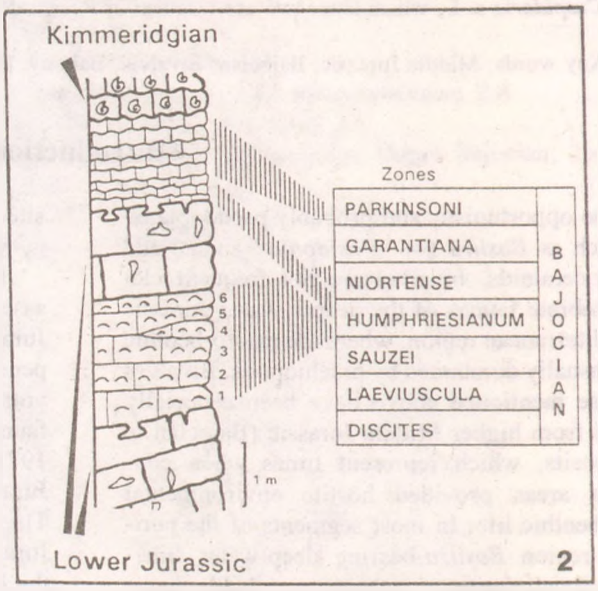


Fig. 1. Locality of the studied bivalves.
Fig. 2. The stratigraphical sequence on the top of the Som Hill.

Bajocian bivalves of the Som Hill: an annotated list

More than 80 bivalve specimens are available. The vast majority of the material has been collected by Konda and Szabó from the fissure-filling. As it can be judged from the collection of Szabó, the lower three beds corresponding to the Humphriesianum Zone proved to be much more rich in bivalves than the upper three. Exact localities and stratigraphic positions of the specimens collected by Konda have remained unfortunately unknown.

Except two articulated *Palaeonucula* specimens, the material consists of single valves. Their internal characteristics, due to the host rock usually harder than the recrystallized shell material, could be studied only exceptionaly.

Palaeonucula sp.

Pl. 6, figs 1–2.

Material: Two articulated specimens and three valves.

Remarks: The specimens are most probably juvenile ones. No attempt has been made to identify them at species level.

Isoarca subtransversa Uhlig, 1881
Pl. 6, figs 3, 4, 8.

Material: 29 valves.

Description: Medium-sized, inflated, strongly inaequilateral valves. Umbones placed at about the anterior one-fourth of the length. Dorsal margin straight. Anterior, ventral and posterior margins rounded. Outer surface ornamented with comarginal striae and radial riblets resulting in a fine granulate pattern. Hinge can not be studied in detail on the available specimens, only traces of taxodont teeth can be observed.

Remarks: *I. subtransversa* differs from *I. plutonis* (Dumortier, 1874), a similar species widespread in the Aalenian (Dumortier, 1874, p. 299. pl. 59, figs 1–3; Vacek, 1886, p. 112. pl. 19, fig. 13) mainly by its more oblique form and more rounded ventral margin. Occurence of *Isoarca* in the Bajocian of the Bakony Mts was first recorded by Vörös (1984).

Arcoid bivalvia, gen. et sp. indet.
(not figured)

Material: One incomplete right valve.

Remarks: The specimen surely belongs to Arcoida, but its poor preservation does not allow a more precise identification.

Catella? caterinae (Parona, 1894)
Pl. 6, fig. 5.

*1894 *Arca (?Macrodon) caterinae* sp. n. – Parona: 293, pl. 1, fig. 43.
1983 *Parallelodon caterinae* (Parona). – Conti & Fischer: 518, text-fig. 20 [cop. Parona, 1894], pl. 3, figs 21–23.
1986 *Parallelodon caterinae* (Parona). – Conti & Monari: 181, pl. 1, figs 10–11.

Material: Five left and four right valves.

Description: Small, inaequilateral, oblique pteriform valves with expanded posterior region. Dorsal margin straight, umbones at about the first fourth of the length. The ornamentation consists of fine growth striae, radial riblets and small tubercles at the intersection of radial and comarginal elements. Internal features can not be studied.

Remarks: Shape and ornamentation of the Bakony specimens correspond well to the description and figures given by Conti & Fischer (1983) and Conti & Monari (1986). Monari's careful studies of Italian specimens (Monari, in press) suggest that *"Arca" caterinae* can be assigned most probably to *Catella* Healey, 1908. *Arca (Eonavicula)* cf. *minuta* (Sowerby), recorded by Wendt (1971, p. 159) from an Upper Bajocian fissure-filling of Rocca Busambra (Sicily) may probably represent *C.? caterinae.*

Limopsis teresitae (Parona, 1894)
Pl. 6, fig. 6.

*1894 *Arca teresitae* sp. n. – Parona: 392, pl. 1, fig. 41–42.
1971 *Isoarca* aff. *teresitae* (Parona) – Wendt: 156–159.
1983 *Limopsis teresitae* (Parona) – Conti & Fischer: 519, text-fig. 21 [cop. Parona 1894], pl. 3, figs 24–25.

Material: two right valves.

Description: Small, subaequilateral valves. Length exceeds height. Dorsal margin straight. Umbones slightly in front of the mid-length. Outer surface covered by very fine comarginal and radial striae. Internal features can not be observed on the available specimens.

Remarks: Dimensions and shape of the Bakony specimens agree well with those of the specimen figured by Conti & Fischer (1983). The rare comarginal rugae are, however, less marked than those shown by the Italian specimen. This difference may be of ecophenotypical nature. *Limopsis minima* (J. de C. Sowerby, 1824), a widespread species in the Bathonian to Oxfordian of Europe (Hallam 1976) differs from *L. teresitae* by its more triangular valves (see e. g. Fischer 1969).

Inoceramus fuscus Quenstedt, 1858
Pl. 6, fig. 7.

Material: Two juvenile valves and an adult one.

Remarks: *I. fuscus* is the most common and usually the only bivalve in Aalenian-Bajocian red, nodular, ammonite-rich limestones of the Bakony Mts. A fine specimen was figured by Prinz (1904, pl. 1, figs 1a–b) from the Aalenian of the Tűzköves Ravine of Bakonycsernye.

Parainoceramus sp.
Pl. 6, figs 9–10

Material: Three valves.

Remarks: Small to medium sized, inflated species of the genus *Parainoceramus* are frequent in some Jurassic deposits of the Bakony Mts and are currently studied by the present author.

Plagiostoma rupicola (UHLIG, 1881)
Pl. 6, fig. 11.

Material: One right valve from the Humphriesianum Zone.

Remarks: The near-orbicular outline, very short lunule and numerous fine radial striae, all are characteristics of *P. rupicola* as described and figured by UHLIG (1881, p. 410, pl. 9, fig. 4.) from the Callovian of the Pieniny Klippen Belt and by SIMIONESCU (1899, pl.1, fig. 14) from the Callovian of the Getic Unit of the Southern Carpathians.

Entolium (E).? sp.
(not figured)

Material: Two fragmentary valves.

Remarks: The available specimens are smooth, incomplete orbicular valves without any trace of ornamentation.

Camptonectes auritus (SCHLOTHEIM, 1813)
Pl. 6, fig. 12.

Material: Two fragmentary valves from the Humphriesianum Zone.

Description: Sub-orbicular disc ornamented with fine antimarginal (= divaricate) striae on all parts of the surface.

Remarks: Although the Som Hill specimens are incomplete, their observable features agree well with those given by JOHNSON (1984) as specific characteristics of *C. auritus*.

Camptonectes sp. B.
Pl. 6, fig. 13.

Material: about 10 valves.

Description: More or less fragmentary valves with byssal notch below the anterior auricle of the right valve. Outer surface ornamented with very fine comarginal nd antimarginal striae.

Remarks: Shape and ornamentation of the specimens slightly resemble those of *Entolium (E.)* (see below). According to JOHNSON (1984), however, *E. (E.) lunare* (ROEMER, 1839), the only Jurassic *Entolium* species with byssal notch is confined to the Early Jurassic.

Camptonectes? sp.
Pl. 6, fig. 14.

Material: A single left valve, most probably from the non-fissure-filling Parkinsoni Zone.

Description: Sub-ovate (H>L) disc ornamented with prominent comarginal lamellae and fine antimarginal striae.

Remarks: The projecting comarginal lamellae shown b the specimen are unusual in *Camptonectes*, and strongly resemble to the ornamentation of *Camptochlamy* ARKELL, 1930, elevated to genus rank by WALLER MARINCOVICH (1992). Radial striae, characteristic o *Camptochlamys* can not, however, be observable. A JOHNSON (1984) pointed out, one of the shell layers o *Entolium* is composed of antimarginal calcite fibre which can be visible when the outer layer is eroded The Som Hill specimen, however, does not show an sign of erosion.

Limea? (Pseudolimea?) sp.
(not figured)

Material: A single right valve.

Remarks: The specimen is too poorly preserved to b identified with certainty even at generic level. Th oblique form and strong radial riblets ornamenting th surface recall *Limea (Pseudolimea)*.

Bositra buchii (ROEMER, 1836)
Pl. 6, fig. 15.

Material: 8 valves.

Remarks: Questions concerning the systematics of *Bositr* species were recently discussed by ABERHAN (1994) CONTI & MONARI (1992) and SZENTE (1995). The Som Hill specimens belong to the more orbicula *"ornati"* morphotype, but the H/L ratio of the valves seems to be considerably increasing during ontogeny, which indicates a more elongated, *"buchii"* shape in juvenile.

Cuspidaria s.l. sp.
Pl. 6, figs 16–18.

Material: 5 valves.

Description: Small-sized, well inflated, postero-dorsally rostrated valves ornamented with fine growth striae. Internal features can not be studied.

Remarks: According to KEEN (1969b) *Cuspidaria* NARDO, 1840 (= *"Neaera* GRIFFITH, 1834") appeared in the Late Cretaceous. YIN & FÜRSICH (1991) presumed that some of the Jurassic *"Neaera"* species in fact belong to Corbulidae. This statement can be surely held for specimens described from nearshore, marginal marine, or even brackish water settings. Data hitherto accumulated by the present author suggest, however, that *"Neaera"* species, which are usually the only macrobenthic organisms associated to the abundant pygopid brachiopods in Upper Jurassic pelagic sediments of the peri-Mediterranean region, really represent *Cuspidaria* s.l. There is no reason to doubt that some Middle Jurassic forms can be also assigned to Cuspidariidae DALL, 1886.

Palaeoecology of the Som Hill bivalve fauna

As it was mentioned above, gastropods are highly dominating elements in the Som Hill fauna: more than 50 species represented by some 440 specimens were recorded by SZABÓ (1990). Ammonites are also more frequent than bivalves: some 300 specimens were collected from the fissure-infilling Bajocian beds (A. GALÁCZ, personal communication, 1995). A sound palaeoecological and biofacies analysis should be therefore based on the study of the fore-mentioned groups. Keeping in mind, however, the uncertainties concerning (palaeo)autecology of ammonites and gastropods, and the fact that bivalves are probably the best known group of marine macro-invertebrates in this respect, some remarks on their palaeoecology are worth to be given here.

Considering the specific sedimentary environment of the deposits yielding the fauna, questions can arise about the autochtonous vs. allochtonous nature of the fossil assemblage. The specimens, although most of them are single valves, do not show traces of significant transport and they can be interpreted as para-autochtonous remains of the former communities. The striking similarities between the compositions of bivalve faunas preserved in fissure fillings also suggest that these characteristic assemblages really populated submarine cavities.

A comparison with coeval non fissure-dweller faunas settled on submarine highs is, however, rather difficult, because "normal" faunas are much poorly documented in the fossil record.

The richest peri-Mediterranean Middle Jurassic benthic molluscan faunas, which supposedly populated submarine highs are mostly of Aalenian age (e. g. BOTTO-MICCA, 1893; GRECO 1898) and many of them are related to the South Alpine San Vigilio oolite and its equivalents (e. g. DE GREGORIO 1886; VACEK 1886; CONTI & SZABÓ 1989; DAL PIAZ 1912, see STURANI 1971). Bivalves are extremely rare in Bajocian and younger Middle Jurassic "normal" benthic assemblages, which are dominated by brachiopods (WENDT 1971). Studies of bivalve faunas from Lower Jurassic and Tithonian "Hierlatzkalk"-type rocks, thought to represent seamount slopes (VÖRÖS 1991) suggest that small, inflated *Parainoceramus* species were more frequent in the seamount-dweller faunas than it was found in the Som Hill assemblage (FŐZY et al. 1994; SZENTE in prep.).

Isoarca subtransversa UHLIG, 1881 is the most frequent species in the Som Hill bivalve fauna (about 34%). Systematic position of the peculiar genus *Isoarca* MÜNSTER, 1842 is rather uncertain. The problem was discussed by several authors in the past (see NICOL 1947) and seems to have been unsolved until now. According to KEEN (1969a) the genus belongs to Nuculanacea H. ADAM & A. ADAM, 1958. HALLAM (1976), however, assigned *Isoarca* to the Arcoida.

Autecology of *Isoarca* is also doubtful. The genus is widespread in Late Jurassic reef- or peri-reefal faunas of South and Central Europe (see e. g. BOEHM 1881, 1883; YAMANI 1975) and HALLAM (1976) interpreted it as a probable nestler within the crevices of coral reefs. HEINZE (1991), however, considered *I. texata* (MÜNSTER), an Upper Jurassic species, as an infaunal suspension filter. From the Middle Jurassic, abundant occurrence of *I. plutonis* was reported by VACEK (1886) from the San Vigilio oolite, where the bivalve fauna is highly dominated by epifaunal forms, especially by *Eopecten*. These examples suggest that *I. subtransversa* were probably an epibyssate bivalve.

Only a limited number of guilds are represented in the bivalve fauna. Epibyssate suspension-feeders are the dominant group. Infaunal deposit-feeders *(Palaeonucula* and questionably *Limopsis)* and carnivores (*Cuspidaria)* are subordinate. Cemented and sessile infaunal forms as well as semi-infaunal and free-lying ones are lacking. WENDT (1971) also documented the rarity of burrowing bivalves in the Sicilian fissure-dweller faunas. The dominance of epibyssate forms indicates that considerable areas of hard substrate were available for attachment.

Occurrence of *Limopsis* and *Cuspidaria*, as the only taxa possessing living relatives, may bear some palaeoenvironmental significance. Recent species of these genera live in cold or deep waters (e. g. KNUDSEN 1967, 1970).

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Plate 6

(all specimens coated with ammonium-chloride)

Figs. 1–2. *Palaeonucula* sp.
- 1. Niortense Zone, 2×
- 2. Humphriesianum Zone?, 5×

Figs. 3–4, 8. *Isoarca subtransversa* UHLIG 1881
- 3. Humphriesianum Zone, 1.5×
- 4. Humphriesianum Zone?, 1.7×
- 8. Humphriesianum Zone?, 2×

Fig. 5. *Catella*? *caterinae* (PARONA 1894). Humphriesianum Zone, 4×

Fig. 6. *Limopsis teresitae* (PARONA 1894) Humphriesianum Zone, 2×

Fig. 7. *Inoceramus fuscus* (QUENSTEDT 1858) Humphriesianum Zone, 1.6×

Figs. 9, 10. *Parainoceramus* sp. Humphriesianum Zone?, 1.5×.

Fig. 11. *Plagiostoma rupicola* (UHLIG) Humphriesianum Zone, 1.9×

Fig. 12. *Camptonectes auritus* (SCHLOTHEIM 1813) Humphriesianum Zone, 1.65×

Fig. 13. *Camptonectes* sp. Humphriesianum Zone, 1.5×

Fig. 14. *Camptonectes?* sp. Parkinsoni Zone?, 1.8×

Fig. 15. *Bositra buchii* (ROEMER 1836) Parkinsoni Zone?, 2×

Figs. 16–18. *Cuspidaria* sp.
- 16. Humphriesianum Zone, 1.6×
- 17. Humphriesianum Zone, 1.7×
- 18. Humphriesianum Zone, 2.0×

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Eucyclidae (Eucycloidea, Gastropoda) as a Liassic palaeoecological index in the Transdanubian Central Range (Hungary)

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(with Plate 7)

Abstract

Beside a revised systematical list of the previously described taxa, designation of *Lokuticyclus* subg. n. *(Eucyclus)* and some new species *[Eucyclus (Eucyclus) tataensis* sp. n., *Eucyclus (Eucyclus) barnabasi* sp. n., *Eucyclus (Lokuticyclus) urkutensis* sp. n., *Eucyclus (Lokuticyclus) kericserensis* sp. n. and *Eucyclus (Lokuticyclus) lokutensis* sp. n. are given below. The studied eucyclids seem to have inhabited similar environments than the living ones.

Key words: Lower Jurassic, Gastropoda, Bakony, Hungary, palaeoecology, new species

Introduction

Members of the superfamily Eucycloidea belong to the most common gastropods in the Jurassic faunas of the Transdanubian Central Range. They are present in most lithological types bearing gastropods, but their occurrences suggest definite dependence on environment. Recent discovery of evolutionary connection to living relatives (MCLEAN 1981) helps to find actualistic data to interpret the facies distribution in the studied area and to complete the Jurassic environmental reconstruction.

Description of the species, only listed here are given in SZABÓ (1982). A species, *Eucyclomphalus cupido* (D'ORBIGNY, 1852) (=?*Eucyclomphalus hierlatzensis* VON AMMON, 1892), previously regarded as member of Eucyclidae seems to be better accomodate in Platyacridae.

The new species are based on old museum material, collected by József FÜLÖP (Tata, Csurgókút, see locality map in FÜLÖP 1976), by Lajos BARTKÓ (Úrkút, Csárdahegy Natural Conservatory Area at the eastern edge of the village) and by József KONDA (Lókút, Kericser; 6th locality in map of KONDA, 1970). The holotypes are deposited in the museum of the Hungarian Geological Survey.

Abbreviations used:
H = total height
HL = height of last whorl
HA = height of aperture
D = diameter
W = width of aperture
A = spiral angle or apical angle and angle of spiral on last measurable whorls in case of coeloconical and cyrtoconical spire (interval given).

An asterisk (*) marks that the value is measured on damaged shell part or on the last measurable section of the shell.

Systematics

Superfamily Eucycloidea KOKEN, 1897
Family Eucyclidae KOKEN, 1897

The superfamily name was proposed by GOLIKOV & STAROBOGATOV (1975) after a long period when even the existence of the nominate family had been not widely accepted. In COSSMANN's (1916) system, *Eucyclus* and the closely related genera belonged to Littorinidae, then WENZ (1938) established his Amberleyidae (Trochonematacea) where *Eucyclus* is only a subgenus in *Amberleya* MORRIS & LYCETT, 1851. COX *in* KNIGHT et al. (1960) introduced superfamily Amberleyacea containing also Platyacridae WENZ, 1938; Cirridae COSSMANN, 1916 and Nododelphinulidae COX, 1960. Most of the other taxonomists were influenced in their classification activity overwhelmingly by the latter three systems.

GOLIKOV & STAROBOGATOV (1975) recognised that inclusion of *Eucyclus* as a subgenus in *Amberleya* is erroneous, that is why they proposed usage of Eucyclidae as family name and Eucycloidea as superfamily name instead of Amberleyidae and Amberleyacea, respectively. [By personal observations, the true *Amberleya* MORRIS & LYCETT, 1851 is not member of Eucycloidea. Its most likely systematical place is near to that of *Paraturbo* COSSMANN, 1907 (?Paraturbinidae).]

Formerly, the superfamily was thought a typically Mesozoic group, having some survivors which became extinct during the Oligocene. McLEAN (1981) recognised that some living gastropods are closely related and he proposed subfamily (Amberleyinae) rank for the extended group in the Trochidae.

HICKMAN & McLEAN (1990) changed the name to Eucyclinae, containing three tribes: Eucyclini, Chilodontini and Calliotropini. Because of the soft body, mainly radula plan characters, the extant relatives (some Chilodontini and Calliotropini) can be classified within the Trochidae, therefore, HICKMAN & McLEAN (1990) suggested a new systematical place also for the Mesozoic–Oligocene forms (Eucyclini) in the same family.

From point of view of shell morphology, most important in palaeontological classification, a distinction between "Eucyclini" and "Calliotropini" does not seem to be simple. HICKMAN & McLEAN (1990) proposed a method, based on the shape of the aperture. In Eucyclini the juvenile and adult apertures are different in shape but similar in the tribe Calliotropini. Unfortunately, the method cannot be checked in all of the members of the tribe Eucyclini. At the same time, the distinction of the Eucyclini from the third tribe ("Chilodontini") needs also a revision because denticle or columellar fold, regarded as specific characters of the Chilodontini, are present in some genera which have been accomodated in the tribe Eucyclini (e.g. *Eunemopsis*, *Oolitica*).

Without completing a detailed revision at the generic level, the close relation of HICKMAN & McLEAN's three tribes is conceivable and these taxa seem applicable also for the fossil material. However, the characteristic shell morphology and ornament permit to attribute higher taxonomical rank for them, they will be subfamilies in Eucyclidae KOKEN, 1897 hereby as members of Eucycloidea KOKEN, 1897. A complete revision of the Eucyclidae, together with other (possibly) related Mesozoic families (?) of the Eucycloidea (Nododelphinulidae, Platyacridae and Cirridae) is a subject of another study.

Subfamily Eucyclinae KOKEN, 1897
Genus *Eucyclus* J.A. EUDES-DESLONGCHAMPS, 1860
Subgenus *Eucyclus* J.A. EUDES-DESLONGCHAMPS, 1860

Eucyclus (Eucyclus) alpinus STOLICZKA, 1861
Eucyclus (Eucyclus) capitanaeus MÜNSTER, 1844

Eucyclus (Eucyclus) tataensis sp. n.
(Plate 7, figs 5–6)

Holotypus: Plate 7, figs 5–6.

Locus typicus: Gerecse Mountains, Tata, Csurgókút.

Stratum typicum: Lower Toarcian, red, manganiferous limestone ("Csurgókút Limestone").

Derivatio nominis: from the name of the town in which the type locality can be found.

Diagnosis: Turriculate shell of convex whorls; rounded periphery; five tubercled cords on penultimate whorl.

Material: four, fragmentary, shelly specimens, one is relatively well preserved but badly damaged at the apex and the aperture.

Measurements:

H = *57
HL = *31.5
HA = *20.5
D = 26.5
W = –
A = 33°

Description: Species having rather large, high turbiniform shell consisiting of numerous whorls. Because of moderately turriculate spire, *Eucyclus (E.)* sp. n.? resembles caenogastropod shell form. Juvenile spire outline slightly concave. Whorls convex and separated by deep channel of suture. Periphery occupied by strong spiral cord (carina). Base convex and flattened near columella. Entire aperture cannot be studied. Cross-section of last whorl and damaged peristome of another specimen suggest aperture shape axially ovate as common in *Eucyclus (Eucyclus)*. Mentioned peristome fragment consisted of parietal lip and part of basal lip. This portion of shell tapering and appearing like narrow callosity.

Spiral ornament consisted of strong, tubercled cords both on whorls and base. Their interspaces crossed by delicate, subregularly repeating collabral threads; their orientation prosocline and slightly opisthocyrt. Strongest spiral cord (= weak carina) gives periphery, strength of others gradually decreasing with increasing distance from periphery. Number of cords: five on all visible spire whorls, lowermost one just along suture or just overlapped by subsequent whorl. Central part of base rather densely covered by (8–10) cords. Size of tubercles nearly equal on cords of same whorl but smaller on basal cords than on last whorl.

Remarks: One of the most similar species is HUDLESTON's "*Amberleya densinodosa*", is an *Eucyclus (Eucyclus)* in fact. The ornaments are quite near (number of spiral cords, strength and orientation of collabral threads, size of tubercles) but the dimensions are significantly different: *Eucyclus densinodosus* has (15–20°) bigger spire angle, lower and fewer whorls.

With its turriculate spire, the type species, *Eucyclus (Eucyclus) obeliscus* (J. A. EUDES-DESLONGCHAMPS, 1860), is also resembling but the shape and the dimensions of the whorls are different, the periphery is sharply carinate.

With the same spire angle and not too different other measurements, *Eucyclus (Eucyclus) elongata* (HUDLESTON) has almost the same shape as *E. (E.) tataensis* sp. n., however, the number of spiral cords of the whorls is smaller and they are stronger in the latter species.

Eucyclus (Eucyclus) alpinus STOLICZKA, the possible ancestor of *E. (E.) tataensis* sp. n., differs in its bigger spiral angle (lower shell), in having two more spiral cords on the penultimate whorl and in bearing fine growth lines instead of collabral threads. However, some of the stratigraphically youngest (Domerian) *E. (Eucyclus) alpinus* specimens, figured by GEMMELLARO, M. (1911), show transitions in shape, tending to be as turriculate as *E. (E.) tataensis* sp. n.

Distribution: Gerecse Mts., Tata, Csurgókút - Lower Toarcian, massive, red, ferro-manganiferous limestone ("Csurgókút Limestone Fm."; for more details see: FÜLÖP 1976, p. 44.).

Eucyclus (Eucyclus) barnabasi sp. n.

Plate 7, fig. 4

Holotypus: Plate 7, fig. 4.

Locus typicus: Gerecse Mountains, Tata, Csurgókút.

Stratum typicum: Lower Toarcian, red, manganiferous limestone ("Csurgókút Limestone").

Derivatio nominis: from the christian name of Professor Barnabás GÉCZY.

Diagnosis: Turriculate shell of coeloconical outline; flattened ramp on whorls; nodose carina at angular periphery.

Material: a single, shelly specimen, badly damaged at the apex and the aperture.

Measurements:

D = *21.5
W = *10.5
A = *14-16°

Description: Medium sized, rather turriculate shell of numerous convex whorls. Outline of spire concave (coeloconical). Moderately wide ramp on whorls between suture and spiral carina, running little above another carina, giving periphery on last whorl. Ramp steep in earlier whorls but its angle to axis gradually growing to last whorl. Surface of ramp flattened, except both edges where narrow concave bands can be found. Below sharp periphery, less concave base suggested by its preserved part and shape of whorls than common in *Eucyclus*. Cross section of strong columella visible.

Beside two prominent spiral carinae, mentioned, one spiral cord exposed on whorls just above suture and one spiral thread runs slightly below middle of ramp. To these four spiral ornamental elements of whorls other cords of base added (8-10 of them could be estimated if their density were similar to that on preserved outer part of base). Strength of spiral thread on ramp not changing on preserved whorls, but other spiral elements become stronger toward last whorl. Fine granulae seat on ramp thread and nudulae ornament carinae at periphery, basal cords bear granulae, too. Collabral ornament consists of delicate, slightly prosocline growth lines.

Remarks: With its coeloconical spire and the ramp on the whorls, *E. (Eucyclus) barnabasi* is a unique species in its genus.

Distribution: Gerecse Mts, Tata, Csurgókút - Lower Toarcian, red, ferro-manganiferous limestone ("Csurgókút Limestone"; for more details see: FÜLÖP 1976, p. 44.).

Subgenus *Lokuticyclus* subg. n.

Type species: *Eucyclus (Lokuticyclus) urkutensis* sp. n. (see below).

Name: Composed of the name of a village (Lókút) near to a locality (Kericser) which yielded shells belonging to the new subgenus and the latinized form (cyclus) of a Greek word κυκλας (= round, roundish).

Diagnosis: Like *Eucyclus* but phaneromphalous.

Description: Medium sized gastropods of thin-walled shells. Their shape high to low littoriniform, broadly phaneromphalous forms tend to have conical outline. Granulae on spiral cords of known species of *Lokuticyclus* subg. n. not so definite than in most of *Eucyclus (Eucyclus)* species and base may be much less convex. Umbilicus may be from quite narrow to rather broad.

Remarks: Some of the *Lokuticyclus* species were identified by SZABÓ (1982) as members of *Eucyclomphalus* VON AMMON, 1892 because of the presence of an umbilicus in the shells. However, *Eucyclomhalus* has some additional characters which distinguish it from *Lokuticyclus* subg. n. In *Eucyclomphalus* the spire is conical or pagodiform, there is a ramp on the whorls, delimited abapically by an angulation, bearing a strong, nodose cord or carina that gives the periphery. The ramp is ornamented only by growth lines (in *Lokuticyclus* subg. n. there are spiral cords between the outermost part of the whorls and the upper suture, the shell region, corresponding to the ramp of *Eucyclomphalus*.

Because of the thin shell, the preservation of the specimens is usually bad. Neither embryonal shell or entire peristome have yet been found.

Distribution: Mediterranean Province - Lower and Middle Liassic.

Eucyclus (Lokuticyclus) urkutensis sp. n.
Plate 7, figs 7–9

Holotypus: Plate 7, figs 7–9.
Locus typicus: Úrkút, Csárdahegy.
Stratum typicum: Hierlatz Limestone Formation, Sinemurian.
Derivatio nominis: after the type locality.
Diagnosis: High littoriniform, narrowly phaneromphalous shell of slightly convex spire outline. Reticulate ornament of spiral cords and collabral riblets on juvenile whorls, only spiral cords, and fine, dense growth lines on last whorl.
Material: A single, inner cast specimen with shell fragments.
Measurements:

H = *21
HL = 14
HA = *10
D = *13
W = –
A = 55–45°

Description: Shell of slightly convex spire outline ("cyrtoconical"). Convex whorls, separated by moderately deep canal of suture. Base strongly convex, rounded angulation around the umbilicus. This angulation, though no element of the peristome preserved, suggests siphonal outlet like modification at foot of "umbilical" lip.

On the earliest preserved whorl six spiral cords appear, their number increases, after three whorls, to seven to penultimate whorl. On juvenile shell spiral cords crossed by subregularly repeating, suture to suture collabral cords of same strength as spiral ones. Transverse cords gradually weaken and become shorter from lower suture, then restricted to narrow band along uppermorst spiral cord on last preserved whorl. In crossing points of cords small granulae sit which disappear little after collabral cords. On last visible whorl granulae present only on two uppermost spiral cords. Base seems also covered by spiral cords, denser than on whorls.

Growth lines slightly prosocline with shallow, just visible opisthocyrt sinus above middle of last preserved whorl. Growth lines extremely fine and dense.

Remarks: The specimen does not seem to represent completely adult stage. More exactly, the shelly part of the base shows that at least another whorl is lacking.The basal cords are almost completely resorbed within the shell as it is shown by the preserved part of the ?last whorl.

In other regions there are published species of similar shapes but without information about presence or absence of an umbilicus. The most similar of them is *"Turbo" ferryi* DUMORTIER, 1864 because of the similar ornament [the number of spiral cords is only little more (7) than in the whorl of the same diameter in *E.(L.) locuticus* sp. n. (5)]. However, on the basis of the considerably lower spire [H/Du ≫ 1.4 while H/D ≫ 2.0–2.2 can be calculated in *E. (L.) lokutensis* sp. n. at the same diameter], the distinction is possible without other characters.

A distinction from *E. (Lokuticyclus) kericserensis* sp. n. (see below) is less simple because of the similar shapes. The number of spiral cords on the (apparent) penultimate whorl gives a good basis for separation: seven in *E. (Lokuticyclus) urkutensis* sp. n. and only five on *E. (Lokuticyclus) kericserensis* sp. n. Beside this, the latter species has subregularly repeating collabral threads between the spiral cords even on the last whorl where only extremely fine growth lines appear in *E. (Lokuticyclus) urkutensis* sp. n.

On the basis of its lower spired shape and the few (four) spiral cords on the penultimate whorl, *E. (Lokuticyclus) lokutensis* sp. n. (see below) is well separable.

E. (Lokuticyclus) urkutensis sp. n. is easily separable from *E. (L.)* aff. *campiliensis* on the much narrower umbilicus, the higher number of spiral cords on the whorls, the density of the collabral elements and the dimensions.

Distribution: Bakony Mts, Úrkút, Csárdahegy – Hierlatz Limestone Fm., Sinemurian.

Eucyclus (Lokuticyclus) kericserensis sp. n.
Plate 7, figs 10–11

1982 *Eucyclomphalus* sp. – SZABÓ, p.27., Pl. III: fig. 10.

Holotypus: Plate 7, figs 10–11.
Locus typicus: Lókút, Kericser.
Stratum typicum: Hierlatz Limestone Fm., Pliensbachian (Davoei Zone).
Derivatio nominis: the excavation, yielded the type specimen, is on the slope of Kericser Hill, near village Lókút in the Bakony Mountains.
Diagnosis: High littoriniform, narrowly phaneromphalous shell. Spiral cords on spire and base. Subregularly repeating, fine, collabral threads between spiral cords on all whorls.
Material: calcitic infilling of a single specimen with preserved shell portions.
Measurements:

H = *21
HL = *13
HA = *9
D = *14
W = *9
A = 55°

Description: Extremely thin-walled shell, consisted of convex whorls and base, suture in moderately deep canal. Narrow umbilicus, joining to base with rounded angulation. Peristome unknown but whorl cross section suggests similar form than in *Eucyclus*.

Spiral cords present on whorls and base, their number five on penultimate whorl; strongest one runs on periphery. Denser spiral cords on base (badly preserved). Collabral threads, typical to Eucyclidae, between spiral cords. Number of threads three in one millimetre on last whorl. Some short, less damaged parts of spiral cords suggest presence of tubercles at meeting points with collabral riblets.

Remarks: Most similar species to *E. (Lokuticyclus) kericserensis* sp. n. is *E. (Lokuticyclus) urkutensis* sp. n. (see distinction above); a close phylogenetical connection between them is very likely.

E. (Lokuticyclus) aff. *campiliensis* (DE STEFANI, 1887) is distinguishable on its wider umbilicus, the rather conical spire and the denser collabral threads (five in one millimetre on the last whorl at the periphery, while only three in *E. (L.) kericserensis* sp. n.).

E. (Lokuticyclus) lokutensis sp. n. (see below) is lower spired, consequently having a more globular shape than *E. (Lokuticyclus) kericserensis* sp. n. The number of spiral cords on the penultimate whorl is less, only four in *E. (Lokuticyclus) lokutensis*.

Distribution: Bakony Mts, Lókút, Kericser – Pliensbachian (Davoei Zone).

Eucyclus (Lokuticyclus) lokutensis sp. n.
Plate 7, figs 12–13

Holotypus: Plate 7, figs 12–13.

Locus typicus: Lókút, Kericser.

Stratum typicum: Hierlatz Limestone Fm., beds with Upper Sinemurian and Lower Pliensbachian (Obtusum to Ibex Zones) mixed fauna.

Derivatio nominis: the excavation, yielded the type specimen (Kericser), is near village Lókút in the Bakony Mountains.

Diagnosis: Low littoriniform, narrowly phaneromphalous shell. Few spiral cords on spire whorls, numerous on base. Extremely fine growth lines as only collabral ornament on adult whorls.

Material: a single, damaged inner mould specimen with preserved shell portions.

Measurements:

HL = *21.5
HA = *15
D = 21
A = 55°

Description: Low littoriniform, cyrtoconical species of extremely thin-walled shell, having convex whorls and strongly convex base. Rim of umbilicus subangulate. Peristome not preserved, whorl cross section suggests *Eucyclus*-type apertural region. Cross section of "umbilical" lip shows moderate thickening on last peristome.

Number of spiral cords four on penultimate whorl, one of them just above suture. Cords on base (12–14) of similar strength than on whorls but more closely spaced. Interspaces between them crossed by delicate growth lines. No evidence for presence of tubercles on spiral cords has been found.

Remarks: The spiral angle value given is measured on last whorl, the apical angle must be much higher because of the cyrtoconical shape.

The strongly different shape, the difference in the number of exposed spiral cords on the penultimate whorl and in the width of the umbilicus of the two species gives an easy way of distinction in case of *E. (Lokuticyclus) lokutensis* sp. n. and *E. (Lokuticyclus)* aff. *campiliensis* (DE STEFANI, 1887). (See distinction from other *Lokuticyclus* species above.)

Distribution: Bakony Mts., Lókút, Kericser – Hierlatz Limestone Fm., beds with Upper Sinemurian–Lower Pliensbachian (Obtusum to Ibex Zones) mixed fauna. (The specimen does not show any trace of rewoking, its Carixian age seems to be likely.)

Eucyclus (Lokuticyclus) aff. *campiliensis*
(DE STEFANI, 1887)

aff. 1887 *Pleurotomaria campiliensis* DE STEFANI, p. 45., pl. 1.: figs. 12–13.
1982 *Eucyclomphalus* aff. *campiliensis* (DE STEFANI, 1887) – SZABÓ, p.26., pl. III: figs. 8–9.
cf. 1991 *Eucyclomphalus* aff. *campiliensis* (DE STEFANI, 1887) – CONTI & MONARI, p. 273., pl. 8., figs. 15–16.

Remarks: Detailed description of the specimens belonging to this species is given by SZABÓ (1982), marked in the list of synonyms. Unfortunately, a possibility for a comparison of the Bakony specimens to DE STEFANI's originals has not yet been found, therefore the level of species identification remains doubtful. The rather poor preservation of the specimens, published by CONTI & MONARI (1991) under the same name, does not make possible a doubtless identification with the Bakony Mts species.

Distribution: ??Northern Apennines – Sinemurian; Bakony Mts, Upper Sinemurian–Lower Pliensbachian (to Davoei Zone); ?Western Pontids: Raricostatum to Ibex Zone

Genus *Riselloidea* COSSMANN, 1909
Riselloidea multistriata (BÖCKH, 1874)

Riselloidea noszkyi sp. n.
Plate 7, figs 1–3

Holotypus: Plate 7, figs 1–3.

Locus typicus: Úrkút, Csárdahegy.

Stratum typicum: Hierlatz Limestone Fm., Sinemurian.

Derivatio nominis: from the family name of Hungarian geologist Jenő NOSZKY who collected the type specimen.

Diagnosis: small size; ornament of strong spiral cords, sparse on whorls, dense on base; collabral ribs on whorls, dense collabral threads on base; cords and ribs reflected on inner cast.

Material: three bad preserved specimens, one of them shows satisfactorily the specific characters.

Measurements:

H = *14
HL = *10
HA = *7
D = *13
A = 70°

Description: Shell trochiform, rather small sized. Spire nearly conical, whorls and base moderately convex, suture in shallow canal. Periphery angulate. Base more flattened than whorls and anomphalous. Peristome not preserved.

Ornament of three spiral cords on last and penultimate whorls, fourth one on periphery, overlapped by suture on earlier whorls. Collabral ribs of strength, similar to that of spiral cords. Ribs stronger at upper suture and gradually weaken toward lower edge of whorls. Tubercles at crossing points of ribs and cords. Dense spiral cords on base, fine collabral threads cross them. Growth lines and other collabral elements weakly prosocline.

Remarks: *Riselloidea noszkyi* sp. n. has sparser ornamental elements on the whorls than *R. multistriata* (BÖCKH, 1874) and collabral elements are much weaker, only cords in the latter species, the dimensions are also significantly different.

Morphologically and by the stratigraphical occurrence, *Riselloidea noszkyi* sp. n. may be the ancestor of *Riselloidea multistriata* (BÖCKH, 1874).

Distribution: Bakony Mts, Úrkút, Csárdahegy – Sinemurian; Sümeg, Mogyorósdomb – Upper Sinemurian.

Subfamily Chilodontinae WENZ, 1938
Genus *Wilsoniconcha* WENZ, 1939

Wilsoniconcha? cf. *biplicata* M. GEMMELLARO, 1911
Plate 7, fig. 14

Material: a naturally prepared cross section on a weathered rock surface, a narrow outer shell part shows the ornament.

Measurements:

HA = 5.1
D = 6.5
W = 4.7
A = ?-22°

Description: High spired, cylindroconical, rather small shell. Whorls weakly convex, suture in shallow canal. Periphery rounded, base strongly convex and anomphalous. Inner space of whorls quadrangular in juvenile shell part, ovate (drop shaped) just like peristome. In whorls, V-shaped cross section of two strong and sharp columellar folds, having rounded, denticle like end at inner lip.

Ornament consists of dense spiral cords, crossed by slightly prosocline collabral threads. Granulae at crossing points.

Remarks: The specimen seems to be the member of *Wilsoniconcha*, the only character differing from its description is that columellar folds are present instead of denticles. It is necessary to clear up whether it is a real difference, or the interior of *Wilsoniconcha* has been unsatisfactorily known.

M. GEMMELLARO (1911) established a new genus *(Cupaniella)* for his species and compared to procerithiid genera. There is no doubt that "*Cupaniella biplicata*" belongs to Chilodontinae. If the difference from *Wilsoniconcha* is real, it should be examined what is the meaning of that. More exactly: is *Cupaniella* a synonym of *Wilsoniconcha*, or its subgenus, or really an independent genus?

Open nomeclature is used in case of the species name, because the mesurements are not well comparable owing to the bad preservation and the cross section of the folds are different from that in GEMMELLARO's figure.

Distribution: Bakony Mts, Lókút, Kericser – Hierlatz Limestone beds with Upper Sinemurian–Lower Pliensbachian (Obtusum to Ibex Zones) mixed fauna; ?East Sicily, Galati, Rocche Rosse, Upper Pliensbachian.

Palaeoecology

Reconstruction of the Jurassic environment in the Transdanubian Central Range and in other Tethyan areas, characterised by similar rock types and faunas, have been continuously attempted. Because modern counterparts of the facies do not exist in most cases, some elements of the reconstructions (e.g. palaeogeographical position or depth of water) vary considerably. Other elements [e.g. tectonical control of the sedimentation and pelagic origin of the red(dish), condensed sequences] are rather widely accepted. Eucyclids seem to be one of the gastropod groups which can add reliable data to eliminate some uncertainties.

Here, the paleoenvironmental model, applied to palaeoecological analysis of brachiopods by VÖRÖS (1986) is adapted to reach the possible highest compability. Within the studied stratigraphical interval (Sinemurian–Toarcian) where the above eucyclids have been found, two main facies groups occur in the the Transdanubian Central ange. One closely connected to submarine topographic eights, the other to the basins. These morphological lements developed during submergence of a former (Late riassic–Hettangian) cabonate platform of a passive ontinental margin along the Tethys (GALÁCZ et al. 1985). he gastropods occur in two main lithological types, onnected to the elevated sea bottom parts. One (massive, ed, manganese-oxide bearing limestone) is regarded by ÖRÖS (1986) as deposited on the top of the submarine ills (?mounts) and the other ("Hierlatz Limestone") eposited on the slopes and at the foot (in the basin). The only lithological type of the basins which have contained gastropods is the condensed red, nodular, ammonite bearing limestone (ammonitico rosso limestone) but most frequently in localities where interfingering with cherty, crinoideal limestone (fluxoturbidite around "seamounts") or with sponge spiculae bearing, cherty limestone (autochtonous) is observed.

Eucyclids show definite dependence on different environments, represented by the above lithological types, as Table 1 demonstrates.

able 1. Distribution of the specimens of the Carixian eucyclid genera in the main lithological types.

	red, manganiferous limestone	Hierlatz limestone	red, nodular limestone
	top of "seamounts"	slope or foot of "seamounts"	basins
Lokuticyclus	0	5	0
Risselloidea	3	5	6
Eucyclus (s. s.)	0	6	15
?*Wilsoniconcha*	0	1	0

From these three main lithological types, the red, anganiferous limestone and the red, nodular limestone ontain predominantly autochtonous gastropods. The ierlatz Limestone may contain gastropods both from the p of the submarine heights and from the basin if deposited at the foot of the "seamounts". From the point of iew of palaeobathymetry, it means that all of the gastroods (and other fossils) adapted to different depths may ccur together in this latter limestone. The red, managaniferous limestone ("seamount" top) may origin from ifferent depths and not necessarily representing the allowest water environments. This means that the only, latively "fix point" is the red nodular limestone in a alaeobathymetrical analysis, started from the facies.

On the top of the submarine heights the hard substrate nd in the basins the soft (unconsolidated) sediments are e more probable.

The specimen numbers in Table 1 show that Eucycnae genera and subgenera preferred the deeper water nvironments (slope and mainly basin) probably with nconsolidated substrate in the Transdanubian Central ange. The frequency in the Hierlatz Limestone seems to e increased by the probably hillfoot deposition at the cality, considered (Lókút, Kericser), and by the more vourable fossilisation possibilities (weaker subsolution) f this lithological type.

The water depth, suggested by VÖRÖS (1986) for the slope and basin environments, is similar to that can be estimated from the actualistic data of the studied gastropod group. Living nearest relatives of the Mesozoic eucyclids (Calliotropinae) occur predominantly in bathyal (>200 m) to abyssal depths of offshore regions on unconsolidated sediment, and they seem to be adapted to cool and cold water (with submergence in equatorial regions); sometimes their individuals locally dominate slope communities (HICKMAN & MCLEAN 1990). The last statement is true also for the poor gastropod associations of the known Toarcian faunas in the Transdanubian Central Range where they give 80–100 % of the specimens.

The living members of the Chilodontinae inhabit primarily tropical intertidal and shallow subtidal biotopes (HICKMAN & MCLEAN 1990). Facies of the Western European Jurassic localities of the Chilodontinae (e.g. Inferior Oolite) suggests a habit similar to that of the living forms. Because the group does not seem to change habit since the Jurassic, the presence of the only Chilodontinae specimen of ?*Wilsoniconcha* cf. *biplicata* (M. GEMMELLARO, 1911) in the Lókút, Kericser Hierlatz Limestone fauna suggests that some parts of the submarine height in the vicinity of the locality reached the depths near the tidal zone during the Late Sinemurian and/or the Early Pliensbachian.

Conclusion

Actualistic data about the habit of eucyclids seem to gree in the Transdanubian Central Range with those of at can be concluded from the palaeoenvironmental econstruction. Eucyclinae lived in bathyal (?abyssal) epths on unconsolidated sediments. Presence of Chiloontininae is regarded as a new datum to (subordinate) presence of shallow subtidal environments on the top of the Early to Middle Liassic submarine topographic heights.

While in the Transdanubian Central Range the reconstructed habitat of the eucyclids is similar to that of the living nearest relatives (Calliotrpinae), HICKMAN &

McLEAN (1990) have found highest abundance in Tethyan shallow water, reef associated paleoenvironments". However, their data seem to be mainly collected from the facies of the Western European epicontinental seas. Further studies are necessary to decide if these differencies are real, or there are some equivalent elements in the habits, reconstruable in the two areas.

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Plate 7

Figs 1-3. *Riselloidea noszkyi* sp. n., 2×, holotype, J 11464.
Fig. 4. *Eucyclus (Eucyclus) barnabasi* sp. n., 1.5×, holotype, J 11460.
Figs 5-6. *Eucyclus (Eucyclus) tataensis* sp. n., 1.5×, holotype, J 11459.
Figs 7-9 *Eucyclus (Lokuticyclus) urkutensis* subg. and sp. n., holotype, 7-8: 2.3×; 9 (details of ornament on hootype): 5.3×, J 11461.
Figs 10-11. *Eucyclus (Lokuticyclus) kericserensis* subg. and sp. n., holotype,, 10: 1.3×; 11 (details of ornament on holotype): 5.5×, J 11462
Figs 12-13. *Eucyclus (Lokuticyclus) lokutensis* subg. and sp. n., holotype, 1.5×, J 11463.
Fig. 14. *Wilsoniconcha* ? cf. *biplicata* (M. GEMMELLARO, 1911), 7×

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Essai de correlations au Lias moyen (Sinemurien supérieur et Carixien) entre les Pontides et les principales regions adjacentes de la Téthys occidentale et de l'Europe du nord-ouest

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(avec 2 figures)

Résumé

Les nouvelles données biostratigraphiques des Pontides (Turquie) sont comparées avec celles des principales régions adjacentes de la Téthys occidentale et de l'Europe du nord-ouest. Les corrélations proposées ici sont basées sur des ammonites du Sinémurien supérieur et du Carixien et sont représentées sous forme d'un tableau syntéthique.

Mots-clés: Jurassique inférieur, Ammonites, Biostratigraphie, NO Europe, Téthys occidentale

Abstract

The new biostratigraphical data from the Pontides (Turkey) are compared with those of the main contiguous regions of the western Tethys and NW Europe. The correlations are based on the Late Sinemurian and Carixian ammonites, and are given in a synthetic table.

Key words: Early Jurassic, Ammonites, Biostratigraphy, NW Europe, Western Tethys.

Introduction

Au Sinémurien supérieur et au Carixien, le provincialisme des faunes d'ammonites ne permet pas d'établir un cadre biostratigraphique homogène pour la totalité des régions envisagées ici (Fig. 1). Rappelons que les échelles biostratigraphiques dans le domaine euroboréal sont basées, pour cette période, essentiellement sur les Asteroceratinae *(Asteroceras, Eparietites)*, les Echioceratidae *(Echioceras, Leptechioceras* et *Paltechioceras)*, les Polymorphitidae *(Platypleuroceras...)*, les Acanthopleuroceratidae *(Acanthopleuroceras)* et les Liparoceratidae *(Beaniceras, Aegoceras, Oistoceras)* alors que les successions dans le domaine téthysien sont fondées sur les Asteroceratinae *(Asteroceras, Parasteroceras)*, les Echioceratidae *(Paltechioceras)*, les Acanthopleuroceratidae *(Tropidoceras)* et les Harpoceratinae *(Protogrammoceras)*. Les éléments communs aux deux domaines sont rares et ne permettent pas des corrélations très fines.

Le cadre biostratigraphique est plus avancé pour certaines régions ce qui accentue encore les problèmes de corrélations. Il y a aussi inégalité dans la valeur des horizons ou niveaux. En effet dans les régions bien documentées, les unités stratigraphiques sont basées sur des assemblages fauniques bien établis avec des successions souvent continues alors que dans d'autres régions, soit moins bien documentées (informations ponctuelles), soit à enregistrements fossiles discontinus ou encore pauvres en fossiles les incertitudes de corrélations sont parfois importantes, même à l'échelle locale. Il existe toutefois de nombreux travaux concernant la biostratigraphie de ces régions, nous avons réuni les dernières versions ou celles considérées comme les plus complètes et les plus précises possible. Les différentes successions biostratographiques (Fig. 2) sont basées sur les travaux de DEAN et al. (1961), DOMMERGUES & MEISTER (1987b, 1992), CORNA et al.(1994), DOMMERGUES et al. (1994) pour le nord-ouest de l'Europe; de DOMMERGUES & MEISTER (1990a) pour le Subbriançonnais (Suisse et France); de DOMMERGUES & MEISTER (1990b) pour l'Austroalpin moyen d'Italie; de BLAU & MEISTER (1991), MEISTER & BÖHM (1993), MEISTER et al. (1994), DOMMERGUES et al. (sous presse) pour l'Austrolapin supérieur d'Autriche; de GÉCZY (1972, 1976, 1982), KOVÁCS (1971), DOMMERGUES et al. (1983), DOMMERGUES & GÉCZY (1989) pour la Hongrie; de PREDA & RĂILEANU

(1960), Patriulus & Popa (1970); Mutihac (1970) Popa et al. (1976, 1985), Gradinaru (1984) pour les différentes régions de Roumanie; de Sapunov (1961), Sapunov & Stephanov (1964), Tchoumatchenko (1988), Dommergues et al. (1987), Tchoumatchenko et al. (1989) pour la Bulgarie; de Alkaya & Meister (sous presse) pour les Pontides (Turquie); de Rivas (1970), Braga & Rivas (1980, 1985), Braga et al. (1984) pour les Bétiques (Espagne) et de Dommergues et al. (1983, 1994), Ferretti (1990), Donovan (1990), Ferretti & Meister (1994) pour les Appennins (Italie). Nous ne reprendrons pas ici les commentaires et les associations décrites par les différents auteurs et nous ne mettrons en évidence que le taxon potentiellement corrélable ou index. Ce travail est donc une tentative de corrélation des principaux évènements fauniques qui ont une signification à une échelle suprarégionale ou supradomaine. Les études biostratigraphiques récentes dans des régions comme l'Austroalpin, le Bakony ou les Pontides où coexistent des faunes provenant des deux domaines paléogéographiques on montré qu'il existe quelques bons éléments de corrélations supra-domaines.

La série d'"horizons" reconnus pour le nord-ouest de l'Europe reste perfectible et représente les principaux évènements fauniques corrélables en Europe moyenne. Elle nous sert ici de référence. Ces "horizons nord-ouest européens" représentent la subdivision la plus fine actuellement possible de la sous-zone et se rapprochent plus de la notion de zonule; ce qui est différent de la conception de Callomon (1985). Par contre pour les autres régions, au moins dans les régions où nous avons travaillé, le terme horizon ou niveau est utilisé au sens de Meister et al. (1994). Remarque: l'épaisseur des cartouches met en évidence l'incertitude d'âge et la précision des corrélations des niveaux ou horizons considérés.

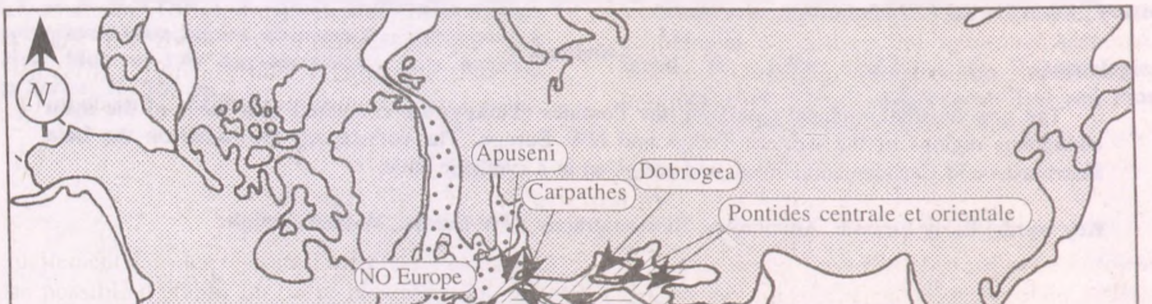


Fig. 1. Localisation des principales régions étudiées dans le cadre paléogéographique du Lias moyen proposé par Barron et al. (1981)

Sinemurien supérieur

Zone à Obtusum

Les sous-zones à Obtusum et à Stellare sont clairement représentées dans les régions envisagées ici. En outre dans la plupart des régions, les faunes à *Asteroceras* sont accompagnées par des *Arnioceras* et spécialement des *Arnioceras* du groupe de *A. rejectum* (FUCINI) sensu lato. A l'exception de l'Europe du nord-ouest, voire (?) du Subbriançonnais où il existe des *Asteroceras* caractéristiques de la sous-zone à Obtusum, les *Asteroceras* présents dans les autres régions possèdent des morphologies "dérivées" c'est-à-dire soit des morphologies intermédiaires entre les *Asteroceras* s.s. et les *Aegasteroceras* avec perte de la tricarénation et tendance, pour certains, aux côtes à passer ventralement, soit des morphologies caractérisées par une perte de l'ornementation et par la perte des sillons ventraux. Ces formes semblent indiquer la sous-zone à Stellare voire la base de la sous-zone à Denotatus plutôt que la sous-zone à Obtusum. L'ensemble des taxons *A. meridionalis* DOMMERGUES, MEISTER & METTRAUX du Subbriançonnais, *A.* aff. *saltriensis* (PARONA) de l'Austroalpin autrichien, *A. suevicum* (QUENSTEDT) des Bétiques et *A. varians* (FUCINI) de l'Appennin semblent donc correspondre à peu près à la même période (sous-zone à Stellare). *"A."* aff. *blakei* SPATH des Pontides indique la partie supérieure de Stellare. En Europe du nord-ouest cette espèce se situe juste sous les *Aegasteroceras saggitarium* (BLAKE). En Hongrie les faunes citées par GÉCZY (1972) évoquent également cette période. Par contre en Roumanie la position systématique des *Asteroceras* demande encore à être précisée. Même si les corrélations ont seulement la précision de la sous-zone en raison de l'absence de taxon identiques, les *Asteroceras* représentent un évènement faunique important dans toute cette partie de la Téthys occidentale et de l'Europe moyenne à l'exception de la Bulgarie ou les faunes du Sinémurien paraissent pour l'instant inconnues si ce n'est par quelques *Arnioceras* dans les olistolithes du Kotel.

Pour la sous-zone à Denotatus, des éléments de corrélations sont reconnus uniquement dans le Subbriançonnais, l'Austroalpin supérieur (Autriche) et le Bakony (Hongrie) bien que certains *Asteroceras* "dérivés" comme évoqués précédemment pourrait y être attribués.

Zone à Oxynotum

Actuellement, elle est seulement reconnue avec certitude dans les unités alpines subbriançonnaises, austroalpines (Livigno, Autriche) et au Bakony (Hongrie). Dans les Apennins, la position stratigraphique des formes à morphologie oxycône n'est pas connue avec précision et une grande partie des ces ammonites sont en fait des Parasteroceras de la zone à Raricostatum (DOMMERGUES et al., 1994)

Zone à Raricostatum

Les corrélations supra-domaines sont peu précises pour cette période. En effet dans les régions d'affinité euroboréale Subbriançonnais, Austroalpin moyen (Livigno), en partie dans l'Austroalpin supérieur pour les faciès "Fleckenmergel" de Lienz (BLAU 1983) en partie en Hongrie (Mecsek) voire en Roumanie, les subdivisions à l'échelle de l'horizon sont basées pour l'essentiel sur les Echioceratidae alors qu'en domaine téthysien (Apennins, Austroalpin supérieur avec les faciès "Ammonitico rosso" d'Adnet ou ceux du Bakony en Hongrie) les horizons sont basés sur des Asteroceratinae particuliers, les *Parasteroceras*.

La sous-zone à Densinodulum peut être reconnue dans le Subbriançonnais, en Autriche, Hongrie et probablement dans les Apennins avec les *Parasteroceras*.

La sous-zone à Raricostatum est partout représentée au moins par un horizon à l'exception de la Bulgarie où on manque de données pour l'ensemble du Sinémurien supérieur. Dans les régions d'affinité euroboréale ou située sur la marge nord de la Téthys: Subbriançonnais, Austroalpin moyen, Mecsek (Hongrie), Roumanie et peut-être Turquie c'est la présence d'Echioceratidae qui confirme sa présence. Mais dans les Pontides, la mauvaises préservation du spécimen *Echioceras* (?) sp. ne permet pas d'attribuer avec certitude ce niveau à la sous-zone Raricostatum plutôt qu'à celle à Macdonnelli. Dans les régions d'affinité téthysienne, cette sous-zone est vraisemblablement représentée par des *Parasteroceras* sp., *P. pulchellum* (FUCINI) voire des *Microderoceras gigas* (QUENSTEDT) dont la position au sein de cette sous-zone est encore à préciser.

La sous-zone à Macdonnelli et la sous-zone à Aplanatum ne peuvent être séparées que dans l'Austroalpin, le Subbriançonnais, en Roumanie et en partie peut-être dans les Apennins avec *P.* aff. *tardecrescens* (HAUER). Dans les autres régions on a un évènement à *Paltechioceras* ssp. ou *P. romanicum* (UHLIG) dont on ne connaît pas encore la position exacte au sein des sous-zones à Macdonnelli et Aplanatum (voire de la partie supérieure de la sous-zone à Raricostatum). Rappelons que le range du genre *Paltechioceras* va du sommet de la sous-zone à Raricostatum au sommet de la sous-zone à Aplanatum (DOMMERGUES & MEISTER, 1992). Les *Leptechioceras*, caractéristiques de la sous-zone à Macdonnelli, ne permettent des corrélations qu'en Europe, dans l'Austroalpin supérieur et moyen et en Roumanie d'après les données de PATRULIUS & POPA (1971). Le *P. romanicum* (UHLIG) provenant de Turquie ne peut être corrélée avec certitude avec aucun *Paltechioceras* du nord-ouest de l'Europe. Dans le domaine téthysien quelques *P.* aff. *romanicum* (UHLIG)

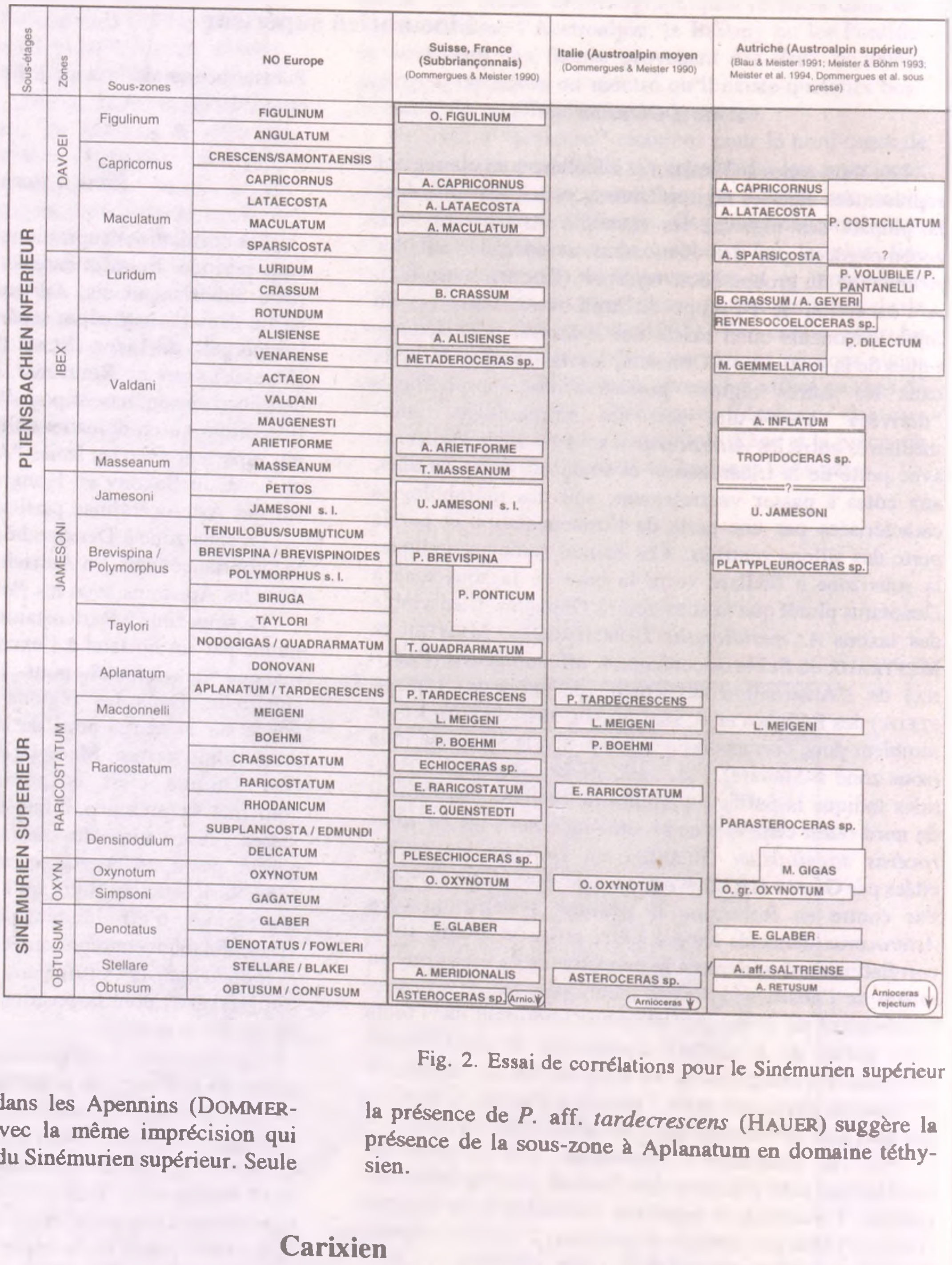


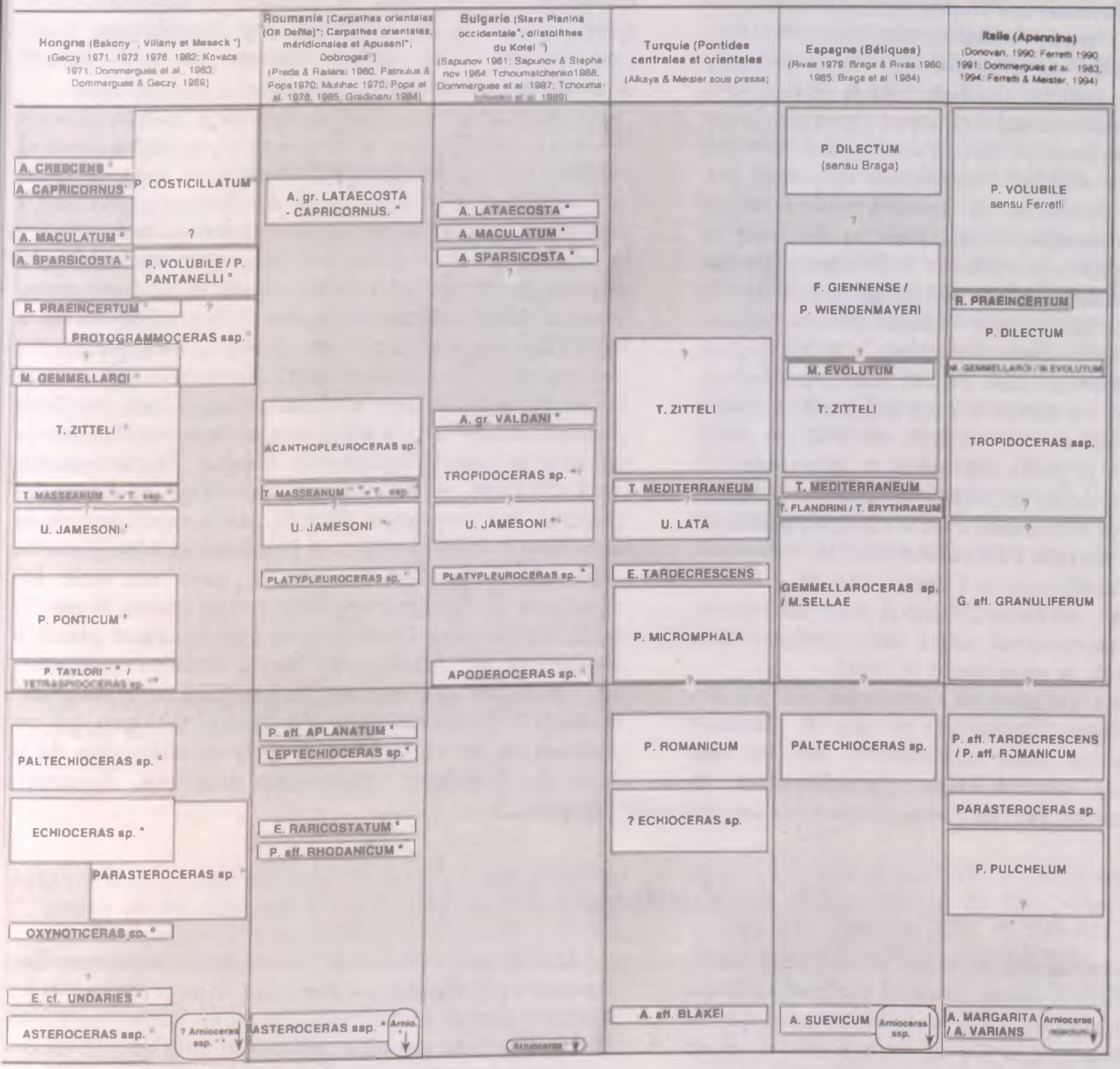
Fig. 2. Essai de corrélations pour le Sinémurien supérieur

ont été également trouvé dans les Apennins (DOMMERGUES et al., 1994) mais avec la même imprécision qui évoque la partie supérieure du Sinémurien supérieur. Seule la présence de *P.* aff. *tardecrescens* (HAUER) suggère la présence de la sous-zone à Aplanatum en domaine téthysien.

Carixien

Zone à Jamesoni

Le passage Sinémurien–Carixien est très bien documenté dans le Yorkshire (nord-ouest Europe) (DOMMERGUES & MEISTER, 1992); dans les autres régions les problèmes sédimentaires et/ou l'absence d'ammonites ne permettent pas de préciser cette limite. Dans les régions envisagées ici, cette limite n'est jamais clairement établie. Même si la présence de *Tetraspidoceras* sp. en Hongrie (Mecsek), de *T. quadrarmatum* (DUMORTIER) dans le Subbriançonnais ou d'*Apoderoceras* sp. en Bulgarie attestent clairement que la partie inférieure du Carixien est présente (base de la sous-zone à Taylori). Par contre en Turquie, les *Pseuduptonia micromphala* (PIA) indiquent sans plus de précision la sous-zone à Taylori voire une partie de la sous-zone à Brevispina/Polymorphus sensu DOMMERGUES & MEISTER (1987) ou peut-être encore le sommet du Sinémurien (?). Les *Pseuduptonia* reconnus dans le Subbriançonnais dans un contexte de banc condensé du Carixien inférieur (DOMMERGUES, 1982) et dans le Mecsek–Villány (DOMMERGUES & GÉCZY, 1989)



et le Carixien dans les confins de la Téthys occidentale.

(Hongrie) reflètent plutôt une période d'incertitude comprise entre la base du Carixien (sous-zone à Taylori) et les niveaux à *Platypleuroceras* de la sous-zone à Brevispina/Polymorphus. Les corrélations avec la zonation standard restent donc un peu ambigues. De même en Téthys (Apennins et Bétiques), la présence de *Gemmellaroceras* sp. (+ *Miltoceras sellae* (GEMMELLARO), *G. granuliferum* (GEMMELLARO) indiquent une période comprise entre les *Paltechioceras* du Sinémurien supérieur et les *Tropidoceras* de la partie supérieure de la zone à Jamesoni ou peut-être déjà de la base de la zone à Ibex.

La sous-zone à Brevispina/polymorphus est représentée par un niveau à *Platypleuroceras brevispina* (SOWERBY) ou *P.* sp. En Turquie, l'horizon à *Eoderoceras tardecrescens* (PIA) caractérisé par l'association *Eoderoceras* – *Platypleuroceras* apparaît clairement être l'équivalent des niveaux à *Platypleuroceras brevispina* (SOWERBY) – *P. brevispinoides* TUTCHER & TRUEMAN du nord-ouest de l'Europe. Ces formes ne sont pas présentes dans les régions d'affinité téthysienne plus franche.

La sous-zone à Jamesoni est bien représentée à l'exception des régions d'affinité téthysienne où sa partie supérieure comprend vraisemblablement les premiers niveaux à *Tropidoceras*. Remarquons que les niveaux à *Uptonia* et les niveaux à Platypleuroceras sont presque toujours présents ensembles.

Zone à Ibex

Le range des *Tropidoceras* est assez long et recouvre la partie supérieure de la sous-zone à Jamesoni jusqu'à la partie moyenne à supérieure de la sous-zone à Valdani aussi bien dans le nord-ouest de l'Europe que dans la Téthys. Aussi les niveaux à *Tropidoceras* sp. ne permettent pas des corrélations très précises bien qu'habituellement les auteurs attribuent ces *Tropidoceras* à la sous-zone à Masseanum. La partie inférieure de cette zone correspond à une acmé de *Tropidoceras (T. masseanum* (D'ORBIGNY)) qui indique classiquement la sous-zone à Masseanum. *T. mediterraneum* (GEMMELLARO) n'a jamais été retrouvé en dehors du domaine téthysien et il est difficile de savoir si c'est vraiment un équivalent des niveaux à *T. masseanum* (D'ORBIGNY); nous avons suggéré ici une contemporanéité. Mais en fait seule la présence de l'espèce index dans le Subbriançonnais, au Bakony et en Roumanie, atteste clairement la présence de cette sous-zone. La sous-zone à Valdani est classiquement caractérisée par les *Acanthopleuroceras*. En Téthys, les niveaux à *Tropidoceras zitteli* FUCINI sont probablement des équivalents de ces derniers, mais leur position exacte doit être affinée. Suivant BRAGA & RIVAS (1985) *T. zitteli* FUCINI représente la partie supérieure de la sous-zone à Valdani, associé avec les premiers *Protogrammoceras* sp. et *P. dilectum* (FUCINI) comme c'est le cas également dans les Pontides. Un horizon à Metaderoceras (*M. venarense* (OPPEL) pour le nord-ouest de l'Europe et à *M. gemmellaroi* (LEVI) - *M. evolutum* (FUCINI) pour les régions téthysiennes est un excellent repère supra-domaine de la partie supérieure de la sous-zone à Valdani.

La sous-zone à Luridum est représentée soit par des *Beaniceras crassum* (BUCKMAN) et des *B. luridum* (SIMPSON) dans les zones euroboréales soit par des *Reynesocoeloceras praeincertum* (DOMMERGUES & MOUTERDE) ou encore par des *Protogrammoceras* ssp. La taxonomie très prolifique de ces derniers demande à être homogénéisée et le problème des corrélations n'est probablement qu'un artefact reposant sur la différence dans les conceptions taxonomiques.

Zone à Davoei

Pour la zone à Davoei, les horizons sont basés soit sur la succession des Liparoceratidae capricornes dans le domaine euroboréal, soit sur la succession des *Protogrammoceras* dans le domaine téthysien. Les corrélations entre les différentes régions de ce domaine sont rendues à nouveau difficiles en raison des différences de conceptions taxonimiques pour les Harpoceratinae. Chez ces Harpoceratinae, il semble y avoir une successsion *Protogrammoceras dilectum* (FUCINI) → *P. volubile* (FUCINI)-*pantanelli* (FUCINI) → *P. costicillatum* (FUCINI)-*detractum* (FUCINI) qui commence dans la partie supérieure de la sous-zone à Valdani et qui se poursuit jusqu'au Carixien supérieur. Cependant les limites entre ces trois assemblages de *Protogrammoceras* restent encore floues. Si la limite Carixien–Domérien est classiquement placée à l'apparition des Amaltheidae dans le domaine euroboréal, en Téthys par contre c'est l'assemblage à *"Protogrammoceras" lavinianum* (FUCINI)-*portisi* (FUCINI) qui est maintement un bon critère pour la détermination de la base du Domérien (Austroalpin supérieur, Apennins, Bétiques...).

Conclusion

1. Actuellement dans les régions d'affinité téthysienne, il n'est pas possible d'établir un cadre biostratigraphique cohérent et reproductible au sein de ce domaine que se soit pour le Sinémurien supérieur ou le Carixien. Si on peut évoquer pour l'ensemble des régions méditerranéennes une certaine hétérogénéité faunique avec des peuplements différents pour une même période, un effort d'homogénéisation de la taxonomie s'avère nécessaire. Pour l'instant les assemblages fauniques supposés reproductibles au sein des régions d'affinité téthysienne considérées ici sont représentés du plus récent au plus ancien par:

- *Protogrammoceras costicillatum-detractum*
- *Protogrammoceras volubile-pantanelli*
- *Reynesocoeloceras praeincertum Protogrammoceras* gr. *dilectum*
- *Metaderoceras gemmellaroi Protogrammoceras* gr. *dilectum*
- *Tropidoceras zitteli*
- *Tropidoceras mediterraneum*
- *Paltechioceras* ssp.
- *Parasteroceras* ssp.
- *Asteroceras* ssp.

La présence d'ammonites nord-ouest européennes dans l'Austroalpin supérieur d'Autriche, dans le Bakony et les Pontides permet de caler plus ou moins précisément cette succession faunique mais les incertitudes restent encore nombreuses surtout pour le Carixien inférieur.

2. Les principaux évènement fauniques supradomaines correspondent:

- dans la zone à Obtusum, à un épisode à *Asteroceras* qui est un évènement à l'échelle au moins de la Téthys occidentale aussi bien présent dans le domaine euroboréal, sur la marge nord téthysienne qu'en domaine téthysien et donc indépendant des différents type de faciès auxquels ces ammonites sont associées.
- dans la zone à Raricostatum, à un évènement reproductible à grande échelle qui est celui des *Paltechioceras*. Pour le reste les corrélations sont plus difficiles que dans la zone à Obtusum car les ammonites *(Echioceras, Leptechioceras)* restent liées au domaine euroboréal et en partie à la marge nord de la Téthys et leur supposé équivalent les *Parasteroceras* (partim) semblent être associés à des faciès de bassins plus ouverts comme les "Ammonitico Rosso" ou les alternances marno-calcaire des Apennins. Cela paraît très net dans l'Austroalpin ou les Echioceratidae sont plus liés au faciès

"Fleckenmergel", ou "Gresten" alors que les *Parasteroceras* sont associés à des faciès de type "Ammonitico Rosso".

– dans la zone à Jamesoni, à aucun évènement reproductible majeur. L'épisode à *Platypleuroceras* caractérise la partie moyenne de cette zone, il se manifeste en Europe du nord-ouest ou dans des régions très proches comme l'Austroalpin supérieur et la marge nord de la Téthys. Par contre il est inconnu dans des zones plus franchement téthysiennnes. Un second épisode avec les *Uptonia*, caractérisant cette fois la partie supérieure de cette zone et a une distribution paléogéographique identique à celle de l'épisode précédent. Notons également l'épisode à *Pseuduptonia* qui évoque un endémisme liés à la marge nord de la Téthys. Des genres tels les *Eoderoceras*, *Metaderoceras* et *Miltoceras* pourraient fournir des éléments de corrélations fiables pour le domaine téthysien comme le suggère les nouvelles données sur le Maroc (travail en cours).

– dans la zone à Ibex, à un évènement à *Tropidoceras* dont la durée au sein de la zonation standard (depuis le top de la zone à Jamesoni jusque dans la zone à Ibex) reste à préciser. Par contre l'évènement à *Metaderoceras*: *M. gemmellaroi* (LEVI) et *M. venarense* (FUCINI) semble relativement court dans le temps et indique un âge précis correspondant à la partie supérieure de la zone à Ibex.

– dans la zone à Davoei à aucun évènement majeur. En fait comme nous l'avions souligné (MEISTER, 1992, FERRETTI & MEISTER, 1994) une période de provincialisme exacerbée s'est mise en place et les échanges supradomaines diminuent n'offrant des éléments de corrélations que dans les zones tampons comme l'Austroalpin supérieur d'Autriche et le Bakony en Hongrie.

3. La figure 1 montre que la région considérée est relativement petite par comparaison à l'échelle du globe et même à ce niveau, les corrélations sont difficiles d'une région à l'autre et parfois peu précises car elles se font au niveau du genre, plus rarement de l'espèce. Le travail biostratigraphique et systématique (homogénéisation taxonomique) à faire reste donc considérable.

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Données nouvelles sur la répartition des Phymatoceratinae (Ammonitina, Toarcien) Exemples de convergences et d'évolution itérative

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(avec 5 figures et Planches 8–11)

Résumé

La comparaison de spécimens de Phymatoceratinae, provenant soit d'Europe du NW, soit des régions téthysiennes, révèle de grandes différences morphologiques et stratigraphiques entre des espèces jusque-là le plus souvent rapportées au genre *Phymatoceras.* Ce nom doit être réservé aux espèces de la zone à Bifrons. Deux autres noms génériques sont proposés: *Furloceras* pour les espèces téthysiennes de la "zone à Erbaense", *Mouterdeiceras* pour les exemplaires recueillis dans la zone à Thouarsense de France et de Lombardie et décrits ici, à partir d'un matériel inédit provenant de la région lyonnaise.

Abstract

The comparison between NW European and Tethyan material evidences that strong morphologic differences exist between species which are attributed to the same genus *Phymatoceras*. The ventral part of the section is of great importance. In conclusion, the name *Phymatoceras* should be reserved to the ogival species known in the Bifrons Zone especially in NW Europe. Two new genera are poroposed for the tricarinate species. *Furloceras* (type: *F. chelussii* PARISH & VIALE) is established for the Tethyan species of the Gradata Zone (lower part of the so-called "Erbaense Zone". *Mouterdeiceras* (type: *M. dubourgi* nov. sp.) is proposed for newly described forms from the Thouarsense zone of France (Lyon area) and previously known in the upper part of the "Erbaense Zone" of Italy (Lombardy).

This revision led us to a new interpretation of the evolution of the subfamily Phymatoceratinae and to question its appartenance to the Hildocerataceae. It seems possible to place them as a family within superfamily Hammatocerataceae.

Mots clés: Toarcien, ammonites, évolution, paléogéographie, biogéographie.
Key-words: Toarcian, ammonites, evolution, palaeogeography, biogeography

Introduction

Les abondants travaux sur les ammonoidés ont prouvé l'importance des hétérochronies de croissance et des phénomènes d'itération évolutive. Il en résulte des convergences qui sont d'autant plus marquées que les groupes étudiés succèdent à une phase de différenciation morphotypique de type cladogénétique.

L'évolution des Phymatocératinae toarciens fournit de tels exemples, car il s'agit d'un groupe de transition entre les Hildocératinae et les Hammatocératinae, en ce qui concerne le domaine téthysien, et entre les Hildoceratinae et les Grammocératinae en domaine NW européen. Il en résulte des évolutions partiellement parallèles dans les deux domaines.

La découverte de formes nouvelles de Phymatoceratinae dans le Toarcien supérieur du Beaujolais attire à nouveau l'attention sur la maléabilité de ce groupe. Certaines formes sont exclusivement connues dans le domaine européen, alors que d'autres espèces et genres sont cantonnés dans le domaine téthysien (MOUTERDE & ELMI, 1991). Cette sous-famille, créée par HYATT (1900) regroupe, selon la conception de GABILLY (1976), les genres *Phymatoceras* (HYATT 1867), *Denckmannia*

(Buckman 1898), *Haugia* (Buckman 1888) et *Chartronia* (Buckman 1898).

La prise en compte de l'originalité des faunes téthysiennes nous amène aussi à poser à nouveau la question de l'appartenance de la sous-famille aux Hildoceratidae (Arkell, 1954; Donovan et al. 1981). L'opinion exprimée par Géczy (1966, p. 15) était de subordonner les Phymatoceratinae aux Hammatoceratidae étendus aussi aux Sonnininae. Il nous semble que cette hypothèse mérite une nouvelle analyse.

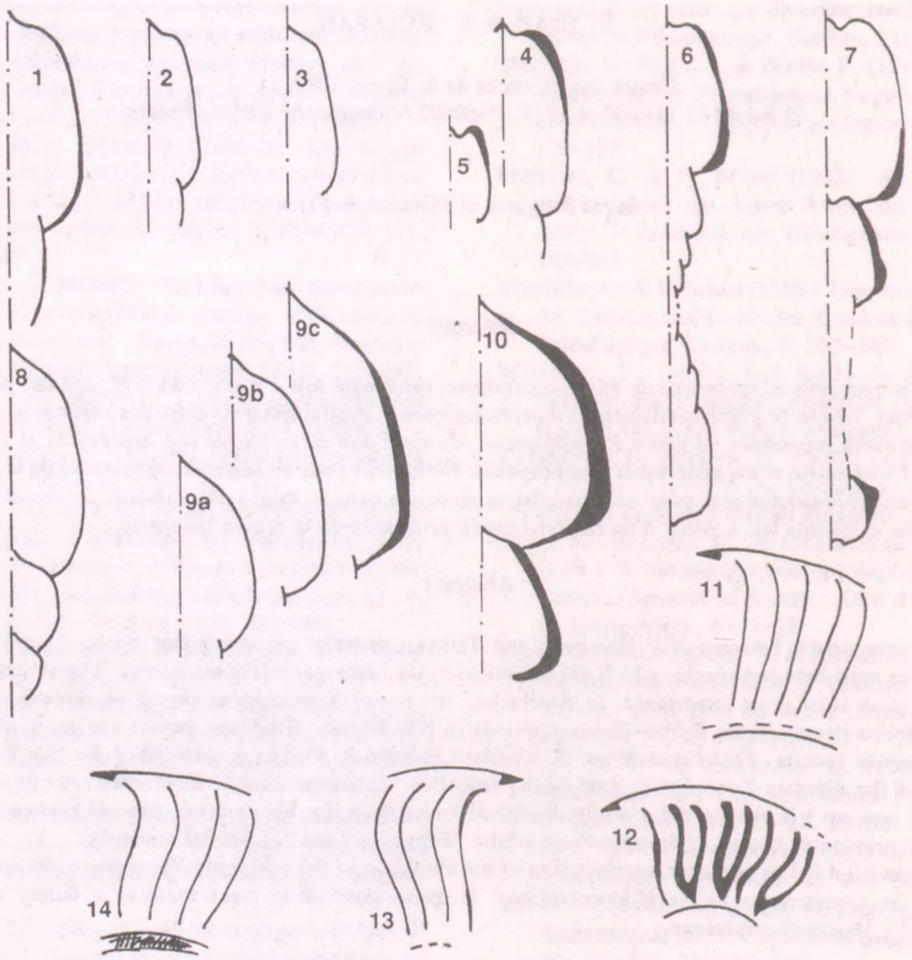


Fig. 1 - Section des tours et ornementation de quelques Phymatoceratinae.

1-3. *Mouterdeiceras dubourgi* n.sp. Holotype (FSL 169223, coll. Rulleau), moule interne; 1: à D = 142 mm; 2: à D = 95 mm; 3: paratype (FSL 169232), à D = 118 mm.
4-5. *Mouterdeiceras viticola* n. sp. Holotype (FSL 169226, coll. Santailler), moule interne; 4: à D = 115 mm; 5: à D = 60 mm environ.
6. *Furloceras* gr. *chelussii* (Parish & Viale), (FSL 169234), Furlo (Pesaro, Italie); moule interne; à D = 92 mm.
7. *Furloceras erbaense* (Hauer), (FSL 169240), Tissedoûra (Algérie); moule interne, à D = 95 mm.
8. *Denckmannia malagma* (Dumortier), lectotype (ML 12219), moule interne, à D = 130 mm environ.
9a-c. *Phymatoceras narbonense* Buckman, holotype (ML 9176), exemplaire muni de son test; a: à D = 120-125 mm; b: à D = 156 mm; c: à D = 190 mm.
10. *Phymatoceras formosum* n. sp., holotype (ML 9182), exemplaire muni de son test, à D = 167 mm.

Ornementation:

11-12. *Mouterdeiceras viticola,* holotype; 11: à D = 115 mm; 12: stade jeune.
13-14. *Mouterdeiceras dubourgi;* 13: holotype, à D = 95 mm environ; 14: paratype (FSL 169232).

Problème nomenclatural

Les particularismes fauniques du Toarcien moyen et supérieur sont maintenant bien connus; les ammonites téthysiennes présentent alors une morphologie bien différente des formes N.W. européennes. Tel est le cas en particulier des Phymatocératinae dont la nomenclature actuelle est cause de confusion, car on emploie un même genre *(Phymatoceras)* pour des formes morphologiquement et chronologiquement bien distinctes.

Formes à région ventrale de section ogivale

Ce sont les Phymatoceras au sens strict d'après la définition de Hyatt; ces espèces sont strictement localisées à la zone à Bifrons du domaine européen (MOUTERDE & ELMI, 1991).

Genre *Phymatoceras* Hyatt, 1867
Pl. 8; pl. 9, fig. 1; pl. 11, fig. 13–14
Fig. 1 (9–10) et fig. 2 (5–6) in text

Espèce-type: *Phymatoceras robustum* HYATT, 1867.

En l'absence de figuration originale, l'espèce-type a été désignée par BUCKMAN en 1897. Il choisit alors la figuration d'*Ammonites tirolensis* HAUER par DUMORTIER (1874, pl. 24, fig. 1–2) qui représente un exemplaire bien différent du type de l'espèce de l'auteur autrichien (1856, pl. 7, fig. 1–3). L'ammonite de DUMORTIER provient de l'Est lyonnais (La Verpillière) et elle fut considérée par BUCKMAN, puis par HYATT lui-même, comme lectotype de *Phymatoceras robustum.*

Diagnose: section ogivale, septicarénée, absence de sillons péricarénaux à l'état adulte.

Position stratigraphique: Toarcien moyen, sous-zone à Bifrons. A notre connaissance (Région lyonnaise, Centre-ouest de la France, Normandie, Grande-Bretagne), ce groupe existe essentiellement dans l'horizon à Bifrons. Sa présence dans l'horizon à Semipolitum n'est pas confirmée.

Répartition géographique: Domaine européen (sensu MOUTERDE & ELMI, 1991).

Synonyme subjectif: *Lillia* BAYLE (1878), emend. BUCKMAN (1889). S.S BUCKMAN insiste sur l'absence de sillons péricarénaux. En outre, la figure de *Lillia lilli* donnée par E. BAYLE (pl. 82) illustre une ammonite de la Verpillière, proche de *P. narbonense* BUCKMAN. L'espèce *lilli* de HAUER (1856, pl. 8, fig. 1–3) appartient au même groupe, car cet auteur signale bien l'absence de sillons péricarénaux: "... Kiel, der von keinen seiten furchen begleitet wird." Cette espèce diffère cependant des espèces françaises car elle est nettement plus évolute. Sa position géographique en fait le représentant le plus méridional actuellement connu.

L'attribution au genre *Phymatoceras* de certaines formes bisulquées du domaine sud téthysien n'est donc pas justifiée.

Principales figurations:

- *Phymatoceras robustum* HYATT (= *A. tirolensis* DUMORTIER, non HAUER)
- *Ammonites erbaensis* DUMORTIER (1874, pl. 23, fig. 1–2), non HAUER (= *Denckmannia iserensis* BUCKMAN non OPPEL). D'après le lectotype désigné par BUCKMAN (1898) et figuré par GALLITELLI-WENDT (1969, pl. 5, fig 6), l'espèce de OPPEL est un synonyme subjectif de *Ammonites erbaensis* HAUER. L'ammonite figurée par DUMORTIER appartient donc à une espèce distincte et nous la proposons comme holotype de *Phymatoceras formosum* nov. sp. Elle se distingue de *P. narbonense* par ses tours plus épais et par son ornementation plus forte et plus grossière (fig. 1).
- *Ammonites lilli* DUMORTIER (1874, pl. 21, fig. 1–2) non HAUER = holotype de *Phymatoceras narbonense* BUCKMAN (1898). Dans la région lyonnaise les types morphologiques les plus fréquents appartiennent à ce groupe, (fig 2, in text, et pl 2, fig 13–14).
- *Phymatoceras jardense* GABILLY (1976, pl. 1, fig. 2–3) est un spécimen qui nous paraît proche de *P. lilli* (HAUER).
- *Phymatoceras quadratum* GABILLY (1976, pl. 1, fig. 4–5). Cet exemplaire fut attribué par GABILLY à une sous-espèce rattachée à *"Denckmannia" cornucopia* MERLA (1933, pl. 2, fig. 4–6,8), ammonite nettement plus involute et dont la livrée ressemble à celle du groupe de *"Lillia" chelussii* PARISCH & VIALE, mais qui ne possède pas de sillons péricarénaux.
- *Phymatoceras* aff. *anomalum* GABILLY (1976, pl. 3, fig .2–3), non MERLA.

Toutes ces formes ont été précédées, en domaine téthysien, par des espèces connues par de rares spécimens figurés: *Phymatoceras* sp., GUEX (1973, pl. 8, fig. 4) de la sous-zone à Falciferum du Moyen Atlas (Maroc) et *Phymatoceras elegans* GALLITELLI-WENDT (1969, pl. 6, fig. 2) non MERLA (?) de la sous-zone à Sublevisoni de Valdorbia. Ces spécimens précoces se caractérisent par un enroulement très évolute, une section quadratique ou comprimée, une carène probablement pleine, l'absence de sillons péricarénaux et une évolution ontogénique spéciale avec des tours internes inermes. Ce groupe est probablement à la souche des Phymatoceratinae et mériterait un nom générique ou sous-générique distinct, en raison des hiatus morphologiques et chronologiques.

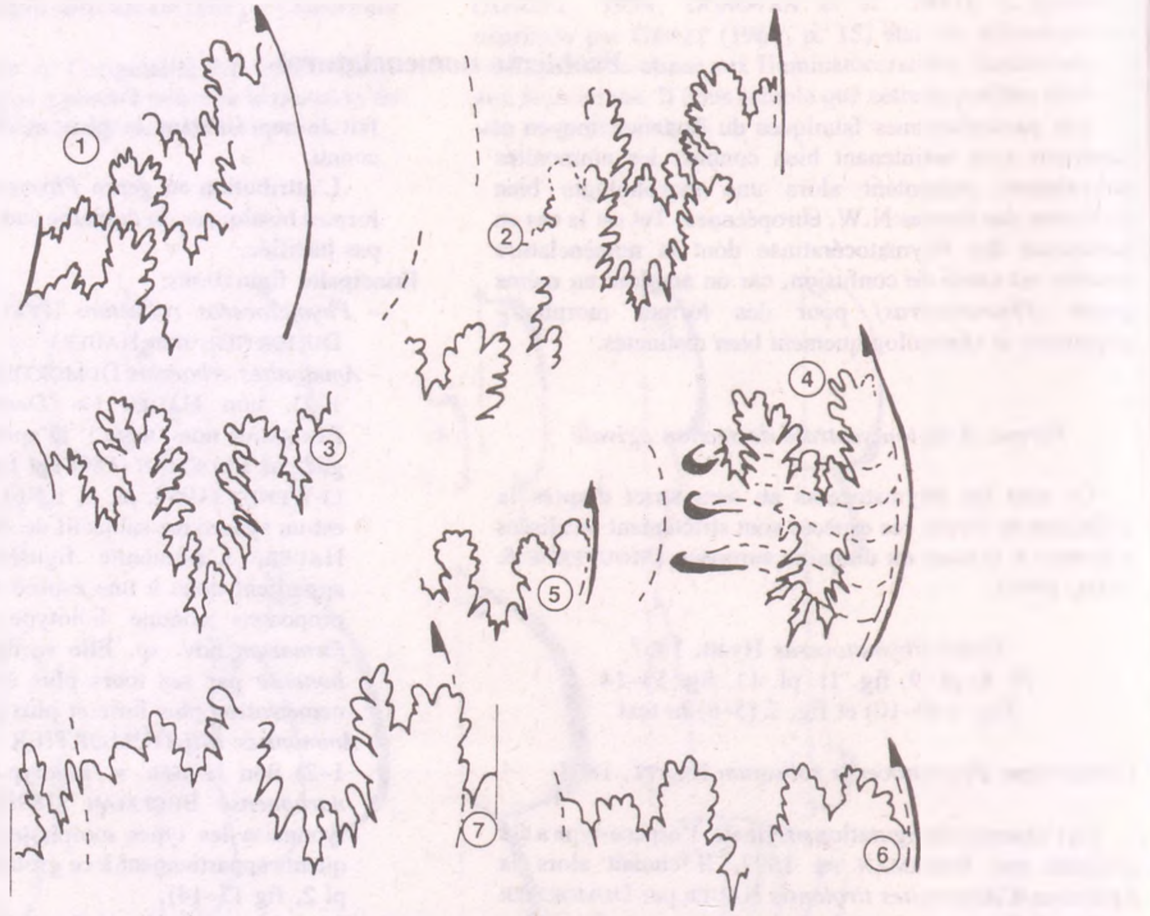


Fig. 2. Lignes de suture de quelques Phymatoceratinae. ×1

1–2. *Mouterdeiceras dubourgi* n. sp. 1: paratype (FSL 169232), à D = 115; 2: holotype (FSL 169223), à D = 120 mm. La ligne de suture de *M. viticola* n. sp. est du même type que celle de *M. dubourgi*, mais elle ne peut être dessinée.
3. *Furloceras* cf. *speciosum* (MERLA), in GÉCZY 1966 (pl. 1, fig. 4 et pl. 37, fig. 3).
4. *Denckmannia* cf. *fabalis* (SIMPSON), in RULLEAU 1993 (pl. 24, fig. 2–3); avec schématisation de la forte ornamentation.
5. *Phymatoceras* gr. *narbonense* BUCKMAN (FSL 16923, coll. RULLEAU), de Belmont, à D = 80 mm environ.
6. *Phymatoceras* gr. *narbonense* BUCKMAN (FSL 169242, coll. RULLEAU), de Charlieu (Loire), à D = 135 mm environ.
7. *Furloceras* gr. *chelussii* (PARISH et VIALE), (collection MOUTERDE et ELMI, SG 215), de San Giao (Portugal), à D = 150 mm environ (5e cloison avant la fin du phragmocône).

Formes à section tricarénée

La tricarination s'observe le plus souvent jusque sur la loge d'habitation: c'est le groupe d'espèces décrit par HAUER (*P. erbaensis* et *P. tirolensis*) et par les auteurs italiens, en particulier PARISCH & VIALE (*"Lillia" chelussii*) et MERLA (*"Phymatoceras" pulcher* et *"P." evolutum*, entre autres). Malgré les difficultés de datation et de corrélation, ces formes existent dans des niveaux qui succèdent à la zone à Bifrons, dans le domaine téthysien, c'est-à-dire dans la zone à Gradata.

Il convient donc de bien individualiser ce groupe et de le séparer génériquement des *Phymatoceras*, afin de ne pas perpétuer une confusion rendue presque inévitable par les mauvaises définitions originelles.

Les formes italiennes [groupe de *"Lillia" chelussii* PARISCH & VIALE (1906, pl. 11, fig. 10–11) et de *"Phymatoceras" pulcher* MERLA (1933, pl. 3 fig. 1–2, 6) ont souvent été rattachées au genre *Chartronia*. Cette attribution ne peut être retenue. En effet, ce genre a été proposé par BUCKMAN pour sa nouvelle espèce *C. binodata* (1898, pl. 1, fig. 11–15). Il est en conséquence caractérisé par une double rangée de tubercules et par la position très haute sur les flancs de la rangée interne (côtes primaires). La position stratigraphique de cette forme, au demeurant très rare, est mal définie ("cephalopod-bed", strate contenant des *Dumortieria*) et peu compatible avec le niveau des autres Phymatoceratinae.

MERLA (1933) utilise le nom de *Chartronia* pour des formes dépourvues de côtes primaires et dont la cloison est très différente de celle de l'espèce-type. ARKELL (1952) met *Chartronia* en synonymie avec *Phymatoceras*, mais DONOVAN (1958), et à sa suite ZANZUCCHI (1963), KOTTEK (1966) et PELOSIO (1968) réutilisent ce taxon, en tant que sous-genre de *Phymatoceras*, pour les formes présentant une rangée régulière et continue de tubercules internes. Enfin, GABILLY (1976) estime que *Chartronia* est un genre bien distinct, limité à l'espèce *C. binodata* et n'appartenant pas forcément aux Phymatoceratinae.

Nous proposons donc pour le groupe de *"Lillia" chelussii* et Ammonites erbasensis un nouveau nom générique: *Furloceras*; c'est à ce genre que correspond la diagnose de GÉCZY (1966, p. 15), qui considère que les *Phymatoceras* ont "des sections de tour carrée ou trapèzoïdale et une partie extérieure large, généralement sillonnée", ce qui n'est pas le cas de *P. robustum* ou de *P. narbonense*.

Genre *Furloceras* nov. gen.

Pl. 9, fig. 2; pl. 11, fig. 9 et 10
Fig. 1 (6-7) et fig. 2 (3-7) in text

Derivatio nominis: d'après la localité de Furlo (province de Pesaro, Italie) où de nombreux spécimens figurés ont été recueillis dans les célèbres carrières.

Espèce-type: *Lillia chelussii* PARISCH & VIALE (1906, p.18, pl. 11, fig. 10-11). L'holotype provient des Monti del Furlo.

Diagnose: Section tricarénée, bisulquée. Carène pleine. La remarque faite par MERLA sur la difficulté d'utiliser ce caractère pour différencier *Denckmannia* et *Phymatoceras* (sensu italico) ne doit pas être prise en considération car les vraies *Denckmannia* septicarénées n'existent pas en Italie.

Position stratigraphique: Toarcien moyen, zone à Gradata.

Répartition géographique: Genre largement répandu dans tout le domaine téthysien (Portugal, Bétiques, Maghreb, Apennins, Alpes méridionales, Hongrie, Grèce, Turquie...). Des citations ont souvent été faites en domaine européen, mais elles semblent le plus souvent être dues à de mauvaises interprétations. C'est en particulier le cas des formes figurées par DUMORTIER (1874) dans le Lyonnais, par REYNÈS (1879) et MONESTIER (1931) dans les Causses, par de BRUN (1929) sur la bordure vivaro-cévenole du Massif Central français ou par DENCKMANN (1887) en Allemagne et GABILLY (1976) dans le Centre-Ouest de la France.

Principales figurations: Au plan morphologique les espèces de *Furloceras* se répartissent en deux groupes qui diffèrent par le détail de l'ornementation latérale.

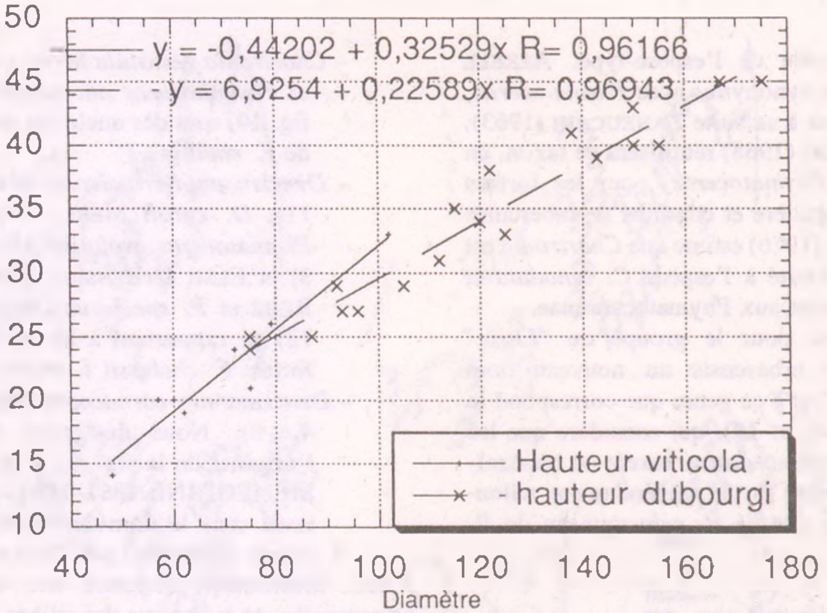
a) Espèces à costulation fine et dense; côtes légèrement rétroversées et le plus souvent regroupées par

- *Lillia chelussii* PARISCH & VIALE (1906; pl 2, fig 1-2).
- *Lillia pulcher* MERLA (1933, pl. 3, fig 1-2,6), synonyme subjectif de *F. chelussii*.
- *Chartronia venustula* MERLA (1933, pl. 2, fig. 9-12) et *Phymatoceras anomalum* MERLA (1933, pl. 8, fig. 10) sont des nuclei ou des individus incomplets de *F. chelussii*.
- *Denckmannia crassicosta* MERLA (1933, pl. 3, fig. 11), *D. caroli* MERLA (1933, pl. 3, fig. 3-4), *Phymatoceras evolutum* MERLA (1933, pl. 2, fig. 3) et ELMI & BENSHILI (1987, p.57, fig. 4) non RENZ et *P. speciosum* MERLA (1933, pl. 2, fig. 13) se rapportent à un morphotype à côtes plus fortes: *F. chelussii* f. *crassicosta*.
- *Denckmannia cornucopia* MERLA (1933, pl. 2, fig. 4,6-8). Nous désignons ici comme lectotype l'original de la fig. 4 (= *A. comensis* IVa forma MENEGHINI, 1867-1881, pl. 7, fig. 3), refiguré aussi sous le nom de *Phymatoceras (Chartronia) fabale* (SIMPSON) par PINNA (1969, pl. 2, fig. 3).

Seul MENEGHINI a donné une vue ventrale de cette ammonite; on y observe des sillons péricarénaux nets bien qu'étroits. Cette constatation permet de la ranger dans le genre *Furloceras*, ce qui confirme les observations de MERLA qui la situe hypothètiquement dans sa zone à Rudis (= zone à Gradata). Il est à remarquer que l'évolution ontogénique de l'épaisseur et du diamètre ombilical sont atypiques par rapport à l'ensemble du groupe (la courbe EMD est harmonique alors que pour les autres *Furloceras* ainsi que les *Mouterdeiceras*, elle est minorante; la courbe O/D est minorante chez *F. cornucopia* alors qu'elle est harmonique ou légèrement majorante pour les autres formes étudiées). Les nombreuses citations erronées de *"Phymatoceras" fabale* (non SIMPSON) en domaine téthysien (ZANZUCCHI, KOTTEK, PELOSIO, VENTURI) doivent être rapportées à *F. cornucopia*. La véritable espèce fabale appartient au genre *Denckmannia* du domaine NW européen.

b) Espèces à costulation forte et espacée, ornées de tubercules saillants et noduleux. Elles présentent un aspect général trapu et irrégulier.

- *Ammonites comensis* VON BUCH (1831, pl. 2, fig. 3)
- *Ammonites erbaensis* HAUER (1855); lectotype (pl. 11, fig. 10-11) désigné par DONOVAN (1958). (fig. 3, in text).
- *Ammonites iserensis* OPPEL (1856); lectotype in GALLITELLI-WENDT (1969, pl. 5, fig. 6)
- *Ammonites tirolensis* HAUER (1856, pl. 7, fig. 1-3) espèce à laquelle nous rattachons *Hildoceras tirolense* in PRINZ (1904, pl. 34-35, fig. 8)
- *Hildoceras erbaense* var. *acarnanica* RENZ (1912, pl. 15, fig. 8)
- *Denckmannia armata* MERLA (1933, pl. 1, fig. 6; pl. 2, fig. 1-3)
- *Phymatoceras robustum muelleri* GÉCZY (1966, pl. 37, fig. 1)
- *Phymatoceras meneghinii* ZANZUCCHI (1963, pl. 20, fig. 10)
- *Phymatoceras* n. sp. PELOSIO (1968, pl. 20, fig. 3).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y = 6,9254 + 0,22589x R= 0,96943
Hauteur viticola
hauteur dubourgi
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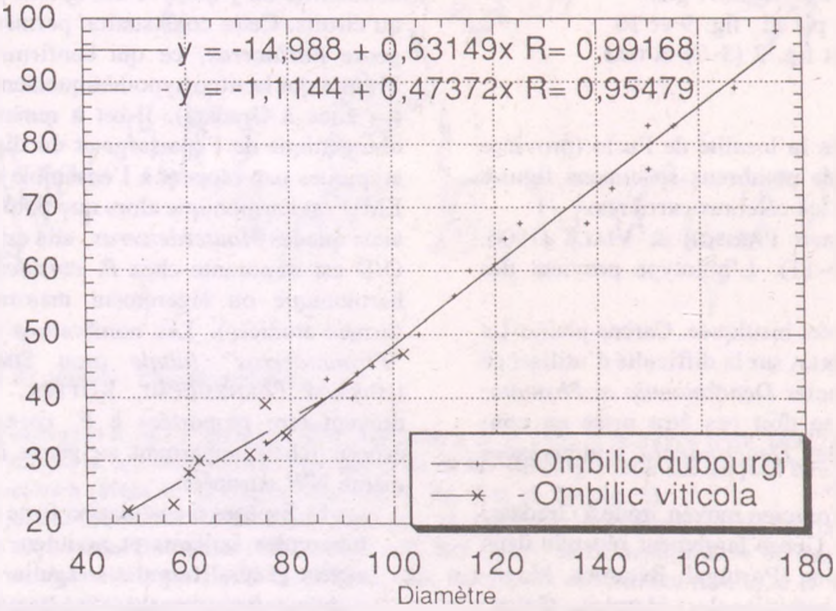
Diamètre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y = -1,1144 + 0,47372x R= 0,95479
Ombilic dubourgi
Ombilic viticola
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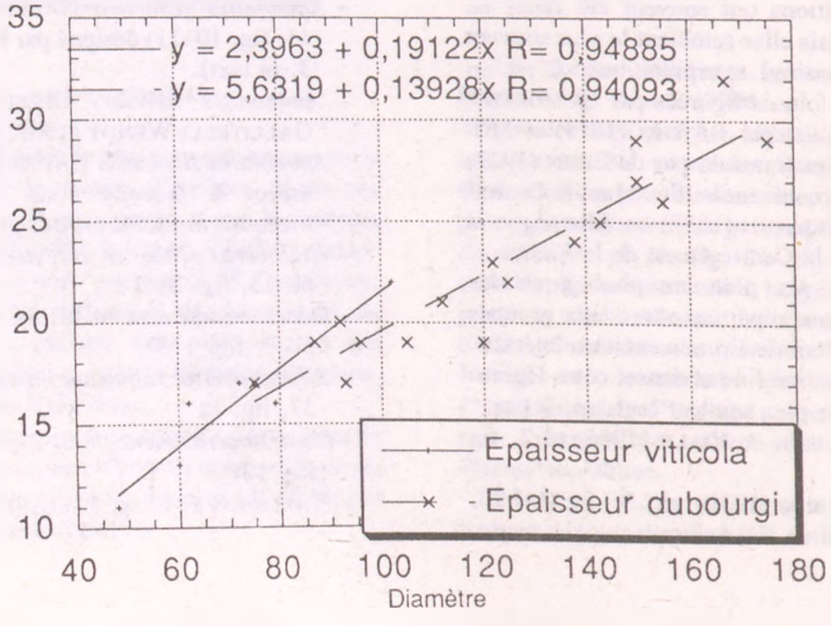
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y = 5,6319 + 0,13928x R= 0,94093
Epaisseur viticola
Epaisseur dubourgi
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180
Diamètre

Formes du Toarcien supérieur

Il existe des formes homéomorphes des *Furloceras*, signalées par GABILLY (1976) dans le Toarcien supérieur (zone à Thouarsense) du Centre-ouest de la France, et nouvellement récoltées dans la région lyonnaise au même niveau stratigraphique. Nous proposons le nom de *Mouterdeiceras* pour les distinguer des *Furloceras* et il semble que l'on doive leur rattacher plusieurs espèces figurées qui proviennent de Lombardie.

Genre *Mouterdeiceras* nov.gen.

Derivatio nominis: en hommage à R. MOUTERDE, géologue et paléontologiste lyonnais.

Espèce-type: *Mouterdeiceras dubourgi* nov. sp. (fig. ici, pl. 10, et pl. 11, fig. 7–8).

Diagnose: Phymatoceratinae macroconches pouvant atteindre une grande taille; coquilles généralement évolutes et comprimées; section tabulée ou tricarénée jusqu'en fin de croissance; côtes rétroversées, à projection ventrale très marquée; tubercules souvent absents, soit sur les derniers tours, soit durant toute l'ontogénèse, carène pleine.

Position stratigraphique: Toarcien supérieur, zone à Thouarsense dans la région lyonnaise, en Normandie et dans le Centre-ouest de la France.

Répartition géographique: domaine NW européen, mais aussi Lombardie et Hongrie.

Principales figurations: deux groupes peuvent être distingués:

a) sillons peu marqués ou inexistants: espèces téthysiennes

- *Phymatoceras tirolense* GÉCZY (1966, pl. 8) non HAUER
- *Hildoceras volzi* PRINZ (1904, pl. 31, fig. 5)
- *Chartronia narbonense* PELOSIO (1968, pl. 20, fig. 12) non BUCKMAN
- *Phymatoceras* cf. *robustum* PELOSIO (1968, pl. 31, fig. 1) non HYATT
- *Phymatoceras chelussii escherilobatum* GÉCZY (1966, pl. 2, fig. 5)
- *Phymatoceras merlai* PELOSIO (1968, pl. 19, fig. 11; pl. 21, fig. 4)
- *Phymatoceras masciadrii* PELOSIO (1968, pl. 19, fig. 12; pl. 21, fig. 10)
- *Phymatoceras mavigliai* PELOSIO (1968, pl. 22, fig. 1, 16).

Ces trois derniers noms nous semblent devoir être mis en synonymie sous le nom de *M. masciadrii* (priorité de page). Cette espèce présente de fortes affinités avec *M. dubourgi* du domaine européen.

On peut rapprocher de ce groupe certaines formes américano-pacifiques figurées par MÖRICKE puis par HILLEBRANDT:

- *Phymatoceras copapiense* MÖRICKE (1894, pl. 1, fig. 5–6)
- *Phymatoceras toroense* HILLEBRANDT (1984, pl. 10, fig. 5–7)

HILLEBRANDT a d'ailleurs rapproché d'autres exemplaires sud-américains du même horizon (h. à Toroense) d'espèces aussi différentes que *F. iserense*, *P. robustum*, *F. speciosum* et *D. pseudoerbaense*. HIRANO a également figuré (1973, pl. 4 fig. 1–2) sous le nom de *Phymatoceras* sp. une forme provenant probablement du Toarcien supérieur, proche des *Mouterdeiceras*. La même remarque s'applique à *P. toyoranum* (MATSUMOTO 1947).

b) sillons bien marqués: espèces NW européennes, décrites ici pour la première fois:

Mouterdeiceras dubourgi n.sp.

Pl. 10; pl. 11, fig. 7–8
Fig. 1 (1–3, 13–14) et 2 (1–2))

1984 *Denckmannia* ? sp. CUBAYNES et al (pl 5, fig 1).

Derivatio nominis: en hommage à M. DUBOURG, Directeur de la Cimenterie Lafarge exploitant les marnes et calcaires de Belmont.

Holotype: spécimen no. 169223 de Belmont; paratype: no. 169232 de Belmont.

Matériel: 11 exemplaires de Belmont, 1 de Feuguerolles (Normandie), 2 des Gard environs de Coury (Gard).

Mensurations: voir fig. 5.

Diagnose: L'holotype est un moule interne en calcaire gris-rougeâtre riche en oolithes ferrugineuses millimètriques. Il est recouvert par des serpules. Section comprimée et angulaire. Mur ombilical en pente douce se raccordant au flanc par une courbe. Flancs subparallèles. Passage à la région ventrale bien marquée. Aire ventrale tabulée jusque sur la chambre d'habitation et dominée par une carène pleine légèrement saillante. Enroulement très évolute.

Côtes droites apparaissant au bord ombilical, fortement retroversées, projetées vers l'avant près du bord ventral. L'holotype ne montre pas de côtes groupées, du moins sur la partie visible.

Fig. 3. Comparaison des courbes ontogénétiques des paramètres H, E et O, exprimés en mm en fonction du diamètre D, chez *M. dubourgi* (croix) et *M. viticola* (points).

Variations: Elles affectent surtout la densité de costulation. Quand cette dernière est élevée (ex. de Feuguerolles) les côtes peuvent s'accoler dans leur partie dorsale de manière à simuler un tubercule qui reste toujours peu saillant.

Le paratype (no. 169 232) est un moule interne entièrement cloisonné qui permet une meilleure observation de l'ornementation des tours internes.

L'exemplaire no. 169 233 est un probable microconque; à un diamètre de 16 mm, il montre une loge qui se développe sur plus de 3/4 de tour et sur laquelle les côtes restent bien dessinées; elles se rapprochent les unes des autres et deviennent plus flexueuses à proximité de l'ouverture.

Mouterdeiceras viticola n.sp.

Pl. 11, fig. 3, 6

1976 *Denckmannia* aff. *erbaensis* GABILLY (p. 72, pl. 9, fig. 3–4)

1967 *Phymatoceras* sp. POPA (p. 46, pl. 4, fig. 1)

Derivatio nominis: par allusion à la localité de Saint-Jean-des-Vignes, sur laquelle s'étend une partie des carrières Lafarge.

Holotype: spécimen no. 169226 de Polymieux au Mont d'or, paratype no. 169231, de Belmont.

Matériel: 2 exemplaires de Belmont, un du Mont d'Or lyonnais (St Romain) un des Villebois (Ain – coll. DUMORTIER au Museum de Lyon), et un des environs de Courry (Gard).

Diagnose: nous choisissons comme holotype l'exemplaire 169226 par qui est un moule interne montrant bien l'ontogénèse. Section comprimée, subrectangulaire. Mur ombilical subvertical. Bord ombilical arrondi. Flancs parallèles, aire ventrale large et tabulée parcourue par deux sillons péricarénaux bien visibles. La carène est pleine et saillante.

Costulation vigoureuse. Sur les tours internes, les côtes sont le plus souvent groupés par deux sur le bord ombilical et elles partent d'un tubercule qui orne le mur ombilical. La côte antérieure de certains faisceaux est proverse à sa base ce qui donne un aspect flagellilforme. Il existe quelques côtes intercalaires réparties irrégulièrement. Il faut noter qu'à diamètre équivalent les *Furloceras* fortement ornés (gr. *erbaense*) ne possèdent pas de mur ombilical franchement distinct du flanc qui dessine une courbe très régulière jusqu'à la ligne d'involution; le mur ne devient distinct que sur les grands spécimens.

Le paratype (169231), montre particulièrement bien l'allure bisulquée de la région ventrale.

Affinités et comparaisons: *M. viticola* se distingue de *M. dubourgi* surtout par la densité des tubercules. Les jeunes exemplaires ressemblent aux *Furloceras* du groupe de *F. erbaense*, ce qui explique la détermination de GABILLY, mais là encore le hiatus géographique et stratigraphique s'oppose à toute assimilation. En outre: allure de la région ombilicale plus différenciée chez *Mout. viticola* et ornementation toujours plus régulière.

Formes convergentes

Les *Denckmannia* (pl. 11, fig. 11–12; fig. 1–8 et 2–4 in text), genre créé par BUCKMAN (1898), avec pour type *D. tumefacta* (pl. 10, fig. 7–10), n'existent que dans le nord-Ouest de l'Europe, où elles accompagnent les *Haugia* dans la zone à Variabilis. Ce sont des formes épaisses, septicarénées, à ornementation grossière et irrégulière. Certaines espèces pourraient subsister à la base de la zone à Thouarsense, selon GABILLY (1976): *D. orbignyi* GAB. (pl. 8, fig. 1–3), mais ne peuvent en aucun cas être confondues avec les *Mouterdeiceras*. Les espèces de *"Denckmannia"* créées par MERLA appartiennent en réalité, comme nous l'avons montré ci-dessus, au genre *Furloceras*. La confusion peut s'expliquer par l'aspect très voisin des tours jeunes dans les deux genres en ce qui concerne l'ornementation du monis, car la section est constamment très différente.

Certaines formes figurées comme Phymatoceratinae ne s'intègrent pas dans ce schéma ou n'appartiennent pas à ce taxon:

- *Ammonites escheri* HAUER (1856, pl. 10, fig. 1–3); ammonite à livrée tout à fait particulière, de type *Lunuloceras*, à côtes falciformes, tubercules et taeniola.
- *Hildoceras nausikaae* RENZ (1912, pl. 14, fig. 4; text-fig. 25), type du genre *Renziceras* ARKELL (1957), peut être interprété comme un microconche de *Furloceras*.
- *Lillia planulata* MENEGHINI in MERLA (1933, pl. 1, fig. 1–4), est probablement un *Catulloceras* très évolué, à section tricarénée annonçant les *Tmetoceras* (cf. *C. perroudi* DUMORTIER).
- *Phymatoceras turatii* PELOSIO (1968, pl. 20, fig. 9): il s'agit probablement d'un *Pseudomercaticeras*.
- *Hildoceras terryi* PRINZ (1904, pl. 32, fig. 4), bien particulier du fait de ses flancs concaves, pourrait être un *Furloceras* écrasé.
- *Denckmannia* ? sp. B GABILLY (1976, pl. 10, fig. 3–4), *Denckmannia gabillyi* GUEX (1975, pl. 2, fig. 2–3) et *Denckmannia* cf. *chelussii* GABILLY (1976, pl. 10, fig. 1–2) récoltées dans la zone à Thouarsense, sont probablement des *Podagrosites* homéomorphes des *Denckmannia*, par réapparition de caractères ancestraux (tuberculation), ce qui serait un nouvel argument, à partir d'un exemple d'évolution itérative, pour étayer l'hypothèse de la filiation Phymatoceratinae-Grammoceratinae soutenue par GABILLY, mais non retenue par les auteurs anglo-saxons.

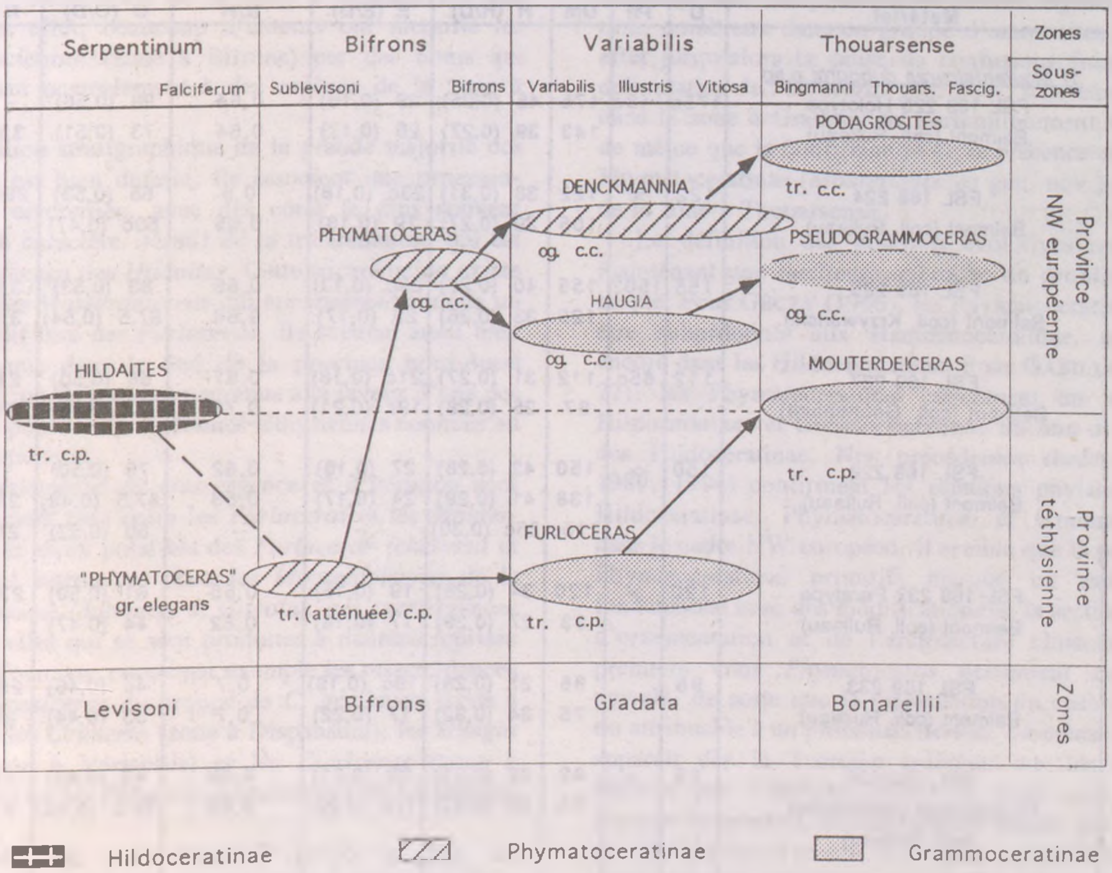

Fig. 4. Phylogenèse supposée des Phymatoceratinae pendant le Toarcien. (c. p.: carène pleine; c. c. carène creuse; tr: section tricarénée; og: section ogivale).

Evolution de la sous-famille et paléogéographie

Au terme de cette étude, les Phymatoceratinae apparaissent comme un ensemble bien plus hétérogène que ce qui était auparavant admis, lorsque l'on ne considérait que l'allure fortement tuberculée de la costulation latérale. Ainsi, une lignée nord-ouest européenne semble évoluer de façon assez différente de la lignée téthysienne apparue plus anciennement.

La lignée nord-ouest européenne s'individualise bien au début de la sous-zone à Bifrons, avec les *Phymatoceras* sensu stricto, à section ventrale ogivale, ornée d'une carène creuse. Force est de reconnaître qu'ainsi défini le groupe apparaît comme cryptogène dans la province considérée. Ensuite, il évolue, comme l'a bien analysé GABILLY (1976), en donnant naissance aux *Haugia* et aux *Denckmannia* de la zone à Variabilis, qui sont elles-mêmes à l'origine des Grammoceratinae. Ils ne semble pas que les *Mouterdeiceras* puissent être rattachés à cette lignée.

La souche des vrais *Phymatoceras* peut-être recherchée dans les formes plus anciennes)sous-zone à Sublevisoni) de la province téthysienne: il s'agit du groupe *"elegans"* de MERLA, dont la section est relativement indifférenciée et qui présente une évolution ontogénétique de l'ornementation encore visible chez *P. formosum* nom. nov. du Sud-Est de la France (un stade à côtes simples et rétroversées précède un stade à côtes bifurquées qui passe très rapidement à un stade dans lequel des tubercules se forment au point de division des côtes). Cette évolution est visible sur les échantillons de l'Apennin figurés par GALLITELLI-WENDT (1969) et VENTURI (1975). La même tendance a été notée par KOTTEK (1966) dans la coupe de Pagania (Grèce). Il est donc fort possible que les *Phymatoceras* du groupe *narbonense* de la région nord-ouest européenne soient un rameau apparu à partir de la souche téthysienne.

L'établissement de la lignée téthysienne présente également des difficultés. Les relations généralement admises avec les *Hildaites* supposent que le caractère ancestral de la tricarènation disparaît ou s'atténue avec les *Phymatoceras*, pour réapparaître chez les *Furloceras* et les *Mouterdeiceras*. Le plus ancien *Phymatoceras* a été cité par GUEX dans la sous-zone à Falciferum duMoyen-Atlas marocain; il s'agit d'une forme dont "les tours paraissent ogivaux et assez comprimés" (GUEX, 1973, p. 507). La transition des *"Phymatoceras"* téthysiens de la zone à

Matériel	D	Ph	Dm	H (H/D)	E (E/D)	E/H	O (O/D)	N
1) Mouterdeiceras dubourgi n.sp								
FSL 169 223 Holotype	175c	148c	175	45 (0,25)	29 (0,16)	0,64	98 (0,56)	-
Belmont (coll. Rulleau)			143	39 (0,27)	25 (0,17)	0,64	73 (0,51)	35
FSL 169 224	122	>	122	38 (0,31)	23c (0,18)	0,6	65 (0,53)	28c
Belmont (coll. Rulleau)			105	29 (0,27)	19 (0,18)	0,65	50c (0,47)	-
FSL 169 225	155	150?	155	40 (0,25)	26c (0,13)	0,65	83 (0,53)	31
Belmont (coll. Krzywanski)			125	33 (0,26)	22 (0,17)	0,66	67,5 (0,54)	30
FSL 169 227	112	65c	112	31 (0,27)	21c (0,18)	0,67	56 (0,50)	23
Belmont (coll. Gouttenoire)			87	25 (0,28)	19c (0,21)	0,76	43 (0,49)	21
FSL 169 228	150	>	150	43 (0,28)	27 (0,18)	0,62	76 (0,50)	-
Belmont (coll. Rulleau)			138	41 (0,29)	24 (0,17)	0,58	67,5 (0,48)	28
			115c	35c (0,30)	-	-	60 (0,52)	26
FSL 169 232 Paratype	120	>	120	34 (0,28)	19 (0,15)	0,55	61 (0,50)	23c
Belmont (coll. Rulleau)			93	27 (0,29)	17 (0,18)	0,62	44 (0,47)	-
FSL 169 233	96		96	27 (0,28)	19c (0,19)	0,7	45 (0,46)	25c
Belmont (coll. Rulleau)			75	24 (0,32)	17 (0,22)	0,7	33 (0,44)	26
FSL 169 235	95	>	92	29 (0,31)	20 (0,21)	0,68	40 (0,43)	26
Feuguerolles (Normandie)			75	25 (0,33)	17c (0,22)	0,68	30,5 (0,40)	27
(coll. Rulleau)								
FSL 169 236	167	150c	167	46 (0,27)	32 (0,19)	0,69	89 (0,53)	-
Belmont (coll. Rulleau)			150	40 (0,26)	29 (0,19)	0,72	83 (0,55)	25c
2) Mouterdeiceras viticola n.sp								
FSL 169 226 Holotype	130c	?	75	21 (0,28)	17 (0,22)	0,8	39 (0,52)	20
Belmont (coll. Santailler)			62	19 (0,30)	16 (0,25)	0,84	30 (0,48)	20
FSL 169 229	102	>	102	33 (0,32)	22 (0,21)	0,66	47 (0,46)	27
Belmont (coll. Gastineau)			79	26 (0,32)	16 (0,20)	0,61	34 (0,43)	28
FSL 169 230	72	>	72	24 (0,33)	17 (0,23)	0,7	31 (0,43)	27
Mont d'or (coll. Rebours)			57	20 (0,35)	-	-	23 (0,40)	26
FSL 169 231 Paratype	59	>	60	20 (0,33)	13c (0,21)	0,65	28 (0,46)	23
Belmont (coll. Rulleau)			48	14 (0,29)	11c (0,22)	0,78	22 (0,45)	22
3) Mouterdeiceras sp.								
FSL 169 222	114	90	114	36 (0,31)	21c (0,18)	0,58	54 (0,47)	28
Belmont (coll. Igolen)			91	29 (0,31)	-	-	40 (0,43)	26
4) Furloceras gr. chelussii (P & V)								
FSL 169 234	102	92	102	30 (0,29)	20 (0,19)	0,66	48 (0,47)	27
Furlo (coll. Rulleau)			78	25 (0,32)	18 (0,23)	0,72	35 (0,44)	24

D = diamètre conservé ; Ph = diamètre du phragmocône ; Dm : diamètre correspondant aux mesures ;
H = hauteur du tour ; E = Epaisseur du tour ; O = diamètre de l'ombilic ; N = nombre de côtes.

Fig. 5. Tableau de mensuration de quelques *Mouterdeiceras* et *Furloceras*.

Bifrons aux *Furloceras* de la zone à Gradata est mal connue. En effet, beaucoup d'auteurs ont identifié les espèces anciennes (zone à Bifrons) par des noms qui appartiennent normalement à des espèces de la zone à Gradata.

La position stratigraphique de la grande majorité des *Furloceras* est bien définie; ils associent une ornementation très diversifiée, avec des côtes le plus souvent divisées, au caractère itératif de la tricarénation, qui est une reminiscence des *Hildaites*. Cette tricarénation existe aussi chez les *Mouterdeiceras* qui apparaissent comme un rameau tardif issu des *Furloceras*. Ils existent aussi bien en Téthys que dans le Sud de la province nord-ouest européenne, où ils seraient parvenus à la faveur d'une des ingressions ponctuelles de faunes téthysiennes connues au Toarcien supérieur.

Des phénomènes de convergence et d'itération sont particulièrement nets entre les *Furloceras* et les *Mouterdeiceras*. Les deux polarités des *Furloceras (chelussii* et *erbaense)* se retrouvent chez les *Mouterdeiceras* de la région lyonnaise *(dubourgi* et *viticola)*. ces convergences rappellent celles qui se sont produites à maintes reprises pendant le Toarcien: citons par exemple les ressemblances entre les *Crassiceras* du groupe de *C. gradatum* (zone à Gradata) et les *Gruneria* (zone à Dispansum), les *Haugia illustris* (zone à Variabilis) et les *Esericeras* (zone à Thouarsense) ou les *Phlyseogrammoceras* (zone à Dispansum).

En conclusion, pour GABILLY (1976, p. 27), les Phymatoceratinae constituent un jalon entre les Hildoceratinae et les Grammoceratinae. Les arguments apportés par cette étude et par les travaux de l'un de nous (RULLEAU 1989, 1994), confirment cette opinion, en particulier par la polarité de l'évolution morphologique et par la similitude des lignes de suture.

En dehors de son intérêt taxinomique, la mise à jour de nos connaissances sur les Phymatoceratinae fournit un élément supplémentaire à l'établissement des corrélations stratigraphiques entre les provinces nord-ouest européenne et téthysienne. Les phénomènes de convergence et d'itération, nombreux dans ce groupe d'ammonites, étaient en effet jusqu'alors la cause de confusions fréquentes. La délimitation de *Furloceras* gen. nov., strictement localisé dans la zone à Gradata, est particulièrement importante, de même que la confirmation de la présence des derniers Phymatoceratinae (*Mouterdeiceras* gen. nov.) au sommet de la zone à Thouarsense.

La définition des polarités évolutives nous permet maintenant une meilleure approche du problème taxinomique. Pour GÉCZY (1966), les Phymatoceratinae doivent être subordonnés aux Hammatoceratidae, qu'il range encore dans les Hildocerataceae. Pour GABILLY (1976, p. 27), les Phymatoceratinae constituent un jalon entre Hildoceratinae et Grammoceratinae au sein de la famille des Hildoceratinae. Nos précédentes études (Rulleau, 1989, 1994) confirment les relations phylétiques entre Hildoceratinae, Phymatoceratinae et Grammoceratinae dans le cadre NW européen. Il semble que la passage aux Phymatoceratinae primitifs marque un saut évolutif fondamnetal avec des modifications de la section, du style d'ornementation et de l'architecture cloisonnaire. Les premiers vrais *Phymatoceras* présentent une section ogivale, de sorte que la réapparition du critère tricaréné est attribuable à un processus itératif. La même innovation apparaît dès le Toarcien inférieur sur les *Rarenodia* définies par VENTURI (1976) de sorte que l'on peut discuter la position nomenclaturale exacte de ce groupe souche. Quoiqu'il en soit, ces arguments plaident pour une nette séparation des Phymatoceratinae-Hammatoceratinae groupe innovateur d'une part, et des Hildocarataceae dont le tronc principal est, pendant le Toarcien un ensemble archaïque en voie d'extinction, d'autre part.

Il nous semble justifié de proposer, à la suite de MOUTERDE (1975), une superfamille des Hammatocerataceae afin de mieux souligner les liens phylétiques. Elle regroupe les familles des Phymatoceratidae, des Hammatoceratidae, des Erycitidae, des Graphoceratidae et des Sonninidae.

Conclusion

L'étude du matériel de la région lyonnaise bien repéré sur le plan stratigraphique, a permis de souligner les différences morphologiques, phylogénétiques et stratigraphiques qui séparent les *Phymatoceras* des *Furloceras* et des *Deckmannia*. La variabilité de l'ornementation a souvent masqué le caractère important constitué par la forme de la section dont l'évolution est itérative.

Remarques et remerciements

Le matériel est conservé dans les collections de l'Université Claude-bernard-Lyon 1 (FSL) et du Muséum d'Histoire naturelle de Lyon (ML). Sauf indication contraire, les exemplaires appartiennent aux collections des auteurs.

Les photographies des planches 8 à 9 et de la pl. 10, fig. 1-2 sont dues à N. PODEVIGNE.

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Explications des planches

Pour toutes les planches:
D = diamètre
H = hauteur du tour
E = épaisseur du tour
O = diamètre de l'ombilic
N = nombre de côtes par demi-tour
Mesures données en millimètres.

Planche 8

Phymatoceras formosum n. sp. ML 9182: exemplaire figuré par Dumortier (1874, pl. 23, fig. 1-2), sous le nom de *Ammonites erbaensis* (Hauer), zone à Bifrons, La Verpillière (Isère, France); ×0,75. Holotype par monotypie.

à D = 165; H = 46 (0,27); E = 42 (),25); O = 87 (0,52); N = 17
à D = 130; H = 37 (0,28); E = 35 (0,26); O = 61 (0,46); N = 18

Planche 9

Fig. 1. *Phymatoceras narbonense* Buckman, ML 9176: exemplaire figuré par Dumortier (1874, pl. 21, fig. 1-2), sous le nom de *Ammonites lillig* (Hauer), zone à Bifrons, La La Verpillière (Isère, France). Ammonite munie de son test; la chambre d'habitation presque complète (phragmocône = 130 mm environ) montre un début de déroulement par relâchement de la spire interne; ×0,75.

à D = 195; H = 52 (0,26); E = 42 (0,21); O = 104 (0,53); N = 24
à D = 155; H = 44 (0,28); E = 33 (0,21); O = 76 (0,49); N = 26

Fig. 2. - *Furloceras erbaense* (Hauer), FSL 169240, zone Gradata (s/z Alticarinata), Djorf Tissedora, Khemis de Beni Snouss, Tlemcen (Algèrie). Moule interne (la dernire partie de la loge n'est pas figure; D max conserv: 120 mm environ); ×0,75.

à D = 107; H = 31 (0,28); E = 26 (0,24); 0 = 55 (0,51)
à D = 62; H = 20 (0,32); E = 19 (0,30); O = 30 (0,48); N = 22c

Planche 10

1–8 *Mouterdeiceras dubourgi* n. sp.

1–2. Holotype: FSL 169223 (coll. RULLEAU), zone à Thouarsense (niveau 6a ou 6b), Belmont (Beaujolais méridional), moule interne pourvu d'une partie de la loge d'habitation (photo N. PODEVIGNE).

3–4. Paratype: FSL 169232 (coll. RULLEAU), zone à Thoursense (niveau 6a ou 6b, Belmont. Moule interne entièrement cloisonné.

5–6. FSL 169233 (coll. RULLEAU), zone à Thouarsense (niveau 6a ou 6b), Belmont. Individu complet, peut-être microconche.

7–8. FSL 169235 (coll. Musitelli), zone à Thouarsense, Feuguerolles (Calvados). Moule interne entièrement cloisonné d'un morphotype à costulation fine, morphologiquement proche des *Podagrosites*.

Coefficient de réduction de toutes les photos: 0,75 ×

Planche 11

1–6. *Mouterdeiceras viticola* n. sp.

1–2. Holotype: FSL 169226 (coll. Santailler), zone à Thouarsense (niveau 6a ou 6b), Belmont (Beaujolais méridional). Moule interne fragmentaire, muni d'une partie de la loge d'habitation.

3–4. Paratype: FSL 169231 (coll. Rulleau), zone à Thouarsense (niveau 5c), Belmont. Moule interne entièrement cloisonné et moule externe partiellement conservé.

5–6. FSL 169230 (coll. Rebours), Toarcien supérieur, Saint Romain-au-Mont d'Or.

7–8. *Mouterdeiceras dubourgi* n.sp. FSL 169227 (coll. gouttenoire), zone à Thouarsense (niveau 6a ou 6b), Belmont. Variant très proche de *M. masciadrii* (PELOSIO).

9–10. *Furloceras* gr. *chelussii* (PARISCH & VIALE) FSL 169234 (coll. RULLEAU), zone à Gradata, Mt Furlo. Moule interne pourvu d'une partie de sa loge.

11–12. *Denckmannia* gr. *malagma* (DUMORTIER) FSM 169239 (coll. DUPOIZAT), base zone à Variabilis (niveau 4e), Belmont.

13–14. *Phymatoceras narbonense* BUCKMAN FSL 169238 (coll. JACQUET), zone à Bifrons, Giverdy (St Didier-au-Mont d'Or).

Coefficient de réduction de toutes les photos: 0,75 ×

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Ammonitina (Hammatoceratidae) of the Toarcian and Aalenian in the Serra de Llevant (Isle of Mallorca, Spain)

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(2 figures and Plates 12–13)

Abstract

For the first time Hammatoceratidae characteristic to the Upper Toarcian and Lower Aalenian from the Serra de Llevant in Majorca (Spain) are recorded and described. They come from a level of redeposition, situated at the base of the Gorg Blau Formation (ALVARO et al., 1989), which contains many reworked fossils with ferruginous, phosphatic and ferromanganese incrustations. They are found associated with Harpoceratinae, Grammoceratinae, Bouleiceratinae? and Leioceratinae characteristic, in their majority, of the Mediterranean Province; some specimens characteristic of Northwest Europe also exist in the recorded assemblage.

Key words: Ammonoidea, systematics, biostratigraphy, Lower Jurassic, Middle Jurassic, Baleares Islands, Spain

Introduction

Majorca Island sits on a continental promontory, which extends north-west in the Mediterranean, as a prolongation of the Cordilleras Béticas. According to the stratigraphical and structural characteristics of the material, two domains have been indentified: the Domain of Sierra Norte and the Domain of Serra de Levant, whose boundaries do not coincide exactly with the physiographic boundaries of either range (ALVARO & DEL OLMO, 1984).

The carbonate sediments of the Lower and Middle Jurassic in the Domain of the Serra de Levant have been described by many authors since the last century. However, there are very few projects in which the ammonoids in the series are recorded or their study undertaken (NOLAN, 1895; DARDER, 1915, 1925; FALLOT, 1922, 1945; COLOM, 1947,1975; BOURROUILH, 1983; ALVARO et al., 1984, 1989; FORNOS et al., 1984, 1988; GOY & URETA, 1988; PRESCOTT, 1988; SANDOVAL, 1994).

The studied Hammatoceratidae came from the northern part of Serra de Levant, from a section situated at Puig Cutri, near Artá (Fig. 1). The assemblages are of great paleogeographic interest, because there are very few data about this group, and in particular, hammatoceratids from the Lower Jurassic in the Balearic Islands have rarely been described.

Stratigraphy

The stratigraphic successions and the sedimentary development of the Jurassic in Majorca were recently synthesized by ALVARO et al. (1989). These authors reorganised the data on lithostratigraphic units which have been defined a few years before (ALVARO et al., 1984), and define five new formations, among others the Gorg Blau Formation, which yielded the studied ammonoids. They also take into account biostratigraphical and biochronological considerations.

In the Puig Cutri Section, the oldest outcropping rocks are massive table dolomicrites of the Felanitx Formation which recall those of the Imón Formation in eastern Spain, attributed to the uppermost part of the Upper Triassic (GOY et al., 1976; BARRON & GOY, 1994).

Simplifying, the following litostratigraphic units are found in ascending order (Fig. 2):

- Dolomite Formation and crevices of Mal Pas (100–150 m),
- Carbonate Formation of Soller (250 m),

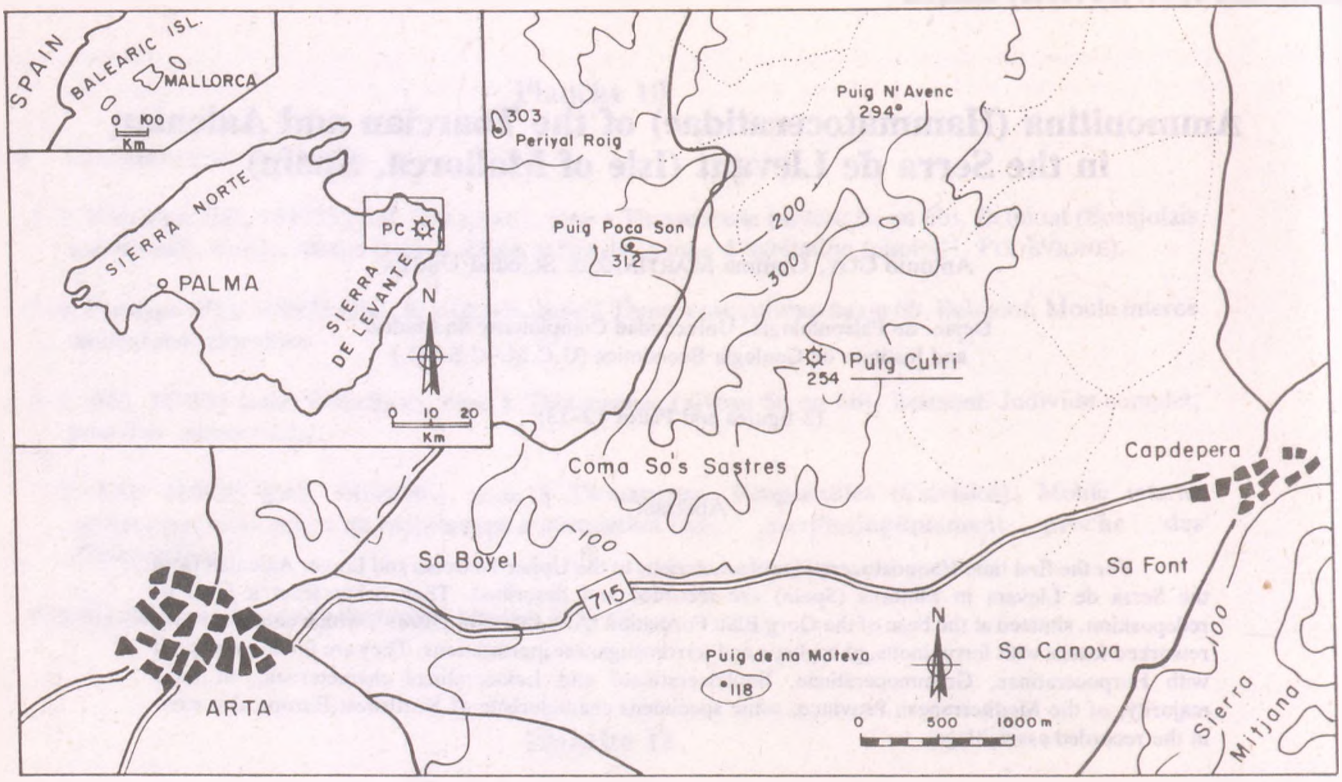

Fig. 1. Geographical situation of studied outcrop in the Puig Cutri area. Serra de Llevant of Majorca.

- Encrinitic Limestone Formation of Es Cosconar (5 m),
- Nodulose Marl-limestone Formation of Gorg Blau (30–40 m).

The first three correspond to the Lower Jurassic, up to the Toarcian, and the fourth to Toarcian (pro parte), Aalenian and Lower Bajocian (up to the Humphriesianun Zone).

In general the Gorg Blau Formation has three levels, a lower one formed by a ferruginous stage which contains reworked ammonoids, an intermediate marl-calcareous stage and an upper stage of nodular and platy limestones. However, in Serra de Levant the intermediate stage may be very small and even be absent as in Puig Cutri.

The ferruginous stage, from which nearly all the studied Hammatoceratidae came, was described by BARNOLAS & SIMÓ (1984) and by PRESCOTT (1988). It is a stage of movement, generally developed on a hard ground which existed at the top of the previous unit, and contains numerous remains of reworked Ammonoids, ferruginous, phosphatic and ferromanganese incrustations. Their formation corresponds to a relatively complex process, with important local variations. Thus in the model area of the Gorg Blau Formation, the recorded faunal lists indicate the Toarcian (Bifrons Zone, Variabilis Zone and possibly Thouarsense Zone) according to GOY & URETA (1988). They probably correspond to the UTS VII.2 and UTS. VII.3 of YEBENES et al. (1988); equivalent of the USD II and USD III of the Toarcian of GOY et al. (1994). In the marly-calcareous layers situated almost immediately above, various associations of ammonites, suggesting the Pseudoradiosa Zone, the Aalensis Zone of the Toarcian, have also been identified (GOY & URETA, 1988).

In Puig Cutri the ferruginous stage contains the following Hammatoceratinae:

Geczyceras cf. *bonarelli* (PARISCH & VIALE)
Geczyceras costulosus (MERLA)
Geczyceras aff. *costulosus* (MERLA)
Geczyceras cf. *speciosum* (JANENSCH)
Geczyceras cf. *allobrogense* (DUMORTIER)
Hammatoceras cf. *insigne* (SCHLÜBLER in ZIETEN)
Hammatoceras praefallax (MONESTIER)
Planammatoceras cf. *planinsigne* (VACEK)
Erycites elaphus MERLA

Associated with these fossils there are different species of *Oxyparoniceras*, *Polyplectus*, *Osperlioceras*, *Pseudogrammoceras*, *Pseudolillia*, *Gruneria*, *Catulloceras*, *Dumortieria*, *Pleydellia and Leioceras* (see ALVARO et al., 1989).

The faunal lists indicate the Toarcian (Thouarsense Zone?, Insigne Zone, Pseudoradiosa Zone and Aalensis Zone) and Aalenian (Opalinum Zone). They probably correspond to the UTS.VII.4 of YEBENES et al. (1988) equivalent to the USD. IV and USD. V of GOY et al. (1994) and to the I sequence of the topmost Toarcian–lower Aalenian of GOY et al. (1991).

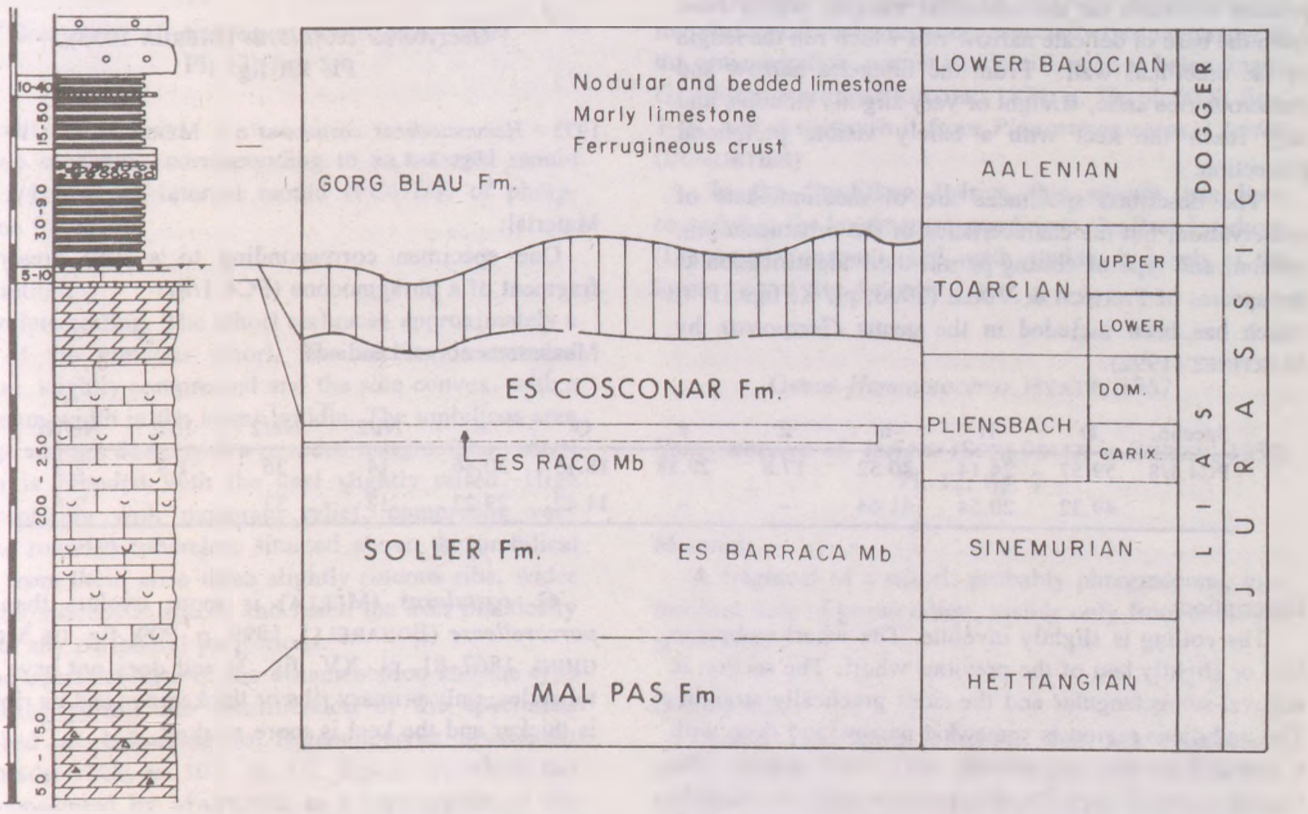

Fig. 2. Synthetic stratigraphical section of the Lower and Middle Jurassic sediments from Serra de Llevant Domain including the chronostratigraphic scale and the recognised lithostratigraphic units.

Systematic description

For the systematic study and taxomomic classification of the specimens, the morphological characteristics of the shell have taken into account, with the following dimensions and indices:

D = diameter of shell (mm),
H = height of whorl (mm),
E = thickness of section (mm),
O = umbilicus width (mm),
h = relative value of height in relation to the diameter,
e = relative value of thickness in relation to the diameter,
o = relative value of the umbilicus size in relation to the diameter,
Ni/2 = number of internal ribs in half a whorl,
Ne/2 =number of external ribs in half a whorl,
H/E = relation between the height and thickness,
NE/NI = relation between the number of external and internal ribs.

Suborder Ammonitina HYATT,1889
Superfamily Hildocerataceae HYATT, 1867

Family Hammatoceratidae, BUCKMAN, 1887‘
Genus *Geczyceras* MARTINEZ, 1992

Geczyceras cf. *bonarelli* (PARISCH & VIALE, 1906)
Pl. 12, figs. 3–4

Material:

Two specimens, one of them (PC4.1/1) very deformed (flattened), the other (PC4.1/2) corresponds to a fragment of whorl, only visible from one of its sides. Probably phragmocones.

Description:

The coiling is evolute, the whorl embraces a third of the previous one. In the inner whorls of the undeformed specimen the section is suboval, slightly compressed, and in the last visible whorl is strongly compressed. It has convex sides, with the maximum width at the lower third.

The umbilical region is wide and not very deep, with slightly convex margin and wall straight and slanting wall. The ventral area is rounded with a narrow, little raised keel. The ornamentation is fine and of moderate to gentle relief; it comprises very small, numerous, round and pointed tubercles on the umbilical margin, which arise from the base of delicate narrow ribs which run the length of the umbilicus wall. From the tubercles narrow and numerous ribs arise, straight or very slightly sinuous, and they reach the keel with a barely visible peripheral projection.

The described specimens are of medium state of preservation, but the characeristics of the ornamentation, section, and type of coiling permit their identification as the species of PARISCH & VIALE (1906, pl. X, figs, 1–4) which has been included in the genus *Geczyceras* by MARTINEZ (1992).

Geczyceras costulosus (MERLA 1933)
Pl. 12, fig. 1

1933 *Hammatoceras costulosus* n.f. MERLA, p. 13; 1. I(I), figs 3–4.

Material:

One specimen corresponding to a well preserved fragment of a phragmocone (PC4.1/8).

Measurements and indices:

Specim.	D	H	h	E	e	O	o	Ni/2	Ne/2	H/E	Ne/Ni
PC4.1/8	59.57	24.14	40.52	17.8	29.88	18.15	30.46	14	36	1.3	2.5
	49.32	20.54	41.64	–	–	14.42	29.23	13	33	–	2.5

Description:

The coiling is slightly involute. The whorl embraces half or slightly less of the previous whorl. The section is suboval-subrectangular and the sides practically straight. The umbilicus region is somewhat narrow and deep with a rounded margin and smooth, very slanting wall. The ventral region is very flat with a narrow and very slightly raised keel. Ornamentation is of moderate to low relief, formed by thick primary ribs or thickenings which arise at the edge of the umbilicus, and before ending in a third of sides, they divide and redivide in thick ribs wider than the space in between. These ribs are numerous and quite straight reaching the keel with a scarcely visible peripheral projection.

G. costulosus (MERLA) is more evolute than *G. porcarellense* (BONARELLI, 1899, p. 209, fig. DE MENEGHINI, 1867–81, pl. XV, fig. 3) and does not have true tubercles, only primary ribs or thickenings and its ribbing is thicker and the keel is more marked.

Geczyceras aff. *costulosus* (MERLA, 1933)
Pl. 12, fig. 2

Material:

One specimen corresponding to a well preserved phragmocone (PC4.1/9).

Measurements and indices:

Specim.	D	H	h	E	e	O	o	Ni/2	Ne/2	H/E	Ne/Ni
PC4.1/9	62.49	25.18	40.29	16.99	27.18	19.91	31.86	14	46	1.48	3.28
	50.26	21.55	42.87	15.47	30.77	15.86	31.55	13	45	1.39	3.46

Descripton:

Coiling moderately evolute, the last visible whorl embraces half or slightly less of the previous whorl. Section suboval-subrectangular, side practically straight, although there is hardly any difference in width, it is somewhat wider in the lower part of the sides. The umbilicus region is wide with a rounded margin and smooth, slightly inclined wall. The ventral region is rounded with a narrow, little raised keel. Ornamentation is of high and of moderate to high relief, formed by not very marked constant and narrow primary ribs which arise from the umbilicus edge and immediately thicken to form rounded tubercles; these redivide before ending in the lower half of the side in numerous, narrow ribs, somewhat wider than the space between, they are straight, or slightly "proverse", and reach the keel practically without peripheral projections.

The tubercles recall those in *G. allobrogense* (DUMORTIER, 1874; p. 79, pl. XIX, figs. 1–2), however the here described specimen is more involute and the section more compressed and the keel is less thick and raised. It differs from *G. porcarellense* (BONARELLI) because the tubercles are in a lower position and the ventral region is more rounded with the keel being less marked. *G. costulosus* (MERLA, 1933; p. 13, pl. I(I), figs. 3–4) is more involute and does not have true tubercles, it has a less marked keel and the ventral region is more rounded.

Geczyceras cf. *speciosum* (JANENSCH, 1902)

Pl. 12, fig. 5

Material:

Two specimens corresponding to an external mould (PC4.1/4) and an internal mould (PC4.1/5) of phragmocone fragments.

Description:

Evolute coiling. The whorl embraces approximately a third of the previous whorl. The section is rounded suboval, slightly compressed and the side convex, with a maximum width in the lower middle. The umbilicus area is large and not deep, with a rounded margin. The ventral region is rounded with the keel slightly raised. High ornamentation with moderate relief, comprising very regular rounded tubercles, situated above the umbilical edge, from these arise three slightly sinuous ribs, wider than the intercostal spaces and reach the keel practically without any peripheral projections.

The characteristics of the ornamentation and the type of coiling permit the identification of the specimens described as belonging to *Hammatoceras speciosum* (JANENSCH 1902; p. 102, pl. IV, figs 1–1a) which has been considered by MARTINEZ as a type-species of the genus *Geczyceras*. *H. insigne* (SCHL. in ZIETEN) has a less distinct ribbing and its section is less compressed in similar stages. *H. capuccinum* BUCKMAN has very similar internal whorls except that it has a more gentle relief in the ornamentation and a wider section for similar stages.

In the Cordillera Ibérica, in the east of peninsular Spain, this species has been recorded in levels corresponding to the Insigne Zone (GOY, 1974; MARTINEZ, 1992).

Geczyceras cf. *allobrogense* (DUMORTIER, 1874)

Pl. 12, fig. 6

Material:

A fragment of whorl, probably phragmocone. Medium state of preservation and only visible from one of the sides (PC4.1/3).

Description:

Coiling moderately evolute, the whorl embraces slightly less than half of the previous whorl. The section is suboval, compressed, with the sides slightly convex. The umbilicus is large, not deep, with the whorls visible, and the margin rounded. It has a narrow, slightly raised keel. Ornamentation comprises tubercles situated near the middle of the sides, in its lower part, prominent, rounded and pointed, specially in the innermost visible whorl. From these arise two secondary ribs and a lobe, thick with moderate to low relief, straight and reaching the ventral region with short, scarcely visible peripheral projections.

Although the specimen is not well preserved, the morphological characteristics, especially those referring to the ornamentation, permit its identification as belonging to *G. allobrogense* (DUMORTIER, 1874; p. 79, pl. XIX, figs. 1–2), and distinguish it from *Planammatoceras* ? *lorteti* (DUMORTIER).

In the Cordillera Ibérica this species has been recorded in the levels corresponding to the Pseudoradiosa (Levesquei Subzone), and, with doubts, in levels of the lower part of the Aalensis Zone.

Genus *Hammatoceras* HYATT, 1967

Hammatoceras cf. *insigne* (SCHLÜBLER in ZIETEN, 1830)

Pl. 12, fig. 7

Material:

A fragment of a whorl, probably phragmocone, in a medium state of preservation, visible only from one side. (PC4.1/7).

Description:

Coiling moderately involute. The whorl embraces aprroximately half of the previous whorl. Section subrounded and slightly compressed in the last visible whorls. The sides are convex and maximum width is in the lower third. The umbilicus is narrow with a rounded margin. The ventral region is not visible. Ornamentation is high and dense, comprising thick rounded tubercles situated above the umbilicus margin. From these arise ridges wider than the spaces in between, slightly concave towards the opening.

Although the specimen does not show a good state of preservation, there are no doubts, due to its morphological characteristics, as to its inclusion in *H. insigne* (SCHLÜBLER in ZIETEN, 1830; p. 30, pl. 15, figs. 2a–c). It is distinguished from other *Hammatoceras* such as *H. semilunatum* (QUENSTEDT) because it has clear tubercles and less sinuous ribbing.

In the Cordillera Ibérica this species has been recorded in levels corresponding to the the Insigne Zone (Insigne Subzone).

Hammatoceras praefallax MONESTIER, 1921

Pl. 12, fig. 8

1921 *Hammatoceras praefallax* n. sp. MONESTIER; p. 36, pl. III, figs. 11, 20–21.

Material:

One specimen corresponding to a well preserved phragmocone (PC4.1/6).

Measurements and indices:

Specim.	D	H	h	E	e	O	o	Ni/2	Ne/2	H/E	Ne/Ni
PC.1/6	13.77	6.40	46.47	9.06	65.79	3.55	25.78	12	22	0.7	1.83

Description:

Coiling involute, the last visible whorl embraces two thirds of the previous one. Cadicone section, with maximum width in the middle lower-part of the sides. Umbilicus is deep and narrow, with a convex edge and vertical wall. Ventral region is rounded with narrow and slightly raised keels. Ornamentation of moderate relief, comprising narrow primary and "proverse" ribs, above the umbilicus margin. They divide into secondary ribs of minor relief which almost reach the keel, with short peripheral projections.

In the description of the species of MONESTIER different types or varieties are distinguished. The specimen described in this study shows a clearly depressed section in the visible whorls. *H. praefallax* MONESTIER, in contrast to *H. insigne* (SCHLÜBLER in ZIENTEN) does not have well defined tubercles; it is more involute and the ribbing is denser than *H. fasciatum* JANENSCH and it shows clear differences in the ornamentation from *H. simulator* MONESTIER.

In the Cordillera Ibérica, this species has been recorded in the levels corresponding to the Insigne Zone (Insigne Subzone)–Pseudoradiosa Zone (Levesquei Subzone).

Genus *Planammatoceras* BUCKMAN, 1922

Planammatoceras cf. *planinsigne* (VACEK, 1886)

Pl. 13, fig. 1

Material:

Two fragments of whorl, possibly phragmocones (PC4.1/14,15).

Description:

Coiling moderately evolute. The whorl embraces approximately half of the previous one. Oval section with slightly convex sides and maximum width in the lower part of the sides. The umbilicus is large and not deep, with a rounded margin, wall somewhat convex and vertical. Ventral region sharp with thick, very raised keel. Ornamentation thick and of moderate relief, comprising straight primary ribs, approximately the same as the intercostal spaces, which arise from the umbilical edge and at the end of the lower third part a small tubercle and from this two slightly narrower ribs arise, somewhat porsiradiate and straight, reaching the keel with very short peripherical projection.

Planammatoceras planinsigne (VACEK, 1886; p. (33)89; pl. XIII, figs. 1, 1a, 2–4) differs from other *Planammatoceras* such as *P. planiforme* BUCKMAN or *P. romani* ELMI with the presence of tubercles and its oval section and high keel.

This species has not been recorded in the East or North of Spain, where a register of other species of *Planammatoceras* (URETA, 1985; MARTÍNEZ, 1992) exists. However it is relatively frequent in the Cordilleras Béticas, where LINARES & SANDOVAL (1994) found it in materials from the Opalinum Zone (Comptum Subzone) in Cerro Méndez, Granada, and from the Murchisonae Zone (Bradfordensis Subzone) in Montillana, Jaén.

Family Erycitidae SPATH, 1928

Genus *Erycites* GEMMELLARO, 1886

Erycites elaphus MERLA, 1933

Pl. 13, fig. 2,3,4

1933 *Erycites elaphus* n. sp. MERLA; p. 25 (25); l. IV (IV), fig. 5.

Material:

Four specimens corresponding to fragments of phragmocones in a medium state of preservation (PC4.1/10, 11, 12, 13).

Description:

Coiling evolute. The whorl embraces somewhat more than a third of the previous one. Section is subrounded, slightly compressed in the visible whorls, and slightly oval, with maximum width situated in the lower part of the strongly convex sides. Umbilicus is large, not deep, with the internal whorls of the section more globular than the external whorls. The margin is rounded and the wall smooth and inclined. The ventral region is slightly oval with a thick, hollow, little raised keel. Ornamentation is thick and of low relief, comprising thick elongated tubercles, rounded and thick, which arise in the umbilical edge, reaching almost the middle of the side, where they divide into mumerous ribs, wider than the spaces between, and also more proradiate and straight. They reach the keel with the barely visible peripheral projections.

It is distinguished from *E. reussi* (HAUER) because this species has a more rounded section and its width is in the middle part of the sides and the ribbing is less thick.

E. rotundiformis MERLA also differs in the section which is less oval and the ribbing is less marked. GÉCZY (1966) points out the differences between this species and

E. crassiventris MERLA, in reference to the style of involution and ribbing and suggests the possibility of the latter being included as a subspecies of the former. This same author points out the differences with *E. intermedius* HANTKEN in PRINZ in respect to the ornamentation, the type of involution and above all the suture line, for which the possibility of including (suggested by DONOVAN, 1958) *E. elaphus* MERLA in this latter species is excluded. This species has not been recorded in the Cordillera Ibérica. In the Cordilleras Béticas, LINARES & SANDOVAL (1994) found it in material from the Reynesi Zone in Cerro Méndez, probably equivalent to the upper part of Insigne Zone or the lower part of Pseudoradiosa Zone in the Cordillera Ibérica (cf. GOY et al., 1988).

Conclusions

In Puig Cutri, in the Gorg Blau Formation, above the ferruginous belt *Ancolioceras opalinoides* (MAYER) (ALVARO et al., 1989) have been recorded at the base of a belt of nodular, platy limestones. This species in the Cordillera Ibérica is characteristic at the top of the Opalinum Subzone and of the Haugi Subzone (URETA, 1985) from which it seems possible that the removal level was formed at one or various stages after the Variabilis Zone and before the Murchisonae Zone.

From the point of view of sedimentary evolution, the intra-Toarcian discontinuity, in the Sierra Norte, and Upper Toarcian–Aalenian of Puig Cutri in the Serra de Llevant is marked, in both cases, by the change of the facies characteristic of a shallow platform (Es Cosconar Formation) to a facies of an exposed platform (Gorg Blau Formation). The recommencing of sedimentation and the development of new beds in wider environments occurred at the end of the Toarcian and the beginning of the Aalenian, on a local and discontinuous level, beginning with the ferruginous level which contains reelaborated fossils. In agreement with ALVARO et al. (1989) the materials from the Gorg Blau Formation present a relationship to the "onlap" type with those underneath.

From the paleobiogeographic point of view, in the taxoregisters the transition Toarcian–Aalenian of the Serra de Llevant, the relative abundance of *Polyplectus discoides* (ZIETEN) stands out. This species is characteristic to Mediterranean areas but with certain frequency it is present in the outcrops in Northwest Europe. Also, one finds more *Geczyceras* than *Hammatoceras*, numerous *Osperlioceras*, *Catulloceras*, *Tmetoceras* and occasionally *Vacekia*, as occurs in Llodrá (ALVARO et al., 1989). On the other hand, there is also a record of species of the genera *Cotteswoldia* and *Pleydellia*, such as *P. costulata* and *P. leura*, which have been identified from material proceeding from England, such as *Oxyparoniceras telemachi* (RENZ), very rare and absent in close Mediterranean areas (Cordilleras Béticas) and of *Leioceras*. The faunas from the upper Toarcian and lower Aalenian of the Puig Cutri can be said to be characteristic of the Mediterranean Province, but they also contain elements of Northwest Europe. With respect to the Hammatoceratidae, while a wide taxonomic divesity exists, the numbers of specimens for each species are very low. Evidence of paleobiocenosis does not exist, and it is possible that in the majority or in all of the cases the shells were transported from distant areas.

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Plate 12

Fig. 1. *Geczyceras costulosus* (Merla, 1933). PC4.1/8. Phragmocone. ×1
Fig. 2. *Geczyceras* aff. *costulosus* (Merla, 1933). PC4.1/9. Phragmocone. ×1
Fig. 3. *Geczyceras* cf. *bonarelli* (Parisch & Viale, 1906). PC4.1/2. Phragmocone. ×2
Fig. 4. *Geczyceras* cf. *bonarelli* (Parisch & Viale, 1906). PC4.1/1. Phragmocone. ×1
Fig. 5. *Geczyceras* cf. *speciosum* (Janensch, 1902). PC4.1/4. Phragmocone. ×1
Fig. 6. *Geczyceras* cf. *allobrogense* (Dumortier, 1874). PC4.1/3. Phragmocone. ×2
Fig. 7. *Hammatoceras* cf. *insigne* (Schlübler in Zieten, 1830). PC4.1/7. Phragmocone. ×2
Fig. 8. *Hammatoceras praefallax* (monestier, 1921). PC4.1/6. Phragmocone. ×2

Plate 13

Fig. 1. *Planammatoceras* cf. *planinsigne* Vacek, 1886. PC4.1/14. Phragmocone. ×1
Fig. 2. *Erycites elaphus* Merla, 1933. PC4.1/12. Phragmocone. ×1
Fig. 3. *Erycites elaphus* Merla, 1933. PC4.1/10. Phragmocone. ×1
Fig. 4. *Erycites elaphus* Merla, 1933. PC4.1/11. Phragmocone. ×1

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Mid-Jurassic Ammonitina from the Central Ranges of Irian Jaya and the origin of stephanoceratids

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(with 2 figures and Plates 14–17)

Abstract

Selected specimens from the Seo and Suzuki ex-situ collections of mainly Bajocian Ammonitina from the Central Ranges of Irian Jaya are described and their phylogeny and/or paleobiogeography discussed. *Riccardiceras* gen. nov., type species *Coeloceras longalvum* VACEK from (late) Aalenian–Early Bajocian of the Alps, is named to distinguish serpenticone *"Docidoceras"* (lately placed in *Stephanoceras*) from the sub-spherocone *Docidoceras* s. str. *Riccardiceras* is the phylogenetic link between the *Erycites* gr. *gonionotus–Abbasitoides* [Erycitidae], and *Stephanoceras* s. l. [Stephanoceratidae], i.e. in parallel to the lineage *Erycites*(?) gr. *fallifax – Docidoceras – Emileia* etc. [Otoitidae]. Macroconch shape and sculpture of *Riccardiceras* resemble early *Stephanoceras*, but also intergrade with contemporary *Docidoceras*; septum/suture and the microconch morphology are close to *Docidoceras*. *Riccardiceras suzukinense* sp. nov. is most closely allied to *G. limatum* (POMPECKJ).

Key words: Ammonoidea, Irian Jaya, taxonomy, biostratigraphy, new species

Introduction

In the seventies, H. SUZUKI, then a student at Kyoto University (presently professor at Doshita University in Kyoto), and H. J. SEO, of Painai Lake Minerals Inc., made ex-situ collections of Middle and Upper Jurassic ammonoids in the Central Ranges of eastern (mainland) Irian Jaya. The ammonites from the Suzuki collection were kindly lent to me through the auspices of professor T. SATO of Tsukuba University, whereas the Seo collection was gifted to me by the exploration company in return for their study. Whereas the Mid-Bathonian to Early Callovian Macrocephalitinae and associated taxa from these collections have been described earlier (WESTERMANN & CALLOMON, 1988), the remaining Mid-Jurassic Ammonitina of exceptional preservation or unique occurrence are presented here.

The Jurassic litho- and biostratigraphy of eastern Indonesia, including Irian Jaya on the island of New Guinea, has recently been reviewed by SUKAMTO & WESTERMANN (1992). The only relatively recent taxonomic study of Middle Jurassic ammonites from Irian Jaya (WESTERMANN & GETTY, 1970) was based on an earlier ex-situ collection from the Central Ranges, i.e. the Le Roux collection stored in the Rijksmuseum van Geologie en Mineralogie in Leiden, The Netherlands. Extensive discussions of previous works on Middle Jurassic ammonoids on eastern Indonesia are found in that work.

The Mid-Bathonian to Early Callovian ammonite taxa of Eastern Indonesia and Papua New Guinea and their ages are now relatively well known, based on my recent field work (partly accompanied by T. SATO, S. SKWARKO and F. HASIBUAN), that resulted in the first significant in-situ collections. Several formal ammonite assemblage zones have been established for the Sula Islands, Irian Jaya and Papua New Guinea, based on relatively rich *Macrocephalites* associations with tulitids, cadomitines and oppeliids (WESTERMANN & CALLOMON, 1988; HILLEBRANDT et al., 1992), i.e. Macrocephalites bifurcatus Zone (Middle Bathonian), M. apertus Zone (Late Bathonian), and M. keeuwensis Zone (late Early Callovian). However, most of the Callovian remains poorly known.

The earlier Mid-Jurassic biostratigraphy, however, remains an enigma owing to poor outcrop conditions, inaccessibility, and very limited field work. In particular, the presence of marine Aalenian has so far not been established, nor indicated by the numerous large ex-situ collections which may contain abundant Early Bajocian ammonites.

1. The oldest Mid-Jurassic ammonite species so far identified, *Fontannesia kiliani* (KRUIZ.) and *"Docidoceras longalvum* cf. *limatum* (POMP.)" = *Riccardiceras suzukinense* n. sp. from the Central Ranges (WESTERMANN & GETTY, 1970), could be as old as latest Aalenian, but

more probably are of early to mid-Lower Bajocian age. *F. kiliani* probably indicates the Laeviuscula Zone according to its occurrence in Tibet (WESTERMANN & WANG, 1988), i.e. about the age of *Pseudotoites* cf. *robiginosus* (CRICK). *P. robiginosus* is rare in Irian Jaya, but occurs abundantly in the Laeviuscula Zone of Western Australia, together with *Fontannesia (Newmarracaroceras)* spp. After many years of hyphonated existence, the *"D." longalvum* group is here given the generic name *Riccardiceras*.

2. The next-younger, larger fauna is known mainly from the Vogelkop Peninsula and Geelvink Bay, consisting of diverse cosmopolitan species of the late-Early Bajocian Stephanoceratinae and a few Sphaeroceratinae (WESTERMANN, 1956 and review by WESTERMANN & GETTY, 1970). Among the endemic species are *Stephanoceras*(?) *etheridgei* (GERTH), *Teloceras*? *indicum* KRUIZINGA, and *Chondroceras boehmi* WEST. But most were based on single, poorly preserved specimens. The holotype of *T.*? *indicum* is almost complete, but with a strongly corroded outer whorl (refigured by WESTERMANN & GETTY, 1970, text-fig. 9). Whereas the inner whorls resemble extremely coarse-ribbed *Teloceras/conchsStemmatoceras*? gr. *subblagdeni* WEISERT, the body-chamber uncoils markedly and becomes much more rounded and, probably, much more smoother (unless this is entirely due to corrosion). This, together with its small size for a macroconch (D=115 mm), suggests that *T.*? *indicum* could be the only known western Pacific *Zemistephanus* (HALL & WESTERMANN, 1980). It is distinguished from *Irianites* WEST. & GETTY by the conical umbilicus of the inner whorls. The problematic ages of *Irianites*, *"Bullatimorphites" costidensus* WEST. & GETTY and similar, but lappeted microconchs are dicussed below.

3. Only very few Late Bajocian ammonites are known. Very rare Leptosphinctinae (previously misidentified as Kimmeridgian *Idoceras*) have been found. One specimen of the early–Late Bajocian genus *Caumontisphinctes* was collected in-situ on Sula (WESTERMANN & CALLOMON, 1988), and two came ex-situ from Irian Jaya (one illustrated by WESTERMANN & GETTY, 1970, pl. 51, figs 3a–b).

4. The endemic *Praetulites kruizingai* WEST., known from Irian Jaya and Sula (WESTERMANN, 1956; WESTERMANN & CALLOMON, 1988), is probably Late to latest Bajocian, possibly ranging into the earliest Bathonian.

5. *Satoceras* WEST. & CALLOMON also occurs mainly in eastern Indonesia, but is also known from Japan. *S. hataii* (TAKAHASHI) was first described as a Callovian perisphinctid from Honshu and is here illustrated from Irian Jaya. *Satoceras* has recently been found in-situ on Sula, where its age can be bracketed between latest Bajocian and early Middle Bathonian (WESTERMANN & CALLOMON, 1988).

Taxonomic descriptions

Family Sphaeroceratidae BUCKMAN, 1920
Genus *Satoceras* WESTERMANN & CALLOMON, 1988

Type-species (orig. des.): *Satoceras satoi* WESTERMANN & CALLOMON, 1988, from Early Bathonian of Irian Jaya and Sula.

Satoceras satoi WESTERMANN & CALLOMON
Plate 16, figs 3a, b

1988 *Satoceras satoi*, WESTERMANN & CALLOMON, p. 40, text-figs 10a–b, plate 16, figs 1–3 [and earlier synonymy therein].

Comments

The Suzuki ex-situ collection from Homejo, Kemabo River, which has furnished the holotype, also includes the topotype illustrated here. Its nucleus closely resembles the impression associated in the same concretion with *Irianites* (Pl. 16, figs 1a–b), which would suggest a mainly Early Bathonian age for *Irianites* (interpretation 2, above). This specimen also displays the sharp primaries ending in small lateral bullae, characteristic for the mature body-chamber. The inner whorls, however, are also closely similar to those of *"Bullatimorphites? (Treptoceras?)* n. sp. A ♂" of WESTERMANN and GETTY (1970), illustrated on plate 14, figures 2a, b and discussed below.

Satoceras hataii (TAKAHASHI)
Plate 14, figs 4 a, b

1969 *Obtusicostites hataii* TAKAHASHI, p. 71, pl. 7, fig. 9 and pl. 9, fig. 6.

1988 *Satoceras hataii* (TAKAHASHI), WESTERMANN & CALLOMON, p. 40.

Description

The phragmocone is subspherical with involute, depressed-oval whorls, similar but more inflated than in *S. satoi*; but the primary and secondary costae are much coarser and much less curved, almost rectiradiate. The body-chamber, 3/4 whorls long, uncoils and rounds gradually, and bears similarly coarse and almost rectiradiate costae as the phragmocone, with exceptionally coarse secondaries. Faint mid-lateral bullae are present at the end of the phragmocone and at the beginning of the bosy-chamber. Compared to *S. satoi* and *S.*? *subkamptum* (SPATH), the ribs are straighter and the secondaries much coarser. The (incomplete) aperture at c. 105 mm diameter is typically constricted and slightly oblique. The septal suture is as in *S. satoi* (WESTERMANN & CALLOMON, 1988, Text-fig. 10a–b), i.e. highly complicated, with radial saddle envelope, deep and narrow L, a U_2 of about half as large as L, and a rather well developed umbilical saddle.

Comments

Only the holotype from the Arato Formation of northwest Honshu, Japan, has been known. Its age is bracketed by the subjacent, early–Late Bajocian Leptosphinctes Zone (SATO & WESTERMANN, 1991) and the Mid– to Late Bathonian *Kepplerites*–(?)*Cadomites* assemblage (= ? Pseudoneuqueniceras yokojamai Zone of SATO & WESTERMANN, 1991) much higher in the sequence. A mainly Early Bathonian age is therefore indicated for the Honshu occurrence, similar as for *S. satoi* on Sula.

The single, large, but somewhat damaged specimen with aperture from the Suzuki collection from Homejo, which was recorded and reclassified by WESTERMANN & CALLOMON (1988), is a significant find and illustrated here. It closely resembles the holotype from Japan, which is a somewhat distorted specimen preserved with one side only and without venter. Poor preservation probably was the reason for its original misplacement in the superfamily Perisphinctaceae. The New Guinea specimen is thus the best preserved known specimen of *S. hataii* and an exceptional biogeographic link.

Tab. 1. Measurements (mm) of MM 19815

	Diameter	Whorl-width	Height	Ww/H	Umbil.	Prim.	& sec.
						1/2 whorl	
Aperture	105	c. 61 (.58)	49	1.25	31.4 (.30)	12	c. 35
end phr.	70	–	31	–	13.0 (.19)	13	36
	64	45 (.70)	28	1.6	12.2 (.)	13	–

Satoceras boehmi (WESTERMANN & GETTY)
Plate 14, figs 5a–c

1913 *Macrocephalites keeuwensis* β-γ BOEHM, p. 16, text-fig. 9, pl. 5, fig. 2 (holotype).
1970 *Subkossmatia obscura* SPATH *boehmi* WESTERMANN & GETTY, p.266, pl. 56, figs 3a–b, 4a–b only.
?1988 (?)*Satoceras boehmi*, WESTERMANN & CALLOMON, p.43, text-fig. 10c, pl. 17, figs 1a–b.

The specimens of the Suzuki collection from an unknown locality of Irian Jaya, here ilustrated, closely resembles the (lost?) holotype from Mamapiri, Irian Jaya. It is also a good match to the large fragment from Assemblage 1a of the Sula islands, described by WESTERMANN & CALLOMON (1988). The Sula assemblage includes *Cadomites* cf. *daubenyi* (GEMM.) and underlies the Mid-Bathonian Bifurcatus Zone, indicating a Late Bajocian–Early Bathonian age.

This species was originally classified (as subspecies) in the Callovian genus *Subkossmatia* of the Subfamily Eucycloceratinae (then a family), which is now known to have been restricted to the Indo-East African Bioprovince. The fragments of "?*Eucycloceras*", also Eucycloceratidae, illustrated on the same plate by WESTERMANN & GETTY (1970, pl. 56, figs 1–2) are probably incomplete microconchs of *Macrocephalites bifurcatus* (BOEHM) (cf. WESTERMANN & CALLOMON, 1988, pl. 9, figs 1–2, 4).

The complete size of the Suzuki specimen from Irian Jaya was c. 95 mm. The exposed ultimate whorl, including the 1/2 whorl body-chamber, is moderately involute with rounded-trapezoidal section, about as high as wide. The converging flanks are separated from the vertical umbilical wall by a rounded margin; the venter is gently rounded. The inner whorls are probably ovate with rounded umbilical slope, and also about as high as wide. The sculpture of the phragmocone (internal mould) consists of blunt, very dense and strongly forward-curved primaries and secondaries, which pass convexly over the venter. On the body-chamber, primaries and secondaries become coarser, but remain blunt on the internal mould and adorally inclined. Remnants of the shell show, however, that the last primaries were sharp and narrow, with maximum elevation (?bullae) at mid-flank. The aperture is obliquely constricted.

Tab. 2. Measurements (mm) of MM 19816

	Diameter	Whorl-width	Height	wW/h	Umbilicus	Prim.	Sec.
						1/2 whorl	
body-ch	89	37 (.42)	35.5	1.04	21.5	13	45
end phr.	64	35 (.48)	30	1.0	11.2	15.5	50

Superfamily Stephanocerataceae NEUMAYR 1875
Family Stephanoceratidae NEUMAYR 1875
Genus *Irianites* WESTERMANN & GETTY 1970

Type-species (orig. design.): *"Coeloceras" moermanni* KRUIZINGA, 1926; a microconch from Sula Islands

Irianites moermanni (KRUIZINGA) ♀/M & ♂/m
Text-figs 1–2 ; Plates 15–16

♂ 1926 *Coeloceras moermanni* KRUIZINGA, p. 44 with text-fig., pl. 13, fig. 2. [refigured in WESTERMANN & GETTY, 1970, text-fig. 14]

♂ 1970 *Irianites moermanni* (KRUIZINGA, 1926) ♂, WESTERMANN & GETTY, p. 274, text-figs 13–16, 20–24, pls. 57–58. [With additional synonymy]

♂ 1970 *Irianites* cf. *I. moermanni* (KRUIZINGA) ♀, WESTERMANN & GETTY, p. 281, text-figs 19–24, pls. 59–62.

Morphology

Irianites is known only in the single, dimorphic type species, *I. moermanni*, from several islands of the Moluccas and from Irian Jaya (see WESTERMANN & GETTY, 1970). In addition to the approximately 75 microconchs and 25 macroconchs of *Irianites* known previously, the 18 microconchs and 4 macroconchs from the new collections also belong to the same morphs, with closely matching inner whorls. We therefore conclude, even in the absence of stratigraphic data, that only one biospecies is present.

The sculpture of the microconchs, collected by H.J. SEO at S. Bija in the S. Badai River bed, is particularly well preserved in the septate whorls illustrated on Plate 16, figs 1a–b.

A macroconch from the same SEO collection (Pl. 15, figs a–d) is the largest and most complete specimen known, yet it misses the aperture. There is almost perfect resemblance to the complete body-chamber whorl illustrated earlier from the Sula Islands (WESTERMANN & GETTY, 1970, text-figs 18a–b). The immature growth stages are as described previously: the platyconic juvenile stage, with lateral nodes and irregular umbilical bullae, is followed by depressed elliptical whorls (Pl. 16, figs 2 a–b). The body-chamber is *Teloceras*/*Stemmatoceras*-like. The ontogeny of shape and sculpture in the new, large specimens is as described previously and follows the developmental trend (Figs 1–2). The width/height ratio of the whorls develops from c. 1.2 in the juvenile (2–5 cm diameter), via c. 1.5 of the penultimate whorl, to c. 2.0 of the body-chamber. The same collections also contains an isolated, large apertural fragment (Pl. 16, figs 3a–b), which may belong to the same morph. It is broadly depressed and with prominent lateral bullae and dense, convex ventral lirae.

Affinity

In the original description WESTERMANN & GETTY (1970) were swayed mainly by the serpenticonic and compressed whorls of the microconch to place *Irianites* tentatively in the Perisphinctaceae, rather than the Stephanoceratacae. However, the characteristic umbilical bullae on evolute-compressed whorls are now known to be present in several stephanoceratid genera. The oldest-known taxon is *Gerzenites* WEST., the microconch to *Kumatostephanus* BUCK. from the Sauzei Zone of western Europe (WESTERMANN, 1964; SANDOVAL, 1983; FERNANDEZ LOPEZ, 1985). Umbilical bullae are developed especially in *K. (G.) aequicostatus* WESTERMANN (1954, fig. 99 and pl. 21, figs 4, 7), which resembles the *Irianites moermanni* microconch also in the evolute, platyconic whorls, and even in the simple septal suture with reduced U_2. Other stephanoceratids with umbilical bullae are the recently described genus *Duashnoceras* SANDOVAL & WEST. from the Lower/Upper Bajocian boundary of Mexico, e.g. *D. undulatum* (BURCK.), *D. paucicostatum* (FELIX), and *D. floresi* (BURCK.), as well as some specimens of *Phaulostephanus* (SANDOVAL & WESTERMANN, 1986, figs 18, 26). On the other hand, blade-like primaries with sharp drop from a high elevation at the umbilical shoulder, and a reduced U_2 lobe, are also developed in the serpenticonic *Parabigotites crassicostatus* IMLAY and its microconch *"Normannites" kialagvikensis* IMLAY, from the Crassicostatus Zone (Sauzei Chron) of North America (IMLAY, 1964, pl. 13, figs 1–8, 10, 11; pl. 29, figs 1–15). But this endemic form could be an early perisphinctid (e.g. TAYLOR, 1988).

The adult *Irianites* macroconch (♀), however, is a close homeomorph to *Teloceras* and *Stemmatoceras* with its trapezoidal, highly sculptured outer whorls (Pl. 15). In fact, without exposure of the flat umbilicus of the inner whorls (i.e. the platyconic inner whorls that can be seen in sagittal section), most mature *Irianites* macroconchs cannot be clearly distinguished from typical late-Early Bajocian stephanoceratids, with the exception of the incipient ventral depression if clearly developed.

Perhaps, *Irianites* can find its place in the Garantianinae [Stephanoceratidae], rather than in the Stephanoceratinae, or it may even be distinct enough for subfamily-status. Again, stratigraphically controlled collections with datable associated fauna are needed to solve this problem.

Age according to one associated spherocone

The only hint at the age of *Irianites* comes from an ex-situ concretion which contained the impressions of a *Sulaites* sp. indet. together with that of a small spherocone, which cannot be identified precisely (Pl. 14, figs 1a–b) (WESTERMANN & GETTY, 1970, pl. 55, figs 4a–b). This important important incomplete specimen is a phragmocone with body-chamber fragment that belonged to a small, relatively evolute spherocone with rounded whorls and very dense, projected costae. There appear to be two plausible alternatives for the affinity and age of this spherocone.

Interpretation 1: Sauzei Chron. The spherocone is a small, fully grown, densely isocostate and lappeted microconch *"Bullatimorphites? (Treptoceras?)*, n. sp. A ♂" of WESTERMANN & GETTY (1970 , pl. 55, figs 1–3) of which the best specimen is shown on Plate 14, figs 2a–b. According to this interpretation, this morph corresponds to the macroconch *"B.? (T.?)" costidensus* WEST. & GETTY (1970, pl. 54, figs 1–4), which is also isocostate, but with "simple" aperture. The septal suture with tri- or multifid lobes and retraction at the umbilicus indicates that this is not a tulitid. If this is indeed a dimorphic pair – which can only be surmised in the absence of stratigraphy – then the dense, isocostate ribbing with long primaries and the moderately involute, gradually uncoiling whorls of the macroconch and microconch suggest that this "species" belongs to *Labyrinthoceras* BUCKMAN of the Early Bajocian family Otoitidae. *Labyrinthoceras* is known from Europe and North America where it is restricted to the Sauzei Chron. Our supposed macroconch is relatively small and not very inflated, resembling the West European *L. intricatum* (BUCKMAN); the rare microconchs with lappets have been illustrated from Spain (SANDOVAL, 1983, pl. 3, fig. 4), Portugal (FERNANDEZ LOPEZ et al., 1994), and the United States, i.e. *"Otoites?" delicatus* IMLAY (1964).

The originally supposed microconch of *Labyrinthoceras* (WESTERMANN, 1964), i.e. the small *Frogdenites* BUCKMAN with lappets, has later been disposed on stratigraphic and morphological grounds (PARSONS, 1974; GALÁCZ, 1980). In contrast to the lappeted microconchs suggested for *Labyrinthoceras* by SANDOVAL and FERNANDEZ LOPEZ (see above), GALÁCZ (1990) has recently described *L. manselli* BUCK., with "simple" aperture, as the corresponding microconch. (He consequently transferred *Labyrinthoceras* from the Otoitidae to the Sphaeroceratidae). This interpretation and GALÁCZ'S suggestion that SANDOVAL'S lappeted [*Labyrinthoceras*] microconch could be a *Kumatostephanus*, i.e. *Gerzenites* [Stephanoceratinae], are not accepted here.

Interpretation 2:. (Late Bajocian–) Early Bathonian. The impression attached to *Irianites* is of the inner whorls of *Satoceras*, so far known only as a macroconch (WESTERMANN & CALLOMON, 1988, pl. 16, fig. 2). According to CALLOMON (in WESTERMANN & CALLOMON, 1988, p. 40), however, *"Bullatimorphites ?" costidensus* WEST. & GETTY could be a *Satoceras* microconch (not a *Labyrinthoceras* macroconch as in 1). The juvenile whorls of *Satoceras satoi* WEST. & CALL., ♀, closely resembling the mentioned impression, are again illustrated on Pl. 14, fig. 3a.

Tab. 3. Measurements (mm) of *Irianites moermanni* ♀ (ROM ....)

Diameter		Whorl-width	height	Umbilicus	Prim.	Second.
					1/2 whorl	
body-ch	132	69.5	37	68 (57)	21.5	c. 28
	87	47	28	39 (45)	26	–

Genus *Riccardiceras* gen. nov.

Type-species: *Coeloceras longalvum* VACEK 1886 (holotype refigured by WESTERMANN, 1964, pl. 6, fig. 1) from the (upper) Aalenian – basal Bajocian of the Southern Alps.

Diagnosis: Resembling early *Stephanoceras* in the platyconic to serpenticonic, rounded whorls with complete, plicate costae; but with biaxial (bullate) septum, suture with two internal saddles and large, subvertical "2nd lateral lobe" U_2.

Origin of name:

yHonouring my long-standing friend and collaborator, Professor Alberto C. RICCARDI, eminent Argentine paleontologist and geologist.

Comments

The new generic name formally separates the serpenticonic species group of *"Docidoceras" longalvum* from the subcadiconic group of *D. cylindroides* BUCKMAN, type species. Intermediate morphospecies, however, existed between these extreme morphologies around the Aalenian-/Bajocian stage boundary (WESTERMANN, 1964, fig. 14 right). This broad species "complex", however, included two major, largely co-existent, cosmopolitan clades, both derived from the mid-Aalenian Erycitidae: (1) the Otoitidae, an offshoot from the *Erycites fallifax – Abbasites* group and with typical *Docidoceras* as oldest-known member, and (2) the Stephanoceratidae, going back to the *"Erycites" gonionotus – Abbasitoides* group and first represented by *Riccardiceras*. Significantly, the septal surfaces and sutures are astonishingly constant across this broad range of coiling (WESTERMANN, 1956a), with the *Riccardiceras* structures clearly distinct from that of typical early *Stephanoceras* with similar coiling and sculpture, or even forms with more depressed whorls, e.g. the *Skirroceras* microconch *Epalxites anceps* (QU.) (Pl. 17, 2c vs. fig. 5).

There remains, however, some confusion about the species-level classification and age of the type-species, *R. longalvum*. The serpenticonic, densely costate lectotype (designated as "holotype") and one or two syntypes (WESTERMANN, 1964, pl. 6, figs 1–2) came from a thin, lenticular grainstone bed on top of the Oolite di San Vigilio at Cap St. Vigilio in the Italian Alps. This level is

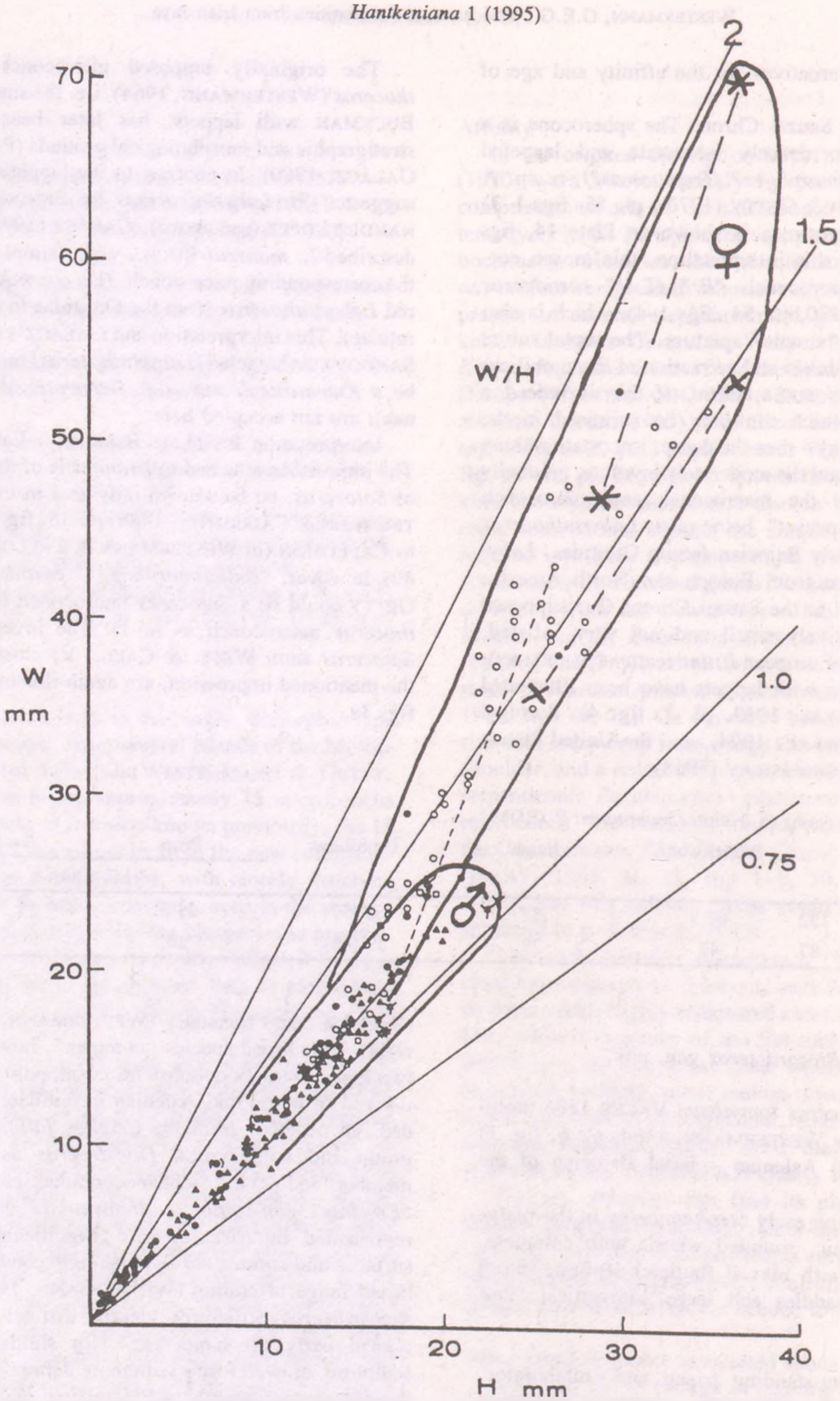
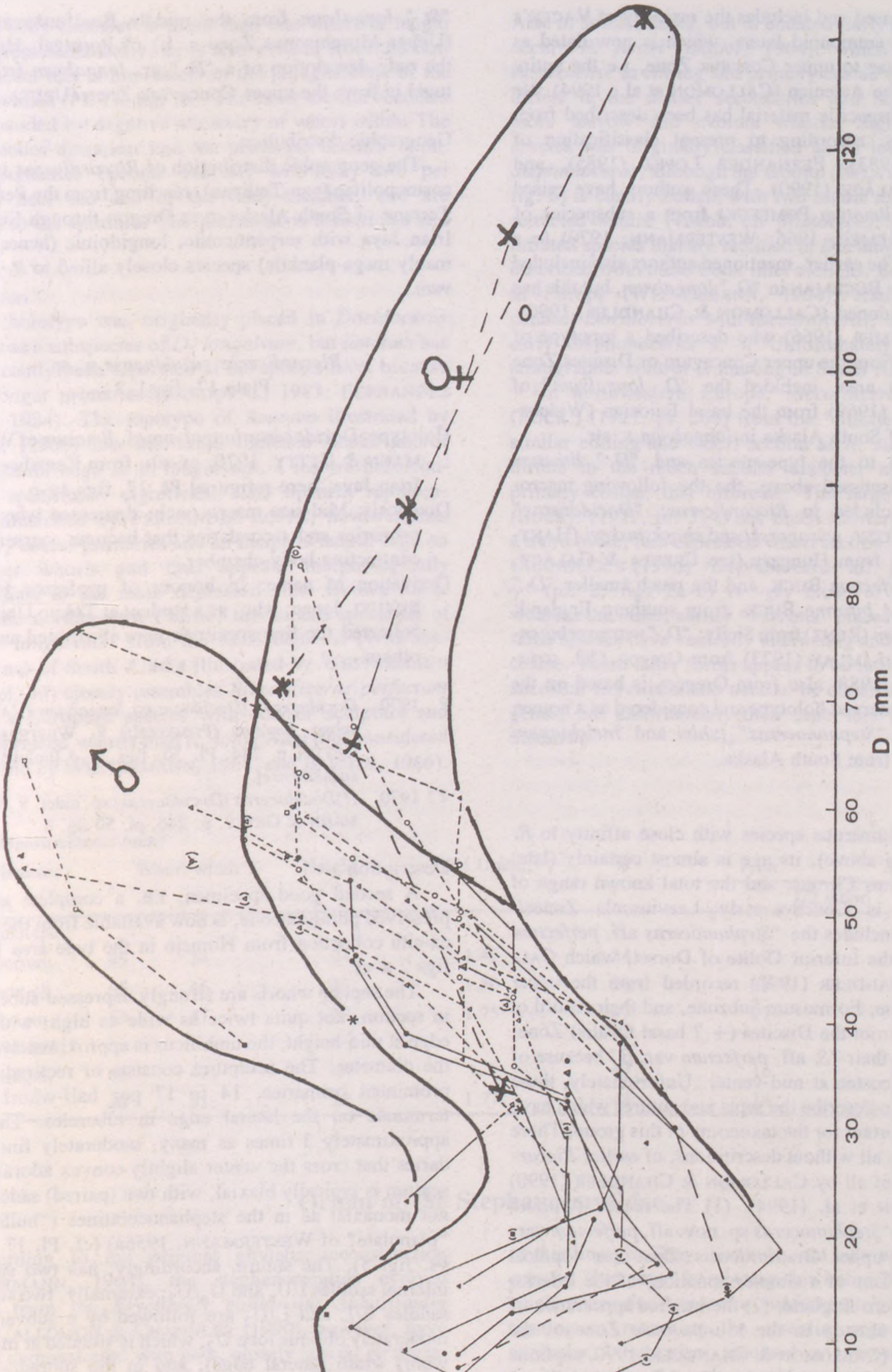


Fig. 1. Morphogenesis of the whorl section (width/height ratio) in *Irianites moermanni* (KRUIZ.), ♀ (macroconch) & ♂ (microconch); heavy crosses mark the new specimens, a large circle the Sula specimen; note the strongly positive allometry for whorl width in the macroconch

Fig. 2. Morphogenesis of sculpture in *Irianites moermanni* (KRUIZ.) ♀ & ♂; number of primary (P) and secondary (S) costae per half-whorl; note the adult modification mainly in the secondaries.


P
33
30
25
20
D mm
10
20
30
40
50
60
70
80
100
120
♀
♂
M

strongly condensed and includes the majority of Vacek's (1886) diverse ammonoid fauna, which is now dated as mid-Murchisonae to upper Concava Zone, i.e the entire upper half of the Aalenian (Callomon et al., 1994). No indubitably conspecific material has been described from other localities, according to present classification of Sandoval (1983), Fernandez Lopez (1985), and Cresta & Galácz (1990). These authors have raised *"Coeloceras" limatum* Pompeckj from a subspecies of *longalvum* (Bremer, 1966; Westermann, 1970) to a species level. The earlier, mentioned authors also included *"D." perfectum* Buckman in *"D." longalvum*, but this has also been abandoned (Callomon & Chandler, 1990). However, Bremer (1966) who described a topotype of *"C." limatum* from the upper Concavum or Discites Zone of the Ankara area, included the *"D. longalvum"* of Westermann (1969) from the basal Bajocian (Widebayense Zone) of South Alaska in *longalvum* s. str.

In addition to the type-species and *"D." limatum* (Pompeckj) discussed above, the the following macroconchs are included in *Riccardiceras: "Docidoceras" telegdirothi* Géczy, *wysogorski* and *chocksinskeyi* (Hantken in Prinz) from Hungary (see Cresta & Galácz, 1990); *"D. perfectum* Buck. and the much smaller *"D." planulatum* and *biforme* Buck. from southern England; *"D." trapanicum* (Renz) from Sicily; *"D." warmspringensis* and ?*lupheri* Imlay (1973) from Oregon (*"D. striatum"* Taylor, 1988, also from Oregon, is based on the very poorly preserved holotype and considered as a nomen dubium); and *"Stephanoceras" juhlei* and ?*nelchianum* Imlay (1964) from South Alaska.

Age

Based on numerous species with close affinity to *R. longalvum* (see above), its age is almost certainly (late) Concava–Discites Chrons, and the total known range of *Riccardiceras* is Concava–early Laeviuscula Zones/-Chrons. This includes the *"Stephanoceras* aff. *perfectum* var. γ" from the Inferior Oolite of Dorset, which Callomon & Chandler (1990) recorded from the upper Concavum Zone, Formosum Subzone, and their record of *G. perfectum* from the Discites (+ ? basal Ovalis) Zone; but it excludes their *"S.* aff. *perfectum* var. β" because of its alternating costae at mid-venter. Unfortunately, these authors failed to describe the septa and sutures which have proved so important for the taxonomy of this group. There are few claims, all without descriptions, of earlier *Riccardiceras*, most of all by Callomon & Chandler (1990) and Callomon et al. (1994). (1) The record (without illustration) of *"Stephanoceras* sp. nov. aff. *perfectum* var. α" from the upper Bradfordensis Zone (or topmost Murchisonae Zone of a simpler zonation) of the Inferior Oolite in southern England; (2) the implied appearance of *R. longalvum* already in the Murchisonae Zone of the Inferior Oolite (Callomon & Chandler, 1990, captions to Pl. 1, figs 2a–c), which is based solely on the alleged dimorphic correspondence with *Abbasitoides modestus* (which was refuted above); and (3) a brief mention of *"St." longalvum* from the middle Bradfordensis Zone (Upper Murchisonae Zone s. l.) of Portugal. However, the only description of a *"D."* gr. *longalvum* from Portugal is from the upper Concavum Zone (Ureta, 1985).

Geographic distribution

The geographic distribution of *Riccardiceras* is quasi-cosmopolitan (pan-Tethyan), reaching from the Peninsular Terrane of South Alaska over Oregon through Europe to Irian Jaya with serpenticonic, longidomic (hence presumably mega-planktic) species closely allied to *R. longalvum*.

Riccardiceras suzukinense n. sp.

Plate 17, figs1–2

Holotype: *Docidoceras longalvum* cf. *limatum* of Westermann & Getty, 1970, ex-situ from Kemaboe River, Irian Jaya, here refigured Pl. 17, figs 1a–c.

Diagnosis: Mid-size macroconch; depressed whorls with primaries and secondaries that become coarser on the contracting body-chamber.

Derivation of name: In honour of professor Hiroyuki Suzuki, Japan, who, as a student at Tokyo University, collected the fine specimen here illustrated and many others.

♀ 1970 *Docidoceras (Docidoceras) longalvum* (Vacek) cf. subsp. *limatum* (Pompeckj) ♀, Westermann & Getty, p. 244, Pl. 50, figs 1a–d [holotype of *R. suzukinense*].
♀? 1970 (?)*Docidoceras (Docidoceras)* sp. indet. ♀, Westermann & Getty, p. 246, pl. 50 fig. 3.

Description

A second good specimen, i.e. a complete and well preserved phragmocone, is now available from the Suzuki ex-situ collection from Homejo in the type area (Pl. 17, figs 2 a–c).

The septate whorls are strongly depressed-subelliptical in section, not quite twice as wide as high, with lateral edge at mid-height; the umbilicus is approximately 50% of the diameter. The sculpture consists of rectiradiate and prominent primaries, 14 to 17 per half-whorl, which terminate on the lateral edge in tubercles. There are approximately 3 times as many, moderately fine secondaries that cross the venter slightly convex adorally. The septum is typically biaxial, with two (paired) saddle axes, not monaxial as in the stephanoceratines ("bullate" vs. "planulate" of Westermann, 1956a) (cf. Pl. 17, fig. 2c vs. fig. 5). The suture, accordingly, has two sub-equal internal saddles I/U_n and U_n/U_3; externally, two sub-equal saddles E/L and L/U_2 are followed by a subvertical or moderately oblique lobe U_2, which is situated at maximum whorl width (lateral edge); and in the subradial saddle envelope, with only the umbilical elements beyond U_2 strongly retracting. In stephanoceratines, U_2 is strongly oblique and situated on the inner flank.

The body-chamber is more than one whorl in length and degresses markedly, as is also evident from the umbilical seam that is impressed on the phragmocone of the new specimen (Pl. 17, fig. 2a). The cross-section becomes more rounded by negative allometry of whorl width. The lateral nodes disappear and the primaries become blunt. The secondaries become coarser, with only two per primary near the end of the body-chamber, and are retained to the aperture. The peristome is constricted and oblique.

Discussion

The holotype was originally placed in *Docidoceras limatum* as a subspecies of *D. longalvum*, but *limatum* has more recently been separated at the species-level because of its longer primaries (SANDOVAL, 1983; FERNANDEZ LOPEZ, 1984). The topotype of *limatum* illustrated by BREMER (1966) has the same flattened flanks and/or absent lateral edge as in *longalvum*, a feature here considered specifically significant. The Spanish representatives illustrated by FERNANDEZ LOPEZ, however, has relatively coarse primaries and an incipient lateral edge on the inner whorls and thus appears morphologically intermediate to the more depressed New Guinea form. Along the northeastern Pacific, the superb specimen of *"D.* aff. *longalvum"* from the basal Bajocian (Widebayense Zone) of South Alaska illustrated by WESTERMANN (1969, pl. 33) closely resembles *Riccardiceras perfectum* BUCK., a European species with coarser sculpture and more depressed whorls than *R. longalvum* (but considered conspecific by WESTERMANN, 1964, and BREMER, 1966). Also in South Alaska, but in undated Early Bajocian beds, occurs *R. juhlei* (IMLAY, 1964), which resembles *R. suzukinense* in coiling and primary costae with nodes, but differs in the denser secondaries and larger, probably more narrow and evolute whorls. Significantly, this species was originally classified as an indubitable early *Stephanoceras*, although the septum (IMLAY, 1964, pl. 16, fig. 6) is clearly bullate with two saddle axes and weakly retracted suture (visible on plastotype). Several, more inflated species that are retained in *Docidoceras* were also described from these Cook Inlet sections. But, similarly as in Europe (WESTERMANN, 1964), transitional forms connect *Docidoceras* with *Riccardiceras*, as well as with early *Stephanoceras* s. l. Unfortunately the required stratigraphic control is missing in South Alaska.

In northwestern Europe, *Riccardiceras planulatum* (BUCK.) (1921, pl. 264) from the "discites hemera" has similar coiling and whorl section as *R. suzukinense*, but differs in the much smaller diameter and the denser primary costae, that bifurcate. The large *R. perfectum* (BUCK). (1922, pl. 314) has much shorter primaries and a more ovate, less depressed whorl section. CALLOMON & CHANDLER'S (1990) *"Stephanoceras* aff. *perfectum* var. γ" (pl. 2, figs 2a–b) is very close to *R. perfectum*, whereas the other, earlier "variants" placed by them in the same species have ventrally alternating and/or interrupted costae. These latter forms appear to be intermediate to the ancestral Erycitidae and need to be classified as a distinct genus, but unfortunately their septa and sutures remain unknown.

Tab. 4. Measurements (mm)

	Diameter	Whorl-width %	Height %	W/H	Umbil. %	Prim.	Sec.
						1/2 whorl	
Holotype							
aperture	95	34	24	1.45	54	c. 22	45
body-ch.	65	46	31	1.50	50	19	55
phragm.	53	47	27	1.75	49	17	–
MM 19817							
phragm.	65	47	28	1.7	47	16	47
	40	51	28	1.77	48	14	–

Origin of the Stephanoceratidae

According to my original phyletic reconstruction (WESTERMANN, 1964), the stephanoceratids evolved directly from the *Erycites*(?) *gonionotus–Abbasitoides* group. CALLOMON & CHANDLER (1990), however, have recently demonstrated with new, closely spaced stratigraphic collections from the Inferior Oolite of Dorset, that a morphologic quasi-continuum existed between mid-Aalenian erycitids and mid-Early Bajocian true *Stephanoceras* s. l., with the *Riccardiceras longalvum* group being part of this lineage. They, however, not only applied extreme generic "lumping" by placing this entire lineage into the single genus *Stephanoceras* (unfortunately without investigating or recording the essential septal and sutural attributes), but also assumed a non-stephanoceratid dimorphism for the early members of their *Stephanoceras* lineage, i.e. the supposed microconchs bearing apertures without lappets. The dimorphic pairs suggested by CALLOMON & CHANDLER (1990) are *"Stephanoceras" [Ric-*

cardiceras] longalvum [M] – *Abbasitoides modestus* (VACEK) [m] (lectotypes designated and refigured by WESTERMANN, 1964, pl. 6, figs 1, 8); *"S." aff. perfectum* BUCK. [M] – *A.* aff. *modestus* [m]; and *"S." perfectum* [M] – *"S.?" planulatum* (BUCK.) [m]. I classify *"Docidoceras" planulatum* as a *Riccardiceras* macroconch, despite its small diameter (72 mm); the size ratio closely resembles that present in the Stephanoceratinae macroconchs, i.e. *Phaulostephanus* versus *Stephanoceras*, *Skirroceras*, *Teloceras*, etc. *A. modestus* contrasts with all known Stephanoceratidae microconchs in the "simple" aperture without lappets and, with micro- and macroconchs of that family, by the minute external lobe E that is characteristic of erycitids (Pl. 17, fig. 4). In my opinion, *Abbasitoides modestus* is almost certainly a small erycitid macroconch, to which the microconch has already been described from the same assemblage, i.e. the minute *A. pumilus* (VACEK) with(?) lappets. Furthermore, the lowest true Stephanoceratinae macroconchs recorded by CALLOMON & CHANDLER (1990) from the Inferior Oolite, i.e. *S. (Skirroceras) leptogyrale* (BUCK.) and *Mollistephanus* cf. *mollis* BUCK., came only from the upper Bradfordensis Zone (uppermost Laeviuscula Zone s. l.), immediately below the Sauzei Zone.

Microconchs

The minute, lappet-bearing microconchiate genus *Trilobiticeras* BUCK. was matched with *Docidoceras* s. l. (including *Riccardiceras*) long ago, because of resemblance of the immature whorls and similar vertical and lateral ranges, from Alaska to eastern Europe (WESTERMANN, 1964). Due to the high sex and size ratios in favour of the macroconchs (including collecting bias against small specimens), however, records of *Trilobiticeras* are very limited. For example, a single complete specimen was recovered from the Widebayense Zone of Wide Bay, South Alaska, in contrast to about one hundred complete macroconchs of *Docidoceras (Pseudocidoceras) widebayense* WEST. and *camachoi* WEST. (WESTERMANN, 1969). Most *Trilobiticeras* occurrences are recorded from the upper Concava–Discites Zones, including the respective type-species of macro- and microconchiate genera in the Inferior Oolite of England, which even CALLOMON & CHANDLER (1990) consider as a pair. But, in western Europe, *Trilobiticeras* ranges into the Laeviuscula Zone, above the range of *Docidoceras* (s. stricto). Here it is associated and has been paired with *Emileites* (GALÁCZ, 1972; SANDOVAL, 1983; FERNANDEZ LOPEZ, 1985; CALLOMON & CHANDLER, 1990), which CALLOMON & CHANDLER (1990) include in *Docidoceras* as a subgenus.

Together with *D. (Emileites)* in the Inferior Oolite occurs another poorly known genus affin to *Trilobiticeras*, i. e. *Frogdenites* BUCKMAN (1921, pl. 215). Originally considered as the microconch of *Labyrinthoceras* (WESTERMANN, 1964), *Frogdenites* was later separated on stratigraphic and morphologic grounds. The aperture is poorly known and *Frogdenites* may even include both dimorphs (PARSONS, 1974, 1977; GALÁCZ, 1982).

Hence, *Trilobiticeras* uniquely comprises the microconchs to several macroconchiate genera classified in the two families, Otoitidae and Stephanoceratidae. The generic name *Trilobiticeras* obviously needs to be retained for these microconchs, just as the Bathonian–Callovian microconchiate genus *Xenocephalites*, which corresponds to several macroconchiate genera of the Eurycephalitinae (RICCARDI & WESTERMANN, 1991).

The specific *Trilobiticeras* microconchs matching *Riccardiceras* are unknown and all are rare; it could be *T. punctum* (VACEK) (lectotype designated and refigured in WESTERMANN, 1964, pl. 6, figs 7a–b) which is kown from the Alps and England (GALÁCZ, 1972), whereas the *Docidoceras* microconchs probably include T. *trilobitoides* BUCK. *Abbasitoides*, on the other hand, has a much more restricted gepgraphic distribution than *Docidoceras* and *Riccardiceras*.

Early phylogeny and the classification of Stephanoceratinae

In my most recent discussion and classification (WESTERMANN, 1993) of the clade or clades leading from erycitids to *Stephanoceras* s. l., *Abbasitoides* is again placed in the Erycitidae (or Erycitinae of Hammatoceratidae), whereas the "group of *Stephanoceras? (Oecostephanus?) longalvum* (VACEK)" [here named *Riccardiceras*] is placed in the Stephanoceratidae (Stephanoceratinae or subfam. nov.?), tentatively as their first member. [*Oecostephanus* BUCK. was tentatively used as the best name available from a list of highly "split" late-Lower Bajocian "genera" named mostly by BUCKMAN for Inferior Oolite macroconchs [*Kallistephanus*, *Rhytostephanus*, *Skolekostephanus*, *Kreterostephanus*, *Freycinetia*, *Baylia*], which should be reduced to a couple of serpenticonic early subgenera of the genus *Stephanoceras*.]

The evolute to serpenticonic species of *Erycites* s. lato, i.e. the group of *E.*(?) *gonionotus* (BEN.) and *"E." modestus* (VACEK) (=*Abbasitoides* GÉCZY, 1966), have been considered ancestral to the stephanoceratids for a long time (e.g. WESTERMANN, 1964). *E.*(?) *gonionotus* differs from the much more inflated and involute *E. fallifax*, type-species, in a very similar way as does *Riccardiceras* from *Docidoceras*, i.e. serpenticonic coiling, and there also are intermediate forms. Hence, for reasons of conformity, these groups should perhaps be separated at generic or, at least, subgeneric level. (I will leave these to the specialists.) *Abbasitoides* is distinct by the broad ventral costae interruption and the small size (the lectotype of *A. modestus*, type-species, cf. Pl. 17, fig. 4, is here considered as a macroconch, as discussed above).

By mid-Aalenian time, these forms tended to become *Stephanoceras*-like by closure of the ventral costae interruption and modification of the septum-suture complex. In the latest Aalenian and early Bajocian, typically serpenticonic *Riccardiceras* lived through much of the pan-Tethyan area, where they were planktic drifters in the upper water masses (WESTERMANN, in press). During the mid-Early Bajocian Laeviuscula Chron, *Riccardiceras* evolved into *Stephanoceras* s. l. (including *Skirroceras*, *Oecostephanus*, etc.) by the (gradual?) change of the monaxial ("planulate") into the biaxial ("bullate") septum. This is reflected in the suture by the reduction and increased obliquity of the "2nd lateral lobe" U$_2$ accompanied by strong retraction of the umbilical lobes, and, dorsally, by the similar reduction and increased obliquity of the "internal lateral lobe" U$_1$/U$_n$. The poorly known *Mollistephanus mollis* BUCKMAN (1922, pl. 344) from the Laeviuscula Zone of southern England appears to have been an important intermediate member of this lineage. According to the original illustrations, it has a subvertical U$_2$ (? and some poorly defined mid-ventral costae irregularity). Perhaps CALLOMON & CHANDLER's (1990) earlier "*Stephanoceras* cf. *perfectum* vars." with ventral costae alternation and/or interruption are best placed in *Mollistephanus*.

It is entirely possible that several parallel lineages existed, even in Europe, e.g. from strongly costate *Riccardiceras* to *Skirroceras*, which has a coarsely costate juvenile stage, and from finely costate *Riccardiceras* to the extremely serpenticonic *Stephanoceras (Oecostephanus)* gr. *baylei* (OPPEL), to *Stephanoceras* s. str.

Coeval clades

The radiation from late erycitids or the early otoitids and stephanoceratids included several other clades. Of particular interest is the basal Bajocian of Oregon. "*Docidoceras" amundsoni* TAYLOR (1988) closely resembles the rare, exceptionally evolute species placed in *Pseudotoites* from South Alaska, i.e. P. (?) *kialagvikensis* and *prestoni* WESTERMANN & RICCARDI (1989; respectively for *P.* cf. *argentinus* and *P.* cf. *transatlanticus* of WESTERMANN, 1969) from the very early Bajocian Widebayense Zone. They all have similar short, bullate primaries ending on the lateral edge that is situated well below mid-flank. In South Alaska, these forms are part of the much more abundant *Docidoceras (Pseudocidoceras)* fauna (WESTERMANN, 1969). *"Docidoceras" lupheri* IMLAY (1964) is more evolute and intermediate between *Riccardiceras* and *"D." amundsoni* in sculpture and whorl section. The typical, more involute and inflated *Pseudotoites* occur in the Laeviuscula Chron (s. l.) of the Andes and Western Australia (WESTERMANN & RICCARDI, 1979). Significantly, what appears to be a broad-whorled, evolute *Pseudotoites* occurs also in the Aalenian/Bajocian boundary beds of Hungary, Spain and Morocco, i.e. *"Docidoceras" zemistephanoides* GÉCZY (1966; FERNANDEZ LOPEZ, 1985; BENSHILI, 1989). GÉCZY noticed that this species differed from *Docidoceras* in the bullate, short primaries, but compared it with the much younger Canadian genus *Zemistephanus*, a stephanoceratid of the Humphriesianum Chron (HALL & WESTERMANN, 1980); but not with *Pseudotoites*. These relationships are, of course, important biogeographically and phylogenetically. Curiously and again illuminating the close affinity between early otoitids and stephanoceratids, the Australian, New Guinean and ?Andean (typical) *Pseudotoites* appear to have originated from forms close to European species of intermediate *Docidoceras* and, especially, *D. (Emileites)*; the northeastern Pacific *Pseudotoites* from *Riccardiceras*. This would, of course, imply polyphyly and require taxonomic revision.

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Plate 14

All figures natural size

Figs 1a–b. Impression of *Irianites* sp. indet. attached to fragment of an evolute spherocone of doubtful affinity, as discussed in text, loose from Kemaboe River bed (reproduced from Westermann & Getty, 1970, Pl. 55, figs. 4a, b).

Figs 2a–b. Complete *"Bullatimorphites? (Treptoceras?)* n. sp. A ♂" of Westermann & Getty (1970, Pl. 55, figs. 1a, c reproduced), loose from Kemaboe River bed; this microconch of ?*Labyrinthoceras* matches Fig. 1b (interpretation 1).

Figs 3a–b. Incomplete *Satoceras satoi* West. & Call. ♀ (Tokyo Univ. Museum UMUT MM 19814); septate whorls with exposed nucleus (3a) and with (3b) body-chamber, ex-situ from Homejo; this nucleus also resembles Fig. 1b (interpretation 2).

Figs 4a–b. Damaged *Satoceras hataii* (Takahashi) ♀ (Tokyo Univ. Museum UMUT MM 19815), ex-situ from Homejo; complete phragmocone and end of body-chamber (removed in 4b).

Figs 5a–c. Almost perfect specimen of *Satoceras boehmi* (West. & Getty) ♀ (Tokyo Univ. Museum UMUT MM 19816) with only the ventral part of aperture missing, from unknown locality of Irian Jaya; note septal suture with deep, trifid lobes characteristic of Sphaeroceratidae.

Plate 15

All figures natural size unless otherwise indicated

Figs a–d. Largest known *Irianites moermanni* (Kruiz.) ♀ (Royal Ontario Museum 51413), with almost complete body-chamber, ex-situ from S. Badai River bed; a x 0.8.

Plate 16

All figures natural size unless otherwise indicated

Figs 1–2. *Irianites moermanni* (Kruiz.) ♀ & ♂, ex-situ from S. Bidai River bed. 1 a–b, septate whorls of microconch (Royal Ontario Museum 51414), x 2; 2 a–b, damaged but almost complete macroconch (ROM 51415).

Figs 3a–b. End of large body-chamber of ?*Irianites* (ROM 51416), ex-situ from S. Bidai River bed.

Plate 17

All figures natural size

Figs 1–2. *Riccardiceras suzukinense* n. sp., ♀/M. 1a–c, Holotype, ex-situ from Kemaboe Valley (reproduced from Westermann & Getty, 1970, Pl. 50, figs. 1a–c); complete with damaged aperture. 2a, b. Probably complete phragmocone (UMUT MM 19817), ex-situ from Homejo; note biaxial ("bullate") septal surface, with two (paired) saddle axes (vs. Fig. 5).

Fig. 3. Topotype (?paralectotype) of *Riccardiceras longalvum* (Vacek) with septal suture inked in (reproduced from Westermann, 1964, Pl. 6, fig. 8); note the large, slightly oblique U_2 situated on rounded lateral edge (max. whorl width), the retracted U_3, and that E is somewhat shorter than L.

Fig. 4. Oblique view of *Abbasitoides modestus* (Vacek), lectotype, with inked-in septal suture (reproduced from Westermann, 1964, Pl. 6, fig. 8); note minute external lobe E and smooth ventral band.

Fig. 5. Septal surface of *Stephanoceras (Epalxites) anceps* (Qu.) ♂ [microconch of *S. (Skirroceras)* gr. *macrum* (Qu.) ♀], from Alfeld, Germany (reproduced from Westermann, 1964, Pl. 6, fig. 3); note monaxial ("planulate") architecture, with only one (paired) saddle axis (vs. Fig. 2c).

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Revision of the Middle Jurassic ammonite fauna from Csóka-hegy, Vértes Hills (Transdanubian Hungary)

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(with 1 figure and Plates 18–19)

Abstract

In the Vértes Hills, a part of the Transdanubian Central Range, exposures of Middle Jurassic rocks are limited to some spots. The best-known occurrence is that on the Csóka-hegy, of which fauna was briefly described in 1960. The depositional and faunal features indicated a revision, what was made on the basis of the original material. The sediments are re-interpreted as fissure-filling materials of Middle Jurassic neptunian dykes, where a Bajocian and a Bathonian ammonite assemblage was recognized. The Bathonian fauna indicating the Oxycerites orbis Zone is richer and more interesting, because it contains forms which are interpreted here as cryptogenetic homoeomorphs. These previously less-known or unrecognized forms (e.g. *"Morphoceras" gignouxi*, *?"Dimorphinites" nodifer*, special *Epistrenoceras* sp., etc.) were preserved here in this locality because the fissure-filling material escaped the normal sedimentologic and diagenetic processes which were general in the area of overwhelming radiolaritic deposition. In addition to these general conclusions, the paper gives short descriptions and figures of the characteristic Bajocian and Bathonian ammonites.

Key words: Transdanubian Central Range, Hungary, submarine fissure-filling, Bajocian, Bathonian, ammonites, rare forms

Introduction

In the Vértes Hills of the Transdanubian Central Range Jurassic rocks are exposed only in the marginal areas (GALÁCZ 1985). Aalenian red, nodular limestone and debris of supposedly overlying Bathonian limestone are recorded east of Vértessomló (FÜLÖP et al. 1960). Brown cherts and limestones were ranged on the basis of microfacies studies in the Callovian-Oxfordian from the eastern margin of the Vértes Hills (KNAUER 1973).

The best-known Middle Jurassic locality of the Vértes is in its western margin, on the Csóka-hegy (Csóka Hill) of Mór, where the rocks are dated by ammonites. The formations and faunas ranged into the Bathonian were first described by FÜLÖP et al. (1960). On the basis of recent field studies and re-evaluation of the fossils, the general conclusions on the formations and the faunal lists of that paper need a revison.

Middle Jurassic rocks on the Csóka-hegy of Mór

The locality is a few tenches on the steep slope of the hill which were made in the late 50's, in the time of field studies for detailed mapping by the Hungarian Geological Institute. "It was unsuccessful to establish the succession of the tectonically disordered beds" (FÜLÖP et al. 1960, p. 18), thus the different rocks were interpreted in a supposed stratigraphic order. FÜLÖP in a later work (1971, fig. 4) published a section of the locality, where the incomplete sequence is figured in undisturbed order. Five Middle Jurassic rock- types were distinguished (see also VIGH 1968, pp. 36–37), of which two yielded ammonite faunas. These two formations, and the published respective faunal lists (determinations by G. VIGH) are as follows:

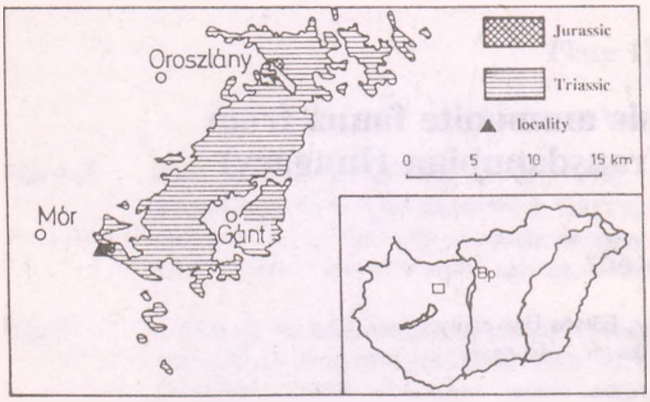

Fig. 1. Triassic and Jurassic rocks in the Vértes Mts, and the location of Csóka-hegy near Mór.

rock-type b ("crinoidal, Posidonomya limestone with manganiferous nodules and manganese-coated skeletal elements"):

Phylloceras sp.
Lytoceras sp.
Hecticoceras sp.
Teloceras sp.
Peltoceras sp.? ("of primitive character").

rock-type c ("red limestone with calcitic fillings and rich fauna"):

Phylloceras sp. aff. *P. kunthi* NEUM.
Phylloceras flabellatum NEUM.
Phylloceras div. sp.
Phylloceras subobtusum KUDERN.
Calliphylloceras sp. aff. *disputabile* ZITT.
Holcophylloceras mediterraneum NEUM.
Holcophylloceras sp. (from the *H. mediterraneum* NEUM. group)
Lytoceras adeloides KUDERN.
Lissoceras oolithicum D'ORB.
Hecticoceras recticostatum DE GROSS. (sic!)
Hecticoceras sp. aff. *H. primaevum* DE GROSS.
Hecticoceras sp.
Teloceras sp.
(?)*Clydoniceras* sp.
Delecticeras sp. (from the *D. legayi* RIGAUX & SAUVAGE group)
Delecticeras sp.
Garantiana cf. *ferruginea* OPP.
Garantiana sp.
Gracilisphinctes cf. *fusciacensis* LISSAJOUS
Siemiradzkia sp.
Berbericeras cf. *schwandorfense* KRUMB.

On the basis of the dominating small-sized forms, the assemblages were regarded by VIGH as dwarfed faunas, and from the embedding of the forms he concluded that the fossils were swept together in shallow, agitated marine water. As of age, he suggested the Bathonian for both.

In addition to the general conclusions drawn from the depositional and petrographic features, the above faunal lists are especially interesting. In his discussion VIGH mentions only *Peltoceras* sp.? as the only element as a contrast with his Bathonian age determination. However, in his lists *Teloceras*, *Garantiana* and *Hecticoceras* are also included, which, being Bajocian and Callovian forms, would also need some explanation.

Probably realizing the presence of true Bajocian forms, FÜLÖP later (1971) "completed" the 4 to 5 m thick sequence, inserting Bajocian beds in between the Sinemurian (identified by brachiopods) and Bathonian (determined by VIGH's ammonites) strata.

The longer faunal list of VIGH (from rock-type c above) has some further interesting elements, because he recorded *Clydoniceras* and *Delecticeras*. These two subgenera are significant from palaeogeographical point of view, because their species are hitherto unknown from s. str. Mediterranean areas (see GALÁCZ 1990).

All these interesting aspects indicated a revision of the fauna. The material, kept in the collections of the Hungarian Geological Museum, was made available by J. KONDA, former director of the Hungarian Geological Institute.

Depositional environment

The locality, as it was described by FÜLÖP et al. (1960) is a clustrer of rocks and blocks standing out from the soil of a covered area. On the southwestern slope of the hill, southeast to the outcropping Lower Cretaceous crinoidal limestone, in a 200 to 400 m wide strip, red, brecciated, crinoidal limestone debris are scattered on the surface. There are some blocks of pale, micritic limestone, which were the sources of Liassic (Sinemurian) brachiopods recorded by FÜLÖP et al. (1960), but all red limestone types are seemingly of fissure filling material. Most belong probably to the Middle Jurassic, as judged from the mass-occurring *Bositra* shells in all rocks. There are now only a single point where Bajocian brachiopods occur (A. VÖRÖS, pers. comm.). We could have not find any ammonite-bearing Middle Jurassic rocks in the recent field studies. This does not exclude the possibiliy of future discovery of in-situ occurrences of Bajocian or Bathonian rocks with ammonites.

On the basis of the lithologic types and the inferred depositional features, FÜLÖP et al. (op. cit. pp. 17,18) concluded that the Liassic rocks are products of transgressive sedimentation following an emerged phase at the Triassic/Jurassic boundary. The Bathonian was interpreted as a sequence with transgressive breccia above the Dachstein Limestone and Liassic rocky shore sediments, which was followed by shallow-water bioclastic accumulation.

Since the publication of FÜLÖP's and VIGH's works, the sedimentological re-evaluation of the Jurassic rocks in the Transdanubian Central Range has been revealed facts which exclude the subaerial exposure – transgressive overflood explanation of incomplete sequences. According to earlier and recent depositional models (GALÁCZ 1984, GALÁCZ & VÖRÖS 1985) the Middle Jurassic was the time of the deepest-water marine environment of the area, where the dominant Bathonian and Callovian sediment is the radiolarite. This fact, and the lithologic features of the Csóka-hegy limestones suggesting submarine fissure-filling material, indicate an explanation for the occurrence as an exceptional depositional site.

According to this explanation the locality indicates the rare case of preservation of ammonitic sediments from an environment otherwise destructive for carbonate shell material. The fissures in the Liassic and Upper Triassic Dachstein Limestone provided preservational shelters for carbonates (with the embedded ammonite shells) which were formed presumably in a short calcareous deposition episode in a period characterised generally by siliceous deposition and carbonate dissolution. These carbonates filled the fissures at least in two phases: in the Bajocian and in the Bathonian. Later – prior to the Lower Cretaceous crinoidal limestone – probably submarine erosion took away all Middle and Upper Jurassic rocks. On the basis of the general development in the Transdanubian Central Range, these rocks might have been Middle Jurassic radiolarites and Upper Jurassic carbonates, not more than 10–20 m in thickness.

This case is significant not only because it shows an exceptional sedimentological situation, but in general perspectives also. In the Mediterranean realm Bathonian and Callovian ammonitic sediments are rare, because in these ages the siliceous radiolarites were developed in most places. The Csóka-hegy example may raise enthusiasm for searching faunas of this time interval in areas generally thought hopeless because of the destructive or hostile sedimentological circumstances.

Stratigraphic results

Because the efforts to collect in-situ material in the field were unsuccessful, the basis of the faunal revision was the museum material.

The ammonite specimens which have been prepared free from the original matrix are not easy to group by their original whereabouts. An additional difficulty is that there are transitions between the rock types which were recordeded previously. However, the systematic revision has resulted in the distinguishing of two, temporally different faunas: one of Upper Bajocian and one of Upper Bathonian age.

The Upper Bajocian ammonites are:

Phylloceras trifoliatum NEUMAYR
Phylloceras kudernatschi (HAUER)
Adabofoloceras belinskji (BESNOSOV)
Adabofoloceras besnosovi (STURANI)
Holcophylloceras zignodianum (D'ORBIGNY)
Ptychophylloceras longarae STURANI
Lytoceras sp. indet.
Nannolytoceras polyhelictum (BÖCKH)
Nannolytoceras pygmaeum (D'ORBIGNY)
Sphaeroceras sp.
Lissoceras oolithicum (D'ORBIGNY)
Cadomites (Cadomites) sp.
Parkinsonia sp. indet.

This fauna suggests most probably the Parkinsonia parkinsoni Zone.

The richer, Upper Bathonian fauna yielded the following determinable forms:

Phylloceras kudernatschi (HAUER)
Adabofoloceras sp.
Calliphylloceras disputabile (ZITTEL)
Holcophylloceras zignodianum (D'ORBIGNY)
Ptychophylloceras flabellatum (NEUMAYR)
Ptychophylloceras sp.
Lytoceras adeloides (KUDERNATSCH)
Oxycerites sp. indet.
Eohecticoceras sp. indet.
Prohecticoceras retrocostatum (DE GROSSOUVRE)
Cadomites (Cadomites) rectelobatus (HAUER)
Cadomites (Cadomites) sp.
?*Cadomites (?Polyplectites) compressus* DE GROSSOUVRE
? "*Dimorphinites*" *nodifer* WENDT
"*Morphoceras*" *gignouxi* GUILLAUME
unnamed genus and species
Epistrenoceras sp.
Bullatimorphites (Bullatimorphites) sp
Bullatimorphites ("Treptoceras") sp.
Parapatoceras distans (BAUGIER & SAUZÉ)
Procerites (Procerites) sp.
Procerites (Siemiradzkia) sp.
?*Choffatia (Homoeoplanulites) pseudoannularis* (LISSAJOUS)

This is an Upper Bathonian fauna, as shown by the diagnostic co-occurrence of *Prohecticoceras retrocostatum*, *Parapatoceras distans* and *Homoeoplanulites pseudoannularis*. The presence of *Epistrenoceras* sp. gives a possibility to narrow the stratigraphic range of the fauna within the Oxycerites orbis Zone (Aspidoides Zone auctt.), because this genus is restricted to the Histricoides horizon, i.e. to the upper part of this zone (see ELMI 1967, p. 453).

The strange forms in the above list (their descriptions see below) are forms of doubtful ages. ?*Cadomites (?Polyplectites) compressus* DE GROSSOUVRE and "*Morphoceras*" *gignouxi* GUILLAUME were recorded form the Middle Bathonian Morrisi Zone. However, both forms are known in the literature by single specimens (i.e. the types), thus their Upper Bathonian occurrences cannot be excluded. ?*C.* (?*P.*) *compressus* is known from the Mecsek Mts, South Hungary (GALÁCZ 1995), where it ranges up into the Upper Bathonian. ?*"Dimorphinites" nodifer* and the form mentioned here as unnamed genus and species are ammonites showing close similarity to species described from Sicily by WENDT (1964), from faunas where Lower and Upper Bathonian forms are equally represented. During recent field work in Monte Kumeta, Sicily, very similar ammonites were collected from an assemblage of similary Upper Bathonian, Oxycerites orbis Zone age (GALÁCZ 1993). Thus there are good indications that these forms are Upper Bathonian homoeomorphs, which need further study and probably new names.

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The small size of the ammonite specimens is striking and needs some explanation. Similarly to many Jurassic ammonites coming from fissure-filling material, the entire or nearly complete forms are of small-size: maximum 1 to 2 cm in diameter. This may suggest dwarfed faunas, as in the case of STURANI's (1971) Upper Bajocian fissure-filling assemblages from North Italy. However, in the Csóka-hegy fauna occasional large (i.e. nomal) specimens, and more commonly fragments of big examples also occur. A 6.5 cm fragment of a phylloceratid of 11 cm estimated diameter occurred in the material, and other fragments from larger ammonites are also not uncommon. Additionally, many of the here mentioned and below described and figured ammonites are small forms when occurring in "normal" sediments: *Nannolytoceras, Sphaeroceras, Adabofoloceras, Epistrenoceras*, etc. An other part of the fauna is represented seemingly by young specimens: individuals, which presumably disappear by diagenetic processes in most other accumulation sites.

These above facts and considerations suggest that the openings of the suddenly splitting fissures might have been size-limiting factors. Specimens – small forms, juveniles and fragments of bigger adults – were apparently sieved into the crevices with the unconsolidated matrix. Eventually a fauna of small ammonites is resulted, which could be misleading to interpret as a dwarfed, or "cave-dwelling" association.

Short description of some Middle Jurassic ammonites from Csóka-hegy

Phylloceras trifoliatum NEUMAYR, 1871

Few small, partly fragmentary specimens. The high-oval whorl section, the sculptureless, only growth-line covered shell and the suture-line make the identification easy. The species was discussed recently (GALÁCZ 1980) in detail. That study supported the view that the species is restriced to the Upper Bajocian.

The items "*Phylloceras* div. sp." and "*Phylloceras* sp." in VIGH's faunal list partly refer to this species.

Phylloceras kudernatschi (HAUER, 1854)

Plate 18, fig. 1

Three small and four bigger, incomplete specimens of which the best-preserved is figured here. In spite of the small size, the species is easily recognizable by the fine, dense ribbing. The umbilicus is relatively wide, though this is a feature generally characteristic to most juvenile phylloceratids.

On the basis of the preservation and matrix, the specimens came from both the Upper Bajocian and the Upper Bathonian faunas.

VIGH did not determine the small specimens, but the bigger ones (the biggest speciemen is of 50 mm diameter) were identified and listed as "*Phylloceras* sp. aff. *P. kunthi* NEUM.". The differences between *P. kunthi* and *P. kudernatschi* were discussed recently (GALÁCZ 1980) on the basis of Bakony material.

Adabofoloceras belinskji (BESNOSOV, 1958)

Three fragmentary specimens which show curved ribs arising deep on the flanks and prevailingly very narrow, almost closed umbilicus – features match very well the figures in BESNOSOV 1958 (pl. 7, figs 6–8).

A. beliskji was described from the Upper Bajocian, but it ranges up into the deeper Bathonian (GALÁCZ 1994).

VIGH's original labels refer to the specimens as "*Phylloceras* div. sp.", corrected later as "*Partschiceras* sp." which is more correct, because *Adabofoloceras* was introduced by JOLY (1976) for Middle Jurassic phylloceratids having been regarded formerly as late *Partschiceras* species.

Adabofoloceras cf. *besnosovi* (STURANI, 1971)

Plate 18, fig. 4

Some *Adabofoloceras* specimens showing sharp umbilical edge and weaker ribs are closer to the species described by STURANI (1971, p. 85).

A. besnosovi was recorded from the Upper Bajocian, and the Csóka-hegy specimens are also of this age. The figured specimen was determined previously as *Calliphylloceras* sp., then as *Partschiceras* sp. indet.

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There are some additional, fragmentary, thus indeterminable *Adabofoloceras* specimens in the material. These include the one which was mentioned by VIGH as "*Phylloceras* cf. *subobtusum* KUDERN.".

Calliphylloceras disputabile (ZITTEL, 1868)

Some phylloceratid nuclei with wide umbilicus, big whorl-width and characteristic constrictions could be ranged into this species.

H. disputabile is a typical Mediterranean ammonite with a wide vertical range; the Csóka-hegy specimens came probably from the Upper Bathonian.

The species was also recorded by VIGH, as *Calliphylloceras* sp. aff. *disputabile* ZITT. in his faunal list.

Holcophlylloceras zignodianum (D'ORBIGNY, 1848)

This is a form occurring as tiny nuclei or fragments of bigger specimens in the fauna. The small specimens show the characteristically bent constrictions, the bigger fragments have the same constrictions just as the young forms, while bear additionally the short, dense ventral ribs.

H. zignodianum is an ammonite of extended vertical range (see GALÁCZ 1980, pp. 41–42). The Csóka-hegy specimens came partly from the Upper Bajocian, partly from the Upper Bathonian.

VIGH also recorded this species, citing "*Holcophylloceras mediterraneum* NEUM." and "*Holcophylloceras* sp. (from the *H. mediterraneum* group)", though part of these identified specimens belongs to *Adabofoloceras* (see above).

Ptychophylloceras longarae STURANI, 1971

Pl. 18. fig. 3

This is the most common phylloceratid in the faunas. Several specimens – all of small-sized – can be well matched with STURANI's species (1971, p. 88), which is a form with flat flanks, widely-arched venter and weak constrictions.

All data suggest that *P. longarae* is restricted to the Upper Bajocian. The Csóka-hegy specimens may belong also to this substage.

Some of the *P. longarae* specimens were listed by VIGH as *Phylloceras* sp.

Ptychophylloceras flabellatum (NEUMAYR, 1871)

Only a single, fragmentary specimen represents this species. It shows the specific features: the characteristic cross-section and the traces of the periumbilical constrictions (rosette).

This is a typical Bathonian species, thus the Csóka-hegy specimen came most probably from the Upper Bathonian beds.

The specimen was also identified by VIGH, as "*Phylloceras flabellatum* NEUM".

Ptychophylloceras sp.

Pl. 18, fig. 2

Some phylloceratid nuclei significantly differ from those of the aforementioned two *Ptychophylloceras* species, mainly by their spiral groove in the lower third of the flanks. Their matrix indicates the Upper Bathonian.

These specimens were identified by VIGH partly as "*Phylloceras* cf. *subobtusum* KUDERN.", and partly as "*Calliphylloceras* sp. aff. *disputabile* ZITT.".

Lytoceras adeloides (KUDERNATSCH, 1851)

Pl. 18, figs 5, 6–7

Two, relatively well-preserved inner whorls showing the characteristic thin collars on the shell.

The specimens probably came from the Upper Bathonian, though the species itself ranges from the Upper Bajocian to the Callovian.

VIGH identified the same species also as "*Lytoceras* cf. *adeloides* KUDERN.".

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There are several *Lytoceras* specimens in the material (from the Upper Bajocian also), but these fragmentary, incomplete examples are insufficent for closer determination.

Nannolytoceras polyhelictum (BÖCKH, 1881)

Pl. 18, fig. 10

Five specimens, of which the biggest is figured here. The characteristic oval cross-section and the numerous (i.e. 5) constrictions suggest BÖCKH's species clearly.

This is one of the most characteristic elements of the Transdanubian Central Range Upper Bajocian faunas, which is easy to identify even in fragmentary state.

VIGH did not give any names for these ammonites, but on the basis of his label, the item "*Lytoceras* sp., 4 specimens" in one of his faunal lists may be regarded as a reference to these forms.

Nannolytoceras pygmaeum (D'ORBIGNY, 1845)

Pl. 18, fig. 11

A single specimen which was damaged during the preparation works. It differs from *N. polyhelictum* (BÖCKH) by its smaller size, extremely wide umbilicus, and fewer, narrower constrictions.

N. pygmaeum is a characteristic, but rare Upper Bajocian ammonite. However, it is widely distributed in Mediterranean and NW European localities.

VIGH did not mention it in his faunal lists.

Lissoceras oolithicum (D'ORBIGNY, 1845)
Pl. 18, figs 8–9

Well-preserved, nearly complete specimen. The specific features: rounded flanks, relatively wide umbilicus, and numerous auxiliaries in the surture are well visible.

L. oolithicum is an Upper Bajocian species. This age is also suggested by the matrix of this Csóka-hegy specimen.

VIGH recorded this form also, with the same name.

Oxycerites sp. indet.
Pl. 18, figs 17–18

In the Csóka-hegy material there are several fragmentary *Oxycerites* specimens which are incomplete to be determined properly. A smaller, better-preserved example is figured here. Its narrow whorls, dense outer riblets, well-distinguished, high keel suggest the genus undoubtedly, but closer determination is impossible.

The specimens came from the Upper Bathonian.

The "?*Clydoniceras* sp. indet." name in VIGH's work refers to a tiny ventral part fragment of a bigger *Oxycerites*. All species of *Clydoniceras* show high keel and characteristic ribs which are well visible on the ventrolateral region at this diameter (see e.g. ARKELL 1951–59, pp. 33–34). In lack of these features, the range of this specimen into the genus *Clydoniceras* can be excluded.

Eohecticoceras sp. indet.
Pl. 18, figs 12–13, 14–15

Several small specimens are present with rather incomplete preservation. The two figured, quite similar forms have narrow whorls, no primary ribs but dense, curved secondaries, and low keel, thus show close relations to *Eohecticoceras*. Very similar nuclei were figured by ELMI (1967, pl. 4) from the Upper Bathonian of Ardéche. However, in lack of well-preserved adults, the Csóka-hegy specimens cannot be determined on specific level.

Genus *Eohecticoceras* ranges from the topmost Lower Bathonian to the Upper Bathonian; the Csóka-hegy specimens are probably of Upper Bathonian.

VIGH determined the two here figured specimens as *Delecticeras* (i.e. "*Delecticeras* sp. ex gr. *D. legayi* RIGAUX & SAUVAGE" for that on Pl. 18, figs 14–15, and "*Delecticeras* sp." for that on Pl. 18, figs 12–13). Both identifications are wrong, because the tricarinate-bisulcate venter of *Delecticeras* could be recognised even at smallest diameters and in fragments (see e.g. ARKELL 1951–59, p. 32).

Prohecticoceras retrocostatum (DE GROSSOUVRE, 1888)
Pl. 18, figs 16, 19–21

This is a species with representation by several incomplete specimens in the fauna. The nucleus is shown in figs 19–21, and an adult, but fragmentary specimen in fig. 16 of Pl. 18. The species is well recognizable by the wide, depressed venter, the strong primaries and the dense secondary ribs shown mainly at bigger diameters.

In the former Bathonian zonal scheme (TORRENS 1967) *P. retrocostatum* had important, zonal index value. This role has changed now, because a wider range (from the later Middle Bathonian to the higher Upper Bathonian) have been demonstrated (see TORRENS 1981). However, *P. retrocostatum* is one of the best indicators of the lower part of the Upper Bathonian Oxycerites orbis Zone (see WESTERMANN & CALLOMON, 1988), thus crucial in the age assignment of the Csóka-hegy fauna.

VIGH has identified also the species (the spelling "*recticostatum*" is evidently a minor error). The names *Hecticoceras* sp. and *Hecticoceras* aff. *H. primaevum* DE GROSS. also refer to specimens of *P. retrocostatum*, just as "*Oecotraustes* sp.". This latter name appears only on labels, but was not included into the faunal lists.

Sphaeroceras sp.
Pl. 19, figs 7–10, 11

These small sphaerocone ammonites are rare elements in the Csóka-hegy fauna. An incomplete specimen (Pl. 19, figs 7–10) shows tightly-coiled, depressed phragmocone whorls with dense, bifurcating ribs, and a quarter-whorl of body chamber with excentric coiling. The other specimen (Pl. 19, fig. 11) also preserved the beginning of the body chamber, which shows the rapid contraction better.

Sphaeroceras species are generally more globular than these Csóka-hegy specimens, but STURANI (1971) demonstrated how variable these forms could be in shape and sculpture.

On the basis of the preservation and matrix, the specimens most probably came from the Upper Bajocian, from the Parkinsoni Zone. Genus *Sphaeroceras* is most common in the Humphriesianum and Niortense Zones (see e.g. WESTERMANN 1956), but there are records of species also from the Garantiana and Parkinsoni Zones (see FERNANDEZ LOPEZ 1985, p. 391).

The figured specimens were previously determined by VIGH also as *Sphaeroceras* sp., but he was seemingly uncertain, and did not include that in his faunal lists.

Cadomites (Cadomites) rectelobatus (HAUER, 1857)
Pl. 18, figs 22–23, 24

Several fragmentary specimens, of which the best-preserved ones are figured. These are inner whorls with cross-section more depressed than in the adult forms.

Characteristic are the strong, pointed tubercles and the sharp secondary ribs.

The type of *C. rectelobatus* was described by HAUER (1857) from the basal Middle Jurassic fauna of Swinitza (see GALÁCZ 1994), but the species has an extended vertical range which includes the Upper Bathonian also (GALÁCZ 1980, p. 73).

VIGH has determined the *Cadomites* specimens from Csóka-hegy as *Teloceras*. Disregarding the facts that inner whorls of *Teloceras* are quite different, and the genus is characteristically Bajocian, VIGH cited them as Bathonian in his faunal lists.

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In addition to the well-recognizable *C. rectelobatus* specimens, there are some fragmentary *Cadomites* specimens also from the Bajocian fauna. One of these was identified on its label as "?*Bigotites* sp.", but omitted from the published faunal lists.

?*Cadomites* (?*Polyplectites*) *compressus*
DE GROSSOUVRE, 1930

Pl. 19, figs 18–19

This is a curious ammonite, represented by four fragments, of which the best is figured here. This is a form with medium-wide umbilicus and high-oval cross-section. Its dense ribbing consists of sharp, projected primaries which bi- or trifurcate at various height on the lower part of the flanks. The secondaries are undulating, but generally proverse, and cross the venter without interruption. This sculpture is exactly the same as that on the type (DE GROSSOUVRE 1930, pl. 40, fig. 5), which is a small specimen from Nièvre.

The generic state of this species is controversial. DE GROSSOUVRE (op. cit., p. 374) ranged it into *Cadomites*, but the style of ribbing and the cross-section are quite different. ARKELL (1951–59, p. 231) put it (with question mark) into *Berbericeras*, ROMAN, which is a morphoceratid. TORRENS (1967, p. 592) cited this form as belonging to a "genus of *Berbericeras*-like homoeomorphs". Later (1971, p. 143) he concluded that this is perhaps a *Polyplectites* nucleus.

Most probably this ammonite represents one group of cryptogenetic homoeomorphs which are so misteriously common in the Upper Bathonian Orbis Zone. In the Mecsek Mts (South Hungary) ?*C.* (?*Polyplectites*) *compressus* specimens occur also in the same stratigraphic level (GALÁCZ 1995).

The here figured ammonite was determined by VIGH as *Garantiana*. However, the Upper Bajocian *Garantiana* is a genus with characteristic tubercles and conspicuous ventral furrow, thus quite different.

Parkinsonia sp. indet.

Pl. 18, fig. 25

A single specimen, a body-chamber fragment of a big *Parkinsonia*. Only a portion of the lateral side is preserved, with the characteristic straight, sharp, bifurcate ribs, which suggest the genus even in lack of the distinctive ventral parts. However, with this state of preservation, the species-group cannot be identified either.

The age of the specimen – judged from its matrix – is probably Upper Bajocian.

According to the original label, VIGH also identified the specimen as *Parkinsonia* sp. (determined as of Upper Bajocian), but he did not include it into his published faunal lists.

?"*Dimorphinites*" *nodifer* WENDT 1964

Pl. 19, figs 12–13

A very interesting small ammonite fragment of puzzling affinity. Its inner whorls are globular with simple, strong ribs and a well-visible deep constriction. The preserved body chamber part shows contraction, whorl-section of rectangular shape with wide, lowly-arched venter. The ribbing is bifurcate, ribs are straight, with tubercle-like swellings near the umbilical margin.

The only similar form in the literature is that described and figured by WENDT (1964, p. 134, pl. 21, fig. 5a–c) from the Bathonian of Monte Inici, Sicily. The type of this ammonite, a curious form, has more differentiated tubercles, more numerous outer ribs, but its style of coiling, constrictions and cross-section are rather similar.

WENDT (op. cit.) found his specimen in a bed (MI 1/2) where Bathonian and Callovian ammonites occurred together ("Mischfauna"). At least one figured ammonite [*Oxycerites aspidoides* in WENDT 1964, pl. 13, fig. 2a–b = *Oxycerites orbis* (GIEBEL)] is of Upper Bathonian in this fauna, thus a same age for "*Dimorphinites*" *nodifer* cannot be excluded. The same Upper Bathonian age for the Csóka-hegy specimen is indicated by its preservation and matrix.

"*Morphoceras*" *gignouxi* GILLAUME, 1927

Pl. 19, figs 20–21, 22–23, 26–28

This is one of the most interesting ammonite species of the Csóka-hegy fauna. The best-preserved, adult specimen (Pl. 19, figs 25–28) shows the aperture at 12 mm maximum diameter. It is an almost perfect morphological equivalent of the Lower Bathonian *Ebrayiceras:* it has compressed whorls, strong ventral furrow, dense, swayed, bifurcate and single ribs, and aperture with short lateral lappets. The only difference is that the inner ribs of *Ebrayiceras* are shorter, tubercle-like (see ARKELL 1951–59, pl. 16; MANGOLD 1970b, pl. 7).

The specimens, especially that on Pl. 19, figs 20–21, show very good agreement with "*Morphoceras Gignouxi*" GILLAUME 1927, p. 217, fig. 1). This is a small, lappetted ammonite from the Caillasse inférieur de Marigny (= Morrisiceras morrisi Zone) of Normandy. A forgotten species, not mentioned in any later works on *Morphoceras*/*Ebrayiceras*, which is probably a cryptogenetic homoemorph, one more of those appearing as rare ancillary forms in Middle and Upper Bathonian faunas (see above). Same forms were collected from Sicily (see GALÁCZ 1993), thus a good material is available to describe and name these forms properly in the near future.

These ammonites belong to the Upper Bathonian Orbis Zone fauna of Csóka-hegy. The age of *"M. Gignouxi"* is Morrisi Zone (see ARKELL 1956, p. 48), which is probably the lower part of the range of closely allied forms, because TORRENS (1967, p. 595) cited indirect evidences for appearance of *"Ebrayiceras"* in the Upper Bathonian, together with *Epistrenoceras*.

One of the figured specimens (that on Pl. 19, figs 22–23) was listed by VIGH as *"Garantiana* cf. *ferruginea* OPP.". This is certainly a misidentification, because *Ammonites ferrugineus* OPPEL is a Lower Bathonian *Oraniceras* (see HAHN 1970, p. 25), of which nuclei are quite different, having well-spaced, regularly bifurcating ribs (see e.g. NICOLESCO 1927, pl. 9, figs 4–8).

Unnamed genus and species
Pl. 19, figs 14–15, 16–17

Two poorly preserved specimens of doubtful affinity. The better specimen (Pl. 19, figs 14–15) is a half-whorl of a small ammonite with deep, medium-wide umbilicus, gently convex umbilical side, and wide, arched flanks and venter, giving a semi-circular cross-section. There are weak primaries on the margin, where dense, radial secondaries arise. The primary/secondary ratio is c. 1/2.5. On the preserved portion there is a very strong, narrow constriction which crosses the ribs in morphoceratid style.

There is no similar ammonite in any published Upper Bathonian faunas. All characters suggest *Berbericeras*, but that is a Lower Bathonian genus, of which all previous Middle Bathonian records were corrected later as *Holzbergia*, the microconch counterpart of *Morrisiceras* (TORRENS 1971).

The only similar form is what described and figured by WENDT (1964, p. 133, pl. 21, fig. 4a–b) as *Dimorphinites* cf. *dimorphus* (ORBIGNY) from the Bathonian of Isola di Favignana, off Sicily. This form was excluded form *Dimorphinites dimorphus* by STURANI (1964, p. 26) and GALÁCZ (1980, p. 102) on morphologic grounds, and its Bathonian age is also an argument. The stratigraphic horizon is indicated by WENDT (op. cit., p. 93) as a level with Bathonian "Mischfauna", where Lower Bathonian *Ebrayiceras* and Upper Bathonian *Prohecticoceras retrocostatum* (DE GROSS.) are also recorded. Thus an Upper Bathonian, Orbis Zone age, what is indicated by the preservation of the here figured Csóka-hegy specimen, cannot be excluded.

VIGH determined his specimens as *"Berbericeras* cf. *schwandorfense* KRUMBECK", what was a reasonable solution in the time of the publication (in 1960).

Epistrenoceras sp.
Pl. 19, figs 24, 29–30

Another interesting and valuable ammonite from the Csóka-hegy fauna. The two available specimens are figured. These are tiny, wide-umbilicated forms with smooth inner and ribbed middle whorls which bear larger, pointed, clavus-like tubercles on the ventrolateral edge. Constrictions also appear. The specimen in Pl. 19, fig. 24 shows the body-chamber as becoming smooth and slightly uncoiled.

The only group which seems possible to accomodate these ammonites is genus *Epistrenoceras*. The variability of one of *Epistrenoceras* species, i.e. that of *E. subcontrarium* (BEHRENDSEN) was discussed and figured by DOUVILLÉ (1915, pl. 7). Some of his figures (e.g. figs 16 and 18 in pl. 7) show forms with wide umbilicus and extremely rare ribs, standing very close to these in the Csóka-hegy fauna. This variant was named by DOUVILLÉ as "var. *Termieri* nov.".

If these ammonites were identified rightly, the age assignment of the Upper Bathonian assemblage can be restricted to the Epistrenoceras horizon of the upper part of the Orbis Zone.

These specimens were left unidentified by VIGH, but these are the only forms which may fit the item *"Peltoceras* sp.? (of primitive character)" in his faunal list.

Bullatimorphites (Bullatimorphites) sp.
Pl. 19, figs 1–3, 5–6

There are several nuclei and middle whorls of *Bullatimorphites* in the Csóka-hegy fauna, of which two are figured here. They show wide, rounded whorls and dense, regular ribbing. The umbilicus is wide in smaller forms and becomes narrower with growth, which is a typical *Bullatimorphites* character. However, in lack of complete forms with adult whorls, identification on species level cannot be made.

Genus *Bullatimorphites* ranges from the topmost Lower Bathonian to the Lower Callovian, thus the species belong to the Upper Bathonian fauna of Csóka-hegy.

VIGH did not mention these forms in his faunal lists, but the label of one of the here figured forms (that on Pl. 19, figs 5–6) bears the name *Emileia* sp. as his determination.

Bullatimorphites ("Treptoceras") sp.
Pl. 19, fig. 4

Together with the macroconchiate *Bullatimorphites*, some microconchs also occur. These are characterised by excentric coiling at small diameters and coarse ribbing which appears also at smaller size.

There is no aswer yet to the question what are the proper names of microconch *Bullatimorphites*. For early forms *Sphaeroptychius* LISSAJOUS, 1927 seems appropriate, while *Bomburites* ARKELL, 1952 is a better pair for s.str. *Kheraiceras*. The name *Treptoceras* ENAY, 1959 is preoccupied (see WESTERMANN & CALLOMON 1988), but the group itself contains almost all Middle and Upper Bathonian *Bullatimorphites* microconchs.

VIGH did not determine these specimens.

Parapatoceras distans (BAUGIER & SAUZÉ, 1843)
Pl. 19, fig. 26

This is a single specimen of 6 mm length. A slightly curved portion of a small heteromorph, with projected ribs bearing tiny, pointed tubercles. In spite of the incomplete preservation, the specimen is well comparable to the young stages of the Upper Bathonian *P. distans* figured by DIETL 1978, especially those shown in his fig. 10 of pl. 8. *P. distans* is known to range through the Upper Bathonian and Lower Callovian (DIETL, op. cit., p. 48). Its first appearance is diagnostic, because it is recorded everywhere in the Orbis Zone (in the Julii Horizon, see e.g. TORRENS 1987, p. 107).

The specimen was collected and carefully prepared by VIGH, but eventually it remained unmentioned in his faunal lists.

Procerites (Procerites) sp.
Pl. 19, fig. 28

A well-preserved inner whorls with dense, straight, mostly bifurcate ribs and 2 deep constrictions per whorl. The Bathonian *Procerites*, even in the cases of fully-grown specimens, are not easy to determine, so this single inner phragmocone is difficult to identify on species level.

As a form belonging to the genus *Procerites*, its age is Bathonian, and its matrix supports the Upper Bathonian assignment.

This specimen was the only ammonite from the entire Csóka-hegy fauna which was figured in the cited earlier paper (FÜLÖP et al. 1960, pl. 2, fig. 2). VIGH determined it as *Gracilisphinctes* cf. *fusciacensis* LISSAJOUS sp.

Procerites (Siemiradzkia) sp.
Pl. 18, figs 29–30

A well-preserved, but incomplete specimen. The ribbing, especially the parabolic nodes, and the suture line indicate the subgenus, however specific identification cannot be made.

Subgenus *Siemiradzkia*, as the microconch counterpart of *Procerites*, ranges through the Bathonian, thus the specimen most probably belongs to the Upper Bathonian fauna.

VIGH determined and put the specimen in his faunal list also as *Siemiradzkia* sp.

?Choffatia (Homoeplanulites) pseudoannularis
(LISSAJOUS, 1923)
Pl. 18, fig. 27

This is a well-preserved inner whorls of a widely-umbilicated perisphinctid. Its whorl-section is circular, ribs bifurcate high on the flanks, near the ventrolateral margin, and it has weak constriction. The commonly occurring similar nuclei or innermost whorls of these perisphinctids are traditionally determined as *C. pseudoannularis*. MANGOLD (1970a, pl. 3, fig. 12) figured a specimen with lappetted aperture at 48 mm diameter, thus the species, in fact, is a small form. Of the several figures in the literature (KRYSTYN 1972, pl. 18, figs 2,3; MARCHAND et al. 1990, pl. 1, fig. 6; etc.) the one in SANDOVAL (1983, pl. 50, fig. 3) is the most similar.

The majority of the stratigraphic data on the species in the literature refers to the Upper Bathonian. The matrix of the Csóka-hegy specimen also suggests this age.

According to its label, the specimen was not identified by VIGH.

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Plate 18

Fig. 1: *Phylloceras kudernatschi* (Hauer), Upper Bathonian (1×)
Fig. 2: *Ptychophylloceras* sp., Upper Bathonian (1×)
Fig. 3: *Ptychophylloceras longarae* Sturani, Upper Bajocian (1×)
Fig. 4: *Adabofoloceras* cf. *besnosovi* (Sturani), Upper Bajocian (1×)
Figs 5, 6–7: *Lytoceras adeloides* (Kudernatsch), Upper Bathonian (2×)
Figs 8–9: *Lissoceras oolithicum* (d'Orbigny), Upper Bajocian (1×)
Fig. 10: *Nannolytoceras polyhelictum* (Böckh), Upper Bajocian (1×)
Fig. 11: *Nannolytoceras pygmaeum* (d'Orbigny), Upper Bajocian (1×)
Figs 12–13, 14–15: *Eohecticoceras* sp. indet., Upper Bathonian (2×)
Fig. 16: *Prohecticoceras retrocostatum* (de Grossouvre), Upper Bathonian (2×)
Figs 17–18: *Oxycerites* sp. indet., Upper Bathonian (1×)
Figs 19–21: *Prohecticoceras retrocostatum* (de Grossouvre), Upper Bathonian (2×)
Figs 22–23, 24: *Cadomites (Cadomites) rectelobatus* (Hauer), Upper Bathonian (22–23:1×; 24: 2×)
Fig. 25: *Parkinsonia* sp. indet., Upper Bajocian (1×)
Fig. 26: *Parapatoceras distans* (Baugier & Sauzé), Upper Bathonian (2×)
Fig. 27: ?*Choffatia (Homoeoplanulites) pseudoannularis* (Lissajous), Upper Bathonian (2×)
Fig. 28: *Procerites (Procerites)* sp., Upper Bathonian (2×)
Figs 29–30: *Procerites (Siemiradzkia)* sp., Upper Bathonian (1×)

Plate 19

Figs 1–3: *Bullatimorphites (Bullatimorphites)* sp., Upper Bathonian (2×)
Fig. 4: *Bullatimorphites ("Treptoceras")* sp., Upper Bathonian (2×)
Figs 5–6: *Bullatimorphites (Bullatimorphites)* sp., Upper Bathonian (1×)
Figs 7–10, 11: *Sphaeroceras* sp., Upper Bajocian (2×)
Figs 12–13: ?*"Dimorphinites" nodifer* Wendt, Upper Bathonian (2×)
Figs 14–15, 16–17: unnamed genus and species, Upper Bathonian (2×)
Figs 18–19: ?*Cadomites (?Polyplectites) compressus* de Grossouvre, Upper Bathonian (2×)
Figs 20–21, 22–23: *"Morphoceras" gignouxi* Guillaume, Upper Bathonian (2×)
Fig. 24: *Epistrenoceras* sp., Upper Bathonian (2×)
Figs 25–28: *"Morphoceras" gignouxi* Guillaume, Upper Bathonian (2×)
Figs 29–30: *Epistrenoceras* sp., Upper Bathonian (2×)

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Upper Jurassic ammonites from Seno di Guidaloca (Western Sicily)

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(with 2 figures and Plates 20–22)

Abstract

A sea-shore profile, in the vicinity of the west Sicilian Monte Inici, yielded a moderately rich ammonite assemblage of Kimmeridgian and Tithonian age. The bed-by-bed collected ammonites and the additional specimens coming from the loose blocks, were ranged into 25 taxa. The Upper Kimmeridgian Beckeri Zone, and the Tithonian succession of the Hybonotum, Darwini, Semiforme and Microcanthum and Durangites Zones were recognized. Although these are not new for western Sicily, some of the ammonites were documented for the first time from the region.

Key words: Upper Jurassic, Ammonoidea, Sicily, biostratigraphy

Introduction

During the late 1980s, a joint research project was established between Università di Napoli and Eötvös University, Budapest. In the frame of this cooperation, a short field work was done in 1990 in Sicily, with a special focus on the Upper Jurassic ammonitiferous rocks. Several localities were visited, and one of them, Guidaloca, was sampled bed-by-bed.

Locality and profile

The studied profile is situated in Western Sicily, on the seaside, between the picturesque city of Castellamare del Golfo and the remote village of Scopello (Fig. 1a). This region is the westernmost part of the Palermo Mountains, and the section is located on the foothills of Monte Inici. Paleogeographically, this region belongs to the Trapanese Pelagic Carbonate Platform (CATALANO & D'ARGENIO, 1979, 1981).

First data on the Upper Jurassic ammonite fauna of this area were given by G. G. GEMMELLARO (1872–1882) and M. GEMMELLARO (1922). Because both the Kimmeridgian and Lower Tithonian is in rubbly-weathering, nodular, light colored limestone facies, the papers above contain mixed ammonites of both stages.

More precisely obtained Jurassic cephalopod data of this region were summarized by ARKELL (1954). In this paper important sections of Rocca che Parra, Monte Bonifato, Balata and Monte Inici were figured, and ammonites were collected from several horizons, ranging from Lower Bathonian to Tithonian. Concerning Upper Jurassic, different levels of Oxfordian and Kimmeridgian, including the well documented Beckeri Zone, as well as Lower and Upper Tithonian were recognized.

In the monograph of CHRIST (1960) many Oxfordian ammonites were figured, but there are only a very few data on the Kimmeridgian and Tithonian cephalopods.

The Santa Anna section in southwestern Sicily is the only Upper Jurassic profile where a modern, detailed and complex biostratigraphic study was made (DE WEVER et al. 1986).

The Guidaloca outcrop (Fig. 1a) can be found in a small bay, close to a camping site, where the road gets very close to the shore. Here, in the eastern part of the small bay, the light colored, nodular, well bedded limestone forms vertical cliffs. Ammonites were collected from the wall, as well as from the loose blocks. The simplified aspect of the section, and the position of the bed numbers are indicated on Fig. 1b. Although certain beds were flexuous, and small faults disturbed the profile, the main succession seemed to be clear. Each circa 1 metre of the thinly layered, very nodular limestone was regarded as a separate "bed".

Ammonites were relatively rich especially in the lower part of the profile, and in certain fallen blocks. Megafossils were very rare, or lacking in the cherty rocks below and above the numbered part of the section. The covering white, cherty, platy limestone is of Biancone type. This Lower Cretaceous rocks form impressive cliffs at Cala Bianca, in the vicinity of the Guidaloca Bay.

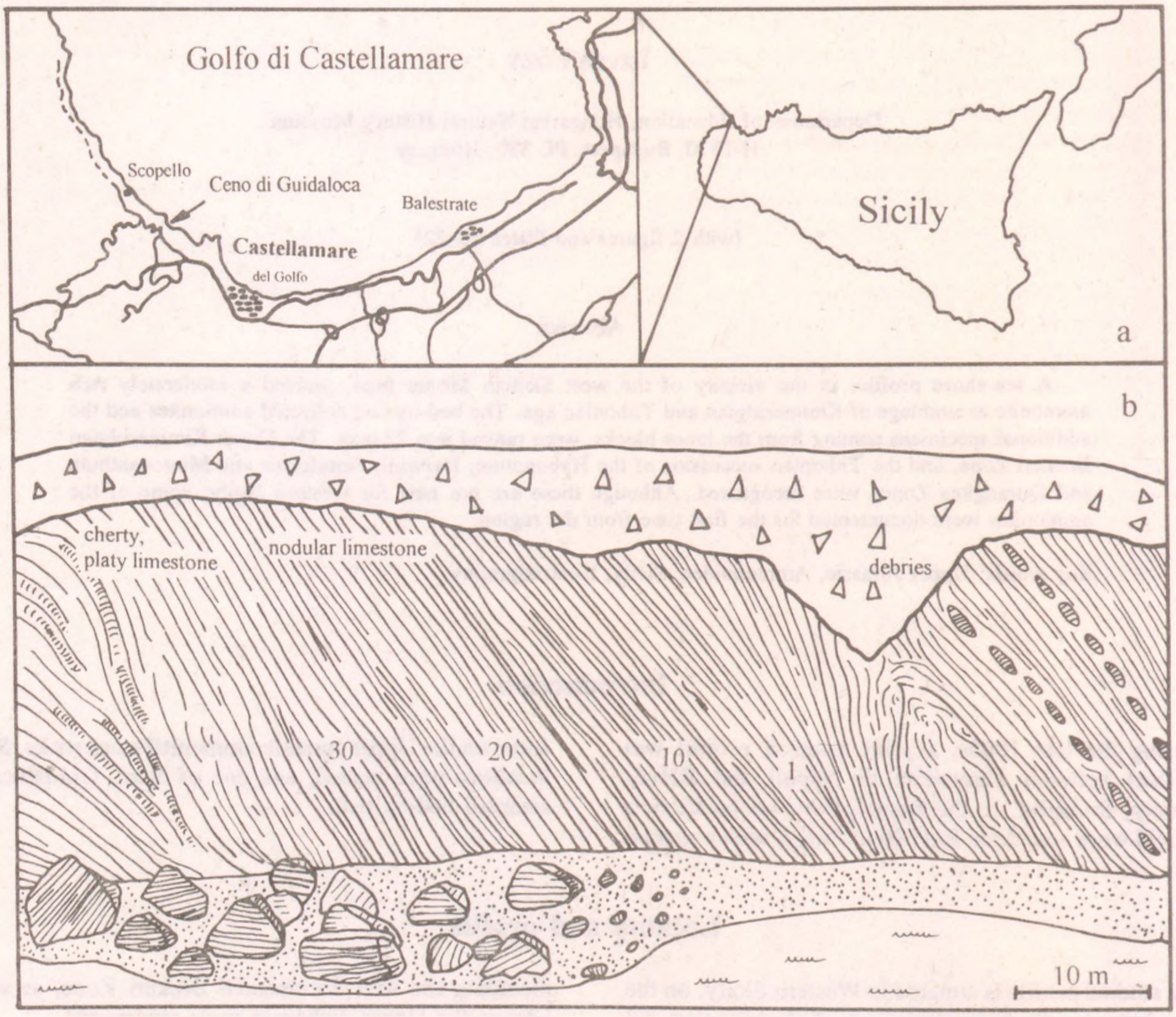

Fig. 1. **a:** Topographic map of Guidaloca. The section is indicated by the asterisk. **b:** A simplified sketch showing the Upper Jurassic rocks and the bed numbering of Guidaloca.

Composition and age of the fauna

Ammonites were the most common megafossils. Beyond the circa 50 collected specimens, only one further pygopid-type brachiopod was found.

Ammonites were moderately well preserved internal moulds, many of them were already a fragment, before the final burial.

The most important ammonites and the biostratigraphic subdivision of the section is given in Fig. 2. The complete faunal list, including ammonites coming from the loose blocks contains the following taxa:

Calliphylloceras kochi (OPPEL)
Holcophylloceras sp.
Ptychophylloceras ptychoicum (QUENSTEDT)
Sowerbyceras sp.
Protetragonites quadrisulcatus (D'ORBIGNY)
Semiformiceras ?darwini (NEUMAYR)
Taramelliceras pugile (NEUMAYR)
Hemihaploceras nobile (OPPEL)
Haploceras elimatum (OPPEL)
Haploceras carachtheis (ZEUSCHNER)
Haploceras verruciferum (ZITTEL)
Haploceras sp.
Schaireria neoburgense (OPPEL)
Aspidoceras sp.
Hybonoticeras cf. *hybonotum* (OPPEL)

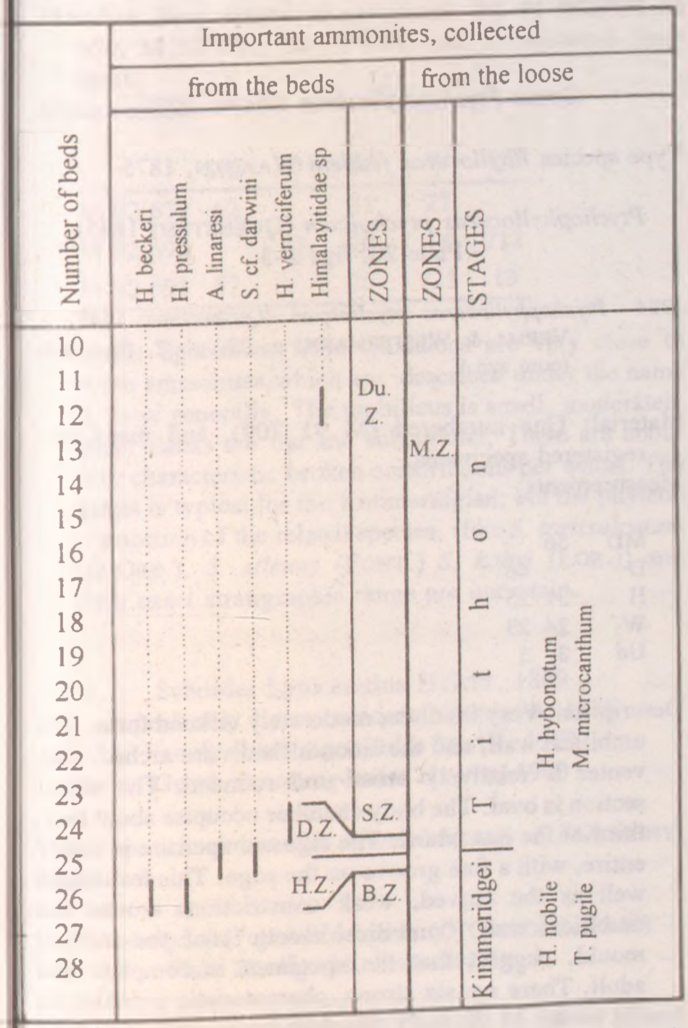

Fig. 2. Simplified stratigraphic column and distribution of important ammonites at Guidaloca. Abbrevations: **B. Z.**: Beckeri Zone, **H. Z.**: Hybonotum Zone, **D. Z.**: Darwini Zone, **S. Z.**: Semiforme Zone, **M. Z.**: Microcanthum Zone, **Du. Z.**: Durangites Zone.

Hybonoticeras beckeri (NEUMAYR)
Hybonoticeras pressulum (NEUMAYR)
Aulasimoceras cf. *linaresi* (OLÓRIZ)
Micracanthoceras microcanthum (OPPEL)
Himalayitidae sp.
Orthosphictes sp.
Discosphinctoides rhodaniforme (OLÓRIZ)
"Subdichotomoceras" sp.
Paraulocosphinctes sp.
Ataxioceratidae div. sp. indet.

Although numerous ammonites were determined on generic level only, and many of the beds yielded no megafossils, the biostratigraphic subdivision of the profile can be drawn. Zonal names refer to ENAY & GEYSSANT (1975).

In the lower part of the section *Sowerbyceras*, ataxioceratids and some taramelliceratids were found, suggesting a fossiliferous Kimmeridgian. Bed 26, yielding *Hybonoticeras beckeri* and *H. pressulum* represents the uppermost Kimmeridgian Beckeri Zone, a level, characteristic for the whole Mediterranean region, and illustrated richly by ARKELL (1954) already in western Sicily. *H.* cf. *hybonotum* showing the presence of the lowermost Tithonian Hybonotum Zone was found in loose blocks only. *Aulasimoceras* cf. *linaresi*, a poorly known ammonite characteristic for the Hybonotum or Darwini Zone(s) was collected from Bed 25. An oppeliid, determined as *Semiformiceras* cf. *darwini*, the index form of Darwini Zone, was collected also from Bed 25. It means that the boundary between the two Lower Tithonian zones can be drawn within the interval, called Bed 25. *Haploceras verruciferum*, an important ammonite, with a maximum frequency in the Semiforme Zone was found in Bed 24. Additional specimens of mainly or exclusively Semiforme Zone ammonites, like *Discosphinctoides rhodaniforme*, *"Subdichotomoceras"* sp., suggest a relatively rich assemblage of this level. Many of the strata above Bed 24 yielded no important ammonites, so the higher zones of the Lower Tithonian remained biostratigraphically undocumented.

The himalayitid found in Bed 12 represents already the uppermost Tithonian Durangites Zone, but *Micracanthoceras microcathum*, the index form of the Microcanthum Zone was also found in loose blocks.

Systematic palaeontology

All the ammonites described are deposited in the Paleontological Department of the Hungarian Natural History Museum, Budapest. Measured and/or illustrated specimens have inventory numbers.

Measurements are given in millimetres, according to the following order: maximal diameter of the specimen (MD), diameter (D), whorl height (H), whorl width (W), and umbilical diameter (Ud). In many specimens, due to the poor state of preservation, measurements are incomplete or missing.

Descriptions are brief, especially in the case of the well-known species. In most cases the synonym list contains the first figuration and some very important recent references only, in order to obtain basic information on the species.

Order Ammonoidea ZITTEL, 1884
Suborder Phylloceratina ARKELL, 1950
Superfamily Phyllocerataceae ZITTEL, 1884

Family Phylloceratidae ZITTEL, 1884
Genus *Calliphylloceras* SPATH, 1927
Type species *Phylloceras disputabile* ZITTEL, 1869

Calliphylloceras kochi (OPPEL, 1865)
Plate 21, fig. 4.

1865 *Ammonites kochi* – OPPEL, p. 550
1984 *Calliphylloceras kochi* (OPPEL) – SARTI, p. 485, pl. 1, figs 2a–b (cum syn.)
1994 *Calliphylloceras kochi* (OPPEL) – ZEISS et al., p. 370, pl. 1, fig. 5.

Material: One moderately well preserved specimen (M 92 696) and some additional, unregistered, strongly corroded fragments.
Measurements

MD	98
H	?58
Ud	?5

Description: Strongly subsolved, medium sized specimen, discoidal is shape. Coiling is very involute, with a minute umbilicus. The oval whorl section is relatively high. The umbilical wall is corroded, the flanks are highly arched with the maximal extension at the upper third part. There are about seven constrictions per whorl, which are straight at first, then moderately prorsiradiate around the venter.
Occurrence: *C. kochi* can be found throughout the whole Tithonian in the Mediterranean region. The specimen described here came from Bed 25, from the lowermost Tithonian.

Genus *Holcophylloceras* SPATH, 1927

Type species *Phylloceras mediterraneum* NEUMAYR, 1871

Holcophylloceras sp.
Plate 21, fig. 6.

Material: One moderately well preserved specimen (M 92 693).
Measurements

MD	74	
D		59
H	39	34
W	15	18
Ud	?9	?8

Description: Incomplete, fragmentary specimen with a small piece of the body chamber. The ammonite is discoidal, very involute. Whorl section is high-oval. There are no ornamentation, only 7 constrictions per whorl on the internal mould. The constrictions are slightly prorsiradiate until the upper third part of the flank, where, after a sharp break, they point backwards.
Occurrence: The specimen, described above, came from the debris, together with typical Kimmeridgian ammonites.

Genus *Ptychophylloceras* SPATH, 1927

Type species *Phylloceras feddeni* WAAGEN, 1875

Ptychophylloceras ptychoicum (QUENSTEDT 1845)
Plate 20, figs 2–3

1984 *Ptychophylloceras ptychoicum* (QUENSTEDT 1845) – VERMA & WESTERMANN, p. 29, pl. 2, fig. 1a–b (cum syn.).

Material: One numbered (M 92 709), and many unregistered specimens.
Measurements

MD	56	
D		46
H	31	25
W	24	23
Ud	3	3

Description: Very involute, moderately inflated form. The umbilical wall, and the smooth flanks are arched. The venter is relatively broad and rounded. The whorl section is oval. The body chamber occupies about two-third of the last whorl. The sigmoid aperture is nearly entire, with a fine groove on the edge. This feature, as well as the curved, weak constrictions around the umbilical wall ("umbilical rosette") of the internal mould, suggest that the specimen is complete and adult. There are six strong, characteristic wrinkles on the venter of the body chamber.
Remarks: The species is easy to recognize because of the distinctive wrinkles on the adult body chamber. It is worth mentioning that only the relatively small (microconchiate) forms were found in Guidaloca. The two, or three times larger macroconhiate forms, abundant in many other localities, were missing in the Sicilian section.
Occurrence: The species is very common throughout the whole Tithonian. It was frequent also in Guidaloca, especially in the lower part of the section. The illustrated specimen was found in Bed 18, in the Lower Tithonian.

Genus *Sowerbyceras* (PARONA & BONARELLI, 1895)

Type species *Ammonites tortisulcatus* D'ORBIGNY, 1849

Sowerbyceras sp.
Plate 20, figs 5–6

Material: Four numbered specimens (M 92 678, M 92 690, M 92 691, M 92 694) and unregistered fragments.

Measurements:

	MD	D	H	W	Ud
M 92 678	62		31	27	
M 92 690		43	20	14	?12
M 92 691	57		25	?21	13

Remarks: Specimens from Guidaloca are very close to those ammonites,which are described under the name *S. loryi* generally. The umbilicus is small, moderately deep, flanks are flat and subparallel. There are about four characteristic broken constrictions per whorl. The genus is typical for the Kimmeridgian, but the phyletic connection of the related species, (like *S. tortisulcatum* (D'ORB.), *S. silenus* (FONT.) *S. kobyi* (LOR.)) and their exact stratigraphic range are uncertain.

Suborder Lytoceratina HYATT, 1889
Superfamily Lytocerataceae NEUMAYR, 1875
Family Protetragonitidae SPATH, 1927
Genus *Protetragonites* HYATT, 1900

Type species *Ammonites quadrisulcatus* (D'ORBIGNY, 1840)

Protetragonites quadrisulcatus (D'ORBIGNY, 1840)
Plate 20, fig. 11, Plate 21, fig. 3.

Material: Two numbered (M 92 710, M 92 711) and additional unregistered specimens.

Measurements

	MD	D	H	W	Ud
M 92 710	84		23		43
		69	18	?19	36
M 92 711	55		16	16	25
		44	15	15	21

Remarks: Coiling is very evolute, the umbilicus is shallow and wide. Whorl section is circular. The straight to slightly curved constrictions are poorly visible on the internal moulds.

Occurrence: This Tithonian to Lower Cretaceous lytoceratid, typical for the Mediterranean region, was common also in Guidaloca. The illustrated specimens came from loose blocks.

Superfamily Haplocerataceae ZITTEL, 1884
Family Oppeliidae DOUVILLÉ, 1890
Genus *Semiformiceras* SPATH, 1925

Type species *Ammonites Fallauxi* OPPEL, 1865

Semiformiceras cf. *darwini* (NEUMAYR, 1873)
Plate 20, fig. 13

1873 *Ammonites darwini* – NEUMAYR, p. 165, pl. 33, fig. 2–4.

1982 *Semiformiceras darwini* (NEUMAYR) – ENAY, p. 118, fig. 3.

1986 *Semiformiceras darwini* (NEUMAYR) – SANTANTONIO, p. 69, pl. 1, fig. 1.

1993 *Semiformiceras* cf. *darwini* (NEUMAYR) – FÓZY, p. 201.

Material: One poorly preserved fragment (M 92 705).

Measurements

MD	57	
D	?33	22
W	?12	8

Description: The subsolved, broken piece of internal mould is built up by a small part of the phragmocone, and by the probable mature body chamber. Very involute form, with a minute umbilicus. Flanks are, however, eroded, subparallel. At the end of the phragmocone, and at the beginning of the body chamber the venter is sharply curved with a calcite keel. The keel is fading towards the aperture, forming a flat, and relatively broad venter, with very week tricarination in the transition. On one side of the specimen, there are weak radial, straight "ridges", altogether three on the half whorl. The species was carefully discussed by ENAY (1982).

Remarks: Related oppeliids *(Neochetoceras mucronatum)* were reported from the lowermost Tithonian (BERCKHEMER & HÖLDER 1959, ZEISS 1968) also. However, these ammonites are smooth, and do not show the characteristic radial ornamentation of the flanks, which are present in *Semiformiceras* in general.

Occurrence: *S. darwini* is the index fossil of the Lower Tithonian Darwini Zone. The Guidaloca specimen was collected from Bed 25, close to Hybonotum Zone elements, thus represents a very early form of the linage.

Genus *Taramelliceras* DEL CAMPANA, 1904

Type species *Ammonites trachinotus* OPPEL, 1863

Taramelliceras pugile (NEUMAYR, 1871)
Plate 21, fig. 2.

1871 *Oppelia pugilis* – NEUMAYR, p. 24.

1873 *Oppelia pugilis* – NEUMAYR, p. 16, pl. 32, fig.1–2.

1978 *Taramelliceras (Taramelliceras) pugile pugile* (NEUMAYR) – OLÓRIZ, p. 94, pl. 7, fig. 2. (cum syn.)

Material: One fragment (M 92 666).

Description: Only a part of the internal mould of a probably adult body chamber. The umbilicus can not be seen. The whorl section is compressed, highly arched. The rounded venter bears very strong clavi above the ventro-lateral shoulder. These nodules continue into faint, blunt ridges on the flank. Between the nodules, just in the median of the shell, there is a third row of tubercles.

Occurrence: This late Kimmeridgian ammonite was collected only from loose blocks at Guidaloca.

Genus *Hemihaploceras* SPATH, 1925

Type species *Oppelia nobilis* NEUMAYR, 1873

Hemihaploceras nobile (NEUMAYR, 1873)

Plate 21, fig. 1.

1873 *Oppelia nobilis* – NEUMAYR, p. 167, pl. 3. fig. 4.
1978 *Hemihaploceras nobile* (NEUMAYR) – OLÓRIZ, p. 117, pl. 7, fig. 5. (cum syn.)

Material: One specimen only (M 92 680).

Measurements

MD	79
H	?32

Description: Medium sized fully grown specimen, with the very characteristic bullae on the ventro-lateral shoulder of the adult body chamber.

Occurrence: This late Kimmeridgian ammonite was collected only from loose blocks at Guidaloca.

Family Haploceratidae ZITTEL, 1884
Genus *Haploceras* ZITTEL, 1868

Type species *Ammonites elimatus* OPPEL, 1865

Haploceras elimatum (OPPEL, 1865)

Plate 20, fig. 9

1865 *Ammonites elimatus* – OPPEL, p. 549.
1986 *Haploceras (Haploceras) carachtheis* (M) (ZEUSCHNER) morphe *elimatum* – ENAY & CECCA, p. 49, pl. 4, fig. 1–5.
1988 *Haploceras (Haploceras) elimatum* (OPP.) – FŐZY, p. 51 (cum syn.).

Material: Two registered specimens (M 92 681, M 92 673) and unregistered fragments.

Measurements

	MD	D	H	W	Ud
M 92 681	44		20	15	?12
M 92 673	57		24	20	?16

Remarks: *Haploceras* is a dimorphic group. According to ENAY & CECCA (1986) the described species is the macroconchiate form of the small and lappet-bearing *carachtheis*-group and can be specify as *Haploceras (Haploceras) carachtheis* (M) (ZEUSCHNER) morphe *elimatum*. In spite of the convincing dimorphism, giving priority to the simplicity, present paper uses the more rigid, but more conventional nomenclature.

Occurrence: The form is very frequent in the Mediterranean region, in the whole Tithonian, especially in the Semiforme - Microcathum Zones. At Guidaloca *H. elimatum* was found in the lower part of the Tithonian.

Haploceras carachtheis (ZEUSCHNER, 1846)

Plate 20, fig. 12.

1846 *Ammonites carachtheis* – ZEUSCHNER, pl. 4, fig. 1.
1986 *Haploceras (Haploceras) carachtheis* (m) (ZEUSCHNER) morphe *carachtheis* – ENAY & CECCA, p. 49, pl. 2, fig. 3, 4, 7, 10, pl. 3, fig. 1–2, 10, 11–16, 18–19.
1988 *Haploceras (Haploceras) carachtheis* (ZEUSCHNER) - FŐZY, p. 59 (cum syn.)

Material: One specimen (M 92 706) only. Fragments of very close, or probably same forms were common at Guidaloca.

Description: The collected specimen is an adult body chamber fragment, with the characteristic folds on the ventral side.

Occurrence: As the microconchiate form of *H. elimatum*, *H. carachtheis* has practically the same distribution in space and time. The illustrated specimen was collected from the Upper Tithonian part of the section, from Bed 20.

Haploceras verruciferum (ZITTEL, 1869)

Plate 20, figs 4, 7

1869 *Ammonites verruciferus* MENEGHINI – ZITTEL, p. 145
1986 *Haploceras (Volanites) verruciferum* (ZITTEL) (m) – ENAY & CECCA, p. 48, pl. 1, fig.
1988 *Haploceras (Hypolissoceras) verruciferum* (ZITTEL, 1869) – FŐZY, p. 63 (cum syn.).

Material: One specimen from the succession (M 92 707) and another (M 92 683) from the loose.

Measurements

	MD	D	H	W	Ud
M 92 707	57		22	16	17
		49	13	11	13

Description: The specimen coming from Bed 24 is a fully grown, nearly entire one. Only the typical "verruca" is broken off, however, its base can be seen. The specimen collected from the loose is the end of an adult body chamber of a small specimen, with the strong ridge on the venter.

Remarks: Details on the priority (MENEGHINI or ZITTEL?) is given in FŐZY (1988). As it was demonstrated by ENAY & CECCA (1986) the species is a microconchiate form. The macroconch was described under the separate name *Haploceras (Haploceras) cassiferum* by FŐZY (1988, p. 57).

Occurrence: The species is a characteristic Lower Tithonian, (mainly Semiforme Zone) element throughout the Mediterranean region. *H. verruciferum* was chosen by OLÓRIZ (1978) as the zonal index of the Verruciferum Zone (equivalent of the Semiforme Zone of ENAY & GEYSSANT 1975). But as it was shown by ENAY & CECCA (1986), the species occurs, however rarely only, below and above the mentioned zone. Specimen from Bed 24, on the basis of size and coiling represents a typical Semiforme Zone form.

Superfamily Perisphinctaceae STEINMANN, 1890
Family Aspidoceratidae ZITTEL, 1895
Genus *Schaireria* CHECCA, 1985

Type species *Aspidoceras avellanum* ZITTEL, 1870

Schaireria neoburgensis (OPPEL, 1863)
Plate 20, fig. 1

1863 *Ammonites neoburgensis* – OPPEL, p. 223, pl. 58, fig. 5.
1985 *Schaireria neoburgensis* (OPPEL) – CHECCA, p. 199, pl. 4, fig. 3–5, pl. 42, fig. 1. (cum syn.)

Material: One specimen (M 92 675) only.

Description: The medium sized ?adult specimen is rather incomplete. The outer whorl is partly broken off, so the globulose inner whorls are well exposed. The umbilicus is very small and deep. Whorls are depressed, without any ornamentation.

Remarks: VIGH (1984, p. 72.) established the new name *Anaspidoceras* for the subgenus of *Physodoceras* HYATT, 1900. CHECCA (1985) gives careful discussion on the species.

Occurrence: The characteristic smooth species is common throughout the Mediterranean Realm in the Lower Tithonian (?Hybonotum – Semiforme Zone). The Guidaloca specimen was found in the debris.

Genus *Aspidoceras* ZITTEL, 1868

Type species *Ammonites rogoznicensis* ZEUSCHNER, 1846

Aspidoceras sp.

Material: One specimen (M 92 667).

Description: Medium sized fragment of a probably immature specimen, with a small part of the phragmocone and with the half whorl of the body chamber. The section is rounded, slightly compressed. Tubercles appear in pairs, forming two rows.

Remark: The subsolved fragment is insufficient for precise determination. On the other hand, there are too many names, with very poor illustrations in the literature. CHECCA's monograph (1985) on the Mediterranean aspidoceratids provides a review, containing only seven distinguished Kimmeridgian *Aspidoceras* s. str. The Guidaloca specimen is very close to *A. longispinum* (SOWERBY) sensu CHECA.

Occurrence: The specimen was collected from the loose blocks, together with Kimmeridgian ammonites.

Genus *Hybonoticeras* BREISTROFFER, 1947

Type species *Ammonites hybonotus* OPPEL, 1863

Hybonoticeras cf. *hybonotum* (OPPEL, 1863)
Plate 22, fig. 7

1863 *Ammonites hybonotus* – OPPEL, p. 254, pl. 71, fig. 1–3.
1959 *Hybonoticeras hybonotum* – BERCKHEMER & HÖLDER, p. 30, pl. 3, fig. 12, pl. 5, figs. 18,19 (cum syn.)

Material: Two fragments (M 92 677, M 92 678).
Measurements

	MD	D	H	W	Ud
M 92 677			20	14	
M 92 678	62		31	27	

Description: The badly preserved phragmocone pieces show the strong rows of tubercles on the umbilical and ventro-lateral edges, connected with faint but wide ribs. The deep ventral furrow exists, but the fine serration on its edges can not be seen.

Remarks: The German material was carefully described by BERCKHEMER & HÖLDER (1959), while OLÓRIZ (1978) listed many new forms, too. All of the extra-European *Hybonoticeras* were discussed by VERMA & WESTERMANN (1984).

Occurrence: The species (and related forms, like *H. ornatum* (SPATH), *H. hildebrandti* (FUTTERER)) are known from Europe, Africa, Madagascar and India. *H. hybonotum* is the zonal index of the lowermost Tithonian Hybonotum Zone. The Guidaloca specimens were found in loose blocks.

Hybonoticeras beckeri (NEUMAYR, 1873)
Plate 22, figs 1, 4–5

1873 *Aspidoceras beckeri* nov. sp. – NEUMAYR, p. 202, pl. 38, fig. 3.

Material: A nearly complete but not adult specimen (M 92 669) and another fragment (M 92 688).

Measurements

	MD	D	H	W	Ud
M 92 669	110		35	14	?49
		91	29	12	40

Description: The shell is medium sized, evolute, the umbilicus is moderately shallow, the umbilical wall is deep. The flanks are subparallel, the ventral groove is bordered by serrated ridges. There are more periumbilical tubercles than ventro-laterals. In some cases the inner tubercles are radial, while the outer appear irregular, forming bullae. Ornamentation is typical for *H. beckeri*, ribbing is dense, irregular, ribs are flexuous, with a very low point of branching.

Occurrence: *H. beckeri* is characteristic for the uppermost Kimmeridgian Beckeri Zone. Specimens from Guidaloca were found in Bed 26 and also in the debris.

Hybonoticeras pressulum (NEUMAYR, 1873)
Plate 22, figs. 6, 8

1873 *Aspidoceras pressulum* nov. sp. – NEUMAYR, p. 201, pl. 37, figs. 2, 3.

1959 *Hybonoticeras pressulum* (NEUMAYR) – BERCKHEMER & HÖLDER, p. 20, pl. 1, fig. 1, pl. 2, figs. 6, 8. (cum syn.)

Material: Two body chamber fragments (M 92 670, M 92 687).

Measurements

	MD	D	H	W	Ud
M 92 670			23	9	
M 92 687		67	21	?19	30

Description: The umbilical wall is vertical, the section is high oval, with maximal width around the umbilical edge. The umbilical row of tubercles contains small, numerous, slightly radial tubercles. The M 92 687 specimen has smooth flanks, like the type, but the other Guidaloca example has weak, curved ribs around the ventro-lateral edge.

Remarks: *H. pressulum*, like most *Hybonoticeras* species, shows a wide range of variability. Many of the forms were formerly described under separate species, or subspecies names. Unfortunately, until now, there are not too much data on the fine biostratigraphic appearance of the very close forms, so the present paper prefers to use not too much names.

Occurrence: The species is very common in Europe, but it was described also from India (Katchch). *H. pressulum* is typical for the uppermost Kimmeridgian Beckeri Zone. One of the specimens from Guidaloca were collected from Bed 26, while the other came from the loose.

Genus *Aulasimoceras* SPATH, 1931

Type species *Waagenia auberti* PERVINQUIÈRE, 1907

Aulasimoceras cf. *linaresi* (OLÓRIZ, 1978)
Plate 22, fig. 3

1978 *Hybonoticeras (Hybopeltoceras) linaresi* – OLÓRIZ, p. 362, pl. 29. fig. 2, pl. 30, figs. 1,2.

Material: One moderately well preserved fragment (M 92 686).

Measurements

H 26
W 22

Description: The specimen is a small part of the phragmocone, and a piece of the body chamber. Coiling is evolute, the umbilical wall is very deep, the flanks are subparallel, the venter is broad, rounded, with wide furrow. Tubercles are distant, appearing in two rows, one above the umbilical edge, and the second on the ventro-lateral shoulder. All tubercles are very strong. The specimen, probably because of the corrosion does not show the robust ribs between the tubercles which is characteristic for the type.

Remarks: *A. linaresi* was described from the Subbetics by OLÓRIZ (1978) under the name *Hybopeltoceras*, on the basis of outer whorls only. According to GEYSSANT (in DE WEVER et al. 1986) *Hybopeltoceras* is the synonym of *Aulasimoceras*, a genus described on the basis of some inner whorls only. In this paper the opinion of GEYSSANT was accepted, although the Guidaloca material contains, again, outer whorls only.

Occurrence: The species was described from the Hybonotum Zone of the Subbeteics. The Guidaloca specimen was found in Bed 25.

Family Himalayitidae SPATH, 1925
Genus *Micracanthoceras* SPATH, 1925

Type species *Ammonites microcanthus* OPPEL, 1865

Micracanthoceras microcanthum (OPPEL, 1865)
Plate 21, fig. 7

1865 *Ammonites microcanthus* – OPPEL, p. 555.

1868 *Ammonites microcanthus* OPPEL – ZITTEL, p. 93, pl. 17, figs. 3–5 (only).

1985 *Micracanthoceras (M.) microcanthum* (OPPEL) – TAVERA, p. 169, pl. 21, figs. 1–4, pl. 22, figs. 1–6. (cum syn.).

Material: One poorly preserved, but probably nearly entire specimen (M 92 685).

Measurements

MD	52
H	14
Ud	28

Description: Small sized, evolute ammonite, with a shallow umbilicus. Cross section is circular, ribs are straight, biplicate, or simple. There are sporadic sharp nodules on certain ribs above the bifurcation points. The ventral side has a strong median groove, bordered by fine swellings of the ribs. The last and crowded suture lines are followed by 3/4 whorl, so the specimen is nearly complete, consequently represents a microconchiate form. The aperture is damaged.

Occurrence: *M. microcanthum* is the index species of the Upper Tithonian Microcanthum Zone (Enay & Geyssant, 1975). According to Tavera (1985) this time interval can be subdivided into the lower Simplisphinctes and to the higher Transitorius Zones. Most of the *M. (M.) microcanthum* specimens in the Subbetics were collected from the Transitorius Zone. The Guidaloca specimen came from the loose blocks.

Himalayitidae sp.
Plate 20, fig. 8

Material: One specimen (M 92 704).
Measurements

H	15
W	14

Description: Small parts of the minute ammonite were dislocated by micro-faults, which made the determination more difficult. The shell is moderately evolute , with a fairly deep umbilicus. Cross section is compressed, the umbilical wall is steep, flanks are subparallel, the venter is rounded, with a shallow groove. Ribbing is built up dominantly by single ribs but there are some biplicate also. Ribs are strongly prorsiradiate, especially on the inner whorls. At about 21 mm diameter the ribs are sharp, and small nodules are formed just below the overlapping next whorl. There are also fine swellings on the venter above certain ribs.

Remark: The specimen is probably related to those forms described by Tavera (1985) under the name *Durangites.*

Occurrence: The specimen came form Bed 12.

Family Ataxioceratidae Buckman, 1921
Genus *Orthosphinctes* Schindewolf, 1925

Type species *Ammonites tiziani* Oppel, 1863

Orthosphictes sp.
Pl. 21, fig. 5

Material: Two specimens (M92 695, M 92 684).
Measurements

	MD	D	H	W	Ud
M 92 684	54		16	?20	24

Description: One of the fragments (M 92 695) is probable an anterior part of an adult body chamber. The whorl section is compressed, flanks are relatively flat. The ribbing is virgatotome, built up by bi- and trifurcating ribs. The other specimen is inner whorls only. It resembles also the Tithonian genus *Lemencia* Donze & Enay, 1961, but it was found together with typical Kimmeridgian ammonites.

Occurrence: Similar forms are known from the Oxfordian – Upper Kimmeridgian interval. The Guidaloca specimen came from the loose material.

Genus *Discosphinctoides* Olóriz, 1978

Type species *Perisphinctes roubyanus* Fontannes, 1879

Discosphinctoides rhodaniforme Olóriz, 1978
Plate 22, fig. 2

1978 *Discosphinctoides (Pseudodiscosphinctes) rhodaniforme* nom. nov. ** *Perisphinctes rhodanicus* Dumortier in del Campana – Olóriz, p. 494, pl. 41, fig. 2.

1990 *Discosphinctoides* cf. *rhodaniforme* Olóriz – Főzy, p. 327, pl. IV, fig. 3.

Material: One specimen (M 92 701).
Measurements

H	16
W	13

Description: Only a half of a whorl was found. The umbilical wall is deep, the umbilical edge is rounded, the flanks slightly curved. The ventral region is arched, the cross section is high oval. Ribbing is built up by dense, straight ribs, crossing the venter without any change. Most of them are bifurcating around the middle of the flanks, however there are also singles.

Remark: The Guidaloca fragment is close to the type, because of its relatively straight ribs. Ribbing is built up by more flexuous ribs in the Bakony specimen (Főzy, 1990).

Occurrence: The species was described by Olóriz (1978) from the Verruciferum Zone of the Lower Tithonian. It was reported also from similar level from Santa Anna section (Sicily) (De Wever et al., 1986), and from the Bakony Mts (Főzy, 1990). The Guidaloca specimen was found in debris together with Tithonian ammonites.

Genus *Subdichotomoceras* SPATH, 1925

Type species *Subdichotomoceras lamplughi* SPATH, 1925

"Subdichotomoceras" sp.

Pl. 20, fig. 14

Material: One specimen (M 92 703) only.

Measurements

MD	66	
D		59
H	?17	?16
Ud	38	33

Description: Rather evolute shell, with a subcircular cross section. Only a small piece of the phragmocone, and the whole body chamber was preserved. Ribbing is biplicate, although singles also appear. Constrictions exist. The small lappet at the aperture is clearly visible.

Remark: *Subdichotomoceras* is a name often reported from the Kimmedgian-Tithonian rocks of Europe, India (Katchch) and Africa. The genus was described on the basis of English ammonites, collected from the Upper Kimmeridge Clay, from a level correlative with Beckeri Zone (COPE, 1978). Later the genus was reported mainly from higher levels of the Mediterranean region. According to OLÓRIZ (1978), the genus is typical for the Lower Tithonian. In the Bakony Mts (FŐZY, 1990) it was common especially in the Semiforme Zone. The problem is that the Kimmeridgian forms are closely related to other biplicate ammonites, like *Katroliceras* (VERMA & WESTERMANN, 1984), while the connection between the Kimmeridgian and Tithonian forms is unclear.

Occurrence: The Guidaloca specimens was collected from the Lower Tithonian, Bed 24.

Genus *Paraulacosphinctes* SCHINDEWOLF, 1925

Type species *Ammonites senex* OPPEL, 1865

Paraulacosphinctes sp.

Pl. 20, fig. 10

Material: One specimen (M 92 701).

Measurements

H	16
W	13

Description: Only a piece of the phragmocone was preserved. The umbilical wall is deep, the flanks are rather flat, the whorl section is compressed, subrectangular. Ribbing is strong and biplicate, with a weak furrow on the venter. The fragment is insufficient for precise determination.

Occurrence: The genus is typical for the uppermost Tithonian. It has a maximum frequency in the upper part of the Microcathum Zone (Transitorius Zone, according to TAVERA, 1985) and in the Durangites Zone. The Guidaloca fragment was collected from the Bed 19.

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Plate 20

Fig. 1. *Schaireria neoburgensis* (OPPEL, 1863), (M 92 675). Phragmocone and crushed body chamber, lateral view. Guidaloca, loose material.

Figs. 2–3. *Ptychophylloceras ptychoicum* (QUENSTEDT 1845), (M 92 709). Adult, microconch shell. Ventral and lateral views. Guidaloca, Bed 18, Tithonian.

Fig. 4. *Haploceras verruciferum* (ZITTEL, 1869), (M 92 683). Fragment of and adult microconch body chamber. Lateral view. Guidaloca, loose material.

Fig. 5. *Sowerbyceras* sp., (M 92 694). Probably adult, nearly complete specimen. Lateral view. Guidaloca, Loose material, Kimmeridgian.

Fig. 6. *Sowerbyceras* sp., (M 92 678). Probably adult, nearly complete specimen. Ventral view. Guidaloca, Bed 28, Upper Kimmeridgian.

Fig. 7. *Haploceras verruciferum* (ZITTEL, 1869), (M 92 707). Adult, microconch, nearly entire specimen. Lateral view. Guidaloca, Bed 24, Lower Tithonian.

Fig. 8. Himalayitidae sp. (M 92 704). Incomplete specimen, with a piece of the body chamber. Lateral view. Guidaloca, Bed 12, Upper Tithonian.

Fig. 9. *Haploceras elimatum* (OPPEL, 1863), (M 92 681). Young, nearly complete macroconch specimen. Lateral view. Guidaloca, loose material.

Fig. 10. *Paraulacosphinctes* sp., (M 92 701). Phragmocone fragment. Lateral view. Guidaloca, Bed 19, Upper Tithonian.

Fig. 11. *Protetragonites quadrisulcatus* (D'ORBIGNY, 1840), (M 92 711). Young specimen, with the part of the body chamber. Lateral view, loose material. Tithonian.

Fig. 12. *Haploceras carachtheis* (ZEUSCHNER 1846), (M 92 706). Fragment of a microconch body chamber. Ventral view. Guidaloca, Bed 20, Tithonian.

Fig. 13. *Semiformiceras* cf. *darwini* (OPPEL, 1863), (M 92 705). Fragment of an adult body camber, with a small part of the end of the phragmocone. Oblique view. Guidaloca, Bed 25, Lower Tithonian.

Fig. 14. *"Subdichotomoceras"* sp. (M 92 703). Adult, microconch shell. Incomplete phragmocone, with a complete body chamber. Entire aperture with lappet. Guidaloca, Bed 24, Lower Tithonian.

All figures in natural size
The little bar marks the beginning of the body chamber

Plate 21

Fig. 1. *Hemihaploceras nobile* (NEUMAYR, 1873), (M 92 680). Adult, nearly complete specimen. Lateral view. Guidaloca, loose material, Kimmeridgian.

Fig. 2. *Taramelliceras pugile* (NEUMAYR, 1871), (M 92 666). Fragment of a probably adult body chamber. Oblique view. Guidaloca, loose material, Kimmeridgian.

Fig. 3. *Protetragonites quadrisulcatus* (D'ORBIGNY, 1840), (M 92 710). Not adult, but nearly complete specimen. Lateral view. Guidaloca, loose material.

Fig. 4. *Calliphylloceras kochi* (OPPEL, 1865), (M 92 696). Immature specimen. Guidaloca, Bed 25, Lower Tithonian.

Fig. 5. *Orthosphinctes* sp. (M 92 684). Inner whorls only. Lateral view. Guidaloca, loose material.

Fig. 6. *Holcophylloceras* sp., (M 92 693). Young specimen, with the fragment of the body chamber. Lateral view. Guidaloca, loose material, Tithonian.

Figs. 7. *Micracanthoceras microcanthum* (OPPEL, 1865), (M 92 685). Young, incomplete phragmocone, with the part of the body chamber. Lateral view. Guidaloca, loose material.

All figures in natural size
The little bar marks the beginning of the body chamber

Plate 22

Fig. 1. *Hybonoticeras beckeri* (NEUMAYR, 1873), (M 92 669). Immature, nearly complete macroconch specimen. Lateral view. Guidaloca, loose material, Upper Kimmeridgian.

Fig. 2. *Discosphinctoides rhodaniforme* (OLÓRIZ, 1978), (M 92 701). Half whorl of a body chamber. Lateral view. Guidaloca, loose material, Tithonian.

Fig. 3. *Aulasimoceras* cf. *linaresi* (OLÓRIZ, 1978), (M 92 686). Piece of the phragmocone, with the part of the body chamber. Lateral view. Guidaloca, Bed 25, lowermost Tithonian.

Fig. 4. *Hybonoticeras beckeri* (NEUMAYR, 1873), (M 92 688). Body chamber fragment. Lateral view. Guidaloca, Bed 26, uppermost Kimmeridgian.

Fig. 5. *Hybonoticeras beckeri* (NEUMAYR, 1873), (M 92 674). Fragment, lateral view. Guidaloca, Bed 26, uppermost Kimmeridgian.

Fig. 6. *Hybonoticeras pressulum* (NEUMAYR, 1873), (M 92 670). Fragment from the loose material. Guidaloca, Upper Kimmeridgian.

Fig. 7. *Hybonoticeras* cf. *hybonotum* (OPPEL, 1863), (M 92 677). Fragment. Oblique view. Guidaloca, loose material, lowermost Tithonian.

Fig. 8. *Hybonoticeras pressulum* (NEUMAYR, 1873), (M 92 687). Body chamber fragment. Guidaloca, Bed 26, uppermost Kimmeridgian.

All figures in natural size
The little bar marks the beginning of the body chamber

Fig. 3 [illegible]

Fig. 4 [illegible]

Fig. 5 [illegible]

Fig. 6 [illegible]

All figures in natural size.
[illegible]

Plate 12

Fig. 1 [illegible]

Fig. 2 [illegible]

Fig. 3 [illegible]

Fig. 4 [illegible]

Fig. 5 [illegible]

Fig. 6 [illegible]

Fig. 7 [illegible]

Fig. 8 [illegible]

All figures in natural size.
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Extinctions and survivals in a Mediterranean Early Jurassic brachiopod fauna (Bakony Mts, Hungary)

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(with 7 figures)

Abstract

Detailed analysis of diversity, turnover and extinction rate has been undertaken for the Pliensbachian brachiopod fauna of the Bakony Mts (Hungary). There is an early peak of diversity in the Ibex Zone, then a steady decline to the Stokesi Zone and a second peak in the Margaritatus Zone. The Early Toarcian crisis is preceded by a rapid fall in the Spinatum Zone. The gradual decline of the Pliensbachian brachiopod fauna is thought to reflect decreasing food supply due to the gradual subsidence of the sea bottom in the Bakony area. The diversity peaks in the Ibex and Margaritatus Zones coincide with episodes of local tectonic movements along fault scarps bordering submarine horsts. These might produce fresh, empty rock surfaces and talus blocks at the foot of the escarpments. This sudden increase in the available rock surfaces greatly enhanced the growth of brachiopod communities. Another factor, possibly related to rejuvenation of tectonic movements, may be the activity of submarine cold seeps carrying nutrients to the starving environment and supporting chemosynthetically based communities.

Key words: Brachiopoda, Early Jurassic, diversity, Bakony, Hungary

Introduction

As the modest descendants of their glorious Paleozoic ancestors, Mesozoic brachiopods passed into the shadow of bivalves in the course of this Era and were forced into the role of a second player in the marine benthonic communities. The end-Triassic and early Toarcian mass extinctions and crises affected them more seriously than the other benthonic groups. Perhaps the Early Jurassic was the last good time for brachiopods, when, in most places, they outnumbered the bivalves and reached really high diversity in the faunal provinces around the Tethys (AGER 1967, VÖRÖS 1993a).

In a compilation on Jurassic brachiopods by ALMÉRAS (1964), the number of brachiopod species per ages increases from the Hettangian (80) to the Pliensbachian (490), falls down to 120 in the Toarcian and never reaches again the high species diversity of the Pliensbachian. A similar, Pliensbachian diversity maximum and a Toarcian "bottleneck" was pointed out by VÖRÖS (1993b) who suggested, that the faunal crisis was caused by the Early Toarcian anoxic event (see JENKYNS 1988). However, the detailed study of the Pliensbachian brachiopod fauna of the Bakony Mts (Hungary) has shown that the "crisis" was preceded by a "prelude": the demise of the extremely rich Pliensbachian fauna was heralded by a gradual decrease of diversity.

Material

Fauna

In previous papers (VÖRÖS 1983, 1993b) I gave comprehensive information (list of species, stratigraphical distribution) on the Pliensbachian brachiopod fauna of the Bakony Mts.

The vast majority of the fauna was collected by the workers of the Hungarian Geological Institute (MÁFI) in the frame of a very ambitious research project in the 60s and early 70s, for gathering reliable information on the Jurassic and Cretaceous stratigraphy of the Bakony Mts. Several dozens of trenches were dug to reveal stratigraphy in soil-covered areas and to collect fossils bed-by-bed. This project was stimulated and controlled by Dr. J. KONDA, former director of the Hungarian Geological Institute. The extremely rich Pliensbachian fauna (mainly ammonoids, but also brachiopods, bivalves and gastropods) was forwarded to the Paleontological Department of the Eötvös University (Budapest) for a detailed study. The ammonoids have been determined and evaluated by Prof. B. GÉCZY who, at the same time, entrusted me with the study of brachiopods.

The brachiopod material consists of more than 6000 specimens. A monograph is planned to give the systematic description of the fauna. In the course of the studies, some of my earlier determinations have been changed, therefore the following species list slightly differs from that published in my earlier papers referred above. Moreover, a few species, collected from detritus or from not well determined stratigraphic horizon, have not been taken into account in the present study. The list of species:

Pisirhynchia pisoides (ZITTEL)
Pisirhynchia retroplicata (ZITTEL)
Pisirhynchia inversa (OPPEL)
Pisirhynchia ? *uhligi* (HAAS)
Pisirhynchia n.sp., aff. *uhligi* (HAAS) A
Pisirhynchia n.sp., aff. *uhligi* (HAAS) B
Pisirhynchia n.sp., aff. *uhligi* (HAAS) C
Kericserella inversaeformis (SCHLOSSER)
Calcirhynchia ? *plicatissima* (QUENSTEDT)
Calcirhynchia ? cf. *fascicostata* (UHLIG)
Cirpa ? *subcostellata* (GEMMELLARO)
Prionorhynchia polyptycha (OPPEL)
Prionorhynchia pseudopolyptycha (BÖCKH)
Prionorhynchia n.sp., aff. *greppini* (OPPEL)
Prionorhynchia ? *flabellum* (GEMMELLARO)
Lokutella palmaeformis (HAAS)
Lokutella liasina (PRINCIPI)
Lokutella kondai VÖRÖS
Pseudogibbirhynchia ? cf. *verrii* (PARONA)
Stolmorhynchia ? *reynesi* (GEMMELLARO)
Stolmorhynchia ? *gemmellaroi* (PARONA)
Stolmorhynchia ? *bulga* (PARONA)
Stolmorhynchia ? n.sp., aff. *bulga* (PARONA)
Apringia paolii (CANAVARI)
Apringia piccininii (ZITTEL)
Apringia mariotti (ZITTEL)
Apringia aptyga (CANAVARI)
Apringia deltoidea (CANAVARI)
Apringia fraudatrix (BÖSE)
Apringia ? *stoppanii* (PARONA)
Apringia ? *altesinuata* (BÖSE)
Apringia ? *atlaeformis* (BÖSE)
Apringia ? cf. *suetii* (HAAS)
Homoeorhynchia acuta (SOWERBY)
Homoeorhynchia ? *lubrica* (UHLIG)
Homoeorhynchia ? *ptinoides* (DI STEFANO)
Gibbirhynchia ? *orsinii* (GEMMELLARO)
Gibbirhynchia ? *sordellii* (PARONA)
Gibbirhynchia ? n.sp., aff. *urkutica* (BÖCKH)
Cuneirhynchia palmata (OPPEL)
Cuneirhynchia cf. *rastuensis* BENIGNI
Piarorhynchia ? *caroli* (GEMMELLARO)
Amphiclinodonta liasina BITTNER
Koninckodonta cf. *waehneri* (BITTNER)
Koninckodonta fuggeri BITTNER
Koninckodonta n.sp., aff. *fuggeri* BITTNER
Koninckodonta ? n.sp., aff. *alfurica* (WANNER)
Liospiriferina alpina (OPPEL)
Liospiriferina cf. *brevirostris* (OPPEL)
Liospiriferina cf. *obtusa* (OPPEL)
Liospiriferina sicula (GEMMELLARO)
Liospiriferina darwini (GEMMELLARO)
Liospiriferina gryphoidea (UHLIG)
Liospiriferina meneghiniana (CANAVARI)
Liospiriferina apenninica (CANAVARI)
Liospiriferina cf. *handeli* (DI STEFANO)
Liospiriferina cf. *globosa* (BÖSE)
Dispiriferina cf. *segregata* (DI STEFANO)
Orthotoma apenninica (CANAVARI)
Orthotoma n.sp., aff. *apenninica* (CANAVARI)
Lobothyris punctata (SOWERBY)
Lobothyris cf. *andleri* (OPPEL)
Rhapidothyris ? n.sp., aff. *beyrichi* (OPPEL)
Viallithyris gozzanensis (PARONA)
Viallithyris ? *delorenzoi* (BÖSE)
Linguithyris aspasia (ZITTEL)
Linguithyris cf. *linguata* (BÖCKH)
Linguithyris cornicolana (CANAVARI)
Securithyris adnethensis (SUESS)
Securithyris filosa (CANAVARI)
Securithyris paronai (CANAVARI)
Papodina bittneri (GEYER)
Hesperithyris renierii (CATULLO)
Hesperithyris cf. *pacheia* (UHLIG)
Hesperithyris ? cf. *costata* (DUBAR)
Hesperithyris ? n.sp., aff. *renierii* (CATULLO)
Lychnothyris rotzoana (SCHAUROTH)
Phymatothyris cerasulum (ZITTEL)
Zeilleria mutabilis (OPPEL)
Zeilleria cf. *waehneri* GEMMELLARO
Zeilleria livingstonei GEMMELLARO
Zeilleria alpina (GEYER)
Zeilleria oenana (BÖSE) ?
Zeilleria bicolor (BÖSE) ?

Zeilleria aquilina (FRANCESCHI)
Antiptychina ? rothpletzi (DI STEFANO)
Antiptychina ? bellunensis (DAL PIAZ)
Antiptychina ? n.sp., aff. *gastaldii* (PARONA)
Aulacothyris ? amygdaloides (CANAVARI)
Aulacothyris ? cf. *fuggeri* (BÖSE)
Aulacothyris ? ballinensis (HAAS)
Bakonyithyris apenninica (ZITTEL)
Bakonyithyris avicula (UHLIG)
Bakonyithyris pedemontana (PARONA)
Bakonyithyris meneghinii (PARONA)
Bakonyithyris ovimontana (BÖSE)
Bakonyithyris ? n.sp., aff. *ovimontana* (BÖSE)
Securina hierlatzica (OPPEL)

Localities

Pliensbachian brachiopods have been found at almost 30 localities in the Bakony Mts. Most of them are indistinct outcrops or not well dated by ammonoids. In the present compilation only 11 sections have been used, mainly those, where the ammonoid biostratigraphy and the zonal subdivision was made by GÉCZY (1971a, 1971b, 1972, 1974, 1976); his zonal scheme is used consequently in the present paper. The location of the sections and outcrops is shown in Fig. 1.

Lithological columns of the sections were published by GÉCZY (1976). The Pliensbachian stage consists of varied, chiefly carbonate, lithologies (Fig. 2) suggesting a dissected submarine bottom topography. Descriptions of these lithologies and paleogeographical interpretations of the differences can be found in KONDA (1970), GALÁCZ & VÖRÖS (1972), VÖRÖS (1974, 1986), VÖRÖS & GALÁCZ (in press) . A summarized description and current interpretation of the main types of Pliensbachian lithologies of the Bakony Mts is as follows:

Red, massive or well-bedded biomicrites with bioclasts encrusted or stained by ferro-manganese oxyde. Condensed sequences with frequent stratigraphic gaps and hardgrounds. Depositional environment: top of submarine highs ("seamounts") or neptunian dykes.

Hierlatz limestones (see VÖRÖS 1991 for details). Usually white to pink biosparites (grainstones). The coquina consists mainly of brachiopod, ammonoid and echinoderm skeletal debris cemented by at least two generations of spar; micrite infiltration form geopetal structures. Depositional environment: flanks or feet of submarine highs, or neptunian dykes.

Variegated crinoidal, spiculitic or cherty limestones (Isztimér Limestone). Found in more or less continuous, relatively thick, allodapic sequences of alternating and interfingering spiculitic biomicrites, crinoidal biosparites and cherty beds. Depositional environment: basin between submarine highs.

Ammonitico rosso limestones. Red, nodular, ammonitic wackestones to mudstones with variable degree of nodularity and clay content. Widespread in continuous sequences, sometimes interfingered with the previous lithology. Depositional environment: pelagic, distal part of basins.

Fig. 2. shows that the sections providing the brachiopod fauna encompass all the main lithologies and depositional environments of the Pliensbachian of the Bakony Mts.This is thought to be a reliable basis for speculations on changes of faunal diversity.

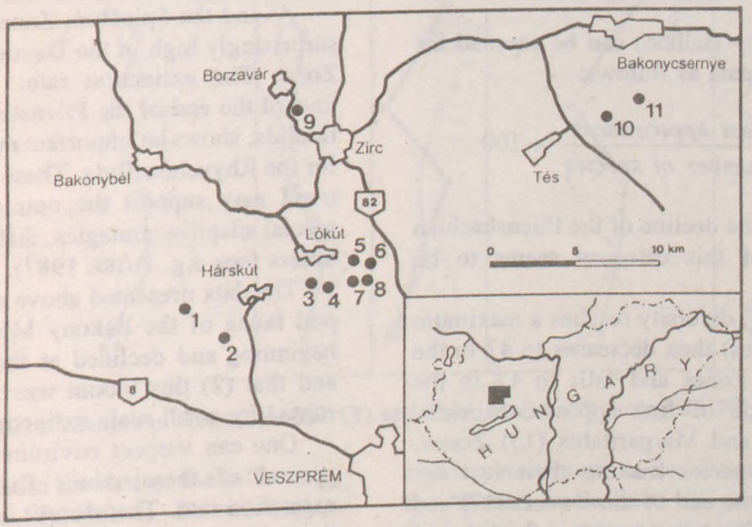

Fig. 1. Map showing the the most important Pliensbachian brachiopod localities of the Bakony Mts.

Diversity changes and faunal turnover

The stratigraphic distribution of the Pliensbachian brachiopod species is given in VÖRÖS (1983), all further data are taken from there. A lot of Pliensbachian species cross the Sinemurian/Pliensbachian boundary, while only one (*Linguithyris aspasia*) survives in the Toarcian (reappears in the Bifrons Zone).

In order to follow the changes of diversity, turnover and extinctions during the Pliensbachian, the method

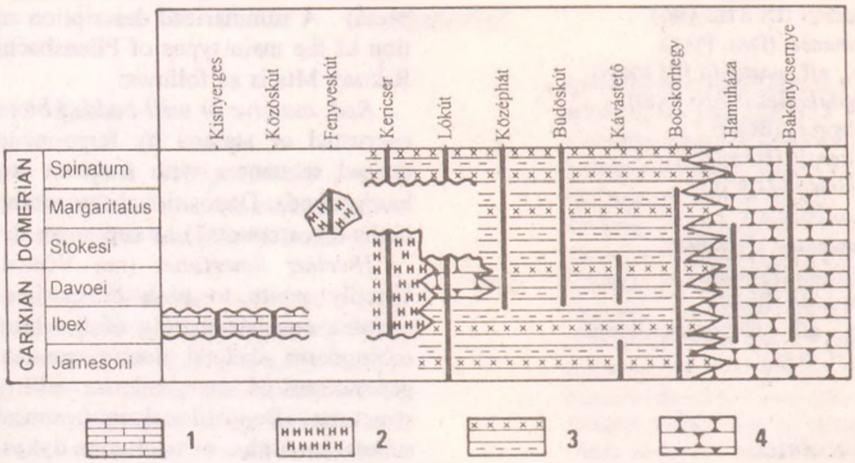

Fig. 2. Chronostratigraphic scheme for the Pliensbachian of the Bakony Mts showing the ranges encompassed by the sections studied. Legend: **1:** massive or well bedded, red biomicrites with manganese coated fossils and hard-grounds, **2:** Hierlatz limestones, **3:** alternation of crinoidal, spiculitic and cherty limestone beds (Isztimér Formation), **4:** Ammonitico Rosso limestones.

developed by HALLAM (1976, 1987) was used in a slightly modified form.

Diversity is expressed here simply by the *number of species* by zones. The categories "*first appearances*" and "*last appearances*" are, in fact, self-explanatory; they are used in the sense of HALLAM (1976, 1987), i.e. they does not necessarily mean origination or extinction on a global scale but refer to the Bakony area. *Turnover rate* is counted for each zone from the above data, as follows:

$$\textit{Turnover rate} = \frac{(\textit{first appearances} + \textit{last appearances})/2}{\textit{number of species}} \times 100$$

Extinction rate (not used by Hallam) can be counted for each zone from the above data as follows:

$$\textit{Extinction rate} = \frac{\textit{last appearances}}{\textit{number of species}} \times 100$$

Since this paper discusses the decline of the Pliensbachian fauna, the introduction of this category seems to be reasonable.

As it is shown in Fig. 3, diversity reaches a maximum in the Ibex Zone (60 species) then decreases to 47 in the Stokesi and Margaritatus Zones and falls to 17 in the Spinatum Zone. The graph of first appearances show maxima in the Ibex (25) and Margaritatus (13) Zones, whereas the number of species making their last appearance is the highest at the end of the Davoei (17) and Margaritatus (30) Zones. The turnover rate is high in the Ibex Zone (34) and after a slight decrease, reaches extremely high value close to the end of the Pliensbachian. The extinction rate is low initially, with a small maximum in the Davoei Zone (at the end of this zone the 30% of the species disappears) and dramatically increases toward the base of the Toarcian.

Similar calculations have been made separately for the three brachiopod orders represented in the fauna. Fig. 4. shows the graphs concerning Rhynchonellida (42 species) and Terebratulida (40 species). The data for Spiriferida (16 species) were not plotted because these fit almost perfectly the trend of Terebratulida.

A simple comparison shows convincingly that the temporal changes of Terebratulida follows very closely those of the whole fauna. On the other hand, rhynchonellids show remarkable deviations. The diversity maximum in the Ibex Zone is not at all so conspicuous, whereas the peak in the Margaritatus Zone is accentuated. The graph of the last appearances has no peak in the Margaritatus Zone but at the end of the Davoei and the Spinatum Zones. The turnover rate is surprisingly high in the Davoei Zone, instead of the Ibex Zone. The extinction rate, which gradually increases toward the end of the Pliensbachian in the case of Terebratulids, shows an important maximum in the Davoei Zone for the Rhynchonellida. These deviations from the general trend may support the opinion that rhynchonellids had special adaptive strategies, different from other brachiopod orders (see e.g. AGER 1987).

The data presented above suggest that (1) the brachiopod fauna of the Bakony Mts became diversified at the beginning and declined at the end of the Pliensbachian, and that (2) this bloom was not uniform but was interrupted by small-scale extinctions and renewals.

One can suspect environmental changes in the background of these minor fluctuations of diversity and extinction rate. Therefore it is reasonable to try to follow these changes in different environmental settings. Four main Pliensbachian paleoenvironments ("seamount top", "seamount slope and foot", "basin margin" and "basin interior") have been differentiated in the Bakony Mts (VÖRÖS 1986). Brachiopod specimen number is insufficient for a detailed study in some of these (e.g. seamount top), therefore in the following, the data set of "seamount slope" will be compared to a cumulative value of the "basin" environments. The "slope" fauna is thought to represent the biotic association of the rocky escarpment of the submarine elevations, while the “basin” fauna reflects the communities of a wider, deep-water, muddy environment. In the present study, the changes of the “slope” fauna were counted from the material of the localities Fenyveskút and Kericser, whereas the graphs of the “basin” fauna are compiled from the data of the following sections: Lókút, Középhát, Büdöskút, Bocskorhegy, Hamuháza, Bakonycsernye (see Fig. 2).

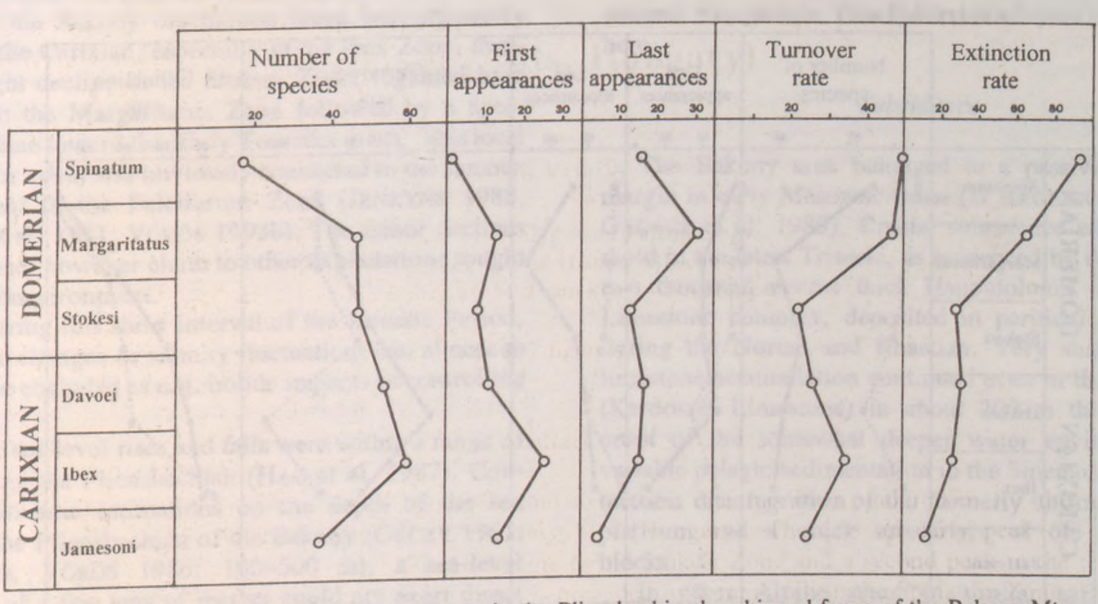

Fig. 3. Graphs showing the temporal changes in the Pliensbachian brachiopod fauna of the Bakony Mts.

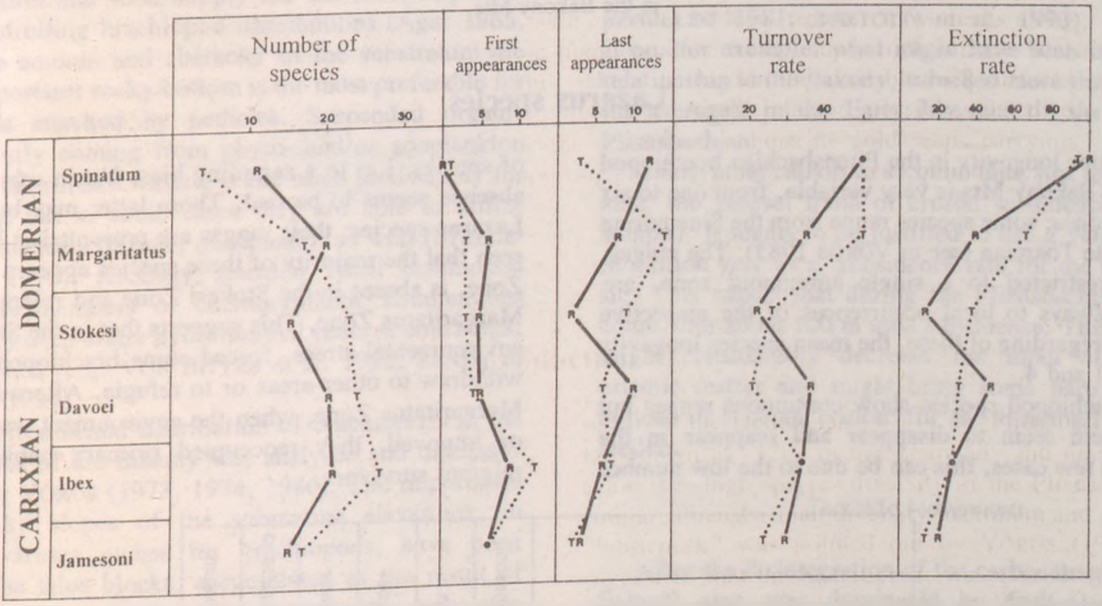

Fig. 4. Graphs showing the temporal changes in Rhynchonellida (R) and Terebratulida (T) during the Pliensbachian of the Bakony Mts.

The “slope” fauna is about ten times more abundant than the “basin” fauna (around 4000, and 300 specimens, respectively) and the diversity (i.e. the number of species) shows similar difference (Fig. 5). The temporal changes are remarkable: the “slope” fauna is very diverse in the Carixian, then, after a minimum in the Stokesi Zone, reaches a maximum in the Margaritatus Zone. On the other hand, the low diversity “basin” fauna shows a striking maximum in the Davoei Zone.The deviation of the “basin” fauna from the general trends in the Davoei Zone can be seen on the other graphs as well. This involves a drastical increase of the extinction rate at the boundary of the Davoei/Stokesi zones which considerably predates the decline of the “slope” fauna.

The “slope” fauna shows almost perfectly the same temporal changes as the bulk Pliensbachian fauna (cf. Fig. 3); these together, can be interpreted as reflecting regional changes of the environment. The end-Pliensbachian decline is evident, the Ibex and Margaritatus Zones may be highlighted for their diversity maxima, whereas the Stokesi Zone appears as a slight minimum. The early increase in the extinction rate graph of the "basin" fauna may suggest that the processes causing the decline of the Pliensbachian brachiopod communities of the Bakony started earlier in the basins than on the submarine elevations.

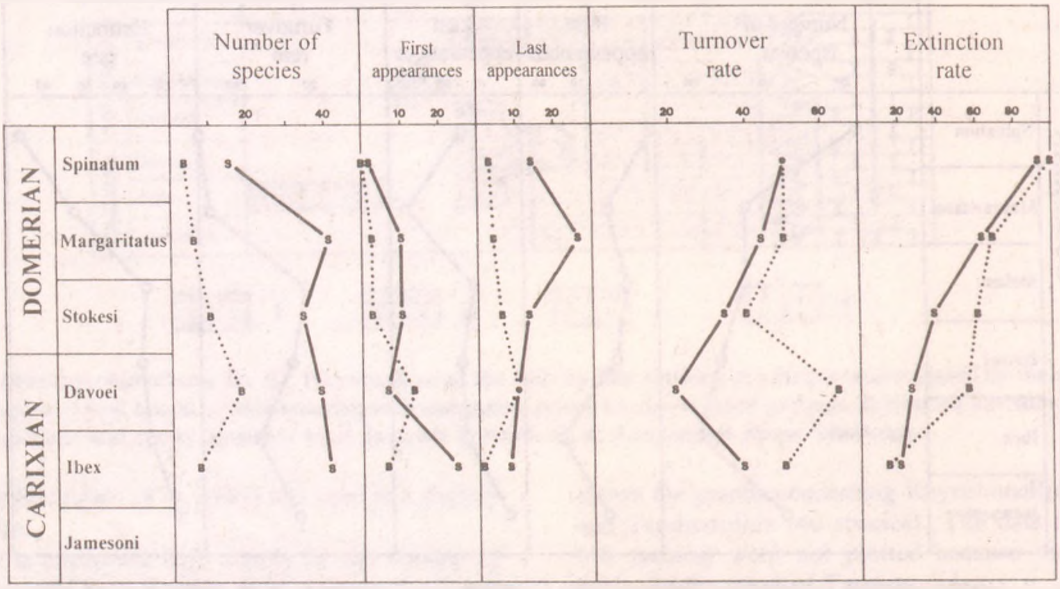

Fig. 5. Graphs showing the temporal changes of the "slope" (S) and "basin" (B) brachiopod fauna during the Pliensbachian in the Bakony Mts.

Lazarus species

The species longevity in the Pliensbachian brachiopod fauna of the Bakony Mts is very variable, from one to six ammonoid zones; some species range from the Sinemurian or even to the Toarcian (see in VÖRÖS 1983). The ranges, seemingly restricted to a single ammonoid zone, are connected always to local occurrences of the respective species. Disregarding of these, the mean species longevity is between 3 and 4.

Most brachiopod species show continuous ranges but some of them seem to disappear and reappear in the record. In a few cases, this can be due to the low number of species, i.e. to a sampling bias, but in other cases the absence seems to be real. These latter may be termed as Lazarus species; their ranges are presented in Fig. 6. It is seen that the majority of these species appears in the Ibex Zone, is absent in the Stokesi Zone and re-appears in the Margaritatus Zone. This suggests that in the Stokesi Zone environmental stress forced some brachiopod species to withdraw to other areas or to refugia. Afterwards, in the Margaritatus Zone, when the environment was stabilized or impoved, they reoccupied primary habitats as immigrant survivors.

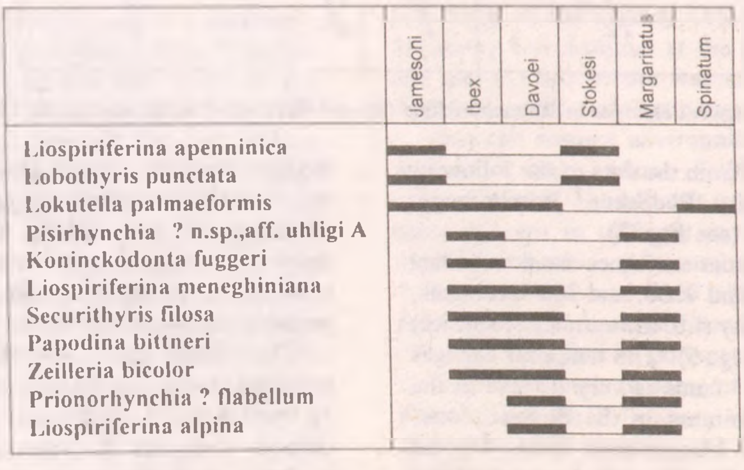

Fig. 6. Range chart of the "Lazarus species" of the Pliensbachian brachiopod fauna of the Bakony Mts.

Discussion

Summarizing the data sets presented above, it can be stated that the Bakony brachiopod fauna was extremely diverse in the Carixian, especially in the Ibex Zone, then, after a slight decline in the Stokesi Zone, regained high diversity in the Margaritatus Zone followed by a spectacular delcine toward the Early Toarcian crash. This local extinction or crisis was obviously connected to the famous anoxic event in the Falciferum Zone (JENKYNS 1988, JENKYNS et al. 1991, VÖRÖS 1993b). The minor declines and recoveries however claim to other explanations sought in the paleoenvironment.

Considering this short interval of the Jurassic Period, temperature changes or salinity fluctuations can almost as definitely be ecxluded as e.g. bolide impacts as controlling factors.

Eustatic sea-level rises and falls were within a range of 40 m during the Pliensbachian (HAQ et al. 1987). Considering authentic estimations on the depth of the sea bottom in the Pliensbachian of the Bakony (GÉCZY 1961: 100–150 m; VÖRÖS 1986: 100–500 m), a sea-level fluctuation of a few tens of meters could not exert direct control on the benthonic communities.

Substratum and food supply are the most important factors controlling brachiopod distributions (Ager 1965, 1967). The amount and character of the substratum are equally important; rocky bottom is the most preferable for brachiopods attached by pedicles. Suspended organic matter, mostly coming from phyto- and/or zooplankton floating in the surface waters, is the basic food supply for brachiopods but in some cases they are able to utilize inorganic nutrients (nitrate, phosphate), as well (STEELE-PETROVIĆ 1976). Recently, peculiar fossil brachiopod associations, members of chemosynthetic communities supported by deep-water hydrothermal vents or cold seeps, were described (e.g. VON BITTER et al. 1992, SANDY & CAMPBELL 1994).

The environmental distribution of brachiopods in the Pliensbachian of the Bakony was analysed and discussed in length by VÖRÖS (1973, 1974, 1986). The importance of the rocky slopes of the submarine elevations, in providing various niches for brachiopods, have been stressed. The talus blocks, accumulated as the result of rockfalls at the feet of the rocky escarpments, were also important sites for brachiopod colonization, because the blocks protruded above the otherwise muddy bottom (VÖRÖS 1991).

The supply of suspended food might have been uniform in the surface waters within the area, but because of the microbial decomposition during the slow fall of organic matter, the net input was much lower at the bottom of the deeper, basinal areas. Consequently, food supply and therefore diversity decreased with increasing depth (VÖRÖS 1973, 1986).

Considering the above principles, VÖRÖS (1993b) concluded that the changes of the Jurassic brachiopod fauna of the Bakony have been controlled mainly by local factors, i.e. the gradual subsidence and the episodic tectonic movements. This opinion is adopted and improved here.

Subsidence

The Bakony area belonged to a passive continental margin in early Mesozoic times (D'ARGENIO et al. 1980, GALÁCZ et al. 1985). Crustal subsidence was extremely rapid in the latest Triassic, as evidenced by the more than two thousand metres thick Hauptdolomit + Dachstein Limestone complex, deposited in peritidal environment during the Norian and Rhaetian. Very shallow marine limestone accumulation continued even in the Hettangian (Kardosrét Limestone) in about 200 m thickness. The onset of the somewhat deeper water environment and variable pelagic sedimentation in the Sinemurian indicates tectonic disintegration of the formerly uniform carbonate platform and a quick subsidence of the downfaulted blocks.

In other Alpine areas of similar early Mesozoic evolution, continuing subsidence has been postulated for the Jurassic (GARRISON & FISCHER 1969, WINTERER & BOSELLINI 1981, BERTOTTI et al. 1993). The Trento Zone, for example, what might have been in the closest relationship to the Bakony, subsided more than 400 m (on the average), in the Early Jurassic, till the end of the Pliensbachian.

There is no reason to suppose that, just in the Bakony area, the general trend of crustal subsidence have been stopped. It seems to be justified to use a value of 10–15 m/million year as a subsidence rate for the Early Jurassic. This means that during the Pliensbachian, we may count with about 100 m total subsidence. This subsidence might considerably decrease the input of suspended organic matter and might bring some parts of the sea bottom to a depth critical for the benthonic suspension feeders.

Tectonic movements

After the disintegration of the carbonate platform, the Bakony area was dominated by fault-scarp bounded submarine horsts and an intervening basin system. Steep rocky escarpments and rock avalanches (scarp breccias) were resulted by repeated tectonic movements along the fault zones bordering the horsts (VÖRÖS 1986, GALÁCZ 1988). The major tectonic movements have been evidenced by the opening phases of neptunian dykes and the deposition of scarp breccias (talus blocks); these episodes have been dated biostratigraphically (see GALÁCZ 1988, VÖRÖS 1993b). Two of them occurred in the Pliensbachian: (1) in the Ibex Zone, and (2) in the Margaritatus Zone. Looking back to the previous chapter (Figs. 3–5), the close correlation between the phases of tectonic movements and the peaks of brachiopod diversity is clear.

One very important aspect of this relationship, notably, the role of tectonic movements in providing hard substratum for brachiopods was discussed above (and in details by VÖRÖS 1986). In longer, tectonically quiet periods, the basinal areas surrounding the submarine horsts were characterized by more or less uniform muddy or sandy, calcareous sediments, unfavourable for brachiopod colonization. The rejuvenation of tectonic movements produced fresh, empty rock surfaces and triggered rock avalanches, spreading talus blocks around the escarpments. This sudden increase in the available rock surfaces greatly enhanced the growth of brachiopod communities (Fig. 7).

Another factor, possibly related to rejuvenation of tectonic movements, may be the activity of submarine cold seeps carrying nutrients to the starving environment and supporting chemosynthetically based communities. Chemosynthesis, as a possible base of higher life communities is a recent discovery of marine research and the methods of its recognition in the fossil record are not well developed. The detailed discussion of this subject and its possible application to the Early Jurassic of the Bakony might be the scope of another paper; here the "cold seep hypothesis" is used only as a theoretical possibility.

The cold seep related interpretation of many "unusual" Mesozoic brachiopod occurrences was put forward by SANDY (1993). In the Tithonian case described in detail (SANDY & CAMPBELL 1994) the source of the seeping fluids was the overpressured accretionary prism along a fossil subduction zone. In the present case, we may use the modern Florida escarpment as a better analogy. Here, oversaturated, dense brines are the inherent part of the hydrodynamic system of the Florida platform. These brines (rich in methane, ammonia and sulphides) flow outwards and discharge at the foot of the escarpment or sometimes on terraces above the escarpment base. Especially methane is metabolized by bacteria and this carbon source is used by dense communities of bivalves and tubeworms. At the same time, the environment is supersaturated for calcium carbonate which results in very rapid precipitation and cementation (PAULL & NEUMANN, 1987, PAULL et al. 1991, 1992, CHANTON et al. 1991).

Obviously, the analogy between the Florida escarpment and the Bakony "seamounts" is far from being perfect. Especially, the huge platform seems to be missing in the background of the Bakony, though, if the close paleogeographic vicinity to the Trento Platform is accepted, the necessary hydrodynamic system might work. Bivalves and tube worms are not especially frequent in the Pliensbachian fossil communities of the Bakony. A possible evidence for the cold seep activity along the fault scarps is the enormous amount of carbonate cement, producing the early lithification of Hierlatz limestones, the origin of which was not at all understood previously (see VÖRÖS 1991). Further positive evidence is expected from studies on stable isotopes of carbon and oxygen.

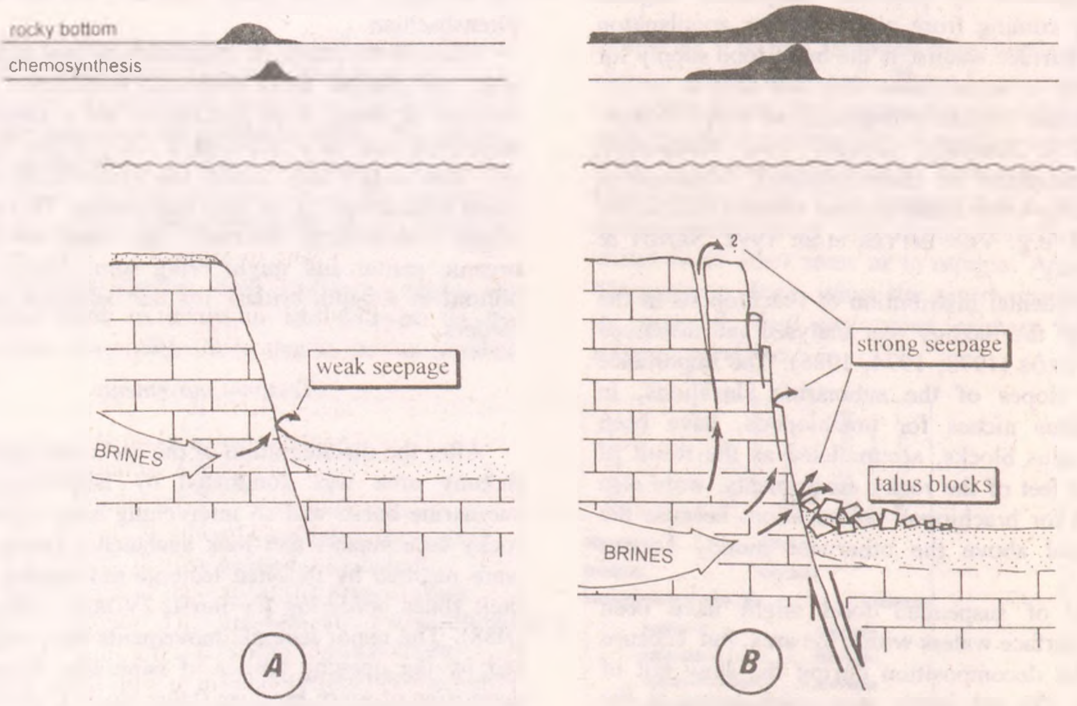

Fig. 7. Cartoon showing the environmental changes caused by rejuvenation of tectonic movements along the fault-scarps bordering the submarine horsts in the Pliensbachian of the Bakony Mts. **A**: tectonically quiet period, **B**: shortly after rejuvenation of faulting. The area of rocky bottom, favourable for attachment and colonization for brachiopods, is greatly increased after tectonic movements. Chemosynthesis, as a possible food supply, is also enhanced by tectonic movements, because fault planes, fractures and fissures might serve as conduits for the nutrient-rich brines seeping out of the submerged platform.

If cold seeps worked along the fault zones bordering the submarine horsts of the Bakony area in Pliensbachian times, their activity was probably increased in episodes of tectonic rejuvenation because the fault planes, and the resulted fissures and fractures might serve as conduits for fluid movements (Fig. 7). The increase in the amount of nutrients and chemosynthetic bacteria might produce an excess of food supply even in the deeper areas.

Acknowledgements

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Bajocian ostracods from the Som Hill (Bakony Mts, Hungary)

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(with 2 figures and Plates 23–24)

Abstract

The fauna from a bed-parallel infilling consists of 13 ostracod species and subspecies. Six of them are new: *Cardobairdia compacta* n. sp., *Bairdia (Akidobairdia) delicata* n. sp., *Bairdia retifera* n. sp., *Ptychobairdia ovata* n. sp., *Pontocyprella aureola gracile* n. ssp., *Pontocyprella cavataformis oblonga* n. ssp. The total absence of Cytheridae and the *Bairdia–Cardobairdia–Pontocyprella–Paracypris* association indicate a deep-water environment. Two Myodocopid forms are dominant in the beds No. 1–2. and decreasing in the beds No. 3, 4 and 6. These forms perhaps were inhabitants of sea-mounts and their decrease indicate the submersion of the sea-mount.

Key words: Middle Jurassic, bajocian, Ostracoda, Bakony, Hungary, new species

Introduction

A big bed-parallel infilling is known in the Liassic Kardosrét Limestone formation of the Som Hill (Bakony Mts, NW-Hungary). Their macrofauna and the geological condition of the section are published in GALÁCZ, 1975, 1985, SZABÓ 1979–1983, and WENDT 1971. The elaboration of the microfauna especially the ostracods have been financially supported by the OTKA project No. T 4431 of J. SZABÓ.

Geology

The Som Hill (Fig. 1) consists of mainly Upper Triassic and Lower Liassic limestones (Dachstein and Kardosrét Limestone Formations) with a lot of infilled fissures. There is a big bed-parallel infilling (about 180 cm) with 6 beds of red-brownish limestone (Fig. 2). It has a rich ammonite-fauna, beds 1–3 belong to the zone Humphresianum, beds 4–6 to the Niortense Zone (Bajocian) (GALÁCZ, 1978).

About 0.5 kg limestone was dissolved from each layer by concentrated acetic acid. There was an investigable ostracod material in rocks exept of bed 5 (from beds 1 and 2 we had a joint material).

The specimen number from beds 1–2 was 204, from bed 3: 211, from bed 4: 175 and from bed 6: 53, altogether 643.

Systematical part

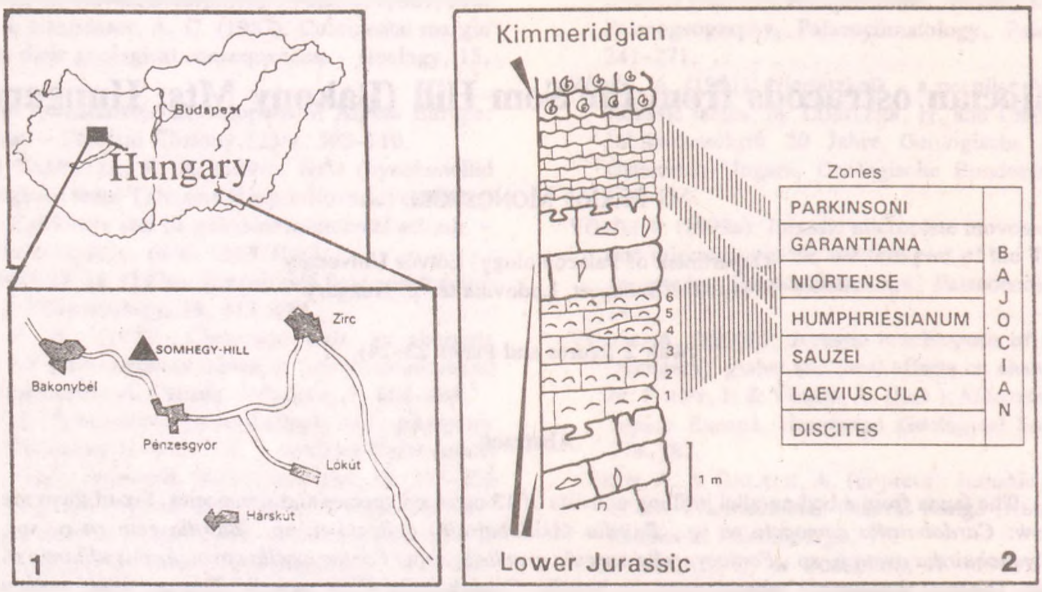
Ostracoda LATREILLE, 1806 classis
Myodocopida SARS, 1866 ordo
Halocypriformis SKOGSBERG, 1920 subordo
Thaumatocyprididae G. W. MÜLLER, 1906 family
Thaumatocypris G. W. MÜLLER, 1906 genus

Thaumatocypris sp.
Pl. 23. fig. 1.

Remarks: Fragmented specimens with circular shape, characteristic for the Jurassic form ornamentation and posterodorsal blund spine.

Dimensions: L> 0.63 mm

Material: 3 fragments from bed 3.



Figs. 1-2. 1. The Som Hill locality. 2. The Bajocian section of the Som Hill. 1-6. The beds of the fissure fill.

Cladocopa SARS, 1866 subordo
Polycopidae SARS, 1866 familia
Polycope G. O. SARS, 1866 genus

Polycope sp.
Pl. 23. fig. 2.

Remarks: Circular form without ornamentation, named by auct. as *P. pelta*. The difficulties of the interpretations are treated in HARLOFF (1933).

Dimensions: L = 0.39–0.51 mm, H = 0.35–0.43 mm, L/H = 1.11–1.19

Material: 68 carapaces from beds 1–2, 3, 4, 6.

Myodocopid form gen. et sp. indet.

Remarks: Nearly spherical outline with a little anterior beak. All other features are unknown, even the genus is not detrminable.

Dimensions: L = 0.23–0.35 mm, H = 0.19–0.30 mm, L/H = 1.14–1.30.

Material: 158 carapaces from beds 1–2, 3, 4.

Podocopida G. W. MÜLLER, 1894 ordo
Metacopa SYLVESTER-BRADLEY, 1967 subordo
Saipanettidae MCKENZIE, 1968 familia
Cardobairdia VAN DEN BOLD, 1960 genus

Cardobairdia inflata spinosa MONOSTORI, 1995
Pl. 23. figs. 3–5.

1995 *Cardobairdia inflata spinosa* n. ssp. – MONOSTORI, p. 159, Pl. 2. f. 4.

Description: the anterior outline is narrowly and asymmetrically arched, it turn gradually into the hardly and asymmetrically arched dorsal outline. After breaking the posterior outline of the left valve nearly straight and goes at 60° angles to the line of length. At 1/3 height it turns abruptly into the slightly and symmetrically arched ventral outline. The posterior part of right valve is much narrower and reaches beyond the left valve at the mid height. The ventral outline sometimes is hardly arched. The left valve somewhat overlaps the right one, except of the caudal part.

Remarks: There is a better material in this locality than in the type locality. Some of the specimens are more elongated.

Dimensions L = 0.61–0.76 mm, H = 0.30–0.36 mm, L/H = 1,74–2.13.

Material: 48 carapaces from beds 1–2, 3, 4, 6.

Cardobairdia compacta n. sp.
Pl. 23. fig. 6.

Derivatio nominis: after its stubby form.

Locus typicus: Som Hill, Bakony Mts.

Stratum typicum: Bajocian, Humphresianum Zone, Bed 1–2.

Description: The anterior outline of the left valves is nearly symmetrically rounded. It turns after a break into the hardly convex dorsal outline at 1/4 of the length. After a break, at 9/10 length the posterior outline is narrowly and somewhat asymmetrically rounded. The ventral outline gradually turns into the symmetrically rounded ventral outline. The dorsal outline of the right valve is somewhat sinuous, the posterior outline is angular with a break in the middle, the ventral outline nearly straight. The left valve

overlap the ritht one throughout, the ventral overlap is very strong. Maximum height at about mid-length.
Comparison: the species is stubby similarly to *C. liassica* (DREXLER, 1958), but the outline is very different.
Dimensions: L = 0.65 mm, H = 0.44 mm, L/H = 1.48.
Material: 47 carapaces from beds 1–2, 3, 4, 6.

Podocopa SARS, 1866, subordo
Bairdiacea SARS, 1866, superfamilia
Bairdiidae SARS, 1888 familia
Bairdia MCCOY, 1844 genus

Bairdia (Akidobairdia) delicata n. sp.
Pl. 23. fig. 7.

Derivatio nominis: after its graceful form.
Locus typicus: Som Hill, Bakony Mts.
Stratum typicum: Bajocian, Niortense Zone bed 4.
Description: The anterior outline of the left valve is very asymmetrically rounded. After a very angular break it turns into the nearly symmetrical dorsal outline beeing anteriorly and posteriorly somewhat concave, in the median part slightly convex. The posterior outline is asymmetrical, very narrow, somewhat acute upwards. The ventral outline is nearly straight, its median part gently convex. Height at the midlength. The dorsal outline of the right valve is more angular.
Comparison: The species is less acute both anteriorly and posteriorly than *B. (A.) farinacciae* OERTLI, 1967.
Dimensions: L = 1.08 mm, H = 0.40 mm, L/H = 2.70
Material: 2 carapaces from bed 4.

Bairdia (Akidobairdia) n. sp. 1
Pl. 23. fig. 8.

Remarks: Incopletely preserved form. It is anteriorly less asymmetrical, dorsally more asymmetrical, the anterodorsal and posterodorsal parts are hardly concave, the posterior end is acute near the level of the ventral outline. Its form definitely differs from that of *B. (A.) delicata*.
Dimensions: L = 0.95 mm, H = 0.37 mm, L/H = 2.57.
Material: 2 carapaces from beds 1–2, 6.

Bairdia hilda JONES, 1884
Pl. 23, figs 9–11.

1884 *Bairdia hilda* n. sp. – JONES, p. 771, Pl. 34. f. 20.
1888 *Bairdia fullonica* n. sp. – JONES & SHERBORN, p. 253, Pl. 5. f. 4a–c.
1963 *Bairdia hilda* JONES, 1884 – BATE, pp. 188–189. Pl. 2., f. 9–12., Pl. 3. f. 1–4.
1969 *Bairdia hilda* JONES, 1884 – BATE, p. 383., Pl. 1., f. 5–6.
1969 *Bairdia hilda* JONES, 1884 – BATE, pp. 397–398., Pl. 4., f. 5–6.
?1978 *Bairdia hilda* JONES, 1884 – PIATKOVA & PERMIAKOVA, p. 124., Pl. 45., f. 6.
1983 *Bairdia hilda* JONES, 1884 – MORRIS, Pl. IV. f. 11–14.
1995 *Bairdia hilda* JONES, 1884 – MONOSTORI, p. 160., Pl. 2., f. 8., Pl. 3., f. 1–2.

Remarks: Most frequent are the elongated forms resembling the type figure. The slope of the posterodorsal part of outline is less abrupt, the upward directed posterior end is more acute in comparison to the Bathonian elongated forms of the Mecsek Mts (MONOSTORI, 1995).
Dimensions: L = 0.69–0.76 mm, H = 0.34–0.42 mm, L/H = 1.81–2.03.
Material: 63 carapaces from beds 1–2, 3, 4, 6.

Bairdia cf. *caudifera* MONOSTORI, 1995
Pl. 23, figs 12–13.

Remarks: Fragmented specimens. The asymmetrical and somewhat angular anterior outline, the abrupt and straight posterodorsal outline turning into the upward directed strong caudal process, the short straight ventral outline are similar to the Bathonian type form from Mecsek Mts. (MONOSTORI, 1995).
Dimensions: L = 0.68–0.92 mm, H = 0.55 mm, W = 0.33, L/H = 1.67.
Material: 7 carapaces from beds 3, 4.

Bairdia retifera n. sp.
Pl. 23. fig. 14.

Derivatio nominis: A part of the surface has a strong network-like ornamentation.
Locus typicus: Som Hill, Bakony Mts.
Stratum typicum: Bajocian, Humphresianum Zone, beds 1–2.
Description: The anterior outline of the left valve is somewhat asymmetrically rounded. The dorsal outline is highly rounded. After a break at 0.8 length the posterodorsal outline is straight and abrupt. The posterior outline is a short and pointed caudal process at about 1/3 height. The ventral outline somewhat sinuous. The dorsal outline of the right valve is more trapezoidal, its median part straight. The posterior half of the right valve bear a strong reticulation.
Comparison: There is no reticulated Jurassic form with similar outline.
Dimensions: L = 0.65 mm, H = 0.40 mm, L/H = 1.63.
Material: 48 carapaces from beds 1–2, 3, 4, 6.

Bairdia div. sp.

Remarks: incompletely preserved specimens of different species.
Material: 5 carapaces from beds 1–2, 6.

Ptychobairdia ovata n. sp.

Pl. 23. figs 15–16.

Derivatio nominis: it has a nearly oval outline.
Locul typicus: Som Hill, Bakony Mts.
Stratum typicum: Bajocian, Niortense Zone, bed 6.
Description: The anterior outline of the left valve is broadly and somewhat asymmetrically rounded, its lower part has larger radius. It turns continuously into the broadly and symmetrically rounded dorsal outline. The posterior outline is nearly symmetrically rounded, it is narrower than the anterior one. The ventral outline is hardly convex. The right valve is more angular dorsally, where there is a distinct overlap. There is a characteristic anterior-anteroventral and posterior-posteroventral ridge near the margins accompanied by depression. The ventrolateral part is swollen.
Comparison: it differs from all Jurassic *Ptychobairdias* with its shape and ornamentation.
Dimensions: L = 0.60–0.87 mm, H = 0.41–0.60 mm, L/H = 1.45–1.46.
Material: 8 carapaces from beds 1–2, 3, 4, 6.

Cypridacea Sars, 1866 superfamilia
Pontocyprididae G. W. Müller familia
Pontocyprella Ljubimova, 1955

Pontocyprella aureola aureola Ljubimova, 1955

Pl. 24. figs 1–2.

1955 *Pontocyprella aureola* n. sp. – Ljubimova, p. 20, Pl. I. f. 2.
1974 *Pontocyprella* cf. *aureola* Ljubimova, 1955 – Dépeche, p. 224, Pl. 3., f. 1–7.
?1978 *Pontocyprella aureola* Ljubimova, 1955 – Piatkova & Permiakova, p. 127, Pl. 47., f. 7.

Remarks: This form is somewhat less pointed posteriorly, similarly to Dépeche's form. The figured specimen of Piatkova & Permiakova (1978) is obviously incomplete.
Dimensions: L = 0.82–0.87 mm, H = 0.41–0.42 mm, L/H = 1.95–2.12.
Material: 29 carapaces from beds 1–2, 3, 4, 6.

Pontocyprella aureola gracile n. ssp.

Pl. 24. fig. 3.

Derivatio nominis: after its narrow shape.
Locus typicus: Som Hill, Bakony Mts.
Stratum typicum: Bajocian, Niortense Zone, bed 4.
Comparison: Very elongated form. The run of the outlines are similar to that in the nominate subspecies. The posterior end is more acute, the overlap is slighter.
Dimensions: L = 0.95 mm, H = 0.37 mm, L/H = 2.57.
Material: 11 carapaces from beds 3, 4.

Pontocyprella cavataformis oblonga n. ssp.

Pl. 24. figs 4–5.

Derivatio nominis: from its elongated form as compared to that of the nominate subspecies.
Locus typicus: Som Hill, Bakony Mts.
Stratum typicum: Bajocian, Humphresianum Zone, bed 1–2.
Comparison: it is more elongated as the nominate subspecies (Monostori, 1995), the overlap is slight as compared to the nominat subspecies.
Dimensions: L = 0.60–0.69 mm, H = 0.33–0.36 mm, L/H = 1.82–1.92.
Material: 29 carapaces from beds 1–2, 3, 4, 6.

"Pontocyprella suprajurassica Oertli, 1959" sensu Morris, 1983

Pl. 24. figs 6–7.

1983 *Pontocyprella suprajurassica* Oertli, 1959 – Morris, Pl. 4., f. 20–22.
1995 *Pontocyprella*? sp. – Monostori, pp. , Pl. 4. f. 2.

Remarks: similar to Bathonian form from the Mecsek Mts.
Dimensions: L = 0.51–0.80 mm, H = 0.27–0.39 mm, L/H = 1.92–2.05.
Material: 17 carapaces from beds 1–2, 3, 4.

Candonidae Kufmann, 1900 familia
Paracypridinae Sars, 1923, subfamilia
Paracypris Sars, 1866

Paracypris redcarensis (Blake, 1876)

Pl. 24. figs 8–9.

1959 *Paracypris redcarensis* (Tate & Blake, 1876) – Apostolescu, p. 806., Pl. II., f. 32.
1975 *Paracypris*? *redcarensis* (Blake, 1876) – Michelsen, pp. 134–135, Pl. 4., f. 48–49.
1980 *Paracypris*? *redcarensis* (Blake, 1876) – Sivhed, p. 43., Pl. III., f. 23, 26, 28.
1982 *Paracypris*? *redcarensis* (Blake, 1876) – Herrig, p. 239., Pl. f. 10.
1985 *Paracypris liassica* (Bate & Coleman, 1975) – Riegraf, p. 77., Pl. 2., f. 10.
1993 *Paracypris*? *redcarensis* (Blake, 1876) – Harloff, pp. 70–73, Pl. 3., f. 5, 13.
1994 *Paracypris*? *redcarensis* (Blake, 1876) – Harloff & Jager, p. 26., Pl. 7., f. 13.

Remarks: These Bajocian specimens are very similar to elongated Liassic specimens (Sivhed, 1980, Harloff, 1993). the *P. liassica* (Bate & Coleman, 1975) in Riegraf (1985) is not similar to the type figures, it belongs to the species *redcarensis*. The Bajocian specimens represent the elongated variants of the species.

Dimensions: H = 0.25 mm, L = 0.55–0.57 mm, L/H = 2.20–2.28.

Material: 66 carapacaes in beds 1–2, 3, 4, 6.

Paracypris obanyensis MONOSTORI, 1995
Pl. 24. figs 10–12.

Remarks: There is a slight variation in the shape of the dorsal outline.

Dimensions: L = 0.63–0.98 mm, H = 0.32–0.50 mm, L/H = 1.96–2.08.

Material: 28 carapaces from beds 1–2, 3, 4, 6.

Cypridae gen. et sp. indet.

Remarks: Some badly preserved forms.

Material: 4 carapaces from beds 3, 4.

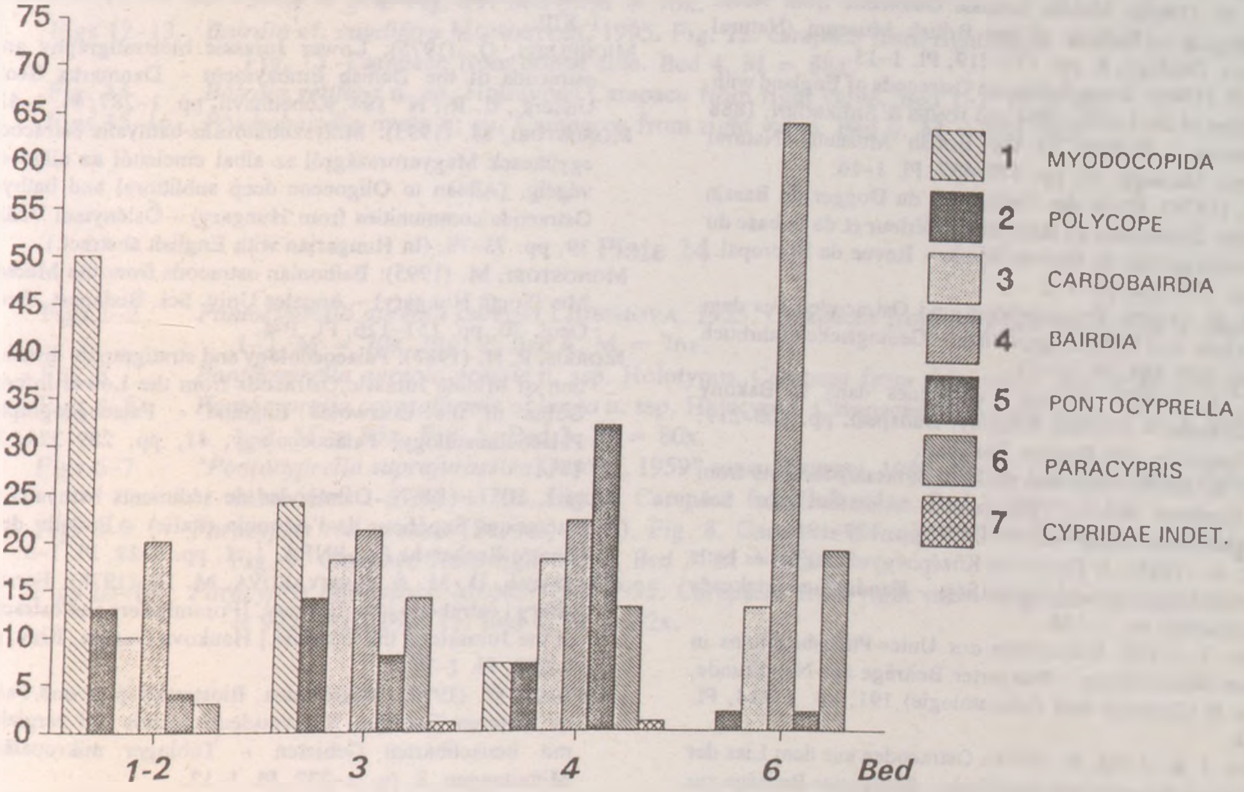


Fig. 3. Statistical distribution of the ostracod genera in the beds of the fissure fill.

Conclusions

The faunal list includes 13 species and subspecies, 6 of them are new. The known species are typical forms in the epicontinental Bajocian and Bathonian except *Paracypris redcarensis* which is a well known epicontinental Liassic form. A part of the ostracods are determinable only on generic or even on family level.

Palaeoecology

Basic character of the fauna is the total abscence of the Cytheridae dominating the epicontinental ostracoda faunas. There is no characteristically shallow-shelf form in the associations. The genera *Cardobairdia* and *Pontocyprella* are common forms in the bathyal ostracod communities of Hungary up to the Paleogene (MONOSTORI, 1993, 1995). Studying the statistical distribution of the genera in the beds we can see some distinct differences (Fig. 3). Most characteristic is the gradual decrease of the percentage of Myodocopida indet. and *Polycope*. There are similar infilled fissures in the Liassic limestones of Úrkút (Bakony Mts.) also with many *Polycope* in the ostracod fauna. The indeterminable Myodocopid genera and the *Polycope* obviously were inhabitants of the sea-mount territories, where the fissures have been formed. Their decreasing percentage may indicate the submerging of the sea-mount. Apart from the Myodocopids, the *Bairdia* is the most frequent among the other forms, also always significant is the *Cardobairdia*. The percentage of the *Pontocyprella* is very variable, perhaps its spatial and temporal distribution was more scattered. The rare *Ptychobairdia* is a form characteristic in the Triassic for the submerging sea-mount or near-platform territories (Monostori, 1995).

Four taxa of 13 are common faunas in epicontinental Jurassic, and this indicate a permanent connection between the deeper epicontinental and Tethyan ostracod faunas. There are 6 common forms with the Bathonian fauna of the Mecsek Mts, which was a transitional region between the Tethys and the epicontinental seas.

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Plate 23

Fig. 1	*Thaumatocypris* sp. Lateral view of carapace fragment. Bed 3. M = 63x.
Fig. 2	*Polycope* sp. Lateral wiew of carapace. Bed 3. M = 103x.
Figs 3–5	*Cardobairdia inflata spinosa* MONOSTORI, 1995. Carapaces from right valve. Fig. 3. Bed 1–2. M = 86x. Fig. 4–5. Bed 4. M = 70x, 80x.
Fig 6	*Cardobairdia compacta* n. sp. Holotypus. Carapace from right valve. Bed 1–2. M = 80x.
Fig. 7	*Bairdia (Akidobairdia) delicata* n. sp. Holotypus. Carapace from left valve. Bed 4. M = 52x.
Fig. 8	*Bairdia (Akidobairdia)* n. sp. 1. Carapace from right valve. Bed 1–2. M = 63x.
Figs 9–11	*Bairdia hilda* JONES, 1884. Carapaces from right valve. Fig. 9. Bed 4. M = 87x. Fig. 10. Bed 3. M = 87x. Fig. 11. Bed 6. M = 76x.
Figs 12–13	*Bairdia* cf. *caudifera* MONOSTORI, 1995. Fig. 12. carapace from right valve. Bed 4. M = 60x. Fig. 13. Carapace from dorsal side. Bed 4. M = 88x.
Fig. 14	*Bairdia retifera* n. sp. Holotypus Carapace from right valve. Bed 1–2. M = 82x.
Figs 15–16	*Ptychobairdia ovata* n. sp. Carapaces from right valve. Bed 6. M = 92x, 60x.

Plate 24

Figs 1–2	*Pontocyprella aureola aureola* LJUBIMOVA, 1955. Carapaces from the right valve. Fig. 1. Bed 1–2. M = 70x. Fig. 2. Bed 4. M = 76x.
Fig. 3	*Pontocyprella aureola gracile* n. ssp. Holotypus. Carapace from right valve. Bed 4. M = 60x.
Figs 4–5	*Pontocyprella cavataformis oblonga* n. ssp. Holotypus. Carapaces from right valve. Fig. 4. Bed 1–2. M = 95x. Fig. 5. Bed 3. M = 80x.
Figs 6–7	"*Pontocyprella suprajurassica* OERTLI, 1959" sensu MORRIS, 1983. Fig. 6. Carapace from right valve. Bed 1–2. M = 70x. Fig. 7. Carapace from left valve. Bed 3. M = 112x.
Figs 8–9	*Paracypris redcarensis* (BLAKE, 1876). Fig. 8. Carapace from left valve. Bed 3. M = 100x. Fig. 9. Carapace from right valve. Bed 3. M = 100x.
Figs 10–12	*Paracypris obanyensis* MONOSTORI, 1995. Carapaces from right valve. Figs 10–12. Bed 3. M = 92x, 70x. Fig. 11. Bed 4. M = 62x.

Plates

Plate 1


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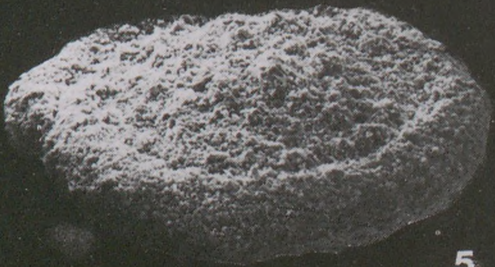
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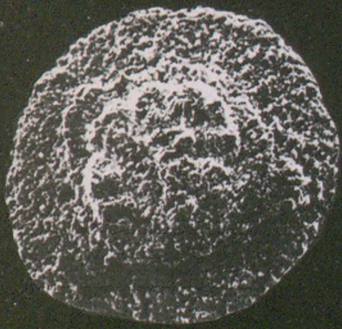
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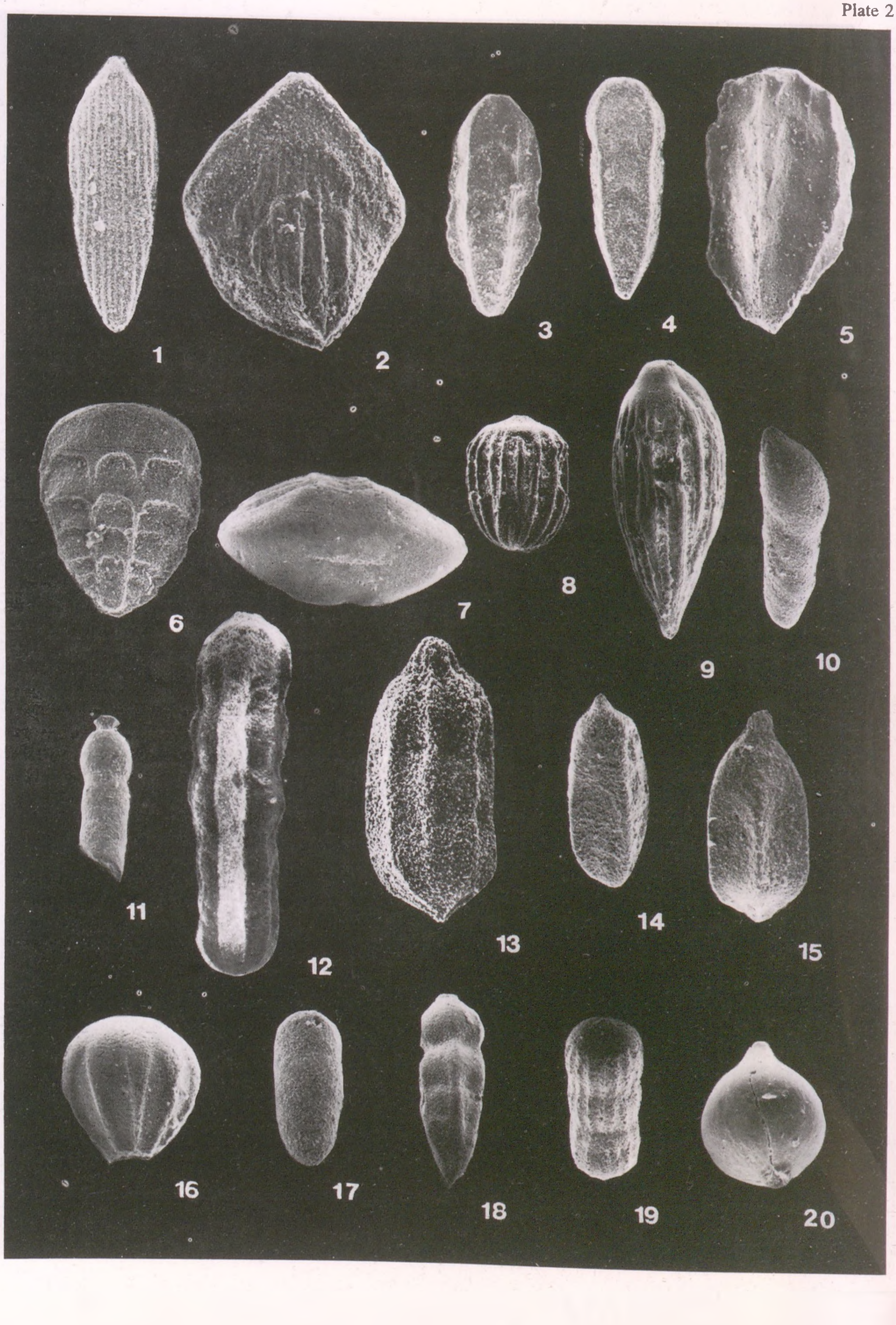

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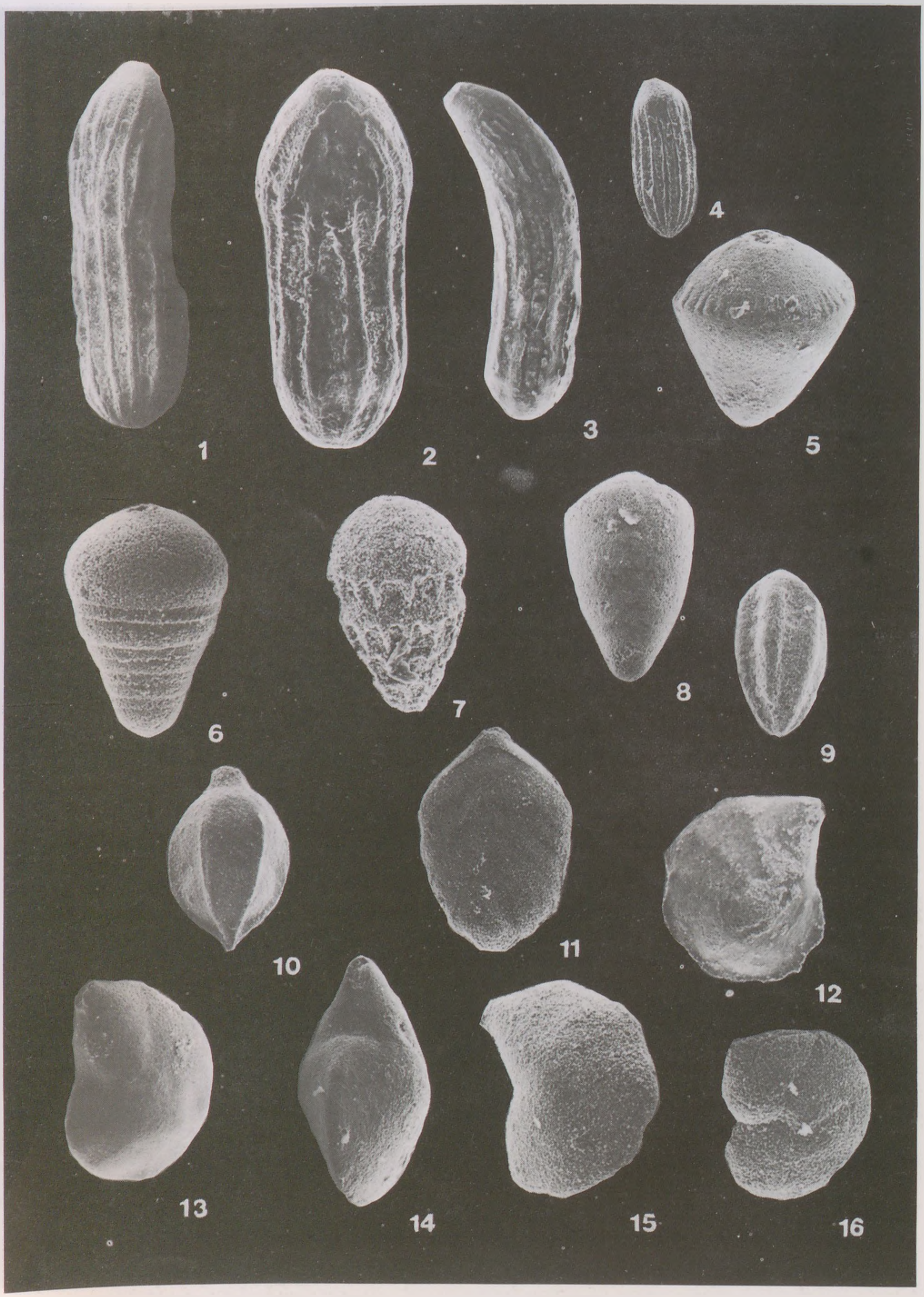

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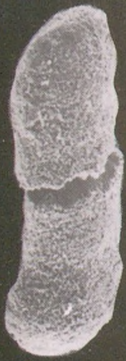
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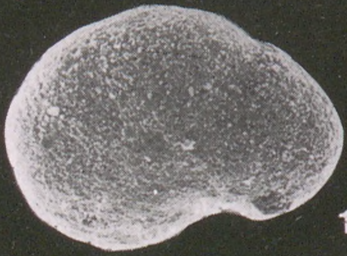
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Plate 5


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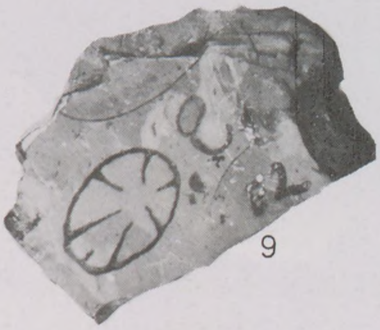
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Plate 6

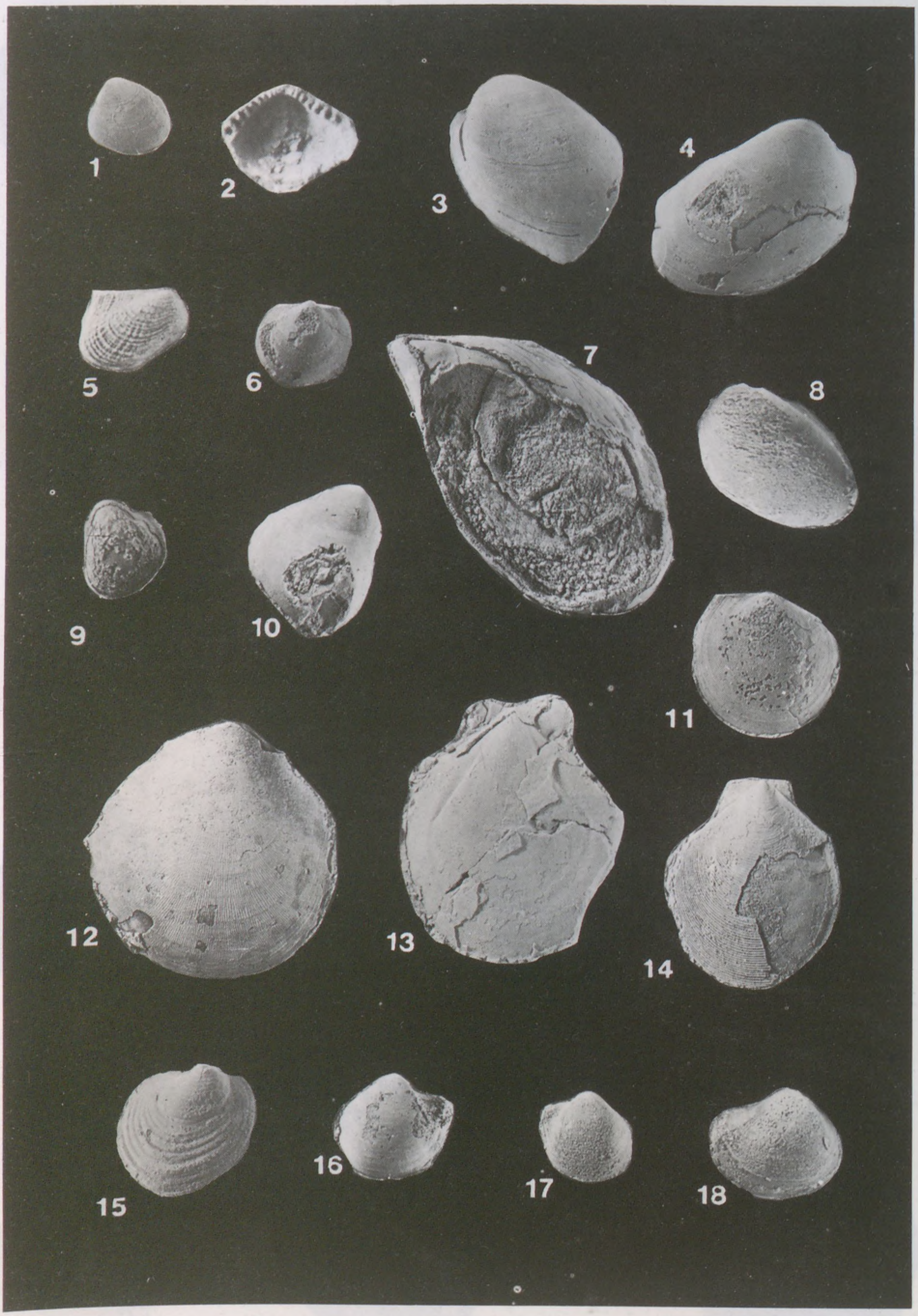

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Plate 7

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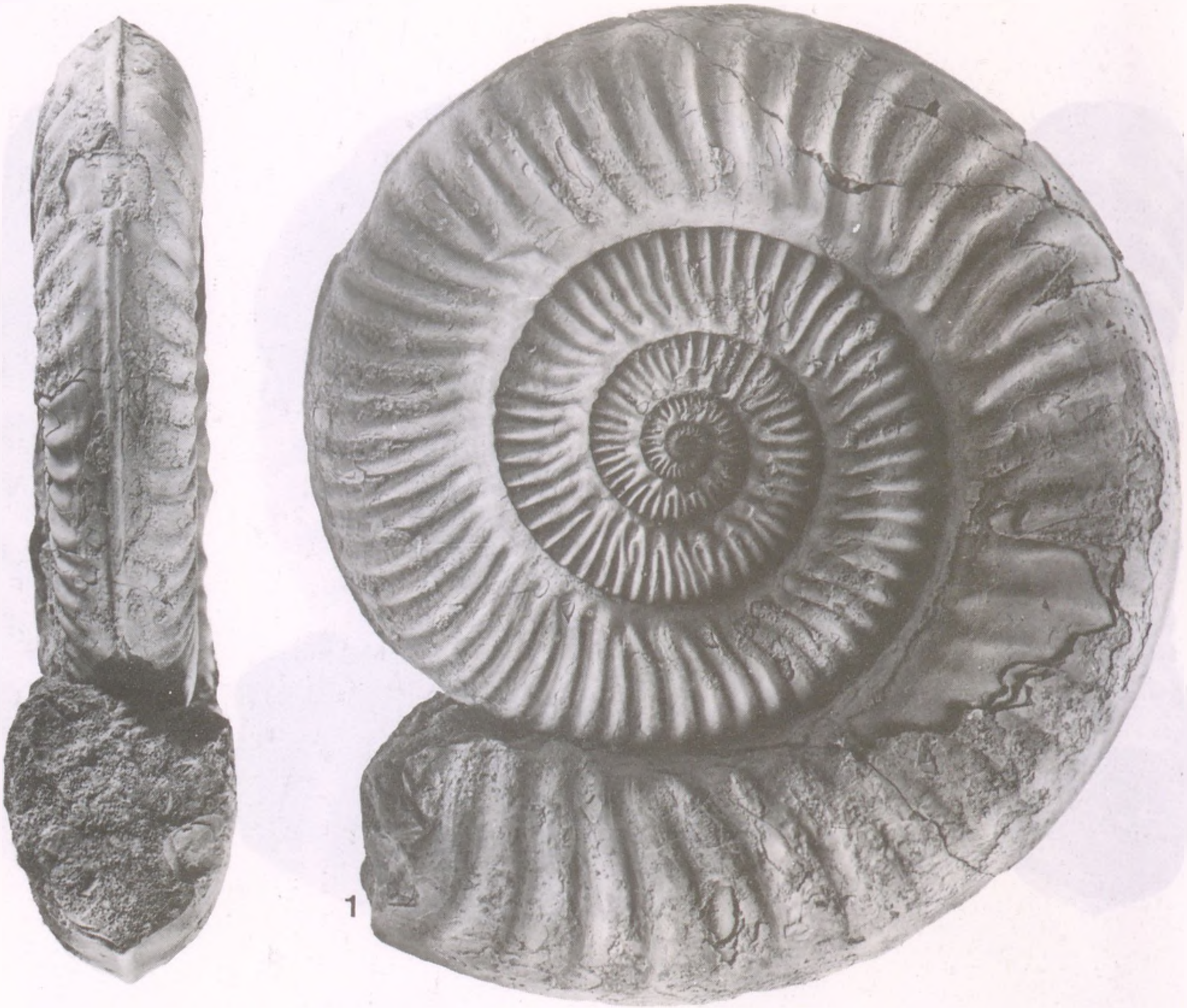
Plate 8

Plate 9



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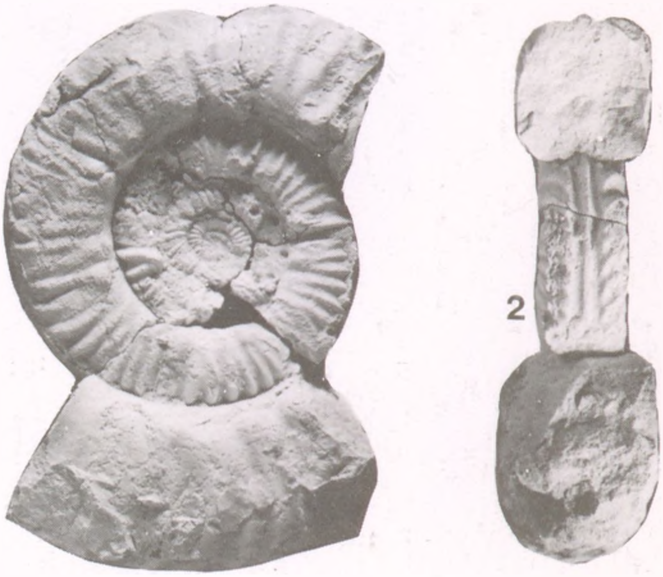

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Plate 10

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Plate 11


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Plate 13


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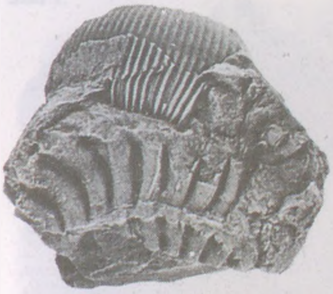
Plate 14


1a


1b


2a


2b


3a


3b


4a


4b


5a


5b

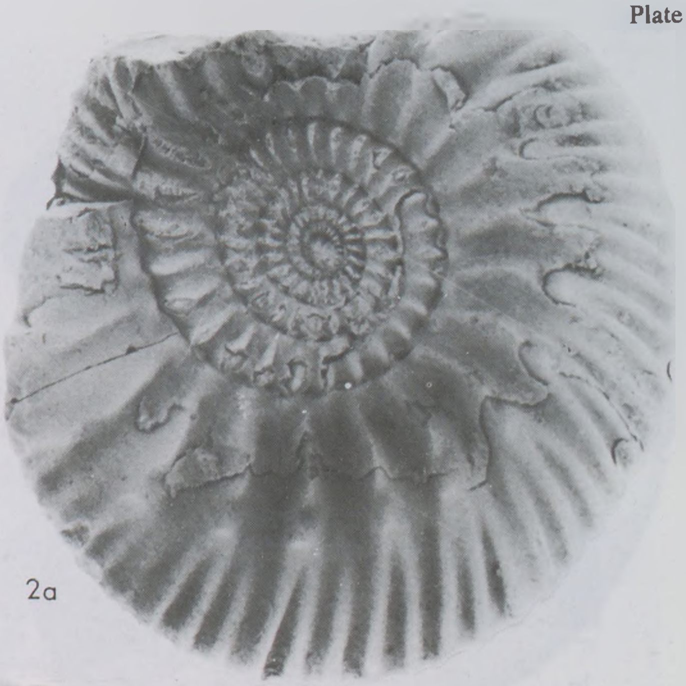

5c

Plate 15

Plate 16


1a


1b

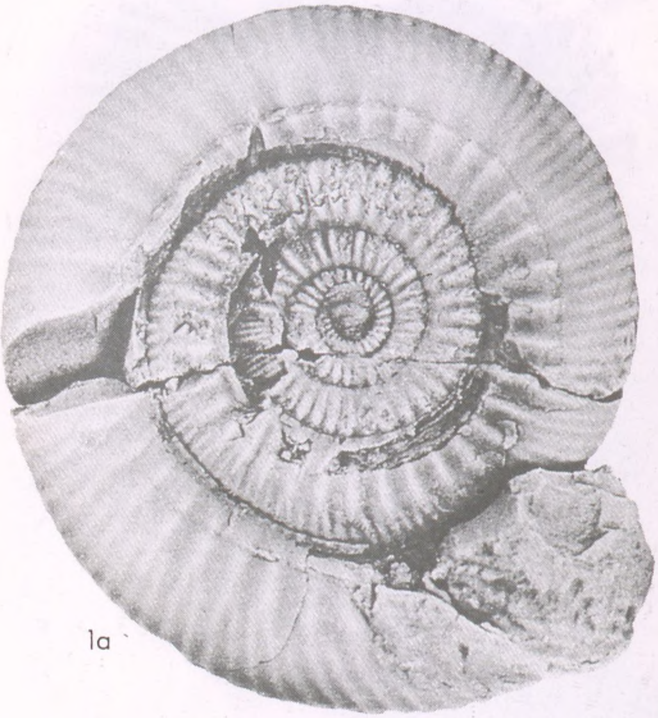

2a


3a


2b


3b

Plate 17


1a


1b


1c


2a


2b


2c


3


4


5

Plate 18

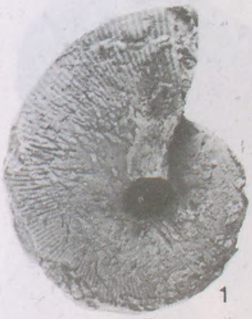

1


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Plate 19


1


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3


4

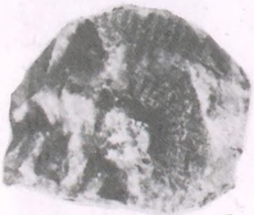
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Plate 20


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Plate 21


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Plate 22


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3


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Plate 23

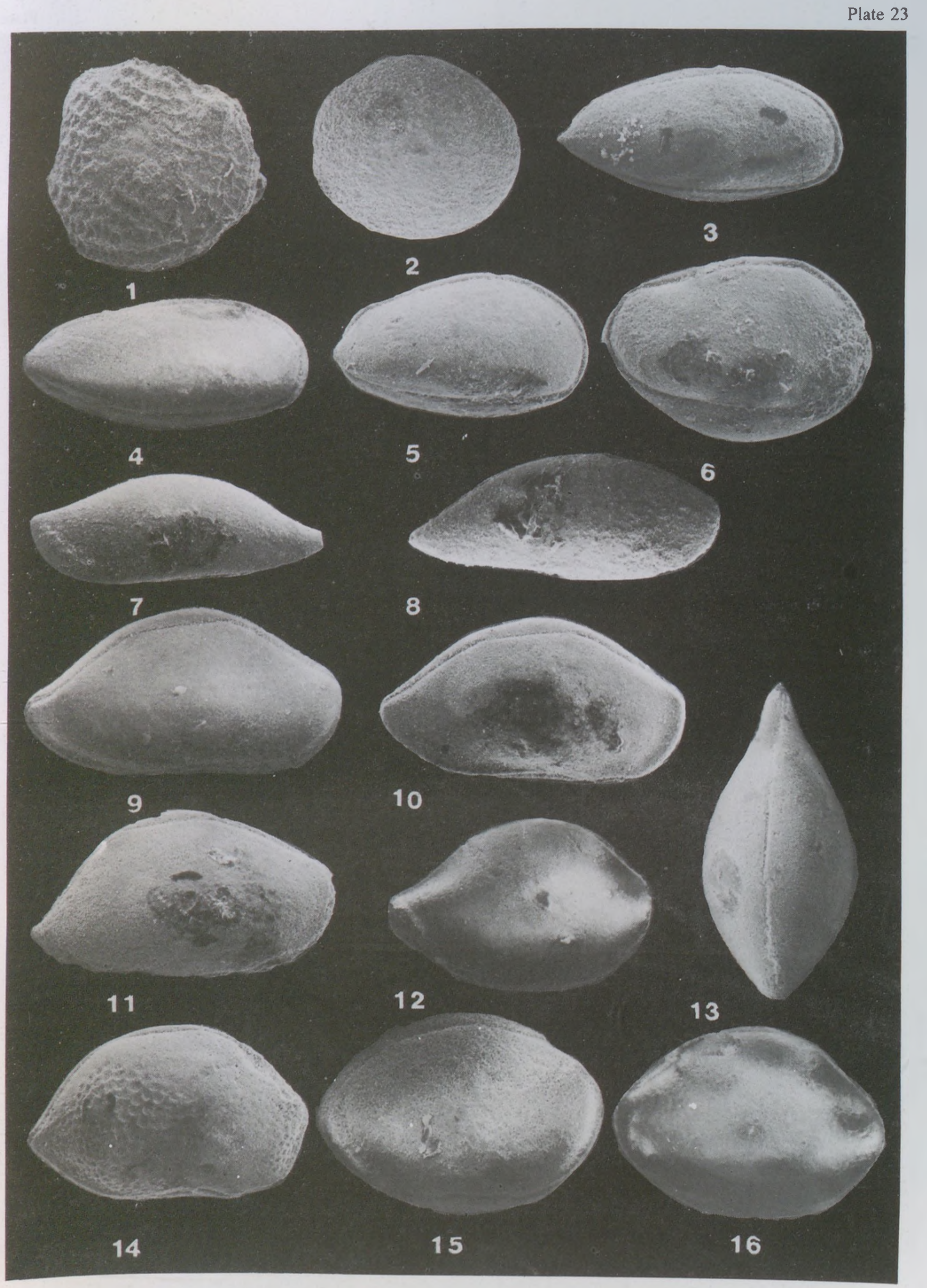
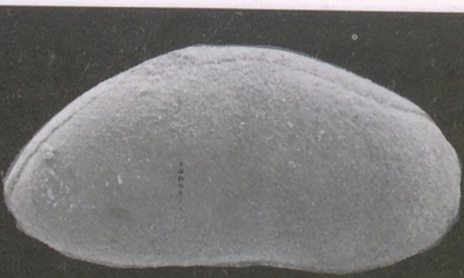


Plate 24



1

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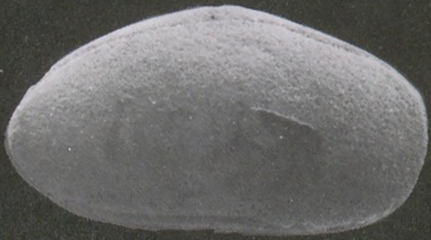
3

4



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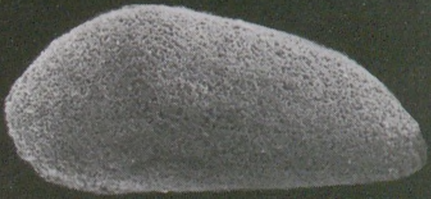
7



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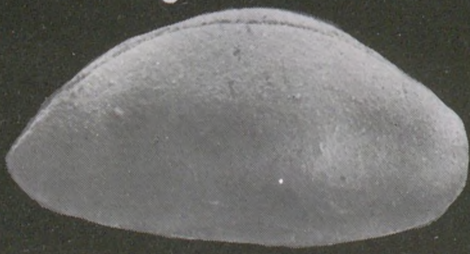

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