

Upper Silurian cephalopods from Southwestern Sardinia

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ABSTRACT — Thirty eight species pertaining to twenty one genera have been recognized among rich material mostly collected by the authors. All the specimens of the old Meneghini's collection (1857) have been revised. This revision of an almost unknown material allows the authors to propose some systematic emendments: 1) *Orthoceras michelini* Barrande, type species of genus *Michelinoceras*, is a junior synonym of *Orthoceras grande* Meneghini; 2) *Orthoceras arion* Barrande, type species of genus *Arionoceras*, is a junior synonym of *Orthoceras affine* Meneghini; 3) *Orthoceras bohemicum* Barrande is a junior synonym of *Orthoceras fluminese* Meneghini. Setting aside the work of Meneghini, two species, *Metarmenoceras? meneghinii* and *Galtoceras sardoum* are proposed as new. Six species are described, illustrated but left as open nomenclature. One specimen, represented by extremely fragmentary material, is not identified generically and specifically. The assemblage tends to demonstrate equivalence with the Barrandium of Czechoslovakia.

From the palaeobiogeographic point of view representatives of actinoceroids and cyrtoceraconic genera are mentioned in the Mediterranean area. This occurrence has been here reported for the first time.

RIASSUNTO — [Cefalopodi del Siluriano superiore della Sardegna sud occidentale] — Viene descritta e illustrata una ricca associazione a cefalopodi in gran parte raccolta dagli autori nei «Calcari a *Orthoceras*, *Monograptus*, *Cardiola* e *Ostracodi*» della Sardegna sud occidentale.

La fauna è costituita da 38 specie appartenenti a 21 generi. Anche gli esemplari della vecchia collezione Meneghini del 1857 sono stati presi in esame e sottoposti a revisione. Tale revisione ha permesso di proporre alcuni emendamenti sistematici: 1) *Orthoceras michelini* Barrande, specie tipo del genere *Michelinoceras*, è sinonimo più recente di *Orthoceras grande* Meneghini; 2) *Orthoceras arion* Barrande, specie tipo del genere *Arionoceras*, è sinonimo più recente di *Orthoceras affine* Meneghini; 3) *Orthoceras bohemicum* Barrande è sinonimo più recente di *Orthoceras fluminese* Meneghini.

A parte il lavoro di Meneghini, due specie, *Metarmenoceras meneghinii* e *Galtoceras sardoum*, sono proposte come nuove. Sei specie sono descritte e illustrate ma lasciate in nomenclatura aperta. Un esemplare, rappresentato da materiale molto frammentario, non è identificato né a livello generico né specifico. Nella associazione, che presenta indubbie affinità con quella del Barrandium della Cecoslovacchia, compaiono anche rappresentanti di generi actinoceroidi e cyrtoceraconi che vengono segnalati nell'area mediterranea per la prima volta.

KEY WORDS — Cephalopods, Upper Silurian, Sardinia, Systematic.

INTRODUCTION

This paper is part of a larger project on Sardinian Paleozoic biostratigraphy and palaeontology in progress, since several years, in the Institute of Palaeontology of Modena University. This study has been preceded by other ones on Upper Ordovician Conularids (Serpagli, 1969), Upper Devonian-Lower Carboniferous Conodonts (Olivieri 1965, 1970), Upper Silurian Conodonts (Serpagli 1967, 1970) and will be followed by contributions on palaeoecology of «*Orthoceras* limestone», Lower Devonian Conodonts and Cephalopods, and Upper Ordovician problematica.

The study has been carried out in close cooperation by the authors.

The present research is supported by some good reasons. First of all, after the paper of Meneghini of 1857, nobody has been deeply interested in such fossils which represent, perhaps, the most neglected systematic units of the Sardinian Silurian fauna. Secondly, one of the more classical formations of Sardinian Lower Palaeozoic is named «*Orthoceras* limestone». Nevertheless, till now the knowledge about what kind of «*Orthoceras*» could characterize that formation was very scarce or inexistent. Thirdly, as far as the palaeobiogeographic history of the Mediterranean area is concerned, a more complete knowledge of the horizontal distribution of Sardinia cephalopods can give a substantial help to the problem.

The study which is based on material mostly collected by the authors in the summer of 1970 and now deposited in the Museum of the Palaeontological Institute, is exclusively a palaeontologic one because, at the present stage of our knowledge, an attempt to give detailed biostratigraphic data through a work on cephalopods seems to be premature.

AKNOWLEDGEMENTS

This present work was performed at the Institute of Palaeontology, Modena University, directed by Professor E. Montanaro Gallitelli. She gave us not only a free access to all working facilities of the institute but also encouragement during all stages of this work and chiefly the occasion for many useful discussions.

We also wish to express our sincere thanks to Professor G. Tavani, Pisa University, who has made the Meneghini collection available for investigation; to Mr. Macagno, Turin, and Dr. F. Massole, Fluminimaggiore, who have given us some important specimens; to Mr. B. Ferraresi, Finale Emilia, who arranged the availability of material collected by C.A.R.C. of Finale Emilia; to the artist of the Institute of Palaeontology G. Leonardi, Modena University, who re-drafted all the figures on the basis of our camera lucida drawings; to Mr. P. Rompianesi, technician at the Palaeontological Institute, Modena University, for his generous help during several stages of the work.

We would also like to thank all the colleagues who kindly sent us papers on Palaeozoic nautiloid cephalopods (chiefly from USSR) not available in our libraries.

Finally, we owe Professor Rousseau H. Flower, New Mexico Bureau of Mines and Mineral Researches, Socorro, New Mexico, special thanks for the critical and linguistical review of the manuscript. This is not to imply that he necessarily agree with all our conclusions or with the English style of our paper.

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PREVIOUS RESEARCHES IN SARDINIA

Some years before J. Barrande started to print, in 1865, the portion of his large monograph on Silurian Cephalopods of Bohemia, G. Meneghini noted their occurrence in Sardinian strata.

Meneghini's paper was printed in 1857 as a part of a monographic study edited by A. La Marmora, entitled « Voyage en Sardaigne ».

The quite general character of the monograph does perhaps explain the reason why Meneghini's work has been almost completely ignored for such a long time. The diagnosis of the species were in latin. The new species were beautifully illustrated, and so they have a sound taxonomic value.

M. Gortani in 1922 and R. Teichmüller in 1931 listed only some species most of which already reported by Meneghini.

The next citation of Silurian « *Orthoceras* » is listed in the catalog of Sardinian fossils published in 1949 by I. Comaschi Caria.

For more than one century nobody has really been interested in such Sardinian fossils despite the fact that just one of the more common formations in Sardinia is named « Calcarei a *Orthoceras* ».

In 1968 the German palaeontologist H. Ristedt in his important revision of Orthoceratidae examined specimens from several parts of the world, Sardinian orthoceratids are also included and some new species established. He starts from the point of view that the morphology of the embryonic stage of these cephalopods represents the fundamental taxonomic element. Consequently his new species are mostly based only on embryonic portions. It is amazing that, despite the fact he collected the samples just from the type locality of species of Meneghini, he seems to have completely ignored the important work of Meneghini.

GEOLOGICAL SETTING

This report is concerned with cephalopods from strata of the Upper Silurian age. In order to place them in perspective, a brief summary of the Silurian rocks of Sardinia is required.

Silurian marine sediments, which are exposed in two main areas (Iglesiente at SW and Gerrei at SE), are represented chiefly by black shales rich in graptolites. Intercalations of lenses of black limestone with *Cardiola*, cephalopods (« *Orthoceras* »), graptolites, ostracods and conodonts, occur in the upper part of the sequence.

A complete Silurian stratigraphic record is not known from anywhere. This is certainly related to the fact that in the whole of Sardinia it is impossible to find continuous sequences of fossiliferous marine strata where the order of superposition can be clearly observed, and it is virtually impossible to trace individual beds over long distances. Further-

more, rapid changes of lithology, intrusion of magmatic rocks, to which the mineralized veins are connected, greatly complicate the stratigraphic exploration of this region.

On the basis of conodonts, some horizons of the Upper Silurian sequence were dated by Serpagli (1967, 1971). He did not consider the problem of the Lower Silurian. Nevertheless he supported that the paleoecological evidence of this age can be recovered in the Lower Silurian of authors. According to the point of view of Coccozza expressed in several papers (Coccozza et alii, 1974, p. 103, 104; Coccozza, 1975, p. 186; Coccozza & Jacobacci, 1975, p. 56, 57) Llandoveryan deposits and many of the Wenlockian ones are entirely lacking in Sardinia. On the contrary H. P. Schonlaub (personal communication to the senior author, June 1976) has a quite different opinion, as he affirms to have found graptolite evidence of the basal Silurian.

The cephalopods, the object of the present research, have been sampled from the lenses of black limestone occurring in the upper part of the Silurian sequence and therefore there are no problems about their stratigraphical situation. Nevertheless detailed biostratigraphy of this base is obviously not possible. We have also collected many specimens in Lower Devonian nodular limestone. Such forms will be studied in a next work.

THE CEPHALOPOD FAUNA

Collections obtained during this investigation have trebled the size of the previous known fauna of the «*Orthoceras* limestone» of SW Sardinia. Among the previously unreported forms are two newly described species: *Metarmenoceras* ? *meneghinii* and *Galtoceras* ? *sardoum*. In addition several other nautiloids appear to be undescribed but are represented by poorly preserved material inadequate for formal description. In all, 38 nautiloid taxa are identified. The complete fauna is listed below (1).

Order Orthocerida Kuhn, 1940

Fam. Orthoceratidae M'Coy, 1844

Subfam. Michelinoceratinae Flower, 1945

Hemicosmorthoceras laterculum Ristedt

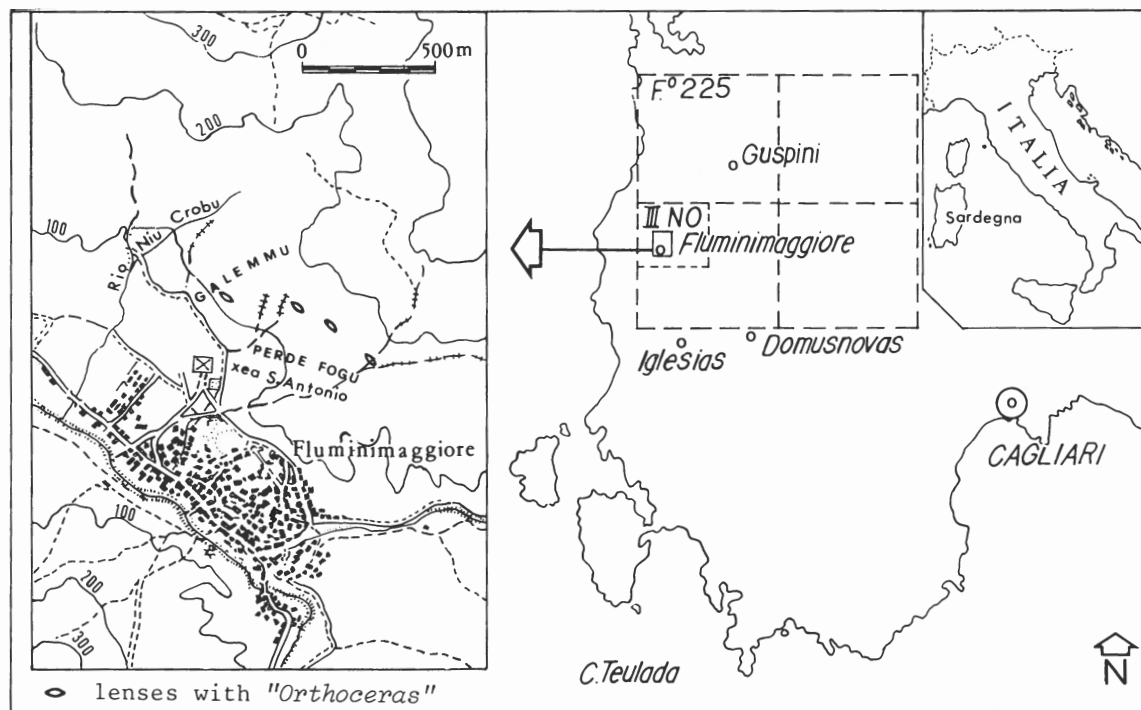
Hemicosmorthoceras semiannulatum (Barrande)

Hemicosmorthoceras sp.

Kopaninoceras jucundum (Barrande)

Kopaninoceras ? *thyrsus* (Barrande)

(1) Because the classifications presently available are unsatisfactory, we have mostly followed that reported in the «Treatise». Anyway we disclaim any responsibility for it.



Text-fig 1 - General and detailed maps showing location of fossiliferous outcrops.

Michelinoceras currens (Barrande)
Michelinoceras grande (Meneghini)
Michelinoceras sp. 1
Michelinoceras sp. 2
Michelinoceras sp. 3
Plagiostomoceras gruenewaldti (Barrande)
Plagiostomoceras cf. *pleurotomum* (Barrande)
« *Parasphaerorthoceras* » sp. B *sensu* Ristedt
« *Parasphaerorthoceras* » sp. H *sensu* Ristedt
« *Parasphaerorthoceras* » sp. J *sensu* Ristedt
« *Parasphaerorthoceras* » sp. K *sensu* Ristedt
Protobactrites ? sp.
« *Sphaerorthoceras* » *beatum* Ristedt
« *Sphaerorthoceras* » *curvum* Ristedt
« *Sphaerorthoceras* » *teichertii* Ristedt
« *Sphaerorthoceras* » sp.

Subfam. Leurocyloceratinae Sweet, 1964

Akrosphaerorthoceras gregale Ristedt
Anaspyroceras pseudocalamiteum (Barrande)
Orthocycloceras ? *fluminese* (Meneghini)
Orthocycloceras ? cf. *lynx* (Barrande)
Merocycloceras declive Ristedt

Subfam. Kionoceratinae Hyatt in Zittel, 1900

Kionoceras doricum (Barrande)
Parakionoceras originale (Barrande)

Fam. Geisonoceratidae Zhuravleva, 1959

Arionoceras affine (Meneghini)
Arionoceras submoniliforme (Meneghini)
Columenoceras sp. cf. *C. column* (Barrande)
Harrisoceras vibrayeii (Barrande)

Order Actinocerida Teichert, 1933

Fam. Ormoceratidae Saemann, 1853

Metarmenoceras ? *meneghinii* n. sp.
« *Orthoceras* » cf. *richteri* Barrande

Order Oncocerida Flower in Flower & Kummel, 1950

Fam. Oncoceratidae Hyatt, 1884

Oocerina abdita (Barrande)
Oonoceras plebeium (Barrande)

Fam. Acleistoceratidae Flower in Flower & Kummel, 1950

Galtoceras ? *sardoum* n. sp.

Fam. Trimeroceratidae Hyatt in Zittel, 1900

Gen. ind. A sp. 1

Taxonomically Orthocerida are dominant (32 taxa) in comparison to Oncocerida (4 taxa) and Actinoce-

rida (2 taxa). Most of the genera are monotypic. Some, however, include two or several species: *Michelinoceras*, *Hemicosmorthoceras*, « *Parasphaerorthoceras* », « *Sphaerorthoceras* », *Kopaninoceras*, *Plagiostomoceras*, *Arionoceras* and *Orthocycloceras*. The commonest species are the smooth orthoceracones. Transversally or longitudinally ornated forms are also present as well as rare cyrthoceraconic species. All are always fragmentary and crushed. Most of the species identified can be referred to already described or known species present in European faunas but, in general, the Sardinian Upper Silurian nautiloid faunas show an intimate relationship with those known from Bohemia. However, precise correlation with the Silurian section in the Barrandium of Czechoslovakia is at present unsatisfactory, mostly because the lack of a modern revision of that large fauna.

In Sardinia few more forms have been reported by the following authors:

Meneghini (1857)

Michelinoceras subconoideum (Meneghini)
« *Parasphaerorthoceras* » ? *subcyprium* (Meneghini)

Teichmüller (1931, p. 17)

« *Orthoceras* » *bronni* Barrande
« *Orthoceras* » *dulce* Barrande
« *Orthoceras* » *potens* Barrande
« *Orthoceras* » *transiens* Barrande

Ristedt (1968)

« *Parasphaerorthoceras* » sp. F *sensu* Ristedt
Hemicosmorthoceras sp. *sensu* Ristedt

The contribution that we have given for a better knowledge of the taxonomy of some genera and species of Silurian cephalopods is here briefly summarized:

1) *Hemicosmorthoceras semiannulatum* is known for the first time also through its inner features, from section.

2) It is proposed to change the name of the type species of the genus *Michelinoceras* which becomes *Orthoceras grande* Meneghini, because *Orthoceras michelini* Barrande is a junior synonym of that species.

3) The variability of inner features of *Orthoceras grande* are illustrated with a beautiful specimen in which, besides the protoconch 26 chambers are preserved and with two fragments of adult phragmocones with 26 and 12 chambers respectively.

4) *Plagiostomoceras pleurotomum* (Barrande),

type species of the genus was established not in 1866, as commonly reported (see also «Treatise» p. 226), but 6 years before because its author figured the species in 1860 in a short paper dealing with septal truncature.

5) After a better knowledge of the inner features of juvenile specimens of *Michelinoceras* it is supposed that probably *Sphaerorthoceras* could be regarded as a synonym of that genus.

6) The genus *Akrosphaerorthoceras* which has been amended on the basis of features of the adult part, has been regarded as belonging to the subfamily Leurocyloceratinae instead of Sphaerorthoceratinae or Michelinoceratinae as previously supported by Ristedt (1968) and Barskov (1972) respectively.

7) The importance of the ornament which, sometimes (like in *A. gregale*), plays an important role as diagnostic feature, has been emphasized.

8) *Orthocycloceras* ? *bohemicum* (Barrande) has to be considered as a junior synonym of *Orthocycloceras*? *fluminense* (Meneghini). Barrande published first (1855) a *nomen nudum*. Between this publication and the issue of his great monography (Barrande, 1866), Meneghini published a satisfying description and illustration of his new species (1857).

9) The genus *Arionoceras* which has been amended on the basis of the feature of protoconch and initial portion of the conch, has been regarded as belonging to the family Geisonoceratidae instead of Michelinoceratidae as previously supported by Barskov (1972).

10) It is proposed to change the name of the type-species of the genus *Arionoceras* which becomes *O. affine* Meneghini because *O. arion* is a junior synonym of that species.

11) Cyrtoceraconic genera like *Oocerina*, *Oonoceras* and *Galtoceras* are reported from Mediterranean regions for the first time.

NAUTILOID PROVINCIALISM AND ENVIRONMENTAL REMARKS

It is very difficult to recognize faunal provinces from the geological past especially from the Silurian time. This is truer if we intend to use nautiloids as tools for this job because our present knowledge of Silurian cephalopods faunas of various areas is not equal. Many faunas are studied reasonably well but large assemblages from other areas have still not been described or require a modern taxonomic revision. Up till now, in fact, Silurian cephalopods have been mostly reported from a few regions i.e. Czechoslovakia, N. America, the British Isles, Sardinia, Sweden,

the Siberian Platform, Kazakhstan, Middle Asia, but we have no knowledge of Silurian cephalopods outside of Europe, N. America, and a large part of Asia.

During the Upper Silurian most of the Mediterranean region, as well as Bohemia, was covered by epicontinental seas where the deposition of platform mudstones and siltstones was predominant. The main elements of the faunal community were locally graptolites, orthocones, pelecypods, ostracods, and conodonts which are mostly pelagic or epiplanctonic. A few gasteropods and brachiopods have also been reported. Of course ostracods, as well as *Cardiola* may have had a different way of life, living epifaunally or infaunally. Graptolites may have floated above the muddy bottom falling down after the death of the colony. In the case of fossil cephalopods it is extremely difficult to recognize the true life distribution area because of the post-mortem drifting. It is, in fact, well known that the shell of chambered cephalopods was very buoyant for long periods after death and hence suitable of long distance transport by currents. But the presence of specimens in all growth stages might be taken as an indication of a true life area. This seems the case of the Sardinian outcrops where adult with young stages are commonly associated.

Such graptolite-orthocone-bivalve association, together with the kind of sediment (dark shales with fine grained bioclastic dark limestones) suggest condition of shallow water with restricted circulation. Euxinic bottom condition are also sometimes indicated by the presence of high content of iron sulphide and by the complete absence of clear benthonic fauna and bioturbation. This environment contrasts with the large platforms of the same age, widespread to the north east and rich in a varied bottom-dwelling fauna, upon which carbonates slowly accumulated and over which the waters were better oxygenated. Continental areas, practically not important, acted as barriers to the migration of shelf faunas and this is, perhaps, the main reason for the cosmopolitan nature of the Silurian shelf faunas throughout the European seas. However, at first sight, some differences appear, if we take into consideration larger areas comparing for instance the Bohemian-Mediterranean nautiloid assemblages with that of the Siberian Platform to the East or of the British Isles to the West. The Uralian Ocean and the Caledonian geosyncline could have acted as barriers eastward and westward respectively. But, at the present stage of our knowledge, the evaluation of the diversity of Paleozoic nautiloid faunas is still too subjective. In the future it is possible that it may be quantified with some degrees of confidence. Most probably the greatest difficulties, in compiling the distribution

maps, will be encountered seeing through the synonyms.

SYSTEMATIC DESCRIPTION

The cephalopods described in the following pages, unless differently noted, are part of the palaeontological collection of Modena University (Italy).

Types and figured specimens are stored in the Museum of the Institute of Palaeontology under the catalog numbers 18974-19085.

To point out that the names of the Meneghini species *Orthoceras fluminese*, *O. grande*, *O. subconoidium*, *O. affine*, *O. submoniliforme*, *O. subcyprium* are not to be considered forgotten names (*nomina oblita*) because they have been used, after their establishment (1857), at least two times: in 1870 by Barrande (p. 30) and 28 years ago, in 1949, by Comaschi Caria (p. 202-204, 335) [art. 23 and 79b of ICZN].

The terminology employed is essentially that advocated by Flower (1964) including the terms apicad (towards the apex of the shell) and orad (towards the aperture).

Order ORTHOCERIDA Kuhn, 1940

Family ORTHOCERATIDAE M'Coy, 1844

Subfamily MICHELINOCERATINAE M'Coy, 1844

Genus HEMICOSMORTHOCERAS Ristedt, 1968

Type-species — *Hemicosmorthoceras laterculum*, Ristedt, 1968.

HEMICOSMORTHOCERAS LATERCULUM Ristedt, 1968

Pl. 1, figs. 4a, b

1968 *Hemicosmorthoceras laterculum*, RISTEDT, pp. 279-281, pl. 5, figs. 8, 9, 9a, 10.

Remarks — The species has been carefully described by Ristedt (1968) and it is not necessary to repeat the description here.

The shape of protoconch and the characteristic ornamentation given by annulations and transversal ridges, leaves no doubt about the taxonomic position of Sardinian specimen.

Occurrence — Silurian (U. Ludlow) of Carnic Alps (Ristedt, 1968).

Repository — Institute of Palaeontology, Modena University, cat. n. 18974 (figured specimen).

Material studied — One specimen.

HEMICOSMORTHOCERAS SEMIANNULATUM (Barrande, 1870)

Pl. 1, figs. 6a, b; text-fig. 2b

1870 *Orthoceras semiannulatum* BARRANDE, pl. 423, figs. 7, 8.

1874 *Orthoceras semiannulatum* BARRANDE, p. 343.

Description — Orthoconic shell with a faintly elliptical cross section. Angle of expansion of the adult part of the shell close to 6-7 degrees and increasing adorally to 10 degrees. Fine characteristic transversal ridges perpendicular to the axis of the conch occur on the ventral side of the shell. The ridges, which are three to four per 1 mm, cover 1/3 of the circumference only. Low and quite rhythmical annulations occur every 5 to 6 ridges. Suture straight and slightly oblique. Camerae long more or less their dorso-ventral diameter. Septa concave, their depth being about 1/3 the diameter. Siphuncle ventrally eccentric slightly more than its own diameter. The last 1/10 the shell diameter. Septal necks short and

EXPLANATION OF PLATE 1

- Figs. 1a, b - *Kopaninoceras jucundum* (Barrande).
1a, dorsoventral section, x2 (n. 18978).
1b, detail of the ornamentation of the same specimen, x10.
- Figs. 2a - 3 - *Kopaninoceras ? thyrsus* (Barrande).
2a, dorsoventral section, x1 (n. 18979).
2b, detail of the septal neck of the same specimen, x10.
3, lateral view, x1 (n. 18980).
- Figs. 4a, b - *Hemicosmorthoceras laterculum* Ristedt.
4a, lateral view, x10 (n. 18974).
4b, ventral view of the same specimen, x10.
- Figs. 5a, b - *Hemicosmorthoceras* sp.
5a, ventral view, x5 (n. 18977).
5b, lateral view of the same specimen, x5.
- Figs. 6a, b - *Hemicosmorthoceras semiannulatum* (Barrande).
6a, ventral view, x5 (n. 18975).
6b, lateral view of the same specimen, x5.



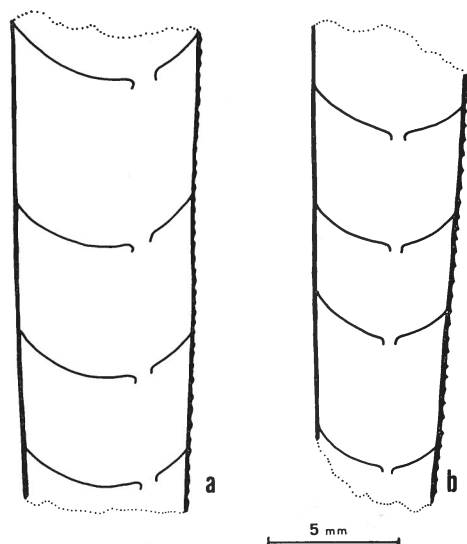
suborthochoanitic, their length being about 1/2 the diameter of septal foramen. Connecting rings not preserved. No cameral and siphonal deposits are present in mature shells.

Remarks — The ornament is believed to be sufficient for a specific diagnosis. However, some inner features, here evidenced for the first time, allow a better knowledge of this very characteristic species.

Occurrence — Silurian of Bohemia (Barrande, 1870, 1874).

Repository — Institute of Palaeontology, Modena University, cat. n. 18975 (figured specimen), 18976 (unfigured specimens).

Material studied — Four specimens.



Text-fig. 2 - a, *Hemicosmorthoceras* sp., diagrammatic dorso-ventral section of specimen figured in pl. 1, fig. 5 (n. 18977); b, *Hemicosmorthoceras semiannulatum* (Barrande), diagrammatic dorsoventral section of specimen figured in pl. 1, fig. 6 (n. 18975).

HEMICOSMORTHOCERAS sp.

Pl. 1, figs. 5a, b; text-fig. 2a

Description — Orthoconic shell with elliptical cross section. Angle of expansion of the adult part of the shell close to 2-3 degrees. Characteristic transversal ridges oblique to the axis of the conch, sloping adorally of about 15-16 degrees, occur on the ventral side. The ridges, which are about 3 per 1 mm, cover half of the circumference. Camerae slightly shorter than their dorso-ventral diameter. Septa concave, their depth being about 1/3 the diameter.

Siphuncle strongly eccentric toward the ventral side. Diameter of the septal foramen about 1/9 the shell diameter. Septal necks short and suborthochoanitic. Connecting rings partly preserved.

Remarks — The poor preservation of the only specimen prevents a more precise identification. The fragmentary specimen shows no relationships with Bohemian hemicosmorthocerids. It could perhaps represent the adult portion of forms like *H. celloni* Ristedt.

Repository — Institute of Palaeontology, Modena University, cat. n. 18977 (figured specimen).

Material studied — One specimen.

Genus KOPANINOCERAS Kisselev, 1969

Type-species — *Orthoceras jucundum* Barrande, 1870.

KOPANINOCERAS JUCUNDUM (Barrande, 1870)

Pl. 1, figs. 1a, b; text-fig. 3

1870 *Orthoceras jucundum* BARRANDE, pl. 380, figs. 4-7; pl. 409, figs. 7-10.

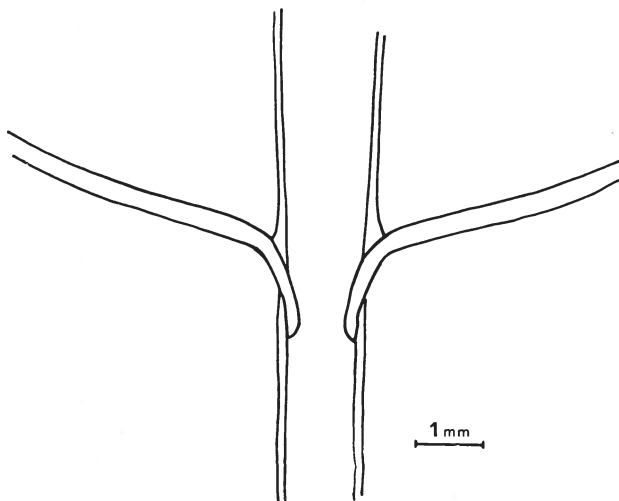
1874 *Orthoceras jucundum* BARRANDE, p. 518.

1962 *Michelinoceras jucundum* (Barrande) - FLOWER, p. 10.

1966 *Michelinoceras jucundum* (Barrande) - BABIN, p. 321.

1970 *Kopaninoceras jucundum* (Barrande) - BARSKOV & KISSELEV, pp. 67, 68, pl. 3, fig. 2.

Description — Orthoconic shell with circular cross section. Angle of expansion of the adult part of the shell close to 8 degrees. Fine transversal lirae, slightly oblique to the axis of the conch and about



Text-fig. 3 - Detail of septal neck of *Kopaninoceras jucundum* (Barrande), (n. 18978).

ten per 1 mm, cover the whole outer surface. Sutures straight, simple and transverse. Camerae $3/5$ the diameter. Septa moderately concave, their depth being about $1/3$ the diameter. Siphuncle central, about $1/10$ the shell diameter. Septal necks weakly conoid, tapering adapically and slightly dilated terminally; their length being a little more than the septal foramen. Connecting rings cylindrical.

Remarks — In spite of the incompleteness of the specimen, inner and outer features allow us to reach a specific identification. The present species is quite similar to *Kopaninoceras giebeli* (Barrande) from which it differs in the wider angle of expansion and the more concave septa.

Occurrence — Upper Silurian (Ludlow) of Bohemia (Barrande, 1870), Armorican Massiv (Babin, 1966) and Polar Urals (Barskov & Kisselev, 1970).

Repository — Institute of Palaeontology, Modena University, cat. n. 18978 (figured specimen).

Material studied — One specimen.

KOPANINOCERAS ? THYRSUS (Barrande, 1870)

Pl. 1, figs. 4a, b

1870 *Orthoceras thyrsus* BARRANDE, pl. 405, figs. 15-18.

1874 *Orthoceras thyrsus* BARRANDE, pp. 555, 556.

1962 *Michelinoceras thyrsus* (Barrande) - FLOWER, p. 10.

1968 *Michelinoceras* n. sp. A, RISTEDT, pp. 246, 247, pl. 1, figs. 4a (3?, 4?).

Description — Orthoconic shell with circular section. Angle of expansion very narrow, less than 4 degrees. Living chamber probably very long. Ornament in form of extremely fine growth lines, sloping 15 degrees apicad from dorsum to venter and one or two per 1 mm. Suture straight, simple and oblique like the ornament. Camerae long, $1/2$ - $1/1$ of the diameter of the shell. Septa concave, their depth being about $1/3$ the diameter. Siphuncle eccentric slightly more than its own diameter from center. Diameter of the septal foramen $1/10$ the shell diameter. Septal necks weakly conoid, tapering adapically, their length being one and half the diameter of the septal foramen. Connecting rings cylindrical. Thin episeptal deposits developed in the apical part of some adult specimens.

Remarks — We have some doubts about the generic position of this species. Some authors regard it as belonging to *Michelinoceras* (see Kisselev, 1972, p. 427) but our specimens, the character of which do comparatively agree with the type of Barrande, have necks (see description) more similar to that of the genus *Kopaninoceras*. While waiting for a revision of *Michelinoceras* and related genera, we prefer to

regard *O. thyrsus* Barrande as belonging, although questionably, to *Kopaninoceras*.

It must be pointed out that Barrande in his original description of *O. thyrsus* (p. 556) regards the fine outer striation as sloping to 35 degrees. However, it is quite evident, by observing plate 405, fig. 15, that the striations are instead inclined to 15-16 degrees, in complete agreement with our material.

Specimens reported from China by Lai Chai-geen (1960) have a too eccentric siphuncle to be regarded exactly as the same species under discussion.

Occurrence — Upper Silurian of Bohemia (Barrande, 1870; Ristedt, 1968).

Repository — Institute of Palaeontology, Modena University, cat. n. 18979-18980 (figured specimens), 18981 (unfigured specimens).

Material studied — Six specimens.

Genus MICHELINOCERAS Foerste, 1932

Type-species — *Orthoceras grande* Meneghini, 1857 (non *Orthoceras michelini* Barrande, 1866).

1932 *Michelinoceras* FOERSTE, p. 72.

1962 *Michelinoceras* Foerste - FLOWER, pp. 10, 11.

1964 *Michelinoceras* Foerste - SWEET, p. K 225.

1968 *Michelinoceras* Foerste - RISTEDT, pp. 243, 244.

1972 *Michelinoceras* Foerste - BARSKOV, pp. 35, 36.

Remarks — *Michelinoceras* is one of the more long ranging genera which is common in the Silurian either in Bohemia or in the Mediterranean area. Because *Orthoceras michelini* Barrande is a junior synonym of *Orthoceras grande* Meneghini we propose, according to the law of priority (art. 67e ICZN,) to change the name of the type species to become *Michelinoceras grande* (Meneghini). This is discussed in the next pages where we also report a re-description of the type species as well as several remarks on the occurrence of cameral and siphonal deposits.

As noted on page 172 the genus *Sphaerorthoceras* Ristedt, 1968 may be regarded as a possible synonym of *Michelinoceras*.

MICHELINOCERAS CURRENS (Barrande, 1866)

Pl. 2, fig. 6

1857 *Orthoceras simplex* Desnoy - MENEGHINI, pl. C, fig. 4Ab', 4Ab'' only.

1857 *Orthoceras submoniliforme* MENEGHINI, pl. C, fig. 9a (non figs. 9b, 9b' = lectotype of *Arionoceras submoniliforme*).

1860 *Orthoceras currens* BARRANDE, p. 624 (*nomen nudum*).

1866 *Orthoceras currens* BARRANDE, pl. 221, fig. 26, pl. 222, figs. 15, 16.

1870 *Orthoceras currens* BARRANDE, pl. 407, figs. 20-33, pl. 411, figs. 16-18.

1874 *Orthoceras currens* BARRANDE, p. 628.

1962 *Michelinoceras currens* (Barrande), FLOWER, p. 10.

1972 *Michelinoceras currens* (Barrande), BARSKOV, p. 36, pl. 1, fig. 5, pl. 2, fig. 5.

Description — Orthoconic shell with circular cross section. Angle of expansion usually 5 degrees, sometimes reaching 7 degrees. No ornament has been observed. Sutures straight, simple and transverse. Height of camerae strongly variable from 4/5 to 2/5 the diameter of the shell. Septa concave, their depth variable from 1/2 to 1/3 the diameter. Siphuncle subcentral. Diameter of the septal foramen about 1/15 the shell diameter. Septal necks orthochoanitic, their length being a little more than the diameter of septal foramen. Connecting rings mostly cylindrical, sometimes slightly expanding within camerae. No deposits have been observed.

Remarks — Also with the present research was impossible to discover some important characters, like that of the embryonic portion.

As pointed out by Barrande (1874, p. 628) *M. currens* shows a big variation in the length of camerae, often in the same specimen.

The species can be distinguished from *M. grande* (Meneghini) chiefly by a wider angle of expansion, shorter camerae and a little narrower siphuncle.

After the direct study carried out on a specimen previously illustrated by Meneghin (1857, pl. C, fig. 9a), and also on inner features, we can state that the specimen is completely different from that of fig. 9b, that we regard as lectotype of *Arionoceras submoniliforme*, and pertains to *Michelinoceras currens* (Barrande).

Occurrence — Upper Silurian of Bohemia (Barrande), Central Asia, Caucasus and Podolia (Barskov, 1972).

Repository — Institute of Palaeontology, Modena University, cat. n. 18982 (figured specimen), 18983 (unfigured specimens).

Material studied — 14 specimens.

MICHELINOCERAS GRANDE (Meneghini, 1857)

Pl. 2, figs. 1-5b; Text-fig. 7a

1857 *Orthoceras grande* MENEGHINI, p. 189-191, pl. C, figs. 4A, a, a'.

1866 *Orthoceras michelini* BARRANDE, pl. 221, figs. 16-17.

1870 *Orthoceras michelini* BARRANDE, pl. 381, figs. 3-16.

1870 *Orthoceras grande* Meneghini, BARRANDE, p. 30.

1874 *Orthoceras michelini* BARRANDE, p. 642.

1932 *Michelinoceras michelini* (Barrande), FOERSTE, p. 51.

1949 *Orthoceras grande* Meneghini, COMASCHI CARIA, pp. 203, 335.

? 1961 *Michelinoceras michelini* (Barrande), SHIMANSKY & ZHURAVLEVA, text-fig. 2(e).

1962 *Michelinoceras michelini* (Barrande), FLOWER, p. 10.

1968 *Michelinoceras michelini* (Barrande), RISTEDT, p. 245, 246, pl. 1, figs. 1, 2.

1972 *Michelinoceras michelini* (Barrande), BARSKOV, p. 36, pl. 1, figs. 1, 2 (?), pl. 2, figs. 1-3.

Holotype — Not designated.

Lectotype — Specimen of plate C, figs. 4a, a', Meneghini 1857.

Redescription — Orthoconic shell with circular cross section. Angle of expansion usually very narrow, lower than 3 degrees. Living chamber, according to the description of Barrande's specimen, slightly conical towards anterior part and developed in length about sixteen times the diameter. No ornament has been observed. Sutures straight, simple and transverse. Camerae long, variable from 1/2 to 1,5 the diameter of the shell. A large variation occurs in the same specimen (Pl. 2 fig. 3a). Septa concave, their depth

EXPLANATION OF PLATE 2

Figs. 1-5b - *Michelinoceras grande* (Meneghini).

1, dorsoventral section of young specimen to show protoconch and the next 26 chambers, x10 (n. 18984).

2, dorsoventral section of adult specimen, x2 (n. 18985).

3a, dorsoventral section to show the variability in the height of chambers, x2 (n. 18986).

3b, detail of the same specimen to show cameral deposits and the black film inside the necks, x10.

4, lateral view, x2 (n. 18987).

5a, dorsoventral section. Lectotype. x1 (Museum of the Institute of Geol. and Palaeont., Pisa University).

5b, lateral view of the same specimen, x1.

Fig. 6 - *Michelinoceras currens* (Barrande), dorsoventral section, x1 (n. 18982).

Figs. 7a, b - *Michelinoceras* sp. 3.

7a, lateral view, x15 (n. 18995).

7b, dorsoventral section of the same specimen, x15.

Figs. 8, 9 - *Protobactrites* ? sp.

8, lateral view, x10 (n. 19013).

9, lateral view, x20 (n. 19014).



variable from 0,28 to 0,46 the diameter. Siphuncle subcentral, never more eccentric than its own diameter. Diameter of the septal foramen variable from 1/11 to 1/5 the shell diameter. Septal necks orthochoanitic, their length being about the diameter of septal foramen or slightly more. Connecting rings mostly cylindrical, only occasionally imperceptibly expanding within camerae. Inside the siphuncle, just orad of the necks, it is sometimes possible to observe a black film, more or less as long as the necks, probably related to the concentration of organic matter. Few and thin episeptal and mural deposits developed in the apical part of some adult specimens. Early ontogenetic portion includes protoconch and about nine chambers. Protoconch subogival in shape, width to length ratio about 1-1,25. Caecum restricted to the adoral part of the protoconch.

Remarks — J. Barrande figured (1866, 1870) and described (1874) this species under the name *O. michelini* and based his diagnosis only on fragments of adult phragmocones. In 1932 Foerste established the new genus *Michelinoceras* and selected as type species *O. michelini* Barrande. Many years later, in 1968, H. Ristedt figured as *M. michelini* one juvenile specimen in which the protoconch and the next 8 chambers were preserved. Ristedt himself (Pl. 1, fig. 2) figured a second small specimen with only 7 chambers, probably belonging to the beginning of the adult part. Finally, I. S. Barskov described in 1972 four fragments of adult phragmocones found from Silurian of Afganistan and Soviet Union.

All the authors named above, who have studied *M. michelini* (Barrande), seem to have disregarded the species described by G. Meneghini in 1857, among which one is certainly identical to *O. michelini*. The types of *O. grande* Meneghini, as well as topotypic material recovered by us in Sardinia, agree either with the types of Barrande or with specimens subsequently reported by other authors. The common characters are the angle of expansion of shell, the absence of any kind of ornament, the depth of camerae, the degree of curvature of septa and the slightly eccentric siphuncle.

We have not been able to see Barrande's material but, if his drawings are correct, there is no doubt that *O. michelini* is conspecific with the species described by Meneghini nine years before and referred to as *O. grande*.

Even if the form under discussion is the type species of the genus, we believe that it is a rather inadequately known species, chiefly as far as internal features are concerned.

The most complete specimens till now recovered are formed, as we have seen, by 8 camerae, besides

the protoconch, of the early ontogenetic stage (Ristedt, 1968, pl. 1, fig. 1) or by 7 camerae of an adult phragmocone (Ristedt, 1968, pl. 1, fig. 2). We have collected one specimen in which, besides the protoconch, 26 camerae are preserved, as well as two fragments of adult phragmocones with 26 and 12 camerae respectively. This is a substantial contribution to the knowledge of variability of internal features of the species.

Opposite points of view regarding the presence or the lack of cameral deposits have been supported by Flower (1962, p. 10) and Ristedt (1968, p. 244) respectively.

According to us it is important to keep in mind the following remarks:

1) No deposits are present either in the embryonal or in the postembryonal portion of young conchs. In this connection you can refer to the specimen figured by Ristedt (1968, pl. 1, fig. 1) and to the specimen recovered by us in Sardinia (pl. 2, fig. 1).

2) Thin mural and episeptal deposits can be observed on the adapical portion of adult phragmocones. For instance, in one fragment with 12 camerae, deposits are restricted only to the 3 earlier camerae.

These contrasting remarks are compatible if we suppose that the deposition of these structures begins in a well defined moment of adult stage, perhaps related to the size of the whole specimen. Most probably, during the early ontogenetic development, the animal, owing to its minute size, did not need any adjustment to stabilize the shell into a horizontal position. Only in a subsequent stage the living nautiloid required to balance itself because the gas in the chambers helped the floating of the apical part.

Another possibility of solving this problem is to regard *Michelinoceras grande* as always being free of any kind of cameral deposits and fragments of adult phragmocones bearing deposits as belonging to « *Sphaerorthoceras* » *curvum* Ristedt (1968). The last species, which shows deposits in the apical portion, is practically undistinguishable from *M. grande* except in the features of protoconch and early embryonic chambers (see also p. 172).

Of course these suppositions could only be proved on the basis of complete adult specimens.

The occurrence of true annuli in the siphuncle, as supported by Flower (1962, p. 10, 11), was never observed in our material, but only, sometimes, the appearance of a black film just orad of the necks. Furthermore, septal foramina are always free of any kind of deposits.

It is of interest to compare the species under discussion with *Michelinoceras productum* (Barrande). The two species are almost identical in the internal features but *M. productum* has a wider angle of

expansion and fine transverse striations on the shell surface.

Some of the principal and diagnostic inner parameters have been tabulated (Tab. 1) in order to point out the variability of the present species.

Occurrence — Upper Silurian of Sardinia (Meneghini, 1857), Bohemia (Barrande, 1866, 1870; Ristedt, 1968), Afganistan and Southern Kazakhstan (Barskov, 1972).

Repository — Institute of Palaeontology, Modena University, cat. n. 18984-18987 (figured specimens), 18988-18990 (unfigured specimens).

Material studied — 74 specimens.

MICHELINOCERAS sp. 1

Pl. 3, fig. 2

Description — Orthoconic shell with circular cross section. Angle of expansion close to 6°. No or-

Authors	EARLY ONTOGENETIC STAGE					
	parameters specimens	Wp	Dc	Ds	ds	α
		$\frac{Wp}{Lp}$	$\frac{Dc}{Sd}$	$\frac{Ds}{Sd}$	$\frac{ds}{Sd}$	
RISTEDT, H., 1968	<i>M. michelini</i> Pl. 1, fig. 1	0.80	0.69	0.24	0.17	2°
SERPAGLI, E. & GNOLI, M.	<i>M. grande</i> Pl. 2, fig. 1	1.00	0.54	0.21	0.18	2°
ADULT STAGE						
MENEGHINI, G. 1857	<i>O. grande</i> Pl. C, fig. 4a	--	0.79	0.41	0.16	1°-2°
BARRANDE, J. 1870	<i>O. michelini</i> Pl. 381, fig. 5	--	0.92	0.37	0.10	2°
	<i>O. michelini</i> Pl. 381, fig. 14	--	0.89	0.36	0.10	2°-3°
RISTEDT, H., 1968	<i>M. michelini</i> Pl. 1, fig. 2	--	0.83	0.32	0.17	2°
BARSKOV, I. S. 1972	<i>M. michelini</i> Pl. 1, fig. 2	--	0.66	0.38	0.10	2°-3°
	<i>M. michelini</i> Pl. 2, fig. 1	--	1.50	0.35	0.15	1°-2°
	<i>M. michelini</i> Pl. 2, fig. 2	--	1.12	0.37	0.14	2°
SERPAGLI, E. & GNOLI, M.	N. cat. 18985	--	1.12	0.36	0.11	3°
	N. cat. 18986	--	1.20	0.41	0.14	2°-3°
	N. cat. 18988	--	0.98	0.34	0.19	2°
	N. cat. 18989	--	0.85	0.33	0.11	2°-3°

Tab. 1 - Wp = Width of protoconch; Lp = Length of protoconch; Dc = Depth of camerae; Sd = Shell diameter; Ds = depth of septa; ds = Diameter of siphuncle; α = Angle of expansion of phragmocone; Lc = Longest camera of the initial portion of the conch.

nament has been observed. Sutures straight, simple and transverse. Camerae very short, about $1/6$ the shell diameter. Septa very thin, if compared to the thickness of the shell wall, and moderately concave. Their depth $1/4$ the shell diameter. Siphuncle eccentric slightly less than its own diameter. Septal foramen about $1/9$ the shell diameter. Septal necks short, orthochoanitic, their length $1/2$ the diameter of septal foramen. Connecting rings mostly cylindrical, only slightly expanding within camerae. No deposits have been observed.

Remarks — The only specimen available, which is one of the largest nautiloids recovered by us, is externally poorly preserved. Anyway it seems to lack surface features.

Michelinoceras sp. 1 is closely related in internal structures to the specimen illustrated by Barrande (1868) in figures 3-5 of plate 327 and named *Orthoceras apollo*. Siphuncle eccentricity, depth of camerae, curvature of septa, septal foramen to shell diameter ratio and length of septal necks are, in fact, almost identical.

Anyway, it is not possible to use the name *apollo* for this form because the holotype (selected by Barrande, pl. 255, figs. 11-14) actually belongs to the Kionoceratinae being longitudinally sculptured.

Occurrence — Upper Silurian of Bohemia ? (Barrande, 1868, pl. 327, figs. 3-5).

Repository — Institute of Palaeontology, Modena University, cat. n. 18991 (figured specimen).

Material studied — One specimen.

MICHELINOCERAS sp. 2

Pl. 3, figs. 1a, b

Description — Orthoconic shell with circular cross section. Angle of expansion close to 5° . Orna-

ment probably of fine transverse growth lines. Sutures straight, simple and ventrorad oblique. Camerae deep $1/3 - 1/2$ the shell diameter. Septa moderately concave, their depth being $1/4$ the shell diameter. Siphuncle subcentral, Septal foramen about $1/10$ the shell diameter. Septal necks orthochoanitic, long like the diameter of septal foramen. Connecting rings slightly expanding. No deposits have been observed.

Remarks — This is the largest form recovered in Sardinia. One of the specimens reaches a diameter of 9 cm in the living chamber.

Michelinoceras sp. 2 is very similar in internal structures to the specimen reported by Barrande (1870) in figure 1 of plate 377 and named *Orthoceras migrans*. However, the other types of this species are so different that they belong to the genus *Temperoceras*.

Occurrence — Upper Silurian of Bohemia? (Barrande, 1870, pl. 377, fig. 1).

Repository — Institute of Palaeontology, Modena University, cat. n. 18992-18993 (figured specimens), 18994 (unfigured specimens).

Material studied — 7 specimens.

MICHELINOCERAS sp. 3

Pl. 2, figs. 7a, b; text-fig. 4

Description — Orthoconic shell with circular cross section. Angle of expansion probably very narrow. No ornament has been observed. Sutures straight, simple and transverse. Camerae short, about $1/3$ the diameter. Septa moderately concave, their depth $1/4$ the shell diameter. Siphuncle eccentric in the first two chambers and then subcentral. Septal foramen about $1/8$ the shell diameter. Septal necks

EXPLANATION OF PLATE 3

Figs. 1a, b - *Michelinoceras* sp. 2.

1a, dorsoventral section, x1 (n. 18992).

1b, outer mould of the ornamentation of the same specimen, x2 (n. 18993).

Fig. 2 - *Michelinoceras* sp. 1, dorsoventral section, x1 (n. 18991).

Figs. 3, 4 - *Plagiostomoceras gruenewaldti* (Barrande).

3, lateral view, x5 (n. 18996).

4, dorsoventral section of another specimen tho show some inner features, x8 (n. 18997).

Figs. 5a, b - *Plagiostomoceras* cf. *pleurotomum* (Barrande).

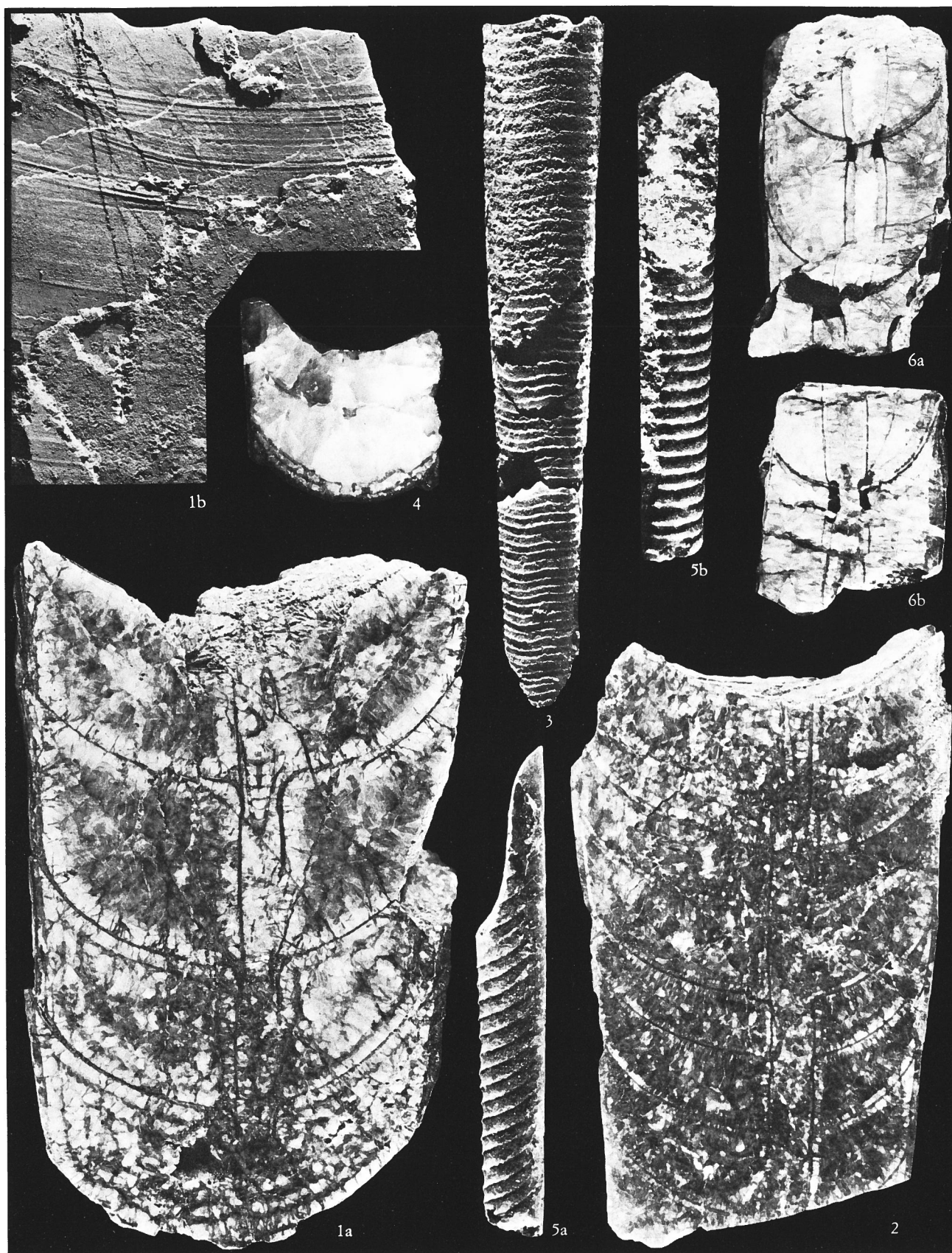
5a, lateral view, x6 (n. 18999).

5b, ventral view of the same specimen, x6.

Figs. 6a, b - *Columenoceras* sp. cf. *columen* (Barrande).

6a, dorsoventral section, x1 (n. 19074).

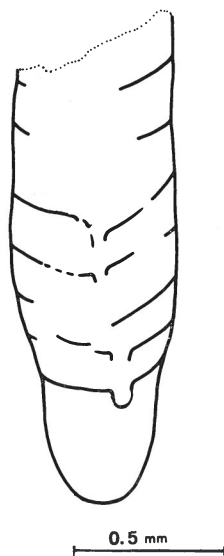
6b, dorsoventral section of another fragment of the same specimen, x1.



orthochoanitic and long equal to diameter of the septal foramen. No internal deposits have been observed. Protoconch ogival in shape, length to width ratio about 1.28. Caecum very short.

Remarks — This form, even if preserved only in the early ontogenetic stage, is of interest because of the shape of the protoconch. The latter, in fact, seems to be transitional between that of *Michelinoceras* and *Sphaerorthoceras* ? *sensu* Ristedt.

Repository — Institute of Palaeontology, Modena University, cat. n. 18995 (figured specimen).



Text-fig. 4 - *Michelinoceras* sp. 3, redrawing of the specimen figured in pl. 2, fig. 7b for a better understanding of inner features (n. 18995).

Genus PLAGIOSTOMOCERAS

Teichert & Glenister, 1952

Type-species — *Orthoceras pleurotomum* Barrande, 1860.

PLAGIOSTOMOCERAS GRUENEWALDTI (Barrande, 1866)

Pl. 3, figs. 3, 4

1857 *Orthoceras* sp. MENEGHINI, pp. 209, 210, pl. C, figs. 12a-d.

1866 *Orthoceras gruenewaldti* BARRANDE, pl. 217, figs. 18, 19.

1868 *Orthoceras gruenewaldti* BARRANDE, pl. 315, figs. 1-19.

1874 *Orthoceras gruenewaldti* BARRANDE, pp. 373, 374.

1877 *Orthoceras gruenewaldti* BARRANDE, pl. 476, fig. VIII.

Description — Orthoconic shell with a faintly compressed cross section. Angle of expansion of the

adult part of the shell close to 4.5 degrees. Fine characteristic transversal ridges perpendicular or slightly inclined to the axis of the conch occur on the outer surface, 3 per millimeter. The ridges, which are shallowly lobated on ventral and dorsal sides and partly imbricated in aspect, become gradually more spaced towards the apex. Sutures straight and slightly oblique. Camerae short, about 1/3 the dorso ventral diameter. Septa concave, their depth being 1/4 the shell diameter. Siphuncle small, subcentral, about 1/10 the shell diameter. Septal necks short, orthochoanitic, their length being equivalent to the diameter of the septal foramen.

Remarks — Considerable difficulties are encountered in determining the specific position of this form because of the lack of a revision of Bohemian fauna. In fact several of Barrande's species, belonging to this genus, are very similar and the differences seem to be insufficient also at a specific level. For instance we believe that « *O.* *timidum* Barrande lies close to « *O.* *gruenewaldti* and the two species can be regarded as synonyms.

The specimen reported by Meneghini as *Orthoceras* sp. (plate C, fig. 12) has been directly compared with our material and according to us it belongs here.

Occurrence — Upper Silurian of Bohemia (Barrande, 1866, 1868, 1874) and of Sardinia (Meneghini, 1857).

Repository — Institute of Palaeontology, Modena University, cat. n. 18996, 18997, (figured specimens), 18998 (unfigured specimens).

Material studied — 11 specimens.

PLAGIOSTOMOCERAS cf. PLEUROTOMUM

(Barrande, 1860)

Pl. 3, figs. 5a, b

1860 *Orthoceras pleurotomum* BARRANDE, pl. 9, figs. 21-23.

1866 *Orthoceras pleurotomum* BARRANDE, pl. 224, figs. 12-14.

1868 *Orthoceras pleurotomum* BARRANDE, pl. 296, figs. 1-24.

1870 *Orthoceras pleurotomum* BARRANDE, pl. 366, figs. 1-4.

1874 *Orthoceras pleurotomum* BARRANDE, pp. 412, 413.

1931 *Orthoceras pleurotomum* Barrande - TEICHMÜLLER, p. 17.

1952 *Plagiostomoceras pleurotomum* (Barrande) - TEICHERT & GLENISTER, pl. 105, figs. 4, 5.

Description — Orthoconic shell with slightly elliptic cross section. Angle of expansion of the adult part of the conch close to 3 degrees. Weak characteristic sinuous ridges, regularly spaced, and in number of two per 1 mm, cover the whole outer surface. They have a strongly oblique slope across the flanks

(40°), are almost horizontal on the ventral side and become lobate and fine as they approach the dorsal side of the shell. Inner features of phragmocone and larval portion not preserved.

Remarks — The outer features are so characteristic that even if one fragment of the living chamber is available it is possible to state good affinities to one Bohemian species. In particular, the specimen figured by Barrande on plate 293 figures 9-13 and named *O. pleurotomum* shows close similarities to the Sardinian form.

It is interesting to point out that this species was established in 1860 and not in 1866 as was commonly thought because in that year Barrande figured the species in a paper dealing with septal truncature.

Occurrence — Silurian of Bohemia (Barrande, 1866, 1868, 1870, 1874) and Sardinia (Teichmüller, 1931).

Repository — Institute of Palaeontology, Modena University, cat. n. 18999 (figured specimen), 19000 (unfigured specimens).

Material studied — 5 specimens.

Genus « *PARASPHAERORTHOCERAS* » Ristedt, 1968

Type-species — *Parasphaerorthoceras accuratum* Ristedt, 1968.

Remarks — This genus needs more clarification because, except from the type species, it has been mostly based only on the early ontogenetic stages. Unfortunately our material does not permit us to reach a better concept of *Parasphaerorthoceras* because we have not been able to recover complete or nearly complete specimens.

As for the relationship between juvenile and mature parts there are 3 possibilities.

1) « *Parasphaerorthoceras* » gradually loses its ornament until it becomes completely or almost completely smooth towards the adoral part. This hypothesis is supported not only by the features of type species which adorally shows only fine ridges but also by new small ($\varnothing = 4$ mm) Sardinian fragments of phragmocone with ventrally eccentric siphuncle (Pl. 6 fig. 8) where the transversal ridges clearly disappear.

2) « *Parasphaerorthoceras* » keeps its ornament throughout the whole conch. This hypothesis is in contrast with the remarks reported above as well as with the high number of juvenile fragments recovered (almost 100) compared with the few mature fragments having transverse ornament. Such adult fragments can, anyway, be set in sound taxonomic places (*Plagiostomoceras*, *Orthocycloceras*).

3) The whole Sardinian population of « *Parasphaerorthoceras* » is represented by young specimens. This hypothesis may temporarily solve the problem of the relationship between juvenile and adult parts and could be supported by the fact that also in other areas, like Central Bohemia, such forms occur with the early ontogenetic stage only (see Kolečaba, 1973, plate II).

In any case we suspect that the mature phragmocones (if they exist) will be not so highly differentiated as supported by Ristedt (1968) from the embryonic part.

Without sound information concerning adult phragmocones of this singular group of forms, their generic position must remain partly uncertain. However, we accept temporarily the solution proposed by Ristedt who separates the embryonic portions only on the basis of outer morphology, even if we believe that his forms A-L will be reduced to a few species.

« *PARASPHAERORTHOCERAS* » sp. B
sensu Ristedt, 1968
Pl. 4, fig. 9

1968 *Parasphaerorthoceras* sp. B, RISTEDT, pp. 269, 271, pl. 4, figs. 3, 3a.

Remarks — No new information is available for this species. It is included here chiefly because of the fine surface markings and to the large size of the protoconch among the Sardinian « *parasphaerorthoceratids* ».

Occurrence — Upper Silurian of Sardinia (Ristedt, 1968).

Repository — Institute of Palaeontology, Modena University, cat. n. 19001 (figured specimen).

Material studied — One specimen.

« *PARASPHAERORTHOCERAS* » sp. H
sensu Ristedt, 1968
Pl. 4, figs. 11-15

1968 *Parasphaerorthoceras* sp. H, RISTEDT, pp. 275, 276, pl. 4, fig. 9; pl. 5, fig. 7.

Remarks — This is a fairly abundant form, though almost invariably represented by fragments of early ontogenetic stages, characterized by a wide angle of expansion of a post-embryonic portion.

Occurrence — Upper Silurian of Sardinia (Ristedt, 1968).

Repository — Institute of Palaeontology, Modena University, cat. n. 19002-19006 (figured specimens), 19007 (unfigured specimens).

Material studied — 24 specimens.

« PARASPHAERORTHOCERAS » sp. J

sensu Ristedt, 1968

Pl. 4, fig. 16

1968 *Parasphaerorthoceras* sp. J, RISTEDT, p. 277, pl. 4, figs. 11, 11a; pl. 5, fig. 5.

Remarks — Our specimens from Sardinia closely resemble Ristedt's form (1968, plate 4, figures 11, 11a) chiefly in the wide sigmoid outline of the lateral view, and it is not necessary to repeat the description here.

Occurrence — Upper Silurian of Sardinia, (Ristedt, 1968).

Repository — Institute of Palaeontology, Modena University, cat. n. 19008 (figured specimen), 19009 (unfigured specimens).

Material studied — 10 specimens.

« PARASPHAERORTHOCERAS » sp. K

sensu Ristedt, 1968

Pl. 4, fig. 10

1968 *Parasphaerorthoceras* sp. K, RISTEDT, pp. 277, 278, pl. 4, fig. 12.

Remarks — Taking into account the fairly wide degree of variation within « *Parasphaerorthoceras* »,

this form can be distinguished from others within the genus chiefly by its slender, elongated outline of the extreme apical part.

Occurrence — Upper Silurian of Sardinia (Ristedt, 1968).

Repository — Institute of Palaeontology, Modena University, cat. n. 19010 (figured specimen), 19011 (unfigured specimens).

Material studied — 7 specimens.

Genus PROTOBACTRITES Hyatt in Zittel, 1900

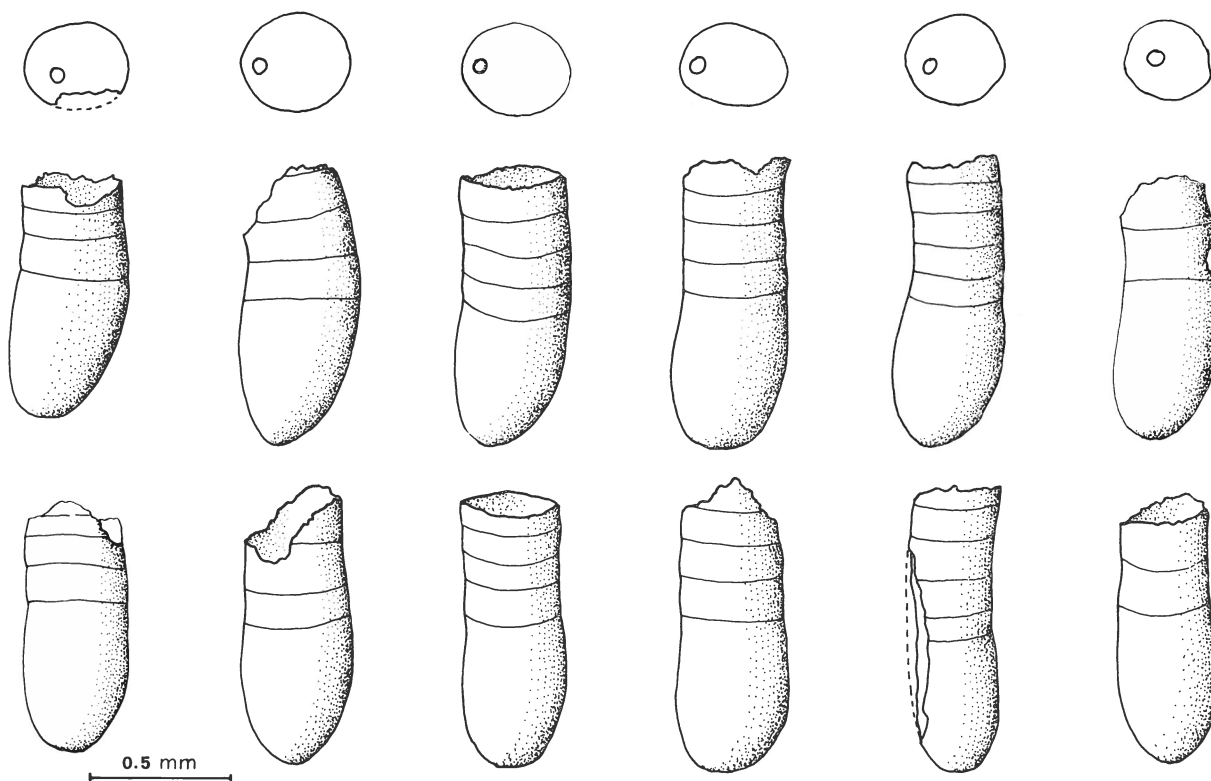
Type-species — *Orthoceras styloideum* Barrande, 1866.

PROTOBACTRITES ? sp.

Pl. 2, figs. 8, 9; text-figs. 5, 6

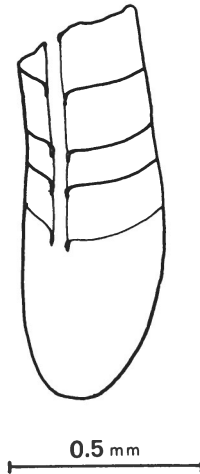
1968 *Protobactrites* (?) sp., RISTEDT, pl. 2, fig. 17.

Description — Embryonal, orthoconic shell with a slightly elliptical cross section. Angle of expansion, just after the earliest chambers, close to 1 degree. Outer surface apparently smooth. Suture straight, simple and transverse. Camerae moderately deep, $1/3$ to $1/2$ their diameter. Septa faintly curved, their depth being $1/5$ to $1/6$ the shell diameter. Siphuncle strongly eccentric with septal foramen about $1/8$ the



Text-fig. 5 - Ventral and lateral views and cross section of 6 specimens of *Protobactrites*? sp. to show variability in the shape of protoconch (n. 19018).

diameter of the shell. Septal necks short and orthochoanitic. Connecting rings apparently cylindrical. Protoconch paraboloid in shape, longer than wide, and slightly ventrally bent. Width to length ratio about 1.20.

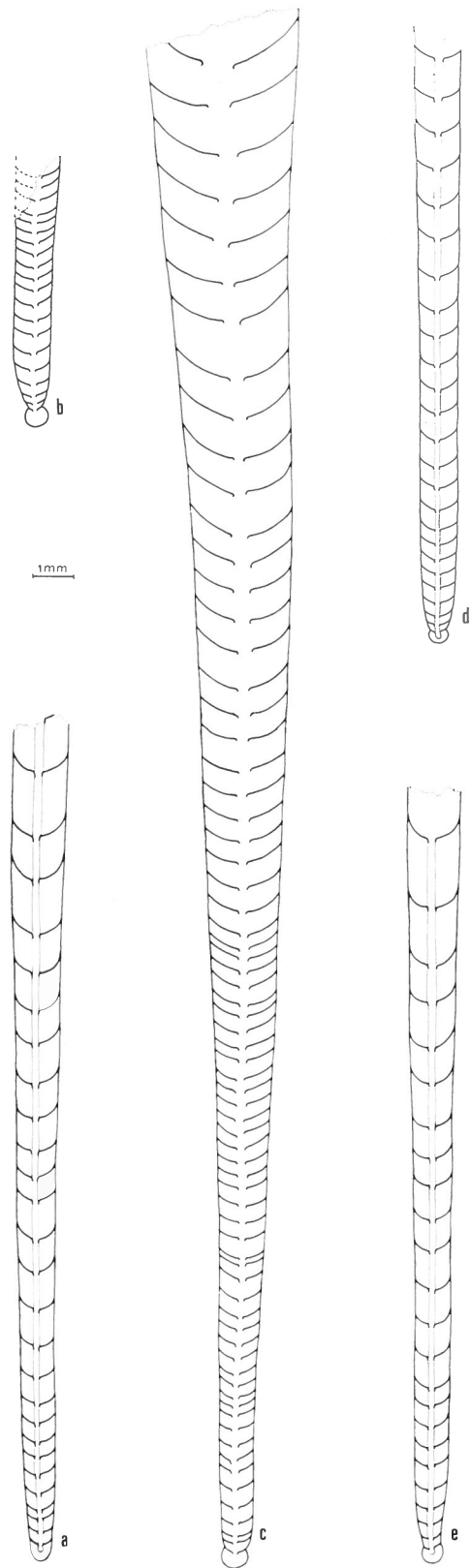


Text-fig. 6 - *Protobactrites* ? sp., dorsoventral section of the specimen figured in pl. 2, fig. 9 to show inner features (n. 19014).

Remarks — We have temporarily placed this group those embryonal forms characterized by subelliptical cross section, strongly eccentric siphuncle, and small paraboloid protoconch. Also, the forms identified by Ristedt (1968) as *Sphaerorthoceras* n. sp. C, D and E belong here.

These specimens, in which usually only protoconch and the early 3 to 6 chambers are preserved, cannot be distinguished on the basis of the present material and we refrain from identifying them in terms of any species.

Text-fig. 7 - a, *Michelinoceras grande* (Meneghini), diagrammatic dorsoventral section of the specimen figured in pl. 2, fig. 1 (n. 18984);
b, «*Sphaerorthoceras*» *beatum* Ristedt, diagrammatic dorsoventral section of the specimen figured in pl. 4, fig. 8 (n. 19019);
c, «*Sphaerorthoceras*» sp., diagrammatic dorsoventral section of the specimen figured in pl. 4, fig. 6 (n. 19030);
d, «*Sphaerorthoceras*» *teichert* Ristedt, diagrammatic dorsoventral section of specimen n. 19028;
e, «*Sphaerorthoceras*» *curvum* Ristedt, diagrammatic dorsoventral section of the specimen figured in pl. 4, fig. 5 (n. 19020).
Interesting to point out the similarity in the inner features of the post embryonic portion of figures a, b and e.



Occurrence — Upper Silurian of Sardinia (Ristedt, 1968).

Repository — Institute of Palaeontology, Modena University, cat. n. 19013, 19014 (figured specimens), 19015-19018 (unfigured specimens).

Material studied — 40 specimens.

Genus « SPHAERORTHOCERAS » Ristedt, 1968

Type-species — *Sphaerorthoceras beatum* Ristedt, 1968.

Remarks — On the whole we agree with Barskov's interpretation (1972) in regarding *Sphaerorthoceras* as a possible synonym of *Michelinoceras* because Ristedt has tended to establish new genera based almost exclusively upon embryonal outer morphology and because *Michelinoceras* appears to be a very uniform genus. Furthermore, the differences in the inner features of juvenile specimens of the two groups are practically absent. Transitional forms have been observed (see *Michelinoceras*? sp. 3). The significance of the construction as pointed out by I. Kolebaba (1973), as well as the shape of protoconch, need more clarification.

For the reason explained above and pending a revision of such groups of forms, the assignment of the following species to the genus *Sphaerorthoceras* is, therefore, doubtful.

« SPHAERORTHOCERAS » BEATUM Ristedt, 1968
Pl. 4, fig. 8; text-fig. 7b

1968 *Sphaerorthoceras beatum* RISTEDT, pp. 252, 253, pl. 2, fig. 1, pl. 3, fig. 4.

Remarks — Unfortunately, this species remains completely unknown, because we have not found mature phragmocones but only a fragment of an early ontogenetic stage, which confirms the occurrence of the species in Sardinia.

Occurrence — Upper Silurian of Southern France and Sardinia (Ristedt, 1968).

Repository — Institute of Palaeontology, Modena University, cat. n. 19019 (figured specimen).

Material studied — One specimen.

« SPHAERORTHOCERAS » CURVUM Ristedt, 1968
Pl. 4, figs. 4, 5; text-fig. 7e

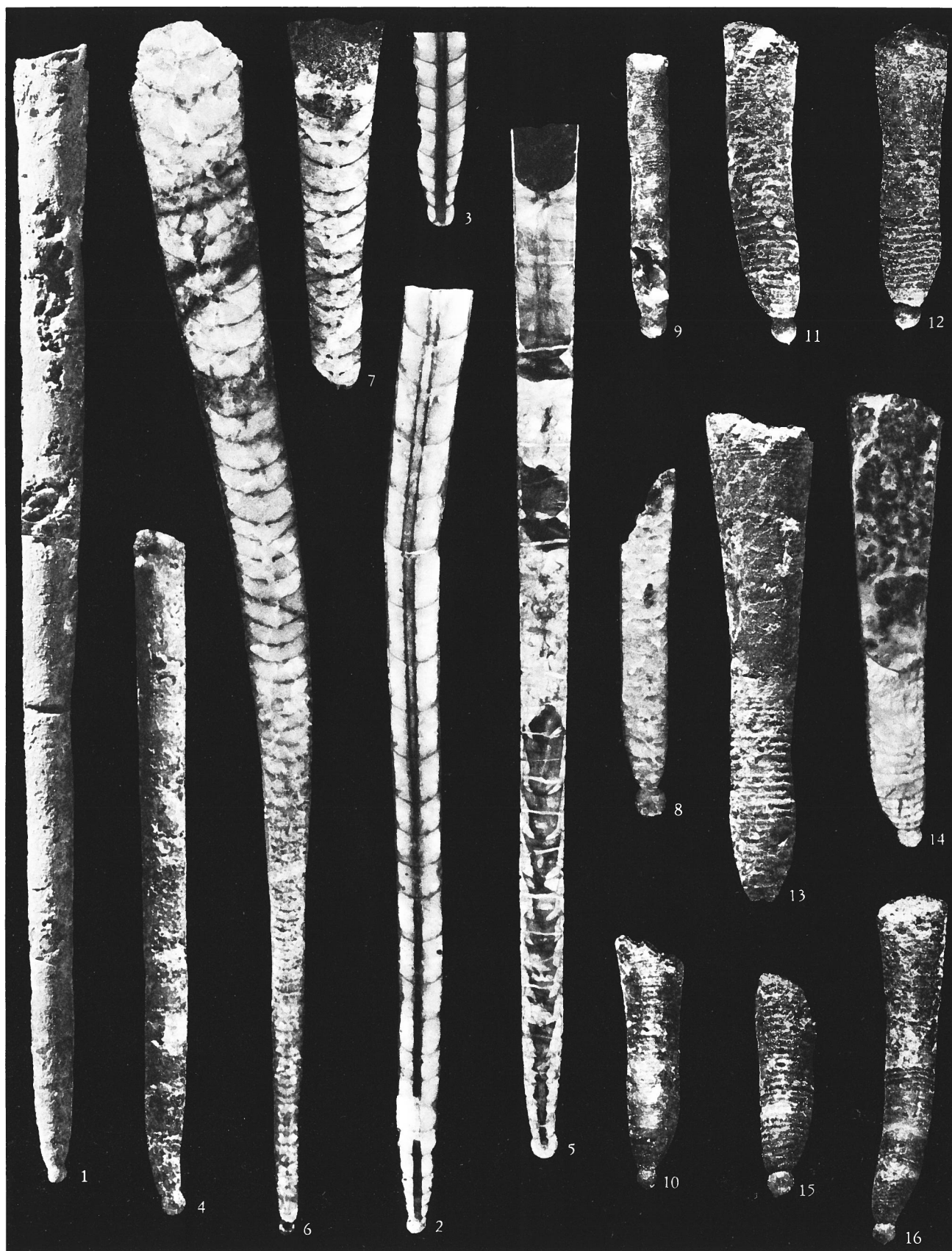
1968 *Sphaerorthoceras curvum* RISTEDT, pp. 255-256, pl. 2, figs. 6, 7; pl. 3, fig. 7.

Remarks — An accurate description of this species has been provided by Ristedt and the only additional feature discovered in the present investigation is the occurrence of cameral deposits. This fact is noticeable because they could provide a sound basis to differentiate the adult fragments of this species from those of *Michelinoceras grande* which could be free of deposits (see the supposition on page 164).

The post-embryonic portion of « *S.* » *curvum* is, in fact, very close to *M. grande* as far as length to

EXPLANATION OF PLATE 4

- Figs. 1-3 - « *Sphaerorthoceras* » *teichertii* Ristedt.
1, lateral view, x10 (n. 19024).
2, dorsoventral section, x10 (n. 19025).
3, dorsoventral section to show the trend of the caecum into the protoconch, x10 (n. 19026).
- Figs. 4-5 - « *Sphaerorthoceras* » *curvum* Ristedt.
4, lateral view, x10 (n. 19020).
5, dorsoventral section, x10 (n. 19021).
- Figs. 6-7 - « *Sphaerorthoceras* » sp.
6, dorsoventral section, x5 (n. 19030).
7, dorsoventral section, x2 (n. 19031).
- Fig. 8 - « *Sphaerorthoceras* » *beatum* Ristedt, dorsoventral section, x10 (n. 19019).
- Fig. 9 - « *Parasphaerorthoceras* » sp. B *sensu* Ristedt, lateral view, x10 (n. 19001).
- Fig. 10 - « *Parasphaerorthoceras* » sp. K *sensu* Ristedt, lateral view, x10 (n. 19010).
- Figs. 11-15 - « *Parasphaerorthoceras* » sp. H *sensu* Ristedt.
11, lateral view, x10 (n. 19002).
12, dorsal view, x10 (n. 19003).
13, dorsal view, x10 (n. 19004).
14, dorsoventral section, x10 (n. 19005).
15, lateral view, x10 (n. 19006).
- Fig. 16 - « *Parasphaerorthoceras* » sp. J *sensu* Ristedt, lateral view, x10 (n. 19008).



width ratio of chambers, degree of curvature of septa, features of siphuncle and angle of expansion of conch are concerned.

Therefore, «*Sphaerorthoceras*» *curvum*, which most probably is a *Michelinoceras* (p. 164), differs from *M. grande* in the features of protoconch and early embryonic chambers and, perhaps, in the occurrence of cameral deposits.

Occurrence — Upper Silurian of Sardinia (Ristedt, 1968).

Repository — Institute of Palaeontology, Modena University, cat. n. 19020, 19021 (figured specimens), 19022, 19023 (unfigured specimens).

Material studied — Four specimens.

«*SPHAERORTHOCERAS*» *TEICHERTI* Ristedt, 1968

Pl. 4, figs. 1-3; text-fig. 7d

1968 *Sphaerorthoceras teichertii* RISTEDT, p. 254, 255, pl. 2, figs. 4, 5, pl. 3, fig. 5.

Remarks — This species has been carefully described by Ristedt and it is not necessary to repeat the description here. An important additional feature pointed out by the present investigation is the shape of caecum which crosses the protoconch for about 3/4 of its length. Also the remaining inner characters, such as shape and trend of siphuncle, curvature of

septa, depth of camerae, are well illustrated for the first time.

«*Sphaerorthoceras*» *teichertii* differs from «*S.*» *curvum* in having the following features: (1) angle of expansion just after protoconch (= K. n. d. l. E. of Ristedt) wider; (2) lack of cameral deposits; (3) chambers shorter.

Further data are tabulated in tab. 2.

Occurrence — Upper Silurian of Sardinia (Ristedt, 1968).

Repository — Institute of Palaeontology, Modena University, cat. n. 19024-19026 (figured specimens), 19027-19029 (unfigured specimens).

Material studied — 9 specimens.

«*SPHAERORTHOCERAS*» sp.

Pl. 4, figs. 6, 7; text-fig. 7c

Description — Orthoconic shell with a circular cross section. Angle of expansion varying from 4 degrees adapically to 6 degrees in the post-embryonal part. Surface apparently smooth. Sutures straight, simple and transverse. Camerae very short, variable from 1/4 to 1/5 the diameter of the shell. Septa concave, medially 1/4 the shell diameter. Siphuncle central with a narrow septal foramen (about 1/7 the shell diameter). Septal necks very short, ortho-

Authors	parameters specimens	Wp	Dc	Ds	ds	α	
		Lp	Sd	Sd	Sd		
RISTEDT, H. 1968	Pl. 2, fig. 5	1.24	0.50	0.17	--	1°-2°	<i>S. teichertii</i>
SERPAGLI, E. & GNOLI, M.	N. cat. 19027	---	0.49	0.19	0.18	1°-2°	
	N. cat. 19026	1.13	0.46	0.18	0.10	1°-2°	
	N. cat. 19028	1.22	0.46	0.18	0.19	1°-2°	
	N. cat. 19025	1.00	0.58	0.22	1.18	1°-2°	
RISTEDT, H. 1968	Pl. 2, fig. 6	1.04	0.50	0.20	--	4°	<i>S. curvum</i>
SERPAGLI, E. & GNOLI, M.	N. cat. 19022	1.17	0.63	0.18	0.19	2°-3°	
	N. cat. 19021	1.11	0.63	0.19	0.18	2°-3°	

Tab. 2 - Wp = Width of protoconch; Lp = Length of protoconch; Dc = Depth of camerae; Sd = Shell diameter; Ds = depth of septa; ds = Diameter of siphuncle; α = Angle of expansion of phragmocone.

choanitic in the first 30 chambers, and gradually becoming suborthochoanitic. Connecting rings never preserved. Protoconch globular in shape, width to length ratio about 1.12. Caecum developed for 2/3 of the protoconch.

Remarks — This form, even if it isn't common in the Upper Silurian of Sardinia, is distinctive in central siphuncle which changes from orthochoanitic (early portion) to suborthochoanitic (mature conch), in a rapid rate of expansion, and in shallow chambers. All these features have been followed through the 70 camerae of one specimen. Part of the living chamber, whose real length is difficult to state, has been preserved in another specimens.

The slight curvature noted in one specimen (Pl. 4, fig. 6) at the height of the 50th chamber is regarded as of post burial origin mostly because it doesn't take place gradually.

This form, which is tentatively placed in « *Sphaerorthoceras* », is of interest because it shows that the transition from orthochoanitic to suborthochoanitic siphuncle occurs inside the same specimen.

Repository — Institute of Palaeontology, Modena University, cat. n. 19030, 19031 (figured specimens), 19032 (unfigured specimens).

Material studied — 6 specimens.

Subfamily LEUROCYCLOCERATINAE Sweet, 1964

Genus AKROSPHAERORTHOCERAS Ristedt, 1968

Type-species — *Akrosphaerorthoceras gregale* Ristedt, 1968.

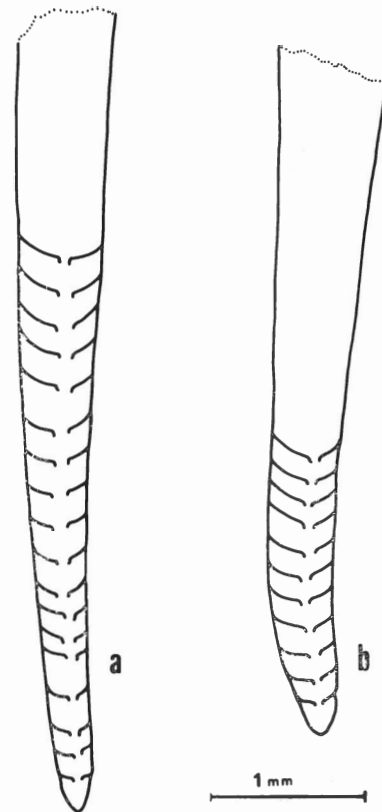
1968 *Akrosphaerorthoceras* RISTEDT, p. 282.

Amended diagnosis — Shell straight, slowly cyrtcone in the embryonic part, adorally dilating. Angle of expansion reaching 6-7 degrees in the adult part. Cross section circular. Shell surface mostly smooth in the early ontogenetic stage and then becoming gradually transversely sculptured with a few (3-4) marked ridges alternating to numerous (7-9) fine lirae. Siphuncle eccentric. Septal necks orthochoanitic. Protoconch very small, ogival in shape with strongly pointed apex.

Remarks — The diagnosis of the genus is here amended and completed with features of the adult part because it was established only on the basis of early ontogenetic stage. In our topotypic material we have, in fact, recovered few complete specimens in which postlarval phragmocones are also preserved. It is interesting to point out that the occurrence of transverse sculpture has already been noted by Ristedt in the type-species description but this feature

has not been regarded as having a generic value. In fact in the diagnosis of the genus, Ristedt speaks about « glatter Schalenoberfläche ».

According to us the genus *Akrosphaerorthoceras* Ristedt can be temporarily placed in the subfamily Leurocyloceratinae Sweet owing to the presence of transversal annulations which are peculiar of the subfamily (Sweet, 1964, p. K 230).



Text-fig. 8 - a, b, diagrammatic dorsoventral section of two specimens of *Akrosphaerorthoceras gregale* Ristedt to show variability in the curvature of embryonal portion. Note that both specimens are complete of protoconch, phragmocone and large part of living chamber. (a = n. 19038; b = n. 19039).

AKROSPHAERORTHOCERAS GREGALE Ristedt, 1968

Pl. 5, figs. 5-9; text-fig. 8a, b

1968 *Akrosphaerorthoceras gregalis* RISTEDT, p. 283, pl. 5, figs. 14-16, text-fig. 4 (1c₈).

Description — Orthoconic shell, slowly cyrtcone in the embryonic part. Angle of expansion of the adult portion of the shell close to 6-7 degrees and decreasing adapically to about 4 degrees. Shell surface mostly smooth in the early ontogenetic stage and then becoming gradually transverse sculptured. Ornament beginning more or less 6 millimetres from

apex with 2 to 3 isolated transverse ridges which become subsequently closely spaced. Surface with low annulations more developed on ventral side. Ridges oblique to the axis of the conch and sloping adorally of about 10 degrees. Ornament following a pattern given by 3 to 4 well marked ridges on the annulations and 7 to 9 more fine lirae on the interspaces. Sutures straight, oblique, not related to the annulated pattern of the conch. Camerae short, $1/3$ to $1/2$ the diameter. Septa moderately concave, their depth being $1/5$ the diameter. Siphuncle ventrally eccentric more than its own diameter. Diameter of the septal foramen about $1/7$ the shell diameter. Septal necks orthochoanitic, their length being $1/2$ the diameter of the septal foramen. Connecting rings unknown. No deposit has been observed. Protoconch very small, ogival in shape with strongly pointed apex. Length to width ratio close to 0.77.

Remarks — As already noted in the generic discussion the occurrence of a few almost complete specimens has allowed us to reach a better concept of this species previously known only from the embryonic stage. It is interesting to note that the ornament, which begins a few millimetres after the apex, more or less at the end of early ontogenetic stage, becomes an important diagnostic feature of the species.

Fragments of fragmocones of the present form are distinguishable from equivalent parts of ornated species belonging to *Parasphaerorthoceras* or to *Merocycloceras* mostly on the basis of the pattern of ornamentation.

Occurrence — Upper Silurian of Sardinia (Ristedt, 1968).

Repository — Institute of Palaeontology, Modena University, cat. n. 19033-19037 (figured specimens), 19038-19041 (unfigured specimens).

Material studied — 25 specimens.

Genus ANASPYROCERAS Shimizu & Obata, 1935, emend. Flower, 1943

Type-species — *Orthoceras anellus* Conrad, 1843.

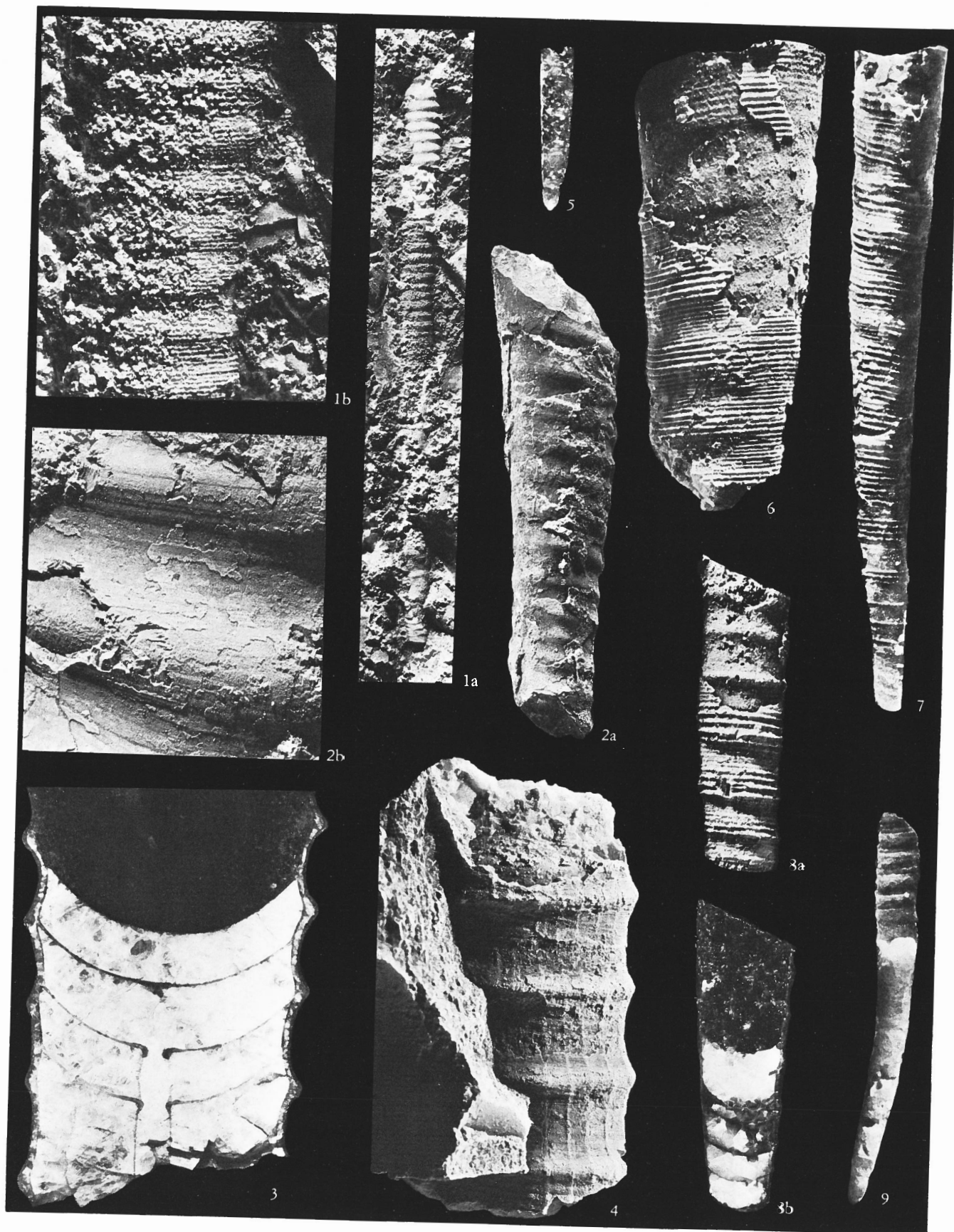
ANASPYROCERAS PSEUDOCALAMITEUM
(Barrande, 1852)
Pl. 5, figs. 3, 4

- 1852 *Orthoceras pseudocalamiteum* Barrande, in QUENSTEDT, p. 342, pl. 26, fig. 8.
? 1866 *Orthoceras pseudocalamiteum* BARRANDE, pl. 217, figs. 8, 9.
1868 *Orthoceras pseudocalamiteum* BARRANDE, pl. 278, figs. 5, 16-20, 24-26, ?(1-4, 6-15, 21-23, 27-33); pl. 286, figs. 16, ?(11-15).
? 1870 *Orthoceras pseudocalamiteum* BARRANDE, pl. 361, figs. 15-17.
1874 *Orthoceras pseudocalamiteum* BARRANDE, pp. 261-264.
1968 *Anaspyroceras pseudocalamiteum* (Barrande) - RISTEDT, pp. 249, 250, pl. 1, fig. 13.

Description — Orthoconic shell with circular cross section. Apical angle 5° . Regular, transverse, well defined annulations on the whole conch. Interspaces widely concave, about twice as broad as the annulations. Shell surface bearing fine, regularly spaced longitudinal ridges, 14-30 in number. Minute transverse striae, parallel to the annulations, are also present. Living chamber partly preserved, probably quite long. Sutures straight, simple and transverse, not related to the annulated pattern of the conch. Camerae short, $1/4$ the diameter. Septa moderately

EXPLANATION OF PLATE 5

- Figs. 1a, b - *Orthocycloceras* ? cf. *lynx* (Barrande).
1a, external view, x2 (n. 19047).
1b, detail of the same specimen, x10.
Figs. 2a, b - *Orthocycloceras* ? *fluminense* (Meneghini).
2a, lateral view, x1 (n. 19046).
2b, detail of the same specimen to show the fine external ornament, x5.
Figs. 3, 4 - *Anaspyroceras pseudocalamiteum* (Barrande).
3, dorsoventral section, x4 (n. 19042).
4, lateral view, x5 (n. 19043).
Figs. 5-9 - *Akrosphaerorthoceras gregale* Ristedt.
5, lateral view, x10 (n. 19033).
6, lateral view to show the kind of ornament in adult part, x10 (n. 19034).
7, lateral view. Note the variation in the ornament going toward the adult part, x10 (n. 19035).
8a, lateral view, x10 (n. 19036).
8b, dorsoventral section of the same specimen, x10.
9, lateral view of the early portion of the conch.
Note that the first chambers are free of ornament and that the ornament begins later as it is visible on the outer mark. x10 (n. 19037).



concave, being as deep as $1/4$ the shell diameter. Siphuncle central, about $1/7$ the shell diameter. Septal necks very short, suborthochoanitic, their length being $1/4$ the diameter of the septal foramen. Connecting rings faintly expanded within camerae. Cameral deposits not known.

Remarks — Following Ristedt (1968), Bohemian specimens which do not show inner features, are dubiously placed in the synonym list. The typical ornament allows one to distinguish this species from closely related forms like «*Orthoceras*» *pulchrum* Barrande (1866, pl. 276) which is characterized by finer longitudinal ridges and a larger siphuncle. We would like to point out that some Sardinian specimens bear a higher number (14-30) of longitudinal ridges than reported by Ristedt (14-20).

Occurrence — Middle Silurian - Lower Devonian of Bohemia (Barrande, 1868).

Repository — Institute of Palaeontology, Modena University, cat. n. 19042, 19043 (figured specimens), 19044, 19045 (unfigured specimens).

Material studied — Five specimens.

Genus ORTHOCYCLOCERAS Barskov, 1972

Type-species — *Orthocycloceras alayense* Barskov, 1972.

ORTHOCYCLOCERAS ? FLUMINESE (Meneghini, 1857)

Pl. 5, figs. 2a, b; text-fig. 9

- 1855 *Orthoceras bohemicum* BARRANDE, p. 450 (*nomen nudum*).
- 1857 *Orthoceras fluminese* MENEGHINI, pp. 188, 189, pl. C, figs. 3a-c.
- 1857 *Orthoceras bohemicum* MENEGHINI, p. 197, pl. C, figs. 6A, a, a'.
- 1866 *Orthoceras bohemicum* BARRANDE, ?pl. 214, figs. 11-13; ?pl. 215, figs. 8-11.
- 1868 *Orthoceras bohemicum* BARRANDE, pl. 288, figs. 1-15; pl. 289, figs. 7-8; ?pl. 310, figs. 16-19.
- 1870 *Orthoceras fluminese* Meneghini - BARRANDE, p. 30.
- 1870 *Orthoceras bohemicum* Meneghini - BARRANDE, p. 30.
- 1874 *Orthoceras bohemicum* BARRANDE, pp. 315-317.
- 1936 *Orthoceras bohemicum* Barrande - TERMIER, H., p. 276.
- 1949 *Orthoceras bohemicum* Meneghini - COMASCHI CARIA, pp. 202, 335.
- 1949 *Orthoceras fluminese* Meneghini - COMASCHI CARIA, pp. 203, 335.
- 1966 *Michelinoceras* cf. *bohemicum* (Barrande) - BABIN, p. 323, pl. 13, fig. 2.

Description — Orthoconic conch with circular cross section. Angle of expansion of the adult part of the shell close to 6° . Wall of the shell ventrally corrugated into rounded and oblique annulations with broad concave interspaces. The annulations

while are gradually decreasing towards the dorsal side of the shell are, on the contrary, more marked near the aperture. Angle between ring-like expansions and axis of the shell slowly increasing adorally (100° at the base of the living chamber and 108° adaperturally).

Surface of the shell ornated by irregular transverse lirae (1 per mm) parallel to the annulations. Fine growth lines are also distinguishable. Septa concave, their depth being about one-third the diameter. Siphuncle subcentral. Septal necks short, orthochoanitic, their length being $1/4$ the diameter of the septal foramen. Diameter of septal foramen $1/10$ of the shell diameter.

Remarks — Morphological features described above have been jointly obtained studying either a 93 mm long fragmentary specimen mostly consisting of living chamber or the type of Meneghini (1857). Both specimens have been sampled in the same locality.

The lack of the most of the inner features, chiefly concerning siphuncle and cameral deposits, leaves some doubts about the generic position of this form. However, this species seems to bear one annulation in each chamber of the fragmocone (Barrande, pl. 288) and for this typical feature is probably more close to *Orthocycloceras* than to *Leurocycloceras*.

According to International Code of Zoological Nomenclature *Orthoceras bohemicum* does not belong to Barrande but to Meneghini because the latter author was the first (1867) to give a full description and illustration of this form. In fact the former citation of Barrande (1855) must be regarded as *nomen nudum*. However, because there are no distinctive characters between the two Meneghini's species *Orthoceras fluminese* and *Orthoceras bohemicum* (pattern of annulation and ornament are exactly the same), the only valid name of this form is *Orthoceras fluminese* Meneghini. Infact *O. fluminese* has been described on p. 188 whereas *O. bohemicum* on p. 197.

Occurrence — According to Barrande this Sardinian species has a widespread geographic distribution (Spain, Pyrenees, Bohemia) and seems to be stratigraphically restricted to Wenlock and Ludlow ages. Recently it has been reported from Silurian of Armorican Massiv, W. France (Babin), Oued Ifrane, Morocco (Termier, H., 1936).

Repository — Institute of Palaeontology, Modena University, cat. n. 19046 (figured specimen).

Material studied — One specimen.

ORTHOCYCLOCERAS ? cf. LYNX (Barrande, 1868)

Pl. 5, figs. 1a, b

1857 *Orthoceras subannulare* Münster - MENEGHINI, p. 206, pl. C, fig. 10 Ab.1868 *Orthoceras lynx* BARRANDE, pl. 336, figs. 21-26.1874 *Orthoceras lynx* BARRANDE, pp. 333, 334.

Description — Orthoconic shell with circular cross section. Angle of expansion 2 degrees. Wall of the conch corrugated into rounded and transverse annulations which are decreasing apically. Ten annulations in a length of ten mm. Surface of the shell sculptured by fine narrow transverse striae quite regularly spaced, averaging ten in the space between the crest of two of the annulations. No internal features were preserved.

Remarks — Owing to the lack of internal features it is difficult to find a satisfactory assignment to a genus and to a species. However, we believe that the present form may be related to « *Orthoceras* » *lynx* Barrande. As a matter of fact the same kind of ornamentation and the disappearance of annulation towards the apical part support this statement.

On the other hand, other Barrande's species like « *O.* » *consolans*, « *O.* » *opimum* and « *O.* » *extensum* are also quite similar in overall shape and in some morphological features to the Sardinian form. Only

a complete revision of Bohemian fauna will show probable synonymies between these annulated species.

Because Barrande (1874, p. 333) points out that the annulated pattern of *O. lynx* corresponds to the subdivision of the chambers, it is possible to include this species (even if with some doubts) into the genus *Orthocycloceras*.

Direct comparison between specimen doubtfully regarded by Meneghini (1857) as *Orthoceras subannulare* Münster and our material, allows one to state that the first belongs here.

Occurrence — Upper Silurian of Sardinia (Meneghini, 1857) and Bohemia (Barrande, 1868).

Repository — Institute of Palaeontology, Modena University, cat. n. 19047 (figured specimen), 19048 (unfigured specimens).

Material studied — 5 specimens.

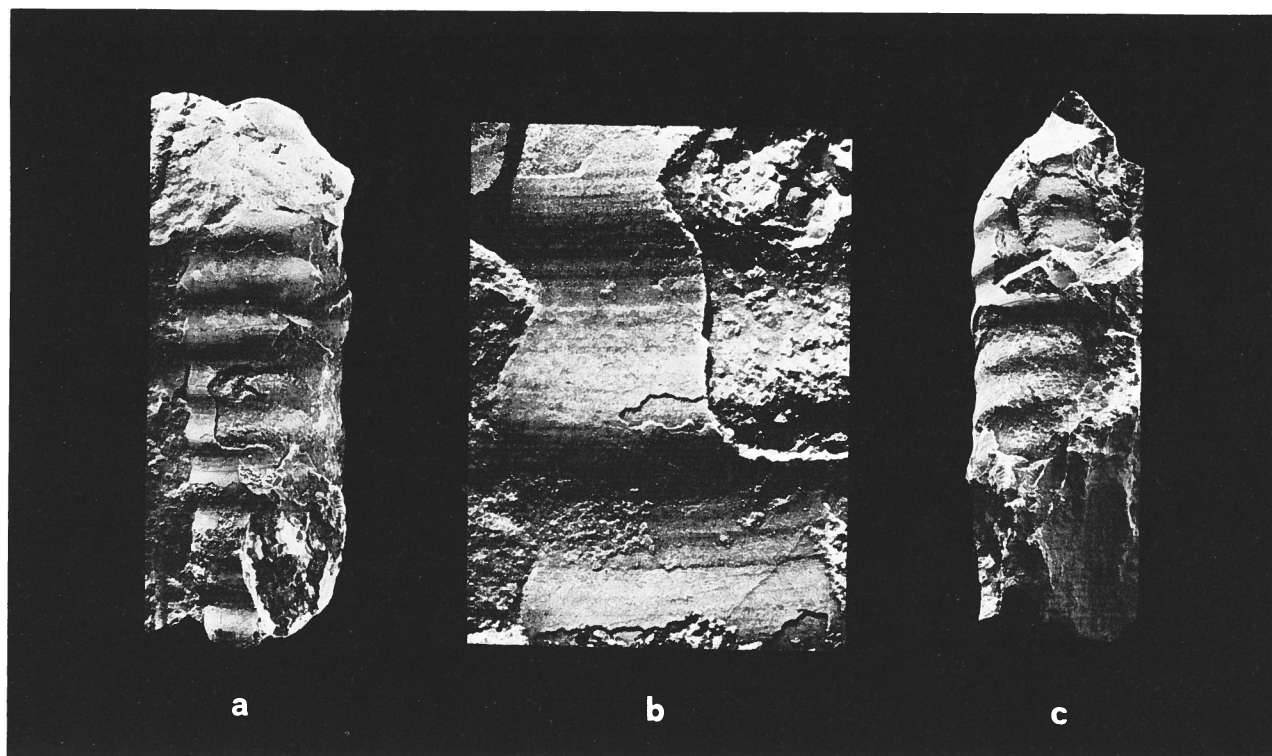
Genus MEROCYCLOCERAS Ristedt, 1968

Type-species — *Merocycloceras declive* Ristedt, 1968.

MEROCYCLOCERAS DECLIVE Ristedt, 1968

Pl. 6, fig. 1

1968 *Merocycloceras declivis* RISTEDT, p. 247, 248, pl. 1, figs. 8-11, text-fig. 3 (3d).



Text-fig. 9 - Holotype of *Orthocycloceras? fluminense* figured by Meneghini (1857) in pl. C, figs. 3a-c.

8a, ventral view, x1; 8b, detail of the same view, x5; 8c, lateral view, x1. (Specimen stored in the Museum of the Institute of Geol. and Paleont., Pisa University).

Remarks — This species has been carefully described by Ristedt and it is not necessary to repeat the description here. The preservation of the characteristic ornamentation leaves no doubt about the taxonomic position of the numerous specimens which, also, came from one of the localities sampled by Ristedt.

Occurrence — Lower Ludlow of Carnic Alps and Uppermost Wenlock-Ludlow of Sardinia (Ristedt, 1968).

Repository — Institute of Palaeontology, Modena University, cat. n. 19049 (figured specimen), 19050, 19051 (unfigured specimens).

Material studied — 17 specimens.

Subfamily KIONOCERATINAE Hyatt in Zittel, 1900

Genus KIONOCERAS Hyatt, 1884

Type-species — *Orthoceras doricum* Barrande, 1868.

KIONOCERAS DORICUM (Barrande, 1868)

Pl. 7, figs. 6a-c

1868 *Orthoceras doricum* BARRANDE, pl. 269, figs. 1-32.

1874 *Orthoceras doricum* BARRANDE, p. 242, 243.

1964 *Kionoceras doricum* (Barrande) - SWEET, p. K229, fig. 159, 1a-c.

Description — Faintly curved shell, narrowly conical, moderately dilating. Angle of expansion of the adult part of the shell close to 10 degrees. Cross section circular. Surface ornamented with longitudinal ridges and less conspicuous transverse striae in the concave interspaces between ridges. Living chamber short. Sutures straight, simple and transverse. Camerae short, medially 1/4 the diameter. Septa moderately concave, being as deep as 1/4 the shell diameter. Siphuncle slightly eccentric towards the convex side

of the shell but no more than its own diameter. This is 1/8 the shell diameter. Septal necks short, suborthochoanitic, their length being 1/3 the diameter of the septal foramen. Connecting rings faintly expanded within camerae. No cameral and endosiphuncular deposits noted.

Remarks — Inner and outer features allow one to reach a specific determination even if only two incomplete specimens are available.

Kionoceras baccus (Barrande) is quite similar to the present species from which it can be distinguished by the more elaborated ornamentation, the more eccentric siphuncle and the less developed septal necks.

Occurrence — Middle and Upper Silurian of Bohemia (Barrande, 1864, 1874).

Repository — Institute of Palaeontology, Modena University, cat. n. 19052 (figured specimens).

Material studied — 1 specimen.

Genus PARAKIONOCERAS Foerste, 1928

Type-species — *Orthoceras originale* Barrande, 1868.

PARAKIONOCERAS ORIGINALE (Barrande, 1868)

Pl. 7, fig. 5

1855 *Orthoceras originale* BARRANDE, p. 450 (*nomen nudum*).

1868 *Orthoceras originale* BARRANDE, pl. 267, figs. 1-20.

1874 *Orthoceras originale* BARRANDE, p. 206-209.

1928 *Parakionoceras originale* (Barrande) - FOERSTE, p. 314.

1972 *Parakionoceras originale* (Barrande) - BARSKOV, p. 47, pl. 1, figs. 9, 10; pl. 2, fig. 14.

Remarks — The species has been carefully described by Barrande (1874) and by Barskov (1972) and it is not necessary to repeat the description here.

EXPLANATION OF PLATE 6

Fig. 1 - *Merocyloceras declive* Ristedt, lateral view, x10 (n. 19049).

Figs. 2a, 7 - *Arionoceras affine* (Meneghini).

2a, dorsoventral section, x5 (n. 19055).

2b, lateral view of the same specimen, x5.

3, dorsoventral section very enlarged to show cameral deposits, x10 (n. 19056).

4, dorsoventral section of an adult specimen, x2 (n. 19057).

5, dorsoventral section of the embryonal portion, x10 (n. 19058).

6, lateral view, x2 (n. 19059).

7, dorsoventral section of the holotype, x2 (Museum of the Institute of Geol. and Palaeont., Pisa University).

Fig. 8 - «*Parasphaerorthoceras*» sp., lateral view. Note that the ornament gradually disappears adorally, x10 (n. 19012).

Figs. 9a, b - *Arionoceras submoniliforme* (Meneghini).

9a, dorsoventral section of a juvenile specimen in which protoconch, 6 chambers and living chamber are preserved, x10 (n. 19066).

9b, lateral view of the same specimen, x10.



The preservation of the characteristic ornamentation, given by sharp-edged longitudinal ridges separated by broader concave interspaces, leaves no doubt about the taxonomic position of Sardinian specimens.

The presence of this species in Sardinia extends the record to include the Mediterranean region.

Occurrence — Silurian of Bohemia (Barrande, 1868, 1874) and Upper Silurian of Southern Kazakhstan (Barskov, 1972).

Repository — Institute of Palaeontology, Modena University, cat. n. 19053 (figured specimen), 19054 (unfigured specimens).

Material studied — 11 specimens.

Family GEISONOCERATIDAE Zhuravleva, 1959

Genus ARIONOCERAS Barskov, 1966

Type-species — *Orthoceras affine* Meneghini, 1857 (non *O. arion* Barrande).

1966 *Arionoceras* BARSKOV, p. 20.

1968 *Psilorthoceras* RISTEDT, p. 263.

1970 *Arionoceras* Barskov - BARSKOV & KISELEV, p. 350.

1972 *Arionoceras* Barskov - BARSKOV, p. 40, 41.

Amended diagnosis — Shell straight or weakly bent, narrowly conical, moderately dilating. Angle of expansion 6-10°. Cross section circular. Shell surface smooth or with weak transverse sculpture. Siphuncle central. Septal necks suborthochoanitic, very short, acuminate, their length less than the diameter of the septal foramen. Connecting rings cylindrical. Owing to the slight but sharp bend of the septal necks, the segments of the siphuncle acquire a distinct constriction in the septal foramen. Protoconch large, pointed apically, ogival in shape and bent ventrally. A long caecum crosses the whole protoconch. Cameral deposits developed in the apical chambers of adult specimens.

Remarks — In our Sardinian collection some complete and well preserved specimens of orthoceratids occur, which, on the basis of features of the protoconch and the early stage, are referable to *Psilorthoceras* Ristedt (1968), whereas the mature conch shows exactly the same characters of the genus *Arionoceras* Barskov, 1966. As things are, we believe that, according to the zoological rules, *Psilorthoceras* must be regarded as a junior synonym of *Arionoceras*.

The diagnosis of the last genus is here amended and completed with the features of the initial parts of the conch. It is interesting to point out that the irregular occurrence of lining like siphuncular deposits, sometimes noted, suggest that *Arionoceras* could

belong to Geisonoceratidae instead of Michelinoceratidae. This supposition has been already pointed out in 1972 by the Russian palaeontologists Barskov (p. 33) and Kiselev (p. 428) chiefly on the basis of reexamination of members of *Psilorthoceras* (= *Arionoceras*) from the topotypic material of Czechoslovakia.

Kiselev (1975) regards the genus *Psilorthoceras* synonym of *Temperoceras* Barskov, 1950, but, as pointed out above, the mature conchs are more close to *Arionoceras*.

For reasons, which will be discussed below, *A. affine* (Meneghini) must be regarded as the new type species of the genus *Arionoceras*.

ARIONOCERAS AFFINE (Meneghini, 1857)

Pl. 6, 2a, b-7; text-fig. 10b

1857 *Orthoceras affine* MENEGHINI, pp. 217, 218, pl. C, fig. 16.

1857 *Orthoceras canonicum* MENEGHINI, pp. 199-201, pl. C, figs. 7a'-a''.

p. 1857 *Orthoceras simplex* Desnoy - MENEGHINI, pl. C, figs. 4Ac, c', c''.

1868 *Orthoceras arion* BARRANDE, pl. 347, figs. 3, 4.

1870 *Orthoceras arion* BARRANDE, pl. 408, figs. 13, 14.

1870 *Orthoceras affine* Meneghini - BARRANDE, p. 30.

1874 *Orthoceras arion* BARRANDE, pp. 619, 620.

1949 *Orthoceras affine* Meneghini - COMASCHI CARIA, p. 202.

1949 *Orthoceras canonicum* Meneghini - COMASCHI CARIA, p. 203.

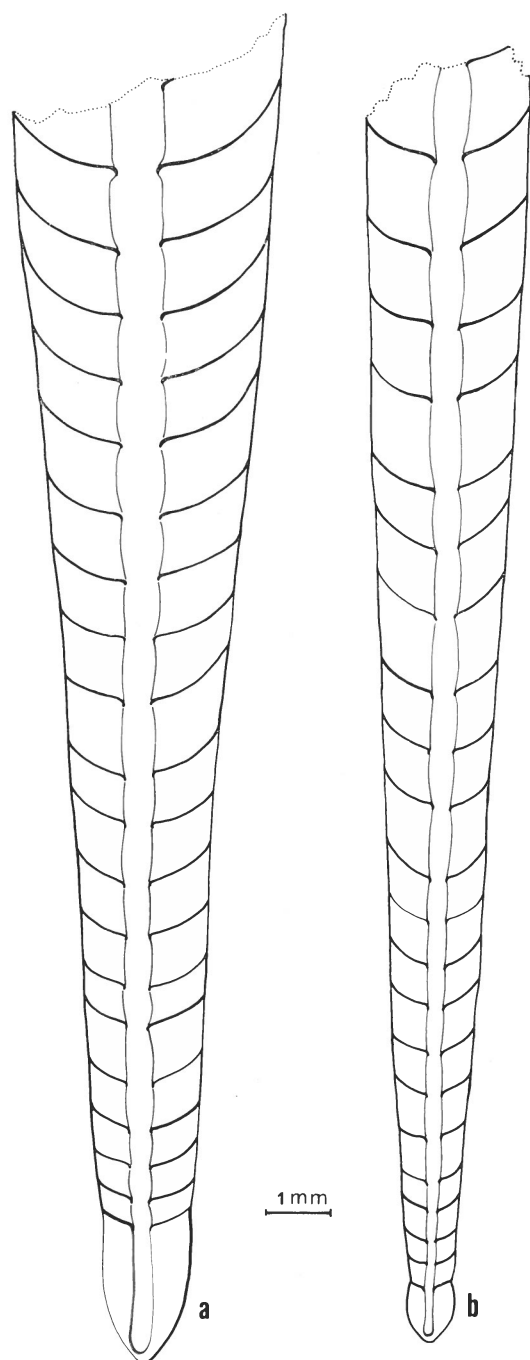
1970 *Arionoceras arion* (Barrande) - BARSKOV & KISELEV, p. 70, pl. 3, fig. 6.

1972 *Arionoceras arion* (Barrande) - BARSKOV, p. 41, pl. 2, figs. 12a, b.

Description — Orthoconic shell with subcircular cross section. Angle of expansion of the initial portion of the shell close to 5-6°, increasing adorally to 7-8°. Shell surface sculptured by fine and irregular growth lines, three to four per 1 mm. Suture straight, simple and transverse. Camerae short, 1/2 the diameter. Septa concave, with mural part more arched, their depth being about one-third the diameter. Siphuncle subcentral, about 1/6 of shell diameter apically and about 1/9 in the mature conch. Septal necks very short, suborthochoanitic, their length half the diameter of the septal foramen. Necks sharply bent, but not yielding distinct brims. Connecting rings cylindrical, extending from acuminate ends of septal necks. Segments of siphuncle cylindrical in region of connecting rings and sharply constricted in septal foramen. Mural and episeptal deposits developed in the apical part of adult specimens. Early ontogenetic portion includes protoconch and about 6 camerae. Protoconch large, pointed apically, ogival in shape

and ventrally bent. Width to length ratio about 0.83. A long caecum crosses the whole protoconch.

Remarks — A comparative study of our newly collected material with that of Meneghini's collection



Text-fig. 10 - a, *Arionoceras submoniliforme* (Meneghini), diagrammatic dorsoventral section of specimen figured in pl. 7, fig. 2 (n. 19068); b, *Arionoceras affine* (Meneghini), diagrammatic dorsoventral section of specimen figured in pl. 6, fig. 2a (n. 19055).

housed in the Museum of the Geological and Palaeontological Institute (Pisa University), allowed us to reach the following remarks and conclusion.

There are no distinctive characters between the specimens of the two Meneghini's species *Orthoceras affine* and *O. canonicum*, and after direct comparison we believe that they belong to the same species. We choose *Orthoceras affine* as a valid species because the holotype is better preserved with a higher number of camerae. The type of *O. canonicum*, in fact, clearly shows one chamber instead of four as illustrated by Meneghini.

The two species of Meneghini have been established only on mature portions of phragmocone.

Our topotypic collection includes a high number of specimens, some of which are complete with the protoconch. In particular, in one specimen, besides protoconch, 33 camerae are preserved.

The adult parts of these complete specimens show the same inner and outer features like *O. affine* and *O. canonicum*.

Bohemian species *Orthoceras arion* Barrande, 1868, belongs here. In fact length of camerae, depth of septa, siphuncle diameter to shell diameter ratio, shape of septal necks and the faint outer ornamentation, are exactly the same as *O. affine* Meneghini, 1857.

One of the specimens regarded by Meneghini as *O. simplex* Desnoy and figured in plate C figs. 4Ac, c', c'', is also believed as belonging to *O. affine* owing to the complete similarity of inner features.

A closely related species is *Arionoceras procerum* (Ristedt) which is characterized by longer protoconch, closer septa and less developed early ontogenetic portion.

Occurrence — Upper Silurian of Sardinia (Meneghini, 1857) Bohemia (Barrande, 1868, 1870, 1874) and Southern Kazakhstan (Barskov & Kiselev, 1970; Barskov, 1972).

Repository — Institute of Palaeontology, Modena University, cat. n. 19055-19059 (figured specimens), 19060-19065 (unfigured specimens).

Material studied — 47 specimens.

ARIONOCERAS SUBMONILIFORME (Meneghini, 1857)

Pl. 6, figs. 9a, b, pl. 7, figs. 1-3;
text-figs. 10a, 11

1857 *Orthoceras submoniliforme* MENEGHINI, p. 202-204, pl. C, figs. 9b, 9b', non fig. 9a.

1857 *Orthoceras* sp. MENEGHINI, p. 215-216, pl. C, fig. 15.

1870 *Orthoceras submoniliforme* Meneghini - BARRANDE, p. 30.

1949 *Orthoceras submoniliforme* Meneghini - COMASCHI CARIA, pp. 204, 335.

1968 *Psilorthoceras procerum* RISTEDT, p. 265, pl. 3, figs. 11, 12, text-fig. 4 (1b₁).

1968 *Psilorthoceras subcrassum* RISTEDT, pp. 265, 266, pl. 3, figs. 13, 13a, 14, 15.

1968 *Psilorthoceras crassum* RISTEDT, pp. 266, 267, pl. 3, fig. 16.

Holotype — Not designated.

Lectotype — Specimen of plate C, figs. 9b, b'.

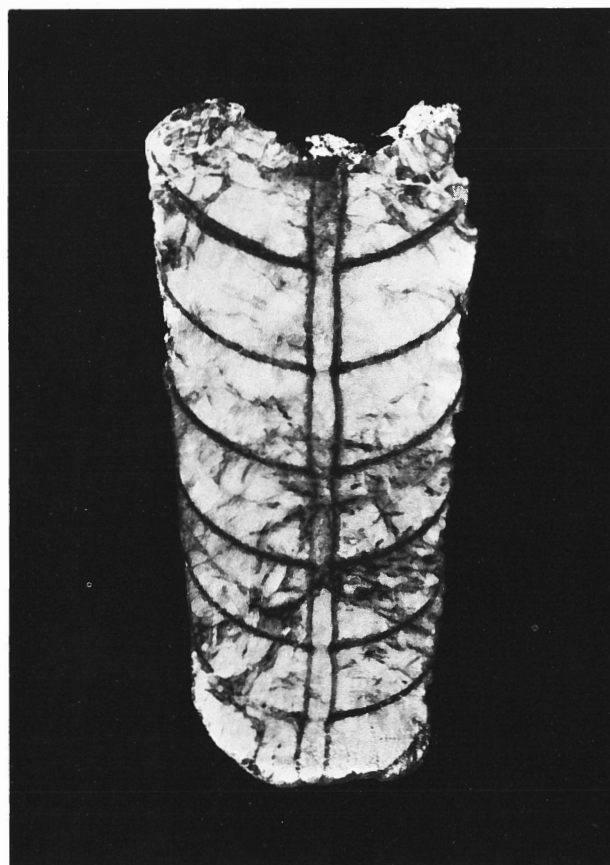
Description — Orthoconic shell almost imperceptibly curved ventrally and moderately dilating. Cross section subcircular. Angle of expansion of the initial portion of the phragmocone close to 5-7°, increasing adorally to 10°. Living chamber well developed, being longer than the phragmocone. Shell surface apparently smooth. Suture straight, simple and transverse. Camerae very short, 1/3 the diameter. Septa moderately concave, their depth being about 1/4 of the shell diameter apically, and 1/3 in the mature conch. Siphuncle slightly eccentric ventrally, 1/5 the shell diameter. Septal necks very short, acuminate, suborthochoanitic, their length 1/4 the diameter of the siphuncle. Connecting rings slightly expanding within camerae. Mural and episeptal deposits well developed in the apical portion of adult specimens; much more on the ventral side of the camerae. Lining-like siphonal deposits occur occasionally in some specimens. Early ontogenetic portion includes protoconch and about 5 camerae, gradually enlarging.

The next camera, which is very short, and the rapid increase of angle of expansion marks the end of early ontogenetic stage. Protoconch large, pointed apically, ogival in shape and bent ventrally. Its length usually more than 2 mm, width to length ratio lies between 0.59-0.63. A long caecum crosses the whole protoconch.

Remarks — Several complete specimens from Fluminimaggiore show the adult parts exactly the same as the lectotype of *O. submoniliforme* described

by Meneghini (1857, pl. C, figs. 9b, 9b') and the early ontogenetic portions identical to the species *Psilorthoceras crassum*, *subcrassum* and *procerum*, all of which come from the same locality (tab. 3).

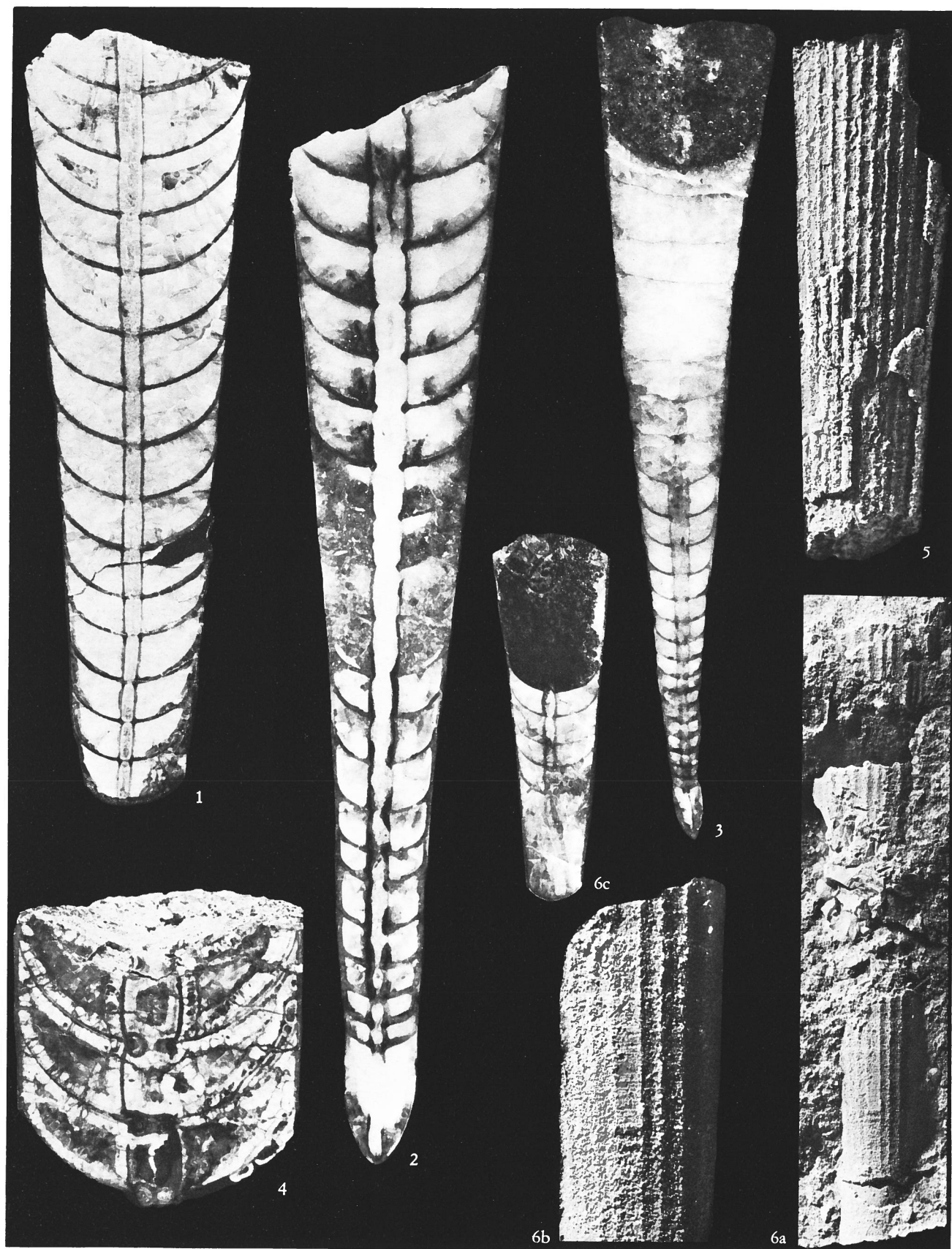
In 1968 Ristedt established 3 new species of the new genus *Psilorthoceras*, using material from Flu-



Text-fig. 11 - Lectotype of *Arionoceras submoniliforme* figured by Meneghini (1857) in pl. C, fig. 9b, x2. (Specimen stored in the Museum of the Institute of Geol. and Palaeont., Pisa University).

EXPLANATION OF PLATE 7

- Figs. 1-3 - *Arionoceras submoniliforme* (Meneghini).
 1, dorsoventral section of adult specimen, x2 (n. 19067).
 2, dorsoventral section of an apical portion of a mature specimen. Note the caecum and cameral and endosiphuncular deposits, x10 (n. 19068).
 3, dorsoventral section of a young complete specimen in which deposits have not yet developed, x5 (n. 19070).
 Fig. 4 - *Harrisoceras vibrayei* (Barrande), dorsoventral section, x1 (n. 19075).
 Fig. 5 - *Parakionoceras originale* (Barrande), external view, x10 (n. 19053).
 Figs. 6a-c - *Kionoceras doricum* (Barrande).
 6a, external view, x5 (n. 19052).
 6b, detail of the same specimen to show the minute transverse ornament, x10.
 6c, dorsoventral section of part of the same specimen, x5.



Authors	parameters specimens	Wp	d 1 st C	Dc	Ds	ds	α	Lc
		Lp		Sd	Sd	Sd		
SERPAGLI, E. & GNOLI, M.	N. cat. 19070	0.59	1.10	1/2-1/3	1/3	1/4-1/5	7°	V
	N. cat. 19071	0.57	1.12	-	-	-	-	-
	N. cat. 19069	0.69	1.08	1/3	1/4	1/5	6°-7°	V
	N. cat. 19066	0.69	1.32	1/2-1/3	1/4	1/5	7°-8°	V
	N. cat. 19068	0.58	1.30	1/2-1/3	1/3-1/4	1/5	5°	V
RISTEDT, H. 1968	<i>P. crassum</i>	0.51	1/25	1/3	1/4	1/4	5°	-
	<i>P. subcrassum</i>	0.58	1.25	1/2	1/3	1/6	4°-5°	IV
	<i>P. procerum</i>	0.55	0.96	1/2-1/3	1/4	1/6	4°	IV
MENECHINI, G. 1857	<i>Orthoceras</i> sp. Pl. C, fig. 15	-	-	1/3	1/4	1/6	8°-9°	-
	<i>O. submoniliiforme</i> Pl. C, fig. 9b	-	-	1/3	1/3-1/4	1/7	7°	-

Tab. 3 - Wp = Width of protoconch; Lp = Length of protoconch; d 1stC = Diameter of first constriction; Dc = Depth of camerae; Sd = Shell diameter; Ds = depth of septa; ds = Diameter of siphuncle; α = Angle of expansion of phragmocone; Lc = Longest camera of the initial portion of the conch.

minimaggiore. According to Ristedt, who was not informed of the paper of Meneghini, the 3 species differed from one another in features of protoconch and early ontogenetic stages.

Also following the method used by Ristedt, but with some differences in selecting parameters (i. e. we believe that instead of the absolute value of protoconch length and width, it is more suitable their ratio), we have obtained the following table which includes data from Ristedt and from our complete specimens.

The table 3 shows that:

1) there are no significant differences between *Psilorthoceras crassum*, *subcrassum* and *procerum*.

2) parameters obtained measuring our specimens are never exactly coincident with one of the 3 forms described by Ristedt but sometimes close to one and sometimes to another.

According to us the very slight differences can be included in the intraspecific variability or sometimes can be related to the difficulty in measuring.

For the reasons explained above we believe that

the 3 species of Ristedt are synonyms of the species of Meneghini. By direct comparison also *Orthoceras* sp. illustrated by Meneghini in pl. C, fig. 15 belongs to *A. submoniliiforme*.

Occurrence — Upper Silurian of Sardinia (Meneghini, 1857; Ristedt, 1968).

Repository — Institute of Palaeontology, Modena University, cat. n. 19066-19070 (figured specimens), 19071-19073 (unfigured specimens).

Material studied — 55 specimens.

Genus COLUMENOCERAS Barskov, 1960

Type-species — *Orthoceras columen*, Barrande, 1868.

COLUMENOCERAS sp. cf. C. COLUMEN
(Barrande, 1868)
Pl. 3, figs. 6a, b

Description — All the specimens studied are

sectioned parts of fragments of phragmocone and it is impossible to give a complete description.

Shell orthoconic with circular cross section. Suture straight, simple and transverse. Camerae long, 5/7 the diameter. Septa concave, their depth being about one-third the diameter, and jointing very gradually the inner surface of the wall. Siphuncle large, slightly eccentric, about 1/4 the shell diameter. Septal necks very short, suborthochoanitic, their length being about 1/2 the diameter of the septal foramen. Connecting rings expanding slightly within camerae. Annulosiphonate deposits in form of simple annuli, each of them mostly developed against neck and partly against upper ring. Thin episepal deposits are present.

Remarks — Owing to the lack of external features as well as the bad preservation of all specimens it is difficult to find a certain assignment to the species. However, we believe that the present form may be more or less closely related to *C. column* (Barrande). As a matter of fact, some features like length of chambers, concavity of septa, annulosiphonate deposits, size of siphuncle are very similar to Bohemian species.

Occurrence — *C. column* has been reported by Barrande (1868-1874) from Silurian of Bohemia and by Barskov (1960) from U. Silurian of Soviet Central Asia.

Repository — Institute of Palaeontology, Modena University, cat. n. 19074 (figured specimen), 19085 (unfigured specimen).

Material studied — 2 specimens.

Genus HARRISOCERAS Flower, 1939

Type-species — *Harrisoceras orthoceroide* Flower, 1939.

HARRISOCERAS VIBRAYEI (Barrande, 1866)

Pl. 7, fig. 4

1866 *Orthoceras vibrayei* BARRANDE, pl. 210, figs. 1-3; pl. 214, figs. 1-3; pl. 227, figs. 1(?), 9, 10.

? 1870 *Orthoceras vibrayei* BARRANDE, pl. 383, figs. 1-4; pl. 450, figs. 4, 5.

1874 *Orthoceras vibrayei* BARRANDE, pp. 562, 563.

1939 *Harrisoceras vibrayei* (Barrande) - FLOWER, p. 475.

1966 *Harrisoceras vibrayei* (Barrande) - BABIN, pp. 325, 326, pl. 13, fig. 6.

Description — Shell apparently orthoconic with circular cross section. Apical angle not definable, probably close to few degrees. Surface marked by extremely fine transversal growth lines. Sutures straight, simple and transverse. Camerae short, 1/3 to 1/4 the diameter. Septa concave, their depth being

about one-third the diameter. Siphuncle subcentral, about 1/5 the shell diameter. Septal necks short, ortho-suborthochoanitic, their length 1/5 the diameter of septal foramen. Connecting rings only slightly expanded within camerae. Annulosiphonate deposits well developed in form of simple annuli characterized by a darker part near the neck. Episepal and rudimentary hyposeptal deposits developed into the ventral side of the chambers.

Remarks — A fragment, 51 mm long and 49 mm wide, of the central portion of the conch is enough to distinguish this typical species.

Occurrence — Silurian of Bohemia (Barrande, 1866, 1874) and Armorican Massiv, W. France (Babin, 1966).

Repository — Institute of Palaeontology, Modena University, cat. n. 19075 (figured specimen).

Material studied — One specimen.

Order ACTINOCERIDA Teichert, 1933

Family ORMOCERATIDAE Saemann, 1853

Genus METARMENOCERAS Flower, 1940

Type-species — *Metarmenoceras bilaterale* Flower, 1940.

METARMENOCERAS ? MENEGHINII n. sp.

Pl. 8, figs. 1a-3, pl. 9, fig. 5; text-fig. 12

Derivatio nominis — In honour of professor G. Meneghini (1811-1889) who first described Silurian nautiloids of Sardinia.

Holotype — Specimen figured in pl. 8, fig. 1a.

Locus typicus — 500 m SE of the village of Fluminimaggiore, SW Sardinia.

Stratum typicum — Lenses of black limestone; Upper Silurian.

Description — Large orthoconic shell with sub-circular cross section. Angle of expansion of the adult part of phragmocone variable from 5 to 6 degrees. Outer surface smooth. Suture straight, simple and slightly oblique. Camerae short, 1/4 to 1/5 the diameter. Septa concave, their depth being about 1/3 the shell diameter. Siphuncle subcentral, its segments almost globular, larger than long apically and longer than large adorally. Septal foramen medially 1/10 the diameter of the shell. Septal necks cyrtochoanitic, recumbent, almost in contact with the posterior surface of septa. Brim very short. Connecting rings with

broad adnation area anteriorly and posteriorly. Free part of connecting rings only slightly convex between septa. Central canal slightly compressed, about $1/25$ the shell diameter. Radial canal straight, branching off in the middle of each segment at right angle from central canal and forming apparently a bilaterally symmetrical pattern. Perispatia partly occluded by perispatial deposits. Episeptal and hyposeptal deposits

well developed on ventral side. Some episeptal deposits are thickened into a circumsiphuncular ridge.

Remarks — Considerable difficulties are encountered in determining the generic position of this interesting form because it shows intermediate characters between armenoceratids and ormoceratids.

The only genus, at the present stage of our knowledge, which combines features of both these groups is *Metarmenoceras* Flower. Basic *Metarmenoceras* characters occurring in the Sardinian form are a) the structure of the central canal which is apparently compressed, b) the bilaterally symmetrical arrangement of radial canals and c) the large development of the adnation area. However, compared to the type species on which the description of the genus has been based, our form shows the following differences:

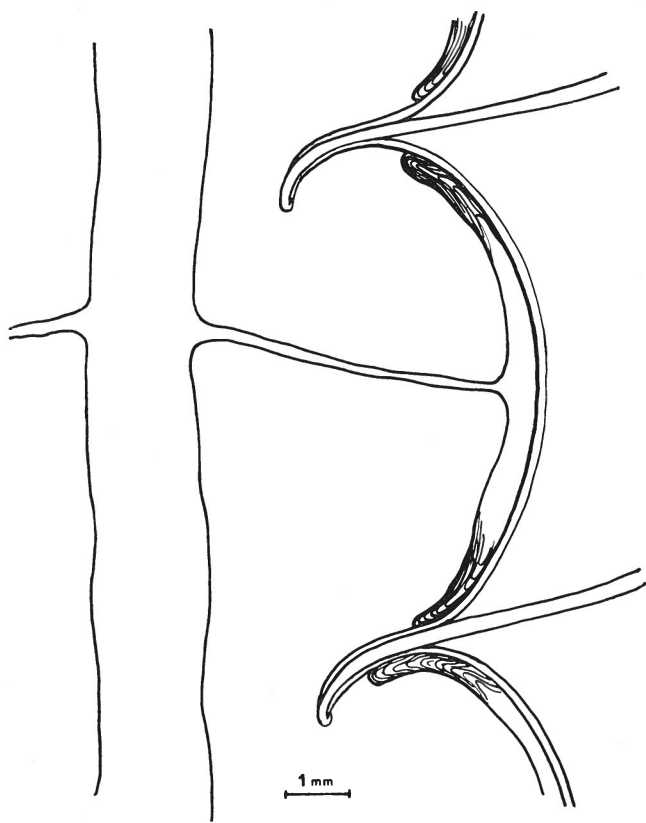
- 1) the segments of siphuncle are not twice as wide as long but narrower, their width being roughly one and a half the length;
- 2) the brims are not twice as long as the neck but shorter than the necks themselves;
- 3) the brims are not free but in contact with the posterior surface of septa.

It is interesting to point out that some features of septal necks like curvature and length of the brim recall *Elrodoceras* Foerste in which, however, the endosiphuncular canal system is arched and more complex.

Metarmenoceras is illustrated from L. Devonian of Eastern N. America but, according to Flower (1940, p. 445), undescribed forms are known also from U. Silurian.

Repository — Institute of Palaeontology, Modena University, cat. n. 19076 (holotype), 19077-19079 (figured paratypes).

Material studied — 4 specimens.



Text-fig. 12 - *Metarmenoceras* ? *meneghinii* n. sp., diagrammatic drawing to show the detail of siphuncular region of the specimen figured in pl. 9, fig. 5 (n. 19079).

EXPLANATION OF PLATE 8

Figs. 1a, 3 - *Metarmenoceras* ? *meneghinii* n. sp.

1a, dorsoventral section. Holotype, $\times 0.75$ (n. 19076).

1b, detail of the same specimen to show features of armenoceroid siphuncle, $\times 5$.

2, dorsoventral section. Paratype, $\times 0.75$ (n. 19077).

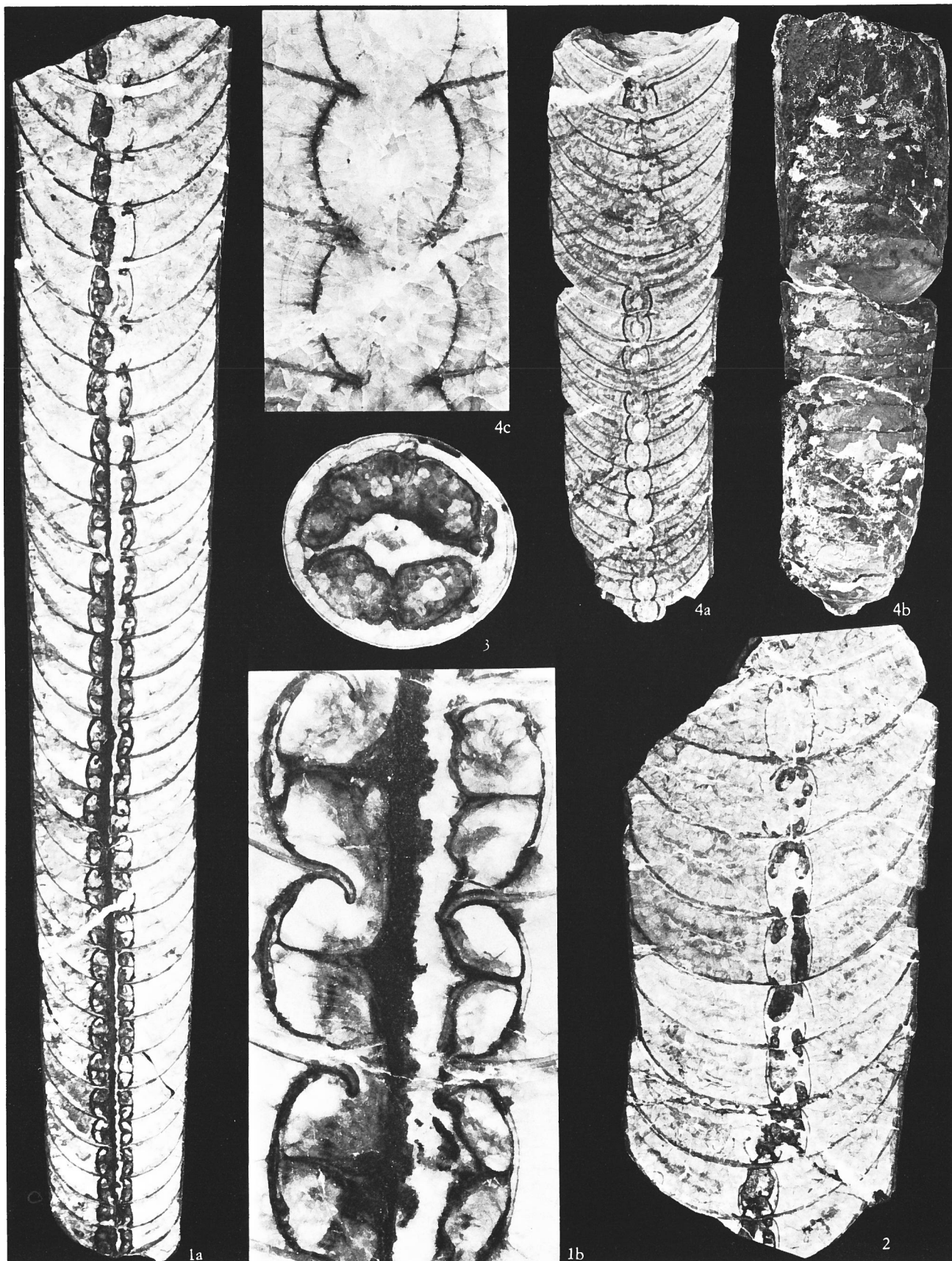
3, siphuncle cross section of another paratype to show compressed central canal and bilaterally symmetrical pattern of radial canals, $\times 5$ (n. 19078).

Figs. 4a, c - «*Orthoceras*» cf. *richteri* Barrande.

4a, dorsoventral section, $\times 0.75$ (n. 19080).

4b, detail of the same section to show features of siphuncle, $\times 4$.

4c, lateral view of the same specimen, $\times 0.75$. M. Macagno collection, Turin.



« ORTHOCERAS » cf. RICHTERI Barrande, 1868
Pl. 8, figs. 4a-c

1868 *Orthoceras richteri* BARRANDE, pl. 318, figs. 5, 6(?);
pl. 322, figs., 1-5; pl. 323, figs. 7-11; pl. 349, figs. 1-10.
1874 *Orthoceras richteri* BARRANDE, p. 570, 571.

Description — Faintly cyrthoconic shell with circular cross section. Angle of expansion variable from 5 to 6 degrees. Outer surface badly preserved but apparently smooth. Suture straight, simple and transverse. Camerae very low, 1/6 their diameter. Septa concave, their depth about 1/3 the diameter. Siphuncle central with septal foramen 1/10 the diameter of the shell. Septal necks very short, suborthochoanitic. Connecting rings expanded within camerae, forming subglobular segments. Adnation area moderately developed. No deposits have been observed in the specimen available.

Remarks — Unfortunately in our material, this important form occurs only with one fragmentary specimen (14.3 cm long) in which 20 mature camerae are preserved. For this reason a lot of diagnostic features are missed.

Difficulties are encountered in recognizing this form both at generic and specific level. As far as the generic assignment is concerned we prefer to leave an open nomenclature (« *Orthoceras* ») instead of attempting a precise attribution. The specific assignment shows a less degree of uncertainty because one of the Bohemian species reported by Barrande as *O. richteri* bears similarities with the form under discussion. In fact, in comparison with the specimen reported by Barrande (1868) in plate 322, figures 1 and

2, it is quite evident that the last 20 camerae, completely free of deposits, are almost identical with our form. For this reason it is not hazardous to suppose that the lack of deposits in Sardinian form is not a taxonomic character but may be related to the incompleteness of the specimen.

Occurrence — Upper Silurian of Bohemia (Barrande, 1868).

Repository — Temporary storage: M. Macagno collection. Torino, Via A. Barbaro, 15.

Material studied — One specimen.

Order ONCOCERIDA Flower *in* Flower & Kummel, 1950

Family ONCOCERATIDAE Hyatt, 1884

Genus OOCERINA Foerste, 1926

Type-species — *Cyrthoceras lentigradum* Barrande, 1866.

OOCERINA ABDITA (Barrande, 1877)

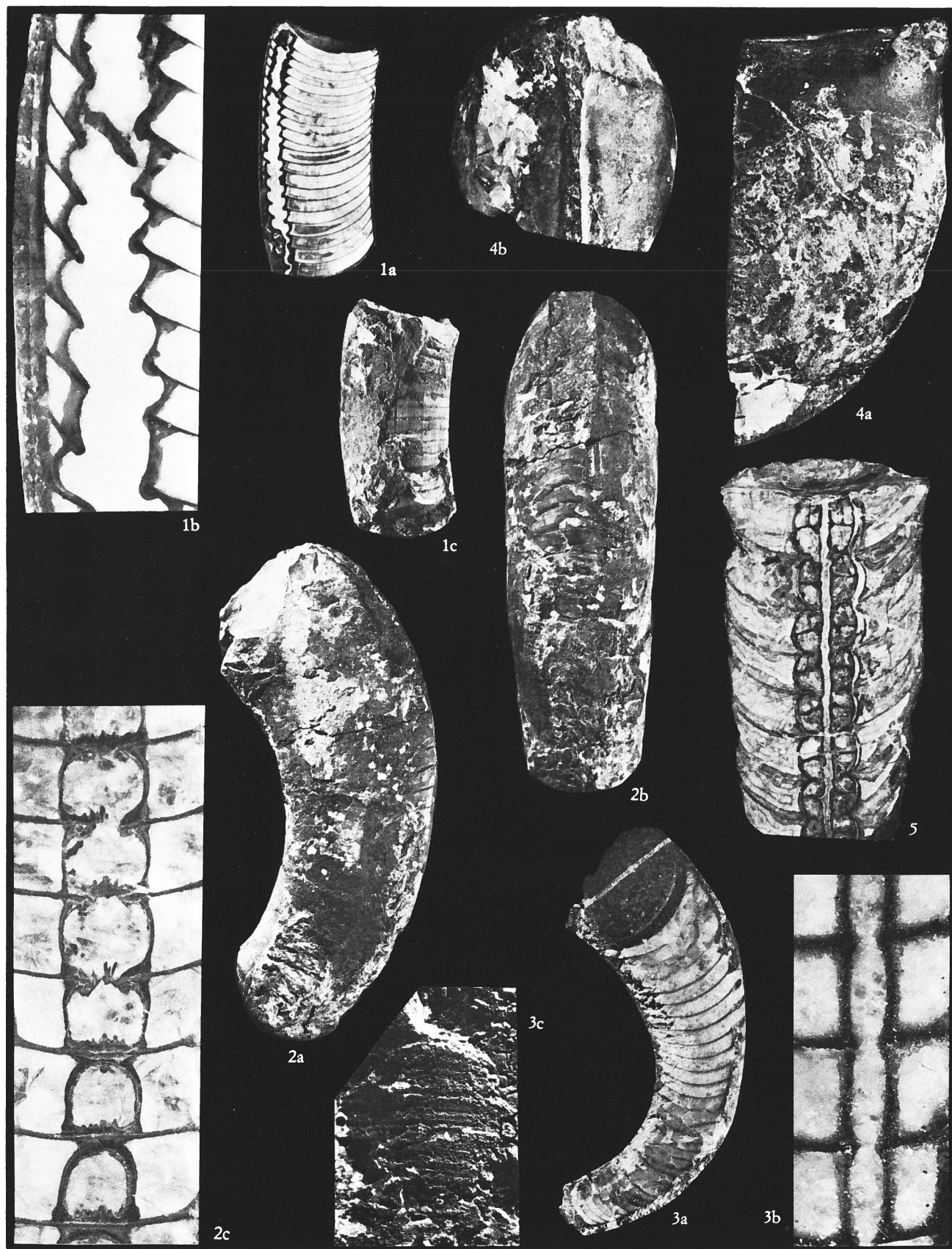
Pl. 9, figs. 2a-c

1877 *Cyrthoceras abditum* BARRANDE, p. 15-16, pl. 480, figs. 1-13.

Description — Exogastric cyrtocone, gradually enlarging, with radius of curvature of the dorsal side close to 4 cm. Cross section slightly compressed, subelliptical. Living chamber preserved for 27 mm on venter. Surface of the conch marked by faint growth lines. Suture simple, with wide ventral saddle. Ca-

EXPLANATION OF PLATE 9

- Figs. 1a-c - *Galtoceras ? sardoum* n. sp.
1a, dorsoventral section. Holotype, x1 (n. 19082).
1b, detail of the same section to show feature of siphuncle, x5.
1c, lateral view of the same specimen, x1.
- Figs. 2a-c - *Oocerina abdita* (Barrande).
2a, lateral view, x1.
2b, ventral view, x1.
2c, detail of siphuncle, x5.
Natural History Museum CARC of Finale Emilia (Modena), cat. n. 129.
- Figs. 3a-c - *Oonoceras plebeium* (Barrande).
3a, dorsoventral section, x2 (n. 19081).
3b, detail of siphuncle, x10.
3c, detail of ornament, x10.
- Figs. 4a, b - Gen. ind. A sp. 1.
4a, lateral view, x1 (n. 19084).
4b, apertural view of the same specimen, x1.
- Fig. 5 - *Metarmenoceras ? meneghinii* n. sp. Paratype.
Dorsoventral section, x1 (n. 19079).



merae very short, their depth being about 1/8 the dorso-ventral diameter. Septa moderately concave, their depth about 1/5 the diameter. Siphuncle, whose diameter is about 1/8 the dorso-ventral one of the conch, located very close to the venter. Septal necks short and cyrtochoanitic. Connecting rings strongly expanded within camerae. Simple, well developed actinosiphonate deposits occur inside the siphuncle.

Remarks — This belongs to a group of cyrtoconic, exogastric longicones described by Barrande but which are all rather inadequately known, particularly in regard to the internal structure. Anyway only few Bohemian forms show endosiphuncular deposits of actinosiphonate type and among them the species *Cyrthoceras abditum* Barrande is perfectly corresponding to the Sardinian one.

This species differs from *Cyrthoceras lentigradum* Barrande, the types species, in the stronger curvature and in having higher chambers. It is distinctive from *Cyrthoceras stygiale* Barrande by longer and more recurved septal necks and a less elliptical cross section. Only a complete revision of Bohemian material will, however, permit us to reach a better concept of all these forms.

The presence of this species in Sardinia extends the record to include the Mediterranean region.

Occurrence — Upper Silurian of Bohemia (Barrande, 1877).

Repository — Natural History Museum, C.A.R.C., Finale Emilia (Modena) cat. n. 129.

Material studied — One specimen.

Genus OONOCERAS Hyatt, 1884

Type-species — *Cyrthoceras acinaces* Barrande, 1866.

OONOCERAS PLEBEIUM (Barrande, 1866)
Pl. 9, figs. 3a-c

1848 *Cyrthoceras plebeium* BARRANDE, p. 208 (*nomen nudum*).

1860 *Cyrthoceras plebeium* BARRANDE, p. 625.

1866 *Cyrthoceras plebeium* BARRANDE, pl. 109, figs. 11-16; pl. 207, figs. 1-5; pl. 208, figs. 10-16.

1867 *Cyrthoceras plebeium* BARRANDE, p. 525, 526.

Description — Exogastric cyrthocone gradually enlarging with radius of curvature of dorsal side close to 25 mm. Cross section slightly elliptical. Living chamber only partly preserved but probably very short. Ornament in form of fine, irregular, transverse ridges in number of 7 per mm. Suture simple and straight. Camerae extremely short, their depth being about 1/9 the dorso-ventral diameter.

Septa moderately concave, their depth slightly more than 1/4 the diameter. Siphuncle, whose diameter is about 1/10 the dorso-ventral one, located very close to the venter. Septal necks short and cyrtochoanitic. Connecting rings moderately expanding within camerae. No deposits have been observed.

Remarks — Silurian forms like those under discussion find their place in the genus *Oonoceras* Hyatt, 1884 thanks to the revision of Flower (1946, pp. 299-305) who clearly defined limits with the genus *Richardsonoceras* Foerste, 1932. The same point of view has been followed also by Sweet (1964, p. K 288) in the chapter Oncocerida of the « Treatise ».

Occurrence — Upper Ordovician (Barrande, 1860) and Upper Silurian (1866) of Bohemia.

Repository — Institute of Palaeontology, Modena University, cat. n. 19081 (figured specimen).

Material studied — One specimen.

Family ACLEISTOCERATIDAE Flower in Flower & Kummel, 1950

Genus GALTOCERAS ? Foerste, 1934

Type-species — *Cyrthoceras arcticameratum* Hall, 1852.

GALTOCERAS ? SARDOUM n. sp.
Pl. 9, figs. 1a-c

Derivatio nominis — Latin *sardous* -a -um, from Sardinia, the region in which this form has been recovered.

Holotype — Specimen figured in pl. 9, figs. 1a-c.

Locus typicus — 500 m SE of the village of Fluminimaggiore, SW Sardinia.

Stratum typicum — Lenses of black limestone; Upper Silurian.

Description — Slender depressed to subcircular cyrtocone of slight curvature and gradual enlargement. Radius of curvature of dorsal side close to 12 cm. Living chamber not preserved. Shell surface smooth externally but with spaced, fine longitudinal striae internally. Suture simple and straight. Camerae very short, their depth 1/10 the dorso-ventral diameter. Septa moderately concave, their depth about 1/5 the diameter. Siphuncle, whose diameter is about 1/7 the dorso-ventral one, located very close to the venter. Septal necks always very short, strongly recumbent on the dorsal side to be in contact with the septa from which they arise. On the venter, necks are slightly shorter and separated from the septum so

that they assume a cyrtochoanitic appearance. Connecting rings broadly expanded within camerae and moderately thickened over their entire length. They are also considerably adapically inflated where they bend around the adapical septal necks. This is particularly true for the ventral side. Circulus structure, apparently granular, occurs inside the camerae against the wall of the rings.

Remarks — This form, which is important from a taxonomic and paleogeographic point of view, occurs in Sardinia only with few incomplete specimens. However, despite their poor preservation, in one specimen it is possible to observe through its 22 preserved camerae many inner features which are enough to establish a new species. In fact none of the numerous Bohemian forms of this kind shows the same siphuncular characters combined with a depressed conch.

Recently, Barskov (1972, p. 71) has regarded many such forms of Barrande as belonging to the genus *Pseudoonoceras* Turner. This genus, however, is assigned to the order Discosorida that implies layered « bullettes » and thick and complex connecting rings.

If the cross section of the shell is really a character of high taxonomic value it is quite difficult to find the right generic assignment for the new species.

Among the genera belonging to Oncocerida, only one has slender, cyrtoconic, depressed shell with empty siphuncle. This genus is *Galtoceras* Foerste which, however, till now has been reported only from Middle Silurian of North America.

The geographic distribution, as well as the lack of detailed information on the structure of siphuncle, leaves some doubts about the taxonomic position of the new species.

Repository — Institute of Palaeontology, Modena University, cat. n. 19082 (holotype), 19083 (unfigured paratypes).

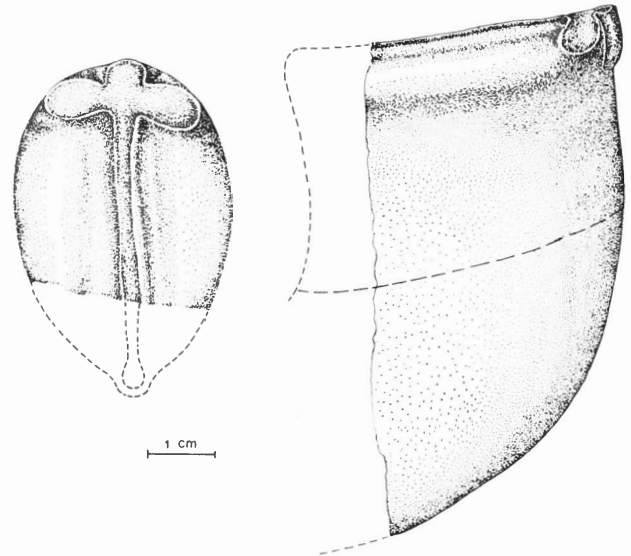
Material studied — Three specimens.

Family TRIMEROCERATIDAE ? Hyatt in Zittel, 1900

GEN. IND. A sp. 1

Pl. 9, figs. 4a, b; text-fig. 13

Description — Cyrtoconic, endogastric (?) compressed shell with strongly contracted aperture. Radius of curvature of dorsal margin close to 6 cm. Peristome with median dorsal sinus, partly projecting beyond dorsal side of shell, one pair of dorsolateral



Text-fig. 13 - Gen. ind. A sp. 1, diagrammatic drawing and partial reconstruction of specimen figured in pl. 9, fig. 4 (n. 19084).

sinuses and a slit-like median element. Hyponomic sinus not preserved. Living chamber occupying about half of the whole shell. The last septum, which is the only one preserved, is relatively deep. The siphuncle, not observed close to the dorsal margin, is probably ventral.

Remarks — On the basis of the inadequate information furnished by the single and fragmentary specimen available it is impossible to recognize this form at a specific and generic level. The assignment to the family Trimeroceratidae, even if dubious, has been mostly based on the presence of the median dorsal sinus.

Anyway, its occurrence in Sardinia is very important from a paleogeographic point of view, because till now no members of this family have been recovered in Mediterranean region.

Repository — Institute of Palaeontology, Modena University, cat. n. 19084 (figured specimen).

Material studied — One specimen.

REFERENCES

- BABIN, C., 1966, Mollusques bivalves et cephalopodes du Paléozoïques Armoricaïn: Thèse de Doctorat, (Imprimerie Comm. et Administra.), pp. 1-470, pls. 1-18, Brest.
- BARRANDE, J., 1855, Remplissage organique du siphon dans certains céphalopodes paléozoïques: Bull. Soc. Geol. France, v. 12, pp. 441-489, pls. A-C, Paris.

- , 1860 a, Troncature normale ou périodique de la coquille dans certains céphalopodes paléozoïques: Bull. Soc. Géol. France, Série II, v. 17, pp. 573-600, pl. 9, Paris.
- , 1860 b, Colonies dans le bassin silurien de la Bohême: Bull. Soc. Géol. France, Série II, v. 17, pp. 602-666, Paris.
- , 1865-77, Système Silurien du centre de la Bohême: I. Rech. Pal., v. 2, Classe des Mollusques, Ordre des Céphalopodes; 1. Série, pls. 1-107 (1865); 2. Série, pls. 108-244 (1866); 3. Série, pls. 245-350 (1868); 4. Série, pls. 351-460 (1870); Suppl. et Série tard., pls. 461-544, Texte III (1870); Texte IV (1877); Texte V (1877); 4. Série, Distribution des Céphalopodes (1870); Prague.
- BARSKOV, I. S., 1959, New Silurian nautiloids from southern Fergany: Akademia Nauk SSSR, Paleont. Zhurnal, n. 3, pp. 55-60, pl. 5, Moscow.
- , 1960, Silurian and Devonian nautiloids from southern Fergany: Byull. MOIP, otd. geol., v. 35, n. 4, pp. 153-154, Moscow.
- , 1972, Late Ordovician and Silurian cephalopods molluscs of Kazakhstan and Middle Asia: Akademia Nauk SSSR, pp. 1-107, pls. 1-12, Moscow.
- , & KISELEV, G. N., 1970, Revision of some Silurian Michelinoceratidae (Cephalopoda, Orthocerida): Akademia Nauk SSSR, Paleont. Zhurnal, v. 3, pp. 66-70, pl. 3, Moscow.
- BERRY, W. B. N., & BOUCOT, A. J., 1967, Pelecypod-graptolite association in the Old World Silurian: Geol. Soc. America Bull., v. 78, n. 12, pp. 1515-1522, 1 text-fig., Boulder, CO.
- CANAVARI, M., 1899, La fauna dei calcari nerastri con *Orthoceras* e *Cardiola* di Xea S. Antonio in Sardegna: Paleontogr. Italica, v. 5, pp. 187-210, 2 pls., Pisa.
- COCOZZA, T., 1975, Structural pattern of Sardinia: in Structural model of Italy ed. by Ogniben, Parotto & Praturlon, Quaderni de la Ricerca Scientifica, v. 90, pp. 183-201, Roma.
- , JACOBACCI, A., NARDI, R., & SALVADORI, I., 1974, Schema stratigrafico-strutturale del Massiccio Sardo-Corso e minerogenesi della Sardegna: Mem. Soc. Geol. Italiana, v. 13, pp. 85-186, 76 text-figs., Pisa.
- , & JACOBACCI, A., 1975, Geological outline of Sardinia: from Geology of Italy ed. by Coy Squyres, pp. 49-81, Tripoli.
- COMASCHI CARIA, I., 1949, I fossili della Sardegna: Istituto per gli Studi Sardi, pp. 1-410, Cagliari.
- , 1974, Animali e piante fossili della Sardegna: pp. 1-73, pls. 1-42, Editrice Sarda Fossataro, Cagliari.
- DONOVAN, D., 1964, Cephalopods classification and phylogeny: Biol. Rev., v. 39, pp. 259-287, Cambridge.
- FISCHER, A. G., & TEICHERT, C., 1969, Cameral deposits in Cephalopods shells: Univ. Kansas Paleont. Contrib., Paper 37, pp. 1-30, text-figs. 1-8, Lawrence, KS.
- FLOWER, R. H., 1939a, Study of the Pseudorthoceratidae: Paleontogr. Americana, v. 2, n. 10, pp. 1-196, pls. 1-9, text-figs. 1-22, Ithaca, NY.
- , 1939b, *Harrisoceras*, a new structural type of orthochoanitic nautiloid: Jour. Paleontology, v. 13, n. 5, pp. 473-480, pls. 49-50, Tulsa, OK.
- , 1940, Some Devonian Actinoceratoidea: Jour. Paleontology, v. 14, n. 5, pp. 442-446, pl. 61, Tulsa, OK.
- , 1941, Revision and internal structures of *Leurocycloceras*: American Jour. of Science, v. 239, n. 7, pp. 469-488, pls. 1-3, New Haven, CT.
- , 1942, An arctic cephalopod faunale from the Cynthiana of Kentucky: Bull. American Paleont., v. 27, n. 103, pp. 41-90, pls. 4-7, Ithaca, NY.
- , 1943a, Studies of Paleozoic Nautiloidea: I-VII, Bull. American Paleont., v. 28, n. 103, pp. 1-140, pls. 1-6, text-figs. 1-3, Ithaca, NY.
- , 1943b, Cephalopods from the Silurian of Arisaig, Nova Scotia: Jour. Paleontology, v. 17, n. 3, pp. 248-257, pl. 40, Tulsa, OK.
- , 1946, Ordovician cephalopods of the Cincinnati region, part 1: Bull. American Paleont., v. 29, n. 116, pp. 1-656, pls. 1-50, text-figs. 1-22, Ithaca, NY.
- , 1959a, Cameral deposits in orthoconic nautiloids: Geol. Magazine, v. 92, n. 2, pp. 89-103, 2 text-figs., London.
- , 1955b, Trails and tentacular impressions of orthoconic cephalopods: Jour. Paleontology, v. 29, n. 5, pp. 857-867, 4 text-figs., Tulsa, OK.
- , 1957, Studies of the Actinoceratida: N. Mex. Inst. Min. and Tech., State Bur. Mines and Mineral Res., Mem. 2, pp. 1-73, pls. 1-13, Socorro, New Mexico.
- , 1961, Major division of the Cephalopoda: Jour. Paleontology, v. 35, n. 3, pp. 569-574, Tulsa, OK.
- , 1962, Part 1, Revision of *Buttsoceras*, Part 2, Notes on the Michelinoceratida: N. Mex. Inst. Min. and Tech., State Bur. Mines and Mineral Res., Mem. 10, pp. 1-52, pls. 1-6, Socorro, New Mexico.
- , 1964, Nautiloid shell Morphology: N. Mex. Inst. Min. and Tech., State Bur. Mines and Mineral Res., Mem. 13, pp. 1-75, pls. 1-6, text-figs. 1-22, Socorro, New Mexico.
- , 1968, Silurian cephalopods of James Bay Lowland, with a revision of the family Narthecoceratidae: Geol. Survey of Canada, Bull. n. 164, pp. 1-88, pls. 1-34, Ottawa.
- , & KUMMEL, B., 1950, A classification of the Nautiloidea: Jour. Paleontology, v. 24, pp. 604-616, 1 text-fig., Tulsa, OK.
- FOERSTE, A. F., 1921, Notes on Arctic Ordovician and Silurian Cephalopods: Denison Univ. Bull. Jour. Sci. Lab., v. 19, pp. 247-306, pls. 27-35, Granville, OH.
- GNOLI, M. & SERPAGLI, E., 1977, Silurian cephalopods of the Meneghini collection (1857)-with reproduction of the original plate: Boll. Soc. Paleont. Italiana, v. 16, n. 2, pp. 137-142, 1 pl., 2 text-fig., Modena.
- GORTANI, M., 1922, Osservazioni sul Paleozoico della Sardegna: Boll. Soc. Geol. Italiana, v. 41, pp. 362-369, 1 pl., Roma.
- HOLLAND, C. H., 1971, Silurian faunal provinces? in Faunal Provinces in Space and Time, Geol. Jour. Special Issue, n. 4, pp. 61-76, text-figs. 1, 2, Liverpool.
- JAEGER, H., 1976, Silur und Unterdevon vom thuringischen Typ in Sardinien und seine regionalgeologische Bedeutung: Nova Acta Leopoldina, Neue Folge, n. 224, Band 45, pp. 263-299, 10 text-figs., 3 pls., Saale.
- JELETZKY, J. A., 1966, Comparative morphology, phylogeny, and classification of fossil Coleoidea: Univ. Kansas Paleontol. Contributions Mollusca, Art. 7, pp. 1-162, pls. 1-25, figs. 1-15, Lawrence, KS.
- KISELEV, G. N., 1968, The scope and definition of the genus *Michelinoceras* Foerste, 1932: 2nd. All-Colloquium on Nautiloids and Related Groups, Abstracts of Proceeding, p. 18, Moscow.

- , 1972, Review of «Zur Revision der Orthoceratidae by H. Ristedt»: *Paleont. Journal*, v. 6, n. 3, pp. 427-428, Moscow.
- , 1975, The structure of the initial portions of the shell in some Silurian geisonoceratids (Orthocerida): *Paleont. Journal*, v. 9, n. 4, pp. 20-23, pl. 3.
- KOLEBABA, I., 1973, Embryonal stages of Wenlockian cephalopods from Central Bohemia: *Casopis Narodniho Muzea, odd. prirodovedny*, v. 142, pp. 28-40, pls. 1-2, Prague.
- KRIZ, J. & POJETA, J. jr., 1974, Barrande's colonies concept and comparison of his stratigraphy of the Middle Bohemian Lower Paleozoic Rocks (Barrandian) of Czechoslovakia: *Jour. Paleont.*, v. 18, n. 3, pp. 489-494, 2 text-figs, Lawrence, KS.
- LAI CHAI-GEEN, 1960, Nautiloid fossils of Yangtzeella Poloid beds from Shensi and Hupei: *Acta Paleont. Sinica*, v. 8, n. 3, pp. 251-271, pls. 1-5, Peking.
- , 1965, Ordovician and Silurian cephalopods from Hanzhung and Ningkiang of Shensi: *Acta Paleont. Sinica*, v. 13, n. 2, pp. 308-342, pls. 1-3, Peking.
- MENEGHINI, G., 1857, Paléontologie de l'Île de Sardaigne (*in* La Marmora, A., *Voyage en Sardaigne*): pp. 1-584, pls. A-H, Imprimerie Royal, Turin.
- MYAGKOVA, E. I., 1967, Silurian nautiloids from Siberian Platform: *Akademia Nauk SSSR, Siberian branch*, pp. 1-46, pls. 1-20, Moscow.
- MURCHISON, R. I., 1858, Siluria. The history of the oldest fossiliferous rocks and their foundations: J. Murray, London, pp. 1-592, pls. 1-41, London.
- MUTVEI, H., 1964a, On the secondary internal calcareous lining of the wall of the siphonal tube in certain fossil «nautiloid» cephalopods: *Arkiv för Zoologi, Ser. 2*, n. 21, pp. 375-424, pls. 1-29, text-figs. 1-23, Stockholm.
- , 1946b, Remarks on the anatomy of recent and fossil Cephalopoda: *Acta Univ. Stockholmiensis, Stockholm Contr. Geol.*, v. 11, n. 4, pp. 79-102, text-figs. 1-8, Stockholm.
- , 1972, Ultrastructural studies on cephalopod shells, Part I-II: *Bull. Geol. Inst. Uppsala, N.S.*, v. 3, n. 8, pp. 237-272, pls. 1-37, text-figs. 1-12, Uppsala.
- NOVARESE, V., 1922-23, Contributo alla geologia dell'Iglesiente: *Boll. R. Uff. Geol. Italia*, v. 49, n. 10, pp. 1-107, pls. 1-3, Roma.
- , & TARICCO, M., 1922, Cenni sommari sul Paleozoico dell'Iglesiente: *Boll. Soc. Geol. Italiana*, v. 41, pp. 316-325, Roma.
- OLIVIERI, R., 1965, L'aspetto della fauna a Conodonti nel Devoniano sup. del Gerrei (Sardegna): *Boll. Soc. Paleont. Italiana* v. 4, n. 1 (1965), pp. 28-63, pls. 3-6, Modena.
- , 1970, Conodonti e zonatura del Devoniano superiore e riconoscimento di Carbonifero inferiore nei calcari di Corona Mizziu (Gerrei-Sardegna): *Boll. Soc. Paleont. Italiana*, v. 8, n. 2 (1969), pp. 63-152, pls. 1-26, Modena.
- RISTEDT, H., 1968, Zur Revision der Orthoceratidae: *Akad. Wiss. u. Literatur, Abhandl. d. math-naturwiss. Klasse, Jahr. 1968*, v. 4, pp. 213-297, pls. 1-5, 4 text-figs., Wiesbaden.
- , 1971, Zum Bau der orthoceriden Cephalopoden: *Palaeontographica, Abt. A*, v. 137, pp. 155-195, pls. 28-42, 5 tabs., 7 text-figs., Stuttgart.
- SERPAGLI, E., 1967, Prima segnalazione di Conodonti nel Siluriano della Sardegna e relative osservazioni stratigrafiche: *Accad. Naz. Lincei, Rend. Cl. Sc. fis. matem. e naturali*, fasc. 6, ser. 8, v. 42, pp. 856-858, Roma.
- , 1970, Ordovician Conularids of Sardinia: *Boll. Soc. Paleont. Italiana*, v. 8, n. 1 (1969), pp. 10, pls. 1, 2, Modena.
- , 1971, Uppermost Wenlockian-Upper Ludlowian (Silurian) Conodonts from Western Sardinia: *Boll. Soc. Paleont. Italiana*, v. 9, n. 1 (1970), pp. 76-96, pls. 21-24, Modena.
- SHIMANSKIY, V. N. & ZHURAVLEVA, F. A., 1961, General question on the sistematics of nautiloids and related groups: *Akademia Nauk SSSR, Paleont. Inst.*, v. 90, pp. 1-176, pls. 1-15, Moscow.
- SWEET, W. C., 1964a, Nautiloidea-Orthocerida: *in* Treatise on Invertebrate Paleontology, ed. by R. C. Moore, Part K (Nautiloidea), pp. K216-K261, figs. 152A-188, Lawrence, KS.
- , 1964b, Nautiloidea-Oncocerida: *in* Treatise on Invertebrate Paleontology, ed. by R. C. Moore, Part K (Nautiloidea), pp. K277-K319, figs. 198-227, Lawrence, KS.
- TARICCO, M., 1913, Il Gothlandiano in Sardegna: *Rend. R. Acc. Lincei*, v. 22, (I Sem. 1913), pp. 109-115, Roma.
- , 1920-21, Sul Paleozoico del Fluminense: *Boll. R. Com. Geol. Italia*, v. 48, n. 6, pp. 1-22, Roma.
- TEICHERT, C., 1933, Der Bau der actinoceroiden Cephalopoden: *Palaeontographica, Abt. A*, v. 78, pp. 111-230, pls. 8-15, Stuttgart.
- , 1940, Contribution to nautiloid nomenclature: *Jour. Paleont.*, v. 14, n. 6, pp. 590-597, Tulsa, OK.
- , 1964, Actinoceratoidea: *in* Treatise on Invertebrate Paleontology, ed. by R. C. Moore, Part K (Nautiloidea), pp. K190-K216, figs. 126-152, Lawrence, KS.
- TEICHMÜLLER, R., 1931, Zur Geologie des Tyrrhenis Gebietes: *Abh. Gesellschaft d. Wissenschaften Z. Göttingen, Math.-Physik. Klasse, III F, H. 3*, pp. 1-124, 3 pls., 47 text-figs., Berlin.
- ZEISS, A., 1969, Weichteile ectocochleater paläozoischer Cephalopoden in Röntgenaufnahmen und ihre paläontologische Bedeutung: *Paläont. Z.*, v. 43, n. 1, 2, pp. 13-27, pls. 1-3, 6 text-figs., Stuttgart.
- ZHURAVLEVA, F. A., 1959a, On the family Michelinoceratidae Flower, 1945: *Materialy K «Osnovam Paleontologii»*, n. 3, pp. 47, 48, Moscow.
- , 1959b, About the embryonic stages of development of Nautiloids: *Akademia Nauk SSSR, Paleont. Zhurn.*, n. 1, pp. 36-48, Moscow.
- , 1964, New Ordovician and Silurian Cephalopoda, Siberian Platform: *Akademia Nauk SSSR, Paleont. Zhurn.*, pp. 87-100, pls. 11, 12, Moscow.
- , 1974, Devonian Nautiloids: *Akademia Nauk SSSR*, v. 142, pp. 1-159, pls. 1-17, Moscow.

Note - After this contribution was submitted we have received the paper:

KOLEBABA, I., 1975, *Caliceras* n. gen. and ontogeny of *C. capillosum* (Barrande) (Nautiloidea, Michelinoceratida): *Casopis pro mineralogii a geologii*, vol. 20, n. 4, pp. 377-392, pls. 1-4, Prague.

The conclusion of this author will be discussed in a further paper.