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# SILURIAN NAUTILOID CEPHALOPODS OF THE CARNIC ALPS (NE ITALY). THE STATE OF THE ART

## CEFALOPODI NAUTILOIDI DEL SILURIANO DELLE ALPI CARNICHE (NE ITALIA). LO STATO DELL'ARTE

**Abstract** - The state of the art of studies on Silurian nautiloid cephalopods from the Carnic Alps is presented. Important collections of these fossils are preserved in both the Friulian Museum of Natural History in Udine, in the Geologischen Bundesanstalt in Vienna, and in other institutions, as the palaeontological museum of Modena and Reggio Emilia University. The first collections in the 19th century were followed in the last century by field campaigns that expanded the collections and knowledge of the nautiloid faunas of the northern margin of Gondwana. Fourteen Families and 25 Genera are up to now documented.
**Key words**: Nautiloid Cephalopods, Silurian, Carnic Alps.

**Riassunto breve** - *Viene presentato lo stato dell'arte degli studi condotti sui Cefalopodi nautiloidei siluriani delle Alpi Carniche. Importanti collezioni di questi fossili sono conservate nel Museo Friulano di Storia Naturale, nel Geologischen Bundesanstalt in Vienna e in altri musei tra cui quello dell'Università di Modena e Reggio Emilia. Alle prime collezioni del XIX secolo, sono seguite, nel secolo scorso, campagne di studio che hanno permesso di ampliare le raccolte e le conoscenze delle Faune a nautiloidi del margine Nord del Gondwana. Attualmente sono documentate 14 Famiglie e 25 Generi.*
**Parole chiave**: *Cefalopodi nautiloidei, Siluriano, Alpi Carniche.*

## Introduction

The Silurian Cephalopod "*Orthoceras*" limestone is well exposed in the Carnic Alps chain; it has been famous since the XIX century and many researchers worked on it. In XX century and in particularly in the second half part of century the scientific activity on Palaeozoic paleontology and mainly on the Silurian terrains of Italian side of the Carnic Alps resulted in collecting a great number of specimens that have been studied to stress their paleontological, paleogeographic and biostratigraphic importance. The aim of this work is to report on current knowledge of the non-amonoid cephalopods of the Silurian of the Carnic Alps, listing taxa in museum collections in addition to specimens found in the last twenty years; this will allow further correlations with other Terranes involved in the northern margin of Godwana.

## Geological Setting

In the Friuli Venezia Giulia region (in the northeastern part of Italy) three mountain chains are welded together: the Palaeocarnic chain, the eastern section of the South alpine chain and the northwestern part of the Outer Dinarides. The Palaeocarnic chain, about 180 km long (from Comelico to Caravanche) and 10/20km wide, presents a metamorphic part, confined in northwestern sector, and a non-metamorphic part represented by an almost continuous Palaeozoic sedimentary succession (Carulli 2006) (Fig. 1). The Palaeozoic outcrops, very rich in palaeontological remains range from the Upper Ordovician to Permian. Silurian deposits are irregularly distributed within the Carnic Chain and show wide lateral facies diversity. The overall thickness does not exceed 60 m. Rocks varies from bioclastic limestones testifying a shallow water environment, to nautiloid-bearing limestones, interbedded shales and finally black graptolithic shales and cherts, testifying deep water basinal environment. Six formations are discriminated (Corradini et al. 2015; Fig. 2).

The Silurian transgression started at the base of the Llandovery, and, due to the disconformity separating the Ordovician and the Silurian, a varying pile of sediments is locally missing, which corresponds to several conodont zones of Llandovery to Ludlow age (Corriga et al. 2021). The Silurian of the Carnic Alps


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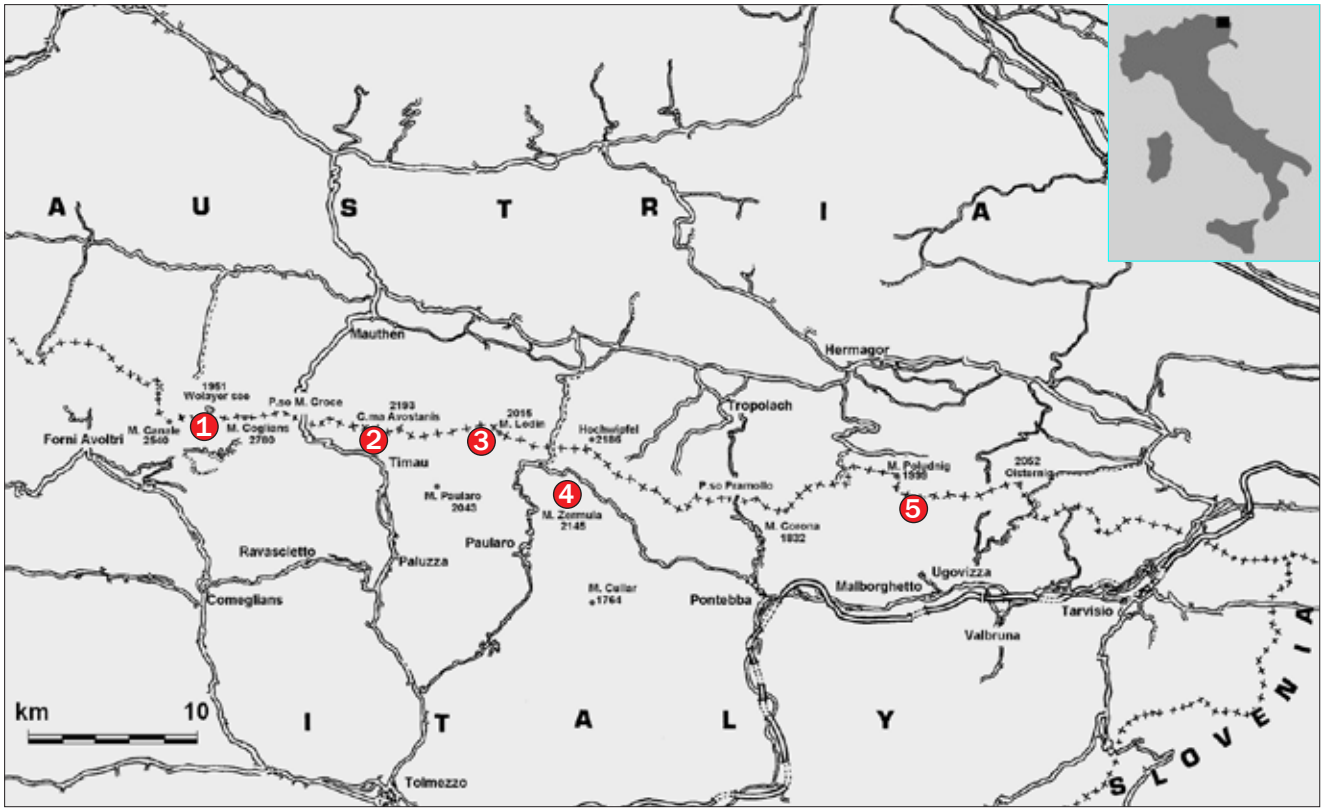



Fig. 1 - Simplified geographical map of the Carnic Alps with indication of the main Silurian cephalopod localities. 1: Passo Volaia; 2: Pal Grande, Pal Piccolo and Creta di Timau; 3: Mt. Cuestalta and Mt. Lodin; 4: Mt. Zermula; 5: Mt. Cocco.
- *Carta geografica semplificata delle Alpi Carniche con indicate le principali aree di provenienza dei cefalopodi silurianai. l: Passo Volaia; 2: Pal Grande, Pal Piccolo e Creta di Timau; 3: Monte Cuestalta e Monte Lodin; 4: Monte Zermula; 5: Monte Cocco.*

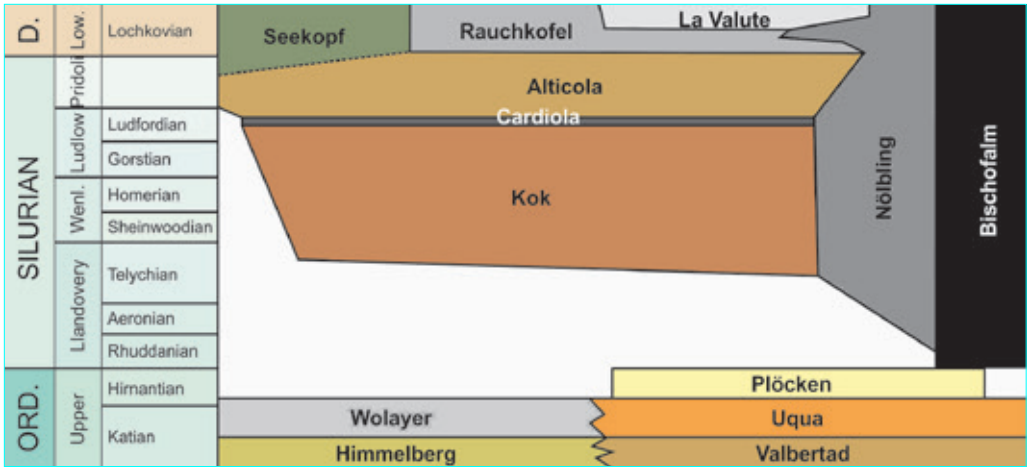



Fig. 2 - The stratigraphic scheme of the Pre-Variscan sequence of the Carnic Alps (after Corradini et al. 2015, modified).
- *Schema stratigrafico della sequenza Pre-Varisica delle Alpi Carniche (modificato da Corradini et al. 2015).*

is subdivided into four major lithological facies (Fig. 3), representing different depths of deposition and different hydrodynamic conditions of the environments (Wenzel 1997). In the central sector of the Carnic Alps four facies can be discriminated from North-West towards South-East: the Wolayer facies, characterized by proximal basin sediments, the Plocken and Findenig facies, with intermediate conditions, and the Bischofalm facies characterized by deep-water sediments. From Llandovery to Ludlow, Silurian sedimentation shows generally a transgressive trend, whereas a diffuse Přídolí carbonate sedimentation shows a steadier condition (Schönlaub 1997).

For a detailed description of the geology of the area and the lithostratigraphic units exposed refer to Corradini et al. (2015) and Corradini & Pondrelli (2021).

This note is an extension of what was presented during the workshop "Geology and Paleontology of Friuli and adjacent areas", organized by the Museo Friulano di Storia Naturale (MFSN) of Udine, in memory of Luca Simonetto (Serventi 2023).

## Previous works on Silurian Carnic Alps Nautiloid Cephalopods

### Historic works

The abundance of fossil remains of nautiloid cephalopods in some Palaeozoic levels of the Carnic Alps aroused the attention of many geologists who undertook the study of the area starting from the second half of the 19th century. The complexity of the Palaeozoic sedimentary succession of the Carnic Alps and the lack, at the time, of valid rock dating methods made difficult to correctly subdivide the stratigraphy of the entire Palaeozoic complex. The presence of easily identifiable macrofossils could solve this problem as demonstrated, among others, by Joachim Barrande (1799-1883) who, studied in detail the Silurian series from Bohemia on the basis of the rich fauna, including the numerous nautiloids. Barrande himself donates a copy of his work and an important comparison collection of around 5200 fossil samples to the Vienna Geological Survey (Histon 1999). The results obtained by Barrande favourably impressed the researchers, but the systematic study of the Silurian faunas was never undertaken by the Austrian geologists, engaged at the time in the geological survey of the entire Carnic area.

In 1872, the Austrian geologist Guido Stache (1833-1921, Fig. 4) recognized for the first time the presence of Silurian rocks, testified by the discovery of graptolite fossil remains, in Monte Osternig, north of Ugovizza. The same author subsequently described Silurian "*Orthoceras*" limestones in numerous localities of the Carnic Alps, collecting a remarkable collection of cephalopods that he would have liked to publish in a monograph. Although Stache's study was already almost ready since 1890 and the author himself had officially announced it several times, he was unable to publish it because became director of the Geologische Reichsanstalt (Geological Institute of Vienna). Only in 1887, the German geologist Fritz Frech (1861-1917, Fig. 5) described, for the first time, two species of orthoceratids; subsequently he established a biostratigraphic relationship between *Orthoceras potens* characteristic of "red limestones of lower *Orthoceras*" and *Orthoceras alticola* of "red limestones of upper *Orthoceras*" (Frech 1894). Still at the end of the 19th century, the Austrian geologist Geyer (1857-1936, Fig. 6), commissioned by the Geological Survey of Vienna to carry out the geological survey of the Carnic Alps for the new geological map of the Austrian monarchy, reported fossil remains of Silurian nautiloids in various localities, without however undertaking a systematic study of the fauna.

The first publication dedicated to the systematics of the fauna of the Silurian strata of the Carnic Alps came out only in 1909 thanks to two Italian geologists: Gortani (1883-1966, Fig. 7) and Vinassa de Regny (1871-1957, Fig. 8). Already engaged for several years in the in-depth study of the geology of the Italian side of the Carnic Alps, they had repeatedly reported the presence of *Orthoceras* remains in the Silurian limestones of this area, limiting themselves, however, like their Austrian colleagues, to simple citations. The discovery of a rich fauna, in fair conservation conditions in the mountains north of Timau, led them to consider the paleontologi-

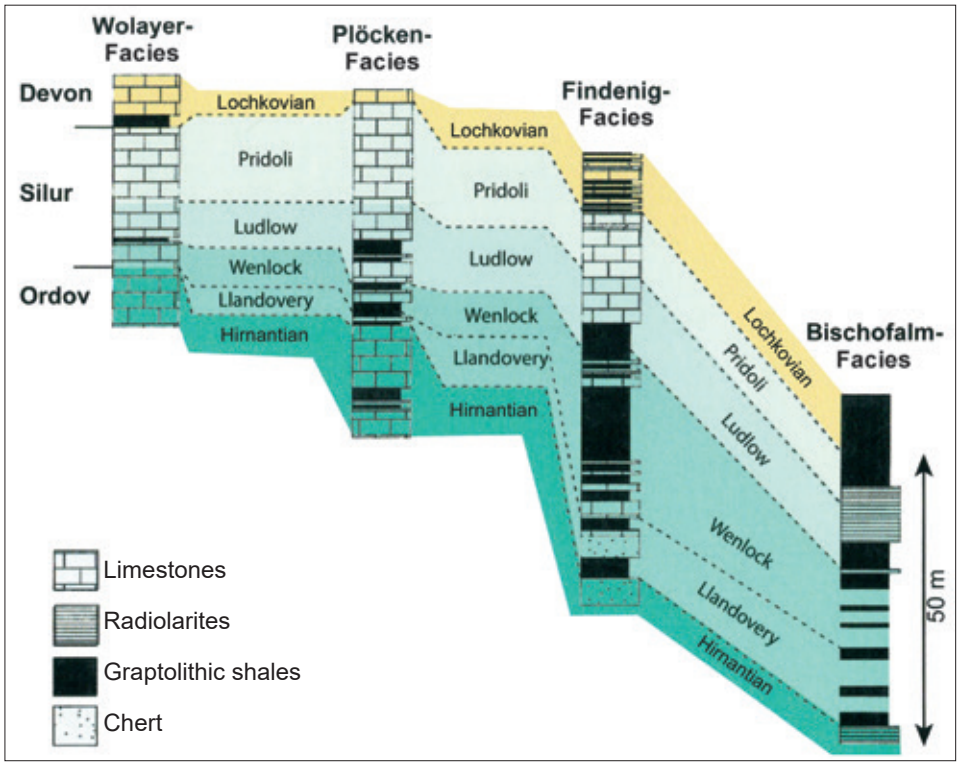



Fig. 3 - Lithology of Silurian sediments of the four different lithofacies of the Carnic Alps (after Wenzel 1997, modified in Schönlaub & Forke 2021).
- *Litologia delle quattro principali litofacies dei sedimenti siluriani delle Alpi Carniche (tratto da Wenzel 1997, modificato da Schönlaub & Forke 2021).*

cal aspect as well and they published the results of their research, describing, in addition to numerous species of tetracorals, tabulates, trilobites, brachiopods, bivalves and gastropods, 11 species of orthoceratids (Gortani & Vinassa de Regny 1909).

In 1929 the Austrian geologist Heritsch (1882-1945, Fig. 9) published the important monograph, an accurate paleontological study of the Silurian faunas of the Carnic Alps. For this work, Heritsch (1929) used both materials collected by himself and his colleague von Gaertner (1906-1982), and the rich collections of Geyer and Stache stored at the Vienna Geological Survey. In addition to the taxonomic description of the faunas, Heritsch also provided precise stratigraphic references on the levels of provenance of the samples. Subsequently, in 1943, he noted that some taxa are more abundant

Fig. 4 - The Austrian geologist Guido Stache (1833-1921, www.geologie.ac.at/en/about-us/our-building/history)
- *Il geologo austriaco Guido Stache (1833-1921)*

Fig. 5 - The German geologist Fritz Frech (1861-1917, Schönlaub & Forke 2021).
- *Il geologo tedesco Fritz Frech (1861-1917)*

Fig. 6 - The Austrian geologist Georg Geyer (1857-1936, www.geologie.ac.at/en/about-us/our-building/history).
- *Il geologo austriaco Georg Geyer (1857-1936).*

Fig. 7 - The Italian geologist Michele Gortani (1883-1966, www.socgeol.it/N3323/michele-gortani-lugo-spagna-1883-tolmezzo-1966.html).
- *Il geologo italiano Michele Gortani (1883-1966).*

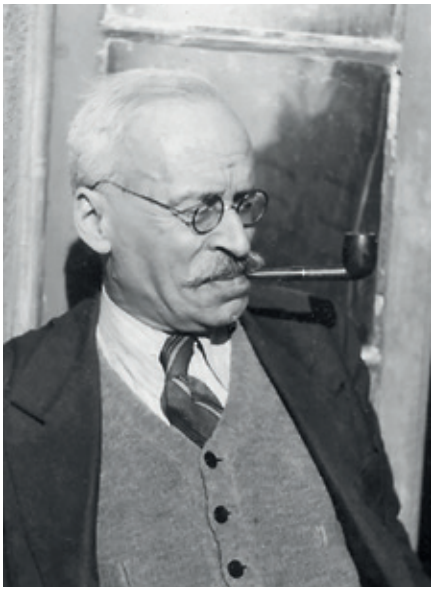


Fig. 8 - The Italian geologist Paolo Vinassa de Regny (1871-1957, commons.wikimedia.org/wiki/File:Paolo_Vinassa_de_Regny.jpg).
- *Il geologo italiano Paolo Vinassa de Regny (1871-1957).*

Fig. 9 - The Austrian geologist Franz Heritsch (1882-1945, after Histon, 1999).
- *Il geologo austriaco Franz Heritsch (1882-1945, da Histon 1999).*


Fig. 10 - Plate VI of Heritsch (1929), illustrating Silurian Orthocerida from Carnic Alps (Italy and Austria).
- *La tavola VI di Heritsch (1929) illustra Orthocerida del Siluriano delle Alpi Carniche (Italia e Austria).*

in certain lithostratigraphic units of the Silurian even if the same author admitted the difficulty in establishing biozones based exclusively on nautiloids due to not always optimal conservation conditions and their not always frequent presence in Silurian rocks.

Recent works

At the end of the nineties of the last century, a new phase of studies on the nautiloids of the Silurian of the Carnic Alps began thanks to the University of Modena and Reggio Emilia with the collaboration of the Museo Friulano di Storia Naturale of Udine and, later, other Italian institutions.

Numerous works on Silurian cephalopods are published at the turn of the new millennium. Some are revisions of museum collections: Gnoli & Histon (1998) describe 18 species of cephalopods belonging to 13 genera, collected in different localities of the Carnic Alps, deposited in part at the Museo Friulano di Storia Naturale; Histon (1999) publishes the revision of the Heritsch collection stored at the Geologische Bundesanstalt in Vienna providing, when possible, a systematic revision at the species level; Gnoli et al. (2000) reviewed the "Gortani and Vinassa de Regny" collection stored in the Palaeontology Museum of Dipartimento di Scienze Biologiche, Geologiche e Ambientali of Bologna University. In the meantime, an accurate survey of the outcrop areas of the Silurian rocks began throughout the Italian side of the Carnic Alps. Simultaneously, interest in cephalopods and *Orthoceras* limestones also resumed on the Austrian side, culminating with the organization of the world cephalopod congress in Vienna in 1999. Studies of a taxonomic nature, in which new data are presented, are due to Gnoli & Serventi (2008), Serventi (1999; 2001; 2010), Serventi & Gnoli (2000), Serventi et al. (2006; 2010). Corradini et al. (2003) in a stratigraphic and micropaleontological study on the area of Monte Cocco, north of Ugovizza, illustrate some specimens of nautiloid cephalopods. A few specimens from Mt. Zermula area were figured by Corradini et al. (2019; 2020).

## Systematic palaeontology

The taxonomic scheme adopted for the study is principally that reported in the Treatise of Invertebrate Palaeontology Part K, Mollusca 3 (Sweet 1964) with integrations from Dzik (1984) and the Data Retrieval System Nautiloidea by Engeser (1999). The terminology employed is essentially that advocated by Flower (1964).

The elements useful for taxonomic recognition are the general shape of the straight or more or less curved shell, the presence of the external ornamentation and the annulation of the shell and, finally, the internal characters (first of all the type of septal collar).

Almost all the specimens studied are part of the geo-paleontological collection of the Museo Friulano di Storia Naturale (MFSNgp) and Geologischen Bundesanstalt in Vienna.

The nautiloid samples collected are in most cases incorporated in centimetric blocks of limestone; however, there are examples isolated from the matrix. The dimensions of the collected samples vary considerably, and in the majority of cases they are broken and fragmented (few centimeters or even millimeters).

Taxa belonging to families Orthoceratidae, Anaspyroceratidae, Arionoceratidae, Geisonoceratidae, Sphooceratidae, Pseudorthoceratidae, Lamellorthoceratidae, Armenoceratidae, Huroniidae, Ormoceratidae, Oncoceratidae, Barrandeoceratidae, Uranoceratidae and Lechritrochoceratidae are listed below.

Class Cephalopoda Cuvier, 1798
Subclass Nautiloidea Agassiz, 1847
Order Orthocerida Kuhn, 1940

Superfamily Orthocerataceae M'Coy, 1844
Family Orthoceratidae M'Coy, 1844
Subfamily Michelinoceratinae Flower, 1945
Genus *Hemicosmorthoceras* Ristedt, 1968
*Hemicosmorthoceras semimbricatum* Gnoli, 1983 (Fig. 11/1)
*Hemicosmorthoceras* aff. s*erratulum* (Barrande, 1868; Fig. 11/2)
*Hemicosmorthoceras* sp.

Genus *Kopaninoceras* Kiselev, 1969
*Kopaninoceras jucundum* (Barrande, 1870; Fig. 11/3)
*Kopaninoceras*? cf. *jucundum* (Barrande, 1870)
*Kopaninoceras thyrsus* (Barrande, 1870)
*Kopaninoceras* sp.

Genus *Michelinoceras* Foerste, 1932
*Michelinoceras (Michelinoceras) michelini* (Barrande, 1866; Fig. 11/4)
*Michelinoceras* cf. *michelini* (Barrande, 1866
*Michelinoceras currens* (Barrande, 1866)
*Michelinoceras* cf. *currens* (Barrande, 1866)
*Michelinoceras*? cf. *migrans* (Barrande, 1866)
*Michelinoceras* sp.

Genus *Merocycloceras* Ristedt, 1968
*Merocycloceras* cf. *declivis* Ristedt 1968
*Merocycloceras*? cf. *declivis* Ristedt 1968
*Merocycloceras*? sp

Genus *Plagiostomoceras* Teichert & Glenister, 1952
*Plagiostomoceras gruenewaldti*

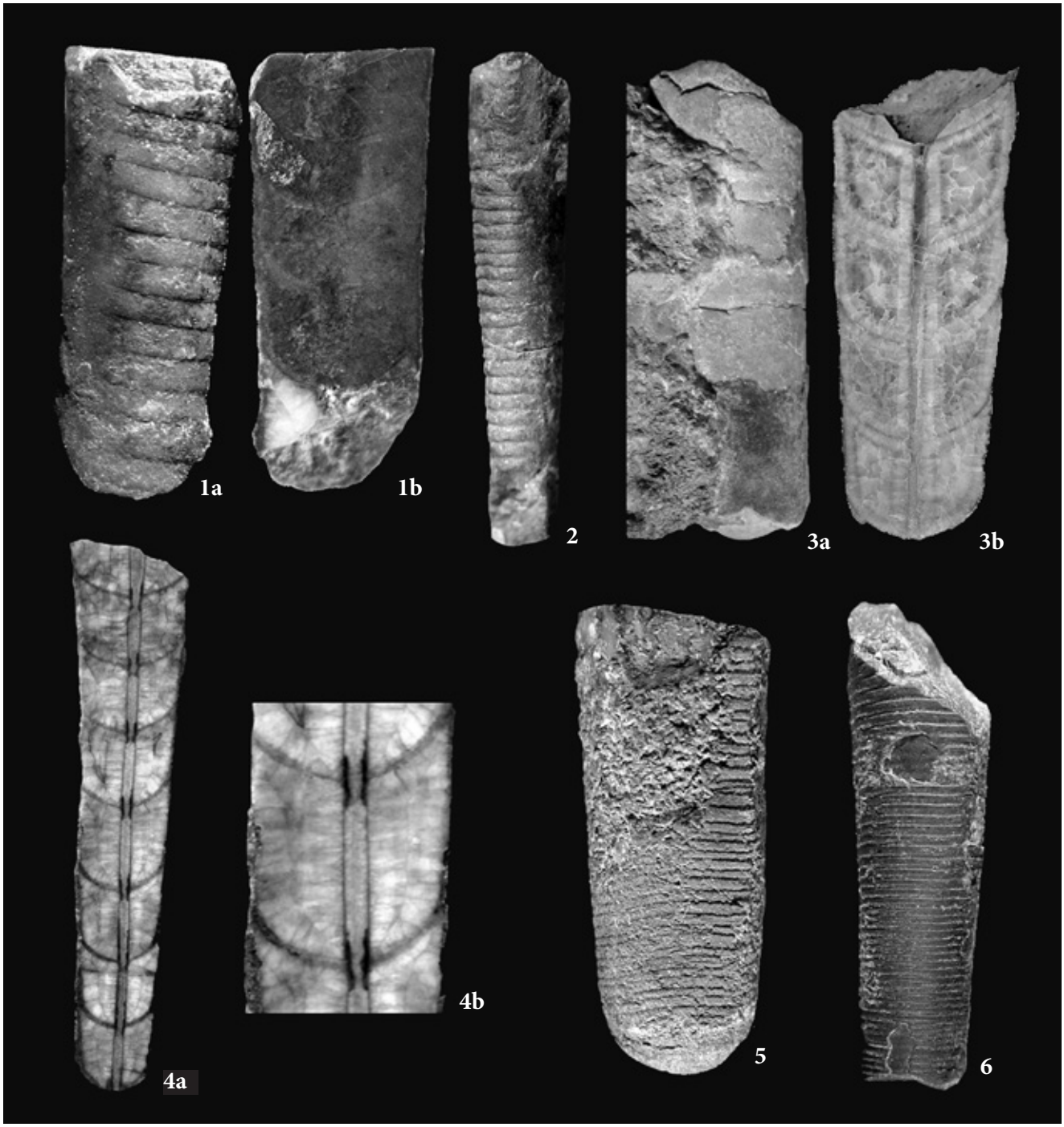



Fig. 11 - 1) *Hemicosmorthoceras semimbricatum* Gnoli, MFSNgp 26352, 7x. 1a) lateral view showing the outer ornamentation on the ventral part only; 1b) polished section showing the inner features. 2) *Hemicosmorthoceras* aff. *serratulum* (Barrande), MFSNgp 26350, 6x. 2) ventral view showing the outer ornamentation. 3) *Kopaninoceras jucundum* (Barrande), MFSNgp 13707. 3a) outer view, 2x; 3b) polished section showing the inner features, 2x. 4) *Michelinoceras* (*Michelinoceras*) *michelini* (Barrande), MFSNgp 26354. 4a) longitudinal polished section showing the inner features, 2x; 4b) enlarged view of some septal necks and endosiphuncular deposits, 4x. 5) *Plagiostomoceras* aff. *gruenewaldti* (Barrande), MFSNgp 26496, 2,7x. Lateral view showing the outer ornamentation. 6) *Plagiostomoceras* ? sp. B sensu Gnoli & Histon, MFSNgp 807, x2. Lateral view showing the outer ornamentation.

- Hemicosmorthoceras semimbricatum *Gnoli, MFSNgp 26352, 7x; 1a) veduta laterale mostrante l'ornamentazione esterna limitata sulla sola metà ventrale; 1b) sezione lucida mostrante i caratteri interni. 2)* Hemicosmorthoceras *aff.* serratulum *(Barrande), MFSNgp 26350, 6x; veduta ventrale mostrante l'ornamentazione esterna. 3)* Kopaninoceras jucundum *(Barrande), MFSNgp 13707. 3a) veduta esterna, 2x; 3b) sezione lucida mostrante i caratteri interni, 2x. 4)* Michelinoceras *(*Michelinoceras*)* michelini *(Barrande), MFSNgp 26354. 4a) sezione longitudinale lucida mostrante i caratteri interni; 2x; 4b) ingrandimento di alcuni collaretti settali e dei depositi endosifuncolari, 4x. 5)* Plagiostomoceras *aff.* gruenewaldti *(Barrande), MFSNgp 26496, 2,7x. Veduta laterale mostrante l'ornamentazione esterna. 6)* Plagiostomoceras *? sp. B sensu Gnoli & Histon, MFSNgp 807, 2x. Veduta laterale mostrante l'ornamentazione esterna.*

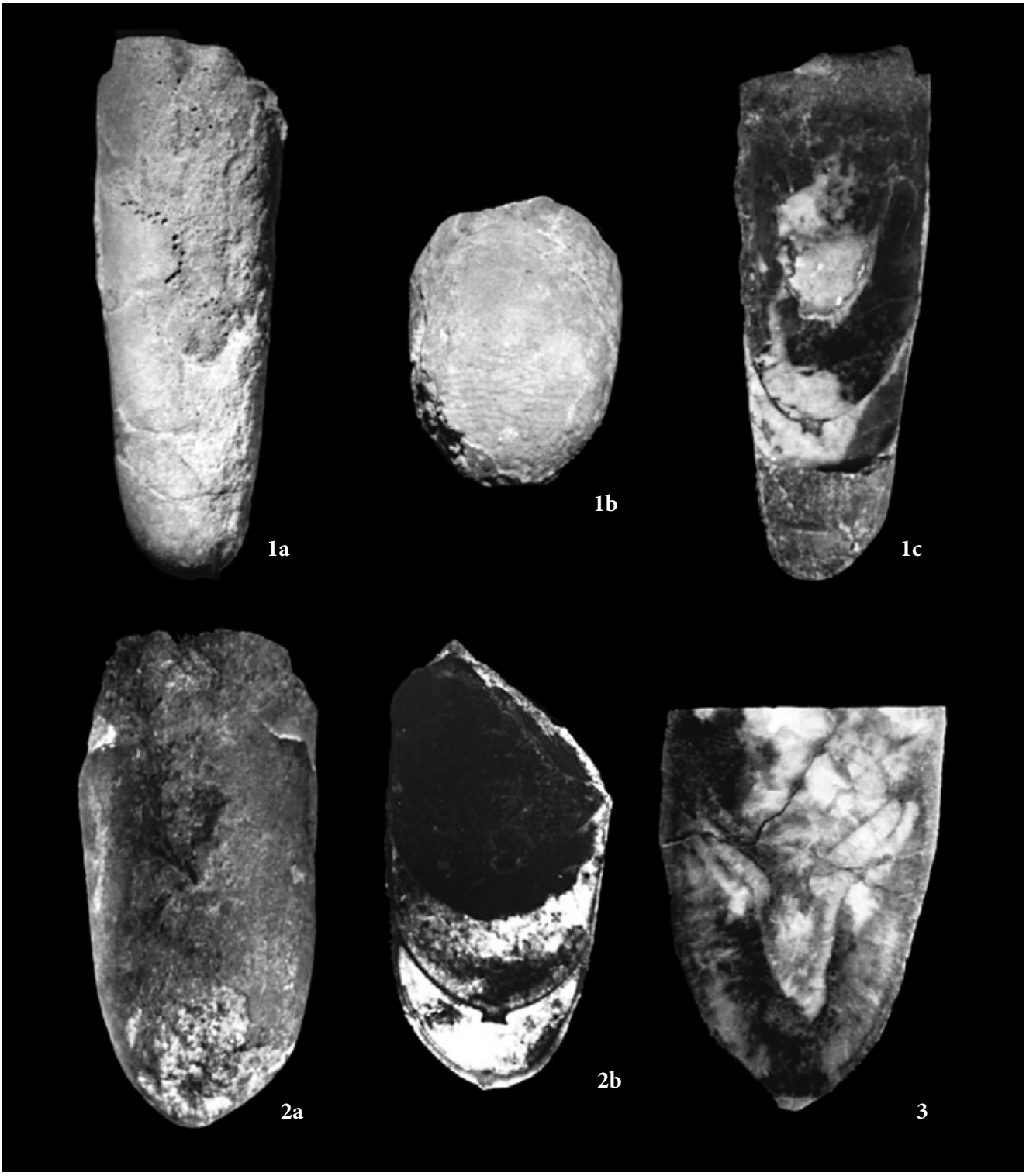



Fig. 12 - 1a) *Sphooceras truncatum* (Barrande), lateral view of specimen MC98/25, 2,2x; 1b) longitudinal polished section of the same specimen, showing the septal neck of orthocoanitic type, 2.2x; 1c) enlargement of the specimen showing the characteristic ornamentation on the truncation formed by concentric striae, 2.5x; 2a) *Andigenoceras andigense* Kiselev, external view of specimen MC98/12, 3x; 2b) longitudinal polished section of the same specimen, showing the septal collarette of suborthocoanitic type, 3x; 3) *Andigenoceras*? sp. A, longitudinal glossy section of specimen MC98/45, showing suborthocoanitic type septal collarette, 2.5x.

- *1a)* Sphooceras truncatum *(Barrande), vista laterale del campionje MC98/25, 2,2x; 1b) sezione lucida longitudinale dello stesso esemplare, mostrante il collaretto settale di tipo ortocoanitico, 2,2x; 1c) ingrandimento del campione mostrante la caratteristica ornamentazione sulla troncatura formata da striae concentriche, 2,5x; 2a)* Andigenoceras andigense *Kiselev, vista esterna dell'esemplare MC98/12, 3x; 2b) sezione lucida longitudinale dello stesso esemplare, mostrante il collaretto settale di tipo subortocoanitico, 3x; 3)* Andigenoceras*? sp. A, sezione lucida longitudinale dell'esemplare MC98/45, mostrante il collaretto settale di tipo subortocoanitico, 2,5x.*

*Plagiostomoceras* aff. g*ruenewaldti* (Barrande, 1866; Fig. 11/5)
*Plagiostomoceras* cf. *gruenewaldti* (Barrande, 1866)
*Plagiostomoceras* cf. *pleurotomum* (Barrande, 1860)
*Plagiostomoceras* aff. *pleurotomum* (Barrande, 1860)
*Plagiostomoceras*? sp. B *sensu* Gnoli & Histon, 1998 (Fig. 11/6)
*Plagiostomoceras* sp.
*Plagiostomoceras*? sp.

Subfamily Kionoceratinae Hyatt in Zittel, 1900
Genus *Kionoceras* Hyatt, 1884
*Kionoceras carminatum*
*Kionoceras* aff. *electum* (Barrande, 1868)
*Kionoceras* cf. *electum* (Barrande, 1868)
*Kionoceras* cf. *tiro* (Barrande, 1868)

Genus *Parakionoceras* Foerste, 1928
*Parakionoceras striatopunctatum* (Barrande, 1868)
*Parakionoceras* cf. *originale* (Barrande, 1868)
*Parakionoceras* sp.

Subfamily Leurocycloceratinae Sweet, 1964
Genus *Akrosphaerorthoceras* Ristedt, 1968
*Akrosphaerorthoceras gregale* Ristedt, 1968.

Genus *Anaspyroceras* Shimizu & Obata, 1935,
*Anaspyroceras* cf. *pseudocalamiteum* (Barrande, 1852)
Genus et species ind. A

Genus *Orthocycloceras* Barskov, 1972
*Orthocycloceras* cf. *lynx* (Barrande, 1868)
*Orthocycloceras*? cf. *subannulare* (Münster, 1840)
Genus et species ind. A

Family Sphooceratidae Flower, 1962
Genus *Sphooceras* Flower, 1962
*Sphooceras truncatum* (Barrande, 1860; Fig. 12/1)

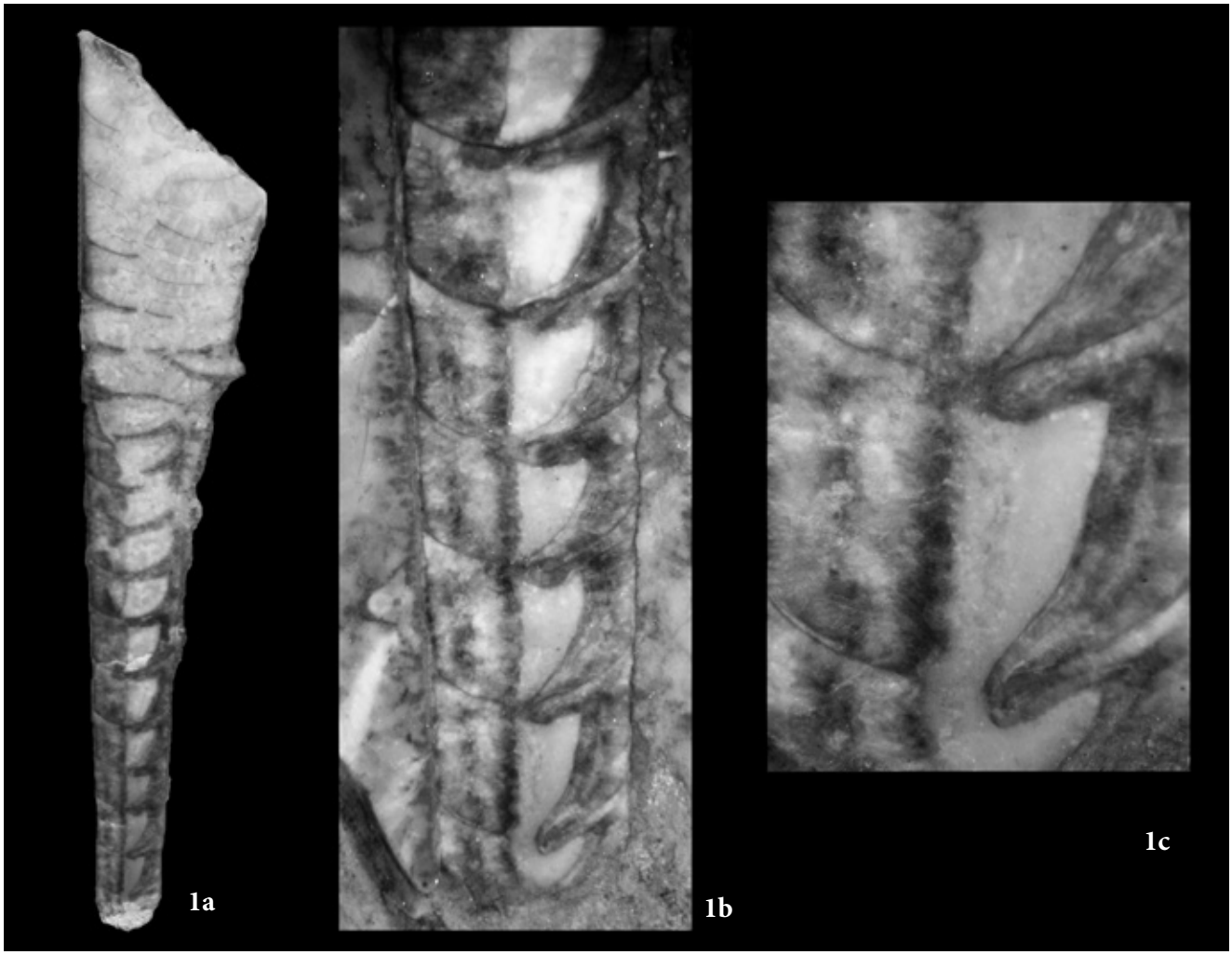
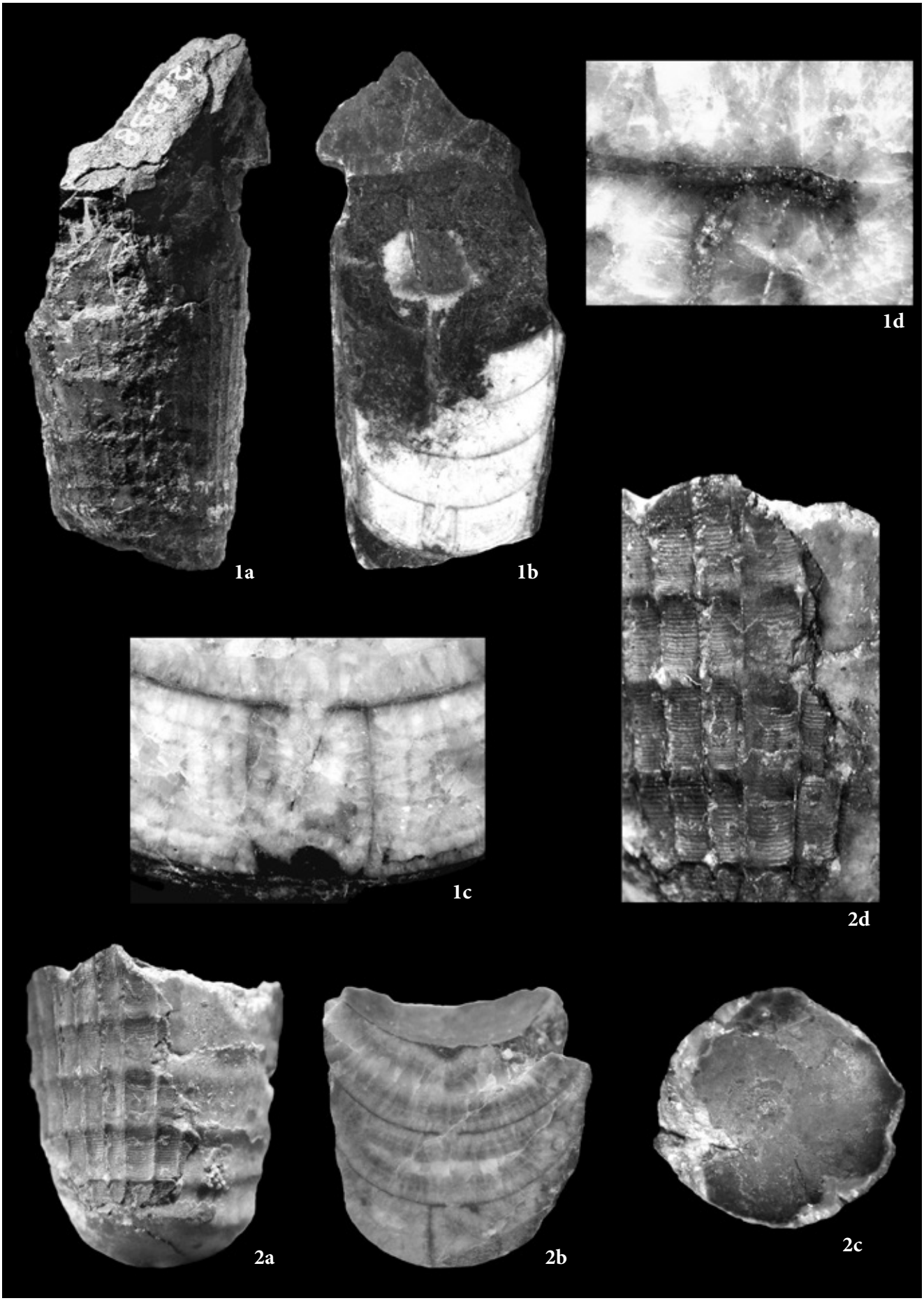



Fig. 13 - *Nucleoceras* aff. *hollandi*, MFSNgp 20824. 1a) polished longitudinal section view, 3x; 1b) enlarged detail of the first 6 chambers, showing the inner features, 7x; 1c) enlarged detail of the second chamber showing the orthocoanitic septal necks.
- Nucleoceras *aff.* hollandi, *MFSNgp 20824. 1a) vista in sezione longitudinale lucida, 3x; 1b) dettaglio ingrandito delle prime 6 camere, che mostra le caratteristiche interne, 7x; 1c) particolare ingrandito della seconda camera, che mostra i collaretti settali ortocoanitici.*


1a
1b
1d
1c
2d
2a
2b
2c

Genus *Andigenoceras* Gnoli in Kiselev, 1992
*Andigenoceras andigense* Kiselev, 1992 (Fig. 12/2)
*Andigenoceras*? sp. A (Fig. 12/3)

Family Geisonoceratidae Zhuravleva, 1959
Genus *Arionoceras* Barskov, 1966
*Arionoceras affine* (Meneghini, 1857)
*Arionoceras* aff. *affine* (Meneghini, 1857)
*Arionoceras submoniliforme* (Meneghini, 1857)
*Arionoceras* aff. *submoniliforme* (Meneghini, 1857)
*Arionoceras* sp.
*Arionoceras*? sp.

Genus *Columenoceras* Barskov, 1960
*Columenoceras*? cf. *duponti* (Barrande, 1866)
*Columenoceras* cf. *agassizi* (Barrande, 1866)
*Columenoceras* aff. *grande* (Meneghini, 1857)
*Columenoceras* sp.

Genus *Geisonoceras* Zhuravleva, 1959
*Geisonoceras rivale* (Barrande, 1866)
*Geisonoceras*? cf. *nobile* (Barrande, 1866)
*Geisonoceras* cf. *nobile* (Barrande, 1866)
*Geisonoceras* cf. *severum* (Barrande 1866)
*Geisonoceras* sp.
*Geisonoceras*? sp.

Genus *Vericeras* Kolebaba, 1977
*Vericeras*? cf. *dorulites* (Barrande, 1874)

Superfamily Pseudorthoceratacea Flower & Caster, 1935
Family Pseudorthoceratidae Flower & Caster, 1935
Subfamily Spyroceratinae Shimizu & Obata, 1935
Genus *Pseudocycloceras* Barskov, 1959
*Pseudocycloceras* cf. *transiens* (Barrande, 1866)
*Pseudocycloceras* aff. *transiens* (Barrande, 1866)
*Pseudocycloceras*? cf. *conviva* (Barrande, 1870)
*Pseudocycloceras? sp.*

Order Pallioceratida Marek, 1998 (=Lituitina Dzik, 1984, partim) (emended Kolebaba, 2002)

Family Lamellorthoceratidae Teichert, 1961 (emended Kolebaba, 1999a)
Genus *Nucleoceras* Kolebaba, 1999a
*Nucleoceras* aff. *hollandi* Kolebaba, 1999b (Fig. 13)

Subclass Actinoceratoidea Teichert, 1933
Order Actinocerida Teichert, 1933

Family Armenoceratidae Troedsson, 1926
Genus *Elrodoceras* Foerste, 1924
*Elrodoceras* sp. ind. A (Fig. 14/1)

Family Huroniidae Foerste & Teichert, 1930
Genus *Hurionella* Foerste, 1924
*Huroniella*? sp. ind. (Fig. 14/2)

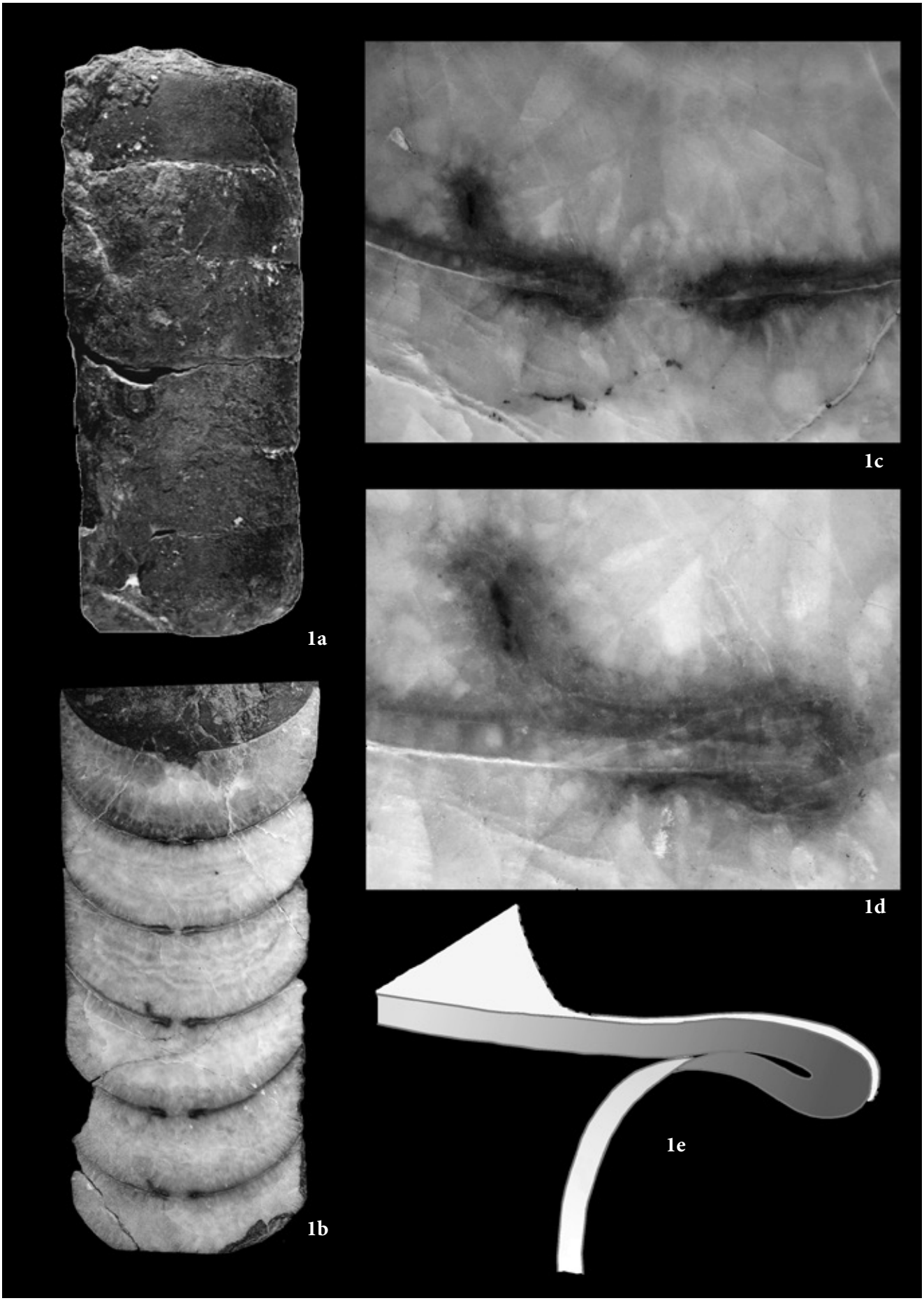
Family Ormoceratidae Saemann, 1853
Genus *Ormoceras* Stokes, 1840
*Ormoceras*? sp. B (Fig. 15)

Order indet
.
Family indet.
Genus *Serpaglioceras* Gnoli & Serventi, 2008 ex *Rutoceras*
*Serpaglioceras forojuliense* Gnoli & Serventi, 2008 (Fig. 16)

Order Barrandeocerida Flower in Flower & Kümmel, 1950

Family Barrandeoceratidae Foerste, 1925
Genus *Barrandeoceras* Hyatt, 1884
*Barrandeoceras*? sp.

Fig. 14 - 1) *Elrodoceras* sp. ind. A. Specimen MFSNgp 31864: 1a) polished oblique section preserving the last chamber of phragmocone, 1.5x; 1b) detail showing the central siphuncle with annular deposits more developed on the ventral side, 3x; 1c) enlarged detail showing the dorsal annular deposit, the recumbent septal neck and the trend of the connecting ring in its proximal part, 8.5x; 1d) enlarged detail of the above reported features in the ventral side of the septal foramen, 7x; 1e) schematic draft showing the septal neck. 2) *Huroniella*? sp. ind. Specimen MFSNgp 31865: 2a) longitudinal polished section showing three chambers, the wide sub-central siphuncle and the preserved inner features, 2x; 2b) enlarged detail of the strongly recumbent actinocerid septal neck with funnel-like huronionid adnation area, 10x; 2c) schematic draft showing the transversal section with the shaded area indicates available material; 2d) schematic draft showing the septal neck.
- 1) Elrodoceras *sp. ind. A. Esemplare MFSNgp 31864: 1a) sezione lucida obliqua che mostrante l'ultima camera del fragmocono, 1.5x; 1b) dettaglio mostrante il sifuncolo centrale con i depositi annulari più sviluppati sul lato ventrale, 3x; 1c) dettaglio ingrandito mostrante I depositi annulari dorsali, il collaretto settale ripiegato e l'andamento degli anelli di connessione nella parte prossimale, x 8.5x; 1d) dettaglio ingrandito dei caratteri riportati sopra nel lato ventrale del foramen settale, 7x; 1e) disegno schematico mostrante il collaretto settale. 2)* Huroniella*? sp. ind. Esemplare MFSNgp 31865: 2a) sezione longitudinale lucida che mostra le tre camere, l'ampio sifone subcentrale e le caratteristiche interne conservate, 2x; 2b) dettaglio ingrandito del collaretto settale di tipo actinoceride fortemente reclinato con area di adnazione dell'huronionide simile a un imbuto, 10x; 2c) bozza schematica che mostra la sezione trasversale con l'area ombreggiata che indica il materiale disponibile; 2d) bozza schematica che mostra il collo settale.*


1a
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Family Uranoceratidae Hyatt In Zittel, 1900
Genus *Uranoceras* Hyatt, 1884
*Uranoceras*? sp.

Family Lechritrochoceratidae Flower
in Flower & Kümmel, 1950
Genus *Lechritrochoceras* Foerste, 1926
*Lechritrochoceras* cf. *hoernesi* (Barrande, 1865)

Order Oncoceratida Flower
in Flower & Kummel, 1950

Family Oncoceratidae Hyatt, 1884
Genus *Oocerina* Foerste, 1926
*Oocerina* cf. *nuntius* (Barrande, 1866)

## Conclusions

The nautiloid fauna of the Carnic Alps is characterised by a predominance of orthocone-shelled taxa with a low angle of expansion (e.g. *Michelinoceras*, *Arionoceras* etc.); however, cirtocone forms (e.g. *Lechritrochoceras*) or brevicone forms with a wide angle of expansion can be found, as is the case with *Serpaglioceras*. The genera *Sphooceras* and *Andigenoceras* bear witness to a direct connection between the Carnic area and Bohemia and Kazakhstan, as well as Sardinia and Montagne Noire in France (Turek & Manda, 2012); also interesting is the finding of *Nucleoceras* reported for the first time in the Carnic Alps outside the Bohemian type area (see Kolebaba 1999a; 1999b; 2002).

The orthocone, cyrtocone morphology of the shell, orthocone, cyrtocone, has been used to indicate the living environment: orthocone shells, i.e. those with a straight shell and a low expansion angle, indicate open sea forms better adapted to swimming, while shells with a high expansion angle and curved shells indicate a more benthic environment (Hewitt & Westermann 1996). The presence of telescoping phenomena and fragmentation of both the outer shell and inner septa indicates the energy of the water. Geopetal structures, dissolution, recrystallisation, fillings or the presence of iron in nautiloid shells have also been related to changes in oxygen content or changes in the depositional environment (Speyer & Brett 1991; Ferretti & Kriz 1995).

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Fig. 15 - *Ormoceras* sp. ind. A. Specimen MFSNgp 23221. 1a) outer view, 1.2x; 1b) longitudinal polished section showing about six chambers and the relatively narrow central siphuncle, 1.3x; 1c) enlarged detail of the septal foramen area showing the recumbent septal neck and the trend of the connecting rings in their proximal part, 10x; 1d) the same dorsal part enlarged, 20x; 1e) schematic draft showing the septal neck.
- Ormoceras s*p. ind. A. Esemplare MFSNgp 23221. 1a) vista esterna, 1,2x; 1b) sezione longitudinale lucida che mostra circa sei camere e il sifuncolo centrale relativamente stretto, 1,3x; 1c) dettaglio ingrandito dell'area del foramen settale mostrante il collaretto settale ripiegato e l'andamento degli anelli di connessione nella loro parte prossimale, 10x; 1d) la stessa parte dorsale ingrandita, 20x; 1e) disegno schematico che mostra il collaretto settale.*

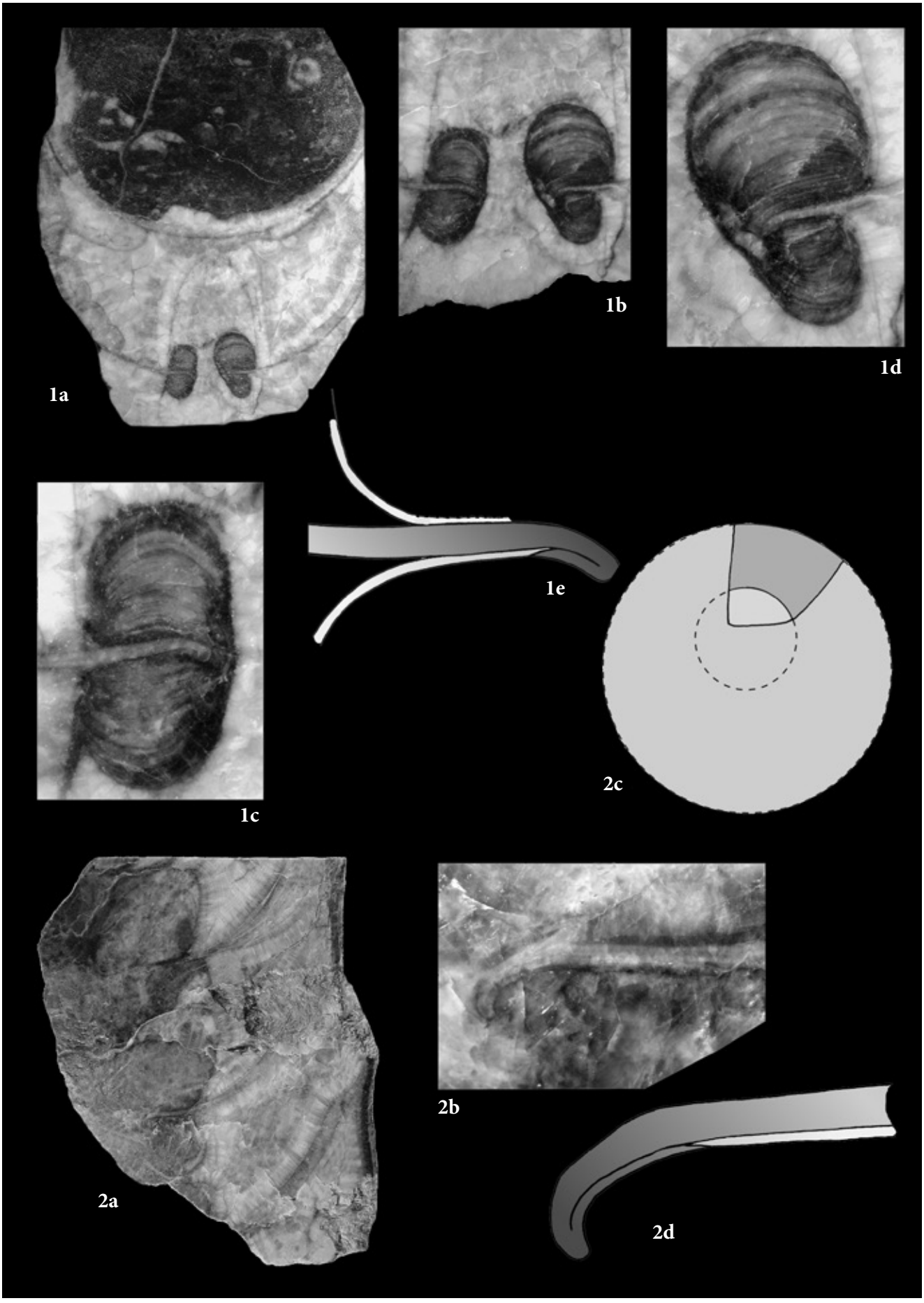
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Fig. 15 - 1. *Serpaglioceras forojuliense*, MFSNgp 28398 1a) outer view, 3.1x; 1b) longitudinal polished section showing the inner features, 3.1x; 1c) enlarged view showing the septal foramen and the connecting ring, 9x; 1d) enlarged detail showing the recumbent septal neck, 5.2x. 2. *Serpaglioceras forojuliense*, IPUM 27965, 2a) outer view, 2.7x; 2b) longitudinal polished section showing the inner features, 2.7x: 2c) septal view showing the sub-central siphuncle, 2.7x; 2d) enlarged view of the outer ornametation, 33x.

- *1.* Serpaglioceras forojuliense*, MFSNgp 28398, 1a) vista esterna dell'esemplare, 3,1x; 1b) sezione longitudinale lucida, mostrante i caratteri interni, 3,1x; 1c) ingrandimento del foramen settale e dell'andamento dell'anello di connessione, x9; 1d) ingrandimento del collaretto settale fortemente ripiegato, 5,2x. 2.* Serpaglioceras forojuliense*, IPUM 27965, 2a) vista esterna dell'esemplare, 2,7x; 2b) sezione longitudinale lucida, mostrante i caratteri interni, 2,7x; 2c) veduta superiore mostrante il sifuncolo subcentrale, 2,7x; 2d) ingrandimento dell'ornamentazione esterna, 33x.*

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