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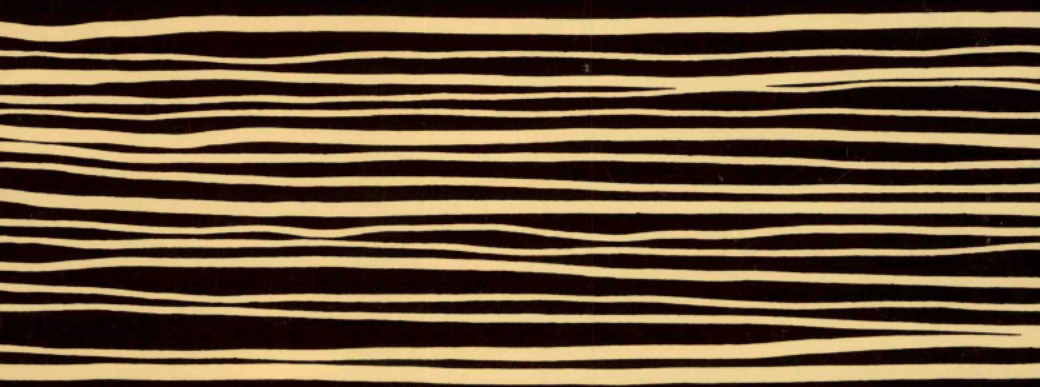
DO  
INSTITUTO GEOLÓGICO E MINEIRO

THE PALAEOZOIC AMMONOIDS OF THE SOUTH PORTUGUESE ZONE

*DIETER KORN*

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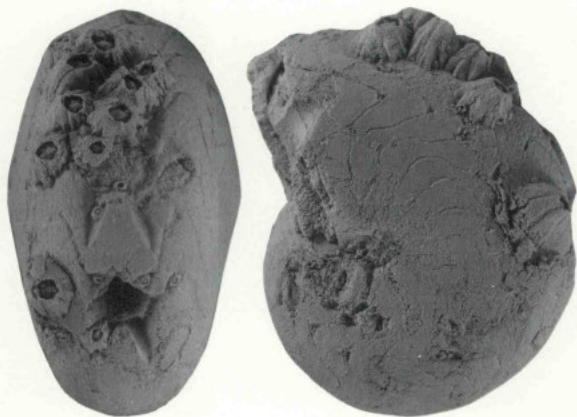
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INSTITUTO GEOLÓGICO E MINEIRO  
N.º 33

## **The Palaeozoic ammonoids of the South Portuguese Zone**

Dieter KORN\*



Lisboa 1997

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\*Institut und Museum für Geologie und Paläontologie der Eberhard-Karls-Universität Tübingen

dedicated to Katharina HORN



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## Preface

The present publication on the Palaeozoic ammonoids of South Portugal represents the end of a long story that concerns almost a century of discontinuous ammonoid research. As with many other fields of Palaeozoic Portuguese geology, it was NERY DELGADO who kicked things off at the end of the last century. He provided the faunas that enabled the first determinations to be made by ROEMER and PRUVOST.

Pioneer work was also carried out by PEREIRA DE SOUSA, a multit talented Portuguese naturalist who, during the 1920s, first recognised the complete marine Carboniferous and mapped the Dinantian and Moscovian successions across the basin. He created a new ammonoid genus which he called *Lusitanoceras*, but its validity has remained controversial for more than fifty years. It is fortunate that, in the present study, Dieter KORN is able to show the accuracy of SOUSA's determinations and recovers a scientific work that apparently was almost lost.

Since SOUSA's work, palaeontological research on the Portuguese marine faunas has been restricted to some discontinuous and mostly tray-based studies by COSTA, FEIO, DELÉPINE and PERDIGÃO. It was only late in the 1970s that a third turning point happened and this coincides with Eva PAPROTH and Manfred HORN's visit to the Portuguese Carboniferous rocks. Since then, enthusiastic and fruitful cooperative work between the German group (including Jürgen KULLMANN) and Portuguese geologists has been developed. This enthusiasm and the warming way I was incorporated in this research group have deeply influenced my later involvement in the study of the South Portuguese Zone geology.

The recovered faunas and the review of the material housed in the Geological Survey of Portugal were the aim of preliminary studies published in the *Comunicações dos Serviços Geológicos de Portugal* and in the *Compte Rendu of the XII International Carboniferous Congress, Madrid*.

The good quality of the fossil associations and the problems that remained to be solved led Dieter KORN to undertake a deeper study of the Portuguese ammonoids, of which the present publication represents the main part.

Dieter KORN is a first-class expert on Devonian and Carboniferous ammonoids and his publications on German faunas are internationally known. Before the present work on the Portuguese faunas he had already studied goniatite associations recovered from several boreholes around the Neves-Corvo Mine, South Portugal; this became a key study for the understanding of the tectono-stratigraphic evolution of the ore body.

The high scientific quality of the present publication represents a fundamental contribution to a better knowledge of the marine Carboniferous of Southern Iberia. I am glad to have encouraged Dieter KORN to do the job, which he has accomplished in such a beautiful and convincing manner.

José Tomás OLIVEIRA

# The Palaeozoic ammonoids of the South Portuguese Zone

Dieter KORN

**Key words:** Devonian, Carboniferous, Biostratigraphy, Ammonoidea, South Portuguese Zone

## Abstract

In the South Portuguese Zone, Late Devonian, Early Carboniferous and early Late Carboniferous sedimentary rocks contain ammonoid faunas which are related to faunal assemblages known from central and northwestern Europe. Especially in the southwestern part of Portugal, on the Atlantic seaboard, ammonoid-bearing beds of various formations are exposed in the antiforms of Aljezur and Bordeira (from base to top):

- Terceiras Formation: An alternation of laminated shales, siltstones, and quartzitic sandstones, usually poor in marine fossils. Ammonoids of the late Famennian *Wocklumeria* Stufe are present.
- Bordaleta Formation: Dark grey to black shales with calcareous lenses and siltstone interbeddings. Ammonoids from the Early and Middle Tournaisian can be collected.
- Murração Formation, with the upper Vale Figueira Member, composed by grey and black shales, dolomitic fossiliferous limestone, and the lower Pedra das Safias Member, built up of grey shales with marly carbonate intercalations: The lower member is poor in ammonoids, and yielded only *Merocantites* sp., which may refer to the Early Viséan. The upper member is rich in goniatites, and at least twelve distinctive horizons are present in the localities Praia das Quebradas and Praia de Murração. The following goniatite zones of the Late Viséan A, B and C are represented: *hudsoni* Zone, *crenistrina* Zone (?), *spirifer* Zone, *gracilis* Zone, *spirale* Zone, *rotundum* Zone (?), *suerlandense* Zone (?), and *poststriatum* Zone.
- Quebradas Formation: Black shales with intercalated carbonate and phosphoric layers, lenses and nodules. Goniatites of the Namurian B and C as well as the basal Westphalian occur in this rock unit. The Namurian A is hardly represented by a fauna, but most of the younger Zones (R1a Zone, R1c1 Zone, R1c2 Zone, R2a Zone, R2b Zone (?), R2c1 Zone, G1a Zone, and G2a Zone) are represented by typical ammonoids. The faunal succession closely resembles the situation in the Subvariscian Realm, e.g. in the British Isles and the Rhenish Massif.
- Brejeira Formation: Greywackes and silty shales of the Baixo Alentejo Flysch Group. Goniatites are rare, but findings of *Gastrioceras listeri* (SOWERBY 1813) indicate a basal Westphalian age.

Additional fossil localities are widespread in the South Portuguese Zone. In the vicinity of Mértola and Pomarão, clymeniids are known from the Late Famennian *annulata* Zone, providing evidence for an occurrence of the widely distributed *annulata* Black Shale. Additionally, goniatites of different zones of the Late Viséan could be collected from a number of localities.

In this paper, a total of 86 taxa are described. Of these, 26 are in open nomenclature, and 22 species are newly introduced. Also, the three new genera *Becanites*, *Aljezurites*, and *Chaerogastrioceras* are erected. The following biostratigraphical units are represented by ammonoid genera:

- Late Famennian *annulata* Zone: 1 taxon (*Platyclymenia*).
- Late Famennian *Wocklumeria* Stufe: 5 taxa (*Cyrtoclymenia*, *Lissoclymenia*, *Linguaclymenia*, and *Acutimitoceras*).
- Early Tournaisian: 1 taxon (*Eocantites*).
- Middle Tournaisian: 4 taxa (*Becanites*, *Goniocyclus*, *Muensteroceras* (?), and *Eurites*).
- Early Viséan: 1 taxon (*Merocantites*).
- Late Viséan A: 12 taxa (*Prolecanites*, *Pronorites*, *Bollandites*, *Beyrichoceras*, *Girtyoceras*, *Nomismoceras*, and *Goniatites*).
- Late Viséan B: 18 taxa (*Prædaraelites*, *Eoglyphioceras*, *Sudetoceras*, *Girtyoceras*, *Sulcogirtyoceras*, *Glyphiolobus*, *Metadimorphoceras*, *Paraglyphioceras*, *Arnsbergites*, *Hibernicoceras*, and *Neoglyphioceras*).
- Late Viséan C: 6 taxa (*Girtyoceras*, *Lusitanoceras*, *Lyrogoniatites*, and *Lusitanites*).
- Namurian A: 1 taxon (*Eumorphoceras*).
- Namurian B: 26 taxa (*Buschkirites*, *Glyphiolobus*, *Metadimorphoceras*, *Anthraceratites*, *Stenoglyphyrites*, *Ramosites*, *Homoceras*, *Aljezurites*, *Vallites*, *Marianoceras*, *Reticuloceras*, *Phillipoceras*, *Tectireites*, *Retites*, *Bilinguites*, and *Homoceratoides*).
- Namurian C: 6 taxa (*Anthraceratites*, *Ramosites*, *Bilinguites*, and *Cancellolobus*).
- Westphalian A: 5 taxa (*Gastrioceras*, *Agastrioceras*, and *Chaerogastrioceras*).

**Palavras-chave:** Devónico, Carbónico, Bioestratigrafia, Ammonoidea, Zona Sul Portuguesa

### Resumo

Na Zona Sul Portuguesa, as rochas sedimentares com idade compreendida entre o Devónico Superior e o início do Carbónico Superior contêm fósseis de amonóides relacionados com os grupos faunísticos do centro e do noroeste da Europa. É sobretudo no sector Sudoeste de Portugal (Antiformes de Aljezur e Bordeira), na costa atlântica, que se encontram as principais jazidas. Temos assim, da base a topo:

- A Formação de Tercenas: alternância de argilitos, siltitos, grés e quartzitos, pobres em fósseis marinhos. Nestes níveis são encontrados amonóides do Fameniano Superior, *Wocklumeria* Stufe.
- A Formação de Bordaleta: argilitos negros com intercalações e lenticulas de siltitos. Presença de amonóides do Tournaisiano Inferior e Médio.
- A Formação de Murração, dividida no membro superior de Vale Figueira (constituído por pelitos, xistos negros e calcários dolomíticos) e no membro inferior de Pedra das Safias (formado por pelitos cinzentos com intercalações de dolomitos e margas). O membro inferior contém um número reduzido de amonóides; sendo *Merocanites* sp. o único género identificado, que poderá indicar o Viseano Inferior. O Membro superior encerra abundantes goniatites; pelo menos doze horizontes distintos são identificados na Praia das Quebradas e na Praia de Murração. Diversas zonas de goniatites do Viseano Superior A, B e C estão aqui representadas, nomeadamente: Zonas *hudsoni*, *crenistris* (?), *spirifer*, *gracilis*, *spirale*, *rotundum* (?), *suerlandense* (?) e *poststriatum*.
- A Formação de Quebradas: xistos negros com intercalações de lenticulas de calcários e horizontes com nódulos fosfatados, no topo. Goniatites do Namuriano B e C assim como do Vestefaliano inferior são assinaladas nesta unidade. O Namuriano A é muito pobre em restos faunísticos, mas a presença de amonóides é assinalada nas zonas mais recentes (Zonas R1a, R1c1, R1c2, R2a, R2b (?), R2c1, G1a e G2a). Esta sucessão faunística é muito semelhante à que ocorre nas Ilhas Britânicas e no Maciço Xisto-Renano, na Alemanha.
- A Formação da Brejeira: grauvaques e siltitos do Grupo do Flysch do Baixo Alentejo. Os fósseis de goniatites são raros, mas a presença de *Gastrioceras listeri* (SOWERBY 1813) data esta formação do Vestefaliano Inferior.

Outras jazidas são conhecidas na Zona Sul Portuguesa. Próximo de Mértola e Pomarão foram encontrados fósseis de amonóides em conexão com a Zona *annulata* do Fameniano Superior; a sua presença em Portugal indica a larga repartição geográfica dos xistos negros típicos desta zona. Fósseis de goniatites de diversas zonas do Viseano Superior foram recolhidos em várias outras jazidas.

Neste trabalho são descritos 86 taxa dos quais 26 são identificados apenas ao nível género, 22 como novas espécies e três novos géneros, *Becanites*, *Aljezurites* e *Chaerogastrioceras*. Os diferentes géneros de amonóides estão representados nas unidades bioestratigráficas seguintes:

- Fameniano Superior Zona *annulata*: 1 taxon (*Platyclymenia*).
- Fameniano Superior Stufe *Wocklumeria*: 5 taxa (*Cyrtoclymenia*, *Lissoclymenia*, *Linguaclymenia* e *Acutimitoceras*).
- Tournaisiano Inferior: 1 taxon (*Eocanites*).
- Tournaisiano Médio: 4 taxa (*Becanites*, *Goniocyclus*, *Muensteroceras* (?) e *Eurites*).
- Viseano Inferior: 1 taxon (*Merocanites*).
- Viseano Superior A: 12 taxa (*Prolecanites*, *Pronorites*, *Bollandites*, *Beyrichoceras*, *Girtyoceras*, *Nomismoceras* e *Goniatites*).
- Viseano Superior B: 18 taxa (*Prodaeraelites*, *Eoglyphioceras*, *Sudetoceras*, *Girtyoceras*, *Sulcogirtyoceras*, *Glyphiolobus*, *Metadimorphoceras*, *Paraglyphioceras*, *Arnsbergites*, *Hibernicoceras* e *Neoglyphioceras*).
- Viseano Superior C: 6 taxa (*Girtyoceras*, *Lusitanoceras*, *Lyrogoniatites* e *Lusitanites*).
- Namuriano A: 1 taxon (*Eumorphoceras*).
- Namuriano B: 26 taxa (*Baschkirites*, *Glyphiolobus*, *Metadimorphoceras*, *Anthraceroceras*, *Stenoglyphyrites*, *Ramosites*, *Homoceras*, *Aljezurites*, *Vallites*, *Marianoceras*, *Reticuloceras*, *Phillipoceras*, *Tectitretites*, *Retites*, *Bilinguites* e *Homoceratoides*).
- Namuriano C: 6 taxa (*Anthraceroceras*, *Ramosites*, *Bilinguites* e *Cancelloceras*).
- Vestefaliano A: 5 taxa (*Gastrioceras*, *Agastrioceras* e *Chaerogastrioceras*).



## I. INTRODUCTION

The South Portuguese Zone marks the southwestern margin of the European Variscides, originating from a sedimentary source - depositional area couplet, the crystalline Beja Massif and the South Portuguese Basin. This principally resembles the Carboniferous sedimentary basin known from northern and central Europe (OLIVEIRA, HORN & PAPROTH 1979).

Despite of the abundance of Carboniferous ammonoids in the sedimentary rocks of the South Portuguese Zone, only few descriptions have been published, and a comprehensive monograph still does not exist. Ammonoids of this geotectonic unit, however, are important for several reasons:

1. Biostratigraphical dating of the Carboniferous sedimentary succession of the South Portuguese Basin, which includes the Baixo Alentejo Flysch Group, can best be achieved with ammonoids. Particularly the clastic sequences only rarely contain limestones which are productive for microfossils such as conodonts and foraminifers.

2. Well-determined and strictly-located ammonoid faunas help to solve the puzzling tectonic construction of the South Portuguese Zone, and can provide evidence of whether a sequence is undistorted or interrupted by faults and overthrusts.

3. Comparison of ammonoid faunas from the South Portuguese Basin with those of other regions uncover faunal relationships and hence provide information about the former constellation and movement of the plates, e.g. of those assembled to form the Iberian Peninsula.

4. In the South Portuguese Zone, well exposed sections with Late Namurian and basal Westphalian sedimentary rocks can be studied in detail in surface outcrops. This is particularly important because of the very difficult and usually only temporarily accessible subsurface outcrops in the Rhenish Massif and the North of England. For these reasons, the ammonoid faunas from the South Portuguese Zone are of particular interest in the context of a multidisciplinary study and a modern analysis of sedimentary sequences as well as plate tectonic investigations.

This study will focus on the faunal interrelationships between the South Portuguese Zone, and the sedimentary basins of Northern Europe, the American Mid-continent, North Africa, the South Urals, and Central Asia. This attempt is based on the database GONIAT, Tübingen (KORN & KULLMANN 1996), from which all the necessary data have been taken.

## II. HISTORICAL REVIEW

Ammonoids from the South Portuguese Zone were already known in the second half of the last century, when the first collection was assembled by the field geologist J.F. NERY DELGADO (1870, 1876) from various localities in the Baixo Alentejo and Algarve regions. These were forwarded to Ferdinand ROEMER, who already noticed that there is a surprising consistency in petrography and palaeontology of the *Posidonia* shales in the Rhenish Massif and South Portugal, and determined the goniatites as belonging to the species „*Goniatites crenistria*“, „*Goniatites sphaericus*“, and „*Goniatites mixolobus*“ (ROEMER 1876).

Some of these ammonoids were sent to PRUVOST, who in a pioneering investigation (1912) described clymeniid from limestone lenses found in the „schistes a néréites“ [= Phyllite-Quartzite Formation] in the vicinity of São Domingos in the Pomarão region. Species assignment however, of the three specimens to *Clymenia laevigata* (MÜNSTER 1832) is uncertain because of their poor preservation [according to the original material described by PRUVOST, and the stratigraphical age of the samples, it is much more likely that the specimens belong to species of *Platyclymenia*].

The first figured Early Carboniferous goniatites are also known from almost the beginning of this century, when PRUVOST (1914) described a few specimens from Bordeira as a new species, „*Prolecanites algarbiensis* nov. sp.“ [= *Becanites algarbiensis*], and others from Murraço as assigned to „*Goniatites subcircularis* MILLER“ [= *Lusitanites clitheroensis* KORN 1988].

Field research on the Carboniferous sedimentary rocks of South Portugal was then achieved by PEREIRA DE SOUSA (1920, 1921), who a little later (1923, 1924) added another new species to the fauna, creating the new genus and species name „*Lusitanoceras algarbiensis*“, which he based on heterogenic material from the Cachopo and Aljezur areas. [Due to the fact that PEREIRA DE SOUSA did not separate this collection in terms of different species, the generic name *Lusitanoceras* was misinterpreted and suppressed for more than six decades (e.g. RUZHENCEV & BOGOSLOVSKAYA 1971), see KORN 1988].

A few years later, PEREIRA DE SOUSA (1926) listed more than 25 goniatite localities (with „*Glyphioceras*“ or „*Gastrioceras*“) from around the syenite complex of Monchique. From Passil near Marmeleiro he briefly described a section in which *Posidonia*-bearing shales with „*Goniatites striatus*“ and „*Goniatites sphaericus*“ are overlain by shales containing „*Lusitanoceras algarbiensis*“. After publication of these articles, interest in the



Palaeozoic ammonoid faunas from Portugal diminished, and within a timespan of more than five decades only a few publications appeared containing descriptions of Palaeozoic ammonoids.

CARRINGTON DA COSTA (1931) reviewed the findings of Palaeozoic ammonoids from the South Portuguese Zone. In 1943, he figured Viséan goniatites, which unfortunately are strongly crushed and distorted, from a few localities in the areas of Odemira and Grândola, referring them to „*Glyphioceras falcatum*“, „*Glyphioceras striatum*“, and „*Glyphioceras granosum*“, etc. The poor preservation of these specimens, however, does not allow confirmation of these determinations with certainty.

The next description of Portuguese goniatites was by FEIO (1946a), who erected a new species from Mértola, „*Glyphioceras myrtillense*“ [= *Paraglyphioceras myrtillense*], which was found in a lenticular limestone bed associated with other goniatites, „*Glyphioceras crenistria* var. *globoides*“, „*Glyphioceras crenistria* var. *globostriata*“, „*Glyphioceras striatum*“, and „*Glyphioceras striatum falcatum*“ [all these described specimens may, according to their cross sections and suture lines, belong to a species of the genus *Arnsbergites*].

Ten years later, DELÉPINE (1957) listed 10 Tournaisian as well as 19 Viséan goniatite-bearing fossil localities within the South Portuguese Zone. DELÉPINE was the first to provide a stratigraphical scheme in which he placed the different faunas known so far. Also, he tried to correlate the Portuguese faunas with those known from England, Russia, and North America.

Only twenty years ago, interest in ammonoids from the South Portuguese Zone increased rapidly. After an investigation of the geotectonic frame of this area, ammonoids were regarded as important tools for dating the Baixo Alentejo Flysch Group, and for suprarregional correlation of sediments deposited in the South Portuguese Basin with those of other Late Palaeozoic sedimentary basins (OLIVEIRA, HORN & PAPROTH 1979).

The second investigation of Devonian ammonoids from the South Portuguese Zone was carried out by TERMIER in FANTINET, DREESEN, DUSAR & TERMIER (1976), who figured some platycleneniids from the vicinity of Mértola, probably being the oldest known ammonoids from South Portugal.

In 1978, PERDIGÃO listed a large number of Carboniferous goniatite localities from various regions within South Portugal, and revised the stratigraphical scheme given before by DELÉPINE. PERDIGÃO figured some Early Carboniferous goniatites:

„*Protocanites algarbiensis*“ [= *Becanites algarbiensis*],

„*Goniatites falcatus*“ [= *Lusitanoceras algarviense* PEREIRA DE SOUSA 1923],

„*Goniatites granosus*“ [= *Lusitanoceras poststriatum* BRÜNING 1923], and

„*Goniatites subcircularis*“ [= *Lusitanites clitheroensis* KORN 1988].

WAGNER-GENTIS (1981) figured „*Sudetoceras regina BISAR*“ [= *Sudetoceras murracaensis* sp. nov.] from the Algarve coast at Murração.

In their innovative paper, OLIVEIRA, HORN & PAPROTH (1979) described and figured a number of goniatite specimens which were mostly collected in the twenties, and are housed in the collections of the Instituto Geológico e Mineiro de Portugal in Lisbon. Unfortunately, locality data for most of this material are poorly recorded, usually without any distinctive information about the stratigraphical origin, but the faunal list reflects a wide range of systematic and biostratigraphical units within the late Early and early Late Carboniferous. Based on the assumption of close relationships with the northern European sedimentary sequences, OLIVEIRA, HORN & PAPROTH determined the faunal elements as being conspecific with species already known from the North of England, the Rhenish Massif, etc. The conclusion of this study was that principally the same goniatite succession occurs in northern Europe and South Portugal.

During mapping fieldwork in the South Portuguese Zone, J.T. OLIVEIRA assembled a collection of goniatites from the Alcoutim and Castro Verde areas, which have been studied by WAGNER-GENTIS in OLIVEIRA & WAGNER-GENTIS (1983). Especially from not far from Vaqueiros, near the type locality of *Lusitanoceras algarviense*, she figured a fauna consisting of

„*Dombartites parafalcatoides*“, „*Platygioniatites* sp. 'early form'“ [both must be assigned to *Lusitanoceras algarviense* or *Lusitanoceras poststriatum* (BRÜNING 1923), see systematic chapter],

„*Lyrogioniatites georgiensis*“, „*Lyrogioniatites mutabilis*“, „*Lyrogioniatites* aff. *eisenbergensis*“, and „*Pachylroceras claudi*“ [all these forms belong to only one species, *Lyrogioniatites liethensis* KORN 1988].

This fauna which originated from the top of the Mértola Formation was regarded as equivalent to the latest Viséan P2 Zone of the British Isles. Unfortunately, WAGNER-GENTIS did not refer these goniatites under study to already described forms, e.g. *Lusitanoceras algarviense*, and hence resulted in misinterpretations suggesting close relations between the South Portuguese Basin and the Mediterranean faunal realm, known from localities in the South Urals, Central Asia, North Africa etc. From the

Neves Corvo Mine south of Castro Verde, „*Goniattites hudsoni*“ [in OLIVEIRA & WAGNER-GENTIS (1983), pl.9 fig.1 shows *Goniattites* (?) *globostratus*; and only pl.9 fig. 2-4 show *Goniattites hudsoni*] was figured and correlated with the British B2 Zone.

With the field work by Eva PAPROTH, Manfred HORN, José Tomás OLIVEIRA, and Katharina HORN between 1977 and 1984, five stratigraphical sections in the Bordeira and Aljezur areas have been studied in detail for the first time. A large goniatite collection has been assembled during these campaigns, and the results have been summarized in subsequent papers (OLIVEIRA 1983; OLIVEIRA, HORN, KULLMANN & PAPROTH 1985; OLIVEIRA 1990). The authors especially focused on the examination of sections near Carrapateira. Particularly the section at the Praia das Quebradas at the western Algarve Coast was investigated in detail with bed-by-bed documentation, realizing its biostratigraphical and palaeontological potential. Determination of the collection showed that in the Praia das Quebradas section at least five different goniatite zones were represented by distinctive species. Although some determinations were only given in open nomenclature, it was clear that goniatite horizons of probably earliest Viséan, Late Viséan, and late Namurian were sampled successfully [Age determinations of the different exposed formations, however, have to be corrected. Specimens assigned to „*Cravenoceras*“ do in fact belong to *Hibernicoceras*, and no typical early Namurian goniatites are known at all from this locality. Hence the Vale Figueira Member of the Murração Formation may completely belong in the Late Viséan. Furthermore, the base of the Westphalian has to be drawn lower in the section because of the occurrence of true *Gastrioceras* species in the upper Quebradas Formation].

Also in that paper, stratigraphical details of six additional sections were given: Vale da Carrapateira, Murração Velho, Rocha da Lagoa, Bordeira-Carrapateira Road, Monte da Nora das Árvores, and Berberia Mill. All are in the region around Carrapateira in the Bordeira Antiform, with the exception of the last two which are located in the Aljezur Antiform.

Goniatites from the Rocha da Lagoa section near Carrapateira were then published by HORN, KULLMANN & OLIVEIRA (1990). Species were referred to taxa belonging to the North American (especially the Fayetteville Shale of Arkansas) rather than to the European faunal spectrum. These were: „*Cravenoceras*? aff. *pisiforme* (GORDON 1965)“ [= *Goniattites* sp.], and „*Fayettevillea paprothae* KULLMANN“ [= *Nomismoceras vittiger* (PHILLIPS 1836)]. Examination of the fauna led to the conclusion that this fauna is of early Late Viséan, rather than Namurian age.

The most recent publication on goniatites from the South Portuguese Zone (NIKOLAIEVA & KULLMANN 1995) deals with species of the latest Namurian genus *Cancelloceras*. In this article, two new species of this genus were erected, „*C. oliveirai*“ [= *C. cancellatum* (BISAT 1923)] and „*C. soliani*“ [= *C. crenellatum* (BISAT 1924)], based on unhorizontalized material from old collections, and were compared with other *Cancelloceras* species.

### III. GEOLOGICAL OUTLINE OF THE SOUTH PORTUGUESE ZONE

The South Portuguese Zone is, along the geosuture indicated by the Beja-Acebuches Ophiolite, incorporated in Iberia (OLIVEIRA 1990). The geotectonic nature of the South Portuguese Zone has been intensively discussed, and recently an interpretation of this unit as being a back-arc basin is favoured (MUNHA 1983; RIBEIRO & SILVA 1983; SILVA, OLIVEIRA & RIBEIRO 1990). Collision of the South Portuguese Terrane with the major part of Iberia is supposed to have happened in pre-Famennian times. Rock sequence as well as metamorphic degree of the South Portuguese Zone is considerably different from the neighbouring, higher metamorphic Ossa Morena Zone (LOTZE 1945). The South Portuguese Zone consists of five tectonostratigraphical domains, generally successively arranged from north to south (OLIVEIRA 1990):

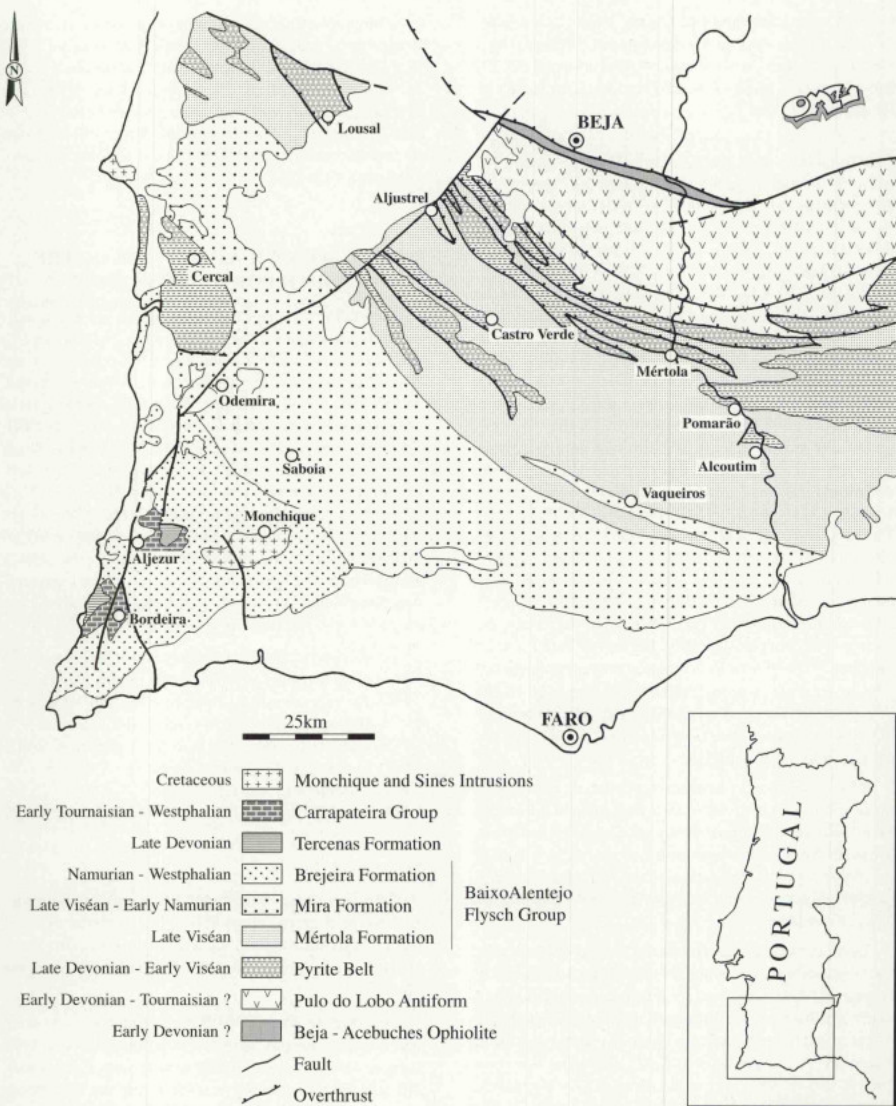
- Beja-Acebuches Ophiolite (metagabbros, a sheeted dyke complex, and metabasalts with intercalated cherts),
- Pulo do Lobo Antiform (metabasalts with MORB affinities as well as acidic and mafic volcanics),
- Pyrite Belt (the Phyllite-Quartzite-Formation, and a Volcano-Sedimentary Complex),
- Baixo Alentejo Flysch Group, and
- Southwest Portugal (Aljezur and Bordeira Antiforms).

Of these structural units, only the latter two yielded frequent ammonoids.

The widest area of the South Portuguese Zone is covered by the Baixo Alentejo Flysch Group, being exposed from the Atlantic coast in the west to the Guadiana River in the east, and extending into the southwest of Spain (Text-fig.1).

Age determination of the Baixo Alentejo Flysch Group was largely achieved by means of ammonoids, and indicates an extremely long stratigraphical range for this sedimentary series, beginning near the base of the Late Viséan and ending not before the basal Westphalian (OLIVEIRA, HORN & PAPROTH 1979; OLIVEIRA 1982). Using the time table by HARLAND et al. (1989), deposition of the Flysch





**Text-fig. 1.** Geological map of the South Portuguese Zone (after OLIVEIRA 1990, with revised stratigraphical determination of the Carboniferous rock units). OMZ = Ossa Morena Zone.

lasted more than 18Ma. OLIVEIRA, HORN & PAPROTH (1979) documented a progressive development of the sedimentation area from the northeast towards the southwest, with progressive invasion of terrigenous material which was derived from a hinterland situated in the northeast. The resemblance of this sequence to that known from the northern margin of the Rhenish Massif led the authors to the conclusion that the South Portuguese Basin is an equivalent of the Rhenohercynian Basin, which shows a similar timing of the sequence. Hence they postulated an original palaeogeographical position of the South Portuguese Zone near the south of Ireland, and estimated a 130° rotation rate of the Iberian Peninsula.

Distribution of ammonoids collected from the Baixo Alentejo Flysch Group already uncovered the fact that the Flysch has a diachronic base, which is stratigraphically oldest in the north and becomes more or less gradually younger towards the southwest:

- In the vicinity of Mértola, *Posidonia*-bearing shales are interbedded in the greywackes (FEIO 1946a, b).
- Near Vaqueiros, the Flysch sedimentation (Mira Formation) begins near the Viséan-Namurian boundary (OLIVEIRA & WAGNER-GENTIS 1983).
- East of Monchique, near Nave Redonda, a middle Namurian R1 fauna was found in the Flysch (OLIVEIRA, HORN & PAPROTH 1979).
- Near Aljezur, *Gastrioceras listeri* was collected, indicating an earliest Westphalian age (OLIVEIRA, HORN & PAPROTH 1979).

A first palaeogeographical model of the sediment source - depositional area for the Baixo Alentejo Flysch was given by LOMBARD (1958), and the continuous progradation of the Flysch basin towards the southwest was first postulated by OLIVEIRA, HORN & PAPROTH (1979). They subdivided the Flysch complex into three formations, which are characterized by their different stratigraphical age, as well as the nature of the predominantly gravity flow sediments:

- Mértola Formation (Late Viséan),
- Mira Formation (latest Viséan and Namurian), and
- Brejeira Formation (Namurian, but predominantly Westphalian).

The discovery of complete stratigraphical sequences within the Baixo Alentejo Flysch Group is difficult because of intensive folding of this complex, and especially because of numerous overthrusts existing in the northern area (OLIVEIRA 1988, SILVA, OLIVEIRA & RIBEIRO 1990).

In southwestern Portugal, two antiforms with a series of siliciclastic and calcareous sedimentary rocks of Late Devonian to Westphalian age are exposed. These rocks

were subdivided by OLIVEIRA (1983) and OLIVEIRA, HORN, KULLMANN & PAPROTH (1985), from bottom to top:

- Tercenas Formation, mainly an alternation of laminated shales, siltstones, and quartzitic sandstones.
- Bordaleta Formation, dark grey to black shales with calcareous lenses and siltstone interbeddings.
- Murração Formation, with the lower Pedra das Safias Member, built up of grey shales with marly carbonate intercalations, and the upper Vale Figueira Member, composed by grey and black shales as well as dolomitic fossiliferous limestones.
- Quebradas Formation, comprising of black shales with intercalated carbonate layers, lenses and nodules. Phosphoritic and manganese nodules are very frequent and form a conspicuous feature of this unit.

The age of the Tercenas Formation is regarded as Late Famennian to earliest Tournaisian, and the latter three of these are grouped to the Carrapateira Group, representing the Middle and Late Tournaisian, Viséan, and Namurian. Palaeogeographical interpretation of the Carrapateira Group (LOMBARD 1958; OLIVEIRA 1990) shows a shallow platform on which the carbonates have been deposited in a restricted subtidal environment. This carbonate platform graded northward into a deeper environment.

The complicated structural geology of the two antiforms was subject of different investigations ((FEIO 1951; FEIO & LOMBARD 1958; RIBEIRO & SILVA 1983; RIBEIRO 1983). These led to the opinion that, as a result of the thin-skinned nature of the South Portuguese thrust belt, nappe structures are very common, but only rarely exposed. The basal thrust plane of the Carrapateira Nappe is well exposed along the Atlantic seaboard between Monte do Engenheiro and the Pedra das Safias salient, characterized by the presence of fault breccias. Additional neotectonic structures (CABRAL 1995) lead to further complication of the geological situation.

#### IV. FOSSIL LOCALITIES IN THE SOUTH PORTUGUESE ZONE

##### A. Pyrite Belt

The complicated lithostratigraphy and tectonostratigraphy of the Pyrite Belt in the region of Mértola and Pomarão has been subject to a series of investigations, describing the nappe structure of this unit (BOOGARD 1967; FRISCHMUTH 1968; PFEFFERKORN 1968a, b; SCHERMERHORN 1971; OLIVEIRA 1983; SILVA, OLIVEIRA & RIBEIRO 1990).

Only few localities are known within the Pyrite Belt which provided determinable ammonoids, and all of them



are of Late Devonian age. The northernmost of these localities lies in the Mértola Nappe and is located 1 km north-west of **Mértola** along a low woodland road cutting. At this place, irregularly lenticular limestone bodies of maximal 20 cm thickness are, by tectonic contact, intercalated in phyllitic shales and quartzitic sandstones. The outcrop was described in detail by FANTINET, DRESEN, DUSAR & TERMIER (1976), who also presented determinations of the conodont fauna, placing them into the middle *velifer* Zone to the upper *styriacus* Zone [= Early *trachytera* to Late *postera* Zones in new zonation (ZIEGLER & SANDBERG 1990)]. During recent new sampling at this locality, only some hardly extractable clymeniids could be gained, which show, however, a *Platyclymenia*-like cross section. The data suggest that this dark fossiliferous limestone is an equivalent of the widely distributed *annulata* Black Shale horizon.

Two other localities have already been described by PRUVOST (1912), who figured three hardly determinable clymenioid specimens collected by J.F. NERY DELGADO in 1905 from 800 m north of **Pomarão**. New sampling of these occurrences yielded rich conodont faunas (BOOGARD 1963), showing that a sample from PRUVOST's first clymenioid locality is to be placed in the *velifer* Zone (now *trachytera* Zone). Younger conodont samples without ammonoids, and belonging to the *postera* and *expansa* Zones, were found in the neighbourhood. Also sampled were Early Carboniferous crinoidal limestones from the **Carvoeiro quarry** 2.4 km north of Mértola, which did not yet yield ammonoid faunas.

### B. Baixo Alentejo Flysch Group

From the vicinity of Mértola, several ammonoid-bearing localities have been reported. The first of these is the abandoned quarry near the **Barranco do Covo bridge** at the eastern margin of Mértola, where FEIO (1946a, b) found a shaly intercalation within the greywackes, containing large clusters of *Posidonia*. From a limestone lens within these shales, he extracted three-dimensionally preserved goniatites, among which he separated his new species „*Glyptoceras myrtilense*“ [= *Paraglyptoceras myrtilense*]. During a recent examination of the still existing outcrop, only extremely weathered limestone nodules could be secured, containing poorly preserved ammonoids of the species mentioned above.

Two goniatite localities 1 resp. 2 km south of **Mértola** were mentioned by MAC GILLAVRY (1961), stating that the goniatites were determined by JOS BOUCKAERT and assigned to „*Neoglyptoceras spiralis* PHILL.

these determinations, the age of these occurrences is similar or a little younger than that of the Barranco do Covo quarry.

During mapping fieldwork in this area, J.T. OLIVEIRA assembled a collection of goniatites from this area:

**Montes Alves** 10 km east of Mértola: *Paraglyptoceras myrtilense* (FEIO 1946).

**Posto Fiscal de Vascão**, 5 km southeast of Pomarão: *Paraglyptoceras myrtilense* (FEIO 1946), *Paraglyptoceras guadianense* sp. nov.

**Ponte Váscua** 13 km west-southwest of Mértola: *Arnsbergites arnsbergensis* (BRÜNING 1923).

1 km northeast of **Almoimha**, 8 km south of Mértola: *Hibernicoceras alentejoense* sp. nov., *Arnsbergites arnsbergensis* (BRÜNING 1923).

**Máhora, Ribeiro do Belo**, 8 km southwest of Mértola: *Paraglyptoceras guadianense* sp. nov.

**Monte Belo** 12 km southwest of Mértola: *Paraglyptoceras guadianense* sp. nov.

**Almoimha Velha**, 12 km south of Mértola: *Arnsbergites arnsbergensis* (BRÜNING 1923).

1 km west of the **Foupana river bridge**, 11 km south-southeast of Alcoutim: *Hibernicoceras hibernicum* MOORE & HODSON 1958.

**Almoimha**, 9 km south of Mértola: *Arnsbergites arnsbergensis* (BRÜNING 1923).

**Máhora**, 8 km southeast of Mértola: *Arnsbergites arnsbergensis* (BRÜNING 1923).

The stratigraphically oldest ammonoids from the Baixo Alentejo Flysch Group derived from the **Neves Corvo Mine** 20 km south-southeast of Castro Verde, where *Goniatites hudsoni* BISAT 1934 and *Goniatites* (?) *globosistriatus* (SCHMIDT 1925) were collected immediately north of the main shaft (OLIVEIRA & WAGNER-GENTIS 1983). Re-examination of this outcrop and exposures in its vicinity revealed more ammonoid specimens of these species, together with *Pronotites meridionalis* sp. nov.

Also seen rather low in the stratigraphy are the faunas listed by CARRINGTON DA COSTA (1943) from localities near **São-Francisco-da-Serra** in the region of Grândola, but he hardly gave any locality details. As much as can be seen in the plates, the faunas are of a middle Late Viséan age, probably containing *Arnsbergites falcatus* (ROEMER 1850). Goniatites from **Cabeça Gorda** near Odemira (CARRINGTON DA COSTA 1943; KLEYN 1960) are too poorly preserved to be determinable.

Ammonoid faunas of latest Viséan age have been known for many years from the Mértola Formation from the Barrada - Almada de Ouro Anticline (PEREIRA DE SOUSA 1923, 1924; OLIVEIRA & WAGNER-GENTIS 1983). Especially some outcrops along the road from **Vaqueiros** to Mon-tinho da Revelada yield goniatite faunas which are rich

in individuals but poor in species. The fauna consists of the following species (original description and revised taxonomy):

- „*Dombartites parafalcatoide*“ = *Lusitanoceras algarviense* PEREIRA DE SOUSA 1923 and *Lusitanoceras poststriatum* (BRÜNING 1923),  
 „*Platygoniatites* sp. ‘early form’“ = *Lusitanoceras poststriatum* (BRÜNING 1923),  
 „*Lyrogoniatites georgiensis*“, „*Lyrogoniatites mutabilis*“, „*Lyrogoniatites aff. eisenbergensis*“, „*Pachylyroceras cloudi*“, „*Neoglyphioceras aff. gradatum*“ = all are *Lyrogoniatites liethensis* KORN 1988, and „*Lusitanites subcircularis*“ = *Lusitanites clitheroensis* KORN 1988.

The goniatites occur in three calcareous nodular horizons within dark shales of the higher part of the Mértola Formation. Some of these localities were re-examined, and large samples of goniatite-bearing nodules could be gained. These nodules are strongly weathered and decalcified, and most of them contain goniatite remains, which usually are preserved as three-dimensional natural moulds. In the lower two horizons, which are separated by two meters of shales, they largely are undistorted, but in the about eight meters higher horizon they are deformed. The shales are poor in goniatites.

In the lower two layers of nodules, *Lusitanoceras algarviense* PEREIRA DE SOUSA 1923 and *Lusitanoceras poststriatum* (BRÜNING 1923) occur. The preservation of these goniatite specimens is exactly like in the lectotype of the first species, which, according to its label, was found 8 km east-southeast of Vaqueiros. The highest of the three horizons contains *Lyrogoniatites liethensis* KORN 1988. A similar fauna occurs at the base of the Mira Formation in localities within the Dogueno - Cabaços Anticline (OLIVEIRA & WAGNER-GENTIS 1983).

Another locality of three-dimensionally preserved goniatites is located in the Santa Cruz - Azinhal Syncline, approximately 2 km southwest of **Almada de Ouro**, where *Girtyoceras tomasi* WAGNER-GENTIS in OLIVEIRA & WAGNER-GENTIS 1983, „*Girtyoceras modestum finale*“ [= *Girtyoceras tomasi*], and *Metadimorphoceras* sp. occur in weathered limestone nodules at the base of the Mira Formation (OLIVEIRA & WAGNER-GENTIS 1983).

Additional goniatite-bearing localities within the Mira Formation are located northwest and southeast of **Saboia**, and only a few exposures yielded individual specimens (OLIVEIRA, HORN & PAPROTH 1979). Only one of them, the **Monte Gaviano** location, yielded an important Namurian fauna, most probably of the lower R1 Zone, containing *Vallites kullmanni* sp. nov. and *Homoceratoides svetlanee* sp. nov.

The same horizon is exposed in the abandoned quarry 3 km south of **Nave Redonda**, 11 km south of Saboia. Here, in two different horizons, crushed as well as three-dimensionally preserved goniatites of the same species occur in large numbers, allowing exact dating of the base of the Brejeira Formation in this region (OLIVEIRA 1983) [KULLMANN & NIKOLAEVA (1995) mentioned *Bilinguites metabilinguis* and several species of *Cancelloceras* from this locality, but there is no such material available for study].

Furthermore towards the southwest, a number of fossil localities within the Brejeira Formation, containing late Namurian or early Westphalian goniatites are known. Usually, the specimens derived from isolated occurrences with limited stratigraphical control, not exactly correlated and placed within the rock column.

List of localities with their investigators and ammonoid content:

- 3 km south of **Nave Redonda**: (coll. M. HORN et al. 1977): *Vallites kullmanni* sp. nov., *Homoceratoides svetlanee* sp. nov., *Homoceratoides* sp.1. from silicious nodules, and *Ramosites* sp.1 as well as *Phillipsoceras* (?) sp. from grey shales.
- 200 m south of **Monte Gaviano** (coll. M. HORN et al. 1977): *Vallites kullmanni* sp. nov., *Homoceratoides svetlanee* sp. nov.
- 1 km northeast of **Estação Saboia** (coll. J.T. OLIVEIRA): *Vallites striolatus* (PHILLIPS 1836), *Reticuloceras* sp.
- **Monte Chã** near Saboia (coll. J.T. OLIVEIRA): *Baschirites* sp.
- 200 m southwest of **Monte Vale Longo** near Saboia (coll. J.T. OLIVEIRA): *Bilinguites superbilinguis* (WRIGHT 1927).
- 300 m west of **Choça near São Marcos da Serra**, 18 km southeast of Saboia (coll. F.L. PEREIRA DE SOUSA): *Ramosites sousai* sp. nov., *Cancelloceras crenellatum* (BISAT 1924).
- **São Totonio** (coll. F.L. PEREIRA DE SOUSA): *Cancelloceras crenellatum* (BISAT 1924).

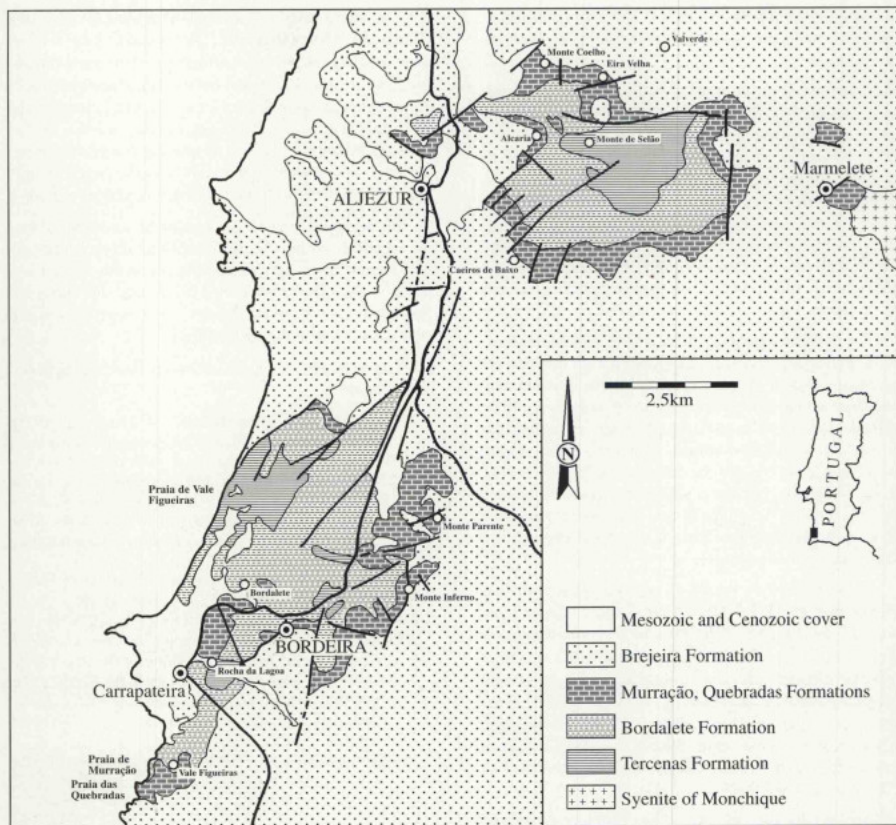
## C. Southwest Portugal

### 1. Aljezur Antiform

The condition of exposures in the Aljezur Antiform is generally poor, most of the numerous ammonoid-bearing outcrops are small and allow only limited insight in the succession of faunas. Additionally, intensive weathering near the surface led to decalcification of carbonates and bleaching of shales.

Best exposed are sandstones and shales of the Late Devonian Terceiras Formation, and the dark shales of the Bordaleta Formation, but ammonoids have hardly been recorded from both. The Murração Formation is the one which suffered most from weathering and cleavage, hence only very few ammonoids have been collected yet. The best





**Text-fig. 2.** Geological map of the Bordeira and Aljezur Antiforms (after SILVA, OLIVEIRA & RIBEIRO 1990), showing the locations of the most important ammonoid localities in southwest Portugal.

outcrop of this formation is located along the new road from Aljezur to Monchique, 2.5 km east of Aljezur. This is called the **Monte da Nora das Árvores** section by OLIVEIRA, HORN, KULLMANN & PAPROTH (1985), who logged it and gave information about some goniatites. Decalcified marls at the top of the section yielded „*Dormarites* sp.“ [= *Hibernicoceras* cf. *hibernicum* MOORE & HODSON 1958, *Neoglyphioceras* cf. *spirale* (PHILLIPS 1841)], and are to be placed in the Late Viséan.

Especially around the **Berberia** mill (2 km east of Aljezur), **Monte Coelho**, and **Eira Velha** (Text-fig. 2), the higher part of the Quebradas Formation and the transition to the following Brejeira Formation is rather well exposed along some woodland road cuttings. Despite the intensive corrosion of shales and carbonates, some of the fossiliferous lenses and nodules yielded well preserved natural moulds and sometimes three-dimensionally preserved goniatites of R1, R2, and G1 age.



In the following list, localities with their investigators and ammonoid faunas are described (for locations see text-fig. 2).

#### Tercenas Formation:

- **Monte de Selão** 5km east-northeast of Aljezur (coll. J.T OLIVEIRA): *Linguacymenia similis* (MÜNSTER 1839).

#### Bordalete Formation:

- **Ribeiro da Cerca** 4km east-northeast of Aljezur (coll. K. HORN 1982): *Becanites algarbiensis* (PRUVOST 1914), *Muensteroceras* (?) sp., *Eurites* sp.

#### Murração Formation:

- **Monte da Nora das Árvores** road section, top of the section (coll. M. HORN et al. 1982): *Hibernicoceras* cf. *hibernicum* MOORE & HODSON 1958, *Neoglyphioceras* cf. *spirale* (PHILLIPS 1841); and from a lower horizon (coll. D. KORN & K. HORN 1995): *Arnsbergites* cf. *arnsbergensis* (BRÜNING 1923), *Hibernicoceras* sp.
- **Maria Serrão** 5.5km northeast of Aljezur (coll. K. HORN 1982): *Lusitanoceras algarviense* PEREIRA DE SOUSA 1923.

#### Quebradas Formation:

- East of **Aljezur**, without exact record (coll. J.T OLIVEIRA): *Eumorphoceras* sp.
- 500m north-northeast of **Alcaria**, 4.5km east-northeast of Aljezur (coll. J.T OLIVEIRA): *Baschkirites* sp.1.
- **Porto da Silva**, 4.8km northeast of Aljezur (coll. K. HORN 1982): *Vallites kullmanni* sp. nov.
- South of **Monte Coelho**, 5.2km northeast of Aljezur (coll. K. HORN 1982): *Vallites kullmanni* sp. nov.
- **Barranco** (coll. K. HORN 1982): *Vallites kullmanni* sp. nov.
- directly south of **Alcaria**, 3.8km east-northeast of Aljezur (coll. D. KORN & K. HORN 1995): *Bilinguites metabilinguis* (WRIGHT 1927).
- **Eira Velha** 6.5km east-northeast of Aljezur (coll. M. HORN et al. 1979, D. KORN et al. 1994): *Cancelloceras cancellatum* (BISAT 1923), *Ramosites sousai* sp. nov., *Bilinguites superbilinguis* (WRIGHT 1927); and from a lower bed *Cancelloceras branneroides* (BISAT 1940).
- 300m east of **Monte Coelho**, 5.3km northeast of Aljezur (coll. D. KORN & K. HORN 1995): *Bilinguites superbilinguis* (WRIGHT 1927), *Cancelloceras cancellatum* (BISAT 1923); and from a single nodule *Cancelloceras crenellatum* (BISAT 1924).
- **Maria Serrão** 5.5km northeast of Aljezur (coll. K. HORN 1982): *Cancelloceras cancellatum* (BISAT 1923).
- 400m east of **Valverde**, 8.5km east-northeast of Aljezur (coll. F.L. PEREIRA DE SOUSA): *Cancelloceras cancellatum* (BISAT 1923).
- **Monte Tranco** 3.5km southeast of Aljezur (coll. M. HORN et al. 1979): *Reticuloceras reticulatum* (PHILLIPS 1836).
- **Caeiros de Baixo**, 2.5km southeast of Aljezur (coll. M. HORN et al. 1979): *Cancelloceras cancellatum* (BISAT 1923), *Cancelloceras branneroides* (BISAT 1940).

#### Brejeira Formation:

- 550m east of **Valverde** (coll. F.L. PEREIRA DE SOUSA): *Gastrioceras listeri* (SOWERBY 1812).
- 1km northwest of **Atalaia** 5km northeast of Aljezur (coll. M. HORN et al. 1979): *Gastrioceras listeri* (SOWERBY 1812).
- **Monte Coelho**, 5.5km northeast of Aljezur (coll. K. HORN 1982): *Gastrioceras listeri* (SOWERBY 1812).

#### 2. Bordeira Antiform

The best exposures of Late Devonian and Carboniferous sedimentary rocks of the South Portuguese Zone are located along the seaboard of the Atlantic Ocean. All the four rock units Tercenas Formation, Bordalete Formation, Murração Formation and Brejeira Formation are represented by almost complete successions, although folding and faulting sometimes prevents study of complete sections. Furthermore, good outcrops inland provide sections to compare with the coastal ones.

##### a) Tercenas-Formation

The Tercenas Formation is present in numerous good localities (OLIVEIRA, GARCIA-ALCALDE, LIÑAN & TRUYOLS 1986, PEREIRA, CLAYTON & OLIVEIRA 1996), of which two yielded clymeniid ammonoids: The first one is the beach south of the **Praia de Vale Figueiras** (Text-fig. 3), where an approximately 20 meter thick succession of light and dark grey laminated shales as well as some quartzite intercalations is exposed. Ten meters below the top of this portion, poorly preserved clymeniids could be traced



**Text-Fig. 3.** Late Devonian claystones with quartzite interbeddings of the Tercenas Formation at the Praia Vale Figueiras.

in horizons with a minor carbonate content, probably belonging to *Cymaclymenia*. The section is continuing in a little gorge and on a slope towards the east, firstly with a 3.3m thick sandstone body with internal gravity flow structures. Above this, an alternation of siltstone and thin quartzite beds or lenses and then 36m of almost pure siltstone follows, before the section ends with a cover of at least 19m thick-bedded sandstones.

The second outcrop is located in the **Vale da Carrapateira**, 3km northeast of the village Carrapateira (OLIVEIRA, HORN, KULLMANN & PAPROTH 1985)). At the base of this section, about 10m thick black shales yielded clymeniids remains, the following sequence is an about 100m thick alternation of laminated shales, siltstones, and quartzitic sandstones. From the vicinity of this section, some clymeniids could be collected from black shales:

*Linguaclymenia clauseni* (KORN & PRICE 1987) from 2km east of Carrapateira (coll. J.T. OLIVEIRA); and *Cyrtoclymenia* sp. from 1km east of Carrapateira.

#### b) Bordaleta Formation

The Bordaleta Formation is best exposed in the **Praia de Murração**, below the Carrapateira thrust plane (FEIO & LOMBARD 1958; RIBEIRO 1983), but is intensively deformed and pierced by numerous veins of posthercynian basic volcanics. This outcrop did not yield ammonoids. Distribution of goniatites within the Bordaleta Formation is random, and it seems that they are limited to certain horizons. Over wide ranges, not a single specimen could be traced, but at some places numerous individuals, mostly poorly preserved fragments or hollow forms, could be detected. Such localities are situated around the **Bordaleta** farm (Vale da Fonte), as well as southwest of **Bordeira** (coll. E. HELLEBRAND 1994). Usually, the goniatites belong to only one species, *Becanites algarbiensis* (PRUVOST 1914).

PRUVOST (1914) and DELÉPINE (1957) listed several fossil localities within the Bordaleta Formation, located in the vicinity of the Bordeira and Carrapateira, containing „*Prolecanites algarbiensis*“, „*Pericyclus* cf. *Kochi*“, and „*Pericyclus* sp.“. During visit of several of these fossil localities, no remains of pericyclid goniatites could be collected.

Localities from which further, most probably Early Tournaisian material is available are:

- 500m west of the **Samoqueira** farm, 2.5km east-northeast of Bordeira (coll. J.T. OLIVEIRA): *Eocanites nodosus* (SCHMIDT 1925).
- **Monte Inferno**, 4km east-northeast of Bordeira (coll. J.T. OLIVEIRA): *Eocanites* sp.

#### c) Murração Formation

Many good outcrops of the Murração Formation exist in the Bordeira Antiform. The northernmost is located along the road **Bordeira - Carrapateira**, at **km 11**, where a faulted section can be studied (OLIVEIRA, HORN, KULLMANN & PAPROTH 1985). In this section, especially the upper part of the Murração Formation, the Vale Figueira Member, is present. In reversed order caused by faults, marly shales with numerous crushed specimens of „*Dombartites*“ [= *Lusitanoceras poststriatum* (BRÜNING 1923) and *Lusitanoceras algarviense* PEREIRA DE SOUSA 1923] can be seen below *Posidonia becheri*-bearing shales containing limonitic specimens of „*Cravenoceras* sp.“ [= *Goniatites* sp.] and „*Fayettevillea* sp.“ [= *Nomismoceras vittiger* (PHILLIPS 1836)].

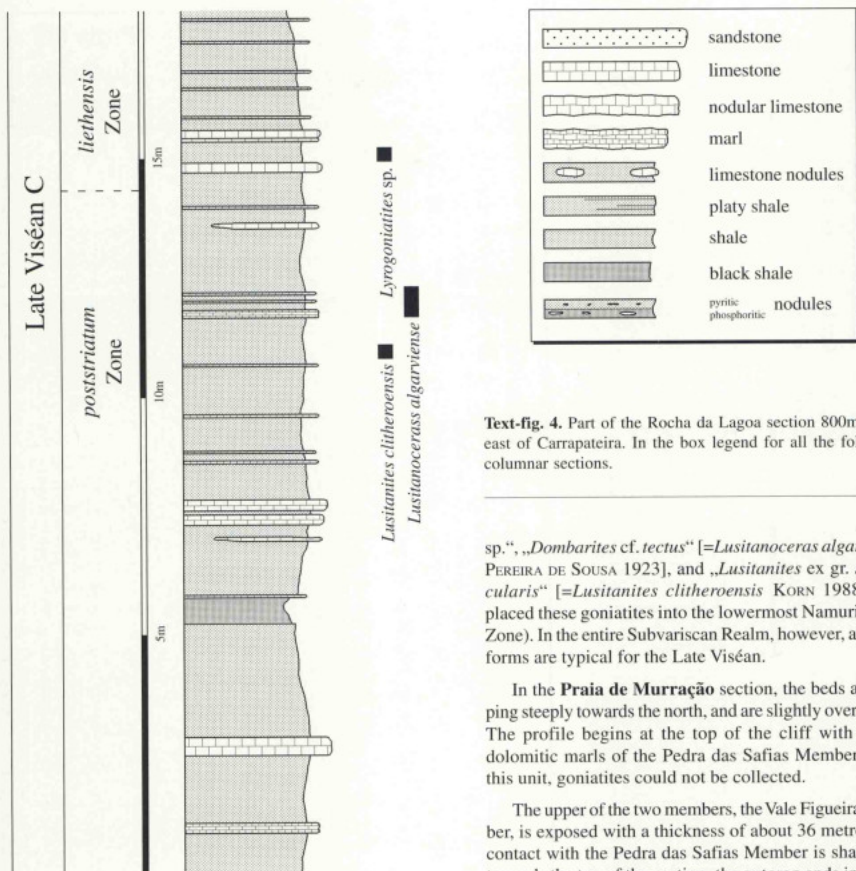
Another exposure of the highest part of the Pedra das Safias Member and the lower portion of the Vale Figueira Member is located 400m north of the road outcrop, 400m southwest of the **Bordaleta** farm. By a steep woodland road cutting, 25 meters of shales with numerous interbedded marly or sideritic carbonate beds are exposed. Due to intensive weathering, only very few badly preserved ammonoids could be collected, but impressions of *Posidonia becheri* are common throughout the section, forming dense clusters on some bedding surfaces.

The **Rocha da Lagoa** section (HORN 1984; HORN, KULLMANN & OLIVEIRA 1990) is exposed on the steep southern flank of the hill 800m northeast of Carrapateira. It ranges from the Pedras das Safias Member up into the highest part of the Quebradas Formation, with the Vale Figueira Member excellently exposed (Text-fig.4). OLIVEIRA, HORN, KULLMANN & PAPROTH (1985) placed the entire Murração Formation into the Namurian, interpreted because of a finding of „*Fayettevillea* sp.“ [later described by KULLMANN in HORN, KULLMANN & OLIVEIRA (1990) as *Fayettevillea paprothae*]. Re-examination of the type material has shown, however, that this species is a junior synonym of *Nomismoceras vittiger* (PHILLIPS 1836), indicating a Late Viséan age of the fauna. Co-occurring *Goniatites* sp. (= „*Cravenoceras* aff. *pisiforme*“ in HORN, KULLMANN & OLIVEIRA, 1990) confirms this age determination.

As in the sections at the Praia de Murração and Praia das Quebradas, *Lusitanites* precedes *Lusitanoceras*, separated by 1.10 metres of shales. 3.50 metres higher, a brittle carbonatic shale contains *Lyrogoniatites* sp., and may indicate the *liethensis* Zone.

In the vicinity of the **Praia de Murração** and **Monte do Engenho**, the Murração Formation is exposed several times, but the best sections are logged at the road





**Text-fig. 4.** Part of the Rocha da Lagoa section 800m north-east of Carrapateira. In the box legend for all the following columnar sections.

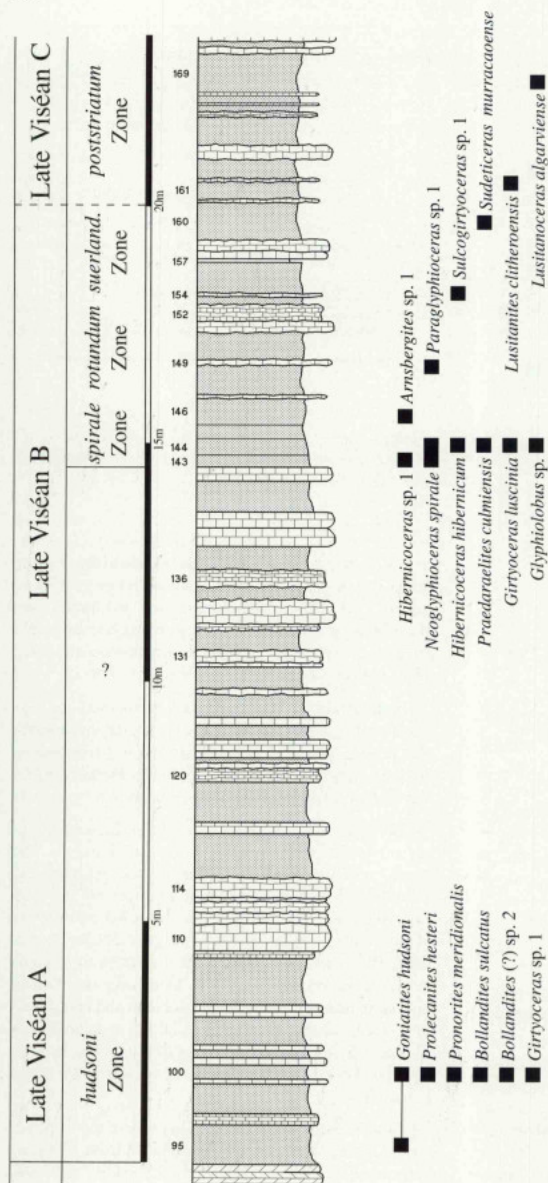
sp.<sup>ss</sup>, „*Dombartites* cf. *tectus*“ [= *Lusitanoceras algarviense* PEREIRA DE SOUSA 1923], and „*Lusitanites* ex gr. *subcircularis*“ [= *Lusitanites clitheroensis* KORN 1988], and placed these goniatites into the lowermost Namurian (E1 Zone). In the entire Subvariscan Realm, however, all these forms are typical for the Late Viséan.

In the **Praia de Murração** section, the beds are dipping steeply towards the north, and are slightly overturned. The profile begins at the top of the cliff with marly, dolomitic marls of the Pedra das Safias Member. From this unit, goniatites could not be collected.

The upper of the two members, the Vale Figueira Member, is exposed with a thickness of about 36 metres. The contact with the Pedra das Safias Member is sharp, and towards the top of the section, the outcrop ends in a fault zone (the Carrapateira thrust plane does not allow study of the continuation into the following Quebradas Formation). The Vale Figueira Member is composed of laminated claystones and siltstones, marls and intercalated limestone beds with a maximal thickness of 45cm. Many of these limestone beds display a nodular structure which is caused by the mass occurrence of goniatites. In most cases, however, these are too poorly preserved for determination.

Goniatites are fairly frequent in some of the beds, determinable specimens could be collected from 12 different levels (Text-fig.5). Seven of these (beds 95, 100, 144,

from the abandoned **Murração Velho** farm to the Praia de Murração (OLIVEIRA, HORN, KULLMANN & PAPROTH 1985) is now badly exposed, and on top of the cliff immediately east of the Praia de Murração (FLEURY 1924; FEIO & LOMBARD 1958). Both sections closely resemble each other, and interest was focused on the latter one which excellently exposes the complete Vale Figueira Member. From the first section, OLIVEIRA, HORN, KULLMANN & PAPROTH (1985) recorded a succession of „*Sudeticer*



Praia de  
Murração  
Section

**Text-fig. 5.** Part of the Vale Figueira Member of the Murração Formation in the Praia de Murração section [For explanation see text-fig.4]. Abbr.: *suerland. Zone* = *suerlandense* Zone

149, 155, 159, 160) yielded ammonoids which are preserved as haematitic internal moulds. They easily allow the examination of sutural ontogeny, but often lack ornamental details. Some beds (143, 146, 169) yielded only crushed specimens from bedding surfaces, and two beds (154, 161) contain three-dimensionally preserved but somewhat distorted limestone specimens.

In the lower two fossil-bearing horizons (beds 95 and 100), *Goniatis hudsoni* BISAT 1934 is the dominant species, hence these two horizons can easily be correlated with the *hudsoni* Zone (B2a of the British zonation). In bed 100, this species occurs in two morphotypes, a slender form such as the lectotype (BISAT 1934, pl. 17 fig. 1,2), and a globose form (see BISAT 1952, pl. 2 fig. 4-6). Accompanying species are *Bollandites sulcatus* BISAT 1952, *Girtyoceras* sp. 1, *Prolecanites hesteri* MOORE 1952, and *Priorityes meridionalis* sp. nov., all of them are from typical genera of this zone.

Above bed 100, 12m of shales and limestones follow, which did not yield determinable ammonoids. Some of the beds contain abundant specimens of *Posidonella becheri*, which sometimes completely cover bedding surfaces. The next higher level with ammonoids is bed 143. Although flattened in the shale, the goniatites can be determined quite well because of their preservation with fine ornament details. On several bedding surfaces, *Neoglyphioceras spirale* (PHILLIPS 1836) and *Hibemicoceras* sp. occur, clearly indicating a *spirale* Zone age (P1c of the British zonation).

Bed 144, a red laminated siltstone bed, contains numerous haematized goniatites in one distinct layer. These specimens display their sutural ontogeny as well as ornament remains, and thus can easily be identified. The fauna consists of *Hibemicoceras hibemicum* MOORE & HODSON 1958, *Girtyoceras luscina* KORN 1988, and *Praedaraelites culmiensis* (KOBOLD 1933). Especially the latter is remarkable since it may allow direct correlation with occurrences in The Rhenish Massif, the Harz Mountains, the North of England, and Ireland. In all these regions, this species occurs in only one horizon within the *spirale* Zone (or P1c Zone of the British zonation). Since *Hibemicoceras* always accompanies *Praedaraelites culmiensis*, a *spirale* Zone age of bed 144 is most likely. This is also true for the next higher goniatite horizon, bed 146, a brown shale containing crushed specimens of *Arnsbergites* sp. 1.

Goniatites collected from bed 149, a thin nodular limestone bed, are either preserved as haematitic internal moulds or distorted limestone specimens. All are poorly preserved, but one haematitic specimen can, according to its suture line, be assigned to *Paraglyphioceras* sp. 1. A clear stratigraphical determination, however, is not pos-

sible. The same is true for the beds 154 (a thin marly limestone bed) and 155 (20cm of grey claystone), which both yielded specimens of *Sulcogirtyoceras* sp. 1. It is likely that this level is an equivalent of the *rotundum* Zone (P1d), which contains in Central and Northwestern Europe *Sulcogirtyoceras burhennei* (BRÜNING 1923).

Bed 159 yielded only juvenile goniatites in haematitic preservation, probably of the genus *Paraglyphioceras*. Larger haematized specimens could be collected from bed 160, a 82cm thick claystone with marly intercalations. All the specimens belong to *Sudetoceras murracaense* sp. nov., a species that is characterized by the lack of spiral ornament. According to the conch shape of these specimens which closely resembles that of *Sudetoceras crenistriatum* (BISAT 1928), a correlation with the *suerlandense* Zone or *poststriatum* Zone is likely.

In bed 161, within a 5cm thin bed of marly nodular limestone, *Lusitanites clitheroensis* KORN 1988 occurs frequently. The specimens are three-dimensionally preserved but distorted. They closely resemble *L. clitheroensis* from the type locality, but have more constrictions (5) than the British specimens. Nevertheless, according to the occurrence of *Lusitanites* in the British Isles and the Rhenish Massif, a *poststriatum* Zone (P2a) is probable. It is noticeable, however, that the genera *Lusitanites* and *Lusitanoceras* co-occur in the Rhenish Massif on the same bedding surfaces with the species *Lusitanoceras poststriatum* (BRÜNING 1923) and *Lusitanites circularis* KORN 1988.

The highest goniatite-bearing horizon (bed 169) is a 84cm thick shale, which contains numerous crushed goniatites, of which *Lusitanoceras algarviense* PEREIRA DE SOUSA 1923 is dominant. This species, which is widespread in the South Portuguese Zone, has not yet been discovered outside of Portugal and hence its exact stratigraphical age is difficult to determine. *Lusitanoceras*, however, occurs in Central and Northwestern Europe in a certain stratigraphical range, the *poststriatum* and *eisenbergensis* Zones. Thus it can be assumed that this horizon has the same age.

The faunal composition of the different succeeding fossiliferous levels in the Praia de Murração section is similar to that known from northwestern and central Europe. In the Murração section, however, some index horizons of central and northwestern Europe are still lacking, e.g. the *crenistris*, *fimbriatus*, and *falcatus* horizons.

A columnar section of the sedimentary succession exposed at the excellent locality along the **Praia das Quebradas** (Text-fig. 6), which is located 600m southwest of the Praia de Murração section, has already been



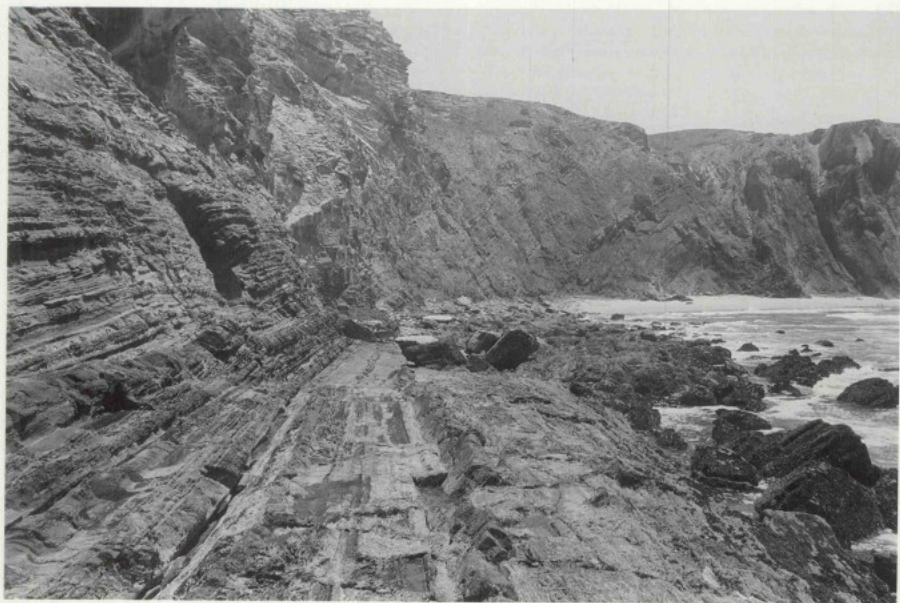
published several times (OLIVEIRA, HORN, KULLMANN & PAPROTH 1985; OLIVEIRA 1983, 1990). The section was described in the first paper in detail, and ammonoid faunas from the Vale Figueira Member of the Murração Formation have been reported. It was stated there that „typical fossils of late Viséan age have not been found“. All the reported faunas were regarded as being of lower Namurian age (E1), they contain:

- „*Pronorites* cf. *mioxolobus*“ [= *Pronorites* sp.],  
 „*Cravenoceras* aff. *arcticum*“, „*Cravenoceras* aff. *fayettevilleae*“ [= *Hibernicoceras carraunense* MOORE & HODSON 1957],  
 „cf. *Dombarites paratectus*“ [= *Lusitanoceras algarviense* PEREIRA DE SOUSA 1923],  
 „*Lusitanites* cf. *benziregensis*“ [= *Lusitanites clitheroensis* KORN 1988],  
 „*Sulcogirtyoceras* sp.“ [= *Sulcogirtyoceras* sp.],  
 „*Neoglyphioceras* sp.“ [= *Girtyoceras* sp.],  
 „*Sudetoceras* sp.“ [= party *Sudetoceras murracaense* sp. nov. and *Paraglyphioceras* sp. 1]

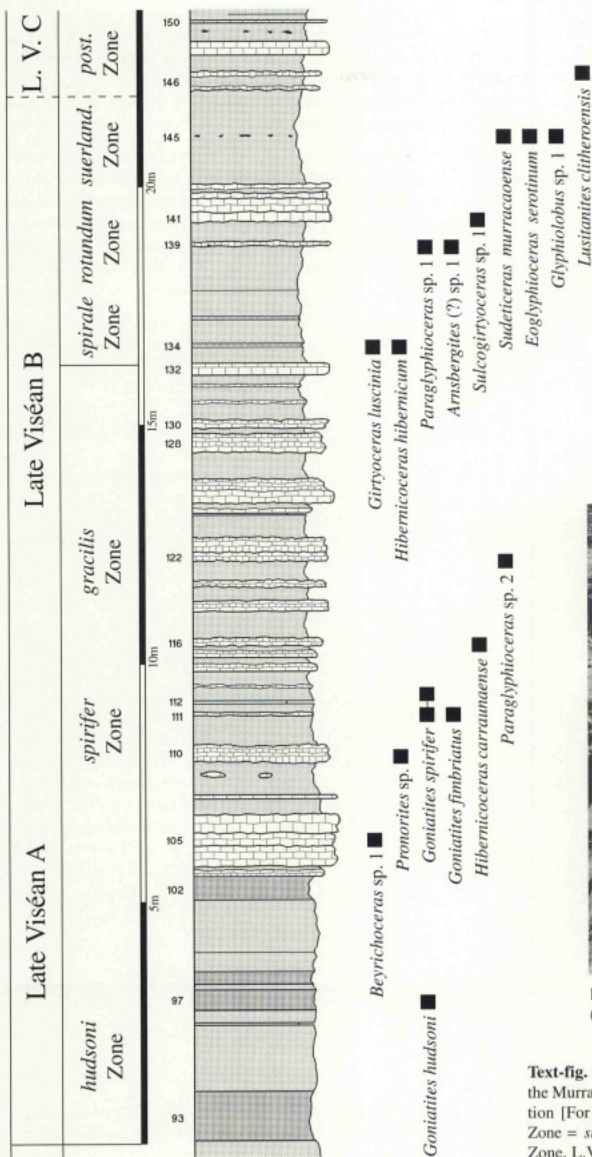
Re-examination of the outcrop and the fossil material gained by the previous authors demonstrates that the lithological succession closely resembles that of the Praia de Murração section, differences are mainly caused by the different exposure to erosion. Many of the fossil horizons are almost identical in both the sections, yielding ammonoids of exclusively Late Viséan age in the same preservation state.

The transition from the Pedra das Safias Member into the Vale Figueira Member is less sharp than in the Murração section (Text-fig. 7), but clearly recognizable by dark shales with a high content of pyrite crystals at the base of the Vale Figueira Member.

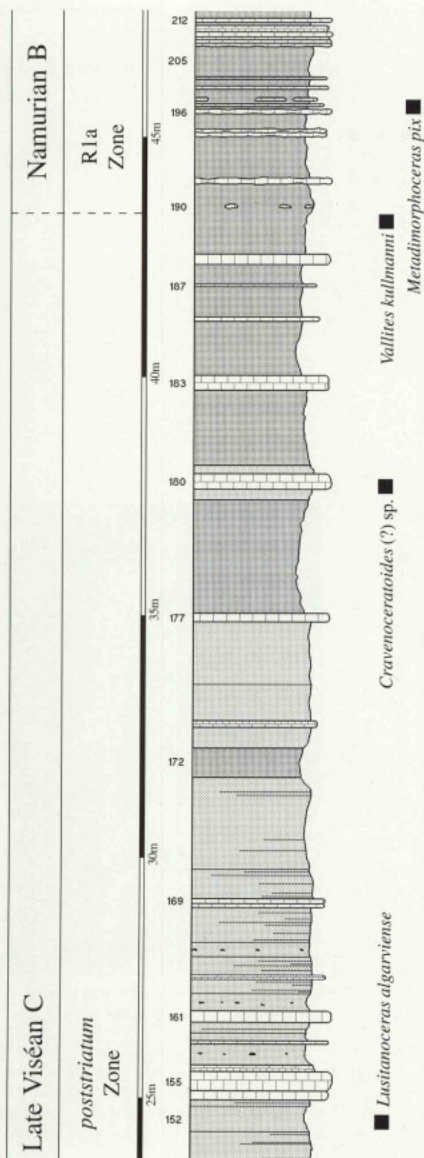
6.30m above the base of the Vale Figueira Member, poorly preserved specimens of *Beyrichoceras* sp. were collected in bed 105. In a horizon 9m above the base (bed 111), spirally ornamented goniatites occur abundantly, which belong to *Goniatites spirifer* ROEMER 1850. Besides these, insufficiently determinable specimens of *Goniatites fimbriatus* (FOORD & CRICK 1897) were found.



Text-fig. 6. The Quebradas section along the Atlantic seabord. View from north to south, in the foreground on the left side part of the Vale Figueira Member of the Murração Formation, in the background Quebradas and Brejeira Formations. All beds overturned.







At 9.20 m, the 5 cm thick conspicuous "residual layer" (bed 112) described in OLIVEIRA, HORN, KULLMANN & PAPROTH (1985: 112) occurs. Immediately above this horizon, *Goniattites spirifer* occurs in rather well preserved specimens, indicating that the "residual layer" does not mark a significant gap in the succession.

The next well preserved goniattites was collected at 10.50 m, where a determinable goniattite fauna could be collected in bed 116. They can be determined as *Hibernicoceras carraunense* MOORE & HODSON 1958, indicating a middle Late Viséan age of this horizon [the goniattites from this horizon, OLIVEIRA, HORN, KULLMANN & PAPROTH (1985) misidentified as cravenoceratids, and hence placed it in the Namurian.].

At 16.8m (bed 134), a black shale contains pyritized goniattites of the species, indicating that this bed is to correlate with bed 144 of the Murração section:

*Hibernicoceras hibernicum* MOORE & HODSON 1958,  
*Girtyoceras luscini* KORN 1988,

220cm higher (bed 139), *Paraglyphioceras* sp. and *Arnsbergites* sp., could be collected, and at 21.1m (in the middle of bed 145), abundant pyritized specimens of the following species could be collected in excellently preserved internal moulds.

*Sudeticeras murraçoense* sp. nov., as well as rare *Eoglyphioceras serotinum* sp. nov. and *Glyphiolobus* sp. 1.

Slightly higher, at 22.3m (bed 146), *Lusitanites clitheroensis* KORN 1988 occurs commonly and indicates a correlation with bed 161 of the Murração section. Finally, at 24.8m (bed 152), a dark shale contains numerous flattened specimens of *Lusitanoceras algarviense* PEREIRA DE SOUSA 1923, and hence directly correlated with bed 169 of the Murração section. According to OLIVEIRA (1983), the boundary to the next higher Quebradas Formation is placed at 32.5m from the base, where the first thicker black shale horizon occurs (Text-fig. 8). The data show that all these fossil horizons were deposited in the Late Viséan, and evidence for an early Namurian age is completely lacking.

Further goniattite-bearing localities:

- **Monte do Engenheiro** (coll. M. HORN et al. 1982): *Goniattites spirifer* ROEMER 1850.

**Text-fig. 8.** The upper part of Vale Figueira Member and the lowest part of the Quebradas Formation in the Praia das Quebradas section [For explanation see text-fig.4].

- along the road from Carrapateira to the Praia de Murracão, directly north of the abandoned **Murracão Velho** Farm (coll. M. HORN et al. 1982): *Lusitanoceras algarviense* PEREIRA DE SOUSA 1923.
- from **km11** along the road from **Bordeira to Carrapateira** (coll. M. HORN et al. 1979): *Lusitanoceras algarviense* PEREIRA DE SOUSA 1923, *Lusitanoceras poststriatum* (BRÜNING 1923).
- **Monte Parente** 5.5km northeast of Bordeira (coll. K. HORN 1983): *Lusitanoceras poststriatum* (BRÜNING 1923).

#### d) Quebradas Formation

At the type locality, the **Praia das Quebradas**, this formation is completely exposed, being mainly composed of black shales with interbeddings of fine grained carbonate lenses, nodules, and beds. These increase in frequency towards the top of the formation, and are replaced by numerous horizons of phosphoritic nodules. In the upper part, a 16m thick intercalation of laminated shales with few thin sideritic limestone beds occurs. The transition to the Brejeira Formation is slow, and marked by distal turbidites.

The basal 12m of the Quebradas Formation are very poor in fossils, and only one limestone bed 6.2m from the bottom yielded poorly preserved indeterminate goniatites, which may belong to the genus *Cravenoceratoides*. At 11.8m from the base, bituminous carbonate nodules (bed 190) frequently contain *Vallites kullmanni* sp. nov., indicating a stratigraphical age of most probably R1a.

Beds 192 and 212 yielded only indeterminate goniatites, but bed 200 contains numerous well preserved specimens of *Metadimorphoceras pix* sp. nov.

Bed 214 (Text-fig.9) deserves special interest, that is the so-called tuffitic layer (OLIVEIRA, HORN, KULLMANN & PAPROTH 1985) at 18.2m from the base, which is a lenticular carbonate bed maximal 30cm thick that especially at its base contains much fossil debris (predominantly goniatites), extraclasts of reworked black shales and bituminous carbonates, quartz grains as well as feldspar and biotite flakes. The latter component was interpreted by the authors as deriving from an eroded volcanic complex, rather than from an isochronous ash fall. The „tuffitic layer“ shows features typical for debris flows:

- An imperfect gradation, but generally with the coarser components at the base and the fine muddy material on top.
- A chaotic internal organisation of the bed: distribution of larger components (goniatites and extraclasts up to a size of 10cm) is somewhat irregular, obviously due to slumping events.

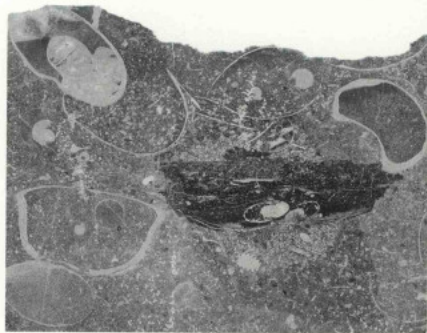
- Some of the large components indicate a short transport distance, proved by the occurrence of completely preserved ammonoid conchs with their body chamber, and by the angularity of extraclasts.
- A lenticular shape of the bed with uneven base.

The bed has a rich content of goniatites, both of different species and individuals, which are assembled in clusters. All growth stages from the very immature conchs of only one millimetre diameter up to adults of approximately ten centimetres diameter can be found.

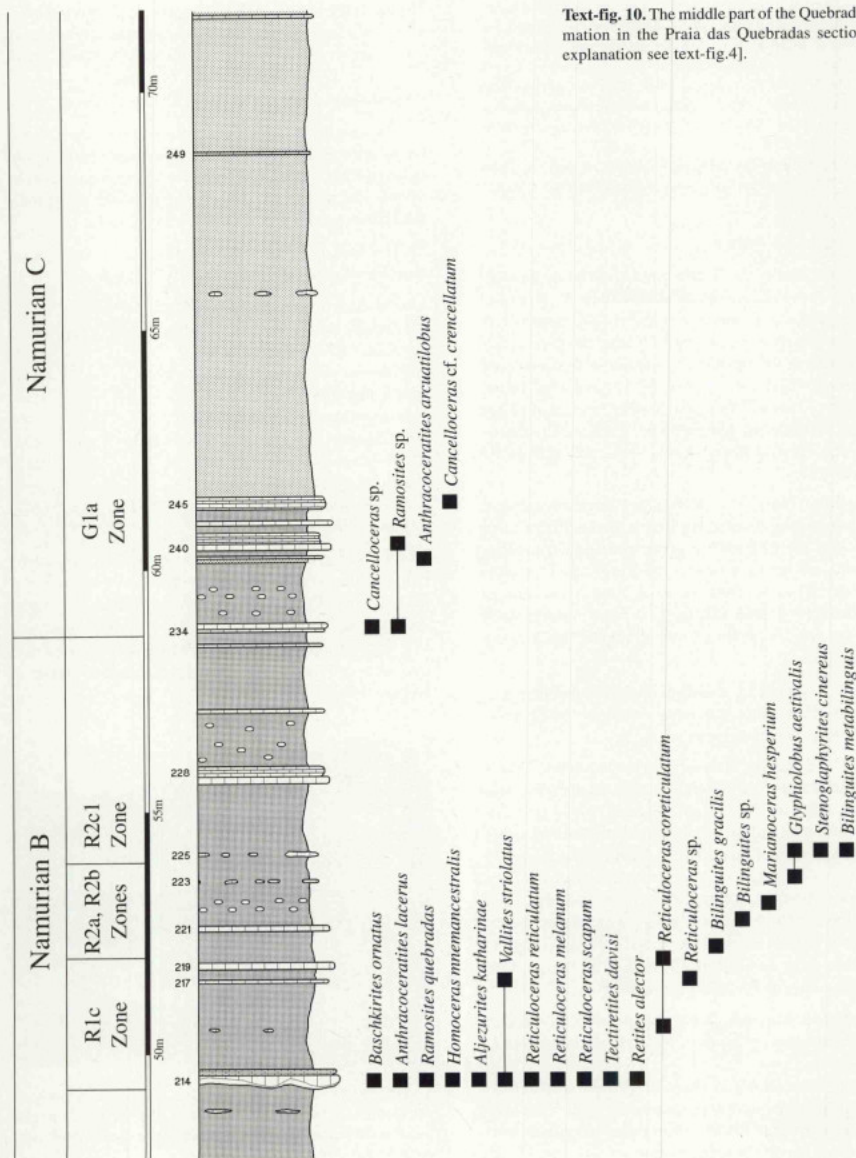
The faunal composition of this bed is as follows (number of extracted individuals in brackets):

<i>Baschkirites ornatus</i> (FOORD & CRICK 1897)	(2)
<i>Anthracoceratites lacerus</i> sp. nov.	(35)
<i>Ramosites quebradas</i> sp. nov.	(5)
<i>Homoceras mnemancestralis</i> sp. nov.	(1)
<i>Aljezurites katharinae</i> sp. nov.	(4)
<i>Vallites striolotus</i> (PHILLIPS 1836)	(47)
<i>Reticuloceras reticulatum</i> (PHILLIPS 1836)	(37)
<i>Reticuloceras melanum</i> sp. nov.	(17)
<i>Reticuloceras scapum</i> sp. nov.	(11)
<i>Tectitites davisi</i> (FOORD & CRICK 1897)	(27)
<i>Retites alector</i> sp. nov.	(6)

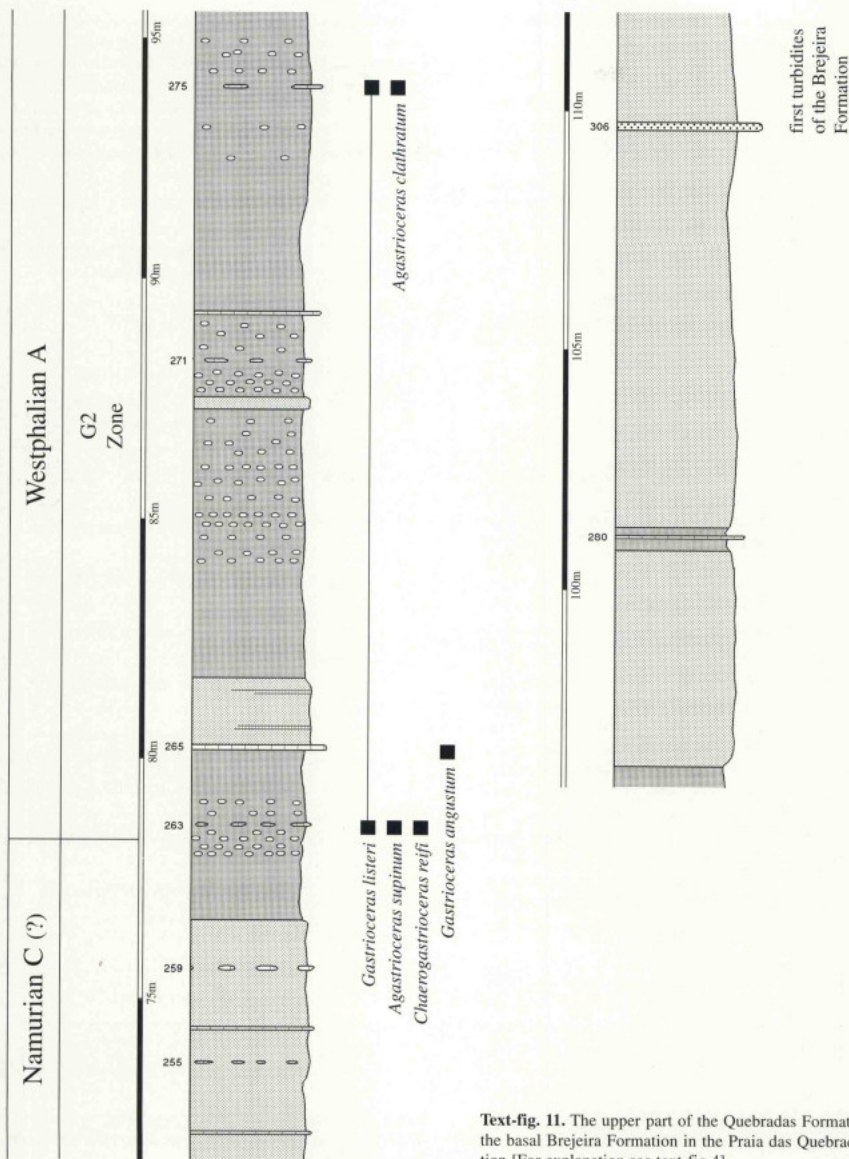
Of these species, *Anthracoceratites lacerus* occurs only in bituminous extraclasts and the bituminous top of the bed, together with rare *Vallites striolotus*. The latter species is the most frequent in the coarsely grained matrix, accompanied by the other listed species. The fauna indicates an R1c1 age of the British zonation (BISAT & HUDSON 1943).



**Text-fig. 9.** Bed 214 of the Quebradas Formation in the Praia das Quebradas section, peel used as negative, x 1. Note the large bituminous extraclast containing a specimen of *Anthracoceratites lacerus* sp. nov.







**Text-fig. 11.** The upper part of the Quebradas Formation and the basal Brejeira Formation in the Praia das Quebradas section [For explanation see text-fig.4].

Higher in the section, goniatites could be extracted from many different horizons and allow rather exact stratigraphical determination (Text-figs. 10, 11; Tab. 1):

- bed 216: *Reticuloceras coreticulatum* BISAT & HUDSON 1943.
- bed 217: *Vallites striolotus* (PHILLIPS 1836), *Reticuloceras* sp.
- bed 219: *Reticuloceras coreticulatum* BISAT & HUDSON 1943.
- bed 220: *Bilinguites gracilis* (BISAT 1924).
- bed 221: *Bilinguites* sp.
- bed 222: *Marianoceras hesperium* sp. nov.
- bed 223: *Glyphiolobus aestivalis* sp. nov.
- bed 225: *Glyphiolobus aestivalis* sp. nov., *Stenoglyphyrites cinereus* sp. nov., *Bilinguites metabilinguis* (WRIGHT 1927)
- bed 229: gen. et sp. indet.
- bed 231: gen. et sp. indet.
- bed 234: *Cancelloceras* sp., *Ramosites* sp. (poorly preserved).
- bed 238: *Anthraceratites arcuatilobus* (LUDWIG 1863).
- bed 240: *Ramosites* sp.
- bed 244: *Cancelloceras crencellatum* (BISAT 1924).
- bed 263: *Gastrioceras listeri* (SOWERBY 1812), *Agastrioceras supinum* sp. nov., *Chaerogastrioceras reifi* sp. nov.
- bed 265: *Gastrioceras angustum* PATTEISKY 1964.
- bed 275: *Gastrioceras listeri* (SOWERBY 1812), *Agastrioceras clathratum* sp. nov.

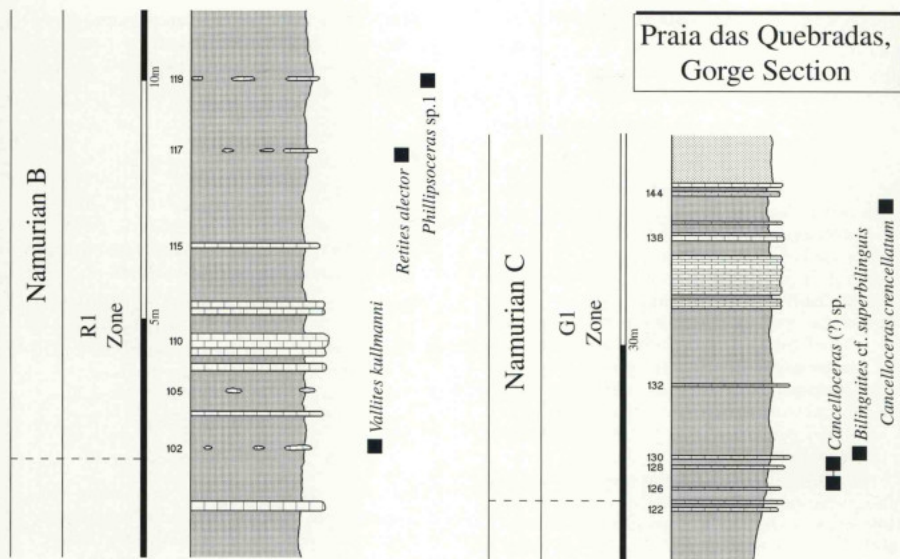
Beds 216 to 219 are to be placed in the R1c2 Zone (*Reticuloceras coreticulatum*), and the R2a Zone begins with bed 220 (*Bilinguites gracilis*). Beds 221, 222, and 223 did not yield index forms, thus it is unclear whether they represent the R2b Zone (Zone of *Bilinguites bilinguis*). The very rich lenticular layer 225 yielded more than 300 goniatites, of which *Bilinguites metabilinguis* is the dominant species. It can be correlated with the R2c1 Zone. Higher in the section, evidence for distinct ammonoid zones is weaker, mainly because of poor preservation of the goniatites. Bed 244 belongs in the G1a Zone, but the specimens cannot be attributed with certainty to *Cancelloceras crencellatum*.

Evidence for the basal Westphalian is provided by the occurrence of *Gastrioceras listeri* in a brittle lenticular bed above the series of laminated shales (Text-fig. 11). A little higher, the finding of *Gastrioceras angustum* confirms this determination. 14m higher, *Gastrioceras listeri* as well as *Agastrioceras clathratum* occur in carbonate lenses only 15m below the beginning of the Flysch sequence, indicating that a portion of the Quebradas Formation belongs in the Westphalian A.

In the vicinity of the Praia das Quebradas, several other smaller outcrops are located, allowing to study parts of the Quebradas Formation. The first of these is the **gorge** immediately east of the beach section, in which especially the *Reticuloceras* and *Cancelloceras* horizons continue. Caused by intensive folding and faulting, a longer section is not possible to log at this place. Because of strong

	standard zonation	fossil horizons with goniatites in southwest Portugal
Westphalian A		• <i>Gastrioceras listeri</i>
	G2	• <i>Gastrioceras angustum</i>  • <i>Gastrioceras listeri</i>
Namurian C	G1b	
	G1a	• <i>Cancelloceras crencellatum</i> • <i>Cancelloceras cancellatum</i> • <i>Cancelloceras branneroides</i>
Namurian B	R2c	• <i>Bilinguites metabilinguis</i>
	R2b	• <i>Marianoceras hesperium</i>
	R2a	• <i>Bilinguites gracilis</i>
	R1c	• <i>Reticuloceras coreticulatum</i> • <i>Reticuloceras reticulatum</i>
	R1b	
	R1a	• <i>Vallites kullmanni</i>
	H2c	

**Tab. 1.** The Namurian and earliest Westphalian goniatite horizons in the South Portuguese Zone. Data mainly from the Praia das Quebradas section.



Text-fig. 12. Two parts of the Quebradas Formation in the Praia das Quebradas Gorge section [For explanation see text-fig.4].

weathering, carbonate horizons are often decalcified, usually providing only natural moulds of goniatites.

Further goniatite-bearing localities are north of the abandoned **Murração Velho** farm along the road from Carrapateira to the Praia de Murração (OLIVEIRA, HORN, KULLMANN & PAPROTH 1985), and immediately east of the **Vale Figueiras** farm. At the latter, the transition into the Brejeira Formation is exposed, and yielding goniatites of early Westphalian age (*Gastrioceras angustum* PATTEISKY 1964) from weathered nodules from few meters below the first Flysch greywackes.

#### Additional localities:

- **Monte Parente** 5.5km northeast of Bordeira (coll. K. HORN 1983): *Gastrioceras listeri* (SOWERBY 1812), *Chaerogastrioceras reiffi* sp. nov. occur in the same black decalcified nodules
- **Monte Inferno**, 4km east-northeast of Bordeira (coll. J.T. OLIVEIRA): *Agastrioceras clathratum* sp. nov., *Gastrioceras listeri* (SOWERBY 1812) occur on the same bedding surfaces.
- **Monte da Gorda** (coll. M. HORN et al. 1981): *Baschkirites* sp.
- **Murração Velho** farm along the road from Carrapateira to the Praia de Murração (coll. M. HORN et al. 1982): *Vallites kullmanni* sp. nov., *Tectiretites davisi* (FOORD & CRICK 1897), *Retites alector* sp. nov., *Cancelloceras cancellatum* (BISAT 1923). These specimens derive from different rock material.
- **Murração**, without closer indication (coll. J.T. OLIVEIRA): *Marianoceras hesperium* sp. nov.
- **Vale Figueiras** 3km south of Carrapateira (coll. J.T. OLIVEIRA): *Ramosites sousai* sp. nov., *Bilinguites* (?) sp., *Bilinguites metabilinguis* (WRIGHT 1927), *Cancelloceras crenellatum* (BISAT 1924). *Gastrioceras angustum* PATTEISKY 1964 was collected in weathered nodules a few meters below the base of the Flysch series (coll. D. KORN & M. HORN 1995).
- **Caixeiro** 5km northeast of Bordeira (coll. J.T. OLIVEIRA): *Bilinguites metabilinguis* (WRIGHT 1927).
- **Monte Novo** (coll. M. HORN et al. 1979): *Cancelloceras cancellatum* (BISAT 1923).
- **Endiabras** farm 5km northeast of Bordeira (coll. M. HORN et al. 1979): an extensive collection of crushed material is available for study. Most of the specimens are not determinable with certainty, but some of the late Namurian horizons are represented.



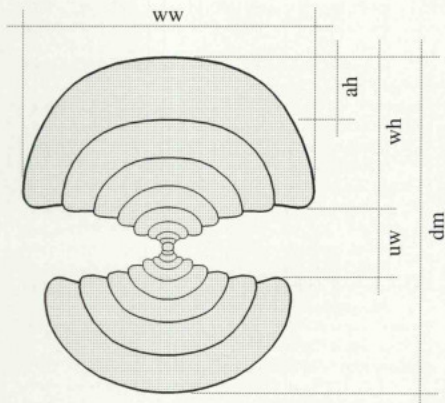
## V. MATERIAL AND METHODS

A total of 1700 goniatite specimens from the South Portuguese Zone were available for study. This material is preserved in a number of different modes:

- pyritized internal moulds from black shales (specimens from the Late Viséan);
- imprints with preserved shell ornament in shales (specimens from the Late Viséan and late Namurian);
- three-dimensionally preserved conchs with shell remains in compact limestones and carbonate lenses (especially from the late Namurian);
- distorted internal moulds from marly carbonates (from the Early and Late Viséan);
- three-dimensional natural moulds (of which latex casts have been made) with partially preserved phragmocones (widespread in Tournaisian, Late Viséan, Namurian and Westphalian rocks); and
- porous carbonate and phosphate internal moulds from shales (specimens from the late Namurian and basal Westphalian).

The entire material is, with only very few exceptions (the material described by HORN, KULLMANN & OLIVEIRA 1990, which is archived in the collection of the Institut für Geologie und Paläontologie, Tübingen) deposited in the collection of the Instituto Geológico e Mineiro, Lisboa, with the catalogue numbers IGML 1 - IGML 405.

Descriptive terms of the conch (Text-Fig. 13) and ornamental features are adopted from RUZHENCEV & BOGOSLOVSKAYA (1971) and KORN (1988).



Text-fig. 13. Conch parameters used in the systematic descriptions.

- Abbreviations of the conch parameters are:

- dm ..... conch diameter;
- ww ..... maximal whorl width;
- wh ..... maximal whorl height;
- uw ..... umbilical diameter; and
- ah ..... aperture height.

- The conch shape is described as follows:

- thinly discoidal .....  $ww/dm < 0.36$ ;
- discoidal .....  $ww/dm = 0.36 - 0.60$ ;
- pachycone .....  $ww/dm = 0.61 - 0.85$ ;
- globular .....  $ww/dm = 0.86 - 1.10$ ; and
- barrel-shaped .....  $ww/dm > 1.11$ .

- The width of the umbilicus, relative to the conch diameter, is characterized as follows:

- punctiform ..... closed umbilicus;
- very narrow .....  $uw/dm < 0.16$ ;
- narrow .....  $uw/dm = 0.16 - 0.30$ ;
- moderately wide .....  $uw/dm = 0.31 - 0.45$ ;
- wide .....  $uw/dm = 0.46 - 0.60$ ;
- very wide .....  $uw/dm > 0.61$ ;

- The direction of the growth lines is defined as follows:

- rectiradial - running in an almost radial direction;
- prorsiradial - projecting on the flanks; and
- rursiradial - turning back over the flanks.

- The course of the growth lines is defined as:

- biconvex - two lateral projections as well as lateral and ventral sinuses are developed;
- concavo-convex - only one ventrolateral projection and a ventral sinus are present;
- convex - a wide projection occupying the flanks and a wide ventral sinus are present;
- linear - projections and sinuses are lacking.

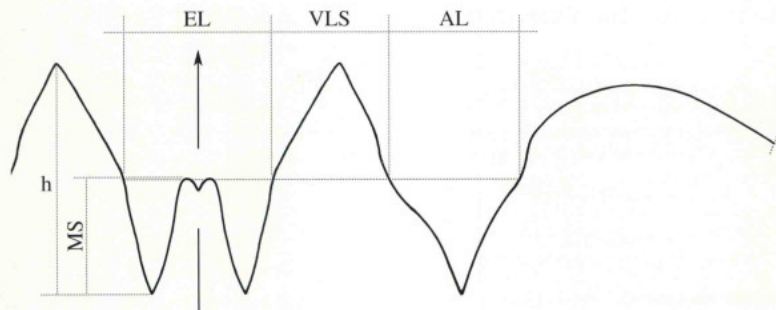
Sutural terminology follows the scheme developed by WEDEKIND (1918) and SCHNEDWOLF (1929). Species of the Order Prolecanitida are regarded to possess principally the same lobes as those of the Order Goniatitida. The separation between an A-type and a U-type sutural ontogeny (SCHNEDWOLF 1929) is not accepted here. The following terms are used:

- E external lobe;
- A adventive lobe;
- L lateral lobe;
- U umbilical lobe; and
- I internal lobe.

Additionally, in the text, the saddles of the outer suture line are characterized as follows:

- median saddle (subdividing the external lobe); and
- ventrolateral saddle (between external lobe and adventive lobe).





Text-fig. 14. Sutural parameters used in the systematic descriptions.

It is worth discussing the ratios of sutural elements (Text-fig. 14), because the majority of the Carboniferous ammonoids display suture lines with the basic elements E A L U I, of which E is subdivided. Despite this common sutural formula, classification of higher taxa is based on sutural differences, e.g. the form and width of lobes and saddles. These characters, however, change remarkably during phylogeny, often showing parallel development. This means that clear autapomorphies of the taxonomic units are hardly recognizable.

Biometrical attempts to analyse suture lines of goniatites are rarely published, with usually only a few measurements of sutural elements being taken. This includes, for instance, the width of the external lobe, taken in the middle, and its ratio to total depth (as used by RUZHNEV & BOGOSLOVSKAYA 1971, 1978), or its ratio to the width of the adventive lobe (as used by RUZHNEV & BOGOSLOVSKAYA 1971 and KORN 1988).

Goniatite sutural complexity is here understood as mainly resulting from the number and position of discrete tie points which act as initiators for the lobes (SEILACHER 1975, 1988), whereas saddles are formed like pneus caused by continuing liquid filling of the new chamber. Hence controlling factors of the formation of the suture line are thought to be limited to:

- the relative distance of the tie points  
(controlling the distances and position of the lobes within one suture line);
- the size of the organic prosepium, considered here to be non-elastic as in modern *Nautilus*  
(controlling the length of the suture line); and

- the timing of attachment of the organic prosepium to the shell wall relative to the filling of the last chamber with cameral liquid  
(controlling the outline of lobes and saddles).

It can be assumed that especially the distance of lobes within one suture line is strictly controlled by the soft body, and is largely independent of other factors. In contrast to this, shape and height of saddles are interrelated to some degree: If the sutural length is constant, height of saddles will decrease with larger distances between lobes as well as with increasing sutural complexity.

Also, the conch shape plays an important role in the outline and size of sutural elements. This can be seen particularly in those forms with remarkable allometric changes of the conch, where an ontogenetic transformation towards a discoidal or acute conch may lead to relatively shallower lobes.

For comparisons of the species, sutural ratios are listed for those goniatites with the sutural formula E A L U I. Abbreviations in these lists are (all taken at half the depth):

- EL ..... width of the external lobe;
- AL ..... width of the adventive lobe;
- MS ..... height of the median saddle; and
- VLS ..... width of the ventrolateral saddle.

The abbreviation h in these lists refers to the total height of the ventrolateral saddle = depth of the external lobe (usually, this is coincident with the maximal height of the suture line). The ratio external lobe/adventive lobe is only used in those cases, where measurement of the height of the ventrolateral saddle was prevented.

## VI. SYSTEMATIC DESCRIPTIONS

Subclass **Ammonoidea** ZITTEL 1884

Order **Clymeniida** HYATT 1884

Suborder **Clymeniina** HYATT 1884

Superfamily **Cyrtoclymeniaceae** HYATT 1884

Family **Cyrtoclymeniidae** HYATT 1884

*Cyrtoclymenia* HYATT 1884

*Cyrtoclymenia* sp.

Pl.1 Fig.1

**Material:** One fragment of a small (10mm diameter) specimen (IGML 324) from the Tercenas Formation (Late Devonian *Wöcklumeria* Stufe) of an outcrop 1km east of Carrapateira. It is a slightly deformed limonitic internal mould that displays the simple suture line.

Superfamily **Clymeniaceae** EDWARDS 1849

Family **Platyclymeniidae** HYATT 1884

*Platyclymenia* HYATT 1884

*Platyclymenia* sp.

Text-figs. 15, 16

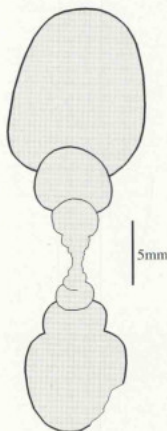
1912 *Clymenia laevigata*. - PRUVOST: 60, pl.1 fig.3.

1976 *Platyclymenia richteri*. - FANTINET, DREESEN, DUSAR & TERMIER: 128, pl.4 fig.1-3, pl.5 fig.1-3, pl.6 fig.1-4.

**Material:** One slab (IGML 372) of dark grey limestone with several embedded specimens from a forestry road cutting 1km northwest of Mértola (locality details in FANTINET et al. 1976). Because of cleavage of the rock, specimens could not be extracted, and only cross sections are visible. Two of them clearly display the typical open-



**Text-fig. 15.** Cross section through dark grey limestone containing a slightly distorted cross section of *Platyclymenia* sp.; specimen IGML 372 (coll. D. KORN & K. HORN 1995); x 1; 1km northwest of Mértola (Late Famennian *annulata* Zone).



**Text-fig. 16.** *Platyclymenia* sp.; slightly distorted cross section of specimen IGML 372 (coll. D. KORN & K. HORN 1995); x 2.5; 1km northwest of Mértola (Late Famennian *annulata* Zone).

umbilicate conch with circular inner and compressed outer whorls.

Three specimens which already were described and figured by PRUVOST (1912) have been re-examined. The largest of these (PRUVOST's fig.1) is a longitudinal section that cannot be determined. His fig.2 (IGML 183) has 30mm diameter and is a badly preserved natural mould with some remains of simply constructed septa. The small specimen on PRUVOST's figure 3 (IGML 184) is a fragmental individual of less than 10mm diameter. Its shell is smooth except for delicate growth lines with concavo-convex course. Only this specimen can be attributed to *Platyclymenia* with certainty.

Family **Kosmoclymeniidae** KORN & PRICE 1987

*Lissoclymenia* KORN & PRICE 1987

*Lissoclymenia* (?) sp.

Pl.1 Fig.2

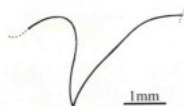
**Material:** One impression (IGML 340) in a sandstone bed of a specimen of approximately 70mm diameter from the Phyllite-Quartzite Formation of Mértola. Unfortunately, no traces of the suture line or shell ornament are visible, hence determination is very problematic. The shell appears to be unsculptured, and the very wide umbilicus with hardly embracing whorls make an assignment to *Lissoclymenia* likely.

*Linguaclymenia* KORN & PRICE 1987*Linguaclymenia similis* (MÜNSTER 1839)

Pl.1 Fig.3

1839 *Clymenia similis* MÜNSTER: 39.1987 *Kosmoclymenia* (*Linguaclymenia*) *similis*. KORN & PRICE: 47, pl.7 fig.53-55, pl.8 fig.56 [for more synonymy].**Holotype:** Specimen Nr. BSP AS VII 544 (coll. MÜNSTER), Bayerische Staatssammlung für Paläontologie und historische Geologie, München.**Type locality and horizon:** Gattendorf (Oberfranken, Germany); Late Devonian (most probably *Wocklumeria* Stufe).**Material:** Only one natural mould (IGML 371) from Monte de Selão 6km east of Aljezur is available for study. It is from a specimen of 16mm diameter, allowing examination of the ornament on a quarter of a volution. Coarse growth lines are here visible, which possess a low dorsolateral projection, but on the flank they arch forward to form a prominent ventrolateral salient.**Stratigraphical and geographical distribution:** Late Devonian *Wocklumeria* Stufe of Germany (Upper Franconia, Saxonia, Rhenish Massif), Austria and Italy (Carnic Alps), Poland (Lower Silesia, Holy Cross Mountains), Great Britain (Cornwall), and South Portugal, where the species occurs in the Tercenas Formation.*Linguaclymenia clauseni* (KORN & PRICE 1987)

Pl.1 Fig.6, Text-fig.17

1985 *Cymaclymenia* sp. OLIVEIRA, HORN, KULLMANN & PAPROTH: 108.1987 *Kosmoclymenia* (*Linguaclymenia*) *clauseni* KORN & PRICE: 49, pl.8 fig.57.1994 *Linguaclymenia clauseni*. KORN in KORN et al.: 115, text-fig.14A-C.**Holotype:** Specimen Nr. de517 (coll. CLAUSEN and KORN 1979), Geologisches Landesamt Nordrhein-Westfalen, Krefeld.**Type locality and horizon:** Drewer, östlicher Provinzial-Steinbruch (Rhenish Massif, Germany); Late Devonian *Wocklumeria* Stufe.**Material:** One deformed specimen (IGML 323) of 50mm diameter from 2km east of Carrapateira is available. It is an individual in which the phragmocone is not completely crushed and displays the *Kosmoclymenia*-like suture line. The body chamber is flattened, mostly existing only as a shadow image. In the apical part the ornament of coarse biconvex growth lines can be seen. These run with a minor dorsolateral and a high ventrolateral projection over the flanks. A weak ventrolateral groove is preserved.**Text-fig. 17.** *Linguaclymenia clauseni* (KORN & PRICE 1987); part of the suture line of specimen IGML 323 (coll. J.T. OLIVEIRA) at dm 21.5mm, wh 7.4mm; x 8; 2km east of Carrapateira, Tercenas Formation (probably Late Famennian *Wocklumeria* Stufe).**Remarks:** The ventrolateral groove at a diameter of 35mm in this specimen is indicative of *Linguaclymenia*. Among the species of *Linguaclymenia* described by KORN & PRICE (1987), *L. clauseni* best fits the specimen from Carrapateira. In both the course and strength of the growth lines the Portuguese specimen resembles exactly the species described from the Rhenish Massif.**Stratigraphical and geographical distribution:** Late Devonian *Wocklumeria* Stufe of Germany (Rhenish Massif), and Tercenas Formation of Southwest Portugal.

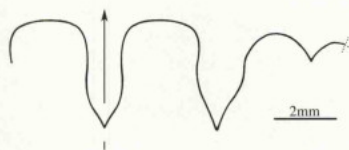
Order **Prolecanitida** MILLER & FURNISH 1957  
 Suborder **Prolecanitina** MILLER & FURNISH 1957  
 Superfamily **Prolecanitaceae** HYATT 1884  
 Family **Prolecanitidae** HYATT 1884  
 Subfamily **Eocanitidae** WEYER 1972

*Eocanites* LIBRIVITICH 1962*Eocanites nodosus* (SCHMIDT 1925)

Pl.1 Figs.4,5, Text-fig.18

1925 *Gattendorfia nodosa* SCHMIDT: 536, pl.19 fig.10, pl.23 fig.2,3.1960 *Protocanites nodosus*. VÖHRINGER: 169, pl.6 fig.1.1994 *Eocanites nodosus*. KORN: 81, fig.73A,B,D, 74A, 75C.**Holotype:** The specimen figured by SCHMIDT (1925, pl.19 fig.10), Institut und Museum für Geologie und Paläontologie, Göttingen.**Type locality and horizon:** Railway cutting near Ober-Rödinghausen (Rhenish Massif, Germany); Hangenberg Limestone (*Gattendorfia* Stufe, Early Tournaisian).**Material:** One specimen (IGML 320) from 500m west of the Samoqueira farm, 2.5km east-northeast of Bordeira. It is a specimen of maximal 25mm diameter, which is three-dimensionally preserved but somewhat deformed. It shows remains of the shell with coarse biconvex growth





**Text-fig. 18.** *Eocanites nodosus* (SCHMIDT 1925); suture line of specimen IGML 320 (coll. J.T. OLIVEIRA) at dm 22.0mm, wh 7.3mm; x 6; 500m west of the Samoqueira farm, Bordaleta Formation (probably Early Tournaisian *Gattendorfia* Stufe).

lines which run in a rursiradial direction. They are arranged at average distances of 0.3mm, and are slightly roughened. The suture line shows a deep lanceolate ventral lobe, an adventive lobe of similar but asymmetric shape, and a tiny V-shaped lateral lobe.

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 320	23.6		7.4	11.5		0.31	0.49

**Remarks:** The specimen can be identified with certainty, although it is not very well preserved. All the characters are typical for *E. nodosus*, which is the species of *Eocanites* with the coarsest ornament.

A second specimen (IGML 321) from a nearby locality shows a considerably wider umbilicus, and an ornament which is much finer. Rursiradial and fine growth lines are here visible only at 12mm diameter. Thus it probably represents another species of *Eocanites*.

**Stratigraphical and geographical distribution:** The species is known from Germany (Rhenish Massif, Thuringia), Poland (Lower Silesia), and Southwest Portugal (from the Bordaleta Formation). According to VÖHRINGER (1960: 170), in the Rhenish Massif the species is distributed throughout the entire *Gattendorfia* Stufe. This was confirmed by WEYER (1965, 1977) for occurrences in Silesia and Thuringia. It is not clear, however, if it is restricted to this time interval, or if it also ranges up into the Middle Tournaisian.

#### *Becanites* gen. nov.

**Type species:** *Prolecanites algarbiensis* PRUVOST 1914.

**Genus definition:** Prolecanitid genus with eight lobes. External lobe parallel-sided and lanceolate, adventive lobe pouched, lateral lobe lanceolate.

**Generic composition** (Many of the Middle Tournaisian prolecanitids are poorly described, hence only the following four species can be attributed to *Becanites* with certainty):

*abnobensis*: *Prolecanites supradevonicus abnobensis* VÖHRINGER 1960: 173. Tournaisian of the Black Forest (Germany).

*algarbiensis*: *Prolecanites algarbiensis* PRUVOST 1914: 17. Bordaleta Formation of Southwest Portugal.

*geigenensis*: *Prolecanites geigenensis* SCHMIDT 1924: 138. Geigenschiefer (Tournaisian) of Franconia (Germany).

*gurlleyi*: *Prolecanites gurlleyi* SMITH 1903: 13. Northview Member of the Chouteau Formation of Missouri (USA).

**Comparisons:** *Becanites* gen. nov. is similar to the genus *Eocanites* LIBROVITCH 1962, but differs in the form of the lateral lobe, which is very small and V-shaped in *Eocanites* but lanceolate in *Becanites* gen. nov. *Prolecanites* has a lanceolate external lobe in preadult specimens, but possesses a simplified V-shaped external lobe in the adult stage, not known from *Becanites*.

**Stratigraphical and geographical distribution:** Probably all the occurrences are from sediments of Middle Tournaisian age. The genus is known from southwestern Portugal, the North American Midcontinent (Missouri), the Black Forest, and Franconia (Germany). Most probably, the genus has a wider geographical distribution.

#### *Becanites algarbiensis* (PRUVOST 1914)

Pl. I Figs. 7-9, Text-fig. 19

1914 *Prolecanites algarbiensis* PRUVOST: 17, fig. 1.

1978 *Prolecanites algarbiensis* - PERDIGÃO: 387, pl. 1 fig. 1.

1996 *Michiganites algarbiensis* - HOUSE: 97, text-fig. 2E.

**Type material:** The specimen figured by PRUVOST (1914, p. 17, fig. 1) could not be traced in the collection of the Instituto Geológico e Mineiro, Lisboa. Thus a neotype from the same formation of the type area is proposed here (IGML 253; pl. 1 fig. 8).

**Type locality and horizon:** 600m southwest of Bordaleta; Bordaleta Formation (probably Middle Tournaisian).

**Material:** 25 specimens, which derived from the vicinity of Bordaleta and the Bordaleta farm, and three from Ribeiro da Cerca 4km east-northeast of Aljezur. The specimens originate from calcareous nodules within black shales and siltstones. They are slightly deformed natural moulds displaying the shell ornament, and only a few are three-dimensionally preserved, but are distorted by cleavage. The suture could be seen in four specimens.

**Species diagnosis:** Type species of *Becanites* with thinly discoidal conch ( $ww/dm = 0.25$ ). Umbilicus wide ( $uw/dm = 0.50$ ), whorl cross section oval ( $ww/wh = 0.75$ ). Suture line with pouched, asymmetric adventive lobe, as well as lanceolate and pointed lateral lobe.

**Conch form:** The whorl cross section is compressed and oval in all growth stages which are larger than 10mm, where the umbilical width remains being half of the conch diameter.



**Text-fig. 19.** *Protocanites algarbiensis* (PRUVOST 1914); suture line of specimen IGML 253 (coll. E. HELLEBRAND 1994) at dm 16.0mm, wh 5.5mm; x 6; 600m southwest of Borda, Borda Formation (Middle Tournaisian).

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 252	33.6		11.2	17.1	0.33	0.51	
IGML 253	29.1		8.9	15.2	0.31	0.52	
	20.3		6.7	10.2	0.33	0.50	
IGML 319	17.2	3.8	5.2	8.8	0.22	0.30	0.51

**Ornamentation:** Only traces of the ornament can be seen in the specimens. At 15mm diameter, specimen IGML 319 displays delicate growth lines which run in a rursiradial direction.

**Suture line:** The suture line of specimen IGML 253 is considerably different to that published by PRUVOST (1914, fig. 1c). PRUVOST shows a weakly indicated umbilical lobe that does not exist in specimen IGML 253. Also, adventive and lateral lobes are more pouched in PRUVOST's figure.

**Remarks:** The evolution of the earliest prolecanitids is discussed by HOUSE (1995), who proposed an evolutionary lineage originating from *Eocanites* of the *E. supra-devonicus* (SCHINDEWOLF 1926) type (with small V-shaped lateral lobe), via eocanitids of the *Becanites gurleyi* (SMITH 1903) type (with lanceolate V-shaped lateral lobe) to *Michiganites* with an additional lobe on the flank, and with a pouched external lobe. He placed *Becanites algarbiensis* into *Michiganites*, citing PRUVOST's sutural figure.

**Comparisons:** Several early prolecanitid species display a lanceolate lateral lobe. *Becanites gurleyi* (SMITH 1903) is clearly distinguished from *Becanites algarbiensis* by its almost circular whorl cross section. Also, the lateral lobe in *Becanites gurleyi* is larger and deeper (see MILLER & COLLINS 1951, p. 478). *Becanites abnobensis* (SPIEGELHALTER 1910) is similar in shape but has a larger lateral lobe, and a more pouched adventive lobe than *Becanites algarbiensis*. *Becanites geigenensis* (SCHMIDT 1924) is difficult to compare because of insufficient description.

**Stratigraphical and geographical distribution:** Borda Formation (most probably Middle Tournaisian) of southwest Portugal.

#### Subfamily *Protocanitinae* WEYER 1972

##### *Merocanites* SCHINDEWOLF 1922

##### *Merocanites* sp.

**Material:** Only a few badly preserved fragments are available for study. They derive from the Pedra das Safias Member and were collected from the Pedra das Safias Member of the Murração Formation. One of the specimens is very large, with a phragmocone diameter of about 20cm, but lacks the ornament. Fragments of the suture line assign the specimen to *Merocanites*.

#### Subfamily *Prolecanitinae* HYATT 1884

##### *Prolecanites* MOJISOVICS 1882

##### *Prolecanites hesteri* MOORE 1952

Pl. I Fig. 10, Text-fig. 20

1952 *Prolecanites hesteri* MOORE: 72, pl. 7 fig. 1.2.

**Holotype:** Specimen Nr. 84710 (coll. MOORE), British Geological Survey, Keyworth, Nottingham.

**Type locality and horizon:** Cowdale Clough (Yorkshire, England); associated with *Goniatis hudsoni* (basal Late Viséan B2a Zone).

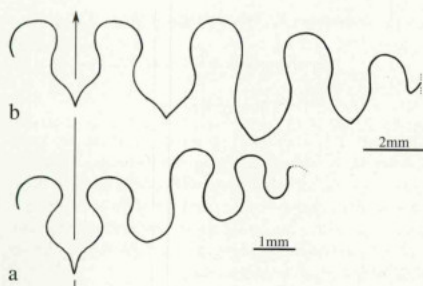
**Material:** One complete phragmocone (specimen IGML 352) of 15mm diameter and two phragmocone fragments of 3mm and 8mm whorl height, being preserved as haematitic internal moulds and displaying sutural development. The whorl cross section is almost circular at 3mm, but clearly compressed at 8mm whorl height. Ornament details are not preserved, but the internal mould of the larger specimen displays impressions of rursiradial growth lines on the flanks. The preadult specimen IGML 274 displays a suture line in which the E lobe is the most dominant element, being very deep and pouched. The three lobes on the flanks are pouched and rounded. At 8.1mm whorl height, the external lobe is shallower than the mammiform adventive lobe and lanceolate lateral lobe (IGML 259).

**Species diagnosis:** *Prolecanites* with thinly discoidal conch ( $ww/dm = 0.30$ ). Umbilicus moderately wide ( $uw/dm = 0.40$ ), whorl cross section oval ( $ww/wh = 0.75$ ). Suture line with pouched, asymmetric adventive lobe, lanceolate and pointed lateral lobe as well as two pointed umbilical lobes on the flanks.

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 352	14.7		5.3	6.1		0.36	0.41
IGML 259			6.0	8.1			
IGML 274			2.8	3.1			





**Text-fig. 20.** Suture lines of *Prolecanites hesteri* MOORE 1952; Praia da Murração, bed 100 (*hudsoni* Zone).

- a. specimen IGML 274 (coll. D. KORN & K. HORN 1995), at ww 2.8mm, wh 3.1mm; x 10.  
b. specimen IGML 259 (coll. D. KORN & K. HORN 1995), at ww 6.0mm, wh 8.1mm; x 6.

**Comparisons:** Knowledge of the different *Prolecanites* species is limited because some of them have not been revised since their original description. *P. serpentinus* (PHILLIPS 1836) has, according to the sutural drawing given by BISAT (1934, fig.27), four lobes on the flanks at 15mm diameter, in contrast to *P. hesteri* which only has three. *P. discoides* FOORD & CRICK 1897 has the same number of lobes, but (see MILLER & FURNISH 1940: Fig.13a) they are much less pouched than in *P. hesteri*.

**Stratigraphical and geographical distribution:** Basal Late Viséan of Great Britain (Yorkshire) and Germany (Rhenish Massif, Harz Mountains). The Portuguese material was collected from the base of the Vale Figueira Member, in a horizon with associated *Goniatites hudsoni* BISAT 1934. Hence this occurrence exactly fits the stratigraphical age (*hudsoni* Zone or B2a) known from the type specimens from Yorkshire.

#### Family *Daraelitidae* TSCHERNOW 1907

##### *Praedaraelites* SCHINDEWOLF 1934

##### *Praedaraelites culmiensis* (KOBOLD 1933)

Pl.1 Fig.11, Text-fig.21

- 1933 *Daraelites culmiensis* KOBOLD: 506, pl.23 fig.45-48.  
1988 *Praedaraelites culmiensis*:- KORN: 33, pl.1 fig.1-4 [for more synonymy].

**Lectotype:** The specimen figured by KOBOLD 1933, pl.23 Fig.45-48.

**Type locality and horizon:** Steigerthal near Lautenthal (Harz Mountains, Germany); Illyl of KOBOLD = *spirale* Zone (Late Viséan).

**Material:** 10 haematitic, three-dimensionally preserved specimens from bed 144 of the Praia de Murração section. All are septate phragmocones between 8 and 26mm diameter, displaying sutural ontogeny but no shell remains. Ornament is only visible as impression on the internal mould.

**Species diagnosis:** *Praedaraelites* with thinly discoidal conch ( $ww/dm = 0.32 - 0.36$ ), and moderately wide umbilicus ( $uw/dm = 0.35$ ). Whorl cross section with flattened flanks at 25mm diameter, ventrolateral shoulder angular. Suture line with slightly pouched, asymmetric and weakly denticulated adventive lobe, pouched and weakly denticulated lateral lobe as well as one rounded umbilical lobe on the flank.

**Conch form:** Preadult specimens, such as IGML 399 show at 10mm diameter slightly oval whorls, which become more flattened during ontogeny. At 26mm diameter (specimen IGML 351), the flanks are flattened and separated from the hemisphaerically rounded venter by an angular ventrolateral shoulder.

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 351	26.0	8.4	10.7	9.2	0.32	0.41	0.35
IGML 373	16.4	5.5	6.6	6.3	0.34	0.40	0.38
IGML 398	9.9	3.3	3.7	4.1	0.33	0.37	0.41

**Ornamentation:** Only IGML 351 provides a little information about the shell ornament. Here, on the flanks of the internal mould, projecting lines are barely visible, which are impressions of stronger growth lines.

**Suture line:** Specimen IGML 351 displays the suture line at 25mm diameter. It is characterized by an asymmetric adventive lobe and a pouched lateral lobe which both possess a very delicate denticulation, probably only visible because of the good limonitic preservation of the phragmocone.

**Comparisons:** It is difficult to compare the various species of *Praedaraelites* on the basis of material with different diameter, and without knowledge of sutural



**Text-fig. 21.** *Praedaraelites culmiensis* (KOBOLD 1933); suture line of specimen IGML 351 (coll. D. KORN & K. HORN 1995) at ww 8.1mm, wh 10.8mm; x 5; Praia de Murração, bed 144 (*spirale* Zone).



ontogeny. This is why a clear separation between *P. culmiensis*, *P. postculmiensis* KULLMANN 1962, *P. simulans* KULLMANN 1962, and *P. saharicus* PAREYN 1961 appears to be impossible. The latter three species have suture lines in which the lateral lobe is lacking denticulation, but this may be due to their smaller sizes.

*P. aktubensis* (RUZHENICEV & BOGOSLOVSKAYA 1971) has a suture line in which the denticulation is much stronger than in *P. culmiensis*, and showing already at 7.3mm whorl width strong denticulation of the lateral lobe

**Stratigraphical and geographical distribution:** The species is a good index fossil for the Late Viséan *spirale* Zone (base of P1d Zone) of Germany (Harz Mountains, Rhenish Massif), Great Britain (Yorkshire), Ireland (Co. Leitrim), and Southwest Portugal (Vale Figueira Member of the Murração Formation).

Superfamily **Medicottiaceae** KARPINSKY 1889

Family **Pronoritidae** FRECH 1901

*Pronorites* MOJSISOVICS 1882

*Pronorites meridionalis* sp. nov.

Pl. I Fig. 12, Text-fig. 22

**Holotype:** Specimen Nr. IGML 246 (coll. D. KORN & K. HORN 1995), Instituto Geológico e Mineiro, Lisboa.

**Type locality and horizon:** Praia de Murração; bed 100, *hudsoni* Zone (Late Viséan).

**Material:** Three specimens between 12 and 60mm diameter from the type horizon (IGML 246, 271), one from the Neves Corvo Mine (IGML 374). All are three-dimensionally preserved internal moulds of phragmocones, of which the three specimens from the Praia de Murração are haematized individuals. Suture ontogeny can partly be documented from these specimens, but shell remains are hardly preserved.

**Species diagnosis:** *Pronorites* with thinly discoidal conch (ww/dm = 0.25 - 0.30); umbilicus at 12mm diameter moderately wide (uw/dm = 0.42), and narrow at 40mm diameter (uw/dm = 0.28). Suture line with slightly pouched, asymmetric adventive, slightly pouched and narrow lateral lobe, as well as three acute and lanceolate umbilical lobes on the flanks.

**Conch form:** The juvenile stage (IGML 271) has at 12mm diameter compressed oval whorls, which become flattened at about 20mm diameter. In the holotype, the venter is broadly rounded at 40mm diameter. The umbilicus becomes relatively narrower during ontogeny.

#### Dimensions in mm and ratios:

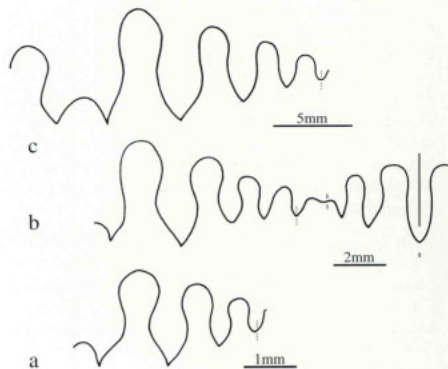
	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
HT IGML 246	39.6	10.4	17.7	11.0	0.26	0.45	0.28
PT IGML 271	12.3	3.5	4.5	5.2	0.28	0.37	0.42

**Ornamentation:** Only the specimen from the Neves Corvo Mine (IGML 374) allows study of the ornament, which here is preserved in the natural mould. The shell appears to be completely smooth at a diameter of about 20mm.

**Suture line:** Except for the ventral portion, the complete suture line can be studied in several individuals. The juvenile form (IGML 271) shows at 12mm diameter strongly pouched lobes, and only one umbilical lobe is present on the flank.

At 6.6mm whorl width (IGML 374), which resembles a conch diameter of 20mm, six umbilical lobes are developed, of which two are placed on the flanks. All these three lobes are lanceolate and pointed. The same sutural outline is preserved in the holotype of 40mm diameter (IGML 246), only with the difference that the lobes here are deeper than in the smaller specimen.

**Comparisons:** *Pronorites meridionalis* has a conch form that generally resembles those of *P. cyclobolus* (PHILLIPS 1836) and *P. molaris* KORN 1988. Differences can be seen in the umbilical width, in which *Pronorites meridionalis* has an intermediate position (uw/dm = 0.28) between the



**Text-fig. 22.** Suture lines of *Pronorites meridionalis* sp. nov.

- paratype IGML 271 (coll. D. KORN & K. HORN 1995) at dm 12.3mm ww 3.5mm, wh 4.5mm; x 10; Praia de Murração, bed 100 (*hudsoni* Zone).
- paratype IGML 374 (coll. D. KORN & J.T. OLIVEIRA 1993) at ww 6.6mm; x 5; near the main shaft of the Neves-Corvo Mine, *hudsoni* Zone.
- holotype IGML 246 (coll. D. KORN & K. HORN 1995) at dm 38.2mm ww 10.1mm, wh 3.0mm; x 3; Praia de Murração, bed 100 (*hudsoni* Zone).

two other species ( $uw/dm = 0.31$  in *P. cyclolobus* and 0.25 in *P. molaris*). Better criteria for separating the three species are provided by the suture line: *P. cyclolobus* has at 28mm diameter only two umbilical lobes on the flank, whereas the two other species have already three. Furthermore, in *P. cyclolobus* the lateral lobe is strongly pouched, in *P. meridionalis* only weakly, and in *P. molaris* barely visible. The main difference to *P. molaris* is that in *P. meridionalis* the umbilical lobes are lanceolate and not V-shaped.

**Stratigraphical and geographical distribution:** Late Viséan *hudsoni* Zone of South Portugal (base of the Vale Figueira Member of the Murração Formation).

Order **Goniatitida** HYATT 1884

Suborder **Tornoceratina** WEDEKIND 1918

Superfamily **Prionocerataceae** HYATT 1884

Family **Prionoceratidae** HYATT 1884

Subfamily **Acutimitoceratinae** KORN 1994

**Acutimitoceras** LIBROVITCH 1957

**Acutimitoceras** sp.

Pl.2 Fig.1

**Material:** Two completely crushed specimens from the Tercenas Formation of Carrapateira with 22 resp. 60mm in diameter. The larger of the two (IGML 316) displays a completely closed umbilicus and an ornament that consists of fine growth lines, which run with a convex course over the flank. There are no traces of ribs or constrictions. The smaller specimen (IGML 317) generally resembles the larger, but the growth lines are here periodically strengthened.

**Remarks:** Despite the poor preservation in a fine-grained sandstone, the specimens allow correlation with other occurrences of the genus. Similarly preserved specimens of *Acutimitoceras* occur frequently in the Hangenberg Shale and Hangenberg Sandstone of the Rhenish Massif (PAPROTH & STREEL 1970; BECKER 1988; KORN et al. 1994). Hence the horizon in which the Portuguese specimens have been collected may be correlated with the *prorsum* Zone, the youngest ammonoid zone within the Devonian. Of the different species known from this zone (KORN 1984, 1995), *Ac. intermedium* (SCHINDEWOLF 1923) is closest to the specimens from South Portugal.

Suborder **Goniatitina** HYATT 1884

Superfamily **Pericyclaceae** HYATT 1900

Family **Pericyclidae** HYATT 1900

**Goniocyclus** GORDON 1986

**Goniocyclus** sp.

Text-fig.23

**Material:** Only an old photograph and a rubber cast of a specimen which could not be traced is available for study. According to the attached label, it derives from Marmeleite (probably from the Bordaleta Formation).

It is a rather large specimen of maximal 70mm diameter, which is coarsely ribbed on all the visible whorls. Both of the last visible whorls have 27 sharp ribs, which from the umbilicus run in rursiradial direction over the flanks. The umbilicus of the specimen is rather wide, being approximately 0.40 of the diameter. The umbilical wall is rounded.



**Text-fig. 23.** *Goniocyclus* sp.; reproduction of an old photograph of a natural mould in the collection of the Instituto Geológico e Mineiro, Lisboa; x 1; Marmeleite, most probably Middle Tournaisian Bordaleta Formation..

Family **Muensteroceratidae** LIBROVITCH 1957

**Muensteroceras** HYATT 1884

**Muensteroceras** (?) sp.

Pl.2 Fig.2

**Material:** One specimen IGML 140 from Bordaleta Formation (Tournaisian) of the road cutting along the Ribeiro da Cerca 4km east-northeast of Aljezur. It is an incomplete conch of 60mm diameter which displays the ornament on the flank, consisting of fine densely arranged growth lines which bend forward to form a wide ventrolateral projection. No suture line is preserved.

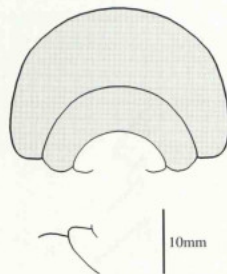
*Eurites* KUSINA 1973*Eurites* sp.

Textfig.24

**Material:** One poorly preserved specimen (IGML 139) of 45mm diameter from the Bordaleta Formation (Tournaisian) of Alcaria, 4km east-northeast of Aljezur. The shell ornament is not preserved, but it is obvious that no ribs are present. The cross section shows broad whorls, which gain in height during ontogeny (ww/wh at 14mm ww = 2.45, at 23mm ww = 1.87, at 33mm ww = 1.55).

**Dimensions in mm and ratios:**

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 139	33.4	21.6	12.3				
	23.2	12.3	9.0				
	18.0	14.2	5.8	7.4	0.79	0.32	0.41



**Text-fig. 24.** *Eurites* sp.; cross section of specimen IGML 139, coll. K. HORN 1982; x 1.25; near Alcaria, 4km east-northeast of Aljezur, Bordaleta Formation (Middle or Late Tournaisian).

*Eoglyphioceras* BRÜNING 1923*Eoglyphioceras serotinum* sp. nov.

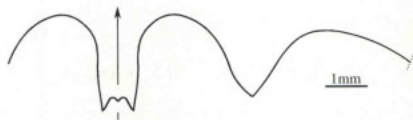
Pl.2 Figs.3, 4, Text-fig.25

**Holotype:** Specimen Nr. IGML 276 (coll. D. KORN & K. HORN 1995), Instituto Geológico e Mineiro, Lisboa.

**Type locality and horizon:** Praia das Quebradas; bed 145, Late Viséan (probably equivalent of the *suerlandense* Zone).

**Material:** Three pyritized specimens from 8 to 13mm diameter from bed 145 of the Praia das Quebradas section. The holotype is a broken phragmocone that allows insight in the inner whorls, on which remains of the shell are attached.

**Species diagnosis:** Small *Eoglyphioceras* with pachyconic conch at 12mm dm (ww/dm = 0.60), and very narrow umbilicus (uw/dm = 0.10). Ornamentation with slightly biconvex, lamellar growth lines. Suture line with narrow, almost parallel-sided ventral lobe (EL/h = 0.45; 0.85 of adventive lobe), and low median saddle (0.15 of ventrolateral saddle). Flanks of the external lobe slightly sinuous.



**Text-fig. 25.** *Eoglyphioceras serotinum* sp. nov.; suture line of specimen IGML 276 (coll. D. KORN et al. 1994) at dm 12.4mm, ww 7.1mm, wh 6.6mm; x 8; Praia das Quebradas, bed 145 (Late Viséan).

**Conch form:** During ontogeny, no remarkable change in the conch ratios occurs. Smaller specimens show a relatively wider conch and a slightly wider umbilicus.

**Dimensions in mm and ratios:**

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
HT IGML 276	11.9	7.2	6.3	1.3	0.61	0.53	0.11
	6.2	5.0	3.4	1.0	0.81	0.55	0.16
PT IGML 285	8.2	5.3	4.5	1.1	0.65	0.55	0.13
PT IGML 381	8.2	5.3	4.4	1.1	0.65	0.54	0.13

**Ornamentation:** Shell remains of the holotype bear lamellar, almost linearly running growth lines. The outer whorl possesses one shallow constriction.

**Suture line:** The suture line is typical for muensteroceratids, with an almost parallel-sided, only slightly pouched external lobe.

**Sutural ratios:**

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
HT IGML 276	11.9	7.2	6.3	0.14	0.43	0.89	0.50

**Comparisons:** The small size of the Portuguese material of *Eoglyphioceras* makes a comparison with the much larger Central European specimens difficult. In *E. truncatum* (PHILLIPS 1836), the external lobe is slightly pouched in immature specimens (KORN 1988), but does not possess as sinuous flanks as *E. serotinum*. Additionally, at the same growth stage, *E. truncatum* has a much wider conch than *E. serotinum*.

**Stratigraphical and geographical distribution:** Vale Figueira Member (Late Viséan) of Southwest Portugal. *E. serotinum* is the stratigraphically youngest species of *Eoglyphioceras*.

*Bollandites* BISAT 1952*Bollandites sulcatus* BISAT 1952

Pl.2 Fig.5, Text-fig.26

1952 *Bollandites sulcatus* BISAT: 175, pl.3 fig.4,5,8.1990 *Fayettevillea paprothae* KULLMANN in HORN, KULLMANN & OLIVEIRA: 479, pl.1 fig.7,8 [only].





**Text-fig. 26.** *Bollandites sulcatus* BISAT 1952; suture line of specimen IGML 270, coll. D. KORN & J.T. OLIVEIRA 1993) at dm 10.7mm, ww 6.6mm, wh 4.0mm; x 10; Praia de Murração, bed 100 (*hudsoni* Zone).



**Text-fig. 27.** *Bollandites* (?) sp. 1; suture line of specimen IGML 267, coll. D. KORN & J.T. OLIVEIRA 1993) at ww 7.0mm, wh 3.0mm; x 12; Praia de Murração, bed 100 (*hudsoni* Zone).

**Holotype:** Specimen Nr. 85627 (coll. BISAT), British Geological Survey, Keyworth, Nottingham.

**Type locality and horizon:** Higher Clough (Cowdale Clough), Yorkshire, Great Britain; low in *hudsoni* Zone, Late Viséan.

**Material:** Three haematitic specimens with 13mm diameter from the base of the Vale Figueira Member (*hudsoni* Zone, bed 100) of the Praia de Murração section. One of these (IGML 270) is a completely chambered phragmocone, in which the shell is not preserved. On the internal mould, three irregularly arranged deep constrictions can be seen. They start in a short distance from the umbilical margin, and run prorsiradiately over the flanks to form a ventral projection. Another, similarly preserved small specimen (IGML 179) comes from Rocha da Lagoa.

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 270	12.6	8.1	5.3	4.0	0.64	0.42	0.32

#### Sutural ratios:

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
IGML 270	10.7	6.6	4.0	0.28	1.00	1.00	0.63

**Stratigraphical and geographical distribution:** Late Viséan *hudsoni* Zone of Great Britain (Yorkshire), Germany (Rhenish Massif), and Southwest Portugal, where the species occurs at the base of the Vale Figueira Member.

#### *Bollandites* (?) sp. 1

Text-fig.27

**Material:** One haematized juvenile specimen (IGML 267) of 10mm diameter is available for study from the base of the Vale Figueira Member (*hudsoni* Zone, bed 100) of the Praia de Murração section. It is a completely chambered barrel-shaped, widely umbilicate phragmocone. The internal mould bears one projecting constriction.

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 267	9.3	8.4	3.1	4.2	0.90	0.33	0.45

#### Sutural ratios:

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
IGML 267	7.0	3.0	0.24	0.65	1.02	0.85	

**Remarks:** The small specimen does not allow certain assignment to a genus of the early Late Viséan. It is placed here in *Bollandites* (?) because of its conch geometry.

#### Family Anthracoceratidae PLUMMER & SCOTT 1937

#### *Sudeticeras* PATTEISKY 1930

#### *Sudeticeras murracoense* sp. nov.

Pl.2 Figs.6-8, Text-figs.28,29

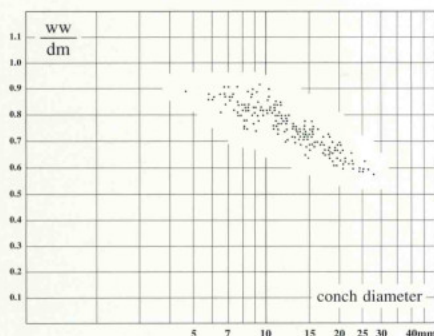
- 1981 *Sudeticeras regina*.- WAGNER-GENTIS: 6, pl.1A,B.  
 1983 *Sudeticeras* sp. OLIVEIRA: 31, textfig. 12.  
 1985 *Sudeticeras* sp. OLIVEIRA, HORN, KULLMANN & PAPROTH: 111-115, textfig. 3,4.  
 1990 *Sudeticeras* sp. HORN, KULLMANN & OLIVEIRA.: 477, textfig. 2.  
 1990 *Sudeticeras* sp. OLIVEIRA: 342, 343, textfig.5.

**Holotype:** Specimen Nr. IGML 250 (coll. D. KORN & K. HORN 1995), Instituto Geológico e Mineiro, Lisboa.

**Type locality and horizon:** Praia das Quebradas; bed 145, Late Viséan (probably equivalent of the *suerlandense* Zone).

**Material:** 311 specimens between 5 and 28mm diameter, mostly from the type locality and the Praia de Murração. Most of them are excellently preserved as pyrite internal moulds, allowing study of conch and suture ontogeny. All specimens are septate, being complete phragmocones. Despite the large number of individuals, only one specimen displays the shell ornamentation, visible within the dorsal whorl zone.

**Species diagnosis:** *Sudeticeras* with pachyconic conch at 20mm dm (ww/dm = 0.70), and thickly discoidal conch (ww/dm about 0.55 - 0.60) in later stages. Umbilicus very narrow (uw/dm = 0.10), umbilical margin rounded. Ornamentation with slightly biconvex, coarse uncrenulated growth lines, lacking spiral lines. Suture line with wide V-shaped ventral lobe (EL/h about 0.85; 1.55 of adventive lobe), and moderate median saddle (0.45 of ventrolateral saddle).



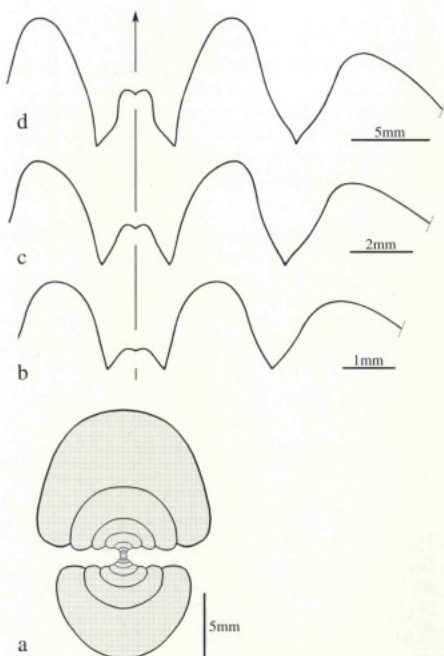
**Text-fig. 28.** *Sudeticeras murracaoense* sp. nov.; Praia das Quebradas, bed 145 (Late Viséan); diagram (with logarithmic scale) showing the ratio between whorl width and conch diameter. Note the wider variability of the juveniles, compared with narrow range of adult conches.

**Conch form:** The cross section (IGML 257) displays the ontogenetic conch development. Up to 5mm diameter, the conch is barrel-shaped with wide umbilicus. During all stages larger than 8mm diameter, the conch shape shows a similar geometry, with a globular form ( $ww/dm = 0.90$ ) at 5mm diameter, a pachyconic form ( $ww/dm = 0.70$ ) at 15mm diameter, and a thickly discoidal form ( $ww/dm = 0.55 - 0.60$ ) at 25mm diameter. In all stages, the venter is broadly rounded, and the conch is widest at the umbilical margin. The relative width of the umbilicus decreases constantly during growth, from more than 0.40 in the initial stage, 0.14 in preadult stages (7mm diameter) to 0.08 in the adult stage (over 20mm diameter). In all growth stages, the umbilical wall is convex and steep.

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
HT IGML 250	27.6	16.1	15.0	2.1	0.58	0.54	0.08
PT IGML 273	12.9	9.0	7.0	1.2	0.70	0.54	0.09
PT IGML 277	7.7	5.8	4.4	1.1	0.75	0.57	0.14
PT IGML 257	18.9	13.0	10.5	1.5	0.69	0.56	0.08
	9.4	8.0	4.9	1.2	0.85	0.52	0.13
	5.3	4.7	2.4	1.4	0.89	0.45	0.26
	3.3	2.8	1.2	1.3	0.85	0.36	0.39
	1.9	1.2	0.5	0.8	0.64	0.28	0.44

**Ornamentation:** Only one specimen (IGML 284) allows study of the shell ornament. This consists at about 7mm whorl width of fine, barely crenulated growth lines, which run almost straight over the flanks and venter, and only possesses a shallow external sinus.



**Text-fig. 29.** *Sudeticeras murracaoense* sp. nov.; Praia das Quebradas, bed 145 (Late Viséan); coll. D. KORN & K. HORN 1995.

- cross section of the paratype IGML 257; x 2.5.
- suture line of the paratype IGML 277; at dm 7.5mm, ww 6.1mm, wh 3.8mm; x 10.
- suture line of the paratype IGML 275; at dm 13.1mm, ww 9.4mm, wh 7.2mm; x 6.
- suture line of the holotype IGML 250; at dm 27.6mm, ww 16.2mm, wh 15.0mm; x 3.

#### Sutural ratios:

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
HT IGML 250	27.6	16.1	15.0	0.43	0.83	0.60	0.52
PT IGML 273	12.9	9.0	7.0	0.41	0.89	0.70	0.56
PT IGML 277	7.7	5.8	4.4	0.24	0.87	0.82	0.59

**Comparisons:** *Sudeticeras murracaoense* is one of the few species of the genus which lacks spiral ornament, and hence easily is separable from most of the species. Other species without spirals are different from *Sudeticeras murracaoense* in the narrower external lobe, such

as *S. laevigatum* RUPRECHT 1937 (vl/ad = 1.25), or in the wider external lobe, such as *S. karagandense* RUZHENCEV & BOGOSLOVSKAYA 1971 (vl/ad = 1.75). *S. varians* BISAT 1950, which closely resembles *S. laevigatum*, is distinguished from *Sudeticeras murracaoense* in the formation of the median saddle that lacks a median lobe. According to the sutural drawings presented by BISAT, the median saddle is lower (MS/h = 0.35 - 0.40) than in *Sudeticeras murracaoense*.

**Stratigraphical and geographical distribution:** Late Viséan (Vale Figueira Member of the Murração Formation) of Southwestern Portugal. The horizon is probably a time equivalent of the Rhenish *suerlandense* Zone (KORN 1996), in which *S. crenistriatum*, a species with similar conch dimensions, occurs. Such an age determination would also correspond to the position in the section.

***Beyrichoceras* FOORD 1903**

***Beyrichoceras* sp. 1**

Text-fig. 30

**Material:** Ten slightly distorted specimens between 9 and 35mm diameter from bed 105 of the Praia das Quebradas section. None of them displays the shell ornament.

**Conch form:** The cross section (IGML 118) allows study of the conch ontogeny. The innermost whorls are evolute, but already at 3mm diameter, the umbilicus becomes narrower and is almost closed in stages larger than 20mm. The ratio whorl width/conch diameter is, between 8 and 20mm diameter, always similar, being about 0.75. In later stages, the conch is more compressed.

**Dimensions in mm and ratios:**

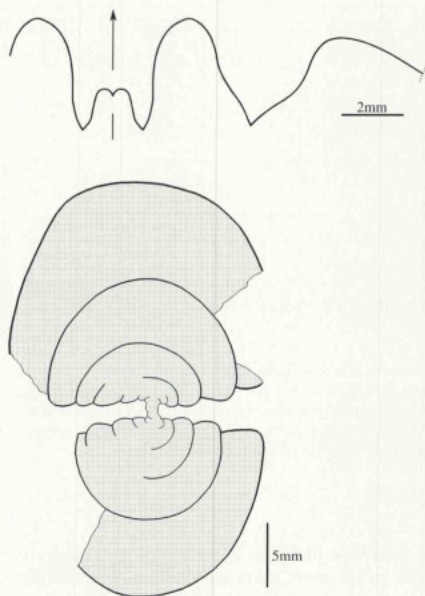
	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 118	34.2	21.5	17.9	2.2	0.63	0.52	0.06
	19.4	14.4	9.9	1.5	0.74	0.51	0.08
	11.7	8.9	5.7	1.0	0.76	0.49	0.09

**Suture line:** The suture line can be examined in specimen IGML 375. It shows, at approximately 12mm diameter, a rather wide parallel-sided external lobe, and a broadly rounded, slightly tectiform ventrolateral saddle.

**Sutural ratios:**

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
IGML 375		9.4	5.7	0.37	0.72	0.61	0.78

**Remarks:** The material is rather poorly preserved, thus assignment to a distinct species is prevented. According to the suture line, it is most probable that the specimens belong in *Beyrichoceras*, but the sutural outline differs in the almost parallel-sided external lobe from other species of the genus.



**Text-fig. 30.** *Beyrichoceras* sp. 1; Praia das Quebradas, bed 105 (Late Viséan); coll. M. HORN et al. 1979.

a. distorted cross section with dislocated internal whorls of specimen IGML 118; x 2.5.

b. suture line of specimen IGML 375; at ww 9.4mm, wh 5.7mm; x 6.

**Superfamily Nomismocerataceae LIBROVITCH 1957**  
**Family Nomismoceratidae LIBROVITCH 1957**

***Nomismoceras* WEDEKIND 1918**

***Nomismoceras vittiger* (PHILLIPS 1836)**

Pl.2 Figs.9-11, Text-fig.31

- 1836 *Goniates vittiger* PHILLIPS: 237, pl.20 fig.59,60.  
 1971 *Nomismoceras vittiger* - RUZHENCEV & BOGOSLOVSKAYA: 163, pl.5 fig.1 [for more synonymy].  
 1985 *Fayettevillea* sp. OLIVEIRA, HORN, KULLMANN & PAPROTH: 114-116, textfig.5.  
 1990 *Fayettevillea paprothae* KULLMANN in HORN, KULLMANN & OLIVEIRA: 479, pl.1 fig.4-6 [only; fig.7,8 are too badly preserved for determination but may belong in *Bollandites*].



**Holotype:** Specimen C273a (coll. GILBERTSON), British Museum (Natural History), London.

**Type locality and horizon:** Bolland (Yorkshire, Great Britain), most probably early Late Viséan.

**Material:** Four specimens from the Rocha da Lagoa section and three from the section at km 11 along the road from Bordeira to Carrapateira. All are limonitic internal moulds, and the largest specimen (IGML 186) has 13mm in diameter.



**Text-fig. 31.** *Nomismoceras vittiger* (PHILLIPS 1836); suture line of specimen GPIT 1676/1661 (coll. K. HORN 1982) at dm 4mm; x 16; Rocha da Lagoa, early Late Viséan [the specimen figured by KULLMANN in HORN et al. (1990) as paratype of *Fayettevillea paprothae*].

**Remarks:** The species *Fayettevillea paprothae* KULLMANN 1990 was erected on the base of juvenile specimens, which do not clearly show the ventrolateral groove. The holotype of this species (GPIT 1676/1658), however, has a maximal diameter of 6.5mm, and shows at this stage a weak indication of an appearing groove. The narrower umbilicate specimens GPIT 1676/1659 and 1788 definitely do not belong to *Nomismoceras vittiger*, but because of their bad preservation cannot be assigned to any other species. They may represent a *Bollandites* species.

**Stratigraphical and geographical distribution:** *Nomismoceras vittiger* is a widely distributed species. It is known from Great Britain (Yorkshire, Devonshire), Belgium, Germany (Rhenish Massif, Harz Mountains), Poland (Lower and Upper Silesia, Holy Cross Mountains), the Czech Republic (North Moravia), Russia (South Urals), Uzbekistan, and South Portugal. It is especially common in the lower part of the Late Viséan, and in South Portugal it occurs in the lower Vale Figueira Member in association with *Goniattites hudsoni* BISAT 1934.

#### *Baschkirites* LIBROVITCH 1957

##### *Baschkirites ornatus* (FOORD & CRICK 1897)

Pl.2 Fig.12

- 1897 *Nomismoceras ornatum* FOORD & CRICK: 218, fig.104.  
1959 *Hudsonoceras ornatum*-. PATTEISKY: 11, pl.1 fig.34-35, pl.6 fig.23 [for more synonymy].

**Holotype:** Specimen Nr. C5279, British Museum (Natural History), London.

**Type locality and horizon:** Halifax (Yorkshire, Great Britain); probably R1c Zone.

**Material:** Two small specimens (IGML 396, 397) from bed 214 of the Praia das Quebradas section. Both are incomplete conchs of about 10mm diameter, showing shell ornament but no suture line. The shell ornament consists of very delicate spiral lines and even finer growth lines which are barely visible. A ventrolateral spiral groove is developed.

**Stratigraphical and geographical distribution:** R1 Zone of Great Britain (Yorkshire, Derbyshire), Ireland, Belgium, Germany (Rhenish Massif), and Southwest Portugal (occurring in the Quebradas Formation).

#### *Baschkirites* sp.

Pl.2 Fig.13

- 1979 *Baschkirites* sp.- OLIVEIRA, HORN & PAPROTH: 160, pl.4 fig.4.

**Material:** Four flattened specimens from three localities: two on a slab from Monte Chã near Saboia (IGML 365), one from Monte da Gorda, and one from 500m north-northeast of Alcaria (IGML 225). The specimens have sizes between 15 and 55mm, and it is not sure that they represent the same species. The umbilicus of all the species is extremely narrow, almost punctiform. During ontogeny, the number of the delicately granulated spirals is increasing: there are about 70 from umbilicus to the venter in the adult specimen from Alcaria (IGML 225; at 48mm diameter), and only 30 in the specimen from Monte Chã (IGML 365; at 28mm diameter). For none of the specimens can an exact stratigraphical age be postulated.

#### Superfamily *Dimorphocerataceae* HYATT 1884

##### Family *Girtyoceratidae* WEDEKIND 1918

#### *Girtyoceras* WEDEKIND 1918

##### *Girtyoceras tomasi* WAGNER-GENTIS 1983

Pl.3 Figs.1-3

- 1983 *Girtyoceras modestum finale*-. WAGNER-GENTIS in OLIVEIRA & WAGNER-GENTIS: 29, pl.8 fig.2-7.  
1983 *Girtyoceras tomasi* WAGNER-GENTIS in OLIVEIRA & WAGNER-GENTIS: 31, pl.8 fig.8,9.

**Holotype:** Specimen Nr. IGML 385 (coll. J.T. OLIVEIRA), Instituto Geológico e Mineiro, Lisboa.

**Type locality and horizon:** Near Ponte de Tabua, 1.6km southwest of Almada de Ouro; basal Mira Formation (probably Late Viséan).

**Material:** Five natural moulds, mostly fragments, of which latex casts have been manufactured, of specimens between 8 and 30mm diameter. They show the conch form and, only barely, the shell ornament.

**Species diagnosis:** *Girtyoceras* with pachyconic conch at 8mm dm (ww/dm about 0.66), and moderately wide umbilicus (uw/dm = 0.38); conch thickly discoidal at 16mm dm (ww/dm = 0.55), umbilicus narrow (uw/dm = 0.20). Umbilical margin at 12mm dm with a weak rim, at 16mm dm rounded, venter in this stage rounded tectiform with weak median keel. Ornamentation with biconvex, fine growth lines. Ribs are lacking.

**Conch form:** Between 8 and 16mm diameter, the umbilicus opens only insignificantly, hence the ratio uw/dm decreases. At 12mm diameter (IGML 386), there is a weak umbilical rim developed, which already has disappeared at 16mm diameter. Here, the umbilical margin is rounded, and the venter is slightly tectiform with a smooth keel.

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
HT IGML 385	16.2	c.9	8.8	3.4	c.0.55	0.54	0.21
IGML 387	8.1	c.5.5	3.4	3.1	c.0.65	0.42	0.38

**Ornamentation:** Specimen IGML 387 displays at 8mm diameter four irregularly arranged constrictions of the internal mould, which slightly project forward on the flanks. At 13mm diameter (specimen IGML 386) has very fine constrictions, and the holotype lacks them completely. Here, at 16mm diameter, only biconvex growth lines are preserved.

**Suture line:** The fragmental suture line has already been figured by WAGNER-GENTIS in OLIVEIRA & WAGNER-GENTIS (1983, p.30); it has the outline of girtyocerids without peculiarities.

**Remarks:** The differences provided by WAGNER-GENTIS in OLIVEIRA & WAGNER-GENTIS (1983) do not justify the separation of two sympatric species. Differences in whorl expansion rate and in umbilical width are due to different growth stages.

**Comparisons:** The lack of ribs in the juvenile stage, and the rather early transformation of the rounded to a carinate venter is the most important feature for comparisons with other species. The most similar species appears to be *Gt. margaritatum* KORN 1988, but this species has a narrower umbilicus (0.14 at 16mm dm, compared with 0.20 in *Gt. tomasi*), and a venter occupied by a slightly serrated keel. Narrower umbilicate is also *Gt. goii* KORN 1988, and *Gt. edwinae* KORN 1988 has a wider conch. The subspecies unified in *Gt. modestum* RUZHENCEV & BOGOSLOVSKAYA 1971 possess a stronger umbilical rim.

**Stratigraphical and geographical distribution:** Basal Mira Formation (probably Late Viséan C) of South Portugal.

## *Girtyoceras luscina* KORN 1988

Pl.3 Figs.5, 6

1988 *Girtyoceras luscina* KORN: 52, pl.7 figs.5-8 (only).

**Holotype:** Specimen Nr. 10028 (coll. RADEMACHER), Westfälisches Museum für Naturkunde, Münster.

**Type locality and horizon:** Limestone quarry directly North of Deinstrop (Rhenish Massif, Germany); *gracilis* Zone.

**Material:** Eight limonitic specimens from the Vale Figueira Member (bed 144, *spirale* Zone) of the Praia de Murração section. They are internal moulds and range from 8 to 26mm diameter. The shell ornament is not preserved in the material, but the conch shape and sculpture allow determination of the specimens.

**Species diagnosis:** *Girtyoceras* with pachyconic conch at 8mm dm (ww/dm about 0.60), and moderately wide umbilicus (uw/dm = 0.35); conch thickly discoidal at 16mm dm (ww/dm = 0.45), umbilicus narrow (uw/dm = 0.25). Umbilical margin at 12mm dm with a weak rim, at 16mm dm rounded, venter in this stage broadly rounded. Venter becoming oxyconic at 24mm diameter. Ornamentation with biconvex, fine growth lines, at 10mm diameter with faint umbilical nodes.

**Conch form:** All the specimens have a similar conch form, with an angular umbilical margin at 10mm diameter, becoming rounded in later growth stages. The largest individuals (IGML 391, 263) indicate that at 24mm diameter the conch becomes oxyconic [In this respect, the original diagnosis given by KORN (1988) must be revised].

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 391	18.2		9.6	4.3		0.52	0.24
IGML 263	15.7	6.8	7.4	4.1	0.43	0.47	0.26
IGML 260	13.4	5.9	6.6	2.7	0.44	0.49	0.20

**Ornamentation:** The inner whorls of specimen IGML 260 display faint umbilical nodes, which are arranged between the slightly projected constrictions. At 12mm diameter, the constrictions run in a biconvex course, and possess a prominent ventrolateral salient. Later in ontogeny, the constrictions become quite frequent, specimen IGML 391 displays, at 20mm diameter, more than ten constrictions within one volution. They are deepest on the midflanks, and disappear towards the venter.

**Suture line:** A complete suture line could not be prepared in the material, but fragments show that there occur no peculiarities in the *Girtyoceras*-type suture.

**Comparisons:** *Girtyoceras brueningianum* (SCHMIDT 1925) is the most similar species, but has a narrower conch (ww/dm = 0.37 at 16mm diameter in comparison with 0.43 in *Gt. luscina*). Furthermore, the umbilicus is wider in *Gt. luscina* (uw/dm = 0.26; 0.18 in *Gt. brueningianum*).



Stratigraphically younger species, such as *Gt. margaritatum* KORN 1988, *Gt. goii* KORN 1988, and *Gt. tomasi* WAGNER-GENTIS 1983 are narrower umbilicate, and usually earlier in ontogeny develop an acute venter. In these species, the umbilical shoulder is more pronounced than in *Gt. luscini*, and sometimes possessing a rim.

**Stratigraphical and geographical distribution:** Late Viséan of Germany (Rhenish Massif; *gracilis* Zone), and South Portugal (Vale Figueira Member of the Murração Formation; *spirale* Zone).

### *Girtyoceras* sp. 1

Pl.3 Fig.4, Text-fig.32

**Material:** Two specimens from the base of the Vale Figueira Member (bed 100, *hudsoni* Zone) of the Praia de Murração section. They have diameters of 6 resp. 13mm, and are preserved as limonitic internal moulds. The smaller of the two (IGML 278) displays the typical calyx stage of the genus with a strict umbilical margin that is armed by numerous weak nodes.

The larger one (IGML 269) shows at 12mm diameter a lenticular conch with a narrow umbilicus that is bound by an angular margin. The internal mould bears four constrictions 90° apart, which project on the flanks and form a ventrolateral salient and a very shallow external sinus.

### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 269	11.8	5.9	5.0	3.6	0.50	0.42	0.31
IGML 278	5.9	4.0	1.3	3.7	0.68	0.22	0.63

### Sutural ratios:

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
IGML 269	11.6	5.9	4.8	0.28	1.04	0.89	0.80

**Remarks:** The material is too incomplete for specific determination. Species with a similar stratigraphical age are *Girtyoceras deani* MOORE 1946, *Gt. simplex* MOORE 1946, *Gt. premeslerianum* MOORE 1946, *Gt. moorei* NICOLAUS 1963, and *Gt. ibergense* KORN 1993. Most of these species are based on relatively large specimens, and thus difficult to compare with the Portuguese material.



**Text-fig. 32.** *Girtyoceras* sp. 1; suture line of specimen IGML 269, coll. D. KORN & J.T. OLIVEIRA 1993) at dm 11.6mm, ww 6.1mm, wh 4.5mm; x 10; Praia de Murração, bed 100 (*hudsoni* Zone).

## *Sulcogirtyoceras* RUZHENCEV 1960

### *Sulcogirtyoceras* sp.

Pl.3 Fig.7-9

1985 *Sulcogirtyoceras* sp. OLIVEIRA, HORN, KULLMANN & PAPROTH: 112, textfig.3.

**Material:** Three specimens between 3 and 25mm diameter from the Vale Figueira Member (beds 154 and 155) of the Praia de Murração, and one fragment from bed 141 of the Quebradas section. All are three-dimensionally preserved but somewhat distorted; the two specimens from bed 155 partly consist of limonite. Only the general conch form can be examined in the specimens, neither suture line nor ornament details can be studied. The assignment of the specimens to the genus *Sulcogirtyoceras* rather than to the similar *Edmooroceras* is supported by the conch form of the juvenile individual, which displays the typical calyx-shaped form only known from *Girtyoceras* and *Sulcogirtyoceras*. The larger specimens of 20 and 25mm diameter (IGML 222, 244) show an angular umbilical margin and a ventrolateral groove.

## *Eumorphoceras* Girty 1909

### *Eumorphoceras* sp.

Pl.3 Fig.10

**Material:** One crushed and poorly preserved specimen of 13mm diameter (IGML 395), collected from the Quebradas Formation east of Aljezur. It shows 25 broad ribs on the last volution, and a single longitudinal ventrolateral groove. Species assignment of this specimen is impossible.

## Family Dimorphoceratidae HYATT 1884

Subfamily *Glyphiolobinae* RUZHENCEV & BOGOSLOVSKAYA 1969

### *Glyphiolobus* GORDON 1965

### *Glyphiolobus aestivalis* sp. nov.

Pl.3 Fig.11, Text-fig.33

**Holotype:** Specimen Nr. IGML 89 (coll. D. KORN & K. HORN 1995), Instituto Geológico e Mineiro, Lisboa.

**Type locality and horizon:** Praia das Quebradas; bed 223, R2c1 Zone.

**Material:** 6 specimens from bed 225 and 12 specimens from bed 223, ranging between 3.5 and 14mm diameter. All are three-



dimensionally preserved and derive from bituminous limestone lenses.

**Species diagnosis:** *Glyphiolobus* with thickly discoidal conch ( $ww/dm = 0.52$ ). Suture line with V-shaped ventral lobe; denticulation of adventive lobe. Ventral lobe not pointed.

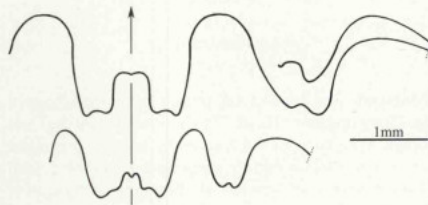
**Conch form:** The conch is widest at the umbilicus and has the typical shape of the genus, with a completely closed umbilicus.

**Dimensions in mm and ratios:**

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
PT IGML 90	9.9	5.3	5.9	0	0.53	0.60	0.00
HT IGML 89	8.3	4.3	5.2	0	0.52	0.63	0.00
PT IGML 70	5.0	2.6	3.0	0	0.52	0.60	0.00

**Ornamentation:** As in most of the dimorphoceratids, the ornament consists of fine growth lines with prominent and equally high lateral projections.

**Suture line:** The two examined suture lines (specimens IGML 89, 69) are similar in their specific feature of rounded adventive and external lobes, but differ considerably in the shape of the ventrolateral saddle, which is wider in the larger specimen, and the size of the median saddle, which is very small in the more juvenile individual.



**Text-fig. 33.** Suture lines of *Glyphiolobus aestivalis* sp. nov.; Praia das Quebradas, bed 223 (probably R2c1 Zone); coll. D. KORN & K. HORN 1995.

a. paratype IGML 69; at dm 3.7mm, ww 2.1mm, wh 2.3mm; x 15.

b. holotype IGML 89; at wh 3.8mm; x 15.

**Comparisons:** Almost all of the species of *Glyphiolobus* display pointed lobes even at smaller diameters. This is especially true for the stratigraphically younger species, such as *Gl. reliquus* RUZHENCEV & BOGOSLOVSKAYA 1978 and *Gl. meridionalis* NIKOLAEVA 1994, which are of a similar stratigraphical age.

**Stratigraphical and geographical distribution:** Upper part of the Quebradas Formation (R2c1 Zone) of Southwest Portugal.

***Glyphiolobus* sp. 1**

**Material:** Three pyritized specimens (IGML 382) from the Vale Figueira Member, bed 145 (Late Viséan, accompanied with *Sudeticerus murracaeense* sp. nov.), of the Praia das Quebradas section. The largest one of these is a thickly lenticular phragmocone with a diameter of 8.5mm, displaying the suture line that is characterized by rounded secondary lobes. Another smaller specimen (IGML 383) is preserved with a completely smooth body chamber.

**Dimensions in mm and ratios:**

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 382	8.5	5.0	5.1	0.5	0.59	0.60	0.06
IGML 383	6.4	4.4	3.8	0.4	0.68	0.59	0.06

***Metadimorphoceras* MOORE 1958**

***Metadimorphoceras pix* sp. nov.**

Pl.3 Figs.13, 14, Text-fig.34

**Holotype:** Specimen Nr. IGML 95 (coll. D. KORN et al. 1994), Instituto Geológico e Mineiro, Lisboa.

**Type locality and horizon:** Praia das Quebradas; bed 200, most probably R1a Zone.

**Material:** 7 three-dimensionally preserved specimens ranging from 4 to 18mm in diameter from small bituminous carbonate lenses. They are well preserved with the shell, and suture lines could be prepared in some of the individuals.

**Species diagnosis:** *Metadimorphoceras* with thickly discoidal conch ( $ww/dm = 0.45$ ). Suture line with subsidiary saddles within the prongs of the ventral lobe and adventive lobe; tertiary denticulation of adventive lobe and ventral lobe.

**Conch form:** In all growth stages, the lenticular conch is widest at the closed umbilicus, and has a rounded venter.

**Dimensions in mm and ratios:**

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
HT IGML 95	14.8	6.7	8.4	0.0	0.45	0.57	0.00
PT IGML 96	10.4	4.4	6.0	0.0	0.42	0.58	0.00
PT IGML 97	8.6	4.1	5.2	0.0	0.48	0.60	0.00



**Text-fig. 34.** *Metadimorphoceras pix* sp. nov.; suture line of the holotype IGML 95 (coll. D. KORN & K. HORN 1995) at ww 3.0mm, wh 6.6mm; x 10; Praia das Quebradas, bed 200 (most probably R1a Zone).

**Ornamentation:** The shell ornament is very weak, and typical for dimorphoceratids with strongly biconvex growth lines. No spiral lines are present.

**Suture line:** It is notable that the ventral lobe is asymmetric, displaying a subdivided E1 lobe on one side and an unsubdivided one on the other side.

**Comparisons:** In accordance with its high stratigraphical level, *Metadimorphoceras pix* displays a rather complex suture line, which in outline is also known from other species of the same age. Other Namurian species of this genus may show a very similar suture, but differ in their conch geometries, which are usually much wider: *M. splendidum* (BROWN 1841), *M. orientale* (RUZHENCEV & BOGOSLOVSKAYA 1971), *M. saundersi* (MANGER & QUINN 1972), and *M. subdivisum* (MANGER & QUINN 1972) have conchs with the ratio  $ww/dm = 0.60$  to  $0.65$ , compared with  $0.45$  in *M. pix*. *M. kenyoni* (BROWN 1841) and *M. ribblesse* (MOORE 1936) possess an ornament with faint spiral lines and are thus distinguished from *M. pix*.

**Stratigraphical and geographical distribution:** Quebradas Formation, most probably R1a Zone, of Southwest Portugal.

*Metadimorphoceras* sp. 1

Pl.3 Fig.12, Text-fig.35

**Material:** One fragmentary, completely chambered specimen of 20mm diameter from the Praia de Murração. It was collected in loose debris of the Vale Figueira Member (Late Viséan), hence an exact stratigraphical determination is prevented. The conch is thickly lenticular ( $ww/dm$  approximately  $0.5$ ) with broadly rounded venter and closed umbilicus. Ornament is not preserved, but the suture line can be studied. It shows subdivided E1 and E2 lobes, and a denticulated adventive lobe.

On the basis of the singular specimen, no distinct species determination can be achieved. The conch form and the degree of denticulation of the lobes show close affinities with *Metadimorphoceras varians* (MOORE 1939), but more material is required to confirm such a determination.



**Text-fig. 35.** *Metadimorphoceras* sp. 1; suture line of specimen IGML 350 (coll. D. KORN et al. 1994) at  $ww$  9.4mm,  $wh$  9.6mm;  $x$  15; Praia de Murração, horizon unrecorded.

*Anthracoceratites* RAMSBOTTOM 1970

*Anthracoceratites lacerus* sp. nov.

Pl.3 Fig.15, Text-fig.36

**Holotype:** Specimen Nr. IGML 34 (coll. D. KORN & K. HORN 1995), Instituto Geológico e Mineiro, Lisboa.

**Type locality and horizon:** Praia das Quebradas; bed 214, R1c Zone.

**Material:** 35 three-dimensionally preserved specimens of 2 to 15mm diameter, from bituminous limestone extraclasts.

**Species diagnosis:** *Anthracoceratites* with thickly discoidal conch ( $ww/dm = 0.35 - 0.40$ ). Suture line with slightly denticulated prongs of the ventral lobe, moderately wide ventrolateral saddle, and broadly rounded adventive lobe.

**Conch form:** All the growth stages larger than 4mm diameter are involute. The conch has always a similar form, but becomes more depressed in adult specimens.

**Dimensions in mm and ratios**

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
HT IGML 34	11.4	4.3	6.8	0	0.38	0.60	0.00

**Ornamentation:** The shell is smooth except for fine, strongly biconvex growth lines. They run with two equally prominent lateral projections over the flanks and show an extremely deep ventral sinus (specimen IGML 35). The internal mould is slightly undulating caused by faint internal strengthenings of growth lines, and shows a few spiral lines in the area of the ventrolateral projection.



**Text-fig. 36.** *Anthracoceratites lacerus* sp. nov.; suture line of the holotype (IGML 34, coll. D. KORN et al. 1994) at  $dm$  14mm,  $wh$  3.3mm,  $wh$  3.8mm;  $x$  15; Praia das Quebradas, bed 214 (R1c Zone).

**Suture line:** The figured suture line can be regarded as adult, because the last septa in this individual are already crowded, when the maximal diameter of this specimen was about 14mm. Characteristic for the suture line is the broadly rounded adventive lobe, and the delicately denticulated ventral lobe.

**Comparisons:** Some of the species assigned to *Anthracoceratites* are known from poorly preserved material, like *A. vanderbeckei* (LUDWIG 1863) and *A. augustevictoriae*

(PATTEISKY 1965), and hence difficult to compare. *A. deansi* RAMSBOTTOM 1970 has a similar conch, but possesses a denticulate adventive lobe, which is rounded in *A. lacerus*. *A. arcuatilobus* (LUDWIG 1863) has rounded prongs of the external lobe, and a narrower ventrolateral saddle.

**Stratigraphical and geographical distribution:** Quebradas Formation (upper *Reticuloceras*-Stufe, R1c) of Southwest Portugal.

*Anthracoceratites arcuatilobus* (LUDWIG 1863)

Text-fig. 37

1863 *Goniatis arcuatilobus* LUDWIG: 285, pl. 48 fig. 3.

1959 *Anthracoceras arcuatilobum* PATTEISKY: 38, pl. 9 fig. 40, 41.

**Material:** Five specimens from bed 238 (probably G1 Zone) of the Praia das Quebradas section. They are preserved in bituminous limestone lenses, and only one (IGML 341) allows examination of the ornament and the suture line.

**Species diagnosis:** *Anthracoceratites* with thickly discoidal conch ( $ww/dm = 0.40$ ). Suture line with rounded prongs of the ventral lobe, narrow ventrolateral saddle, and broadly rounded adventive lobe.

**Conch form:** The conch shape is lenticular and widest near the closed umbilicus. In all the respects, it is typical for dimorphoceratids.

**Dimensions in mm and ratios:**

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 341	12.0	4.8	7.3	0	0.40	0.61	0.00

**Ornamentation:** IGML 341 possesses strongly biconvex growth lines, which are periodically strengthened to form weak riblets. Both lateral projections are of equal height, and the ventral sinus is deep. Very faint spiral lines can be seen on the outer flanks.

**Suture line:** The suture line (IGML 341) is characterized by rounded lobes without indication of denticulation, and the asymmetric and rather narrow ventrolateral saddle.



**Text-fig. 37.** *Anthracoceratites arcuatilobus* (LUDWIG 1863); suture line of specimen IGML 341 (coll. M. HORN et al. 1981) at  $ww$  3.9mm,  $wh$  4.0mm; x 10; Praia das Quebradas, bed 238 (probably G1 Zone).

**Comparisons:** The stratigraphically older species *Anthracoceratites lacerus* sp. nov. possesses a slightly denticulated external lobe, even at smaller diameter, in contrast to *A. arcuatilobus* with rounded external lobe. Also, the ventrolateral saddle is wider and more symmetric in *A. lacerus*. *A. deansi* RAMSBOTTOM 1970 has a denticulate adventive lobe and is thus easily distinguishable.

**Stratigraphical and geographical distribution:** Late Namurian R2c and G1 Zones of Germany (Rhenish Massif), Belgium, the Netherlands, and Southwestern Portugal (Quebradas Formation, G1 Zone).

Superfamily *Goniatitaceae* DE HAAN 1825

Family *Goniatitidae* DE HAAN 1825

*Goniatites* DE HAAN 1825

*Goniatites hudsoni* BISAT 1934

Pl. 4 Figs. 1-5; Text-fig. 38

1934 *Goniatites hudsoni* BISAT: 303, pl. 17 fig. 1,2.

1983 *Goniatites hudsoni* WAGNER-GENTIS in OLIVEIRA & WAGNER-GENTIS: 33 [pt.], pl. 9 fig. 1,2,4 [non pl. 9 fig. 3 = *Goniatites* (?) *globostriatus* SCHMIDT 1925].

1988 *Goniatites hudsoni* KORN: 89, pl. 19 fig. 1.

1990 *Goniatites hudsoni* KORN: 29, pl. 5 fig. 1-10, pl. 6 fig. 1-11, pl. 7 fig. 1-6.

**Holotype:** Specimen Nr. 53530 (coll. HUDSON), British Geological Survey, Keyworth, Nottingham.

**Type locality and horizon:** Swinden quarry, Grassington (Yorkshire, Great Britain); B2 Zone of the Late Viséan.

**Material:** A total of 43 specimens, of which 34 are haematitic internal moulds collected from the Praia de Murração (rarely from bed 95, and frequently from bed 100 - IGML 247, 268, 294). These specimens are seldom well preserved, mostly being encrusted by pressure shadow crystallisation or corroded, and hence lacking shell ornament. Some of the specimens, however, display full phragmocone details, allowing the specimens to be sufficiently determined.

Another group of specimens (8) derives from near the main shaft of the Neves Corvo Mine south of Castro Verde (IGML 336, 389). These individuals derive from marly shales, in which the specimens are preserved as porous phragmocones, which are slightly distorted because of cleavage of the shales. In the natural moulds of these specimens, ornament details are preserved. Additionally, one septate specimen from Mértola (IGML 304) is available for study.

**Species diagnosis:** *Goniatites* with globular to spindle-shaped conch at 10mm diameter ( $ww/dm = 0.90 - 1.25$ ), pachyconic to globular conch ( $ww/dm = 0.70 - 0.90$ ) at 30mm diameter, and pachyconic conch ( $ww/dm = 0.70 - 0.80$ ) at 50mm diameter. Umbilicus very narrow in all stages ( $uw/dm = 0.05 - 0.12$ ).



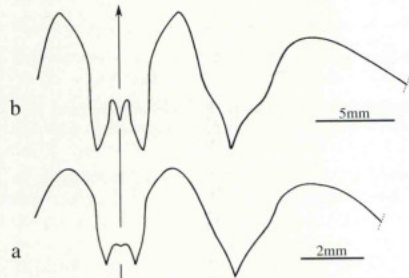
Ornamentation with crenulated biconvex and rectiradiate growth-lines with distinct dorsolateral projection. Dorsolateral and ventrolateral projection with the same height, external sinus moderately deep. Suture line with moderately narrow ventral lobe ( $EL/h = 0.40 - 0.50$ ), and moderate median saddle (less than 0.40 of ventrolateral saddle).

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 247	23.3	18.2	12.2	2.1	0.78	0.52	0.09
IGML 272	22.6	21.5	11.6	1.8	0.95	0.51	0.08
IGML 268	19.0	16.3	9.4	2.0	0.86	0.50	0.11
IGML 294	9.3	11.8	4.2		1.27	0.45	

#### Sutural ratios:

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
IGML 247	23.3	18.2	12.2	0.38	0.42	0.38	0.48
IGML 304	20.6	18.0		0.37	0.40	0.39	0.51
IGML 268	19.0	16.3	9.4	0.37	0.48	0.43	0.49
IGML 294	9.3	11.8	4.2	0.22	0.48	0.63	0.64



**Text-fig. 38.** Suture lines of *Goniatites hudsoni* BISAT 1934; Praia de Murração, bed 100 (*hudsoni* Zone).

- a. specimen IGML 294 (coll. D. KORN & K. HORN 1995) at dm 9.3mm, ww 11.8mm, wh 4.2mm; x 6.  
b. specimen IGML 257 (coll. D. KORN & K. HORN 1995) at dm 23.3mm, ww 18.2mm, wh 12.2mm; x 3.

**Remarks:** As with the populations known from North England and the Rhenish Massif, the Portuguese material shows the same variability regarding the ratio between conch diameter and whorl width. An extreme specimen is IGML 294 which has a spindle-shaped conch, much wider than any other specimen known so far. A character not influenced by variation is the umbilical width, always being about one tenth of the diameter.

**Stratigraphical and geographical distribution:** Basis of the Late Viséan of Great Britain (Lancashire, Yorkshire, Isle of Man), Germany (Rhenish Massif), Czech Republic (North Moravia), Poland (Holy Cross Mountains), and South Portugal (base of the Vale Figueira Member of the Murração Formation).

#### *Goniatites crenistria* PHILLIPS 1836

Pl.4 Fig.6

- 1836 *Goniatites crenistria* PHILLIPS: 234, pl.19 fig.7-9.  
1988 *Goniatites crenistria*- KORN: 83, pl.17 fig.1-4, pl.18 fig.1-11 [for more synonymy].

**Holotype:** Specimen Nr. c282, British Museum (Natural History), London.

**Type locality and horizon:** Bolland (Yorkshire, Great Britain); „Mountain Limestone“ (= Late Viséan).

**Material:** One specimen from the Mértola Formation, collected 500m east of Bens near Mértola (IGML 302), shows the typical involute conch form of the species and displays crenulated growth lines which generally have a convex course. They form barely visible lateral projections and a broad and deep ventral sinus.

**Stratigraphical and geographical distribution:** *Goniatites crenistria* is widely reported, but many occurrences require confirmation. The species is known from Great Britain (Yorkshire, Derbyshire, Staffordshire, Isle of Man, Cumberland, Westmoreland, Devonshire), Belgium, Germany (Rhenish Massif, Harz Mountains), Poland (Lower Silesia, Holy Cross Mountains, Lublin Coal Basin), the Czech Republic (North Moravia), and South Portugal, where it could be collected from the Mértola Formation.

#### *Goniatites fimbriatus* (FOORD & CRICK 1897)

Pl.4 Fig.7, 8

- 1988 *Glyptoceras fimbriatum* FOORD & CRICK: 165, fig.77.  
1988 *Goniatites fimbriatus*- KORN: 89, pl.20 fig.1-7, pl.21 fig.1-6, pl.22 fig.1-4 [for more synonymy].  
1990 *Goniatites crenistria*- KORN: 29, pl.4 fig.12,13.  
1990 *Goniatites fimbriatus*- KORN: 32, pl.8 fig.1-12, pl.9 fig.1-11, pl.10 fig.1-5.

**Holotype:** Specimen Nr. c284a (coll. GILBERTSON), British Museum (Natural History), London.

**Type locality and horizon:** Locality not recorded, probably Yorkshire, Great Britain; Late Viséan.

**Material:** Two three-dimensionally preserved specimens from calcareous nodules within the Mértola Formation of an exposure 500m east of Bens near Mértola (IGML 300, 301). They range in their size from 25 to 55mm, and all the necessary features are preserved for determination. This is especially the slightly rursiradiate course of the biconvex growth lines which, due to their strong crenulation, develop a faint spiral ornamentation. Also, the width of the umbilicus is typical for *G. fimbriatus*.

8 fragments derive from bed 111 of the Praia das Quebradas section. Assignment of the specimens to this species is based on the ornament with strongly crenulated

growth lines which run in rursiradiate direction with a low ventrolateral projection (IGML 337).

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 300	51	c.35	23	8.7	c.0.69	0.45	0.17

**Stratigraphical and geographical distribution:** *Goniates fimbriatus* is the guide fossil for the *fimbriatus* Zone in the Rhenish Massif (KORN 1996). It is known from Great Britain (Yorkshire, Lancashire), Ireland (Co. Leitrim), Belgium, Germany (Rhenish Massif, Harz Mountains), Czech Republic (North Moravia), and Poland (Lower Silesia, Holy Cross Mountains). The specimens from South Portugal derive from the Mértola Formation.

#### *Goniates spirifer* ROEMER 1850

Pl.4 Fig.10, 11

- 1850 *Goniates spirifer* ROEMER: 51, pl.8 fig.16.  
 1957 *Goniates striatus* DELÉPINE 1957: 297-299 [pt.?  
 1988 *Goniates spirifer* KORN: 93, pl.23 fig.3, 4 [for more synonymy].  
 1990 *Goniates spirifer* KORN: 33, pl.11 fig.1-10, pl.12 fig.9-11.  
 1992 *Goniates spirifer* GISCHELER & KORN: 285, text-fig.7A.

**Holotype:** Specimen 389 (coll. ROEMER), Institut und Museum für Geologie und Paläontologie, Clausthal.

**Type locality and horizon:** Lautenthal (Harz Mountains, Germany); Late Viséan.

**Material:** 25 partly crushed specimens derive from bed 111 and 113 of the Praia das Quebradas section. The best specimen (IGML 126) of these is a fragment of a slightly deformed conch of approximately 50mm diameter. From the very narrow umbilicus to the midventer, about 95 spiral lines are developed. They are spaced at varying distances and form a spider-web like pattern around the umbilicus. At the junctions with the growth lines, the spiral lines are strongly granulated. The growth lines are much finer than the spirals and run rectiradiately in a slightly biconvex course with equal lateral projections. No constrictions are visible. Further, similarly preserved specimens derive from Monte do Engenho (2 specimens).

**Comparisons:** Separation from the similar species *Goniates* (?) *globostratus* (SCHMIDT 1925) is extremely difficult in crushed material. A useful feature is the strength of the spiral lines: In *G. spirifer*, the spirals are as wide as the spaces in between them, whereas in *G. (?) globostratus* they are much finer. Apart from this, the granulation of the spiral lines is much stronger in *G. spirifer*.

**Stratigraphical and geographical distribution:** *Goniates spirifer* is characteristic for the *spirifer* Zone, where it cooccurs with *G. fimbriatus* and (in some places) *Para-*

*glyphioceras radiatum* (HODSON & MOORE 1959). It is known from Germany (Harz Mountains, Rhenish Massif), Great Britain (Yorkshire, Derbyshire, Devonshire), Ireland (Co. Leitrim), the Czech Republic (North Moravia), Poland (Lower Silesia, Holy Cross Mountains), Belgium, and Southwest Portugal, where the species occurs in the lower part of the Vale Figueira Member.

#### *Goniates* (?) *globostratus* (SCHMIDT 1925)

Pl.4 Fig.9

- 1925 *Glyphioceras crenistria* var. *globostrata* SCHMIDT: 566, pl.23 fig.13.  
 1934 *Goniates maximus* BISAT: 298, pl.20 fig.1, pl.21 fig.2,3, pl.22 fig.1-6.  
 1983 *Goniates hudsoni* WAGNER-GENTIS in OLIVEIRA & WAGNER-GENTIS: 33 [pt.], pl.9 fig.3 [only].  
 1988 *Goniates* (?) *globostratus* KORN: 94, pl.19 fig.2-5, pl.59 fig.1-4 [for more synonymy].  
 1990 *Goniates* (?) *globostratus* KORN: 34, pl.10 fig.6-9.

**Holotype:** Specimen 480-47 (coll. SCHMIDT), Institut und Museum für Geologie und Paläontologie, Göttingen.

**Type locality and horizon:** Oese near Menden (Rhenish Massif, Germany); „*crenistria* Zone“ (most probably *globostratus* Zone in new terminology).

**Material:** 3 crushed specimens were collected in the vicinity of the Neves-Corvo Mine, near the main shaft (IGML 334, 335). IGML 334 is an impression of a specimen with about 50mm diameter in the shale, that excellently displays the shell ornament consisting of delicate spiral lines and very delicate biconvex growth lines.

**Stratigraphical and geographical distribution:** *Goniates* (?) *globostratus* is the guide fossil for the *globostratus* Zone in the Rhenish Massif (KORN 1995), resp. the B2b Zone of North England (RILEY 1990). The specimens from South Portugal derive from the lower part of the Vale Figueira Member of the Murração Formation.

#### *Paraglyphioceras* BRÜNING 1923

##### *Paraglyphioceras myrtilense* (FIEO 1946)

Pl.5 Fig.1; Text-fig.39

- 1946 *Glyphioceras myrtilense* FIEO: 112, pl.2 fig.6,7.

**Lectotype:** The specimen figured by FIEO (1946) in text-fig.3/1 [the original material could not be traced in the collections].

**Type locality and horizon:** Mértola, quarry at the Barranco do Covo bridge; limestone nodule within *Posidonia* Shales (Mértola Formation).

**Material:** The type material could not be traced, and well preserved topotypes could not be collected. During a visit of the abandoned quarry, only extremely weathered nod-



ules of porous material were secured, which contain poorly preserved goniatite fragments. The largest of these (IGML 333) is from a goniatite of about 80mm diameter, in which ornament details can be seen on the last and the previous whorl. The umbilical area is not preserved, but the volution before the last (corresponding to about 50mm conch diameter) shows delicate spiral lines over flanks (were they are weaker) and venter. It can be estimated that there were approximately 200 spirals on flanks and venter. The growth lines are a little finer than the spirals, and run backwards over the flanks. On the last volution, spirals are restricted to the venter, whereas the flanks only bear widely spaced growth lines. There are obviously no constrictions.

Another specimen (IGML 297) from Posto Fiscal de Vascão, 5km southeast of Pomarão, adds information of the adult conch. It is a deformed, but rather well preserved specimen displaying the shell ornament at 70mm diameter. This consists of fine widely spaced and biconvex growth lines and spiral lines around the umbilicus and on the venter. The growth lines run in a slightly rursiradate direction and form lateral projections of equal height.

One individual from Montes Alves (IGML 308) is a slightly deformed septate specimen of about 16mm diameter, but displays the shell ornament on an impression of a later volution. Shell ornament is as in specimen IGML 333 with very dense, strongly crenulated growth lines.

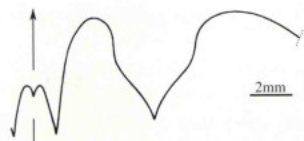
**Species diagnosis:** *Paraglyphioceras* with pachyconic conch diameter (ww/dm = 0.70 at 10mm, and 0.60 at 30mm diameter). Umbilicus very narrow (uw/dm = 0.10 at 10mm diameter, and 0.06 at 30mm diameter); umbilical margin rounded. Ornamentation with 200 spiral lines on flanks and venter as well as fine and crenulated growth lines with biconvex and rursiradate course. Adult stage over 50mm diameter with weakening of spiral lines on the flanks. Suture line with moderate external lobe (EL/h about 0.50), the median saddle attains less than half the height of ventrolateral saddle.

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 297	72		38	8		0.53	0.11
Feio's type	39	23	22	2.5	0.59	0.56	0.06
	19.3	12.7	10.3	1.3	0.66	0.53	0.07
	10.7	7.7	5.8	0.9	0.72	0.54	0.08
	5.9	4.5	2.9	1.2	0.76	0.49	0.20

**Suture line:** FEIO's (1946) figures give an impression of the suture line in this species. They show a probably not very accurately drawn suture with a well rounded ventrolateral saddle, a moderate ventral lobe (110% of adventive lobe), and a moderately high median saddle (35-40% of ventrolateral saddle).

In specimen IGML 308, the suture line is distorted but displays the main characteristics. These are the narrow ventral lobe in this growth stage, and the rounded



**Text-fig. 39.** *Paraglyphioceras myrtilense* (FEIO 1946); suture line of specimen IGML 308 (coll. J.T. OLIVEIRA) at ww 12mm, wh approximately 8mm; x 4; Montes Alves 10km east of Mértola, Mértola Formation (probably *gracilis* Zone).

ventrolateral saddle. In both respects it resembles the drawings provided by FEIO (1946: 113).

#### Sutural ratios:

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
IGML 308		8	12	0.42	0.50	0.52	0.60

**Remarks:** The lack of the type material makes *Paraglyphioceras myrtilense* a problematic species. It can be stated with certainty, however, that it in fact belongs to this genus, but more evidence is needed to confirm the statement that the newly collected material is conspecific.

**Comparisons:** *Paraglyphioceras myrtilense* and *P. (?) semistriatum* (NICOLAUS 1963) are unique in the genus because of their very narrow umbilicus, which in comparable stages of the other species is at least twice as wide. *P. (?) semistriatum*, however, has a much weaker radial ornament, and no stage in which the entire conch bears spiral ornament.

The relatively narrow ventral lobe (110% of adventive lobe) distinguishes *P. myrtilense* from *P. rotundum* (BRÜNING 1923), *P. striatum* (SOWERBY 1814), and *P. rudis* (MOORE & HODSON 1958), in which it is 150%. *P. castor* KORN 1988 also has a narrow ventral lobe, but has an ornament with rectiradate growth lines in contrast to rursiradate in *P. myrtilense*. *P. guadianense* possesses a similar ornament, but has a much wider umbilicus (uw/dm = 0.17 compared with 0.06 in *P. myrtilense*).

**Stratigraphical and geographical distribution:** *Posidonia*-bearing shales within the Mértola Flysch series. *Paraglyphioceras* occurs from the *spirifer* Zone to the *rotundum* Zone, but those species with narrower ventral lobe are restricted to the *spirifer* and *falcatus* Zones. *Paraglyphioceras myrtilense* has a comparatively narrow ventral lobe, hence it may be assumed that its horizon belongs to the stratigraphical older occurrences of this genus. Associated forms mentioned by FEIO (1946) are „*Glyphioceras crenistria* var. *globoides*“ and „*Glyphioceras crenistria* var. *globostriata*“, both most probably belonging to an *Arnsbergites* species.



*Paraglyphioceras guadianense* sp. nov.

Pl.5 Fig.2, 4; Text-fig.40

**Holotype:** Specimen Nr. IGML 315 (coll. J.T. OLIVEIRA), Instituto Geológico e Mineiro, Lisboa.

**Type locality and horizon:** Máhora, Ribeiro do Belo, 8km southwest of Mértola; Mértola Formation (most probably *spirifer* to *rotundum* Zone of the Late Viséan B).

**Material:** Two fragmentary natural moulds of large specimens (60 resp. 100mm diameter, IGML 315, 298) and one partly three-dimensionally preserved fragment of estimated 35mm diameter (IGML 311).

**Species diagnosis:** *Paraglyphioceras* with pachyconic conch at 30mm diameter ( $ww/dm = 0.70$ ), umbilicus moderately narrow ( $uw/dm = 0.17$ ) but opening considerably in the adult stage. Ornamentation with spiral lines around the umbilicus and on venter. Coarse and crenulated growth lines with biconvex and strongly rursiradiate course. Suture line with moderate ventral lobe ( $EL/h = 0.60$ ), the median saddle attains the half height of ventrolateral saddle.

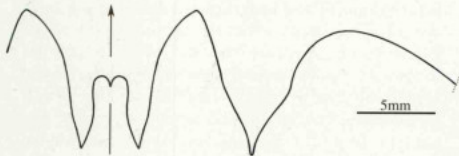
**Conch form:** The material available for study does not allow a reconstruction of the conch shape of the species. It is clear, however, that the umbilicus opens rather widely during late ontogeny.

**Dimensions in mm and ratios:**

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
HT IGML 315			28	13.5			

**Ornamentation:** At approximately 15mm whorl height, specimen IGML 311 displays an ornament that consists of fine and strongly crenulated growth lines, and spiral lines which are strongest near the umbilicus and on the venter. The course of the growth lines is biconvex with a clearly visible lateral sinus.

The larger specimens (IGML 298, 315) show the ornament in the adult stage. Here, from 20 to 40mm whorl height, the spiral ornament is restricted to the umbilical area and venter, whereas the flanks only bear crenulated growth lines. These run in a backward direction over the flank and form only a low ventrolateral projection.



**Text-fig. 40.** *Paraglyphioceras guadianense* sp. nov.; suture line of the paratype (IGML 311, coll. J.T. OLIVEIRA) at wh approximately 20mm; x 3; Posto Fiscal de Vascão, 5km south-east of Pomarão, Mértola Formation (Late Viséan).

**Suture line:** Only one suture line could be examined (IGML 311). At approximately 35mm conch diameter, it shows a relatively narrow external lobe (in comparison with most of the other species of *Paraglyphioceras*). The ventrolateral saddle is subacute, and the adventive lobe V-shaped with weakly sinuous flanks.

**Sutural ratios:**

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
PT IGML 311			c.20	0.51	0.61	0.49	0.49

**Comparisons:** *P. guadianense* is distinguished from other species of *Paraglyphioceras* by its strongly rursiradiate growth lines and by the wide umbilicus that especially opens in the adult stage.

**Stratigraphical and geographical distribution:** All the specimens were collected in the Mértola Flysch. Since *Paraglyphioceras* in the Rhenish Massif is restricted to the *spirifer* to *rotundum* Zones, such an age determination is likely for the South Portuguese specimens.

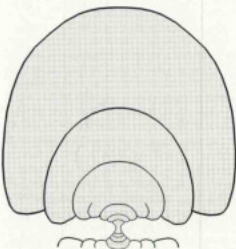
*Paraglyphioceras* sp. 1

**Material:** Two pyritized specimens from bed 149 of the section at the Praia de Murração and four from the equivalent bed 139 at the Praia das Quebradas. The ornament is not preserved in these specimens, which show, besides the general conch form, only the external part of the suture line. These characters allow an assignment of these specimens to *Paraglyphioceras*, but for determination of the species the material is too poorly preserved.

*Paraglyphioceras* sp. 2

Text-fig.41

**Material:** Five fragmentary specimens from bed 122 of the Praia das Quebradas section. The ornament is not preserved in the material, but some of the specimens display parts of the suture line which assigns them to *Paraglyphioceras*. A cross section (IGML 129) shows evolute



**Text-fig. 41.** *Paraglyphioceras* sp. 2; cross section of specimen IGML 129 (coll. M. HORN et al. 1981); x 2.5; Praia das Quebradas, bed 122 (probably *gracilis* Zone).

inner whorls up to 5mm diameter, and a pachyconic adult conch with almost closed umbilicus.

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 129	34.3	22.7	18.3	2.6	0.66	0.53	0.08

**Remarks:** In their conch form, the specimens closely resemble the species *Paraglyphioceras myrtilense*, but because of the lack of a complete suture line and shell ornament, a definite assignment is impossible.

#### *Arnsbergites* KORN 1988

##### *Arnsbergites arnsbergensis* (BRÜNING 1923)

Pl.5 Figs.3, 5, 6; Text-fig.42

1923 *Paraglyphioceras arnsbergense* BRÜNING: 265.

1988 *Arnsbergites arnsbergensis* KORN: 104, pl.27 fig.1-4.

**Holotype:** Specimen 3768 (coll. BRÜNING), Institut für Geologie und Paläontologie, Marburg.

**Type locality and horizon:** Herdringen (Rhenish Massif, Germany); Kulmplattenkalk Formation (probably *gracilis* or *spirale* Zone).

**Material:** Six specimens of about 25mm diameter from the vicinity of Mértola and Pomarão (IGML 314, 299, 309, 310, 307, 303). All are preserved in calcareous nodules, being dissolved and displaying the ornament in the natural moulds, or preserved with the phragmocones.

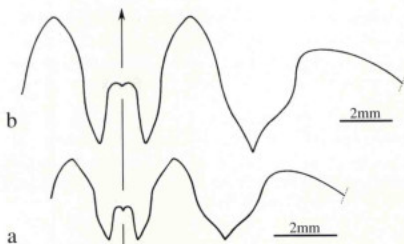
**Species diagnosis:** *Arnsbergites* with pachyconic conch at 20mm diameter (ww/dm = 0.80), umbilicus narrow (uw/dm = 0.25), umbilical margin rounded. Ornamentation with 250 very delicate spiral lines on flanks and venter as well as very fine and crenulated growth lines with biconvex and rursiradiate course. Suture line with Y-shaped, moderate ventral lobe (EL/h about 0.65), the median saddle attains less than the half height of ventrolateral saddle (0.45 of ventrolateral saddle).

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 314	21.7	17.6	11.8	6.1	0.81	0.54	0.28
IGML 309	23.5	c.18	12.2	6.3	c.0.77	0.52	0.27

**Ornamentation:** Specimen IGML 314 displays the best preserved ornamentation. There are 250 extremely delicate spiral lines from umbilicus to umbilicus, arranged at distances of 0.1 to 0.2mm. The transverse ornament consists of crenulated, very fine growth lines. They run with a biconvex course, with equally prominent lateral projections and sinuses over flanks and venter.

**Suture line:** Characteristic for the suture line at about 15mm diameter (specimen IGML 307) is the form of the ventral lobe. It shows a Y-shaped outline with sinuous flanks, known from other *Arnsbergites* species from smaller growth stages. The adventive lobe is wider than



**Text-fig. 42.** Suture lines of *Arnsbergites arnsbergensis* (BRÜNING 1923).

- a. specimen IGML 307 (coll. J.T. OLIVEIRA) at ww 12.6mm, wh 5.2mm; x 6; Ponte Váscua 13km west-southwest of Mértola, Mértola Formation (*gracilis* or *spirale* Zone).  
b. specimen IGML 299 (coll. J.T. OLIVEIRA) at dm 20.0mm, ww 14.8mm, wh approximately 7mm; x 5; Mértola Formation (*gracilis* or *spirale* Zone).

the ventral lobe, a feature that is also typical for juvenile forms of the genus *Arnsbergites*.

The adult suture line could be studied in specimen IGML 299, here the ventral lobe is still Y-shaped with sinuous flanks, and is only a little wider than the adventive lobe. The adventive lobe is asymmetric with a pouched umbilical flank.

#### Sutural ratios:

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
IGML 299	20	14.8	c.7	0.47	0.62	0.46	0.56
IGML 307		12.6	5.2	0.40	0.68	0.55	0.74

**Remarks:** Many of the described species of *Arnsbergites* share a very similar morphology, and hence are difficult to separate. Thus there may occur some junior synonyms. Some features in the morphology of the species may vary within wide ranges, like the conch shape and the width of sutural elements. It is therefore necessary to define the different species by invariable criteria, of which ornament characters as well as shape and ratio of sutural elements may be the best.

**Comparisons:** *Arnsbergites arnsbergensis* is characterized by the very dense spiral ornament (250 or more spiral lines counted from umbilicus to umbilicus), which separates it from other species of this genus, which possess about 200 spirals. Another distinguishing feature is the shape of the ventral lobe, being V-shaped in the most species of *Arnsbergites* such as *A. sphaericostratus* (BISAT 1924), *A. warslowensis* (BISAT 1957), *A. robustus* (MOORE & HODSON 1958), and *A. gracilis* KORN 1988.



*Arnsbergites arnsbergensis* is very similar to variant b of *A. warslowensis*, which was described by BISAT (1957: 18). This is a more slender variant of the nominate species, possessing sinuous flanks of the ventral lobe at 18mm diameter.

**Stratigraphical and geographical distribution:** Late Viséan (probably *spirale* Zone) of Germany (Rhenish Massif), perhaps from Great Britain (Staffordshire), and South Portugal (Mértola Formation).

*Arnsbergites* sp. 1

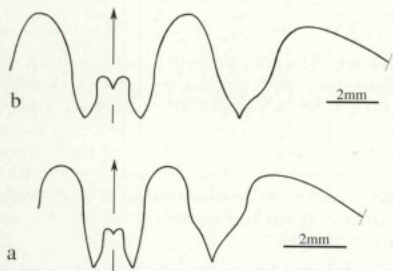
Pl.5 Fig.9

**Material:** One crushed specimen of about 45mm diameter from bed 146 (*spirale* Zone) of the Praia de Murração. The shell ornament of the specimen is quite well preserved, showing approximately 100 delicate spiral lines between umbilical margin and midventer. The growth lines are even finer, barely visible, and run with a rather deep lateral sinus over the flanks. The ventrolateral projection is not much higher than the dorsolateral.

*Arnsbergites* (?) sp. 1

Pl.5 Fig.7, 8; Text-fig.43

**Material:** Two specimens, one not in situ collected at the Praia de Murração section (IGML 262), and one from bed 134 (*spirale* Zone) of the Praia das Quebradas section display similar conch morphologies with a wide



**Text-fig. 43.** Suture lines of *Arnsbergites* (?) sp. 1.

- a. specimen IGML 275 (coll. M. HORN et al. 1979) at dm 13.2mm, ww 12.1mm, wh 5.5mm; x 6; Praia das Quebradas, bed 134 (*spirale* Zone).
- b. specimen IGML 262 (coll. D. KORN et al. 1994) at dm 16.3mm, ww 17.7mm, wh 5.6mm; x 5; Praia de Murração, horizon not recorded (probably Late Viséan *gracilis* or *spirale* Zone).

umbilicus, and suture lines which make an assignment to *Arnsbergites* most likely, but it is not clear if the two specimens belong to the same species. IGML 262 has a suture line with very wide lobes, not known from other species of the genus *Arnsbergites*. Especially the external lobe with a ratio  $EL/h = 0.79$  is uncommon for that genus.

**Dimensions in mm and ratios:**

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 262	17.1	15.6	7.1	4.6	0.91	0.42	0.27
IGML 275	13.1	12.2	5.7	3.5	0.93	0.43	0.27

**Sutural ratios:**

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
IGML 262	16.3	14.7	6.2	0.40	0.79	0.60	0.54
IGML 275	13.1	12.2	5.7	0.38	0.62	0.48	0.48

*Hibernicoceras* MOORE & HODSON 1958

*Hibernicoceras hibernicum* MOORE & HODSON 1958

Pl.6 Figs.3-5; Text-fig.44

1958 *Hibernicoceras hibernicum* MOORE & HODSON: 87, pl.3 fig.1,2.

**Holotype:** Specimen Nr. ZI 3025 (coll. MOORE & HODSON), British Geological Survey Museum, Keyworth, Nottingham.

**Type locality and horizon:** 2 miles southwest of Killyclogher, northeastern slope of Dough Mountain (Co. Leitrim, Ireland), Late Viséan P1d Zone.

**Material:** 64 specimens, three-dimensionally preserved as pyritic or limonitic internal moulds, which are mostly only phragmocones. 51 specimens are from bed 144 of the Praia de Murração section, 12 from bed 134 of the neighbouring Praia das Quebradas section, and one from Pomarão. Additionally, a few ambiguous natural moulds, mostly of juveniles, from the Monte da Nora das Árvores section (IGML 181) are available.

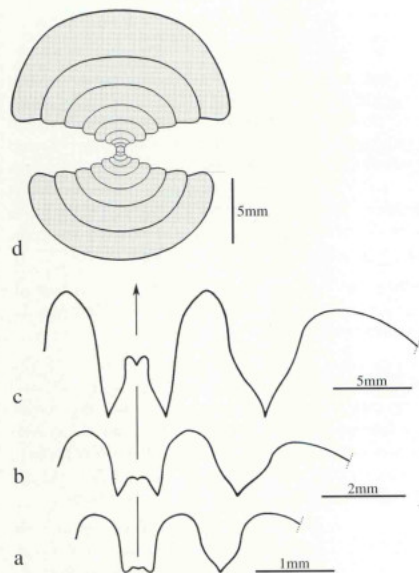
**Species diagnosis:** *Hibernicoceras* with globular conch at 10mm diameter ( $ww/dm = 0.90$ ), and pachyconic conch ( $ww/dm = 0.80$ ) at 20mm diameter; venter very broad. Umbilicus moderately wide at 10mm diameter ( $uw/dm = 0.40$ ), and narrow ( $uw/dm = 0.20$ ) at 20mm diameter; umbilical margin rounded. Ornamentation with coarse and crenulated growth lines as well as spiral lines around the umbilicus. Growth lines biconvex and rectiradiate, without ventral sinus. Suture line with moderate ventral lobe ( $EL/h = 0.60 - 0.65$ ), the median saddle attains half the height of the ventrolateral saddle.

**Conch form:** The cross section (IGML 313) is from a rather globose specimen. It shows evolute and wide inner whorls with semilunate section. The conch is globular between 4 and 15mm diameter, later it is pachyconic. In all stages, an umbilical shoulder is well developed. The umbilicus has its maximal relative width in the innermost whorls. Later, the umbilicus opens only slowly. The cross section is remarkable because of its very low aperture.



## Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 248	25.0	18.3	11.7	4.2	0.73	0.47	0.17
IGML 251	23.7	18.3	11.2	4.5	0.77	0.47	0.19
IGML 290	21.6	17.1	9.6	4.1	0.79	0.44	0.19
IGML 261	17.3	13.6	8.5	4.1	0.79	0.49	0.24
IGML 258	17.2	13.0	8.4	4.0	0.76	0.49	0.23
IGML 293	15.6	13.9	6.8	3.2	0.89	0.44	0.21
IGML 291	13.1	12.0	5.7	3.6	0.92	0.44	0.27
IGML 288	7.6	6.5	2.9	3.2	0.86	0.38	0.42
IGML 313	19.2	16.2	8.5	4.1	0.84	0.44	0.21
	13.4	11.8	5.3	3.7	0.88	0.40	0.28
	9.4	8.3	3.8	3.2	0.88	0.40	0.34
	6.2	5.6	2.2	2.3	0.90	0.35	0.37
	4.3	3.8	1.7	1.4	0.88	0.40	0.33

Text-fig. 44. *Hibernicoceras hibernicum* MOORE & HODSON 1958.

- a. suture line of specimen IGML 292 (coll. D. KORN & K. HORN 1995) at ww 3.8mm, wh approximately 0.9mm; x 15; Praia de Murração, bed 144 (spiral Zone).  
 b. suture line of specimen IGML 251 (coll. D. KORN & K. HORN 1995) at dm 23.7mm, ww 18.3mm, wh 11.2mm; x 3; Praia de Murração, bed 144 (spiral Zone).  
 c. suture line of specimen IGML 291 (coll. D. KORN & K. HORN 1995) at ww 9.0mm, wh 3.6mm; x 8; Praia de Murração, bed 144 (spiral Zone).  
 d. cross section of specimen IGML 313 (coll. J.T. OLIVEIRA); x 2.5; 1km west of the Foupina river bridge, 11km south-southeast of Alcoutim, Mértola Formation.

**Ornamentation:** The ornament is best preserved in IGML 266 at a diameter of 20mm. Here, strongly crenulated lamellose growth lines are preserved, running with a clear lateral sinus over the flanks and then projecting forwards to form a broad, flat ventral projection. On the venter, the growth lines are arranged at distances of 0.3mm. In a zone of about 4mm around the umbilicus, fine spiral lines are present, which are densely arranged (there are 8 spirals in one millimetre). The internal mould is smooth except for one last constriction at about 15mm diameter, following the course of the growth lines.

**Suture line:** The ontogenetic development of the suture line is characterized by a continuous widening of the ventral lobe to maximal 1.20 of the adventive lobe, and by a simultaneous increasing of the median saddle height to half of the ventrolateral saddle. Another trend is towards relatively deeper lobes, and especially that the ventrolateral saddle becomes narrower, transforming from broadly rounded to subacute at 24mm diameter.

## Sutural ratios:

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
IGML 251	23.7	18.3	11.2	0.50	0.58	0.42	0.50
IGML 248	20.2	16.8	9.3	0.53	0.66	0.48	0.52
IGML 291	9.0	3.6	0.27	0.78	0.77	0.77	0.73
IGML 292	3.8	1.1	0.10	0.60	0.77	0.77	0.63

**Comparisons:** Unfortunately, the ontogenetic development has not been described of most of the *Hibernicoceras* species, hence comparison of the Portuguese material is difficult. Species with well-known early stages are *H. striatosphaericum* (BRÜNING 1923), *H. tumidum* MOORE & HODSON 1958, and *H. doliolum* KORN 1988, of which the first species is clearly separated from *H. hibernicum* by the spindle-shaped stage at 10mm diameter, and *H. tumidum* is narrower umbilicate ( $uw/dm = 0.20$  compared with 0.27 in *H. hibernicum*) in juvenile stages of 13mm diameter. In this respects, *H. hibernicum* closely resembles *H. doliolum*.

*Hibernicoceras hibernicum* is a species possessing coarse growth lines, a character which makes it easy to distinguish it from *H. mediocris* MOORE & HODSON 1958, *H. ramsbottomi* MOORE & HODSON 1958, and *H. doliolum* KORN 1988.

A feature which separates *H. hibernicum* from the most similar species, *H. carraunense* MOORE & HODSON 1958, is the course of the growth lines, which in *H. hibernicum* even at 20mm diameter do not possess a ventral sinus, rather being projected on the outer flanks and running in a radial direction over the venter. In this character, *H. hibernicum* is distinguished from most of the *Hibernicoceras* species. *H. hibernicum* can, in this respect, be regarded as a paedomorphic form.

**Stratigraphical and geographical distribution:** Late Viséan B (*spirale* Zone; Vale Figueira Member of the Murração Formation) of Southwestern Portugal.

***Hibernicoceras carraunense* MOORE & HODSON 1958**

Text-fig.45

- 1958 *Hibernicoceras carraunense* MOORE & HODSON: 89, pl.4 fig.2.  
 1985 cravenoceratids OLIVEIRA, HORN, KULLMANN & PAPROTH: 111, text-fig.3.  
 1985 *Cravenoceras* aff. *arcticum*- OLIVEIRA, HORN, KULLMANN & PAPROTH: 112.  
 1985 *Cravenoceras* aff. *fayettevillae*.- OLIVEIRA, HORN, KULLMANN & PAPROTH: 112.  
 1990 cravenoceratids OLIVEIRA: 342, text-fig.5.

**Holotype:** Specimen Nr. ZI 3845 (coll. MOORE & HODSON), British Geological Survey Museum, Keyworth, Nottingham.

**Type locality and horizon:** 1.7 miles south-southeast of Killycloher, Townland of Carraun (Co. Leitrim, Ireland), Late Viséan Plc Zone.

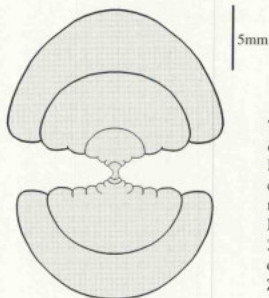
**Material:** 24 specimens from one single limestone horizon (bed 116) in the Praia das Quebradas section, 125cm above the „residual layer“. Most of the specimens are poorly preserved, suffering from lateral distortion and from weathering of the shell surface. Many of the specimens have been cut for preparation of the inner whorls, and some of the individuals display shell remains.

**Species diagnosis:** *Hibernicoceras* with globular conch at 10mm diameter ( $w/dm = 0.85$ ), and pachyconic conch ( $w/dm = 0.70$ ) at 25mm diameter; venter very broad. Umbilicus moderately wide at 10mm diameter ( $uw/dm = 0.40$ ), and narrow ( $uw/dm = 0.16$ ) at 20mm diameter; umbilical margin rounded. Ornamentation with fine and hardly crenulated growth lines as well as fine spiral lines around the umbilicus. Growth lines biconvex and rectiradiate, with shallow ventral sinus. Suture line with moderate ventral lobe ( $EL/h = 0.60 - 0.65$ ), the median saddle attains the half height of ventrolateral saddle.

**Conch form:** The cross section of specimen IGML 119 allows study of the ontogeny, although, by dolomitization, some whorls are incompletely preserved. Up to 4mm diameter, the conch is evolute with crescent-shaped whorls, and at 6mm diameter the umbilicus is relatively widest. In later ontogenetic stages, it opens only slowly, and at 22mm diameter its width is only 0.14 of the diameter. In all stages, the umbilical margin and the venter are broadly rounded.

**Dimensions in mm and ratios:**

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 119	22.2	16.1	10.7	3.2	0.73	0.48	0.14
	17.4	13.8	8.2	3.0	0.79	0.47	0.17
	13.9	10.7	6.2	2.8	0.77	0.45	0.20



**Text-fig. 45.** *Hibernicoceras carraunense* MOORE & HODSON 1958; cross section of specimen IGML 119 (coll. M. HORN et al. 1982); x 2.5; Praia das Quebradas, bed 116 (*gracilis* Zone).

**Ornamentation:** Specimen IGML 127 shows the shell ornament at 15mm diameter. In this stage, finely crenulated growth lines are present, arranged on the venter at distances of about 0.3mm. They run with a dorsolateral projection and a lateral sinus over the flanks and arch forward to form a broad ventral projection. Around the umbilicus, a few fine spiral lines are visible. Smaller specimens (IGML 121, 122) show at 8 - 10mm diameter very delicate growth lines, and no spiral lines.

**Suture line:** Only fragments of the juvenile can be studied in specimen IGML 121, which do not allow specific interpretation.

**Comparisons:** *Hibernicoceras carraunense* is distinguished by its rather fine and widely spaced transversals from many other species of the genus, especially from *H. hibernicum* MOORE & HODSON 1958, and *H. striatosphaericum* (BRÜNING 1923). In *H. alentejoense* sp. nov., the transversals are even more widely spaced, and run strongly rursiradiate, very unlike *H. carraunense*.

**Stratigraphical and geographical distribution:** Late Viséan Plc Zone (= *gracilis* Zone) of Ireland (Co. Leitrim), Germany (? Rhenish Massif), and South Portugal (Vale Figueira Member of the Murração Formation).

***Hibernicoceras alentejoense* sp. nov.**

Pl.6 Figs. 1, 2; Text-fig.46

**Holotype:** Specimen Nr. IGML 296 (coll. J.T. OLIVEIRA), Instituto Geológico e Mineiro, Lisboa.

**Type locality and horizon:** 1km northeast of Almoinha, 8km south of Mértola; Mértola Formation, probably *gracilis* or *spirale* Zone.

**Material:** Only the holotype is available for study. It is a slightly distorted specimen of maximal 50mm diameter, pre-



served in a silicious claystone nodule. The phragmocone is completely dissolved, but the sediment-filled body chamber is preserved displaying ornament details of two volutions.

**Species diagnosis:** *Hibernicoceras* with pachyconic conch at 25mm diameter ( $w/w_{dm} = 0.75$ ), and thickly discoidal conch ( $w/w_{dm} = 0.50$ ) at 50mm diameter. Umbilicus very narrow ( $u/w_{dm}$  is less than 0.10) between 25mm and 50mm diameter; umbilical margin rounded. Ornamentation with fine, widely spaced and weakly crenulated growth lines as well as few spiral lines around the umbilicus. Growth lines biconvex and strongly rursiradiate, with prominent dorsolateral projection. Suture line with moderate ventral lobe (1.40 of adventive lobe), the median saddle attains the half height of the subacute ventrolateral saddle.

**Conch form:** The only specimen is characterized by the very narrow umbilicus that is less than a tenth of the conch diameter. The shape of the conch underlies a modification from pachyconic in the middle stage to thickly discoidal in the adult stage.

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 296	48	25	24.5	4.5	0.52	0.51	0.09
	30.6	21.4	16.3	c.2.5	0.70	0.53	c.0.08
	26.7	20.4			0.76		

**Ornamentation:** The latex cast of the inner whorl of the holotype displays the shell ornament between 20 and 30mm diameter. In this stage, fine weakly crenulated growth lines occur, widely spaced on the venter at distances of 0.6 to 0.8mm. Their course is biconvex and strongly rursiradiate, with a prominent dorsolateral projection. Around the umbilicus, very few (about 10) fine spiral lines are visible.

The body chamber of the specimen shows at 50mm conch diameter a very similar ornament. The growth lines are here spaced at distances of more than a millimetre, and cause an undulating pattern on the internal mould.

**Suture line:** Only parts of the suture line, which suffered from distortion, can be examined at the last septum. It shows a ventral lobe with a width of approximately 1.4

of the adventive lobe. The median saddle may have been about half of the height of the ventrolateral saddle that is subacute.

**Comparisons:** None of the other known *Hibernicoceras* species show an umbilicus that is as narrow as in *H. alentejoense*. Another typical feature for *H. alentejoense* is the wide spacing of the growth lines, which in their strength and strong rursiradiate direction are unique among the *Hibernicoceras* species.

**Stratigraphical and geographical distribution:** *Hibernicoceras alentejoense* is known only from the Mértola Flysch, most probably from the *gracilis* or *spirale* Zone.

#### *Hibernicoceras* sp. 1

Pl.6 Fig.6

**Material:** One crushed specimen of approximately 30mm diameter from bed 143 (*spirale* Zone) of the Praia de Murração section. It shows a very narrow umbilicus and an ornament consisting of fine rursiradiate and crenulated growth lines, and about ten spiral lines around the umbilicus. Only with these characters, specific assignment is not possible.

#### *Lusitanoceras* PEREIRA DE SOUSA 1923

**Type species:** *Lusitanoceras algarviensis* PEREIRA DE SOUSA 1923 by monotypy.

**Genus definition:** Conch moderately large, adults thickly discoidal to globular, juveniles globular and often three-segmented. Umbilicus in juveniles wide, in adults very narrow. Ornament in juveniles with crenulated growth lines, in adults dominate 80 to 150 often granulated spiral lines. Direction of the biconvex growth lines is prorsiradiate in juveniles and rectiradiate or rursiradiate in adults. Suture line with moderately wide, Y-shaped ventral lobe and moderate median saddle. Ventrolateral saddle subacute, adventive lobe slightly pouched.

#### Generic composition:

*algarviense*: *Lusitanoceras algarviensis* PEREIRA DE SOUSA 1923: 304. Late Viséan, South Portugal.

*barruelense*: *Mesoglyphioceras granosus* var. *barruelensis* WAGNER-GENTIS 1963: 11. „E1“, Province of Palencia, Cantabrian Mountains.

*cantina*: *Dombarties cantina* WAGNER-GENTIS 1980: 12. probably Late Viséan, Province of Palencia, Cantabrian Mountains.

*cuboides*: *Neuglyphioceras cuboides* BRÜNING 1923: 30. „Zone Gp“, Rhenish Massif.

*granofalcatum*: *Goniattites* (*Goniattites*) *granofalcatum* KULLMANN 1961: 305. Lower *granosus* Zone, Montó Region (Province of Leon), Cantabrian Mountains.



**Text-fig. 46.** *Hibernicoceras alentejoense* sp. nov.; suture line of the holotype (IGML 296, coll. J.T. OLIVEIRA) at dm 30.6mm, ww 21.4mm, wh 16.3mm; x 3; 1km northeast of Almoimha, 8km south of Mértola, Mértola Formation (*gracilis* to *rotundum* Zone).



- granosum*: *Goniattites granosus* PORTLOCK 1843: 407. Co. Tyrone, Ireland.
- irtyshense*: *Goniattites irtyshensis* LIBROVITCH 1940: 162. North Kazakhstan.
- jasterdorfiense*: *Glyptioceras granosum* forma *jasterdorfiensis* PATTEISKY 1930: 268. Lower Wagstädter Schichten (III<sub>fy</sub>), Czech Republic.
- occidentale*: *Goniattites (Goniattites) granosus occidentalis* KULLMANN 1961: 301 (non *Goniattites occidentalis* MILLER 1889). Oberes Goy, Montó Region (Province of Leon), Cantabrian Mountains.
- occidentis*: *Goniattites (Goniattites) granosus occidentis* KULLMANN in BUDINGER & KULLMANN 1964: 418. [New name for *Goniattites (Goniattites) granosus occidentalis*.]
- orientale*: *Goniattites orientalis* LIBROVITCH 1940: 152. North Kazakhstan.
- polaris*: *Goniattites polaris* KUZINA 1987: 59. Visé, Novaya Zemlya.
- poststriatum*: *Neoglyptioceras poststriatum* BRÜNING 1923: 30. „Zone Gp”, Rhenish Massif.
- spiraloides*: *Glyptioceras granosum spiraloides* SCHMIDT 1925: 571. III<sub>fy</sub>, Rhenish Massif.

**Comparisons:** *Lusitanoceras* is the genus with a phylogenetic position between *Goniattites* and *Domarites*. From the stratigraphically older *Goniattites* it is clearly distinguishable because of its open umbilicate inner whorls, the wider ventral lobe (1.20 to 1.30 of adventive lobe, compared with 0.80 to 1.00 in *Goniattites*), and the stronger and fewer spiral lines. This is a feature that also makes a separation between *Lusitanoceras* and genera such as *Arnsbergites*, *Hibemicoceras* and *Paraglyptioceras* easy. Furthermore, these three genera do not develop such constrictions as *Lusitanoceras*, which lead to three-segmented conchs.

*Goniattitella* has a similar ornament, but has only a small conch (up to 20mm diameter, compared with more than 60mm in *Lusitanoceras*), and also lacks triangular coiling of the juvenile conch. Additionally, the suture line shows clear differences: *Goniattitella* has a more distinctively Y-shaped, narrower external lobe with almost parallel flanks.

*Domarites* resembles *Lusitanoceras* in conch form and ornament, but this genus displays a advanced suture line. The median saddle in *Domarites* is higher than the half of the ventrolateral saddle, and especially the adventive lobe is different: in *Domarites*, the flanks of this lobe show a clear angular projection, which in *Lusitanoceras* is only barely visible and rounded.

**Remarks:** In a biography of Francisco Luís PEREIRA DE SOUSA, written by OLIVEIRA SIMÕES (1931), the (incomplete) publication list gives indication of an article published in vol. 13 of the Comunicações in which *Lusitanoceras* is

already established in 1921. The article obviously meant, however, does not include the introduction of the new genus, so that 1923 must be regarded as the year of its first description.

After its introduction by PEREIRA DE SOUSA (1923), both the genus name *Lusitanoceras* and the species name *algarviensis* have for a long period been ignored by other authors. This is probably due to the fact that PEREIRA DE SOUSA figured a quite heterogenic assemblage under the name *Lusitanoceras algarviensis*, which preprogrammed suppression of this name, e.g. by DELÉPINE (1957) and WAGNER-GENTIS in OLIVEIRA & WAGNER-GENTIS (1983).

Only RUZHENCEV & BOGOSLOVSKAYA (1971) made an attempt to solve the *Lusitanoceras* problem by their designation of PEREIRA DE SOUSA's figure pl.9 fig.3 as the lectotype of *Lusitanoceras algarviense*. These authors, however, regarded *Lusitanoceras* as a junior synonym of *Goniattites*.

In revising the goniattites from the Kulmplattenkalk Formation of Southern Westphalia, KORN (1988) separated different morphological groups which formerly have been assembled in the voluminous genus *Goniattites*, and separated the former „*granosus* group” by reintroduction of the genus name *Lusitanoceras*.

**Stratigraphical and geographical distribution:** *Lusitanoceras* is apparently restricted to a short stratigraphical timespan and occurs in the Late Viséan (*poststriatum* Zone and *eisenbergensis* Zones, resp. P2 Zone). It has a global distribution: South Portugal, Ireland, Great Britain (Yorkshire, Lancashire), Germany (Rhenish Massif, Harz Mountains), Czech Republic, Poland, Spain, North America (Arkansas, Alaska), Russia (Novaya Zemlya), and Kazakhstan.

### *Lusitanoceras algarviense* PEREIRA DE SOUSA 1923

Pl.6 Figs.7, 8; Pl.7 Figs. 1-6; Text-fig.47

- 1923 *Lusitanoceras algarviensis* PEREIRA DE SOUSA: 304, pl.9 fig.3 [non pl.9 fig.1-3 = *Lusitanoceras poststriatum* (BRÜNING 1923); non pl.9 fig.4 = *Neoglyptioceras spirale* (PHILLIPS 1836); non pl.9 fig.6 = indeterminate]
- 1924 *Lusitanoceras algarviensis* PEREIRA DE SOUSA: 48, pl.2 fig.3 [non pl.2 fig.1-3 = *Lusitanoceras poststriatum* (BRÜNING 1923); non pl.2 fig.4 = *Neoglyptioceras spirale* (PHILLIPS 1836); non pl.2 fig.6 = indeterminate]
- 1957 *Goniattites striatus*, *Goniattites falcatus*, *Goniattites granosus*.- DELÉPINE: 297-299 [pt.?).
- 1978 *Goniattites falcatus*.- PERDIGÃO: 388, pl.1 fig.3.
- 1983 *Domarites* sp. OLIVEIRA: 31, text-fig. 12.

- 1983 *Dombartites parafalcatoide*.- WAGNER-GENTIS in OLIVEIRA & WAGNER-GENTIS: 16, pl.1 fig.1; text-fig.1, pl.2 fig.1, pl.3 fig.1.2, pl.4 fig.1.2, pl.5 fig.1.3 [non pl.1 fig.2.3, pl.6 fig.4 = *Lusitanoceras poststriatum*].
- 1983 *Platygoniatis* sp. 'early form' WAGNER-GENTIS in OLIVEIRA & WAGNER-GENTIS: 19, pl.4 fig.1.2.
- 1985 *Dombartites* sp. OLIVEIRA, HORN, KULLMANN & PAPROTH: 110-117, text-fig. 2-6.
- 1990 *Dombartites* sp. HORN, KULLMANN & OLIVEIRA.: 477, text-fig. 2.
- 1990 *Dombartites* sp. OLIVEIRA: 342, 343, text-fig.5.

**Lectotype:** Specimen Nr. IGML 223 (coll. F.L. PEREIRA DE SOUSA), Instituto Geológico e Mineiro, Lisboa [designated by RUZHENCEV & BOGOSLOVSKAYA (1971: 322) as the lectotype].

**Type locality and horizon:** 8km south-southeast of Vaqueiros; top of the Mértola Formation (Late Viséan).

**Material:** Remains of about 55 specimens are available for study. Most of them (30) are from manganocarbonatic nodules within the upper part of the Mértola Formation and were collected in the area southeast of Vaqueiros. Usually they are preserved as slightly undeformed three-dimensional natural moulds, and displaying very delicate ornament details. Thus latex casts have been manufactured for the figures. Only very seldom, remains of the phragmocones are preserved in this material, allowing study of the suture line. Another specimen was collected 4km north-northwest of Azinhal.

The second group of specimens (25 specimens, mostly fragments) comes from the Aljezur e Bordaia synforms and are usually preserved as crushed impressions in shales. These specimens sometimes display the typical ornament of the species and thus are determinable with certainty. They derive from Murração (1 internal mould, IGML 305), Maria Serrão (4 fragments), from the outcrop along the road from Carrapateira to the Praia de Murração (10 fragments, among these IGML 240), from bed 169 of the Praia de Murração (two fragments), from km11 along the road from Bordaia to Carrapateira (8 specimens), from north of the Samoqueira farm, and from bed 152 of Praia das Quebradas section (specimen IGML 130).

**Species diagnosis:** *Lusitanoceras* with globular conch at 10mm diameter ( $ww/dm = 1.00$ ), three-segmented by three deep constrictions. Conch at 30mm diameter pachyconic to globular

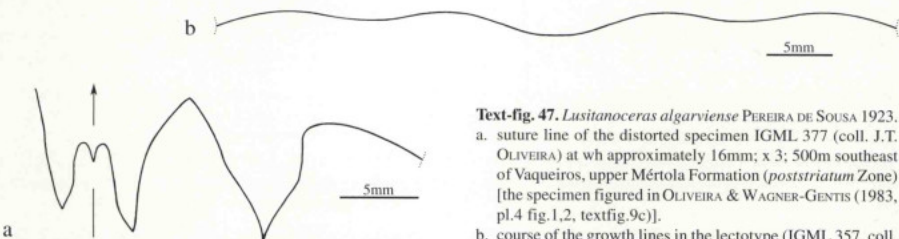
( $ww/dm = 0.70 - 0.90$ ), and at 50mm diameter pachyconic ( $ww/dm = 0.65 - 0.70$ ). Umbilicus very narrow in all these stages ( $uw/dm = 0.12 - 0.15$ ). Ornamentation at 6mm diameter with coarse, crenulated growth lines which run biconvex and prorsiradiate, and 100 very fine spiral lines; at 12mm diameter with about 100 spiral lines which are stronger than the growth lines; over 30mm diameter with 120 to 150 granulated spiral lines as well as crenulated, biconvex and rectiradiate growth-lines. Weak constrictions of the shell cause a falcate ornament in this stage. Dorsolateral and ventrolateral projection of growth lines with the same height, external sinus deep. Suture line with moderate ventral lobe ( $EL/h = 0.70$ ), the median saddle exceeds half the height of ventrolateral saddle.

**Conch form:** The earliest ontogenetic stages are serpentine with a crescent-shaped whorl section; at 2mm conch diameter the ratio  $uw/dm$  is about 0.50. At 5mm diameter, the conch is already globular and triangularly coiled, with three deep constrictions and a very narrow umbilicus ( $uw/dm = 0.15$ ). The triangular coiling then disappears until the conch has 10mm diameter, at this stage the conch has the form of a globe. Stages between 20 and 50mm diameter are strikingly variable in their conch proportions. This is with regard to the ratio  $ww/dm$  which varies between 0.70 and 0.85, whereas the umbilical width remains constant ( $uw/dm = 0.12$ ).

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 235	51.6	25.2	6.8	0.49	0.13		
IGML 234	33.7	27.5	16.3	4.2	0.82	0.48	0.12
IGML 236	30.5	21.2	14.3	4.1	0.70	0.47	0.13
IGML 239	21.9	18.1	10.3	2.7	0.83	0.47	0.12
IGML 399	9.8	9.7	4.7	1.4	0.99	0.48	0.14

**Ornamentation:** At 5mm diameter (IGML 279), the ornament consists of coarse growth lines which run with a sinus over the flanks and bend forward to a ventral projection. They are strongly crenulated, which forms an additional, finer spiral ornamentation. From umbilicus to umbilicus there are about 100 spirals. This stage is characterized by three conspicuous,  $120^\circ$  apart constrictions, which are deepest on the midflank area.



**Text-fig. 47.** *Lusitanoceras algarviense* PEREIRA DE SOUSA 1923.  
a. suture line of the distorted specimen IGML 377 (coll. J.T. OLIVEIRA) at wh approximately 16mm; x 3; 500m southeast of Vaqueiros, upper Mértola Formation (*poststriatum* Zone) [the specimen figured in OLIVEIRA & WAGNER-GENTIS (1983, pl.4 fig.1.2, textfig.9c)].  
b. course of the growth lines in the lectotype (IGML 357, coll. F.L. PEREIRA DE SOUSA) at wh 16.5mm; x 2.5.



At 10mm diameter (IGML 399), the constrictions are already much weaker and only visible on the flanks. The course of the growth-lines has not changed, in contrast to their strength: The dominant ornamental elements are now the spiral lines (100 to 110 from umbilicus to umbilicus), and the growth lines are much finer.

Larger specimens between 30 and 50mm diameter show a wide variety of ornamental pattern. Specimen IGML 234 shows excellently the ornament at 34mm diameter. In this stage, 140 distinctly granulated spiral lines are countable from umbilicus to umbilicus, and being more densely spaced on the venter. A weak falcate ornament appears at 32mm diameter, and three conspicuous constrictions are present 120° apart.

On the lectotype, 150 granulated spiral lines, standing in regular distances, are present at about 40mm diameter. The growth lines form weak, equally high lateral projections and a ventral sinus which is four times deeper than the lateral sinus. At the end of the volution, a falcate ornament is formed, which is generated by numerous, irregularly spaced weak shell constrictions. Three shell constrictions are present in the specimen, they stand at distances of about 100° apart.

IGML 235 is the specimen that shows the ornament that comes closest to the lectotype. Only 110 spiral lines, however, are preserved, but the falcate ornament is very well preserved. This becomes very dominant at 70mm diameter, where some growth lines rhythmically become stronger, and together with the spiral lines form a coarse reticulate pattern.

**Suture line:** Only very few of the specimens allow study of the suture line. One of these is a ventrolaterally crushed specimen (IGML 377) in the collection already published by OLIVEIRA & WAGNER-GENTIS (1983: pl.4 fig.1,2 and Text-fig.9C). This is the slightly distorted suture line of a specimen with approximately 15mm whorl height. It shows the typical outline of that genus, with Y-shaped ventral lobe and subacute ventrolateral saddle. Dimensions and ratios can only be approximated.

**Sutural ratios** (all values approximated):

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
IGML 377			15	0.55	0.70	0.70	0.55

**Remarks:** The species name *Lusitanoceras algarviense* was long suppressed by workers on Carboniferous ammonoids from Portugal. Probably, DELÉPINE (1957) listed specimens of this species under the names „*Goniatis striatus*“, „*Goniatis falcatus*“, and „*Goniatis granosus*“.

WAGNER-GENTIS in OLIVEIRA & WAGNER-GENTIS (1983) has described specimens from the type area as „*Domba-*

*rites parafalcatooides*“ and „*Platygoniatites* sp. ‘early form’“. It is obvious that all these specimens fit within the variability of *Lusitanoceras algarviense* (and *L. poststriatum*), and that the suppression of the original name was not justified. The figured individual of „*Platygoniatites*“ is nothing more than a ventrally crushed specimen, which, caused by deformation, has a ventral lobe that appears wider than to be typical for *Lusitanoceras*.

Re-examination of the available specimens of the type material of *Lusitanoceras algarviense* lead to the conclusion that only two specimens belong in fact in this species, PEREIRA DE SOUSA's figures 3 and 5 on plate 9.

**Comparisons:** *Lusitanoceras algarviense* is easily distinguishable from the other species of *Lusitanoceras* when the ornament of specimens larger than 30mm diameter is preserved. In this stage, *L. algarviense* develops the characteristic falcate pattern known only from few species of the genus. Smaller specimens, however, are very difficult to separate, specimens of *L. algarviense* and *L. poststriatum* (BRÜNING 1923) are hard to distinguish. Another species with falcate ornament is *L. granofalcatum* (KULLMANN 1961), but this has a much wider umbilicus ( $uw/dm = 0.25$  compared with 0.12).

**Stratigraphical and geographical distribution:** The co-occurrence with *L. poststriatum* leads to the conclusion that this species has its stratigraphical range within the *poststriatum* Zone of the Late Viséan. It is known only from South Portugal (upper part of the Mértola and Murração Formations).

### *Lusitanoceras poststriatum* (BRÜNING 1923)

Pl. 6 Fig.9, Pl.7 Figs.7, 8; Text-fig.48

- 1923 *Neophylloceras poststriatum* BRÜNING: 30, pl.9 fig.1-3 [only].
- 1923 *Lusitanoceras algarviense* PEREIRA DE SOUSA: 304, text-fig.8f, 10a.
- 1924 *Lusitanoceras algarviense* PEREIRA DE SOUSA: 48, pl.2 fig.1-3 [only].
- 1978 *Goniatis granosus*.- PERDIGÃO: 387, pl.6 fig.1.
- 1983 *Dombartites parafalcatooides*.- WAGNER-GENTIS in OLIVEIRA & WAGNER-GENTIS: 16 [pt.], pl.1 fig.2,3, pl.6 fig.4.
- 1988 *Lusitanoceras poststriatum*.- KORN: 129, pl.36 fig.1-7, pl.37 fig.1-12, pl.38 fig.1-7, pl.39 fig.1-10, pl.60 fig.7,8 [for more synonymy].
- 1990 *Lusitanoceras poststriatum*.- KORN: 37, pl.15 fig.1-12.

**Lectotype:** Specimen Nr. 3452 (coll. BRÜNING), Institut für Geologie und Paläontologie, Marburg.

**Type locality and horizon:** Herdringen (Rhenish Massif, Germany); Zone Gp (*poststriatum* Zone).



**Material:** Differently preserved specimens are known from several places in South Portugal, mostly from the same localities in which *L. algarviense* PEREIRA DE SOUSA 1923 is present: the vicinity of Vaqueiros (three specimens), Rocha da Lagoa (2), Monte Parente (1), Aljezur (1 = IGML 224), Murração (1 = IGML 305), and from km 11 of the road Bordeira-Carrapateira (3 specimens).

**Species diagnosis:** *Lusitanoceras* with globular conch at 10mm diameter ( $ww/dm = 0.90 - 1.00$ ), three-segmented by deep constrictions. Conch at 30mm diameter pachyconic ( $ww/dm = 0.70$ ), and at 50mm diameter thickly discoidal to pachyconic ( $ww/dm = 0.55 - 0.60$ ). Umbilicus very narrow in all these stages ( $uw/dm = 0.15$ ). Ornamentation at 6mm diameter with coarse, crenulated growth lines which run biconvex and prorsiradiate; at 12mm diameter with about 100 spiral lines which are stronger than the growth lines; at 30mm diameter with 120 granulated spiral lines as well as crenulated, slightly biconvex and rectiradiate growth-lines. Dorsolateral and ventrolateral projection of growth lines with the same height, external sinus moderately deep. Suture line with moderate ventral lobe ( $EL/h = 0.65$ ), the median saddle attains half the height of the ventrolateral saddle.

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 305	56.5	31.2	25.0	8.4	0.55	0.44	0.15
IGML 238	43.7	20.5	7.1	0.47	0.47	0.16	
IGML 237	39.2	25.2	19.0	5.9	0.64	0.48	0.15

**Ornamentation:** Specimen IGML 238 at 43mm diameter possesses 120 slightly granulated spiral lines. The fine growth-lines run almost linearly over the flanks and form a shallow ventral sinus. The shell bears three evenly spaced, weak constrictions on the flanks.

**Suture line:** Two complete outer suture lines could be studied (IGML 306, 376) in the Portuguese material. They show the typical outline of an adult *Lusitanoceras* suture, with a Y-shaped ventral lobe and subacute ventrolateral saddle.

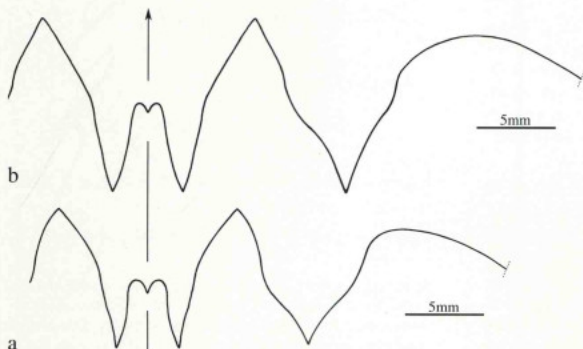
#### Sutural ratios:

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
IGML 376			22.8	0.51	0.66	0.51	0.56
IGML 306		23	16	0.50	0.64	0.51	0.63

**Comparisons:** All the species of *Lusitanoceras* display very similar morphologies, and sometimes are only determinable on the basis of well preserved material. *L. granosum* (PORTLOCK 1843) has, according to an illustration of the type (GORDON 1965, pl.18 fig.7), only 80 spiral lines in a growth stage when *L. poststriatum* possesses 120 of them. *L. irtysense* (LIBROVITCH 1940) is narrower umbilicate ( $uw/dm < 0.10$ ) compared with *L. poststriatum* ( $uw/dm = 0.15$ ). *L. orientale* (LIBROVITCH 1940) and *L. occidentis* (KULLMANN 1964) are different because of their stronger biconvex growth lines, and *L. granofalcatum* (KULLMANN 1961) has a wider umbilicus ( $uw/dm = 0.25$ ).

Clear separation of *L. poststriatum* and *L. algarviense* PEREIRA DE SOUSA 1923 is sometimes difficult, especially when the ontogenetic development is not observable. Adult stages over 30mm diameter, however, are clearly distinguishable because of the falcate ornament in *L. algarviense*, a feature not known from *L. poststriatum*. Besides this, the umbilicus is slightly wider in *L. poststriatum* ( $uw/dm = 0.15$  compared with 0.12), and usually the number of spiral lines is smaller than in *L. algarviense* (100 to 120 compared with 120 to 150).

**Remarks:** The differences in ornamentation and umbilical width allow a clear separation of the species *Lusitanoceras poststriatum* and *L. algarviense*, which occur together in South Portugal. Because real intermediates between the two species are not known, and a set of distinguishing features is always present, both species are regarded to be valid. Falcate *Lusitanoceras* species do not occur in Northwestern and Central Europe, suggesting that *L. algarviense* is not only a variant of *L. poststriatum*.



**Text-fig. 48.** Suture lines of *Lusitanoceras poststriatum* (BRÜNING 1923).

- specimen IGML 246 (coll. J.T. OLIVEIRA) at  $ww$  23mm, wh 16mm; x 3; Murração, (*poststriatum* Zone).
- specimen IGML 376, coll. J.T. OLIVEIRA) at  $wh$  22.8mm; x 3; 3.8km west of Almada de Ouro, near the road Azinhal - Portela Alta, upper Mértola Formation (*poststriatum* Zone) [the specimen figured in OLIVEIRA & WAGNER-GENTIS (1983, pl.1 fig.2.3, text-fig.9a)].

**Stratigraphical and geographical distribution:** Late Viséan (*poststriatum* Zone and *eisenbergensis* Zone resp. P2a) of Germany (Rhenish Massif, Harz Mountains), Poland (Lower Silesia), Great Britain [?] (Lancashire, Yorkshire), Ireland [?] (Co. Leitrim), and South Portugal. Here, it occurs in the upper part of the Mértola and Murração Formations.

Superfamily **Neoglyphiocerataceae** PLUMMER & SCOTT  
1937

Family **Cravenoceratidae** RUZHENCEV 1957

Subfamily **Lyrogoniatitinae** RUZHENCEV &  
BOGOSLOVSKAYA 1971

**Lyrogoniatites** MILLER & FURNISH 1940

**Lyrogoniatites liethensis** KORN 1988

Pl.8 Figs.1-4; Text-fig.49

- 1983 *Lyrogoniatites georgiensis*. - WAGNER-GENTIS in OLIVEIRA & WAGNER-GENTIS: 20, pl.7 fig.3,4.  
1983 *Lyrogoniatites mutabilis*. - WAGNER-GENTIS in OLIVEIRA & WAGNER-GENTIS: 21, pl.5 fig.4.  
1983 *Lyrogoniatites* aff. *eisenbergensis*. - WAGNER-GENTIS in OLIVEIRA & WAGNER-GENTIS: 22, pl.6 fig.1, pl.7 fig.1.2.  
1983 *Pachyloceras cloudi*. - WAGNER-GENTIS in OLIVEIRA & WAGNER-GENTIS: 23, pl.6 fig.2,3.  
1983 *Neoglyphioceras* cf. *N. gradatum*. - WAGNER-GENTIS in OLIVEIRA & WAGNER-GENTIS: 25, pl.6 fig.5.  
1988 *Lyrogoniatites liethensis* KORN: 152, pl.48 fig.1-8, pl.49 fig.1-9.

**Holotype:** Specimen Nr. 10220 (coll. KORN 1975), Westfälisches Museum für Naturkunde, Münster.

**Type locality and horizon:** Kalte Lieth near Oelinghausen (Rhenish Massif, Germany); *liethensis* Zone (Late Viséan).

**Material:** About 20 specimens larger than 10mm, and numerous smaller individuals (IGML 230-233, 325-327). All except for one (from Vale da Gato) were collected 500m southeast of Vaqueiros. They originate from decalcified nodules at the top of the Mértola Formation, usually being preserved as deformed negative imprints allowing the production of latex casts. All ornament details are excellently preserved, but only one juvenile specimen displays the suture line.

All growth stages between 15mm and maximal 35mm show a similar ornament. There are about 50 spiral lines from umbilicus to umbilicus, usually distributed in equal distances and only sometimes more densely arranged. The growth lines, which are considerably finer than the spirals, have a concavo-convex course with low ventrolateral projection and shallow external sinus. Three or four shell constrictions occur in one volution.



**Text-fig. 49.** *Lyrogoniatites liethensis* KORN 1988; suture line of specimen IGML 325 (coll. J.T. OLIVEIRA) at ww 6.0mm, wh 2.4mm; x 10; 500m southeast of Vaqueiros, upper Mértola Formation (*liethensis* Zone) [the specimen figured in OLIVEIRA & WAGNER-GENTIS (1983, pl.6 fig.2, text-fig.11a-c)].

The juvenile suture line (specimen IGML 325) is characterized by a narrow and slightly pouched ventral lobe with almost parallel flanks.

**Remarks:** Re-examination of the material described by WAGNER-GENTIS in OLIVEIRA & WAGNER-GENTIS (1983) led to the conclusion that five of the goniatite species mentioned in that paper in fact belong in only one species. Resemblance with the original material from the Rhenish Massif is close, the Portuguese specimens display the same number of spiral lines, the same course of the growth lines, and the same juvenile suture line. The conch shape is not preserved in the Portuguese material, but it can be assumed that these specimens belong to a rather globose form.

**Stratigraphical and geographical distribution:** Late Viséan *liethensis* Zone of Germany (Rhenish Massif), most probably Great Britain (Yorkshire, Lancashire), and South Portugal. Specimens from Vaqueiros have been collected about eight meters above the horizon containing *Lusitanoceras algarviense* in the upper Mértola Formation.

Subfamily **Stenoglyphyritinae** RUZHENCEV &  
BOGOSLOVSKAYA 1971

**Stenoglyphyrites** RUZHENCEV & BOGOSLOVSKAYA 1971

**Stenoglyphyrites cinereus** sp. nov.

Pl.8 Figs.7, 9; Text-fig.50

**Holotype:** Specimen Nr. IGML 60 (coll. D. KORN et al. 1994), Instituto Geológico e Mineiro, Lisboa.

**Type locality and horizon:** Praia das Quebradas; bed 225, R2c1 Zone.

**Material:** 14 three-dimensionally preserved specimens between 6 and 50mm diameter, preserved in bituminous limestone lenses. The majority are fragments, but some are almost complete conchs, displaying ornament and suture lines.



**Species diagnosis:** *Stenoglyphyrites* with pachyconic conch (ww/dm = 0.75 at 15mm diameter and 0.65 at 30mm diameter) and narrow umbilicus (uw/dm = 0.15 to 0.20). Umbilical margin slightly angular. Ornamentation with slightly biconvex, fine and lamellose growth lines. Suture line with very moderately wide ventral lobe (EL/H = 1.20; 1.40 of adventive lobe) and moderate median saddle (0.40 of ventrolateral saddle).

**Conch form:** The cross section (IGML 88) shows an evolute juvenile form up to about 2.5mm diameter, where the conch is serpenticonic with semilunatic whorl section. At this diameter, the umbilicus is relatively widest. In later stages, the umbilicus opens slowly, in contrast to the whorl width which leads to a globular conch form at 8mm diameter. In the adult conch, the whorl height increases, and, at 24mm diameter, the conch is pachyconic.

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
HT IGML 60	27.0	17.9	13.2	4.7	0.66	0.49	0.17
PT IGML 61	15.3	11.4	7.5	2.5	0.75	0.49	0.16
PT IGML 88	24.0	15.8	11.4	3.9	0.66	0.48	0.16
	13.2	10.7	6.1	2.4	0.81	0.46	0.18
	7.5	6.9	3.4	1.9	0.89	0.45	0.25
	4.5	4.0	1.7	1.6	0.89	0.38	0.36
	2.8	2.1	0.9	1.2	0.75	0.32	0.43

**Ornamentation:** The shell appears to be almost completely smooth. On the holotype, lamellar but very fine growth lines occur at 27mm diameter. They run biconvex and slightly rursiradiate, with a low ventrolateral projection and rather deep ventral sinus. The internal mould is almost smooth, without constrictions.

**Suture line:** The inner whorls of specimen IGML 59 display the suture line, when the whorl width is approxi-

mately 8mm. At this stage, ventral and adventive lobes are pointed.

#### Sutural ratios:

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
IGML 59		c.8		0.40	1.20	0.79	0.83

**Comparisons:** *Stenoglyphyrites cinereus* is among the stratigraphically youngest species of the genus. It differs from *St. sakmarensis* RUZHNEV & BOGOSLOVSKAYA 1978, from the Nm2c2 Zone (equivalent to the G1 Zone), by the wider umbilicus (uw/dm = 0.18 in *St. cinereus* and 0.12 in *St. sakmarensis*), and by the fact that the prongs of the ventral lobe are pointed in the first species. Of the other Uralian species, only *St. superincisus* RUZHNEV & BOGOSLOVSKAYA 1978 shows a ventral lobe with almost parallel sides as in *St. cinereus*, but is different in possessing a much narrower umbilicus (uw/dm = 0.18 at 18mm diameter, compared with 0.27 in *St. cinereus*).

**Stratigraphical and geographical distribution:** All the specimens derive from the horizon of *Bilinguites metabilinguis* (bed 225, R2c1 Zone) within the Quebradas Formation, and were found in the Praia das Quebradas section, Southwest Portugal.

#### Family Neoglyphioceratidae PLUMMER & SCOTT 1937

##### *Neoglyphioceras* BRÜNING 1923

##### *Neoglyphioceras spirale* (PHILLIPS 1841)

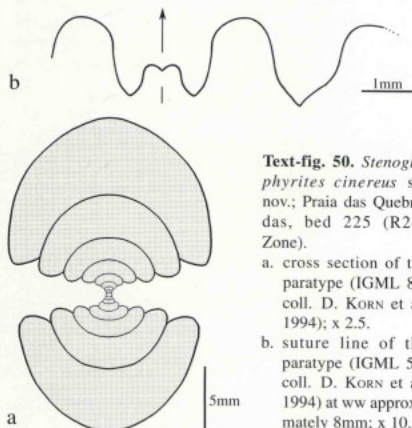
Pl.8 Figs.5, 6

- 1841 *Goniatites spiralis* PHILLIPS: 121, pl.50 Fig.233.  
 1923 *Lusitanoceras algarviensis* PEREIRA DE SOUSA: 304, pl.9 fig.6 [only]  
 1924 *Lusitanoceras algarviensis* PEREIRA DE SOUSA: 48, pl.2 fig.6 [only]  
 1979 *Neoglyphioceras spirale*.- OLIVEIRA, HORN & PAPROTCH: 158, pl.3 fig.1.  
 1988 *Neoglyphioceras spirale*.- KORN: 157, pl.52 fig.1-7. [for more synonymy]

**Neotype:** Specimen Nr. c1640 (coll. LEE), British Museum (Natural History), London.

**Type locality and horizon:** Bampton (Devonshire, Great Britain); probably P1d Zone.

**Material:** One limonitic, fragmentary specimen from Rocha da Lagoa, and crushed remains of about 20 specimens from bed 143 of the Praia de Murraça. The best preserved specimen (IGML 388) shows 55 spiral lines at 20mm diameter. The umbilicus in this stage is very small, being about 0.12 of the conch diameter. In all these characters, the specimen compares well with the better preserved material from Ireland and the Rhenish Massif.



**Text-fig. 50.** *Stenoglyphyrites cinereus* sp. nov.; Praia das Quebradas, bed 225 (R2c1 Zone).

- a. cross section of the paratype (IGML 88, coll. D. KORN et al. 1994; x 2.5).  
 b. suture line of the paratype (IGML 59, coll. D. KORN et al. 1994) at ww approximately 8mm; x 10.



About 10 fragments are available from Maria Serrão, and one natural mould of a rather globose specimen (questionable determination) from the Monte da Nora das Árvores section (IGML 180).

More specimens derive from the Mértola region. One natural mould comes from Pomarão, and another one from 600m south of Barrada near Martim Longo (IGML 312, figured in PEREIRA DE SOUSA 1923, 1924). This is of a very narrowly umbilicated conch, showing 25 spiral lines from umbilicus to midventer. Shell constrictions are strongest on the flanks.

**Stratigraphical and geographical distribution:** The species is a good index fossil because it is restricted to only one zone (*spirale* Zone = lower part of the P1d Zone). It is widely distributed in Europe: Great Britain (Devonshire, Lancashire), Ireland (Co. Leitrim), Germany (Rhinish Massif, Harz Mountains), Czech Republic (North Moravia), and South Portugal. In the Praia de Murração, *Neoglyphioceras spirale* occurs together with *Hibernioceras* sp., indicating that the stratigraphical distribution is the same as in Central and Northwestern Europe.

#### *Lusitanites* RUZHENCEV & BOGOSLOVSKAYA 1971

##### *Lusitanites clitheroensis* KORN 1988

Pl. 8 Figs. 10, 11

- 1914 *Goniatis subcircularis*. - PRUVOST: 19, text-fig. 2.  
 1978 *Goniatis subcircularis*. - PERDIGÃO: 387, pl. 3 fig. 2.  
 1983 *Lusitanites subcircularis*. - WAGNER-GENTIS in OLIVEIRA & WAGNER-GENTIS: 25, pl. 7 fig. 5.6.  
 1985 *Lusitanites subcircularis*. - OLIVEIRA: 30 [*Lusitanites* in text-fig. 12].  
 1985 *Lusitanites* cf. *benziregensis*. - OLIVEIRA, HORN, KULLMANN & PAPROTH: 112 [*Lusitanites* in text-fig. 3].  
 1985 *Lusitanites* ex gr. *subcircularis*. - OLIVEIRA, HORN, KULLMANN & PAPROTH: 113, text-fig. 4.  
 1988 *Lusitanites clitheroensis* KORN: 164, pl. 57 fig. 7-9.  
 1990 *Lusitanites* OLIVEIRA: 342, text-fig. 5.

**Holotype:** Specimen Nr. 906-11 (coll. Moore), Institut und Museum für Geologie und Paläontologie, Göttingen.

**Type locality and horizon:** Dinckley near Clitheroe (Lancashire, Great Britain); most probably P2 Zone.

**Material:** A total of 34 specimens; they derive from bed 146 of the Praia das Quebradas (11 specimens), bed 161 of the Praia de Murração (22 specimens; IGML 245, 265, 295), and from the Rocha da Lagoa section (1 specimen; IGML 328). All but the last specimen originate from the same thin marly horizon which contains numerous individuals of this species. Preservation is bad without remains of the shell wall because of dissolution and lateral distortion, hence the ornament is not preserved in the ma-

terial. According to the internal mould, 30 to 35 spiral lines are present which are arranged in regular distances. The internal moulds show four to five constrictions which are strongest in the midflank area. Two questionable, crushed specimens are available from Dogueno.

**Species diagnosis:** *Lusitanites* with discoidal conch at 20mm dm (ww/dm = 0.40). Umbilicus very narrow (uw/dm = 0.15), umbilical margin rounded. Ornamentation with 30 to 35 spiral lines, internal mould with four or five slightly projected constrictions. Suture line with moderate, V-shaped ventral lobe (EL/H = 0.65; 1.00 of adventive lobe) and moderately low median saddle (0.25 of ventrolateral saddle).

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 245	23.4	8.4	11.3	3.7	0.36	0.48	0.16
IGML 265	19.7		9.5	3.0		0.48	0.15
IGML 295	18.4		9.6	2.7		0.52	0.15

**Remarks:** Although all the available specimens are distorted, the characteristic features of the species are recognizable. These are the low number of spiral lines (30 to 35, compared with *Lusitanites circularis* KORN 1988 with more than 50 spirals), the slight projection of the constrictions, and the umbilical width of 0.15. The latter feature distinguishes *Lusitanites clitheroensis* KORN 1988 from the species *L. zousanensis* (DOLLÉ 1912), *L. benziregensis* (PAREYN 1961), *L. concavus* RUZHENCEV & BOGOSLOVSKAYA 1971, and *L. multicavus* RUZHENCEV & BOGOSLOVSKAYA 1971, which have a narrower umbilicus (uw/dm constantly about 0.10). Finally, *L. subcircularis* (MILLER 1889) displays a wider umbilicus (uw/dm = 0.20).

**Stratigraphical and geographical distribution:** Late Viséan (most probably P2 Zone) of Great Britain (Lancashire) and South Portugal. In the Quebradas and Murração sections the species occurs 2.20m below the horizon with *Lusitanoceras algarviense*, and in the Rocha da Lagoa section, the distance between the two horizons is 1.20m.

Superfamily **Neodimorphocerataceae** FURNISH & KNAPP 1966

Family **Ramositidae** RUZHENCEV & BOGOSLOVSKAYA 1969

#### *Ramosites* RUZHENCEV & BOGOSLOVSKAYA 1969

##### *Ramosites quebradas* sp. nov.

Pl. 9 Figs. 1, 2; Text-fig. 51

**Holotype:** Specimen Nr. IGML 41 (coll. D. KORN & K. HORN 1995), Instituto Geológico e Mineiro, Lisboa.

**Type locality and horizon:** Praia das Quebradas; bed 214, R1c Zone.

**Material:** Five (and one questionable) specimens between 20 and 75mm diameter from the type locality. They are well preserved in limestone as phragmocones with few shell remains, displaying the suture lines as well as ornamentation.

**Species diagnosis:** *Ramosites* with thickly discoidal conch (ww/dm about 0.55) and very narrow umbilicus (uw/dm = 0.10). Umbilical margin in preadult specimens slightly angular. Ornamentation with slightly biconvex riblets which split dichotomously in the inner midflank area, ventrolateral projection moderately high. Suture line with very wide ventral lobe (1.95 of adventive lobe) and moderately high median saddle (0.55 of ventrolateral saddle).

**Conch form:** At 20mm dm (holotype IGML 41), the conch is thickly discoidal (ww/dm = 0.56) with broadly rounded venter. The whorl is broadest at the umbilical margin, which is slightly angular, and the umbilical wall is steep. The umbilicus is only a little wider than one tenth of the diameter.

In a questionable specimen of about 30mm dm (IGML 3), the conch is slightly flattened (ww/dm = 0.5), with the flanks converging to the narrowly rounded venter. The umbilical margin is rounded, and the umbilical wall less steep than in the holotype. The umbilicus is minute, only about 0.05 of the conch diameter.

#### Dimensions in mm and ratios:

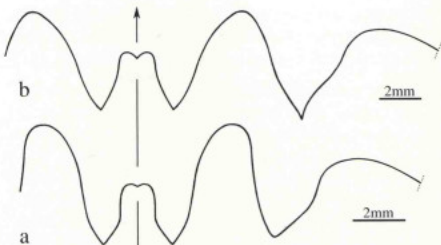
	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 3	c.27	14.1	16.2	c.1.5	c 0.52	c 0.60	c.0.06
HT IGML 41	21.1	11.9	11.0	2.4	0.56	0.52	0.11

**Ornamentation:** The inner whorls of specimen IGML 15 display, at 8mm diameter, slightly projecting riblets. These only sometimes dichotomize on the flanks.

The holotype best displays the ornament at 20mm diameter, where it consists of riblets which dichotomize in the inner midflank area. On the venter, they stand at distances of 0.8mm and are separated by narrower grooves, showing a steep apical and shallow ventral side. The riblets run in a rectiradial direction with a biconvex course. The dorsolateral projection, the lateral sinus as well as the ventrolateral projection are barely visible, but the external sinus is prominent. On the internal mould, the riblets are visible as rounded undulations.

The larger specimen IGML 3 shows the same ornament at 30mm diameter, but the course is much more biconvex, with a prominent ventrolateral projection. Because of the different ornament, it cannot be assigned to *R. quebradas* with certainty.

**Suture line:** At 19mm diameter (holotype IGML 41), the ventral lobe is Y-shaped with a width of 1.95 of the adventive lobe. It has lanceolate, symmetric branches. The median saddle is exactly half as high as the asymmetric and broadly rounded ventrolateral saddle.



**Text-fig. 51.** Suture lines of *Ramosites quebradas* sp. nov.; Praia das Quebradas, bed 214 (R1c Zone).

a. holotype (IGML 41, coll. D. KORN et al. 1994) at dm 18.9mm, ww 10.7mm, wh 10.3mm; x 5.

b. questionable specimen (IGML 3, coll. D. KORN et al. 1994) at ww 12.6mm, wh 14.5mm; x 4

At about 25mm diameter (larger specimen IGML 3), the ventral lobe is V-shaped with a width of 1.90 of the adventive lobe. The branches are also V-shaped and symmetric, and the median saddle exceeds  $\frac{1}{2}$  the height of the slightly asymmetric and narrowly rounded ventrolateral saddle. This questionable specimen shows wider sutural elements, relative to the height of the saddles, and differs in this character from the holotype..

#### Sutural ratios:

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
IGML 3	12.6	14.5	0.58	1.28	0.71	0.67	
HT IGML 41	18.9	10.7	10.3	0.51	0.94	0.52	0.48

**Remarks:** *Ramosites divaricatus* (HIND 1905) is a problematic species because it has never been strictly revised since its original description. The specimen figured by HIND (1905, pl.6 Fig.16) comes from Foynes Ireland (Co. Limerick), probably from the R1 Zone. It is a specimen of 21mm diameter, displaying only the ornament but no suture line. The ornament shows a prominent ventrolateral projection of the riblets, much stronger than in *R. quebradas*. Later, BISAT (1924) figured two specimens from the „Bullion Bed of the Lower Coal Measures of Lancashire“ (*Gastrioceras listeri* beds) as „*Homocera-toides divaricatus* mut  $\theta^*$ “ (Pl.I fig.4) and „mut  $\beta^*$ “ (Pl.III Fig.9,10). These specimens display a broader ventral lobe (more than 2.20 of the adventive lobe) than the other, stratigraphically older *Ramosites* species, and are here placed within the new species *Ramosites sousai* sp. nov.

**Comparisons:** *R. divaricatus* (HIND 1905) has, at the same diameter, a much more pronounced ventrolateral projection of the riblets, and at about 20mm diameter an um-



bilicus that is twice as wide as in *R. quebradas*. *R. fortelirifer* RAMSBOTTOM 1958 from the R2 Zone has, at a comparable growth stage, a much wider umbilicus.

Of the species described by RUZHENCEV & BOGOSLOVSKAYA (1978), only *Ramosites magnus* RUZHENCEV & BOGOSLOVSKAYA 1978 displays an ornament which, in its strength, is comparable with that of *R. quebradas*. Furthermore, *R. corpulentus* RUZHENCEV & BOGOSLOVSKAYA 1969, *R. ramosus* RUZHENCEV & BOGOSLOVSKAYA 1969, *R. subtilis* RUZHENCEV & BOGOSLOVSKAYA 1978, and *R. rectus* RUZHENCEV & BOGOSLOVSKAYA 1978 have a much narrower ventral lobe. *R. erectus* RUZHENCEV & BOGOSLOVSKAYA 1978, *R. brevisellatus* RUZHENCEV & BOGOSLOVSKAYA 1978, *R. schartymensis* (LIBROVITCH 1939), and *R. praesagus* RUZHENCEV & BOGOSLOVSKAYA 1978 display, in contrast to *R. quebradas*, very asymmetric branches of the ventral lobe. *R. magnus*, however, is similar but has a pronounced umbilical margin and a vertical umbilical wall not known in *R. quebradas*.

**Stratigraphical and geographical distribution:** Quebradas Formation (upper *Reticuloceras*-Stufe, R1c) of South-western Portugal.

### *Ramosites sousai* sp. nov.

Pl.9 Figs.3-5

- 1924 *Homoceratoides divaricatus* mut.  $\theta$  BISAT: pl.1 fig.4.  
 1924 *Homoceratoides divaricatus* mut.  $\beta$  BISAT: pl.10 fig.9,10.  
 1979 *Homoceratoides divaricatus*.- OLIVEIRA, HORN & PAPROTH: 160, pl.4 fig.3.

**Holotype:** Specimen Nr. IGML 219 (coll. F.L. PEREIRA DE SOUSA 1919), Instituto Geológico e Mineiro, Lisboa.

**Type locality and horizon:** 300m west of Choça near São Marcos da Serra; most probably G1 or lower G2 Zone.

**Material:** Five specimens, of which two are almost complete conchs of 14 resp. 34mm diameter. The largest one, the holotype, is a slightly distorted specimen. Additionally, three fragments are available from Vale Figueiras (IGML 167) as well as Maria Serrão, and one well preserved natural mould of a immature individual from Eira Velha (IGML 228).

**Species diagnosis:** *Ramosites* with thickly discoidal conch (ww/dm about 0.45) and very narrow umbilicus (uw/dm = 0.1 in earlier stages and 0.05 in later stages). Umbilical margin in preadult specimens slightly angular. Ornamentation with strongly biconvex riblets which split dichotomously in the inner midflank area, ventrolateral projection high. Suture line with very wide ventral lobe (2.25 of adventive lobe) and moderately high median saddle (0.55 of ventrolateral saddle).

**Conch form:** In all stages, the conch has a similar form. At 13mm diameter (paratype IGML 228), it is already

lenticular with very narrow umbilicus. In the holotype (IGML 219), at 34mm diameter, the umbilicus is less than one tenth of the diameter, the flanks converge towards a narrowly rounded venter.

### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
HT IGML 219	34	15	19.5	2.8	0.44	0.57	0.08
PT IGML 228	13.6		7.4	1.6		0.54	0.12

**Ornamentation:** Remarkable for the material is the comparatively high ventrolateral projection of the riblets, even in a specimen of 13mm diameter (IGML 228). The adult holotype (IGML 219) displays a prominent ventrolateral projection and an even more prominent external sinus of the riblets. In their strength and formation they resemble those in *Ramosites quebradas*.

**Suture line:** Except for some fragments in IGML 167, not seen in the Portuguese material. BISAT's (1924, pl.10 fig.10) sutural drawing of his „mut.  $\beta$ “ shows an extremely wide external lobe, and a lanceolate adventive lobe.

**Remarks:** The two variants described by BISAT (1924) are insufficiently figured, hence assignment to the species newly described here is based on the combination of his photograph (of mut.  $\theta$ ) and sutural drawing (of mut.  $\beta$ ). The dorsal outline he figured in pl.10 fig.9 shows a tectiform venter, which is, however, not known from any species of *Ramosites*, and may be an error.

**Comparisons:** *Ramosites sousai* is distinguished from most of the other species of the genus by its pronounced ventrolateral sinus of the riblets, being the main difference to the older *R. quebradas* and all the species described by RUZHENCEV & BOGOSLOVSKAYA (1978), except for *R. schartymensis*. This species, however, has an umbilicus that is almost twice as wide as in *R. sousai*.

**Stratigraphical and geographical distribution:** Latest Namurian G1 Zone and Westphalian A of South Portugal (Quebradas Formation and Brejeira Formation), and Great Britain (Lancashire).

### *Ramosites* sp. 1

Pl.9 Fig.6

- 1979 *Homoceras beyrichianum*.- OLIVEIRA, HORN & PAPROTH: 159, pl.3 fig.3.

**Material:** One completely crushed specimen of about 20mm diameter from the Brejeira Formation (R1a Zone) of the old quarry 3km south of Nave Redonda. It displays strongly arched riblets and a very narrow umbilicus, hence close affinities to *Ramosites divaricatus* (HIND 1905). Specific determination, however, is impossible with such a material.



Superfamily **Gastriocerataceae** HYATT 1884  
Family **Homoceratidae** SPATH 1934

**Homoceras** HYATT 1884

**Homoceras mnemancestralis** sp. nov.

Pl. 9 Fig. 7; Text-fig. 52

**Holotype:** Specimen Nr. IGML 2 (coll. D. KORN et al. 1994), Instituto Geológico e Mineiro, Lisboa.

**Type locality and horizon:** Praia das Quebradas; bed 214, R1c Zone.

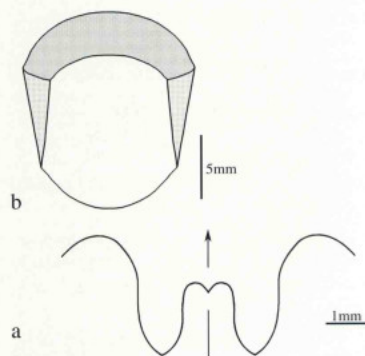
**Material:** Only the holotype. It is a specimen of 17mm diameter, preserved in limestone and showing shell ornament as well as parts the suture line.

**Species diagnosis:** *Homoceras* with pachyconic conch at 15mm dm ( $ww/dm = 0.82$ ), and moderately wide umbilicus ( $uw/dm = 0.42$ ). Umbilical margin angular with noded rim. Ornamentation with extremely fine, almost linear growth lines. Suture line with wide external lobe ( $EL/h = 1.15$ ) and moderately high median saddle (0.60 of ventrolateral saddle). Branches of the external lobe symmetric and lanceolate.

**Conch form:** At 17mm diameter the pachyconic conch is coronate with broad, regularly rounded venter and angular umbilical margin which is supported by a rim. Umbilical wall very steep.

**Dimensions in mm and ratios:**

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
HT IGML 2	16.1	13.2	5.4	6.8	0.82	0.34	0.42



**Text-fig. 52.** *Homoceras mnemancestralis* sp. nov.; holotype (IGML 2, coll. D. KORN et al. 1994), Praia das Quebradas, bed 214 (R1c Zone).

- a. suture line of the at  $ww$  10.0mm,  $wh$  3.2mm; x 8.  
b. dorsal outline, x 2.5.

**Ornamentation:** Extremely delicate transverse lines are visible. They have a slightly prorsiradial direction and run almost straight, with a very shallow projection over flanks and venter.

**Suture line:** Only the ventral part can be examined in the holotype. It shows a broad external lobe with symmetric, lanceolate and pointed branches. The median saddle is moderately high, 0.60 of the broadly rounded ventrolateral saddle.

**Sutural ratios:**

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
HT IGML 2	10.0	3.2	0.61	1.16	c.0.70		

**Comparisons:** *H. mnemancestralis* is clearly distinguished from the other known species of *Homoceras* by its extremely delicate growth lines, in contrast to all other species which show coarse transverse ornament in a comparable growth stage. Similar species are *H. coronatum* (HAUG 1898) and *H. haugi* RUZHENCEV & BOGOSLOVSKAYA 1978, but additionally to the coarser ornament, these species show asymmetric branches of the external lobe.

**Stratigraphical and geographical distribution:** *H. mnemancestralis* is the stratigraphically youngest known species of *Homoceras*. It occurs in the Quebradas Formation (R1c Zone) of Southwestern Portugal.

**Homoceras (?) sp. 1**

**Material:** Only one crushed specimen (IGML 182) of 20mm diameter from the Quebradas Formation near the Praia de Murração can be studied. It shows an almost punctiform umbilicus, and dense undichotomizing riblets which run with a convex course over the flanks.

**Aljezurites** gen. nov.

**Type species:** *Aljezurites katharinae* sp. nov.

**Genus definition:** Genus of the family Homoceratidae with small pachyconic conch, and a rim-formed, noded umbilical margin. Umbilicus moderately wide. Juveniles up to 12mm diameter with midventral groove. Ornamentation with concave-convex riblets which dichotomize near the umbilicus. Suture line with very wide external lobe and high median saddle. Branches of the external lobe asymmetric and ventrally pouched.

**Generic composition:** Only the type species.

**Comparisons:** *Aljezurites* gen. nov. possesses a morphology that is comparable to two other known genera of the family Homoceratidae, *Umbetoceras* RUZHENCEV & BOGOSLOVSKAYA 1971, and *Bogdanoceras* RUZHENCEV & BOGOSLOVSKAYA 1971. *Umbetoceras*, which is known from the

Nm2b3 and Nm2c2 Zones of the South Urals and Central Asia, has a similar conch morphology with a midventral groove, but does not display dichotomizing ribs such as in gen. nov. *Bogdanoceras*, known from the Nm2b1 Zone of the South Urals, bears dichotomizing ribs but, in contrast to *Aljezurites*, possesses two ventral grooves, and a suture line with a much narrower external lobe.

**Stratigraphical and geographical distribution:** Upper *Reticuloceras*-Stufe (R1c Zone) of Southwestern Portugal.

*Aljezurites katharinae* sp. nov.

Pl.9 Fig.8; Text-fig.53

**Holotype:** Specimen Nr. IGML 1 (coll. D. KORN et al. 1994), Instituto Geológico e Mineiro, Lisboa.

**Type locality and horizon:** Praia das Quebradas; bed 214, R1c Zone.

**Material:** Two almost complete specimens between 20 and 25mm diameter and two fragments from the type locality. They are preserved in limestone as phragmocones with very few shell wall remains, and display the suture lines as well as some of the ornament features.

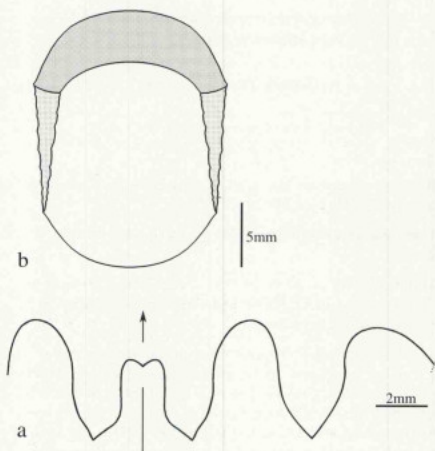
**Species diagnosis:** *Aljezurites* with pachyconic conch at 21mm dm (ww/dm = 0.70); umbilicus moderately wide (uw/dm = 0.40). Umbilical margin angular with noded rim. Juveniles up to 12mm diameter with midventral groove. Ornament of concave-convex riblets which dichotomize near the umbilicus. Suture line with very wide external lobe (EL/h = 1.15; 1.75 of adventive lobe) and high median saddle (0.65 of ventrolateral saddle). Branches of the external lobe asymmetric and ventrally pouched.

**Conch form:** At a diameter of 20mm, the coronate conch is pachyconic (ww/dm = 0.70) with a broadly rounded venter and a moderately wide umbilicus (uw/dm = 0.40). The conch is broadest at the angular umbilical margin, and the umbilical wall that bears a pronounced rim is almost vertical.

**Dimensions in mm and ratios:**

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
HT IGML 1	21.0	14.4	6.7	8.2	0.69	0.32	0.39

**Ornamentation:** The ornament of the holotype consists of concave-convex riblets which on the venter stand at distances of 0.6mm. They appear at distances of 0.5mm from the umbilical rim, where they are strongest, and then dichotomize 2mm further towards the venter. The general direction in which the riblets run is rectiradial, with a shallow and broad ventrolateral projection and a chevron-like ventral sinus. In longitudinal section, they show an imbricate pattern with steep apical and shallow apertural side. The angular umbilical margin is supported by 20 spiny nodes. Up to a diameter of about 16mm, this specimen shows a midventral groove, which is caused by



**Text-fig. 53.** *Aljezurites katharinae* sp. nov.; Praia das Quebradas, bed 214 (R1c Zone).

- a. suture line of the paratype (IGML 36, coll. D. KORN et al. 1994) at wh 7.4mm; x 5.  
b. dorsal outline of the holotype (IGML 1, coll. D. KORN et al. 1994); x 2.5.

an internal shell thickening. This groove suddenly weakens and is then, for another third of a volution, only barely visible. The internal mould is covered by impressions of the riblets, that display an undulating pattern.

**Suture line:** A complete outer suture line could be drawn from the fragmentary paratype IGML 36. Here, at 7.4mm whorl height, the external lobe is Y-shaped and 2.2 times as wide (wl/hl = 1.13) as the symmetric, lanceolate adventive lobe. The ventral branches of the external lobe are also symmetric and lanceolate. The broadly rounded ventrolateral saddle is almost symmetric.

In the holotype, at 4.1mm whorl height, the branches of the external lobe are much more asymmetric and ventrally pouched, with a steep dorsal flank.

**Sutural ratios:**

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
PT IGML 36			7.4	0.67	1.13	0.53	0.52

**Comparisons:** There are no species in the Namurian of Central and Western Europe, which are similar to *Aljezurites katharinae*. Only the Asian *Umbetoceras kurulicum* RUZHENCEV & BOGOSLOVSKAYA 1978 has a similar conch and ornamentation, but in this species the ribs are not



dichotomizing. *Bogdanoceras bifurcatum* RUZHENCEV & BOGOSLOVSKAYA 1971 is also rather similar, but possesses two ventral grooves, and a much narrower external lobe (only 1.50 of adventive lobe, compared with 2.20 in *Aljezurites katharinae*).

**Stratigraphical and geographical distribution:** Quebradas Formation (R1c Zone) of Southwestern Portugal.

*Vallites* RUZHENCEV & BOGOSLOVSKAYA 1971

*Vallites kullmanni* sp. nov.

Pl.9 Figs.9-11; Text-fig.54

1979 *Homoceras henkei*- OLIVEIRA, HORN & PAPROTH: 159 [pt.].

**Holotype:** Specimen Nr. IGML 254 (coll. M. HORN et al. 1982), Instituto Geológico e Mineiro, Lisboa.

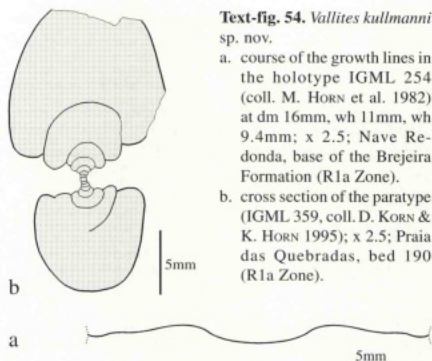
**Type locality and horizon:** Old quarry 3km south of Nave Redonda; base of the Brejeira Formation (most probably R1a Zone).

**Material:** A rich collection of about 115 three-dimensionally preserved individuals is available for study. 5 silicified specimens derive from the type locality Nave Redonda (IGML 254), accompanied by a series of completely crushed material from this locality, of which species assignment is uncertain. 32 specimens between 7 and 22mm diameter from bed 190 of the Praia das Quebradas (IGML 73, 78, 359, 360) are preserved in bituminous limestone nodules, allowing observation of the ornament ontogeny.

The other specimens are natural moulds in decalcified nodules. They were collected at Porto da Silva (4 specimens; IGML 138), south of Monte Coelho (11 specimens; IGML 148, 159), Barranco (20 specimens), Murração Velho (20 specimens; IGML 143, 151, 152), bed 102 of the Praia das Quebradas gorge section (20 specimens), from near the Praia de Murração (1 specimen), and 200m south of Monte Gavianito (3 specimens). In these specimens, the shell ornament is excellently preserved.

**Species diagnosis:** *Vallites* with pachyconic conch at 12mm diameter ( $ww/dm = 0.70$ ), and thickly discoidal conch ( $ww/dm$  about 0.60) at 25mm diameter. Umbilicus very narrow ( $uw/dm = 0.15$ ), umbilical margin slightly angular. Ornamentation with slightly biconvex, coarse and roughened growth lines, which are a little strengthened on the umbilical margin.

**Conch form:** The cross section (IGML 359) shows a distorted specimen, but the general conch morphology can be studied [The dimensions in the list below are, because of distortion of the specimen, mainly approximated]. The inner whorls up to 3mm diameter are evolute, and between 3 and 10mm diameter they have an almost circular section. Later in ontogeny, the whorl height increases faster, and the conch is thickly discoidal. The umbilical margin is rounded and does not show a rim.



**Text-fig. 54.** *Vallites kullmanni* sp. nov.

- a. course of the growth lines in the holotype IGML 254 (coll. M. HORN et al. 1982) at dm 16mm, wh 11mm, wh 9.4mm; x 2.5; Nave Redonda, base of the Brejeira Formation (R1a Zone).  
b. cross section of the paratype (IGML 359, coll. D. KORN & K. HORN 1995); x 2.5; Praia das Quebradas, bed 190 (R1a Zone).

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
HT IGML 254	18.2	12.4	9.3	2.9	0.68	0.51	0.16
PT IGML 151	16.1	10.6	8.2	2.7	0.66	0.51	0.17
PT IGML 78	13.1	9.1	6.8	2.0	0.69	0.52	0.15
PT IGML 360	8.1	5.3	3.6	2.1	0.65	0.44	0.26
PT IGML 152	6.4	4.7	2.8	2.0	0.73	0.44	0.31
PT IGML 359	22.5	11.8	11.6	3.2	0.52	0.52	0.14
	9.9	6.2	4.9	1.9	0.63	0.49	0.19
	5.0	3.1	2.0	1.7	0.62	0.40	0.34
	3.0	1.8	1.1	1.3	0.60	0.37	0.43

**Ornamentation:** The well preserved juvenile specimen IGML 360 displays the ornament from 5 to 8mm diameter. Coarse growth lines run almost straight over flanks and venter, and only a very shallow ventral sinus is visible. The internal mould has an undulating surface caused by impressions of the growth lines. Rather strong constrictions arranged at 90° apart are present.

These constrictions are weaker at 13mm diameter (specimen IGML 78), and then disappear. Well preserved natural moulds (IGML 138, 143) of 13mm diameter excellently display the shell ornament. Coarse growth lines which run almost linearly over flanks and venter are present. On the venter, they are spaced in distances of 0.5mm. An umbilical rim is barely visible.

In the largest specimens (IGML 254, 73), the shell ornament consists of coarse, slightly roughened growth lines spaced at varying distances, averaging 0.5mm in the middle of the venter. On the umbilical margin, the growth lines form a concave arch, and on the inner flank area a low projection. The lateral sinus is very shallow, and the ventrolateral projection is inconspicuous. The main element in the course of the growth lines is the ventral sinus. None of the specimens displays spiral ornament.



**Comparisons:** *Vallites kullmanni* is distinguished from *V. henkei* (SCHMIDT 1925) by several characters: (1) the umbilical rim is much more pronounced in the second species, (2) the ventrolateral projection in *V. henkei* is stronger than in *Vallites kullmanni*, (3) the umbilicus is slightly wider in *V. henkei* (ratio  $uw/dm = 0.20$  at 18mm diameter, compared with 0.16 in *Vallites kullmanni*), and (4) *Vallites kullmanni* in the juvenile stage possesses strong constrictions of the internal mould.

Within the genus *Vallites*, *V. henkei* and *Vallites kullmanni* are the species with the coarsest ornament, providing a character for a separation of these species from *V. schmidtii* RUZHENCEV & BOGOSLOVSKAYA 1971.

**Stratigraphical and geographical distribution:** *Vallites kullmanni* occurs in South Portugal in localities in the Bordeira and Aljezur Antiforms in a monospecific fauna (Quebradas Formation), and in localities near the Monchique syncline complex (Brejeira Formation) in company with *Homoceratoides svetlanae* sp. nov. Thus, the stratigraphical age can be stated as most probably the base of the *Reticuloceras* Stufe (R1a Zone).

***Vallites striolatus* (PHILLIPS 1836)**

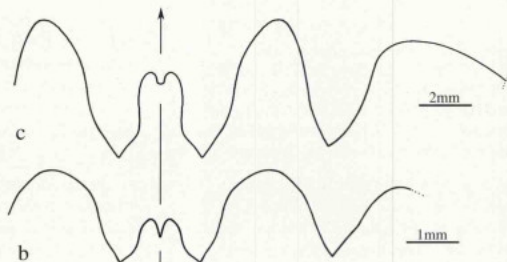
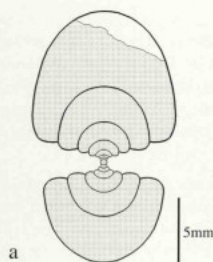
Pl.10 Figs.1-5; Text-fig.55

1836 *Goniatis striolatus* PHILLIPS: 234, pl.19 fig.14-19.

1943 *Homoceras striolatum*, BISAT & HUDSON: 407, pl. 27 fig.1 [for more synonymy].

**Lectotype:** The specimen figured by PHILLIPS 1836, pl.19 fig.14 (coll. GIBSON), probably Manchester Museum.

**Type locality and horizon:** High Green Wood, Hebden Bridge (Yorkshire, Great Britain); probably 70 feet below base of Crimsworth Dean Grit (R1c Zone).



**Text-fig. 55.** *Vallites striolatus* (PHILLIPS 1836); Praia das Quebradas, bed 214 (R1c Zone).

a. cross section of specimen IGML 359 (coll. D. KORN & K. HORN 1995); x 2.5;

b. suture line of specimen IGML 26 (coll. D. KORN & K. HORN 1995) at  $ww$  8.3mm; x 10.

c. suture line of specimen IGML 25 (coll. D. KORN & K. HORN 1995) at  $dm$  20.0mm,  $ww$  11.1mm,  $wh$  11.2mm; x 5.

**Material:** 47 specimens between 6 and 55mm diameter from bed 214 of the Praia das Quebradas section. They are preserved in limestone as phragmocones with adhering parts of the body chamber. The ontogenies of suture lines, as well as the ornamentation, can be described from the specimens.

Additionally, one specimen is available from bed 217 of the Praia das Quebradas section, and one mature conch (IGML 220) from 1km northeast of the Estação Saboia. The latter does not display ornament and sutural features, and can thus only insufficiently be determined.

**Species diagnosis:** *Vallites* with pachyconic conch at 15mm  $dm$  ( $ww/dm = 0.65 - 0.70$ ), and thickly discoidal conch ( $ww/dm$  about 0.55) in later stages. Umbilicus very narrow ( $uw/dm = 0.15$  in earlier stages and 0.10 in later stages). Umbilical margin slightly angular. Ornamentation with biconvex, fine growth lines and four to five weak spiral lines on the umbilical margin. Suture line with very wide external lobe (2.35 of adventive lobe) and moderately high median saddle (0.60 of ventrolateral saddle). Branches of the external lobe lanceolate, almost symmetric.

**Conch form:** The cross section (IGML 26) shows that major changes of the conch geometry are not performed during ontogeny. The conch is always pachyconic or thickly discoidal, and only the relative width of the umbilicus decreases during growth. In all stages, the umbilicus is rounded without a rim.

**Dimensions in mm and ratios:**

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 220	52.0	21.6	28.6	4.6	0.42	0.55	0.09
IGML 24	26.7	15.4	14.8	2.7	0.58	0.55	0.10
	16.4	11.0	9.7	2.1	0.67	0.59	0.13
IGML 25	21.6	11.7	11.3	2.0	0.54	0.52	0.09
IGML 26	19.0	10.7	9.9	2.9	0.56	0.52	0.15
	9.7	6.8	4.8	1.8	0.70	0.49	0.19
	5.8	4.1	2.3	1.4	0.71	0.40	0.24
	2.9	2.1	1.1	1.0	0.72	0.38	0.34

**Ornamentation:** Specimen IGML 24 best displays the ornamentation, which in this specimen can be described from three different volutions. In the earliest visible volution (at about 11 mm diameter), the internal mould bears riblet-like undulations caused by coarse growth lines, running with a broad sinus over the venter.

At 17 mm diameter, the shell ornament consists of fine, smooth growth lines with a rectiradiate direction. They form a weak dorsolateral projection, a lateral sinus and a ventrolateral projection, but a broad and deep ventral sinus. The distance of the growth lines is 0.3 mm on the venter. In this stage, four to five spiral lines are present on the umbilical margin, supported by a slight crenulation of the growth lines.

In the adult stage, at 27 mm diameter, the growth lines are more widely spaced, from 0.5 to 0.6 mm. They are strongly biconvex with a prominent ventrolateral projection. In the midflank area, new growth lines are intercalated.

**Suture line:** In the juvenile suture line at 8.3 mm whorl width (IGML 24), the external lobe is wide (2.20 of adventive lobe) and V-shaped with slightly curved flanks of the branches. The median saddle is 0.46 as high as the symmetric, broadly rounded ventrolateral saddle.

At 20 mm diameter (11.1 mm whorl width; IGML 25); the external lobe is even wider (2.35 of the adventive lobe) and now Y-shaped, the ventral branches almost symmetric and lanceolate. The median saddle is here 0.55 of the height of the ventrolateral saddle, which is narrowly rounded and asymmetric. The adventive lobe is V-shaped with steep ventral and shallow, curved dorsal flank.

#### Sutural ratios:

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
IGML 25	20.0	11.1	11.2	0.61	1.05	0.52	0.43
IGML 24		8.3		0.47	1.26	0.94	0.54

**Comparisons:** *Vallites striolatus* is clearly separated from the species *V. henkei* (SCHMIDT 1925), *V. kullmanni* sp. nov., *V. moorei* (BOUCKAERT 1960), and *V. demaneti* (BOUCKAERT & HODSON 1960) [the latter two described from extremely poor, crushed material (see BOUCKAERT 1960), preventing exact separation from *V. henkei*] in the character of the growth lines, which are coarse in the three other species and are much finer in *V. striolatus*. Furthermore, the umbilical rim and the spirals occupying the umbilical margin are less strong in *V. striolatus*.

From *V. schmidtii* RUZHENCEV & BOGOSLOVSKAYA 1971, it differs in the less developed umbilical margin, and the shape of the branches of the external lobe, which are symmetric and lanceolate in *V. striolatus*, but clearly asymmetric in *V. schmidtii*.

**Stratigraphical and geographical distribution:** *Vallites striolatus* belongs to the stratigraphically youngest homoceratids. It occurs in the upper *Reticuloceras*-Stufe (R1c) of Great Britain (Yorkshire, Lancashire, Devonshire), Ireland (Co. Galway, Co. Cork), Belgium, Germany (Rhenish Massif), Czech Republic (North Moravia), and Southwestern Portugal, where it occurs in the Quebradas Formation.

Family **Surenitidae** RUZHENCEV & BOGOSLOVSKAYA  
1975

#### *Marianoceras* LIBROVITZ 1962

##### *Marianoceras hesperium* sp. nov.

PL.10 Figs. 6-8; Text-fig. 56

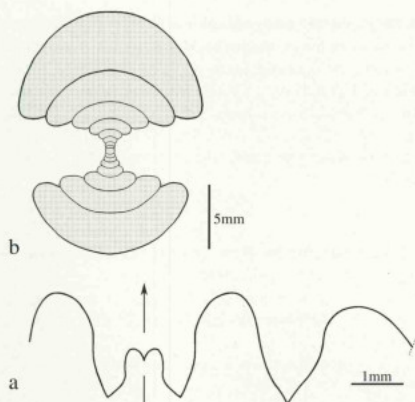
**Holotype:** Specimen Nr. IGML 79 (coll. D. KORN & K. HORN 1995), Instituto Geológico e Mineiro, Lisboa.

**Type locality and horizon:** Praia das Quebradas; bed 222, probably basal R2 Zone.

**Material:** 14 three-dimensionally preserved specimens of 8 to 40 mm diameter from bed 222 of the type locality, displaying the ornament and, in the holotype, the suture line. Additionally, natural moulds in decalcified silicious lenses are available for study. Four derive from near the Praia de Murração (IGML 154), and about 15 from the gorge of the Praia das Quebradas (IGML 145, 146). These specimens, of which latex casts have been manufactured, display excellently the shell ornament.

**Species diagnosis:** *Marianoceras* with globular conch at 12 mm diameter ( $w/dm = 0.90$ ) and moderately wide umbilicus ( $uw/dm = 0.35$ ); pachyconic conch at 25 mm diameter ( $w/dm = 0.75$ ); umbilicus moderately wide ( $uw/dm = 0.30$  to  $0.35$ ). Umbilical margin angular. Ornamentation with coarse biconvex growth lines, without ribs and spiral lines. Suture line with wide external lobe ( $EL/h = 0.95$ ; 1.65 of adventive lobe) and moderate median saddle (0.50 of ventrolateral saddle). Branches of the external lobe asymmetric and ventrally slightly pouched.

**Conch form:** The ontogeny of the conch form is excellently displayed in the paratype IGML 81, where it passes three different stages. The initial one ranges up to about 5 mm diameter, where the evolute conch is serpenticonic with semilunate whorl section. Then, between 5 and 12 mm diameter, the whorl width increases to form a thickly pachyconic conch. It has an open umbilicate form with crescent-shaped whorl section, possessing a very narrow aperture. The adult stage is characterized by a stagnating umbilical opening, and by an increase of apertural height. The umbilical shoulder is narrowly rounded without a distinct margin. In all the growth stages, the venter is broadly rounded.



**Text-fig. 56.** *Marianoceras hesperium* sp. nov.; Praia das Quebradas, bed 222 (probably basal R2 Zone).

- a. suture line of the holotype (IGML 79, coll. D. Korn et al. 1994) at ww 8.8mm, wh 3.6mm; x 10.  
b. cross section of the paratype (IGML 81, coll. D. Korn et al. 1994); x 2.5;

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
HT IGML 79	11.8	11.5	4.8		0.97	0.41	
PT IGML 80	37.6		17.3	11.9		0.46	0.32
PT IGML 81	18.4	13.5	7.9	5.0	0.73	0.43	0.27
		6.9	5.5	2.1	0.80	0.30	0.48
		4.6	2.9	1.3	0.63	0.28	0.54
		3.0	1.6	0.8	0.53	0.27	0.53

**Ornamentation:** From 6 to 12mm diameter, the surface of the internal mould (holotype IGML 79) shows an undulate pattern generated by the growth lines on the shell. Around the umbilicus, faint nodes are preserved.

The shell ornament can best be examined in latex casts of the natural moulds. All the investigated growth stages show a similar ornament, consisting mainly of lamellose growth lines. These run, at 8mm diameter (IGML 145), radially over the flanks, but arch forward to form a pronounced ventrolateral projection and a shallow ventral sinus.

At 12mm diameter (IGML 154), there is also a dorso-lateral projection developed, and all projections and sinuses are of equal prominence. On the venter, the growth lines are spaced at distances of 0.2 to 0.3mm. The only fragmentary preserved largest specimen (on IGML 154) shows at approximately 45mm diameter very fine, rough-

ened growth lines with a well developed dorsolateral projection.

**Suture line:** Characteristic for the suture line is the slightly pouched external lobe with lanceolate and almost symmetric branches. In this respect, it is typical for the Surenitidae.

#### Sutural ratios:

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
LL74		3.6	8.8	0.47	0.94	0.61	0.57

**Comparisons:** *Marianoceras* is currently a monospecific genus. *M. marianum* (DE VERNEUIL 1841) is distinguished from *M. hesperium* by its narrower conch ( $ww/dm = 0.75$  at 15mm diameter in contrast to 0.90 in *M. hesperium*), and the finer growth lines. Additionally, *M. hesperium* possesses weaker umbilical plications than *M. marianum*.

**Stratigraphical and geographical distribution:** Quebradas Formation (probably basal R2 Zone) of Southwest-ern Portugal.

#### Family Reticuloceratidae LIBROVITCH 1957

##### *Reticuloceras* BISAT 1924

##### *Reticuloceras reticulatum* (PHILLIPS 1836)

Pl.10 Fig.11; Pl. 11 Figs.1-4; Text-fig.57

- 1836 *Goniites reticulatum* PHILLIPS: 235, pl.19 fig.26-32.  
1924 *Reticuloceras reticulatum*.- BISAT: 114, pl.4 fig.1,2.  
1943 *Reticuloceras reticulatum*.- BISAT & HUDSON: 411.  
1978 *Reticuloceras reticulatum*.- RUZHENCEV & BOGOSLOVSKAYA: 279, pl.36 fig.7, [for more synonymy]

**Neotype:** Specimen Nr. 62446, Geological Survey Museum, Keyworth, Nottingham; figured by BISAT (1924: pl.4 fig.2) and designated by BISAT & HUDSON (1943: 411).

**Type locality and horizon:** Near Outwood, Crimsworth Dean, Hebden Bridge (Yorkshire, Great Britain); 70 feet below base of Crimsworth Dean Grit (R1c1 Zone).

**Material:** 37 three-dimensionally preserved specimens from bed 214 of the Praia das Quebradas section. Their size is between 6 and approximately 45mm, and most of them are preserved with shell remains, allowing study of ontogenetic development of the ornament.

Two possible, crushed specimens from Monte Tranco 3.5km southeast of Aljezur (IGML 390) display a shell ornament that resembles that of the three-dimensionally preserved specimens.

**Species diagnosis:** *Reticuloceras* with thickly discoidal conch between 12 and 28mm diameter ( $ww/dm = 0.52$  to 0.60), and narrow umbilicus ( $uw/dm = 0.22 - 0.30$ ). Umbilical margin slightly angular, flanks and venter broadly rounded. Ornament-

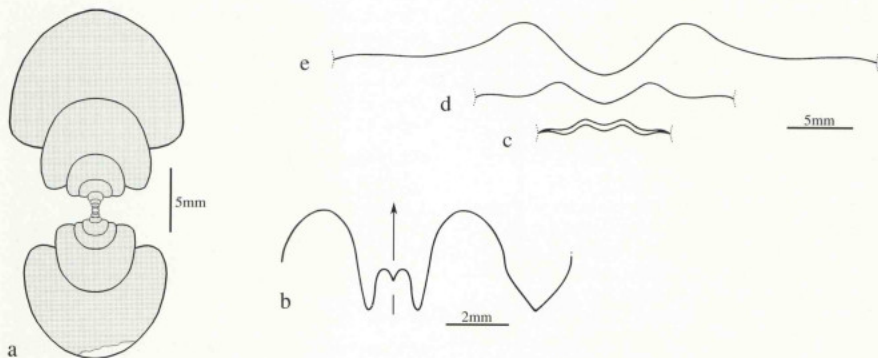


tation at 20mm diameter with coarse fastigate growth lines and coarse spiral lines generating a reticulate pattern. Direction of growth lines prorsiradiate with high ventrolateral projection and deep, chevron-shaped external sinus. Suture line with moderately wide, V-shaped external lobe (EL/h = 0.75) and moderately low median saddle (0.40 of ventrolateral saddle).

**Conch form:** *Reticuloceras reticulatum* is a very variable species, hence it is difficult to present a „typical“ cross section. IGML 51 fairly represents the average of the Portuguese material, but is unique in the character that the umbilicus suddenly opens in the last volution. The inner whorls of the specimen, up to 5mm diameter, are serpenticonic, and later in ontogeny, both whorl height and whorl width increase simultaneously. The umbilical wall and the venter are constantly rounded.

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 10	26.1	14.7	10.5	6.3	0.56	0.40	0.24
	19.8	11.6	8.0	5.7	0.59	0.40	0.29
IGML 9	24.1	13.2	11.0	5.3	0.55	0.46	0.22
IGML 51	26.6	13.6	11.1	7.2	0.51	0.42	0.27
	14.9	8.3	7.1	2.8	0.56	0.48	0.19
	7.4	4.3	3.3	2.1	0.58	0.45	0.28
	4.3	2.5	1.3	1.7	0.58	0.30	0.40
	2.4	1.2	0.7	1.3	0.50	0.29	0.54
IGML 56	18.6	9.1	7.5	5.6	0.49	0.40	0.30
IGML 53	18.2	10.8	9.3	3.8	0.59	0.51	0.21
IGML 54	15.2	8.8	6.8	4.3	0.58	0.45	0.28
IGML 58	12.3	7.4	5.5	2.5	0.60	0.45	0.20
IGML 55	6.7	5.0	2.3	2.8	0.75	0.34	0.42



**Text-fig. 57.** *Reticuloceras reticulatum* (PHILLIPS 1836); Praia das Quebradas, bed 214 (R1c Zone).

a. cross section of specimen IGML 51 (coll. D. KORN et al. 1994); x 2.5.

b. suture line of specimen IGML 10 (coll. D. KORN et al. 1994) at ww 11.0mm, wh 7.9mm; x 6.

c. course of the riblets in specimen IGML 54 (coll. D. KORN & K. HORN 1995) at dm 10.8mm, ww 6.8mm; x 2.5.

d. course of the growth lines in specimen IGML 53 (coll. D. KORN & K. HORN 1995) at dm 18mm, ww 10.6mm; x 2.5.

e. course of the growth lines and a constriction in specimen IGML 10 (coll. D. KORN et al. 1994) at ww 20.0mm, wh 21.6mm; x 2.5.

**Ornamentation:** Specimen IGML 55 shows, at 6mm diameter, faint umbilical plications spaced at two per millimetre. They dichotomize near the umbilicus, causing coarse and roughened growth lines which ventrally are irregularly spaced at distances of 0.4 to 0.6mm. Between the concave-convex growth lines, much finer spiral lines are visible.

At 12mm diameter IGML 58, umbilical plications are barely visible but still dichotomize into roughened and coarse growth lines, which also intercalate in between the plications. The spirals are still much finer and more densely spaced than the concave-convex transversals. Two prominent shell constrictions run parallel to the growth lines.

In specimens larger than 15mm (IGML 53, 54), the spiral ornament becomes more well defined, and at 18mm diameter together with the transversals it generates an almost regular reticulate pattern. In this stage, umbilical plications are barely visible, and roughened growth lines run with a weak dorsolateral projection in a prorsiradiate direction. The ventrolateral projection is pronounced, and the ventral sinus is chevron-shaped and deep (Text-fig. 57d). On the internal mould of specimen IGML 54, five constrictions following the course of the growth lines can be seen.

Adult specimens such as IGML 10 show, at 40 to 50mm diameter, fine and densely spaced growth lines with

a biconvex course, but no spiral ornament. The internal mould bears numerous constrictions which are strongest developed on the venter.

**Suture line:** This has an outline which is remarkable because of its V-shaped external lobe that in other species of *Reticuloceras* is rather parallel-sided (see RUZHNEV & BOGOSLOVSKAYA 1978: 276-282).

#### Sutural ratios:

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
IGML 10	26.1	14.7	10.5	0.41	0.73	0.73	0.66

**Remarks:** The far-reaching variability of *Reticuloceras reticulatum* makes a clear separation with other species of the genus difficult. Determination of singular specimens is sometimes impossible.

BISAT & HUDSON (1943: 411) listed five forms which they placed in *Reticuloceras reticulatum*, being distinguished by conch and ornamental features in specimens of 15mm diameter. This was based on only ten described specimens, which do not allow a decision with certainty if different species are represented here, or if the five morphotypes only result from variability within one species. The „type form“, however, has an umbilicus that is considerably smaller ( $uw/dm = 0.15$ ) than in the Portuguese specimens ( $uw/dm$  is between 0.20 and 0.30). Furthermore, the growth lines are weaker in the „type form“. The forms A and B of BISAT & HUDSON closely resemble the specimens from the Praia das Quebradas, but form A has an almost smooth internal mould, and form B possesses a slightly weaker transverse ornament. Forms C and D do not show distinct spiral ornament and thus are not consistent with the new material.

*Reticuloceras reticulatum* is a species that has been often cited in the literature (see RUZHNEV & BOGOSLOVSKAYA 1978: 279). Some of these citations, however, appear to be very doubtful because of poorly preserved material or lack of a modern description.

**Comparisons:** The small size of most of the *Reticuloceras* species introduced by BISAT & HUDSON (1943) does not allow clear separation of the different species. *R. reticulatum* is characterized by its equally strong developed, coarse transverse and spiral ornament, that distinguishes the species from the co-occurring *R. melanum*, in which the transversals are much finer. A co-occurring form is *R. scapum*, but this has a wider conch and, like *R. melanum*, a rounded ventral sinus of the growth lines, in contrast to *R. reticulatum*, in which the ventral sinus is characteristically chevron-shaped.

**Stratigraphical and geographical distribution:** R1c Zone of Great Britain (Yorkshire, Lancashire, Devonshire), Ireland, Belgium, the Netherlands, Germany (Rhe-

nish Massif), and Ukraine (Donets Basin). Reports from other regions (North Africa, China) are questionable and require confirmation. In South Portugal, the species occurs in the Quebradas Formation.

#### *Reticuloceras melanum* sp. nov.

Pl.11 Figs.5-7; Text-fig.58

**Holotype:** Specimen Nr. IGML 43 (coll. D. KORN & K. HORN 1995), Instituto Geológico e Mineiro, Lisboa.

**Type locality and horizon:** Praia das Quebradas; bed 214, R1c Zone.

**Material:** 17 three-dimensionally preserved specimens from the type horizon. They are between 9 and 42mm in diameter, and usually preserved as internal moulds of the body chamber. Ornamental details are preserved in some of the specimens.

**Species diagnosis:** *Reticuloceras* with thickly discoidal conch between 12 and 28mm diameter ( $ww/dm = 0.48$  to 0.58), and narrow umbilicus ( $uw/dm = 0.22 - 0.30$ ). Umbilical margin slightly angular, flanks and venter broadly rounded. Ornamentation at 20mm diameter with fine and roughened growth lines; spiral lines barely visible. Direction of growth lines prosirradiate, with high ventrolateral projection and deep, rounded external sinus. Suture line with moderately wide external lobe ( $EL/h = 0.75$ ) and moderately low median saddle (0.45 of ventrolateral saddle).

**Conch form:** The extremely evolute, serpenticonic inner whorls can be seen in the cross section (IGML 44) up to 4mm diameter. Then, the whorls become wider, and at 8.5mm diameter, they are relatively widest. The conch is pachyconic in this stage, with a wide umbilicus. Later in ontogeny, at 11mm diameter, the whorl height increases to form a thickly lenticular conch. The umbilicus opens slowly and becomes, relative to the conch diameter, narrower.

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
HT IGML 43	25.0	12.3	12.1	5.2	0.49	0.48	0.21
	20.8	10.4	10.1	4.7	0.50	0.49	0.23
PT IGML 44	27.8	13.6	13.6	5.4	0.49	0.49	0.19
	14.5	9.0	6.1	4.4	0.62	0.42	0.30
	8.5	5.7	3.2	3.2	0.67	0.38	0.38
	5.6	3.1	1.6	2.9	0.55	0.29	0.52
	3.6	1.4	0.8	2.3	0.39	0.22	0.64
PT IGML 7	13.4	9.0	5.2	4.1	0.67	0.39	0.31

**Ornamentation:** The inner whorls of a paratype (IGML 21) are preserved with shell remains and show riblets with a spacing of 0.5 to 0.8mm at 10mm conch diameter, and no spiral lines. These riblets project forward in the outer flank area and form a rounded, very shallow and narrow ventral sinus. Additionally, the internal mould bears three deep asymmetric constrictions which run parallel to the riblets.

The adult ornament at 25mm diameter (holotype IGML 43) consists of very fine, roughened growth lines, spaced eight per mm in the centre of the venter. They are biconvex with a very low dorsolateral, but prominent ventrolateral projection. The internal mould has four deep constrictions which are sometimes visible on the shell.

**Suture line:** There occurs a wide variability in the suture lines of this species. Almost all the studied suture line are different, despite the close similarity of the conch in the specimens.

Specimen IGML 11 has a suture line which can be regarded as typical for the genus *Reticuloceras*. The median saddle is rather low, and the prongs of the external lobe are narrowly rounded. Also typical is the almost exactly V-shaped adventive lobe. The suture of the smaller individual IGML 7 has a similar outline, but with a large and almost lanceolate adventive lobe.

Specimen IGML 42 displays a suture line that is not very typical for a *Reticuloceras* species. The branches of the external lobe are V-shaped and pointed, the ventrolateral saddle is very wide, and the adventive lobe is V-

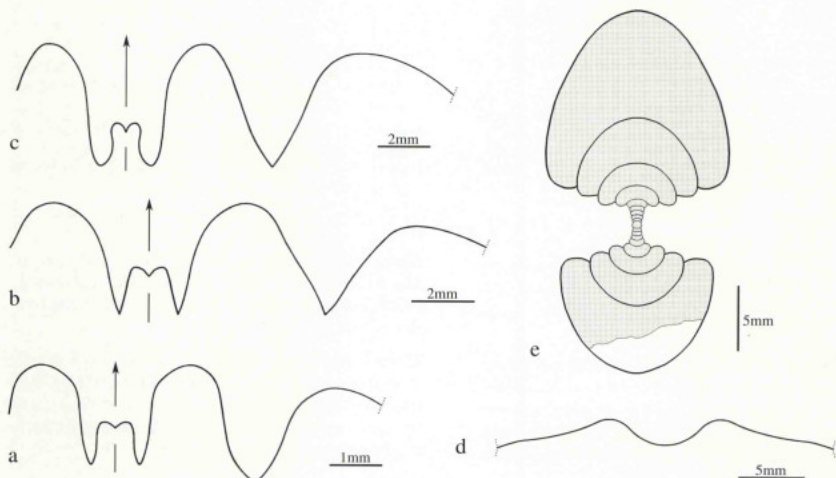
shaped. Other specimens, such as IGML 23 (not figured), possess a parallel-sided external lobe.

#### Sutural ratios:

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
PT IGML 11		12.3	11.3	0.35	0.64	0.62	0.50
PT IGML 42		11.2	9.1	0.43	0.75	0.90	0.62
PT IGML 7		8.0	5.2	0.41	0.70	0.73	0.68

**Comparisons:** The co-occurring *Reticuloceras reticulatum* has an ornament that is characterized by growth lines and spirals of equal strength. In this, *Reticuloceras melanum* is very dissimilar, as here the spiral lines are only barely visible, and the transverse lines are much finer (5 to 8 to one mm, compared with 2 or 3 in *R. reticulatum*). Furthermore, the external sinus of the growth lines in *Reticuloceras melanum* is widely rounded, clearly distinct from the V-shaped external sinus in *Reticuloceras reticulatum*.

Distinction from other species of *Reticuloceras* is difficult when adult material is poorly known. The delicate growth lines, however, make a separation from other *Reticuloceras* species, such as the otherwise similar *R. subreticulatum* (FOORD 1903), rather easy in this stages.



**Text-fig. 58.** *Reticuloceras melanum* sp. nov.; Praia das Quebradas, bed 214 (R1c Zone).

- suture line of the paratype (IGML 7, coll. D. KORN et al. 1994) at ww 8.0mm, wh 5.2mm; x 10.
- suture line of the paratype (IGML 42, coll. D. KORN & K. HORN 1995) at ww 11.2mm, wh 8.1mm; x 6.
- suture line of the paratype (IGML 11 coll. D. KORN et al. 1994) at ww 12.3mm, wh 11.3mm; x 5.
- course of the growth lines in the holotype (IGML 43, coll. D. KORN & K. HORN 1995) at dm 24mm, ww 12.8mm; x 2.5.
- cross section of the paratype (IGML 33, coll. D. KORN & K. HORN 1995); x 2.5.



**Stratigraphical and geographical distribution:** Quebradas Formation (upper *Reticuloceras*-Stufe, R1c Zone) of Southwestern Portugal.

***Reticuloceras scapum* sp. nov.**

Pl.11 Figs.8-10; Text-fig.59

**Holotype:** Specimen Nr. IGML 6 (coll. D. KORN & K. HORN 1995), Instituto Geológico e Mineiro, Lisboa.

**Type locality and horizon:** Praia das Quebradas; bed 214, R1c Zone.

**Material:** 11 specimens between 13 and 30mm diameter from the type locality. They are three-dimensionally preserved internal moulds, and display remains of the shell ornament.

**Species diagnosis:** *Reticuloceras* with pachyconic conch between 12 and 30mm diameter (ww/dm = 0.65 - 0.75), and narrow umbilicus (uw/dm = 0.20 - 0.25). Umbilical margin slightly angular, flanks and venter broadly rounded. Ornamentation at 30mm diameter with fine and roughened growth lines, but no spiral lines. Direction of growth lines recitradiate, with high ventrolateral projection and deep, chevron-shaped external sinus. Suture line with wide external lobe (EL/h = 0.85) and moderate median saddle (0.40 of ventrolateral saddle).

**Conch form:** During the growth stages from 6 to 15mm diameter (IGML 32), the general form of the conch remains stable, only the umbilical width decreases. The venter is broadly rounded, and the umbilical wall steep.

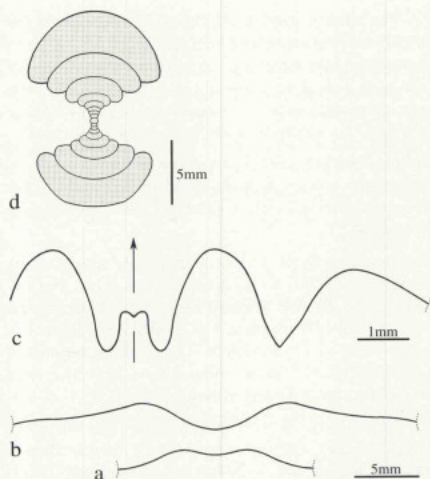
**Dimensions in mm and ratios:**

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
HT IGML 6	29.8	19.3	12.8	6.8	0.65	0.43	0.23
PT IGML 16	18.9	13.9	8.6	3.6	0.74	0.46	0.19
PT IGML 50	17.7	12.5	8.3	3.4	0.71	0.47	0.19
PT IGML 32	14.9	9.8	5.3	2.4	0.66	0.36	0.36
	9.6	7.0	2.9	4.0	0.73	0.30	0.42
	6.3	4.2	1.9	2.9	0.67	0.30	0.46
	4.2	2.6	1.0	2.2	0.62	0.24	0.52

**Ornamentation:** The small paratype IGML 20 shows, at 9mm diameter, rounded riblets around the umbilicus, from which coarse, projecting growth lines originate. These form a very shallow ventral sinus.

The paratype IGML 50 bears only little remains of the shell at 12 - 18mm diameter. Here the ornament consists of widely arranged coarse growth lines, running concavo-convex with a shallow ventral sinus. The internal mould bears two projecting constrictions, running parallel to the growth lines.

In the holotype (specimen IGML 6), the shell ornament is much finer at 30mm diameter. Here, delicate and slightly roughened growth lines are visible. They have a biconvex course, a minor dorsolateral projection, a more prominent ventrolateral projection, and a very deep, chevron-shaped ventral sinus. Spiral lines are lacking. On the



**Text-fig. 59.** *Reticuloceras scapum* sp. nov.; Praia das Quebradas, bed 214 (R1c Zone).

- course of a constriction in the paratype (IGML 7, coll. D. KORN et al. 1994) at dm 13.7mm, ww 9.1mm; x 2.5.
- course of the growth lines a constriction in the holotype (IGML 6, coll. D. KORN et al. 1994) at dm 29.4mm, ww 17.8mm; x 2.5.
- suture line of the holotype (IGML 6, coll. D. KORN et al. 1994) at ww 12.4mm, wh 8.8mm; x 5.
- cross section of the paratype (IGML 32, coll. D. KORN & K. HORN 1995); x 2.5;

internal mould, four deep constrictions are visible, irregularly arranged, and mainly paralleling the course of the growth lines. The ventral sinus of the constrictions, however, is broadly rounded.

**Suture line:** The holotype IGML 6 possesses a wide V-shaped external lobe, which has an amount of 1.65 of the V-shaped adventive lobe. The branches of the external lobe are rounded. In these features, the species fits within the genus *Reticuloceras*.

**Sutural ratios:**

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
HT IGML 6		12.4	8.8	0.39	0.85	0.77	0.51

**Comparisons:** *Reticuloceras scapum* is the species of this genus with the widest conch, allowing clear separation from the co-occurring *R. reticulatum* (PHILLIPS 1836) and *R. melanum*. The course of the growth lines with the chev-

ron-shaped ventral sinus is as in *R. reticulatum*, but in *R. scapum* a spiral ornament is lacking in later stages.

The lack of umbilical ribs or plications at a diameter of 10mm is an important feature that distinguishes *R. scapum* from other species, such as *R. nodosum* BISAT & HUDSON 1943, *R. stubblefieldi* BISAT & HUDSON 1943, and *R. coreticulatum* BISAT & HUDSON 1943.

**Stratigraphical and geographical distribution:** Quebradas Formation (upper *Reticuloceras*-Stufe, R1c Zone) of Southwestern Portugal.

***Reticuloceras coreticulatum* (BISAT & HUDSON 1943)**

Pl.12 Figs.1, 2; Text-fig.60

- 1925 *Eumorphoceras reticulatum*.- SCHMIDT: 587, pl.25 fig.17-19.  
 1926 *Eumorphoceras reticulatum*.- SCHMIDT: 198.  
 1943 *Reticuloceras co-reticulatum* BISAT & HUDSON: 417, pl.27 fig.2.  
 1959 *Reticuloceras coreticulatum*.- PATTEISKY: 23, pl.5 fig.4, pl.6 fig. 28-30.

**Holotype:** Specimen For 1820, Geological Survey Museum, Keyworth, Nottingham; figured by BISAT & HUDSON (1943: pl.27 fig.2).

**Type locality and horizon:** Northeast of the railroad station of Gevelsberg (Rhenish Massif, Germany); Obere Arnsberger Schichten (R1c2 Zone).

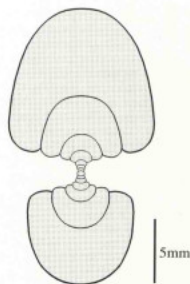
**Material:** 18 three-dimensionally preserved specimens from beds 216 and 219 of the Praia das Quebradas section. In their size, they range from the immature stage of 5mm diameter up to almost adult fragmentary conchs of 30mm diameter. The ontogeny of the ornament can be observed, but the specimens do not allow study of the suture line.

**Species diagnosis:** *Reticuloceras* with thickly discoidal conch between 12 and 25mm diameter ( $ww/dm = 0.55 - 0.60$ ), and narrow umbilical ( $uw/dm = 0.15 - 0.20$ ). Umbilical margin rounded, flanks and venter broadly rounded. Ornamentation at 30mm diameter with fine growth lines, but no spiral lines. Direction of growth lines prorsiradial, with prominent ventrolateral projection and deep, rounded external sinus.

**Conch form:** The cross section of specimen IGML 85 shows evolve inner whorls up to 4mm diameter. In later stages up to 14mm diameter, the whorl sections are circular or rectangular, and only the last half volution displays a whorl section with increased whorl height. In all the stages, the umbilical margin is rounded.

**Dimensions in mm and ratios:**

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 85	21.2	11.2	9.1	3.0	0.53	0.43	0.14
	10.3	6.2	4.4	2.3	0.60	0.43	0.22
	5.3	3.2	1.9	1.9	0.60	0.36	0.36
	3.1	1.7	0.9	1.5	0.55	0.29	0.48



**Text-fig. 60.** *Reticuloceras coreticulatum* BISAT & HUDSON 1943; cross section of specimen IGML 32 (coll. D. KORN & K. HORN 1995); x 2.5; Praia das Quebradas, bed 219 (R1c2 Zone).

**Ornamentation:** The small individual IGML 74 displays, at 11mm diameter, numerous riblets on the internal mould, together with three constrictions. Both run in a concavo-convex course with high ventrolateral projection a deep and rather narrow ventral sinus.

In specimen IGML 84 with 15mm diameter, the riblets are already replaced by growth lines, and in the largest specimen (IGML 75) of approximately 30mm diameter, the growth lines are fine and form a prominent ventrolateral projection. The internal mould bears constrictions with the same course.

**Remarks:** SCHMIDT (1926) figured the immense variability of the conch geometry within this species. Hence it is unclear which form can be regarded as typical. The specimens collected in South Portugal show some variability, as can be seen in the two figured specimens.

**Comparisons:** Immature individuals are hardly distinguishable from those of *R. reticulatum* (PHILLIPS 1836), but the ornament of specimens larger than 15mm diameter shows clear differences. *R. coreticulatum* possesses a well rounded ventral sinus of the growth lines, in contrast to the chevron-shaped ventral sinus in *R. reticulatum*. Furthermore, the ventrolateral projection of the growth lines is more prominent in *R. coreticulatum*.

The adult conchs of *R. coreticulatum* and *R. melanum* are comparable, but the latter species possesses a juvenile conch that is very dissimilar, with a very weak ventral sinus of the growth lines. Furthermore, *R. coreticulatum* has a slightly angular ventrolateral shoulder.

**Stratigraphical and geographical distribution:** The species is the index goniatite for the Upper *Reticuloceras*-Stufe (R1c2). It is recorded from Germany (Rhenish Massif), Great Britain (Yorkshire), and Southwestern Portugal Quebradas Formation).



*Reticuloceras* sp. 1

Pl.10 Fig.9

**Material:** About 10 natural moulds from a nodular horizon within the Quebradas Formation of Alcaria, showing the ornament of specimens between 6 and 15mm diameter. Here, the growth lines originate by a dichotomizing of weak plications around the umbilicus. The ventrolateral projection is prominent, and no ventrolateral groove can be seen in the material.

*Phillipsoceras* RUZHENCEV & BOGOSLOVSKAYA 1975*Phillipsoceras* sp. 1

Pl.12 Fig.3

**Material:** 12 specimens between 5 and 16mm diameter from bed 119 of the Praia das Quebradas gorge section. All are preserved as natural moulds in a decalcified carbonate lens, and display the conch ornament. The best specimen IGML 394 shows, at 15mm diameter, faint crenulated riblets which dichotomize and project on the flanks, form a prominent ventrolateral salient, and a narrow ventral sinus. On the umbilical margin, they are a little strengthened, developing from ribs which can be seen in the inner whorls. The conch of the specimen is pachyconic with a moderately wide umbilicus.

*Tectitretites* RUZHENCEV & BOGOSLOVSKAYA 1975*Tectitretites davisi* (FOORD & CRICK 1897)

Pl. 10 Fig. 10; Pl.12 Figs.4-7; Text-fig.61

1897 *Glyptoceras Davisi* FOORD & CRICK: 198, fig.95.  
1943 *Reticuloceras davisi* - BISAT & HUDSON: 412.

**Holotype:** Specimen Nr. C 5284 (coll. DAVIS), British Museum (Natural History), London.

**Type locality and horizon:** Halifax (Yorkshire, Great Britain); R1c Zone.

**Material:** 27 specimens from 7 to 46mm diameter, of which all but six are fragments. They are well preserved conchs, usually with perfectly preserved shell ornament, and some with the suture line exposed.

**Species diagnosis:** *Tectitretites* with pachyconic conch between 12 and 35mm diameter (ww/dm = 0.60 to 0.75), and moderately wide umbilicus (uw/dm = 0.40). At 20mm diameter transformation to tectiform conch shape, the umbilical margin becomes angular, and the venter bears a rounded keel. Ornamentation with riblets around the umbilicus, fastigate coarse growth lines and coarse spiral lines generating a reticulate pattern. Suture line with wide, V-shaped external lobe (EL/H = 0.80) and high median saddle (0.65 of ventrolateral saddle).

**Conch form:** The cross section, although from a distorted specimen (IGML 13), displays typical features of the species. A serpenticone juvenile stage up to 4mm diameter is followed by a stage with almost circular whorl section. At 9mm diameter, the whorl width increases remarkably, and at 16mm diameter, the conch is pachyconic with low aperture.

The large specimen IGML 47 displays the adult conch morphology. At 35mm diameter, the whorl section is tectiform with a prominent umbilical rim and concave inner flanks. The venter is narrowly rounded, but suggests to become acute only a little later in the ontogenetic development.

**Dimensions in mm and ratios:**

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
HT C 5284	60	30	27	15	0.50	0.45	0.25
IGML 47	37.2	22.5	16.0	14.7	0.60	0.43	0.40
	31.6	20.4	11.6	13.4	0.65	0.37	0.42
IGML 5	26.2	17.0	10.7	10.2	0.65	0.41	0.39
IGML 14	20.7	15.8	7.7		0.76	0.37	
IGML 4	15.2	11.3	4.4	6.8	0.74	0.29	0.45
IGML 49	14.3	9.8	4.6	5.7	0.69	0.32	0.40

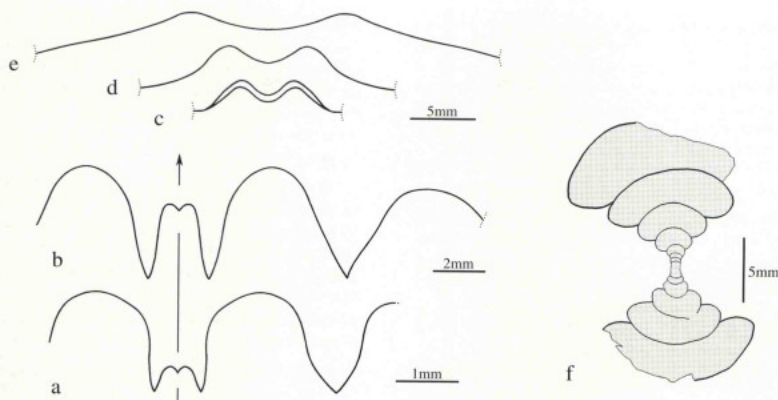
**Ornamentation:** In the juvenile specimen IGML 48, at 12mm diameter, there are about 16 prominent umbilical nodes. Over a short distance on the umbilical margin they run in an exactly radial direction, and then arch forward sharply, where they give rise to weaker riblets. These form a high ventrolateral projection and a shallow ventral sinus. Between the riblets, much finer spiral lines can be seen. The internal mould bears one constriction and a midventral groove.

The shell ornament remains the same up to almost 15mm diameter (specimen IGML 4), but at 20mm diameter (IGML 14), the umbilical tubercles and riblets are considerably finer. In this stage, the spiral ornament is almost as strong as the transverse lines, and a reticulate pattern is present. Irregularly distributed constrictions are still visible on the internal mould, but a midventral groove is no longer present.

The largest specimen (IGML 47) is mainly an internal mould of the body chamber, with only a few preserved shell remains. The internal mould bears four irregularly arranged constrictions, and the shell ornament at 45mm diameter consists of delicate, crenulated growth lines and stronger spirals. Faint ribs are visible on the first half volution, but decrease rapidly in strength and then disappear.

**Suture line:** The adult suture line (in specimen IGML 47) is remarkable because of its high median saddle, measuring almost two thirds of the ventrolateral saddle. The narrow, pointed branches are typical for species of *Tectitretites*.





**Text-fig. 61.** *Tectiretites davisi* (FOORD & CRICK 1897); Praia das Quebradas, bed 214 (R1c Zone).

- a. suture line of specimen IGML 48, coll. D. KORN & K. HORN 1995) at ww 6.1mm, wh 2.4mm; x 12.  
 b. suture line of specimen IGML 47, coll. D. KORN & K. HORN 1995) at ww 16.3mm, wh 8.2mm; x 5.  
 c. course of the riblets in specimen IGML 4 (coll. D. KORN et al. 1994) at dm 10.0mm, wh 4.6mm; x 2.5.  
 d. course of the growth lines in specimen IGML 16 (coll. D. KORN et al. 1994) at dm 19.3mm, ww 15.1mm; x 2.5.  
 e. course of the growth lines and a constriction in specimen IGML 47 (coll. D. KORN & K. HORN 1995) at dm 34mm, ww 19.2mm; x 2.5.  
 f. distorted cross section of specimen IGML 13 (coll. D. KORN & K. HORN 1995); x 2.5;

#### Sutural ratios:

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
IGML 47	16.3	8.2	0.66	0.81	0.84	0.53	
IGML 48	6.1	2.4	0.24	0.54	0.93	0.52	

**Remarks:** Despite the fact that *Tectiretites davisi* is a very conspicuous goniatite, its presence in the literature is remarkably scarce. This is probably a result of the relatively rare occurrence in North England, and its probable absence in continental Europe. The holotype of the species is an individual of 60mm diameter and hence difficult to compare with the smaller Portuguese material. The umbilicus, which is relatively narrower in the holotype compared with the new material, may be explained by stagnation of umbilical opening in adult specimens, a feature that is indicated also in specimen IGML 47 where the absolute width of the umbilicus is constant at 15mm during the last volution.

**Comparisons:** *Tectiretites davisi* has a wider conch than the co-occurring *Retites alector* sp. nov.. Additional distinguishing characters are the stronger projection of the riblets in *T. davisi*, and the fact that also the venter shows already a rounded keel at 25mm diameter. Of the species described by RUZHENCEV & BOGOSLOVSKAYA (1978), only *T. hodsoni* displays an ornament that in its strenght is

comparable with *T. davisi*. None of these species, however, shows the strong constrictions of the internal mould which are typical for *T. davisi*.

**Stratigraphical and geographical distribution:** Upper *Reticuloceras*-Stufe (R1c Zone) of Great Britain (Yorkshire), and Southwestern Portugal (Quebradas Formation).

#### *Retites* McCaleb 1964

##### *Retites alector* sp. nov.

Pl. 12 Figs. 8-10; Text-fig. 62

**Holotype:** Specimen Nr. IGML 38 (coll. D. KORN & K. HORN 1995), Instituto Geológico e Mineiro, Lisboa.

**Type locality and horizon:** Praia das Quebradas; bed 214, R1c Zone.

**Material:** Six almost complete internal moulds preserved in limestone from 8 to 26mm diameter, and one fragment of a specimen of about 20mm diameter. Also available for study are 6 natural moulds from bed 117 of the Praia das Quebradas gorge section (IGML 378), displaying the shell ornament nicely, and one natural mould from the outcrop along the road near Murração Velho.

**Species diagnosis:** *Retites* with pachyconic conch at 20mm diameter ( $ww/dm = 0.60$  to  $0.65$ ), and moderately wide umbilicus ( $uw/dm = 0.35$ ). In this stage, the umbilical margin is slightly angular, and the flanks and venter are broadly rounded. Ornamentation with riblets around the umbilicus, fastigate coarse growth lines and coarse spiral lines generating a reticulate pattern. Suture line with wide, V-shaped ventral lobe ( $EL/h = 0.80 - 0.90$ ) and moderate median saddle ( $0.45 - 0.50$  of ventrolateral saddle).

**Conch form:** Between 8 and 24mm diameter (specimens IGM 40, 39, 38), the conch has a very similar pachyconic shape with broadly rounded flanks and venter, and a moderately wide umbilicus. The umbilical margin becomes angular at 15mm diameter, and a midventral groove on the internal mould has disappeared in specimen IGM 40 at about 8mm.

The holotype shows a very weak indication of a transition to a tectiform shape, when at 25mm diameter the umbilical margin becomes pronounced, and a shallow depression appears on the inner flanks.

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
HT IGM 38	23.2	14.3	8.1	8.2	0.62	0.35	0.35
PT IGM 39	14.8	9.1	5.2	5.1	0.61	0.35	0.34
PT IGM 40	8.5	5.7			0.67		

**Ornamentation:** Only the holotype (specimen IGM 38) displays remains of the shell ornament between 18 and 25mm diameter. Around the umbilicus, sharp transverse plications arranged at distances of 1mm occur, which bifurcate a little further towards the venter and diminish in strength, being visible as coarse transverse lines. Additional transverse lines are intercalated with the umbilical plications. The growth lines run with a shallow sinus over the flanks, and form a prominent, narrow ventrolateral projection and a deep ventral sinus. Between the coarse

transverse striae, slightly weaker spiral lines are developed on the entire whorl, together forming a reticulate ornament. On the internal mould, three deep constrictions are visible. They are not arranged regularly at  $120^\circ$ , but they follow the same course as the transverse shell ornament. Also on the internal mould, a very faint midventral groove occurs for a quarter of a revolution.

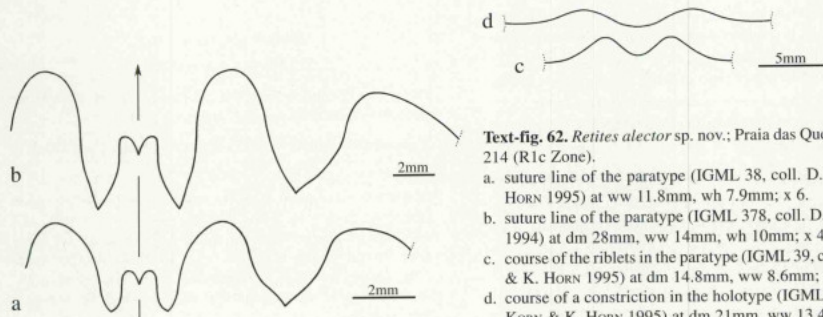
Juvenile specimens, which are only available as internal moulds, display an ornament that is characterized by stronger umbilical plications. In specimen IGM 39, at 14mm diameter, the bifurcation of the plications is irregular and can be completely absent. The smallest specimen (IGM 40) shows a midventral groove at 8mm diameter. Both juveniles display principally the same type of transverse constrictions as the larger specimen.

**Suture line:** At 11.8mm whorl width (holotype IGM 38), the suture line shows a broad V-shaped, diverging ventral lobe, with symmetrical lanceolate, pointed branches. The median saddle exceeds 0.45 of the height of the broad and rounded ventrolateral saddle. The adventive lobe is V-shaped and slightly pouched. The suture line of the larger paratype IGM 378 displays a higher median saddle, but a narrower external lobe.

#### Sutural ratios:

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
PT IGM 378	28	14	10	0.52	0.81	0.53	0.52
PT IGM 38	11.8	7.3	0.46	0.92	0.77	0.75	

**Remarks:** A tectiform adult stage of this species is only barely indicated in the holotype, hence assignment to the genus *Retites* is favoured. For such a generic designation, the suture line can be regarded as an additional important criterion: species of *Phillipsoceras* and *Reticuloceras* usually show parallel-sided ventral lobes, whereas in *Retites* this is V-shaped in some species. Furthermore,



**Text-fig. 62.** *Retites alector* sp. nov.; Praia das Quebradas, bed 214 (R1c Zone).

- suture line of the paratype (IGM 38, coll. D. KORN & K. HORN 1995) at ww 11.8mm, wh 7.9mm; x 6.
- suture line of the paratype (IGM 378, coll. D. KORN et al. 1994) at dm 28mm, ww 14mm, wh 10mm; x 4.
- course of the riblets in the paratype (IGM 39, coll. D. KORN & K. HORN 1995) at dm 14.8mm, ww 8.6mm; x 2.5.
- course of a constriction in the holotype (IGM 38, coll. D. KORN & K. HORN 1995) at dm 21mm, ww 13.4mm; x 2.5.



in *Phillipsoceras* and *Reticuloceras* the branches of the ventral lobe are usually rounded, in contrast to the pointed branches in *Retites*.

**Comparisons:** It is difficult to compare *Retites alector* sp. nov. with most of the species described by BISAT & HODSON (1943) from the British Isles, because these authors often showed crushed or juvenile material lacking suture lines. A similarly ornamented species is „*Reticuloceras nodosum* BISAT & HODSON 1943“, which in fact may be a *Retites* species. This species, however, is much more compressed at a comparable diameter:  $w/w_{dm} = 0.55$  compared with 0.67 in *Retites alector*.

Within *Retites*, *R. alector* is unique because of its relatively high median saddle, reaching half of the ventrolateral saddle. A species with similar conch and ornament is *R. obscurus* RUZHENCEV & BOGOSLOVSKAYA 1978.

**Stratigraphical and geographical distribution:** Quebradas Formation (upper *Reticuloceras*-Stufe, R1c Zone) of Southwestern Portugal.

#### *Bilinguites* LIBROVITCH 1946

##### *Bilinguites gracilis* (BISAT 1924)

1924 *Reticuloceras reticulatum* mut.  $\alpha = gracilis$  BISAT: 51, 115, pl.3 fig.7-9, pl.7 fig.1-4.

**Lectotype:** Specimen Nr. C 18013, British Museum (Natural History), London.

**Type locality and horizon:** Probably from Castle Carr tunnel, Luddenden Valley (Yorkshire, Great Britain), R2a Zone.

**Material:** Only four very fragmentary specimens are available from bed 220 of the Praia das Quebradas section. The best preserved of these is specimen IGML 93 with about 16mm diameter. It is thickly discoidal, and bears a spider-web like ornament with growth lines that form a prominent ventrolateral projection. A weak ventrolateral groove is visible. Parts of the suture line can be studied, in which the adventive lobe is broadly rounded. The juvenile individual IGML 94 shows, at 11mm diameter, strengthened growth lines on the flanks.

**Remarks:** *Bilinguites gracilis* can be distinguished from *Bilinguites bilinguis* (SALTER 1864) by the much more delicate growth lines, and by the weaker ventrolateral groove. The close relationship between the two species is expressed here in placing the species *gracilis* in *Bilinguites* [contra RUZHENCEV & BOGOSLOVSKAYA (1978); KULLMANN & NIKOLAIEVA (1995)], rather than in *Phillipsoceras*.

**Stratigraphical and geographical distribution:** The species is the index fossil for the R2a Zone (Late Namurian).

It is known from Great Britain (Yorkshire, Lancashire), Belgium, Germany (Rhenish Massif), and South Portugal, where it occurs in the higher part of the Quebradas Formation.

#### *Bilinguites metabilinguis* (WRIGHT 1927)

Pl.13 Figs.1-4; Text-fig.63

- 1926 *Reticuloceras reticulatum*, early mut.  $\gamma$  WRIGHT: 194, pl.12 fig.1,2,6.
- 1927 *Reticuloceras reticulatum*, early mut.  $\gamma = metabilingue$  WRIGHT: 114, pl.6 fig.1,2,6.
- 1959 *Reticuloceras superbilingue metabilingue*.- PATTEISKY: 25, pl.1 fig.36, pl.7 fig.1-24, pl.8 fig.1-31, pl.9 fig.38,39.
- 1978 *Bilinguites metabilinguis*.- RUZHENCEV & BOGOSLOVSKAYA: 283, pl.37 fig.1-3 [for more synonymy].
- 1979 *Reticuloceras todmordenense* ?.- OLIVEIRA, HORN & PAPROTIC: 159, pl.4 fig.1.

**Holotype:** Specimen Nr. 37930, British Geological Survey Museum, Keyworth, Nottingham.

**Type locality and horizon:** 300 yards southeast of Witton's Farm, Hall Wood, Longworth Valley, west-northwest of Egerton (Lancashire, Great Britain); marine bands above the Helmshore Grit, R2c Zone.

**Material:** A total of 278 specimens from one single horizon of limestone nodules (bed 225) within the Quebradas Formation. All growth stages from the very initial stage up to the adult of about 60mm diameter are represented in well preserved material, which allows complete documentation of the ontogeny.

Additional material is available as natural moulds: 5 specimens from the gorge of the Praia das Quebradas (IGML 141), two from Caixaero 5km northeast of Bordeira, one slab with about 20 poorly preserved individuals from Alcaria, and one rock piece with five specimens from Vale Figueiras. One rock with some natural moulds from Vale Figueira is available.

**Species diagnosis:** *Bilinguites* with thickly discoidal conch at 12mm diameter ( $w/w_{dm} = 0.60$ ) and narrow umbilicus ( $uw/dm = 0.22$ ); thickly discoidal conch at 25mm dm ( $w/w_{dm} = 0.50$ ), and narrow umbilicus ( $uw/dm = 0.16$ ). Umbilical margin angular. Two longitudinal ventrolateral grooves in the middle growth stage, adult conch tectiform with acute venter. Ornamentation with fine radial ribs up to 8mm diameter. Later with only slightly crenulated growth lines, without ribs and with very weak spiral lines. Course of the growth lines strongly biconvex, with prominent and narrow ventrolateral projection. Suture line with moderately narrow ventral lobe ( $EL/h = 0.80$ ) and low median saddle (0.30 of ventrolateral saddle). Adventive lobe broadly rounded.

**Conch form:** Several cross sections have been manufactured. A smaller specimen (IGML 68) shows the evolute inner whorls up to 3mm diameter. Between 3 and 10mm diameter, the whorls are then almost circular, and the conch is pachyconic with moderately wide umbilicus.



Later in ontogeny, the whorl height increases faster, and hence the relative width of the conch and the umbilical width decrease.

The larger specimen (IGML 67) shows that in the adult stage a transformation towards a triangular cross section with an angular umbilical margin occurs. In IGML 65, the whorl section is, at 30mm whorl height, tectiform with a narrowly rounded venter and a prominent umbilical rim.

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 63	31.6	14.7	15.4	4.9	0.47	0.49	0.16
IGML 64	19.2	10.0	9.1	3.1	0.52	0.47	0.16
IGML 62	11.7	7.0	5.6	2.6	0.60	0.48	0.22
IGML 67	35.4	15.9	17.3	5.8	0.45	0.49	0.16
	17.2	9.6	8.3	3.8	0.56	0.48	0.22
	8.4	5.5	3.9	2.8	0.65	0.46	0.33
IGML 68	18.9	10.4	8.7	3.6	0.55	0.46	0.19
	9.6	5.9	4.5	2.1	0.61	0.47	0.22
	5.1	2.8	1.9	1.9	0.55	0.37	0.37
	3.1	1.5	0.9	1.6	0.48	0.29	0.52

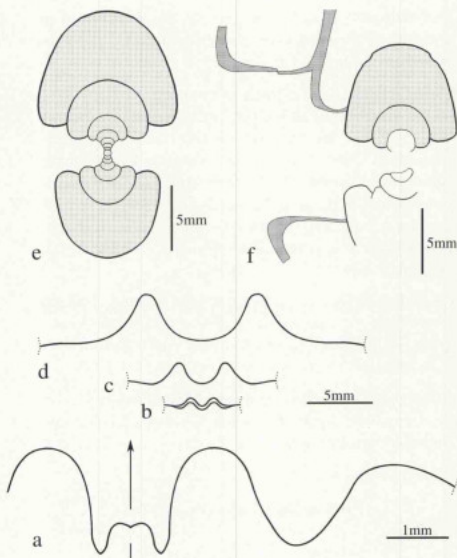
**Ornamentation:** At 7mm diameter (IGML 66), 25 ribs are developed. These are strongest on the umbilical margin, diminish in strength on the flanks, and are barely visible on the outer flanks and venter. Their course is concavo-convex with a pronounced ventrolateral projection and a deep ventral sinus. Some of the ribs dichotomize near the umbilicus.

During ontogeny, the ribs rapidly lose their strength, and at 12mm diameter (IGML 62) only coarse growth lines are present. They are a little roughened and form a prominent ventrolateral projection as well as a deep, semi-circular ventral sinus. Here, the growth lines stand at distances of 0.25mm.

In larger specimens, this course of the growth lines is confirmed, with the addition of a very low lateral sinus (specimen IGML 64). Here the shell ornament consists only of fine roughened growth lines, of which eight are spaced within one millimeter on the middle of the venter.

A fragment of a larger specimen (IGML 65) indicates that at about 30mm whorl height the ventrolateral projection of the growth lines is relatively lower compared with smaller specimens. The growth lines are slightly renulated, but do not form a spiral ornament.

Additional ornamental features are constrictions of the internal mould, which occur irregularly throughout all growth stages, but are strongest in specimen IGML 63 at 30mm diameter. The constrictions are well developed on the venter, but are only weak on the outer flanks and almost disappearing towards the umbilicus. A double ventrolateral groove is characteristically developed between 8 and 50mm diameter. The two grooves are of equal strength and best visible on the internal mould.



**Text-fig. 63.** *Bilinguites metabilinguis* (WRIGHT 1927); Praia das Quebradas, bed 225 (R2c Zone).

- suture line of specimen IGML 62 (coll. D. KORN et al. 1994) at ww 6.0mm, wh 4.4mm; x 12.
- course of the riblets in specimen IGML 66 (coll. D. KORN et al. 1994) at dm 6.6mm, wh 3.4mm; x 2.5.
- course of the growth lines in specimen IGML 62 (coll. D. KORN et al. 1994) at dm 10.3mm, ww 5.6mm; x 2.5.
- course of the growth lines in specimen IGML 64 (coll. D. KORN et al. 1994) at dm 19.4mm, ww 10.1mm; x 2.5.
- cross section of specimen IGML 68 (coll. D. KORN et al. 1994); x 2.5
- cross section of specimen IGML 65 (coll. D. KORN et al. 1994); x 2.5.

**Suture line:** As specimen IGML 62 shows, the paedomorphic suture line is characterized by its V-shaped, broadly rounded adventive lobe, and by the rather low median saddle.

#### Sutural ratios:

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
IGML 62		6.0	4.4	0.30	0.78	0.81	0.80

**Comparisons:** *Bilinguites metabilinguis* is an intermediate link connecting *B. bilinguis* (SALTER 1864) and *B. superbilinguis* (BISAT 1924). From the first, it is separated

by the more prominent ventrolateral projection of the growth lines, and the double ventrolateral groove. From the latter, it differs in its roughened growth lines.

**Stratigraphical and geographical distribution:** R2c1 Zone of North England (Lancashire), Belgium, Germany (Rhenish Massif), Russia (South Urals), Uzbekistan (Fergana), China (Gansu), and South Portugal, where it occurs in the Quebradas Formation.

*Bilinguites superbilinguis* (BISAT 1924)

Pl.13 Fig.5

- 1924 *Reticuloceras reticulatum* mut.  $\gamma$  = *super-bilingue* BISAT: 51, 117, pl.5 fig.5-7.  
 1959 *Reticuloceras superbilingue superbilingue*.- PATTEISKY: 27, pl.9 fig.19-37.  
 1978 *Bilinguites superbilinguis*.- RUZHENCEV & BOGOSLOVSKAYA: 284, pl.37 fig.4-7 [for more synonymy].  
 1979 *Reticuloceras superbilingue*.- OLIVEIRA, HORN & PAPROTH: 160.

**Type material:** A lectotype has not been selected yet.

**Type locality and horizon:** The specimens figured by BISAT (1924, pl. 5 fig. 5-7) derive from Brow Grains, Meltham (Yorkshire, Great Britain).

**Material:** Six specimens derive from 200m southwest of Monte Vale Longo near Saboia (IGML 366). They are between 4 and 15mm diameter, and display the ornament development throughout ontogeny. At 4mm diameter the conch is ribbed, but the ribs lose rapidly in strength, giving rise to lamellose uncrenulated growth lines. These have a concavo-convex course and form a prominent, narrow ventrolateral projection that is placed in between the two ventrolateral grooves, of which the inner one is a little stronger. The conch is discoidal, venter and umbilical margin are rounded.

One fragment, a natural mould from Monte Coelho (IGML 201), is a specimen of 22mm diameter. It has an ornament with fine uncrenulated growth lines, which have a barely visible dorsolateral and a prominent ventrolateral projection. Two additional, poorly preserved natural moulds have been collected near Eira Velha, and one in bed 130 of the Praia das Quebradas gorge section.

**Species diagnosis:** *Bilinguites* with thickly discoidal conch at 12mm diameter (ww/dm = 0.55) and narrow umbilicus (uw/dm = 0.22); and thickly discoidal conch at 25mm dm (ww/dm = 0.50), and narrow umbilicus (uw/dm = 0.16). Umbilical margin angular, two longitudinal ventrolateral grooves. Ornamentation with fine radial ribs up to 8mm diameter. Later with only uncrenulated growth lines, without ribs and with very weak spiral lines. Course of the growth lines strongly biconvex, with prominent and narrow ventrolateral projection.

**Stratigraphical and geographical distribution:** R2c2 and G1 Zones of Great Britain (Yorkshire, Devonshire), Belgium, Germany (Rhenish Massif), Poland (Lublin Coal Basin), Ukraine (Donets Basin), Russia (South Urals), Uzbekistan (Fergana), China (Gansu), and South Portugal, where it occurs in the upper part of the Quebradas Formation in accompany with *Cancelloceras cancellatum*.

Family *Gastrioceratidae* HYATT 1884

*Cancelloceras* RUZHENCEV & BOGOSLOVSKAYA 1969

*Cancelloceras cancellatum* (BISAT 1923)

Pl.13 Figs.6-11; Text:fig.64

- 1923 *Gastrioceras cancellatum* BISAT: 47, pl.8.  
 1979 *Gastrioceras cancellatum*.- RAMSBOTTOM & CALVER: 574, pl.14 fig.4,5.  
 1979 *Gastrioceras cancellatum*.- OLIVEIRA, HORN & PAPROTH: 160, pl.3 fig.2.  
 1995 *Cancelloceras (Crenelloceras) oliveirai* NIKOLAEVA & KULLMANN: 370.

**Holotype:** Specimen Nr. C 25767, British Museum of Natural History (designated by RAMSBOTTOM & CALVER 1962, p.574).

**Type locality and horizon:** Ring Road cutting, Leeds (Yorkshire, Great Britain); below Rough Rock (G1a Zone).

**Material:** A total of about 65 specimens are available for study. They derive from Caeiros de Baixo (21; IGML 170-173, 214), 400m east of Valverde (1; IGML 221), Monte Novo (3), from along the road from Carrapateira to the Praia de Murração (IGML 174), and from the gorge of the Praia das Quebradas (6). Most of these specimens are preserved as internal moulds of the body chamber, usually with dissolved phragmocones.

Additionally, about 35 specimens from Eira Velha (IGML 191-198, 226, 227, 343), representing all growth stages between 2 and about 70mm in diameter. Most of them are preserved as well ornamented natural moulds which occur in a violet-grey marly claystone, sometimes showing the suture line.

**Species diagnosis:** *Cancelloceras* with pachyconic conch at 15mm diameter (ww/dm = 0.65), with moderately wide umbilicus (uw/dm = 0.45). Conch thickly discoidal at 30mm diameter (ww/dm = 0.50), umbilicus moderately wide (uw/dm = 0.30 to 0.40). Umbilical margin slightly angular, flanks and venter broadly rounded. Ornamentation at 30mm diameter with weak nodes around the umbilicus, fastigate coarse growth lines and coarse spiral lines generating a reticulate pattern. Suture line with wide ventral lobe (EL/H = 0.90; 1.55 of adventive lobe) and moderately high median saddle (0.55 of ventrolateral saddle).

**Conch form:** During ontogeny, only a minor modification of the conch geometry occurs. The umbilical width is reduced from 0.45 of the diameter at 15mm to 0.30 to 0.35 at 30mm diameter. In parallel, a slight reduction of



the whorl width occurs. Only at over 25mm diameter is the umbilical margin slightly angular, but a coronate conch form is never developed.

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 214	32.8	16.0	11.4	12.3	0.49	0.35	0.38
	27.6	13.7	9.7	10.9	0.50	0.35	0.39
IGML 174	30.7	15.8	12.1	9.2	0.51	0.39	0.30
IGML 172	27.1	12.7	10.0	10.8	0.47	0.37	0.40
IGML 221	24.4	12.9	9.6	7.1	0.53	0.39	0.29
IGML 170	23.9	13.0	9.1	8.7	0.54	0.38	0.36
IGML 171	20.2	12.0	8.1	7.3	0.59	0.40	0.36

#### specimens from Eira Velha

IGML 226	63		31	13.5		0.49	0.21
IGML 194	33.4		12.4	11.0		0.37	0.33
IGML 195	21.7		8.3	7.6		0.38	0.35
IGML 197	20.6	12.3	7.0	8.1	0.60	0.34	0.39
IGML 198	19.8	11.9	7.5	7.3	0.60	0.38	0.37
IGML 191	15.3	10.1	5.7	6.6	0.66	0.37	0.43
IGML 198	14.7	9.2	5.5	6.2	0.63	0.37	0.42
IGML 193	13.9		5.4	5.9	0.66	0.39	0.42
IGML 192	12.8	7.9	4.1	6.0	0.62	0.32	0.47
IGML 226	5.6		1.9	2.4		0.34	0.43

**Ornamentation:** The ontogenetic development of the shell ornament is best recorded in the material from Eira Velha, which allows study of all growth stages. The immature stage at 5mm, corresponding to the fifth volution (IGML 343), has 30 fine but sharp ribs, which extend from the umbilical wall over the flanks where they dichotomize and become much weaker towards the venter. New riblets are also intercalated on the umbilical margin, and one shell constriction occurs. These specimens show that the previous four volutions are ribbed.

At 12mm diameter (IGML 191, 192, 193, 196), 25 strong and slightly elongate ribs are visible on the umbilical margin. They give rise to coarse, crenulated growth

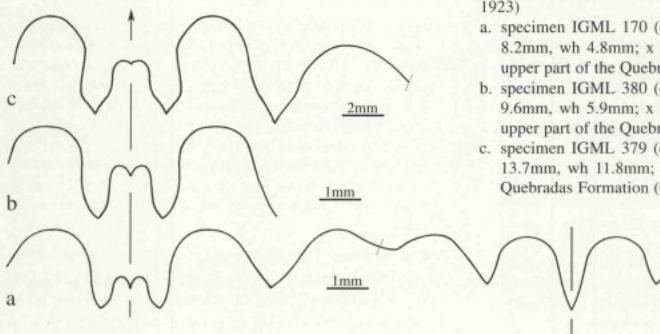
lines (of which some originate between the ribs) which project onto the flanks and form a shallow external sinus. A spiral ornamentation can be seen, which is much weaker than the radial ornament, but the combination of both generates a reticulate pattern. On the flanks and venter there are approximately 75 spiral lines. Two or three shell constrictions are strongest on the umbilical margin.

Larger specimens show a considerable weakening of the shell ornament. Specimen IGML 195 displays, at 20mm diameter, 25 weak umbilical tubercles. The growth lines are rather fine and crenulated; they run with a biconvex course with an external sinus. The distance between the growth lines is 0.15 to 0.2mm. Together with the spiral lines, which have the same strength, they form a delicate reticulate pattern. There are 110 to 120 spiral lines on flanks and venter.

At 33mm diameter (IGML 194), the internal mould shows only very weak indications of umbilical tubercles. Four shallow constrictions are visible, separated by almost exactly 90°. Shell remains on the venter indicate that in this specimen the growth lines are stronger than in specimen IGML 195.

The largest known specimen (IGML 226) at 60mm diameter show extremely fine and crenulated growth lines. On the venter, where a deep sinus is formed, there are about eight growth lines per millimetre. The umbilical margin is free of nodes or tubercles.

**Suture line:** *Cancelloceras cancellatum* displays the typical suture of the genus. The branches of the external lobe are slightly pouched, and the ventrolateral saddle is broadly rounded (specimen IGML 379). The inner suture line of a juvenile individual (IGML 170) displays simple V-shaped internal and umbilical lobes.



**Text-fig. 64.** Suture lines of *Cancelloceras cancellatum* (BISAT 1923)

- specimen IGML 170 (coll. M. HORN et al. 1979) at ww 8.2mm, wh 4.8mm; x 8; Caeriuos de Baixo, presumably upper part of the Quebradas Formation (G1a Zone).
- specimen IGML 380 (coll. M. HORN et al. 1979) at ww 9.6mm, wh 5.9mm; x 8; Caeriuos de Baixo, presumably upper part of the Quebradas Formation (G1a Zone).
- specimen IGML 379 (coll. M. HORN et al. 1979) at ww 13.7mm, wh 11.8mm; x 4; Eira Velha, upper part of the Quebradas Formation (G1a Zone).



**Sutural ratios:**

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
IGML 379	13.7	11.8	0.54	0.87	0.65	0.55	
IGML 380	9.6	5.9	0.58	1.04	0.83		
IGML 170	4.8	8.2	0.40	1.01	1.07	0.60	

**Remarks:** NIKOLAEVA & KULLMANN (1995) described the material presented here, and formed the new species name *Cancelloceras oliveirai*. There is, however, no distinguishing character in the Portuguese material that justifies this separation. The idea that in *C. cancellatum* the spirals are stronger than the transverse ornament is only correct for growth stages of about 30mm diameter, and cannot be used for separation of subgenera within *Cancelloceras*.

**Comparisons:** *Cancelloceras crencellatum* (BISAT 1924), which only occurs a little higher in stratigraphy, has a similar ornament, but develops a coronate conch form at 30mm diameter. Other species of *Cancelloceras*, such as *C. branneroides* (BISAT 1940), *C. crenulatum* (BISAT 1924), and *C. cumbriense* (BISAT 1924) do not show equally strong transverse and spiral ornament and thus lack the reticulate pattern typical for *Cancelloceras cancellatum*.

**Stratigraphical and geographical distribution:** Glia Zone of Great Britain (Yorkshire, Pembrokeshire), Belgium, the Netherlands, Germany (Rhenish Massif), and South Portugal (occurring in the upper part of the Quebradas Formation and probably in the lower Brejeira Formation).

***Cancelloceras crencellatum* (BISAT 1924)**

Pl.14 Figs. 1-8; Text-fig.65

- 1924 *Gastrioceras cancellatum* var. *crencellatum* BISAT: 122, pl.4 fig.6.  
 1959 *Gastrioceras cancellatum crencellatum*- PATTEISKY: 31, pl.11 fig.3-25, pl.12 fig.18-23 [for more synonymy].  
 1962 *Gastrioceras crencellatum*- RAMSBOTTOM & CALVER: 574, pl.14 fig.6,7.  
 1978 *Gastrioceras cumbriensis*- PERDIGÃO: pl.8 fig.1.  
 1979 *Gastrioceras crenulatum*- OLIVEIRA, HORN & PAPROTH: 160, pl.3 fig.5.  
 1995 *Cancelloceras* (*Crencelloceras*) *solari* NIKOLAEVA & KULLMANN: 373.

**Lectotype:** Specimen Nr. RE 4330, British Geological Survey, Keyworth (chosen by RAMSBOTTOM & CALVER 1962, p.574).

**Type locality and horizon:** Royshaw Brickworks near Blackburn (Lancashire, Great Britain); Holcombe Brook Series (Glia Zone).

**Material:** A total of 23 individuals, which come from Vale Figueiras (5; IGML 162, 215, 216, 218, 280), 300m west of Choça near São Marcos da Serra (1), Maria Serrão (1; IGML 176), São Teotónio (1; IGML 217), the gorge at the Praia das Quebradas (6), Monte Coelho (1; IGML 199), and from un-

known localities (6; IGML 168, 205). The size of the specimens, which are mostly internal moulds, ranges from 18 to 52mm. Shell remains are rarely preserved, but can be examined in the impressions in the dissolved inner whorls. Two small natural moulds are available from Monte Inferno.

**Species diagnosis:** *Cancelloceras* with pachyconch conch (ww/dm = 0.60 to 0.65), and moderately wide umbilicus (uw/dm = 0.35 to 0.40 at 20mm dm and 0.40 to 0.45 at 40mm dm). Umbilical margin rounded in juveniles, becoming angular at 30mm diameter, leading to a coronate conch shape. Ornamentation at 30mm diameter with elongate riblets around the umbilicus, fastigate coarse growth lines and coarse spiral lines generating a reticulate pattern. Suture line with wide ventral lobe (EL/h = 0.90; 1.45 of adventive lobe) and moderately high median saddle (0.6 of ventrolateral saddle).

**Conch form:** The Portuguese material displays the typical development of the conch form. At 18 at 25mm diameter (IGML 280, 215), the umbilical margin is rounded, and the ratio umbilical width/conch diameter is less than 0.4. The larger specimens (IGML 218, 205) show the rapid development of the angular umbilical margin, leading to a coronate conch shape with slightly wider umbilicus than in the juveniles.

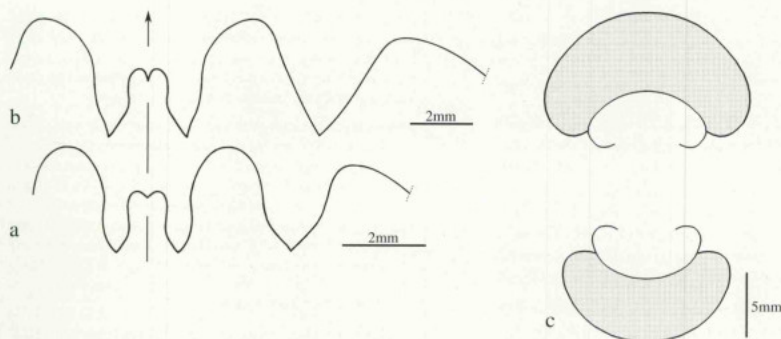
**Dimensions in mm and ratios:**

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 205	41.8	25.4	13.7	18.0	0.61	0.33	0.43
IGML 217	31.0	16.3	10.7	10.6	0.53	0.35	0.34
IGML 216	29.8	16.3	11.7	9.0	0.55	0.39	0.30
IGML 215	29.2	16.0	9.4	11.1	0.55	0.32	0.38
	23.4	13.2	7.9	8.1	0.56	0.34	0.35
IGML 199	27.7	15.7	9.7	9.8	0.57	0.35	0.35
IGML 207	27.5	16.9	9.6	9.2	0.61	0.35	0.33
IGML 280	18.0	11.0	6.8	6.8	0.61	0.38	0.38
IGML 168	18.3	11.3	6.7	6.9	0.62	0.37	0.38
	13.9	9.7	5.4		0.70	0.39	

**Ornamentation:** The main ornament features are elongate nodes around the umbilicus. The smallest specimen (IGML 280) shows, at 18mm diameter, 35 of these riblets around the umbilicus, a number that is reduced during ontogeny. At 25 and 30mm diameter, only 25 to 30 relatively stronger ribs are present (specimens IGML 215, 217). In this stage, strong constrictions of the internal mould can be developed. These are irregularly distributed and can completely be absent.

The shell ornament can best be studied in the latex cast of specimen IGML 199. The inner whorls display the reticulate pattern at 24mm diameter, caused by equally strong transversal and spiral lines. The growth lines are spaced at distances of 0.25mm.

**Suture line:** The juvenile suture line (at 4.4mm whorl height) examined in specimen IGML 208 shows already pointed prongs of the ventral lobe. Characteristic for the later stage (IGML 168) is the asymmetric ventrolateral saddle and the almost symmetric adventive lobe.



**Text-fig. 65.** *Cancelloceras crencellatum* (BISAT 1924).

- a. suture line of specimen IGML 168 (coll. M. HORN et al. 1979) at dm 18.3mm, ww 11.8mm, wh 6.7mm; x 6; , presumably upper part of the Quebradas Formation (G1a Zone).  
 b. suture line of specimen IGML 208 (coll. M. HORN et al. 1982) at wh 4.4mm; x 8; Praia das Quebradas gorge, upper part of the Quebradas Formation (G1a Zone).  
 c. cross section of specimen IGML 176 (coll. K. HORN 1982); x 2.5; Maria Serrão .

#### Sutural ratios:

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
IGML 168	18.3	11.3	6.7	0.58	0.92	0.73	0.60
IGML 208			4.4	0.58	0.81	0.67	0.59

**Remarks:** The original description of *Cancelloceras crencellatum* is based on crushed and distorted individuals, which are difficult to compare with the three-dimensionally preserved specimens known from other regions. According to BISAT (1940), the species occurs slightly above *Cancelloceras cancellatum* (BISAT 1923), and is in Central Europe constantly associated with *Agastrioceras carinatum* (FRECH 1899). Thus it can be presumed that the well preserved specimens from Silschede described by PATEISKY (1959) are conspecific with the type material, and the Portuguese specimens can easily be compared.

*Cancelloceras (Crencelloceras) solari* NIKOLAEVA & KULLMANN 1995 is a junior synonym of *C. crencellatum*, as shown by re-examination of well preserved material from the Rhenish Massif. The authors introduced a new subgenus of *Cancelloceras*, *Crencelloceras* with its type species *C. elegans* RUZHENCEV & BOGOSLOVSKAYA 1978, that was separated from the type subgenus by an ornament in which the transversals are stronger than the spirals (in contrast to *Cancelloceras* s.str., where this is supposed to be opposite). In *C. crencellatum*, however, this is dependant on the growth stage: in smaller individuals the transverse ornament is stronger, while in adults it is the spirals. Hence this character cannot be used for dif-

ferentiation of subgenera within *Cancelloceras*, and *C. (Crencelloceras)* is regarded here as junior synonym.

**Comparisons:** *Cancelloceras cancellatum* (BISAT 1923) is similar but has a slightly narrower conch ( $ww/dm = 0.5$  at 30mm diameter), and has short, node-like tubercles around the umbilicus, whereas *C. crencellatum* has elongate riblets. Another criterion for a clear distinction is that in *C. crencellatum* the umbilicus becomes angular at 30mm diameter. Other species of *Cancelloceras* do not show the reticulate pattern in combination with a coronate adult stage.

**Stratigraphical and geographical distribution:** G1a Zone of Great Britain (Lancashire, Pembrokeshire), Germany (Rhenish Massif), and South Portugal (upper part of the Quebradas Formation, G1a Zone).

#### *Cancelloceras branneroides* (BISAT 1940)

Pl.14 Figs.9-11

- 1940 *Gastrioceras branneroides* BISAT: fig.2.  
 1962 *Gastrioceras branneroides*.- RAMSBOTTOM & CALVER: 574, pl.14 fig.1-3.  
 1979 *Gastrioceras weristerense*.- OLIVEIRA, HORN & PAPROTH: 160, pl.3 fig.4.

**Holotype:** Specimen Nr. 62441, British Geological Survey Museum, Keyworth, Nottingham.

**Type locality and horizon:** Minera Mill, Wrexham (North Wales, Great Britain); G1a Zone.



**Material:** About 20 more or less intensively distorted specimens (IGML 344-347) from greenish shales are available from Eira Velha, collected approximately one meter below the bed with *Cancelloceras cancellatum* (BISAT 1923). They have diameters between 8 and 55mm and display the shell ornament throughout ontogeny. The conch form is not documented because of deformation of all the specimens.

The inner five volutions are ribbed (IGML 345), and at approximately 8mm diameter there are 40 fine, sharp ribs visible, which are strongest at the umbilical margin and disappear on the flanks.

At 20mm diameter (IGML 347), the ribs are reduced to elongate nodes positioned on the umbilical margin. There are 32 of these tubercles, which give rise to rather coarse, slightly crenulated growth lines. These run almost straight over the flanks and form a rather deep sinus on the venter. The same ornament can be seen in specimen 346, at 30mm diameter.

In the largest specimen of 50mm diameter (IGML 344), there are no more umbilical tubercles visible. The biconvex growth lines are slightly crenulated and dense; 8 to 10 lines can be counted per millimetre.

4 additional, three-dimensionally preserved specimens are available from Caieiros de Baixos (IGML 362), one specimen from Vale Figueiras (IGML 166), and one from near the Endiabradas farm 5km northeast of Bordeira.

**Stratigraphical and geographical distribution:** G1a Zone of Great Britain (North Wales), and Southwest Portugal, where, in accordance to the type material, the species occurs in the upper part of the Quebradas Formation below *Cancelloceras cancellatum* (BISAT 1923).

### *Gastrioceras* HYATT 1884

#### *Gastrioceras listeri* (SOWERBY 1812)

PL.15 Figs. 1-6; Text-fig. 66

- 1809 *Conchylolithus* N. *Ammonites (listeri)* MARTIN: pl.35 fig.3.  
 1812 *Ammonites listeri* SOWERBY: 97, pl.455.  
 1951 *Gastrioceras listeri*. - STUBBLEFIELD: 121, pl.7 fig.2.3.  
 1965 *Gastrioceras listeri*. - PATTEYSKY: 17, pl.5 fig.12-17, pl.6 fig.1-5 [for more synonymy].  
 1978 *Gastrioceras cf. cumbriense*. - PERDIGÃO: 392, pl.5 fig.1.  
 1978 *Gastrioceras subcrenatum*. - PERDIGÃO: 392, pl.5 fig.2.  
 1985 *Cancelloceras* sp. OLIVEIRA, HORN, KULLMANN & PAPROTH: 114, text-fig.3 [pt.].

**Lectotype:** Specimen Nr. 43909b (coll. STEINHAUER), British Museum (Natural History), London.

**Type locality and horizon:** Bradford Road 2.5 miles north of Halifax (Yorkshire, Great Britain); basal Westphalian.

**Material:** More than 30 specimens are available for study. They derive from several localities: the best preserved material (13 specimens between 2 and 62mm diameter) come from black porous nodules collected at Monte Parente. The larger of these (over 20mm diameter) are laterally deformed, but the smaller individuals are undeformed and preserved as phragmocones of natural moulds. The material allows observation of ornate ontogeny, as well as the suture line.

7 fragmentary specimens are available from bed 275 of the Praia das Quebradas section (IGML 114-116). They derive from lenticular nodules and are slightly deformed. The largest of these (IGML 115) has a diameter of about 75mm, and in this stage the angular umbilical wall is still occupied by pointed nodes. One volution earlier, fine growth lines are visible that run over the umbilical wall and flanks.

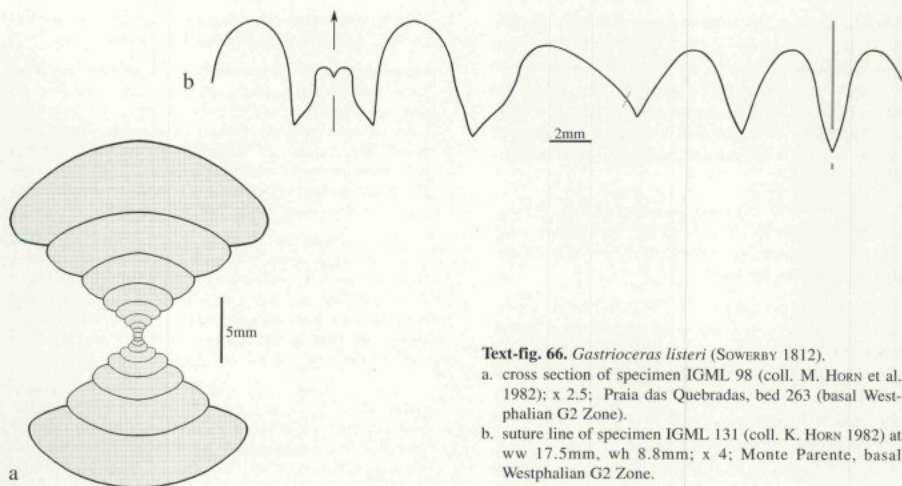
Six undeformed specimens between 8 and 48mm diameter (IGML 98-100) from bed 263 of the Praia das Quebradas section, one large (diameter of about 70mm) specimen (IGML 203) from Fome Aguda 4km east-northeast of Bordeira, and one large specimen (IGML 210) of about 80mm diameter from the Quebradas cliff are available. The latter is laterally crushed, showing sharp umbilical nodes and very fine growth lines. The umbilicus itself is obscured by matrix containing numerous diminutive goniatite individuals (protoconchs and first volutions).

Additionally, one juvenile specimen from the Endiabradas farm (IGML 150), two fragments from Monte Inferno 4km east-northeast of Bordeira, three specimens (IGML 158, 160) from Valverde, one slightly deformed specimen (IGML 204) from the Praia das Quebradas gorge, one specimen from Monte Coelho (IGML 209), and one fragment from the Quebradas Gorge have been studied.

**Species diagnosis:** *Gastrioceras* with pachyconch conch between 15 and 60mm diameter (at 15mm dm: ww/dm = 0.80, at 30mm dm: ww/dm = 0.70, at 45mm dm: ww/dm = 0.60), umbilicus wide (uw/dm = 0.45) throughout these stages. Umbilical margin angular, flanks and venter broadly rounded. Ornamentation at 30mm diameter with 25 elongate, pointed nodes around the umbilicus, fastigate riblet-like growth lines and few spiral lines between the umbilical nodes. Suture line with moderately wide, Y-shaped ventral lobe (EL/H = 0.85; 1.35 of adventive lobe) and moderately high median saddle (0.55 of ventrolateral saddle).

**Conch form:** The cross section (IGML 98) shows that the coronate conch shape is already present in juvenile stages, and that a significant modification does not occur during ontogeny. The whorl width increases to a ratio ww/dm = 0.80 at 17mm diameter, and then decreases slightly in the adult conch. In all stages, the umbilicus has a width of 0.45 of the conch diameter. It appears that the umbilical margin, which is well rounded in juveniles, becomes more pronounced in the adult stage.





**Text-fig. 66.** *Gastrioceras listeri* (SOWERBY 1812).

- a. cross section of specimen IGML 98 (coll. M. HORN et al. 1982); x 2.5; Praia das Quebradas, bed 263 (basal Westphalian G2 Zone).  
 b. suture line of specimen IGML 131 (coll. K. HORN 1982) at ww 17.5mm, wh 8.8mm; x 4; Monte Parente, basal Westphalian G2 Zone.

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 133	62	38	23.5	27	0.61	0.38	0.44
IGML 131	46	27	16	20	0.59	0.35	0.43
IGML 132/1	17.7	14.2	6.4	8.1	0.80	0.36	0.46
IGML 132/2	7.4	6.6	2.6	3.4	0.89	0.35	0.46
IGML 98	26.5	19.3	8.2	12.2	0.73	0.31	0.46
	17.1	13.6	4.9	8.1	0.80	0.29	0.47
	11.1	8.4	3.4	5.2	0.76	0.31	0.47
	7.1	5.2	2.2	3.1	0.73	0.31	0.44
	4.6	3.2	1.3	2.1	0.70	0.28	0.46
	2.9	1.9	0.9	1.3	0.66	0.31	0.45
	1.8	1.2	0.5	0.8	0.67	0.28	0.44

**Ornamentation:** The ontogenetic development of the ornament is recorded in the material from Monte Parente. The smallest specimen (IGML 132) shows at 2mm diameter 20 concave and sharp ribs on the flanks.

At 7mm diameter (IGML 132), these 20 ribs per whorl are still concave, but are shorter and restricted to the umbilical margin. From these nodes, fine noncrenulated growth lines originate, which run prorsiradiately and form a very shallow ventral sinus. The spacing of the growth lines is regularly 0.15mm. Two shell constrictions paralleling the growth lines are present.

Principally, the same ornament is still present at 15mm diameter (IGML 132), but here finely crenulated growth lines and a few spiral lines can be seen in between the umbilical nodes.

At 35mm diameter (IGML 135), there are 25 strong, slightly elongate umbilical nodes, between which distinctively crenulated growth lines occur. Spiral lines are only barely visible.

Larger specimens are only available as internal moulds. At 45mm diameter, IGML 131 shows three weak constrictions per volution, and about 25 weak umbilical nodes. This is also displayed in specimen IGML 133, where at 60mm diameter 12 weak but pointed umbilical nodes occur in the last half volution. One weak constriction of the internal mould is visible at 50mm diameter.

**Suture line:** Although *Gastrioceras* can be regarded as deriving from *Cancelloceras*, the suture line has a simpler outline, as recorded in specimen IGML 131. This secondary simplification especially concerns the shape of the external lobe, which in *G. listeri* has V-shaped branches, in contrast to the pouched branches in species such as *Cancelloceras cancellatum* (BISAT 1923).

#### Sutural ratios:

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
IGML 131	17.5	8.8	0.55	0.85	0.72	0.62	

**Comparisons:** *Gastrioceras listeri* has the widest conch of the European species of the genus. In contrast to *G. carbonarium* (VON BUCH 1832), *G. angustum* PATTEISKY 1964, and *G. circumnodosum* FOORD 1903, it possesses spiral lines between the umbilical nodes.

**Stratigraphical and geographical distribution:** Base of the G2 goniatite Zone of Great Britain (Yorkshire, Lancashire, Devonshire), the Netherlands, Belgium, Germany (Rhenish Massif), Poland (Upper Silesia, Lublin Coal Basin), and possibly Ukraine. The specimens from Southwest Portugal derive from the topmost Quebradas Formation and base of the Brejeira Formation.

*Gastrioceras angustum* PATTEISKY 1964

Pl.15 Fig.7

1964 *Gastrioceras carbonarium angustum* PATTEISKY: 650, pl.1 fig.1; text-fig.10-13.

1965 *Gastrioceras carbonarium angustum* PATTEISKY: 20, pl.7 fig.12-15, pl.8 fig.1-3.

**Holotype:** Specimen Nr. P223 (coll. BÖGER), Deutsches Bergbau-Museum, Bochum.

**Type locality and horizon:** Hammertal, Pleßbach pit (near Bochum-Stiepel, Rhenish Massif, Germany); marine horizon above Sarnsbank 2 coal seam, G2 Zone (base of Westphalian A).

**Species diagnosis:** *Gastrioceras* with pachyconic conch at 15mm diameter (dm: ww/dm = 0.70), and moderately wide umbilicus (uw/dm is about 0.35). Umbilical margin angular, flanks and venter broadly rounded. Ornamentation at 30mm diameter with 25 elongate, pointed nodes around the umbilicus, fastigate riblet like growth lines and few spiral lines between the umbilical nodes. Suture line with moderately wide, Y-shaped ventral lobe (1.35 of adventive lobe) and moderately high median saddle (0.55 of ventrolateral saddle).

**Material:** 12 specimens between 8 and 18mm diameter from Vale Figueiras (IGML 364), mostly preserved as natural moulds in a silicious sideritic nodule. Because of coarse crystallisation, shell ornament is hardly visible. In this material, no remarkable ontogenetic changes of the conch form could be observed.

One specimen is from the road to the Praia de Murração, and three specimens (IGML 149) from 1km north-west of Atalaia, and two from bed 265 of the Praia das Quebradas (IGML 113). All these specimens are smaller than 15mm.

**Dimensions in mm and ratios:**

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 364	17.2	11.9	6.7	5.4	0.69	0.39	0.31
	14.0	9.5	4.6	4.8	0.68	0.33	0.34

**Comparisons:** As PATTEISKY (1964, 1965) pointed out, there appears to be no intermediate form between *G. angustum* and *G. carbonarium* (VON BUCH 1832), and hence separation is justified. The species is separated from *G. listeri* (SOWERBY 1812) by the lack of spiral lines between the umbilical nodes, and from *G. circumnodosum* FOORD 1903 by the much lower number of umbilical nodes.

**Stratigraphical and geographical distribution:** Known so far from basal Westphalian sediments of Germany (Rhenish Massif), probably from Great Britain (Yorkshire, Lancashire), and South Portugal, where specimens were collected in the uppermost part of the Quebradas Formation.

*Agastrioceras* SCHMIDT 1938

*Agastrioceras supinum* sp. nov.

Pl.15 Figs.9, 10; Text-fig.67

**Holotype:** Specimen Nr. IGML 110 (coll. M. HORN et al. 1982), Instituto Geológico e Mineiro, Lisboa.

**Type locality and horizon:** Praia das Quebradas; bed 263, basal Westphalian G2 Zone.

**Material:** 8 three-dimensionally preserved specimens between 14 and 28mm diameter from the type horizon. They derive from brittle carbonate lenses and display ornament details and suture line.

**Species diagnosis:** *Agastrioceras* with pachyconic conch (ww/dm = 0.75 to 0.85); umbilicus narrow to moderately wide (uw/dm = 0.25 to 0.30). Umbilical margin slightly angular, flanks and venter broadly rounded. Ornamentation with coarse growth lines running rursidradially with a biconvex course and with weak ventrolateral projection. Suture line with moderately wide, Y-shaped ventral lobe (EL/h = 0.70; 1.40 of adventive lobe) and moderately high median saddle (0.45 of ventrolateral saddle). Prongs of ventral lobe symmetric.

**Conch form:** All the specimens have a similar shape, which varies in the width of the conch, and the width of the umbilicus is variable (see measurements).

**Dimensions in mm and ratios:**

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
HT IGML 110	21.8	8.8	6.7			0.40	0.31
PT IGML 112	15.1	12.6	7.3	3.7	0.83	0.48	0.25
PT IGML 111	10.5	8.2	5.1	3.3	0.78	0.49	0.31

**Ornamentation:** All the specimens show a similar ornament, consisting of slightly rursidradial lamellar growth lines, spaced at distances of 0.3 to 0.4mm. They have a



**Text-fig. 67.** *Agastrioceras supinum* sp. nov.; suture line of the paratype (IGML 111, coll. M. HORN et al. 1982) at ww 6.8mm, wh 5.9mm; x 10; Praia das Quebradas, bed 263 (basal Westphalian G2 Zone).

biconvex course in which the dorsolateral projection and the ventral sinus dominate.

**Suture line:** The gastrioceratid suture line (IGML 111) shows remarkably tight branches of the ventral lobe, which are different from those known from genera such as *Cancelloceras* and *Gastrioceras*. The other sutural elements resemble these genera.

**Sutural ratios:**

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
PT IGML 111	6.8	3.5	0.47	0.71	0.69	0.51	

**Comparisons:** *Agastrioceras supinum* has a similar conch as *Ag. subcrenatum*. The latter species has much finer growth lines which are sometimes even difficult to trace, in contrast to the lamellose growth lines in *Ag. supinum*. Another difference is the lack of umbilical nodes in *Ag. supinum*.

**Stratigraphical and geographical distribution:** Upper part of the Quebradas Formation (G2 Zone, basal Westphalian) of Southwestern Portugal.

*Agastrioceras clathratum* sp. nov.

Pl.16 Figs.1-3

**Holotype:** Specimen Nr. IGML 117 (coll. D. Korn et al. 1994), Instituto Geológico e Mineiro, Lisboa.

**Type locality and horizon:** Praia das Quebradas; bed 275, G2 Zone.

**Material:** 5 adult specimens from bed 275 of the Praia das Quebradas section (IGML 115,117, 342). They are fragmentary preserved in brittle limestone nodules and partly covered by gypsum crystals, hence preparation of these specimens was impossible.

A decalcified nodule from Monte Inferno 4km east-northeast of Bordeira contains two crushed natural moulds of 20 and 80mm diameter (IGML 369), displaying the ornament in these stages. Another nodule with one large specimen derives from east of Fome Aguda 4km east-northeast of Bordeira.

**Species diagnosis:** *Agastrioceras* with thickly discoidal conch; umbilicus narrow ( $uw/dm = 0.25$ ). Umbilical margin slightly angular, flanks and venter broadly rounded. Ornamentation with elongate umbilical plications, spiral lines, and crenulated growth lines. These run prorsiradiately with a biconvex course and with prominent ventrolateral projection as well as deep ventral sinus.

**Conch form:** None of the specimens is uncrushed, hence a complete description of the conch geometry is prevented. The holotype shows that the venter was broadly rounded at a conch diameter of about 45mm, and that the umbilicus has a width of about 1/4 of the conch diameter.

**Ornamentation:** The smaller of the two specimens from Monte Inferno (IGML 369) shows at 20mm diameter 24

elongate umbilical plications, which are occupied by coarse spiral lines. The growth lines are weakly crenulated and have a strongly biconvex course with a prominent ventrolateral projection. Spiral lines are especially well developed in the outer flank area, in addition to the umbilical margin. The larger specimen shows, at 80mm diameter, densely spaced growth lines, which form a high ventrolateral projection and a deep ventral sinus.

**Comparisons:** Only *Agastrioceras carinatum* (FRECH 1899) is a similar species and possesses a similar ornament, but has umbilical plications only in the juvenile stage, and develops an acute venter at 40mm diameter, when the venter of *Ag. clathratum* is broadly rounded.

**Stratigraphical and geographical distribution:** *Agastrioceras clathratum* is associated with *Gastrioceras listeri* (SOWERBY 1812) in the uppermost part of the Quebradas Formation. Its stratigraphical age is therefore basal Westphalian (G2).

Superfamily **Thalassocerataceae** HYATT 1900

Family **Bisatoceratidae** MILLER & FURNISH 1957

*Homoceratoides* BISAT 1924

*Homoceratoides svetlanae* sp. nov.

Pl.16 Figs.4-6; Text-fig.68

1979 *Reticuloceras* cf. *compressum*.- OLIVEIRA, HORN & PAPROTH 159.

1979 *Homoceratoides varicatus*.- OLIVEIRA, HORN & PAPROTH 159.

**Holotype:** Specimen Nr. IGML 353 (coll. M. Horn et al. 1982), Instituto Geológico e Mineiro, Lisboa.

**Type locality and horizon:** Old quarry 3km south of Nave Redonda; base of the Brejeira Formation (most probably R1a Zone).

**Material:** A total of about 40 specimens, similarly preserved in silicified limestone nodules. Of these, 10 specimens derive from 200m south of Monte Gaviano (IGML 142, 155-157), and 30 specimens from Nave Redonda (IGML 353-358). They range between 4.5 and 18mm diameter, and most of them display the shell ornament.

**Species diagnosis:** *Homoceratoides* with pachyconic conch between 5 and 12mm diameter ( $ww/dm = 0.60$  to  $0.65$ ), and thickly discoidal conch over 15mm diameter ( $ww/dm = 0.55$  to  $0.60$ ); umbilicus moderately wide ( $uw/dm = 0.30$  to  $0.40$ ) throughout these stages. Umbilical margin, flanks and venter broadly rounded. Ornamentation at 15mm diameter with weak, forwardly pointing plications around the umbilicus, and fine growth lines running with a biconvex course and with weak ventrolateral projection. Suture line with very wide, Y-shaped



ventral lobe (EL/h = 0.90) and moderately high median saddle (0.55 of ventrolateral saddle). Prongs of ventral lobe almost symmetric.

**Conch form:** The cross section of the paratype IGML 358 shows very evolute inner whorls up to 3.5mm diameter. In later stages, the umbilicus opens only slowly and its width decreases relative to the conch diameter. The whorl section is semilunate in the stages up to 9mm diameter, but the whorl height increases in the adult conch. In all stages, the venter is broadly rounded.

#### Dimensions in mm and ratios:

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
IGML 353	17.6	10.2	7.8	5.5	0.58	0.44	0.31
IGML 357	16.7	9.9	7.4	5.1	0.59	0.44	0.31
IGML 354	15.3	8.6	6.3	5.2	0.56	0.41	0.34
IGML 355	11.9	7.3	5.1	4.0	0.61	0.43	0.34
IGML 356	4.7	3.1	1.8	1.8	0.66	0.38	0.38
IGML 358	11.8	7.1	5.4	3.5	0.60	0.46	0.30
	6.9	4.6	2.6	2.8	0.67	0.38	0.41
	4.4	2.6	1.3	2.2	0.59	0.30	0.50
	2.8	1.3	0.7	1.6	0.46	0.25	0.57

**Ornamentation:** At 4.5mm conch diameter (specimen IGML 356), the main ornament elements are umbilical plications (35 per whorl), which sometimes dichotomize and degenerate into coarse striae. In between the plications, additional transversal striae are introduced. The transversals have a concavo-convex course with a low ventrolateral projection and rather shallow ventral sinus.

Larger specimens (such as IGML 354, 353, 357) show much weaker and more dense umbilical plications at 15mm diameter. They run in a prorsiradial direction to form a low dorsolateral projection, and give rise to fine growth lines. The course of the growth lines is slightly

biconvex, with a barely visible ventrolateral projection and a more prominent ventral sinus. The internal mould bears irregularly arranged constrictions, paralleling the course of the growth lines. Specimen IGML 155 (20mm diameter) shows 8 such constrictions per whorl.

**Suture line:** The suture line (IGML 170) is characterized by the parallel-sided, wide external lobe and an adventive lobe of exactly half the height of the ventrolateral saddle.

#### Sutural ratios:

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
IGML 355	10.5	7.2	4.5	0.56	0.92	0.63	0.60

**Comparisons:** *Homoceratoides svetlanae* is distinguished from other species of the genus by the weaker transverse ornament, and the forwardly bent umbilical plications. It also differs from the species *Ht. magistrorurs* (HODSON 1957) by the height of the median saddle, which in the Portuguese material exceeds half of the ventrolateral saddle, but in the Irish species is only less more than one third. *Ht. varicatum* (SCHMIDT 1933) possess an umbilical rim, not present in *Ht. svetlanae*.

**Stratigraphical and geographical distribution:** Most probably base of the *Reticuloceras* Stufe (R1a) of Southern Portugal, where the species accompanies *Vallites kullmanni* sp. nov. at the base of the Brejeira Formation.

#### *Homoceratoides* sp. 1

**Material:** One specimen of 12mm diameter (IGML 185) from the highest quartzite beds of the old quarry 3km south of Nave Redonda. It has a diameter of 12mm, and a whorl width of 10.5mm (ww/dm = 0.88), with a narrow umbilicus (uw/dm approximately 0.30). The ornament consist of lamellar growth lines which project on the flanks to form a ventral salient. Parallel to the growth lines run weak shell constrictions. The umbilical margin is occupied by faint nodes. The single specimen cannot be determined with certainty, but appears to be closely related to *Ht. magistrorurs* (HODSON 1957).

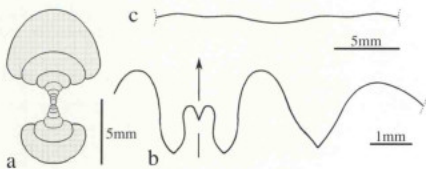
#### Superfamily indet.

#### Family indet.

#### *Chaerogastriceras* gen. nov.

**Type species:** *Chaerogastriceras reifi* sp. nov.

**Genus diagnosis:** Goniatite genus with small pachyconic conch, umbilicus moderately wide. Ornamentation with extremely fine, crenulated growth lines which run almost linearly over flanks and venter. Suture line with very wide, parallel-sided external lobe and high median saddle. Prongs of the external lobe symmetric and tight.



**Text-fig. 68.** *Homoceratoides svetlanae* sp. nov.; Nave Redonda, base of the Brejeira Formation (R1a Zone).

- cross section of the paratype IGML 358 (coll. M. HORN et al. 1982); x 2.5.
- suture line of the paratype IGML 170 (coll. M. HORN et al. 1982) at dm 10.5mm, ww 7.2mm, wh 4.5mm; x 8.
- course of the growth lines in the paratype IGML 357 (coll. M. HORN et al. 1982) at dm 14.6mm, wh 9.5mm, wh 6.6mm; x 2.5.

**Generic composition:** Only the type species.

**Comparisons:** *Chaerogastrioceras* gen. nov. has a morphology that differs from all the other genera which are present in the latest Namurian and Early Westphalian. For this reason, it is difficult to arrange it to a certain family. *Gaitherites solidus* (GORDON 1965) has a similar conch form and a comparable shell ornament, but is very dissimilar in the suture line: In *G. solidus*, the external lobe is narrower and V-shaped, the median saddle is rather low, and the adventive lobe is rounded.

Also similar in conch morphology is *Pygmaeoceras morrowense* (MILLER & MOORE 1938), but here also the suture line is different. At a comparable diameter, the external lobe is perfectly parallel-sided and much narrower. The prongs of this lobe are rounded, in contrast to *Chaerogastrioceras*. The suture line of *Chaerogastrioceras reifi* is similar to that of gastrioceratids, but differs in the very tight branches of the external lobe.

**Stratigraphical and geographical distribution:** Early Westphalian (G2 Zone) of Southwestern Portugal.

*Chaerogastrioceras reifi* sp. nov.

Pl.16 Figs.7-10; Text-fig.69

**Holotype:** Specimen IGML 108 (coll. M. HORN et al. 1982), Instituto Geológico e Mineiro, Lisboa.

**Type locality and horizon:** Praia das Quebradas; bed 263, G2 Zone.

**Material:** Three three-dimensionally preserved specimens (IGML 108, 109) between 10 and 21 mm diameter from the type horizon (brittle carbonate nodules) of the type locality. Similarly preserved juvenile specimens (less than 10 mm diameter) are available from near the Praia da Murração (IGML 182-184).

Additionally, some natural moulds are available: one from Monte Parente (IGML 137), one of a larger specimen (ca. 30 mm diameter) from 200 m southeast of Monte Parente (IGML 147), one decalcified carbonate lens with about 5 natural moulds from Murração Velho (IGML 367), one nodule with five natural moulds from the Pedra das Carneiros north of the Praia das Quebradas (IGML 370), and one slab with three natural moulds from Monte de Vale da Fonte.

**Species diagnosis:** *Chaerogastrioceras* with pachyconic conch ( $w/dm = 0.65$ ); umbilicus narrow ( $uw/dm = 0.25$  to  $0.30$ ). Umbilical margin slightly angular, flanks and venter broadly rounded. Ornamentation with very fine, crenulated growth lines running with a weak biconvex course and with low ventrolateral projection. Suture line with wide, parallel-sided ventral lobe ( $EL/h = 0.75$ ; 1.60 of adventive lobe) and moderately high median saddle (0.60 of ventrolateral saddle). Prongs of ventral lobe slightly asymmetric.

**Conch form:** All the specimens have a very similar conch geometry, as can be seen in the measurements. The small individuals (IGML 182-184) have a relatively wider conch and a wider umbilicus than the larger specimens.

**Dimensions in mm and ratios:**

	dm	ww	wh	uw	ww/dm	wh/dm	uw/dm
HT IGML 108	19.8	13.1	9.2	4.9	0.66	0.46	0.25
PT IGML 367	12.4		5.9	3.5		0.48	0.28
PT IGML 109	11.8	7.3	5.4	3.5	0.62	0.46	0.30
PT IGML 182	9.9	7.3	3.9	3.3	0.67	0.39	0.33
PT IGML 183	7.7	6.6	3.0	2.8	0.86	0.39	0.36
PT IGML 184	7.6	6.4	3.0	2.7	0.84	0.40	0.36

**Ornamentation:** The inner whorls are weakly ribbed, but at 10 mm diameter (paratype IGML 109), the shell bears only extremely fine, crenulated growth lines which run almost straight over flanks and venter. The internal mould possesses one constriction that parallels the growth lines.

The shell ornament is best exposed in the latex casts of the natural moulds. In the specimens IGML 137 and IGML 367, at 12 mm diameter, there are 20 very weak umbilical nodes. The fine growth lines run with a weak biconvex course. They are crenulated and give rise to widely spaced spiral lines which are particularly good visible around the umbilicus. Principally the same ornament is present in specimens IGML 370 and IGML 147 at 25 resp. 30 mm diameter.



**Text-fig. 69.** *Chaerogastrioceras reifi* sp. nov.; suture line of the holotype (IGML 108, coll. M. HORN et al. 1982) at ww 10.0 mm, wh 6.0 mm; x 6; Praia das Quebradas, bed 263 (basal Westphalian G2 Zone).

**Suture line:** The suture has a gastrioceratid outline, but with an almost parallel external lobe. It is rather wide, and is remarkable because of the tight symmetric branches.

**Sutural ratios:**

	dm	ww	wh	MS/h	EL/h	VLS/h	AL/h
IGML 108		10.0	6.0	0.58	0.75	0.62	0.45

**Comparisons:** Because of its peculiar ornament, the species cannot be confused with any other species from the Namurian and Westphalian of South Portugal.

**Stratigraphical and geographical distribution:** Upper part of the Quebradas Formation (G2 Zone, basal Westphalian) of Southwest Portugal.



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## PLATES



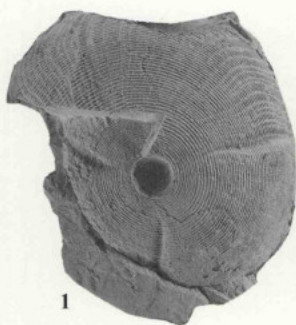
### Plate 7

Figs 1-6. *Lusitanoceras algarviense* PEREIRA DE SOUSA 1923; from the upper Mértola Formation [1-4] and upper part of the Murração Formation [5] (*poststriatum* Zone).

- 1 - lectotype IGML 223 (coll. F.L. PEREIRA DE SOUSA), latex cast; 8km eastsoutheast of Vaqueiros; x 1.25.
- 2 - IGML 236 (coll. D. KORN & J. ROMÃO 1993), latex cast; 500m southeast of Vaqueiros; x 1.5.
- 3 - IGML 235 (coll. D. KORN & J. ROMÃO 1993), latex cast; 500m southeast of Vaqueiros; x 1.
- 4 - IGML 234 (coll. D. KORN & J. ROMÃO 1993), latex cast; 500m southeast of Vaqueiros; x 1.5.
- 5 - IGML 240 (coll. M. HORN et al. 1982); from along the road Carrapateira - Praia da Murração; x 1.
- 6 - IGML 279 (coll. D. KORN & J. ROMÃO 1993), latex cast; 500m southeast of Vaqueiros; x 4.

Figs 7, 8. *Lusitanoceras poststriatum* (BRÜNING 1923); from the upper Mértola Formation (1-3) and upper part of the Murração Formation (4,5) (*poststriatum* Zone).

- 7 - IGML 238 (coll. D. KORN & J. ROMÃO 1993), latex cast; 500m southeast of Vaqueiros; x 1.25.
- 8 - IGML 237 (coll. D. KORN & J. ROMÃO 1993), latex cast; 500m southeast of Vaqueiros; x 1.5.



1



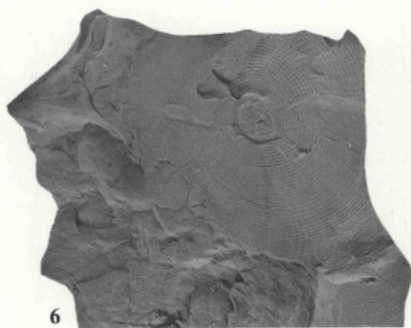
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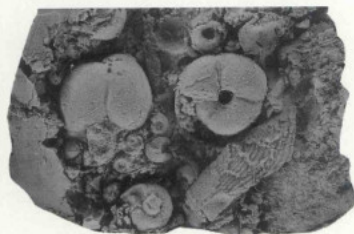
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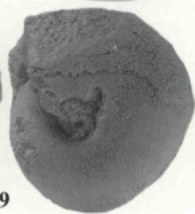
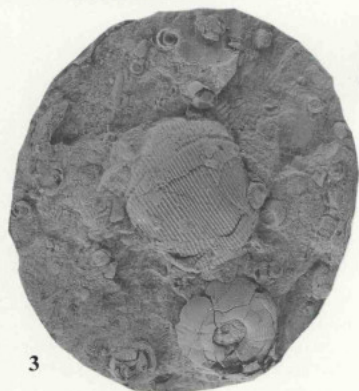
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## Plate 8

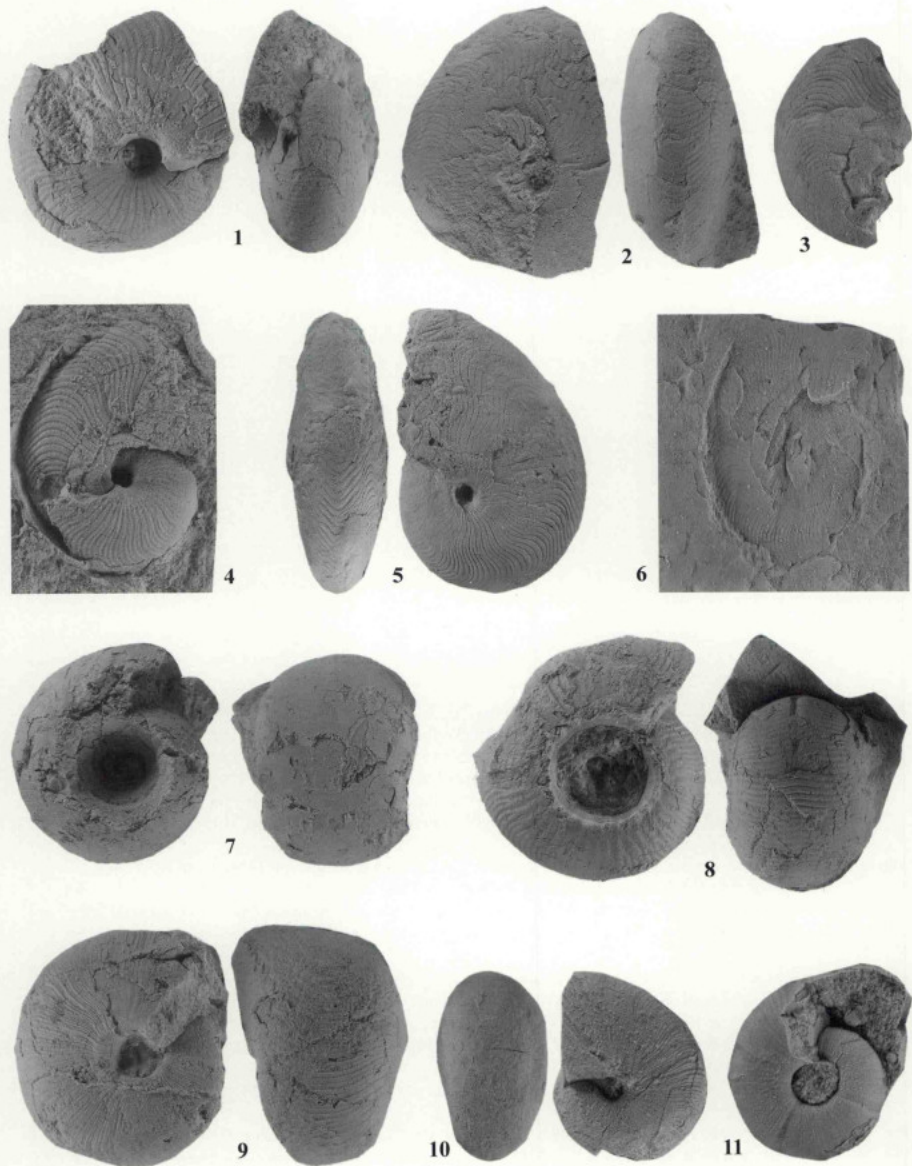
- Figs 1-4. *Lyrogoniattites liethensis* KORN 1988; from the upper Mértola Formation (*liethensis* Zone).  
 1 - IGML 232 (coll. J.T. OLIVEIRA), latex cast; 500m southeast of Vaqueiros; x 1.5 [figured by WAGNER-GENTIS in OLIVEIRA & WAGNER-GENTIS (1983) under the name *Lyrogoniattites* aff. *L. eisenbergensis*].  
 2 - IGML 230 (coll. J.T. OLIVEIRA), latex cast; 500m southeast of Vaqueiros; x 1.25 [figured by WAGNER-GENTIS in OLIVEIRA & WAGNER-GENTIS (1983) under the name *Lyrogoniattites georgiensis*].  
 3 - IGML 325 (coll. J.T. OLIVEIRA); 500m southeast of Vaqueiros; x 3 [figured by WAGNER-GENTIS in OLIVEIRA & WAGNER-GENTIS (1983) under the name *Pachylyroceras claudi*].  
 4 - IGML 233 (coll. J.T. OLIVEIRA), latex cast; 500m southeast of Vaqueiros; x 1.5.
- Figs 5,6. *Neoglyphioceras spirale* (PHILLIPS 1836); from the *spirale* Zone.  
 5 - IGML 312 (coll. F.L. PEREIRA DE SOUSA); Mértola Formation of 600m South of Barrada near Martim Longo; x 2.5 [already figured by PEREIRA DE SOUSA (1923) as well as HORN et al. (1979)].  
 6 - IGML 388 (coll. D. KORN & K. HORN 1995); Murração Formation of the Praia de Murração, bed 143; x 2.
- Figs 7,9. *Stenoglyphyrites cinereus* sp. nov.; from the Quebradas Formation (R2c1 Zone).  
 7 - holotype (IGML 60, coll. D. KORN et al. 1994); Praia das Quebradas, bed 225; x 1.75.  
 9 - paratype (IGML 61, coll. D. KORN et al. 1994); Praia das Quebradas, bed 225; x 2.
- Fig. 8. *Hibernioceras* sp., *Neoglyphioceras* sp.; from the Murração Formation (probably *spirale* Zone).  
 IGML 180 (coll. J.T. OLIVEIRA); Monte da Nora das Árvores; x 2.5.
- Figs 10,11. *Lusitanites clitheroensis* KORN 1988; from the Murração Formation (Late Viséan).  
 10 - IGML 245 (coll. D. KORN & K. HORN 1995); Praia de Murração, bed 161; x 1.75.  
 11 - IGML 265 (coll. D. KORN & K. HORN 1995); Praia de Murração, bed 161; x 2.





## Plate 9

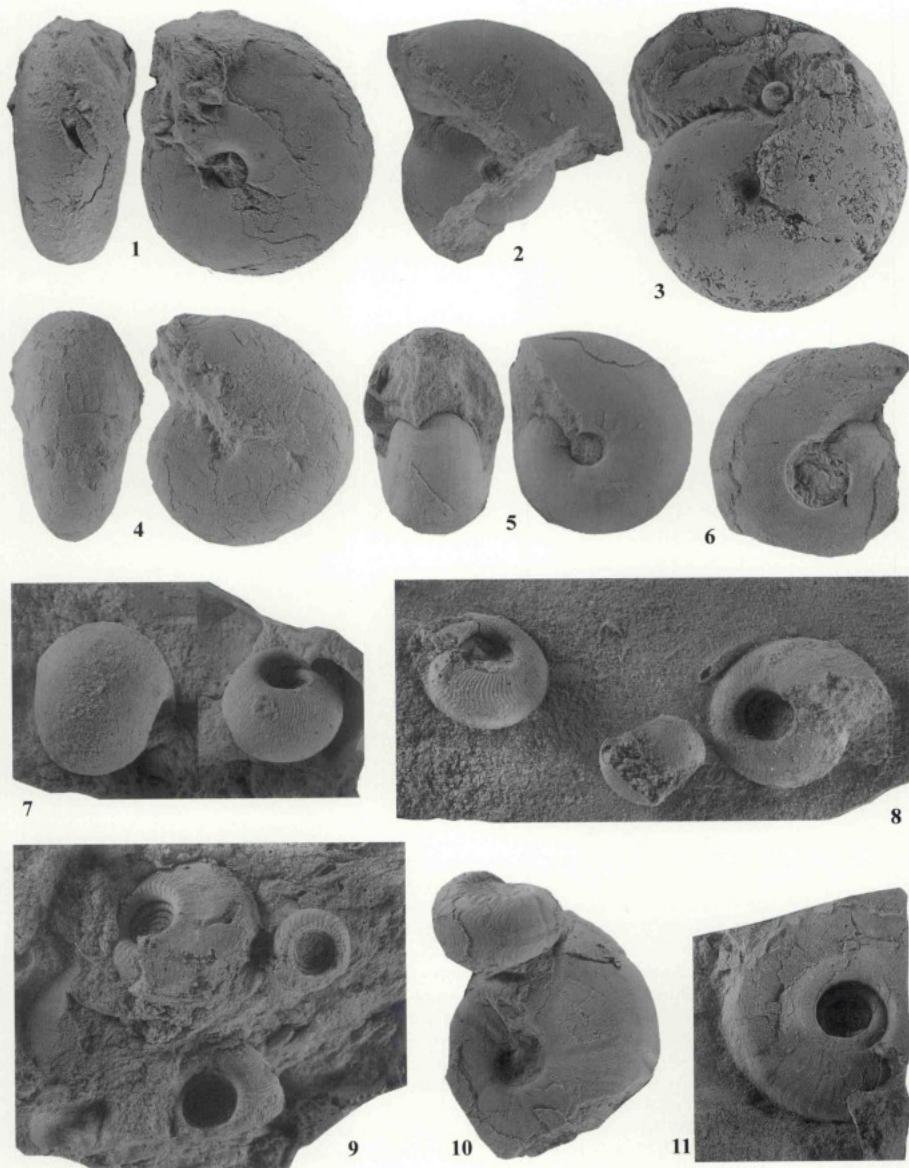
- Figs 1,2. *Ramosites quebradas* sp. nov.; from the Quebradas Formation (R1c Zone).  
 1 - holotype IGML 41 (coll. D. KORN & K. HORN 1995); Praia das Quebradas, bed 214; x 2.  
 2 - questionable specimen (IGML 3, coll. D. KORN et al. 1994); Praia das Quebradas, bed 214; x 1.75.
- Figs 3-5. *Ramosites sousai* sp. nov.; from the Quebradas [3,4] and Brejeira Formations [5] (probably Late Namurian G1 Zone).  
 3 - paratype IGML 167 (coll. F.L. PEREIRA DE SOUSA); Vale Figueiras 3km south of Carrapateira; x 1.25.  
 4 - paratype IGML 228 (coll. D. KORN et al. 1994); Eira Velha 6.5km eastnortheast of Aljezur; x 2.5.  
 5 - holotype IGML 219 (coll. J.T. OLIVEIRA); 300m west of Choça near São Marcos da Serra; x 1.25 [figured by HORN et al. (1979) under the name *Homoceratoides divaricatus*].
- Fig. 6. *Ramosites* sp. 1; from the Brejeira Formation (Late Namurian R1a Zone).  
 IGML 161 (coll. J.T. OLIVEIRA); 3km south of Nave Redonda; x 1.75 [figured by HORN et al. (1979) under the name *Homoceras beyrichianum*].
- Fig. 7. *Homoceras mnemancestralis* sp. nov.; from the Quebradas Formation (R1c Zone).  
 holotype IGML 2 (coll. D. KORN et al. 1994); Praia das Quebradas, bed 214; x 2.5.
- Fig. 8. *Aljezurites katharinae* sp. nov.; from the Quebradas Formation (R1c Zone).  
 holotype IGML 1 (coll. D. KORN et al. 1994); Praia das Quebradas, bed 214; x 2.
- Figs 9-11. *Vallites kullmanni* sp. nov.; from the Brejeira [9] and Quebradas Formations [10-12] (R1a Zone).  
 9 - holotype IGML 254 (coll. M. HORN et al. 1982); 3km south of Nave Redonda, bed 26; x 2.5.  
 10 - paratype IGML 78 (coll. D. KORN et al. 1994); Praia das Quebradas, bed 190; x 2.5.  
 11 - paratype IGML 360 (coll. D. KORN et al. 1994); Praia das Quebradas, bed 190; x 4.





### Plate 10

- Figs 1-5. *Vallites striolatus* (PHILLIPS 1836); from the Quebradas [1,2,4,5] and Brejeira Formations [3] (R1c Zone).  
 1 - IGML 19 (coll. D. KORN & K. HORN 1995); Praia das Quebradas, bed 214; x 1.5.  
 2 - IGML 24 (coll. D. KORN & K. HORN 1995); Praia das Quebradas, bed 214; x 1.75.  
 3 - IGML 220 (coll. OLIVEIRA); 1km northeast of the Estação Saboia; x 1.  
 4 - IGML 25 (coll. D. KORN & K. HORN 1995); Praia das Quebradas, bed 214; x 1.75.  
 5 - IGML 17 (coll. D. KORN & K. HORN 1995); Praia das Quebradas, bed 214; x 3.
- Figs 6-8. *Marianoceras hesperium* sp. nov.; from the Quebradas Formation (probably basal R2 Zone).  
 6 - paratype IGML 80, coll. D. KORN et al. 1994); Praia das Quebradas, bed 222; x 1.  
 7 - paratype (IGML 146, coll. M. HORN et al. 1979) latex cast; Praia das Quebradas gorge; x 2.5.  
 8 - paratype (IGML 154, coll. F.L. PEREIRA DE SOUSA) latex cast; near the Praia da Murração; x 2.5.
- Fig. 9. *Reticuloceras* sp.; from the Quebradas Formation (R1c Zone).  
 IGML 393 (coll. K. HORN 1982), latex cast; Alcaria 3.5km east-northeast of Aljezur; x 2.5.
- Fig. 10. *Tectitretes davisi* (FOORD & CRICK 1897) and *Reticuloceras reticulatum* (PHILLIPS 1836); from the Quebradas Formation (R1c Zone).  
 IGML 46 (coll. D. KORN & K. HORN 1995); Praia das Quebradas, bed 214; x 1.75.
- Fig. 11. *Reticuloceras reticulatum* (PHILLIPS 1836); from the Quebradas Formation (R1c Zone).  
 IGML 390 (coll. M. HORN et al. 1979), latex cast; Monte Tranco 3.5km southeast of Aljezur; x 1.75.



**Plate 11**

- Figs 1-4. *Reticuloceras reticulatum* (PHILLIPS 1836); from the Quebradas Formation (R1c Zone).  
1 - IGML 10 (coll. D. KORN et al. 1994); Praia das Quebradas, bed 214; x 1.25.  
2 - IGML 9 (coll. D. KORN et al. 1994); Praia das Quebradas, bed 214; x 1.75.  
3 - IGML 53 (coll. D. KORN & K. HORN 1995); Praia das Quebradas, bed 214; x 2.  
4 - IGML 54 (coll. D. KORN & K. HORN 1995); Praia das Quebradas, bed 214; x 3.
- Figs 5-7. *Reticuloceras melanum* sp. nov.; from the Quebradas Formation (R1c Zone).  
5 - holotype IGML 43 (coll. D. KORN & K. HORN 1995); Praia das Quebradas, bed 214; x 1.75.  
6 - paratype IGML 11 (coll. D. KORN et al. 1994); Praia das Quebradas, bed 214; x 1.75.  
7 - paratype IGML 42 (coll. D. KORN & K. HORN 1995); Praia das Quebradas, bed 214; x 1.5.
- Figs 8-10. *Reticuloceras scapum* sp. nov.; from the Quebradas Formation (R1c Zone).  
8 - holotype IGML 6 (coll. D. KORN et al. 1994); Praia das Quebradas, bed 214; x 1.5.  
9 - paratype GML 50 (coll. D. KORN & K. HORN 1995); Praia das Quebradas, bed 214; x 2.  
10 - paratype IGML 7 (coll. D. KORN & K. HORN 1995); Praia das Quebradas, bed 214; x 3.





### Plate 12

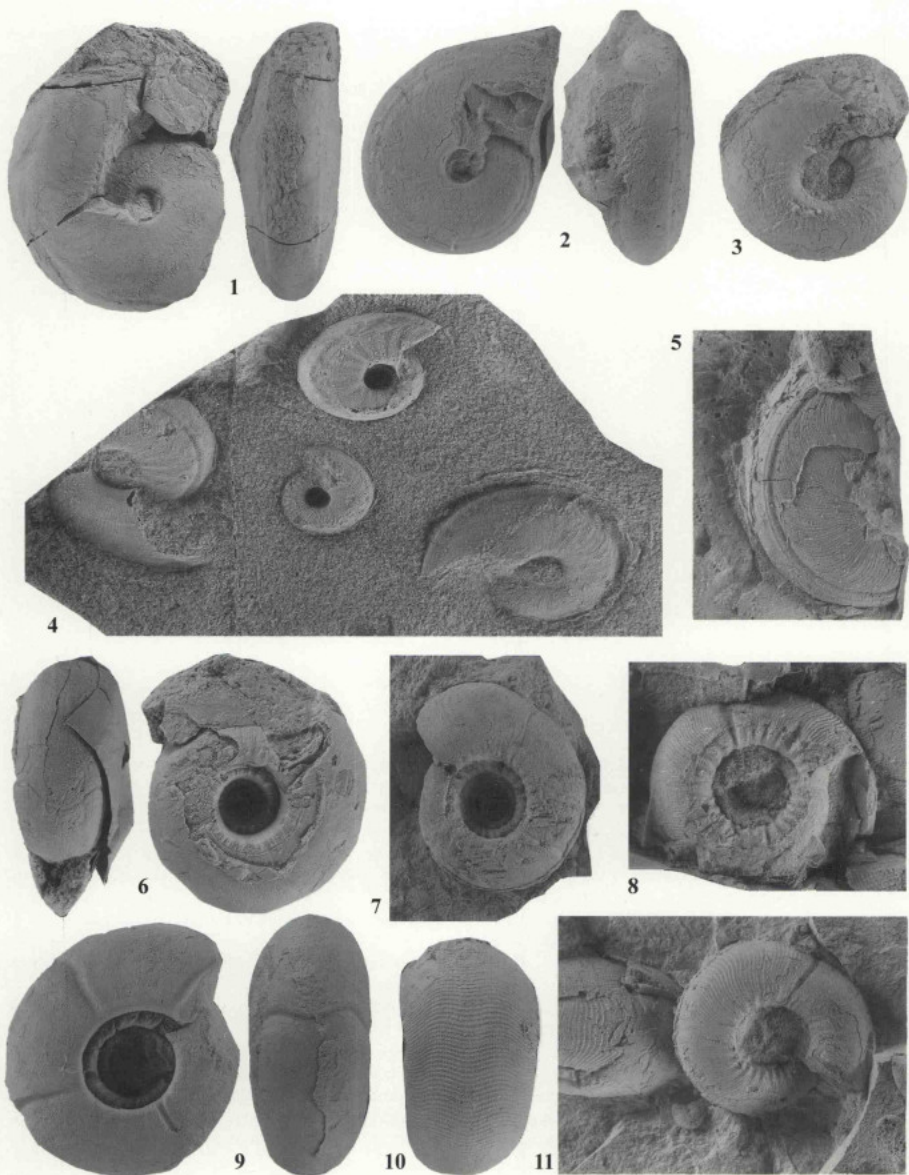
- Figs. 1, 2. *Reticuloceras coreticulatum* (BISAT & HUDSON 1943); from the Quebradas Formation (R1c Zone).  
 1 - IGML 74 (coll. D. KORN & K. HORN 1995); Praia das Quebradas, bed 216; x 3.  
 2 - IGML 84 (coll. D. KORN et al. 1994); Praia das Quebradas, bed 219; x 2.5.
- Fig. 3. *Phillipsoceras* sp. 1; from the Quebradas Formation (R1 Zone).  
 IGML 394 (coll. D. KORN et al. 1994); Praia das Quebradas gorge, bed 119; x 2.5.
- Figs 4-7. *Tectiretites davisi* (FOORD & CRICK 1897); from the Quebradas Formation (R1c Zone).  
 4 - IGML 47 (coll. D. KORN & K. HORN 1995); Praia das Quebradas, bed 214; x 1.75.  
 5 - IGML 5 (coll. D. KORN et al. 1994); Praia das Quebradas, bed 214; x 1.75.  
 6 - IGML 14 (coll. D. KORN & K. HORN 1995); Praia das Quebradas, bed 214; x 2.  
 7 - IGML 4 (coll. D. KORN et al. 1994); Praia das Quebradas, bed 214; x 2.5.
- Figs 8-10. *Retites alector* sp. nov.; from the Quebradas Formation (R1c Zone).  
 8 - holotype IGML 38 (coll. D. KORN & K. HORN 1995); Praia das Quebradas, bed 214; x 1.75.  
 9 - paratype IGML 39 (coll. D. KORN & K. HORN 1995); Praia das Quebradas, bed 214; x 2.5.  
 10 - paratype IGML 229 (coll. KORN et al. 1994); Praia das Quebradas gorge, bed 117; x 1.75.
- Fig. 11. gen. et sp. indet. from the Quebradas Formation (R2 Zone).  
 IGML 91 (coll. D. KORN et al. 1994); Praia das Quebradas, bed 229; x 2.5.





### Plate 13

- Figs 1-4. *Bilinguites metabilinguis* (WRIGHT 1927); from the Quebradas Formation (R2c1 Zone).  
 1 - IGML 63 (coll. D. KORN et al. 1994); Praia das Quebradas, bed 225; x 1.25.  
 2 - IGML 64 (coll. D. KORN et al. 1994); Praia das Quebradas, bed 225; x 1.75.  
 3 - IGML 62 (coll. D. KORN et al. 1994); Praia das Quebradas, bed 225; x 1.75.  
 4 - IGML 144 (coll. M. HORN et al. 1982); road to the Praia de Murração; x 1.75.
- Fig. 5. *Bilinguites superbilinguis* (BISAT 1924); from the Quebradas Formation (G1a Zone).  
 IGML 201 (coll. D. KORN & K. HORN 1995); 300m east of Monte Coelho, 5.3km northeast of Aljezur; x 2.5.
- Figs 6-11. *Cancelloceras cancellatum* (BISAT 1923); probably from the uppermost Quebradas Formation (G1a Zone).  
 6 - IGML 221 (coll. F.L. PEREIRA DE SOUSA); 400m east of Valverde, 8.5km east-northeast of Aljezur; x 1.5 [figured by HORN et al. (1979) under the name *Gastrioceras cancellatum*].  
 7 - IGML 195 (coll. M. HORN et al. 1979), latex cast; Eira Velha 6.5km east-northeast of Aljezur; x 1.75.  
 8 - IGML 193 (coll. M. HORN et al. 1979), latex cast; Eira Velha 6.5km east-northeast of Aljezur; x 2.5.  
 9 - IGML 214 (coll. M. HORN et al. 1979); Caeiros de Baixo 2.5km southeast of Aljezur; x 1.5 [holotype of *Cancelloceras (Cancelloceras) oliveirai* NIKOLAEVA & KULLMANN 1995].  
 10 - IGML 256 (coll. M. HORN et al. 1979), latex cast of the inner whorls; Caeiros de Baixo 2.5km southeast of Aljezur; x 2.5 [figured by NIKOLAEVA & KULLMANN (1995) under the name *Cancelloceras (Cancelloceras) oliveirai*].  
 11 - IGML 196 (coll. M. HORN et al. 1979), latex cast; Eira Velha 6.5km east-northeast of Aljezur; x 2.5.



# Plate 14

Figs 1-8. *Cancelloceras crenellatum* (BISAT 1924); probably from the uppermost Quebradas Formation (G1a Zone).

1 - IGML 205; locality unrecorded; x 1.

2 - IGML 218 (coll. F.L. PEREIRA DE SOUSA); Vale Figueiras 3km south of Carrapateira; x 1.25.

3 - IGML 217 (coll. F.L. PEREIRA DE SOUSA); São Teotônio; x 1.5.

4 - IGML 215 (coll. F.L. PEREIRA DE SOUSA); Vale Figueiras 3km south of Carrapateira; x 1.5 [figured by HORN et al. (1979) under the name *Gastrioceras crenulatum*; holotype of *Cancelloceras (Crenelloceras) soliari* NIKOLAEVA & KULLMANN 1995].

5 - IGML 216 (coll. F.L. PEREIRA DE SOUSA); Vale Figueiras 3km south of Carrapateira; x 1.5.

6 - IGML 168; locality unrecorded; x 2.5.

7 - IGML 199 (coll. D. KORN & K. HORN 1995), latex cast; 300m east of Monte Coelho, 5.3km northeast of Aljezur; x 1.75.

8 - IGML 280; locality unrecorded; x 2.5 [figured by NIKOLAEVA & KULLMANN (1995) under the name *Cancelloceras (Cancelloceras) soliari*].

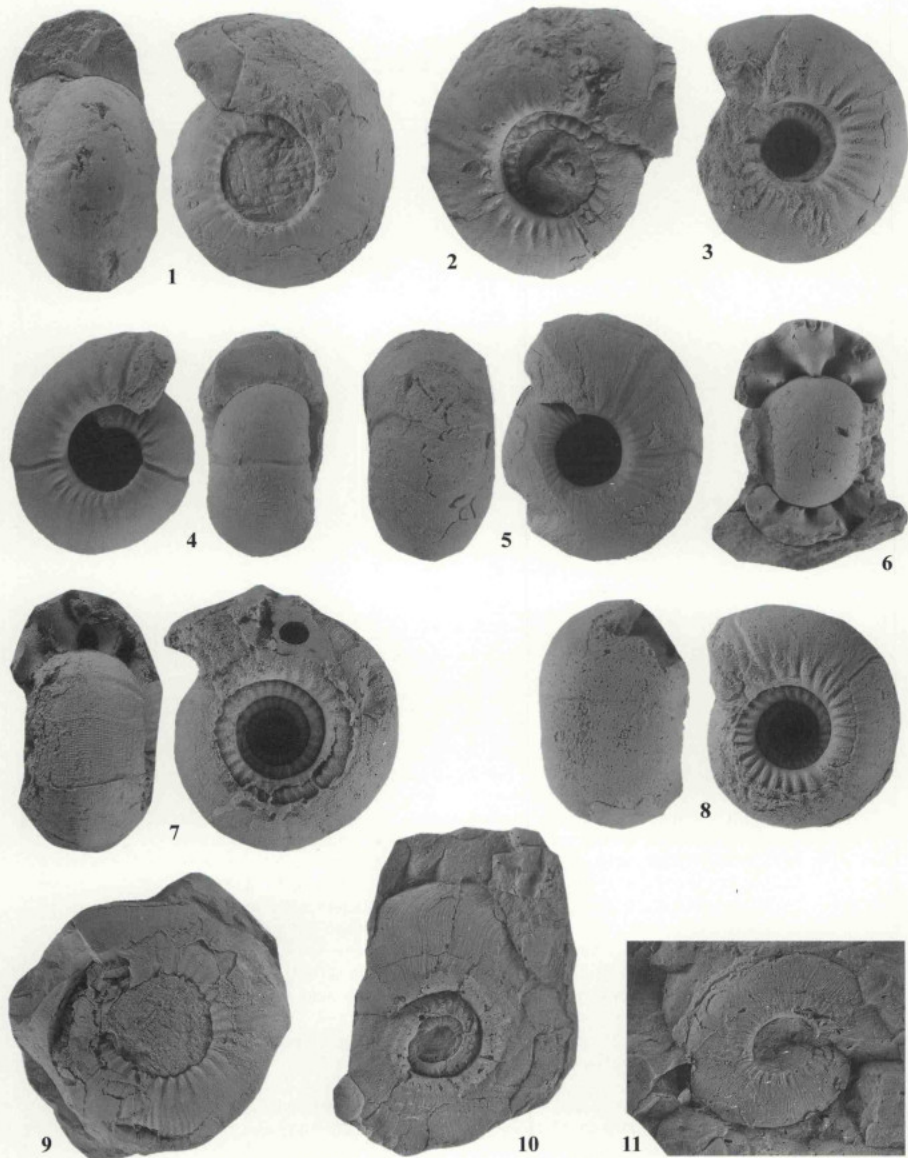
Figs 9-11. *Cancelloceras branneroides* (BISAT 1940); from the uppermost Quebradas Formation (G1a Zone).

9 - IGML 362 (coll. M. HORN et al. 1979); Caeiros de Baixo 2.5km southeast of Aljezur; x 1.75.

10 - IGML 344 (coll. D. KORN et al. 1994), latex cast; Eira Velha 6.5km east-northeast of Aljezur; x 1.

11 - IGML 347 (coll. D. KORN et al. 1994), latex cast; Eira Velha 6.5km east-northeast of Aljezur; x 1.75.





### Plate 15

- Figs 1-6. *Gastrioceras listeri* (SOWERBY 1812); probably from the upper part of the Quebradas Formation (basal G2 Zone).  
 1 - IGML 133 (coll. K. HORN 1983); Monte Parente 5.5km northeast of Bordeira; x 1.  
 2 - IGML 204 (coll. M. HORN et al. 1982); Praia das Quebradas gorge; x 1.  
 3 - IGML 135 (coll. K. HORN 1983); Monte Parente 5.5km northeast of Bordeira; x 1.5.  
 4 - IGML 132 (coll. K. HORN 1983), latex cast and natural mould; Monte Parente; x 2.  
 5 - IGML 134 (coll. K. HORN 1983), latex cast; Monte Parente 5.5km northeast of Bordeira; x 1.5.  
 6 - IGML 150 (coll. J.T. OLIVEIRA); Endiabras farm 5km east-northeast of Bordeira; x 3.
- Fig. 7. *Gastrioceras angustum* PATTEISKY 1964; from the upper part of the Quebradas Formation (basal G2 Zone). IGML 364 (coll. D. KORN & K. HORN 1995); Vale Figueiras 3km south of Carrapateira; x 3.
- Fig. 8. gen. et sp. indet; probably from the Brejeira Formation (latest Namurian or basal Westphalian). IGML 212 (coll. J.T. OLIVEIRA); 200m southeast of Halhao; x 3.
- Figs 9, 10. *Agastrioceras supinum* sp. nov.; from the upper part of the Quebradas Formation (basal G2 Zone).  
 9 - paratype IGML 111 (coll. M. HORN et al. 1982); Praia das Quebradas, bed 263; x 2.5.  
 10 - holotype IGML 110 (coll. M. HORN et al. 1982); Praia das Quebradas, bed 263; x 2.5.



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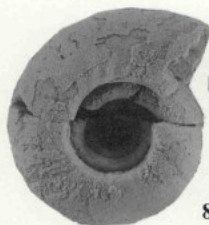
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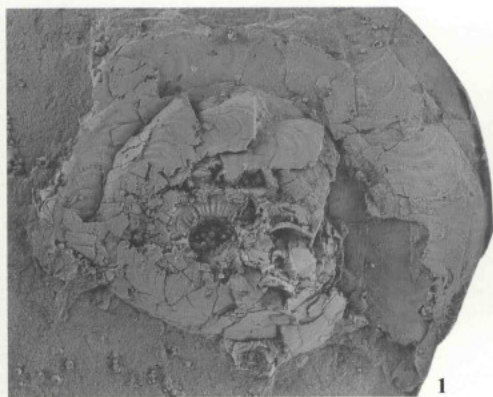
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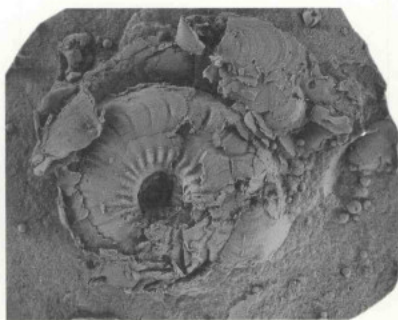


### Plate 16

- Figs 1-3. *Agastrioceras clathratum* sp. nov.; from the upper part of the Quebradas Formation (probably G2 Zone).  
 1 - paratype IGML 369 (coll. J.T. OLIVEIRA), latex cast; Monte Inferno; x 1.  
 2 - paratype IGML 369 (coll. J.T. OLIVEIRA), latex cast of another specimen on the same slab; Monte Inferno 4km east-northeast of Bordeira; x 1.75.  
 3 - holotype IGML 117 (coll. D. KORN et al. 1994); Praia das Quebradas, bed 275; x 1.
- Figs 4-6. *Homoceratoides svetlanae* sp. nov.; from the lower part of the Brejeira Formation (R1a Zone).  
 4 - holotype IGML 353 (coll. M. HORN et al. 1982); 3km south of Nave Redonda; x 2.5.  
 5 - paratype IGML 155 (coll. J.T. OLIVEIRA); 200m south of Monte Gaviano; x 2.  
 6 - paratype IGML 357 (coll. M. HORN et al. 1982); 3km south of Nave Redonda; x 2.5.
- Figs 7-10. *Chaerogastrioceras reifi* sp. nov.; from the uppermost part of the Quebradas Formation (G2 Zone).  
 7 - holotype IGML 109 (coll. M. HORN et al. 1982); Praia das Quebradas, bed 263; x 2.5.  
 8 - paratype IGML 370 (coll. M. HORN et al. 1982), latex cast; Pedra das Carneiros north of the Praia das Quebradas; x 2.  
 9 - paratype (IGML 367, coll. K. HORN 1982) latex cast; Murração Velho; x 3.  
 10 - paratype (IGML 137, coll. K. HORN 1983) latex cast; Monte Parente 5.5km northeast of Bordeira; x 2.5.



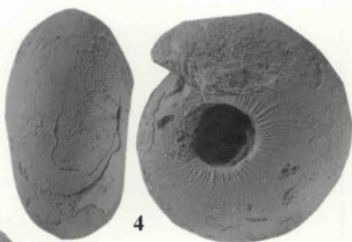
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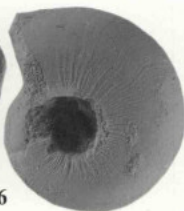
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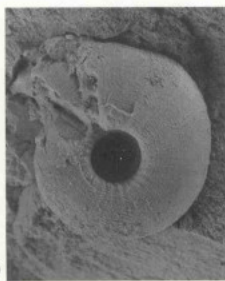
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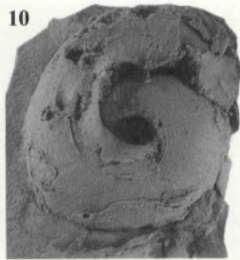
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