

ORDOVICIAN TERGOMYA AND GASTROPODA (MOLLUSCA) OF THE ANTI-ATLAS (MOROCCO)

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Abstract. A large collection of the Ordovician Tergomya and Gastropoda, discovered and gathered by Jacques Destombes during his research of the Anti-Atlas (Morocco), is described. Of 23 identified species, characterising the cold Mediterranean Palaeoprovince, 10 are common to Bohemia (the Barrandian Area), four to France (the Montagne Noire), and 10 are endemic to Morocco. Ascertained genera of Tergomya include *Sinuitopsis*, *Cyrtodiscus*, *Quasisinuities*, *Carcassonnella*, *Tachillanella*, and *Thoralispira*; ascertained genera of Gastropoda include *Sinuities*, *Selesinuities*, *Tritonophon*, *Bucanopsina*, *Tropidodiscus*, *Lesueurilla*, *Ptychonema*, *Clathrospira*, *Lophospira*, *Nonorios*, *Holopea*?, and *Loxonema*?. New subfamily and taxa of Tergomya named herein are Carcassonnellinae subfam. n., *Baltiscanella* gen. n., *Tachillanella tafilaltensis* gen. et sp. n.; new taxa of Gastropoda are *Sinuities destombesi* sp. n., *Atlantophon maider* gen. et sp. n., *Ptychonema maroccanum* sp. n., *Clathrospira amouguerana* sp. n., and *Lophospira? debganensis* sp. n. Important results concern morphology (muscle attachment areas in *Sinuitopsis*, *Selesinuities*, and *Sinuities*; secondary shell deposits in *Sinuities destombesi*; presence of a sinus on the keel in *Lesueurilla prima*), taxonomy, functional morphology, palaeoecology, mode of life, shell repair, and palaeobiogeography.

■ Mollusca, Tergomya, Gastropoda, new taxa, taxonomy, palaeoecology, functional morphology, palaeobiogeography, mode of life, shell repair, cold-water fauna, Ordovician, Mediterranean Palaeoprovince, Morocco, Anti-Atlas, Bohemia, Barrandian Area

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*This paper is dedicated
to the 100th anniversary
of the publication of the monograph
The Lower Silurian Gastropoda of Minnesota
by E. O. Ulrich and W. H. Scofield
Minneapolis 1897
which initiated a new epoch of investigation
of the Ordovician gastropods*

Calymenina), R. J. Horný (Tergomya and Gastropoda), K. Ingham (Trilobita - Trinucleidae), L. Marek (Bivalvia and Hyolithida), M. Mergl (Brachiopoda), N. Spjeldnaes (Bryozoa), H. and G. Termier (Bryozoa), G. Ubaghs (Echinodermata), and S. Willefert (Graptolithina). Owing to the large scope of the collections and various other reasons, only a part of the results has been published (e.g., Chauvel 1966, 1969, 1977, 1978, Destombes 1963b, 1966, 1967a,b, 1972, Havlíček 1968, 1971, Marek 1983, Mergl 1981, 1988, Ubaghs 1963). The main results of the investigations of the Ordovician in general (stratigraphy, palaeogeography, facies development etc.), accomplished by J. Destombes, were issued in 1962, 1963a, 1970, 1971, and 1985.

The collection of gastropods and tergomyans, consisting of 23 species taxa (8 cyrtoneid tergomyans and 15 gastropods) based on about 1200 specimens, was recovered from 57 localities between the years 1959 and 1967. The samples studied come from all Ordovician series, with the exception of the Tremadoc. Although very carefully gathered, the collection undoubtedly represents only a part of the abundance of these molluscs actually occurring in the local taphocoenoses. Nevertheless, the collection gives a good picture of the Ordovician tergomyan and gastropod assemblages, and its examination provides an important contribution to the knowledge of the cold-water fauna, distributed in that part of the Mediterranean Palaeoprovince.

Introduction

During his investigations of the Ordovician strata in the Anti-Atlas (Tindouf Bassin, Morocco), carried out since 1959, Jacques Destombes has discovered and gathered, mostly between the years 1959 and 1967, a large collection of Ordovician invertebrate fauna. This collection has been made available to many specialists, mostly those interested in the cold-water fauna distributed in the Mediterranean *Selenopeltis* Palaeoprovince. According to Destombes et al. (1985; complemented), the material is being or has been studied by C. R. Barnes (Conodontophorida), J. F. Bockelie (Crinoidea), B. Bouček (Conulariida), D. L. Bruton (Trilobita - Odontopleuridae, Illaenidae), J. Chauvel (Echinodermata), J. Destombes (Trilobita - Phacopina and others), J. Deunff (microplankton), N. Grekoff (Ostracoda), V. Havlíček (Brachiopoda), J.-L. Henry (Trilobita -

The study of the gastropod and tergomyan collection was carried out in the Department of Palaeontology, National Museum, Prague.

History and present state of the investigation of the Ordovician tergomyans and gastropods in the Mediterranean Palaeoprovince

Within the Mediterranean Palaeoprovince, Ordovician gastropods and tergomyans occur chiefly in the Bohemian Massif (Czech Republic, Bohemia), Armorica (France, Spain, and Portugal) and Anti-Atlas (Tindouf Basin, Morocco). Of these three territories, the Ordovician sea in Bohemia (Perunica) was inhabited by the most diversified communities and the Barrandian Area yielded the best preserved specimens, coming from various facies distributed throughout the complete sequence of only slightly tectonically affected Ordovician strata (Havlíček 1982, Havlíček and Fatka 1992). Although still not yet completely recognized, the fauna contains more than 80 so far described species belonging to seven genera of Tergomya, five genera of Paragastropoda, and at least 30 genera of Gastropoda. The majority of them were known to Joachim Barrande, whose unfinished manuscript was completed and edited by Jaroslav Perner in 1903, 1907, and 1911. The oldest description is a species described by J. Barrande in 1867 (*Pterotheca consobrina* BARRANDE, 1872); another species was described (as *Onychochilus*) by J. Perner in 1900 (*Mimospira helmhackeri* (PERNER, 1900)). Numerous papers following the Perner monograph concern tergomyan and gastropod nomenclature, taxonomy, systematics, biostratigraphy and palaeobiology (J. B. Knight 1937, 1941; R. J. Horný 1961, 1962, 1963a,b,c, 1964, 1965, 1990, 1991a,b,c, 1992, 1996a,b,c, 1997a,b,c,d,e,f,g,h,i; L. Marek 1983; and J. Frýda 1988, 1989).

America contains several areas with rich benthic fauna, including gastropods and tergomyans. Nevertheless, our knowledge of these molluscs - no doubt because of their predominantly poor preservation in tectonically affected rocks - is generally rather incomplete. The best recognized are the Lower Ordovician (Tremadocian and Arenigian) gastropods and tergomyans of the Montagne Noire, often preserved in siliceous concretions. The first published species from this area is the well-known and widely distributed *Peelerophon oehlerti*, described (as *Bellerophon*) by J. Bergeron in 1889. A few more taxa were added later (1935) by M. Thoral: *Sinuities* sp., *Cymbularia laevis* THORAL, 1935, and *Lesueurilla prima* PERNER, 1903. In 1982, E. L. Yochelson revised all tergomyan and gastropod species, reporting *Archinacella* cf. *ovata* BARRANDE in PERNER, 1903, *Archinacella* sp., *Sinuities* cf. *sowerbyi* PERNER, 1903, ?*Megalomphala* sp. ind., *Gamadiscus courtessollei* YOCHELSON, 1982, *Peelerophon oehlerti* (BERGERON, 1903), *Cymbularia laevis* THORAL, 1935, *Cymbularia* cf. *laevis* THORAL, 1935, *Pararaphistoma* (*Climacorphistoma*) *vaginati* KOKEN, 1925, *Lesueurilla prima* (BARRANDE in PERNER, 1903), and *Lesueurilla* sp. ind. He also mentioned a find of poorly preserved Caradocian specimens of *Cyclonema* sp. from Hérault. Thanks to excellently preserved new material, collected by D. Vizcaïno,

new functional morphology studies were carried out by Horný and Vizcaïno (1995) and Horný and Peel (1996) which also resulted in taxonomical revision (new genera *Thoralispira* HORNÝ et VIZCAÏNO, 1995 and *Carcassonnella* HORNÝ et PEEL, 1996, and new species *Thoralispira? occitana* HORNÝ et VIZCAÏNO, 1995 and *Carcassonnella vizcainoi* HORNÝ et PEEL, 1996). The current investigations concern the genera *Sinuities*, *Archinacella*, and *Peelerophon*, and the species *Thoralispira? occitana* HORNÝ and VIZCAÏNO, 1995.

Other regions of the Central and Armorican Massifs and different localities in northern France and Belgium yielded less well preserved material, mostly of Lower and Middle Ordovician (Llanvirnian and Dobrotivian) age. In spite of local abundance of finds, the specimens are often preserved as tectonically deformed internal moulds and, therefore, difficult to determine exactly. This was probably the main reason why these gastropods have never been studied and described monographically. Several species were repeatedly mentioned, but neither described in detail, nor figured in many older papers, e.g. d'Orbigny (1840), Rouault (1851), Tromelin (1876), Tromelin and Lebesconte (1875, 1877), Hermite (1878), Barrois (1886), Kerfome (1901), and others (e.g. *Bellerophon acutus* SOWERBY in MURCHISON, 1839, *B. bilobatus* SOWERBY in MURCHISON, 1839, *B. trilobatus* SOWERBY in MURCHISON, 1839, *Pleurotomaria bussacensis* SHARPE, 1853, and *B. sacheri* TROMELIN and LEBESCONTE, 1876). Together with these names, several *nomina nuda* appeared, lacking proper description and figure (e.g. *Bellerophon lhuissieri* ROUAULT, 1851, *B. alixi* ROUAULT, 1851, *B. lebescontei* TROMELIN, 1877, *B. deslongschampsii* ORBIGNY, 1840, *Holopea caumonti* TROMELIN, 1877, *Capulus subcompressus* TROMELIN et LEBESCONTE, 1875, etc.; see Pillet 1992, Frýda and Gutiérrez-Marco 1996). Unfortunately, none of the more recent and contemporary papers contain descriptions and figures allowing objective comparison (Péneau 1928, Cavet et Pillet 1968, Pillet 1990). An important paper, demonstrating the present state of investigation, is that of J. Pillet (1992), describing and figuring Lanvirnian and Llandeilian (Dobrotivian) gastropods from Anjou (*Tropidodiscus acutus* [SOWERBY in MURCHISON, 1839], *Sinuities bilobatus bilobatus* [SOWERBY in MURCHISON, 1839], *S.? meignannensis* PILLET, 1992, *Lesueurilla* aff. *prima* [BARRANDE in PERNER, 1903], *Clathrospira bussacensis* [SHARPE, 1853], and *Holopea laevis* PILLET, 1992).

The Iberian Peninsula (Iberia) is very important for the palaeobiogeography of Ordovician gastropods and tergomyans. Remarkably, the oldest paper validly describing a gastropod species from the Mediterranean Province, *Pleurotomaria bussacensis* from the neighbourhood of Bussaco, Portugal, is that of D. Sharpe (1853). Already in 1849 Sharpe described, although invalidly, *Bellerophon duriensis* SHARPE, 1849 from Vallongo. Also J. Barrande took part in the research of this territory: Verneuil and Barrande (1855) described and figured *Bellerophon acutus* and *B. bilobatus*, and described *Pleurotomaria bussacensis*. J. Delgado (1908) listed (but unfortunately not figured) about 30 taxa of Portuguese Ordovician gastropods, which testify to rather rich gastropod assemblages (several species of "*Bellerophon*", most frequently *B. bilobatus*, *B. trilobatus*, *B. acutus*; *Holopea* (about five species), *Pleurotomaria bussacensis*, and other, seemingly only approximately

determined genera (e.g. *Euomphalus*, *Straparollus*, *Trochomena*, *Cyclonema*, *Natica*, *Platyostoma*, *Murchisonia* or *Loxonema*, *Subulites*). In 1916, A. Born described and partly figured *Bellerophon* cf. *acutus*, *Protowarthia hispanica* BORN, 1916, *Salpingostoma* sp., *Pleurotomaria (Mourlonia) bussacensis* SHARPE, *Pleurotomaria* sp. n. from the Lower and Middle Ordovician at Almaden (Spain). The modern biostratigraphical investigation of the Iberian Peninsula brings new and important data even for gastropod and tergomyan fauna. Gutiérrez-Marco and Martín-Sánchez (1983) described the Dobrotivian *Archinacella ovata* BARRANDE in PERNER, 1903 and *Pygmaeoconus gnomicus* GUTIÉRREZ-MARCO et MARTÍN-SÁNCHEZ, 1983 from central Spain. In 1984 Gutiérrez-Marco, Rábano et al. reported *Sinuities (Sinuities) hispanicus* (BORN), *Cymbularia* sp., *Clathrospira? bussacensis* (SHARPE), *Tropidodiscus (Peruniscus)* sp. n., *Lophospira* sp. n., and *Pleurotomariinae* indet. from Central Spain (Central-Iberian Zone, Hesperian Massif), and in the same year (1984) Gutiérrez-Marco and Rábano listed *Sinuities* sp. from the Villaodrid syncline. In 1996 (Gutiérrez-Marco, Albani et al.) reported "*Clathrospira?*" *bussacensis* (SHARPE, 1853), *Sinuities (Sinuities) hispanicus* (BORN, 1916), undetermined pleurotomarioideans and *Pygmaeoconus?* sp. from the Sueve Formation (Llanvirn - Dobrotivá) in northern Spain. Frýda and Gutiérrez-Marco (1996) described *Hispanosinuities peeli* FRÝDA et GUTIÉRREZ-MARCO, 1996 from the lower Llanvirnian (Oretanian) deposits of the Central Iberian Shelf (Toledo Mountains country) and briefly discussed the previous references concerning "*Bellerophon*" and "*Protowarthia*" from Armorica. The authors also mentioned a large number (several thousands) of gastropods gathered by the Spanish team throughout the last eighteen years, unfortunately mostly poorly preserved as weakly to intensely deformed internal moulds (p. 603).

The Ordovician of the Anti-Atlas (Tindouf Basin) is similar to that of the Barrandian Area, as far as the quantity and preservation of tergomyans and gastropods are concerned. While the Ordovician of the Barrandian Area was subject to detailed palaeontological studies since Barrande's time, recognition of gastropods in Morocco (Anti-Atlas) is of much younger date. The first (and so far the last) published Ordovician gastropods from Morocco are the few taxa briefly reported and partly figured by G. and H. Termier in 1950. Unfortunately, the published determination was rather approximate, based on a superficial comparison of the specimens with old published drawings (Sowerby in Murchison 1839, McCoy 1851-1854, Perner 1903). Comments on the individual taxa:

Sinuities bilobatus (SOWERBY). Upper Llanvirn, Caradoc. None of the sinuitids from the collected material are similar or related to this species. The name "*Sinuities bilobatus*" was often used for different Ordovician species of *Sinuities* in older papers (see Knight 1941). The species *S. bilobatus* (SOWERBY in MURCHISON, 1839), as re-defined by Knight (1941), probably does not occur in the southern parts of the Mediterranean Palaeoprovince.

Bucanella bohemica (PERNER). Caradoc. According to Horný (1963b and in press c), *B. bohemica* is restricted to the Upper Ordovician (Královdivor and Kosov Series), and according to Peel (1974) questionably belongs to the genus *Tritonophon*. The species, to which the Termiers' species refers, is probably the Caradocian *Tritonophon peeli* HORNÝ, 1997.

Tropidodiscus sp. Upper Llanvirn. This is seemingly the only Moroccan representative of this genus, described herein as *Tropidodiscus pusillus* (BARRANDE in PERNER, 1903).

Conradella sp. (aff. *multilineata* REED). Llanvirn. The shell, figured on Pl. 131, figs 4-6, does not belong to the Reed species, the generic determination of which was originally questioned (*Conradella? multilineata* REED, 1920). It does not belong to the genus *Conradella* ULRICH et SCOFIELD, 1897 (= *Phragmolites* CONRAD, 1838) either. As there are no similar specimens contained in the new material, the shell remains unrecognizable.

Lophospira cf. *tropidophora* (BARRANDE) (sic! = MEEK, 1873). Ordovician. The figured fragment is unrecognizable.

Lophospira sp. Caradoc. This specimen was probably figured on Pl. 129, figs 8, 9, and by mistake determined there as *Cryptaenia?* (according to Knight et al. 1960, *Cryptaenia* EUDES-DESLONGCHAMPS, 1864 is a synonym of *Ptychomphalus* AGASSIZ, 1839, which is a Jurassic genus). Nevertheless, the fragment remains unrecognizable.

Lophospira gyrogonia (McCOY). Caradoc. The fragmentary specimen is not recognizable.

Indéterminé (Pl. 128, figs 4-8). Llandeilo, El Maïfid. This may be the Llanvirnian *Ptychonema marocanum* sp. n., described herein.

Indéterminé (Pl. 128, figs 9, 10). Ordovician. Unrecognizable fragments.

Stratigraphy

This short review of the Ordovician stratigraphy of the Anti-Atlas has been compiled after Destombes (1985): Ordovician, in: Destombes, J., Hollard, H., Willefert, S.: Lower Palaeozoic rocks of Morocco. The original usage of the generic names of taxa has not been changed, and the series names have not been conformed to the Bohemian scheme, but the table shows the correlation of all units used in this paper.

Tremadoc

Lower Fezouata shale Formation

Predominantly fine, blue-green sandy argillites, often glauconitic, sometimes shaly. Microfauna (*Veryhachium*, *Priscogalea*, *Diornatosphaera*, *Arbusculidium*), graptolites (*Anisograptus*, *Bryograptus*), dendroids (*Rhabdinopora*), brachiopods (*Ranorthis*), trilobites (*Asaphellus*, *Bavarilla*, *Dikelokephalina*, *Platypeltoides*, *Symphysurus*, *Orometopus*), echinoderms (*Rhopalocystis*, *Aristocystites*). Tergomyans and gastropods have not been collected.

Arenig

Upper Fezouata shale Formation (lower and middle Arenig)

Predominantly shaly yellow-green argillites. Abundant fauna of trilobites (*Symphysurus*, *Bathycheilus*, *Apatokephalus*, *Pterygometopus*, *Euloma*, *Bavarilla*, *Neseuretus*, *Platycoryphe*), brachiopods (*Ranorthis*, *Tarfaya*, *Paurorthis*), echinoderms (*Balantiocystis*, *Chauvelicystis*, *Thoralicystis*), graptolites (*Clonograptus*,

Morocco - Anti-Atlas		
Series	Groups	Formations
UPPER ASHGILL	SECOND BANI SANDSTONES	UPPER SECOND BANI
UPPER ASHGILL p.p.		LOWER SECOND BANI
UPPER ASHGILL	KTAOUA CLAY AND SANDSTONES	W UPPER KTAOUA E
UPPER CARADOC		ROUID AISSA UPPER TIOURIRINE
MIDDLE AND LOWER CARADOC		LOWER
		BOU HAJAJ LOWER TIOURIRINE
	FOM ZGUID KTAOUA	
LLANDEILO	FIRST BANI SANDSTONES	IZGOUIREN OUINIRHEN IGZERT BOU ZEROUAL TADRIST
LLANVIRN	OUTER	TACHILLA SHALES
MIDDLE ARENIG		ZINI SANDSTONES
MIDDLE AND LOWER ARENIG		FEIJAS
	SHALES	LOWER FEZOUATA SHALES
TREMADOC		LOWER FEZOUATA SHALES

Bohemia - Barrandian Area	
Series	Formations
KOSOV	KOSOV
KRÁLODVOR	KRÁLŮV DVŮR
BEROUN	BOHDALEC
	ZAHOŘANY
	VINICE
	LETNÁ
	LIBEŇ
DOBROTIVÁ	DOBROTIVÁ
LLANVIRN	ŠÁRKA
ARENIG	KLABAVA
TREMADOC	MÍLINA
	TŘENICE

Fig. 2. Comparison of the Ordovician of the Anti-Atlas (Morocco) and the Barrandian Area (Bohemia). - After Havlíček and Marek 1973, Destombes et al. 1985, and Havlíček, Vaněk, and Fatka 1994

Tetragraptus, *Didymograptus*, *Isograptus*), hyolithids (*Elegantilites*, *Pauxilites*, *Nephrotheca*), bivalves, conulariids.

Tergomyans: *Carcassonnella courtessolei*, *Thoralispira laevis*, *Thoralispira?* cf. *occitana*. Gastropods: *Lesueurilla prima*.

Localities. 34. E of Jbel Bou Dehir (N of Zagora); 331. E of Jbel Bou Dehir (N of Zagora); 983. Jbel el Khantra (Zini massif, Tarfaya Province); 985. Jbel el Khantra (Tarfaya Province); 1540. SW of the Jbel Tijakhet (Tafilalt), near village of Ouzina; 1572. Trhit (W of Tissint between Foum Zguit and Tata); 1621. Jbel el Mhazil (ESE of Foum Zguit); 1682. Jbel Tibaskoutine (E of Zagora); 1685. E of Jbel Bou Dehir (N of Zagora); 1689. E of Jbel Bou Dehir (N of Zagora); 1743. Oued Bou Tious (Graben of Zagora, W of Zagora).

Zini sandstone and quartzite Formation (middle Arenig)

A local facies of massive sandstones and quartzites, developed in the south-western Anti-Atlas. Rare fauna of brachiopods (*Paurorthis*) and trilobites (*Neseuretus*). Tergomyans and gastropods have not been collected.

Llanvirn

Tachilla shale Formation

Locally exceptionally thick formation of transgressive character (1200 metres in the western Anti-Atlas) consists predominantly of shaly, micaceous argillites and rare sandstone beds. Typically with bioturbation and presence of frequent beds with fossiliferous nodules, resembling those of the Šárka Formation from the Barrandian Area. Abundant fauna of trilobites (*Colpocoryphe*, *Plaesiacomia*, *Bathycheilus*, *Placoparia*, *Zeliszella*, *Selenopeltis*, *Neseuretus*, *Ormathops*), ostracodes (*Tetradella*), echinoderms (*Calix*), graptolites (*Pseudoclimacograptus*, *Didymograptus*, *Glyptograptus*), hyolithes (*Gompholites*, *Pauxilites*, *Elegantilites*), bivalves, rare conulariids, microfossils.

Tergomyans: *Cyrtodiscus nitidus*, *Tachillanella tafilaltensis*, *?Thoralispira* sp. Gastropods: *Sinuities sowerbyi*, *Selesinuites perneri*, *Tropidodiscus pusillus*, *Lesueurilla prima*, *Ptychonema maroccanum*.

Localities. 563. Along the road Tilemsoun-Messeied (S of Tantan, Tarfaya Province); 1050. Ikf n'Ourarh (S of Tinerhir, N of Jbel Sarhro massif); 1236. Jbel Bou Legroun (western Tafilalt); 1247. Tinjarfiouine (W of Rissani, Tafilalt); 1320. E of Khabt el Hejar (E of Erfoud, Tafilalt).

Llandeilo

First Bani sandstone Group

(Includes five individual sandstone units: Taddrist Formation, Bou Zeroual Formation, Igzert Formation, Ouininirhen Formation, Izgouiren Formation).

The thickest and most constant and extensive sandstone group of the Anti-Atlas Ordovician. Abundant trilobites (*Colpocoryphe*, *Plaesiacomia*, *Neseuretus*, *Eohomalonotus*, *Ectillaenus*, *Microparia*, *Selenopeltis*, *Zeliszella*, *Crozonaspis*), brachiopods (*Paterorthis*, *Atlantida*, *Orthambonites*, *Tissintia*), echinoderms (*Aristocystites*, *Calix*, *Phlyctocystis*,

Mitrocystella, *Isidanocystis*), rare conulariids, bivalves, hyolithes (*Gompholites*), rare bryozoans, graptolites (*Didymograptus*).

Tergomyans: *Quasisinuites rapax*.

Localities. 20. Bou-Rbia - Sidi-Touhama (W of Zagora) (Bou Zeroual Formation); 273. Hassi Brahim (W of Tata) (Bou Zeroual Formation).

Caradoc

Lower Ktaoua Formation (lower-middle Caradoc)

Grey-white argillites, frequently with large concretions of brown pelitic carbonates, sometimes rich in fossils. The formation locally contains two sandstone bands, locally calcareous, subdividing the formation into five members. Rich fauna of trilobites (*Ormathops*, *Mucronaspis*, *Eudolaites*, *Dalmanitina*, *Kloucekia*, *Colpocoryphe*, *Selenopeltis*, *Deanaspis*), brachiopods (*Irhirea*, *Triplesia*, *Rafinesquina*, *Tazzarinia*, *Heterorthis*, *Drabovia*, *Tafilaltia*, *Gelidorthis*, *Bicuspina*, *Dalmanella*, *Protomendacella*), echinoderms (*Maghrebocystis*, *Destombesia*, *Echinospaerites*, *Deutocystites*, *Arachnocystites*, *Heliocrinites*, *Codiacystis*), conulariids, bivalves, hyolithes, ostracodes, graptolites (*Orthograptus*), microfossils (*Cyathochitina*, *Conochitina*, *Rhabdochitina*, *Veryhachium*).

Tergomyans: *Sinuitopsis neglecta*, *Sinuitopsis?* sp. Gastropods: *Bucanopsina calypso*, *Tritonophon peeli*, *Atlantophon maider*, *Clathrospira amouguerana*, *Nonorios pater*, *Holopea?* *antiquata*.

Localities. Lower Caradoc: 399. Jbel Tafenna (SE of Zagora); 628. Jbel Bou Isidane (S of Alnif); 882. Inakiane plain (SW of Amjerane, Maider); 899. Jbel Bou Ingarf (ENE of Zagora); 1100. Jbel Amouguer (E of Tazzarine); 1640. Takkat n'Ait Alouene (E of Tagounite); 1778. Jbel Amouguer (E of Tazzarine). Middle Caradoc: 86. Jbel Amouguer (E of Tazzarine); 1265. Bou el Koualb (W of Rissani); 1266. Bou el Koualb (W of Rissani); 1270. Tizi ou Mekhazni (between Rissani and Msissi, Tafilalt); 1276. Istlhou (E of Msissi, Tafilalt). "Middle Caradoc": 88. Jbel Amouguer (E of Tazzarine); 1302. Rkint ech Chih (E of Erfoud, Tafilalt); 1305. Rkint ech Chih (E of Erfoud, Tafilalt); 1313. NW of Merzane (E of Erfoud, Tafilalt); 1315. NW of Merzane (E of Erfoud, Tafilalt); 1652. Tiliwine (High Atlas, N of Ourzazate). Upper? Caradoc: 1282. E of Jbel Taklimt (W of Rissani, Tafilalt).

Upper sandstone formation of Tiouririne or its western equivalent, the Roud-Aissa Formation (upper Caradoc)

Dark grey micaceous sandstones, with some intercalations of coquina limestones or bluish arenaceous limestones or with pelitic carbonate nodules. A local biostrome of bryozoan limestones (Khabt-et-Hajar to the east of Erfoud) is developed in the highest member. Locally rich fauna with Bohemian elements characteristic for the Beroun Stage. Locally abundant fauna of trilobites (*Mucronaspis*, *Eudolaites*, *Kloucekia*, *Baniaspis*, *Calymenella*, *Flexicalymene*, *Actinopeltis*, *Prionocheilus*), brachiopods (*Aegiromena*, *Destombesium*, *Drabovia*, *Eostropheodonta*, *Kiaeromena*, *Cliftonia*, *Rostricellula*), echinoderms (*Maghrebocystis*, *Destombesia*, *Hemicystites*, *Echinospaerites*), bryozoans (*Arthropora*, *Prasopora*, *Stigmatella*, *Trematopora*).

Tergomyans: *Sinuitopsis neglecta*. Gastropods: *Clathrospira amouguerana*, *Lophospira* sp., *Holopea? antiquata*.

Localities. 83. Jbel Amouguer (E of Tazzarine); 134. Jbel Tibert n'Gaiz (N of Alnif); 585. Jbel Amouguer (E of Tazzarine); 1134. N of Jbel Amouktir (E of Agdz); 1250. S of Tinjarfiouine (W of Rissani, Tafilalt).

Ashgill

Upper Ktaoua Formation (Ashgill)

Grey-green argillites with numerous fossiliferous pelitic carbonate concretions. Fauna: trilobites (*Baniaspis*, *Eudolaites*, *Klouceka*, *Dreyfussina*, *Mucronaspis*, *Flexicalymene*, *Brongniartella*, *Amphitryon*, *Calymenella*, *Sele-nopeltis*, *Onnia*), brachiopods (*Eostropheodonta*, *Eochonetes*, *Chonetoidea*, *Comatopoma*), echinoderms (*Placocystites*, *Destombesia*, *Heliocrinites*, *Maghrebocystis*, *Echinospaerites*, *hyolithes* (*Elegantilites*), *conulariids*, bivalves, cephalopods (*Armenoceras*), ostracodes, microfossils (*Veryhachium*, *Cyathochitina*, *Rhabdochitina*, *Lagenochitina*, *Conochitina*, *Leiofusa*).

Gastropods: *Sinuites destombesi*, *Lophospira? debganensis*, *Loxonema? sp.*

Localities. 49. Jbel Bou Ingarf (NE Zagora); 750. Jbel Arhou Amejout (S of Alnif); 757. Tizi n'Takhrif (WSW of Tazzarine); 885. Jbel Mimount (W of Amjerane, Maïder); 901. Southern part of Jbel Bou Deb-gane (E of Tagounite); 1077. Isk n'Brahim (E of Tazzarine); 1078. Isk n'Brahim (E of Tazzarine); 1080. Isk n'Brahim (E of Tazzarine); 1109. Plaine d'Inakiane (S of Amjerane, Maïder); 1125. Jbel Tidri (E of Inakiane plain, S of Amjerane, Maïder); 1132. Rich Bjarine (E of Amjerane, Maïder); 1146. Zaouia Tafetchna (E of Tansikht); 1624. Jbel Bou Deb-gane (E of Tagounite); 1649. Jbel Bou Deb-gane (E of Tagounite); 1651. Jbel Bou Deb-gane (E of Tagounite); 1791. Jbel Assammar (E of Tazzarine).

Second Bani sandstone Group

Consists of two sandstone formations.

Lower Second Bani sandstone Formation (upper Ashgill)

Predominate argillaceous and siliceous sandstones, quartzites, arenaceous argillites, at the base local limestones with bryozoans. Trilobites (*Mucronaspis*, *Actinopeltis*, *Calymenella*), brachiopods (*Hirnantia*, *Rostricellula*, *Eostropheodonta*, *Destombesium*, *Dalejina*, *Horderleyella*), echinoderms (*Maghrebocystis*, *Herpetocystis*, annelids, bryozoans, microfossils. Tergomyans and gastropods have not been collected.

Upper Second Bani sandstone Formation (upper Ashgill)

Conglomerates with granite and rhyolite pebbles, arenaceous clays, sandstones, quartzites. The formation bears signs of glacial environment. Rare fauna of brachiopods (*Hirnantia*, *Eostropheodonta*, *Plectothyrella*), bryozoans, bivalves, fragments of trilobites. Tergomyans and gastropods have not been collected.

Systematic descriptions

Class Tergomya HORNÝ, 1965

Order Cyrtonellida HORNÝ, 1965

Family Cyrtolitidae S. A. MILLER, 1889

Genus *Sinuitopsis* PERNER, 1903

Type species. *Sinuitopsis neglecta* BARRANDE in PERNER, 1903. Middle Ordovician, Beroun; Barrandian Area, Bohemia, Czech Republic.

Sinuitopsis neglecta BARRANDE in PERNER, 1903

Pl. 1, figs 1-13; Pl. 2, fig. 1

1903 *Sinuitopsis neglecta* BARRANDE; J. Perner, Gastéropodes, 1, pp. 68-71, text-figs 42-46, Pl. 85, fig. 11, Pl. 88, figs 28-30, 38-40.

1907 *Sinuitopsis neglecta* BARRANDE; J. Perner, ibidem, 1, Pl. 97, figs 39-41.

1941 *Sinuitopsis neglecta* PERNER, 1903; J. B. Knight, Paleozoic gastropod genotypes, p. 320, Pl. 6, figs 4a-c.

1960 *Sinuites* (*Sinuitopsis*) *neglecta* (PERNER, 1903); J. B. Knight et al., Treatise 1, 1, p. 1176, Fig. 93: 7ab.

1981 *Sinuitopsis neglecta* PERNER, 1903. J. Dzik, Larval development etc., Figs la,b.

1991c *Sinuitopsis neglecta* (PERNER, 1903); R. J. Horný, pp. 81-100, Text-figs 1-5, 8, 9, 11-16; Pls 1-10, 12.

1997e *Sinuitopsis neglecta* (BARRANDE in PERNER, 1903); R. J. Horný, Shell breakage etc., pp. 137-142.

Material. 22 specimens, mostly isolated internal moulds.

Description. The collection contains 22 differently sized, juvenile and mature specimens from several localities, all from the Lower Ktaoua Formation. Most of them are preserved as internal moulds (often with retractor muscle scars), but one external mould and several specimens with patches of shell showing outer sculpture are also present. The smallest, juvenile specimen, 6.7 mm long (Pl. 2, fig. 1), comes from locality 899. A counterpart of an external mould, 12 mm long (Pl. 1, figs 7, 8) comes from locality 1778; slightly larger internal moulds, probably of immature specimens, measuring 22.0 and 23.5 mm (l/w ratio around 2.0), were found at the same locality (Pl. 1, figs 9-11). An internal mould of a typical specimen with l/w ratio 1.6, 31.0 mm long and 18.8 mm wide, in identical proportions with specimens from the Barrandian Area, comes from locality 134. The largest specimens, reaching almost 4.0 mm across the shell, come from localities 86 and 88. One of them, NM S 2573 (Pl. 1, figs 3, 4), is rather narrow (length 38.5 mm, width 17.0 mm, l/w ratio 2.3); this may be due, however, to *post mortem* lateral pressure. External shell surface of immature specimens bears a regular "wattle-like" sculpture (specimen NM S 2574, Pl. 1, figs 7, 8), the adult specimens have simple, rounded, often unequal, 0.1-0.3 mm wide, transverse ribs (Pl. 1, fig. 3). The relation of the "wattle-like" sculpture, usually occurring in the juvenile specimens, and the simple transverse, slightly irregular collabral ribs has not been satisfactorily explained so far (compare Horný 1963b, Pl. 6, fig. 6 and Pl. 9, fig. 4, and Horný 1991c, Pl. 1, fig. 2 and 8, Pl. 5, fig. 4, or Pl. 6, fig. 2). The shell is lamellar, thick (in specimen NM S 2572 about 0.6 mm thick on the dorsum and 1.5 mm on the sides, up to 3.5 mm within the lateral constrictions; see Pl. 1, fig. 6). Several internal moulds show well preserved, raised dorsal, lateral, and

ventral retractor muscle scars (see Pl. 1, figs 1, 5, 11, and 12). In the specimen NM S 2572, both the main and the accessory dorsal and dorsolateral scars are preserved (Pl. 1, fig. 5). The main, elliptic dorsal scar is about 2.5 mm long and 2.0 mm wide, the dorsolateral composite scar is about 5.0 mm long and 1.5 mm wide at the adumbilical end. Both small accessory scars are doubled, being about 3.5 mm (the dorsal) and about 5.0 mm (the dorsolateral) adaperturnally distant from the main scars (compare Horný 1991c, Pl. 4, figs 1-3 and 4-6, and Peel 1991, figs 18d-f). The specimen NM S 2665 shows a small part of the typical mediadorsal structures (the "ridge-furrow complex"), preserved in the specimen NM S 2572 as a flat, 1.8 mm wide, dorsal band, bordered with rounded angulations (Pl. 1, fig. 6).

Mode of life. According to Horný (1991c), *Sinuitopsis neglecta* probably inhabited a soft penetrable sea bottom as a slow, semifossorial, seemingly organic suspension feeder at the sediment/water interface. Periodical constrictions and irregularities of the shell, observed in mature specimens from locality 86 (e.g., NM S 2572, NM S 2573, and NM S 2665), may indicate resting phases connected with transfer of the muscle attachments (see Horný 1991c for this supposition), or a reinforcement of the shell. Repaired injuries of shell have not been ascertained.

Distribution. *Sinuitopsis neglecta* is a common tergomyan mollusc, widely distributed in the Caradocian (Berounian) shallow-water deposits of the Mediterranean Palaeoprovince. In the Barrandian Area, it is most abundant in the Berounian Zahofany Formation. The oldest known representative of *Sinuitopsis* (unnamed) occurs in the Lower Ordovician Llanvirnian Šárka Formation of the Barrandian Area. A few species probably occur in the Middle Ordovician of Baltica, hidden under other generic names (e.g., *Pharetrolites? tumidus* (KOKEN, 1897), *Pharetrolites? elegans* (KOKEN, 1925) (both originally described as *Temnodiscus* KOKEN, 1896 (see Yochelson 1963). One species, *Sinuitopsis congruens* REED, 1920, was described from Avalonia (Lower Ordovician, Girvan). Dzik (1981) reported *S. neglecta* from Baltic erratic boulders, discussing the possible synonymy of *Pharetrolites elegans* with this species. The genus is seemingly absent in Laurentia, where it was substituted by abundant *Cyrtolites* CONRAD, 1838 with a planar aperture, adapted to harder sea bottom; this genus, however, extends to Avalonia as well (Reed 1920).

Occurrence. Lower Caradoc, Lower Ktaoua Formation: locality 628, **Jbel Bou Isidane (S of Alnif)**; locality 899, **Jbel Bou Ingarf (ENE of Zagora)**; locality 1778, **Jbel Amouguer (E of Tazzarine)**. Middle Caradoc, Lower Ktaoua Formation: locality 86, **Jbel Amouguer (E of Tazzarine)**. "Middle" Caradoc, Lower Ktaoua Formation: locality 88, **Jbel Amouguer (E of Tazzarine)**; locality 134, **Jbel Tibert n'Gaiz (N of Alnif)**; locality 1265, **Bou el Koualb (W of Rissani)**. *Sinuitopsis neglecta* mostly occurs in calcareous siltstones, in taphocoenoses with *Tritonophon peeli*, *Bucanopsina calypso*, *Clathrospira amouguerana*, *Lophospira* sp., *Nonorios pater*, and *Holopea? antiquata*.

Sinuitopsis? sp.
Pl. 2, figs 5, 6

Description. Two specimens on one slab, NM S 2674 and NM S 2675, have been found in the Lower Ktaoua Formation, locality 399, **Jbel Tafenna (SE of Zagora)**. The

laterally flattened external moulds of incomplete shells with damaged spires, 19.0 and 15.6 mm across, probably belong to a new, undetermined species of *Sinuitopsis*. Small fragments of spires suggest that the shell probably consisted of three whorls. Dense, regular, nonundulated, adaperturnal convex ribs (5-8 per mm), becoming finer with age, indicate an aperture with rounded lateral sides and probably a narrow, deep, V-shaped dorsal reentrant. A small impression of a steep umbilical wall bears dense, fine, oblique striae. The most important parts of the shell, the dorsum, spire and the umbilical area are lost. Both specimens are illustrated in the hope that better preserved specimens will eventually be collected.

Discussion. The simple, regular, nonundulated ribs in juvenile stages indicate that the specimens do not belong to *Sinuitopsis neglecta*. Their assignment to *Sinuitopsis* is questioned.

Preservation. External moulds in light grey, micaceous, silty shale.

Occurrence. Lower Caradoc, Lower Ktaoua Formation: locality 399, **Jbel Tafenna (SE of Zagora)**. A taphocoenosis with undetermined bivalves and a fragment of a gastropod (? *Tritonophon* sp.).

Genus *Cyrtodiscus* PERNER, 1903

Type species. *Oxydiscus (Cyrtodiscus) procer* BARRANDE in PERNER, 1903. Lower Ordovician, Beroun; Barrandian Area, Bohemia, Czech Republic.

Discussion. The recently described, well preserved specimens of *Cyrtodiscus procer* (BARRANDE in PERNER, 1903) (see Horný 1997d) completed the description of this species, originally based on two incomplete internal moulds (see Knight 1941, Horný 1963b). The differences between *Cyrtodiscus* and *Gamadiscus* HORNÝ, 1962 (less lanceolate whorl profile, narrow dorsal sinus, regular outer shell sculpture in *Gamadiscus*) are currently re-interpreted as characters of species level. *Cyrtodiscus* is classified as a verified cyrtoneid tergomyan, after the tergomyan retractor muscle scar pattern was recognized in *C. nitidus* (BARRANDE in PERNER, 1903) (Horný 1996b).

Cyrtodiscus nitidus (BARRANDE in PERNER, 1903)
Pl. 2, figs 2-4

- 1903 *Oxydiscus (Cyrtodiscus) nitidus* BARRANDE; J. Perner, *Gastéropodes*, 1, Pl. 86, figs 8-13, p. 75.
- 1962 *Gamadiscus nitidus* (PERNER, 1903); R. J. Horný, *New genera etc.*, pp. 473, 474.
- 1963b *Gamadiscus nitidus* (PERNER, 1903); R. J. Horný, *Lower Paleozoic Bellerophonina etc.*, pp. 88, 89, Pl. 13, figs 3-8.
- 1966 *Gamadiscus nitidus* (PERNER); V. Havlíček and J. Vaněk, *The biostratigraphy etc.*, p. 50.
- 1982 *Gamadiscus nitidus*; E. L. Yochelson, *Mollusques monoplacophores et gastropodes*, p. 56.
- 1996b *Gamadiscus nitidus* (BARRANDE in PERNER, 1903); R. J. Horný, *Retractor muscle scars etc.*, pp. 245-249, Figs 1-6.

Material. Five specimens.

All specimens were found in silty, siliceous concretions in the Tachilla Formation at locality 1320, **E of Khabt el Hejar (E of Erfoud, Tafilalt)**. The specimens are morpho-

logically identical with those from the Bohemian Šárka Formation, and occur in a similar taphocoenosis. Two almost complete specimens are 4.5 and 5.3 mm long, which is the average size of the Bohemian specimens (the lectotype is 6.6 mm long and the largest known specimen reached a length of 9.7 mm).

Distribution. *C. nitidus* is a characteristic Llanvirnian species, present both in Perunica (Barrandian Area) and the Anti-Atlas (Tindouf Basin). The genus is a widespread perigondwanan mollusc, distributed through the Ordovician (*C. nitidus* - Llanvirn, *C. simaki* HORNÝ, 1997 - Beroun, *C. evolvens* (BARRANDE in PERNER, 1903) - Královodvor and Kosov), and probably continuing in the Silurian. Its relation to the similar, seemingly tergomyan genera *Temnodiscus* KOKEN, 1896 and *Pharetrolites* WENZ, 1943 is probable but has not been studied in detail, nor sustained by the find of dorsal retractor muscle scar pattern in these two genera. A very similar North American species, *Temnodiscus nitidulus* (ULRICH, 1879), originally assigned to *Cyrtolites* CONRAD, 1838 but included in *Cyrtolitina* ULRICH in ULRICH et SCOFIELD, 1897 (which is an objective synonym of *Temnodiscus* KOKEN, 1896), differs from the Mediterranean species only by a slightly wider, less lanceolate shell and by the presence of a selenizone (?) which is, according to an extremely short, shallow "slit-like" sinus, imperfectly developed and borderless (see also Wahlman 1992, p. O125). On account of the uncertain systematic value of the selenizone, the relation of *T. nitidulus* to the European representatives of *Cyrtodiscus* should be studied in detail.

Occurrence. Llanvirn, Tachilla Formation; locality 1320, E of Khabt el Hejar (E of Erfoud, Tafilalt). The species rarely occurs in silty, siliceous nodules containing taphocoenosis with *Lesueurilla prima* (BARRANDE in PERNER, 1903), *Sinuities sowerbyi* (BARRANDE in PERNER, 1903), and numerous small specimens of *Tropidodiscus pusillus* (BARRANDE in PERNER, 1903) and *Ptychonema maroccanum* sp. n.

Genus *Quasisinuities* HORNÝ, 1997

Type species: *Quasisinuities rapax* HORNÝ, 1997. Middle Ordovician, Dobrotivá; Anti-Atlas, Morocco.

Quasisinuities rapax HORNÝ, 1997 Pl. 2, figs 7-12

1997i *Quasisinuities rapax* sp. n.; R. J. Horný, *Quasisinuities* etc., pp. 340-350.

Material. 5 specimens.

Description. For detailed description see Horný 1997i. Four specimens of this species, 6.8-23.0 mm long, have been recovered from locality 273. The species is characterized by a globose, in maturity slightly laterally compressed shell, resembling shells of *Sinuities* KOKEN, 1896 but without apertural shields. A thick shell, filling narrow umbilici, is thickest in the constriction, subparallel to the apertural margin. The dorsally positioned muscle attachments are of typically cyrtoneid pattern, with two pairs of dorsal and dorsolateral scars, ray-like muscle impressions and mediodorsal structures (NM S 2652, Pl. 2, figs 10, 12). Shell sculp-

ture is cancellate, in the dorsal area consisting of infrequent, straight, variably thick spiral threads and flat, wide, collabral ribs (the shell with sculpture is lacking in other parts of the shell). A single, incomplete, imperfectly preserved internal mould in sandstone (NM S 2679), collected in the same formation at locality 20, Bou-Rbia - Sidi-Touhama (W of Zagora), may also belong to this species.

Discussion. Discovery of the *Sinuities*-like *Quasisinuities* enlarges the group of cyrtoneid tergomyans with recognized retractor muscle attachments, adapted to various living conditions. *Quasisinuities* is suspected to represent an active, probably semiinfaunal predator. Compared with *Thoralispira* HORNÝ et VIZCAÍNO, 1995, *Quasisinuities* acquired the compact shell in a different way. It lacks a slit and anterolateral lobes, and the shell is heavier, often possessing different irregularities, probably adapted to more dynamic conditions. While *Thoralispira* probably developed from the slit-bearing *Carcassonnella*, *Quasisinuities* retained the more simple sinus, perhaps indicating origin from slow cyrtoneidids of *Sinuities* type.

Preservation. All specimens are preserved as internal moulds in grey, bioclastic, arenaceous limestone. The shell easily separates from the internal moulds along the lowermost lamellae of the hypostracum. The shell wall is recrystallized, almost black, cracking along the crystal flats.

Mode of life. *Quasisinuities rapax* is a cyrtoneid tergomyan with a most compact, involute, globose shell with completely closed umbilici. These characters are suspected to testify to an active, perhaps predatory life (Linsley 1978, Peel 1984, Horný 1995, 1997i). A rather thick and heavy shell, strongly reinforced by constrictions and hypostracal deposits in the umbilici, corresponds to a life in high energy conditions. Two specimens show deformations of the internal shell surface (the holotype and the paratype NM S 2653), which may have been caused by a collision with a hard object during a storm or surge, or when burrowing and seeking prey. All these morphological observations agree with the hydrodynamic conditions in which the rock, a grey, bioclastic limestone with arenaceous admixture, originated. Adult specimens of *Q. rapax* occur together with immature specimens and juveniles (Pl. 2, fig. 7).

Occurrence. Llandeilo s. l. (Dobrotivá), Bou Zeroual Formation (First Bani Group); locality 273, Hassi Brahim (W of Tata). A grey, bioclastic, arenaceous limestone with numerous fragments of bivalves, *Quasisinuities rapax*, and trilobites. Probably also locality 20, Bou-Rbia - Sidi-Touhama (W of Zagora).

Family *Cyrtolitidae* S. A. MILLER, 1889

Sub-family *Carcassonnellinae* subfam. n.

Diagnosis. *Cyrtolitidae* with widely phaneromphalous shells; whorls low, wide; V-shaped reentrant culminating in a narrow sinus or a shallow slit, generating a selenizone, usually raised or located on a dorsal crest and bordered with cords, threads or lines; dorsally positioned muscle attachment scars with aperturally radiating muscle impressions (recognized in *Carcassonnella*); outer shell sculpture, collabral lines of growth, or ribs, rarely in combination with continuous spiral structures.

Discussion. Members of *Carcassonnellinae* are characteristic cyrtoneid tergomyans, distributed in the Lower and

Middle Ordovician of the peri-Gondwanan Palaeoprovince. While *Carcassonnella courtessolei* is known from the Arenig of the Montagne Noire and the Anti-Atlas, *C. vizcainoi* was ascertained only in the Arenigian strata of the Montagne Noire. *C. pragensis* has been recovered in the Llanvirnian of the Barrandian Area. The type species of *Sarkanella*, *S. vokovicensis* (HORNÝ, 1963), is an index fossil of the Dobrotivian Dobrotivá Formation in the Barrandian Area. *Baltiscanella christianaie* (KOKEN, 1925) is known from the Berounian? (4b?) strata of southern Baltica of the Oslo region (see Yochelson 1963, pp. 164-166, Pl. 3, figs 10, 11, 14, 15). (This species, originally attributed to *Bucaniella* KOKEN, 1896 by Koken, 1925, was later reinterpreted as a species of *Tetranota* ULRICH et SCOFIELD, 1897 by Teichert (1932) and questionably as *Bucania* HALL, 1847 by Yochelson 1963.) Several species of *Kokenospira* BASSLER, 1915, figured by Reed 1920, may likely also belong to *Baltiscanella* gen. n. (e.g., *Kokenospira lingualis girvanensis* REED, 1920). The genera *Tetranota* and *Kokenospira*, species of which are common in the Baltica, Avalonia, and Laurentia, may both belong to the Sub-family Carcassonnellinae.

Distribution. Lower-Middle Ordovician, peri-Gondwanan Palaeoprovince (Tindouf Basin, Armorica, Perunica, Baltica, probably also Avalonia and Laurentia).

Genera included (with brief diagnoses).

Carcassonnella HORNÝ et PEEL, 1996

Shell wide, selenizone wide, located usually on a keel. Umbilical walls steep or oblique. Collabral ribs to fine growth lines. Muscle scar attachments of cyrtoneid type. Uppermost Tremadoc - Llanvirn.

Tachillanella gen. n.

Shell narrow, selenizone narrow, slightly raised. Umbilical walls steep. Fine collabral growth lines. Llanvirn.

Sarkanella HORNÝ, 1997

Shell narrow, selenizone wide, located on a prominent keel. Umbilical walls steep. Collabral ribs are irregularly undulated on lateral sides. Dobrotivá.

Baltiscanella gen. n.

Shell wide, selenizone wide, collabral ribs and spiral cords or threads, umbilical walls rounded.

Type species: *Bucaniella Christianiae* KOKEN; Koken 1925, Die Gastropoden etc., p. 20, Pl. 23, figs 10-16. Beroun?, 4b?. Norway.

Genus *Carcassonnella* HORNÝ et PEEL, 1996

Type species. *Gamadiscus courtessolei* YOCHELSON, 1982. Lower Ordovician, Tremadoc-Arenig; Montagne Noire, France.

Carcassonnella courtessolei (YOCHELSON, 1982)

Pl. 3, figs 1-7

1982 *Gamadiscus courtessolei* YOCHELSON, n. sp.; E. L. Yochelson, p. 56, figs 1-3, 7.

1982 ? *Megalomphala* species indeterminate; E. L. Yochelson, pp. 55-56, Pl. 15, figs 4-6, 8, 9.

1996 *Carcassonnella courtessolei* (YOCHELSON, 1982); R. J. Horný and J. S. Peel, pp. 305-331, Figs. 1-1, Pls. 1-7.

Material. 11 incomplete, mostly compressed specimens.

Description. Six differently aged specimens and about five fragments were derived from four localities in the Upper Fezouata Formation. With one exception, they are preserved as variably flattened external moulds in fine, soft, greenish micaceous shales (localities 331, 1572, 1689). The largest, adult specimen comes from brown siliceous sandstone (locality 985; Pl. 3, figs 5-7). The immature specimens, 4.0-8.0 mm long, are coarsely ribbed (the distance of transverse ribs varies between 0.1-0.4 mm), the ribs being more irregular and finer in the largest, mature specimen, which is 12.0 mm long. The selenizone is located on a slightly raised median crest; it is 0.7 mm wide in the juvenile specimen NM S 2584 (Pl. 3, fig. 3) and 1.0-1.3 mm wide in the adult specimen NM S 2583 (Pl. 3, figs 5-7). The selenizone is slightly concave and bears lunulae. All specimens agree with the lower Arenigian *C. courtessolei* from the Montagne Noire, as described by Yochelson (1982) and by Horný and Peel (1996). Similar to the Montagne Noire, it occurs together with *Thoralispira laevis* (THORAL, 1935) (Pl. 3, fig. 3).

Distribution. *Carcassonnella courtessolei* has been ascertained only in the uppermost Tremadocian and lower Arenigian strata of the Montagne Noire, and in the lower Arenig of the Anti-Atlas. Its absence in the Barrandian Area may be explained by unfavourable local conditions for these molluscs in the Arenigian strata in this territory. A related, similar, stratigraphically younger species *C. pragensis* HORNÝ, 1997 occurs there rarely in the Llanvirnian Šárka Formation; this species, however, has not been found in the Anti-Atlas.

Preservation. The majority of specimens are preserved as deformed, fragmentary, internal or external moulds in soft argillites. One specimen comes from a silty nodule (locality 985), where it is preserved as a cavity with fine details of external shell surface.

Mode of life. Similar to the conditions in the Arenig of the Montagne Noire, *C. courtessolei* inhabited, in the Anti-Atlas, a shallow sea with a silty or sandy, harder bottom. According to Horný and Peel (1996), it was a slow, probably herbivorous animal. Occurrence of immature specimens in argillitic rocks may indicate unfavourable environmental conditions or ecological segregation.

Occurrence. Lower Arenig, Upper Fezouata Formation: locality 331, E of Jbel Bou Dehir (N of Zagora); locality 985, Jbel el Khantra (Tarfaya Province); locality 1689, E of Jbel Bou Dehir (N of Zagora). "Middle" Arenig, Upper Fezouata Formation: locality 1572, Trhit (W of Tissint between Fom Zguit and Tata). The species occurs in taphocoenoses with *Thoralispira laevis* (THORAL, 1935).

Genus *Tachillanella* gen. n.

Type species. *Tachillanella tafilaltensis* sp. n. Lower Ordovician, Llanvirn; Anti-Atlas, Morocco.

Derivatio nominis. *Tachillanella* (feminine), after the Tachilla Formation.

Diagnosis. Shell small (about 5 mm), with at least four whorls, widely phaneromphalous, with about half of each earlier whorl exposed within umbilici. Dorsum rounded, aperture with a deep V-shaped sinus terminated in a slit, genera-

ting a narrow, slightly raised selenizone with lunulae, bordered with fine lines. Outer shell sculpture, fine, irregular, collabral lines.

Discussion. The genus is similar to *Carcassonnella* but is distinguished by narrow, higher whorls, slowly increasing in width, and a narrow selenizone. In gross morphology, it is suggestive of the smooth shell of *Peelerophon oehlerti* (BERGERON, 1889) with a narrow selenizone. In the absence of more prominent collabral structures it resembles the contemporary Llanvirnian species *Carcassonnella pragensis* HORNÝ, 1997 from the Barrandian Area. The new genus enlarges the group of the slit-bearing, phaneromphalous cyrtoneidids (*Carcassonnella*, *Sarkanella* HORNÝ, 1997).

Occurrence. Lower Ordovician, Llanvirn; Anti-Atlas, Morocco.

Species included: *Tachillanella tafilaltensis* sp. n.

Tachillanella tafilaltensis sp. n.

Pl. 3, figs 8-11

Holotype. Specimen NM S 2667, figured here on Pl. 3, figs 8-11.

Paratypes. None.

Stratum typicum. Llanvirn, Tachilla Formation.

Locus typicus. Locality **1320, E of Khabt el Hejar (E of Erfoud, Tafilalt)**.

Derivatio nominis. *tafilaltensis*, after Tafilalt (Morocco, Anti-Atlas).

Material. Besides the holotype none.

Description. The only known specimen, the holotype, is 4.5 mm long, 2.6 mm wide at the aperture, and about 3.3 mm high. The apertural margin is broken off, and the adapertural part of the shell shows no tendency to flare. The shell is widely phaneromphalous, laterally slightly compressed, with about half of each earlier whorl exposed within the umbilici. The whorl profile at the dorsum and the lateral sides of the shell is roundly arched, abruptly turning around the rounded shoulder and passing to almost perpendicular umbilical walls. A deep, V-shaped emargination in the aperture with slightly convex sides, culminates in a dorsal slit of unknown depth, generating a slightly raised, narrow, about 0.15 mm wide, flat selenizone with weak lunulae, bordered with thin continuous lines. Thin, slightly irregularly crowded lines of growth runs from the selenizone at an angle of 30°, passing the sides of the whorl with moderate forward obliquity and slightly turning backwards at the shoulder; they are unknown on the umbilical walls. The shell wall is unknown, seemingly thin. Muscle insertions are unknown.

Discussion. The number of whorls, which agrees with that in adult specimens of *Carcassonnella courtessolei*, *C. pragensis* and *Sarkanella vokovicensis* (HORNÝ, 1963), indicates that the specimen is probably mature. It represents, therefore, the smallest known member of this group of coiled, slit-bearing cyrtoneidid tergomyans.

Preservation. A cavity in a silty, siliceous nodule, preserving fine details of the external shell surface. The shell was substituted by a dusty, limonitic substance.

Occurrence. Llanvirn, Tachilla Formation: locality **1320, E of Khabt el Hejar (E of Erfoud, Tafilalt)**. A taphocoenosis with many, mostly unbroken, specimens of *Tropidodiscus pusillus* (BARRANDE in PERNER, 1903) and *Ptychonema marocanum* sp. n.

? Family **Cyrtolitidae** S. A. MILLER, 1889

Sub-family uncertain

Genus *Thoralispira* HORNÝ et VIZCAÍNO, 1995

Type species: *Cymbularia laevis* THORAL, 1935. Lower Ordovician, Arenig; Montagne Noire, France.

Thoralispira laevis (THORAL, 1935)

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

1935 *Cymbularia laevis* nov. sp.; M. Thoral, Contribution etc., p. 146, Pl. 12, figs 6a, 6b, 7-9.

1982 *Cymbularia laevis* THORAL, 1935; Yochelson, Mollusques Monoplacophores etc., pp. 57-58, Pl. 14, figs 4-9.

1995 *Thoralispira laevis* (THORAL, 1935); Horný and Vizcaíno, *Thoralispira* etc., figs 1-3, 4d, 5-15, 17a, 19.

Material. 52 specimens, predominantly deformed and incomplete internal moulds.

Description. *Thoralispira laevis* is a characteristic Arenigian species, occurring abundantly in the Montagne Noire (Thoral 1935, Yochelson 1982, Horný and Vizcaíno 1995). About 50 specimens and fragments, mostly deformed and incomplete, have been collected in the lower and "middle" Arenig of the Anti-Atlas. Most of them are internal moulds, flattened in shales and incompletely preserved in silty concretions and sandstones, without observable fine external shell sculpture. Nevertheless, the gross shell morphology, the presence of a wide selenizone (specimen NM S 2585 on Pl. 3, fig. 3), and characteristic fillings of umbilici allow a reliable determination. The smallest specimen observed is about 3.0 mm long (Pl. 4, fig. 6), the largest, adult specimens reach 22.0-30.0 mm (estimate). Similar to *Carcassonnella courtessolei*, *Thoralispira laevis* has not been reported outside southern France and Morocco.

Mode of life. A detailed functional morphology analysis of *Thoralispira laevis*, accomplished by Horný and Vizcaíno (1995), following mainly the opinions of Linsley (1978), Linsley and Peel (1983), and Peel (1984a) showed that *Thoralispira* was probably an advanced, mobile, and probably semi-infaunal and perhaps even carnivorous cyrtoneidid. Shell morphology - the deep anal emargination, slit and apertural lobes seem to indicate a similar biology as reconstructed in *Beyrichidiscus* LINSLEY et PEEL, 1983. This mode of life, however, required a penetrable sea bottom; deposits of soft argillites, siltstones and sandstones (e.g. pelitic storm deposits) offered such conditions.

Occurrence. Lower Arenig, Upper Fezouata Formation: locality **34, E of Jbel Bou Dehir (N of Zagora)**; locality **983, Jbel el Khantra (Zini massif, Tarfaya Province)**; Upper Fezouata Formation: locality **1540, SW du Jbel Tijakhet, near village of Ouzina (Tafilalt)**. Lower-middle Arenig, Upper Fezouata Formation: locality **1682, Jbel Tibaskoutine (E of Zagora)**. "Middle" Arenig, Upper Fezouata Formation: locality **1572, Trhit (W of Tissint between Foum Zguit and Tata)**; locality **1621, Jbel el Mhazil (ESE of Foum Zguit)**.

A problematic specimen, NM S 2696, comes from the Llanvirnian Tachilla Formation, from locality **563, along the Tilemsoun-Messeied road (S of Tantane, Tarfaya Province)**. The general morphology of the internal mould, preserved in brown, fine-grained sandstone, although

slightly compressed (see Pl. 4, figs 4, 5), indicates *T. laevis*. Nevertheless, the post-Arenigian age of this species cannot be accepted prior to finds of better preserved specimens.

Thoralispira? cf. *occitana* HORNÝ et VIZCAÏNO, 1995
Pl. 4, fig. 8

1995 *Thoralispira?* *occitana* sp. n.; Horný and Vizcaïno, *Thoralispira* etc., pp. 35-37, figs 16, 17b, 18.

Description. A small fragment of a counterpart of a specimen NM S 2703 has been found at locality 1540, showing a dorsal part of a juvenile shell with preserved outer shell sculpture. A concave selenizone bears lunulae, and transverse ribs (8 per mm) resemble those of *Thoralispira?* *occitana* HORNÝ et VIZCAÏNO, 1995, figured by Horný and Vizcaïno (1995) on Figs 18a,b. The associated internal moulds have, however, narrow umbilici which agree, in gross morphology, with *T. laevis*. *T.?* *occitana* is a characteristic species known from the Montagne Noire, where it occurs together with *T. laevis* in a rather short time interval in the basal Arenig (Formation de Saint-Chinian, horizon f). Better preserved material is required for more exact determination.

Occurrence. Lower Arenig, Upper Fezouata Formation: locality 1540, SW du Jbel Tijakhet, near village of Ouzina (Tafilalt).

Class **Gastropoda** CUVIER, 1797

Subclass **Prosobranchia** MILNE EDWARDS, 1848

Superfamily **Bellerophontoidea** McCOY, 1851

Family **Sinuitidae** DALL in ZITTEL-EASTMAN, 1913

Genus *Sinuites* KOKEN, 1896

Type species. *Bellerophon bilobatus* SOWERBY in MURCHISON, 1839. Middle Ordovician, Beroun (Caradoc); Shropshire, England.

Sinuites sowerbyi PERNER, 1903

Pl. 5, figs 1-2

1903 *Sinuites Sowerbyi* PERNER; J. Perner, *Gastéropodes*, 1, pp. 61-64, text-figs 28-32, 35, 36, Pl. 86, figs 27-32.

1963b *Sinuites sowerbyi* PERNER, 1903; R. J. Horný, *Lower Paleozoic Bellerophontina* etc., pp. 73, 74, Pl. 2, figs 1-4, Pl. 3, figs 1-7, Pl. 4, fig. 6.

1992 *Sinuites sowerbyi* PERNER, 1903; R. J. Horný, *Svalové vtisky* etc., text-figs 1-3, 4a, 5, 8, 11d, 12, Pl. 1, figs 1-11, Pl. 2, figs 1-13, Pl. 3, figs 1-6.

1996a *Sinuites sowerbyi* PERNER, 1903; R. J. Horný, *Secondary shell deposits* etc., text-figs 1a, Pl. 8, figs 1-6.

Material. 4 specimens.

Description. In the material collected at the Llanvirnian locality 1320, two deformed and incomplete specimens of this species have been found possessing remains of shell (NM S 2578 and 2579).

Specimen NM S 2579 (Pl. 5, fig. 1, right). A fragment of an adapertural part of the final whorl, with preserved shell on the dorsum and on the right side. Width 10.0 mm. The

dorsal part bears a characteristic, "feather-like" or "tree-like" sculpture (Pl. 5, fig. 2), covering the ribs within the dorsal sinus. Collabral ribs are simple, regular, 5-6 per mm.

Specimen NM S 2578 Pl. 5, fig. 1, left). Incomplete specimen, showing a partly exposed, 11.6 mm long, left side of the final whorl. Dorsal and adapical parts are corroded or embedded in rock. Density of ribs is 5-6 per mm.

Preservation. Both specimens come from siliceous concretions with taphocoenoses of rich fauna, including *Selesinuites perneri*, *Temnodiscus pusillus*, *Lesueurilla prima*, and *Ptychonema marocanum*. Fossils are mostly preserved as internal moulds with surfaces covered with a dusty, limonitic residuum of weathered shell.

Mode of life. Several papers offer data contributing to the mode of life of *Sinuites* (e.g. Titus and Cameron 1976, Byers and Galvin 1979, Hurst 1979, Titus 1982, Wahlman 1992, Horný 1996a, Frýda and Gutiérrez-Marco 1996). A detailed functional morphology analysis (Horný 1996a), carried out on two Lower Ordovician species from the Barrandian Area (*S. reticulatus* PERNER, 1903 and *S. sowerbyi*) showed that *Sinuites* probably lived as an active, semiinfaunal predator, burrowing in soft clayey and silty deposits and hunting various infauna. The character of deposits in the Anti-Atlas, containing shells of two species of *Sinuites*, supports this hypothesis.

Occurrence. Llanvirn, Tachilla Formation; locality 1320, E of Khabt el Hejar (E of Erfoud, Tafilalt).

Sinuites destombesi sp. n.

Pl. 5, figs 3-10; Pl. 6, figs 1-11; Pl. 7, figs 1-3

Holotype. Specimen NM S 2560, figured here on Pl. 5, figs 5-10.

Paratypes. NM S 2561, 2562, 2563, 2564, 2565, 2566, 2567, 2568, 2569, 2570, and 2571.

Stratum typicum. Upper Ashgill, Upper Ktaoua Formation. Locus typicus. Locality 1624, Jbel Bou Debgane (E of Tagounite).

Derivatio nominis. *destombesi*, for Jacques Destombes, who significantly contributed to our knowledge of the Ordovician of Morocco.

Material. 30 specimens.

Diagnosis. Large (more than 50 mm) shell, elliptic in cross section, with roundly arched dorsum in immature stage, in mature specimens slightly flattened at the periphery; narrow umbilici filled with labro-umbilical deposits; deep V-shaped sinus with widely rounded apex; constrictions not observed; a pair of large circumbilical retractor muscle attachment areas; well-developed subinductura around the umbilici; outer shell sculpture, dense network of fine, rounded, collabral ribs and finer, straight, spiral lines.

Description. The smallest specimen, paratype NM S 2563 (Pl. 6, fig. 3) is 19.5 mm (incomplete) long, 14.0 mm (incomplete) wide at the aperture, and 15.0 mm high. The holotype (Pl. 5, figs 5-10) is 38.0 mm (incomplete) long, 27.5 mm wide at the aperture, and 26.0 mm high. The paratype NM S 2565 (Pl. 7, fig. 3, internal mould) is 47.0 mm long, 35.0 mm wide at the aperture, and 38.0 mm high. The largest collected specimen, NM S 2564, is 51.0 mm long and 43.0 mm wide at the aperture, and even longer is NM S 2705, which measures 54.2 mm. Immature shells are more elliptical in cross section than adults; dorsum of immature

shells is roundly arched but slightly flattened at maturity. Dorsal reentrant is V-shaped with widely rounded apex, the lateral sides being almost straight, forming an angle of 60–80° (the angle is narrower in juvenile shells). Lateral lobes are asymmetrical, roundly triangular, with sides forming an angle of about 90°. The adapertural arm of the lateral lip (columellar labrum) is directed towards the centre of the umbilicus (not towards the lateral side of the preceding whorl as in *Sinuities reticulatus*; see Horný 1996a, text-fig. 2 and Pls 6 and 7), and the labro-umbilical depression is, therefore, narrower. Shell wall in mature specimens is 0.2–0.3 mm thick on the dorsum and 0.4–0.5 mm thick on the lateral sides (NM S 2565). Specimen NM S 2571 shows seven layers of shell and inductural deposits in the parietal area (Pl. 6, figs 4–6). Empty umbilici, visible in the internal mould, are conspicuously narrow (about 4.0 mm in an almost mature specimen NM S 2566, Pl. 7, fig. 1).

Muscle attachment areas. Five specimens show adapertural parts of circumbilical retractor muscle attachment areas, the adapertural margin of which is located about a half whorl back from the aperture. The attachment areas, positioned just above the circumbilical shoulder, are maximally 6–7 mm wide, slightly raised, flat, well bordered towards the lateral side of the whorl, and passing over the shoulder onto the umbilical walls. The adapertural parts of the attachment areas bear periodical increments, indicating the abandoned convex anterior margins of the area, and passing down over the shoulder onto the umbilical wall in oblique adapical direction. The attachment area, gradually increasing in width, was followed for about 360° in specimen NM S 2566 (Pl. 7, fig. 1). The flat functional surface of the attachment area in NM S 2563 bears fine crescentic increments, and a very faint, wrinkled foliated structure in front of the attachment area. The attachment area in NM S 2566 bears a fibrillar structure (Pl. 7, fig. 2); both structures have been described in the Silurian *Bellerophon scaber* (Horný 1995, Pl. 4, figs 2, 4, and 6), and testify to the close shell structure in both genera. A detailed description of the muscle attachment areas in *S. destombesi* will be published elsewhere.

Shell sculpture. The external shell sculpture consists of closely spaced, rounded ribs (6–7 per mm in immature specimens, 5 in adults), crossed by thin, straight, regularly spaced spiral lines (8–10 per mm in immature specimens, 5–6 in adults) (measured on lateral sides of the shell). An adult, probably gerontic specimen NM S 2568 (Pl. 6, fig. 1) shows several growth increments, emphasized by stronger ribs. One adult specimen (NM S 2562) shows a minor irregularity on the internal mould near the aperture, corresponding to a retarded growth of the shell (Pl. 6, fig. 7).

Secondary shell deposits. Inductural deposits have been observed in three specimens: the small juvenile paratype NM S 2563, and two adults, NM S 2569, NM S 2568. Specimen NM S 2563 (Pl. 6, fig. 3) bears typical subinductural deposits in the area surrounding the labro-umbilical depression, similar to those described in *Sinuities reticulatus* PERNER, 1903 (Horný 1996a, Pl. 4, fig. 2). Specimen NM S 2569 (Pl. 7, figs 4, 5) bears thin, flat, pustulose islets near the umbilical area, probably the “basal” layer of the inductural vallum. Specimen NM S 2568 shows a part of the inductural vallum, located nearer to the centre of umbilicus than that in *S. reticulatus* (Pl. 6, fig. 2). Specimen NM S 2571, showing the seven transversely sectioned shell layers (including parietal deposits), bears an irregularly pustulose layer in its adapertural dorsal and dorsolateral parts, cove-

ring the shell surface with cancellate sculpture. This layer, which - by position - mimics the perinductura, is probably of inorganic origin (Pl. 6, figs 4, 5).

Discussion. *Sinuities destombesi* sp. n. is by far the largest known representative of the genus, characteristic for the Mediterranean cold-water Ashgillian fauna. The biggest specimen is 54.2 mm long, and must have measured 45 mm in width before breakage. It belongs among the species with cancellate outer shell sculpture, commonly distributed in the Lower, Middle, and Upper Ordovician. Species characteristic for the Lower Ordovician include *Sinuities reticulatus* PERNER, 1903 (Bohemia, Barrandian Area), *S. discoides* REED, 1920 (England, Balclatchie), *S. sphaeroidalis* REED, 1920 (England, Balclatchie), *S. hispanicus* BORN, (1916) (Spain, Almaden), *S. niger* KOKEN, 1897 (Norway, Oslo Region), *S. corpulentus* KOKEN, 1925 (Norway, Oslo Region), *S. rugulosus subtilistriatus* KOKEN, 1925 (Sweden, Öland). Middle Ordovician species with reticulate sculpture are *S. elongatus* (PORTLOCK, 1843) (Ireland, Tyrone), *S. semirugosus* SALTER in REED, 1920 (England), *S. soudleyensis* REED, 1920 (England, Shropshire), *S. pervolutus* ULRICH et SCOFIELD, 1897 (USA, Kentucky, Minnesota), *S. planodorsatus* ULRICH in ULRICH et SCOFIELD, 1897 (USA, Kentucky, New York), *S. granistriatus* ULRICH in ULRICH et SCOFIELD, 1897 (USA, Ohio, Kentucky), *S. cancellatus* (HALL, 1847) (eastern half of the United States and Canada). From the Upper Ordovician come *S. crypticus* (REED, 1906) (S. Wales), and *S. cancellatus* (HALL, 1847) (eastern half of the United States and Canada).

Each of these species differs from *S. destombesi* by smaller size, by gross shell morphology, or by detailed characters of the outer shell sculpture. Moreover, they were all distributed, with the exception of *S. reticulatus* and *S. hispanicus*, in warm-water territories of Baltica, Avalonia, and Laurentia. The only two contemporary species are *S. crypticus* and *S. cancellatus*. Both were distributed in different, warm climatic conditions, and both differ morphologically. The Welsh *S. crypticus* had a narrower, much smaller shell (diameter 8–10 mm). *S. cancellatus*, distributed from Middle to Upper Ordovician (Kirkfieldian to Richmondian = Caradoc to Ashgill) in the eastern half of the United States and Canada, had similar, although variable, gross shell morphology, but differs in size (adult shells are maximally about 25 mm long), in its rounded dorsum, not flattened in maturity, and in the frequent presence of characteristic corrugations (constrictions) of the shell. (Wahlman [1992, p. O112] suspected that the corrugations were the result of compaction; I cannot verify this supposition). According to Wahlman (1992), the species was originally described from the Trenton Group of New York (Caradoc), and its persistence to the uppermost Ordovician is doubtful.

Mode of life. See *S. sowerbyi*.

Preservation. The majority of specimens are preserved as dark grey shells in brown siltstone. All specimens are partly deformed or crushed, seemingly by syndimentary and postdiagenetic pressures. Internal moulds are smooth, with preserved morphological details.

Occurrence. Upper Ashgill, Upper Ktaoua Formation: locality 750, Jbel Arhou Amejout (S of Alnif); locality 901, southern part of Jbel Bou Debgame (E of Tagounite); locality 1078, Isk n'Brahim (E of Tazzarine); locality 1080, Isk n'Brahim (E of Tazzarine); locality 1109, Plaine d'Inakiane (S of Amjerane, Maider); locali-

ty 1132, Rich Bjarine (E of Amjerane, Maïder); locality 1624, Jbel Bou Debgame (E of Tagounite); locality 1651, Jbel Bou Debgame (E of Tagounite). Upper Ktaoua Formation, upper part: locality 885, Jbel Mimount (W of Amjerane, Maïder). Upper Ktaoua Formation (top): locality 1791, Jbel Assammar (E of Tazzarine). The species frequently occurs in taphocoenoses with *Lophospira? debganensis* and *Loxonema? sp.*

Genus *Selesinuites* HORNÝ, 1997

Type species: *Selesinuites perneri* HORNÝ, 1997. Lower Ordovician, Llanvirn, Šárka Formation; Barrandian Area, Bohemia, Czech Republic.

Selesinuites perneri HORNÝ, 1997

Pl. 7, figs 4-12; Pl. 8, figs 1-5

1997d *Selesinuites perneri* sp. n.; R. J. Horný, New, rare, etc., pp. 230-231, Text-figs 12a,b.

Material. 2 specimens.

Description. Three specimens were collected in the Tachilla Formation, locality 1320, E of Khabt el Hejar (E of Erfoud, Tafilalt). One adult (NM S 2676) and a juvenile (NM S 2677), were embedded close together in a siliceous concretion.

Specimen NM S 2677 (Pl. 8, figs 1-5). The incomplete, juvenile specimen is preserved as an empty cavity, originally filled with dusty limonite and weathered, soft silty deposit. All observations were made on a latex impression. The visible adapical half of the final whorl is 7.5 mm long and 5.5 mm wide, and the fragmentary aperture is 10.0 mm wide. The narrowly rounded dorsum of the early part of the whorl bears a flat, very slightly raised selenizone, 0.5-0.6 mm wide, bordered with sharp threads, fading away in the adapertural direction when the whorl reaches a width of about 6.0 mm. In the adapertural part of the whorl, the narrow U-shaped sinus culminates on a slightly raised band, forming a kind of a pseudo-selenizone. Fine, densely crowded growth lines (about 10 per mm) join the selenizone at an angle of 25-30°. Both lateral lips are perpendicular to the umbilicus. The columellar labrum joins the shoulder of the preceding whorl, the joint being surrounded with a plate of inductural deposit. The labro-umbilical ridge is directed to the centre, without forming the adumbilical, sickle-shaped curve. The labro-umbilical depression is, therefore, much narrower than e.g. in *S. reticulatus*, but deep and slightly shifted adaperturally at its base.

Specimen NM S 2676 (Pl. 7, figs 4-8). The adult specimen is preserved as a free, incomplete internal mould and its partial counterpart, which allowed preparation of a good latex impression with fine details. The internal mould is 21.0 mm long, 16.0 mm wide (estimate) and 17 mm high. An imperfectly preserved, slightly raised, circumbilical retractor muscle attachment area is visible on the left side of the mould (Pl. 7, fig 5). The latex impression shows an excellently preserved external surface of the shell, consisting of collateral ribs (5-6 per mm), crossed by very thin, sharp, straight, spiral lines (12-15 per mm), which are present also within the dorsal sinus.

Specimen NM S 2580 (Pl. 7, fig. 9). Laterally depressed and partly crushed specimen, 20.5 mm long, with damaged

dorsum. The right lateral side of the final whorl with preserved shell is exposed, bearing regularly developed ribs, coarse (5-6 per mm) in the middle part of the whorl, and gradually becoming finer towards the apertural margin of the lobe (8-9 per mm near the margin). A small islet on the lateral side bears oblique, spiral striae.

Besides these three specimens with partly preserved shell, one more internal mould of a juvenile specimen NM S 2581 has been collected, which cannot be determined with certainty (Pl. 7, figs 10, 11).

Discussion. The find of the specimens is important, as their morphology completes the description of the holotype from the Llanvirnian Šárka Formation from Bohemia. New characters are the detailed morphology of the selenizone, presence of fine, spiral lines, shell size, and morphology of the labro-umbilical area.

Occurrence. Llanvirn, Tachilla Formation, locality 1320, E of Khabt el Hejar (E of Erfoud, Tafilalt). A taphocoenosis with *Tropidodiscus pusillus*.

Family *Bellerophontidae* McCOY, 1851

Sub-family *Plectonotinae* BOUCOT et YOCHELSON, 1966

Genus *Tritonophon* ÖPIK, 1953

Type species. *Kokenospira (Tritonophon) trimetra* ÖPIK, 1953. Silurian; Victoria, Australia.

Discussion. The gastropod collection from the Anti-Atlas contains two different Caradocian, trilobed bellerophontoids which undoubtedly belong to two distinct genera. One of them is known from four specimens; one external mould from locality 399, Jbel Tafenna (SE of Zagora), and three undetermined, but seemingly conspecific, internal moulds from locality 899, Jbel Bou Ingarf (ENE of Zagora). The specimen from the Jbel Tafenna, possessing traces of a bounded selenizone, belongs to the species *Tritonophon peeli* HORNÝ, 1997, described from the Berounian (Caradocian) Letná to Bohdalec Formations of the Barrandian Area. The second species, known from a single specimen, coming also from the lower Caradocian Lower Ktaoua Formation, was found at locality 882, Inakiane plain (SW of Amjerane, Maïder). It definitely lacks a selenizone (see Peel 1974, p. 236 for discussion concerning the shape of the anal emargination in *Bucanella* MEEK, 1951 and its allies). This specimen is the holotype of a new species, described here as *Atlantophon maider* gen. et sp. n.

G. and H. Termier (1950) reported *Bucanella bohémica* (PERNER, 1903) from the Caradoc of the Anti-Atlas, 3 km N of Taouz (Pl. 131, fig. 3). As shown by Horný (1963b, 1997d,h), *B. bohémica* (= *Tritonophon? bohemicus*) is restricted to the Upper Ordovician Ashgillian (Králdvorian and Kosovian) strata in the Barrandian Area, and according to Peel (1974) questionably belongs to the genus *Tritonophon* ÖPIK, 1953. The Bohemian Caradocian specimen, by Perner (1903) originally included in the species *B. bohémica*, has been reinterpreted by Horný (1997h) as a separate species *Tritonophon? peeli* HORNÝ, 1997. The figure (seemingly an internal mould), presented by G. and H. Termier, may also belong to this species.

Tritonophon peeli HORNÝ, 1997

Pl. 8, figs 6, 7

- 1903 *Bucaniella bohémica* PERNER; J. Perner, Gastéropodes, 4, 1, Pl. 86, figs 40-42.
?1950 *Bucanella bohémica* PERNER; G. and H. Termier, Paléontologie Marocaine, 2, Pl. 131, fig. 3.
1963b *Bucanella* sp.; R. J. Horný, Lower Paleozoic Bellerophontina, p. 81.
1997d *Bucanella?* sp.; R. J. Horný, New, rare, etc., p. 231, Fig. 14.
1997h *Tritonophon peeli* sp. n.; R. J. Horný, Circumbilical retractor etc., pp. 333-338.

Material. 4 specimens.

Description. One incomplete external mould, NM S 2668, comes from the lower Caradocian Lower Ktaoua Formation, at locality **399, Jbel Tafenna (SE of Zagora)**; three undetermined, but seemingly conspecific, internal moulds are derived from the same formation, locality **899, Jbel Bou Ingarf (ENE of Zagora)**. Specimen NM S 2668 from the **Jbel Tafenna** (Pl. 8, fig. 6) shows the right side of the shell which is 5.5 mm (estimate) long and 3.8 mm (estimate) high. It bears fine, densely crowded growth lines similar to those in the holotype, crossing the lateral lobe and the concave dorso-lateral groove, and sweeping obliquely backwards on a straight, steep, almost perpendicularly inclined side of the median lobe where they join at a very sharp angle of about 30° the spiral thread, probably bordering the selenizone. The top surface of the narrow median lobe is not preserved. Although slightly larger than the holotype, the specimen NM S 2668 has a slightly lower median lobe (0.7 mm between the base of the lateral groove and the dorsal cord; this distance measures 1.0 mm in the holotype). The internal moulds found at locality **899** are similar to those from the Barrandian Area, having narrower and sharper median lobes than the external moulds, which is probably due to loss of the shell thickness and reduction of the deposit volume filling the median lobe. (For more details and discussion see Horný 1997h.)

Mode of life. *Tritonophon peeli* is an important element of the Mediterranean bellerophotoidean assemblages. Its contemporary occurrence and presence in various facies (sandstones, siltstones, and fine clayey shales) is remarkable, and may indicate a specialised mode of life. According to its small size, inhabitation of algal thali cannot be excluded (perhaps similar to *Tropidodiscus pusillus*; see Peel 1978).

Preservation. The described external mould is preserved in light grey, soft, fine, micaceous shale, containing fragments of undetermined bivalves. The incomplete internal moulds, coming from the **Jbel Bou Ingarf**, are preserved in limonitic sandstone or siltstone.

Occurrence. Lower Caradoc, Lower Ktaoua Formation; locality **399, Jbel Tafenna (SE of Zagora)**; locality **899, Jbel Bou Ingarf (ENE of Zagora)**.

Sub-family **Bucaniinae** ULRICH et SCOFIELD, 1897

Genus *Bucanopsina* HORNÝ, 1997

Type species: *Bucanopsis calypso* PERNER, 1903. Middle Ordovician, Beroun; Barrandian Area, Czech Republic.

Bucanopsina calypso (PERNER, 1903)

Pl. 9, figs 1-9

- 1903 *Bucanopsis Calypso* PERNER; J. Perner, Gastéropodes, 1, p. 157, Text-fig. 110.
1963b *Bucanopsis calypso* PERNER, 1903; R. J. Horný, Lower Paleozoic Bellerophontina etc., pp. 113-114, Pl. 28, figs 6-9.
1997b *Bucanopsina calypso* (PERNER, 1903); R. J. Horný, *Bucanopsina* gen. n. etc., Text-figs. 1b, 2b, 3-10.

Material. 13 specimens.

Description. The collection contains two better preserved specimens of this taxon, derived from the lower Caradocian Lower Ktaoua Formation, localities **1640, Takkat n'Ait Alouene (E of Tagounite)**, and **1778, Jbel Amouguer (E of Tazzarine)**. Although preserved in a very different way, they seemingly represent one taxon. A sample of limonitic, weathered siltstone from the locality **899, Jbel Bou Ingarf (ENE of Zagora)** contains at least ten, poorly preserved, fragmentary (in the main immature) specimens of this species.

Specimen NM S 2659, Lower Ktaoua Formation, locality **1640, Takkat n'Ait Alouene (E of Tagounite)** (Pl. 9, figs 1, 2). Dorsally flattened and deformed, mature specimen in fine, grey, micaceous shale, 23.0 mm long and 34.0 mm wide. The posterior part is partly crushed and without observable details. The shell is much wider than long, of elliptic outline, with details of the outer shell surface, preserved on the external mould and its counterpart. The adapical part of the final whorl slightly overhangs the anterior margin of the aperture. The anterior margin bears a short slit, located on a keel, maximally 1.3 mm wide, running along the whole exposed part of the final whorl, being slightly emphasized by dorsal pressure. The outer shell sculpture consists of fine, inequivalent, collabral lines of growth, indicating irregular increments of the apertural margin and sectioning (and periodically interrupting) the spiral structures. The spiral structures consist of grains arranged in discontinuous rows, running slightly obliquely towards the selenizone in anterior direction.

Specimen NM S 2660, Lower Ktaoua Formation, locality **1778, Jbel Amouguer (E of Tazzarine)** (Pl. 9, figs 3-9). Incomplete, immature specimen preserved in brown siltstone as an internal mould and its counterpart, clearly showing the outer shell surface. Length 14.0 mm (estimate), width 15.0 mm (estimate), height 13.6 mm. The internal mould shows a slightly raised dorsal keel, maximally 6.0 mm wide, with shallow median groove and several obscure, low, spiral, concomitant, very slightly raised spiral rib-like structures; the ventral side bears a characteristic, sharp groove after the median carina on the dorsal surface of the parietal callus (Pl. 9, fig. 4). The parietal callus was less intensively developed, and the ventral wall of the coil is, therefore, less deflected than in the specimens from the Barrandian Area (Pl. 9, fig. 5). The external mould in latex impression shows details of the outer shell sculpture. The dorsal area with selenizone is slightly corroded, but the lateral sides bear characteristic, spiral, irregularly spaced, oblique, discontinuous, wrinkled threads, interrupted by collabral increments of the shell (Pl. 9, fig. 9). The imperfectly preserved selenizone probably bears a thin, central groove. The narrow, deep umbilici show two and a half whorls.

Discussion. The limited material provided enough data to prove that this Bohemian species belongs to the bellerophontoideans, widely distributed among the cold-water Medi-

terranean faunas. The only small difference in morphology, the less intensively developed parietal deposit, may be caused by immaturity of the specimen. It could be, however, even a result of a different chemistry of cold water, controlling the secretion of shell matrix. Only additional material may prove this assumption.

Mode of life. The palaeobiological investigations of this species, carried out on the Bohemian material (Horný 1997b), demonstrated that *Bucanopsina calypso*, characterized by an explanate aperture, was adapted to shallow-water, near-shore areas in higher energy conditions. It may have lived on exposed, harder silty to sandy elevations, influenced by the wave activity and storm waves as a slow, slug-like epifaunal grazer, feeding on algal-coated sea bottom (see also Linsley 1978, Peel 1975, 1993). Similar conditions existed in the sea surrounding Gondwanaland.

Occurrence. Lower Caradoc, Lower Ktaoua Formation; locality **899, Jbel Bou Ingarf (ENE of Zagora)**; locality **1640, Takkat n'Ait Alouene (E of Tagounite)**; locality **1778, Jbel Amouguer (E of Tazzarine)**.

Sub-family ?

Genus *Tropidodiscus* MEEK et WORTHEN, 1866

Type species. *Bellerophon curvilineatus* CONRAD, 1842. Lower Devonian; New York, U. S. A.

Tropidodiscus pusillus (BARRANDE in PERNER, 1903)
Pl. 9, figs 10, 11; Pl. 10, figs 1-5

1903 *Temnodiscus pusillus* BARR. sp.; J. Perner, Gastéropodes, 1, p. 76, Pl. 86, figs 18-21.

1963b *Tropidodiscus (Peruniscus) pusillus* (PERNER, 1903); R. J. Horný, Lower Paleozoic Bellerophontina etc., pp. 117, 118, Pl. 30, figs 1-7, Pl. 31, fig. 1.

1997d *Tropidodiscus pusillus* (BARRANDE in PERNER, 1903): R. J. Horný, New and rare etc., p. 233.

Material. About 400 specimens, predominantly internal moulds and imperfectly preserved counterparts.

Description. The species was described by Perner 1903 and re-described in detail and re-figured by Horný (1963). The Moroccan Llanvirnian specimens agree with the Bohemian, as far as it is possible to compare them in the most frequent state of preservation. Hundreds of specimens fill the siliceous and silty concretions at several localities (the majority of them have been collected at Llanvirnian locality **1320, E of Khabt et Hejar [E of Erfoud, Tafilalt]**). Similar to the Bohemian material, they are usually preserved as empty cavities, often filled or covered with limonitic matter, or incomplete internal moulds lacking dissolved or weathered initial parts. The smallest specimens are about 1.5 mm long, the two largest reach 6.8 mm. The majority of specimens fluctuate between 3.0 and 4.5 mm. In exceptional cases a counterpart of the external surface is preserved, showing fine lines of growth (20-25 per mm). Such specimens occur in a grey silty concretion from locality **1320**, figured here on Pl. 9, fig. 11, and Pl. 10, figs 1, 2. Morphology of the selenizone has not been observed.

Discussion. Similar to the Anti-Atlas, *Tropidodiscus pusillus* is a dominant bellerophontoidean species in the Llanvirnian Šárka Formation in the Barrandian Area, but

persists there till the Dobrotivian Dobrotivá Formation. In the Barrandian Area, this species usually fills some concretions with hundreds of small specimens, but occurs here also singly or in small groups and then reaches a much larger size (cf. Horný 1963b, Pl. 30 and 31). This case has not been observed in the Moroccan material. The length of the majority of small, very abundant specimens from the Barrandian Area fluctuates between 3.0 and 6.0 mm. According to Horný (1997d), a further, small, new, similar species with a laterally explanate aperture occurs in the Dobrotivá Formation, which is (possibly for facies reasons) absent in the Anti-Atlas. The subgenus *Peruniscus* HORNÝ, based on *T. pusillus*, has not been almost used since being established in 1962, and seems to be superfluous.

Pillet (1992), describing gastropods from the Ordovician of Anjou, discussed also the Llanvirnian and Dobrotivian finds of *Tropidodiscus*. Following many foregoing authors (e.g. Verneuil and Barrande 1855, Tromelin and Lebesconte 1875, Hermite 1878, Péneau 1928) he concluded, that the French finds belong to the British species, *Tropidodiscus acutus* (SOWERBY in MURCHISON, 1939). Comparing this species with *T. pusillus* (BARRANDE in PERNER, 1903), he argued that "Il est donc très possible que les deux formes soient synonymes." (p. 3). This view, however, requires a few comments. According to Reed (1920), *T. acutus* of Sowerby comes from the Bala Series (Caradoc), which is too late for *T. pusillus*. Furthermore, *T. acutus* is much larger, reaching an average length 10-40 mm, and much narrower (4-5! mm) (this may be due to the lateral pressure). It also has wider umbilici (one-third or rather less than one-third the diameter of the shell), whilst *T. pusillus* has smaller umbilici (about one-fifth the shell diameter). Nevertheless, the specimen figured by Pillet as Fig. 1 on p. 3 shows a much narrower umbilicus (almost one-seventh the shell diameter), whilst the specimen figured on Pl. 2, fig. 1 has an umbilicus similar to the Bohemian species (about one-fifth the shell diameter, but the specimen seems to be slightly deformed by pressure). (In any case, umbilici in specimens with preserved shell cannot be compared with those in specimens preserved as internal moulds; see Pl. 10, figs 3, 4 herein.) The final problem concerns the outer sculpture. Reed (1920, p. 19) states that the surface of shell in *Tropidodiscus acutus* is covered with fine, transverse, oblique striae, and this statement agrees with the photograph on Pl. 4, fig. 2. Specimens of *T. pusillus* from the Barrandian Area, similar to those from the Anti-Atlas, possess only very fine lines of growth. As a result of this discussion, I cannot accept the opinion that *T. pusillus* (BARRANDE in PERNER, 1903) is synonymous with *T. acutus* (SOWERBY in MURCHISON, 1939). The taxon from Armorica, however, should be studied in detail using better preserved, undeformed specimens, showing the outer shell surface.

Mode of life. *Tropidodiscus pusillus* is a widely distributed, dominant bellerophontoidean species in the cold-water Llanvirnian faunas of the Mediterranean Province. Its shell with a tangential (but not flaring) aperture was adapted to life on the surface of substrata. Linsley (1978) expected that *Tropidodiscus* was a streamlined and fast gastropod living in quiet sedimentary conditions. Peel (1977, 1978) expressed an opinion that certain species lived as algal foliage dwellers. According to its size, inhabitation of algal stands seems to be quite appropriate in the conditions of the Mediterranean Llanvirnian sea. In taphocoenoses, the shells

occur mostly unbroken and undamaged, with no signs of transport or wave activity. The associated species are *Ptychonema marocanum*, *Cyrtodiscus nitidus*, *Sinuities sowerbyi*, *Selesinuites perneri*, *Lesueurilla prima*, and *Tachillanella tafilaltensis*.

Occurrence. Llanvirn, Tachilla Formation; locality **1050, Ikhf n'Ourarh (S of Tinerhir, N of Jbel Sarhro massif)**; locality **1236, Jbel Bou Legroun (western Tafilalt)**; locality **1247, Tinjarfiouine (W of Rissani, Tafilalt)**; locality **1320, E of Khabt el Hejar (E of Erfoud, Tafilalt)**.

Family indeterminate

Genus *Atlantophon* gen. n.

Type species. *Atlantophon maider* sp. n. Middle Ordovician, Caradoc; Anti-Atlas, Morocco.

Derivatio nominis. *Atlantophon* (masculine). After the Anti-Atlas; the suffix is derived from *Bellerophon*.

Diagnosis. A trilobate bellerophontoidean with collabral ribs, continuously passing across the whorl, forming a narrow sinus on the median lobe. No selenizone.

Discussion. *Atlantophon* gen. n. is the largest Ordovician trilobate bellerophontoidean (see discussion in Horný in press d). It is seemingly the only known genus which has uninterrupted growth structures continuously passing the median lobe. The Lower to Middle Ordovician species possessing (or probably possessing) selenizone, *Tritonophon peeli* HORNÝ, 1997 or *Tritonophon? bohemicus* (BARRANDE in PERNER, 1903), show strong curvature of growth structures on the sides near the top of the median lobe, which indicates the presence of a slit and selenizone, and are much smaller. Similar morphology has been ascertained by Peel in *Bucanella nana* MEEK, 1871 (see Peel 1974 and Horný 1997h).

Atlantophon gen. n. distinguishes itself from other Ordovician trilobate bellerophontoideans also by shallower umbilici, shallower dorsal emargination, generating a simple sinus, and the outer shell sculpture, consisting of coarse, separated, transverse ribs. Although trilobate, the genus is probably not related to the genera, currently accumulated in the Sub-family Plectonotinae (see Peel 1974). Its systematic position and relationship are unclear.

Occurrence. Middle Ordovician, Caradoc; Anti-Atlas, Morocco.

Species included: *Atlantophon maider* sp. n.

Atlantophon maider sp. n.

Pl. 8, figs 8-11

Holotype. Specimen NM S 2673, figured here on Pl. 8, figs 8-11.

Paratypes. None.

Stratum typicum. Lower Caradoc, Lower Ktaoua Formation.

Locus typicus. Locality **882, Inakiane plain (SW of Amjerane, Maïder)**.

Derivatio nominis. *maider*, after the basin Maïder (Anti-Atlas).

Material. Besides the holotype none.

Diagnosis. See the genus.

Description. The holotype, NM S 2673, is a partly depressed, crushed, mature specimen, with its left lateral side embedded in reddish siltstone. It is 15.0 mm long, and 11.0 mm high. The width probably measured about 8-10 mm prior to lateral compression of the shell. The right lateral side of the entire final whorl is exposed; the earlier whorls, umbilicus and the umbilical wall are hidden in the rock. The lateral lobe is separated from the median lobe by a shallow depression. The median lobe occupies less than half of the height of the whorl; the dimensions, however, are slightly changed by the lateral pressure. Interesting is the shape of the external sculpture (Pl. 8, figs 10, 11). It consists of fine collabral ribs, densely crowded on the lateral lobe (6-8 per 1 mm), but widening as separated ribs when passing the depression and widest on the median lobe (4-5 per mm). A different situation was described by Peel (1974) in the Lower Ordovician *Bucanella nana* MEEK, 1851, where the lateral lobes carry strong collabral ribs which change suddenly to finer growth lines on the median lobe (p. 233). The wide ribs on the median lobe of *A. maider* have a peculiar morphology, being arranged obliquely as roofing tiles: the adapertural edges are highest, separated from the following "segment" by a steep edge. The growth structures pass the lateral lobe, the groove and the base of the median lobe obliquely backwards, without major changes in direction. On the lateral side of the median lobe, they turn slightly backwards, forming a relatively shallow emargination and without any interruption culminate in a narrow, but shallow sinus on the top of the median lobe.

Occurrence. Lower Caradoc, Lower Ktaoua Formation; locality **882, Inakiane plain (SW of Amjerane, Maïder)**. Found in a taphocoenosis with indeterminate fragments of shells, probably of pleurotomarioideans.

Superfamily **Euomphaloidea** de KONINCK, 1881

Family **Euomphalidae** de KONINCK, 1881

Genus *Lesueurilla* KOKEN, 1898

Type species. *Maclurea infundibulum* KOKEN, 1896. Middle Ordovician; Sweden.

Lesueurilla prima (BARRANDE in PERNER, 1903)

Pl. 5, fig. 1; Pl. 9, fig. 10; Pl. 10, figs 6-13

1903 *Ophileta prima* BARRANDE; J. Perner, Gastéropodes, 1, Pl. 73, figs 45-48.

1903 *Lesuerella bohémica* BARRANDE; J. Perner, ibidem, Pl. 73, figs 17-20.

1903 *Ophileta oriens* BARRANDE; J. Perner, ibidem, Pl. 73, fig. 21.

1903 *Raphistoma primum* BARRANDE; J. Perner, ibidem, Pl. 86, figs 25, 26.

1907 *Raphistoma (Lesuerella) primum* BARRANDE; J. Perner, ibidem, 2, pp. 156-158, Text-fig. 188, Pl. 114, fig. 18.

1935 *Lesueurilla prima* PERNER; M. Thoral, Contribution etc., p. 145, Pl. 12, figs 1a,b, 2, 3.

1966 *Lesuerella prima* (PERNER); Havlíček and Vaněk, The biostratigraphy etc., p. 51.

1982 *Lesueurilla prima* (PERNER); E. L. Yochelson, Mollusques etc., p. 59, Pl. 13, figs 8-10.

1984 *Lesueurilla prima* (PERNER); E. L. Yochelson, Historic and current etc., pp. 264-268, Fig. 1A, G?

Material. 34 specimens.

Description. A relatively large collection, 34 specimens, comes from the Llanvirnian Tachilla Formation. Of these only three specimens are adult (diameter 19.0, 21.0, 21.5 mm, all incomplete); the remaining specimens are immature, the smallest having a diameter of 2.8 mm. The large, adult specimens are preserved as counterparts with well preserved outer shell sculpture, studied on latex impressions.

The Llanvirnian specimens, preserved in siliceous and silty concretions, all come from the Tachilla Formation, locality **1320, East of Khabt el Hejar (E of Erfoud, Tafilalt)**. NM S 2635, diameter 19.0 mm, umbilical side with two whorls (the initial part of the shell is not visible). Fine growth lines with several small resting phases, only slightly disturbing the shell surface. The growth lines on the steep umbilical wall are slightly sigmoidal, showing a wide, shallow sinus. NM S 2637 (Pl. 10, figs 11, 12), diameter 21.0 mm, umbilical side with 2¼ whorls, with three resting phases crowded just at the beginning of the final whorl. After each of them the new shell grew from below the old, abandoned, shell margin. The apertural margin, about 0.2 mm thin, sharply joins the surface of the penultimate whorl, and the thin inductural deposit obliterates the old growth structures. The apertural margin clearly shows the wide, shallow sinus near the joint with the suture. NM S 2639 (Pl. 10, figs 6-9), diameter 21.5 mm, a fragment of two whorls showing a part of the periphery of the final whorl, its narrow keel and the adjacent part of the inclined, apical shell surface. The closely spaced growth lines are regular and fine (about 10 per mm on the final whorl), with one small resting phase in the middle part of the final whorl. The growth lines pass the periphery of the basal surface at about a 70° angle to the keel, sweeping back to the keel at about a 30° angle, forming a clear, narrow sinus culminating at the keel and at a 30° angle running forward, crossing the upper whorl surface without interruption at an angle of about 45° (Pl. 10, figs 8, 9).

The only Arenigian specimen, NM S 2634 (Pl. 10, fig. 13), is a compressed counterpart of the flat, apical shell surface, showing the gross morphology but almost lacking the growth lines which are preserved only near the periphery. Diameter is 18.5 mm. Preservation of the fossil in a greenish shale resembles the finds from the Arenigian Klabava shales from the neighbourhood of Rokycany in the Barrandian Area.

Discussion. The stratigraphic distribution of the species in the Anti-Atlas is identical to that in the Barrandian Area. The species was also reported from the lower Arenigian strata of the Montagne Noire (Thoral 1935, Yochelson 1982). It has also been reported, although with a reservation (due to poor preservation of material), from the Llanvirnian strata of the Massif Armoricain (Pillet 1992). *L. prima* thus represents a characteristic element of the cold-water Mediterranean fauna. Outstandingly good preservation made it possible to observe the sinus on the keel (Pl. 10, fig. 8), and thus to solve (at least partly) the long lasting sinus/slit problem (Perner 1903, Yochelson 1982, 1984). The non-existence of a slit and selenizone may help to clear up hypotheses about affinities of this genus (for details see Yochelson 1974, Morris 1991). (The genus has been placed in the Family Euomphalidae within the Paragastropoda by Linsley and Kier 1984, but in the Family Macluritidae within the Gastropoda by Morris 1991). These problems, however, are not within the limits of this work.

Mode of life. According to the morphology of the shell, *L. prima* was a sessile, filter-feeding, epibenthic mollusc. The high mortality of immature specimens, recorded in the Anti-Atlas localities is noteworthy.

Occurrence. Lower Arenig, Upper Fezouata Formation: locality **1689, East of Jbel Bou Dehir (N of Zagora)**. Llanvirn, Tachilla Formation; locality **1247, Tinjarfiouine (W of Rissani, Tafilalt)**; **1320, East of Khabt el Hejar (E of Erfoud, Tafilalt)**, in taphocoenoses with *Tropidodiscus pusillus*, *Cyrtodiscus nitidus*, *Sinuities sowerbyi*, *Selesinuites perneri*, and *Ptychonema maroccanum*.

Superfamily **Pleurotomarioidea** SWAINSON, 1840

Family **Eotomariidae** WENZ, 1938

Genus **Ptychonema** PERNER, 1903

Type species. *Ptychonema nigrum* BARRANDE in PERNER, 1903. Middle Ordovician, Beroun; Barrandian Area, Bohemia, Czech Republic.

1903 *Ptychonema* PERNER; J. Perner, *Gastéropodes*, 1, expl. Pl. 57.

1911 *Pleurotomaria?*; J. Perner, *ibidem*, 3, p. X.

1941 *Ptychonema* PERNER; J. B. Knight, *Paleozoic gastropod genotypes*, p. 287.

non 1960 *Loxoplocus (Lophospira)* WHITFIELD, 1886; J. B. Knight et al., *Treatise I*, 1, p. 1208.

Emended diagnosis. Shell trochiform, of moderate size (up to 25 mm high), slightly gradate, narrowly phanerocephalous or anomphalous; protoconch unknown; base rounded or slightly elongate, columellar lip slightly reflected; outer lip with short sinus or slit (this feature may be variable within a species), generating a slightly raised selenizone which is distinct but weakly bordered, located at the whorl periphery, in the median part of the whorl. Shell sculpture, fine growth lines.

Discussion. The genus was established by Perner (1903), in the explanation of Pl. 57, figs 16-19, containing the necessary data about its stratigraphical position and locality. The first description of the type species was published by Knight (1941), p. 287. All existing types, the lectotype and two paralectotypes, are rather poorly preserved in black, micaceous shale, inseparable from the shell surface. The lectotype, however, shows a partly exposed, smooth, internal mould. All observable characters are given in Knight's description. Relatively important is the note about the whorl profile, which is "seemingly with two, obscure angulations, one at about midwhorl and the other just below the line of suture". In the discussion, Knight (1941, p. 87) wrote: "Although Perner in 1903 proposed the generic name *Ptychonema* for this form, he later recognized that its true characters were indeterminable so that the only further mention of it is in the Addenda and Corrigenda on p. X of Perner (1911), where he substitutes "*Pleurotomaria?*" for "*Ptychonema*". Indeed he seems to make no other reference of any sort to the genus or species and neglects even an attempt to describe or index it. Nevertheless, *Ptychonema* is nomenclaturally in good standing, and it is suggested that the best way to handle it is probably to refer it, with a query, to the subjective synonymy of *Lophospira* WHITFIELD, 1886, which see. The two revolving angulations shown on

the whorls of steinkerns strongly suggest *Lophospira*, though whether or not the upper one carried a selenizone may never be known." Following this statement, Knight et al. (1960) synonymized *Ptychonema* PERNER, 1903 with *Loxoplocus* (*Lophospira*) WHITFIELD, 1886.

During the study of the material from the Anti-Atlas, I found numerous trochiform shells from the Llanvirnian strata, resembling the imperfectly preserved types of *Ptychonema nigrum* in gross morphology. Investigating the available material in the collections deposited in the Department of Palaeontology in the National Museum, Prague, I have found an old Barrande box with about 25 specimens, identical with Barrande's types of *Ptychonema nigrum*. (The attached, original Barrande label, written in pencil, indicates *Trochus nudus* BARR., and the locality **Staré Strašnice**, which is the type locality of *Ptychonema nigrum*. The manuscript name *Trochus nudus* seemingly originally indicated different shells, belonging to different taxa. Barrande also used this name for shells from the Ashgillian Králův Dvůr Formation, published *pro parte* as *Lophospira? nuda* BARRANDE in PERNER, 1903.) The majority of specimens are preserved in black, micaceous shales, but a few are in grey or even brown micaceous silty shale. This original Barrande lot contained two specimens which were carefully prepared to show all morphological details characterizing *Ptychonema* as a well defined, separate genus.

A characteristic feature of the genus is the variable shape of the anal emargination. Its peculiar variability within a species can be well demonstrated in *Ptychonema desideratum* (BARRANDE in PERNER, 1903). The majority of specimens have a very short slit, generating a selenizone, but many specimens possess a simple sinus, generating a pseudo-selenizone or a weak, band-like, often slightly raised zone. The selenizone is only rarely sharply bounded with continuous lines, the lunulae being often irregular or asymmetrical.

The genus *Ptychonema* includes several taxa, characteristic for the Lower and Middle Ordovician of the Mediterranean Palaeoprovince. The oldest validly published species probably is the Llanvirnian to Dobrotivian *Ptychonema bussacense* (SHARPE, 1853), described from Portugal as *Pleurotomaria bussacensis* and reported from different localities in Spain and France (e.g. Verneuil and Barrande 1855, Tromelin and Lebesconte 1875, Kerforne 1901, Delgado 1908, Born 1916, Gutiérrez-Marco, Rábano et al. 1984 [as *Clathrospira? bussacensis*], Gutiérrez-Marco, Albani et al. 1996 [as "*Clathrospira? bussacensis*"], Pillet 1992 [as *Clathrospira bussacensis*]). (Although the type is not available for study, I base this conclusion on a realistic description and good illustration by Sharpe [1853, p. 157, Pl. 9, fig. 18]; see Pl. 11, fig. 4 herein). Nevertheless, Born (1916) stated that "Vielleicht steht *Mourlonia egens* Barr. (l. c. S. 95, Taf. 112. V. Fig. 1-4) unserer Form [= *Pleurotomaria* (*Mourlonia*) cf. *bussacensis*] recht nahe" (p. 346). The second species is the contemporary *Ptychonema desideratum* (BARRANDE in PERNER, 1907), described as *Pleurotomaria* (*Mourlonia*) *desiderata*, distributed in the Šárka and Dobrotivá Formations of the Barrandian Area. Although slightly smaller than *Ptychonema bussacense*, *P. desideratum* may be a younger synonym of this species. The third taxon is represented by large populations of a small *Ptychonema marocanum* sp. n., occurring in the Llanvirnian Tachilla Formation of the Anti-Atlas.

Relations. The main morphological character distinguishing *Ptychonema* from the "immortal" (Ordovician to Carboniferous) genus *Mourlonia* de KONINCK, 1883 is a very deep slit in the latter genus, occupying about one-third of the circumference of the final whorl in depth, according to Knight (1941). Perhaps several Ordovician species, so far considered as members of this genus, will find their placement in *Ptychonema*. Probably nearer to *Ptychonema* is the contemporary *Clathrospira* ULRICH et SCOFIELD, 1897, which has a similarly shallow slit but this is located lower in the aperture, and its whorls are rather flattened above the periphery, giving the shell a trochiform appearance. Comparison with *Lophospira* WHITFIELD, 1886, with which it was synonymized by Knight et al. (1960), and with similar "lophospirid" genera is difficult, as *Ptychonema* lacks most of comparable characters. The lower revolving angulation, mentioned by Knight, was not ascertained from the additional material. Somewhat similar, but imperfectly known is the Upper Cambrian *Taeniospira* ULRICH et BRIDGE, 1931.

Occurrence. Llanvirn to Beroun (Caradoc) of the Mediterranean Palaeoprovince.

Species included. *Ptychonema nigrum* BARRANDE in PERNER, 1903; ? *P. bussacense* (SHARPE, 1853); *P. desideratum* (BARRANDE in PERNER, 1907); *P. marocanum* sp. n.

Ptychonema nigrum BARRANDE in PERNER, 1903

Pl. 11, figs 1, 2

- 1903 *Ptychonema* (n. g.) *nigrum* BARRANDE; J. Perner, *Gastéropodes*, 1, Pl. 57, figs 16-19, and expl. Pl. 57.
1911 *Pleurotomaria?*; J. Perner, *ibidem*, 3, Addenda et Corrigenda, p. X.
1941 *Ptychonema nigrum* PERNER, 1903; J. B. Knight, pp. 287, 288, Pl. 33, figs 16, 17.

Lectotype. Designated by Knight (1941), specimen NM L 9470, figured by Perner (1903, Pl. 57, figs 16, 17), and by Knight (1941, Pl. 33, fig. 1b).

Paralectotypes. NM L 9471, figured by Perner (1903, Pl. 57, figs 18, 19), and by Knight (1941, fig. 1a), and NM L 9472 (an additional specimen to Perner's figures).

Stratum typicum. Beroun, Zahořany Formation.

Locus typicus. **Praha-Strašnice (Staré Strašnice)**.

Diagnosis. Species of *Ptychonema* with five whorls; base elongate, anomphalous, whorls roundly arched above the periphery and flatly below, sutures shallower than in *P. desideratum*, selenizone developed, the base becoming more inflated in maturity; shell medium thick, pleural angle 68°.

Description. *P. nigrum* is similar to *P. desideratum*, but differs by its anomphalous base, less roundly arched whorl below the selenizone (which is connected with higher lower part of the whorls and elongate base), shallower sutures, slightly deeper slit, generating better developed selenizone, thicker shell (up to 0.4 mm) and bigger maximum size (up to 25 mm height and 26 mm width). Width of mature specimens fluctuates between 15-19 mm. Apical angle is 86°, pleural angle 68°.

Occurrence. Bohemia, Barrandian Area: Beroun, Zahořany Formation; **Praha-Strašnice**.

Ptychonema desideratum (BARRANDE in PERNER, 1907)
Pl. 11, fig. 3

- 1907 *Pleurotomaria (Mourlonia) desiderata* BARRANDE; J. Perner, *Gastéropodes*, 2, p. 56, Pl. 96, figs 19-22.
1966 *Mourlonia desiderata* (PERNER); V. Havlíček and J. Vaněk, *The biostratigraphy etc.*, p. 51.
1997d "*Mourlonia*" *desiderata* (BARRANDE in PERNER, 1907); R. J. Horný, *New, rare, etc.*, p. 228.

Lectotype. Here designated, specimen NM L 11367, figured by Perner (1907) on Pl. 96, figs 21, 22.

Paralectotypes. NM L 11366, figured *ibidem* (Pl. 96, fig. 19), and NM L 11368, figured *ibidem* (Pl. 96, fig. 20).

Stratum typicum. Llanvirn, Šárka Formation.

Locus typicus. **Osek near Rokycany.**

Diagnosis. Species of *Ptychonema* with five whorls; base rounded, narrowly phaneromphalous, whorls roundly arched above the periphery and below, sutures deeper than in *P. nigrum*, slit short, may be substituted with a short sinus, selenizone often unbordered, shell thin, pleural angle about 70°.

Description. *P. desideratum* is similar to *P. nigrum*, but differs by its rounded base, symmetrically roundly arched whorls above and below the selenizone, deeper sutures, slightly shorter slit, which is often substituted by a short, narrow sinus with subparallel sides. Selenizone, if developed, is often unbordered, the culmination of the anal emargination being marked by a slightly raised zone, better visible on internal moulds; shell thin (up to 0.2 mm). Maximum size up to 14.5 mm in height and 14.0 mm in width, width of mature specimens fluctuates between 9.0-12.0 mm. The narrow umbilicus remains empty throughout the whole ontogeny. Apical angle is about 85°, pleural angle about 70°.

Occurrence. Bohemia, Barrandian Area: Llanvirn, Šárka Formation, **Osek near Rokycany, Praha-Šárka**; Dobrotivá, Dobrotivá Formation, **Kařízek, Praha-Šárka.**

Ptychonema marocanum sp. n.
Pl. 11, figs 5-13; Pl. 12, figs 1-6

Holotype. Specimen NM S 2593, figured here on Pl. 11, figs 7-9.

Paratypes. NM S 2594, 2595, 2596, 2597, 2598, 2599, 2600, 2601, 2602, 2603, 2604, 2605, 2606.

Stratum typicum. Llanvirn, Tachilla Formation.

Locus typicus. Locality **1320, East of Khabt el Hejar (E of Erfoud, Tafilalt).**

Derivatio nominis. *marocanum*, after the country of origin, Morocco.

Material. About 500 specimens, mostly internal moulds and counterparts.

Diagnosis. Species of *Ptychonema* with four whorls; base rounded, narrowly phaneromphalous, whorls flatly arched above the periphery and roundly below, sutures deeper than in *P. nigrum*; protoconch unknown; the short slit may be substituted by a short sinus, selenizone is often unbordered, shell thin, pleural angle about 90°.

Description. *P. marocanum* is similar to *P. desideratum*, but has only four whorls which are flatly arched above the

selenizone and roundly below; sutures are deep; a very short slit is often substituted by a short, narrow sinus with subparallel sides. Selenizone, if developed, is often unbordered, 0.4 mm wide, the culmination of the anal emargination being marked by a slightly raised zone, better visible on internal moulds; shell thin (about 0.1 mm). Maximum measured size up to 5.8 mm high and 6.2 mm wide, width of 20 specimens fluctuate between 2.2-6.2 mm. One questionable fragment of a base (NM S 2609) measures 8.0 mm. The narrow umbilicus remains empty throughout the whole shell. Apical angle is about 100-110°, pleural angle about 90°; the shell is, therefore, wider than high.

Discussion. *P. marocanum* is, after *Tropidodiscus pusillus*, the second most abundant gastropod in the Ordovician of the Anti-Atlas. The siliceous concretions, contained in the Llanvirnian Tachilla Formation, are often crowded with chaotically deposited, differently aged specimens. Although contemporary and similar to *P. desideratum*, it is distinguished by several characters which confirm its separate specific position. The relationship with the contemporary *T. bussacense* should be studied when comparative material of the latter species is available.

Shell repair. Two specimens show signs of a large amount of damage to the shell by a predator. Both attacks were centred on the weakest, apertural part of the whorl, including the anal emargination with adjacent parts of the shell. Specimen NM S 2606 (Pl. 12, fig. 6) lost its apertural margin across the whole outer side of the whorl, and the slit area was deeply wrenched out. The new shell grows from below the sharp, angular margin of the fracture. As far as it is possible to deduce from the regular development of new shell, the predator probably did not injure the soft body. Specimen NM L 2605 (Pl. 12, fig. 5) survived a violent attack which caused a deep fracture running along the upper suture and obliquely backwards across the selenizone and down to the base (the lower part of the fracture is hidden below the upper margin of the final whorl). The breakage was deep and probably injured the soft organs as the deformation (irregular inflation) of the whorl and a strong deviation of growth lines can be followed for about one third of the final whorl. Similar fractures have been described and explained by Peel (1984), Horný (1997c, in press a) and Lindström and Peel (1997); it is suspected that the most probable predators may have been nautiloid cephalopods.

Mode of life. Because of its small size, *P. marocanum* may have inhabited algal stands in low energy areas or perhaps even floating algae. This mode of life could have protected the animal from fouling the gills with mud, usually covering the sea bottom in these conditions.

Occurrence. Llanvirn, Tachilla Formation; locality **1247, Tinjarfiouine (W of Rissani, Tafilalt)**; locality **1320, E of Khabt el Hejar (E of Erfoud, Tafilalt).**

Genus *Clathrospira* ULRICH et SCOFIELD, 1897

Type species. *Pleurotomaria subconica* HALL, 1847. Middle Ordovician; New York, U. S. A.

Discussion. *Clathrospira* is a genus characteristic for more distant, warm-water regions of the peri-Gondwanan Palaeoprovince, predominantly occurring in the eastern territories of Laurentia, in Avalonia, and Baltica. Its occurrence in the Mediterranean Palaeoprovince is rather limited. The generic name was attributed by Perner (1903) to the

Upper Ordovician (Králdvorian) *Clathrospira infirma* BARRANDE in PERNER, 1903 (= *Lophospira? infausta* BARRANDE in PERNER, 1903). Later it was used, although with a question, by Gutiérrez-Marco and al. in 1984 for *Clathrospira? bussacensis* (SHARPE), and in 1996 as "*Clathrospira?*" *bussacensis*; Pillet (1990, 1992) accepted *Clathrospira bussacensis*. The genus has been reported by Horný (1997d) from the Dobrotivian Dobrotivá Formation at Kařízek near Rokycany, but without describing a species. *C. egens* (BARRANDE in PERNER, 1907) is, unfortunately, imperfectly known, as the material available is fragmentary and lacks the base with aperture. In general, even the genus *Clathrospira* is imperfectly known and defined, lacking modern revision, and its interpretation is rather wide (Ulrich and Scofield 1897, Longstaff 1924, Koken 1925, Vostokova 1955; see also Wagner 1996). The only modern, detailed paper concerning one European species, *Clathrospira elliptica* (HISINGER, 1829) from the Oslo region, is that of Yochelson (1963). The very fine revolving lirae, a character which is present in the type species, has not been largely accepted as a generic sign.

Clathrospira amouguerana sp. n.

Pl. 12, figs 7-13; Pl. 13, figs 1-3

Holotype. Specimen NM S 2654, figured here on Pl. 12, figs 7-9.

Paratypes. NM S 2655, 2656, 2657.

Stratum typicum. Lower Caradoc, U. Tiouririne Formation.

Locus typicus. Locality **585, Jbel Amouguer (E of Tazzarine)**.

Derivatio nominis. After Jbel Amouguer (E of Tazzarine).

Material. Besides the types, 47 specimens.

Diagnosis. Species of *Clathrospira* similar to *C. egens* (BARRANDE in PERNER, 1907), having more arched whorls below the selenizone and shallower sutures.

Description. The collection contains 47 specimens in different, mostly poor, states of preservation in carbonate siltstone and sandstone. Internal moulds with exfoliated shell predominate. The external shell surface has been observed only on small patches of shell. Shell is turbiniform, with a spire angle 84°-95°, anomphalous, consisting of six whorls. The upper whorl surface is flatly arched, the lower is rounded, passing into a rounded base. A deep, V-shaped sinus culminates in a short slit, generating an almost vertical selenizone located at the subangular periphery above the suture, in a distance approximately equal to its width. The selenizone with lunulae, bordered with fine threads, is 1.5 mm wide in the final whorl of the holotype NM S 2654 (Pl. 12, figs 7-9), which is 23.0 mm high and 21.0 mm wide. The columellar lip is slightly reflected over the columella; it is clearly visible in the juvenile specimen NM S 2657 (Pl. 12, figs 10, 11) and strongly emphasized in a mature, probably gerontic specimen NM L 2656 (Pl. 13, figs 1, 2). The shell is about 0.2-0.3 mm thick, thickest and multilamellar in the umbilical area. Outer shell surface is smooth with fine lines of growth, in adult specimens sometimes irregularly spaced or even lamellar at the base near the apertural margin (Pl. 13, figs 1, 2). Size: The smallest, juvenile specimen, paratype NM S 2657, is 5.3 mm high and 5.0 mm wide; two mature specimens: the holotype NM L 2654: height 21.5

mm, width 22.5 mm; paratype NM L 2655: height 23.2 mm, width 21.0 mm.

At least two specimens have been found in the Moroccan material having a lower and wider shell: NM S 2685 (height 15.5 mm, incomplete, width 20.0 mm, spiral angle about 90°), and NM S 2681 (height 13.5 mm, width 16.0 mm, spiral angle 95°; Pl. 13, fig. 3). They may represent a different species, but the material available is too scarce and fragmentary to establish a separate taxon.

Discussion. *C. amouguerana* sp. n. is seemingly related to the Bohemian *Clathrospira egens* (BARRANDE in PERNER, 1907) (figured herein on Pl. 12, fig. 14). This species, originally attributed to *Pleurotomaria (Mourlonia)*, has not been revised since being described. It was based on four specimens, coming from the old Barrande collection. All were derived from the Zahořany or Bohdalec Formations, from **Praha-Jinonice**. The type series, however, contains three different genera and species; only two specimens belong to *C. egens*. The larger syntype, NM L 11774, figured by Perner (1907, Pl. 112, figs V/1, 3, 4), is here designated the lectotype. A smaller, immature part of a shell, which is an additional, non-figured specimen, is the paralectotype NM L 11773, associated with a counterpart of *Anastrophina vermiculosa* (BARRANDE in PERNER, 1903). Two additional syntypes, which have been used for fig. V/2, are counterparts of umbilici of *Sinuitopsis neglecta* (BARRANDE in PERNER, 1903), NM L 11775 and NM L 11776, misinterpreted as bases of *C. egens*. The type lot contains a fifth syntype, NM L 11777, which is a counterpart of another specimen of *Anastrophina vermiculosa*. The presence of *A. vermiculosa* and *S. neglecta* testifies to the Berounian age of the find, excluding the Králdvorian Králův Dvůr Formation, as originally declared.

Differences between *C. amouguerana* and *C. egens* concern the size of the shell, vaulting of whorls, and the depth of the sutures. The two Bohemian specimens are smaller, but they are incomplete and probably even immature. Their whorls are slightly more arched below the selenizone, which causes deeper sutures.

Mode of life. The species probably lived in more dynamic conditions with clearer water, inhabiting the surface of a shallow sea bottom. One specimen was found associated with an incomplete shell of *Sinuitopsis neglecta*.

Occurrence. Lower Caradoc, Lower Ktaoua Formation: locality **882, Inakiane plain (SW of Amjerane, Maïder)**; locality **1100, Jbel Amouguer (E of Tazzarine)**; locality **1778, Jbel Amouguer (E of Tazzarine)**. Middle Caradoc, Lower Ktaoua Formation: locality **86, Jbel Amouguer (E of Tazzarine)**; locality **1266, Bou el Koualb (W of Rissani)**. "Middle" Caradoc, Lower Ktaoua Formation: locality **88, Jbel Amouguer (E of Tazzarine)**; locality **1652, Tiliwine (High Atlas, N of Ouarzazate)**. Upper Caradoc, Upper Tiouririne Formation: locality **585, Jbel Amouguer (E of Tazzarine)**; locality **1134, N of Jbel Amouktir (E of Agdz)**. Upper? Caradoc, Lower Ktaoua Formation: locality **1282, E of Jbel Taklimt (W of Rissani, Tafilalt)**.

Family **Lophospiridae** WENZ, 1938

Genus **Lophospira** WHITFIELD, 1886

Type species. *Murchisonia bicincta* HALL, 1847. Middle Ordovician; New York, U. S. A.

Note. Tofel and Bretsky (1987) returned *Lophospira* WHITFIELD, 1886 to a generic status (see Knight et al. 1960). This standpoint has been accepted in this paper.

Lophospira sp.
Pl. 13, figs 4-6

Description. The material from the Anti-Atlas contains four incomplete specimens which can be determined as a true *Lophospira*. Specimen NM S 2689 is an incomplete internal mould with patches of shell, 7.8 mm high and 7.6 mm wide, lacking the apical part and most of the apertural margin. The fragment consists of four whorls, spire angle is about 80°. Base is anomphalous. The final whorl, preserved as an internal mould, bears a poorly visible angulation in the upper third of the whorl, corresponding to the selenizone, more pronounced near the apertural margin where it joins the apex of a symmetrical, V-shaped emargination, forming an angle of about 45-50°. The morphology of the upper, slightly concave whorl surface is better viewed on a latex impression (Pl. 13, fig. 5), at the boundary between the penultimate and final whorls. Sutures are shallow, not impressed, the upper edge of the whorl forming a narrow swelling addressed to the suture. The whorl lacks prominent angulations, the rounded periphery being the locus of a selenizone. Fine growth lines form a sharp, deep sinus seemingly culminating in a short notch, generating a well bordered selenizone bearing lunulae and a narrow, low, rounded, median carina, located closer to the lower margin of the selenizone and surrounded with shallow spiral depressions. The rounded lower whorl surface bears an indistinct, rounded angulation, in the early whorls embraced by a succeeding whorl. Specimen NM S 2687 is less well preserved. It is 7.5 mm high and 7.4 mm wide, consisting of four whorls. The rounded base, showing no angulation, bears fragments of shell, which is 2.0-2.5 mm thick, consisting of two layers, the lower being multilamellar. The third, largest but poorly preserved, specimen NM L 2688, partly embedded in rock, is about 10 mm high and about 10 mm wide.

Discussion. The three briefly described specimens belong to one species lacking or almost lacking the prominent spiral angulations. Unfortunately, the material available for the present study is too scarce and incomplete, and it would be premature to formally assign a specific name or to compare it with the existing taxa. Several similar shells have been insufficiently figured and described under different names by Perner (1903-1911) from the Berounian strata of the Barrandian Area, but the type specimens are mostly poorly preserved and so far not revised. A rare occurrence of the genus in the Anti-Atlas testifies to a vast difference between the cold-water gastropod fauna of the southern near-shore areas of the Mediterranean Palaeoprovince and that of the contemporary warm-water assemblages in Laurentia, characterized by an extreme expansion of varied lophospirid taxa (see e.g. Ulrich and Scofield 1897, Tofel and Bretsky 1987, Wagner 1995).

Occurrence. Upper Caradoc, Upper Tiouririne Formation: locality 134, **Jbel Tibert n'Gaiz (N of Alnif)**. Grey arenaceous limestones with numerous unidentified, mostly fragmentary shells of gastropods and other fauna.

Lophospira? debganensis sp. n.

Pl. 13, figs 7-10; Pl. 14, figs 1-9

Holotype. Specimen NM S 2644, figured here on Pl. 13, figs 7-9.

Paratypes. Specimens NM S 2645, 2646, 2647, and 2648.

Stratum typicum. Upper Ktaoua Fm., upper Ashgill.

Locus typicus. Locality 1132, **Rich Bjarine (E of Amjerane, Maïder)**.

Derivatio nominis. *debganensis*, after the mountain chain Jbel Bou Debgame.

Material (Anti-Atlas). 37 specimens, mostly fragmentary or incomplete internal moulds.

Diagnosis. Shell of medium size (up to 35 mm), trochiform, at maturity slightly coeloconoidal, with 5-7 whorls, anomphalous; aperture with a deep V-shaped sinus culminating in a short notch, generating a vertical selenizone in the immature shell, later changing to a pseudo-selenizone bordered at the upper margin, gradually passing to a narrow, sharp sinus located at the peripheral, reinforced keel; selenizone and its equivalents are positioned slightly above the suture; upper sides of whorls are flat in immature shell, concave in maturity. Outer shell sculpture, fine, irregular, collabral lines.

Description. The best preserved specimen, possessing the initial part of the shell, is the holotype NM S 2644 (Pl. 13, figs 7-9). Its apical part is somewhat abraded, but the spire is excellently preserved, showing details of the external shell surface. The whorls have almost straight sides, forming a cone-like shell of spire angle 75°, with shallow sutures (the "*Clathrospira* stage"). The selenizone can be followed from the third whorl, being 0.4-0.5 mm wide and located just above the suture so that its lower margin is hidden by the succeeding whorl. The selenizone is best preserved in the fourth whorl, where it is flat and vertical. Its upper margin is bordered with a continuous structure, indicating the presence of a short notch or, perhaps, a "one-sided" slit (an opposite case with bordered lower margin of selenizone has been observed in the Lower Devonian genus *Branzovya* HORNÝ, 1994). Lunulae are regular, slightly asymmetrical, with an ill-defined, almost invisible median line, observable only on the fourth whorl. On the fifth whorl, the selenizone or "band" is located slightly above the suture so that its lower margin is exposed, clearly showing the lower flank of the sinus smoothly and continuously passing the margin. The "band" is still almost vertical, but, in contrast to the fourth whorl, concave. The upper surface of the fifth whorl is still flat but wavy, bearing about 1.0-1.5 mm wide, slightly inflated, increments of shell. The sixth whorl (final in this specimen) becomes concave in the course of its evolution, especially near the pseudo-selenizone, which gradually loses its upper boundary and becomes strongly convex, forming a narrow, peripheral keel. The keel is reinforced with the shell matrix, which reaches 1.2 mm (the average thickness of the shell wall is 0.4-0.5 mm in the final whorl). Because of the reinforcement of the keel, the exfoliated internal mould of the whorl is more widely arched at its periphery. The collabral growth lines (about 15 per mm) form a narrow, slightly asymmetrical sinus within the pseudo-selenizone, passing its lower margin with forward convexity and after forming a short lateral lobe turning back to the umbilicus. Paratype NM S 2647 (Pl. 14, figs 1-5) has preserved the last four whorls, the three apical whorls and the base being lost. The upper margin of the

pseudo-selenizone in the fourth whorl is indistinctly bordered, and in the course of the fifth whorl it becomes entirely unbordered and convex, bearing V-shaped lunulae. After an injury in the sixth whorl, the pseudo-selenizone moved abapically and is hidden by the final whorl for about a half whorl distance. The seventh, final whorl has a narrow peripheral keel, with the V-shaped sinus culminating exactly on its sharp edge. The spire angle of this specimen is about 90°. Paratype NM S 2645 (Pl. 13, fig. 10) is a fully adult specimen, clearly showing the deeply concave upper surface of the final whorl and a partly exfoliated, weathered, anomalous base.

All four specimens are more or less incomplete, with brown, grey to almost black shell, embedded in yellow or brown arenaceous carbonate. Two specimens are partly weathered by desert weathering. Their size is, therefore, to some extent an estimate. Holotype NM S 2644: height 26.3 mm, width 22.3 mm; paratype NM S 2645: height 34.0 mm, width 32.0 mm; paratype NM S 2646: height 29.0 mm, width 26.5 mm; paratype NM S 2647: height 32.0 mm, width 30.7 mm.

Discussion. *Lophospira? debganensis* is similar to *Clathrospira* in immature specimens, having a trochiform shell with straight sides at an angle of about 75°, and an almost vertical selenizone with lunulae located at the whorl periphery. In adult shells, however, the whorls become concave on the upper sides and widen quite rapidly so that the shell reaches a coeloconoidal profile with a spire angle of about 90°, thus resembling *Eotomaria* ULRICH et SCOFIELD, 1897. The selenizone and its pseudo-selenizone modifications, however, are not located on the upper side of the shell periphery as in *Eotomaria*, but at the peripheral angulation, developed as a sharp keel located within the pseudo-selenizone at maturity. These features resemble *Lophospira*, but the morphology and location of the selenizone in immature stages and the general shell morphology disagree with the diagnosis of this genus. Nevertheless, even species of *Clathrospira* can demonstrate various changes in the morphology of selenizone during the ontogeny, as shown by Yochelson (1963) in *C. elliptica* (HISINGER, 1829) from the Middle Ordovician of Baltica. *Lophospira? debganensis* sp. n. and the similar Bohemian, contemporary *Lophospira? infausta* (BARRANDE in PERNER, 1903) may represent a separate genus, derived from “small lophospirids” in the cold-water environments of the Mediterranean Palaeoprovince in the late Middle and the Upper Ordovician seas.

Lophospira? debganensis sp. n. differs from *Lophospira? infausta* (BARRANDE in PERNER, 1903) in several characters. The selenizone in *L.? infausta* is located slightly higher above the suture, and is bordered on both sides with continuous threads (its development is unknown in the fully adult final whorl). A narrow, sharp, raised median keel, dividing the selenizone into equivalent parts, forms the whorl periphery. Lunulae are V-shaped. Sutures are deeper, sunken below the peripheral keel of the previous whorl. Upper surfaces of whorls are slightly concave even on younger whorls. *L.? infausta* lived in different environments; the majority of collected specimens come from soft, clayey shales.

Barrande in his manuscript distinguished two stratigraphically synchronous taxa: *Pleurotomaria infausta*, based on deformed external moulds, and *Trochus nudus*, based on smooth internal moulds. In 1903, Perner published three names in explanations to the plates: *Pleurotomaria infausta*

BARRANDE, *Lophospira tropidophora* MEEK, and *Lophospira? nuda* BARRANDE. In 1907, Perner re-interpreted these “different species” as *Lophospira infausta* BARRANDE [or *Pleurotomaria (Lophospira) infausta* BARRANDE] and *Lophospira tropidophora* MEEK, 1873. In 1911, Perner changed his original opinion and replaced the name *Lophospira tropidophora* MEEK, 1873 with *Lophospira tropidophora nuda* BARRANDE, thus preserving the original manuscript name of Barrande at least for a subspecies. The situation was even more complicated by *Clathrospira infirma* BARRANDE in PERNER, 1903, which represents immature shells of *Lophospira? infausta* BARRANDE in PERNER. *L. tropidophora* of Meek, however, cannot be regarded as conspecific with *Lophospira? infausta* (different gross shell morphology, development of selenizone or pseudo-selenizone, width of the final whorl and the shape of the base). Besides, the presence of a Laurentian, warm-water species in the cold-water Mediterranean Palaeoprovince would be a paradox.

Mode of life. *Lophospira? debganensis* was an epibenthic gastropod, living in a similar way to *Clathrospira* (see e.g. Bretsky 1970, Fig. 6). Its wider basal whorl, however, may have required a slightly different living position. *L.? infausta* must have been adapted to soft argillaceous deposits, and probably this factor influenced the width of the adult shell. The Moroccan species, on the contrary, has a rather reinforced peripheral keel, which may indicate life in a higher energy zone.

Shell repair. Specimen NM S 2647 shows an exceptional example of shell breakage and repair (Pl. 14, figs 1-5). Four, repeated fractures of shell, each resulting in partial loss of the adaperural part of the outer lip, are located at the beginning of the final whorl (similar repaired fractures have been observed in the lectotype of *L.? infausta*; see Pl. 13, fig. 11). The first, largest attack resulted in a large part of the adaperural part of the outer lip being torn off, seemingly including the anal emargination. The last, long, irregular fracture with sharp edges obliquely crosses the upper whorl surface, the keel, and then the upper whorl area of the lower part of the final whorl, almost parallel with the keel. The place, where the injury was deepest, is located in the upper part of the base (Pl. 14, fig. 5). New shell, growing from below the fracture, has here a chevron or feather-like structure, resembling an anal emargination (similar structure of shell repair has been figured by Horný [1996b, Fig. 4a] in *Gamadiscus* [= *Cyrtodiscus*] *nitidus*). This small area may indicate the point of attack, probably of a nautiloid, armed with a sharp beak (see Horný 1997e). (Failed predation on the Moroccan gastropods will be described in detail in a separate paper.) One specimen exhibits a pattern of small pits, about 0.2 mm across, which originated in the internal shell surface of an empty shell (Pl. 14, figs 8, 9). Similar structures, attributed to the activity of unknown organisms, have been described by Horný and Peel (1995) in the Silurian gastropod *Tophicola linsleyi* HORNÝ et PEEL, 1995 (see Horný and Peel [1995] for additional references).

Occurrence. Ashgill, Upper Ktaoua Formation: locality 49, Jbel Bou Ingarf (NE Zagora); locality 757, Tizi n'Takhrif (WSW of Tazzarine); locality 901, Southern part of Jbel Bou Debane (E of Tagounite); locality 1078, Isk n'Brahim (E of Tazzarine); locality 1109, Plaine d'Inakiane (S of Amjerane, Maïder); locality 1132, Rich Bjarine (E of Amjerane, Maïder); locality 1146, Zaouia Tafetchna (E of Tansikht); locality 1649, Jbel Bou

Debgane (E of Tagounite). Upper Ktaoua Formation (top): locality 1077, Isk n'Brahim (E of Tazzarine); locality 1125, Jbel Tidri (E of Inakiane plain, S of Amjerane, Maïder); locality 1791, Jbel Assammar (E of Tazzarine).

Superfamily **Platyceratoidea** HALL, 1859

Family **Holopeidae** WENZ, 1938

Genus **Holopea** HALL, 1847

Type species. *Holopea symmetrica* HALL, 1847. Middle Ordovician; New York, U.S.A.

Holopea? antiquata (BARRANDE in PERNER, 1903)

Pl. 15, figs 1-13; Pl. 16, figs 1-6

- 1903 *Naticopsis?* (*Natica antiquata* BARRANDE M. S.); J. Perner, *Gastéropodes*, 1, Pl. 54, figs 31, 33.
?1907 *Natica impressa* BARRANDE (*partim*); ibidem, 2, Pl. 108, fig. III/4.
?1911 *Platyostoma ferrigenum* PERNER; ibidem, 3, pp. 170, 171, Text-fig. 279.

Lectotype. Here designated, specimen NM L 8443, figured by Perner (1903) on Pl. 54, fig. 33.

Paralectotype. Specimen, figured by Perner (1903) on Pl. 54, fig. 31 (not found in the collections of the Department of Palaeontology, National Museum, Prague).

Material (Anti-Atlas). 15 specimens, mostly incomplete internal moulds.

Description. Naticiform shell with 3-4 rapidly expanding, roundly arched whorls; aperture tangential, almost straight, without undulations; columellar lip reflected, base rounded, anomphalous, shell reinforced in the umbilical area; protoconch unknown, apical part in all specimens damaged or lost; spire angle of about 90°, in old specimens 110°, shell wall about 0.15-0.5 mm thick, with two layers; hypostracum lamellar, thin lamellae often adhering to internal mould (Pl. 15, figs 1-4); growth lines are thin, dense, 5-10 per mm, running slightly obliquely backward from the upper suture, gently convex forward, passing the median part of the whorl almost in straight direction to the umbilical area, in specimen NM S 2628 (Pl. 15, fig. 5) somewhat irregular, with rare anastomoses or rarely bifurcating; specimen NM S 2628 (Pl. 15, fig. 6) with very weak revolving structures in the median part of the whorl; mature and gerontic specimens often show irregular, periodical increments of shell, clearly visible on internal moulds. Height/width ratio about 1.0, size of the most complete specimens: NM S 2629, height 13.9 mm, width 13.4 mm; NM S 2701, height 21.2 mm, width 21.0 mm; NM S 2702, height 29.7 mm, width 28.0 mm. The largest specimen, NM S 2697, is 39.0 mm wide.

Discussion. All specimens available for the present study are either slightly deformed or incomplete. Moreover, the majority of specimens of two species, *Nonorios pater* and *Holopea? antiquata*, similar in gross morphology, are preserved as incomplete, internal moulds with no traces of external sculpture; they are unrecognizable in such cases. None of the specimens has preserved aperture, columellar lip or parietal deposits. A serious problem is also the mode of preservation of the shell wall and its changes during post-

mortal processes, which may have resulted in the shell having quite a variable appearance.

The generic classification of *H.? antiquata* is questioned as the study of Bohemian populations has not yet been finished, and certain morphological similarities with *Holopea* HALL, 1847 have not been evaluated. Internal moulds of many similar shells have commonly been determined as *Holopea*, as shown in various species of this widely interpreted genus, reported e.g. by Ulrich and Scofield (1897, Pl. 79) or Koken (1925) (*H. simplex* KOKEN, 1925, *H. eichwaldi* KOKEN, 1925, or *H. aequalis* KOKEN, 1925); see also Perner's note in Koken (1925, p. 218) (*Abhang zur Gattung Holopea*), and Vostokova (1955). Even more recent authors use this generic name for shells with an inflated final whorl and reinforced columellar lip, probably connected with a plate-like excavation. Bradley (1930) described *Holopea missouriensis*, which also shows similar gross shell morphology. Wilson (1951) figured at least two similar shells (*Holopea rotunda* ULRICH et SCOFIELD, 1897, and *H. informis* WILSON, 1932). Thompson (1970) tried to solve the relationships of *Holopea*, *Naticonema*, and *Cyclonema* and, again, figured several "naticiform" species, including *Cyclonema transversum* ULRICH in ULRICH et SCOFIELD, 1897.

Holopea? antiquata represents the Mediterranean "holopeids", widely distributed in the cold-water Caradocian sea, and probably not closely related to the otherwise similar species from Laurentia and Baltica.

Mode of life. Little is known of the aperture of this species, but its tangential character indicates an epibenthic gastropod, adapted to harder substrata. Its abundant occurrence in the sedimentary iron ores, which originated in shallow subtidal or intertidal environments (in the Barrandian Area), illustrates its adaptation to a shallow photic zone. It occurs almost always together with *Nonorios pater*, which may indicate similar ecological requirements or other, so far unclear interrelationship.

Occurrence. Morocco, Anti-Atlas: middle Caradoc, Lower Ktaoua Formation: locality 1266, **Bou el Koualb (W of Rissani)**. "Middle" Caradoc, Lower Ktaoua Formation: locality 88, **Jbel Amouguer (E of Tazzarine)**; localities 1302 and 1305, **Rkint ech Chih (E of Erfoud, Tafilalt)**; localities 1313 and 1315, **NW of Merzane (E of Erfoud, Tafilalt)**. Upper Caradoc, Upper Tiourine Formation: locality 1250, **S of Tinjarfiouine (W of Rissani, Tafilalt)**.

Family **Platyceratidae** HALL, 1859

Genus **Nonorios** HORNÝ, 1997

Type species. *Turbonitella pater* BARRANDE in PERNER, 1903. Ordovician, Beroun; Barrandian Area, Bohemia, Czech Republic.

Nonorios pater (BARRANDE in PERNER, 1903)

Pl. 16, figs 7-13

- 1903 *Turbonitella pater* BARRANDE; J. Perner, *Gastéropodes*, 1, Pl. 51, figs 1-3.
1903 *Cyclonema? Vražensis* BARRANDE; J. Perner, ibidem, Pl. 54, figs 22-25.
1903 *Oriostoma? (derelictum)* BARRANDE; J. Perner, ibidem, Pl. 62, figs 27-30.
1903 *Polytropis? pectinata* BARRANDE; J. Perner, ibidem, Pl. 69, figs 48-50.

- 1907 Fragment indéterminable (*Turbo desolatus* BARRANDE M. S.); J. Perner, *Gastéropodes*, 2, Pl. 108, figs V/1-4.
1997g *Nonorios pater* (BARRANDE in PERNER, 1903); R. J. Horný, *Nonorios* etc., p. 104.

Material. 3 specimens.

Description. Three specimens assigned to this species with certainty come from the middle Caradocian localities of the Lower Ktaoua Formation, **Bou el Koualb (1266)**, **Tizi ou Mekhazni (1270)**, and **Isthou (1276)**. All are isolated, weathered, incomplete external moulds in brown siltstone, with an imperfectly preserved surface, showing weak traces of irregularly spaced collabral increments and even less well visible, irregularly spaced, revolving structures. The specimens lack apertural margins and apical parts of the shells. Each of them, however, possesses an impression of the basal part of the penultimate whorl within the final whorl, showing its external surface, originally obliterated and protected by the parietal deposits. Specimen NM S 2630 (Pl. 16, figs 12, 13) is immature, 17.8 mm high and 25.6 mm wide. The impressed, cancellate sculpture consists of straight, regularly spaced collabral ribs (5 per mm) and thicker, also regularly spaced revolving cords (4 per mm). The columellar part of the internal mould bears features indicating a reflected columellar lip. Another immature specimen, NM S 2631 (Pl. 16, figs 10, 11), 17.0 mm high and 22.8 mm wide, bears a similar impression showing regularly spaced, straight collabral ribs (6-10 per mm) and thicker revolving cords (4 per mm). The third, adult specimen NM S 2632 (Pl. 16, figs 7-9), 25.3 mm high and 39.0 mm wide, shows a large impression corresponding to the whole length of the penultimate whorl. The oblique, straight collabral ribs (4-6 per mm) are crossed with strong, irregularly spaced revolving cords (3-4 per mm).

Discussion. The Moroccan specimens are similar to those from the contemporary Bohemian Letná, Vinice, and Zahořany Formations. Even the mode of preservation is similar. Specimens with cancellate sculpture occur together with turbiniform to naticiform shells, lacking revolving cords, in both regions. These specimens were described by Barrande in Perner (1903) as *Natica antiquata* and in 1907 as *Natica impressa* (partim), and by Perner (1911) as *Platyostoma ferrigenum*. The epibenthic *Nonorios* Community thus contained two or more, in gross morphology similar species, differing in outer shell sculpture. The "smooth" species is, however, questionably regarded as a representative of the genus *Holopea* HALL, 1847.

A similar situation perhaps concerns the related genus *Cyclonema* HALL, 1852, widely distributed in the eastern half of the United States and consisting of species with rather variable external sculpture, including those in which the revolving elements are almost or entirely lacking (e.g. *Cyclonema sublaeve* ULRICH in ULRICH et SCOFIELD, 1897). These gastropods, as sessile inhabitants of crinoids (Bowsher 1955, Thompson 1970), were susceptible to such a variability, but *Nonorios*, lacking a proper host, may have lived as a slow or almost sessile animal fixed on local, specific conditions of the sea bottom (in the Barrandian Area it is most common in iron ore deposits which originated in intertidal or shallow subtidal conditions). An absence of suitable crinoids in the Mediterranean Palaeoprovince was probably the reason why the genus *Cyclonema* has not been ascertained so far in that cold-water area.

As far as the gross morphology of shell is concerned, the mature specimens of *Nonorios pater* resemble the Cincinnati (Maysvillian) *Cyclonema transversum* ULRICH in ULRICH et SCOFIELD, 1897. When establishing this species, Ulrich and Scofield (1897) pointed out its extraordinary shape with a rapidly expanding final whorl, a wide apical angle, a wide final whorl gently convex in the upper slope and abruptly rounded at the periphery, and the aperture unusually large in the basal view. Important is their description of the outer shell sculpture (Ulrich and Scofield, p. 1062): "The surface is more or less strongly marked with oblique lines and wrinkles of growth without a trace of revolving lines except on the smallest specimen. In this the inner half of the last whorl presents several very obscure revolving lines on the lower half of the outer slope. Aside from the almost total absence of revolving lines, the rapid expansion of the last whorl and shallow suture will distinguish *C. transversum* from most of the preceding species of the genus [*Cyclonema*]". The species was collected in the lower half of the Loraine Group, Covington, Kentucky, and Cincinnati, Ohio. This level is, however, too high for the Mediterranean species, which occurs for the first time as early as in the middle Caradocian strata.

In 1970, E. H. Thompson published her important paper on the Upper Ordovician *Cyclonema* from the Cincinnati Province, where she redescribed also *C. transversum*. Her description fully agrees with that of Ulrich in Ulrich and Scofield (1897). As far as the outer shell sculpture is concerned, she states in the diagnosis, that the spiral ornament is absent (p. 252). Nevertheless, in the description she states, that "spiral ornament is generally absent, faint costae may be present on abapertural side of body whorl" (Thompson, pp. 252-253). She also states in the discussion, that *C. transversum* is distinguished from any other species of *Cyclonema* by its exceedingly flattened shell, auriform aperture, and lack of spiral lines. According to Thompson, *C. transversum* is generally limited to the Fairmount Member, Fairview Formation, in the vicinity of Cincinnati, Ohio, and Covington and Newport, Kentucky.

Bowsher (1955) figured a few shells of *Naticonema* PERNER, 1903, which are similar to *Nonorios*. Of the Ordovician representatives, there is a small *Naticonema* sp. from the Maysville Group (Pl. 1, figs 10, 11). Discussing the genus, Bowsher stated that many species of Ordovician and Silurian gastropods from North America that have been referred by various authors to *Platyceras*, *Strophostylus*, *Diaphorostoma* and *Platyostoma* actually belong to *Naticonema* (p. 7). As one of the diagnostic features of *Naticonema*, Bowsher mentioned undulating transverse threads and growth lines; these are characteristic for the Silurian type species of *Naticonema*, *N. simile* PERNER, 1903, but never occur in *Nonorios*. As far as the stratigraphical range of *Naticonema* is concerned, Bowsher states Middle Ordovician (Trenton) to Devonian, interpreting the *Naticonema* species as sedentary coprophagous platycerids, inhabiting crinoid calyces. This is, of course, not the case of *Nonorios pater* with its large shells and straight, non-undulated growth lines, indicating a straight outer lip.

Occurrence. Morocco, Anti-Atlas: middle Caradoc, Lower Ktaoua Formation: locality **1266, Bou el Koualb (W of Rissani)**; locality **1270, Tizi ou Mekhazni (between Rissani and Msissi, Tafilalt)**; locality **1276, Isthou (E of Msissi, Tafilalt)**.

Series (G.B.)	Anti-Atlas	Montagne Noire
ASHGILL	○ <i>Sinuites destombesi</i> + <i>Lophospira? debganensis</i> + <i>Loxonema? sp.</i>	
CARADOC	* <i>Sinuitopsis neglecta</i> * <i>Sinuitopsis? sp.</i> ○ <i>Tritonophon peeli</i> ○ <i>Atlantophon maider</i> ○ <i>Bucanopsina calypso</i> + <i>Clathrospira amouguerana</i> + <i>Lophospira sp.</i> + <i>Holopea? antiquata</i> + <i>Nonorios pater</i>	
LLANDEILO	* <i>Quasisinuites rapax</i>	
LLANVIRN	* <i>Cyrtodiscus nitidus</i> * <i>Tachillanella tafilaltensis</i> ○ <i>Sinuites sowerbyi</i> ○ <i>Selesinuites perneri</i> ○ <i>Tropidodiscus pusillus</i> + <i>Lesueurilla prima</i> + <i>Ptychonema marocanum</i>	
ARENIG	* <i>Carcassonnella courtessolei</i> * <i>Thoralispira laevis</i> * <i>Thoralispira? cf. occitana</i> + <i>Lesueurilla prima</i>	* <i>Carcassonnella courtessolei</i> * <i>Thoralispira laevis</i> * <i>Thoralispira? occitana</i> + <i>Lesueurilla prima</i>

Series (Bohemia)	Barrandian Area
KOSOV	
KRÁLODVOR	
BEROUN	* <i>Sinuitopsis neglecta</i> ○ <i>Tritonophon peeli</i> ○ <i>Bucanopsina calypso</i> + <i>Holopea? antiquata</i> + <i>Nonorios pater</i>
DOBROTIVÁ	○ <i>Sinuites sowerbyi</i> ○ <i>Tropidodiscus pusillus</i>
LLANVIRN	* <i>Cyrtodiscus nitidus</i> ○ <i>Sinuites sowerbyi</i> ○ <i>Selesinuites perneri</i> ○ <i>Tropidodiscus pusillus</i> + <i>Lesueurilla prima</i>
ARENIG	+ <i>Lesueurilla cf. prima</i>

Fig. 3. Distribution of Moroccan Ordovician tergomyans and gastropods in the Anti-Atlas (Morocco), Montagne Noire (France), and Barrandian Area (Czech Republic). * - cyrtoneid tergomyans, ○ - bellerophontoidean gastropods, + - other gastropods. The species are arranged systematically within each series

Family *Loxonematidae* KOKEN, 1889

Genus *Loxonema* PHILLIPS, 1841

Type species. *Terebra? sinuosum* J. de C. SOWERBY, 1839.
Silurian; England.

Loxonema? sp.
Pl. 16, figs 14, 15

Description. The only specimen available for study is an imperfect external mould, lacking the surface layer of shell and partly exposing the weathered, internal shell surface. The generic determination is dubious, but weak, poorly visible traces of thin, asymmetrical, opisthocline growth lines, continuously passing the rounded whorls, exclude a slit-bearing genus. The incomplete specimen, studied on a latex impression, consists of 10 whorls; protoconch is not preserved, sutures shallow, spire angle 25°. Length is 14.5 mm, width at the base is 5.5 mm, at the apex 0.3 mm.

Discussion. The specimen is too poorly preserved to warrant restoration of its original morphology and to compare it with the contemporary species of the genus. Similarly inconvenient is the preservation of the small, Bohemian Králodvorian (lower Ashgillian) specimens (e.g. of *Loxonema parvulum* BARRANDE in PERNER, 1903), rarely occurring in fine, clayey shale.

Occurrence. Upper Ashgill, Upper Ktaoua Formation (top): locality 1791, Jbel Assammar (E of Tazzarine).

Succession, assemblages, mode of life and affinities of the tergomyan and gastropod fauna in the Ordovician of the Anti-Atlas

Arenig

The lower and middle Arenigian strata (Upper Fezouata shale Formation and Zini sandstone and quartzite Formation) contain a characteristic, poorly diversified shallow-water *Carcassonnella-Thoralispira* Community. The epibenthic *Carcassonnella courtessolei* and the semi-infaunal *Thoralispira laevis* have been found both in shales and arenaceous deposits. Quite interesting is a find of *Thoralispira?* cf. *occitana*, indicating the base of Arenig in the Montagne Noire and occurring in the Lower Arenig of the Anti-Atlas. Only one specimen of an additional taxon, *Lesueurilla prima*, has been found in the Upper Fezouata shales. *C. courtessolei* and *T. laevis* are common species in the Montagne Noire (Yochelson 1982, Horný and Vizcaïno 1995), and *Lesueurilla* sp. has been reported from the Arenigian Klabava Formation from the Barrandian Area. The typically Tremadocian *Peelerophon* Community has so far not been ascertained in the Lower Fezouata Formation. (For a comparison with the Ordovician benthic communities in the Barrandian Area see Havlíček [1982] and Havlíček and Vaněk [1990], and with the Caradocian benthic communities in North Wales see Pickerill and Brenchley [1979].)

Llanvirn

In the Tachilla Formation, a richly diversified fauna is contained in siliceous and silty concretions (originally probab-

ly with carbonate cement), occurring in argillaceous deposits with bioturbation. This facies represents an environment beyond reach of wave activity or a quiet-water environment (benthic assemblage 3-4 in Boucot's classification), protected by sandy bars, with a rich import of nutrients from land and probably characterized with extensive algal stands. An abundant fauna includes the semi-infaunal *Sinuities sowerbyi* Community with rare finds of the supposed predators *Sinuities sowerbyi* and *Selesinuities perneri*, the epibenthic *Euorthisina-Placoparia* Community with rare *Tachillanella tafilaltensis* and *Cyrtodiscus nitidus*, and a characteristic and relatively common, perhaps immobile, filter-feeding *Lesueurilla prima*, lying on the bottom. The suprabenthic (and probably even epinektic) *Tropidodiscus* Community inhabited algal stands or floating algae with innumerable masses of *Tropidodiscus pusillus* and *Ptychonema marocanum*.

The Llanvirnian assemblages show close affinities with the Barrandian Area in Bohemia. Of the seven ascertained species, five species (71 per cent) are common to Bohemia, and two species (29 per cent) have been identified in Morocco (*Tachillanella tafilaltensis* and *Ptychonema marocanum*). Of the five species common to Bohemia, two species have been questionably recognized in other parts of the Mediterranean Palaeoprovince: *Tropidodiscus pusillus* (Armorica), *Lesueurilla* cf. *prima* (Armorica). *Ptychonema marocanum* is closely related to the Bohemian *P. desideratum* and probably also to the Portuguese, Spanish and French *T. bussacense*.

Llandeilo

This series is represented mostly by thickly bedded sandstones in the Anti-Atlas (First Bani sandstone Group), divided in five formations. From these strata, only one species of a unique, endemic *Sinuities*-like tergomyan has been recovered, *Quasisinuities rapax*. This advanced, cyrtoneid tergomyan with a tightly coiled, thick shell inhabited a high-energy zone, probably in extremely shallow water and perhaps even intertidal environments, characterized by clastic and organoclastic deposits. Gross morphology of the shell indicates that *Quasisinuities* was an active, probably predatory tergomyan. The rich Dobrotivian gastropod and tergomyan fauna in Bohemia, containing several species common to the underlying Llanvirnian Šárka Formation, is totally missing in the Anti-Atlas. This agrees with the information of Havlíček, Vaněk and Fatka (1994), that the Bohemian-type faunas decreased in diversity towards the south circumpolar region in the Dobrotivá Series. It could be, however, a question of sedimentary facies.

Caradoc

The Lower Ktaoua Formation is a complex of argillaceous and arenaceous deposits, divided into five members. The formation contains a very rich fauna, according to Destombes et al. (1985) including many elements common to the Barrandian area. This concerns also gastropods and tergomyans. Most of the species have been recovered from silty, carbonate concretions; fewer finds come from fine micaceous shales and fine-grained sandstones. In general, the faunal assemblages predominantly correspond to benthic assemblage 3 and 4 in Boucot's classification. Characteristic is the semi-infaunal *Sinuitiesopsis* Community, containing

the cyrtoneid tergomyan *Sinuitopsis neglecta* and an additional, undescribed species of this genus. A shallow-water, epibenthic *Nonorios* Community, mostly consisting of species with solid shells, adapted to harder substrata - *Nonorios pater*, *Holopea? antiquata*, *Lophospira* sp., and *Clathrospira amouguerana*. The majority of shells are undamaged or only slightly damaged, as the animals probably lived beyond reach of wave activity or in quiet environments, protected by sandy bars. The presence of an explanate bellerophontoidean *Bucanopsina calypso* is interesting, also adapted to a harder bottom, and the rare *Atlantophon milder*, found in arenaceous sediment. The smaller species, *Tritonophon peeli*, may have been a suprabenthic species, inhabiting algal thali.

The Caradocian assemblages show very close affinities with the contemporary Berounian assemblages in Bohemia. Of the nine ascertained species, 5 species (55 per cent) are common to Bohemia, and 4 species (45 per cent) have been identified in Morocco (*Sinuitopsis?* sp., *Atlantophon milder*, *Clathrospira amouguerana* and *Lophospira* sp.). All five species common to Bohemia are, so far, restricted to the Barrandian area (but *Nonorios pater* and *Holopea? antiquata* may have been found in Portugal [as *Naticonema* cf. *saenzi* and *Holopea?* sp.; see Romao, Gutiérrez-Marco, et al. 1995]).

Ashgill

All finds of gastropods come from the Upper Ktaoua Formation. The majority of specimens were recovered from pelitic carbonate concretions, embedded in grey-green arenaceous argillites. The otherwise abundant fauna consists of only three species. Most common is *Sinuities destombesi*, the largest known representative of the genus, which probably lived semi-infaunally and represents a very characteristic, easily recognizable, endemic species. Quite frequent is the epibenthic *Lophospira? debganensis*, which is, again, the largest representative of the "pleurotomarioideans" in the Ordovician of Morocco. The third species, known from one poor specimen, is the only Moroccan representative of the epibenthic, high-spined, loxonematoidean gastropods, *Loxonema?* sp., unfortunately too poorly preserved to be compared with similar species from the Mediterranean or other palaeoprovinces.

The collected and described tergomyan and gastropod taxa from the Anti-Atlas represent only about one third of the total number of species known in the Ordovician of Bohemia. Of the 23 species described in this paper, 10 (43 per cent) of the species are common to Bohemia, and the same number are endemic to Morocco. With the exception of *Sinuitopsis neglecta* and *Versispira* cf. *gracilis* (KOKEN, 1897), known from Baltica (see Dzik 1981, Wängberg-Eriksson 1979), there are no other species in Bohemia and Morocco common to Baltica, Avalonia, and Laurentia. This situation may be, however, illusory, partly due to the near absence of modern works, concerning Great Britain, Scandinavia, the Baltic republics and Russia. Nevertheless, the temperature of sea currents, or, in other words, the latitudinal-climate control, was seemingly the main factor influencing the migration and distribution of tergomyan and gastropod species within the Mediterranean Palaeoprovince (Havlíček 1989). However, a study and revision of all col-

lections accumulated in France, Spain, and Portugal may bring interesting and surprising results.

The absence of certain groups or genera in the collections from the Anti-Atlas is remarkable and cannot be explained by the method of collecting. Entirely missing are the paragastropods of the families Onychochilidae and Clisospiridae; their domain is Baltica, but five genera with about ten species are present in Bohemia. *Archinacella* ULRICH et SCOFIELD, 1897, *Patelliconus* HORNÝ, 1961 and *Pygmaeoconus* HORNÝ, 1961, frequent in Llanvirn and Dobrotivá Series, are also missing. *Grandostoma*, typical for Beroun and Králodvůr, have also not been ascertained. Another two species, which have not been found and which are characteristic for the Berounian Zahořany Formation, are *Trochonema excavatum* BARRANDE in PERNER, 1903 and *Anastrophina vermiculosa* (BARRANDE in PERNER, 1903). *Climacorphistoma vaginatum* (KOKEN, 1925), reported from the Arenig of the Montagne Noire (Yochelson 1982), brings about another serious problem. This warm-water species, characteristic for the Lower Ordovician limestones of Baltica, does not occur in Bohemia, and has not been found in Morocco. Its southern occurrence in the Montagne Noire is rather strange even for the genus, and should be carefully verified.

The majority of tergomyan and gastropod communities in the Ordovician of the Anti-Atlas were dominated by bellerophontiform molluscs. In general, eight species of six genera belong to the cyrtoneid tergomyans, seven species of six genera to the bellerophontoidean gastropods, and only eight species of seven genera to other gastropods. Innumerable accumulations of tiny shells, namely of *Tropidodiscus pusillus* and *Ptychonema marocanum* in the Llanvirnian strata, may testify to suitable conditions for these suprabenthic or epiplanktic animals - probably to the presence of algal stands or floating algae, similar in the Anti-Atlas and in the Barrandian Area. Both epibenthic and suprabenthic/epiplanktic gastropods had common durophagous predators, seemingly nautiloid cephalopods, as observed in several shells of the Llanvirnian *Ptychonema marocanum* and in the Ashgillian *Lophospira? debganensis*.

The less diversified benthic tergomyan and gastropod fauna of the cold-water circumpolar sphere near Gondwanaland and its relationships confirms the results of investigations of other invertebrate groups, namely the brachiopods and trilobites, as well as the palaeogeographic and palaeoclimatic syntheses (e.g. Spjeldnaes 1961, 1967, Havlíček 1974, 1989, Babin et al. 1976, Hammann et al. 1982, Destombes 1967b, 1972, Destombes et al. 1985, Gutiérrez-Marco and Rábano 1987, Cocks and Fortey 1988, Robardet et Gutiérrez-Marco 1990, Havlíček, Vaněk, and Fatka 1994). The tergomyan and gastropod faunas, however, do not confirm the observations made for several other groups, e.g. hyolithids (Marek 1983), regarding stratigraphical differences in the occurrence of certain taxa caused by slow migration, dependent on gradual climatic changes. This observation may be affected, however, by less detailed characters of tergomyan and gastropod shells, which do not allow the detection of minor changes in morphology (e.g., if compared with carapaces of trilobites). Moreover, the tergomyan and gastropod shells, in relation to brachiopods or trilobites, are much more susceptible to postmortal changes, tectonics and weathering processes; tectonic deformations seem to be the main reason for generally less favourable preservation of these molluscs.

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List of the localities

(prepared by J. Destombes 1996, including the names of associated fauna; Tergomya and Gastropoda added by R. J. H.)

- 20. Bou-Rbia - Sidi-Touhama (W of Zagora).** $x = 418.1$, $y = 343.75$, topographic sheet at 100000° El Gloa Fm. Bou Zeroual (First Bani Group), Llandeilo s. l.
Tergomya: *Quasisinuities rapax*
Associated fauna: *Plaesiacomia* sp., *Neseuretus* sp., *Colpocoryphe* sp., *Crozonaspis chouberti*, *Zeliszella* sp., *Phlyctocystis regularis*, *Orthambonites fraternus*, *Atlantida amplexomya*, ostracods, *Elegantilites?* sp.
- 34. East of Jbel Bou Dehir (N of Zagora).** $x = 472.4$, $y = 378.7$, topographic sheet Zagora
Upper Fezouata Fm., lower Arenig
Tergomya: *Thoralispira laevis*
Associated fauna: *Euloma?* sp., *Asaphellus* aff. *jujuanus*, *Neseuretus* sp., *Redonia* cf. *michelae*
- 49. Jbel Bou Ingarf (NE of Zagora).** $x = 483.3$, $y = 397$, sheet Tazzarine
Upper Ktaoua Fm., upper Ashgill
Gastropoda: *Lophospira?* *debganensis*
Associated fauna: *Flexicalymene ouzregui*
- 83. Jbel Amouguer (E of Tazzarine).** $x = 494.8$, $y = 424.5$, sheet Tarhbalt
Upper Tiouririne Fm., upper Caradoc
Gastropoda: undeterminable fragment
Associated fauna: *Mucronaspis zagoraensis*, *Eudolaites (Banilaites) inflatus*, *Calymenella (C.)* sp., *Cloucekiea* aff. *solitaria*, *Actinopeltis* sp., Trinucleidae, Illaenidae, *Praenucula costae*
- 86. Jbel Amouguer (E of Tazzarine).** $x = 493$, $y = 424.9$, sheet Tarhbalt
Lower Ktaoua Fm., middle Caradoc
Tergomya: *Sinuitiesopsis neglecta*; Gastropoda: *Clathrospira amouguerana*
Associated fauna: *Dalmanitina (D.) proaeva*, Trinucleidae, conulariids, hyolithids
- 88. Jbel Amouguer (E of Tazzarine).** $x = 493$, $y = 424.85$, sheet Tarhbalt
Lower Ktaoua Fm., "middle" Caradoc
Tergomya: *Sinuitiesopsis neglecta*; Gastropoda: *Clathrospira amouguerana*, *Holopea?* *antiquata*
Associated fauna: *Mucronaspis zagoraensis*, Illaenidae, *Aegiromena aquila aquila*, *Arachnocystites infaustus infaustus*, *Heliocrinites tafalaltensis*, *Deutocystites modestus*
- 134. Jbel Tibert n'Gaiz (N of Alnif).** $x = 522.35$, $y = 69.7$, sheet Alnif
Upper Tiouririne Fm., upper Caradoc
Tergomya: *Sinuitiesopsis neglecta*; Gastropoda: *Clathrospira?* sp., *Lophospira* sp.
Associated fauna: *Flexicalymene tazarinensis*, *Actinopeltis* sp., *Calymenella (C.)* sp., *Cloucekiea* aff. *solitaria*, Trinucleidae, Illaenidae, *Nephrotheca gairiana*, *Nephrotheca?* *destombesi*, *Leolites* sp., *Joachimilites?* *orphanus*, "Hyolithes" *orthotheccoides*
- 273. Hassi Brahim (W of Tata).** $x = 240.55$, $y = 302.40$, sheet Tleta de Tagmoute
Bou Zeroual Fm. (First Bani Group), Llandeilo s. l.
Tergomya: *Quasisinuities rapax*
Associated fauna: *Neseuretus* sp., *Eohomalonotus* sp.
- 331. E of Jbel Bou Dehir (N of Zagora).** $x = 475.7$, $y = 388.5$, sheet Zagora
Upper Fezouata Fm., lower Arenig
Tergomya: *Carcassonnella courtessolei*
Associated fauna: *Didymograptus nicholsoni* var. *planus*, *D. nicholsoni*, *Asaphellus* aff. *jujuanus*, *Ampyx* cf. *priscus*, *Colpocoryphe* sp., *Ceraurinella?* sp., *Bathyscheilus?* sp., *Gamalites?* sp.
- 399. Jbel Tafenna (SE of Zagora).** $x = 515.6$, $y = 344.7$, sheet Hassi Bou Haiara
Lower Ktaoua Fm., lower Caradoc
Tergomya: *Sinuitiesopsis?* sp.; Gastropoda: *Tritonophon peeli*
Associated fauna: *Calymenella (C.)* sp., Phacopina, *Phestia?* sp., *Praenucula* sp.
- 563. Along the road Tilemsoun-Messeied (S of Tantane, Tarfaya Province).** $x = 317$, $y = 155.4$, topographic sheet Goulimine at scale of 200000

- Tachilla Fm., Llanvirn
Tergomya: *Thoralispira?* sp.
Associated fauna: *Neseuretus attenuatus*, *Plaesiacomia* sp., Asaphidae, orthothecidarum
- 585. Jbel Amouguer (E of Tazzarine).** x = 494.7, y = 424, sheet Tarhbalt
Upper Tiouririne Fm., upper Caradoc
Gastropoda: *Clathrospira amouguerana*
Associated fauna: *Eudolatites (Banilatites) inflatus*, *Kloucekia* aff. *solitaria*, *Calymenella (C.)* sp., Trinuclidae
- 628. Jbel Bou Isidane (S of Alnif).** x = 524.5, y = 44.6, sheet of Alnif
Lower Ktaoua Fm., lower Caradoc
Tergomya: *Sinuitopsis neglecta*
Associated fauna: *Colpocoryphe grandis*, *Tafilaltia destombesi*
- 750. Jbel Arhou Amejout (S of Alnif).** x = 520.1, y = 421.35, sheet Tarhbalt
Upper Ktaoua Fm., upper Ashgill
Gastropoda: *Sinuites destombesi*
Associated fauna: *Brongniartella platynota marocana*
- 757. Tizi n'Takhrif (WSW of Tazzarine).** x = 477.75, y = 417, sheet Tazzarine
Upper Ktaoua Fm., upper Ashgill
Gastropoda: *Lophospira? debganensis*
Associated fauna: *Flexicalymene ouzregui*, *Onnia* sp., Illaenidae
- 882. Inakiane plain (SW of Amjerane, Maïder).** x = 516.7, y = 389, sheet Tarhbalt
Lower Ktaoua Fm., lower Caradoc
Gastropoda: *Atlantophon maider*, *Clathrospira amouguerana*
Associated fauna: *Dalmanitina (D.) socialis*, Trinuclidae
- 885. Jbel Mimount (W of Amjerane, Maïder).** x = 512.25, y = 389.75, sheet Tarhbalt
Upper Ktaoua Fm. (upper part), upper Ashgill
Gastropoda: *Sinuites destombesi*
Associated fauna: *Dreyfussina struvei*, *Mucronaspis termieri*, *Flexicalymene ouzregui*, *Eudolatites maiderensis*, *Brongniartella platynota marocana*, *Calymenella (C.)* sp., Illaenidae, Trinuclidae, *Eochonetes canaliferus*
- 899. Jbel Bou Ingarf (ENE of Zagora).** x = 482.6, y = 395.5, sheet Tazzarine
Lower Ktaoua Fm., lower Caradoc
Tergomya: *Sinuitopsis neglecta*; Gastropoda: *Bucanopsina calypso*, *Tritonophon peeli*
Associated fauna: *Scotiella taouzensis*, *Kloucekia* aff. *solitaria*, *Dalmanitina (D.)* cf. *socialis*, *Plaesiacomia* sp., Trinuclidae, Beyrichiacea s. l.
- 901. Southern part of Jbel Bou Debgame (E of Tagounite).** x = 497.7, y = 320.4, sheet Masmouda
Upper Ktaoua Fm., upper Ashgill
Gastropoda: *Sinuites destombesi*, *Lophospira? debganensis*
- Associated fauna: *Mucronaspis termieri*, *M. greti*, *Brongniartella platynota marocana*, *Baniaspis globosa*, Trinuclidae, Illaenidae, *Calymenella (C.)* sp., *Selenopeltis* sp., *Maghrebocystis formosa*, *Heliocriantes* sp., *Elegantilites formosus*
- 983. Jbel el Khantra (Zini massif, Tarfaya Province).** x = 11°25', y = 27°53', sheet Ain Semaiera at scale of 200000
Upper Fezouata Fm., lower Arenig (lower Bendigonian for S. Willefert)
Tergomya: *Thoralispira laevis*
Associated fauna: *Schizograptus* sp., *Tetragraptus quadribrachiatum*, *Tetragraptus reclinatus* or *T. serra*, cf. *Tetragraptus approximatus*, *Bathycheilus gallicus*, *Toletanaspis* aff. *borni*, *Colpocoryphe* sp., *Ampyx* sp., *Apatokephalus* sp., Trinuclidae, Asaphidae, *Tarfaya marocana*, *Ranorthis fasciata*, *Balantiocystis regnelli*, *Anatifopsis escandei thoralis*, *Nephrotheca?* sp., *Pauxillites* sp.
- 985. Jbel et Khantra (Tarfaya Province).** x = 11°24', y = 27°49', sheet Ain Semaiera at scale of 200000
Upper Fezouata Fm., lower Arenig
Tergomya: *Carcassonnella courtessolei*
Associated fauna: *Bathycheilus gallicus*, *Ampyx* sp., *Apatokephalus* sp., Asaphidae, *Chauvelicystis ubaghsi*, *Babinka* sp., *Redonia* cf. *melchiae*
- 1050. Ikf n'Ouarh (S of Tinerhir, N of Jbel Sarhro massif).** x = 507.2, y = 84.4, sheet Alnif
Tachilla Fm., Llanvirn
Gastropoda: *Tropidodiscus pusillus*
Associated fauna: *Ormathops clariondi*, *Plaesiacomia* sp., *Colpocoryphe* sp., *Placoparia* sp., Asaphidae, Illaenidae, *Euorthisina minor*, *Redonia deshayesi*, *Pauxillites pauxillus meridionalis*
- 1077. Isk n'Brahim (E of Tazzarine).** x = 499.35, y = 419.8, sheet Tarhbalt
Upper Ktaoua Fm. (top), upper Ashgill
Gastropoda: *Lophospira? debganensis*
Associated fauna: *Dreyfussina struvei*, Illaenidae
- 1078. Isk n'Brahim (E of Tazzarine).** x = 499.35, y = 419.8, sheet Tarhbalt
Upper Ktaoua Fm., upper Ashgill
Gastropoda: *Sinuites destombesi*, *Lophospira? debganensis*
Associated fauna: *Brongniartella platynota marocana*, *Flexicalymene ouzregui*, *Calymenella (C.)* sp., Trinuclidae
- 1080. Isk n'Brahim (E of Tazzarine).** x = 499.4, y = 419.9, sheet Tarhbalt
Upper Ktaoua Fm., upper Ashgill
Gastropoda: *Sinuites destombesi*
Associated fauna: *Flexicalymene ouzregui*, *Mucronaspis termieri*, *Eudolatites maiderensis*, *Actinopeltis* sp., *Calymenella (C.)* sp., Trinuclidae, Illaenidae, *Elegantilites* aff. *elegans*, *Rostricellula termieri*, *Maghrebocystis pachythea cupuliformis*

- 1100. Jbel Amougner (E of Tazzarine).** x = 497.1, y = 423.8, sheet Tarhbalt
Lower Ktaoua Fm., lower Caradoc
Gastropoda: *Clathrospira amouguerana*
Associated fauna: *Colpocoryphe grandis*, *Dalmanitina (D.) socialis*, *Eudolaites* aff. *dubius*, *Marrolithus* sp., *Eccoptychile* sp., *Tazarinia drotae*
- 1109. Plaine d'Inakiane (S of Amjerane, Maïder).** x = 525.3, y = 389.2, sheet Tarhbalt
Upper Ktaoua Fm., upper Ashgill
Gastropoda: *Sinuities destombesi*, *Lophospira? debganensis*
Associated fauna: *Brongniartella platynota marocana*, *Mucronaspis termieri*, Trinucleidae, Illaenidae, *Actinopeltis* sp., *Gompholites* sp.
- 1125. Jbel Tidri (E of Inakiane plain, S of Amjerane, Maïder).** x = 525.7, y = 397.5, sheet Tarhbalt
Upper Ktaoua Fm. (top), upper Ashgill
Gastropoda: *Lophospira? debganensis*
Associated fauna: *Dreyfussina struvei*, Illaenidae, Trinucleidae, *Elegantilites* sp.
- 1132. Rich Bjarine (E of Amjerane, Maïder).** x = 547, y = 387, sheet Tanoute n'Ourhioul
Upper Ktaoua Fm., upper Ashgill
Gastropoda: *Sinuities destombesi*, *Lophospira? debganensis*
Associated fauna: Trinucleidae, *Maghrebocystis pachytheca* cf. *cupuliformis*
- 1134. N of Jbel Amouktir (E of Agdz).** x = 439.6, y = 412.6, sheet Agdz
Upper Tiouririne Fm., upper Caradoc
Gastropoda: *Clathrospira amouguerana*
Associated fauna: *Flexicalymene tazarinensis*, *Eudolaites (Banilatites) inflatus*, *Mucronaspis zagoraensis*, *Kloucekia* aff. *solitaria*, *Actinopeltis* sp., *Calymenella (C.)* sp., *Selenopeltis* sp., Trinucleidae, Illaenidae
- 1146. Zaouia Tafetchna (E of Tansikht).** x = 440, y = 410.55, sheet Agdz
Upper Ktaoua Fm., upper Ashgill
Gastropoda: *Lophospira? debganensis*
Associated fauna: *Destombesia diedra acuta*
- 1236. Jbel Bou Legroun (western Tafilalt).** x = 596, y = 86, sheet Erfoud
Tachilla Fm., Llanvirn
Gastropoda: *Tropidodiscus pusillus*, *Lesueurilla prima*
Associated fauna: *Ormathops* sp., *Colpocoryphe* sp., Asaphidae, *Pauxillites* sp.
- 1247. Tinjarfiouine (W of Rissani, Tafilalt).** x = 589.8, y = 80.6, sheet Erfoud
Tachilla Fm., Llanvirn
Gastropoda: *Tropidodiscus pusillus*, *Lesueurilla prima*, *Ptychonema marocanum*
Associated fauna: *Colpocoryphe* sp.
- 1250. S of Tinjarfiouine (W of Rissani, Tafilalt).** x = 588.7, y = 76.8, sheet Erfoud
Upper Tiouririne Fm., upper Caradoc
Gastropoda: *Holopea? antiquata*
Associated fauna: *Calymenella (C.)* sp., Trinucleidae, *Aristocystites bohemicus bohemicus*, *conulariids*
- 1265. Bou el Koualb (W of Rissani).** x = 586.55, y = 70.8, sheet Erfoud
Lower Ktaoua Fm., middle Caradoc
Tergomya: *Sinuities neglecta*
Associated fauna: *Prionocheilus* sp., *Calymenella (C.)* sp., Trinucleidae, *Aristocystites bohemicus bohemicus*, conulariids
- 1266. Bou el Koualb (W of Rissani).** x = 588.2, y = 69.1, sheet Erfoud
Lower Ktaoua Fm., middle Caradoc
Gastropoda: *Nonorios pater*, *Holopea? antiquata*, *Clathrospira amouguerana*
Associated fauna: *Prionocheilus pulcher pulcher*, *Eudolaites bondoni*, *Calymenella (C.)* sp., *Aristocystites bohemicus bohemicus*, *A. b. sinuosus*, *Heliocrinites tafilaltensis*, *Sololites? clausus*
- 1270. Tizi ou Mekhazni (between Rissani and Msissi, Tafilalt).** x = 587.1, y = 73.5, sheet Erfoud
Lower Ktaoua Fm., middle Caradoc
Gastropoda: *Nonorios pater*
Associated fauna: *Eudolaites (Banilatites) inflatus*, *Dalmanitina (D.)* cf. *proaeva*, *Calymenella (C.)* sp., *Howellites macrostoma*, *Destombesia diedra robusta*, *Aristocystites bohemicus bohemicus*, *A. b. sinuosus*. *Maghrebocystis pachytheca*, *Arachnocystites infaustus*, *Codiacystis?* or *Phlyctocystis?*
- 1276. Isthou (E of Msissi, Tafilalt).** x = 574.8, y = 72.8, sheet Msissi
Lower Ktaoua Fm., middle Caradoc
Gastropoda: *Nonorios pater*
Associated fauna: *Prionocheilus pulcher*, *Dalmanitina* sp., *Calymenella (C.)* sp., *Eudolaites* sp., Trinucleidae, Illaenidae, *Aristocystites bohemicus bohemicus*
- 1282. East of Jbel Taklimt (W of Rissani, Tafilalt).** x = 596.7, y = 72.3, sheet Erfoud
Lower Ktaoua Fm., upper? Caradoc
Gastropoda: juvenile *Clathrospira?* sp.
Associated fauna: Trinucleids
- 1302. Rkint ech Chih (E of Erfoud, Tafilalt).** x = 616.4, y = 91.1, sheet Erfoud
Lower Ktaoua Fm., "middle" Caradoc ?
Gastropoda: undeterminable internal mould
Associated fauna: Trinucleids, bryozoans
- 1305. Rkint ech Chih (E of Erfoud, Tafilalt).** x = 617.9, y = 90.7, sheet Erfoud
Lower Ktaoua Fm., "middle" Caradoc
Gastropoda: *Holopea? antiquata*
Associated fauna: *Calymenella (C.)* sp., *Mucronaspis* sp., Trinucleidae, *Protomendacella eos*
- 1313. NW of Merzane (E of Erfoud, Tafilalt).** x = 621.4, y = 92.7, sheet Erfoud
Lower Ktaoua Fm., "middle" Caradoc

Gastropoda: *Holopea? antiquata*

Associated fauna: *Calymenella* (C.) sp., *Mucronaspis* sp., Trinucleidae, *Protomendacella eos*, *Eostropheodonta filicosta*, *Rostricellula termieri*

1315. NW of Merzane (E of Erfoud, Tafilalt). x = 621.4, y = 92.7, sheet Erfoud

Lower Ktaoua Fm., "middle" Caradoc

Gastropoda: *Holopea? antiquata*

Associated fauna: *Mucronaspis* sp., *Selenopeltis* sp., Trinucleidae, *Cliftonia tenuicostata*, *Drabovia* sp.

1320. East of Khabt el Hejar (E of Erfoud, Tafilalt). x = 630, y = 92.5, sheet Erfoud

Tachilla Fm., Llanvirn

Tergomya: *Cyrtodiscus nitidus*, *Tachillanella tafilalten-sis*; Gastropoda: *Sinuities sowerbyi*, *Selesinuities perneri*, *Tropidodiscus pusillus*, *Lesueurilla prima*, *Ptychonema marocanum*

Associated fauna: *Ormathops clariondi*, Asaphidae, *Colpocoryphe* sp., *Placoparia* sp., Lichidae, Trinucleidae, *Euorthisina minor*, cf. *Ctenodonta escosurae*, *Praenucula* cf. *sharpei*, *Redonia deshayesi*, *Elegantilites hejarensis*, *Gompholites* sp., *Tetradella* aff. *complicata*

1540. SW of the Jbel Tijakhet (Tafilalt), near village of Ouzina. x = 612.9, y = 423.95, topographical sheet Taouz-Ouest

Upper Fezouata Fm., lower Arenig

Tergomya: *Thoralispira laevis*, *Thoralispira?* cf. *occitana*

Associated fauna: *Ogyginus* sp., *Ampyx* sp., *Plectorthis simplex*, *Macrocytella* cf. *mariae*, *Elegantilites* sp. A, *Cavernolites* sp.

1572. Trhit (W of Tissint between Fom Zguit and Tata). x = 303, y = 319.6, sheet Tissint

Upper Fezouata Fm., "middle" Arenig

Tergomya: *Carcassonnella courtessolei*, *Thoralispira laevis*

Associated fauna: *Colpocoryphe* sp., *Prionocheilus* sp., *Bathycheilus* sp., cf. *Ctenodonta escosurae*, *Praenucula* sp., *Redonia* cf. *michelae*

1621. Jbel el Mhazil (ESE of Fom Zguit). x = 391.6, y = 338.4, sheet Fom Zguit

Upper Fezouata Fm., "middle" Arenig

Tergomya: *Thoralispira laevis*

Associated fauna: *Basilicus* sp., *Neseuretus* sp., Illaenidae

1624. Jbel Bou Debgame (E of Tagounite). x = 496.8, y = 330, sheet Masmouda

Upper Ktaoua Fm., upper Ashgill

Gastropoda: *Sinuities destombesi*

Associated fauna: *Mucronaspis termieri*, *Brongniartella platynota marocana*, *Baniaspis globosa*, *Actinopeltis* sp., *Selenopeltis* sp., Trinucleidae

1640. Takat n'Ait Alouene (E of Tagounite). x = 514.2, y = 327.6, topographical sheet Masmouda

Lower Ktaoua Fm., lower Caradoc

Gastropoda: *Bucanopsina calypso*

Associated fauna: *Dalmanitina* (D.) *socialis*, *Calpichitina* (C.) *lenticularis*, *Cyathochitina campanulaeformis*, *Jenkinochitina* sp.

1649. Jbel Bou Debgame (E of Tagounite). x = 498.1, y = 337.9, sheet Hassi Bou Haiara

Upper Ktaoua Fm., upper Ashgill

Gastropoda: *Lophospira? debgameensis*

Associated fauna: *Brongniartella platynota marocana*, *Baniaspis globosa*, *Mucronaspis termieri*, *Actinopeltis* sp., *Selenopeltis* sp., Trinucleidae, Illaenidae, *Heliocrinites* sp., *Elegantilites* aff. *elegans*, *Elegantilites* sp.

1651. Jbel Bou Debgame (E of Tagounite). x = 498, y = 337, sheet Hassi Bou Haiara

Upper Ktaoua Fm., upper Ashgill

Gastropoda: *Sinuities destombesi*

Associated fauna: *Brongniartella platynota marocana*, *Baniaspis globosa*, *Mucronaspis termieri*, Trinucleidae

1652. Tiliwine (High Atlas, N of Ouarzazate). x = 349.7, y = 74, sheet Skoura

Lower Ktaoua Fm., "middle" Caradoc

Gastropoda: *Clathrospira amouguerana*

Associated fauna: Bryozoans, conularids, Sphaeronitidae

1682. Jbel Tibasksoutine (E of Zagora). x = 483.35, y = 367, sheet Zagora

Upper Fezouata Fm., lower-middle Arenig

Tergomya: *Thoralispira laevis*

Associated fauna: *Pradoella tazzarinensis*, *Colpocoryphe* sp., Asaphidae

1685. E of Jbel Bou Dehir (N of Zagora). x = 474.2, y = 393.45, sheet Tazzarine

Upper Fezouata Fm., lower Arenig

Specimens not studied

Associated fauna: *Asaphellus fezouataensis*, *Colpocoryphe thoralis?*, *Macrocytella bohémica*, *Thoralicystis zagoraensis*, *Paurorthis tadrastensis*

1689. E of Jbel Bou Dehir (N of Zagora). x = 473.8, y = 393.3, sheet Tazzarine

Upper Fezouata Fm., lower Arenig

Tergomya: *Carcassonnella courtessolei*; Gastropoda: *Lesueurilla prima*

Associated fauna: *Asaphellus* aff. *jujuanus*, *Ampyx* cf. *priscus*, *Cavernolites senex*, *Babinka prima*, *Ribeiria* sp.

1743. Oued Bou Tious (Graben of Zagora, W of Zagora). x = 426.6, y = 374.8, sheet El Gloa

Upper Fezouata Fm., lower Arenig

specimens not studied

Associated fauna: Cheirurids

1778. Jbel Amouguer (E of Tazzarine). x = 492.35, y = 425.5, sheet Tarhbalt

Lower Ktaoua Fm., lower Caradoc

Tergomya: *Sinuitopsis neglecta*; Gastropoda: *Bucanopsina calypso*, *Clathrospira amouguerana*

Associated fauna: *Colpocoryphe grandis*, *Dalmanitina* (*D.*) *socialis*, *Eudolatites* cf. *dubius*, *Eccoptychile* sp., *Selenopeltis* sp., *Prionocheilus* sp., Illaenidae, Trinucleidae, *Triplesia simplex*, *Rafinesquina* cf. *vinicensis*, *Tazarinia drotae*

1791. Jbel Assammar (E of Tazzarine). x = 498.3, y = 420, sheet Tarhbalt

Upper Ktaoua Fm. (top), upper Ashgill

Gastropoda: *Sinuites destombesi*, *Lophospira?* *debganensis*, *Loxonema?* sp.

Associated fauna: *Dreyfussina struvei*, Illaenidae, *Heliocrinites* sp., *Elegantilites* sp.

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Explanation of the plates

The figured specimens are housed in the collections of the Department of Palaeontology, National Museum of Natural History, National Museum, Prague. Coated with ammonium chloride before photographing.

PLATE 1

Sinuitopsis neglecta (BARRANDE in PERNER, 1903)

- 1, 2. Left lateral and dorsal views of an adult specimen NM S 2575. Internal mould showing the ventral muscle scar (arrowed) and a constriction near the aperture. × 2. Locality 134, Upper Tiouririne Fm., upper Caradoc.
- 3, 4. Right lateral and dorsal views of an adult specimen, NM S 2573, showing irregularly spaced, variably thick collabral ribs and shallow constrictions. × 2. Locality 88, Lower Ktaoua Fm., "middle" Caradoc.
- 5, 6. Left lateral and dorsal views of an adult specimen NM S 2572. Internal mould with preserved main dorsal and dorsolateral muscle scars, and a pair of small, adaperturally positioned additional scars (arrowed). × 2. Locality 88, Lower Ktaoua Fm., "middle" Caradoc.
- 7, 8. Right lateral and oblique right dorsolateral views of an immature specimen NM S 2574, showing wattle-like outer shell sculpture and a dorsal sinus. Latex impression, × 4. Locality 1778, Lower Ktaoua Fm., lower Caradoc.

- 9, 10. Right lateral and dorsal views of an immature specimen NM S 2694. Internal mould. × 2.5. Locality 1778, Lower Ktaoua Fm., lower Caradoc.
11. Left lateral view of an internal mould with clearly visible adumbilical part of the dorsolateral muscle scar, and the ventral scar (arrowed). Immature specimen NM S 2576, × 2.5. Locality 1778, Lower Ktaoua Fm., lower Caradoc.
12. Oblique left ventro-lateral view of an immature specimen NM S 2693, an internal mould with well preserved ventral muscle scar (arrowed). Note the deep traces after dissolved tubes of infaunal, "worm-like" organisms, originally attached to the internal shell surface. × 2.5. Locality 628, Lower Ktaoua Fm., lower Caradoc.
13. A deeply weathered, immature specimen NM S 2664 with exposed impression of the umbilicus, showing fine, dense growth lines on the umbilical wall, and the left anterior inhalant sinus near the suture. × 4. Locality 88, Lower Ktaoua Fm., "middle" Caradoc.

PLATE 2

Sinuitopsis neglecta (BARRANDE in PERNER, 1903)

1. Right lateral side of a juvenile specimen NM S 2577. Weathered internal mould in a limonitic sandstone. × 6. Locality 899, Lower Ktaoua Fm., lower Caradoc.

Cyrtodiscus nitidus (BARRANDE in PERNER, 1903)

2. Immature specimen NM S 2641, dorsal side with a narrow sinus. Latex impression. × 10. Locality 1320, Tachilla Fm., Llanvirn.
3. Left side of specimen NM S 2642, partly with exposed internal shell surface near the aperture. Latex impression, × 8. Locality 1320, Tachilla Fm., Llanvirn.
4. Left side of specimen NM S 2643 with well preserved external shell sculpture. Latex impression, × 8. Locality 1320, Tachilla Fm., Llanvirn.

Sinuitopsis? sp.

5. Two laterally depressed specimens, NM S 2674 and NM S 2675 in light grey micaceous shale. × 3.5. Locality 399, Lower Ktaoua Fm., lower Caradoc.
6. Latex impression of the immature part of specimen NM S 2674, showing collabral ribs on the right side, becoming gradually thin in the adapertural direction. × 5.

Quasisinuities rapax HORNÝ, 1997

- 7-9. The holotype NM S 2650. 7 - left side with dorsal muscle scar (arrowed), a large injury in the centre, and a deep constriction near the apertural margin. A juvenile specimen, paratype NM S 2651, lies near the right margin. × 2.5. 8 - postero-dorsal view of the holotype with the sinus and a patch of shell on the dorsum. × 2.5. 9 - enlarged shell with outer shell sculpture, showing the dorsal sinus and fine, spiral threads. × 7. Locality 273, Bou Zeroual Fm. (First Bani Group), Llandeilo.
- 10-12. Paratype NM S 2652, an internal mould in dorsal, postero-dorsal, and oblique dorso-lateral positions.

Note the radiating muscle impressions in figs 10 and 12, the mediadorsal structure in fig. 10, and the narrow sinus and constriction in fig. 11. All $\times 3$.

Locality **273**, Bou Zeroual Fm. (First Bani Group), Llandeilo.

PLATE 3

Carcassonnella courtessolei (YOCHELSON, 1982)

1. A slab of greenish shale NM S 2587 with two immature, flattened specimens, preserved as internal moulds. $\times 5$.
Locality **1689**, Upper Fezouata Fm., Lower Arenig.
2. Two compressed specimens and a fragment of shell, all showing external shell surface with collabral ribs. Latex impression. $\times 5$.
Locality **331**, Upper Fezouata Fm., Lower Arenig.
3. A slab of brown shale with many indeterminate fragments. NM S 2584 is a partly distorted, immature, coarsely ribbed specimen of *C. courtessolei* with a raised selenizone. NM S 2585 is an immature specimen of *Thoralispira laevis* in apertural view, with preserved patches of parietal inductura and a wide selenizone (arrowed). $\times 4$.
Locality **1572**, Upper Fezouata Fm., "middle" Arenig.
4. A coarsely ribbed fragment of specimen NM S 2586. $\times 10$.
Locality **1572**, Upper Fezouata Fm., "middle" Arenig.
- 5-7. A mature specimen NM S 2583 in siltstone, showing growth lines and a raised selenizone with lunulae, bordered with fine threads. 5 - dorsal, 6 - oblique dorsolateral views, $\times 4$; 7 - enlarged dorsum with selenizone, $\times 7$.
Locality **985**, Upper Fezouata Fm., lower Arenig.

Tachillanella tafilaltensis gen. et sp. n.

- 8-11. Four views of the holotype NM S 2667: figs 8, 9 left dorsolateral, 10 dorsal, and 11 left lateral views. Note the growth lines and a narrow selenizone in figs 8-10 and the wide umbilicus in fig. 11. Latex impression. $\times 10$.
Locality **1320**, Tachilla Fm., Llanvirn.

PLATE 4

Thoralispira laevis (THORAL, 1935)

1. Left side of a strongly laterally compressed specimen NM S 2589, an internal mould with traces of growth lines and a selenizone. $\times 2$.
Locality **34**, Upper Fezouata Fm., lower Arenig.
2. Left side of a strongly compressed and mashed specimen NM S 2588 with an exposed counterpart of the right lateral adapertural side of the shell with fine, collabral lines of growth. $\times 2$.
Locality **34**, Upper Fezouata Fm., lower Arenig.
3. The same specimen, enlarged adapertural part of the shell with growth lines. $\times 5$.
- 4, 5. Specimen S 2696, a slightly dorsally compressed internal mould in brown sandstone. This specimen is of Llanvirnian age but its determination is uncertain. $\times 3$.
Locality **563**, Tachilla Fm., Llanvirn.

6. Internal mould of an immature specimen NM S 2590. Apertural view. Note the juvenile specimen, preserved as a cavity in siltstone near the lower margin of the shell (diameter of about 3.0 mm). $\times 3.5$.
Locality **983**, Upper Fezouata Fm., lower Arenig.
7. A taphocoenosis of adult specimens, preserved as internal moulds (NM S 2592) in a fine-grained sandstone, $\times 2.5$.
Locality **1621**, Upper Fezouata Fm., "middle" Arenig.

Thoralispira? cf. *occitana* HORNÝ et VIZCAÍNO, 1995

8. Specimen NM S 2703, a counterpart of a dorsal area with a slightly sunken, concave selenizone with lunulae, and coarse collabral ribs. Latex impression. $\times 7$.
Locality **1540**, Upper Fezouata Fm., lower Arenig.

PLATE 5

Sinuities sowerbyi PERNER, 1903

1. Two incomplete specimens, NM S 2578 and NM S 2579, with preserved outer shell sculpture. Note a juvenile specimen of *Lesueurilla prima*. $\times 3.5$.
2. Enlarged dorsal area of specimen NM S 2579 to show a feather-like sculpture covering the ribs within the dorsal sinus. $\times 10$.
Locality **1320**, Tachilla Fm., Llanvirn.

Sinuities destombesi sp. n.

- 3, 4. Paratype NM S 2569, with syndiagenetic cracks, mimicking repaired fractures of shell. Note the islets of subinductural deposit (probably a relic of a vallum) surrounding the umbilical area. 3 - left side of the shell, $\times 2$; 4 - enlarged part of shell surface with a crack and a basal layer of the subinductural vallum with pustulose surface (arrowed), $\times 5$.
Locality **1651**, Upper Ktaoua Fm., Upper Ashgill.
- 5-10. The holotype, NM S 2560. 5 - right lateral side showing the labro-umbilical structures; 6 - apertural view; 7 - dorsal view; 8 - left lateral side, all $\times 1.6$. 9 - umbilical area with deep labro-umbilical depression, $\times 5$; 10 - external shell sculpture in the left lateral lobe, $\times 5$.
Locality **1624**, Upper Ktaoua Fm., upper Ashgill.

PLATE 6

Sinuities destombesi sp. n.

1. Paratype NM S 2568. Oblique dorsolateral view of a fully adult specimen showing the morphology of the lateral lobe and dorsal sinus. Note the irregular increments of collabral ribs. $\times 1.6$.
Locality **1651**, Upper Ktaoua Fm., upper Ashgill.
2. The same specimen, umbilical area with weak subinductural vallum (arrowed). $\times 3$.
3. Paratype NM S 2563. Immature specimen, internal mould with small patches of shell in the umbilical area, bearing subinductural deposits. $\times 5$.
Locality **1624**, Upper Ktaoua Fm., upper Ashgill.
- 4-6. Paratype NM S 2571. Partly exfoliated, immature specimen with several layers of shell and inductural deposits. 4 - oblique antero-lateral view showing a deposit,

obliterating the external shell surface, visible through a small "window". The deposit may be of anorganic origin. $\times 2.5$. 5 - enlarged area with the "window", uncovering the external shell surface, $\times 10$. 6 - an oblique apertural view showing several (at least six) layers of shell and inductural deposits. $\times 2.5$.

Locality **1109**, Upper Ktaoua Fm., upper Ashgill.

7. Paratype NM S 2562, internal mould of a fully adult specimen with a "resting phase", reflecting the shape of the dorsal sinus. $\times 1.5$.

Locality **1624**, Upper Ktaoua Fm., upper Ashgill.

- 8-10. Paratype NM S 2570, internal mould with patches of shell. 8, 9 - left and right latero-dorsal views showing a sharply bounded, slightly raised, circumbilical muscle attachment area, $\times 1.8$. 10 - antero-dorsal view demonstrating numerous tubes of infaunal organisms, inhabiting the internal shell surface, $\times 1.5$.

Locality **1132**, Upper Ktaoua Fm., upper Ashgill.

11. Dorsal area of paratype NM S 2561 with external shell sculpture, consisting of regular, dense, collabral ribs and fine, straight, revolving lines. $\times 10$.

Locality **1624**, Upper Ktaoua Fm., upper Ashgill.

PLATE 7

Sinuities destombesi sp. n.

- 1, 2. Paratype NM S 2566. 1 - right side with a circumbilical muscle attachment area, slightly raised above the surface of the internal mould, $\times 2$. 2 - the same, enlarged surface of the attachment area with a fibrillar structure, $\times 5$.

Locality **1080**, Upper Ktaoua Fm., upper Ashgill.

3. Paratype NM S 2565 with exposed circumbilical muscle attachment area, $\times 1.5$.

Locality **1080**, Upper Ktaoua Fm., upper Ashgill.

Selesinuities perneri HORNÝ, 1997

- 4-6. Paratype NM S 2676, internal mould. 4 - right lateral, 5 - oblique dorsolateral, 6 - postero-dorsal views; note the weak, raised circumbilical muscle attachment area in fig. 5. All $\times 2.5$.

Locality **1320**, Tachilla Fm., Llanvirn.

- 7, 8. Latex impression of the counterpart of the same specimen, showing the mature external shell surface. 7 - dorsal view with collabral ribs forming a narrow sinus, 8 - dorsolateral view showing fine, sharp, straight spiral lines. $\times 6$.

9. Laterally flattened specimen NM S 2580 with preserved collabral ribs, becoming finer and more dense aperturally. An arrow shows a small islet with cancellate sculpture. $\times 4$.

Locality **1320**, Tachilla Fm., Llanvirn.

- 10, 11. A juvenile specimen NM S 2581, internal mould, which probably belongs to *S. perneri*. Dorsal and left lateral views. $\times 3$.

Locality **1320**, Tachilla Fm., Llanvirn.

12. The holotype of *S. perneri*, NM L 32362. Note the selenizone in ontogenetically earlier stages and subinductural structures to the left. $\times 9$.

Locality **Osek near Rokycany**, Šárka Fm., Llanvirn; Barrandian Area, Bohemia, Czech Republic.

PLATE 8

Selesinuities perneri HORNÝ, 1997

- 1-5. Immature specimen NM S 2677. 1 - apertural view showing the morphology of columellar lips, their joints with the penultimate whorl, and development of the selenizone, bounded by faint threads in ontogenetically earlier stages. 2 - dorsal view, showing the development of selenizone, gradually fading away in the course of the whorl. 3 - slightly oblique view of the parietal area showing thin, sharp threads bounding the selenizone. 4, 5 - right and left lateral views, demonstrating the morphology of labro-umbilical structures. All $\times 7$.

Locality **1320**, Tachilla Fm., Llanvirn.

Tritonophon peeli HORNÝ, 1997

6. Specimen NM S 2668, right side of an external mould in grey micaceous shale. Note the spiral thread (arrowed), bordering the selenizone, which is not preserved. $\times 10$.

Locality **399**, Lower Ktaoua Fm., lower Caradoc.

7. The holotype NM L 31999, showing better preserved growth lines. $\times 10$.

Locality **Praha-Vysočany**, Letná Fm., Beroun; Barrandian Area, Bohemia, Czech Republic.

Atlantophon maider gen. et sp. n.

- 8-11. The holotype NM S 2673. 8 - right lateral, 9 - oblique right dorsolateral views, showing collabral ribs, continuously passing over the lateral and median shell lobes. $\times 4$. 10 - enlarged part of lateral side of the median lobe with coarse ribs, separated by flat, wide grooves. $\times 7$. 11 - narrow median lobe with patches of shell bearing coarse ribs, continuously passing over the lobe. Their direction on the left side of the lobe is steeper owing to lateral pressure. $\times 7$.

Locality **882**, Lower Ktaoua Fm., lower Caradoc.

PLATE 9

Bucanopsina calypso (PERNER, 1903)

- 1, 2. Specimen NM S 2659, a dorsally compressed external mould with raised selenizone and relics of fine outer shell sculpture. 1 - $\times 2$, 2 - enlarged anal emargination with adjacent part of the selenizone with lunulae. Latex impression, $\times 6$.

Locality **1640**, Lower Ktaoua Fm., lower Caradoc.

- 3-5. Specimen NM S 2660, an incomplete internal mould; 3 - dorsal side with a raised keel, 4 - ventral side with a sharp groove after dissolved carina at the base of the whorl, 5 - right lateral side showing an asymmetrical umbilicus. All $\times 3.5$.

Locality **1778**, Lower Ktaoua Fm., Lower Caradoc.

- 6, 7. Latex impression of the same specimen; 6 - right lateral side, 7 - oblique dorsolateral view showing the explanate aperture. $\times 5$.

- 8, 9. The same, enlarged outer shell sculpture of the dorsal area with a keel and spiral threads (8 - $\times 8$), and wrinkled, inconspicuous spiral elements on the lateral side near the aperture (9 - $\times 10$).

Tropidodiscus pusillus (BARRANDE in PERNER, 1903)

10. Taphocoenosis in a brown, siliceous concretion NM S 2621, containing numerous, unequally aged and chaotically accumulated specimens, and two immature specimens of *Lesueurilla prima* (arrowed). $\times 2$.
Locality **1320**, Tachilla Fm., Llanvirn.
11. Taphocoenosis in a grey, hard, siliceous concretion NM S 2616, containing numerous, well preserved internal moulds. $\times 3$.
Locality **1320**, Tachilla Fm., Llanvirn.

PLATE 10

Tropidodiscus pusillus (BARRANDE in PERNER, 1903)

- 1, 2. Two best preserved specimens, NM S 2617 (left) and NM S 2618, from the siliceous concretion NM S 2616. Note fine growth lines, selenizone, and a deep slit in NM S 2618. Latex impression. 1 - $\times 6$, 2 - $\times 8$.
Locality **1320**, Tachilla Fm., Llanvirn.
3. Specimen S 2622, a latex impression showing the outer shell surface with a "narrow" umbilicus. $\times 10$.
Locality **1236**, Tachilla Fm., Llanvirn.
4. Specimen NM S 2620, internal mould with a "wide" umbilicus. $\times 9$.
Locality **1320**, Tachilla Fm., Llanvirn.
5. A fragmentary specimen NM S 2704, with exposed inside of the final whorl. Latex impression, $\times 10$.
Locality **1320**, Tachilla Fm., Llanvirn.

Lesueurilla prima (BARRANDE in PERNER, 1903)

- 6-9. Specimen NM S 2639, a fragment of an adult shell with exceptionally well preserved keel; latex impression. 6, 7 - normal and oblique views to the keel, showing a depressed spire and fine growth lines, $\times 4$; 8, 9 - two views of an enlarged part of the keel with sinuate emargination, $\times 9$.
Locality **1320**, Tachilla Fm., Llanvirn.
10. Immature specimen NM S 2638, latex impression. $\times 5$.
Locality **1320**, Tachilla Fm., Llanvirn.
- 11, 12. Mature specimen NM S 2637, umbilical side with partly preserved, thin apertural margin in two different views. Note three "resting phases" between the penultimate and final whorls. Latex impression. 11 - $\times 2.5$; 12 - $\times 3$.
Locality **1320**, Tachilla Fm., Llanvirn.
13. Apical side of specimen NM S 2634, flattened in greenish shale. $\times 2$.
Locality **1689**, Upper Fezouata Fm., Lower Arenig.

PLATE 11

Ptychonema nigrum BARRANDE in PERNER, 1903

1. Specimen NM L 32403 with preserved external shell surface, bearing fine growth lines and a short slit, generating a selenizone. The specimen comes from the original Barrande lot, and has been prepared to show the external shell morphology. $\times 2.5$.
Locality. **Praha-Strašnice**, Zahořany Fm., Beroun (Caradoc); Barrandian Area, Bohemia, Czech Republic.

2. An additional, immature specimen from the original Barrande lot, NM L 32404, internal mould with patches of shell and with a partly preserved apertural margin with a short slit. $\times 2.5$.
Locality. **Praha-Strašnice**, Zahořany Fm., Beroun (Caradoc); Barrandian Area, Bohemia, Czech Republic.

Ptychonema desideratum (BARRANDE in PERNER, 1907)

3. The lectotype, NM L 11367, figured by Perner (1907, Pl. 96, fig. 21), not fully adult specimen, preserved as a cavity in a siliceous concretion. Latex impression, $\times 4$.
Locality. **Osek near Rokycany**, Šárka Fm., Llanvirn; Barrandian Area, Bohemia, Czech Republic.

Ptychonema bussacense (SHARPE, 1853)

4. Original drawing published by Sharpe (1853), Pl. 9, fig. 18. Height 1 inch (= 25.4 mm). $\times 1.8$.
Locality: **Serra de Bussaco**, Llanvirn-Dobrotivá, Portugal.

Ptychonema marocanum sp. n.

5. Sample NM S 2607, a taphocoenosis in a siliceous concretion, chaotically accumulated, containing unequally aged, mostly undamaged internal moulds and counterparts. $\times 3$.
6. Two adult paratypes, NM S 2602 (above) and NM S 2603, internal moulds, associated with an immature shell. Latex impression, $\times 10$.
- 7-9. The holotype, NM S 2593, an adult specimen in different positions (lateral, oblique lateral, and apical). Note the faint growth lines. Latex impression, all $\times 8$.
10. Paratype NM S 2601, an adult specimen; oblique lateral view. Faint growth lines are preserved on the final whorl above the selenizone. Latex impression, $\times 8$.
11. Paratype NM S 2596, an internal mould of an almost mature specimen with preserved apertural margin. A short notch or a shallow slit, variable in depth, is here developed as a shallow sinus. $\times 12$.
12. The same paratype, NM S 2596, associated with another, adult paratype NM S 2597, and with a specimen of *Tropidodiscus pusillus* (to the lower right). $\times 8$.
13. An incomplete paratype NM S 2604, showing a slightly raised selenizone. $\times 7.5$.
Locality. All specimens of *P. marocanum* sp. n. come from the locality **1320**, Tachilla Fm., Llanvirn.

PLATE 12

Ptychonema marocanum sp. n.

1. Oblique lateral view of paratype NM S 2594, showing a deep anal emargination. Latex impression, $\times 10$.
2. Oblique lateral view of paratype NM S 2595. Note the well developed growth lines above the selenizone. Latex impression, $\times 10$.
3. Paratype NM S 2598, a strongly weathered internal mould with a preserved, filled internal cavity of the umbilicus, proving a narrowly phanerocephalous nature of the species. $\times 8$.
4. Two paratypes, NM S 2599 and NM S 2600, exposed from the basal side. Note the straight increments passing across the base, and the narrow umbilici. $\times 8$.

5. Paratype NM S 2605, lateral view of a shell with a large, repaired fracture. The animal lost most of the apertural margin across the whole whorl, which caused a strong deviation of growth structures including the anal emargination, and an inflation of the final whorl. Latex impression, $\times 10$.
6. Paratype NM S 2606, the final whorl with a long fracture across the whorl. The animal lost the whole apertural margin including the anal emargination, but new shell, growing from below the sharply fractured margin, retained the original morphology of growth structures and the selenizone. Latex impression, $\times 10$.
Locality. All specimens of *P. marocanum* sp. n. come from the locality **1320**, Tachilla Fm., Llanvirn.
6. Specimen NM S 2687, a partly exfoliated specimen in arenaceous carbonate with numerous fragments of various fauna. Note fine growth lines above the selenizone. $\times 10$.
Locality **134**, Upper Tiouririne Fm., upper Caradoc.

Clathrospira amouguerana sp. n.

- 7-9. The holotype NM S 2654, an adult specimen with partly exfoliated shell. A wide, flat selenizone bears lunulae, better visible on a latex impression (fig. 8). Note the thick shell wall below the suture. 9 - oblique basal view, showing a thick, reflected columellar lip (below the fragment of a trinucleid trilobite; compare Pl. 13, figs 1, 2). Fig. 7 - $\times 2.5$, fig. 8 - $\times 4$, fig. 9 - $\times 2.5$.
Locality **585**, Upper Tiouririne Fm., upper Caradoc.
- 10, 11. Paratype NM S 2657, an almost complete juvenile specimen. 10 - an anomphalous base with slightly reflected columellar lip, 11 - lateral view of the shell. Latex impression, $\times 5$.
Locality **1778**, Lower Ktaoua Fm., Lower Caradoc.
12. Paratype NM S 2655, incomplete adult specimen with typically shallow sutures, $\times 2$.
Locality **585**, Upper Tiouririne Fm., upper Caradoc.
13. Specimen NM S 2683, incomplete internal mould in brown carbonate siltstone. $\times 2$.
Locality **86**, Lower Ktaoua Fm., middle Caradoc.

Clathrospira egens (BARRANDE in PERNER, 1907)

14. Lateral view of the lectotype NM L 11774, figured by Perner (1907, Pl. 112, figs V/1, 3, 4). Latex impression, $\times 3$.
Locality: **Praha-Jinonice**, Zahořany or Bohdalec Formation, Beroun (Caradoc); Barrandian Area, Bohemia, Czech Republic.

PLATE 13

Clathrospira amouguerana HORNÝ, 1997

- 1, 2. Paratype NM S 2656, fragment of base. Two basal views of a fully adult, probably gerontic specimen with a thick shell, lamellose increments and reflected, in the middle part slightly widened columellar lip. Latex impression, $\times 3$.
Locality **1778**, Lower Ktaoua Fm., lower Caradoc.
3. Specimen NM S 2681, poorly preserved in reddish siltstone. It is similar to *C. amouguerana*, but it has a slightly lower shell and a wider spiral angle. $\times 3.5$.
Locality **882**, Lower Ktaoua Fm., lower Caradoc.

Lophospira sp.

- 4, 5. Specimen NM S 2689, internal mould with patches of shell. The selenizone with central angulation is better visible on the latex impression, fig. 5. 4 - $\times 6$, 5 - $\times 8$.
Locality **134**, Upper Tiouririne Fm., upper Caradoc.

Lophospira? debganensis sp. n.

- 7-9. The holotype, NM S 2644, with a well preserved outer shell sculpture. 7 - lateral, 8 - oblique basal views, $\times 2.5$; 9 - oblique lateral view, $\times 4$.
Locality **1132**, Upper Ktaoua Fm., upper Ashgill.
10. Paratype NM S 2645, a weathered base showing a narrow umbilicus, entirely filled with black, recrystallized shell matrix. $\times 1.5$.
Locality **1078**, Upper Ktaoua Fm., upper Ashgill.

Lophospira? infausta (BARRANDE in PERNER, 1903)

11. Specimen NM L 9675, the lectotype of *Pleurotomaria infausta* BARRANDE in PERNER, 1903 (Pl. 66, fig. 27). Latex impression, $\times 2.8$. Note the repaired injury (arrowed).
Locality **Králův Dvůr**, Králův Dvůr Fm., Královodvor (lower Ashgill), Barrandian Area, Bohemia, Czech Republic.

PLATE 14

Lophospira? debganensis sp. n.

- 1-5. A fully adult specimen, paratype NM S 2647 with preserved shell. 1 - 3, apical, oblique lateral and lateral views, illustrating gradual changes of the gross shell morphology. Note the large, repaired injury, best visible in fig. 2. All $\times 2$. 4 - periphery of the final whorl, enlarged part to show the V-shaped sinus, and the fracture, perpendicularly crossing the keel. $\times 5$. 5 - a part of the base with a large fracture, a result of a failed predation, probably by a nautiloid. New shell, growing from below the fracture, bears differently oriented growth lines. In the place of attack (arrowed), where the injury was deepest, originated a characteristic feather-like sculpture. $\times 5$.
Locality **1132**, Upper Ktaoua Fm., upper Ashgill.
6. Paratype NM S 2648, lateral view of the base with well preserved, sigmoidally curved growth lines. $\times 3.5$.
Locality **901**, Upper Ktaoua Fm., upper Ashgill.
7. Paratype NM S 2646, strongly weathered and partly embedded in brown, silty limestone. $\times 2$.
Locality **1078**, Upper Ktaoua Fm., upper Ashgill.
- 8, 9. Paratype NM S 2649, internal surface of the base of a final whorl, bearing numerous, about 0.2 mm wide pits originated by the activity of an unknown, etching organism. Latex impression. 8 - $\times 3.5$, 9 - $\times 11$.
Locality **1649**, Upper Ktaoua Fm., upper Ashgill.

PLATE 15

Holopea? antiquata (BARRANDE in PERNER, 1903)

- 1-3. Specimen NM S 2627, apical, oblique lateral, and lateral views. The internal mould bears patches of lowermost lamellae of hypostracum. All $\times 2$.
Locality **1305**, Lower Ktaoua Fm., "middle" Caradoc.

4. Apertural view of specimen NM S 2702 (see also figs 1 and 2 on Pl. 16). Note the lamellae of hypostracum, adhering to the internal mould. $\times 2$.
Locality 1305, Lower Ktaoua Fm., "middle" Caradoc.
- 5, 6. An immature specimen NM S 2628, showing the outer shell sculpture; fig. 6 is lightened in different direction to emphasize the weak, spiral structures. $\times 3$.
Locality 1315, Lower Ktaoua Fm., "middle" Caradoc.
7. Specimen NM S 2700, a smooth internal mould with small crystals of pyrite on its surface. An impression of the base of the penultimate whorl bears straight transverse striae (see Pl. 16, fig. 5). $\times 2$.
Locality 88, Lower Ktaoua Fm., "middle" Caradoc.
- 8, 9. A fully adult specimen NM S 2698, apical and apertural views of an internal mould with a collabral irregularity near the aperture. A small islet of fine growth lines is preserved on the spire (see Pl. 16, fig. 6). $\times 1.8$.
Locality 88, Lower Ktaoua Fm., "middle" Caradoc.
- 10, 11. Immature specimen NM S 2629 with partly preserved shell bearing fine growth lines. Apertural and lateral views, showing the gross shell morphology. $\times 4$.
Locality 1315, Lower Ktaoua Fm., "middle" Caradoc.
- 12, 13. Specimen NM S 2701, internal mould with growth structures. Lateral and oblique basal views. $\times 2.5$.
Locality 1250, Upper Tiouririne Fm., upper Caradoc.
5. Specimen NM S 2700, base of the penultimate whorl with straight transverse striae (compare Pl. 15, fig. 7). Latex impression, $\times 7$.
Locality 88, Lower Ktaoua Fm., "middle" Caradoc.
6. Specimen NM S 2698, enlarged apical part of the internal mould bearing a small islet of the external mould with dense, transverse striae (compare Pl. 15, fig. 8, 9). $\times 9$.
Locality 88, Lower Ktaoua Fm., "middle" Caradoc.

Nonorios pater (BARRANDE in PERNER, 1903)

- 7-9. Incomplete internal mould of a fully adult specimen NM S 2632. Note the impressed base of the penultimate whorl with typical cancellate sculpture. 7 - lateral view, $\times 1.5$, 8 - apical view, $\times 1.5$; 9 - base of the penultimate whorl with cancellate sculpture, partly overlain by smooth parietal deposits. Latex impression, $\times 5$.
Locality 1276, Lower Ktaoua Fm., middle Caradoc.
- 10, 11. Immature specimen NM S 2631, a smooth internal mould lacking the spire. 10 - oblique lateral view, $\times 2$; 11 - base of the penultimate whorl with a small "window" showing the cancellate sculpture. Latex impression, $\times 8$.
Locality 1270, Lower Ktaoua Fm., middle Caradoc.
- 12, 13. Immature specimen NM S 2630, an incomplete, corroded internal mould lacking the spire. 12 - oblique lateral view, $\times 2$; 13 - base of the penultimate whorl with preserved cancellate sculpture. Latex impression, $\times 6$.
Locality 1266, Lower Ktaoua Fm., middle Caradoc.

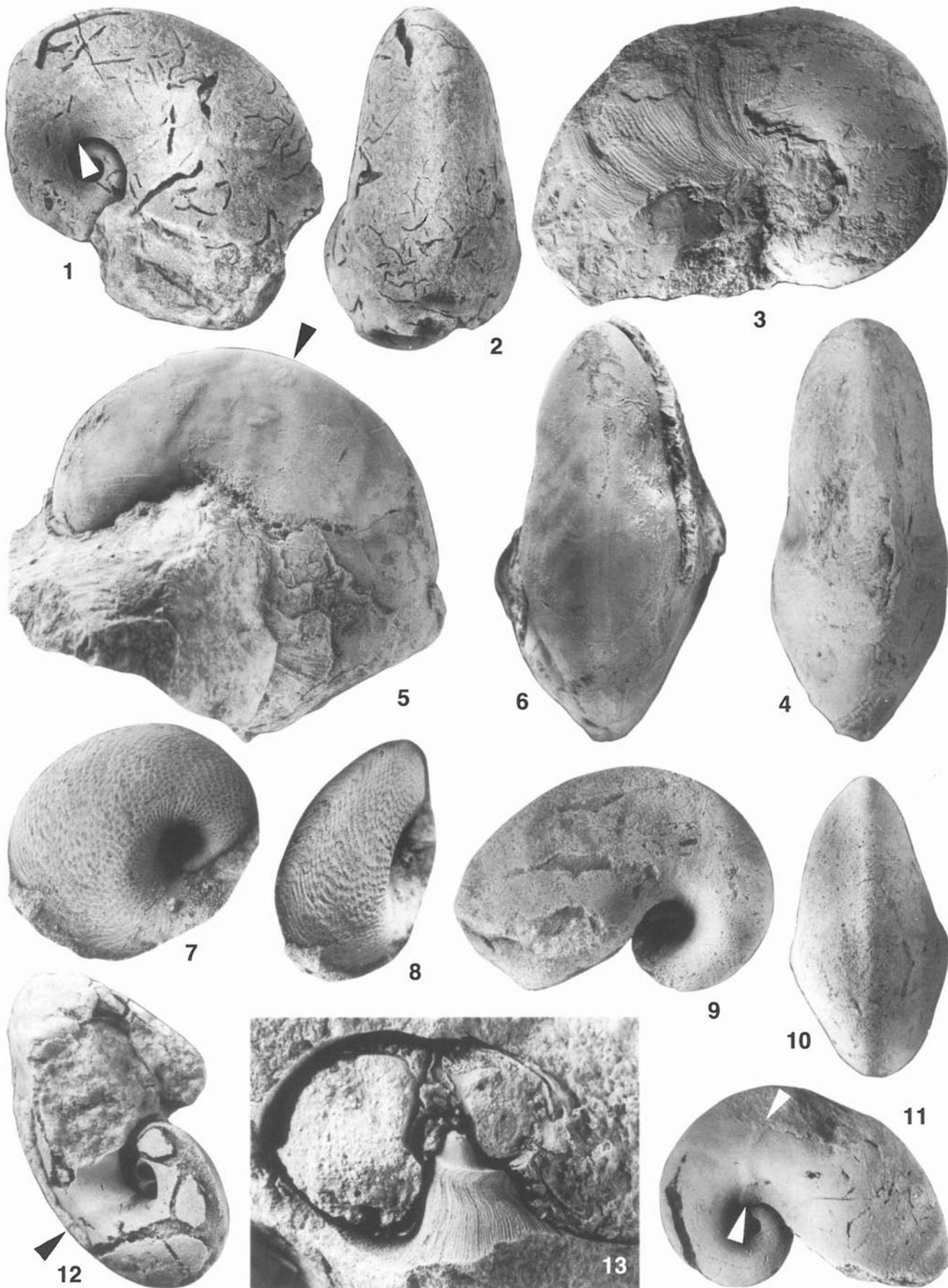
Loxonema? sp.

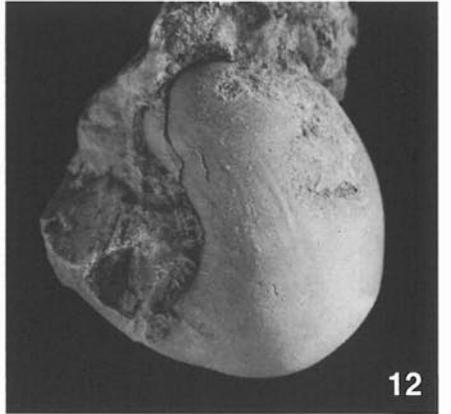
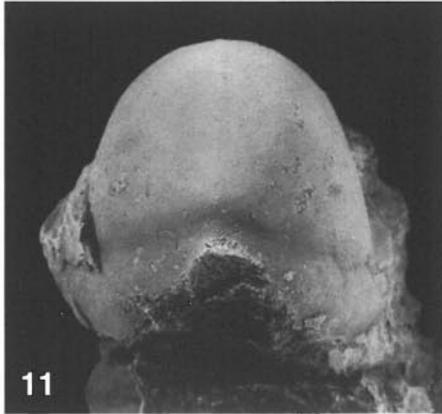
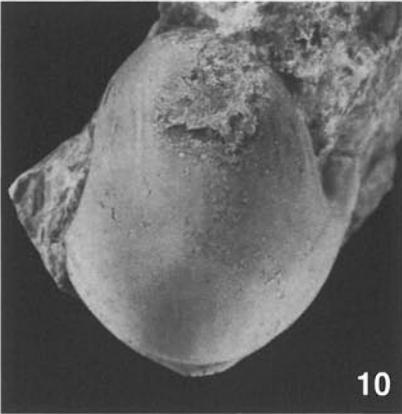
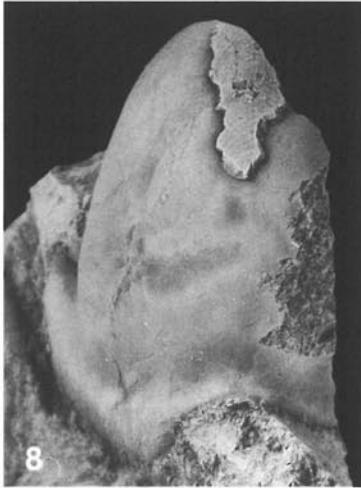
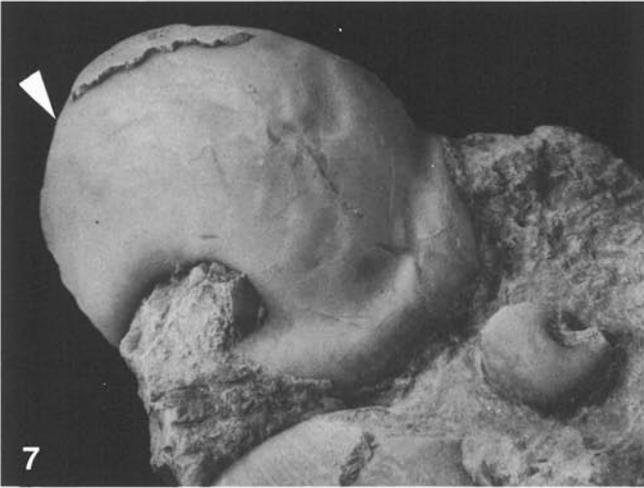
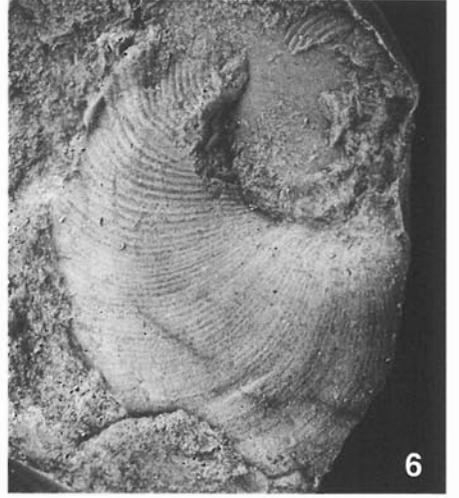
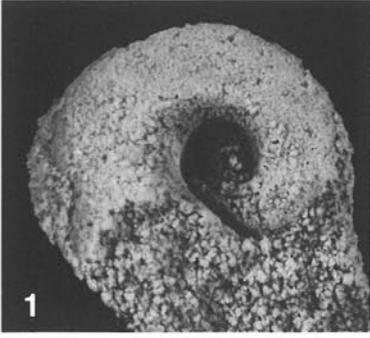
- 14, 15. Specimen NM S 2666, composite mould with faint traces of outer shell sculpture, not visible on the photograph. Two lateral views showing the gross shell morphology. Latex impression, $\times 5$.
Locality 1791, Upper Ktaoua Formation (top), upper Ashgill.

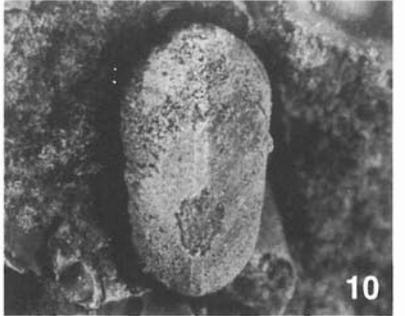
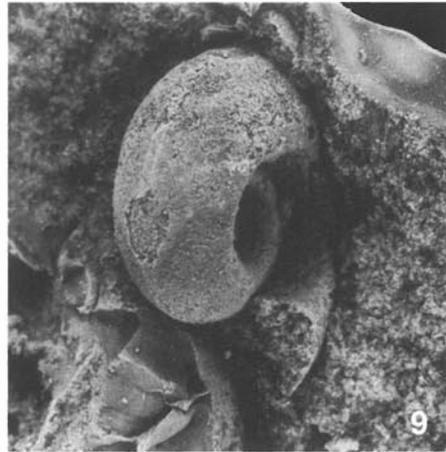
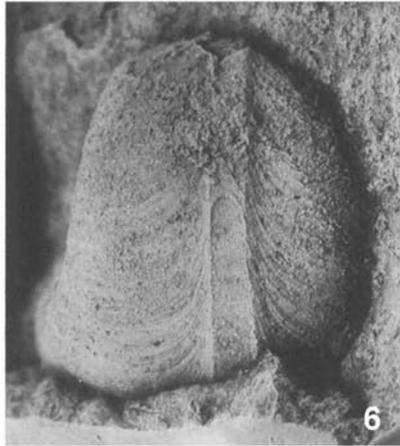
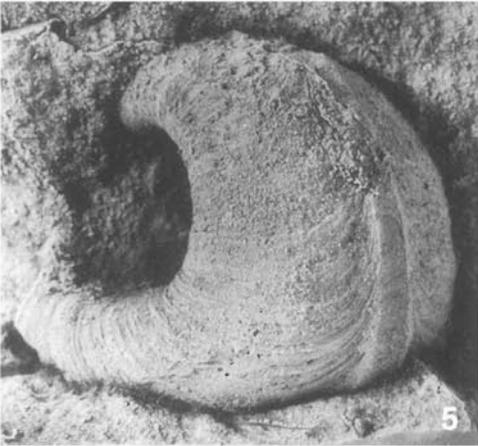
PLATE 16

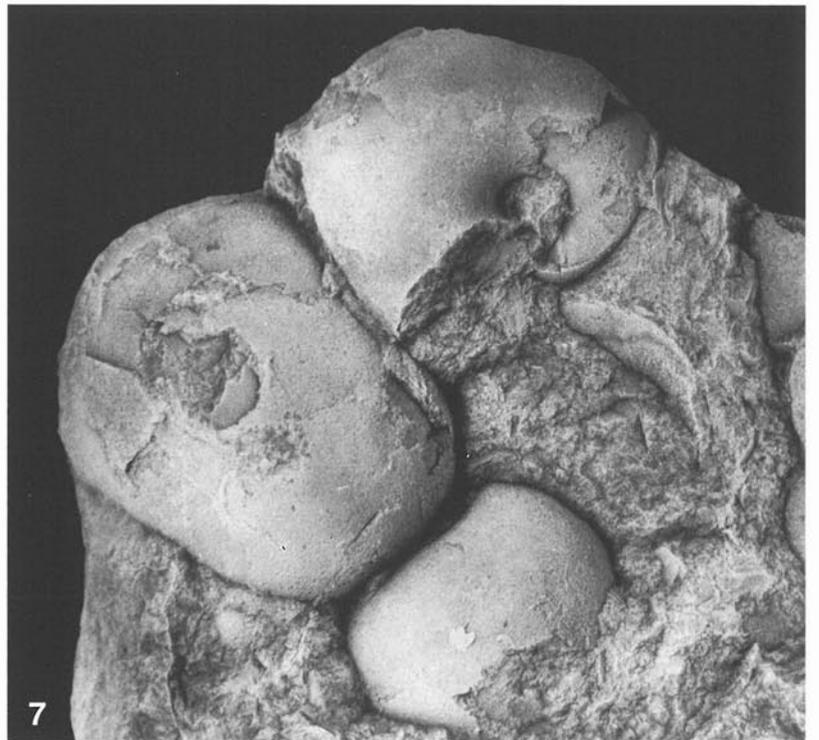
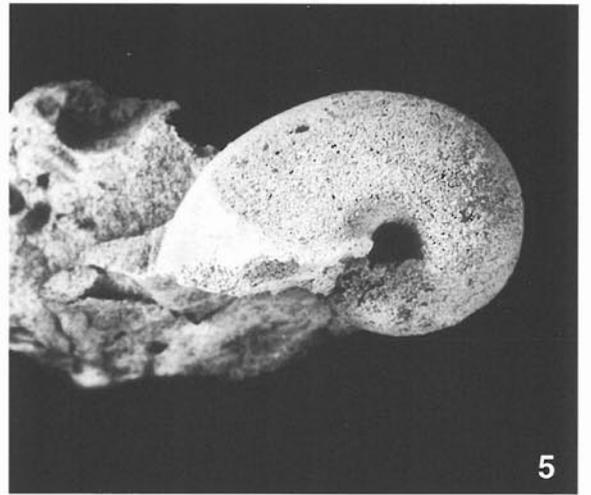
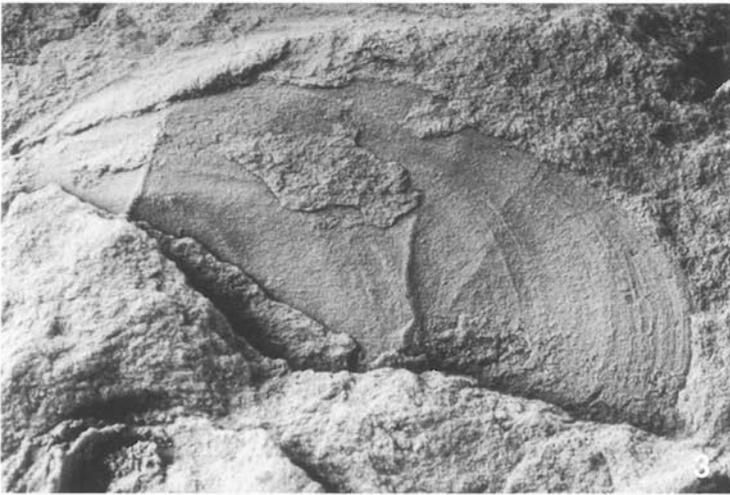
Holopea? antiquata (BARRANDE in PERNER, 1903)

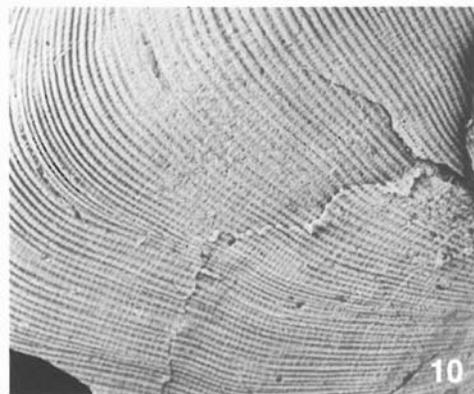
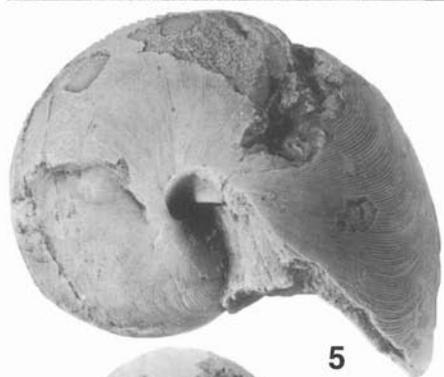
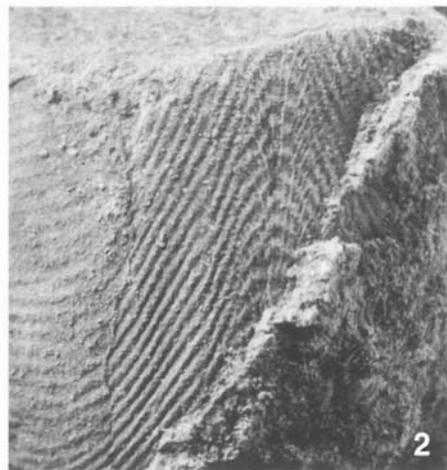
- 1, 2. Specimen NM S 2702, internal mould with patches of lowermost lamellae of hypostracum and a small fragment of shell showing the external surface with striae near the suture. 1 - $\times 1.5$, 2 - $\times 4$. Compare Pl. 15, fig. 4.
Locality 1305, Lower Ktaoua Fm., "middle" Caradoc.
- 3, 4. An immature specimen NM S 2626 with partly preserved shell with fine, dense growth striae. 3 - $\times 2$, 4 - $\times 4$.
Locality 1313, Lower Ktaoua Fm., "middle" Caradoc.

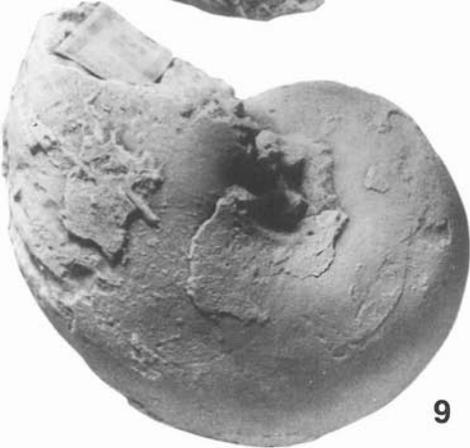
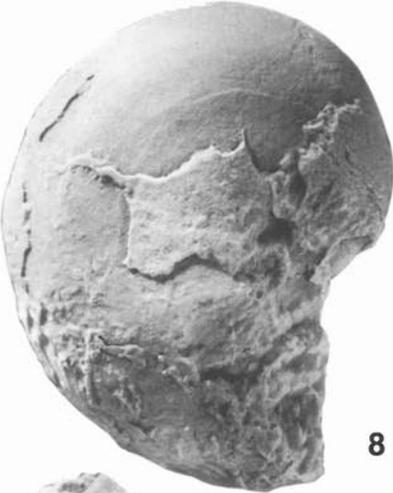
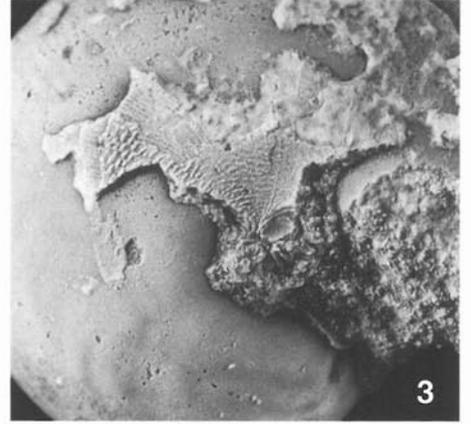
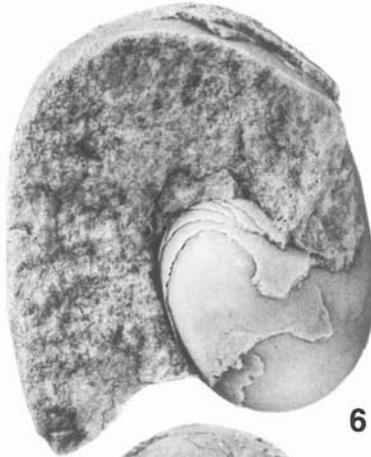
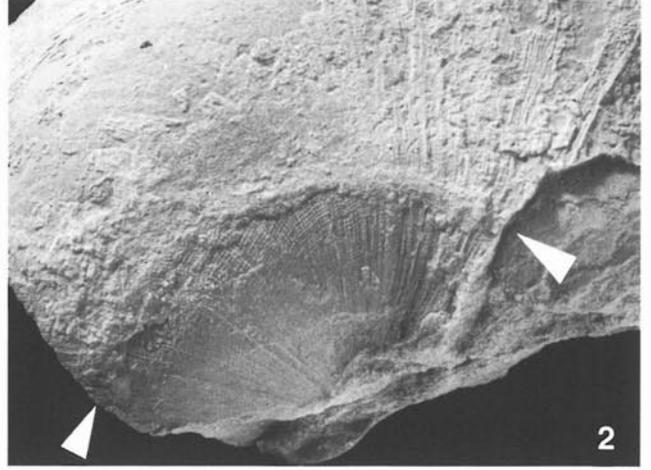














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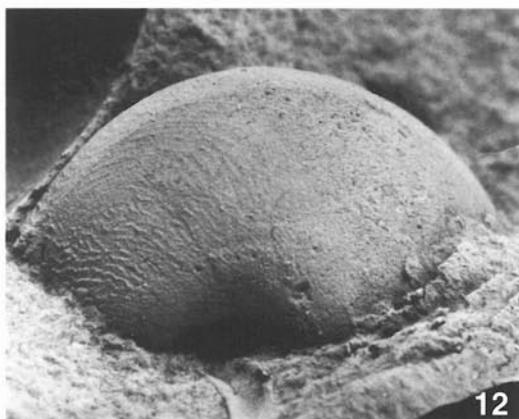
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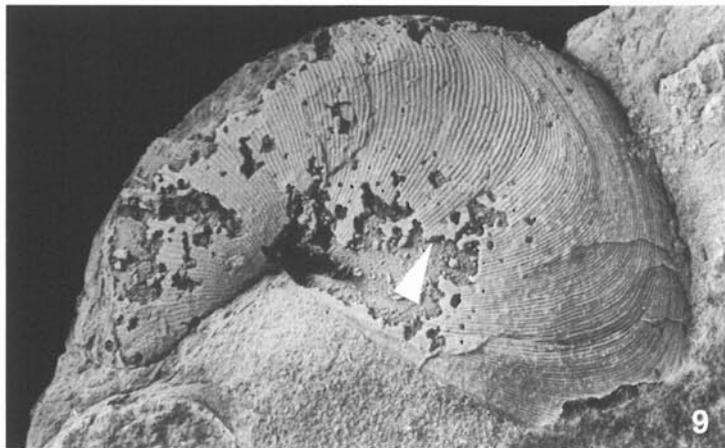
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