«ANNALES DU MUSÉUM D'HISTOIRE NATURELLE DE NICE - TOME IV - 1976»

MID-CRETACEOUS BIOSTRATIGRAPHY OF NORTHERN SPAIN

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ABSTRACT

In the Vascogotic and northern Celtiberic Ranges of northern Spain, the Middle Cretaceous sequence is thick, well exposed and fully developed. Equally important to the interpretation and correlation of Mid-Cretaceous biostratigraphy is the presence in these areas of highly diverse lithofacies and biofacies, representing Tropical Tethyan and North Temperate zone marine climates. Characteristic fossil groups of each facies are abundant throughout the sequence. Of special importance is the geographical overlap, in these faunal associations, of Mediterranean (Tethyan) and North Temperate species, facilitating the correlation between these two faunal realms and allowing the development of an integrated biostratigraphy. These factors allow the identification of key reference sections in northern Spain which are important to the interpretation of Middle Cretaceous events. This contribution is restricted to analysis of the most important fossil groups, i.e. ammonites, inoceramids and planktonic foraminifera. This is a first attempt to correlate not only these fossil groups, but as well North American and Western European Mid-Cretaceous sequences.

INTRODUCTION

Northern Spain can be regarded as one of the key regions for study and definition of the "Middle" Cretaceous. The best regions for such a study are the Vascogotic Ranges (Wiedmann, 1960) located between the true Pyrenees and the Hercynian Cantabrian Mountains, and the northern Celtiberic Ranges (Text-Fig. 1A). Within the true Pyrenees and the Pre- and Subbetic Ranges it is difficult to trace the Middle Cretaceous at present, and several areas are largely unstudied, i.e. the subbetic Turonian outcrops.

The most important features of the Middle Cretaceous in northern Spain which enhance geological investigations are :

1. Excellent exposures, and great sedimentary thicknesses, at least in the central basins, in most cases lacking stratigraphic condensations. The tectonic framework is generally simple (Lotze, 1973) ;
2. A great variety of lithofacies and biofacies, passing from nearshore environments near the Hercynian Meseta to flysch deposits in the central trough bordering the Bay of Biscay (Wiedmann, 1962a) ;
3. The occurrence in all facies of well preserved, diverse and characteristic fossil assemblages, in some cases blending Mediterranean (Tethyan) and North Temperate faunas in single stratigraphic units (Wiedmann, 1960, 1962b, 1975b).

The main fossil groups under investigation are the nautiloids, ammonites, rudistids, inoceramids, oysters, echinoids, ostracodes, and benthic and planktonic foraminifers, which in many cases can be found together in single assemblages. This preliminary study is restricted to a review of the ammonites, inoceramids, and selected planktonic foraminifera, i.e. the most important groups for biostratigraphic zonation and regional correlation. An important biostratigraphic system results from the integration of faunal elements drawn from the North Temperate and Tethyan Mediterranean faunal provinces in the Vascogotic Trough ; the "Boreal" ammonites and most inoceramids were derived mainly from the northernmost basinal areas, while Mediterranean ammonites, mostly associated with oysters, were mainly migrants from the southern epicontinental seas. This is shown in Text-Fig. 1B, which represents a general paleobiogeographic sketch of the Iberian Lower Turonian that may be representative - in its broad interpretation - for the complete Iberian Middle Cretaceous.

This may be the proof that in this case ammonite provincialism is due to water temperature, which is in the present case controlled by water depth (Wiedmann, 1975b, 1976, in press). It needs to be mentioned that the resulting ammonoid zonation of northern Spain (Table 1) has to be combined from various sections, sometimes hardly to correlate (Wiedmann, 1960). The detailed sections will be published separately.

There is, moreover, in some cases incongruity with previous work, due to the decisions of the MCE-Conference at Uppsala (1975). There it has been agreed that, contrary to the previous usage, a Middle Cenomanian, Middle Turonian and Middle Coniacian has to be established. Moreover the previously lowermost subzone of the Turonian as defined by *Metoicoceras whitei* and allied forms (Spath, 1926 ; Cobban, 1953 ; C.W. Wright, 1957) has now been transfered to the Upper Cenomanian. This means that the "Turonian I" of Wiedmann (1960 ff.) has to be altered into Cenomanian VII. According to Kennedy & Hancock (this volume) *M. whitei* and allied forms are synonymized with the European *M. geslinianum*. On the other hand, Cenomanian VI, as newly defined, is largely identical with the "Zone of Actinocamax plenus".

In consequence, the Turonian starts with the "Zone of Vascoceras gamai" (previously "Turonian II"). The repeated proposal made by Berthou & Lauverjat (1974a, 1974b), to include this as well into the Cenomanian because of the co-occurrence with praealveolinas at its type locality in Portugal, is not accepted for the following reasons :

(1) Stratigraphic boundaries are generally defined by the first appearence of the characteristic fossil species or group. In the present case, the Lower Turonian, this is the group of vascoceratids.

(2) In defining Mesozoic standard scale units ammonites have priority in relation to benthic foraminifera.

(3) There is no reason, to restrict *Praealveolina* to the Cenomanian ; its stratigraphic range is largely controlled by ecologic reasons which evidently favoured its local persistence into the lowermost Turonian of Portugal (see also Loeblich & Tappan, 1964, p. C 510).

The Vascogotic Cretaceous is therefore a key area where the correlation between the Middle Cretaceous, North Temperate or European "Boreal" faunas and the Mediterranean Tethyan faunas can be defined in detail. Unfortunately belemnites did not immigrate into the Vascogotic Trough, which would have allowed even more northerly correlation of the sequence.
The first author is responsible for the review of ammonites and foraminifera, the second author for that of inoceramids.

REGIONAL DISCUSSION

Celtiberic Ranges, northern part. — The Celtiberic Middle Cretaceous was deposited in a shallow inner shelf environment and is accordingly characterized by an abundance of oysters, rudistids, echinoids, and mostly benthic microfossils. The marine Cretaceous transgression followed in this area the deposition of Weald-like sediments and occurred at or near the Albian-Cenomanian boundary. Here, deltaic-estuarine sediments, the coal-bearing and kaolinitic Utrillas Sands (Albian) gradually change upward into shallow marine detritic limestones and marls of Cenomanian age, containing oysters and ostracodes. Cephalopods have been found only in the upper part of this sequence, i.e. *Angulithes mermeti* (COQ.), *Euomphaloceras tuberculatum* (PERV.), *Calycoceras naviculare* (MANT.), *C.* sp. cf. *C. subgentoni* SPATH, *Pseudocalycoceras jacobi* (COLL.), *Ps. harpax* (STOL.), as examples see Pl. 5, Fig. 3 ; Pl. 6, Figs. 4, 6. These species are of Middle and Upper Cenomanian age, but are too rare to allow further biostratigraphic or age refinement. The thicknesses of this Cenomanian sequence generally does not exceed 50 m.

The Turonian is the best developed stage of the Celtiberic Cretaceous sequence. At the famous Picofrentes locality near Soria (Wiedmann, 1975a), the following zonation can be observed (as examples see Pl. 7, Figs. 2-4 ; Pl. 8, Figs. 1, 2) :

Upper Turonian
- 25 m of rudistid and gastropod-bearing limestones

Lower and Middle Turonian
- 30 m of highly fossiliferous marls which can be subdivided into

Middle Turonian
- VI. Zone of Wrightoceras submunieri WIEDM.
- V. Zone of Wrightoceras munieri (PERV.)

Lower Turonian
- IV. Zone of Ingridella malladae (FALL.)
- III. Zone of Paramammites (?) saenzi WIEDM.
- II. Zone of Fallotites subconciliatus (CHOFF.)

Zone II is characterized by a high diversity of fallotitid ammonites (*Fallotites robustus* WIEDM., etc.). Within zone III occur, in addition to the index species, *Paramammites (?) postsaenzi* WIEDM., *Fallotites* sp. cf. *F. obliquus* (KARR.), *Vascoceras* sp. cf. *V. gamai* CHOFF., *Discovascoceras* sp. cf. *D. subtriangulare* (CHOFF.) and *Leoniceras* sp. cf. *L. segne* (SOLGER). In zone IV, *Paramammites tuberculatus* BARBER and the cryptogene *Donenriquoceras forbesiceratiforme* WIEDM., are associated with *Ingridella malladae* (FALL.), while a younger *Ingridella* (*I. depressa* WIEDM.) occurs in zone V representing the earliest Middle Turonian Substage. Zones IV and V further include several pachyvascoceratid species, and *Discovascoceras* (*D.* sp. cf. *D. silvanense* (CHOFF.)), *Parammamites* (*P. inflatus* BARBER, *P. raricostatus* BARBER), *Hoplitoides* sp. cf. *H. ingens* (KOEN.) and *Mammites nodosoides afer* (PERV.). The highest part of zone VI, still within the Middle Turonian, yielded only a few ammonites : *Wrightoceras, Hoplitoides* (*H.* sp. cf. *H. gibbosulus* (KOEN.)), *Paramammites* (?) and *Neoptychites* (*N. cephalotus* (COURT.)).

The basal Fallotites subconciliatus Zone permits direct correlation with Portugal (Choffat, 1898), and in the Celtiberic Ranges of Burgos and Soria, lies directly on the Upper Cenomanian where it contains some of the above mentioned ammonites and *Exogyra columba* (LMK.). The basal Turonian zones based on vascoceratids, which underlie the Zone of Fallotites subconciliatus in Portugal, are not represented in these sections. The presence of a pronounced hard-ground (Wiedmann 1975b, pl. 1, fig. 1) at the base of the nodular limestone with *Fallotites subconciliatus* suggests that a disconformity is present at this lowest Turonian level. The basal zones of the Turonian as well as the top of the Cenomanian, are found, however, towards the Meseta, in the southernmost Cretaceous sections known from the Guadarrama borderland. Near Somolinos (Guadalajara) the lowest Turonian zone is recognized as I. Zone of Vascoceras gamai (Pl. 7, Fig. 1). This is underlain by the latest Cenomanian (VII) Zone of Metoicoceras geslinianum. At this locality, *Gombeoceras* has been found in the Turonian II and *Ezilloella* in the Turonian III.

The Upper Turonian is quite unfossiliferous in all of these sections, as it is in most parts of northern Spain. The same is true for the Coniacian of the northern Celtiberic Ranges, which is in most cases characterized by limestones and marls with oysters (*Pycnodonte vesicularis* (LMK.)). Only one ammonite level has been found in the Celtiberic Ranges of Burgos, where *Hemitissotia celtiberica* WIEDM., *H.* sp. cf. *H. galleppei* PERV., *Hemitissotia dullai* (KARR.), and *Gauthiericeras* sp., *Reesideoceras nicklesi* (GROSS.) and *R.* sp. cf. *R. gallicum* BASSE suggest a lower Upper Coniacian age. Up to now no inoceramids have been discovered in the Celtiberic Cretaceous. Text-Fig. 2 presents one of the reference sections of the northern part of the Celtiberic Ranges.

Vascogotic Ranges. — During the Middle Cretaceous the southern Vascogotic and northern Celtiberic Troughs were joined by the same nearshore, inner shelf zone (Wiedmann, 1962a). The separation between the two basins became obvious in the Coniacian, where glauconitic or sandy marls with cephalopods were deposited troughout the western Vascogotic Trough, while limestones with oysters have been deposited in the Celtiberic Ranges. In this study, the most interesting parts of this trough are the outer shelf and the central basins, i.e. the actual valleys of Rio Mena, Rio Losa and Rio Nela in the western Vascogotic Ranges and the Barranca-Estella region in its eastern part (Wiedmann, 1960).

1. THE VALLEYS OF RIO MENA, LOSA AND NELA

This region is comparable with the Celtiberic Ranges in that fully marine environments were established approximately at the base of the Cenomanian. The Cenomanian here overlies the partly marine "Complexe gréseux supérieur" (Rat, 1959) of Albian age, which parallels in many aspects the Utrillas facies in the south. The marine Upper Cretaceous in this area consists of alternating marls and well-bedded limestones attaining considerable thicknesses. The Cenomanian rapidly increases from 50 m in the Nela valley in the West to more than 1 000 m in the Mena valley, near the center of subsidence. In the Mena valley the following Cenomanian zonation has been established (Wiedmann, 1960, 1965 ; Lotze, 1960) (see examples, Pl. 4, Figs. 1, 3-5 ; Pl. 5, Fig. 4 ; Pl. 6, Figs. 1, 3, 5, 7) :

Upper Cenomanian (pars)
- V. Zone of Calycoceras (Lotzeites) lotzei WIEDM.

Middle Cenomanian
- IV. Zone of Pseudocalycoceras jacobi (COLL.)
- III. Zone of Euomphaloceras cunningtoni (SHARPE)

Lower Cenomanian
- II. Zone of Mantelliceras mantelli (J. SOW.)
- I. Zone of Graysonites sp.

Highest Cenomanian as well as basal Turonian strata seem to be absent in the Mena area, but can be defined in the Nela section. There the late Upper Cenomanian is represented by the

- VII. Zone of Metoicoceras geslinianum (D'ORB.)
- VI. Zone of Metoicoceras muelleri COBBAN

associated with *Exogyra columba* (LMK.). In Nela, *Metoicoceras muelleri* COBBAN, immediately overlies a rich *Neolobites* assemblage, probably equivalent to the Zone of C. (Lotzeites) lotzei in the Mena Valley, and here named the

- V. Zone of Neolobites vibrayeanus (D'ORB.).

No inoceramids up to now have been found in the Cenomanian of the western Vascogotic Ranges.

In the overlying Turonian of the Nela area, thickness ranging in between 100 and 350 m, the following zonation has been recognized (see examples, Pl. 9, Figs. 2-4, 6 ; pl. 10, Figs. 2, 3) :

Upper Turonian
- IX. 50-80 m of limestones with *Vaccinites praecorbaricus* TOUCAS, ranging downwards into the Middle Turonian. Their lower part can be refered to
- VIII. Zone of Romaniceras deverianum (D'ORB.) and

Middle Turonian
- VII. Zone of Collignoniceras (C.) sp. with *Parapuzosia* sp. cf. *P. gaudama* (FORBES), *Pachydesmoceras denisonianum* (STOL.), and *Forresteria (F.)*, n. sp.

  This limestone member is underlain by 60 m of marls with :
- VI. Zone of Neoptychites spp. and Pseudaspidoceras spp.
- V. Zone of Spathitoides sulcatus WIEDM. and Fagesia spp.

Lower Turonian
- IV. Zone of Wrightoceras llarenai (KARR.) and Schindewolfites spp.
- III. Zone of Leoniceras discoidale (PERV.)
- II. Zone of Fallotites subconciliatus (CHOFF.)
- I. Zone of Vascoceras gamai (CHOFF.).

Within this part of the basin puzosiids have their peak of occurrence. The most important paleobiological aspect of this region is the association of species of the North Temperate climatic Realm (especially mammitids, collignoniceratids, puzosiids and pachydiscids) with those of the Tethyan Mediterranean Realm (especially vascoceratids and pseudotissotiids). Both faunas seem to have actually been biologically associated in this area of overlap ; there is no evidence for a *postmortem*-accumulation and mixing of North Temperate and Mediterranean elements.

The Inoceramidae (Bivalvia) constitute another important faunal element for correlation of Mediterranean and "Boreal" faunas in this part of the central Vascogotic region. Middle Cretaceous forms have been recently restudied and their biostratigraphy is presented here for the first time. The following zonation of inoceramids seems to be present in the Lower and Middle Turonian of the west-central Vascogotic Ranges (see examples Pl. 2, Figs. 1-3, 7, 14, 15) :

Middle Turonian
- VII. "Zone" of Inoceramus (I.) ex cuvieri-lamarcki lineage. This "zone" is normally divisible into several zones based on evolutionary stages of the lineages, but is presently known from this area only by rare, poorly preserved specimens, prohibiting its subdivision
- VI. Zone of Mytiloides hercynicus (Petrascheck) with *M. jacobi* (HEINZ) (= *"Inoceramus latus"* of authors)
- V. Zone of Mytiloides subhercynicus (SEITZ), and forms transitional to *M. mytiloides* (MANTELL) and *M.* sp. cf. *M. jacobi* (HEINZ)

Lower Turonian
- IV. Zone of Mytiloides labiatus (SCHLOTHEIM), not well developed in northern Spain, but normally lies between zones III and V in Western Europe and North America
- III. Zone of Mytiloides mytiloides (MANTELL) with *M. opalensis elongata* (SEITZ)
- II. Zone of Mytiloides opalensis (BOESE) and forms transitional to *M. mytiloides* (MANTELL)
- I. Zone of Mytiloides submytiloides (SEITZ). This is the earliest representative of the *M. labiatus* lineage and marks the lowest Turonian in both Europe and North America. Locally, this species ranges into the uppermost Cenomanian, where it is associated with youngest representatives of the *Inoceramus pictus* lineage. *M. opalensis* (BOESE) first appears at the top of this zone in many areas.

No Upper Turonian inoceramids are definitely known from the Vascogotic Ranges. The Lower and Middle Turonian inoceramid zonation described here can be closely integrated with the ammonoid zonation (see Table 1).

The overlying Coniacian of the Nela, Losa and Mena valleys is characterized by sandy or glauconitic marls increasing in thickness from west to east, from 100 to 200 m. These yield fossils permitting a refined zonation by ammonites and inoceramids. The ammonites mainly are of Tethyan Mediterranean affinities, while the inoceramids belong to cosmopolitan species which are more common in Temperate areas. The following ammonite zonation has been developed (Pl. 11, Figs. 1-5 ; Pl. 12, Figs. 2, 3, show examples) :

Upper Coniacian
- V. Zone of Hemitissotia lenticeratiformis WIEDM., n. sp.
- IV. Zone of Hemitissotia turzoi KARR.

Middle Conacian
- III. Zone of Gauthiericeras vallei CIRY

Lower Conacian
- II. Zone of Reymentoceras hispanicum WIEDM.
- I. Zone of Tissotioides haplophyllus (REDT.)

Middle (and Upper ?) Coniacian is probably equivalent with an upper
- III. Zone of Inoceramus (Magadiceramus) subquadratus SCHLUETER, with *I. "vancouverensis" longealatus* TROEGER, and a lower
- II. Zone of Cremnoceramus inconstans (WOODS).

Lower Coniacian ammonite zones I and II are represented by a single bivalve zone
- I. Zone of Inoceramus ernsti HEINZ, and I. winkholdioides ANDERT. Plate 2, Figs. 10, 12, 13, 16 show examples of these inoceramids.

This basal inoceramid zone (I) of the Coniacian in Spain is characterized by only rare bivalve specimens, but clearly correlates with the Zone of I. rotundatus FIEGE of the standard North American and European sequence.

The Coniacian marls are covered throughout this region by similar marls of the Lower Santonian containing *Texanites texanus* (ROEMER) (see Pl. 12, Fig. 4), *Lenticeras andii* (GABB), and *Platyceramus cycloides* WEGNER, two subspecies.

2. THE BARRANCA-ESTELLA REGION

The eastern Vascogotic Ranges of Alava and Navarra Provinces, and especially the neighborhood of Estella, were characterized by remarkable subsidence during the Middle Cretaceous. Here the base of the marine transgression can be dated as upper Middle Albian in age (Zone of Mojsisoviczia remota (SPATH)). The "Complexe gréseux supérieur" (*sensu* Rat 1959), over which the marine transgression lies, is in this area therefore of Lower to lower Middle Albian age. The diachronous nature of this transgression can easily be demonstrated between the Vascogotic Ranges from the Estella region in the east, to the Nela Valley in the west, where the transgressive deposits are of Cenomanian age.

Within the mainly biodetrital series of Middle and Upper Albian age, where there are locally intercalated reefs, the following ammonoid zonation has been established (Pl. 3, Figs. 1-7 show examples) :

Upper Albian (including Vraconian)
- V. Zone of Stoliczkaia dispar (D'ORB.)
  - b. Subzone of Paraturrilites (Bergericeras) quadrituberculatus (BAYLE)
  - a. Subzone of Pervinquieria (P.) fallax BREISTR.
- IV. Zone of Pervinquieria (P.) inflata (J. SOW.) and P. (Deiradoceras) cunningtoni (SPATH).
- III. Zone of Hysteroceras orbignyi SPATH

Middle Albian
- II. Zone of Mojsisoviczia (M.) remota (SPATH)
- I. Unnamed Zone, without ammonites.

These zones are well developed in the Estella region as well as in the northern Barranca of Navarra and Alava. Inoceramids are not yet known from this part of the sequence, but they have been collected from equivalent beds in the higher Albian of Mallorca. Thus, the ammonoid zonation can indirectly be compared with the following two inoceramid zones from the Albian of Mallorca (Pl. 1, Figs. 1-14 show typical examples) :

- Zone of Birostrina concentrica concentrica (PARKINSON) with *B. munsoni* (CRAGIN), n. subsp. and *B. concentrica*, n. subsp. 2 (= early Upper Albian)
- Zone of Birostrina concentrica, n. subsp. 1 (= Middle Albian).

Also the lowermost Cenomanian is questionably represented by inoceramids only in the Palma region of Mallorca, where a

- Zone of Inoceramus (I.) pictus cf. I. pictus neocaledonicus JEANNET may be represented by a single small specimen obtained at the top of a thick limestone sequence which yields early Late Albian inoceramids in the lower part. The specimen has characteristics unlike known inoceramids belonging to the Albian *B. concentrica* lineage but which are identical to those of *I. (I.) pictus neocaledonicus* as illustrated by PERGAMENT (1966, especially Pl. 30, fig. 2) and some Lower Cenomanian descendents of the *B. concentrica* lineage such as illustrated by PERGAMENT (1966, pl. 1, fig. 3) as "*Inoceramus* cf. *concentricus*."

The largely infraneritic pelagic sediments of the Cenomanian and Turonian in the Estella region attain thicknesses up to 450 m and show the following ammonoid sequence (Pl. 4, Fig. 2; Pl. 5, Figs. 1, 2, 5; Pl. 6, Fig. 2; Pl. 9, Figs. 1, 5; Pl. 10, Figs. 1, 4 show examples) :

Upper Turonian
- VIII. 80 m of marls with *Romaniceras deveranium* (D'ORB.), puzosiids, pachydiscids and nautiloids.

They are underlain by 75 m of marls which can be subdivided into :

Middle Turonian
- VII. Zone of Romaniceras inerme (GROSS.)
- VI. Zone of Neoptychites spp. and Pseudaspidoceras spp.
- V. Zone of Fagesia spp.

Lower Turonian
- IV. Zone of Schindewolfites ganuzai WIEDM.
- III. Zone of Leoniceras discoidale (PERV.)
- II. Zone of Fallotites subconciliatus (CHOFF.).

Turonian zone I and Cenomanian zone VII are not yet adequately documented in this area or may be absent despite the fact that there is no obvious evidence of sedimentary discontinuity in the sequence.

Upper Cenomanian

20 m of marls with

VI. + V. Zone of Calycoceras sp. cf. C. subgentoni SPATH

Middle Cenomanian

100 m of marls with

IV. Zone of Eucalycoceras spathi COLL. and Calycoceras n. sp. cf. C. paucinodatum (CRICK)

III. Zone of Euomphaloceras cunningtoni (SHARPE)

Lower Cenomanian

150 m of similar marls with

II. + I. Zone of Euturrilites scheuchzerianus (BOSC).

A more complete faunal list (WIEDMANN, 1960, 1965) clearly indicates that Mediterranean Tethyan species gradually disappear (i.e. species of *Neolobites*, vascoceratids and pseudotissotiids) in the Estella Basin and are replaced by "northern" Temperate species of mammitids, puzosiids, etc.)

At the same time inoceramids become more abundant. At least three inoceramid zones may be discerned in the Cenomanian of the Estella Basin (Pl. 1. Figs. 15-18 show examples) :

III. Zone of Inoceramus (I.) pictus SOWERBY, n. subsp., with *I. (I.)* sp. cf. *I. flavus* SORNAY. These taxa are widely known from the Middle to middle Late Cenomanian of the Western Interior and western Gulf Coast of North America, and in western Europe (especially in the English-French sequence). They are collectively most typical in the late Middle and early to middle Late Cenomanian. Normally they have ranges which are different enough to allow biostratigraphic subdivision of the Middle and Late Cenomanian, but the knowledge of their occurrences in northern Spain is not sufficient to allow such a subdivision. This zone largely correlates with zone VI of the ammonoid zonation.

II. Zone of Inoceramus (Inoceramus) sp. aff. I. prefragilis STEPHENSON, a common Middle to early Late Cenomanian species in North America, equivalent to ammonite Zone IV.

I. Zone of Inoceramus (I.) etheridgei WOODS, s.l., and "Inoceramus" reachensis ETHERIDGE, n. subsp. B (form illustrated by WOODS, 1911, pl. 48, fig. 5). This broad Lower to Middle Cenomanian "zone' is represented by rare, poorly preserved specimens which do not allow, for the most part, identification to subspecies as they do in England (see paper in this volume). This in turn prohibits equally refined biostratigraphic division of the Spanish Lower and Middle Cenomanian sequence on the basis of inoceramids at this time. Specimens of *I. (I.) etheridgei* do occur somewhat higher in the sequence (equivalent to lower part of ammonite zone IV) than does *"I." reachensis* which approximately correlates with Zones II and III of the ammonoid succession.

The Turonian inoceramid zonation in this area seems to be the same as that given in the preceding chapter (for examples see Pl. 2, Figs. 4-6, 10, 11, 15), but it has to be mentioned that in the Ganuza section several of the Turonian index species co-occur in one single layer ($H_{10}161057$).

During the Coniacian of the Estella region, water depths decreased rapidly and this resulted in lower ammonoid diversity and abundance. Inoceramids seem to be absent in this part of the Estella section. For the time being ammonites allow division of the sequence only into two Coniacian assemblages :

Middle and Upper Coniacian

70 m of limestones with

Parabevahites sp. cf. *P. emscheris* (SCHLUETER)

Gauthiericeras aberlei (REDTENBACHER)

Gaudryceras vascogoticum WIEDMANN, and

Scaphites compressus D'ORBIGNY

Lower Coniacian

50 m of limestones with

Tissotia (Metatissotia) sp. cf. *T. (M.) robini* (THIOLLIERE)

Forresteria (Reesideoceras) sp. cf. *F. (R.) camerounensis* BASSE

Proplacenticeras sp.

The overlying black marls yielded *Texanites texanus hispanicus* COLLIGNON and *Micraster coranguinum* (LAMARCK), both regarded as Lower Santonian in age.

CORRELATIONS AND CONCLUSIONS

This brief review of the principal Middle Cretaceous biostratigraphic data from northern Spain points out the importance of this fauna, allowing considerable refinement of biostratigraphic subdivision and correlation, and especially in the correlation of the Tethyan and "Boreal" Realms. This correlation is facilitated by the first discovery of inoceramids in the basinal part of the Vascogotic Trough, where they co-occur with Tethyan ammonites. Another very important feature of the vascogotic marine Cretaceous is the association of biostratigraphically important ammonites with planktonic foraminifera in the central and northern part of the trough. Planktonic foraminifera are progressively replaced by benthonics towards the south. These factors compensate for the obvious disadvantage of faunal provincialism and high levels of endemism, even among ammonites, in biostratigraphic studies of the northern Spanish basins. Nevertheless, these biological factors restrict biostratigraphic zonation to broad units and allow only general correlation among the different Mid-Cretaceous sections in northern Spain, and between northern Spain and other Cretaceous areas of the world, summarized in Table 1.

To start with the Albian, this stage is unfortunately incompletely known due to the late Lower Cretaceous transgression. This transgression was, moreover, diachronous and did not affect the western part of the Vascogotic Trough. It started with the upper Middle Albian in the east and reached the western confines and the Celtiberic Trough only in the early Cenomanian. In contrast to the following stages the Albian fauna is of cosmopolitan relationships. But the water depth in this Albian seaway of northern Spain was apparently not sufficient to allow the immigration of planktonic foraminifera into the central trough. A small Upper Albian planktonic association is known from the northern flysch trough, however (Herm, 1965). Inoceramids are not yet known in Albian deposits of northern Spain, but contemporaneous inoceramids could be inserted into the zonal scheme from the Palma area of Mallorca.

A much more refined zonal scheme is possible for the Cenomanian, and improves upon the standardized subdivision of the Cenomanian, which contains only two zones. A detailed zonation has been proposed by Thomel (1962, 1972) for Southern France which closely parallels that of the Spanish sequences (Wiedmann, 1960). Some important characteristics of the Spanish Cenomanian biotas are the presence and co-occurrence of the American Tethyan genus *Graysonites* with *Hypoturrilites gravesianus* and *Orbitolina texana aperta* at the base of the European Cenomanian. In the upper part of the Stage Eurafrican Tethyan species of *Neolobites* are associated with Euramerican Temperate taxa of *Metoicoceras* and *Calycoceras*. Moreover, these can now be related to cosmopolitan inoceramids of the *I. ? crippsi* and *I. (I.) pictus* lineages, as well as to the normal sequence of *Rotalipora* species, to form a complex, widely correlated, biostratigraphic system.

The Cenomanian-Turonian boundary has been drawn in accordance with Cobban & Scott (1972), Kennedy & Hancock (this volume) and others at the last occurrence of *Metoicoceras* (Sciponoceras gracile Zone of Euramerica) and the *Inoceramus (I.) pictus* lineage. The Turonian zonation still offers several serious problems. One is the incongruity between the Lower, Middle and Upper Turonian Substages. The extreme faunal diversity and degree of evolution of Lower and Middle Turonian ammonites, permits a refined zonation of these sequences ; but diversity considerably decreases into the Upper Turonian, and great care and effort are necessary to establish an effective zonation of this Substage. This obvious incongruity between faunas of lower and higher Turonian ages is a common feature of the European and African confines, and may be partially due to differing ecological factors. A comparison with the highly developed Upper Turonian of the Western Interior basin of North America (Cobban, 1952 ; Cobban & Reeside, 1952) is thus very problematic (Table 1). In this case the correlation of ammonites with inoceramids and planktonics occurring in both regions is of extreme importance.

From the correlation chart it becomes obvious that neither *Mytiloides labiatus* (SCHLOTH.) nor *Globotruncana helvetica* BOLLI are index fossils for the base of the Turonian, as has been proposed by various authors. Both species are characteristic of the middle to late Lower Turonian as established on the ammonoid sequence by the presence of doubtful paramammitids *(P. ? saenzi* WIEDM.), leoniceratids, late fallotitids (*Ingridella malladae* (FALL.)) and representants of *Schindewolfites*. The lowermost Turonian is, however, characterized, by the first appearance of true vascoceratids (*V. gamai* CHOFF., *V. mundae* CHOFF.), which can be correlated with the ancestors of *Mytiloides labiatus* (*M. submytiloides* (SEITZ), *M. opalensis* (BOESE), *M. mytiloides* (MANTELL) in ascending succession), and by an association of praeglobotruncanids (i.e. *Praegl. lehmanni* (PORTHAULT)).

The Middle Turonian as recently defined, is characterized by the bulk of mammitids, true pseudaspidoceratids, neoptychitids, wrightoceratids and fagesiids. The ammonite zones established can again be related with the occurrence of inoceramids, in this case with *Mytiloides subhercynicus* (SEITZ), and *M. hercynicus* (PETR.) of the *labiatus* lineage and further species of the *I. cuvieri-lamarcki* group. Among the planktonic foraminifera this interval is defined by the appearance of *Globotruncana sigali* REICH., *G. schneegansi* SIGAL, *G. angusticarinata* GAND., and allied forms, all of which are commonly attributed to the Coniacian. But their occurrence in the Middle Turonian sequence has clearly been observed by J. Klaus (1959). The correspondence with the sequence and zonation of planktonics from the Préalps is nearly precise.

The Upper Turonian of northern Spain does not present equivalent biostratigraphic opportunities. It is characterized only by a poor ammonite content, especially among romaniceratids and generalized puzosiids and pachydiscids. No inoceramids are known from this interval.

Within the Coniacian, ammonite diversity and abundance once more increase and permit subdivision into 5 local zones and definition of the Turonian-Coniacian boundary on the association of *Tissotioides haplophyllus* (REDT.) with *Inoceramus winkholdioides* ANDERT and *I. ernsti* HEINZ. Lower Coniacian is defined by the further evolution of tissotiids (*Reymentoceras, Tissotia*), early barroisiceratids, gauthiericeratids and peroniceratids. *Globotruncana angusticarinata* and allied forms persist into the Lower Coniacian.

A Middle Coniacian may be separated on the base of *Gauthiericeras vallei* CIRY, and allied forms (*G. gordum* KARR.). These are correlated with the inoceramid *Cremnoceramus* of the *C. inconstans* lineage and the first appearance of the Upper Coniacian species *Magadiceramus subquadratus* (SCHLUETER). The contemporaneous foraminiferal association contains mostly benthic species as *Neoflabellina praerugosa* and *Stensiöina praeexsculpta*. Badly preserved planktonics may belong to *Globotruncana concavata* (BROTZEN).

The Upper Coniacian may be subdivided into two zones, that of Hemitissotia turzoi KARR. and H. lenticeratiformis WIEDM., n.sp. Within these two zones *Parabevahites*, *Muniericeras* and some other taxa occur, grading continuously to the Santonian *Lenticeras* and *Texanites*. *Magadiceramus subquadratus* especially occurs in this upper part of the sequence, and becomes associated with true *Globotruncana concavata* (BROTZEN).

Despite the fact that Lower Santonian sediments cannot be distinguished from those of the Upper Coniacian in most parts of northern Spain, the base of the Santonian is paleontologically well defined. It is marked by the appearance of *Texanites texanus* (ROEMER), *Lenticeras andii* (GABB), *Placenticeras syrtale* (MORTON), by platyceramids of the *P. cycloides* WEGNER group, and by the continuation of *Globotruncana concavata* (BROTZEN).

The first correlation of the zonation of the northern Spain Mid-Cretaceous with that of North America, as given on Table 1, does not need further treatment. How numerous the problems of correlation still are, becomes obvious in comparing the Temperate American neogastroplitid succession with that of western Europe. This is, however, much better to correlate with the Albian of Texas, even if several identical species are regarded to be different in both areas. Similar problems arise in comparing the North American collignoniceratids and scaphitids of Middle and Upper Turonian and Coniacian age with the contemporaneous European faunas. Therefore it has been very important to study the more useful inoceramids with "American eyes" to avoid further incongruity or even "provincialism" by different naming of American and European species. One of the most surprising results of this paper was the identity or at least similarity of most of the inoceramid species of both faunal provinces.

Future research on other important fossil groups will greatly enhance our regional biostratigraphic correlations and add further data to our understanding of Mid-Cretaceous faunal associations and their history, especially in northern Spain. Especially important will be a detailed study of the faunal differentiation in this single basin, in relation to differing environmental and paleogeographic situations. The intercorrelation of ammonites, inoceramids and planktonic foraminifera is one of the first steps toward developing a more refined, regionally applicable biostratigraphy, and may help to solve the problem of relating the distinct biozonations of the North Temperate and Tethyan Mediterranean Realms of Europe. Detailed correlation of the complex northern German Mid-Cretaceous biostratigraphic system with the Mediterranean zonation, and the standard scale, can now be anticipated, and will be one of the most important future tasks.

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The second author had the opportunity to study and revise the inoceramid collection during a research stay at the Sonderforschungsbereich 53 "Palökologie" at the Universität Tübingen.

Abbreviations :

GIPT : Geol.-paläont. Institut Universität Tübingen
GIPG : Geol.-paläont. Institut Universität Göttingen
GPIM : Geol.-paläont. Institut Universität Münster
IGD : Institut Géologique Université Dijon
CSP : Collection Sorbonne Paris
CCF : Collection Collège de France Paris
SGL : Serviços Geológicos de Portugal, Lisboa

Explanations of Text-Figures

Text-Fig. 1. Distribution of marine Iberian Middle Cretaceous and its paleogeography. A : Map of distribution of marine Mid-Cretaceous (L. Turonian) sediments. B : Simplified cross-section through the west and north Iberian basins during the Lower Turonian.

Text-Fig. 2. Reference section of the northern Celtiberic Upper Cretaceous at the Picofrentes (prov. of Soria).

Table 1. Correlation Chart of the Middle Cretaceous sequences of northern Spain compared with North America.

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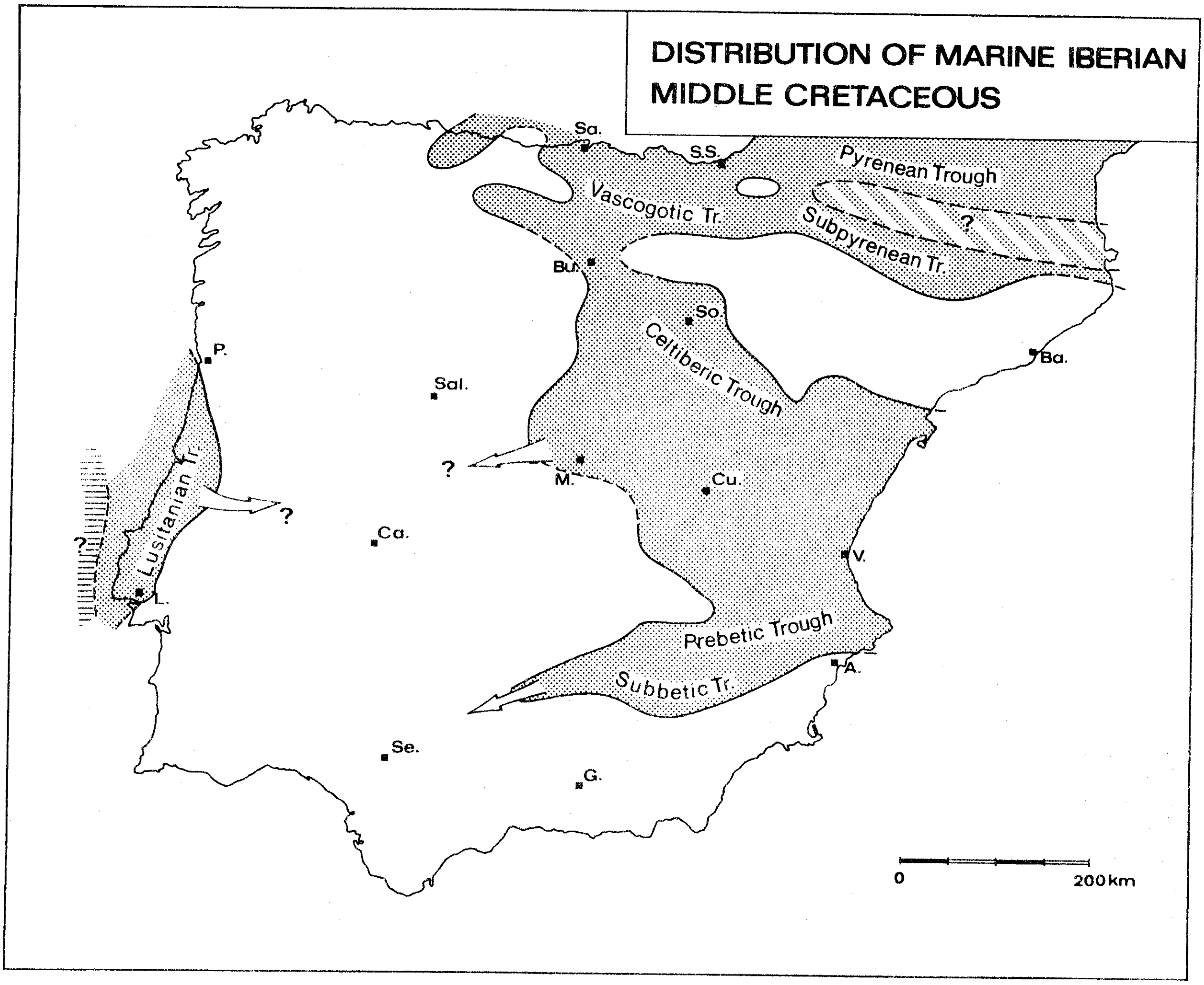
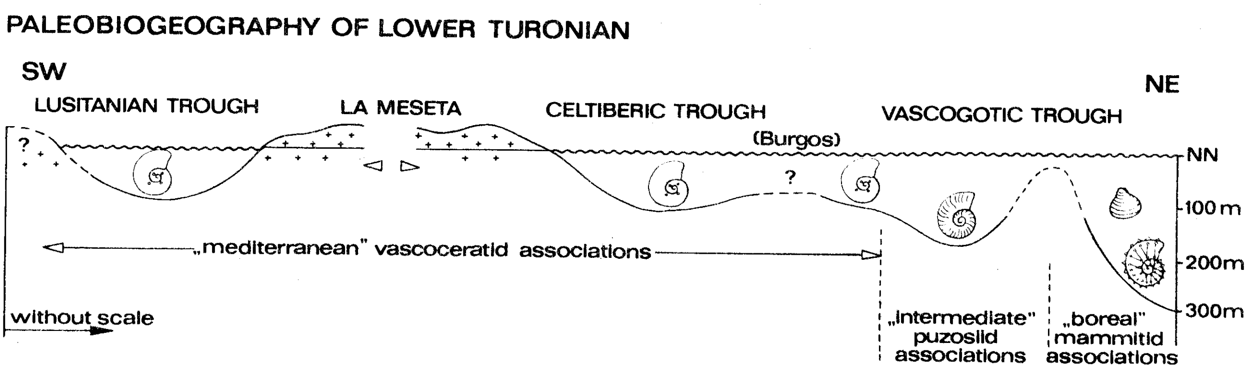


Text-Fig 1A



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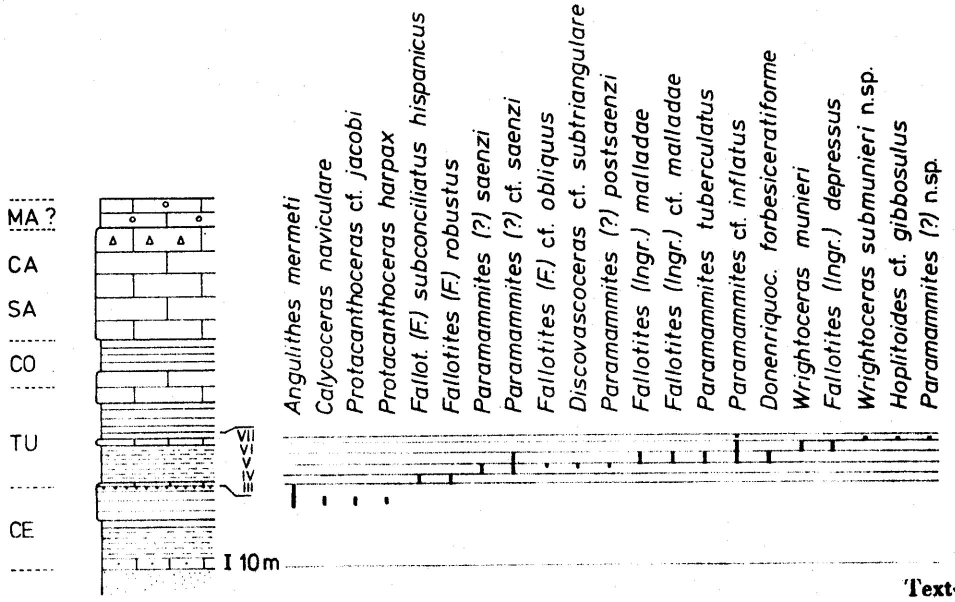


Text-Fig 2

		N. AMERICA	N. SPAIN		
		MOLLUSC ZONATION	AMMONOID ZONATION	INOCERAMID ZON.	PLANCTONIC FORAMINIFERA*
SANT.	LOWER	*Scaphites depressus*	*Texanites texanus*	*Platyceramus cycloides* subspp. *P. rhomboides heini*	*Globotruncana concavata*
CONIACIAN	UPPER	*Scaphites ventricosus*	*Hemitissotia lenticeratiformis*	*Magadiceramus subquadratus*	(*Neoflabellina praerugosa*) (*Stensioina praeexsculpta*) ?
			H. turzoi		
	MIDDLE		*Gauthiericeras vallei*	*Cremnoceramus* n.sp. ex gr. *inconstans*	
	LOWER	*Scaphites preventricosus, Inoceramus deformis*	*Reymentoceras hispanicum* + *Barroisiceras* spp.	*Inoceramus winkholdioides* *I. ernsti*	no record
		Inoceramus erectus (late form)			
		Inoceramus erectus s.s. *Barroisiceras, Peroniceras*	*Tissotioides haplophyllus*		
TURONIAN	UPPER	*Inoceramus waltersdorfensis* *I. kleini, I. frechi, Mytiloides fiegi, M.? lusatiae*	no record	no record	
		Inoceramus perplexus n.subsp. *Prionocyclus* n.sp.			
		Scaphites whitfieldi *Inoceramus perplexus*			
		Prionocyclus wyomingensis *Inoceramus dimidius* (late form)		[*I. dimidius* aff. *labiatoides*]	
		Prionocyclus macombi *Lopha lugubris* (early form)	*Romaniceras deverianum*	*I. costellatus* - *I. jacobi* ?	
	MIDDLE	*Prionocyclus hyatti* *Lopha bellaplicata bellaplicata*			
		Prionocyclus hyatti *Lopha bellaplicata novamexicana*			
		Inoceramus flaccidus *Prionocyclus hyatti*			
		Mytiloides latus *Collignoniceras woollgari?*	*Collignoniceras (C.)?* sp.	*I.* ex. gr. *lamarcki-cuvieri?*	
		Mytiloides hercynicus *Collignoniceras woollgari*	*Neoptychites* + *Pseudospidoceras armatum*	*Mytiloides hercynicus*	*Globotruncana angusticarinata*
		Collignoniceras woollgari, Myt. subhernicus	*Wrightoceras munieri* + *Spathitoides sulcatus*	*M. subhercynicus*	*G. schneegansi*
	LOWER	*Mytiloides labiatus* s.s.	*Ingridella malladae* + *Schindewolfites* spp.	[*M. labiatus?*]	*G. sigali*
		Myt. mytiloides *Mammites nodosoides*	*Leoniceras discoidale* + *Paramammites saenzi*	*M. mytiloides*	*G. helvetica*
		Myt. opalensis *Watinoceras coloradoense*	*Fallotites subconciliatus*	*M. opalensis*	*Praeglobotr. lehmanni*
			Vascoceras gamai	*M. submytiloides*	
CENOMANIAN	UPPER	*Sciponoceras gracile*	*Metoicoceras geslinianum*	*Inoceramus pictus* n.subsp.	*Rotalipora cushmani* *R. montsalvensis*
		Dunveganoceras albertense	*Metoicoceras muelleri*		
		Dunveganoceras conditum	*Calycoceras (Lotzeites) lotzei* + *Neolobites vibrayeanus*		
		Dunveganoceras pondi			
		Plesiacanthoceras wyomingense	*Eucalycoceras spathi*	*I.* aff. *pretragilis*	*R. brotzeni*
		Acanthoceras amphibolum			
	MIDDLE	*Acanth. muldoonense*	?	*I. etheridgei* s.l. ?	*R. appenninica*
		Acanth. granerosense	*Euomphaloceras cunningtoni*	*I. reachensis* n.subsp. B.	
		Calycoceras (Conlinoceras) gilberti			
	LOWER	"*Inoceramus*" *bellvuensis* (late form) ?="*I.*" *crippsi* s.l.	*Mantelliceras mantelli*		
		"*Inoceramus*" *dunveganensis* "*I.*" *athabaskensis* "*I.*" *bellvuensis*, n.subsp.	*Graysonites* sp. + *Hypoturrilites mantelli*	[*I. pictus* cf. *neocaledonicus*]	(*Orbitolina texana aperta*)[1]
ALBIAN	UPPER	*Neogastroplites maclearni*	*Stoliczkaia dispar* *Paraturrilites quadrituberculatus* *Pervinquieria (P.) fallax*		
		Neogastropl. americanus			
		Neogastropl. muelleri			*Ticinella roberti*
		Neogastropl. cornutus	*Pervinquieria (P.) inflata*		
		Neogastropl. haasi		?	
		unzoned	*Hysteroceras orbignyi**	[*Birostrina concentrica concentrica*] *B. munsoni* s.l.	
	MIDDLE	unzoned	*Mojsisoviczia remota*	[*Birostrina concentrica* n.subsp.]	no record
	LOWER	unzoned	no record		

*FIRST APPEARANCES

Table 1

PLATE 1

MIDDLE CRETACEOUS INOCERAMIDAE OF MALLORCA AND NORTHERN SPAIN

FIGS. 1, 2, 7. — *Birostrina concentrica* (PARKINSON), n. subsp. 1 (aff. n. subsp. B of England and South Africa / KAUFFMAN, this volume)

Lateral views of internal molds.
Middle Albian, Wiedmann loc. C_3 10557, between Son Vida and Santa Eulalia, near Palma de Mallorca.
1, 2. Right and left valves of GPIT 1457/16 and 1457/19, respectively. 2/1.
7. Right valve, with shell adhering dorsally, GPIT 1457/18. 2/1.

FIGS. 3-6, 8, 10. — *Birostrina concentrica* (PARKINSON), n. subsp. 2 (aff. *B. concentrica brasiliensis* (WHITE) transitional to subsp. C, D of England and South Africa).

Internal molds.
Late Middle to early Late (?) Albian. Same locality as above.
3, 4. Anterior and lateral views, respectively, left valve of specimen GPIT 1457/5, transitional to subsp. *brasiliensis*, and showing possible gastropod boring. 1/1.
5. Left valve of specimen GPIT 1457/15, transitional to subsp. D.
6. Anterior view, right valve of GPIT 1457/6. 1/1.
8. Left valve of abnormally smooth specimen GPIT 1457/8, transitional to subsp. 1. /2/1.
10. Typical right valve, GPIT 1457/10. 2/1.

FIGS. 9, 13. — *Birostrina concentrica concentrica* (PARKINSON).

Finely ribbed form between subsp. 1 and 2. Lateral views, internal molds of left valves.
Late Middle to early Late (?) Albian. Same locality as above.
9. Hypotype GPIT 1457/20. 1/1.
13. Hypotype GPIT 1457/17. /2/1.

FIG. 11. — *Birostrina munsoni* (CRAGIN), *s.l.*, n. subsp. with weak sulci.

Lateral view of internal mold, left valve, hypotype GPIT 1457/2. 2/1.

FIG. 12. — *Birostrina concentrica concentrica* (PARKINSON).

Late broad form of early Late Albian (?) age. Same locality as above.
Lateral view of internal mold, left valve, hypotype 1457/9. 1/1.

Fig. 14. — *Birostrina concentrica concentrica* (PARKINSON).

Anterior view of internal mold, left valve, hypotype 1457/4, with possible gastropod boring. 2/1.
Early Late Albian (?). Same locality as above.

FIG. 15. — *Inoceramus (Inoceramus)* sp. aff. *I. prefragilis* STEPHENSON.

Lateral view of partial right valve, GPIT 1456/32. 2/1.
Late Cenomanian, N of Ganuza, near Estella (Navarra).
Wiedmann loc. L_2 131062.

FIG. 16. — *Inoceramus (Inoceramus) pictus* SOWERBY, n. subsp. with fine concentric ornament.

Internal mold of left valve, GPIT 1456/2. 2/1.
Late Cenomanian, E of Ganuza (Navarra). Loc. M_{14}13465.

FIG. 17. — *"Inoceramus" reachensis* ETHERIDGE, n. subsp. B (see WOODS, 1911, pl. 48, fig. 5).

Right lateral view of internal mold, GPIT 1456/1. 1/1.
Lower to Middle Cenomanian, near Metauten (Navarra).
Wiedmann loc. H_1 211057.

FIG. 18. — *Inoceramus (Inoceramus) etheridgei* WOODS, *s.l.*

Left valve, lateral view, hypotype GPIT 1456/3. 2/1.
Middle Cenomanian, N of Ganuza (Navarra), Wiedmann loc. C_2 131062.

FIG. 19. — *Mytiloides submytiloides* (SEITZ).

Internal mold of right valve, lateral view, hypotype GPIT 1456/23. 1/1.
Turonian IV, E of Ganuza (Navarra). Wiedmann loc. H_{10} 161057.

FIG. 20. — *Inoceramus (Inoceramus) pictus* SOWERBY cf. subsp. *neocaledonicus (sensu* PERGAMENT, 1966, pl. 30, figs. 2, 3).

Internal mold of right valve, lateral view, GPIT 1456/14. 2/1.
Earliest Cenomanian (?), Wiedmann locality $C_4$17557, 50 m W of Selva, Mallorca.

FIG. 21. — *"Inoceramus" crippsi* MANTELL.

Hypotype 1456/98. Internal mold of right valve, lateral view. 1/1.
Wiedmann locality $C_3$18858, Dieulefit-Bourdeaux (Drôme, France). Illustrated to demonstrate the concept of species used in Spain (material poor).

FIG. 22. — *Mytiloides opalensis elongata* (SEITZ).

Hypotype GPIT 1456/7, transitional to *M. opalensis s.s.*.
Lateral view, internal mold of right valve. 1/1.
Turonian IV (loc. H_{10}161057), E of Ganuza (Navarra).

FIG. 23. — *Mytiloides submytiloides* (SEITZ), new rugate subsp. transitional to early *M. mytiloides*.

Internal mold of left valve, lateral view, GPIT 1456/99. 1/1.
Turonian IV (loc. H_{10}161057), E of Ganuza (Navarra).

PLATE 2

MIDDLE CRETACEOUS AND CONIACIAN INOCERAMIDAE OF NORTHERN SPAIN

FIGS. 1, 4. — *Mytiloides subhercynicus* (SEITZ).

Lateral views, right and left valves, respectively.
Turonian V of Northern Spain.
1. Hypotype GPIT 1456/21, transitional to *M. mytiloides*. Wiedmann locality $C_1$241056, near Poza de la Sal (Burgos).
4. Hypotype GPIT 1456/18. Locality $C_1$51062, near Izurdiaga (Navarra). Both 1/1.

FIG. 2. — *Mytiloides hercynicus* (PETRASCHECK).

Lateral view, internal mold of left valve, hypotype GPIT 1456/25. 1/1.
Turonian VI (loc. $C_5$2961), Railroad cut near Puentedei (Burgos).

FIGS. 3, 7. —*Mytiloides mytiloides* (MANTELL).

Right lateral views, internal composite molds.
Turonian III.
3. Hypotype GPIT 1456/4, posterior auricle broken off. Wiedmann locality L_3 24960, near San Martín de las Ollas (Burgos).
7. Hypotype GPIT 1456/5, posterior auricle deformed. Same locality.

FIGS. 5, 11. —*Mytiloides opalensis elongata* (SEITZ).

Internal composite molds, lateral views. Turonian IV.
5. Typical left valve, hypotype GPIT 1456/8. 2/1. Locality H_{10}161057, E of Ganuza (Navarra).
11. Right valve, Hypotype GPIT 1456/10. 1/1. Same locality.

FIGS. 6, 15. — *Mytiloides jacobi* (HEINZ), *s.l.* (=*M, "latus"* of many authors).

Lateral views, composite internal molds. Turonian IV.
6. Right valve, hypotype 1456/26. 1/1. Wiedmann locality H_{10}161057, E of Ganuza (Navarra).
15. Left valve, hypotype GPIT 1456/28. 1/1. Wiedmann locality $C_2$4465, near La Hoz (Alava).

FIGS. 8, 9. — *Inoceramus (?)* sp. ex gr. *I. dachslochensis* ANDERT - *I. koeneni* MÜLLER - *I. ernsti* HEINZ.

Right lateral and anterior views, respectively, internal mold, hypotype GPIT 1456/39. 1/1.
Early Coniacian, Cubillos del Rojo (Burgos). Wiedmann locality $C_2$19957.

FIG. 10. — *Cremnoceramus* sp. aff. *C. inconstans* WOODS, n. sp. with fine, equal ornament.

Internal mold of juvenile left valve prior to slope break. Hypotype GPIT 1456/34. 3/1.
Late Early to Middle Coniacian, S of Olazagutía (Alava). Wiedmann locality $C_6$7465.

FIG. 12. — *Inoceramus longealatus* TRÖGER, n. subsp. (with coarse ribs).

Lateral view of internal mold, left valve, hypotype GPIT 1456/36. 1/1.
Late Early Coniacian, W of Osma (Burgos). Locality $C_6$16857.

FIG. 13. — *Inoceramus winkholdioides* ANDERT.

Lateral view, internal mold of broken left valve, hypotype GPIT 1456/37. 1/1.
Early Coniacian, NW of Nidaguila (Burgos). Locality $C_4$31757.

FIG. 14. — *Mytiloides subhercynicus transiens* (SEITZ) ?.

Doubtful hypotype GPIT 1456/19. Internal composite mold of right valve, lateral view. 1/1.
Early Middle Turonian, Quintanabaldo-Puentedei (Burgos). Wiedmann locality $H_7$22957.

FIG. 16. — *Magadiceramus subquadratus* (SCHLÜTER).

Internal mold, crushed right valve, lateral view, hypotype GPIT 1456/41. 1/1.
Middle Coniacian, S of Villamartín (Burgos). Wiedmann locality H_{12}31062.

PLATE 3

VASCOGOTIC ALBIAN AMMONITES

FIG. 1. — *Pervinquieria (Pervinquieria) fallax* BREISTROFFER.

Hypotype GPIM L 6004. (leg. Lotze). Lateral view of compressed middle age whorls. 2/3.
Lower Vraconian (Albian Va), Road cut N of Villareal de Alava, Northern Spain.

FIG. 2 — *Stoliczkaia dispar* (D'ORBIGNY).

Hypotype GPIT 1456/101 (leg. Wiedmann). Lateral view of mature specimen. 1/1.
Sandstone member of Lower Vraconian (Albian Va), S of Villareal de Alava, Northern Spain (locality $C_1$7961).

FIG. 3. — *Paraturrilites (Bergericeras) quadrituberculatus* (BAYLE), (= *P. (B.) bergeri crassituberculatus* in WIEDMANN 1962b, pl. 11, fig. 1).

Hypotype GPIT 1162/61 (leg Wiedmann). Lateral view of part of phragmocone. 1/1.
Black limestone member of Upper Vraconian (Albian Vb), S of Villareal de Alava, Northern Spain (locality $H_1$121057).

FIG. 4. — *Pervinquieria (Deiradoceras) cunningtoni* (SPATH).

Hypotype GPIM L 6003 (leg. Lotze).
Limestone member of middle Upper Albian (Albian IV ?), near Irurzun (Navarra).
A. Lateral view of phragmocone, *B.* Ventral view. *C.* Cross section. 2/3.

FIG. 5. — *Hysteroceras orbignyi* SPATH.

Hypotype GPIT 1456/102 (leg. Wiedmann).
Marly member, lowermost Upper Albian (locality $C_3$7961), near Echarri Aranaz (Navarra).
A. Lateral view, *B.* ventral view of incomplete specimen. 2/1.

FIG. 6. — *Hyphoplites (Discohoplites) subfalcatus* (SEMENOV).

Hypotype GPIT 1456/103 (leg. Wiedmann).
Black limestone member of Upper Vraconian (Albian Vb), S of Villareal de Alava (locality $H_1$121057).
A. Lateral, *B.* ventral view of specimen with shell preserved. 1/1.

FIG. 7. — *Mojsisoviczia (Mojsisoviczia) remota* (SPATH).

Hypotype IGD Ce 044 (leg. Ciry).
Marly member of upper Middle Albian (Albian II), railway station Alsasua (Navarra).
A. Lateral, *B.* frontal, *C.* ventral view of specimen with living chamber preserved. 1/1.

MEASUREMENTS :

		Dm.		W.h.	W.b.	Dm. U.
1.	~	105 mm	<	47 mm (0.45)	—	> 38 mm (0.36)
2.		61 mm		26 mm (0.43)	—	12 mm (0.20)
3.		——				
4.	~	135 mm		45 mm (0.33)	49 mm (0.36)	63 mm (0.47)
5.		16 mm		6 mm (0.37)	5 mm (0.31)	5 mm (0.31)
6.	~	40 mm		16.5 mm (0.41)	11 mm (0.28)	~ 11.5 mm (0.29)
7.		32 mm		15 mm (0.47)	14.5 mm (0.45) or 12 mm (0.37)	8.5 mm (0.26)

PLATE 4

VASCOGOTIC LOWER CENOMANIAN AMMONITES

FIG. 1. — *Hypoturrilites mantelli* (SHARPE).

Hypotype GPIT 1456/104 (leg. Wiedmann).
Red sandstone member of Cenomanian I ($C_2$17463), between Nava de Ordunte and La Vega (Burgos). Below the base of "Lower Ordunte Beds" of LOTZE (1960).
A. Lateral, *B.* basal view. 2/1.

FIG. 2. — *Turrilites (Euturrilites) scheuchzerianus* BOSC.

Hypotype GPIM L 6001 (leg. Lotze). Fragmentary specimen. 1/1.
Marly Lower Cenomanian of Izurdiaga (Navarra).

FIG. 3. — *Mantelliceras hyatti* SPATH.

Hypotype GPIM L 6016 (leg. Lotze).
Black marly limestone of Cenomanian II (Base of "Campillo Beds" of LOTZE (1960)), SE of Burceña (Burgos).
A. Lateral, *B.* ventral view of crushed mature specimen. 1/1.

FIG. 4. — *Mantelliceras tuberculatum* (MANTELL).

Hypotype GPIM L 6009 (leg. Lotze).
"Flysch à boules" - member of Cenomanian II, N of Agüera (Burgos). "Upper Ordunte Beds" of LOTZE (1960).
A. Lateral, *B.* ventral view of fragmentary specimen. 1/1.

FIG. 5. — *Graysonites* sp.

Poorly preserved specimen, GPIT 1456/105.
Red sandstone member of Cenomanian I (below base of "Lower Ordunte Beds" of LOTZE (1960)), Pantano de Ordunte (Burgos).
A. Lateral view of crushed living chamber fragment.
B. Lateral, *C.* ventral view of inner whorl. 1/1.

MEASUREMENTS :

	Dm.	W.h.		W.b.	Dm. U.
3.	90 mm	37.5 mm (0.42)	>	23 mm (0.26)	25.5 mm (0.28)
4.	—	31 mm		30 mm	—

PLATE 5

VASCOGOTIC AND CELTIBERIC MIDDLE CENOMANIAN AMMONITES

FIG. 1. — *Calycoceras* n. sp. *C. paucinodatum* (CRICK).

Specimen with part of living chamber preserved, GPIT 1456/106 (leg. Wiedmann).
Cenomanian IV of locality $H_2$161057, E of Ganuza (Navarra), Vascogotic Ranges.
A. Lateral, *B.* frontal view. 1/3.

FIG. 2. — ***Eucalycoceras spathi*** COLLIGNON.

Hypotype GPIT 1456/107 (leg. Wiedmann), with part of living chamber.
Cenomanian IV (locality $C_4$131062), N of Ganuza (Navarra), Vascogotic Ranges.
A. Lateral, *B.* ventral view. 2/3.

FIG. 3. — *Euomphaloceras tuberculatum* (PERVINQUIERE).

Hypotype CSP Ce 01 (leg. Larrazet).
Upper Middle Cenomanian (III ?), between Briongos and Tejada (Burgos), Celtiberic Ranges.
A. Lateral, *B.* ventral view. 1/1.

FIG. 4. — *Eucalycoceras rowei* (SPATH).

Hypotype GPIT 1456/108 (leg. Schroeder), with part of living chamber, lateral view. 2/3.
Cenomanian IV (?), N of Agüera (Burgos), Vascogotic Ranges.

FIG. 5. — *Euomphaloceras cunningtoni* (SHARPE) n. subsp. ?

Doubtful hypotype GPIG 5931 (leg. Selzer), with living chamber.
Middle Cenomanian (III), between Sopeira and Conudella (Navarra), Vascogotic Ranges.
A. Lateral, *B.* frontal view. 2/3.

MEASUREMENTS :

1.	245 mm	108 mm (0.44)		133 mm (0.54)	66 mm (0.27)
2.	96 mm	39 mm (0.41)		39 mm (0.41)	30 mm (0.31)
3.	65 mm	28 mm (0.43)		36 mm (0.56)	22 mm (0.32)
4.	100 mm	38 mm (0.38)	>	30 mm (0.30)	36 mm (0.36)
5.	~ 95 mm	38 mm (0.40)	>	40 mm (0.42)	35 mm (0.37)

PLATE 6

VASCOGOTIC AND CELTIBERIC UPPER CENOMANIAN AMMONITES

FIG. 1. — *Calycoceras (Lotzeites) lotzei* WIEDMANN.

Holotype GPIT 1162/1 (see WIEDMANN 1960, pl. 2, figs. 1, 2).
Cenomanian V ("Hijuela Beds" of LOTZE (1960)), NE of La Mata near Villasana de Mena (Burgos), Vascogotic Ranges.
A. Lateral, *B.* ventral view. 1/1.

FIG. 2. — *Eucalycoceras gothicum* (KOSSMAT).

Hypotype GPIM L 6026 (leg. Lotze).
Cenomanian V (?) of Izurdiaga (Navarra), Vascogotic Ranges.
Specimen with part of living chamber, lateral view. 1/1.

FIG. 3. — *Metoicoceras muelleri* COBBAN.

Hypotype GPIT 1456/109 (leg. Wiedmann).
Cenomanian VI of locality $H_2$28957, W of Puentedei (Burgos), Vascogotic Ranges.
A. Lateral, *B.* ventral view of inner whorl. 1/1.

FIG. 4. — *Metoicoceras geslinianum* (D'ORBIGNY) (= *M. whitei* in WIEDMANN, 1960)

Hypotype GPIT 1456/110 (leg. Wiedmann).
Uppermost Cenomanian (VII), locality $C_1$8657, near Rello (Soria), Celtiberic Ranges.
A. Lateral, *B.* ventral view of immature specimen with living chamber preserved. 1/1.

FIG. 5. — *Metoicoceras geslinianum* (D'ORBIGNY).

Hypotype GPIT 1456/111 (leg. Wiedmann).
Uppermost Cenomanian (VII), locality $L_2$23957, W of Puentedei (Burgos), Vascogotic Ranges.
Lateral view of specimen with evolving initial part of living chamber. 2/3.

FIG. 6. — *Calycoceras* sp. cf. *C. subgentoni* SPATH.

GPIT Ce 1456/112 (leg. Wiedmann).
Upper Cenomanian (V?) of locality $C_1$19757, NW of Hinojar de Cervera (Burgos), Celtiberic Ranges.
A. Lateral, *B.* ventral view of immature specimen. 1/1.

FIG. 7. — *Neolobites vibrayeanus* (D'ORBIGNY).

Hypotype GPIT 1456/113 (leg. Wiedmann).
Upper Cenomanian (VI), locality H_{10}22957, W of Puentedei (Burgos), Vascogotic Ranges.
A. Lateral, *B.* frontal view of phragmocone. 1/1.

MEASUREMENTS :

1.		43 mm		18 mm (0.42)		25 mm (0.58)	
					or	20 mm (0.47)	14 mm (0.33)
2.		66 mm		28 mm (0.42)		26 mm (0.39)	18 mm (0.27)
3.		46 mm		26 mm (0.56)	>	10 mm (0.22)	4 mm (0.09)
4.		60 mm		30 mm (0.50)	>	19 mm (0.32)	9.5 mm (0.16)
5.	~	100 mm	~	45 mm (0.45)	>	23 mm (0.23)	22 mm (0.22)
6.	~	35 mm		14 mm (0.40)		13 mm (0.37)	8.7 mm (0.25)
7.		85 mm		48 mm (0.57)		24.5 mm (0.29)	7.5 mm (0.09)

PLATE 7

LUSITANIAN AND CELTIBERIC LOWER TURONIAN AMMONITES

FIG. 1. — *Vascoceras gamai* CHOFFAT.

Paratype SGL coll. no. 808 (see CHOFFAT, 1898, pl. 7, fig. 2), with living chamber preserved, lateral view. 1/2.
Turonian I (Bed 21), Meirinhas-de-Baixo, Portugal.

FIG. 2. — *Fallotites subconciliatus choffati* WIEDMANN.

Hypotype CSP Ceph 23 (leg. Chudeau).
Turonian II, Villaciervos (Soria).
A. Lateral, *B.* frontal view of phragmocone. 1/1.

FIG. 3. — *Paramammites (?) saenzi* WIEDMANN.

Hypotype CSP Ceph 11 (leg. Chudeau), lateral view of phragmocone. 1/1.
Lower Turonian III, Picofrentes (Soria).

FIG. 4. — *Ingridella malladae* (FALLOT).

Hypotype CCF Amm 2 (leg. Fallot), with living chamber preserved, lateral view. 1/1.
Late Lower Turonian (IV), Picofrentes (Soria).

MEASUREMENTS :

1.	115 mm	43 mm (0.39)		—	39 mm (0.34)
2.	67 mm	33 mm (0.49)		41 mm (0.61) or 36 mm (0.54)	12 mm (0.18)
3.	97 mm	38 mm (0.39)	>	50 mm (0.51)	30 mm (0.31)
4.	115 mm	37 mm (0.32)	>	50 mm (0.43)	55 mm (0.48)

PLATE 8

CELTIBERIC MIDDLE TURONIAN AND CONIACIAN AMMONITES

FIG. 1. — *Wrightoceras munieri* (PERVINQUIERE).

Hypotype GPIT 1471/1 (leg. Wiedmann), with living chamber, lateral view. 1/2.
Turonian V (locality C_8 101055), Picofrentes (Soria).

FIG. 2. — *Wrightoceras submunieri* WIEDMANN.

Holotype GPIT 1471/2 (leg. Wiedmann).
Lower part of Turonian VI (locality C_8 61055), Picofrentes (Soria).
A. Lateral, *B*. frontal view of phragmocone. 1/1.

FIG. 3. — *Hemitissotia celtiberica* WIEDMANN.

Holotype GPIT 1471/3 (leg. Wiedmann).
Upper Coniacian (locality C_1 23757), km 65, between Hortezuelos and Espinosa de Cervera (Burgos).
A. Lateral, *B*. frontal view of mature specimen. 1/1.

MEASUREMENTS :

1.	163 mm	91 mm (0.56)	52 mm (0.32)	10 mm (0.06)
2.	84 mm	48 mm (0.57)	28 mm (0.33)	6 mm (0.07)
3.	110 mm	63 mm (0.57)	26 mm (0.24)	. 3 mm (0.02)

PLATE 9

VASCOGOTIC LOWER AND MIDDLE TURONIAN AMMONITES

FIG. 1. — *Jeanrogericeras* cf. *binicostatum* (PETRASCHECK).
Doubtful hypotype GPIT 1456/114 (leg. Wiedmann).
Lower Turonian (III), locality H_5 161057, E of Ganuza (Navarra).
A. Lateral, *B*. ventral view of phragmocone. 1/1.

FIG. 2. — *Choffaticeras quaasi* (PERON).
Hypotype IGD Ce 020 (leg. Ciry).
Lower Turonian (II), between Santa Cruz del Tozo and Terradillos de Sedano (Burgos).
A. Lateral, *B*. ventral view of phragmocone. 2/3.

FIG. 3. — *Leoniceras* cf. *L. barjonai* (CHOFFAT).
Doubtful hypotype IGD Ce 08 (leg. Ciry).
Same horizon, same locality.
Lateral view of mature specimen. 1/2.

FIG. 4. — *Fallotites subconciliatus* (CHOFFAT).
Hypotype GPIT 1456/115 (leg. Wiedmann), typical specimen.
Glauconitic Lower Turonian (II ?), locality $H_6$23957, Railway cut La Robla, near Pedrosa (Burgos).
Lateral view of mature specimen. 2/3.

FIG. 5. — *Schindewolfites ganuzai* WIEDMANN.
Holotype GPIT 1162/7 (leg. Wiedmann).
Upper Lower Turonian (IV), locality H_{10}161057), E of Ganuza (Navarra).
A. Lateral, *B*. ventral view of fragmentary specimen. 1/1.

FIG. 6. — *Neoptychites (Spathitoides)* sulcatus WIEDMANN.
Holotype GPIT 1162/4 (leg. Wiedmann).
Early Middle Turonian (V), locality $H_4$23957, Railway cut La Robla, near Pedrosa (Burgos).
A. Lateral, *B*. ventral view of mature specimen. 2/3.

MEASUREMENTS :

1.	62 mm	31 mm (0.50)	> 17 mm (—)	10 mm (0.16)
2.	100 mm	51 mm (0.51)	30 mm (0.30)	13 mm (0.13)
3.	> 135 mm	65 mm (0.48)	> 40 mm (—)	20 mm (0.15)
4.	115 mm	50 mm (0.43)	45 mm (0.39)	30 mm (0.26)
5.	~ 52 mm	19 mm (0.37)	21 mm (0.40)	~ 19 mm (0.37)
6.	117 mm	60 mm (0.51)	60 mm (0.51)	15 mm (0.13)

PLATE 10

VASCOGOTIC MIDDLE AND UPPER TURONIAN AMMONITES

FIG. 1. — *Romaniceras inerme* (GROSSOUVRE).

Hypotype GPIT 1456/116 (leg. Wiedmann).
Late Middle Turonian (VII), locality H_{19}161057, near Ganuza (Navarra).
A. Lateral, *B*. ventral view of phragmocone. 2/3.

FIG. 2. — *Neoptychites (Neoptychites) cephalotus* (COURTILLER).

Hypotype GPIT 1456/117 (leg. Wiedmann).
Middle Turonian (VI), locality $C_4$17957, near San Martín de las Ollas (Burgos).
A. Lateral, *B*. frontal view of phragmocone. 1/1.

FIG. 3. — *Mammites vielbanci* (D'ORBIGNY).

Hypotype GPIT 1456/118 (leg. Wiedmann).
Middle Turonian (V), locality $C_2$3957, Road cut, km 4, between Masa and Saldaña (Burgos).
A. Lateral, *B*. ventral view of phragmocone. 1/1.

FIG. 4. — *Pseudaspidoceras salmuriense* (COURTILLER).

Hypotype GPIT 1456/119 (leg. Wiedmann).
Middle Turonian (VI), locality H_{22} 161057, near Ganuza (Navarra).
A. Lateral, *B*. frontal view of incomplete specimen. 1/2.

MEASUREMENTS :

1.	103 mm	44 mm (0.43)	>	43 mm (0.42)	35 mm (0.34)
2.	73 mm	43 mm (0.59)		30 mm (0.41)	5 mm (0.07)
3.	85 mm	40 mm (0.47)		44 mm (0.52)	18 mm (0.21)
4.	190 mm	67 mm (0.35)	>	50 mm (0.27)	70 mm (0.42)

PLATE 11

VASCOGOTIC LOWER AND MIDDLE CONIACIAN AMMONITES

FIG. 1. — *Gauthiericeras gordum* KARRENBERG.

Hypotype GPIT 1456/125 (leg. Merten).
Middle Coniacian (III?), Castrobarto, SW of Villasana d.M.).
A. Lateral, *B*. ventral view. 1/1.

FIG. 2. — *Tissotia (Metatissotia) ewaldi* (BUCH).

Hypotype IGD, Ce 011 (leg. Ciry).
Marly Lower Coniacian (I), near Terradillos de Sedano (Burgos).
A. Lateral, *B*. frontal view of phragmocone. 1/1.

FIG. 3. — *Barroisiceras (?)* cf. *B. sequens* (GROSSOUVRE).

Doubtful hypotype GPIT 1456/120 (leg Wiedmann).
Middle Coniacian (III), locality H_{10} 1857, near Nidaguila (Burgos).
A. Lateral, *B*. ventral view of specimen with initial part of living chamber, intermediate between *Barroisiceras sequens* and *Texasia* ex gr. *dartoni* REESIDE. 1/2.

FIG. 4. — *Tissotioides haplophyllus* (REDTENBACHER).

Hypotype GPIT 1456/121 (leg. Wiedmann), with living chamber preserved. Lateral view. 2/3.
Glauconitic marls of Lower Coniacian (I), locality C_5 13857, near Terradillos de Sedano (Burgos).

FIG. 5. — *Reymentoceras hispanicus* WIEDMANN.

Holotype GPIT 1162/8 (leg. Wiedmann).
Lower Coniacian (II), locality C_0 2957, near Terradillos de Sedano (Burgos).
A. Lateral, *B*. frontal view. 1/1.

MEASUREMENTS :

1.	71 mm	27.5 mm (0.39)	32 mm (0.45)	26 mm (0.37)
2.	90 mm	49 mm (0.54)	28 mm (0.31)	9 mm (0.10)
3.	182 mm	70 mm (0.38)	> 34 mm (0.19)	55 mm (0.30)
4.	101 mm	46 mm (0.45)	> 37 mm (0.36)	23.5 mm (0.23)
5.	64 mm	30 mm (0.47)	27 mm (0.42)	14 mm (0.22)

PLATE 12

VASCOGOTIC UPPER CONIACIAN AND LOWER SANTONIAN AMMONITES

FIG. 1. — *Parabevahites emscheris* (SCHLÜTER).

Hypotype GPIM L 6053 (leg. Lotze), lateral view of living chamber fragment. 2/3.
Lower Upper Coniacian (IV), Lower "Lastras Formation" (LOTZE 1960) S of Villasana de Mena (Burgos).

FIG. 2. — *Hemitissotia lenticeratiformis* WIEDMANN, n. sp.*

Holotype GPIT 1456/122.
Uppermost Coniacian (V), locality $C_2$24957, near Turzo (Burgos).
A. Lateral, *B*. ventral view of phragmocone. 1/1.

FIG. 3. — *Hemitissotia turzoi* KARRENBERG.
Hypotype GPIT 1456/123 (leg. Wiedmann).

Early Upper Coniacian (IV), locality $C_2$2957, near Terradillos de Sedano (Burgos).
A. Lateral, *B*. ventral view of mature specimen. 2/3.

FIG. 4. — *Texanites* n. sp. cf. *T. hourcqi* COLLIGNON.

Specimen GPIT 1456/124 (leg. Wiedmann).
Lower Santonian (I), locality H_{10}181057, near Osma (Alava).
A. Lateral, *B*. ventral view of phragmocone. 2/3.

*Diagnosis : Inflated hemitissotiid species with lanceolate whorl section having the maximum thickness near the small umbilicus. 12 blunt and straight ribs per whorl, especially on outer part of whorls.
Affinities : Similar to "plesiotissotiids" of the *michaleti* PERON group, with sharper primary and secondary ribs, and *H. batnensis* PERON, with even more inflated whorls. Intermediate between *Hemitissotia* (= *"Plesiotissotia"*) and *Lenticeras*.
Age : Uppermost Coniacian, Occurrence : Northern Spain.

MEASUREMENTS :

1.	—	70 mm	~	50 mm	
2.	79 mm	45 mm (0.57)	>	23 mm (0.29)	9 mm (0.11)
3.	131 mm	69 mm (0.52)		24 mm (0.18)	—
4.	155 mm	46 mm (0.30)	>	27 mm (0.17)	74 mm (0.48)

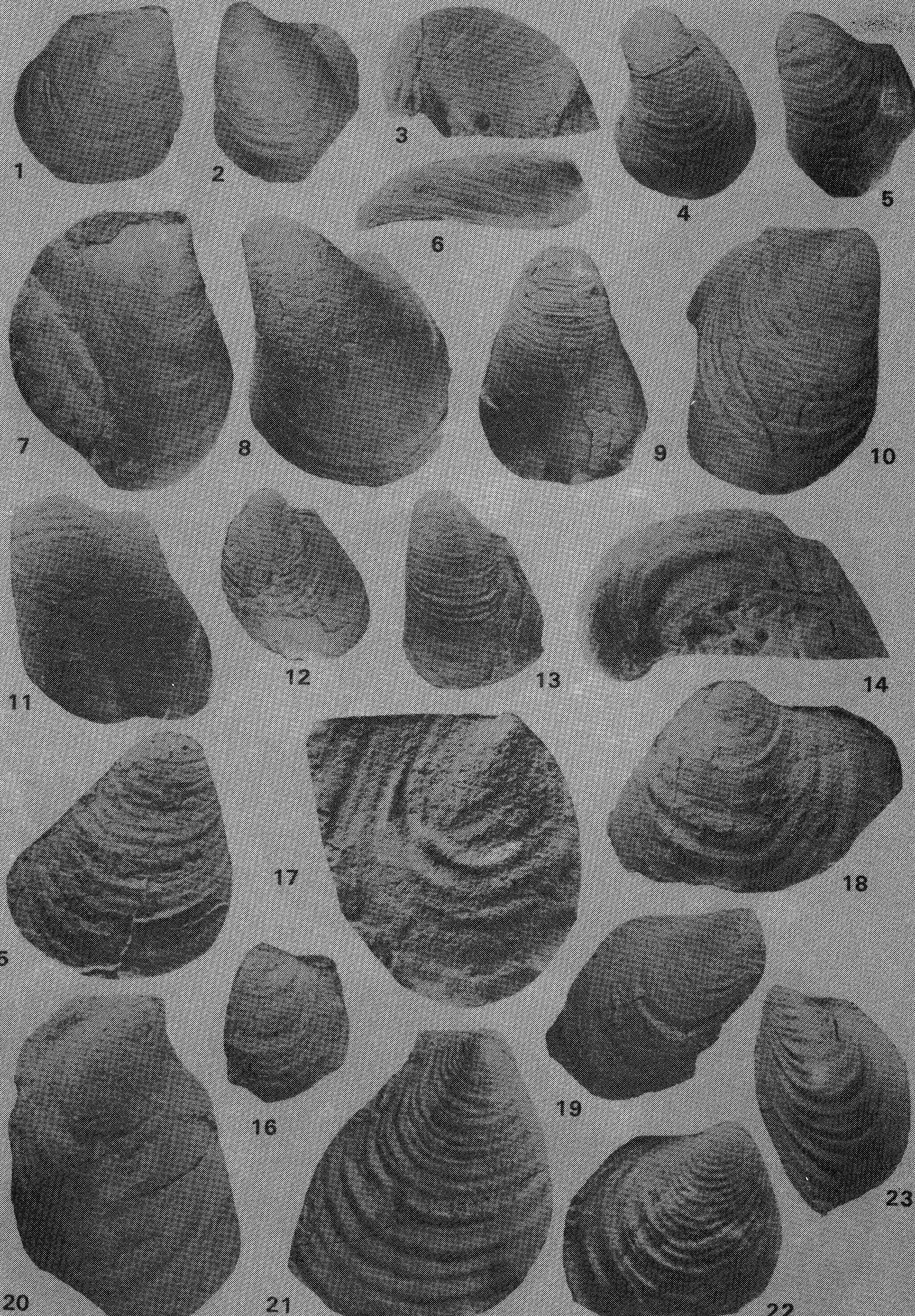


Plate 1

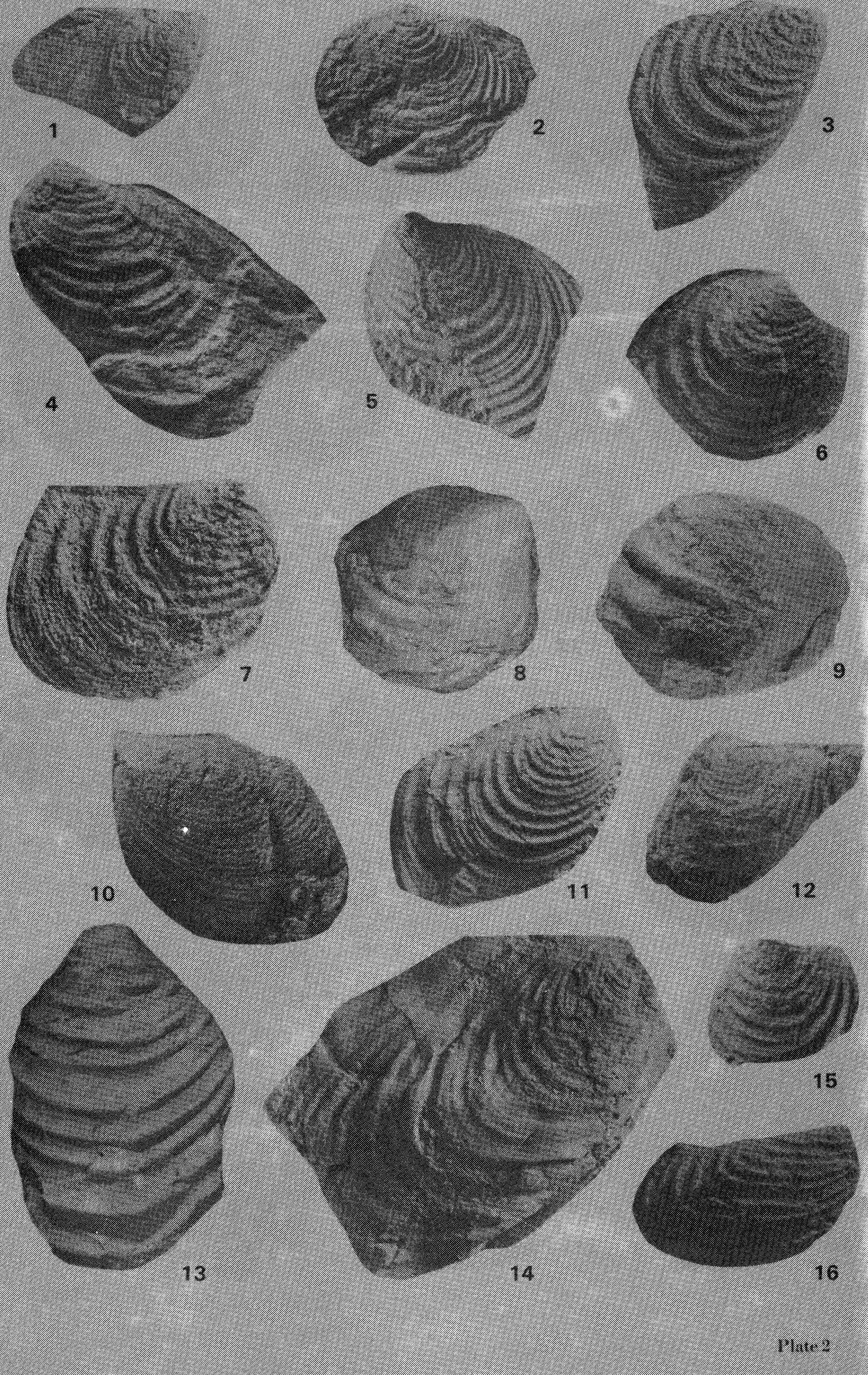
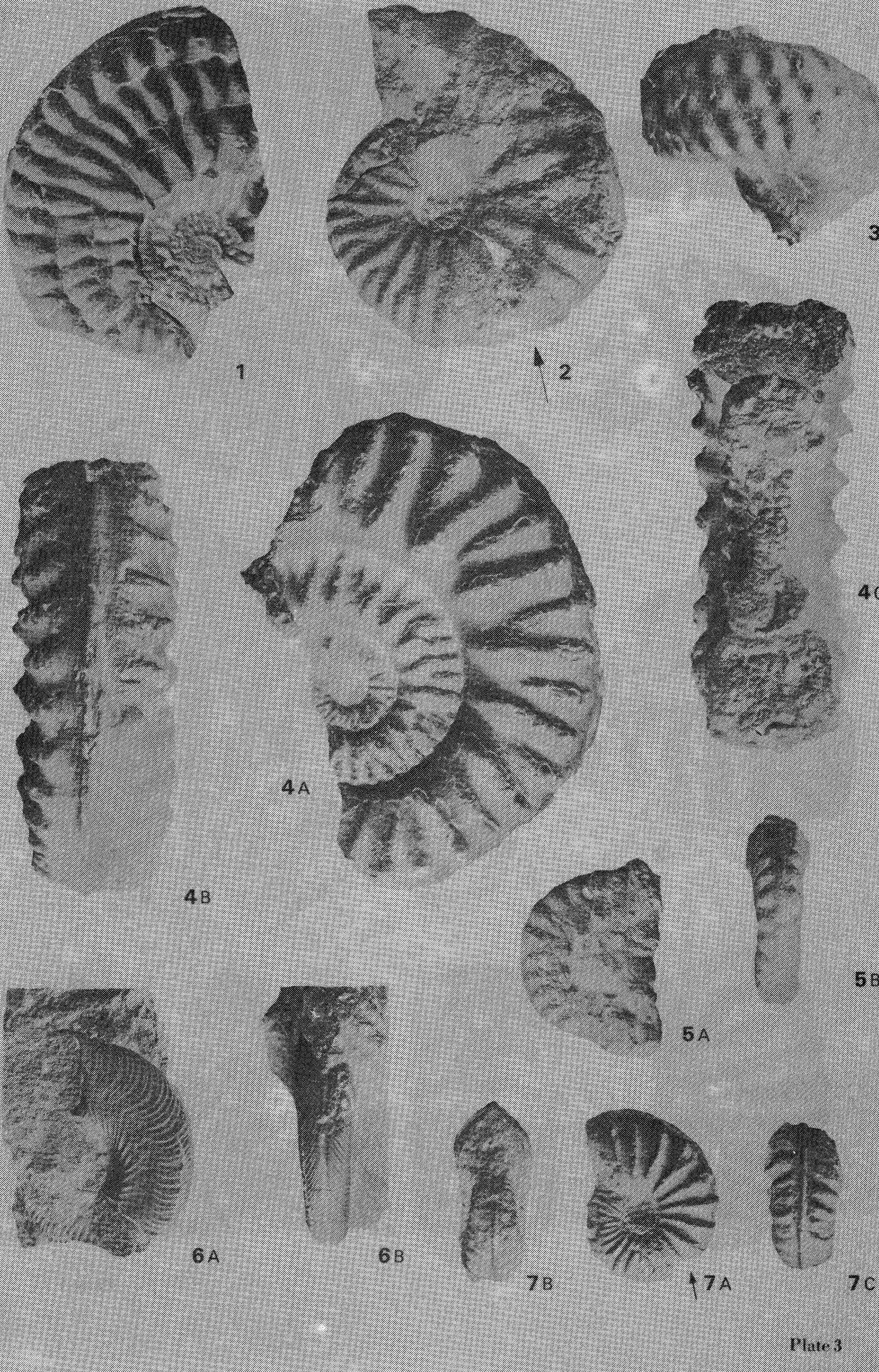


Plate 2



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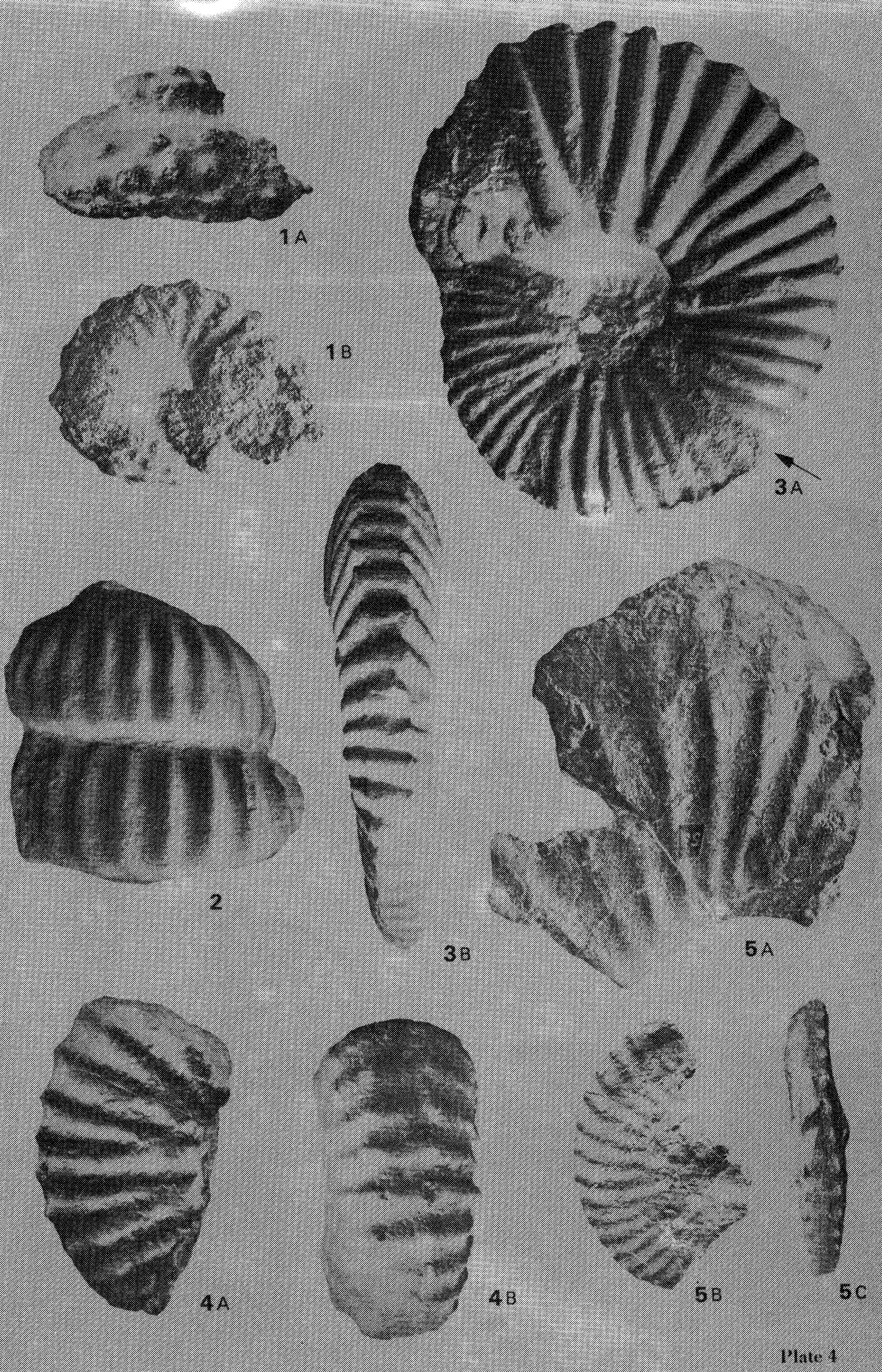

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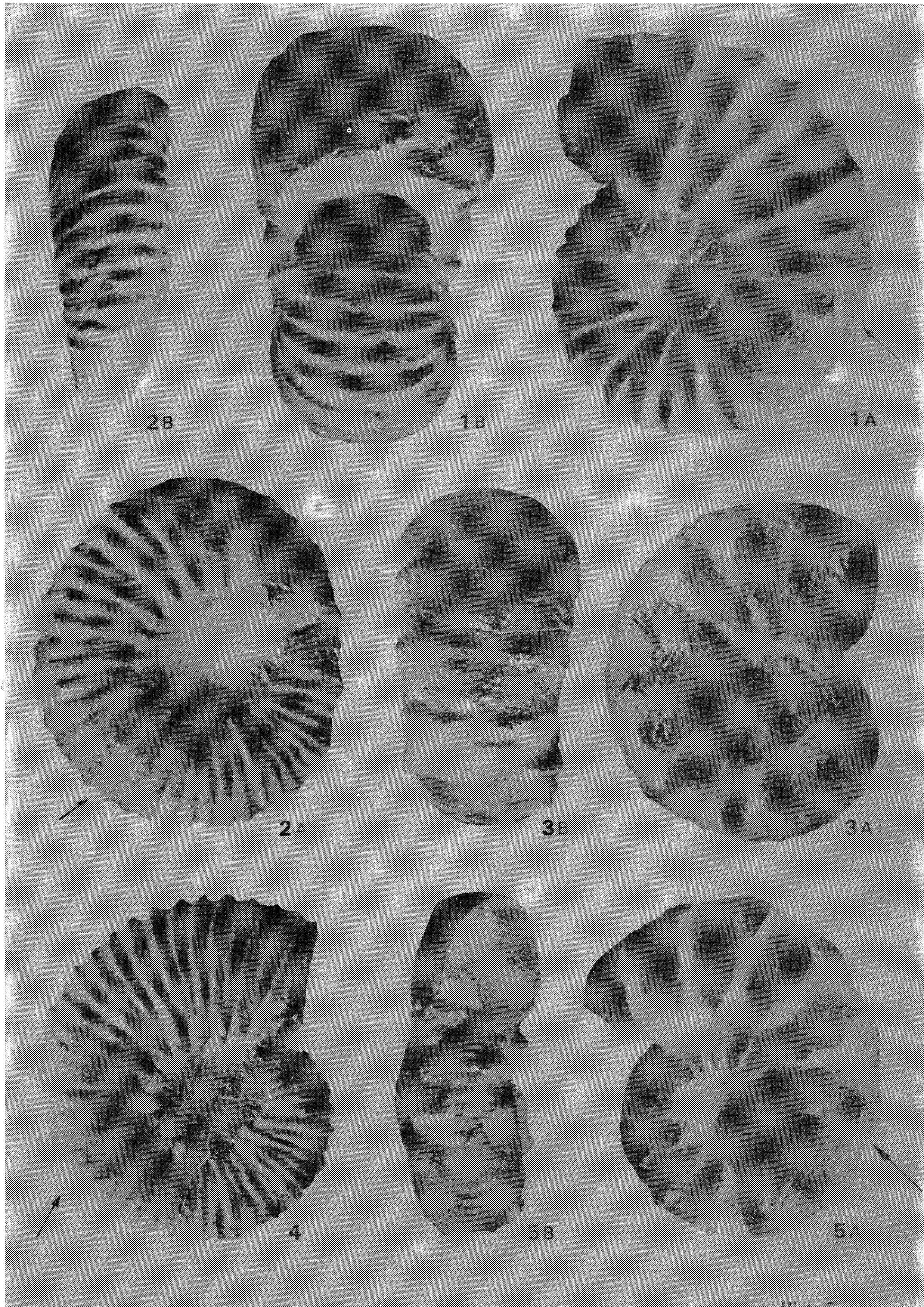

Plate 5

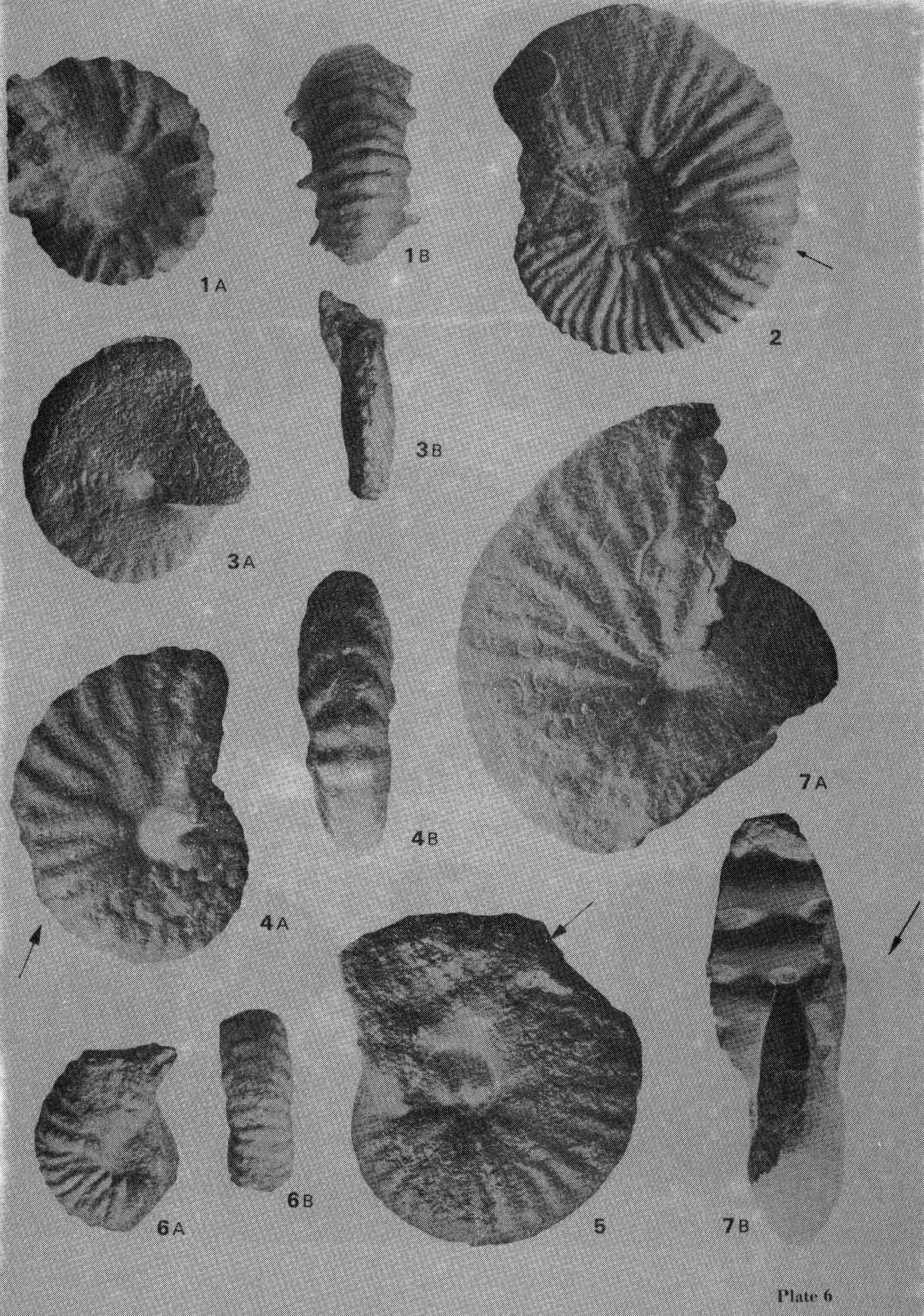

Plate 6

1

3

2A

2B

4

Plate 7

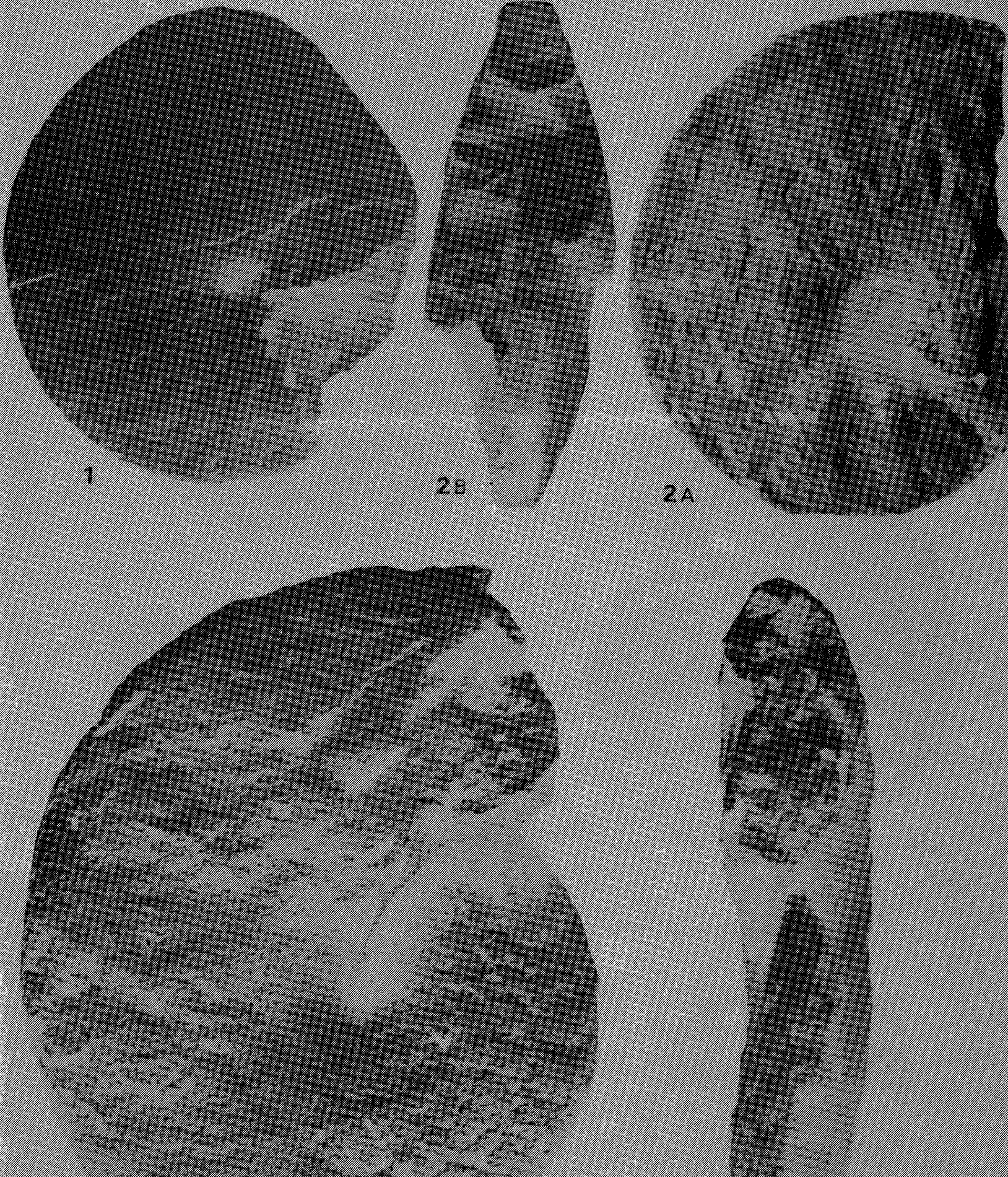

Plate 8

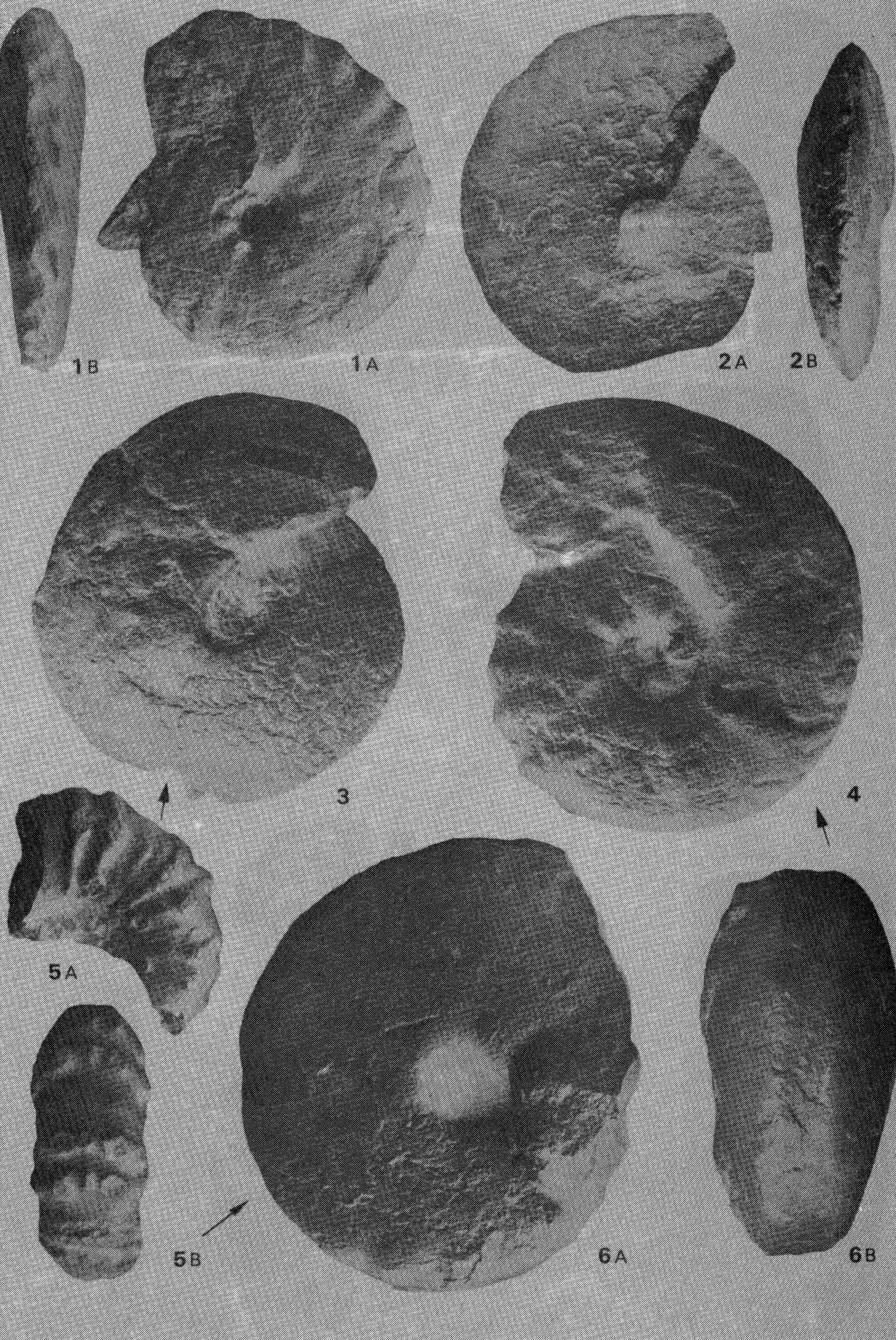

Plate 9

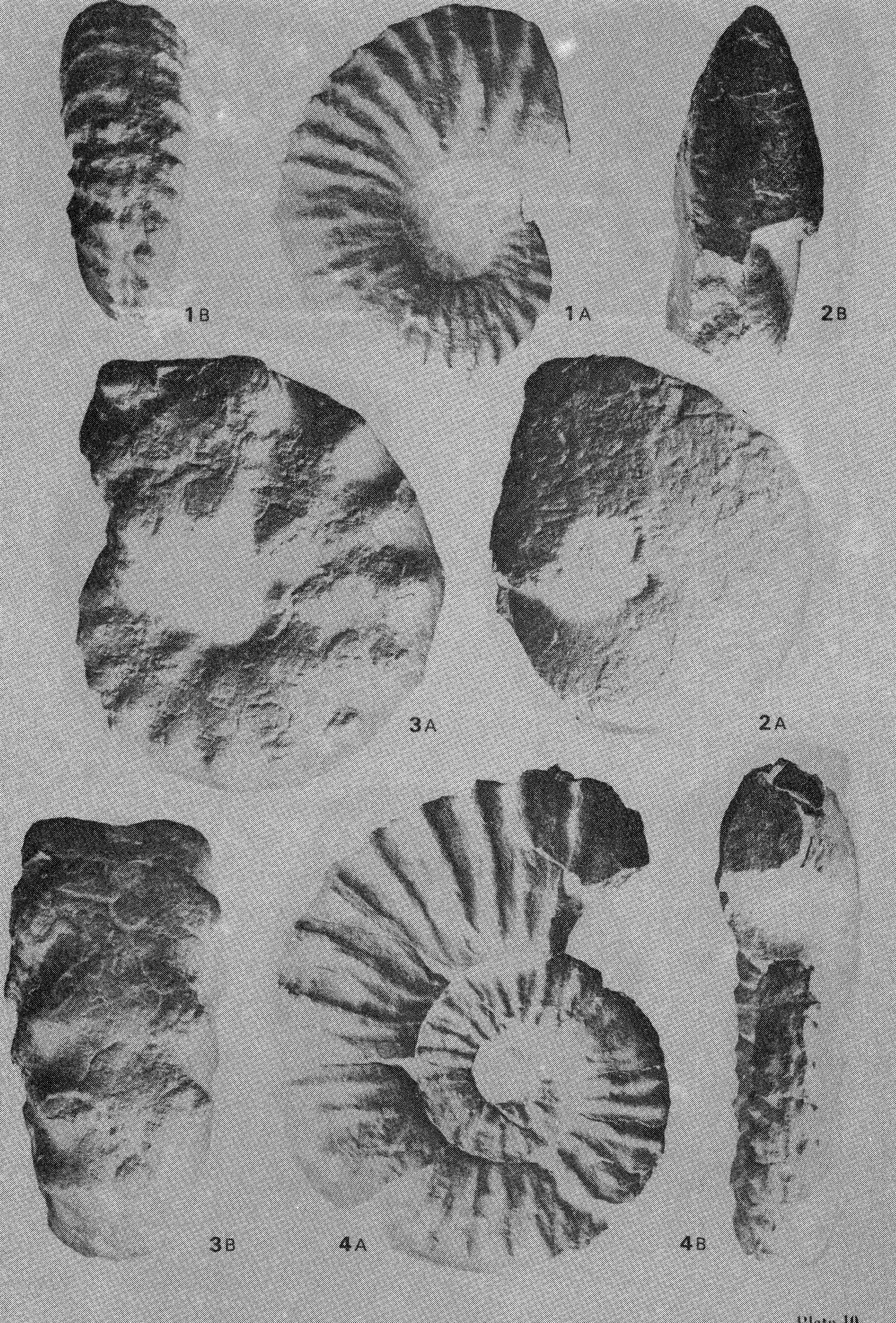

Plate 10

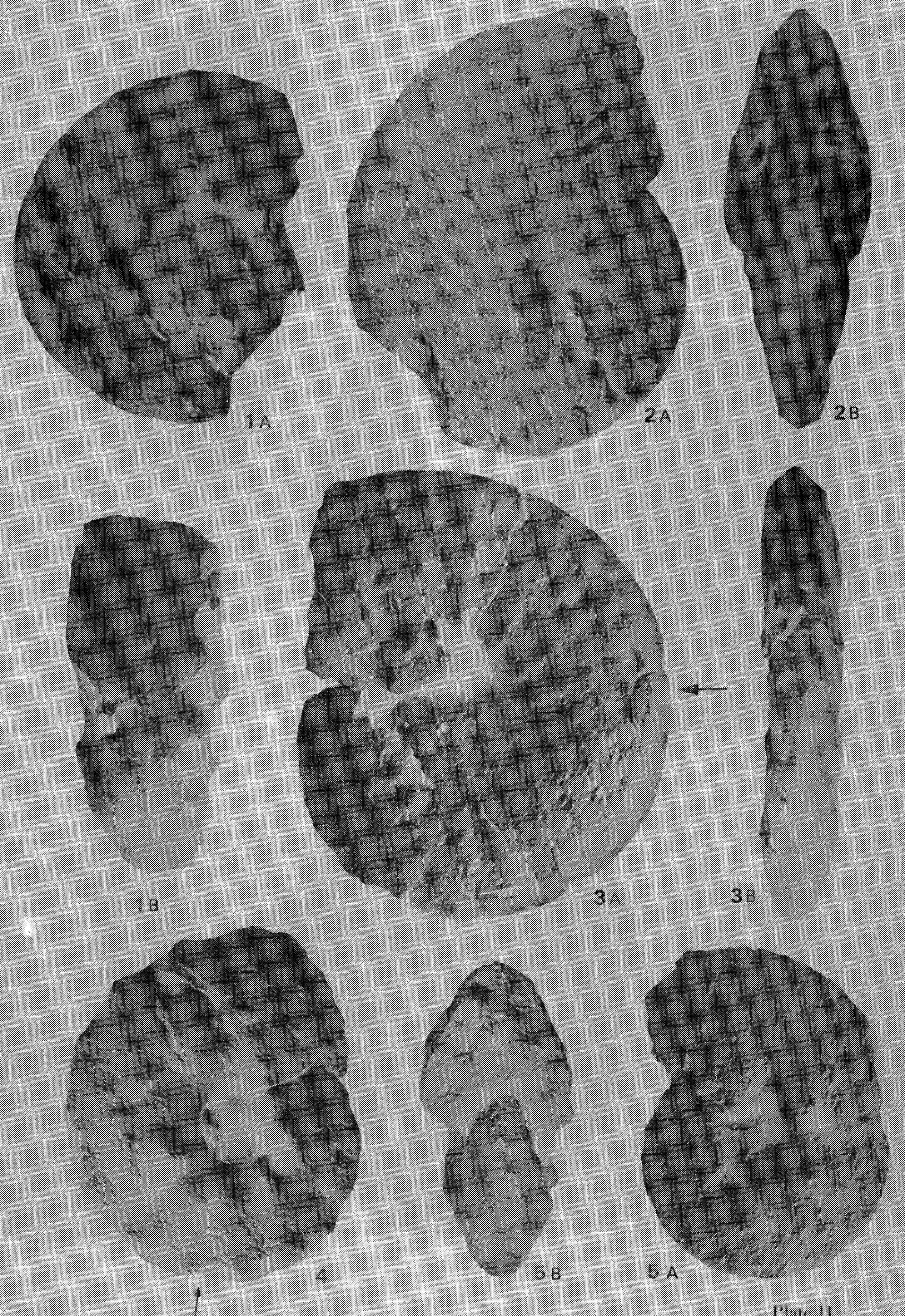

Plate 11

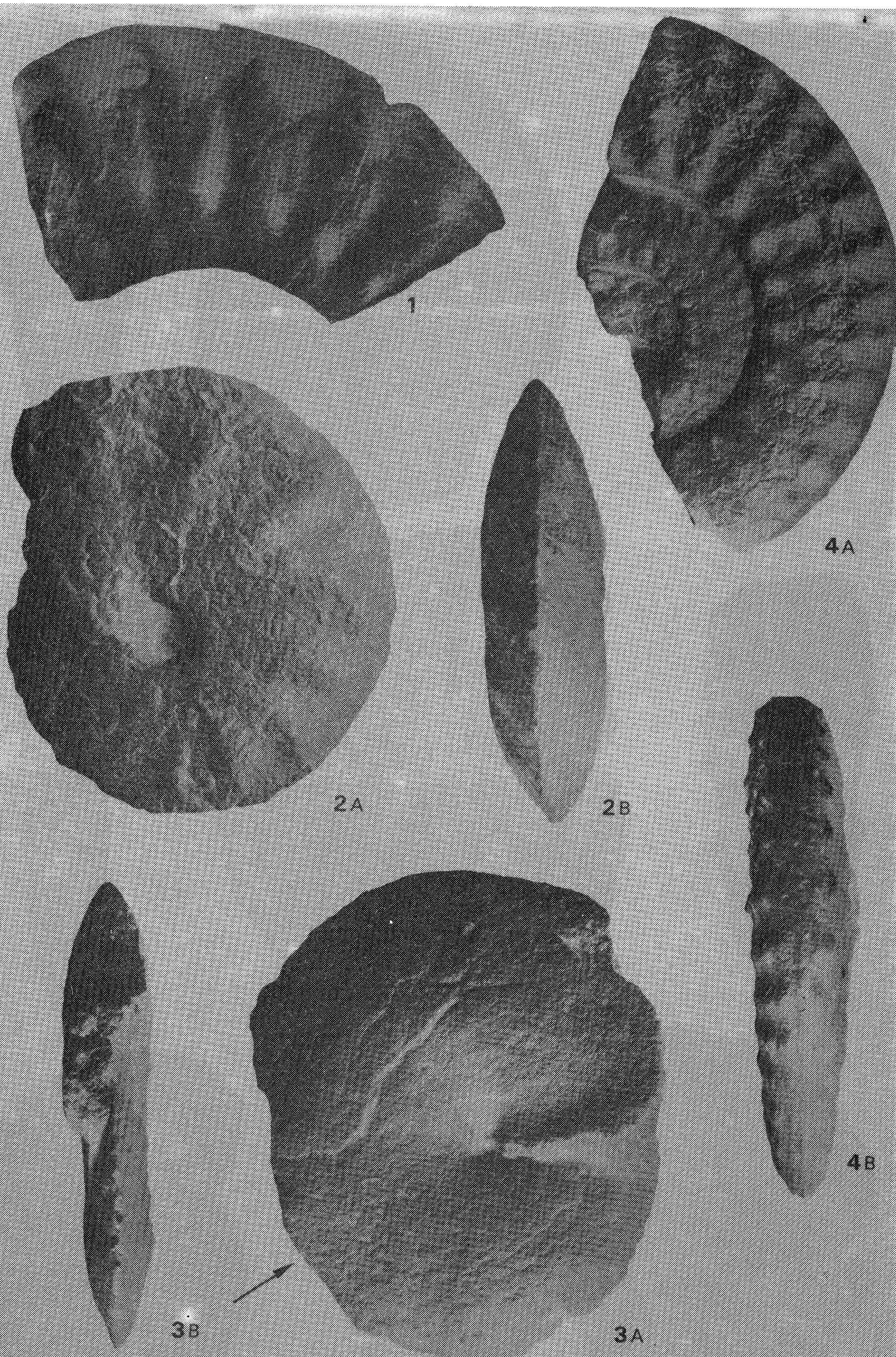

Plate 12