Zeitschrift: Eclogae Geologicae Helvetiae

Herausgeber: Schweizerische Geologische Gesellschaft

Band: 63 (1970)

Heft: 2

Artikel: Jurassic carbonate facies and new ammonite faunas from western Greece

Autor: Bernoulli, Daniel / Renz, Otto

DOI: https://doi.org/10.5169/seals-163861

Eclogae geol. Helv.	Vol. 63/2	Pages 573-607	With 6 figures and 2 tables in the text and 6 plates (I-VI)	Basle, July 1970

Jurassic Carbonate Facies and New Ammonite Faunas from Western Greece

By DANIEL BERNOULLI[1]) and OTTO RENZ[2])

ABSTRACT

During the Early Jurassic, the subsiding continental margin bordering the opening Tethyan Ocean in the south was affected by intense block-faulting and developed into a number of shallow-marine platforms and deeper basins. In the *Ionian zone* of western Greece, the formation of a deeper trough started in the Middle Liassic and was accompanied by an *intrabasinal* differentiation into submarine highs («seamounts»), on which only little sediment accumulated, and local depressions with continuous deposition. On the highs, thin sequences of pelagic limestones are found which are largely composed of calcareous nannoplankton and which contain chiefly pelagic organisms such as calcitized radiolaria, pelagic lamellibranchs and globigerinids. Low rates of sedimentation and repeated phases of non-deposition and submarine erosion are indicated by subsolved ammonite shells; early lithification, subsequent subsolution and reworking of sediment, and the development of ferruginous and phosphatic hard-grounds. In the basins, well-bedded pelagic limestones, marls, siliceous argillites and cherts are associated with slump-folded complexes, intraformational conglomerates and lime turbidites which, in the axial parts of the Ionian zone, contain mainly pelagic limestone clasts and fossils and only occasionally fragments of preexisting formations. All the components must be derived from intrabasinal sources, such as submarine highs and associated fault-scarps which indicate considerable relief of sea-bottom morphology due to synsedimentary tectonic movements. Such movements are corroborated by the occurrence of sedimentary dykes in the "seamount" sequences and by abrupt changes of facies and thicknesses. From the Upper Tithonian onwards, irregularities of bottom morphology tended to be eliminated by a higher rate of sedimentation, but continuation of differential subsidence is indicated by considerable differences in thicknesses.

In the Upper Jurassic, accumulations of ammonite faunas are restricted to the condensed "seamount" sequences, whereas in the coeval basinal cherty successions no ammonites are preserved. Two ammonite faunas of Upper Oxfordian to Lower Kimmeridgian age, entirely new for western Greece, are described from condensed sequences in the Louros valley (Epirus) and from Lefkas Island.

ZUSAMMENFASSUNG

Der absinkende Kontinentalrand, welcher die sich öffnende Tethys im Süden begrenzte, wurde im unteren Jura durch intensive Bruchbewegungen zerstückelt. Durch diese tektonischen Bewegungen wurde die Ablagerung von Flachwasser-Karbonaten über weite Teile des Kontinentalrandes unterbrochen und es entstanden eine Reihe seichter Karbonat-Plattformen, welche durch tiefere Meeresbecken voneinander und zum Teil auch vom Kontinent getrennt waren.

In Westgriechenland begann die Einsenkung des ionischen Troges im mittleren Lias. Sie war von synsedimentären tektonischen Bewegungen begleitet, welche im Trog selbst zu einer Differenzierung in submarine Schwellen («seamounts») mit reduzierter Sedimentation und in tiefere Teilbecken mit kontinuierlicher Ablagerung führten. Auf den Schwellen bildeten sich geringmächtige Serien pelagischer Kalke. Sie enthalten hauptsächlich pelagische Organismen, wie (kalzitisierte) Radiolarien,

[1]) Geological Institute of the University, Basel, Switzerland.

[2]) Museum of Natural History, Basel, Switzerland.

pelagische Lamellibranchiaten und Globigeriniden. Das feine Sediment wird zur Hauptsache von kalkigem Nannoplankton aufgebaut. Die langsame Sedimentation wurde wiederholt unterbrochen und von Phasen submariner Erosion abgelöst, wie sich aus den Spuren submariner Anlösung (Subsolution) von Ammonitenschalen, frühdiagenetischer Lithifizierung, Subsolution und Aufarbeitung der Sedimente sowie der Entstehung von eisenreichen und phosphatischen Hard-grounds ergibt.

In den Teilbecken wurden gut geschichtete pelagische Kalke, Mergel, Kieselpelite und Hornsteine abgelagert. Sie sind mit submarin verfalteten Komplexen, intraformationellen Breccien und Kalkturbiditen assoziiert. In den axialen Teilen der ionischen Zone enthalten diese Rutschungsbreccien und Kalkturbidite beinahe ausschliesslich pelagische Fossilien und Fragmente gleichaltriger pelagischer Gesteine; nur selten finden sich Fragmente älterer Formationen. Sämtliche Komponenten müssen deshalb von Liefergebieten innerhalb des ionischen Troges stammen: insbesondere von submarinen Schwellen und mit diesen assoziierten Bruchstufen. Synsedimentäre Bruchbewegungen, welche die submarine Topographie des ionischen Troges bestimmten, werden durch sprunghafte Fazies- und Mächtigkeitsänderungen und sedimentäre Gänge in den kondensierten Schwellensedimenten erhärtet. Vom oberen Tithon an verschwanden die topographischen Unebenheiten weitgehend, doch zeigen beträchtliche Mächtigkeitsschwankungen eine Fortdauer der Subsidenzdifferenzen an.

Im oberen Jura sind Ammonitenfaunen auf die kondensierten Schwellensedimente beschränkt, während in den gleichalterigen kieseligen Beckensedimenten keine Ammoniten erhalten geblieben sind. In der Folge werden zwei für Griechenland neue Ammonitenfaunen beschrieben und abgebildet; sie umfassen Formen des oberen Oxfordien bis unteren Kimmeridgien und stammen von kondensierten Serien des mittleren Louros-Tales (Epirus) und von Leukas.

CONTENTS

Geological frame

In western Greece the most external zones of the Hellenides are represented by a broad folded belt, running in a NNW-SSE-direction along the coast of the Greek mainland and the Peloponnese. This belt comprises a number of "isopic zones" (J. AUBOUIN, 1958) which have been mainly defined with respect to their Mesozoic facies development; they coincide, however, rather with the pattern of facies distribution of the Tertiary orogenic flysch sediments and with the Alpine structural trends. From west to east the following zones have been distinguished (C. RENZ and M. REICHEL, 1945; J. AUBOUIN, 1958; G. BIZON, 1967): 1. *Zante zone*, 2. *Paxos zone* (Preapulian zone of J. AUBOUIN), 3. *Ionian zone*, 4. *Gavrovo zone* (Fig. 1). In western Greece no crystalline basement is known. The Mesozoic-Tertiary sequences of the Zante, the Paxos (W. D. GILL, 1965) and the Ionian zones (INSTITUT DE GÉOLOGIE etc., 1966) have been sheared off their substratum along a thick formation of Upper

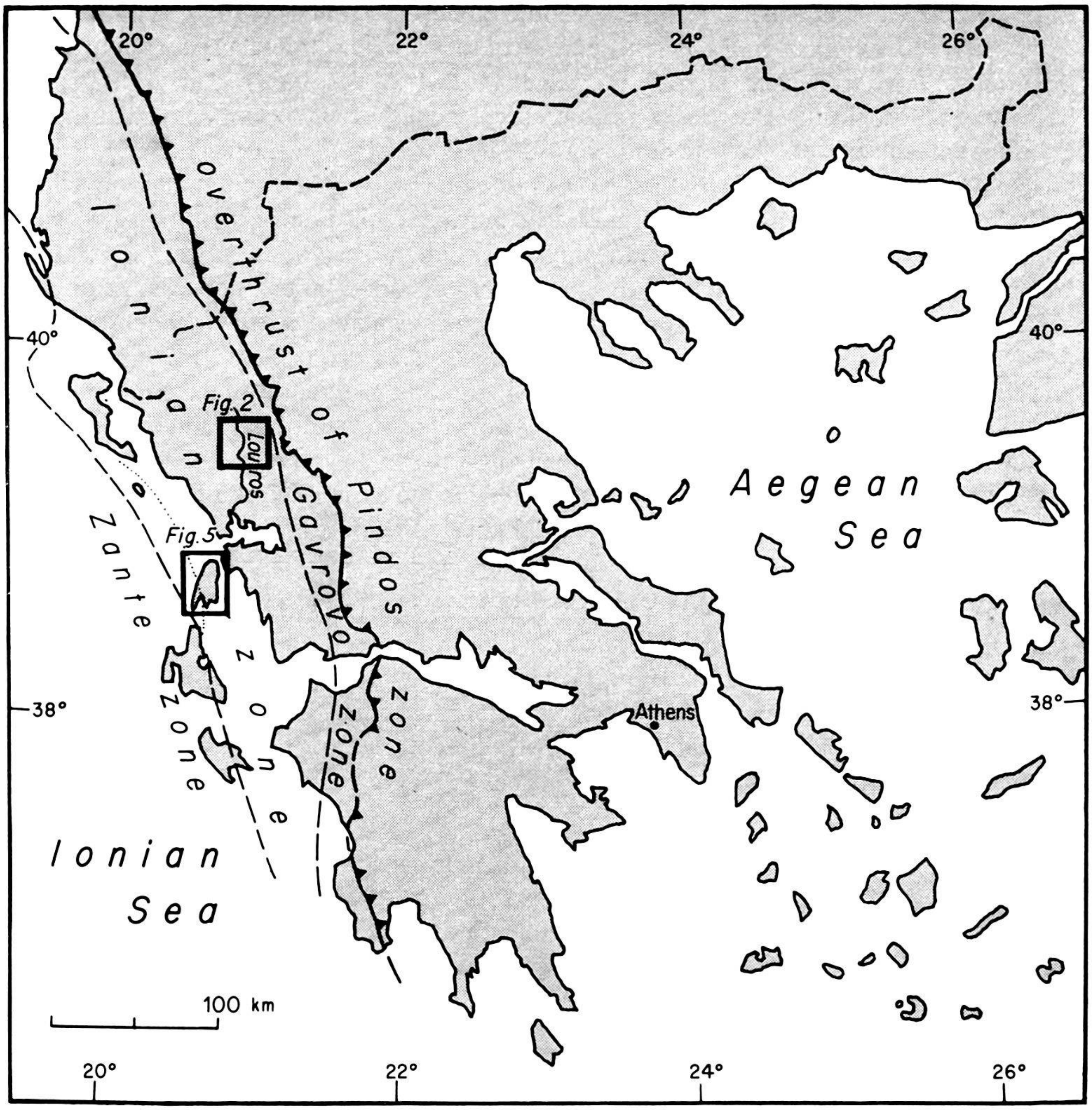


Fig. 1. Index map.

Triassic evaporites and shifted towards the west. Most of the Gavrovo zone is covered by more internal allochthonous units, namely the Pindos zone, a sedimentary cover nappe, which has been stripped off its substratum and thrust onto the more external zones.

The foundations of the stratigraphy of western Greece are due to CARL RENZ, who from 1903 until his death in 1951 devoted most of his time to the geological exploration of Greece. The results of his investigations, which are scattered throughout numerous papers, have been reassembled and published (after his death) in a comprehensive work on the stratigraphy of Greece (C. RENZ, 1955). Later J. AUBOUIN (1959) mapped large parts of central and western Greece and presented a number of most attractive and consistent paleogeographic models (J. AUBOUIN, 1960, 1963, 1964), which for the *external zones* of the peri-Adriatic orogens (Hellenides, Dinarides, Apennines) have to be only slightly modified (D. BERNOULLI, 1969). During the Late Triassic and the Earliest Jurassic most of these zones which became the southern continental margin of the opening Tethyan Sea (H. P. LAUBSCHER, 1969), were covered by an extensive carbonate platform, on which evaporites and shallow marine carbonates accumulated. During the Early Jurassic this continental margin was affected by intense block-faulting and only a few Bahamian-type platforms separated by deeper troughs persisted. On the platforms, production and sedimentation of shallow-water carbonates kept up with subsidence, whereas in the deeper realms pelagic sediments and lime turbidites composed of shallow-water carbonate particles and neritic fossils were laid down. This palaeogeographic configuration continued with minor off- and onlap movements along the platform margins until the Late Cretaceous or Early Tertiary, when orogenic movements and flysch sedimentation set in. In the Gavrovo and in the Ionian zone, the main orogenic movements took place at the end of the Lower Miocene, in the Paxos and Zante zone during the Plio-Pleistocene (INSTITUT DE GÉOLOGIE etc., 1966; G. BIZON, 1967).

Throughout western Greece the Upper Triassic evaporites are overlain by shallow-water limestones and dolomites (Pantokrator Limestone and Dolomite). From Middle Liassic to Late Eocene times the Ionian zone was occupied by a deeper marine basin, which was flanked on both sides by carbonate platforms in the Zante and in the Gavrovo zone (J. AUBOUIN, 1958, 1959). The sedimentary sequence of the Paxos zone keeps an intermediate position (mainly slope environment) between the Ionian trough and the Zante platform.

The Middle Liassic to Upper Jurassic carbonate sequence of the Ionian zone has been interpreted by C. RENZ and by J. AUBOUIN as an essentially pelagic, deeper marine succession without breaks in sedimentation. This interpretation is mainly based on the fine grain of the sediment, the abundance of planktonic or nektonic organisms and the absence of autochthonous neritic biota. In recent years, however, numerous stratigraphical gaps within the Jurassic sequence of the Ionian zone have been found (J. BORNOVAS, 1964; INSTITUT DE GÉOLOGIE, 1966; A. XHOMO et al., 1969). These gaps encompass different time intervals; in extreme cases the Upper Tithonian Vigla Limestone rests directly on the Lower Liassic Pantokrator Limestone. Palaeogeographically the gaps have been attributed to local emersions following the formation of "embryonic" anticlines during early Alpine orogenic movements of Jurassic age. Accordingly a littoral to shallow-marine depositional environment has been allocated to the sediments associated to the stratigraphic gaps (Siniais Limestone, Ammonitico Rosso etc.). Analogous stratigraphic gaps in the Jurassic sequence of the Umbrian-Marchean zone in the central Apennines have been explained recently in a similar way (R. COLACICCHI and G. PIALLI, 1967, 1969; A. FARINACCI, 1967). If right, these interpretations would cast serious doubt on the pelagic nature of the Ammonitico Rosso and associated sediments, as assumed by many authors (G. MERLA, 1951; R. TRÜMPY, 1960; J. AUBOUIN, 1964; D. BERNOULLI, 1964, 1967; H. GRUNAU, 1959; R. E. GARRISON and A. G. FISCHER, 1969, and others). Alternatively stratigraphic gaps in the Tethyan Jurassic may be attributed to non-deposition and sub-aquatic erosion in a deeper marine realm (D. BERNOULLI, 1964; R. HOLLMANN, 1964). In this case the breccias and conglomerates associated with the continuous sequences would not be derived from subaerial erosion of the rising "cordilleras" but from the erosion of current-swept, submerged highs ("seamounts") and from associated submarine fault scarps.

In order to test the different palaeogeographic models, the first author visited the well exposed, easily accessible and already carefully described (INSTITUT DE GÉOLOGIE etc., 1966) Jurassic sequences of the Louros valley between Arta and Iannina in Epirus (Figs. 1–3). The most important palaeogeographic results which, according to our view, favour the second working hypothesis, have been presented in two preliminary notes (D. BERNOULLI, 1967, 1969). In this paper a short account of the stratigraphy and sedimentology of the Jurassic sequences in the Louros valley is given, and two Upper Jurassic ammonite faunas, entirely new for western Greece are described and figured. The fauna from the Louros valley has been collected by the first author in 1967; the second, collected by C. RENZ on the island of Lefkas during 1927, has not been described until now. As in the central Apennines, accumulations of Upper Jurassic ammonites are restricted to small areas, characterized by stratigraphically condensed and incomplete sequences, whereas in the continuous basinal successions no ammonites are preserved. In view of the palaeogeographic importance of the reduced sequences the sediments and associated faunas have been investigated in some detail. A detailed sedimentological analysis of the basinal sequences will be given in a forthcoming paper.

The depositional textures of limestones are described in terms of R. J. DUNHAM's (1962) classification.

The Jurassic sequences of the Ionian zone in the Louros valley

The Jurassic sequences of the middle Louros valley have been mapped in great detail and investigated stratigraphically by the Greek Institute for Geology and Subsurface Research and the Institut Français du Pétrole (INSTITUT DE GÉOLOGIE etc., 1966). Based on this map, five sections have been selected and analysed sedimentologically (Figs. 2 and 3). Of these sections, two (B and C = INSTITUT DE GÉOLOGIE etc., 1966: Figs. 8, 9: sections 7 and 10) have already been described; section E corresponds more or less to section Klissoura (l.c. Fig. 9: section 8), but all sections have been entirely remeasured. The geological situation and the stratigraphical relationship of the formations is given in Figure 2; for all stratigraphical details the reader is referred to Figure 3.

Sections A and B belong to the same palaeotectonic unit which is characterized by continuous sedimentation. Sections C and D are located near the centre of a Jurassic high, whereas section E is situated on the eastern part of the same swell.

1. Pantokrator Limestone

The Pantokrator Limestone is characterized by an association of white, massive to thick-bedded onkoidal lime pack- to grainstones, rich in dasyclad and codiacean algae; pelletal/intraclast lime grainstones and pelleted lime mudstones with "fenestrae".

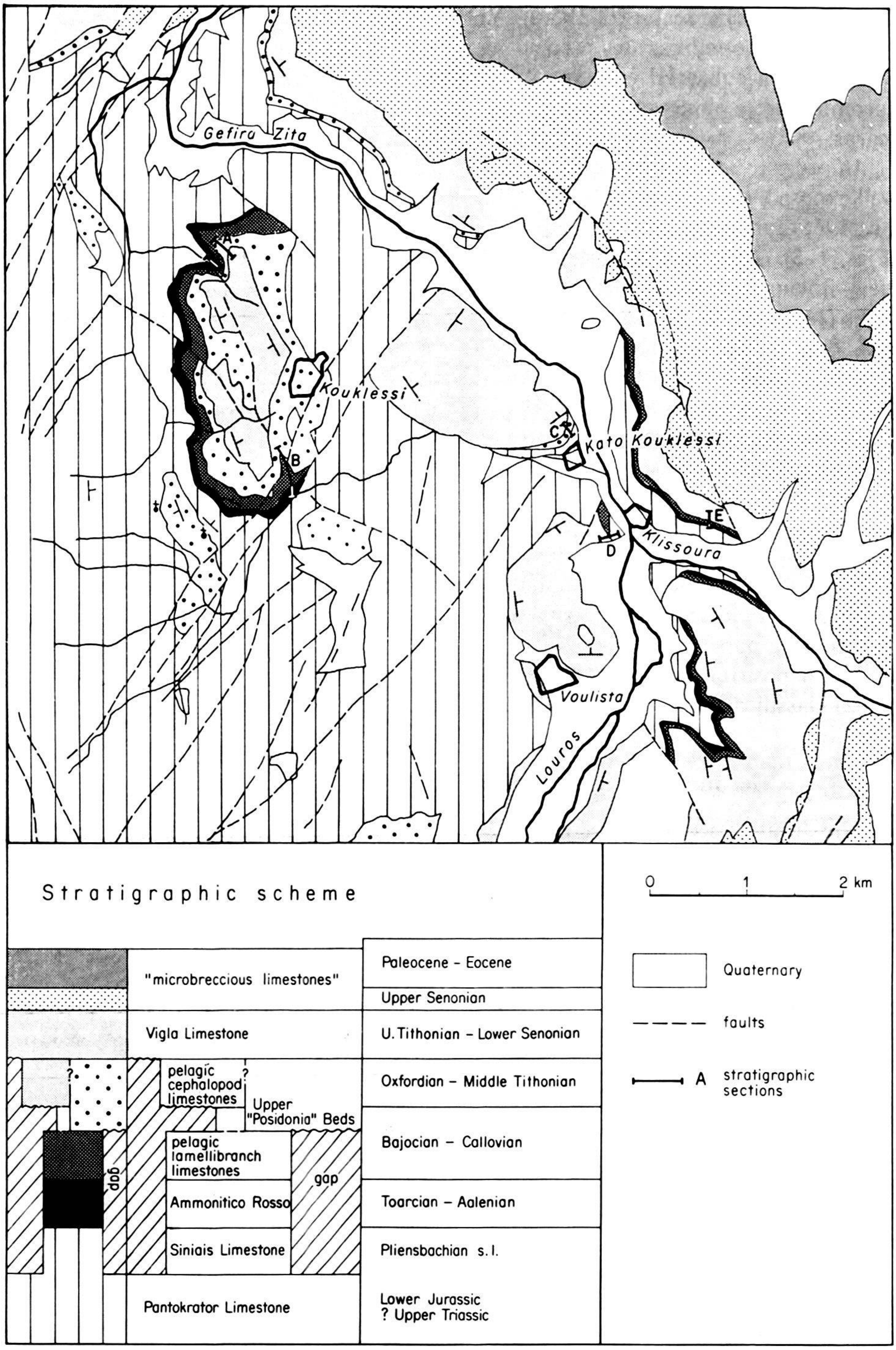


Fig. 2. Geological map of the middle Louros valley and location of sections. From Institut de Géologie etc. (1966, Pl. 2).

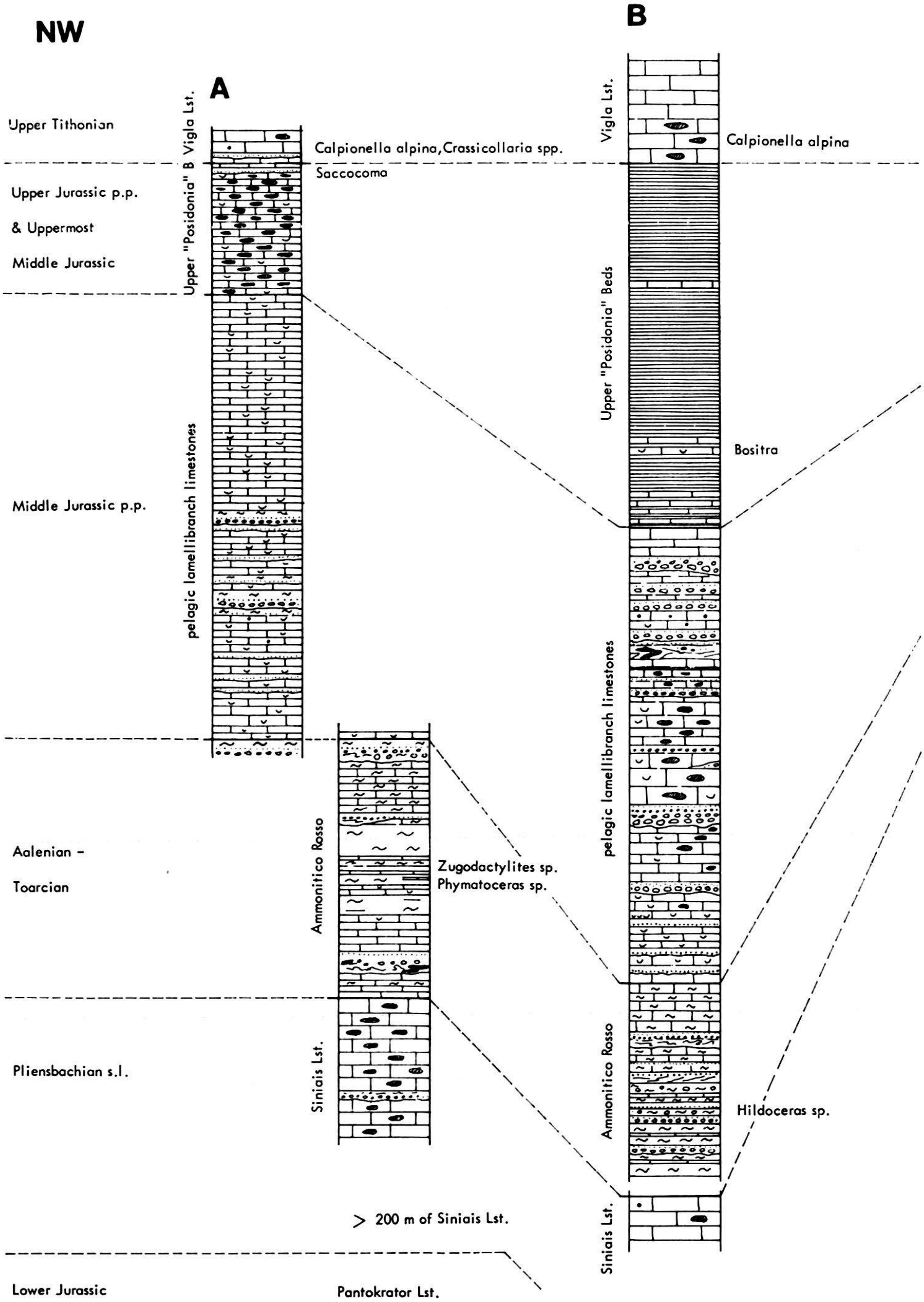
Stromatolite lime boundstones occur frequently and the lithological assemblage closely ressembles that of the Alpine Dachstein Limestone (A. G. FISCHER, 1964). In section A the contact with the overlying Siniais Limestone is disturbed by faulting. In section C the top of the Pantokrator Limestone is heavily brecciated and intruded by sedimentary dykes filled with angular fragments of the host rock and unconsolidated sediment of the overlying Middle to Upper Jurassic pelagic limestones. In section D the Pantokrator Limestone is overlain by a thin series of finely pelleted microbioclastic lime packstones which contain "*Vidalina*" *martana* FARINACCI, *Frondicularia hexogona* TERQUEM and *Frondicularia woodwardi* HOWCHIN, and possibly are of Middle Liassic age. In section E mainly massive lime mud- to wackestones are present, which are followed by well-bedded Siniais Limestone.

A Lower Jurassic age of the Pantokrator Limestone is indicated by a typical algal association, which contains amongst other forms *Palaeodasycladus mediterraneus* (PIA) (J. AUBOUIN, 1959; INSTITUT DE GÉOLOGIE etc., 1966). In section C this form has been found immediately below the top of the Pantokrator Limestone. The absence of typical Middle Liassic shallow water fossils as *Orbitopsella* points to an Upper Triassic to Lower Liassic age of the typical facies of the Pantokrator Limestone. C. RENZ (1955, p. 24–25, 51) mentions Middle Liassic brachiopods from the "Pantokrator Limestone" of Kouklessi; it is, however, not known whether they come from the transitional facies of the limestones with "*Vidalina*" *martana* or from the Siniais Limestone.

2. Siniais Limestone

The Siniais Limestone is only present in sections A, B and E; in section C it is missing and in section D only a thin series of microbioclastic limestones has been found which might represent a lateral equivalent of the Siniais Limestone. In section A a thickness of more than 200 m has been measured, but in the other sections the formation is considerably thinner; according to INSTITUT DE GÉOLOGIE etc. (1966) it varies between 0 and about 100 m. Lithologically the formation consists of white, well-bedded bioclast lime wackestones which often contain bands and lenses of black replacement chert. Intercalated thin beds of dark grey marls occur. Amongst the biota radiolaria are predominant; they are, however, only poorly preserved as calcitic spherules; additionally, tiny echinoderm fragments, ostracods and undeterminable microbioclastic hash are present. In section A several intercalations of slump-conglomerates have been observed. They contain sparse rounded intraformational pebbles in a fluidally textured groundmass and plastically deformed lenses of black chert. Calcarenites containing redeposited carbonate platform material such as onkoids, algae etc. have up till now been found only from the transition zone towards the Zante-Apulia platform (Ithaka, W. OTT, 1966, not interpreted as such). It seems therefore that the absence of the Siniais Limestone in sections C and D is due rather to non-deposition or to subsequent submarine erosion than to a partial interfingering between Pantokrator and Siniais Limestone (cf. alternative 1 in Fig. 6, INSTITUT DE GÉOLOGIE, 1966).

According to C. RENZ (1955, p. 27), B. BISCHOFF (1966) and A. V. KOTTEK (1966) the Siniais Limestone contains ammonites of Upper Pliensbachian (Domerian) age.


NW
A
B
Upper Tithonian
Upper Jurassic p.p.
& Uppermost
Middle Jurassic
Middle Jurassic p.p.
Aalenian -
Toarcian
Pliensbachian s.l.
Lower Jurassic
Vigla Lst.
Upper "Posidonia" B
pelagic lamellibranch limestones
Ammonitico Rosso
Siniais Lst.
Calpionella alpina, Crassicollaria spp.
Saccocoma
Zugodactylites sp.
Phymatoceras sp.
> 200 m of Siniais Lst.
Pantokrator Lst.
Vigla Lst.
Calpionella alpina
Upper "Posidonia" Beds
Bositra
pelagic lamellibranch limestones
Ammonitico Rosso
Hildoceras sp.
Siniais Lst.

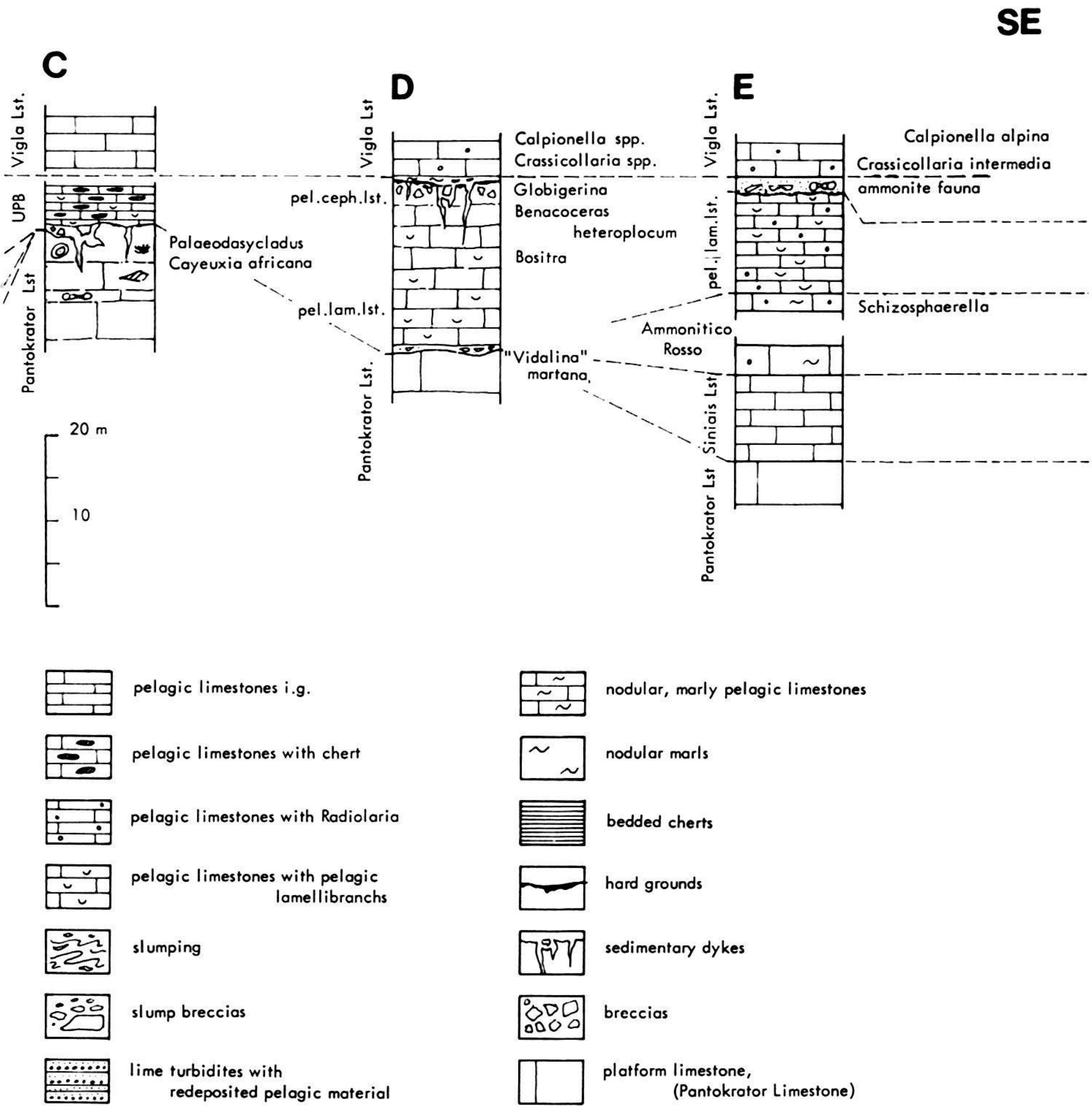


Fig. 3. Columnar sections of the Jurassic sequences in the middle Louros valley, Epirus, Greece.

3. Ammonitico Rosso

Like the Siniais Limestone, the Ammonitico Rosso is present only in sections A, B and E, and there are major differencies in thickness (0–40 m) and lithology between the different sections.

In section A and B, the Siniais Limestone is overlain by green to grey marls and marly, slightly siliceous lime wackestones rich in radiolaria and fucoids. The limestones may be partly homogenous or may show a characteristic flaser-texture. In section A, dark grey to black foliated marls to marly shales are intercalated. Minor intercalations of slump conglomerates are associated with graded calcarenites and calcisiltites, but finer graded and laminated lithoclast/bioclast calcarenites and calcisiltites occur also independently from slumped beds. In section B two intercalations of graded conglomerates up to one metre thick are present: they contain closely packed subangular boulders and pebbles of Siniais Limestone in a lithoclast calcarenite matrix and grade through such calcarenites and calcisiltites into grey, laminated marls.

The upper part of the Ammonitico Rosso comprises red to lilac marls passing into an alternation of nodular marly lime mud- to wackestones and marls of the same colour. In both sections this interval contains slump-folded beds which pass laterally into retextured marly sediments with deformed limestone clasts and phacoids; these slumped beds are invariably associated with lime turbidites. In section B, there occurs a large complex of slump-folded and -thrusted limestones which simulates large-scale cross-bedding (cf. INSTITUT DE GÉOLOGIE etc., 1966, Fig. 8). Apart from the clasts derived from the Siniais Limestone, only penecontemporaneously displaced pelagic limestone clasts and fossils have been observed in the redeposited sediments. The sedimentary structures observed correspond exactly to those found in the Ammonitico Rosso and the associated sediments of the Southern Alps (D. BERNOULLI, 1964, Figs. 22–31, 34–38) and of the Umbrian-Marchean Apennines (D. BERNOULLI, 1969, Figs. 5–10).

In section E, the Ammonitico Rosso is reduced to about 8–9 m of nodular lime mud- to wackestones with radiolaria and pelagic lamellibranchs. No slump conglomerates or turbidites are present and marls are restricted to very thin interbeds. A limestone sample of this section (DB 1533) was investigated with the stereoscan electron microscope. It appeared to be composed almost entirely of tests of *Schizosphaerella* DEFLANDRE and DANGEARD, a planktonic form of unknown systematic position which has been found in the Ammonitico Rosso and in the pelagic lamellibranch limestones of Umbria, sometimes in rock-forming quantities (Pl. II, Fig. 2, 6–7).

The age of the Ammonitico Rosso is well established by rich ammonite faunas which range from the Lower Toarcian to the Aalenian (C. RENZ, 1955; J. AUBOUIN, 1959; A. V. KOTTEK, 1966).

The facies of siliceous argillites and bedded cherts (Lower "Posidonia" Beds) which is present elsewhere in the Toarcian of the Ionian zone, does not occur in the Louros valley.

4. Pelagic lamellibranch limestones

(Calcaires en plaquettes, J. AUBOUIN, 1969; Calcaire à filaments, INSTITUT DE GÉOLOGIE etc., 1966). The pelagic lamellibranch limestones are mainly built up of well-bedded, red, pink, yellow or white lime mud- to wackestones with thin marl interbeds; in the limestones abundant pelagic lamellibranchs and radiolaria occur. In section A and B the formation is about 60–65 m thick and contains some intercalations of intraformational slump breccias and associated graded calcarenites and calcisiltites. In some places the turbiditic layers are reduced to some centimetre- or millimetre-thin streaks or laminae of graded pelagic shell beds (D. BERNOULLI, 1969, Fig. 11). Decimetre- to metre-thick red marly lime mudstones are associated with the graded beds to which they are genetically linked: they apparently represent the finest and most distal deposits of the turbidity currents. All clastic intercalations contain exclusively pelagic material (D. BERNOULLI, 1967, Figs. 8 and 9; 1969, Fig. 11). In section B, slump-folded complexes and intraformational breccias may reach several metres in thickness and some 400 m west of this section even 10 to 15 metres.

In section C the formation is not present. In section D thick-bedded lime mud- to wackestones with abundant pelagic lamellibranchs overlie the microbioclastic limestones with "*Vidalina*" *martana*. They could, however, not be separated lithologically from the overlying pelagic cephalopod limestones yielding Upper Jurassic ammonites.

In section E, about 11 m of well-bedded lime wackestones with pelagic lamellibranchs and radiolaria are present. They are disconformably overlain by the pelagic cephalopod limestones. The groundmass of the pelagic lamellibranch limestones contains abundant coccoliths in a neomorphically formed calcite fabric. Though not determinable with certainty, the forms observed show great affinities with those found in the Middle Jurassic of the Umbrian-Marchean zone at Valdorbia (Pl. II, Figs. 1–5).

In the pelagic lamellibranch limestones west of the village of Kouklessi J. AUBOUIN (1959) has found *Skirroceras bayleanum* (OPPEL) indicating a Middle Bajocian age. Ammonites of the same age have been cited by C. RENZ (1955, p. 74) from different localities of the Ionian zone. Since the stratigraphical position of the overlying Upper "*Posidonia*" Beds is not exactly known (see below), the upper limit of the pelagic lamellibranch limestones cannot be dated precisely.

5. Upper "Posidonia" Beds

The Upper "Posidonia" Beds are restricted to sections A, B and C. Only in section B are they represented by the typical facies of thin-bedded siliceous argillites and cherts containing abundant pelagic lamellibranchs and radiolaria. In the lower part, thin intercalations of mostly chertified lumachelles with large planktonic lamellibranchs (*Bositra* = "*Posidonia*") are present, which have given the formation its name. In section A, the formation is built up of thin-bedded microbioclast lime wackestones with bands and lenses of chert. Occasionally there are still lime turbidites containing crinoid ossicles (*Saccocoma*) and exceptionally very fine material derived from a distant carbonate platform.

In section C only a few metres of badly exposed, well-bedded microbioclast lime wackestones rich in chert are present. They rest disconformably on the Pantokrator Limestone, the surface of which is brecciated and intruded by sedimentary dykes of the overlying formation (cf. A. CASTELLARIN, 1966; J. WENDT, 1963, 1965; F. WIEDENMAYER, 1963). In section D and E the Upper "Posidonia" Beds are missing or replaced by other formations.

By analogy with the other "Posidonia" alpina Beds of the Mediterranean Jurassic (Southern Alps, Sicily etc., cf. W. J. ARKELL, 1956; C. STURANI, 1964, 1967) most authors allocated the Upper "Posidonia" Beds to the Upper Bajocian-Bathonian (C. RENZ, 1955; J. AUBOUIN, 1959). The stratigraphical range of *Bositra buchi* (RÖMER) (= "*Posidonia*" *alpina* (GRAS)), however, is much longer and ranges from the Toarcian to the Oxfordian (R. P. S. JEFFERIES and P. MINTON, 1965). It therefore seems that the typical "Posidonia" alpina lumachelles of the Southern Alps and Sicily, which partly might be winnowed bioclast lime grainstones, reflect an evolutionary stage in the subsidence of seamounts of the Mediterranean Tethys rather than a well defined chrono-stratigraphical interval. As *Bositra buchi* seems to be restricted to the lower part of the Upper "Posidonia" Beds (INSTITUT DE GÉOLOGIE etc., 1966) and as the Upper Tithonian Vigla Limestone overlies the Upper "Posidonia" Beds without an apparent gap, the latter may also comprise most of the Upper Jurassic. They would then be of more or less the same age as the radiolarites in the Umbrian-Marchean Apennines (Scisti ad Aptici, Diaspri) and in the Lombardian Alps.

6. Pelagic cephalopod limestones

The pelagic cephalopod limestones are only present in the stratigraphically reduced sequences of sections D and E.

In section D the pelagic lamellibranch limestones pass upwards into massive intraclast lime wacke- to packstone containing centimetre-sized, sometimes compound pebbles of microbioclast lime wackestones. Some of the components are sharp edged and enveloped by a darker ferruginous rind; others show traces of mutual deformation and of pressure solution. Ammonites are very frequent but only one specimen could be isolated from the hard limestone: it has been identified as *Benacoceras heteroplocum* (GEMMELLARO) (Pl. IV, Fig. 2), an Upper Jurassic form. Laterally the intraformational conglomerates pass into intraclast lime grainstones (Pl. III, Fig. 2), which are almost identical with the Middle Liassic "Scheck" of the Adnet Beds in the Northern Calcareous Alps (A. HALLAM, 1967; J. D. HUDSON and H. C. JENKYNS, 1969; H. JURGAN, 1969). In places the cementation by sparry calcite has been preceeded by internal deposition of fine geopetal sediment which, however, is coarser than the matrix of the components.

The pelagic cephalopod limestones contain mainly small ammonites, pelagic lamellibranchs, calcitized radiolaria and, in the higher levels, *Globigerina* (Pl. III, Fig. 1). At the eastern side of the quarry, the top of the *Globigerina*-bearing limestones is characterized by planes of ferruginous staining which are gradational downwards but sharply terminate upwards (cf. R. E. GARRISON and A. G. FISCHER, 1969, Fig. 7.3) and which represent stages of non-deposition and submarine lithification and/or submarine solution. The top of these rocks is formed by a centimetre thick, locally silicified, crust of collophane[3] with a clear replacement structure (ghosts of foraminifera and pelagic lamellibranchs). This in turn is overlain by some 15 centimetres of breccia containing sharp-edged, corroded and encrusted fragments of the previously lithified rocks and of collophane-replaced sediment, all in a slightly recrystallized (microsparite) matrix of finely microbioclastic packstone with abundant pelagic lamellibranchs and occasional foraminifera (*Lenticulina*). The following 75 centimetres are made up of white microbioclastic lime wackestones with pelagic lamellibranchs and calcitized radiolaria as well as internal horizons of non-deposition or solution. They are topped by a thin ferromanganiferous crust, overlain by a breccia of angular, irregularly shaped and subsolved fragments of the underlying pelagic limestones containing corroded ammonite shells and aptychi. This breccia possibly corresponds to the thin horizon of pelagic cephalopod limestone in section E (Upper Oxfordian – Lower Kimmeridgian). The breccia is overlain by fine pelagic limestones with nannofossils of Upper Valanginian or younger age (Vigla Limestone).

---

[3]) Phosphorus was qualitatively determined as a main component by electron-microprobe analysis.

In the western part of the quarry, the "Scheck"-like conglomerates are disconformably overlain by lithoclast packstones and marly microbioclast lime wackestones (pelagic lamellibranchs) which fill depressions in the underlying rocks. They are overlain by about 40 cm of fine microbioclast lime wackestones with *Stomiosphaera* which contain small sedimentary dykes (DB 1529A, Table 2) of the immediately overlying, *Calpionella*-bearing Vigla Limestone (DB 1529B, Table 2) (here: Upper Tithonian).

Sedimentary dykes are not only present at the top of the sequence in section D, but also at different levels in the Middle to Upper Jurassic and in the underlying Pantokrator Limestone. They have not been investigated systematically, but it seems that different generations of intruded sediment are present.

In *section E* the well-bedded pelagic lamellibranch limestones of the Middle Jurassic are disconformably overlain by up to 50 centimetres slightly rubbly limestones (for exact location of samples see Fig. 4). At the base, a discontinuous bed of homogenous radiolaria lime wackestone, up to 20 cm thick, is present (sample DB 1483). It is in turn followed by about 30 cm of lime wackestone (samples DB 1480–1482). The base of this bed (Pl. I, Fig. 1) contains numerous corroded and encrusted

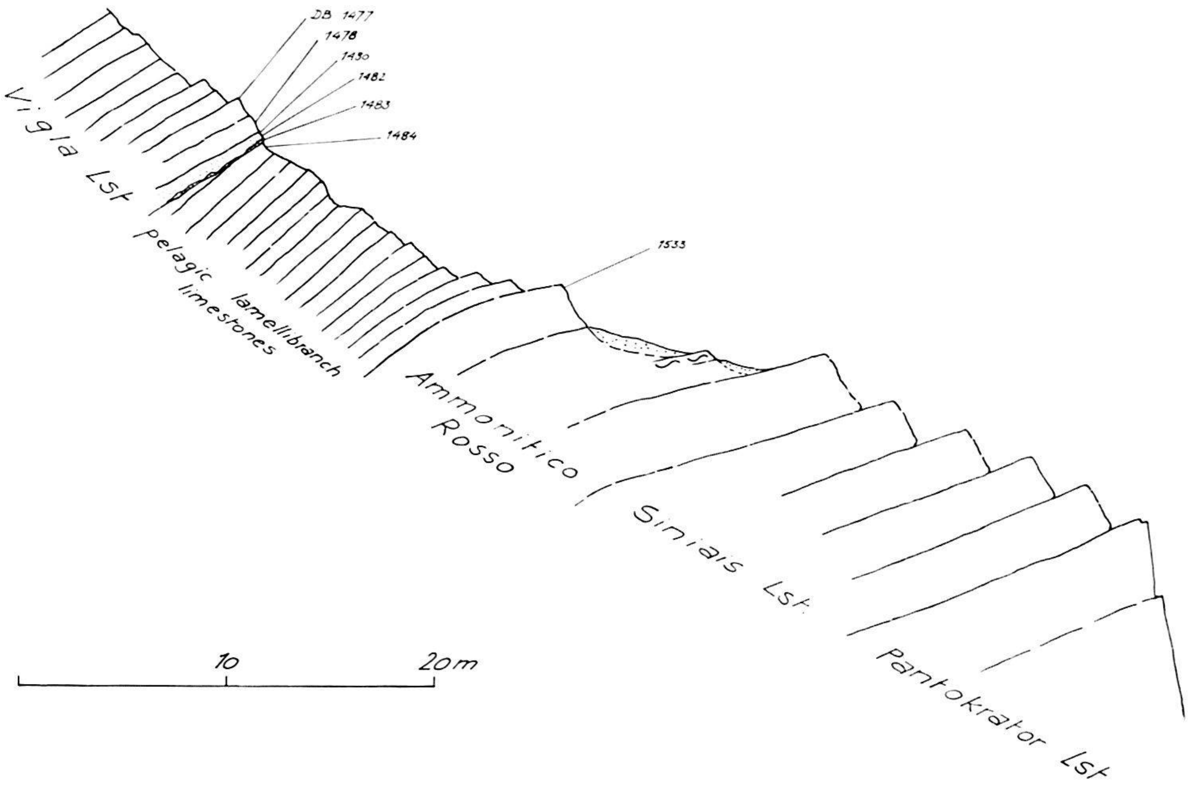


Fig. 4. Stratigraphic section and location of samples in section E, Louros valley, Epirus.

ammonite shells, well preserved aptychi, echinoderm remains and occasional belemnite rostra with the latter sometimes bored by organisms. The upper side of the ammonite shells is often completly removed by solution (cf. R. HOLLMANN, 1964, Taf. 7–8; R. E. GARRISON and A. G. FISCHER, 1969, Fig. 8) and there are numerous planes of ferruginous staining as described from section D (Pl. I, Fig. 1). They sometimes coincide with the upper limit of subsolved ammonite shells and may represent ancient sea-floors on which solution and early lithification took place. In places they are modified by later migration of ferruginous material and internal solution (stylolitization). In the middle and upper part of the bed a few cracks are present in which serpulid tubes in an apparently recrystallized calcite fabric are found; the interior of the cracks is filled with internal sediment (cf. A. FARINACCI, 1967, Fig. 13 and Pl. IX, Figs. 1 and 2).

Table 1

	Number of individuals		
	Louros Valley Section D Sample DB 1513	Louros Valley Section E Sample DB 1482	Lefkas Dekatiés
Several poorly preserved forms belonging to *Ph.* (*Hypophylloceras*) and *Holcophylloceras*			14
Ptychophylloceras ptychoicum		2	2
Ptychophylloceras geminum			4
Sowerbyceras (*Sowerbyceras*) *tortisulcatum*			2
Lytoceras liebigi		3	?
Protetragonites quadrisulcatus			5
Haploceras (*Haploceras*) *elimatum*			1
Haploceras (*Haploceras*) aff. *elimatum*			1
Haploceras (*Haploceras*) *rasile planiusculum*		2	
Haploceras (*Haploceras*) *carachtheis*		1	1
Aspidoceras (*Aspidoceras*) *rogoznicense*			1
Aspidoceras (*Aspidoceras*) *longispinum*			1
Aspidoceras (*Aspidoceras*) *cyclotum*			3
Aspidoceras (*Aspidoceras*) aff. *wolfi*			1
Physodoceras altenense periacense			1
Physodoceras circumspinosum			2
Benacoceras heteroplocum	1		
Simoceras volanense			3
Simoceras sp., group of *S. volanense*, Pl.V, Figs. 5, 6		2	
Simoceras sp., group of *S. volanense*, Pl.V, Fig. 4		1	
Perisphinctes (*Orthosphinctes*) aff. *colubrinus*			2
Perisphinctes (*Orthosphinctes*) cf. *adelus*			2
Perisphinctes (*Orthosphinctes*) aff. *sutneri*			7
Perisphinctes (*Orthosphinctes*) *serranus*		2 ?	4
Katroliceras sp., cf. *K.* (*Katroliceras*) *aceroides*			1
Lithacoceras (*Lithacoceras*) sp.		1	1
cf. *Enosphinctes*			1

The ammonite fauna has been listed in Table 1. The majority of the species indicate an Upper Oxfordian to Lower Kimmeridgian age. A more accurate age determination and correlation with the established ammonite zones in Southern Germany is not yet possible using the available material. A correlation with the rich and well preserved faunas described by K. A. VON ZITTEL (1868, 1870), M. CANAVARI (1897) and more recently by G. RAMACCIONI (1939) and R. COLACICCHI and G. PIALLI (1967) is sometimes hampered by lack of information concerning the exact stratigraphical position of most of the fossils. It seems, however, that the fauna from sample DB 1482 is condensed and may comprise forms from different ammonite zones.

The fine sediment of the rock contains *Stomiosphaera moluccana* WANNER and abundant calcitized radiolaria (Pl. I, Fig. 2); it is essentially pelagic and is almost entirely composed of coccoliths and their fragments which are sometimes closely packed by solution-welding (Pl. I, Figs. 4–5; A. G. FISCHER et al., 1967); occasionally neomorphically formed calcite and some tiny euhedral dolomite rhombs are found (Pl. IV, Figs. 4–5). Amongst the coccoliths the following forms have been recognized (determinations by B. PRINS):

sample DB 1480:	*Watznaueria* cf. *barnesae* (BLACK 1959) PERCH-NIELSEN 1968 (Pl. IV, Fig. 4)
	Zeugrhabdotus REINHARDT 1965
sample DB 1482:	? *Nannoconus steinmanni* KAMPTNER 1931
	Watznaueria communis REINHARDT 1964
	prob. *Eiffelitaceae*
	? *Discorhabdus* NOËL 1965
	? *Zeugrhabdotus* REINHARDT 1965
sample DB 1483:	*Watznaueria barnesae* (BLACK 1959) PERCH-NIELSEN 1968
	Zeugrhabdotus erectus (DEFLANDRE 1954) REINHARDT 1965
	Cyclagelosphaera NOËL 1965 (Pl. I, Fig. 4–5; Pl. IV, Fig. 5)

Most of the determined genera and species have a long stratigraphic range covering the whole of the Middle and Upper Jurassic, only *Zeugrhabdotus erectus* is restricted to the Bathonian to Kimmeridgian with a maximum occurrence in the Callovian-Oxfordian – which is more or less in agreement with the age of the ammonite fauna.

The limestone bed with the condensed ammonite fauna is overlain by about 1.50 m of fine, burrowed microbioclast lime wackestones with *Stomiosphaera moluccana* grading into the Upper Tithonian Vigla Limestone.

7. Vigla Limestone

During the uppermost Jurassic, the abrupt changes of facies and thicknesses characteristic of the Jurassic, tended to disappear and the entire realm of the Ionian zone was covered by the monotonous facies of the Vigla Limestone. This formation, composed of well-bedded, white or light grey to yellowish lime wackestones rich in planktonic organisms (radiolaria, tintinnids in the lower part, planktonic foraminifera in the Middle to Upper Cretaceous) contains nodules and bands of replacement chert and is comparable to the coevel pelagic sediments widespread over the whole of the Mediterranean Tethys (Maiolica, Biancone, Lattimusa etc.). As in the case of the Maiolica Formation of the central Apennines (A. FARINACCI, 1964; P. CANUTI and M. MARCUCCI, 1969) coccoliths and their fragments make up the largest part of the fine sediment (Pl. I, Fig. 3). The thickness of the formation varies between less than 100 m and 750 m (INSTITUT DE GÉOLOGIE etc., 1966).

In the basinal sequences (sections A and B) the boundary between the Upper "Posidonia" Beds and the Vigla Limestone is somewhat gradational and the exact boundary has been conventionally indicated with the appearence of tintinnids. In section A, some intercalations of graded bioclastic breccias and calcarenites with skeletal fragments of aptychi and pelagic crinoids (*Saccocoma*) are present at the boundary between the Upper "Posidonia" Beds and the Vigla Limestone. In section C, the actual boundary between the two formations has not been observed, but it seems that the well-bedded cherty limestones with pelagic lamellibranchs grade into the Vigla Limestones. In sections D and E, the Vigla Limestone overlies thin microbioclast lime wackestones which constitute the top of the condensed sequence (see p. 584).

In the basal part of the Vigla Limestone rich tintinnid faunas are present. The associations found are listed in Table 2 (determinations by F. ALLEMANN). Most of the associations indicate an Upper Tithonian age, and fall into the *Crassicollaria*-zone of J. REMANE (1964). The faunas in section A (samples DB 1503–1505) and in section D

Table 2. Microfossil assemblages in the basal Vigla Limestone, determinations by F. ALLEMANN and B. PRINS.

	section A			section D			section E
	DB 1503	1504	1505	1514	1529A	1529B	1477
Coccolithiphoridae							
Watznaueria REINHARDT 1964							+
? Sollasites BLACK 1967	not investigated						+
? Discorhabdus NOËL 1965, or Palaeopontosphaera NOËL 1965							+
Calpionellidae							
Calpionella alpina LORENZ	x	x	x		x	•	x
Calpionella elliptica CADISCH	?	/	1		/	1	
transitional form C. alpina-C. elliptica	/						
Crassicollaria intermedia (DURAND-DELGA)	/	•	•		x	/	x
Crassicollaria massutiniana (COLOM)		/	/		1?	/	
Crassicollaria brevis REMANE	/	/	/		x	/	
Crassicollaria parvula REMANE	/	/	/		1		
incertae sedis							
Nannoconus wassalli BRÖNNIMANN				+			
Nannoconus cf. elongatus BRÖNNIMANN				+			
Nannoconus globulus BRÖNNIMANN				+			
Nannoconus truitti BRÖNNIMANN				+			
Nannoconus sp.							x
Cadosina lapidosa VOGLER				+			
Cadosina sp.				+			
Stomiosphaera moluccana WANNER	•	x	x		x	x	x

• abundant x frequent / rare 1 single + qualitative occurrence

(western side of the quarry, samples DB 1529 A and B) belong to the *brevis-massutiniana*-subzone, and those in section E to the *intermedia-alpina*-subzone (J. REMANE, 1964). In section D (eastern side of the quarry, sample DB 1514) the basal Vigla Limestone contains locally a nannofossil assemblage of Upper Valanginian or younger age (assemblage 3 of P. BRÖNNIMANN, 1955) indicating local persistence of conditions of non-deposition and/or penecontemporaneous submarine erosion during deposition of the Vigla Limestone.

The upper boundary of the Vigla Limestone is gradational: in the axial parts of the Ionian zone it has been delineated by the appearence of lime turbidites derived from the margins of the adjacent carbonate platforms (Lower/Upper Senonian boundary, J. AUBOUIN, 1959).

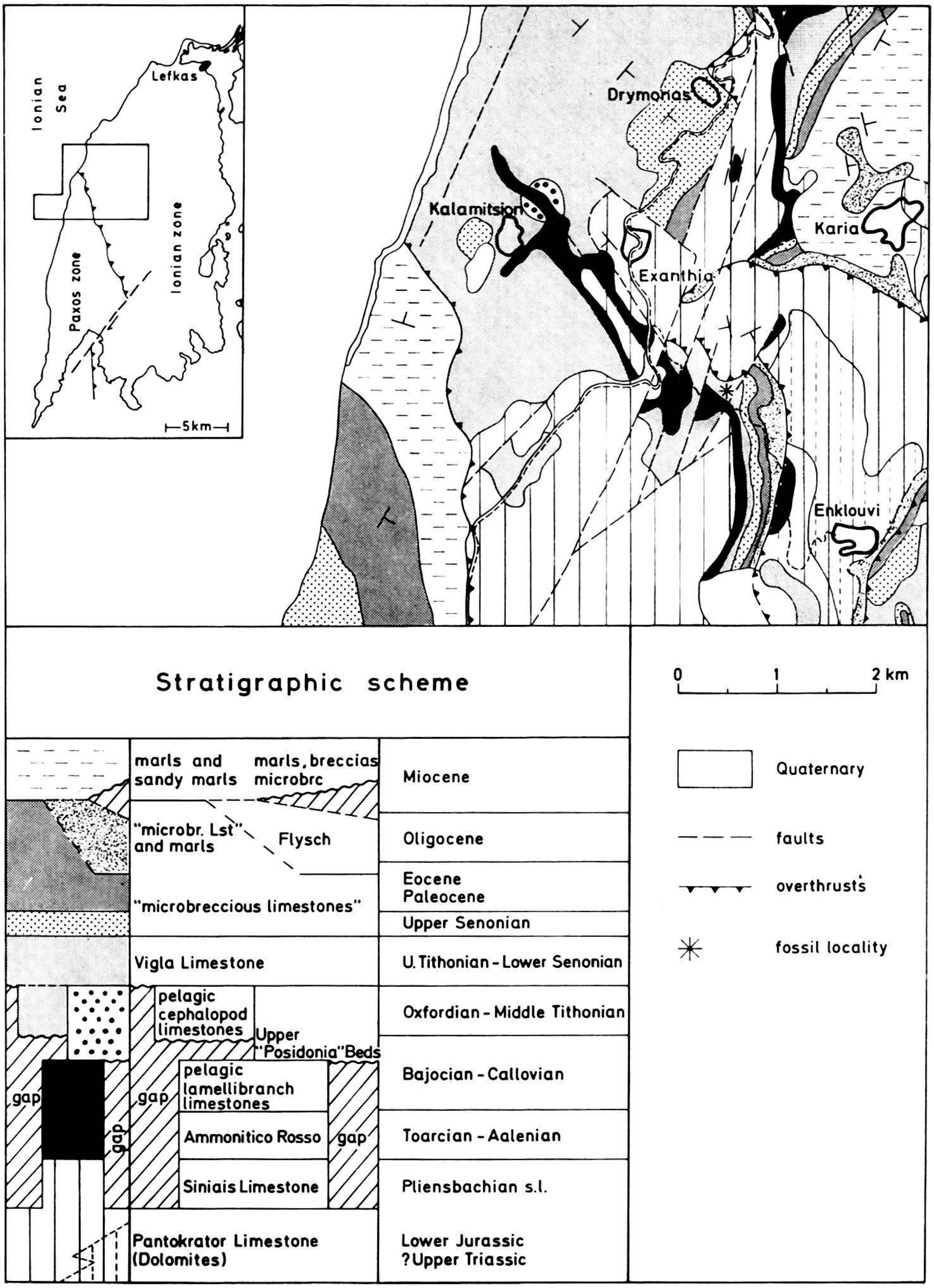


Fig. 5. Geological map of the area between Exanthia and Enklouvi (Dekatiés), Lefkas Island. From J. Bornovas (1964).

Note on the Jurassic of Lefkas Island

The sedimentary sequences of Lefkas Island have been described in detail by C. Renz (1936, 1955) and J. Bornovas (1964). The westernmost part of the island (Lefkata peninsula) belongs to the Paxos zone, whereas the main part of the island is part of the external margin of the Ionian zone.

The oldest rocks exposed in the *Paxos zone* are white to light grey, coarsely crystalline and in general strongly cataclastic dolomites, in which all fossils and depositional textures have been obliterated. They could represent either dolomitized equivalents of the Lower Liassic Pantokrator Limestone or dolomitized Middle to Upper Jurassic slope deposits of the eastern flank of the Zante-Apulia carbonate platform. Since Middle to Upper Jurassic dolomites have been reported from Ithaka (W. Ott, 1966) and from the transition zone between the Apulia carbonate platform and the prolongation of the Ionian zone in the eastern M. Gargano peninsula (G. Pavan and C. Pirini, 1965) a Middle to Upper Jurassic age seems more likely. The dolomite sequence is overlain by an association of limestones and black shales in which J. Bornovas (1964) has found *Perisphinctes* sp. and *Laevaptychus* sp. indicating an Upper Jurassic age. The overlying Mesozoic sequence of the Paxos zone (Vigla Limestone, limestone microbreccias) shows only minor differences compared with that of the adjacent Ionian zone, as summarized in Figure 5.

Along the external margin of the *Ionian zone* the same formations as in its axial parts (Louros valley) are found (Figs. 2 and 3). In the Middle and Upper Jurassic, graded and laminated microbreccias and calcarenites occur; they contain redeposited carbonate platform material such as fragments of shallow-water limestones, ooids, *Trocholina* etc. (section of Anavrisada, D. Bernoulli, unpubl.). According to J. Bornovas (1964) the Vigla Limestone rests locally on the Pantokrator Limestone. This, together with "neritic limestones" intercalated in the Vigla Limestone, would, according to Bornovas, indicate positive tectonic movements during the Jurassic. It seems more likely, however, that the stratigraphical gaps correspond rather to a submarine hiatus and that the organisms found by Bornovas (corals, cyanophycean algae) are displaced.

The ammonite fauna which is described in this paper was collected by C. Renz on the southern slopes of Meganoros near the locality of Dekatiés situated along the trail from Exanthia to Enkluvi (Fig. 5) (C. Renz, 1936, Fig. 2, p. 423; 1955, p. 186–187, 191–192). The geological map of Lefkas by Bornovas indicates in this locality a normal stratigraphic succession ranging from the Ammonitico Rosso to the Vigla Limestone. The sequence is affected by some NNW-SSE-striking faults and overthrusted in the north by the Pantokrator Limestone of the Meganoros.

The rock in which the ammonite fauna is conserved is a light grey bioclast lime wacke- to packstone with abundant bioclasts, amongst others *Stomiosphaera moluccana* Wanner, foraminifera, aptychi (*Lamellaptychus*, *Laevaptychus*), *Saccocoma*, many echinoderm remains and recrystallized shell fragments. The groundmass of the rock frequently contains coccoliths in a neomorphically formed calcite mosaic (Pl. IV, Figs. 3, 6–7) and the following forms could be determined (det. B. Prins): *Watznaueria barnesae* (Black 1959) Perch-Nielsen 1968, ? *Zeugrhabdotus embergeri*

(NOËL 1959) nov. comb. Under the steroscan electron microscope occasional euhedral dolomite rhombs up to 5 μ could be detected (cf. Pl. IV, Fig. 5).

The ammonite fauna is listed in Table 1. The majority of the species indicate an Upper Oxfordian to Lower Kimmeridgian age with possible condensation or reworking of the fauna.

Together with the ammonites a few echinoderms occur, which have been determined as *Tithonia* (*Collyrites*) cf. *transversa* D'ORBIGNY by A. JEANNET (1928, Pl. 36, Figs. 1–9, p. 463).

In the overlying Vigla Limestone C. RENZ and M. REICHEL (1946) and J. BORNOVAS (1964) have found microfossil assemblages of the Upper Tithonian and the Berriasian-"Neocomian" respectively.

Environmental and palaeotectonic evolution

During the Upper Triassic and the Lower Liassic a vast carbonate platform extended over the whole of western Greece. Strong subsidence was balanced by prolific carbonate sedimentation, resulting in the build-up of a shallow-water carbonate sequence more than a thousand metres thick (Pantokrator Dolomite and Limestone). The occurrence of abundant codiacean and dasyclad algae, onkolites, pellets and algal stromatolites with "fenestrae" indicates that the limestones were deposited in a intertidal to shallow subtidal environment with restricted water circulation.

In the Ionian zone, from the Middle Liassic onwards, the general faunal content and lithological composition of the formations suggest a general deepening of the sea – or at least an increased "oceanic" influence– whereas accumulation of shallow-water carbonates continued in the Zante and Gavrovo zones. At the same time, a differentiation into areas with continuous and interrupted sedimentation took place *within* the Ionian zone; the continuous sequences apparently correspond to more basinal deposits which were separated by intrabasinal swells. As shown by the occurrence of sedimentary dykes and the abrupt changes of facies and thicknesses (INSTITUT DE GÉOLOGIE etc., 1966), the palaeogeographic units, which in some cases did not exceed a few kilometres across, were structurally controlled and correspond to blocks which sank at different rates. True tangential movements as assumed by INSTITUT DE GÉOLOGIE etc. (1966) could not, however, be confirmed.

The basinal deposits (complete sequences of Siniais Limestone, Ammonitico Rosso, pelagic lamellibranch limestones; Upper "Posidonia" Beds) contain mainly planktonic, pseudo-planktonic or nektonic organisms (pelagic lamellibranchs [*Bositra*], radiolaria and ammonites [mainly Phylloceratidae and Lytoceratidae]); no autochthonous neritic biota are found. Along the external margin of the Ionian zone, however, there are frequent intercalations of slump conglomerates and lime turbidites composed of redeposited carbonate platform material, such as broken shells of neritic organisms, ooids, onkoids and intraclasts of shallow water limestones (Ithaka: W. OTT, 1966, not interpreted as such; Lefkas: D. BERNOULLI, unpubl.; Igoumenitza: INSTITUT DE GÉOLOGIE etc., 1966). These turbidites indicate that considerable topographic gradients existed along the margins of the carbonate platforms and it seems therefore that the basinal deposits were deposited in rather deep water, say at least some hundreds of metres or even more. On the other hand, depths in the order of several thousand metres as assumed by R. E. GARRISON and A. G. FISCHER (1969) for the Jurassic basinal deposits of the Northern Calcareous Alps are not likely, as the basinal sediments of the Ionian zone were deposited on a sunken continental margin presumably underlain by a granitic basement.

The axial parts of the Ionian zone were apparently sheltered by intrabasinal highs, as no turbidites derived from the carbonate platform margins are found before the uppermost Jurassic. The turbidites and slumped beds which occur in the axial parts of the Ionian zone contain mainly pelagic limestone clasts and the same organisms as the host rock, and only occasionally redeposited fragments of pre-existing formations are found (boulders of Siniais Limestone in Ammonitico Rosso of section B; for other examples see C. RENZ, 1927, 1955). They must all be derived from intrabasinal sources, such as submarine highs ("seamounts") and associated fault scarps, and indicate considerable relief of sea-bottom morphology due to pronounced tectonic activity. Terrigenous clays which are trapped in the depressions are not derived from the swells but from distant areas outside the Ionian zone.

In the basinal sequences water depth increased considerably during the Jurassic and reached its maximum during the Toarcian and the Upper Jurassic, when siliceous argillites and bedded cherts were deposited (Lower and Upper "Posidonia" Beds). Since the fossil remains in these beds are exclusively calcitic (*Bositra*, aptychi) and ammonite remains are only found in slumped beds or in relatively shallower facies of the same age (Toarcian: Ammonitico Rosso; Upper Jurassic: pelagic cephalopod limestones), the sea bottom must have locally reached conditions of aragonite solution. This interpretation of relative bathymetry is confirmed by the occurrence of pebbly mudstones of Ammonitico Rosso material in the Lower "Posidonia" Beds at Palaeospita (Korfu, C. RENZ, 1955).

On the swells, no evidence of emersion or of shallow-water carbonate production younger than Middle Liassic has been found, and therefore the highs must have developed into limestone "seamounts" from the Upper Liassic onwards (cf. H. C. JENKYNS and H. S. TORRENS, 1969). The pelletal limestones with "*Vidalina*" *martana* in section D, which are possibly of Middle Liassic age, have still been deposited in relatively shallow water; however, the absence of dasyclad or codiacean algae and the occurrence of crinoid ossicles and sponge spicules points to an open marine environment. On the other hand the Upper Liassic to Upper Jurassic limestones of the "seamounts" are essentially pelagic as they seem to be built up largely by calcareous nannoplankton; they further contain planktonic microfossils (radiolaria, *Globigerina*, planktonic lamellibranchs), ammonites and occasional crinoid ossicles; and, in fact, crinoid- and *Globigerina*-sands are common on modern current-swept seamounts (e.g. M. BLACK et al., 1964; R. M. PRATT, 1967, 1968). Low rates of sedimentation characteristic for seamount environments are indicated by the occurrence of subsolved ammonite shells (cf. R. HOLLMANN, 1964), by early lithification and subsequent solution of fine carbonate material (cf. H. ZANKL, 1969), the development of ferruginous hard-grounds and by replacement of sediment by phosphates. Dolomite which occurs in tiny euhedral rhombs in the condensed sequences is known to occur in Recent sediments in different submarine environments (A. G. FISCHER and R. E.

GARRISON, 1967; G. THOMPSON et al., 1968) and is not necessarily indicative of shallow water environments or temporary exposure.

The origin of the "Scheck" of the Adnet Beds in Austria has been discussed recently by J. D. HUDSON and H. C. JENKYNS (1969) and by H. JURGAN (1969). Their interpretation of the "Scheck" as marine resedimented conglomerate, cemented in a submarine environment, is consistent with our own observations. However, a turbiditic origin of the "Scheck" as suggested by R. E. GARRISON and A. G. FISCHER (1969) does not seem very likely since the "Scheck"-like conglomerate in the Louros valley is apparently restricted to a very limited area and therefore might represent a product of local reworking, accumulating in small depressions of a seamount. In fact, the sequence of the Adnet quarries is condensed compared with the considerably thicker basinal sequence at the Glasenbach gorge a few kilometres north of Adnet which contains slumped beds and lime turbidites comparable to the basinal deposits of the Louros valley (D. BERNOULLI and H. C. JENKYNS, in preparation).

Pelagic sediments are not necessarely deposited at great depth. However, as no algal stromatolites like the ones reported from different condensed pelagic sequences (e.g. A. RADWÁNSKI and M. SZULCZEWSKI, 1965; H. C. JENKYNS and H. S. TORRENS, 1969) of the Tethyan Jurassic have been found up till now, it seems that most of the seamounts did not reach the photic zone – which in clear oceanic waters may extend down to 150 metres (J. H. RYTHER, 1956). Following B. ZIEGLERS (1967) bathymetric interpretation of Upper Jurassic ammonite faunas the composition of both faunas (Fig. 6) would indicate water depth below 200 metres for the pelagic cephalopod limestones. In the fauna from the Louros valley Phylloceratidae and Lytoceratidae make up about 40% of the fauna and Aspidoceratidae and Perisphinctidae are quite common (55%), but Oppeliidae are rather rare (5%). According to B. ZIEGLER, the composition of this fauna suggests a water depth of more than 300 metres. Compared

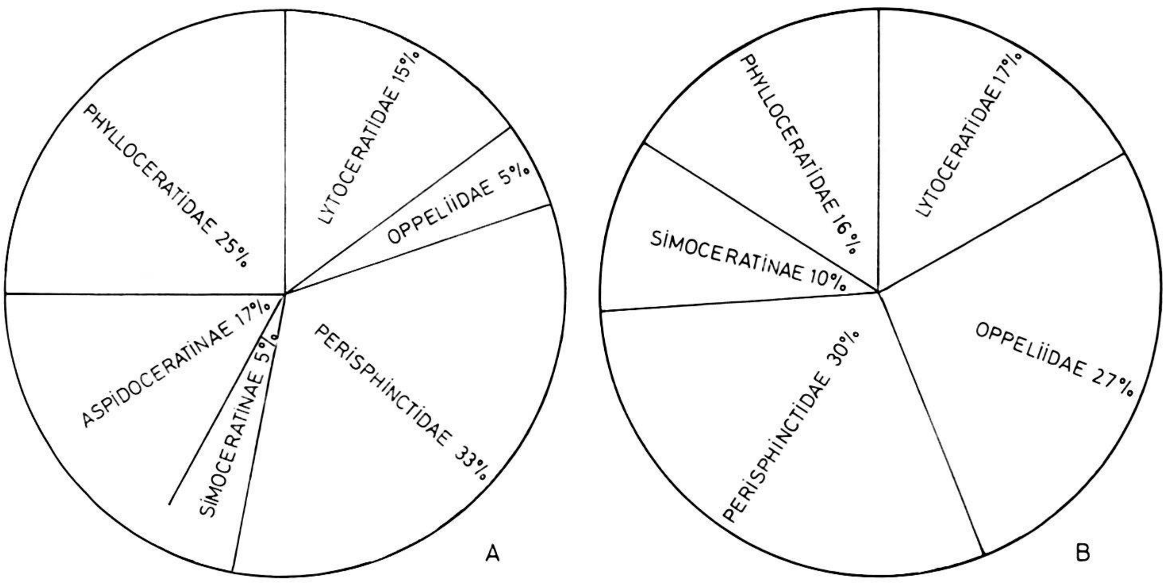


Fig. 6. Composition of ammonite faunas (individuals) from the Upper Jurassic of western Greece. A: Louros valley, section E. B: Dekatiés, Lefkas Island.

with the fauna of the Louros valley, the fauna from Lefkas contains less Phylloceratidae and Aspidoceratidae, but considerably more Oppeliidae and this would indicate a somewhat shallower depth (according to B. ZIEGLER around 250 m). It seems, however, that the composition of the faunas is only indirectly related to water depth as the relatively large forms (chiefly macroconchs) were most probably adapted to swimming in an "oceanic" environment (J. GUEX, 1969) – and might also have undergone post-mortal dispersal. Therefore it is difficult to arrive at any well-reasoned bathymetric figure from the faunal content: however, depths in the order of at least a few hundred metres seem plausible. Nevertheless one could suggest that the faunal assemblage from the axial Ionian zone has been deposited at greater depth than the assemblage from Lefkas.

From the Upper Tithonian onwards, irregularities of bottom morphology were eliminated by a higher rate of carbonate sedimentation (Vigla Limestone), but considerable differencies in thickness indicate differential subsidence in the Ionian trough during the Lower Cretaceous.

Palaeontological descriptions

The collection consists of 58 determinable ammonites from the locality Dekatiés in Lefkas and 15 from the Louros valley in Epirus. The ammonites predominantly occur as fragments of internal molds with poorly visible suture lines.

Abbreviations:
Dm = Diameter, Wh = Whorl height, Ww = Whorl width, U = Umbilical width.

All specimens are deposited in the Museum of Natural History in Basle.

Family Phylloceratidae ZITTEL 1884

Genus *Phylloceras* SUESS 1865

On the Isle of Lefkas the genus *Phylloceras* is abundant and represented by 15 individuals, which are mostly fragments without preserved tests. The sutures, indispensable for a specific determination, are poorly recognizable and even the septa are often partly dissolved.

A flat, high whorled and smooth form (J 19011) coincides satisfactorily, as far as the dimensions are concerned, with *Phylloceras* (*Hypophylloceras*) *serum* (OPPEL). This species has been mentioned by ZITTEL (1870, p. 161) from a similar facies in the Central Apennines.

Less abundant are broad, smooth forms. A specimen (J 19043) with constrictions might represent a *Holcophylloceras* SPATH 1927.

Apparently the family has been as variably represented on the Isle of Lefkas as in the Apennines.

Genus *Ptychophylloceras* SPATH 1927

Ptychophylloceras ptychoicum (QUENSTEDT 1847)

1847 *Ammonites ptychoicus* QUENSTEDT, Pl. 17, Fig. 12, p. 219.
1927 *Phylloceras ptychoicum* QUENSTEDT, C. RENZ, p. 493.

This widely distributed species is represented by several individuals from section E in the Louros valley and also occurs on Lefkas Island in the surroundings of the locality Dekatiés. In both sections *P. ptychoicum* is satisfactorily preserved. This form has been known from the Apennines since 1868 when it was described by ZITTEL (Pl. 4, Figs. 3–9).

Measurements (mm):	Dm	Wh	Ww	U
ZITTEL 1868, p. 59:	50–60	0.56–0.59	0.50	0.05
J 19012 (Louros valley):	59	34 (0.57)	28 (0.47)	2 (0.03)

Ptychophylloceras geminum (BENECKE 1866)

1866 *Ammonites geminus* BENECKE, Pl. 10, Figs. 3a, b, p. 189.

Measurements (mm):	Dm	Wh	Ww	U
BENECKE 1866:	45	23 (0.51)	15.5 (0.34)	5 (0.11)
J 19014 (Lefkas):	47	24 (0.51)	18 (0.38)	5 (0.10)

The size of the shell and the number of periodic flares over the rounded venter coincide well with the holotype from Monte Nago near Rovereto. Our specimen from Lefkas is, however, somewhat broader.

Genus *Sowerbyceras* PARONA and BONARELLI 1895

Subgenus *Sowerbyceras* WIEDMANN 1963

Sowerbyceras (*Sowerbyceras*) *tortisulcatum* (D'ORBIGNY 1849)

1849 *Ammonites tortisulcatus* D'ORBIGNY, Pl. 189, p. 506.

On the Isle of Lefkas this form seems to be common, but occurs in relatively small specimens.

Measurements (mm):	Dm	Wh	Ww	U
J 19013:	30	14 (0.46)	11 (0.36)	6 (0.20)

Family Lytoceratidae NEUMAYR 1875

Genus *Lytoceras* SUESS 1865

The genus is less common than *Phylloceras* and represented by only three specimens.

Lytoceras liebigi (OPPEL 1865)

1865 *Ammonites Liebigi* OPPEL, p. 551.
1868 *Lytoceras Liebigi* OPPEL, ZITTEL, Pl. 9, Figs. 6, 7; Pl. 10, Fig. 1, p. 74.

From Louros valley *L. liebigi* is represented by three individuals (J 19015/1–3) with partly preserved tests. The straight, crinkled, slightly prorsiradiate growth lines are well developed. On a fragment of an outer whorl a few stronger riblets (flares), corresponding to constrictions on the internal mold, are recognizable. The whorl width exceeds the whorl height in all available individuals. The measurements of a small specimen are: Dm = 31 mm, Wh = 12 mm (0.40), Ww = 14 mm (0.45), U = 11.5 mm (0.37).

A still septated fragment (J 19015/1), with a whorl height of 35 mm, indicates that this species attained a considerable size also in Greece.

Family Protetragonitidae SPATH 1927

Genus *Protetragonites* HYATT 1900

Protetragonites quadrisulcatus (D'ORBIGNY 1840)

1840 *Ammonites quadrisulcatus* D'ORBIGNY, Pl. 49, Figs. 1–3, p. 151.

ZITTEL (1870, Pl. 26, Fig. 2, p. 162) mentions this widespread species from numerous localities in the Central Apennines. From Lefkas Island it is represented by several small individuals, all of them preserved as internal molds (J 19016).

Family Haploceratidae ZITTEL 1884

Genus *Haploceras* ZITTEL 1870

The representatives of this genus are amongst the commonest ammonites from Lefkas Island as well as from Louros valley.

Haploceras (Haploceras) elimatum (OPPEL 1865)

1865 *Ammonites elimatus* OPPEL, p. 549.
1868 *Ammonites elimatus* OPPEL, ZITTEL, Pl. 13, Figs. 1–7, p. 79.
1966 *Haploceras (Haploceras) elimatum* (OPPEL), WIEDMANN, part 1: Pl. 1, Fig. 1; part 2: Textfigs. 42b, 43a, p. 61.

Measurements (mm):	Dm	Wh	Ww	U
ZITTEL 1868, p. 80:	50–70	0.46	0.34	0.18–0.23
J 19017 (whorl width restored):	68	31 (0.45)	? 22 (0.32)	15 (0.22)

Of this widely distributed form only one specimen from Lefkas is present. Its phragmocone reaches a diameter of 55 mm.

Haploceras (Haploceras) aff. *elimatum* (OPPEL 1865)

Pl. V, Figs. 3a, b

Measurements (mm):	Dm	Wh	Ww	U
J 19018 (Lefkas):	79	32 (0.40)	25 (0.31)	23 (0.29)
H. (H.) subelimatum FONTANNES 1879, p. 12:	54	0.42	0.26	0.28

A specimen from Lefkas is distinguished from the typical *H. (H.) elimatum* by a wider umbilicus and a corresponding shorter whorl height. Its whorl width, however, coincides well with the type. The diameter of the phragmocone reaches 68 mm.

H. (H.) subelimatum FONTANNES 1879 (Pl. 2, Figs. 5, 6, p. 12) from the Château de Crussol in the Ardèche has an equally wide umbilicus as the form from Greece. Its whorl section, however, is considerably flatter.

Haploceras (Haploceras) rasile planiusculum ZITTEL 1870

Pl. V, Figs. 3a, b

1870 *Haploceras rasile* OPPEL var. *planiuscula* ZITTEL, Pl. 28, Figs. 3a, b, p. 173.
1939 *Lissoceras rasile* var. *planiuscula* ZITTEL, RAMACCIONI, Pl. 13, Fig. 12, p. 195.

Holotypus: ZITTEL, Pl. 28, Figs. 3a, b, p. 174.
Locus typicus: Rogoznik (Carpathians).

ZITTEL (1870) distinguishes two subspecies, a flatter "*planiuscula*" and a thicker one "*inflata*".

Measurements (mm):	Dm	Wh	Ww	U
ZITTEL 1870, p. 174:	20–37	0.40–0.43	0.23–0.27	0.27
J 19019 (Louros valley):	38	17 (0.44)	11 (0.29)	10 (0.26)

An additional, less favorably preserved specimen (J 19020) from the same locality is distinguished by its wider umbilicus and its considerably broader whorl section. The measurements are: Dm = 27 mm, Wh = 15 mm (0.40), Ww = 12 mm (0.32), U = 12 mm (0.32). This individual might represent an approximation to *Haploceras rasile inflatum* ZITTEL from Monte Catria (Central Apennines). According to ZITTEL the subspecies "inflatum" has a whorl width of 32 to 37% of the diameter and an umbilicus ranging between 26 to 35%.

Haploceras (*Haploceras*) *carachtheis* (ZEUSCHNER 1846)

Pl. V, Figs. 2a, b

1846 *Ammonites carachtheis* ZEUSCHNER, Pl. 4, Fig. 3.
1868 *Ammonites carachtheis* ZEUSCHNER, ZITTEL, Pl. 15, Figs. 1–3, p. 84.
1879 *Haploceras carachtheis* ZEUSCHNER, FONTANNES, Pl. 2, Fig. 3, p. 10.
1939 *Lissoceras carachtheis* ZEUSCHNER, RAMACCIONI, Pl. 13, Fig. 13, p. 196.

Holotypus: ZEUSCHNER, 1846, Pl. 4, Fig. 3.
Locus typicus: Tatra Mountains (Carpathians).

Measurements (mm):	Dm	Wh	Ww	U
ZITTEL 1868, p. 85:	25–50	0.45–0.50	0.34	0.24
J 19021 (Louros valley):	42	21 (0.50)	14.5 (0.34)	9 (0.21)

With the beginning of the body chamber, weak falcate growth lines appear on remains of the test. The feeble ventral folds developed towards the end of the body chamber are not preserved on the present specimen, as the external part of the body chambers is broken off. The umbilical margin is regularly rounded and does not form a sharp edge as in *Neolissoceras*.

A smaller somewhat deformed specimen (J 19022) from Lefkas has most of its body chamber preserved. The ventral folds developed towards the end of the body chamber are here well visible. The septate portion reaches a diameter of only about 25 mm. From the typical *H.* (*H.*) *carachtheis* this form differs by its smaller size and its narrow umbilicus (15% of the diameter). It seems to be related to *H.* (*H.*) *pseudocarachtheis* (FAVRE, 1879, Pl. 2, Fig. 11, p. 30) which, however, possesses denser ventral folds.

Family Aspidoceratidae ZITTEL 1895

Subfamily Aspidoceratinae ZITTEL 1895

In Greece this subfamily is well represented, especially as far as the number of individuals is concerned. Four species belong to the genus *Aspidoceras* ZITTEL 1868 and two to *Physodoceras* HYATT 1900. Both genera are so far restricted to Lefkas.

Genus *Aspidoceras* ZITTEL 1868

Aspidoceras (*Aspidoceras*) *rogoznicense* (ZEUSCHNER 1846)

1846 *Ammonites Rogoznicensis* ZEUSCHNER, Pl. 4, Figs. 4a–d.
1868 *Ammonites* (*Aspidoceras*) *Rogoznicensis* ZEUSCHNER, ZITTEL, Pl. 24, Figs. 4, 5, p. 116.
1870 *Aspidoceras Rogoznicense* ZEUSCHNER, ZITTEL, Pl. 3, Figs. 1a, b, p. 197.

Measurements (mm):	Dm	Wh	Ww	U
ZITTEL 1868, p. 117:	20–100	0.45	0.65	0.26
J 19023 (Lefkas):	205	86 (0.43)	? 115 (0.56)	65 (0.31)

The present specimen is completely septate and ornamented to its end by flat ribs, crossing over the broad venter. The form is remarkable for its considerable size of over 200 mm. Individuals reaching a diameter between 150–160 mm are described by ZITTEL 1870 (p. 197) from Monte Catria in the Central Apennines.

Aspidoceras (Aspidoceras) longispinum (J. DE C. SOWERBY 1825)

1825 *Ammonites longispinus* SOWERBY, Pl. 501, Figs. 3, 4.
1874 *Ammonites longispinus* SOWERBY, LORIOL and PELLAT, Pl. 2, Fig. 2, p. 24.

This widely distributed species is represented by internal volutions only.

Measurements (mm):	Dm	Wh	Ww	U
LORIOL and PELLAT, p. 24:	90–120	0.37	0.46	0.33
J 19024 (Lefkas):	54	21 (0.39)	27 (0.50)	17 (0.31)

Aspidoceras (Aspidoceras) cyclotum (OPPEL 1865)

1865 *Ammonites cyclotus* OPPEL, p. 552.
1870 *Aspidoceras cyclotum* OPPEL, ZITTEL, Pl. 30, Figs. 2–5, p. 201.

Measurements (mm):	Dm	Wh	Ww	U
ZITTEL 1870, p. 202:	112	0.53	0.66	0.21
J 19025 (Lefkas):	35	17.5 (0.50)	24 (0.68)	5 (0.14)

Several globular shells from Lefkas show no sign of sculpture and can best be compared with *Aspidoceras cyclotum* described by ZITTEL from Monte Catria. The slightly narrower umbilicus might be connected with the small size of the available specimens, which apparently represent internal volutions.

Aspidoceras (Aspidoceras) aff. *wolfi* NEUMAYR 1873

Pl. VI, Figs. 1a, b

1873 *Aspidoceras Wolfi* NEUMAYR, Pl. 38, Fig. 5, p. 195.

Holotypus: NEUMAYR 1873, Pl. 38, Fig. 5, p. 195.
Locus typicus: Csofranka in Siebenbürgen (Romania), red limestones with *Aspidoceras acanthicum*.

Measurements (mm):	Dm	Wh	Ww	U
NEUMAYR 1873, Fig. 5:	93	38 (0.41)	35 (0.38)	23.5 (0.25)
J 19026 (Lefkas):	51	22 (0.43)	25 (0.49)	13.5 (0.26)

A well-preserved *Aspidoceras* with a completely smooth surface can best be compared with *A. wolfi* NEUMAYR. It differs from the holotype in its noticeably broader whorl section.

Aspidoceras (A.) episoides FONTANNES 1879 (Pl. 13, Fig. 10, p. 10) characterized by a smaller whorl width, possesses flat ribs crossing over the venter.

Genus *Physodoceras* HYATT 1900

Physodoceras altenense periacense (FONTANNES 1879)

Pl. V, Figs. 7a, b

1877 *Ammonites (Aspidoceras) Altenensis* D'ORBIGNY, FAVRE, Pl. 7, Figs. 5a, b.
1879 *Aspidoceras Altenense* var. *Periacensis* FONTANNES, Pl. 13, Fig. 3, p. 95.
1931 *Physodoceras altenense* (D'ORBIGNY), SPATH (1927–1933), p. 618.

Holotypus: FONTANNES 1879, Pl. 13, Fig. 3, p. 95.
Locus typicus: Château de Crussol, Ardèche (France).

Measurements (mm):	Dm	Wh	Ww	U
FONTANNES 1879, p. 96:	35	(0.51)	(0.51)	(0.17)
FAVRE 1877, p. 66:	45	(0.53)	(0.50)	(0.15)
J 19027 (Lefkas):	38	20 (0.52)	19 (0.50)	5 (0.13)

The group of *Physodoceras altenense*, characterized by flanks converging towards the venter, is represented by one specimen found on Lefkas Island. It differs from the holotype (D'ORBIGNY 1847, Pl. 204, p. 537) in possessing a narrower umbilicus and satisfactorily coincides with a subspecies from the Château de Crussol referred to as "var. *periacensis*" by FONTANNES 1879. From the Apennines ZITTEL 1870 (p. 199) mentions a representative of this group from Monte Catria.

Physodoceras circumspinosum (QUENSTEDT 1858)

1849 *Ammonites inflatus macrocephalus* QUENSTEDT, Pl. 16, Fig. 14, p. 196.
1858 *Ammonites circumspinosus* QUENSTEDT p. 609.
1877 *Aspidoceras circumspinosum* QUENSTEDT, FAVRE, Pl. 8, Fig. 2, p. 67.
1878 *Aspidoceras circumspinosum* QUENSTEDT, P. DE LORIOL, Pl. 20, Fig. 2, p. 119.
1929 *Physodoceras circumspinosum* OPPEL, WEGELE, Pl. 11, Fig. 2, p. 88.

Measurements (mm):	Dm	Wh	Ww	U
QUENSTEDT 1858:	39	0.54	0.64	0.13
FAVRE 1877:	50	0.51	0.62	0.22
J 19028 (Lefkas):	45	22 (0.50)	31 (0.68)	5 (0.11)

The specimens from Lefkas are distinguished by a broader whorl section and a wider umbilicus when compared with those of France (FONTANNES 1879) and Switzerland (FAVRE 1877).

Subfamily Simoceratinae SPATH 1924

Genus *Benacoceras* SPATH 1925

Benacoceras heteroplocum (GEMMELLARO 1877)

Pl. IV, Fig. 2

The only specimen (J 19044) from section D in the Louros valley resembles in all features (in what is preserved), the holotype from the province of Trapani in Sicily (GEMMELLARO 1877, Pl. 15, Fig. 6, p. 204).

Genus *Simoceras* ZITTEL 1870

Three species belonging to this genus are available, two come from Louros valley and one from Lefkas.

Simoceras volanense (OPPEL 1863)

Pl. VI. Figs. 2a-c

1863 *Ammonites Volanensis* OPPEL, Pl. 58, Fig. 2, p. 231.
1870 *Simoceras Volanense* OPPEL, ZITTEL, Pl. 32, Figs. 7–8, p. 213.

Holotypus: OPPEL 1863, Pl. 58, Fig. 2, p. 231.
Locus typicus: Volano near Rovereto (Southern Alps).

Measurements (mm):	Dm	Wh	Ww	U
ZITTEL 1870, p. 213:	150–180	0.24	0.18–0.22	0.58–0.60
J 19029, restored (Lefkas):	48	10.5 (0.22)	15 (0.29)	30 (0.62)

The few individuals available from Greece differ from the holotype by a whorl section slightly higher than wide.

Simoceras sp., group of *S. volanense* (OPPEL)

Pl. V, Figs. 5a, b, 6

1942 *Simoceras* sp. juv. cf. *S. volanense* (OPPEL), IMLAY, Pl. 3, Fig. 3, p. 1445.
1967 *Aspidoceras phoenicum* GEMMELLARO, COLACICCHI and PIALLI, Figs. 2E, 3B, p. 186.

Aspidoceras phoenicum GEMMELLARO 1877 (Pl. 20, Fig. 19, p. 170) belongs, according to SPATH (1927–33, p. 617), to *Epaspidoceras* SPATH 1931.

Measurements (mm):	Dm	Wh	Ww	U
J 19031, restored:	68	15 (0.22)	14 (0.20)	40 (0.58)
J 19032 (Louros):	32.5	7.2 (0.22)	8 (0.24)	19 (0.58)

The two individuals from Louros valley seem to belong to the group of *S. volanense* with the lateral clavi not alternating. The specimen J 19031 (Pl. V, Fig. 5) is still partly covered by the test, especially on the inner volution. Two of the broad flattened ribs, which still are well preserved, rise on the inner third of the flank into very flat tubercles. Towards the venter these ribs end in a broad ventrolateral clavus, which rises considerably over the venter and is responsible for its concave outline. The test on each of those clavi is ornamented by about seven fine riblets, which end in tiny knots along their outer rim. The ventrolateral clavi do not alternate. The periodic constrictions are distinctly inclined forward (clearly visible on juvenile specimen J 19032, Pl. V, Fig. 6).

From the holotype of *S. biruncinatum* (QUENSTEDT) 1847 (Pl. 19, Fig. 14, p. 260) and the specimens figured by ZITTEL (1870, Pl. 32, Figs. 5, 6, p. 210) from Rovereto the Greek forms differ mainly by not possessing alternating ventrolateral clavi.

Simoceras sp., group of *S. volanense* (OPPEL)

Pl. V, Figs. 4a, b

Measurements (mm):	Dm	Wh	Ww	U
J 19033 (Louros valley):	68	15 (0.22)	14 (0.20)	39 (0.57)

The present form is characterized by more and narrower ribs which terminate in smaller ventrolateral clavi. The tubercles rising on the inner third of the ribs are, however, more pronounced than on the form discussed above. Where the test is preserved, tiny knobs around the edge of the clavi are recognizable. The ventrolateral clavi do not alternate.

Family Perisphinctidae STEINMANN 1890

Subfamily Perisphinctinae STEINMANN 1890

Genus *Perisphinctes* WAAGEN 1869

Modern revisions of the Perisphinctidae, as prepared by GEYER (1961) and KOERNER (1963) for southern Germany, are not yet available for the Mediterranean regions. Moreover, the preservation of most of our material is rather unsatisfactory. An accurate determination of the present *Perisphinctes* from Greece is therefore difficult.

The collection comprises 28 individuals, four of which come from Louros valley and 24 from Lefkas. It is difficult to free the ammonites from the hard splintery limestone, especially those from Louros valley. Representatives of *Perisphinctes*, mainly the subgenus *Orthosphinctes*, and furthermore of *Katroliceras* and of questionable *Lithacoceras* could be identified. 17 specimens belong to *Orthosphinctes*, which seems to represent the most important group.

Subgenus *Orthosphinctes* SCHINDEWOLF 1925

Perisphinctes (*Orthosphinctes*) aff. *colubrinus* (REINECKE 1818)

Pl. VI, Figs. 4a, b

1961 *Perisphinctes (Orthosphinctes) colubrinus* (REINECKE), GEYER, Pl. 1, Fig. 1; Pl. 2, Fig. 3, p. 22.
1963 *Perisphinctes (Orthosphinctes) colubrinus* (REINECKE), KOERNER, Fig. 45, p. 350.
1967 *Perisphinctes colubrinus* (REINECKE), COLACICCHI and PIALLI, Fig. 2C, p. 186.

The species might be represented by the specimen Nr. J 19034 (Pl. VI, Fig. 4) from Lefkas. It attains a diameter of 44 mm. At a size of 40 mm the number of ribs near the umbilical edge is 46, compared with 29 to 40 on forms from Southern Germany (KOERNER, 1963, p. 350). The proportion of the 78 secondary ribs crossing the venter to the umbilical ribs amounts to 1.6 whilst the ratio of whorl height to umbilical width attains 0.52. The present form differs therefore from the typical *P.* (*O.*) *colubrinus* by a slightly higher number of ribs at the umbilical edge and furthermore by its lower whorl height to umbilical width ratio.

Measurements (mm): Dm = 44 Wh = 11 (0.25) Ww = 14 (0.31) U = 23 (0.52)

Perisphinctes (*Orthosphinctes*) cf. *adelus* GEMMELLARO 1872

Pl. VI, Figs. 3a, b

1872 *Perisphinctes adelus* GEMMELLARO, Pl. 8, Fig. 7, p. 51.
1897 *Perisphinctes adelus* GEMMELLARO, CANAVARI, Pl. 22, Figs. 1, 2; Pl. 27, Fig. 3, p. 203.

Holotypus: GEMMELLARO 1872, Pl. 8, Fig. 7, p. 51.
Locus typicus: Burgilamuni near Favara (Sicily).

Measurements (mm):	Dm	Wh	Ww	U
GEMMELLARO 1872, p. 51:	50	0.31	0.42	0.48
CANAVARI 1897, Fig. 1, Pl. 22:	50	0.31	0.40	0.44
J 19036 (Lefkas):	63	19 (0.30)	? 20 (0.32)	32 (0.50)

The holotype from Sicily, as well as the example figured by CANAVARI from the Apennines, are both rather poorly reproduced. Unfortunately the specimens from Greece are also incomplete and the increase of the number of ribs in the course of growth is not determinable. The size of this species seems to be rather small, as the septate portion of the specimen here reproduced attains a diameter of only 61 mm. The ribbing is predominantly biplicate and external intercalatory ribs are subordinate.

At a diameter of 40 mm the umbilical edge is reached by 34 ribs, compared with 42 at 60 mm. The ratio whorl height/umbilical width at a diameter of 60 mm attains 0.53. These few obtainable figures all coincide with those of *P.* (*O.*) *tiziani* (OPPEL 1863). The whorl section of the present form is, however, subquadrate due to flatter flanks and a slightly flattened venter, which distinguishes it from *P.* (*O.*) *tiziani*, which has a more circular whorl section.

Perisphinctes (*Orthosphinctes*) aff. *sutneri* (CHOFFAT 1893)

Pl. VI, Figs. 5a, b

1893 *Perisphinctes Sutneri* CHOFFAT, Pl. 5, Figs. 2a, b, p. 42.
1905 *Perisphinctes Sutneri* CHOFFAT, DEL CAMPANA, Pl. 7, Fig. 2, p. 75.
1939 *Perisphinctes Sutneri* CHOFFAT, RAMACCIONI, Pl. 14, Fig. 2, p. 198.

Holotypus: CHOFFAT 1893, Pl. 5, Fig. 2, p. 42.
Locus typicus: Valle-de-Cortes, Portugal.

The seven individuals present indicate that the form is common.

Measurements (mm):	Dm	Wh	Ww	U
CHOFFAT 1893, p. 42:	64	0.29	0.24	0.45
J 19037:	55	17 (0.30)	16 (0.29)	26 (0.47)

On the Island of Lefkas this species remains rather small, attaining a diameter of only 65 mm. The aperture with lappets is well preserved. Nearly all ribs bifurcate regularly when reaching the outer third of the flank. The whorl section is greater in height than width and differs herewith from all the other *Orthosphinctes* so far obtained from Lefkas. At a diameter of 40 mm, 45 ribs reach the umbilical edge. The ratio whorl height/umbilical diameter amounts to 0.65. The reproduced specimen differs from the holotype in possessing a somewhat greater whorl width.

Perisphinctes (*Orthosphinctes*) *serranus* CANAVARI 1898

Pl. VI, Figs. 6a, b

1898 *Perisphinctes serranus* CANAVARI, Pl. 21, Fig. 1, p. 214.

Holotypus: CANAVARI 1898, Pl. 21, Figs. 1a–c, p. 214.
Locus typicus: Monte Serra near Camerino (Central Apennines).

From the Louros valley as well as from the Isle of Lefkas some of the *Perisphinctes* approach *P.* (*O.*) *serranus*, especially as far as the number of ribs and the dimensions are concerned.

Measurements (mm):	Dm	Wh	Ww	U
CANAVARI, p. 214:	73	0.30	0.36	0.37
J 19038, Pl. VI, Fig. 6 (Lefkas):	55	18 (0.32)	19.5 (0.35)	25 (0.45)
J 19039 (Lefkas):	46	14 (0.30)	16 (0.34)	22 (0.40)

All four individuals seem to be relatively small and the end of the phragmocone on the figured specimen is indicated with a line. At a diameter of 40 mm a second specimen (J 19039) possesses 42 ribs near the umbilical edge. The degree of coiling amounts to 0.63 on the holotype, compared with 0.72 on the specimen J 19038 (Pl. VI, Fig. 6) and to 0.61 on J 19039.

Genus *Katroliceras* SPATH 1924

Subgenus *Katroliceras* SPATH 1924

Katroliceras sp., cf. *K.* (*Katroliceras*) *aceroides* GEYER

Pl. IV, Fig. 1

1961 *Katroliceras* (*Katroliceras*) *aceroides* GEYER, Pl. 3, Fig. 3; Pl. 5, Figs. 5–7, p. 41.

Holotypus: GEYER 1961, Pl. 3, Fig. 3, p. 41.
Locus typicus: Reichenbach i. T. (Württemberg), Weissjura Ober-γ

Measurements (mm):	Dm	Wh	Ww	U
J 19040 (Lefkas):	112	35 (0.31)	28 (0.25)	51 (0.45)

Genus *Lithacoceras* HYATT 1900

Subgenus *Lithacoceras* HYATT 1900

The presence of the subgenus *Lithacoceras* is indicated by poorly preserved fragments with oval whorl sections and fine, dense, bi- and trifurcating ribs.

Genus *Enosphinctes* SCHINDEWOLF 1925

Enosphinctes sp.

Pl. VI, Fig. 7

This genus might be represented by a complete but partly worn specimen, characterized by its small size. The aperture with lappets is clearly preserved. On the phragmocone the ribs branch from small, poorly recognizable tubercles on the umbilical edge and begin to curve slightly backwards on the inner half of the flank; this becomes more distinct towards the body chamber. A similar form with small tubercles is described as *Enosphinctes hararinus* by VENZO (1959, Pl. 4, Figs. 4a, b, p. 38) from the Altipiani Hararini (Somalia).

Acknowledgements

The authors wish to express their sincere thanks to B. PRINS (Rijswijk) for the determination of coccoliths. F. ALLEMANN (Bern) determined the tintinnids from the lowermost Vigla Limestone: J. GUEX (Lausanne) identified some ammonites of the Toarcian. H. SCHWANDER (Basel) kindly determined the phosphates by electron microprobe analysis. H. C. JENKYNS critically read the manuscript and made valuable suggestions.

The first author is very grateful to the Government of the Canton of Basle and to the "Freiwillige Akademische Gesellschaft" in Basle for covering the costs of the field work. The laboratory investigations were carried out with financial help of the Swiss National Science Foundation. J. R. Geigy Ltd. Basle, kindly allowed the use of their stereoscan electron microscope. Miss C. BRÜCHER operated the microscope and assisted examination of the samples with great patience. The photographs of ammonites, polished surfaces and thin slides were made by W. SUTTER (Museum of Natural History, Basle), E. WAGNER and C. KAPELLOS (Geological Institute of the University, Basle).

REFERENCES

A. Regional Geology and Sedimentology

ARKELL, W. J. (1956): *Jurassic Geology of the World.* Oliver & Boyd (Edinburgh and London).

AUBOUIN, J. (1958): *Essai sur l'évolution paléogéographique et le développement tecto-orogénique d'un système géosynclinal: le secteur grec des Dinarides (Hellénides).* Bull. Soc. géol. France (6) *3*, 731–749.

– (1959): *Contribution à l'étude géologique de la Grèce septentrionale: les confins de l'Epire et de la Thessalie.* Ann. géol. Pays hellén. (1) *10*, 1–403.

– (1960): *Essai sur l'ensemble italo-dinarique et ses rapports avec l'arc alpin.* Bull. Soc. géol. France (7) *2*, 487–526.

– (1963): *Esquisse paléogéographique et structurale des chaines alpines de la Méditerranée moyenne* Geol. Rdsch. *53*, 480–534.

– (1964): *Réflexions sur le faciès «Ammonitico Rosso».* Bull. Soc. géol. France (7) *6*, 475–501.

BERNOULLI, D. (1964): *Zur Geologie des Monte Generoso (Lombardische Alpen).* Beitr. geol. Karte Schweiz (NF) *118*.

– (1967): *Probleme der Sedimentation im Jura Westgriechenlands und des zentralen Apennin.* Verh. natf. Ges. Basel *78*, 35–54.

– (1969): *Redeposited Pelagic Sediments in the Jurassic of the Central Mediterranean Area.* Preprint. Colloquium on Mediterranean Jurassic Stratigraphy, Budapest, 1969, to be published in: Ann. Inst. Geol. Publ. Hung.

BISCHOFF, B. (1966): *Die Geologie von Nord-Ithaka (Griechenland).* Diplomarbeit Inst. Paläont. hist. Geol. Univ. München. Manuskript.

BIZON, G. (1967): *Contribution à la connaissance des foraminifères planctoniques d'Epire et des iles ioniennes (Grèce occidentale) depuis le Paléogène supérieur jusqu'au Pliocène.* Soc. Editions Technip, Paris.

BLACK, M., HILL, M. N., LAUGHTON, A. S., MATTHEWS, D. H. (1964): *Three Non-magnetic Seamounts off the Iberian Coast.* Quart. J. geol. Soc. London *120*, 477–517.

BORNOVAS, J. (1964): *Geological Study of Leukas Island.* Inst. Geol. Subsurface Res., geol. geophys. Res. *10*/1, 1–142.

CANUTI, P., MARCUCCI, M. (1969): *Osservazioni al microscopio elettronico sul calcare Maiolica in diversi affioramenti della Toscana centro-meridionale.* Boll. Soc. geol. ital. *88*, 81–105.

CASTELLARIN, A. (1965): *Filoni sedimentari nel Giurese di Loppio (Trentino meridionale).* Giorn. Geol. (2) *33*, 527–546.

COLACICCHI, R., PIALLI, G. (1967): *Dati a conferma di una lacuna dovuta ad emersione nel Giurese del Monte Cucco (Appennino umbro).* Boll. Soc. geol. ital. *86*, 179–194.

– (1969): *Relationships Between Some Peculiar Features of Jurassic Sedimentation and Paleogeography in the Umbro-Marchigiano Basin (Central Italy).* Preprint. Colloquium on Mediterranean Jurassic Stratigraphy, Budapest, 1969, to be published in: Ann. Inst. Geol. Publ. Hung.

DUNHAM, R. J. (1962): *Classification of Carbonate Rocks According to Depositional Texture.* Amer. Ass. Petrol. Geol., Mem. *1*, 108–121.

FARINACCI, A. (1964): *Microorganismi dei calcari «maiolica» e «scaglia» osservati al microscopio elettronico (Nannoconi e Coccolithophoridi).* Boll. Soc. paleont. ital. *3*, 172–181.

– (1967): *La serie giurassico-neocomiana di Monte Lacerone (Sabina). Nuove vedute sull'interpretazione paleogeografica delle aree di facies umbro-marchigiana.* Geol. romana *6*, 421–480.

FISCHER, A. G. (1964): *The Lofer Cyclothems of the Alpine Triassic.* Kansas geol. Surv., Bull. *169*, 107–149.

FISCHER, A. G., GARRISON, R. E. (1967): *Carbonate Lithification on the Sea Floor.* J. Geol. *75*, 488–496.

FISCHER, A. G., HONJO, S., GARRISON, R. E. (1967): *Electron Micrographs of Limestones and their Nannofossils* (Princeton University Press).

GARRISON, R. E., FISCHER, A. G. (1969): *Deep-water Limestones and Radiolarites of the Alpine Jurassic.* Soc. econ. Paleont. Mineral., Spec. Publ. *14*, 20–56.

GILL, W. D. (1965): *The Mediterranean Basin.* In: Salt basins around Africa. London (Inst. Petrol.).

GRUNAU, H. R. (1959): *Mikrofazies und Schichtung ausgewählter, jungmesozoischer, Radiolarit-führender Sedimentserien der Zentral-Alpen.* Internat. sediment. petrograph. Ser. *4*, Leiden (Brill).

GUEX, J. (1969): *Sur le sexe des ammonites.* Bull. Soc. vaud. Sci. nat. *70*, 1–6.

HALLAM, A. (1967): *Sedimentology and Paleogeographic Significance of Certain Red Limestones and Associated Beds in the Lias of the Alpine Region.* Scott. J. Geol. *3*, 195–220.

HOLLMANN, R. (1964): *Subsolutions-Fragmente.* N. Jb. Geol. Paläont. Abh. *119*, 22–82.

HUDSON, J. D., JENKYNS, H. C. (1969): *Conglomerates in the Adnet Limestone of Adnet (Austria) and the Origin of the "Scheck".* N. Jb. Geol. Paläont. Mh. *1969*, 552–558.

INSTITUT DE GÉOLOGIE ET RECHERCHES DU SOUS-SOL, ATHÈNES, et INSTITUT FRANÇAIS DU PÉTROLE, MISSION GRÈCE (1966): *Etude géologique de l'Epire (Grèce nordoccidentale).* Ed. Technip et Institut franç. du Pétrole, Paris.

JEFFERIES, R. P. S., MINTON, P. (1965): *The Mode of Life of Two Jurassic Species of "Posidonia" (Bivalva).* Palaeontology *8*, 156–185.

JENKYNS, H. C., TORRENS, H. S. (1969): *Palaeogeographic Evolution of Jurassic Seamounts in Western Sicily.* Preprint. Colloquium on Mediterranean Jurassic Stratigraphy, Budapest, 1969, to be published in: Ann. Inst. Geol. Publ. Hung.

JURGAN, H. (1969): *Sedimentologie des Lias der Berchtesgadener Kalkalpen.* Geol. Rdsch. *58*, 464–501.

KOTTEK, A. V. (1966): *Die Ammonitenabfolge des griechischen Toarcium.* Ann. geol. Pays hellén. (1) *17*, 1–157.

LAUBSCHER, H. P. (1969): *Mountain Building.* Tectonophysics *7*, 551–563.

MERLA, G. (1951): *Geologia dell'Appennino settentrionale.* Boll. Soc. geol. ital. *70*, 95–382.

OTT, W. (1966): *Geologisch-mikropaläontologische Untersuchungen in Süd-Ithaka (Ionische Inseln, Griechenland).* Diplomarbeit Inst. Paläont. hist. Geol. Univ. München. Manuscript.

PAVAN, G., PIRINI, C. (1965): *Stratigrafia del Foglio 157 «Monte S. Angelo».* Boll. Serv. geol. Ital. *86*, 1–43.

PRATT, R. M. (1967): *Photography of Seamounts.* In: HERSEY, J. B. (Ed.): Deep-Sea Photography: 145–158 (Johns Hopkins Press, Baltimore).

– (1968): *Atlantic Continental Shelf and Slope of the United States, Physiography and Sediments of the Deep-Sea Basin.* U.S. geol. Surv., Prof. Paper, *529-B.*

RADWÁNSKI, A., SZULCZEWSKI, M. (1965): *Jurassic Stromatolites of the Villany Mountains (Southern Hungary).* Ann. Univ. Sci. Budapest, Sect. geol. *9*, 87–107.

RENZ, C. (1927): *Die Verbreitung und Entwicklung des Oberlias und Doggers im adriatisch-ionischen Faziesgebiet von Hellas und Albanien.* Verh. natf. Ges. Basel *38*, 482–515.

– (1936): *Neue Beiträge zur Geologie der Insel Leukas und ihrer Umgebung (Westgriechenland).* Eclogae geol. Helv. *29*, 409–447.

– (1955): *Die vorneogene Stratigraphie der normalsedimentären Formationen Griechenlands.* Inst. Geol. Subsurface Res., Athens.

RENZ, C., REICHEL, M. (1945): *Beiträge zur Stratigraphie und Paläontologie des ostmediterranen Jungpaläozoikums und dessen Einordnung im griechischen Gebirgssystem.* Eclogae geol. Helv. *38*, 211–313.

RYTHER, J. H. (1956): *Photosynthesis in the Ocean as a Function of Light Intensity.* Limnol. Oceanogr. *1*, 61–76.

STURANI, C. (1964): *La successione delle faune ad ammoniti nelle formazioni mediogiurassiche delle Prealpi venete occidentali.* Mem. Ist. Geol. Mineral. Univ. Padova *24*, 1–63.

– (1967): *Reflexions sur les faciès lumachelliques du Dogger mésogéen («Lumachelle à Posidonia alpina» auctt.).* Boll. Soc. geol. ital. *86*, 445–467.

THOMPSON, G., BOWEN, V. T., MELSON, W. G., CIFELLI, R. (1968): *Lithified Carbonates from the Deep-Sea of the Equatorial Atlantic.* J. sediment. Petr. *38*, 1305–1312.

TRÜMPY, R. (1960): *Paleotectonic Evolution of the Central and Western Alps.* Bull. geol. Soc. Amer. *71*, 843–908.

WENDT, J. (1963): *Stratigraphisch-paläontologische Untersuchungen im Dogger Westsiziliens.* Boll. Soc. paleont. ital. *2*, 57–145.

– (1965): *Synsedimentäre Bruchtektonik im Jura Westsiziliens.* N. Jb. Geol. Paläont. Mh. *1965*, 286–311.

Wiedenmayer, F. (1963): *Obere Trias bis mittlerer Lias zwischen Saltrio und Tremona (Lombardische Alpen). Die Wechselbeziehungen zwischen Stratigraphie, Sedimentologie und syngenetischer Tektonik.* Eclogae geol. Helv. *56*, 529–640.

Xhomo, A., Kondo, A., Papa, A., Balluku, I., Kanani, J., Alikaj, N., Nasi, V. (1969): *La transgression tithonique-néocomienne dans la Zone Ionienne d'Albanie.* Preprint. Colloque on Mediterranean Jurassic Stratigraphy, Budapest, 1969, to be published in: Ann. Inst. Geol. Publ. Hung.

Zankl, H. (1969): *Structural and Textural Evidence of Early Lithification in Fine-grained Carbonate Rocks.* Sedimentology *12*, 241–256.

Ziegler, B. (1967): *Ammoniten-Ökologie am Beispiel des Oberjura.* Geol. Rdsch. *56*, 439–464.

B. Palaeontology

Benecke, E. W. (1866): *Über Trias und Jura in den Süd-Alpen.* Geognost.-paläont. Beitr. *1*/1, 202 p,, 11 pl.

Brönnimann, P. (1955): *Microfossils Incertae Sedis from the Upper Jurassic and Lower Cretaceous of Cuba.* Micropaleontology *1*, 28–51, 2 pl.

Canavari, M. (1897): *La fauna degli strati con Aspidoceras acanthicum di Monte Serra presso Camerino.* Palaeontographia Italica *3*, 201–234, pl. 21–30.

Choffat, P. (1893): *Description de la faune jurassique du Portugal. Ammonites du Lusitanien de la Contrée de Torres-Vedras.* Dir. Trav. géol. Portugal, 82 p., 19 pl.

Colacicchi, R., Pialli, G. (1967): *Dati a conferma di una lacuna dovuta ad emersione nel Giurese del Monte Cucco (Appennino umbro).* Boll. Soc. geol. ital. *86*, 179–194.

Campana, D. del (1905): *Fossili del Giura superiore dei Sette Communi in provincia di Vicenza.* Pubbl. R. Ist. Studi sup. Firenze *28*, 140 p., 7 pl.

Deflandre, G., Dangeard, L. (1938): *Schizosphaerella, un nouveau microfossile méconnu du Jurassique moyen et supérieur.* C. R. Acad. Sci. Paris *207*, 1115–1117.

Favre, E. (1877): *La zone à Ammonites acanthicus dans les Alpes de la Suisse et de la Savoie.* Mém. Soc. paléont. Suisse *4*, 113 p., 9. pl.

– (1879): *Fossiles des couches tithoniques des Alpes fribourgeoises.* Mém. Soc. paléont. Suisse *6*, 74 p., 5 pl.

Fontannes, F. (1879): *Description des Ammonites des calcaires du Château de Crussol, Ardèche.* Paris et Lyon, 122 p., 13 pl.

Gemmellaro, G. G. (1872–1882): *Sopra alcune faune giuresi e liasiche della Sicilia.* Fasc. 1–8, 434 p., 31 pl., Palermo.

Geyer, O. F. (1961): *Monographie der Perisphinctidae des Unteren Unterkimeridgium (Weisser Jura γ, Badener-Schichten) im Süddeutschen Jura.* Palaeontographica, Abt. A, *117*, 157 p., 22 pl.

Imlay, R. W. (1942): *Late Jurassic Fossils from Cuba and their Economic Significance.* Bull. geol. Soc. Amer. *53*, 1417–1478, 12 pl.

Jeannet, A. (1928): *Sur quelques Echinides jurassiques de la collection Renz.* Eclogae geol. Helv. *21*, 460–465.

Koerner, U. (1963): *Beiträge zur Stratigraphie und Ammonitenfauna der Weissjura-α/β-Grenze (Oberoxford) auf der westlichen Schwäbischen Alb.* Jb. geol. Landesamt Baden-Württ. *6*, 337–394, pl. 22–32.

Loriol, P., Pellat, E. (1874): *Monographie paléontologique et géologique des étages supérieurs de la formation jurassique des environs de Boulogne-sur-Mer.* Paris, 155 p., 10 pl.

Meneghini, G. (1867–1881): *Monographie des fossiles du calcaire rouge ammonitique de Lombardie et de l'Apennin de l'Italie centrale.* Paleont. lombarde (A. Stoppani, Milano).

Neumayr, M. (1873): *Die Fauna der Schichten mit Aspidoceras acanthicum.* Abh. k. k. geol. Reichsanstalt *5*/6, 141–257, pl. 31–43.

Noël, D. (1965): *Coccolithes jurassiques.* Centre Nat. Rech. Sci. Paris, 209 p., 29 pl.

Oppel, A. (1862–1863): *Über jurassische Cephalopoden.* Palaeont. Mitt. Mus. k. bayer. Staates *3*, 127–162 (1862); 163–266 (1863), pl. 40–74.

– (1865): *Die tithonische Etage.* Z. dtsch. geol. Ges. *17*, 547–555.

Orbigny, A., d' (1842–1851): *Paléontologie française; Terrains jurassiques 1, Cephalopodes,* Paris.

Pavlow, A. P. (1886): *Les Ammonites de la zone à Aspidoceras acanthicum de l'Est de la Russie.* Mém. Com. géol. St. Petersbourg *2*, 91 p., 10 pl.

PERCH-NIELSEN, K. (1968): *Der Feinbau und die Klassifikation der Coccolithen aus dem Maastrichtien von Dänemark.* Biol. Skr. Dan. Vid. Selks *16*/1, 1–96, 32 pl.

QUENSTEDT, F. A. (1845–1849): *Petrefactenkunde Deutschlands. Die Cephalopoden.* 580 p., 36 pl.

– (1858): *Der Jura.* Tübingen, 842 p., 100 pl.

– (1883–1888): *Die Ammoniten des schwäbischen Jura.* Stuttgart, 1140 p., 126 pl.

RAMACCIONI, G. (1939): *Fauna giuraliassica e cretacea di Monte Cucco e dintorni (Appennino centrale).* Palaeontographia Italica *39*, 143–213, pl. 10–14.

REINHARDT, P. (1966): *Zur Taxionomie und Biostratigraphie des fossilen Nannoplanktons aus dem Malm, der Kreide und dem Alttertiär Mitteleuropas.* Freib. Forsch. C *196*, 1–109.

REMANE, J. (1964): *Untersuchungen zur Systematik und Stratigraphie der Calpionellen in den Jura-Kreide-Grenzschichten des Vocontischen Troges.* Palaeontographica *123*/A, 1–57, 6 pl.

SCHINDEWOLF, O. H. (1925): *Entwurf einer Systematik der Perisphincten.* N. Jb. Mineral., Geol. Paläont. Beilageband *52*, 309–343.

SPATH, L. F. (1927–1933): *Revision of the Jurassic Cephalopod Fauna of Kachh (Cutch).* Mem. geol. Survey India, Palaeont. Indica, N.S. *9*/2, 945 p., 130 pl.

– (1925): *Ammonites and Aptychi from Somaliland.* Mon. Hunterian Mus. Univ. Glasgow *1*, 111–164, pl. 15–16.

STRADNER, H. (1963): *New Contributions to Mesozoic Stratigraphy by Means of Nannofossils.* Proc. 6th World Petrol. Congr. *1*.

TOUCAS, A. (1890): *Etude de la faune des couches tithoniques de l'Ardèche.* Bull. Soc. géol. France (3) *18*, 560–628, pl. 13–18.

TOULA, F. (1907): *Die Acanthicus-Schichten im Randgebirge der Wiener Bucht bei Giesshübl (Mödling-WNW).* Abh. k. k. geol. Reichsanst. *16*/2, 120 p., 19 pl.

WAAGEN, W. (1873–1875): *Jurassic Fauna of Kutch; Cephalopoda.* Mem. geol. Surv. India, Palaeont. Indica *9*/1.

WEGELE, L. (1929): *Stratigraphische und faunistische Untersuchungen im Oberoxford und Unterkimeridge Mittelfrankens.* Palaeontographica *72*, 143 p., pl. 1–11.

VENZO, S. (1959): *Cefalopodi neogiurassici degli Altipiani Hararini.* Accad. naz. Lincei, Roma, 97 p., 14 pl.

WIEDMANN, J. (1963): *Unterkreide-Ammoniten von Mallorca. 2. Lief.: Phylloceratina.* Acad. Wiss. Lit. *4*, 151–256, 11 pl.

– (1966): *Stammesgeschichte und System der posttriadischen Ammonoideen.* N. Jb. Geol. Paläont. Abh. *125*, 49–79, 2 pl.; *127*, 13–81, 6 pl.

ZEUSCHNER, L. (1846): *Nowe lub niedokladnie opisane gatunki skamien.* Tatrowych Poszyt *1*, 132 p., pl. 1–4 (Warszawa).

ZITTEL, K. A. (1868): *Die Cephalopoden der Stramberger Schichten.* Paläont. Mitt. Mus. k. bayer. Staates *2*/1, 33–118, pl. 1–24.

– (1870): *Die Fauna der älteren Cephalopoden führenden Tithonbildungen.* Paläont. Mitt. Mus. k. bayer. Staates *2*/2, 119–310, pl. 25–39.

Plate I

Fig. 1 Bioclast lime wackestone with corroded and encrusted ammonite shells, aptychi and other bioclasts and postdepositional ferruginous segregations.
Pelagic cephalopod limestones.
Upper Jurassic.
Louros valley, section E, Epirus, Greece (sample DB 1482).
Polished surface, natural size.

Fig. 2 Bioclast lime wackestone (Plate I, Fig. 1) containing abundant radiolaria and aptychi.
Pelagic cephalopod limestones.
Upper Jurassic.
Louros valley, section E, Epirus, Greece (sample DB 1482).
Thin-section, 7 ×.

Fig. 3 Coccolith (damaged specimen of *Watznaueria* REINHARDT 1964) from micritic groundmass of Vigla Limestone.
Vigla Limestone.
Upper Tithonian.
Louros valley, section E, Epirus, Greece (sample DB 1477).
Stereoscan electron micrograph of fresh broken surface, gold-coated, 7500 ×.

Fig. 4 Groundmass of pelagic cephalopod limestones. The fine sediment consists almost entirely of coccoliths and their fragments. Upper left: *Cyclagelosphera* NOËL 1965 and *Zeugrhabdotus erectus* (DEFLANDRE 1954) REINHARDT 1965; centre and middle right *Watznaueria* REINHARDT 1964 (determinations by B. PRINS).
Pelagic cephalopod limestones.
Upper Jurassic.
Louros valley, section E, Epirus, Greece (sample DB 1483).
Stereoscan electron micrograph of fresh broken surface, gold-coated, 2000 ×.

Fig. 5 Close-up of Fig. 4. *Cyclagelosphaera* NOËL 1965. Note abundance of coccolith fragments.
Pelagic cephalopod limestones.
Upper Jurassic.
Louros valley, section E, Epirus, Greece (sample DB 1483).
Stereoscan electron micrograph of fresh broken surface, gold-coated, 5000 ×.

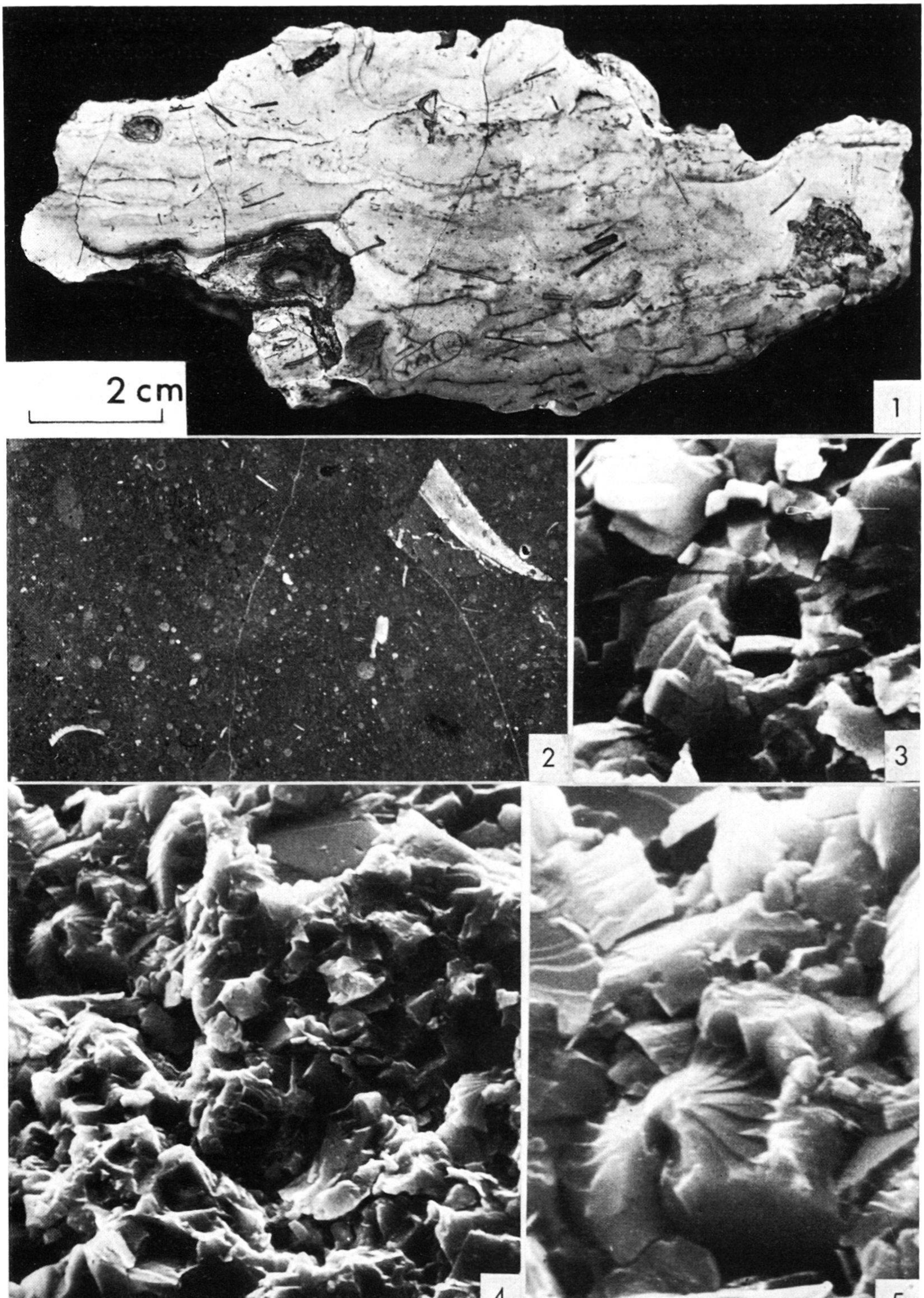

2 cm
1
2
3
4
5

Plate II

Fig. 1 Groundmass of pelagic lamellibranch limestone containing abundant coccoliths and their fragments in a neomorphically formed calcite fabric. The coccoliths belong to the genus *Bidiscus* BUKRY 1969 or to the genus *Discorhabdus* NOËL 1965 (det. B. PRINS).
Pelagic lamellibranch limestones.
Middle Jurassic.
Louros valley, section E, Epirus, Greece (sample DB 1484).
Stereoscan electron micrograph of fresh broken surface, gold-coated, 2500 ×.

Fig. 2 Groundmass of pelagic lamellibranch limestone containing coccoliths of the genus *Bidiscus* BUKRY 1969 or of the genus *Discorhabdus* NOËL 1965. The small calcite crystals are elements of more or less disintegrated tests of the planktonic organism *Schizosphaerella* DEFLANDRE and DANGEARD 1938 (see Pl. II, Figs. 6–7).
Pelagic lamellibranch limestones.
Middle Jurassic.
Valdorbia, Umbrian Apennines, province of Perugia, Italy (sample DB 1841).
Stereoscan electron micrograph of fresh broken surface, gold-coated, 2500 ×.

Figs. 3–5 Coccoliths from the pelagic lamellibranch limestones. The specimens may represent only one species, belonging to the genus *Bidiscus* BUKRY 1969 or to the genus *Discorhabdus* NOËL 1965. Both genera are related and differ from each other in the absence or presence of a long spine in the centre of the coccolith. The range of *Bidiscus* is Lower Jurassic to Upper Cretaceous and of *Discorhabdus* Bathonian to Oxfordian (Kimmeridgian ?). Since *Discorhabdus* is far more abundant in the Middle Jurassic than *Bidiscus*, it is more probable, that a species of *Discorhabdus* is represented here; however, in none of the specimens a trace of the characteristic long central spine is visible (determinations and comment by B. PRINS).
Pelagic lamellibranch limestones.
Middle Jurassic.
Louros valley, section E, Epirus, Greece (sample DB 1484).
Stereoscan electron micrographs of fresh broken surfaces gold-coated, Figs. 3 and 4: 2500 ×; Fig. 5: 5000 ×.

Fig. 6 Groundmass of a microbioclast lime wackestone with pelagic lamellibranchs. The sediment appears to be composed almost entirely of tests of *Schizosphaerella* DEFLANDRE and DANGEARD 1938, many layered form (det. B. PRINS). *Schizosphaerella* is a planktonic form of unknown systematic position which ranges in age from the Lower Jurassic to the Bathonian. All the small crystals visible on the micrograph belong to tests of *Schizosphaerella*, of which a well preserved specimen is visible in the centre of the micrograph. The skeletal material is cemented by larger calcite crystals.
Ammonitico Rosso.
Toarcian-Aalenian.
Louros valley, section E, Epirus, Greece (sample DB 1533).
Stereoscan electron micrograph of fresh broken surface, gold-coated, 2000 ×.

Fig. 7 *Schizosphaerella* DEFLANDRE and DANGEARD 1938, many layered form, det. B. PRINS. White rhombs are euhedral dolomite crystals.
Ammonitico Rosso.
Toarcian-Aalenian.
Louros valley, section E, Epirus, Greece (sample DB 1533).
Stereoscan electron micrograph of polished and etched surface, gold-coated, 2000 ×.

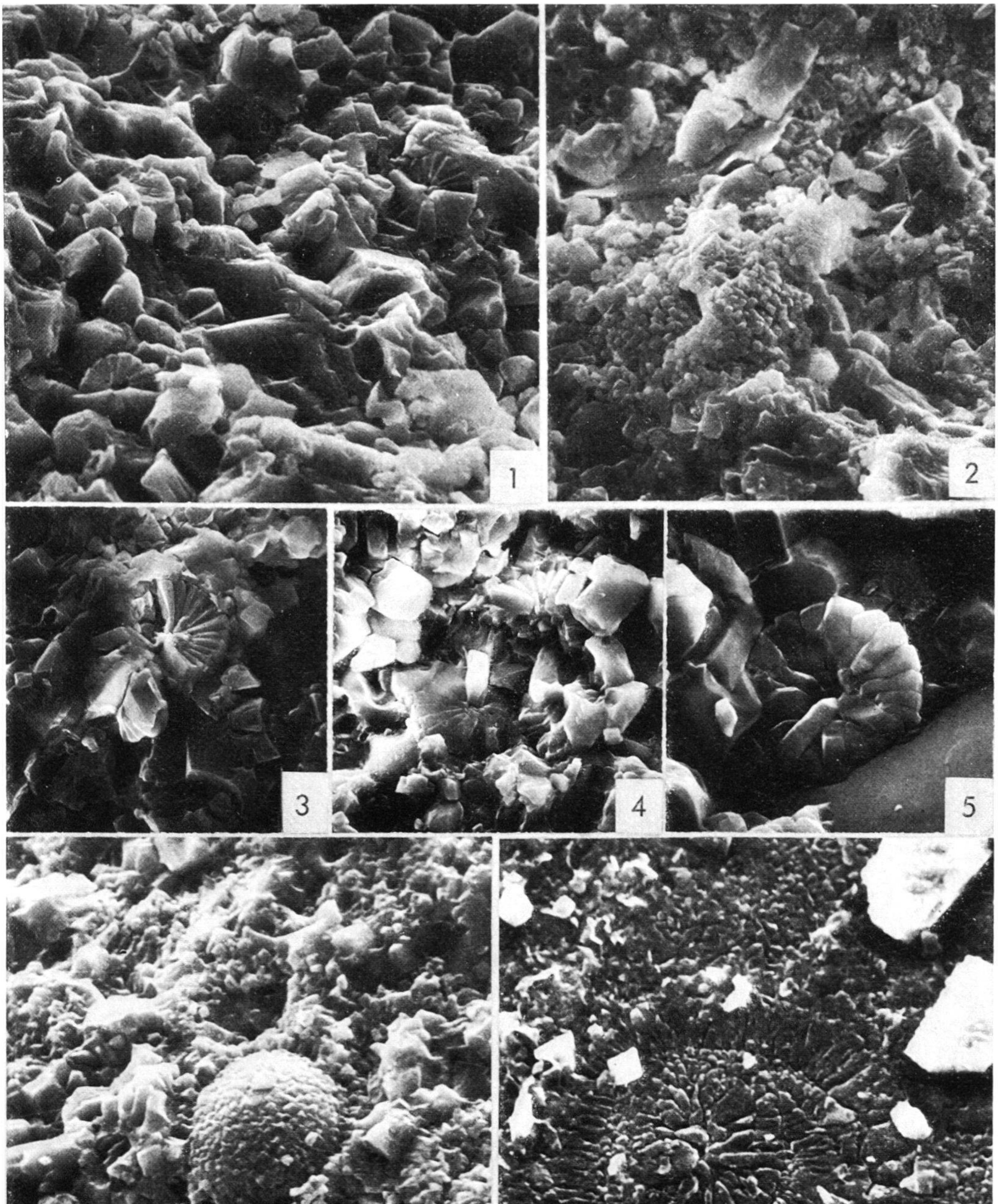

1
2
3
4
5
6
7

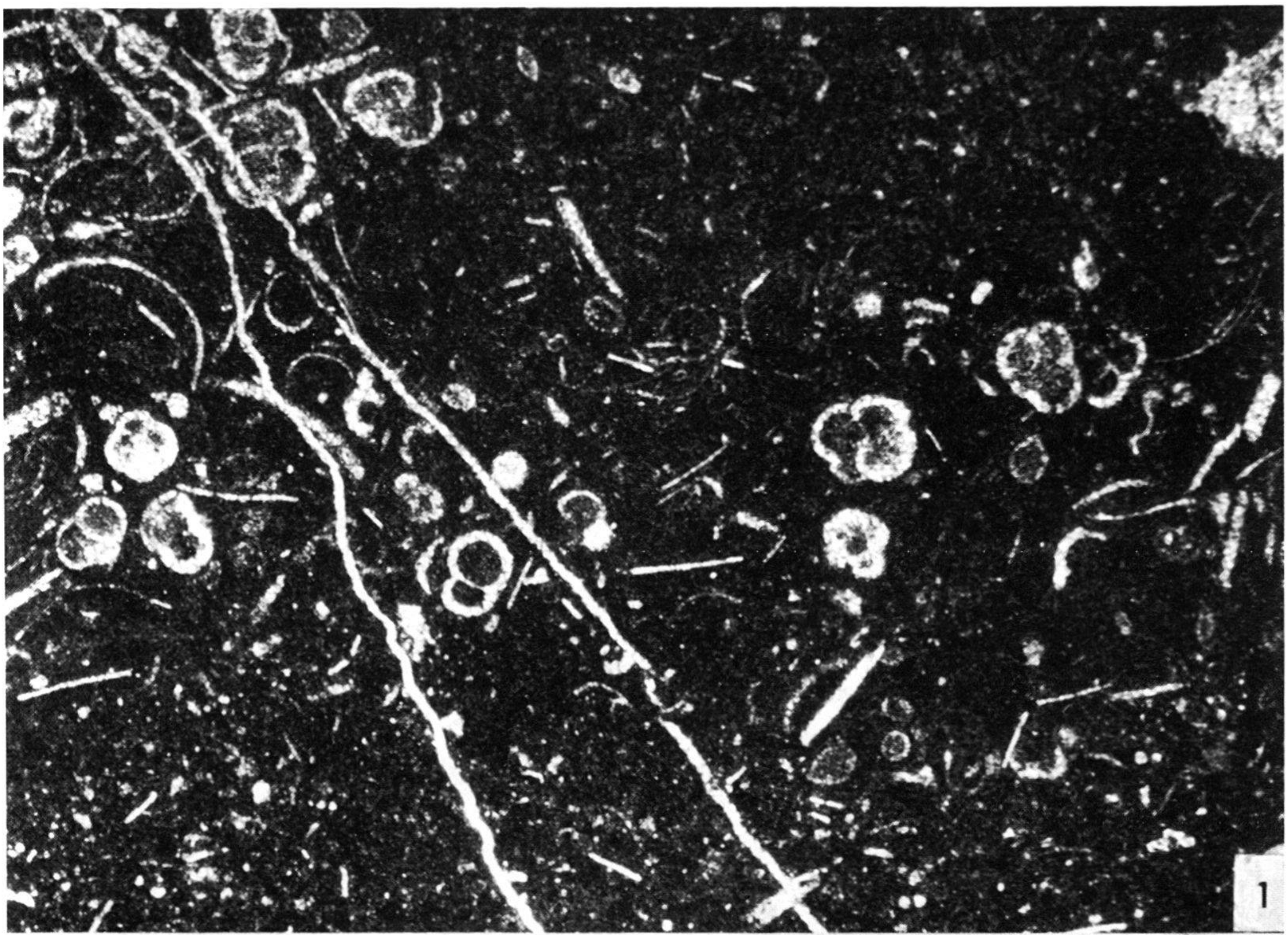
Plate III

Fig. 1

Microbioclast lime wackestone, containing numerous tests of *Globigerina* sp.
Pelagic cephalopod limestones.
Upper Jurassic.
Louros valley, section D, Epirus, Greece (sample DB 1520).
Thin-section, 45 ×.

Fig. 2

Intraclast lime grainstone, containing pebbles of microbioclast (pelagic lamellibranchs, radiolaria, small ammonites) wackestone in a sparry calcite cement in which two generations can be distinguished. The rock resembles very much the Middle Liassic "Scheck" of the Adnet Beds of the Northern Calcareous Alps.
g = geopetal infill of internal sediment.
Pelagic cephalopod limestones.
Upper Jurassic.
Louros valley, section D, Epirus, Greece (sample DB 1524).
Thin-section, 7 ×.


1

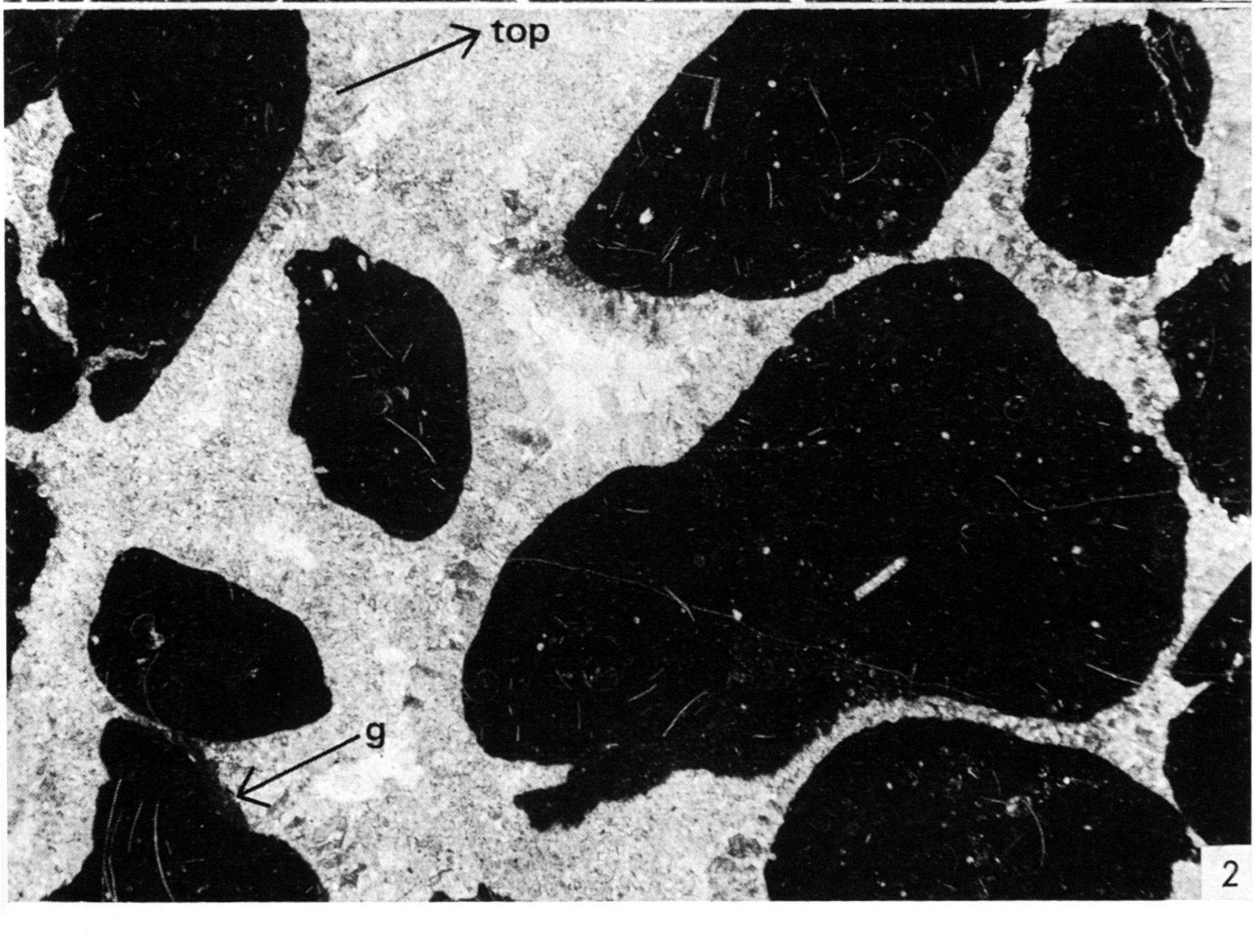

top
g
2

Plate IV

Fig. 1	*Katroliceras* sp., cf. *K.* (*Katroliceras*) *aceroides* Geyer, J 19040. Upper Jurassic. Dekatiés, Lefkas Island, Greece. p. 603. Natural size.
Fig. 2	*Benacoceras heteroplocum* (Gemmellaro), J 19044. Upper Jurassic. Louros valley, section D, Epirus, Greece. p. 599. Natural size.
Fig. 3	? *Zeugrhabdotus embergeri* (Noël 1959) nov. comb. (det. B. Prins). Pelagic cephalopod limestones. Upper Jurassic. Dekatiés, Lefkas Island, Greece. Stereoscan electron micrograph of fresh broken surface, gold-coated, 5000 ×.
Fig. 4	Groundmass of pelagic cephalopod limestone, containing coccoliths in a neomorphically formed calcite mosaic. Upper right: *Watznaueria* cf. *barnesae* (Black 1959) Perch-Nielsen 1968, middle below: part of the rim area of *Zeugrhabdotus* Reinhardt 1965 and small not identified element (*Discorhabdus* Noël 1965, cross-section through *Nannoconus steinmanni* Kamptner 1931 or through the spine of *Zeugrhabdotus* Reinhardt 1965). Determinations by B. Prins. Pelagic cephalopod limestones. Upper Jurassic. Louros valley, section E, Epirus, Greece (sample DB 1480). Stereoscan electron micrograph of polished and etched surface, gold-coated, 2500 ×.
Fig. 5	Groundmass of pelagic cephalopod limestone containing coccoliths (*Watznaueria* cf. *barnesae* (Black 1959) Perch-Nielsen 1968) and euhedral dolomite rhombs in a neomorphically formed calcite mosaic. Upper Jurassic. Louros valley, section E, Epirus, Greece (sample DB 1483). Stereoscan electron micrograph of polished and etched surface, gold-coated, 2500 ×.
Figs. 6–7	Coccosphere of *Watznaueria barnesae* (Black 1959) Perch-Nielsen 1968 in a neomorphically formed calcite mosaic. Pelagic cephalopod limestone. Upper Jurassic. Dekatiés, Lefkas Island, Greece. Stereoscan electron micrographs of fresh broken surfaces, gold-coated, Fig. 6: 2000 ×; Fig. 7: 10000 ×.

PLATE IV

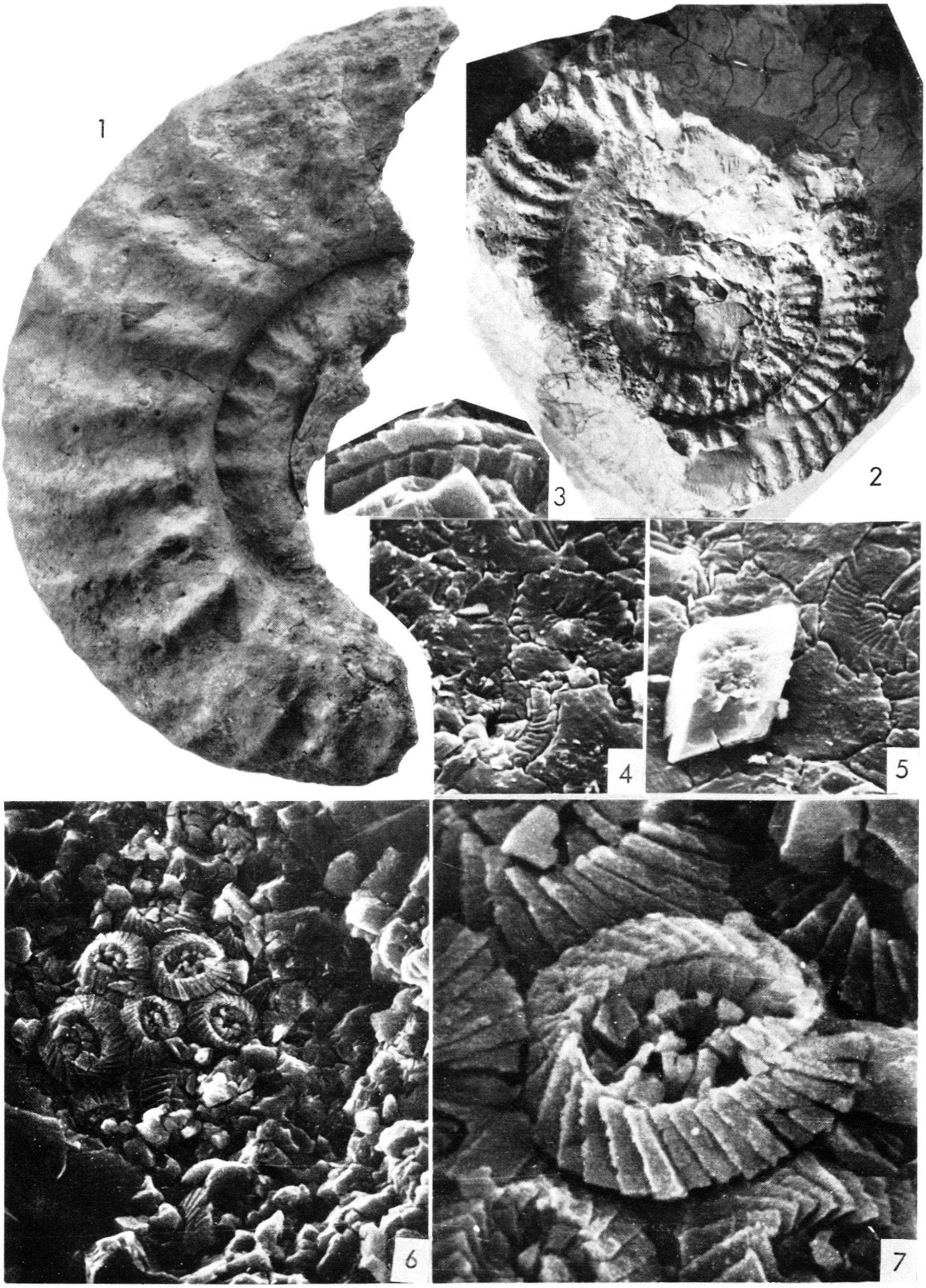


Plate V

Fig. 1a, b — *Haploceras* (*Haploceras*) aff. *elimatum* (OPPEL), J 19018.
1b = whorl section near the end of the phragmocone.
Upper Jurassic.
Dekatiés, Lefkas Island, Greece.
p. 596.

Fig. 2a, b — *Haploceras* (*Haploceras*) *carachtheis* (ZEUSCHNER), J 19021.
Upper Jurassic.
Louros valley, section E, Epirus, Greece.
p. 597.

Fig. 3a, b — *Haploceras* (*Haploceras*) *rasile planiusculum* ZITTEL, J 19019.
Upper Jurassic.
Louros valley, section E, Epirus, Greece.
p. 596.

Fig. 4a, b — *Simoceras* sp., group of *S. volanense* (OPPEL), J 19033.
Upper Jurassic.
Louros valley, section E, Epirus, Greece.
p. 600.

Fig. 5a, b — *Simoceras* sp., group of *S. volanense* (OPPEL), J 19031.
Upper Jurassic.
Louros valley, section E, Epirus, Greece.
p. 600.

Fig. 6 — *Simoceras* sp., group of *S. volanense* (OPPEL), J 19032, inner volution.
Upper Jurassic.
Louros valley, section E, Epirus, Greece.
p. 600.

Fig. 7a, b — *Physodoceras altenense periacense* (FONTANNES), J 19027.
Upper Jurassic.
Dekatiés, Lefkas Island, Greece.
p. 598.

All figures natural size.
As far as preserved, the end of the phragmocone
is indicated by a small arrow.

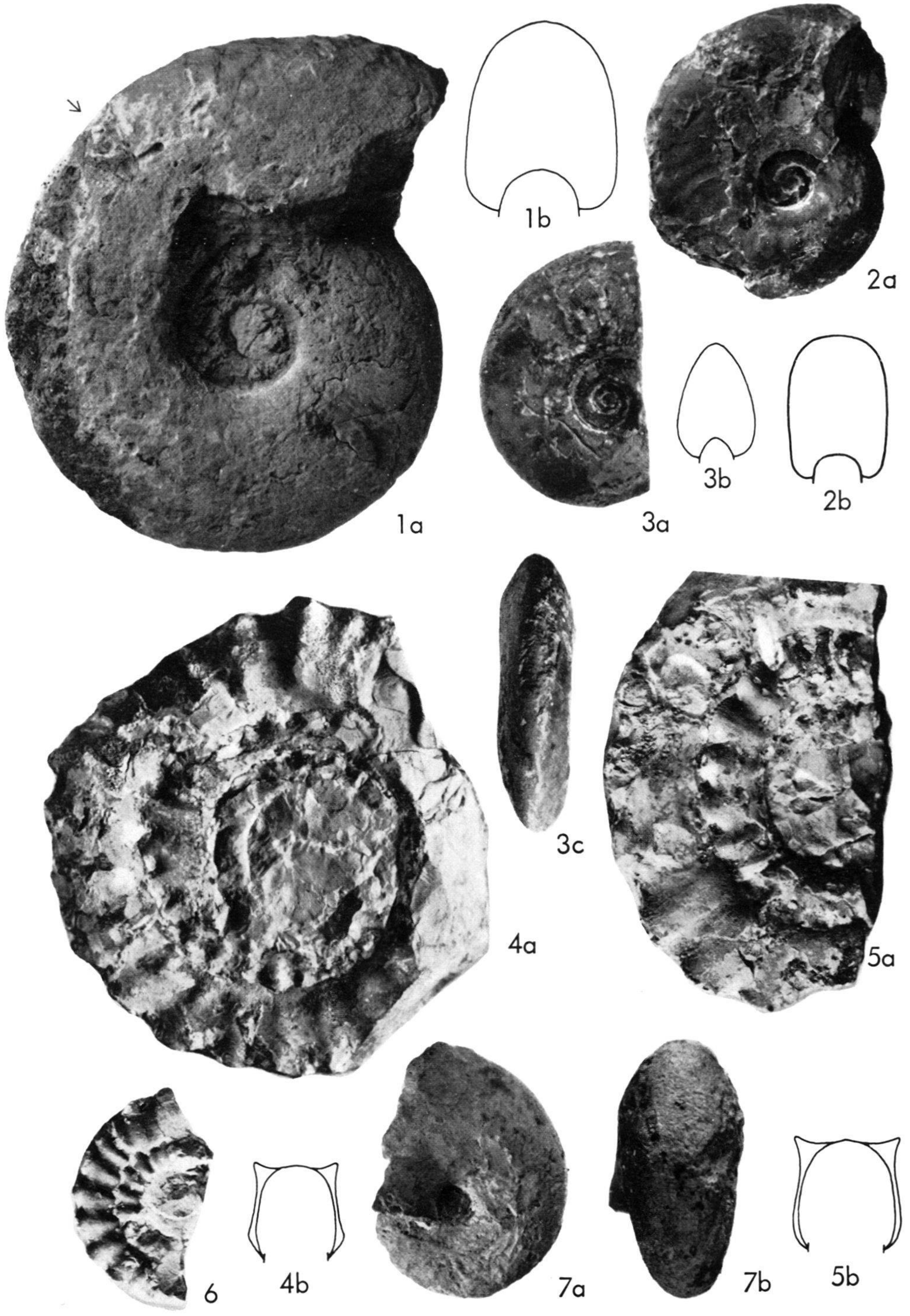

1a
1b
2a
2b
3a
3b
3c
4a
4b
5a
5b
6
7a
7b

Plate VI

Fig. 1a, b — *Aspidoceras* (*Aspidoceras*) aff. *wolfi* NEUMAYR, J 19026.
Upper Jurassic.
Dekatiés, Lefkas Island, Greece.
p. 598.

Fig. 2a–c — *Simoceras volanense* (OPPEL), J 19029, 2c = living chamber, J 19030.
Upper Jurassic.
Dekatiés, Lefkas Island, Greece.
p. 599.

Fig. 3a, b — *Perisphinctes* (*Orthosphinctes*) cf. *adelus* GEMMELLARO, J 19036.
Upper Jurassic.
Dekatiés, Lefkas Island, Greece.
p. 601.

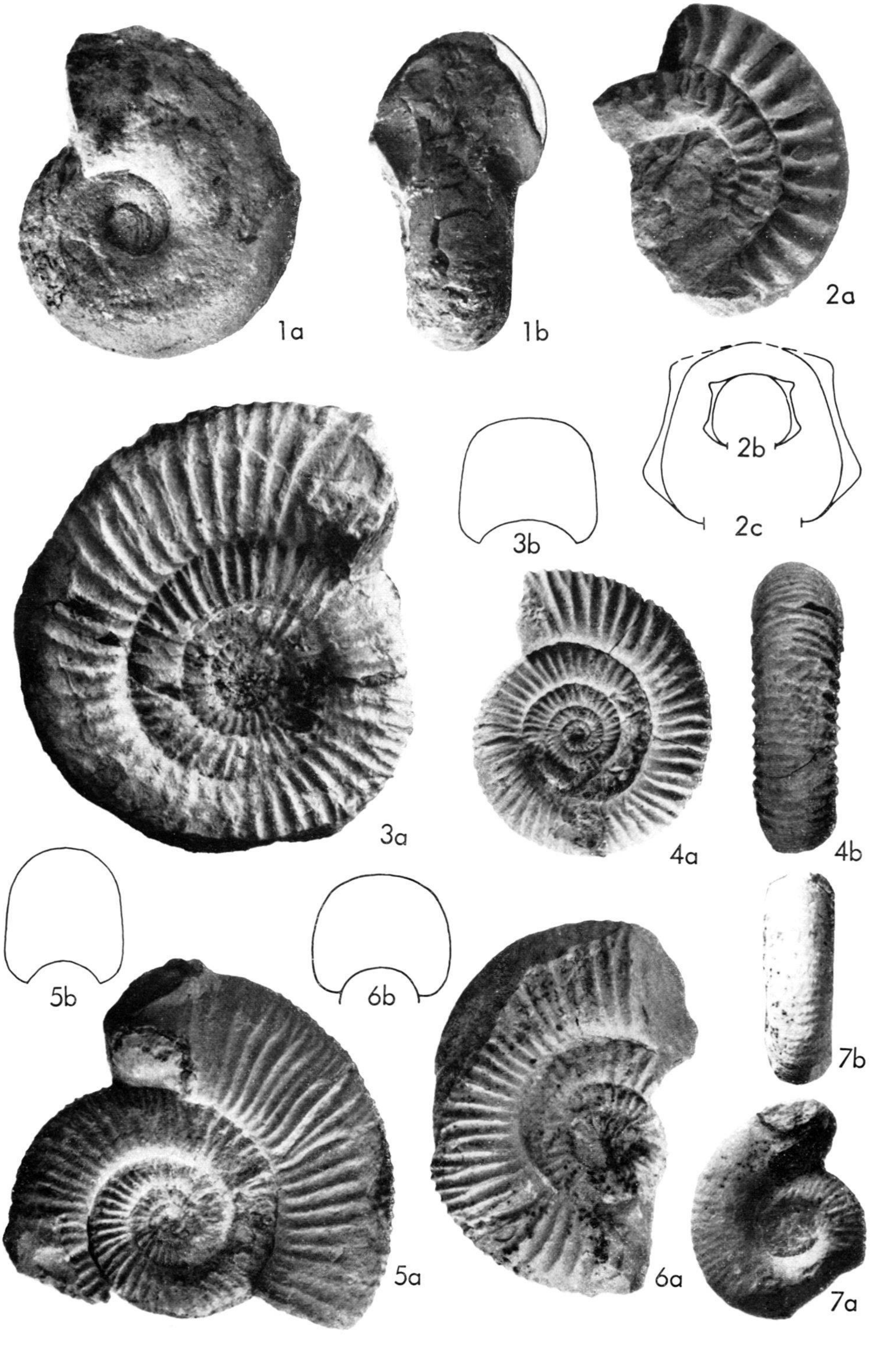
Fig. 4a, b — *Perisphinctes* (*Orthosphinctes*) aff. *colubrinus* (REINECKE), J 19034.
Upper Jurassic.
Dekatiés, Lefkas Island, Greece.
p. 601.

Fig. 5a, b — *Perisphinctes* (*Orthosphinctes*) aff. *sutneri* CHOFFAT, J 19037.
Upper Jurassic.
Dekatiés, Lefkas Island, Greece.
p. 602.

Fig. 6a, b — *Perisphinctes* (*Orthosphinctes*) *serranus* CANAVARI, J 19038.
Upper Jurassic.
Dekatiés, Lefkas Island, Greece.
p. 602.

Fig. 7a, b — cf. *Enosphinctes* SCHINDEWOLF, J 19042.
Upper Jurassic.
Dekatiés, Lefkas Island, Greece.
p. 603.

All figures natural size.
As far as preserved, the end of the phragmocone is indicated by a small arrow.


1a
1b
2a
2b
2c
3a
3b
4a
4b
5a
5b
6a
6b
7a
7b