



Upper Jurassic Brachiopod Faunas of Central and North Dobrogea (Romania): Biostratigraphy, Paleoecology and Paleobiogeography

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14 Text-Figures, 1 Table and 4 Plates

*Rumänien
Dobrukscha
Brachiopoden
Oberjura
Oxford
Kimmeridge
Biostratigraphie
Paläoökologie
Paläobiogeographie
Taxonomie*

To celebrate 125 years from the publication of the classic monograph
"Grundlinien zur Geographie und Geologie der Dobrukscha"
written by the Austrian geologist
KARL FERDINAND PETERS (1825-1881)

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Oberjurassische Brachiopodenfaunen der zentralen und nördlichen Dobrudscha (Rumänien): Biostratigraphie, Paläoökologie und Paläobiogeographie

Zusammenfassung

Während in den Flachwasserkarbonaten der zentralen Dobrudscha reiche Brachiopodenfaunen des Mitteloxford–Kimmeridge zu finden sind (ca. 50 Arten aus 11 Familien), kommen in den resedimentierten Flachwasserkarbonaten oder in den Tiefwasserkarbonaten der nördlichen Dobrudscha Brachiopoden nur sehr selten vor (nur 7 Arten aus 5 Familien wurden bisher registriert).

In der zentralen Dobrudscha treten in der **Casimcea-Formation** drei umfangreichere, brachiopodenführende, biogene Karbonatserien auf, die Visterna-Schwamm-Algen-Serie, die Cekirgea-Stromatolithen-Serie und die Topalu-Korallen-Algen-Serie, jede mit ausgeprägten, im wesentlichen autochthonen Brachiopodengemeinschaften, die Unterschiede in Wassertiefe und -durchbewegung anzeigen.

In der nördlichen Dobrudscha war die markante Verarmung der Brachiopodenfaunen entweder auf tektonisch bedingte, sehr begrenzte, kurzzeitige Flachwasserkarbonat-Sedimentation im Peceneaga-Camena-Zerrungsbecken, wo die **Cârjelari-Formation** auftritt, zurückzuführen oder auf eine Tiefwasser-Schlamm-Sedimentation, wie im Fall der sehr ausgedünnten Brachiopodenfauna des **Carabair-Kalks**.

Verschiedene paläoökologisch-taphonomische Aspekte, umweltbedingte Homöomorphie und die Beziehungen der oberjurassischen Brachiopodenfaunen der Dobrudscha mit anderen benthischen Organismen wurden untersucht.

Paleobiogeographisch gehören alle oberjurassischen Brachiopodenfaunen der Dobrudscha zum submediterranen Bereich des Jura.

Eine neue Art, *Dorsoplicathyris petersi* n.sp., wird beschrieben; die taxonomische Stellung von *Placothyris carsiensis* (SIMIONESCU) wird revidiert.

Abstract

While plentiful Middle Oxfordian–Lower Kimmeridgian brachiopod faunas are to be found in the shallow-water carbonate platform rocks of Central Dobrogea, where around 50 species, included in 11 families, have been registered, very scarce coeval brachiopod faunas occur in the resedimented shallow-water and basinal carbonate rocks of North Dobrogea, where only 7 species, included in 5 families, have been registered.

In Central Dobrogea, the **Casimcea Formation** displays three major brachiopod-bearing biogenous carbonate facies series, viz. Visterna Bioconstructed Spongalgal Series, Cekirgea Stromatolitic Algal Series and Topalu Bioconstructed Coralgal Series, each of them bearing distinct, essentially autochthonous brachiopod paleocommunities, primarily reflecting differences in water depth and energy levels.

In North Dobrogea, the marked impoverishment of brachiopod faunas was related either to tectonically-stressed and very limited, short-lasting shallow-water carbonate sedimentation episodes in the Peceneaga-Camena transtensional basin, where the allochthonous brachiopod assemblage from the **Cârjelari Formation** is to be found, or to a deep-water muddy sedimentation for the very scattered brachiopod faunule from the **Carabair Limestone**.

Various paleoecologic-taphonomic aspects, as well as the environmentally-induced homeomorphy and relationships of the Dobrogean Upper Jurassic brachiopod faunas with other benthic organisms have been examined.

Paleobiogeographically, all the Upper Jurassic brachiopod faunas from Dobrogea belonged to the Sub-Mediterranean (Jura) realm.

A new species, *Dorsoplicathyris petersi* n.sp., is described, and the taxonomic treatment of *Placothyris carsiensis* (SIMIONESCU) is revised.

1. PETERS' vs. WILSER's Statements on the Dobrogean Upper Jurassic Geology: The Brachiopod Distribution Pattern as a Test Case

Among the Upper Jurassic faunas of Dobrogea, the brachiopods represent one of the best documented groups, although unevenly distributed on this territory.

As early as 1867 PETERS recorded the presence of the Upper Jurassic rocks and collected brachiopods in all the areas where the Jurassic System is to be found in Dobrogea. Furthermore, according to our present knowledge concerning the Dobrogean Upper Jurassic geology, it is worthwhile emphasizing the high value of most of PETERS' observations and opinions.

Unfortunately, ARKELL's famous synthesis (1956:189) on worldwide Jurassic geology completely ignored PETERS' valuable monograph on the Dobrogean geology and paid attention only to the very uninspired account made by WILSER (1928). The latter had failed in synthesizing and correctly interpreting the disparate and reduced, often contradictory, data of the relevant geological literature. Therefore, in spite of the field evidence, WILSER (1928:178) reported that in Dobrogea gently undulated Upper Jurassic deposits rest directly upon sharply folded Triassic deposits. Thanks to ARKELL's authority, WILSER's highly fallacious picture on the Dobrogean Upper Jurassic geology was accredited and acquired wider circulation. HÖLDER (1964:480) also promoted WILSER's account. Quite recently, DEWEY et al. (1973: Text-Fig. 7) have used ARKELL's synthesis, as only reference work for Dobrogea, in a well-known plate tectonics essay on the Mediterranean re-

gions, obviously with negative implications for their assertions when referring to the Dobrogean Jurassic geology.

Nowadays the origin of WILSER's mis-statements is easily to be explained.

Firstly, WILSER completely ignored the Peceneaga-Camena Fault and its significance for the Dobrogean geology, although several years before MRAZEC (1912) and MACOVEI (1912) had clearly indicated that the above-mentioned fault bounded two distinct Dobrogean sectors showing very different geological evolutions and tectonic regimes, i.e. a "pre-Balkan" platform southwards and a "Variscan-Cimmerian" folded belt northwards, respectively. On the contrary, WILSER overestimated the importance of the "Linie Hirşova – Constanza" by which he artificially divided the Dobrogean territory into two distinct parts: a northern one, the so-called "Grundgebirge", grouping all the deformed rocks of both North and Central Dobrogea, older than the Late Jurassic, and a southern one, the so-called "Deckgebirge", grouping the slightly deformed Late Jurassic and much younger rocks of the "pre-Balkan" platform.

It is true, however, that in adopting such a position, WILSER was greatly influenced by MURGOCI (1915), who unexpectedly minimized the importance of the Peceneaga-Camena Fault, in separating very dissimilar tectono-stratigraphic terrains, Central-South and North Dobrogea, respectively.

Secondly, in the 1920s a major stepback occurred in the knowledge of the North Dobrogean Jurassic System as compared with PETERS' monograph. On the one hand, the presence of the Lower and Middle Jurassic in North Dobrogea, as it was shown by PETERS, has not been confirmed, with good reason, by REDLICH (1896) and POMPECKJ (1897). On the other hand, only doubtful Lower Jurassic rocks were inferred to exist by SIMIONESCU (1927). Lastly, as far as the Upper Jurassic is concerned, in spite of PETERS' expectations (1867:189) the later field-works failed to identify the outcrop area of the so-called "Planulaten-Kalkstein vom Kara-bair", which could have been a very important key in outlining the differences between the North and Central Dobrogean Jurassic geology. Besides, the structural position of the Upper Jurassic deposits of the Cârjelari region was not clearly established yet (SIMIONESCU, 1911). Thus, no objective elements existed at that time to contradistinguish the Jurassic System of North Dobrogea from that of Central Dobrogea, for which much progress was achieved in the meantime thanks to the basic studies carried out by SIMIONESCU (1907, 1910 a–b).

That is why WILSER (1928:Tab. II), to whom the stratigraphic columns of the Central and North Dobrogean sectors seemed to be complementary owing to the foregoing outlined circumstances, wrongly extended the Upper Jurassic deposits of Central Dobrogea over the Triassic deposits of North Dobrogea.

PETERS' monograph, in spite of its imperfections, provided a much more accurate picture of the Dobrogean Upper Jurassic geology than the one sketched by WILSER. Had ARKELL (1956) relied on PETERS' monograph, much of his unfounded digressions upon the Cimmerian orogeny in North Dobrogea, and the possible correlations with the Crimea, could have been avoided.

First of all, PETERS (1867:177) had clearly stated that there were no direct relationships between the Upper Jurassic deposits of Central Dobrogea and the Triassic deposits of North Dobrogea.

"... Die ganze Trias, so wie auch Alles, was ich vom Lias und Mittel-Jura im Lande vorfand, ist auf den nördlichen, gebirgigen Theil desselben beschränkt. Südlich von dem grossen Walle aus grünen Schiefern beginnt eine andere Natur. Bedeutende Aufbrüche gibt es hier nicht mehr; mit den Triasschichten sind auch die ihnen zugehörigen Massengesteine fern geblieben. Der obere Jura hat sich ebend über die Schollenfläche jener Schiefer gebreitet ..."

Moreover, PETERS (1867:178), who had the opportunity, unlike the subsequent researchers, to examine in the field the Upper Jurassic deposits of both Central and North Dobrogea, had recognized very early that these deposits display very different development patterns in the two Dobrogean sectors:

"... Ein kleiner osteuropäischer Bezirk vereinigt somit Typen in sich, die in Mitteleuropa nur an weit auseinander liegenden Punkten entwickelt sind ..."

"... Sie beziehen sich ausschließlich auf das Tafelland der mittleren und südlichen Dobrudscha, d. h. auf die südlich von dem grossen Walle aus grünen Schiefern gelegenen Strecken. – Nördlich davon hat die einzige bisher nachgewiesene Ablagerung von oberem Jura einen anderen Charakter. Am Kara-bair, der äussersten Grundgebirgsmasse, die der Dunavez umkrümmt, liegt unter der mächtigen Lössdecke ein schwärzlich oder bräunlichgrauer Kalkstein mit Planulaten und einigen anderen Resten, deren Aussehen an den Moskauer Jura erinnert. Sehr interessant wäre es, wenn künftige Forschungen erweisen würden, dass diese Schichte hier wirklich eine Art von Vermittlung zwischen der karpathischen Facies, prägnanten Formen des südlichen (ausseralpinen) Mitteleuropas und den in so vielfacher Hinsicht eigenthümlichen Juragebilden des Inneren von Russland herstelle. – Dermalen ist nur das eine sicher, dass sie durch ihre Gesteinsbeschaffenheit von gleichzeitigen Ablagerungen in der mittleren und südlichen Dobrudscha, die dergleichen westliche Beziehungen deutlich genug verrathen, auffallend verschieden ist. Es scheint demnach, dass die Gebirgsmasse der nördlichen Dobrudscha als kleiner Überrest eines der

ältesten und bedeutendsten Gebirgsgrate der Mediterranregion Europas auch für den oberen Jura die Rolle eines Scheiderückens gespielt habe, und dass seine südwestliche Seite nicht nur den brachiopodenreichen Kalkbildungen der mittleren Donauländer („Stramberger Schichten" u. s. w.) sondern auch Ablagerungen offen stand, die mit gleichzeitigen Absätzen im Nordwesten der Alpen eine grosse Ähnlichkeit haben ..."

Although PETERS' opinions on the paleobiogeographic relationships of the Central and North Dobrogean sectors during the Late Jurassic times are now obsolete, his empirical but intuitive picture upon the areal distribution and facies differences of the Upper Jurassic deposits on the Dobrogean territory, is, however, of a remarkable value even after 125 years, being mostly confirmed by the present data. Since the Peceneaga-Camena Fault was identified much later, he could not realize at the time that the Jurassic paleogeography on the Dobrogean territories had a strong tectonic control. However this does not diminish in any way the high value of PETERS' pioneering work.

The differing aspects of the Upper Jurassic deposits in the two Dobrogean sectors, lying north and south of the Peceneaga-Camena Fault, respectively, are correspondingly reflected also at the level of the fossil organism paleocommunities, as PETERS (1867) had already recognized. One of the most significant differences is illustrated by the highly unbalanced distribution of the Upper Jurassic brachiopod faunas on the Dobrogean territory. Whereas rich and very diversified Upper Jurassic brachiopod faunas are to be found in Central Dobrogea, very reduced coeval brachiopod faunas occur in North Dobrogea.

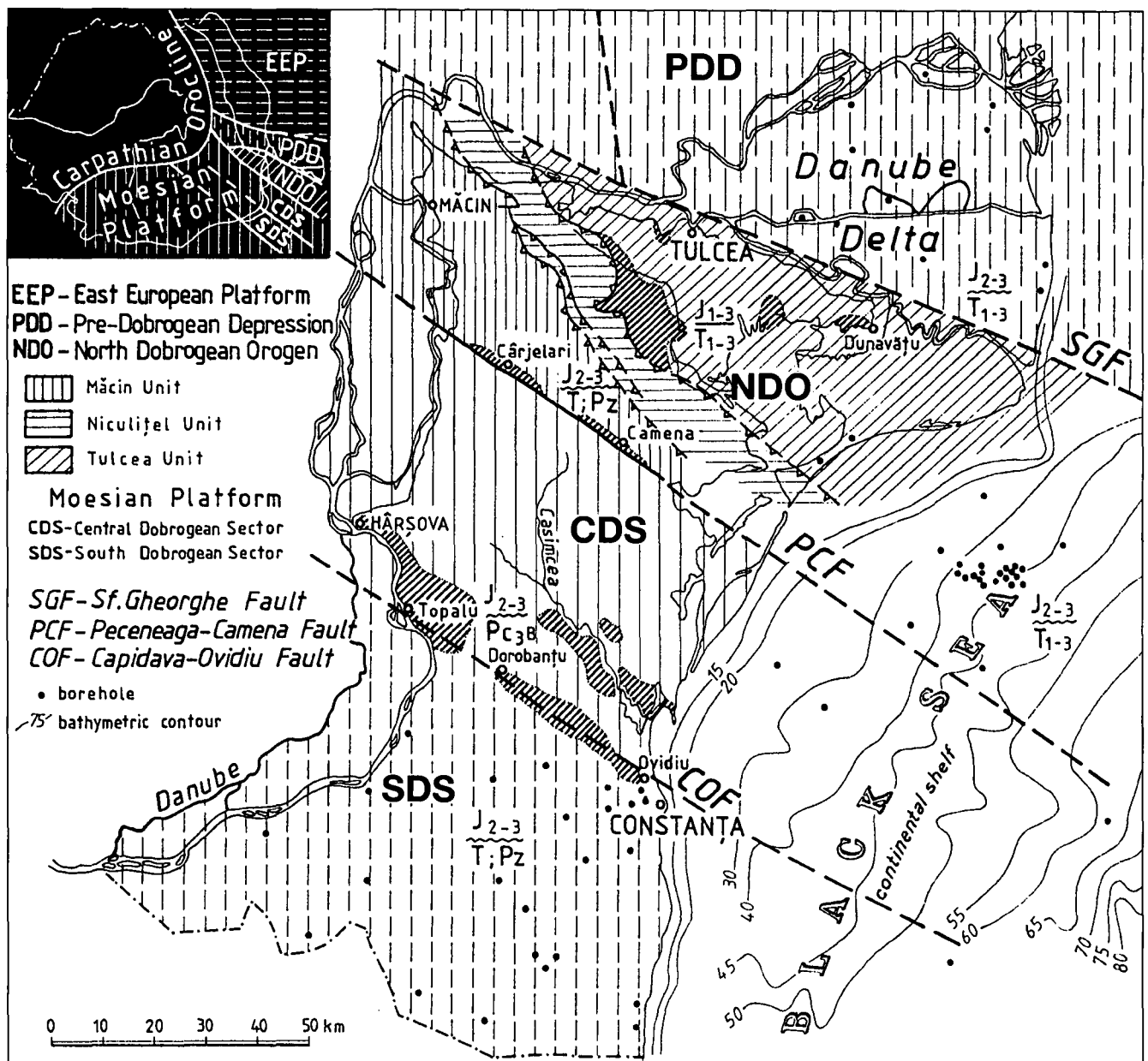
The field-works carried out in Dobrogea in the last decades allowed us or other geologists to collect rich and varied Upper Jurassic brachiopod faunas, especially from Central Dobrogea. The study of these materials afforded a more complete knowledge on the areal and stratigraphic distribution patterns of the different taxa, as well as on the paleoecologic relationships of the different brachiopod assemblages with the differing depositional environments, and finally much insight into the paleobiogeographic interpretations. Although much taxonomic work is still to be done, the present study provides a measure of the advance made in recent times in the knowledge of the Dobrogean Upper Jurassic brachiopod faunas.

Therefore, the purpose of the present paper is two-fold: firstly, to demonstrate that the distribution pattern of the Upper Jurassic brachiopod faunas on the Dobrogean territory was highly dependent on the Late Jurassic paleogeography; secondly, to reveal that both areal and stratigraphic distribution patterns of these faunas have been clearly connected with the local changing environmental factors.

Our paper is dedicated to the memory of the distinguished Austrian geologist Karl Ferdinand PETERS (1825–1881) for his great contribution to the knowledge of the Dobrogean Jurassic geology and for the first record of Upper Jurassic brachiopod faunas in all the Dobrogean geological units.

2. Geologic Setting and Stratigraphic Occurrence of the Central and North Dobrogean Upper Jurassic Brachiopod Faunas: A Highly Unbalanced Distribution Pattern

The Dobrogea province lies in the southeastern part of Romania, between the lower course of the Danube and the Black Sea coast (Text-Fig. 1).



Text-Fig. 1.
Geological sketch map showing the surface (outcropping areas are hatched by closely-spaced thick-lines) and subsurface (boreholes) distribution pattern of Jurassic rocks on the Dobrogean territory and adjoining areas, and their stratigraphic relationships with the underlying rocks. Inset map shows the position of Dobrogean sectors within the major geological structure of Romania.

During the Jurassic, the Dobrogean territory was largely covered by seas. At present, the corresponding deposits are only partially preserved in all the three geological sectors of Dobrogea (Text-Fig. 1). All these sectors, showing basically different tectono-sedimentary developments in most periods, are tectonically bounded by major deep-seated, NW-SE trending faults, the geodynamics of which strongly influenced the Dobrogean Jurassic paleogeography.

It was especially the Peceneaga-Camena Fault which separated two distinct Jurassic sedimentary realms, namely, a shallow-water siliciclastic/carbonate platform southwards, occupying the areas of the Central and South Dobrogean sectors, and at least two major basins of very dynamic sedimentation situated northwards in the area of the North Dobrogean sector.

The Capidava-Ovidiu Fault dissected the Dobrogean Jurassic siliciclastic/carbonate platform into two distinct

parts, corresponding to the actual Central and South Dobrogean sectors, respectively.

In the Central Dobrogean sector, the uppermost Middle Jurassic and Upper Jurassic shallow-water epicontinental deposits, displaying a very large facial complexity, are widely outcropping and thus well-studied (SIMIONESCU, 1910a; BĂRBULESCU, 1974; CHIRIAC et al., 1977; DRĂGĂNESCU, 1976, 1985). The most important occurrences of the Jurassic deposits are limited to three main NW-SE trending zones (Text-Fig. 1): Hârșova-Topalu-Bălăgești Zone in the west, Casimcea Zone in the middle-east, and Dorobanțu-Ovidiu Zone in the south-east. The Jurassic stratigraphic column starts with uppermost Bathonian-Lower Callovian terrigenous calcaro-detrital deposits (Tichilești Formation), directly overlying the Vendian-Lower Cambrian Green Schist Series of the epi-Baikalian Moesian Platform-composite basement, and continues upwards with the Upper Callovian calcarenitic

crinoidal limestones (**Gura Dobrogei Formation**) and the most impressive Oxfordian–Lower Kimmeridgian bioaccumulated to bioconstructed limestones (**Casimcea Formation**).

In the sunk South Dobrogean sector, the uppermost Middle and Upper Jurassic deposits, a thick pile of dolomites and limestones, more than 400 m thick, were studied only by drillings (CHIRIAC et al., 1977; IORDAN et al., 1987 a–b), and they exhibit a lithostratigraphic sequence mostly comparable to that in the Central Dobrogean sector.

In the North Dobrogean sector, characterized by important Cimmerian to mid-Cretaceous folding and thrusting processes, the Jurassic deposits are at present to be found in the innermost part of the Măcin Unit, and, on much larger surfaces, in the Tulcea Unit, respectively (GRĂDINARU, 1981, 1984, 1988). In the first unit, it is the Jurassic Cârjelari-Camena Outcrop Belt which represents the topmost part of the Lower Mesozoic sedimentary cover of the Măcin Unit and borders the Peceneaga-Camena Fault immediately in its northern side. The stratigraphic column includes in the basal part Middle Jurassic terrigenous turbidites (**Aiorman Formation**), disconformably overlain by a lot of different Upper Jurassic deposits, of both shallow-water (**Cârjelari Formation**) and deep-water facies (**Başpunar Formation**). The latter, which are laterally interfingering with rhyolitic volcanic rocks, are topped by spilitic rocks. The Jurassic sedimentary rocks and bimodal volcanics of the Cârjelari-Camena Outcrop Belt characterized a very dynamic basin genetically linked with the transtensive tectonic regime of the Peceneaga-Camena Fault during Middle to Late Jurassic times.

The Lower Mesozoic sedimentary cover of the Tulcea Unit includes Jurassic rocks which were deposited in an ensialic deep-water basin. Lower Jurassic terrigenous, mid-fan and outer-fan turbidites (**Nalbant Fan**) and hemipelagites (**Poșta Sandstone**) are to be found in the western part, whereas Middle Jurassic terrigenous, mid-fan turbidites (**Dunavățu Fan**) and Middle Oxfordian pelagic crinoidal and cherty limestones (**Carabair Limestone**) are outcropping in the easternmost part of the Tulcea Unit.

All the Dobrogean sectors are downplunging eastwards into the subsurface of the continental shelf of the Black Sea, where several boreholes crossed a very thick Jurassic sequence, somewhat very differing facially from those of the Dobrogean land (PETROMAR, unpubl.data).

Lastly, northwards the North Dobrogean sector is in tectonic contact, along the Sf. Gheorghe Fault, with the Pre-Dobrogean Depression (VISARION, SÂNDULESCU et al., 1990), where very thick Lower (?) to Middle Jurassic terrigenous and Upper Jurassic carbonate sequences were crossed by boreholes (SLIUSARI, 1971; PĂTRUȚ et al., 1983).

It is now obvious that the areal and stratigraphic distribution patterns of the Jurassic brachiopod faunas in Dobrogea were closely dependent on both the regional paleogeographic frame and the local changing environmental factors. As a direct consequence, a strong imbalance resulted in the distribution of the Dobrogean Jurassic brachiopod faunas.

In the Central Dobrogean sector, the Jurassic brachiopod faunas have had two important development intervals: the first during the latest Bathonian–Early Callovian, the second during the Middle Oxfordian–Early Kimmeridgian. A fairly rich uppermost Bathonian–Lower Cal-

lovian brachiopod fauna is associated with the terrigenous calcareo-detrital sequence of the **Tichilești Formation** (BĂRBULESCU, unpubl.data). After an interval of interruption during the Middle and Late Callovian and partially during the Early Oxfordian, owing to some stratigraphic gaps or to unfavourable facial conditions for their development, the brachiopod faunas have had a spectacular development beginning with the Middle Oxfordian, but reaching a maximum diversity and abundance during Late Oxfordian to Early Kimmeridgian times. Their development was linked especially to the **Casimcea Formation** bioaccumulated and bioconstructed calcareous facies bearing stromatolites, sponges and corals. Towards the end of the Early Kimmeridgian the brachiopods, alongside other macrofossils, disappeared from Central Dobrogea owing to a major regional regression.

In the North Dobrogean sector, the Jurassic brachiopod faunas have had a meagre development, both in the Cârjelari-Camena Outcrop Belt and in the Tulcea Unit. In the first area their occurrence is limited only to the Upper Oxfordian–Lower Kimmeridgian biodetrital calcareous deposits included in the **Sfânta Facies** of the **Cârjelari Formation**. In the easternmost part of the Tulcea Unit, a brachiopod faunule was yielded by the Middle Oxfordian pelagic cherty limestones (**Carabair Limestone**).

Thus, the foregoing outlined imbalance is obscured for the Dobrogean Middle Jurassic brachiopod faunas, as these are completely lacking in North Dobrogea, while clear-cut for the Upper Jurassic brachiopod faunas for which the available data leave abundant scope for a thoroughgoing analysis of faunistic composition. That is why, only the Upper Jurassic faunas will be taken into account in the present paper. For the Central Dobrogean sector, where the Upper Jurassic brachiopod faunas are largely occurring, there were selected only the brachiopod faunas delivered by the bioaccumulated and the intercalated bioconstructed limestones of the Oxfordian–Lower Kimmeridgian **Casimcea Formation** which are biostratigraphically well-constrained by coeval ammonoid faunas. These sequences are positionally restrained to the Hârșova-Topalu area (along the Danube cliff) and to the Visterna and Casimcea valleys, viz. to the western and middle-eastern areas of Central Dobrogea (Text-Fig. 2). For North Dobrogea, the coeval brachiopod faunas from the Cârjelari and Dunavățu de Jos area will be considered (Text-Fig. 3).

The first mentions on the Dobrogean Upper Jurassic brachiopod faunas date down to the 19th century (PETERS, 1867; POMPECKJ, 1897; ANASTASIU, 1898). More numerous data were provided later by ANASTASIU (1903, 1907), MACOVEI (1907), SIMIONESCU (1910 a–b), PATRULIUS & ORGHIDAN (1964), PAJAUD & PATRULIUS (1964), BĂRBULESCU (1974, 1976). The most important contributions in point of wealth of data on taxonomy and stratigraphic occurrences and also of excellent illustrations are those of SIMIONESCU (1910 b) and PATRULIUS & ORGHIDAN (1964).

In this paper the taxonomy was prepared by the second author, while most of all other sections were jointly written by both authors.

We have deliberately enlarged the general geologic, stratigraphic and facial background of the present paper, aiming not only to introduce the reader to the Jurassic geology of the region, but also to provide a measure of the progress we have achieved in the knowledge of the Dobrogean Jurassic System as compared with ARKELL's synthesis (1956).

3. Central Dobrogean Upper Jurassic Brachiopod Faunas

3.1. Casimcea Formation (Oxfordian–Lower Kimmeridgian): An Extensive Brachiopod Occurrence in a Shallow-Water Carbonate Platform

The Casimcea Formation, which yielded by far the richest and most varied Upper Jurassic brachiopod faunas in Dobrogea, shows a very impressive polyfacial complexity for a thickness ranging only from 150 to 500 m.

DRĂGĂNESCU (1976, 1978, 1979) recognized eight mappable facies series or members, highly diachronous, intergrading both laterally and vertically in a remarkable facially-ordered distribution pattern, reflecting roughly sub-parallel depositional belts relating to a presumed shoreline to the north.

The brachiopod faunas display a clear-cut, environmentally-controlled distribution, these being ecologically restrained only to some of the facies series. The paleogeographic setting of these facies series was a shallow-water, open marine depositional area during a regressive cycle, with a variable bottom topography developed upon a dissected carbonate platform providing extensive niche partitioning available for high brachiopod colonization.

In order to emphasize the particularities of the areal and stratigraphic distribution patterns of the brachiopod faunas, and thus to account for their environmental control, the brachiopod-bearing facies series of the Casimcea Formation will be characterized both litho- and biofacially following DRĂGĂNESCU (1976), and, respectively, SIMIONESCU (1910 a–b), PATRULIUS & ORGHIDAN (1964) and BĂRBULESCU (1968, 1969 a–b, 1970, 1971 a–b, 1972, 1974, 1976, 1979).

3.1.1. Visterna Bioconstructed Spongalgal Series (Text-Fig. 2 B, facies series I and II a–b)

It consists of bioconstructed spongalgal limestones to which bioaccumulated to bioclastic spongalgal limestones are quite subordinately associated. The limestones are composed mainly of patelliform sponges, pseudostromata crusts and oncolitic grains. The absence

of corals and corallophile faunas is to be noticed. Having in view both the spatial development pattern and the texture of the spongalgal-built calcareous masses, two distinct complexes may be stratigraphically recognized in the Visterna Series, as follows:

- the lower, Biostromal Complex (Text-Fig. 2 B, facies I) is made up of spongalgal boundstones, developed as successive pseudostromata-encrusted sponge layers, subordinately interspersed with lenses of bioaccumulated to bioclastic spongalgal packstones-wackestones;
- the upper, Biohermal Complex (Text-Fig. 2 B, facies II) is made up of tangent columnar bioherms, 15–20 m in diameter and 20–70 m high, showing a lower, massive part composed of bioconstructed spongalgal limestones slightly dipping centripetally, towards the center of the bioherms (the massive stage of the bioherms) (Text-Fig. 2 B, facies II a), and, respectively, an upper, ring-shaped part consisting of an external, bioconstructed wall, 2–5 m thick, encircling an internal “microlagoon” filled with slightly cemented, fine-grained spongalgal packstones-wackestones (the “microatoll” stage) (Text-Fig. 2 B, facies II b).

The depositional environment, corresponding to a rather plane, constructional platform having little topographic elevation above the surrounding sea-floor, was similar to that depicted by GAILLARD (1983) for the same type of facies evolving in Southern Jura. The absence of any washing in the spongalgal facies suggests that its deposition took place at depths varying between 10 and 20 m below mean sea-level, in generally low- to moderate-energy environments, below wave base in offshore shelf areas, but within the reach of shoaling currents. The upper limit of the depth range corresponds to the common wave base and the lower one to the generally accepted maximum depth for symbiotic blue-green algae activity.

Although the outcropping areas of the Visterna Series are much more extensive than those of the other facies series of the Casimcea Formation, only few localities delivered quite rich brachiopod assemblages.

When referring to the stratigraphic occurrence and facies connection, the brachiopod assemblages of the lower, Biostromal Complex are fairly different from those of the upper, Biohermal Complex.

Text-Fig. 2.

Stratigraphic and facial distribution of brachiopods in the Upper Jurassic of Central Dobrogea.

Lithostratigraphy: DRĂGĂNESCU (1976); Biostratigraphy: BĂRBULESCU (1974, and new data).

A) Western-Central Dobrogea.

Facies series of the Casimcea Formation: I = Visterna Bioconstructed Spongalgal Series, Biostromal Complex; II = Cekirgea Stromatolitic Algal Series; V = Topalu Bioconstructed Corallgal Series.

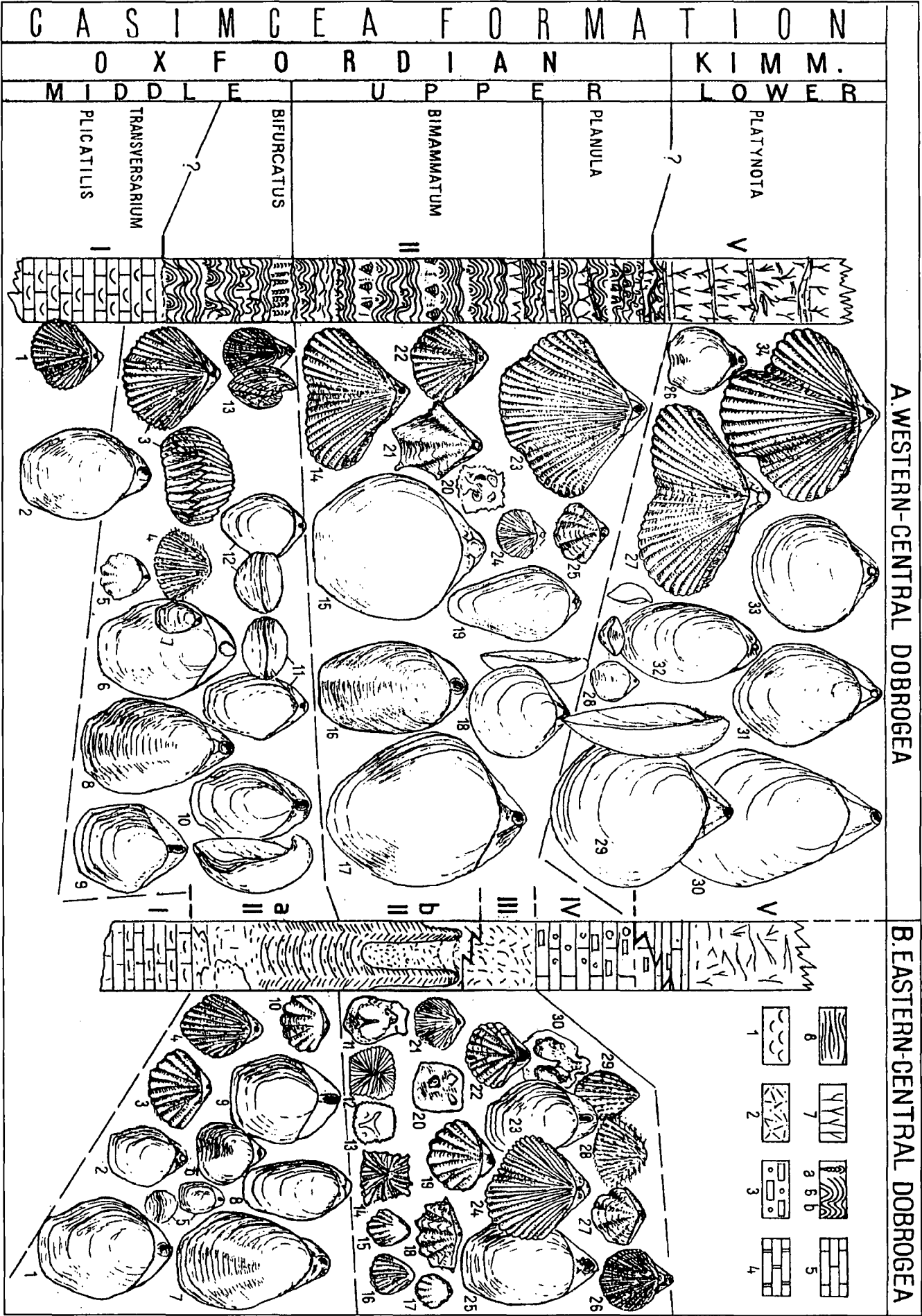
Species index: 1 = *Lacunosella* sp.; 2 = *Moeschia alata*; 3 = *Lacunosella cracoviensis*; 4 = *Acanthorhynchia spinulosa*; 5 = *Monticlairella strioplicata*; 6 = *Moeschia alata*; 7 = *Argovithyris baugieri*; 8 = *Dorsoplicathyrus farcinata*; 9–10 = *Placothyrus carsiensis*; 11–12 = *Zeillerina delemontana*; 13 = *Dictyothis kurri*; 14 = *Torquirhynchia speciosa*; 15 = *Moeschia granulata*; 16 = *Dorsoplicathyrus petersi*; 17 = *Juralina subformosa*; 18 = *J. bullingdonensis*; 19 = *Zeillerina delemontana*; 20 = *Crania lamellosa*; 21 = *Cheirothyris fleurieusa*; 22 = *Septaliphoria pinguis*; 23 = *S. moravica*; 24 = *Terebratulina (Cruralina) substriata*; 25 = *Ismenia pectunculoides*; 26 = *Digonella* sp.; 27 = *Torquirhynchia speciosa*; 28 = *Aulacothyrus* sp.; 29 = *Juralina kokkoziensis*; 30 = *Juralina* sp.; 31 = *J. topalensis*; 32 = *Zeillerina delemontana*; 33 = *J. castellensis*; 34 = *Septaliphoria moravica*.

B) Eastern-Central Dobrogea.

Facies series of the Casimcea Formation: I = Visterna Bioconstructed Spongalgal Series, Biostromal Complex; II = Visterna Bioconstructed Spongalgal Series, Biohermal Complex; a = massive stage, b = “microatoll” stage; III = Gara Târgușor Triturated Spongalgal Series; IV = Sârtorman Corpuscular Algal Series; V = Topalu Bioconstructed Corallgal Series.

Species index: 1 = *Moeschia alata*; 2 = *Argovithyris stockari*; 3 = *Lacunosella arolica*; 4 = *L. trilobataeformis*; 5 = *Argovithyris baugieri*; 6 = *Nucleata nucleata*; 7 = *Dorsoplicathyrus farcinata*; 8 = *Zeillerina delemontana*; 9 = *Placothyrus carsiensis*; 10 = *Septocrurella sancteclarae*; 11 = *Agerinella lyrata*; 12 = *Crania lineata*; 13 = *Craniscus suevicus*; 14 = *Crania lamellosa*; 15 = *Monticlairella cf. triloboides*; 16 = *M. rollieri*; 17 = *M. strioplicata*; 18 = *Trigonellina intercostata*; 19 = *T. aff. pectunculus*; 20 = *Crania laevisissima*; 21 = *Terebratulina (Cruralina) substriata*; 22 = *Trigonellina trimedia*; 23 = *Placothyrus* sp.; 24 = *Lacunosella* sp.; 25 = *Dorsoplicathyrus* sp.; 26 = *Dictyothis kurri*; 27 = *Ismenia pectunculoides*; 28 = *Acanthorhynchia spinulosa*; 29 = *A. senticosa*; 30 = *Riouttina virdunensis*.

Lithology: 1 = bioconstructed spongalgal limestone; 2 = bioclastic (trituated) spongalgal limestone; 3 = echinagal, oncolitic limestone; 4 = dolomite; 5 = well-bedded calcilutite, biomicrite-biocalcarenite; 6 = stromatolitic limestone; a = ministromatolith; b = megastromatolith; 7 = bioconstructed corallgal limestone of arborescent coral colonies; 8 = bioconstructed corallgal limestone of crustiform colonies.



From the Biostromal Complex two quite homogeneous brachiopod faunas were collected in the Casimcea valley and, respectively, in the Sârtorman valley (Text-Fig. 4, locs. 5 and 6).

In the Casimcea valley, on the right-hand bank, 1000 m south of Cheia village, the limestones occurring in the basal part of the Biostromal Complex, very rich in crinoid debris, contain besides silicisponges, bivalves, rare ammonoids and nautiloids, a relatively varied brachiopod fauna, from which the following species were identified:

Septocrurella sancteclarae (ROEMER)
Monticlairella strioplicata (QUENSTEDT)
Lacunosella arolica (OPPEL)
Lacunosella trilobataeformis WISNIEWSKA
Argovithyris stockari (MOESCH)
Placothyris sp.
Moeschia alata (ROLLET)
Nucleata nucleata (SCHLOTHEIM)
Zeillerina delemontana (OPPEL)

It is worth mentioning that the last species, otherwise very rare in Central Dobrogea, has a high frequency in this locality. The associated ammonoid fauna, including *Campylites* (*Neoprioceras*) *laulingensis* (ROLLIER), *Sowerbyceras tortisulcatum* (D'ORBIGNY), *Euaspidoceras* sp. ex gr. *E. perarmatum* (SOWERBY), is indicative for the Middle Oxfordian-*Transversarium* Zone.

In the second locality, situated in the Sârtorman valley, a rich brachiopod fauna, besides rare and poorly-preserved ammonoids, was collected by DRĂGĂNESCU, including:

Lacunosella arolica (OPPEL)
Lacunosella trilobataeformis WISNIEWSKA
Argovithyris stockari (MOESCH)
Dorsoplicathyris farcinata (DOUVILLÉ)
Placothyris sp.
Moeschia alata (ROLLET)
Moeschia sp.
Nucleata nucleata (SCHLOTHEIM)
Zeillerina delemontana (OPPEL).

Three of the above-mentioned brachiopods in the two localities, i.e. *Lacunosella trilobataeformis*, *Argovithyris stockari* and *Nucleata nucleata*, are illustrated on Pl. 1 (Figs. 17–19 and Figs. 21–24) in the present paper.

From the Biohermal Complex very rich and varied, mostly silicified, Late Jurassic faunas, etched by natural chemical weathering of the spongalgal limestones, were recovered in the Visterna valley (Text-Fig. 4, loc. 7) during washing and sieving of the residual clays accumulated in a series of natural caves. These faunas, described and illustrated by PATRULIUS & ORGHIDAN (1964), are composed of Hyalospongea-type silicisponges (*Craticularia*), numerous cyclostome bryozoans (*Ceriopora* spp.), brachiopods, serpulid worms, bivalves (*Pectinidae*, *Dimyidae*, *Arcidae*), crinoids (*Pentacrinus*, *Isocrinus*, *Balanocrinus*), echinoids (*Cidaroida*). Few specimens of *Arisphinctes* sp. ex gr. *A. plicatilis* (SOWERBY) and *Gregoryceras riasi* (GROS-SOUVRE) were collected from the underlying limestones, so that the limestones which have yielded the above-mentioned faunas can be assigned to the Upper Oxfordian-*Bimammatum* Zone). The excellently-preserved, generally small-sized brachiopod fauna includes the following species (PATRULIUS & ORGHIDAN, 1964; BĂRBULESCU, new material):

Crania lineata (QUENSTEDT)
Crania lamellosa (QUENSTEDT)
Crania laevissima PATRULIUS
Craniscus suevicus (QUENSTEDT)

Monticlairella strioplicata (QUENSTEDT)
Monticlairella rollieri WISNIEWSKA
Monticlairella cf. *triloboides* (QUENSTEDT)
Lacunosella sp.
Acanthorhynchia spinulosa (OPPEL)
Acanthorhynchia senticosa (SCHLOTHEIM)
Placothyris sp.
Dorsoplicathyris petersi n.sp.
Dorsoplicathyris sp.
Dictyothyris kurri (OPPEL)
Dictyothyris cf. *rollieri* (HAAS)
Terebratulina (*Cruralina*) *substriata* (SCHLOTHEIM)
Ismenia pectunculoides (SCHLOTHEIM)
Trigonellina intercostata (QUENSTEDT)
Trigonellina loricata (SCHLOTHEIM)
Trigonellina pectunculus (SCHLOTHEIM)
Trigonellina trimedia (QUENSTEDT)
Agerinella lyrata PATRULIUS
Rioulina virdunensis (BUVIGNIER).

It must be emphasized that the species richness of the above-listed brachiopod fauna is very impressive as compared with those found in the two foregoing localities. It seems more likely that this apparent richness should be rather an expression of the virtual existence of several distinct paleocommunities within the Biohermal Complex of the Visterna Series. As already stressed the fauna studied by PATRULIUS & ORGHIDAN (1964) undoubtedly represents a secondary concentrated loose material. However, this is not a major inconvenience, as this collective brachiopod fauna, although taken as a whole, gives us an appropriate idea on the taxonomic variety of brachiopod paleocommunities living in the Biohermal Complex of the Visterna Series, and thus permitted to compare them globally with the coeval brachiopod paleocommunities of the contemporaneous Upper Jurassic shallow-water facies series of the Casimcea Formation occurring in Central Dobrogea.

Biostratigraphically, most of the above-listed brachiopod species, illustrated in PATRULIUS & ORGHIDAN's paper, have a much longer stratigraphic range, being recorded in the Middle Oxfordian–Lower Kimmeridgian (α , β units) limestones from Swabia and Franconia. A comparison with the coeval brachiopod faunas from the western part of Central Dobrogea points to the absence or scarcity of the large-sized *Rhynchonellidae* and *Terebratulidae* species commonly occurring there.

A quite similar small-sized fauna was collected by the second author from the lower part of the Biohermal Complex outcropping on the left-hand bank of the Visterna valley, nearby the railway bridge, including *Monticlairella* sp., *Rioulina virdunensis* (BUVIGNIER), besides large-sized specimens of *Lacunosella* sp., *Moeschia* sp., *Placothyris* sp., *Dictyothyris kurri* (OPPEL) and *Zeillerina delemontana* (OPPEL).

3.1.2. Cekirgea Stromatolitic Algal Series (Text-Fig. 2 A, facies series II)

The most important development area of this series, restricted only to the western part of Central Dobrogea, is to be found in the Cekirgea-Veriga sector, northwards of Topalu. This facies, built up exclusively by stromatolitic boundstones, displays two different morphologic groups: mega- and ministromatoliths, respectively.

The megastromatoliths, ascribed to the LLH-C type, are built up of continuous-stromatolitic masses

evolved from the superposition of continuous-stromatolitic laminae, calcilititic to calcarenitic in grain size, 1 mm to 2 cm in individual thickness. Depending on the amplitude of the wave-shaped component laminae, the megastromatoliths vary from high-domal (more than 0.5 m in wave amplitude) to low-domal (0.2–0.5 m in w.a.) and quasiplanar stromatoliths (less than 0.2 m in w.a.).

The ministromatoliths, by far the richer in entrapped faunal elements, are represented by continuous bioconstructed structures consisting of small columnar stromatoliths either of SV-type or LLH-S type, and fine-waved quasiplanar stromatoliths.

Whereas in the lowermost part of the Cekirgea Series the two types co-occur, the major remaining part of this facies is alternatively composed of megastromatoliths or of ministromatoliths. The stromatolitic facies has developed as a continuous barrier-bank, resulting in an extensive biostrome covering the western Central Dobrogea and displaying a final thickness as high as 150–170 m.

The stromatoliths seem to have had an original hard consistence, due to a rapid lithification of laminae, as shown by several lines of evidence: the attachment of the epibiont faunas (sponges, ostreids, brachiopods) to the surface of several laminae, without causing bending or sagging as a loading effect; the open, tubular voids strongly resembling organic borings in a hard substratum; the frequent microerosional surfaces occurring into the megastromatoliths that sharply cut across the laminae. Some megastromatolitic layers display interruption in the stromatolith upward-growth and dolomitized tops, which, besides the occurrence of desiccation cracks and borings, indicate that they built up to intertidal levels, being locally subjected to subaerial exposure.

As for the depositional environment, the association of the stromatoliths with typical shallow-marine benthic faunas (sponges, corals, brachiopods, bivalves, echinoderms) is congruent with a sedimentation in a wave-agitated, shallow subtidal, marine environment, the depths ranging presumably between 5 and 10 m, much shallower than for the spongalgal facies series.

The main paleontologic characteristic for the lower part of the Cekirgea Series is given by the abundance of the large-sized silicisponges, usually with cylindrical to conical, columnar forms, and subordinately plate-like forms, also by the high frequency and large variety of the ammonite and brachiopod faunas. For the Veriga sector, it is very interesting to note the gradual transition from the sponge-bearing facies in the lower section of the Cekirgea Series to a facies lodging scattered coral patch reef in the uppermost part of the same series, which paved the way for the occurrence of the succeeding Topalu Bioconstructed Coralgal Series.

The very rich faunas associated to the stromatolitic facies in the Cekirgea valley is mainly composed of benthic epifaunal elements, sponges and brachiopods, subordinately of epi- and infaunal elements, such as bivalves, echinoderms, worms, bryozoans (SIMIONESCU, 1910 b; BĂRBULESCU, 1968, 1969 a, 1974). The nekton, represented by numerous and varied ammonites, allowed a very well-constrained biostratigraphy of the Middle Oxfordian–Lower Kimmeridgian sequence (SIMIONESCU, 1907, 1910 a; BĂRBULESCU, 1969 b; 1974). *Ochetoceras canaliculatum* (v. BUCH), *O. hispidum* (OPPEL), *O. semifalcatum* (OPPEL), *Perisphinctes* (*Arisphinctes*) *cotovui* SIMIONESCU, *P.* (*A.*) *helenae* DE RIAZ, *P.* (*Dichotomosphinctes*) *dobrogensis* SIMIONESCU, *P.* (*D.*) *buckmani* (ARKELL), *Gregoryceras* sp., *P.* (*Perisphinctes*) *parandieri* (DE

LORIO) are indicative for the Middle Oxfordian–*Antecedens/Parandieri* Subzones. The *Bifurcatus* Zone is represented by the index species, *P.* (*Dichotomoceras*) *bifurcatus* (QUENSTEDT). The lower part of the *Bimammatus* Zone is documented by *Epipeltoceras berrense* (FAVRE), *Euspidoceras hypselum* (OPPEL), whereas the upper part by *Epipeltoceras bimammatus* (QUENSTEDT), *Ochetoceras marantianum* (D'ORBIGNY), *Decipia topalensis* (SIMIONESCU), etc. The upper part of the Cekirgea Series yielded *Idoceras laxevoluta* (FONTANNES) and *Sutneria galar* (OPPEL), which are representative for the *Planula* Zone in the Late Oxfordian, and also an Early Kimmeridgian ammonite fauna including *Physodoceras contemporaneum* (FAVRE), *P. liparum* (OPPEL), *Aspidoceras* sp., *Ataxioceras* sp. ex gr. *A.* (*Parataxioceras*) *inconditum* (FONTANNES).

Two stratigraphically distinct brachiopod assemblages are occurring in the Cekirgea Series, the one being allied to the sponge-bearing lower section and the other to the coral patch reef-bearing upper section. The difference between the two assemblages is not likely to be due to distinctiveness in taxonomic level but mainly to the relative abundance of some species and subordinately to the entering of some new species.

The first brachiopod assemblage (Text-Fig. 2 A – Middle to basal Upper Oxfordian; Text-Fig. 3, loc. 3) includes the following taxa:

Monticlairella strioplicata (QUENSTEDT)
Monticlairella rollieri WISNIEWSKA
Lacunosella cracoviensis (QUENSTEDT)
Acanthorhynchia spinulosa (OPPEL)
Septaliphoria sp.
Argovithyris baugieri (D'ORBIGNY)
Dorsoplicathyris farcinata (DOUVILLÉ)
Placothyris carsiensis (SIMIONESCU)
Moeschia alata (ROLLET)
Juralina topalensis (SIMIONESCU)
"Terebratulina" dobrogensis (SIMIONESCU)
Dictyothyris kurri (OPPEL)
Nucleata nucleata (SCHLOTHEIM)
Terebratulina (*Cruralina*) *substriata* (SCHLOTHEIM)
Zeillerina delemontana (OPPEL)
Ismenia pectunculoides (SCHLOTHEIM).

The above-listed assemblage includes several brachiopods normally occurring in the sponge-bearing facies elsewhere, such as *Lacunosella cracoviensis* (sharing small-sized, asymmetric specimens in the *Transversarium* Zone and large-sized, either asymmetric or symmetric, specimens in the *Bimammatus* Zone), *Moeschia alata*, *Dorsoplicathyris farcinata*, besides the large-sized *Placothyris carsiensis* and *Zeillerina delemontana*. Also, there occur frequently *Acanthorhynchia spinulosa*, *Dictyothyris kurri* and subordinately the small-sized *Monticlairella strioplicata*, *Argovithyris baugieri* and *Terebratulina* (*Cruralina*) *substriata*. This fauna is occurring in the stromatolitic limestones outcropping along the Cekirgea valley and the Veriga Arm (Danube) cliff, between its confluences with Cekirgea and Scrofeni valleys, and overlaps the sequence from the *Transversarium* Zone up to the basal part of the *Bimammatus* Zone.

Southwards, when the coralligenous masses are inter-leaving in the upper section of the Cekirgea Series, the brachiopod fauna records the highest diversity (Text-Fig. 2 A – Upper Oxfordian; Text-Fig. 4, loc. 4 – ox₃), but it should be noted that the following list checks brachiopods which in reality illustrate very diversified life habits that intricately have been recurring or intergrading during the latest Late Oxfordian (*Planula* Zone) in the western part of Central Dobrogea, viz. stromatolitic, reefal, peri-reefal

and inter-reefal ones. Hence, the subsequent list collectively includes the following taxa:

Crania lineata (QUENSTEDT)
Crania lamellosa (QUENSTEDT)
Monticlairella strioplicata (QUENSTEDT)
Lacunosella cracoviensis (QUENSTEDT)
Acanthorhynchia spinulosa (OPPEL)
Septaliphoria pinguis (ROEMER)
Septaliphoria moravica (UHLIG)
Torquirhynchia speciosa (MÜNSTER)
Dorsoplicathyrus farcinata (DOUVILLÉ)
Dorsoplicathyrus petersi n.sp.
Dorsoplicathyrus sp.
Moeschia alata (ROLLET)
Moeschia granulata BOULLIER
Moeschia zietenii (DE LORIO)
Moeschia sp.
Juralina subformosa (ROLLIER)
Juralina bullingdonensis (ROLLIER)
Juralina castellensis (DOUVILLÉ)
Juralina topalensis (SIMIONESCU)
"Terebratula" dobrogensis (SIMIONESCU)
Dictyothyris kurri (OPPEL)
Terebratulina (Cruralina) substriata (SCHLOTHEIM)
Zeillerina delemontana (OPPEL)
Cheirothyris fleurieusa (D'ORBIGNY)
Ismenia pectunculoides (SCHLOTHEIM)
Riolutina virdunensis (BUVIGNIER).

This brachiopod fauna stands out mostly by the presence of some large-sized species, such as *Dorsoplicathyrus petersi* n.sp., *Moeschia granulata*, *"Terebratula" dobrogensis*, *Juralina subformosa* currently occurring in the coralligenous facies, whereas the inter-reefal, bedded argillaceous and the biodetrital limestones bear only small-sized brachiopods, such as *Dorsoplicathyrus* sp., *Terebratulina (Cruralina) substriata*, *Ismenia pectunculoides*, *Cranidae* and rare *Thecididae*. The rhynchonellids are represented by *Septaliphoria pinguis* and a very large-sized, yet undescribed species of *Septaliphoria*.

The most representative brachiopod species occurring in the two facially distinct sections of the Cekirgea Series are illustrated on Plates 2 and 3 in the present paper.

3.1.3. Topalu Bioconstructed Corallal Series (Text-Fig. 2 A, facies series V)

It corresponds to the upper sedimentary body of the homonymous facies series occurring at several stratigraphic levels in the Central Dobrogean Oxfordian–Lower Kimmeridgian sequence.

Largely widespread in the westernmost part of Central Dobrogea (Topalu-Capidava sector) and directly overlying the Cekirgea Bioconstructed Stromatolitic Algal Series, the Topalu Bioconstructed Corallal Series starts with the arborescent corallo-pseudostromata subfacies, the so-called "Topalu reef" in the previous literature, being largely exposed along the Veriga Arm (Danube) cliff – northwards of the Topalu village, and also in the Tătaru valley, running across the Topalu village. It includes prevalingly variable-sized arborescent and, subordinately, spheroidal and crustous corals (about 70 species inventoried by RONIEWICZ, 1976), coated by pseudostromata crusts that usually fill up the inter-calyx spaces of arborescent colonial corals; in minor amounts, corallal grainstone lenses and fillings occur in-

side the arborescent corallal boundstones. The arborescent subfacies evolved as a nearly continuous barrier reef originating in an extensive corallal biostrome, thus illustrating an extremely shallow subtidal, high-energy environment, less than 1 m in depth, as DRĂGĂNESCU (1976) stated.

The age of the arborescent subfacies results from its stratigraphic position, being underlain by Early Kimmeridgian aspidoceratid-bearing stromatolitic limestones of the Cekirgea Series. The rich coral assemblage, in which *Epistreptophyllum giganteum* RONIEWICZ is frequent, assesses the same age for the arborescent subfacies. The other faunas associated to this subfacies include brachiopods, epi- and infaunal bivalves, echinoids, gastropods and small-sized colonies of hydrozoans (BĂRBULESCU, 1965, 1972, 1974; TURNSEK & BĂRBULESCU, 1969). The brachiopod fauna is composed of a remarkable assemblage of rhynchonellids and terebratulids (Text-Fig. 2 A –Lower Kimmeridgian; Text-Fig. 4, loc. 4 – km₁), as follows:

Septaliphoria moravica (UHLIG)
Septaliphoria pinguis (ROEMER)
Torquirhynchia speciosa (MÜNSTER)
Moeschia granulata BOULLIER
Juralina topalensis (SIMIONESCU)
Juralina subformosa (ROLLIER)
Juralina bullingdonensis (ROLLIER)
Juralina castellensis (DOUVILLÉ)
Juralina kokkoziensis (MOISEEV)
Juralina sp.
"Terebratula" dobrogensis SIMIONESCU
Terebratulina (Cruralina) substriata (SCHLOTHEIM).

The rhynchonellid group includes both quite numerous asymmetric types, such as *Torquirhynchia speciosa*, and fairly frequent trilobate, symmetric types, such as *Septaliphoria moravica*, the latter being in our opinion very similar to *Rhynchonella moeschi* (ROLLIER) sensu MOISEEV (1934). The terebratulids, by far the best represented group, are illustrated almost exclusively by large-sized *Juralina* species provided with strong and erect umbo, such as *J. topalensis*, *J. kokkoziensis*, *J. subformosa*. Large-sized specimens of *Zeillerina delemontana* and very rare *Digonella* sp., *Aulacothyris* sp., *Cheirothyris fleurieusa* and *Ismenia pectunculoides* are also to be found.

Some brachiopod species occurring in the arborescent corallal subfacies of the Topalu Series are selectively figured on Plates 3 and 4 in the present paper.

As it clearly results from the above presentation, the Cekirgea-Topalu sector, by its very rich and varied brachiopod faunas, is the reference region in Dobrogea for the Upper Jurassic brachiopod faunas connected both with the Cekirgea bioconstructed corallal facies and the Topalu Bioconstructed Corallal Facies, while the Casimcea Zone is the reference region for the Upper Jurassic brachiopod faunas allied to the Visterna bioconstructed spongalgal facies. Outside of these reference regions, coeval brachiopod faunas, much less varied and not so rich, occur also in other localities north of the Cekirgea valley, such as the Atârnați point, also the Baroi and "La Vii" hills, north of Hârșova town, always for the Cekirgea stromatolitic algal facies. It is notable in both localities (Text-Fig. 4, locs. 1–2), that northwards of the Cekirgea-Topalu sector a marked decline in diversity of the brachiopods took place, and also that the distinctiveness at the taxon level

between the Middle Oxfordian and, respectively, the Upper Oxfordian–Lower Kimmeridgian sections of the Cékirgea Series is more strikingly expressed here.

In the following sections of the present paper, various paleoecologic and taphonomic aspects, as well as the paleobiogeographic affiliation of the Central Dobrogean Upper Jurassic brachiopod faunas will be analyzed.

Although general knowledge of the Upper Jurassic brachiopod faunas from Central Dobrogea is much expanded by the present paper further more detailed studies will undoubtedly contribute to a better understanding of other intimate aspects, e.g. the distribution of brachiopods in the varied depositional subenvironments of the complex Visterna and Cékirgea facies series. Lastly, the richness and high taxonomic diversity of the Oxfordian–Lower Kimmeridgian brachiopod faunas from Central Dobrogea leave abundant scope for minute studies of evolution in species-level lineages in the fossil record. As at present there is relatively little information bearing on the brachiopod phylogenesis spanning this time interval, it would be highly interesting to study the genetic variability and the adaptive responses of the Central Dobrogean Upper Jurassic brachiopods to the different shallow-water carbonatic environments which could have triggered markedly differing phylogenetic lineages.

To answer the purpose of the present paper, brachiopods from different Central Dobrogean Upper Jurassic facies series have been selectively illustrated on the accompanying plates. Since the brachiopods of the Visterna Series were already well figured by PATRULIUS & ORGHIDAN (1964), those interested are referred to their paper.

The present study is completed with the description of a new species, *Dorsoplicathyris petersi* n.sp., to commemorate the important contribution of PETERS (1867) to the knowledge of Upper Jurassic brachiopods from Central Dobrogea. The generic assignment of *Placothyris carsiensis* (SIMIONESCU) is also revised.

All illustrated specimens have been assigned Laboratory of Paleontology – Bucharest University catalogue numbers and are housed in the type collection of this institution.

4. North Dobrogean Upper Jurassic Brachiopod Faunas

4.1. Cârjelari Formation – Sfânta Facies (Oxfordian–Lower Kimmeridgian): A Restricted Brachiopod Occurrence in a Transtensional Basin

In the Cârjelari Zone (Text-Fig. 1), the Upper Jurassic carbonate rocks of the Cârjelari Formation are occurring in two NW–SE trending, en echelon-arranged, morphological alignments, the north-eastern Amara alignment and, respectively, the south-western Sfânta alignment, which are tectonically separated by the Hasanlar Fault. The two distinct carbonate facies characterizing the respective alignments, i.e. the Amara Facies and the Sfânta Facies, respectively, represent remnants of the two carbonate deposition belts corresponding to the formerly opposite margins of the Peceneaga-Camena transtensional basin (GRĂDINARU, 1988).

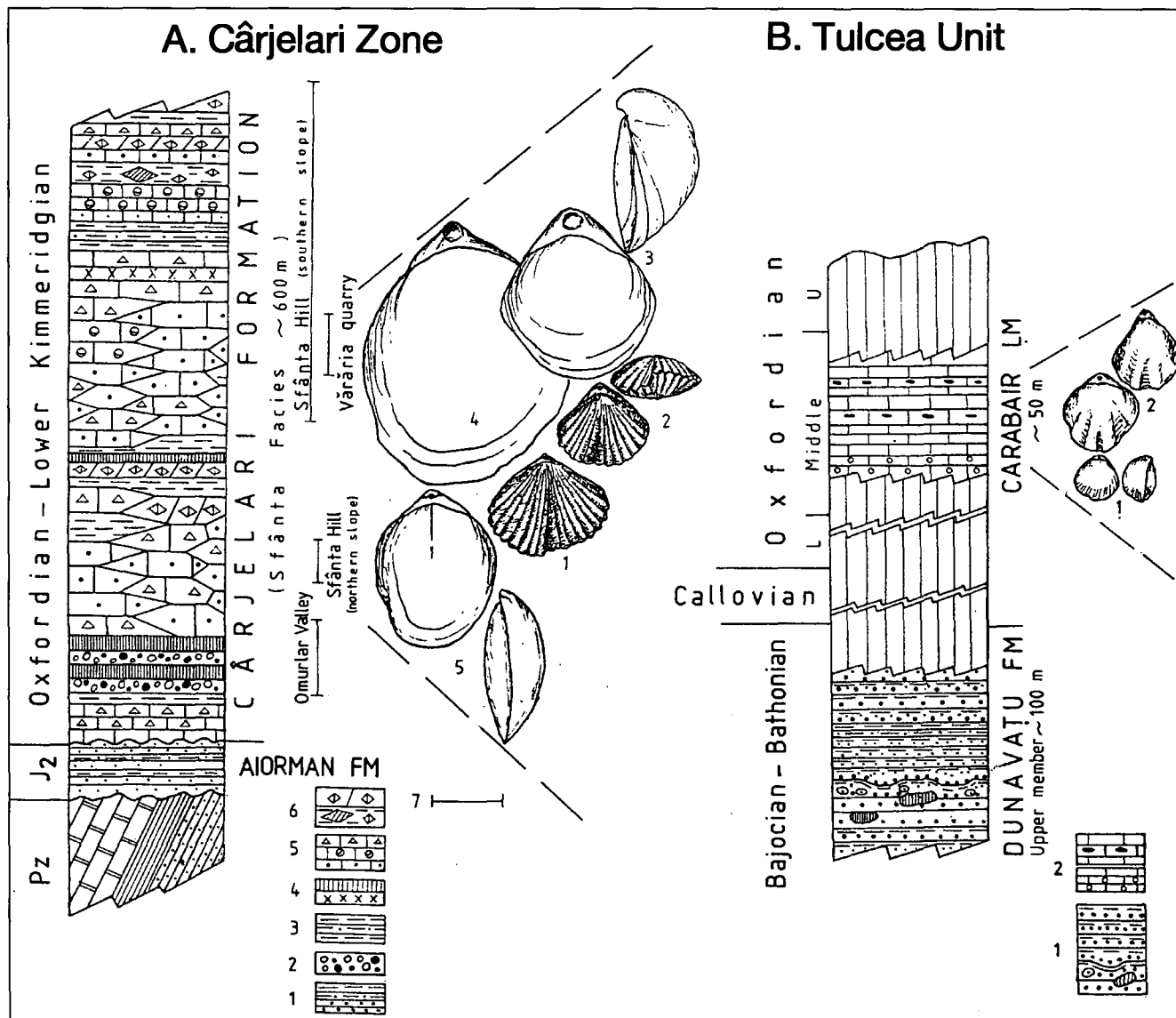
The strikingly differing major sedimentary features of the two facies demonstrate a clear-cut asymmetric cross-sectional morphology for this basin, with a “stationary”, fault-angle depression on the “northern”

downthrown side of the transtensional Peceneaga-Camena Fault, and a “southern” highstanding sliding block on the upthrown side, i.e. the Central Dobrogean “Green Schists Block”, limited by a basinward-facing seismically active fault-scarp. The assumption of an asymmetric half-graben structure allows us to better understand the obviously asymmetric carbonate facies distribution in the Cârjelari area, that exhibit coarse-grained facies at the steep and straight, strike-slip margin, the deposition site for the Sfânta Facies, and finer-grained facies at the gentler gradient, irregular and broader “normal” margin, the deposition site of the Amara Facies.

The Sfânta Facies, developing in the Sfânta hill and the “Vărăria” quarry-hill, about 600 m thick in the exposed sequence, and showing a weakly-developed or indistinct bedding (Text-Fig. 3), is composed of light-coloured, pre-vaillingly bioclastic limestones, ranging in size from calcilutites to calcirudites, associated with scarcely occurring calcilutites, oolitic calcarenites and various biolithites. The carbonate rocks of the Sfânta Facies are stratigraphically bounded by or are commonly interlacing with unsorted and poorly cemented, matrix- or clast-supported disorganized polymictic conglomerates, gray spongolitic or spongo-radiolarian gaizes and spiculitic marls of Başpunar Formation-type, and rhyolitic air-fall tuffs (Sfânta Tephra), usually as lensoid bodies. At some levels on the southern slope of the Sfânta hill, also west of the “Vărăria” quarry, the fine-grained carbonate rocks of the Sfânta Facies show a massive influx of well-sorted and graded, angular-shaped clasts of Central Dobrogean-type “Green Schists”, sometimes even as huge olistoliths. These mixtures or pebbly mudstones were formed by admixture of the gravitationally-emplaced “Green Schists” epiclastites with the intraformationally-reworked carbonate sediments of the Sfânta Facies. They represent distal facies of mass- and turbidity flows genetically relating to the Amara Breccia, a very coarse-grained clast-supported monomictic sedimentary breccia made up exclusively of unsorted cobble- to boulder-sized, angular-shaped blocks of the Central Dobrogean-type “Green Schists” bound within a whitish calcareous matrix. The Amara Breccia is interpreted as a remnant of once more extensive fault-scarp scree breccia draping the northern seismically-active strike-slip margin of the Central Dobrogean “Green Schists Block”, as a narrow fringe pinching out into or lapping the coeval carbonate deposits of the Cârjelari Formation.

The intricately interspersed lithologies of the Sfânta Facies may be explained as the result of the catastrophic disintegration of the carbonate sediments due to the syn-sedimentary repetitive transtensional slipping of the basinward-facing faulted-margin of the Central Dobrogean “Green Schists Block”. Concomitantly, short-lived phases of rapid sinking of the sedimentary area nearby the leading edge of the Central Dobrogean Block has allowed the westward recurrent onlapping of the Başpunar Formation-type deep-water spongo-radiolarian gaizes over the tectonically collapsed shallow-water carbonate rocks of the Sfânta Facies.

All the particular lithologies associated with the collapse breccias of the basinward-facing Central Dobrogean Block fault scarp document intermittent, seismic fault movements with both strike-slip and dip-slip components occurring concurrently with sedimentation. As a consequence, the Sfânta Facies of the Cârjelari Formation, when examined on a larger scale, especially in the area of the Sfânta hill, shows a weakly developed bedding



Text-Fig. 3.

Stratigraphic distribution of brachiopods in the Upper Jurassic of North Dobrogea. Lithostratigraphy and general biostratigraphy: GRĂDINARU (1984, 1988); Brachiopod biostratigraphy: GRĂDINARU & BĂRBULESCU (in the present paper).

A) Cârjelari Zone.

Cârjelari Formation, Sfânta Facies.

Species index: 1–2 = *Torquirhynchia astieriformis*; 3 = *Moeschia granulata*; 4 = *Juralina* cf. *subformosa*; 5 = *Zeillerina* sp.

B) Tulcea Unit.

Carabair Limestone.

Species index: 1 = *Monticarella czenstochowiensis*; 2 = *Lacunosella sparsicosta*.

Lithology:

A) Cârjelari Zone: Aiorman Formation: 1 = terrigenous turbidites; Cârjelari Formation, Sfânta Facies: 2 = polymictic conglomerates; 3 = marly and silty shales; 4 = rhyolitic air-fall tuffs and spongo-radiolarian gaizes; 5 = bioclastic and oolitic limestones; 6 = pebbly mudstones with Central Dobrogean "Green Schists" epiclastites; 7 = local outcropping sequence.

B) Tulcea Unit: Dunavatu Formation: 1 = terrigenous turbidites organized in Ta, Tae and rare Tcd or Tde Bouma sequences, with non-leaved distributary channels, mudstone rip-up clasts and sandstone spheroids centered by mud clasts; Carabair Limestone: 2 = crinoidal calcarenites and pelagic marly limestones with cherty nodules and lenses.

and lenticular-shaped bodies of the constituent rocks which accounts for the interpretation of this facies as a huge syndimentary megabreccia of seismotectonic collapse origin.

Microfacially, the corallgal and echinalgal packstones to grainstones are the main types which characterize the carbonate rocks of the Sfânta Facies. They contain arenite- to rudite-sized skeletal grains, usually bioclasts, only rare biomorpha, of corals, hydrozoans, chaetetids, calcisponges, echinoderms, foraminifera, bryozoans, gastropods, bivalves, brachiopods, crustaceans and scarce fragmentary ammonites of perisphinctid-type, asso-

ciated with arenite-sized algal corpuscles, usually cor-toids, lumps and onkoids. Reef rudstones with debris of arborescent colonial corals and coated bioclasts of various corallophile faunas are also to be found. Oolitic and oolitic-bioclastic packstones to grainstones, lumpal packstones, spiculitic wackestones, pseudostromata algal bindstones and crustous sponge-bearing biolithites are sparsely encountered in the Sfânta Facies.

By their biofacies, the calcareous rocks of the Cârjelari Formation are highly consanguineous with the shallow-water rocks of the Central Dobrogean Oxfordian–Lower Kimmeridgian carbonate platform. The radiolarian fauna

of the spongo-radiolarian gaizes interbedded in the Sfânta Facies, in the Homurlar valley, is also indicative for the Oxfordian–Early Kimmeridgian time interval (DUMITRIĆĂ, in GRĂDINARU, 1988).

Depositionally, the Cârjelari Formation represents the westward, seismically-disturbed, shallow-water counterpart of the coeval deep-water rocks of the Bașpunar Formation, which are intricately intergrading with contemporaneous, intermittent submarine hot-gas-fluidized pyroclastic flows, rhyolitic lava flows and quenched hydroclastic deposits, and finally topped by spilitized basaltic lava flows.

The occurrence of brachiopods in the limestones from the Cârjelari area was recorded by PETERS as early as 1867. He mentioned "*Rhynchonella concinna* SOWERBY", on which a Middle Jurassic age has been assigned to the limestones, although the facies and the occurrence of other macrofaunas seemed to suggest their similarities with the Upper Jurassic carbonate rocks examined by him along the Danube cliff of Central Dobrogea. POMPECKJ (1897), compared the faunas of the Cârjelari limestones with those of the "Calcare a *Terebratula janitor*" from Sicily. SIMIONESCU (1911) described, besides other varied macrofossils, three brachiopod species, i.e. "*Rhynchonella corallina* LEYM.", "*Terebratula* aff. *formosa* SUESS" and "*Terebratula* sp. ex gr. *bisulfarcinata* Sow.", some specimens of the last one being in author's opinion quite similar to "*Ter. farcinata* DOUV." and "*Ter. Zieleni* LOR", commonly occurring in the Upper Jurassic strata from Central Dobrogea. Accordingly, SIMIONESCU compared with good reason the Cârjelari limestones with those occurring in the Topalu area.

New brachiopods were collected from the Cârjelari area by the senior author of the present paper, mainly from the fine-grained, whitish biotrital limestones occurring in the median part of the "Vărăria" quarry. Here, besides epifaunal bivalves and crustaceans, a fairly abundant but low diverse brachiopod fauna is occurring, with species of wide size range from juvenile through gerontic growth stage, including the following taxa:

Torquirhynchia astieriformis CHILDS

Moeschia granulata BOULLIER

Moeschia sp.

Juralina cf. *subformosa* (ROLLIER).

One single specimen of *Zeillerina* sp. has been collected on the northern slope of the Sfânta hill in the biotrital limestones occurring upwards of the exploration mining gallery, while one fragmentary specimen of *Torquirhynchia* sp. has been found in the large quarry open on the southern slope of the Sfânta hill. Most of these brachiopods are commonly occurring in Central Dobrogea in the Upper Oxfordian–Lower Kimmeridgian sequence.

The well-preserved specimens in this fauna are illustrated on Pl. 1 in the present paper.

Finally, the brachiopod fauna in the Cârjelari limestones of Sfânta Facies evinces either an extremely restricted or a very dispersed occurrence, as major characterizing features.

4.2. Carabair Limestone (Middle Oxfordian): A Scattered Brachiopod Occurrence in a Deep-Water Carbonate Basin

The Carabair Limestone, poorly developed in the easternmost part of the Tulcea Unit, with only a small exposure westerly of the Dunavățu de Jos locality (Text-Fig. 1), re-

presents the single outcropping lithostratigraphic term of the Upper Jurassic Series, highly removed by the subsequent erosion. It corresponds to the so-called "Planulaten-Kalkstein vom Kara-bair", whose presence in the Dunavățu region was previously mentioned by PETERS (1867:189). All the later field-works in the region failed to identify the outcrop area of these limestones, until the 1970s, when the recovery of an old paleontological material, which was collected by ȘTEFĂNESCU (1906) in the same region, made actual once again PETERS' very important finding and the above-mentioned outcrop area was finally identified (GRĂDINARU, 1984).

The Carabair Limestone, with only a partially exposed sequence, around 50 m thick, shows light gray crinoidal calcarenites and mainly dark gray, fine-grained pelagically marly limestones, showing odd, dark-black chert nodules and lenses (Text-Fig. 3). These limestones yielded a few epiplanktonic bivalves, rare belemnites, but a fairly abundant ammonoid fauna, including *Sowerbyceras tortisulcatum* (D'ORBIGNY), *Holcophylloceras zignodianum* (D'ORBIGNY), *Ochetoceras hispidum* (OPPEL), *Glochiceras subclausum* (OPPEL), *Dichotomosphinctes elisabethae* (DE RIAZ), *D. sp. ex gr. D. wartae* (BUKOWSKI), *Dichotomoceras bifurcatoides* ENAY, *D. sp. ex gr. D. stenocycloides* (SIEMIRADZKI), which are diagnostic for the *Transversarium* and basal *Bifurcatus* Zones of the Middle Oxfordian.

Only very scattered, small-sized specimens were yielded by the Carabair Limestone, which are attributable only to two taxa which are figured on Pl. 1 (Figs. 1–5) in the present paper, as follows:

Monticarella czenstochowiensis (ROEMER)

Lacunosella sparsicosta (QUENSTEDT).

It is worth mentioning that the first record of brachiopods in this region was made also by PETERS (1867) who cited "*Rhynchonella lacunosa* SCHLOTHEIM".

As compared with Central Dobrogea, the Dobrogean areas lying north of the Peceneaga-Camena Fault show a drastic impoverishment of the North Dobrogean Upper Jurassic brachiopod faunas, thus reflecting a coincident northward decrease in environmental stability from the stable carbonate platform of Central Dobrogea to the tectonically-active Peceneaga-Camena transtensional basin. Text-Fig. 4 points out that the Dobrogean Upper Jurassic brachiopod faunas tend to show a marked northward diversity reduction. A major decreasing gradient of this parameter may be observed when going from Hârșova area towards Cârjelari. As already emphasized, there are several lines of compelling evidence which strengthen that the Central Dobrogean carbonate platform was in close paleogeographic connections with the Peceneaga-Camena transtensional basin, mainly in its western, shallow-water wedge-shaped segment (GRĂDINARU, 1988), thus accounting for free faunal communications. However, major physical changes in environmental conditions allowed only transient successful settlement of the brachiopod faunas in the Cârjelari area during Late Jurassic times.

The much more pronounced impoverishment of the coeval brachiopod faunas in the Tulcea Unit was due to the deeper water environmental conditions.

All the illustrated specimens of the North Dobrogean Upper Jurassic brachiopod faunas from Cârjelari and Dunavățu de Jos localities have been assigned Laboratory of Paleontology – Bucharest University catalogue numbers and are housed in the type collection of this institution.

5. Paleoecologic Analysis

In order to delineate the relationships between the various characteristic Dobrogean Upper Jurassic brachiopod faunas and the different paleoenvironments in which they have lived, our attention will be further focused on some elements concerning their paleoecologic and taphonomic features, such as the areal distribution pattern, diversity and density, size-frequency distribution, preservation state, brachiopod morphology in response to environmental factors, brachiopod relationships with other invertebrate groups.

5.1. Areal Distribution Pattern

A highly unbalanced distribution pattern of the Upper Jurassic brachiopod faunas can be observed on the Dobrogean territory (Table 1 and Text-Fig. 4). Whereas extremely rich and very diversified brachiopod faunas were yielded by the Upper Jurassic shallow-water carbonate platform rocks of the Central Dobrogean sector, only very scarce coeval brachiopod faunas were recovered from the Upper Jurassic shallow-water and, respectively, deep-water carbonate rocks of the North Dobrogean sector. Also, even for each of the two Dobrogean sectors a rather irregular distribution pattern of the Upper Jurassic brachiopod faunas is to be found. It is firstly for Central Dobrogea, where a quite unequal distribution exists between the middle-eastern and western zones, respectively (Text-Fig. 4, locs. 1 to 4 vs. locs. 5 to 7). As for North Dobrogea, the comparative analysis of the coeval brachiopod faunas from Cârjelari and Dunavățu de Jos localities also discloses a clear-cut imbalance in brachiopod distribution on the territory of this sector (Text-Fig. 4, loc. 8 vs. loc. 9).

The quantitative paleobiocoenotic analysis of the Dobrogean Upper Jurassic brachiopod faunas clearly demonstrates that the complex areal distribution of these faunas can be conveniently explained as reflecting varied ecological grouping, the variation in distribution and taxonomic composition being evidently related to environmental differences. The chart portraying the areal distribution pattern of brachiopod taxa on the Dobrogean territory (Text-Fig. 4), drawn on a count of all specimens being in our collections, and including also the specimens reported by PATRULIUS & ORGHIDAN (1964), provides the best indication of original taxonomic composition and diversity.

The areal distribution of the Dobrogean Upper Jurassic brachiopod faunas was decisively related to varied environmental-facial and bathymetric factors, as it resulted from the complex analysis of the brachiopod-bearing carbonate depositional facies made in the foregoing sections of the present paper. Undoubtedly, the adaptation of brachiopod communities to the variable environments of carbonate sedimentation was related to the differing ecological tolerance of the brachiopod taxa to varied physical environmental factors, such as substrate, water-depth and energy levels, rates of sedimentation, light intensity, temperature and salinity.

Primarily, Central Dobrogea evinces a conspicuously high settling potential of the Upper Jurassic brachiopod faunas for such particular biogenous carbonate facies as those of the Visterna bioconstructed spongalgal facies, the Cekirgea stromatolitic algal facies and the Topalu bioconstructed corallgal

facies (Text-Fig. 2). All these environmentally distinct biofacies assured very efficient living opportunities for plentiful brachiopod communities. In all instances, these normal-marine, shallow-water biogenous carbonate facies provided both extensive firm substrates available for attachment and ample nutrient supply. Particularly, the stromatolitic algal facies, which represented during geological times one of the most efficient sites of oxygen generation through oxygen-releasing photosynthesis of cyanobacteria, provided a well-oxygenated and consequently a current-swept, nutrient-enriched environment, highly convenient for the development of very diversified and abundant brachiopod-bearing benthic communities. As for the bioconstructed spongalgal facies, several authors, such as WISNIEWSKA (1932), AGER (1965), GAILLARD (1983) and BOULLIER (1981), have already interpreted this facies as being very favourable for the development of brachiopod populations, owing mainly to abundant food supplied by the intense and constant water-currents produced by such efficient filterers like sponges. Lastly, the intricate, successful cohabitation relationships between the corals and the varied corallophile faunas of the bioconstructed corallgal facies of arborescent colonies, the brachiopods being a prominent constituent but not exceeding other megafaunas, were collectively favoured by the extremely shallow-water, high-energy, wave- and current-agitated environment, allowing not only well-aerated water and high levels of food resources but also numerous and commonly extensive areas suitable for larval settling and ample living spaces for richly brachiopod-bearing benthic communities. All these normal-marine, shallow-water biogenous carbonate facies record a progressive transition from offshore shelf zone to inshore subtidal shoals.

From the same chart (Text-Fig. 4), it is also noteworthy that each of the above-mentioned specific biogenous carbonate facies, laterally contiguous but with gradational contacts, had its own distinct brachiopod community, the distinctiveness of the essentially coeval brachiopod communities being reflected at the level of their key species and trophic nuclei, the latter referring to the species biomass dominance as it results from the relative importance of species and organism's size.

Although several brachiopods of the Central Dobrogean Upper Jurassic fossil assemblages are either cosmopolitan or long-ranging species, thus able to thrive or to survive in a variety of environments, it should be mentioned, however, that the compositional shifts in the faunal emphasis, expressed both in taxonomic variety and individual abundance, of the essentially coeval Central Dobrogean Upper Jurassic brachiopod assemblages (Text-Figs. 2 and 4), were undoubtedly controlled by environmental-facial changes rather than time differences since the brachiopod faunas come from a relatively restricted stratigraphic interval.

No significant differences existed between the Central Dobrogean Upper Jurassic biogenous facies as regards both the food supply and firm substrate availability, thus allowing successful brachiopod settlement. However, it must be further strengthened that all these laterally contiguous but faunally distinct Central Dobrogean Upper Jurassic brachiopod communities bear clear-cut evidence that strong environmental control was exerted on their distribution, and that distinctiveness in their taxonomic composition primarily reflects differences in water-depth and energy levels, and only secondarily differences in niche-size and trophic amensalism relationships, as main ecologically-governing factors.

Table 1.

Check list and facial-stratigraphic distribution of Upper Jurassic brachiopods in Central and North Dobrogea.

	C E N T R A L D O B R O G E A				NORTH DOBROGEA		
Superfamilies & Species	V i s t e r n a Bioconstructed Spongalgal Series		C e k i r g e a Stromatolitic Algal Series		Top a l u Bioconstructed Coralgal Series	Cârjelari Formation	Carabair Formation
	Biostrom. Complex	Bioherm. Complex	lower complex	upper complex	km ₁	ox -km ₁	ox ₂
	ox ₂	ox ₃	ox ₂₋₃	ox ₃			
CRANIACEA							
Crania lineata (QUENSTEDT)		====		0000			
Crania lamellosa (QUENSTEDT)		====		0000			
Crania laevisissima PATRULIUS		====					
Craniscus suevicus (QUENSTEDT)		====					
RHYNCHONELLACEA							
Septocrurella sancteclarae (ROEMER)	====						
Monticliarella strioplicata (QUENSTEDT)	====	====	0000	0000			
Monticliarella rollieri WISNIEWSKA		====	0000				
Monticliarella cf. triloboides (QUENSTEDT)		====					
Monticliarella czenstochowiensis (ROEMER)							vvvv
Lacunosella arctica (OPPEL)	====						
Lacunosella sparsicosta (QUENSTEDT)			0000				vvvv
Lacunosella trilobataeformis WISNIEWSKA	====						
Lacunosella cracoviensis (QUENSTEDT)			0000	0000			
Lacunosella sp.		====					
Acanthorhynchia spinulosa (OPPEL)		====	0000	0000			
Acanthorhynchia senticosa (SCHLOTHEIM)		====					
Supraliphoria pinguis (ROEMER)				0000	xxxx		
Septaliphoria moravica (UHLIG)			0000	0000	xxxx		
Supraliphoria sp.			0000				
Torquirhynchia astieriformis CHILDS				0000		++++	
Torquirhynchia speciosa (MUNSTER)					xxxx		
Torquirhynchia sp.						++++	
TEREBRATULACEA							
Dorsoplicathyrus farcinata (DOUVILLÉ)	====		0000	0000			
Dorsoplicathyrus petersi n.sp.		====		0000			
Dorsoplicathyrus sp.		====		0000			
Placothyris carsiensis (SIMIONESCU)	====		0000				
Placothyris sp.		====	0000				
Argovithyrus baugieri (D'ORBIGNY)			0000				
Argovithyrus stockari (NOESCH)	====						
Moeschia alata (ROLLET)	====		0000	0000			
Moeschia granulata BOULLIER				0000	xxxx	++++	
Moeschia zietenii (DE LORIO)				0000	xxxx		
Moeschia sp.	====	====		0000		++++	
Juralina subformosa (ROLLIER)				0000	xxxx	++++	
Juralina bullingdonensis (ROLLIER)				0000	xxxx		
Juralina castellensis (DOUVILLÉ)				0000	xxxx		
Juralina topalensis (SIMIONESCU)			0000	0000	xxxx		
Juralina kokkoziensis (NOISEEV)					xxxx		
Juralina sp.					xxxx		
"Terebratula" dobrogensis SIMIONESCU			0000	0000	xxxx		
Dictyothyris cf. rollieri (HAAS)		====					
Dictyothyris kurri (OPPEL)		====	0000	0000			
Nucleata nucleata (SCHLOTHEIM)	====		0000				
Terebratulina substriata (SCHLOTHEIM)		====	0000	0000	xxxx		
ZEILLERACEA							
Zeillerina delemontana (OPPEL)	====		0000	0000	xxxx		
Zeillerina sp.					xxxx	++++	
Digonella sp.					xxxx		
Aulacothyris sp.					xxxx		
TEREBRATELLACEA							
Cheirothyris fleurieusa (D'ORBIGNY)				0000	xxxx		
Ismenia pectunculoides (SCHLOTHEIM)		====	0000	0000	xxxx		
Trigonellina intercostata (QUENSTEDT)		====					
Trigonellina loricata (SCHLOTHEIM)		====					
Trigonellina pectunculus (SCHLOTHEIM)		====					
Trigonellina trimedia (QUENSTEDT)		====					
THECIDEIDEA							
Rioulina virdunensis (BUVIGNIER)		====		0000			
Agerinella lyrata PATRULIUS		====					

As for the other Central Dobrogean Upper Jurassic facies described by DRĂGĂNESCU (1976), such as Gara Târgusor triturated spongalgal facies, Piatra bioconstructed coralgal facies, Sârtorman corpuscular algal facies, Furcil corpuscular

coralgal facies and Luminița micritic lagoonal facies, the brachiopods are almost completely lacking in some facies, whereas in the other facies they occur only sparsely. It suggests paleoecological and sedimentological conditions inimical to brachiopod-bearing benthic life.

All the above-mentioned facies represented high-stress or hostile depositional environments, characterized either by a high sedimentation rate and excessive hydrodynamics or by a muddy sedimentation lacking substrate firmness and, finally, by restrictive hypersaline conditions.

Lastly, to evince once more the close biological affinity of the Central Dobrogean Upper Jurassic brachiopod-bearing benthic communities for some definite, open-marine, shallow-water biogenous carbonate facies, it is very interesting to note that the southward progressive migration of the main facies tracts on the Central Dobrogean territory during the whole Middle Oxfordian to Early Kimmeridgian time interval, responsible for the marked diachronism of the resultant facies belts paralleling a presumable NW–SE depositional strike – these getting constantly younger southwards, as DRĂGĂNESCU (1976) stated – was concomitantly accompanied by a coincident southward migration with time of the brachiopod faunas and their co-associated benthic organisms, normally with the corresponding stratigraphic-induced, qualitative shifts in their taxonomic composition.

The local distribution pattern of the Central Dobrogean Upper Jurassic brachiopods, within the definite biogenous carbonate facies, is highly variable being closely dependent on the niche-size availability in certain benthic communities in a given bottom section.

Commonly, the Middle Oxfordian brachiopods appear as isolated individuals, such as in the Cekirgea stromatolitic algal facies from “La Vii” hill-section near Hârșova town, also in the Visterna bioconstructed spongalgal facies, as it may be seen in several fossil occurrences in the Casimcea Zone. These two facies offered numerous, isolated tiny niches to be settled by brachiopods. In some instances, brachiopods were observed welded tangentially to the surface of several stromatolitic laminae, presumably in apparent life position. In other sections, the brachiopods are essentially patchy in their distribution, being clustered in small pockets at several distinct, laterally-continuous levels in the Middle Oxfordian sponge-bearing stromatolitic algal facies from the Cekirgea valley, nearby its confluence with the Danube-Veriga Arm. It is a convincing evidence that the respective brachiopods lived gregariously in small colonies.

The brachiopods in the uppermost Oxfordian *Planula* Zone are frequently lying on and randomly oriented with regard to the bedding plane of the inter-reefal biodetrital and argillaceous limestones or dispersed around the small-sized coralligenous buildups intertonguing in the upper section of the Cekirgea Stromatolitic Algal Series, whereas the Lower Kimmeridgian brachiopods are occurring in the free interstices between the arborescent coral colonies forming the fourth coralligenous complex outcropping along the Veriga Arm (Danube) cliff, northwards of Topalu village, i.e. in the arborescent subfacies of the Topalu Bioconstructed Coralline Series. In all the above-described instances, as can be interpreted from the sedimentary structures and taphonomic features, the brachiopods appear to be essentially indigenous fossil assemblages without exotic elements. Reworking, even if present, always went on in place.

The shell orientation pattern in the rock is also very variable, reflecting either primary features or thanatocoenosis overprints.

Even when studying smaller-sized populations, it is obvious that the brachiopod shells are currently lying at different angles to the bedding plane, in almost all investigated localities from Central Dobrogea.

The abandoned quarries from the Cekirgea valley display well-exposed and accessible stratigraphic sections and thus afforded an excellent opportunity to examine the shell orientation pattern. The percentage of shells lying parallel to the bedding plane and showing the pedicle valve in lower position reaches around 50 % of the total. The remaining shells were noted either in oblique position, with one of the valve looking to the bedding plane, or even perpendicular to it, the latter position being commonly recorded for rhynchonellids. All the above-mentioned styles of shell orientation clearly suggest no significant post-mortem movement of the shells, which are always articulated.

Also, the analysis of the brachiopod distribution pattern in the Topalu bioconstructed coralline facies obviously allows the major conclusion that the brachiopods appear to be typical life assemblages of unaltered composition (biocoenosis), i.e. colonies of brachiopods which lived and have been fossilized in the same environment, many individuals being apparently preserved near to or in growth position. It is especially evident for some *Juralina* species, which share many individuals frequently found in vertical life position, the geopetal structures clearly accounting for it. Often, the anterior part of the shells are either empty or filled with sparry calcite, whereas the infilling carbonate sediment is limited only to the posterior part, thus testifying a semi-infaunal life-style of the adult individuals of the *Juralina* species.

Only occasionally in the fourth stromatolitic complex of the Cekirgea Stromatolitic Algal Series exposed along the Veriga Arm (Danube) cliff, southerly of the Cekirgea valley mouth, the terebratulid brachiopods are overwhelmingly disarticulated valves and associated with well-winnowed skeletal fragments of sponges and echinoderms giving thin, discrete levels underlying the stromatolitic algal limestones. The large-sized, broken terebratulid shells are infilled by well-preserved, small-sized terebratulids. The essentially unsorted and unoriented material, strongly reworked but clearly indigenous, testifies a very shallow, high-energy, wave-abraded environment, recurrently occurring within the long-lasting moderate-energy environment enabling the flourishing of the stromatolitic facies.

To conclude, all lines of evidence clearly prove that the brachiopod faunas environmentally confined to the above-described specific Central Dobrogean Upper Jurassic biogenous carbonate facies have to be regarded as essentially autochthonous assemblages, mixing of faunas derived from various habits prior to burial being completely precluded. Obviously, most of the brachiopod yielded by the Central Dobrogean Upper Jurassic biogenous carbonate facies were buried at or close to their living sites.

When comparing the Upper Jurassic brachiopod faunas from North Dobrogea with the coeval brachiopod faunas from Central Dobrogea, the drastic impoverishment of the former is strikingly evident (Text-Fig. 4, locs. 8 to 9). In all instances, the North Dobrogean brachiopod faunas appear as essentially limited communities, showing considerably reduced diversity, thus witnessing either unstable or high-stress environments for the Upper Jurassic depositional areas lying north of the Peceneaga-Camena Fault.

For the brachiopod fauna included in the biodetrital limestones of the Cârjelari Formation in Sfânta Facies (Text-Fig. 3) there are several lines of compelling evidence, such as the wide size range of the shells repre-

sented by juvenile through gerontic stages, therefore suggesting that there has been no selective transport of individuals by current activity, also the relatively great proportion of disarticulated often fragmentary shells, all accounting for a clear-cut allochthonous nature. The same aspects are shown by the associated bivalve and arthropod faunas, both with disarticulated shells or carapaces. To put together such contrasting aspects, i.e. the essentially unsorted appearance and the high proportion of disarticulated and fragmentary shells, a cohesive mass-flow triggering mechanism should be inferred to conveniently explain the allochthony of the Cârjelari brachiopod-bearing fossil assemblage. The homogeneous and compatriotic, reduced taxonomic composition of the Cârjelari brachiopod fauna, at variance with a notable abundance of individuals, suggests derivation from a population for which large numbers and localized extent represented original distributional features. Such a population, essentially opportunistic, was capable of rapid temporary expansion in size during short time intervals of stable carbonate sedimentation, although very restricted spatially to some small-sized, ephemeral submarine swells or to the upper slope of their flanking fault-scarps, in an otherwise very tectonically-active setting, such as the Jurassic Peceneaga-Camena transtensional basin.

The even much more impoverished brachiopod fauna yielded by the basinal cherty limestones of the Middle Oxfordian **Carabair Limestone** (Text-Fig. 3) unambiguously reflects not only very limited settlement availability on a soft, deep-water muddy substrate, but especially a very limited food supply, relating to extremely quiet, poorly oxygenated waters bottom conditions. This conclusion is supported by the fining and darker colour of sediments, the increase in organic matter, all accounting for the almost complete lacking of suspension feeders and the extensive burrowing by soft-bodied organisms. All these aspects fairly well explain the overall reduction both in population and individual shell-size.

5.2. Diversity and Density

The taxonomic variety and individual characteristics of the Dobrogean Upper Jurassic brachiopods will be dealt with both qualitatively and quantitatively in terms of facies dependence.

Text-Fig. 4, depicting the proportional share of both individual species and higher rank taxa within the whole fauna in every Dobrogean Upper Jurassic shallow-water biogenous carbonate facies, displays the marked, geographically-varying diversity and density of the associated brachiopod faunas. As already emphasized, in some instances, such as for the upper sections of the Cekirgea and Visterna facies series, the excessive taxonomic composition of the brachiopod assemblages unambiguously reflects the existence of several distinct trophic associations within these major facies series. Their more detailed knowledge needs further study. That is why the present survey is merely concerned with the global pattern of diversity and density in each major brachiopod-bearing facies series.

Although no special sampling was done in the field to determine the faunal composition in definite facies and localities, the brachiopods in collections are present in sufficient numbers to make fairly accurate general comments with regard to fossil communities and to assess the major differences between them. Certainly, we are fully

aware that the percentage would undoubtedly vary with a more intense collecting in some occurrences, but we are confident that the relative proportion would not change significantly within individual communities.

Firstly, if we take into account the taxon number, it can be stressed that the brachiopod communities from the western part of the Central Dobrogean sector exhibit by far the highest taxonomic variety. Especially, plentiful brachiopod communities flourished in the extreme shallow-water biogenous carbonate facies developing mainly in the Cekirgea-Topalu sector (Text-Fig. 4, locs. 3 to 4) and subordinately in the Hârşova sector (Text-Fig. 4, locs. 1 to 2).

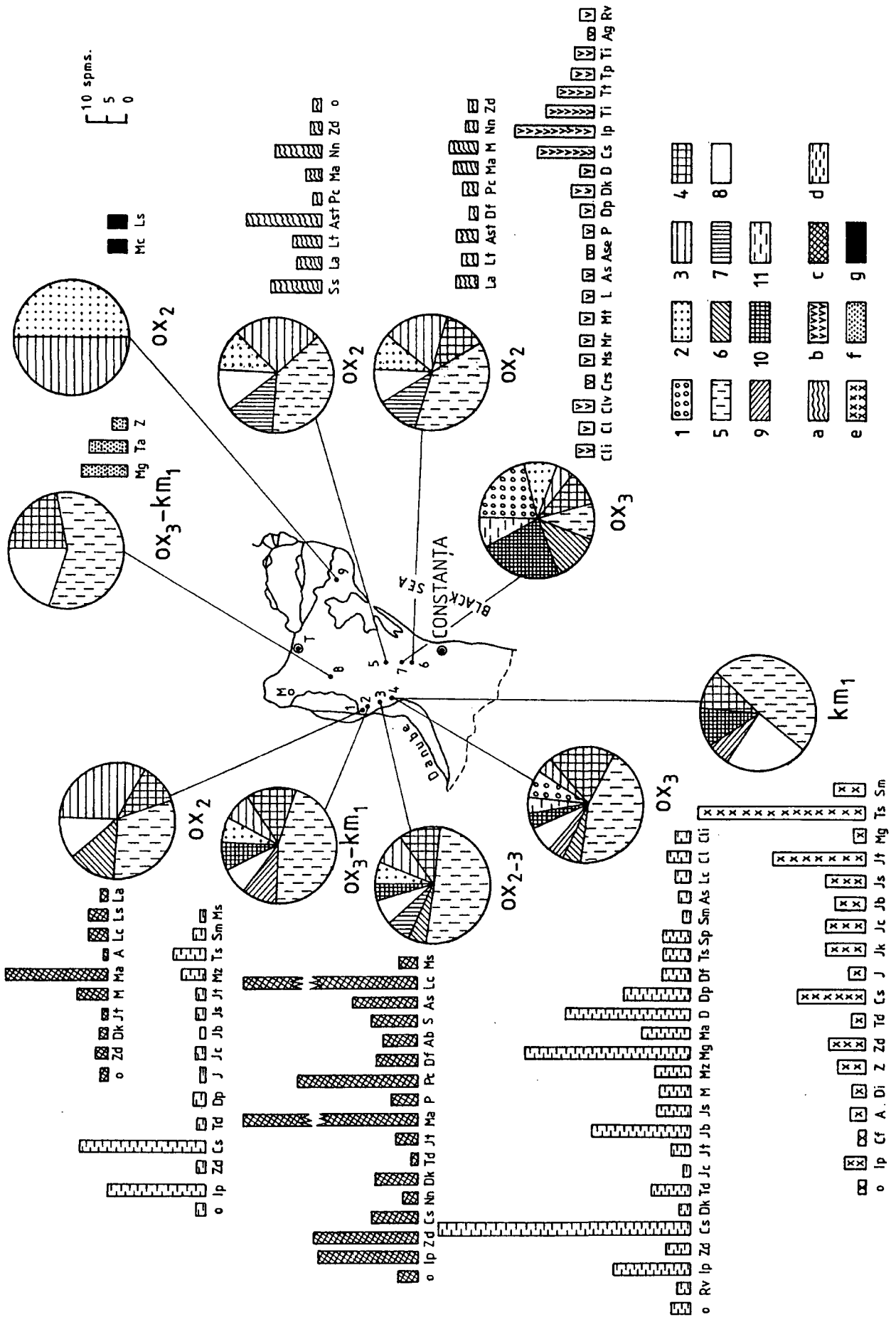
Secondly, the brachiopod assemblages recorded in the western part show not only a high taxonomic variety but also a remarkable individual abundance and high concentration of some taxa making up the trophic nuclei in both the Cekirgea stromatolitic algal and Topalu bioconstructed corallgal facies, thus accounting for ample nutrient-supply and extensive firm substrate for attachment as well.

When comparing the essentially coeval brachiopod faunas of Visterna bioconstructed spongalgal and Cekirgea stromatolitic algal facies, the offshore to inshore increase in both faunal diversity and density is fairly evident. It is customary to account for it by invoking an increased food supply, because phytoplanktonic concentrations are often greatest in the inshore zones and more plankton reaches the bottoms in shallower, higher-agitated waters.

Also, from Text-Fig. 4 it may be observed that the Central Dobrogean Upper Jurassic brachiopod communities recorded a pronounced overall rise in diversity and population size during the Late Oxfordian time interval, thereby accounting for a maximum areal expansion of Dobrogean epeiric sea leading to an increased habitat heterogeneity.

Lastly, while emphasizing the dissimilarities in the environment and the faunal composition, it is also worth noting the overall presence of some common and opportunistic brachiopods having the greatest ability to tolerate different facies conditions. However, as already mentioned in the foregoing section, the brachiopod communities environmentally-confined to the major Central Dobrogean Upper Jurassic biogenous carbonate facies are distinguished by their distinct key species and trophic nuclei. When counting the specimen number per species, often one single species is dominant within the individual brachiopod communities, almost in every locality and stratigraphic level. When two or more species have a similar abundance, they currently belong to different genera.

The Visterna bioconstructed spongalgal facies bears two brachiopod assemblages which markedly differ in faunal emphasis, being stratigraphically and environmentally constrained to the lower, Middle Oxfordian Biostromal Complex, characterized by less-diversified brachiopod communities (Text-Fig. 4, locs. 5 to 6) and, respectively, to the higher, Upper Oxfordian Biohermal Complex, characterized by a much more diversified brachiopod community (Text-Fig. 4, loc. 7). The main controlling factors refer to niche-size availability and trophic amensalism relationships which became more favourable upwards. Whereas the Middle Oxfordian brachiopod communities were numerically dominated by *Terebratulidae* and *Wellerellidae*, the other families (*Dimerellidae*, *Pygopidae*, *Zeilleriidae*) are almost equally represented, or preferentially occurring (*Rhynchonellidae*). The Upper Oxfordian



brachiopod community records the major occurrence of both *Cranidae* and *Dallinidae*, reaching together up to 50 % of the total, the entering of *Dictyothisridae* besides the constant occurrence of *Wellerellidae*, both with a participation ranging between 10 and 18 %, to the major prejudice of *Terebratulidae* and *Rhynchonellidae*, which form no more than minor constituents in the fossil assemblages.

The key species in the Visterna bioconstructed spongalgal facies are represented by *Argovithyris stockari*, *Septaliphoria sancteclarae* and *Nucleata nucleata* in the Middle Oxfordian Biostromal Complex (Text-Fig. 4, loc. 5), whereas *Ismenia pectunculoides* and *Terebratulina (Cruralina) substriata* alongside several species of *Trigonellina*, among which *T. intercostata* and *T. loricata* are the most common, make up an enlarged trophic nucleus in the brachiopod fauna of the Upper Oxfordian Biohermal Complex. If we compare the two brachiopod assemblages yielded by the Middle Oxfordian Biostromal Complex (Text-Fig. 4, loc. 5 vs. loc. 6), there are little qualitative differences between the two localities. The striking difference is not likely to be due to the difference in taxonomic level, but mainly to the relative participation of the species. Lastly, in comparing the brachiopod faunas of the two subfacies in the Visterna bioconstructed spongalgal facies it should be kept in mind that the extreme diversity of the brachiopod fauna in the Biohermal Complex, which shares a great mixture of taxa, obviously reflects the existence of several, though poorly defined, trophic associations, it being undoubtedly related to the availability of very diversified favourable niches in the spongalgal biohermal buildups.

As for the brachiopod communities occurring in the Cekirgea stromatolitic algal facies, the overwhelming participation of *Terebratulidae* is to be noticed, heading in almost all localities to around 50 % of the total, being followed at a greater distance by *Rhynchonellidae*. In the Cekirgea sponge-bearing stromatolitic subfacies (Text-Fig. 4, loc. 3) the brachiopod community is numerically dominated by far by *Lacunosella cracoviensis* and *Moeschia alata*, which highly outnumber other species showing also important participations, such as *Placothyris carsiensis*, *Ismenia pectunculoides* and *Zeillerina delemontana*.

On the other hand, it is noticeable that a marked stratigraphic shift in taxonomic composition and diversity is recorded throughout the Upper Oxfordian rock-sequence outcropping along the Veriga Arm (Danube) cliff when the coralligenous buildups are interleaving in the upper sec-

tion of the Cekirgea stromatolitic algal facies. It is strikingly correlating with the highest taxonomic variety known for the Central Dobrogean Upper Jurassic brachiopod faunas, thus reflecting the existence of very diversified environmental-facial conditions within the stromatolitic algal facies during the Late Oxfordian in the Cekirgea-Topalu sector. Consequently, the brachiopod assemblage yielded by the upper section of the Cekirgea facies series includes brachiopods belonging to very different trophic associations, environmentally-confined to reefal, peri- and inter-reefal, or stromatolitic subfacies. Looking at it as a whole, the trophic nucleus is overwhelmingly dominated by *Terebratulina (Cruralina) substriata* and some species of *Moeschia*, *Juralina* and *Dorsoplicathyris*, such as *M. granulata*, *J. bullingdonensis* and *D. sp.*

Lastly, it is noteworthy for the Cekirgea-Topalu sector, the brachiopod faunas straddling the boundary between Late Oxfordian and Early Kimmeridgian underwent a marked decline upwards, so as in the fourth coralligenous level, i.e. in the lower arborescent corallgal subfacies of the Topalu bioconstructed corallgal facies, the brachiopod/coral ratio is clearly less than 1, as a result of a progressive process of shallowing and shoaling upwards in response to the overall regional regression of the Central Dobrogean Upper Jurassic epicontinental sea.

Text-Fig. 5 clearly demonstrates the inverse trending in temporal changes in the taxonomic composition of contemporaneous coral and brachiopod faunas, respectively, during Late Oxfordian to Early Kimmeridgian time interval. Seemingly, it suggests that the biologic competition between coral communities and other benthic organisms may have played a major role in diminishing the diversity of brachiopod faunas. In the arborescent corallgal subfacies of the Topalu bioconstructed corallgal facies, although the rhynchonellids are exceedingly outnumbered by the terebratulids in proportion of 1:5, the key species is however represented by a rhynchonellid, i.e. by *Torquirhynchia speciosa*. The trophic nucleus also includes numerous species of *Juralina*, among which *J. topalensis* is the most prevalent by far, alongside the increasing participation of zeilleriids which reach up to 20 % of the total.

Northwards, in the Hârşova zone (Text-Fig. 4, locs. 1 to 2), the brachiopod faunas occurring in the Cekirgea facies series are drastically diminishing both in taxonomic composition and individual abundance, the relative importance of key species being also modified, reflecting important changes of depositional environments north of Cekirgea-Topalu area.

Text-Fig. 4.

Areal distribution pattern and quantitative paleobiocoenotic analysis of Upper Jurassic brachiopod assemblages from Central and North Dobrogea.

Circles: Taxonomic composition of the brachiopod faunas (families).

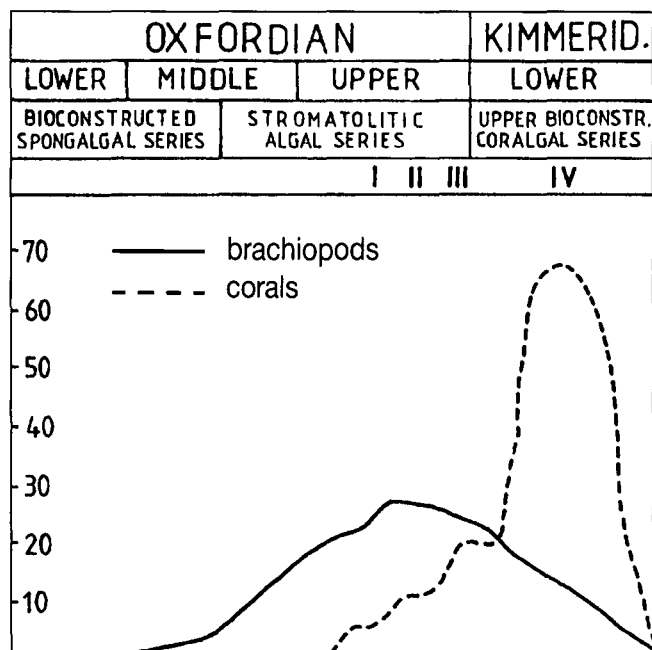
Histograms: Number of specimens.

Locality index: 1–2 = "La Vii" hill, north of Hârşova; 3 = Cekirgea valley; 4 = Veriga Arm (Danube) cliff, north of Topalu; 5 = Sârtorman valley; 6 = Casimcea valley; 7 = Visterna valley; 8 = Cârjelari; 9 = Dunavăţu de Jos.

Family-symbol key: 1 = *Cranidae*; 2 = *Dimerellidae*; 3 = *Wellerellidae*; 4 = *Rhynchonellidae*; 5 = *Terebratulidae*; 6 = *Dictyothisridae*; 7 = *Pygopidae*; 8 = *Zeilleridae*; 9 = *Cancellothyrididae*; 10 = *Dallinidae*; 11 = *Thecideidae*.

Facies series-symbol key: a = Visterna Bioconstructed Spongalgal Series, Biostromal Complex; b = Visterna Bioconstructed Spongalgal Series, Biohermal Complex; c = Cekirgea Stromatolitic Algal Series, sponge-bearing lower complex; d = Cekirgea Stromatolitic Algal Series, coral patch reef-bearing upper complex; e = Topalu Bioconstructed Corallgal Series; f = Cârjelari Formation, biodetrital limestones; g = Carabair Limestone, basinal limestones.

Species-symbol key: A = *Aulacothyris* sp.; Ab = *Argovithyris baugieri*; Ast = *A. stockari*; Ag = *Agerinella lyrata*; As = *Acanthorhynchia spinulosa*; Ase = *A. senticosa*; Cf = *Cheirothyris fleureusea*; Cl = *Crania lamellosa*; Cli = *C. lineata*; Clv = *C. laevissima*; Crs = *Craniscus suevicus*; Cs = *Terebratulina (Cruralina) substriata*; Di = *Digonella* sp.; Df = *Dorsoplicathyris farcinata*; Dp = *D. petersi*; D = *D. sp.*; Dk = *Dictyothisyris kurii*; Ip = *Ismenia pectunculoides*; Jb = *Juralina bullingdonensis*; Jc = *J. castellensis*; Jk = *J. kokkoziensis*; Js = *J. subformosa*; Jt = *J. topalensis*; J = *J. sp.*; La = *Lacunosella arolica*; Lc = *L. cracoviensis*; Ls = *L. sparsicosta*; Lt = *L. trilobataeformis*; L = *L. sp.*; Ma = *Moeschia alata*; Mg = *M. granulata*; Mz = *M. zietenii*; M = *M. sp.*; Mc = *Monticarella czenstochowensis*; Mr = *M. rollieri*; Ms = *M. striplicata*; Mt = *M. triloboides*; Nn = *Nucleata nucleata*; Pc = *Placothyris carsiensis*; P = *P. sp.*; Rv = *Rioutina viridunensis*; Sm = *Septaliphoria moravica*; Sp = *S. pinguis*; S = *S. sp.*; Ss = *Septocrurella sancteclarae*; Ta = *Torquirhynchia astierformis*; Ts = *T. speciosa*; Td = *"Terebratula" dobrogensis*; Ti = *Trigonellina intercostata*; Tl = *T. loricata*; Tp = *T. pectunculus*; Tt = *T. trimedia*; Zd = *Zeillerina delemontana*; Z = *Z. sp.*; o = others.



Text-Fig. 5.
Stratigraphic distribution of brachiopod vs. coral species in the Upper Oxfordian–Lower Kimmeridgian rock-sequence from Veriga Arm (Danube) cliff, north of Topalu.
I–III = coralligenous levels in Cekirgea Stromatolitic Algal Series; IV = Topalu Bioconstructed Coralgall Series ("Topalu reef").

The brachiopod faunas occurring in the two subfacies of the Cekirgea stromatolitic algal facies in the "La Vii" hill-rock sequence show a considerably reduced diversity and they are usually strongly dominated by few taxa. Thus, whereas the *Moeschia alata* is the dominant species in the Middle Oxfordian Cekirgea sponge-bearing stromatolitic subfacies, *Terebratulina* (*Cruralina*) *substriata*, although having a predominance over *Ismenia pectunculoides*, both strongly dominate all the remaining species in the Upper Oxfordian–Lower Kimmeridgian Cekirgea stromatolitic-coralligenous subfacies. Generally, our available data clearly indicate a gradient in diversity decline of brachiopod faunas from south to north on the territory of the Central Dobrogean sector.

In some particular situations, the high diversity is not matched by a corresponding high density. For instance, in the brachiopod faunas yielded by the Biohermal Complex of the Visterna bioconstructed spongall facies (Text-Fig. 4, loc. 7), although one of the most diversified among the Central Dobrogean Upper Jurassic brachiopod faunas, most of the species occur in low numbers. A similar share is characterizing the Cekirgea stromatolitic algal facies developing in the Hârşova area (Text-Fig. 4, locs. 1 to 2).

As already emphasized, the major Central Dobrogean Upper Jurassic brachiopod paleocommunities, although environmentally distinct, currently include many cosmopolitan or long-ranging brachiopods. Thus, the *Zeilleriidae*, maybe eurytopic organisms, are found in almost all the brachiopod assemblages, thus proving a wider range of tolerance for varied sedimentary environments. They are commonly conspicuous in the moderate-energy Cekirgea stromatolitic algal facies, where *Zeillerina delemontana* shows a notable abundance of individuals, and, respectively, in the very shallow-water, high-energy Topalu arborescent corallgal subfacies, where the total occurrence of *Zeillerina* species is re-

markably increasing. Although several brachiopods, such as *Moeschia alata*, *Terebratulina* (*Cruralina*) *substriata*, *Ismenia pectunculoides*, *Juralina topalensis* or "*Terebratula*" *dobrogeensis* are long-ranging species, each of them currently shows a preference for a definite facies, where they occur in great abundance and high concentration, commonly representing the key species in the respective facies. Lastly, the Upper Oxfordian–Lower Kimmeridgian brachiopod assemblages in Central Dobrogea record an outstanding species-lineage of *Juralina*, which exhibits an increasing species diversity and abundance upwards from the Cekirgea facies series to the Topalu facies series, where *Juralina* species exceedingly dominate the other brachiopods in total number of individuals.

Taking into account the Upper Jurassic brachiopod faunas from North Dobrogea, the diversity drops dramatically north of Peceneaga-Camena Fault, thus enhancing so much the more the gradient of diversity decline when going from the Hârşova area towards the North Dobrogea.

The Middle Oxfordian brachiopod fauna of the Cârjelari Formation in Sfânta Facies, although extremely reduced in taxonomic diversity (Text-Fig. 4, loc. 8), shares in turn a relative great abundance of the *Terebratulidae*, which overshadowed the *Rhynchonellidae* and *Zeilleriidae*. To account for this major decline in diversity, it should be noted that faunas in the unstable environment are always subject to high stress and accordingly restricted to eurytopic organisms showing low diversity. Furthermore, the brachiopod fauna delivered by the Middle Oxfordian Carabair Limestone is even much more sharply restrained both in high rank taxa and species number, the *Wellerellidae* and *Dimerellidae* playing an equal role (Text-Fig. 4, loc. 9). In the last case, the extreme reduction in population size was related to the problem of colonizing a muddy substrate and disparities in food distribution. The only available firm surfaces for attachment were provided either by the ammonite shells or by some non-preservable, firm organic substrate, e.g. seaweed fronds, the latter situation implying an epiplanktonic life-style for the only two species being in the fauna, *Monticlairella czenstochowiensis* and *Lacunosella sparsicosta*, at least for the larval stage.

5.3. Size-Frequency Distribution

With regard to this parameter, which primarily reflects the quality of the life habits, there is a wide range of individual size, from millimetric specimens, as for the *Craniidae*, *Thecideidae*, *Wellerellidae*, *Trigonellinae* and some *Rhynchonellidae* (*Monticlairella*), up to 70 mm for some specimens of *Moeschia*, *Juralina*, *Torquirhynchia* and *Septaliphoria*.

A clear-cut shell size-variation can also be found in point of ontogenetic development. There are species for which large-sized adults are commonly recorded, such as *Moeschia granulata*, *Juralina subformosa*, *J. kokkoziensis*, *Dorsoplicathyrus farcinata*, *Torquirhynchia speciosa*, *Septaliphoria moravica*, whereas for other species the dwarfism is fairly obvious, such as for *Argovithyrus baugieri*. This large variation in shell size was closely related to niche size in a specific facies or due to some high-stress physical factors influencing growth patterns, e.g. lowered contents of dissolved oxygen, reduced food supply or variable salinity. It is conspicuous that adult shells of small physical size are dominantly occurring in the protected quiet, shallow-water de-

positional environment of the Visterna bioconstructed spongalgal facies (Text-Fig. 2 B, facies II a–b), where the patelliform sponges provided also very tiny bottom niches for other benthic organisms. Commonly, niche-size diminishing enhanced the trophic amensalism relationships in suspension-feeding benthic communities, by introducing strong interspecific competition between organisms requiring equivalent food resources. That is why the Piatra bioconstructed corallgal facies bearing crustiform colonies is completely barren of brachiopods owing to any niche partitioning.

On the contrary, both the Cekirgea stromatolitic algal facies and the Topalu bioconstructed corallgal facies provided the best sites for brachiopod settlement, within which large-sized specimens are very abundant (Text-Fig. 2 A, facies II and V), thus proving the presence of the most favourable conditions, i.e. well-agitated waters by currents and waves, ample food supply and extensive firm substrates available for larval attachment.

Very interesting is also the shell size-variation in the stratigraphic record. Generally, the very scattered Lower Oxfordian brachiopods have smaller sizes as compared with the congeneric Middle Oxfordian brachiopods, such as *Moeschia* and *Placothyris*. A spectacular size growth is typical of the uppermost Oxfordian–Lower Kimmeridgian brachiopods (Text-Fig. 2 A, facies V), which was coincidental with the appearance and development of the very shallow-water arborescent coralligenous facies, for which the trophic resources stability and higher energy environment represented the fundamental ecologically governing factors.

For North Dobrogea a major distinction exists between the brachiopod faunas from the Cârjelari and Dunavățu de Jos localities. At Cârjelari, the brachiopod assemblage includes specimens of wide size range, e.g. *Torquirhynchia astieriformis* (Pl. I, Figs. 6–10), which is in good accordance with its allochthonous origin by cohesive debris flow reworking, also explaining the poor sorting, the high degree of disarticulation and fragmentation of the shelly faunas. In exchange, at Dunavățu de Jos, all specimens recovered from the basinal Carabair Limestone are represented only by almost equal, small-sized (< 1 cm in length), presumably either immature or dwarfed individuals (Text-Fig. 3 B; Pl. 1, Figs. 1–5). Obviously, the generalized reduction both in population and individual shell size in the deep-water muddy environments can be accounted for most plausibly by a sharp decline in food supply.

5.4. Preservation State

The analysis of this parameter is required by the necessity to assess thanatocoenosis overprints when trying to delineate some original paleoecological features, such as the amount of disarticulation or the degree of reworking and of exotic admixture of the faunal assemblages.

Most of the Central Dobrogean Upper Jurassic brachiopod faunas show a very good state of preservation. The percentage of disarticulated valves is extremely reduced in both the Cekirgea and Topalu facies series. It is inferred from the sedimentary aspects and paleoecologic-taphonomic features that most of the recovered specimens were preserved in what was clearly the life habit, post-mortem reworking and mixing of fossil assemblages being completely precluded.

The amount of broken or deformed shells is fairly moderate and mainly ascribed either to deformation after burial or to sampling operations. For instance, in the western part of the Central Dobrogean sector the deformation affected especially the brachiopods included in the thin-bedded argillaceous limestones intercalated between the first and second coralligenous levels from the Veriga sequence, interleaved in the upper section of the Cekirgea facies series. Not only the large-sized specimens of *Dorsoplicathyris*, *Juralina*, *Zeillerina* but also the small-sized specimens of *Terebratulina* are crushed or completely flattened owing either to sediment surcharge or to compaction during lithification. Especially, the deformation may be explained by the patch-reef overloading causing differential compaction of the underlying deposits. Also, in the Middle Oxfordian spongalgal limestones of Visterna facies series from Casimcea Zone a high number of the large-sized terebratulids and rhynchonellids reveal post-mortem deformation with changing in outline and size. Some are chipped but the fragments remained yet in connexion. Lastly, though the brachiopods delivered by the reefal coralligenous limestones show a very good state of preservation, a large number of *Juralina* specimens were often damaged during freeing from matrix, the high umbo or the empty anterior part being currently broken.

On the other hand, there are some types of deformations which were clearly achieved during life time. It is especially worth noting the particular case of some specimens of *Moeschia*, *Dorsoplicathyris* and *Juralina*, which display growth irregularities achieved during life, such as slight asymmetries and the uneven development of growth lines, due to crowding during growth in high-concentrated “cluster-like” associations, which is consistent with an oyster-like gregarious life-style.

The excellent state of preservation is especially obvious for the small-sized, partially or wholly silicified Upper Oxfordian brachiopods sieved from the cave-residual clays resulting from weathering of Visterna facies series, which share a remarkable freshness both for *Cranidae* and *Thecideidae*, thus suggesting quiet shallow-water conditions and rapid burial. Though frequently disarticulated, the shells bear no evidence of transport prior to burial, the disarticulation being likely related to etching out by chemical weathering. The best state of preservation is shown however by the brachiopods collected from the stromatolitic algal limestones occurring in the Cekirgea valley, near its confluence with the Danube-Veriga Arm. The faint growth-lines and all elements of the umbonal area, such as beak-ridges, pedicle foramen, as well as all details of deltidium are very well-preserved. The fine ornamental elements of *Acanthorhynchia* species, such as the delicate spines on the rib crests of the lateral areas, and also the granular reticulate ornamentation of *Dicthyothyris kurri*, both taxa being represented by small-sized, thin-shelled specimens, are key indicators proving the existence of some sheltered niches within the Cekirgea stromatolitic algal facies.

As for North Dobrogea, two extreme situations are to be found. Firstly, a high degree of post-mortem disarticulation is particularly characteristic for the Cârjelari brachiopod fauna, within which more than 30 % of the total number of specimens were embedded as disarticulated valves, often as fragments, thus accounting for a very dynamic sedimentation in the tectonically-active Peceneaga-Camena transtensile basin. Secondly, the small-sized brachiopod faunule of Dunavățu de Jos area, though very

deformed after burial, being either stretched, flattened or crushed, remained essentially articulated, a primary feature testifying extreme quiet waters bottom conditions for the deposition of Carabair Limestone.

5.5. Brachiopod Morphology in Response to Environmental Factors

The brachiopods, which are marine, epibenthic, suspension-feeding and sessile-pivoting, generally pedically-attached organisms, are highly dependent on the environmental factors. It is especially the external morphology and frequently the internal structure which are closely adapted to these factors. Always, the morphological adaptations of brachiopods have been oriented on the perfect utilisation of sources in any niche.

Some Dobrogean Upper Jurassic brachiopod genera and species are particularly interesting by their constant preference for some facies, to which they adapted the morphology. For instance, *Lacunosella*, although recorded in most of the Dobrogean Upper Jurassic brachiopod communities, shares a higher frequency in the Middle and Upper Oxfordian sponge-bearing carbonate buildups relating to Visterna facies series and, respectively, to Cekirgea facies series. The massive shells, often showing an asymmetric outline, and the persistent foramen, testifying a functional pedicle muscle in the adult stage, all seem to indicate high adaptive strategies of this genus to the main environmental factors controlling the development of sponge-bearing carbonate buildups, i.e. moderately- to highly-agitated waters by currents and waves, ample food supply and extensive firm substrates for attachment. Although the remarkable co-occurrence of *Lacunosella cracoviensis* and sponges was already emphasized by QUENSTEDT (1871), WISNIEWSKA (1932) and AGER (1965), it is not yet clear why this species restricted its preference for the sponge-bearing carbonate buildups and what special advantage they could have from it (CHILDS, 1969). In our opinion, it may reflect a raised potential of this species for high utilisation of living spaces provided by the spongalgal buildups.

Monticlairella is another genus frequently recorded in the Middle and Upper Oxfordian sponge-bearing carbonate buildups. In opposition to *Lacunosella*, the small-sized and the delicate shells of *Monticlairella* species suggest either an epiplanktonic life style, being pendant to non-calcareous algae fronds, or a more reduced chance in the interspecific competition for niche settlement.

Some terebratulids, frequently associated either to the Visterna bioconstructed spongalgal facies or to the Cekirgea sponge-bearing stromatolitic algal subfacies, such as *Moeschia alata*, *Argovithyris stockari*, *A. baugieri* and *Placothyris carsiensis*, although very differing in size, all exhibit some homeomorphic features in their external morphology (Text-Fig. 2), while the internal structures are clearly differing, especially for *Placothyris*. Their nearly flat brachial valves and the uniplicate or slightly sulcate anterior commissure suggest, in the opinion of BOULLIER (1976), that the individuals of these species were either directly lying on the substrate or suspended along the brachial valve.

Another very interesting case of homeomorphy is that of *Lacunosella cracoviensis* which exhibits a luxuriant abundance in the Middle and Upper Oxfordian Cekirgea sponge-bearing stromatolitic algal subfacies, a situation very comparable with that recognized in

Central Poland by WIERZBOWSKI (1970). Owing to the high asymmetric, globose outline, the adult individuals of this species have been formerly assigned by SIMIONESCU (1910 b) to "*Rhynchonella inconstans* Sow.", a species now referred to *Torquirhynchia*. At present, it is clearly demonstrated that *T. inconstans* has no confirmed record in Central Dobrogea, this species commonly occurring in the Lower Kimmeridgian biogenous facies from NW Europe. Instead, other species of *Torquirhynchia* are occurring in Central Dobrogea, essentially coeval with *L. cracoviensis* and showing strong homeomorphy in external morphology with the latter. It is mainly the long-ranging *T. speciosa* occurring both in the Upper Oxfordian Cekirgea stromatolitic algal facies and the Lower Kimmeridgian Topalu bioconstructed corallgal facies (Text-Fig. 2 A, facies II and V). However, it should be stressed that although by its asymmetry *Lacunosella cracoviensis* is highly homeomorphic with some species of *Torquirhynchia*, the style of ornamentation is very different. Whereas the former shares both bifurcate and intercalatory ribs, the latter share only simple ribbing. Though the reason of this odd developing of shells to *Lacunosella cracoviensis* cannot be conveniently explained, CHILDS (1969) considers that undoubtedly in the case of asymmetric shells the exaggerating growth of the brachial valve currently determined a corresponding reduction in size of the pedicle valve. It has been customary to think that these asymmetrical adult individuals of *Lacunosella* and *Torquirhynchia* were always able to maintain the same configuration of the anterior commissure when reversing the living position of shells. As a result, an increasing chance could be achieved in the successful adaptive strategy of these species in response to some high-stress physical environmental factors, especially in response to an increasing rate of sedimentation, by allowing both the left and the right lobes of the mantle cavity to remain physiologically independent. For *T. speciosa* occurring in the Topalu arborescent corallgal subfacies (Text-Fig. 2 A, facies V; Pl. 2, Figs. 12–13), the independence of the two lateral mantle lobes was even more enhanced by the intervention of a well-developed sulcus. Finally, it seems likely that in response to similar environmental factors all these homeomorphic brachiopods should be obliged to develop hydrodynamically stable shells which commonly show comparable shell deformation resulting from burial in living position.

Torquirhynchia astieriformis (Pl. 1, Figs. 6–10), occurring in the Middle Oxfordian brachiopod fauna of the Cârjelari Formation in Sfânta Facies, shares also strong, similar asymmetric outline for the adult individuals. However, when studying the ontogenetic development of this species, for which convenient material exists, it is clear that the juveniles show more or less rectimarginate or low uniplicate anterior commissure. These extremely-differing ontogenetic development stages were undoubtedly related to a reclining ambitopic behaviour, the juveniles having a pendant life-style whereas the adults were able to live free on mobile substrates.

In both uppermost Oxfordian Cekirgea stromatolitic-coralligenous subfacies and Lower Kimmeridgian Topalu arborescent corallgal subfacies (Text-Fig. 4, loc. 4 – ox₃ and km₁), the trophic nuclei include, besides *T. speciosa* as key species, a very abundant population of varied species of *Juralina*, such as *J. topalensis*, *J. kokkoziensis*, *J. castellensis*, *J. subformosa* and *J. bullingdonensis*. By their large-sized and thick, slightly convex shells, bearing either rectimarginate or low uniplicate anterior commissure and a large foramen devoid of beak-ridges, thus

testifying a strong functional pedicle muscle throughout life, the *Juralina* population adopted a successful morphological adaptive strategy for the highly, wave- and current-agitated reefal and peri-reefal environments, as it was already emphasized by AGER (1965), CHILDS (1969) and BOULLIER (1976). Some species of *Juralina* occurring in the Topalu arborescent coralline subfacies, i.e. the thick-shelled *J. kokkoziensis*, *J. topalensis* and *J. subformosa* (Text-Fig. 2 A, facies V), are provided with a high, erect beak and a very developed deltidium, which warrants a semi-infaunal life-style on mobile, bioclastic sandy sediments of these brachiopods living in the high-energy coralligenous environments. It is the thick callus of the umbonal internal side which led to the overweighting of the posterior part of the shells, thus enabling a much more efficient anchorage of these heavy, thick-shelled brachiopods. By their large-sized shells, all these species of *Juralina* provide strong evidence that the arborescent-coralligenous environment was very favourable for their development. Seemingly, the varied *Juralina* species, likewise those of *Torquirhynchia*, were largely reclining ambitopic organisms, being essentially dependent on a hard site for larval attachment but then able to grow out freely over mobile, bioclastic sandy substrates in adult stages, so as to exploit successfully the living spaces between the arborescent coral colonies.

Lastly, by their external morphology, some species of *Juralina* from the Central Dobrogean Upper Oxfordian–Lower Kimmeridgian biogenous carbonate facies are also diachronously homeomorphic with some brachiopods commonly occurring in the Kimmeridgian and Tithonian Štramberk-type coralligenous facies of the Carpathians regions, e.g. with the varied Upper Tithonian species of *Tropeothyris* described by SMIRNOVA (1975) in the Polish Carpathians (Inwald).

Therefore, it is worth mentioning that all the above-mentioned cases of homeomorphy characterizing several brachiopods commonly occurring in the Central Dobrogean Upper Jurassic biogenous carbonate facies highly confirm the finding that both sponge- and coral-bearing reefal facies constrained the opportunistic brachiopods to adopt some convergency in their external morphology, regardless of their differing stratigraphic occurrence, so as to efficiently exploit the niche space and food resources in moderate- to high-energy environments. However, for all the above-described examples, the interpretation of the adaptive responses in the functional morphology requires further study.

The brachiopod fauna of Dunavățu de Jos is currently composed of small-sized, simple-ornated *Lacunosella sparsicosta* bearing deep-sulcate pedicle valves, such a morphology being very advantageous in quiet deep-water environments with very limited food supply. The deep sinus of the anterior margin of the pedicle valve increased the divergence between the inhalant and exhalant feeding-currents and assured a high utilisation of suspended organic matter.

5.6. Brachiopod Relationships with Other Benthic Organisms

In the Upper Jurassic brachiopod-bearing biogenous facies from Central Dobrogea, besides the major invertebrates contributing to the biogenous carbonate facies as pivotal frame-builders, such as algae, sponges and corals, several other organisms are also represented, such

as forams, bryozoans, worms, bivalves, gastropods, cephalopods, crustaceans, crinoids and echinoids, making up plurispecific fossiliferous taphocoenosis.

Some very interesting, direct trophic relationships were established between the brachiopods and other epifaunal organisms from the above-quoted groups, the brachiopods suitably providing firm support for some epibionts. On the other hand, the brachiopods themselves exhibit permanent or temporary epizoid behaviour.

In the Cekirgea stromatolitic algal facies the epifauna encrusting the terebratulid shells (*Moeschia* spp.) includes foliaceous bryozoans (*Plagioecia*), serpulid worms and frequent bivalves (*Athreta*, *Ostrea*). The epizoans are always encrusted towards the periphery of the valves. As these did not mould over the commissure and also did not overgrow the pedicle foramen, it is clear that the brachiopods were living during the settlement and growth of the above-mentioned epifaunas. Also, multiple generations of epizoans have not been identified, and only two of the above-mentioned epibiontic organisms are occasionally attached on the same valve. These findings and the reduced sizes of the epizoans suggest that the brachiopods remained unburied only a short time after their death. The rhynchonellid shells are sparsely encrusted by epizoans, particularly by oysters and serpulid worms.

As to the epizoid attachment of brachiopods on the organic substrate, the intimate relationships between some brachiopods (*Lacunosella*, *Monticarella*) and sponges were already discussed in the foregoing section of the present paper. The preferential attachment of *Cranidae* and *Thecideidae* on sponges and corals is also clearly established. The undersides of patelliform sponges from the Visterna bioconstructed spongalgal facies are encrusted with thecideids (*Rioulina*), besides serpulid worms (*Serpula flaccida*, *S. gordialis*, *S. tricarinata*), bryozoans (*Plagioecia*, *Stromatopora*, *Ceriacava*), calcisponges (*Neuropora*). On the contrary, the uppersides are covered by relatively thick algal coatings. The “tritych” given by the co-occurrence of thecideids, serpulids and bryozoans, as already reported by GAILLARD (1971, 1983) and PAJAUD (1974), was dependent on two major ecologically-limiting factors for growth, i.e. the substrate and the light, whereas the colonization by the blue-green algae on the uppersides of patelliform sponges was determined by the need to use for growth the reduced light which penetrates down to 50 m, representing the lower limit of depth range required as optimal for the development of sponge bioherms.

The “gallery” organisms included in the above-mentioned “tritych” were most likely either sciaphilic or much more tolerant in point of light requirements. This great tolerance is proved by the fact that many of the species of *Cranidae*, *Thecideidae* and *Terebratellidae* recorded in the Visterna facies series were also cited by BARCZYK (1970) in the biogenous facies bearing ramose corals and bryozoans from Bałtów (Poland). This author already emphasized the close resemblance of the Bałtów brachiopod assemblage with those from Visterna valley. A similar fossil assemblage, including *Cranidae*, *Thecideidae* and *Terebratellidae*, occur in the western part of Central Dobrogea in the second coralligenous level interleaved within the upper section of the Cekirgea facies series.

The coincident occurrence of the above-mentioned brachiopod groups, with many common elements at the generic and species level, both in the spongieric and coralligenous buildups accounts for the much larger ecologic tolerance for the light factor of these cavity-dwelling bra-

chiopods. Obviously, the colonization of the undersides of patelliform sponges by the foregoing mentioned epizoan organisms was due mainly to the algae concurrence, which, requiring agitated-water conditions in the photic zone, settled efficiently the uppersides of patelliform sponges during the competition for substrate. On the other hand, one can expect that the preferential settlement of filamentous algae on the uppersides of patelliform sponges was the consequence of mutually-profitable symbiotic relationships with host sponges. It is thought that by photosynthesis the algae may provide oxygen and photosynthetically-derived products to the host, remove carbon dioxide and waste products or be instrumental in providing protective colouring. It was already proved that the symbiosis of different frame-building organisms with photosynthesizing algae is especially convenient for the host organisms by enhancing rates of skeletogenesis (TALENT, 1988).

Lastly, when referring to the coral/brachiopod ratio in the coralligenous buildups occurring in the Cekirgea sponge-bearing stromatolitic algal subfacies, it is noticeable that the upward increase in the taxonomic composition and abundance of the coral faunas was concomitantly accompanied by a progressive decline in brachiopod population size and also in number of species. It reached the lowest value in the fourth coralligenous level belonging to the succeeding Topalu bioconstructed corallgal facies bearing arborescent coral colonies (Text-Fig. 5). The high proliferation of arborescent corals in the fourth level indicates shallowing up through an inshore carbonate depositional area, within wave base and coming into proximal environment. The more reduced taxonomic variety of the Lower Kimmeridgian brachiopod community in the Topalu arborescent corallgal subfacies is correspondingly counterbalanced by a notable individual abundance and shell-physical size increasing of some opportunistic species, such as *Torquirhynchia speciosa* and the varied species of *Juralina* and *Zeillerina*. It reflects much more efficient adaptive recruitment strategies of these species to the rather unstable, reefal depositional environment characterized by extremely-reduced water-depth, a higher water-energy and luminosity, evolving strong trophic group amensalism between corals, brachiopods and other benthic organisms for living spaces and food resources. Seemingly, the successful settlement of the above-mentioned opportunistic brachiopods in the coralligenous reefal environment was ensured also by the initial high abundance of larvae from spawning and a shorter duration of the larval phase, so as to compensate the predation of brachiopod larvae by coral polyps.

6. Paleobiogeographic Analysis

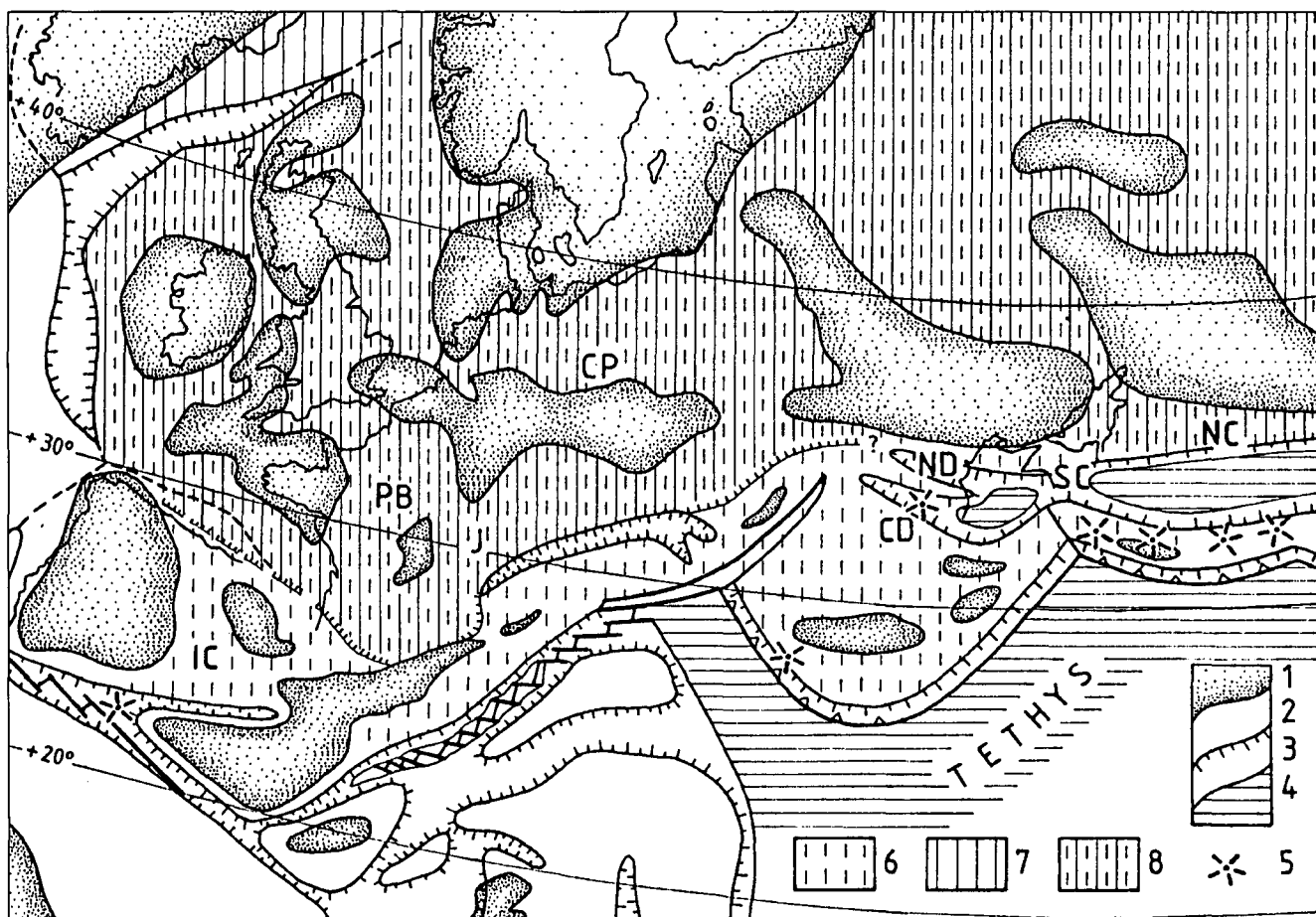
Undoubtedly, the paleobiogeographic affiliation of the varied Dobrogean Upper Jurassic brachiopod faunas was clearly dependent on the rather diversified paleogeographic frame of the Dobrogean areas in the Late Jurassic times. As brachiopods share a high potential for paleobiogeographic studies, owing both to a very short planktonic larval stage and their sessile benthic life style in adult stage (VÖRÖS, 1982, 1984, 1988, 1993; MICHALIK, 1992), apparently there should be no problems in deciphering the paleobiogeographic relationships of the Dobrogean Upper Jurassic brachiopod faunas.

However, whereas the high diversity and density of the Upper Jurassic brachiopod faunas from the Central Dobrogea are highly suitable for a reliable paleobiogeographic analysis, conversely, for the coeval brachiopod faunas from Dunavățu de Jos locality in North Dobrogea it is not possible to have a similar confidence in delineating the paleobiogeographic affiliation due to a very impoverished occurrence.

On the other hand, it should be noted that while extensive paleobiogeographic analyses have been carried out for the European Lower and Middle Jurassic brachiopod faunas, little attention has been paid to the compatriotic Upper Jurassic brachiopod faunas, except those of the Tithonian. As a result we have felt the absence of relevant studies, wherein to integrate our results. Furthermore, the terminology used by different authors in naming the paleobiogeographic units, more or less overlapping in scope, is profusely expanded, and very differing not only for varied time intervals of the Jurassic Period but also for different groups of organisms. As for the European Jurassic brachiopod provinciality the following bioprovinces are currently in usage: the NW-European province vs. the Mediterranean province, for the Early and Middle Jurassic time interval (AGER, 1967, 1971; VÖRÖS, 1977, 1984, 1988, 1993), and Boreal, Sub-Mediterranean (Sub-Tethyan or Jura) and Tethyan realms for the Late Jurassic time interval (MICHALIK, 1992).

During the Late Jurassic, Central Dobrogea was situated in the easternmost part of a vast Mid-European shallow-water carbonate epicontinental platform lying north of the Tethys and extending longitudinally from Spain, through the Paris Basin, Jura and Central Poland, up to Central Dobrogea, and further to South Crimea, North Caucasus and Kopet-Dagh (Text-Fig. 6). In terms of Early and Middle Jurassic brachiopod provinciality, the European epicontinental seas were the home of the NW-European bioprovince. Comparatively, the European Late Jurassic epeiric seas overflowed much larger areas on the northern side of the Tethys, due to a major sea level rise already initiated by Callovian times (ENAY, 1980), which led to a more increased habitat heterogeneity and thereby accounts for a more pronounced overall rise in faunal diversity of brachiopod-bearing benthic communities. At the same time, large paleobiogeographic connections and faunal exchanges were established between the varied paleobioprovinces of the Boreal and Tethyan realms, thus making the exact delimitation of their mutual boundaries rather uncertain.

The Upper Jurassic fossil assemblages of Central Dobrogea, including a plentiful nekton (ammonites, nautiloids, belemnites) and an extremely diversified and abundant benthos, are strikingly comparable with the coeval fossil assemblages from the above-quoted European regions, thus evincing free shelf sea communications (SIMIONESCU, 1910 a; PATRULIUS, 1964; BĂRBULESCU, 1974). However, when comparing Central Dobrogea with these regions, the complete absence of any Boreal faunistic elements is to be noticed, due to its much more southern position. Insofar as the ammonoid faunas are concerned, the Central Dobrogean Oxfordian–Lower Kimmeridgian Casimcea Formation records a high variety and abundance of large-sized perisphinctids, bearing strong ribs on the body chamber, such as *Kranaosphinctes*, *Perisphinctes*, *Subdisosphinctes* for the Middle Oxfordian, or *Ortosphinctes* and *Decipia* for the Upper Oxfordian, which are characteristic members in the Sub-Mediterranean bioprovince, as it was outlined by CARIU et al. (1985). On the other hand, the



Text-Fig. 6.

Paleogeographic setting of Dobrogea during Middle Oxfordian to Early Kimmeridgian times and the main coeval European brachiopod occurrences showing similarities with the Dobrogean brachiopod faunas. Paleogeographic grid from DERCOURT et al. (1986), modified for the north-westward adjoining areas of the Proto-Black Sea; Ammonite-related paleobiogeography from ENAY (1980) and CARIOU et al. (1985).

1 = Probable land areas; 2 = Epicontinental seas (s.l.); 3 = Continental margins of oceanic and rifting areas; 4 = Oceanic areas and marginal basins; 5 = Volcanoes; 6 = Areal distribution of Sub-Mediterranean ammonite faunas; 7 = Areal distribution of Boreal and Sub-Boreal ammonite faunas; 8 = Overlapping areas of Boreal, Sub-Boreal and Sub-Mediterranean ammonite faunas.

Abbreviations: IC = Iberian Chain; PB = Paris Basin; CP = Central Poland; CD = Central Dobrogea; ND = North Dobrogea; SC = South Crimea; NC = North Caucasus.

other hand, the occurrence of some **Oppeliidae** (*Trimarginites*, *Ochetoceras*, *Taramelliceras*), **Aspidoceratinae** (*Euaspidoceras*, *Physodoceras*) and **Peltoceratinae** (*Epipeltoceras*) and *Sutneria* testifies large-scale relationships with the Mediterranean bioprovince.

It is worth emphasizing the strong similarity of the Central Dobrogean Upper Jurassic brachiopod assemblages occurring in biogenous facies bearing sponges or corals in point of taxonomic composition and biomass features with the brachiopod faunas which currently are paleoecologically restrained to the contemporaneous, comparable biofacies commonly developing in the varied areas of the ammonoid-related Sub-Mediterranean bioprovince, e.g. Jura and Central Poland. It is especially the sponge-bearing biofacies which elsewhere in the Sub-Mediterranean epicontinental platform share in common the *Lacunosella* species as main biomass (WIERZBOWSKI, 1970).

Furthermore, for the Upper Jurassic coralligenous facies from Central Dobrogea, it is worth mentioning the outstanding occurrence of some brachiopods which are commonly found in South Crimea and North Caucasus, thus strengthening extensive paleobiogeographic connections eastwards for Central Dobrogea, too. It is mainly the occurrence of some large-sized terebratulids (*Juralina* spp.) besides both symmetric and asymmetric rhyn-

chonellids (*Septaliphoria* and *Torquirhynchia*), also with large-sized shells. Their strong homeomorphy, both in outline and size, with some Tithonian brachiopods of the Štramberg-type shallow-water facies, largely widespread in the Inner Carpathian areas – to which PETERS (1867) and some subsequent researchers wrongly referred the Dobrogean Upper Jurassic brachiopod faunas – is given only to the environmentally-controlled convergency in their external morphology.

Apart from the ammonoid faunas for which the Mediterranean influence was already foregoing outlined, it is lacking or much less evident for the Central Dobrogean Jurassic brachiopod faunas. For instance, no Tethyan-type pygopids or other Mediterranean brachiopods are occurring in the brachiopod assemblages of the Central Dobrogean Lower Kimmeridgian coralligenous facies. The absence or scarceness of the Tethyan elements in the Central Dobrogean Upper Jurassic brachiopod faunas can be accounted for most plausibly by the differing depth requirements as a fundamental controlling physical factor in the distributional pattern of the benthic faunas of these two bioprovinces.

With regard to the conterminous Dobrogean territories lying northerly of the Peceneaga-Camena Fault, the paleobiogeographic affiliation of the Oxfordian–Lower Kim-

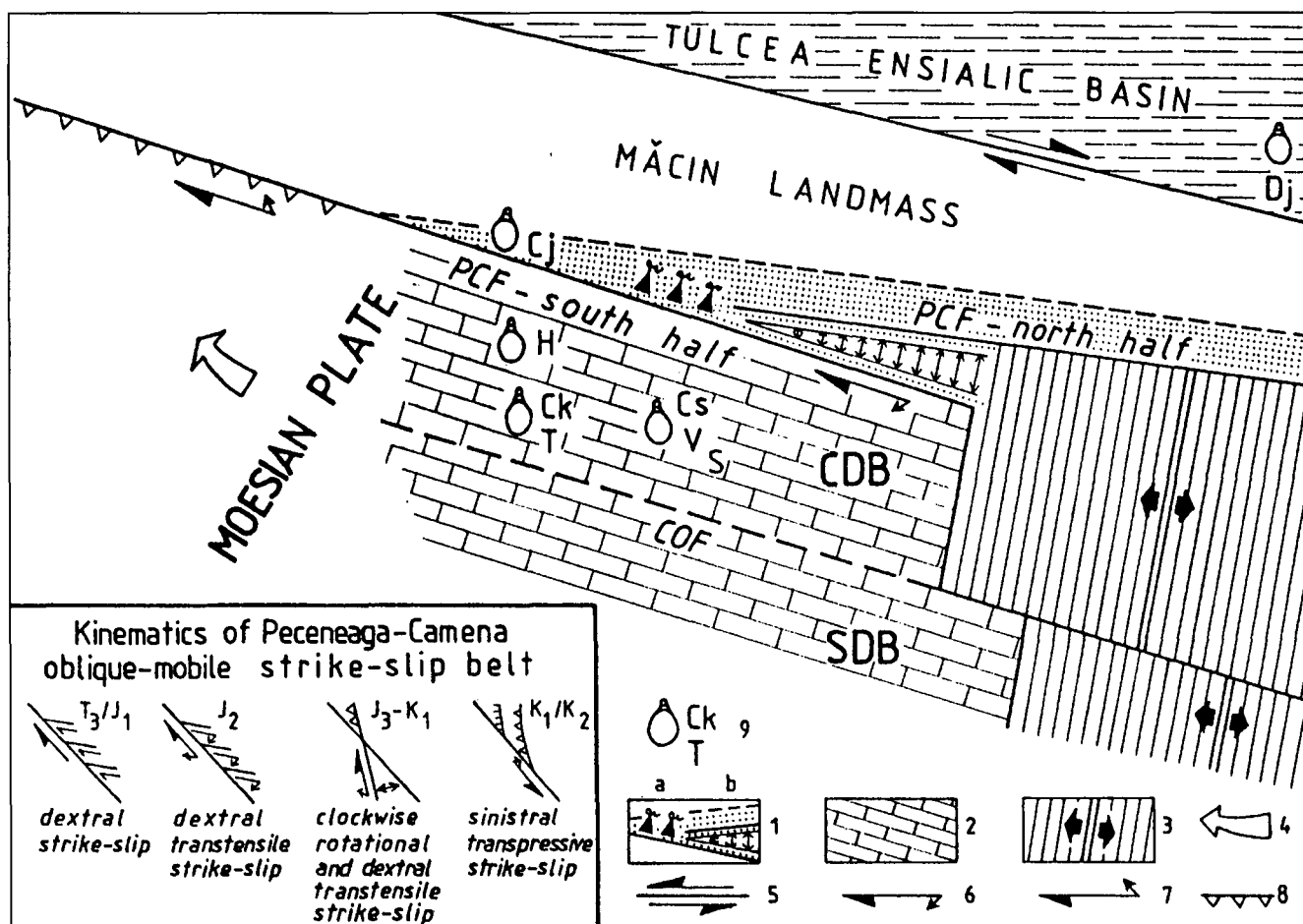
meridian brachiopod faunas delivered by the Sfânta Facies of the Cârjelari Formation was plainly similar to that already outlined for the coeval Central Dobrogean brachiopod faunas. As it results from both the litho- and biofacies development pattern of the calcareous rocks from the Cârjelari area, the western part of the tectonically-active, Peceneaga-Camena transtensive basin was in close paleogeographic connections with the tectonically-stable, Central Dobrogean shallow-water carbonate platform (GRĂDINARU, 1988).

As some tectonicians, such as BURCHFIEL (1980) and NUR & BEN-AVRAHAM (1982) referred to the Dobrogean blocks in the terms of the exotic terrane tectonics, it is to be stressed that nowadays, in spite of the opinions of the above-mentioned authors favouring more recent times, there is compelling evidence which warrants that the Central Dobrogean block, the so-called "Green Schist Block" of the relevant literature, was already juxtaposed to the North Dobrogea terrain during Late Jurassic times along the Peceneaga-Camena continental boundary transform fault (GRĂDINARU, 1984). Providing sound arguments for it, it is once again proved that the brachiopods represent a group which shares high potential for solving a number of

paleobiogeographic and tectonic problems, as already stressed by VÖRÖS (1993).

As noted earlier, the meagre brachiopod fauna of the Middle Oxfordian Carabair Limestone from Dunavățu de Jos locality is fairly insufficient to allow paleobiogeographic affiliation to be conveniently ascertained. The Măcin landmass, acting as a major zoogeographic barrier, disconnected the main Jurassic sedimentary basins evolving on the Dobrogean areas, i.e. the Tulcea ensialic basin, on the one hand, and the couple of the Central Dobrogean shallow-water platform and the Peceneaga-Camena transtensive basin, on the other hand, so that more or less active faunal communications could have been possible only around their easternmost ends by the intermediary of the Proto-Black Sea basin (Text-Fig. 7).

The apparent "Mediterranean-looking" development pattern of the Carabair Middle Oxfordian highly-scattered, oligospecific brachiopod fauna may be related to the problem of colonizing a muddy substrate and disparities in food supply in deep-water environments, thus accounting for the drastic reduction not only in population size but also in individual physical size. However, the more abundant and diversified ammonite fauna of the Carabair



Text-Fig. 7.

Hypothetical palinspastic sketch-map portraying the inferred plate-tectonic relationships and paleogeography in the north-westward adjoining areas of the Proto-Black Sea during Late Jurassic times (not drawn to scale) and the postulated kinematics (inset) of the Peceneaga-Camena oblique-mobile strike-slip belt.

1 = Peceneaga-Camena transtensional belt including the westward rhyolitic volcanic chain (a) and the eastward incipiently developing para-oceanic transtensive gash (b); 2 = Central and South Dobrogean sectors of the East Moesian Late Jurassic shallow-water carbonate platform; 3 = Proto-Black Sea oceanic basin; 4 = direction of relative motion of the Moesian Platform; 5 = pure strike-slip (transcurrent) fault; 6 = extensional strike-slip (transtensive) fault; 7 = compressional strike-slip (transpressive) fault; 8 = thrust (triangles on the overriding plate); 9 = Main occurrences of the Dobrogean Upper Jurassic brachiopod faunas.

Abbreviations: Cj = Cârjelari; Ck = Cekirgea; Cs = Casimcea; Dj - Dunavățu de Jos; H = Hârșova; S = Sârtorman; T = Topalu; V = Visterna; PCF = Peceneaga-Camena Fault; COF = Capidava-Ovidiu Fault; CDB and SDB = Central and South Dobrogean blocks.

Limestone displays a clear-cut affiliation to the Sub-Mediterranean bioprovince by the perisphinctid and oppeliid genera (*Dichotomosphinctes*, *Dichotomoceras*, *Glochiceras*, *Ocheioceras*), although the relatively high percentage of phylloceratids (*Holcophylloceras*, *Sowerbyceras*) witnesses a strong influence of the oceanic biome of Tethys, which is also conveniently explainable, likewise for the brachiopod faunas, as a result of the intervening depth control, rather than to a veritable provincialism.

Therefore, it may be concluded that the very diversified Dobrogean Upper Jurassic brachiopod faunas are closely related to the coeval brachiopod communities which currently inhabited the areas of the ammonite-related Sub-Mediterranean bioprovince. In terms of the European Late Jurassic brachiopod provinciality, the latter is largely overlapping in scope on the Sub-Mediterranean (Sub-Tethyan or Jura) realm of MICHALIK (1992).

7. Systematic Paleontology

(Prepared by A. BÄRBULESCU)

Phylum: Brachiopoda DUMERIL, 1806
Class: Articulata HUXLEY, 1869
Order: Terebratulida WAAGEN, 1868
Suborder: Terebratulidina WAAGEN, 1868
Superfamily: Terebratulacea GRAY, 1840
Family: Terebratulidae GRAY, 1840
Genus: *Dorsoplicathyrus*
 ALMERAS, 1971

Type species: *Terebratula dorsoplicata* SUESS-DESLONGCHAMPS, 1886.

Dorsoplicathyrus petersi n.sp.

(Pl. 3, Figs. 5–8; Text-Figs. 8–11)

Holotype: LPB.III.B.0124*) – Pl. 3, Figs. 7 a–c.

Dimensions of holotype: (in mm)

L = 46.6; W = 27.8; T = 26.3

Stratum typicum and locus typicus: Upper section of the Cekirgea stromatolitic algal series, Upper Oxfordian (*Bimammatum* and *Planula* Zones), Veriga Arm (Danube) cliff, north of Topalu, Central Dobrogea.

Derivatio nominis: Species named in honour of the Austrian geologist K.F. PETERS.

Material: 30 well-preserved specimens, as follows: LPB.III.B.0123 to 0125 (3 specimens), 0267 (20 specimens), 0268 to 0269 (2 specimens, serially-sectioned) from Cekirgea Stromatolitic Algal Series, Upper Oxfordian, Veriga Arm (Danube) cliff, north of Topalu; 0258 (2 specimens) from Cekirgea Stromatolitic Algal Series, Upper Oxfordian, “La Vii” hill, north of Hârşova; 0259 (3 specimens) from Visterna Bioconstructed Spongalgal Series, Upper Oxfordian, Visterna valley.

Dimensions: (in mm) – median value and range of variation:

*) Abbreviations:
 LPB.III.B. – Collection of the Laboratory of Paleontology, Bucharest University, Catalogue Romania – Brachiopoda; L = length of shell; W = width of shell; T = thickness of shell; W/L = width/length ratio; T/L = thickness/length ratio; mW/L = maximum width/length ratio; P/A = posterior/anterior ratio.

L = 41.4 (30.7–49.2); W = 27.1 (21.0–31.2); T = 20.8 (15.5–25.6)

W/L = 0.64 (0.57–0.65); T/L = 0.50 (0.46–0.57); mW/L = 0.57 (0.50–0.63)

Diagnosis: Shell elongate-oval in ventral profile, with width about 0.65 of length. Convexity moderate to accentuate. Strong and massive umbo. Beak-ridges rounded or lacking. Foramen large, circular, permesothyrid to epithyrid. Symphytium not exposed. Anterior commissure uniplicate to weakly sulcinate. Shell folded, with straight plicae of variable length and confined to the anterior half of the shell. Large hinge-plates, initially gently concave, may become horizontal; well differentiated from inner socket-ridges. Crural processes straight, higher than the crura. Moderately high-arched transverse band.

Description: Biconvex, elongate shell, reaching a maximum length of 49.2 mm. Maximum width nearly in the middle of the shell or a little posteriorly. P/A ratio of whole shell about 1 or slightly more. Umbo wide, massive, suberect to erect, almost in contact with the brachial valve, covering the symphytium. Foramen wide, circular, weakly to strongly marginate, or labiate for about 20 % of specimens. Lateral commissure oblique to arched. Anterior commissure uniplicate to slightly sulcinate, with a narrow or rounded median sinus. The two lateral plicae not reaching halfway length of the dorsal valve. Ventral valve strongly convex in the middle of the posterior half. Maximum convexity of the whole shell approximately halfway the length. All the specimens available are adult or gerontic. Folding of the shell and biplication of the anterior commissure appear not to develop until the shell is at least 25–30 mm in length.

Remarks: The external characters are sufficiently distinctive to justify recognition of a new species. *Dorsoplicathyrus petersi* n.sp. is differing from other large-sized Oxfordian species of *Dorsoplicathyrus*, such as *D. farcinata* (DOUVILLÉ, 1886), *D. prolifera* BOULLIER, 1976 and *D. subinsignis* (ETALLON, 1862), in being relatively narrower and thicker, more oval, less triangular posteriorly or sub-pentagonal. The new species described here is approaching the oval morphe of *D. richei* BOULLIER, 1976, but differs from it in being much larger-sized and more convex, also in having a more pronounced oval outline.

Occurrence: Veriga Arm (Danube) cliff, north of Topalu, from Cekirgea Stromatolitic Algal Series, where *D. petersi* n.sp. was collected from the well-bedded limestones intercalated between the first and second

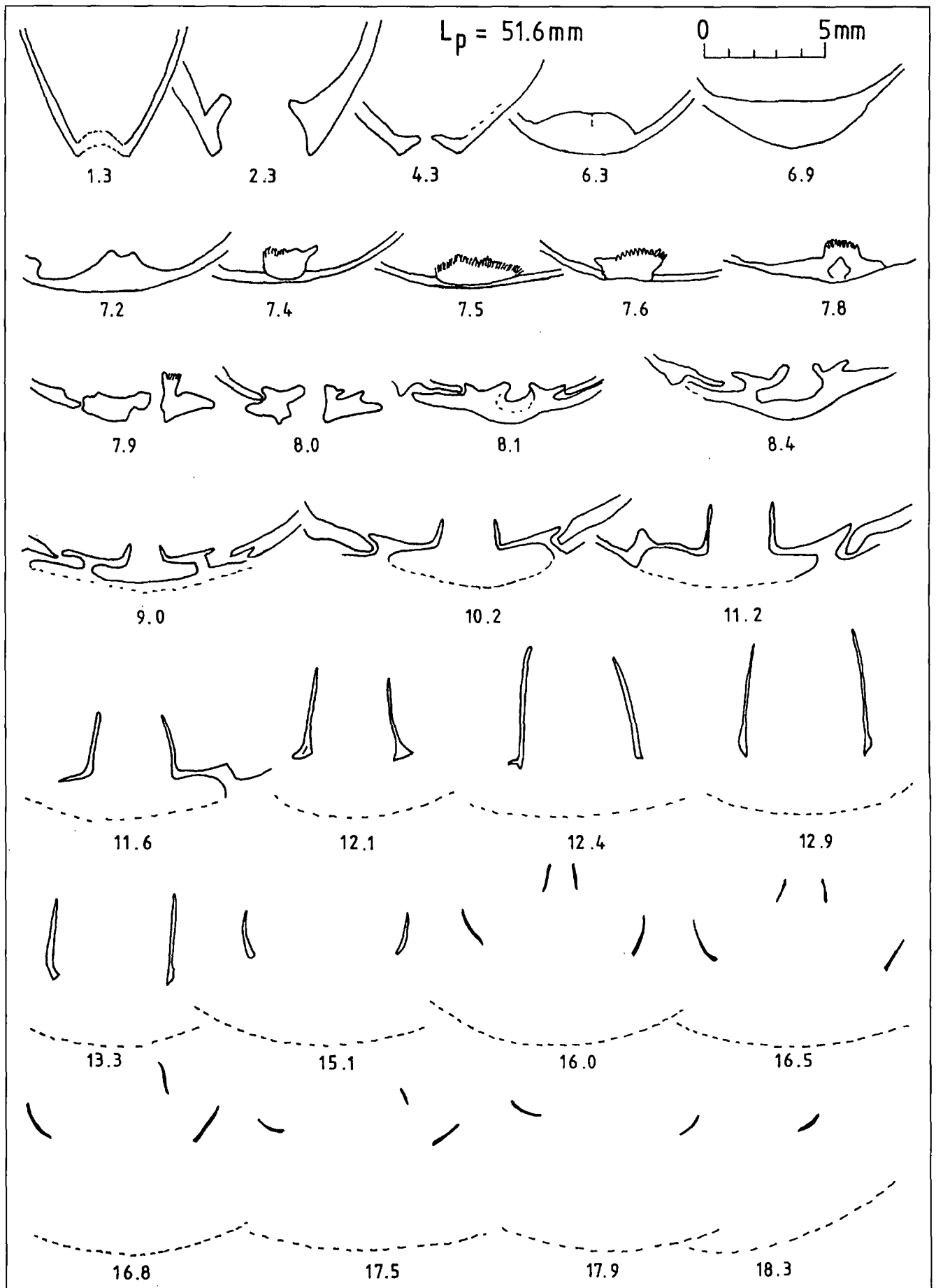
Text-Fig. 8 (p. 70)
 Serial transverse sections through *Dorsoplicathyrus petersi* n. sp., LPB. III. B. 0268.

The cardinal process is seen at 2.3; the initially concave shape of the hinge-plates is shown at 8.0–8.1; the horizontal shape of hinge-plates is well shown at 9–11.2; note the height of the crural bases at 10.2–11.6; the maximum development of the crural process with the carenate base is seen at 12.4–12.9, and the height of the transverse band above the floor of the dorsal valve at 16.0–16.5.

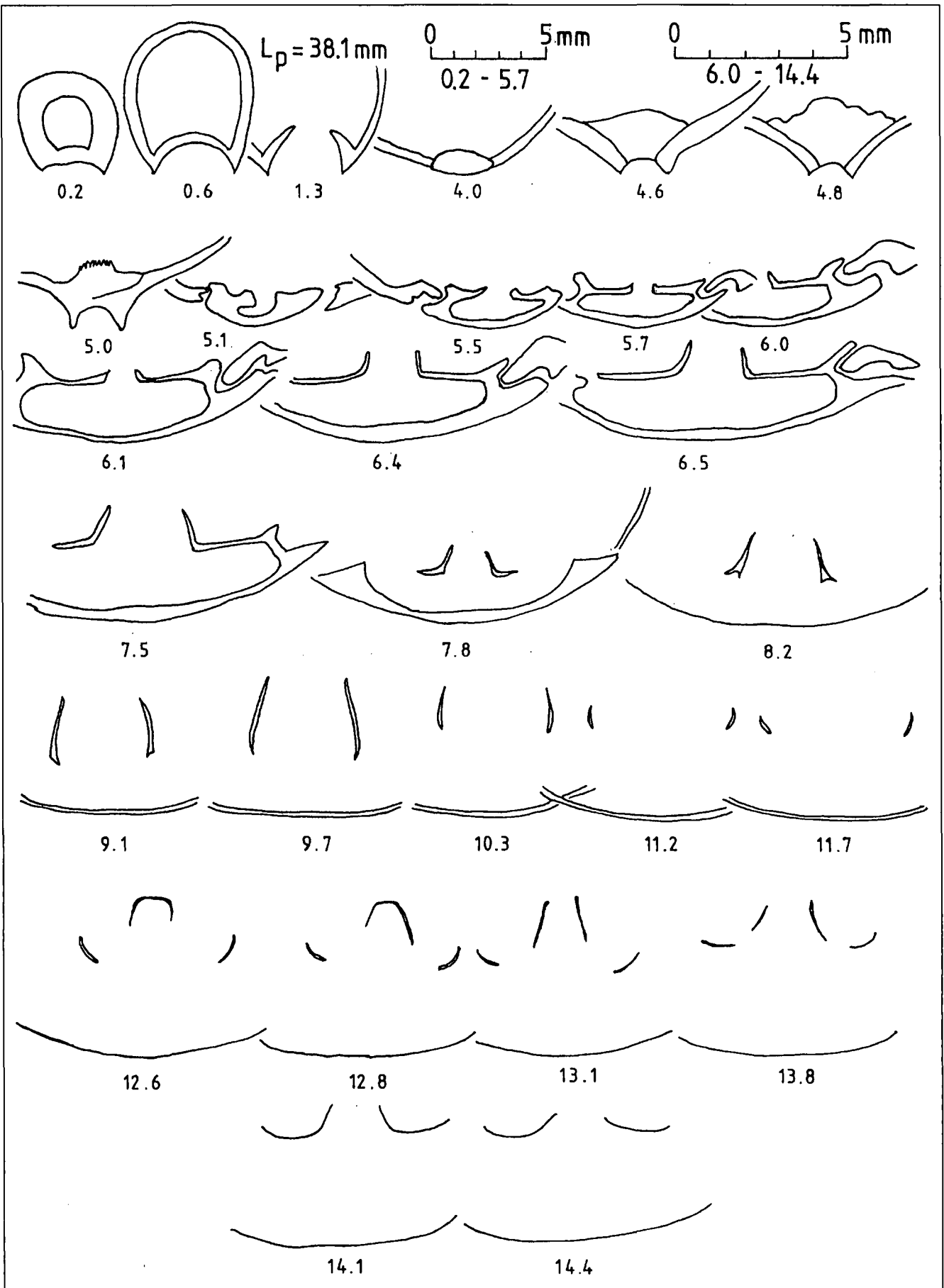
Numbers under serial sections indicate the distance in mm from the posterior end of the shell; Lp = original length of the pedicle valve; the bar shows the scale of serial sections.

Text-Fig. 9 (p. 71)
 Serial transverse sections through *Dorsoplicathyrus petersi* n. sp., LPB. III. B. 0269.

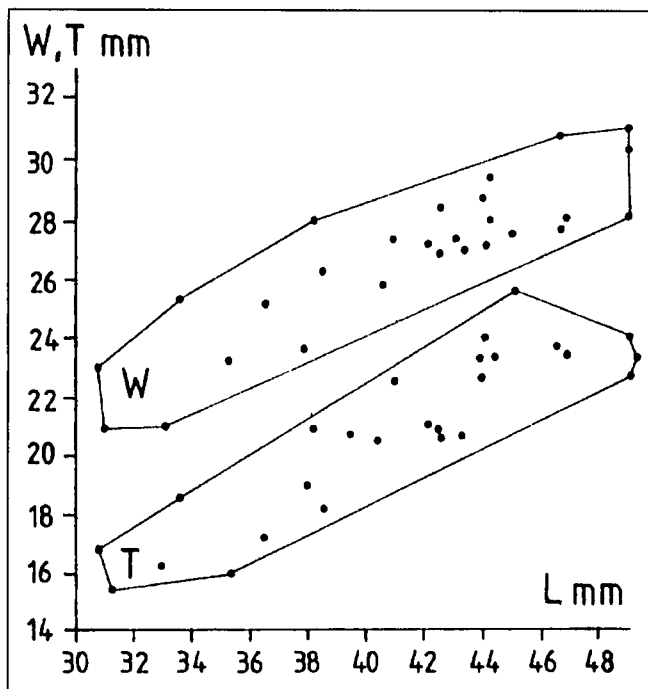
The pedicle-collar is seen at 0.6–1.3; the long horizontal hinge-plates are to be seen at 6.1–6.5; the distinct inner socket-ridge at 6–6.5; the transverse band with plate-apex is shown at 12.6–12.8.



Text-Fig. 8.
Explanation see p. 69.



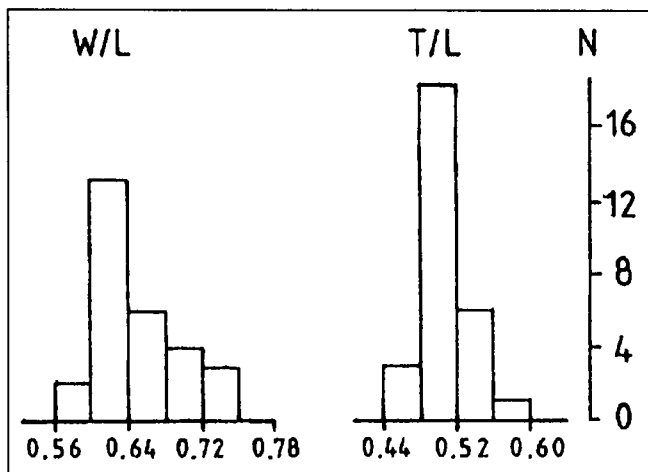
Text-Fig. 9.
Explanation see p. 69.



Text-Fig. 10.

Scatter-diagram showing the relationships of width (W) to length (L) and thickness (T) to length (L) in *Dorsoplicathyris petersi* n. sp., based on measurements of 27 specimens.

coralligenous levels, also from the marginal parts of the coralligenous buildups of the second level; "La Vii" hill, north of Hârşova, from Cekirgea Stromatolitic Algal Series; Visterna valley, from Visterna Bio-constructed Spongalgal Series; Upper Oxfordian (*Bimammatum* and *Planula* Zones) for all occurrences.



Text-Fig. 11.

Histograms showing the frequency of W/L and T/L ratios in *Dorsoplicathyris petersi* n. sp.; N = number of measured specimens.

Genus: *Placothyris* WESTPHAL, 1970

Type species: *Placothyris rollieri* HAAS, 1893 pars

Placothyris carsiensis (SIMIONESCU, 1910)

(Pl. 3, Figs. 1–3; Text-Figs. 12–14)

1910 *Terebratula carsiensis* SIMIONESCU, p. 401, Pl. V, Figs. 3–4.
non 1961 *Neumayrithyris carsiensis* (SIMIONESCU); KYANSEP, p. 78,
Pl. VI, Figs. 1 a–c, Text-Fig. 32.
1976 *Placothyris* sp. BOULLIER, Pl. XI, Figs. 6 a–c.

Material: 35 well-preserved specimens, as follows: LPB.III.B.0121 (24 specimens); 0274 (1 specimen, serially-sectioned) from Cekirgea Stromatolitic Algal Series, Middle-Upper Oxfordian, Cekirgea valley; 0270 (2 specimens) from Cekirgea Stromatolitic Algal Series, Upper Oxfordian, Veriga Arm (Danube) cliff, north of Topalu; 0271 (4 specimens) from Cekirgea Stromatolitic Algal Series, Upper Oxfordian, Atârnaţi, south of Ghindăreşti; 0272 (1 specimen) from Cekirgea Stromatolitic Algal Series, Upper Oxfordian, "La Vii" hill, north of Hârşova; 0273 (3 specimens) from Cekirgea Stromatolitic Algal Series, Upper Oxfordian, Visterna valley.

Dimensions: (in mm) – median value and range of variation:

L = 34.4 (25.6–43.0); W = 26.5 (20.2–31.5); T = 20.3 (14.6–25.5)

W/L = 0.76 (0.68–0.90); T/L = 0.60 (0.47–0.80); mW/L = 0.61 (0.54–0.67)

Description: Shell pentagonal in ventral profile; unequally biconvex. Brachial valve flattened, pedicle valve much more convex. Umbo strongly incurved, in contact with the brachial valve. Symphytium hidden. Foramen elongate, oval, labiate, tends to be narrower faniform for gerontic specimens. Beak-ridges rounded. Lateral commissure strongly arched, in anterior half inclining ventralwards at about 100°. Anterior commissure rectimarginate to quadrate-uniplicate or episulcate-parasulcate. Shell folding is represented by two short, lateral plicae separating a large median depression, relatively deep at the largest-sized specimens. Hinge-plates subhorizontal or horizontal, thin and long, with long crural bases, initially dorsally-attached, later both dorsally and ventrally; the free crurae extending dorsalwards; the crural processes long and thin, slightly curved. Moderately-arched transverse band.

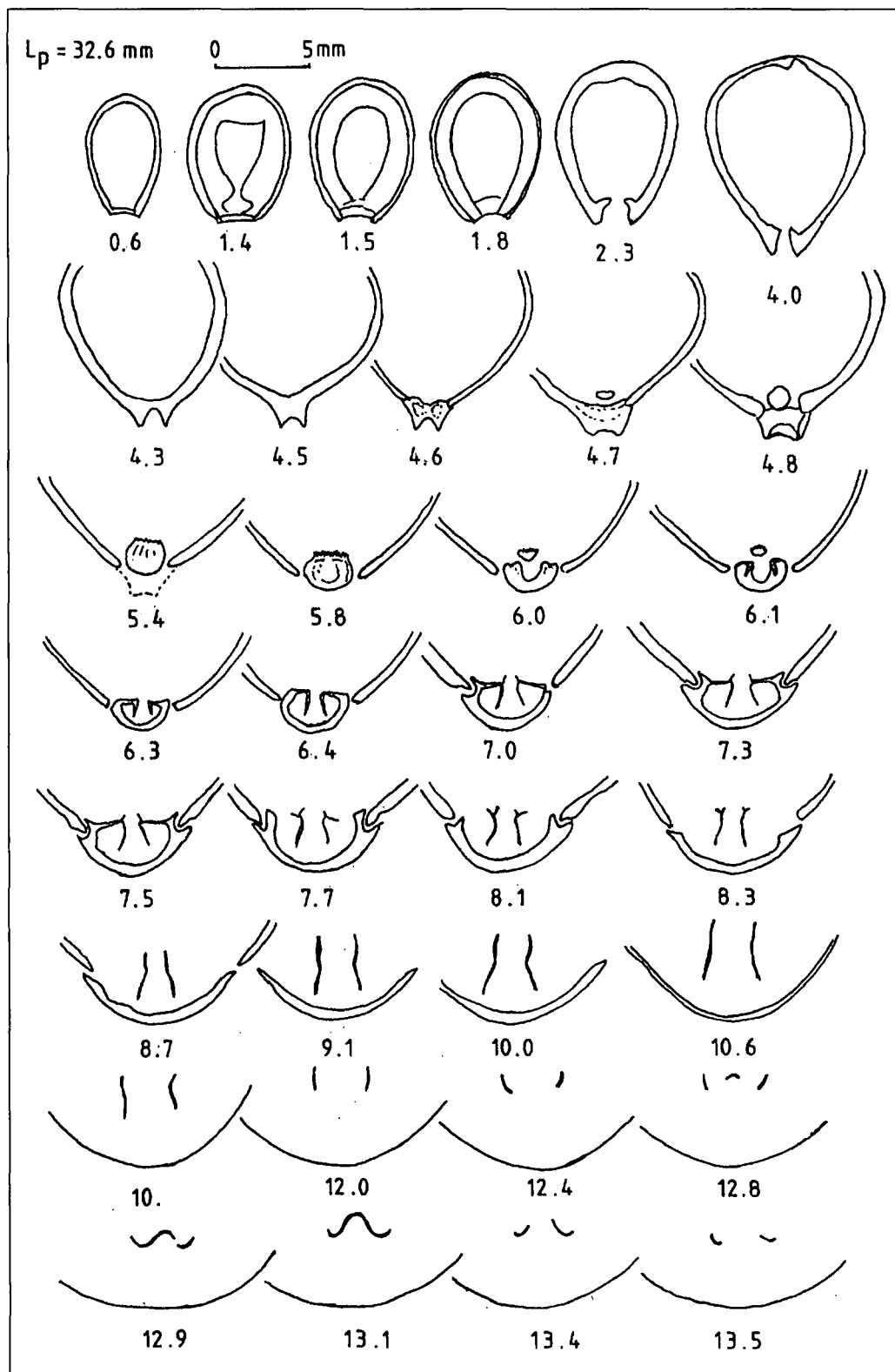
Remarks: Studying the Upper Jurassic brachiopods from Central Dobrogea, SIMIONESCU (1910 b) described the new species *Terebratula carsiensis*. The name of the species was derived from the Latin name, Carsium, of the present town Hârşova. The material available for creating the new species has been represented by two specimens, from which only one complete. No information was given in the original description regarding the internal structure. Later, KYANSEP (1961) interpreted the Crimean specimens referred by him to SIMIONESCU's species as belonging to the genus *Neumayrithyris* TOKUYAMA, 1956. Our investigations on the internal structure of specimens recovered from the stratotype of *Terebratula carsiensis* SIMIONESCU, 1910 pointed to the presence of a distinctive character materialized by the pendant aspect of crural bases, projecting towards the brachial valve (Text-Fig. 12). They are initially dorsally-attached and later both dorsally and ventrally. This character was decisive when WESTPHAL (1970) described the new genus *Placothyris*. BOULLIER (1976) also identified this internal character to the specimens from Jura and Poitou. Therefore, by its internal structure SIMIONESCU's *Terebratula carsiensis* must be assigned to the genus *Placothyris*.

Moreover, the external characters of the genus *Neumayrithyris* are differing from those of *Placothyris*. The former has a much less convex shell, more sinuous lateral commissure and incipient sulcinate anterior commissure.

Text-Fig. 12.

Serial transverse sections through *Placothyris carsiensis* (SIMIONESCU). LPB.III.B.0274.

The pedicle collar is shown at 1.8–2.3; the horizontal, fine hinge-plates and the crural bases, only dorsally-attached, are seen at 6.1–6.4; both those dorsally- and ventrally-attached, appear at 7.0–7.5; the free crura extending dorsalwards as thin long curve is seen at 7.7–8.3; the maximum development of crural process at 10.0–10.6, and the moderately low-arched transverse band at 12.9–13.1.



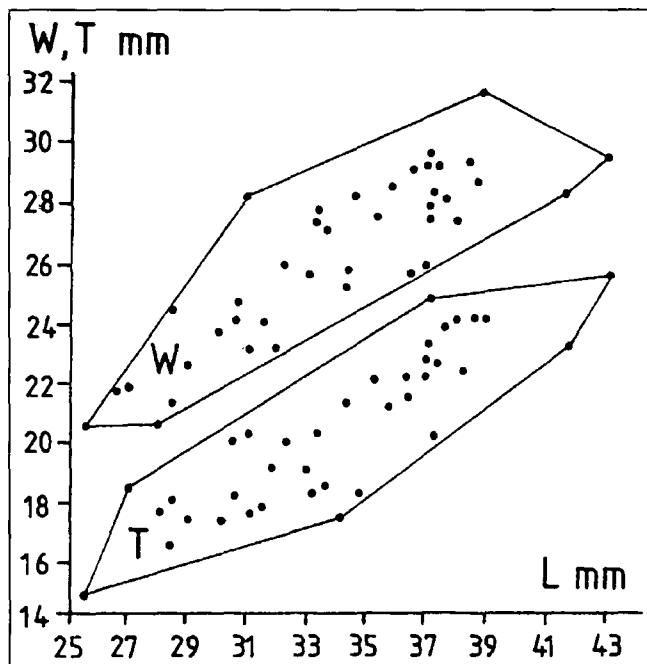
Placothyris carsiensis is differing from *P. rollieri* (HAAS, 1893), the type species of the genus, and, respectively, from *P. welshi* BOULLIER, 1976 in being markedly larger-sized and thicker, with strongly incurved umbo and much more arched lateral commissure.

Occurrence: *Placothyris carsiensis* is frequently occurring in the Cekirgea Stromatolitic Algal Series, Middle to Upper Oxfordian (*Transversarium* and *Bimammatum* Zones), Cekirgea valley and Veriga Arm (Danube) cliff, north of Topalu. It is sparsely occurring in the Visterna

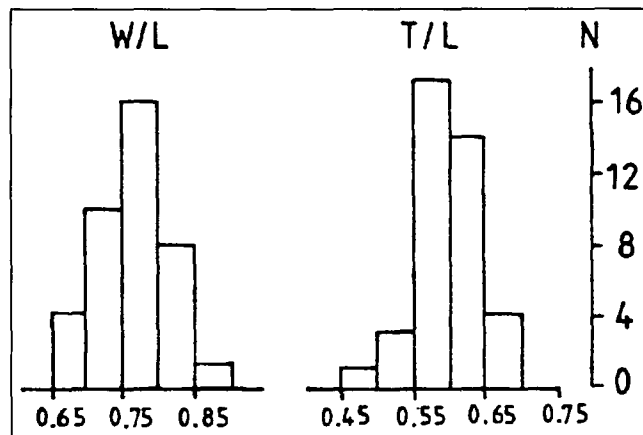
Bioconstructed Spongalgal Series, Middle Oxfordian, Casimcea Syncline.

Acknowledgements

This paper was presented at the Regional Field Symposium on Mesozoic Brachiopods, held in Vörösberey, Hungary, 6.–11. September, 1992. The authors gratefully acknowledge the organizers' financial assistance which facilitated their attendance to the symposium. We are particularly grateful to Dr. ATTILA VÖRÖS (Budapest), who also critically reviewed the manuscript and made valuable suggestions for its improvement. Special



Text-Fig. 13.
Scatter-diagram showing the relationships of width (W) to length (L) and thickness (T) to length (L) in *Placothyris carsiensis* (SIMIONESCU), based on measurements of 38 specimens.



Text-Fig. 14.
Histograms showing the frequency of W/L and T/L ratios in *Placothyris carsiensis* (SIMIONESCU); N = number of measured specimens.

thanks are given to Mrs. SORANA GEORGESCU-GORJAN for her help in improving the English text.

Finally, warm thanks are expressed to Dr. ALBERT DAURER, the Editor of *Jahrbuch der Geologischen Bundesanstalt*, for the opportunity to publish this paper in the present volume.

Plate 1

North Dobrogea

Carabair Limestone

Monticlarella czenstochowiensis (ROEMER).

Figs. 1a; 2 a-b:
x 3, LPB. III. B. 0098 – Coll. GRÄDINARU.
Middle Oxfordian, Carabair hill.

Lacunosella sparsicosta (QUENSTEDT).

Figs. 3a-b; 4a,d; 5 a:
LPB. III. B. 0099 – Coll. GRÄDINARU.
Middle Oxfordian, Carabair hill.

Cârjelari Formation – Sfânta Facies

Torquirhynchia astieriformis CHILDS.

Figs. 6a-c; 7a-c; 8a,c; 9a; 10 a:
LPB. III. B. 0100 – Coll. GRÄDINARU.
Upper Oxfordian–Lower Kimmeridgian, Vărăria quarry.

Moeschia sp.

Figs. 11a-c:
LPB. III. B. 0101 – Coll. GRÄDINARU.
Upper Oxfordian–Lower Kimmeridgian, Vărăria quarry.

Moeschia granulata BOULLIER.

Figs. 12a; 13a-c; 14 a-b:
LPB. III. B. 0102 – Coll. GRÄDINARU.
Upper Oxfordian–Lower Kimmeridgian, Vărăria quarry.

Zeillerina sp.

Figs. 15a-c:
LPB. III. B. 0103 – Coll. GRÄDINARU.
Upper Oxfordian–Lower Kimmeridgian, Vărăria quarry.

Figs. 16a-c:
LPB. III. B. 0104 – Coll. GRÄDINARU.
Oxfordian–Lower Kimmeridgian, Sfânta hill–northern slope.

Juralina cf. *subformosa* (ROLLIER).

Figs. 20a-b:
LPB. III. B. 0105 – Coll. GRÄDINARU.
Upper Oxfordian–Lower Kimmeridgian, Vărăria quarry.

Central Dobrogea

Casimcea Formation

Visterna Bioconstructed Spongalgal Series

Lacunosella trilobataeformis WISNIEWSKA.

Figs. 17a,c; 19a-c:
LPB. III. B. 0106 – Coll. BĂRBULESCU.
Middle Oxfordian, Casimcea valley.

Figs. 18a:
LPB. III. B. 0107 – Coll. DRĂGĂNESCU.
Middle Oxfordian, Sărtorman valley.

Argovithyris stockari (MOESCH).

Figs. 21a-c; 23a:
LPB. III. B. 0108 – Coll. BĂRBULESCU.
Middle Oxfordian, Casimcea valley.

Figs. 24a,c:
LPB. III. B. 0109 – Coll. DRĂGĂNESCU.
Middle Oxfordian, Casimcea valley.

Nucleata nucleata (SCHLOTHEIM).

Figs. 22a-c:
LPB. III. B. 0110 – Coll. BĂRBULESCU.
Middle Oxfordian, Casimcea valley.

All figures natural size unless indicated otherwise.

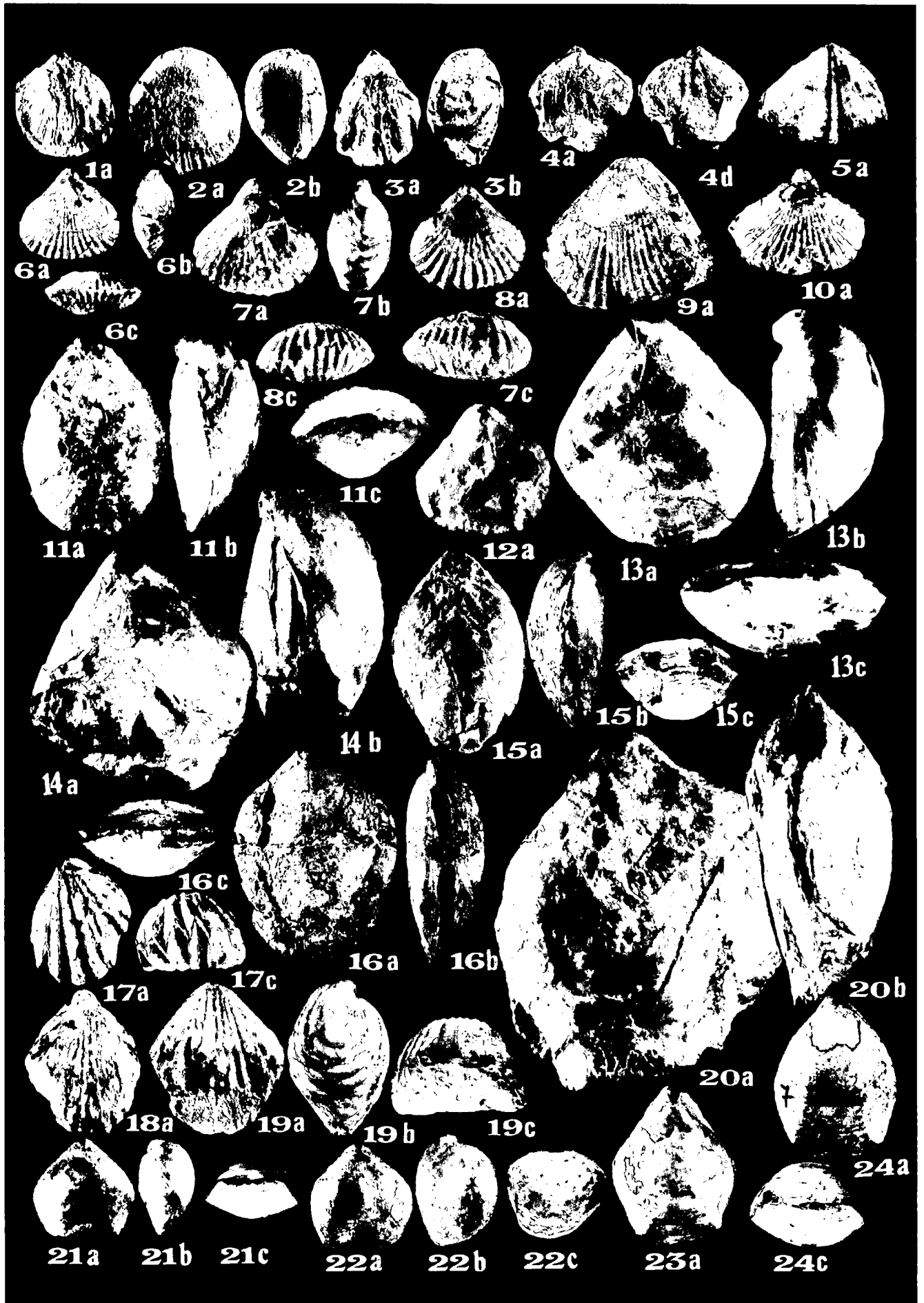


Plate 2

Central Dobrogea

Casimcea Formation

Cekirgea Stromatolitic Algal Series

***Monticlairella strioplicata* (QUENSTEDT).**

Figs. 1a–d:

× 2.5, LPB. III. B. 0111 – Coll. BĂRBULESCU.
Middle Oxfordian, Cekirgea valley.

***Septaliphoria pinguis* (ROEMER).**

Figs. 2a–c:

LPB. III. B. 0112 – Coll. BĂRBULESCU.
Upper Oxfordian, Veriga Arm (Danube) cliff, north of Topalu.

***Lacunosella sparsicosta* (QUENSTEDT).**

Figs. 3a, c–d; 5a–d:

LPB. III. B. 0113 – Coll. BĂRBULESCU.
Middle Oxfordian, Baroi hill, north of Hârşova.

Figs. 4a, d:

LPB. III. B. 0114 – Coll. BĂRBULESCU.
Middle Oxfordian, “La Vii” hill, north of Hârşova.

***Acanthorhynchia spinulosa* (OPPEL).**

Figs. 6a–b:

LPB. III. B. 0115 – Coll. BĂRBULESCU.

Figs. 18a, c:

× 1.8, LPB. III. B. 0115 – Coll. BĂRBULESCU.

All figures – Middle-Upper Oxfordian, Cekirgea valley.

***Lacunosella cracoviensis* (QUENSTEDT).**

Figs. 7a–c; 8a; 9a–c:

LPB. III. B. 0116 – Coll. BĂRBULESCU.

Figs. 10a; 11a–c; 14a–c:

LPB. III. B. 0116 – Coll. BĂRBULESCU.

All figures – Middle-Upper Oxfordian, Cekirgea valley.

***Torquirhynchia speciosa* (MÜNSTER).**

Figs. 12a; 13a–c:

LPB. III. B. 0117 – Coll. BĂRBULESCU.
Upper Oxfordian, Veriga Arm (Danube) cliff, north of Topalu.

***Moeschia alata* (ROLLET).**

Figs. 15a–c; 16a:

LPB. III. B. 0118 – Coll. BĂRBULESCU.
Middle Oxfordian, Cekirgea valley.

***Moeschia granulata* BOULLIER.**

Figs. 17a–b:

LPB. III. B. 0119 – Coll. BĂRBULESCU.
Uppermost Oxfordian, Cekirgea valley.

***Dictyothyris kurri* (OPPEL).**

Figs. 19a–c:

LPB. III. B. 0120 – Coll. BĂRBULESCU.
Middle Oxfordian, Cekirgea valley.

All figures natural size unless otherwise indicated.

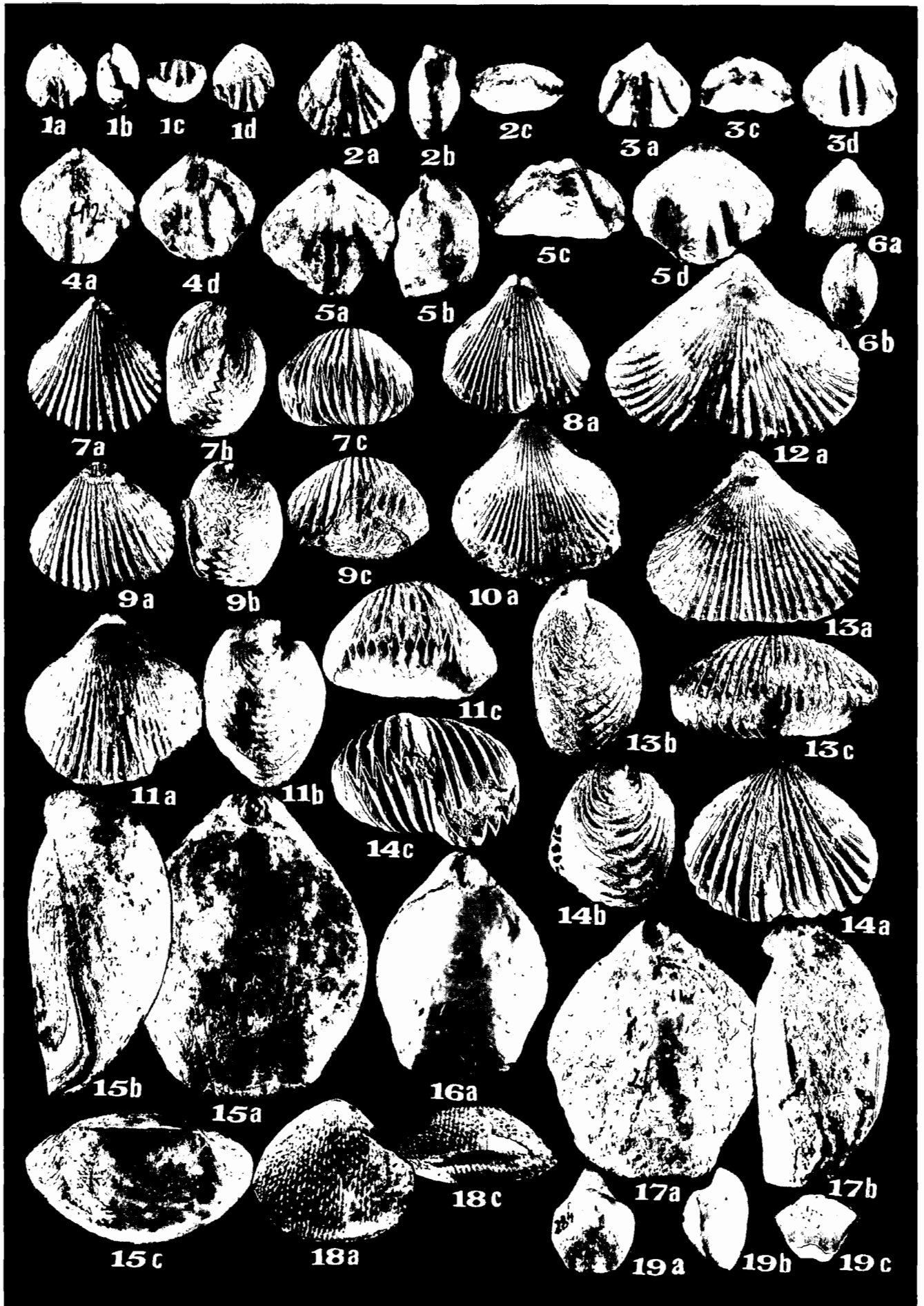


Plate 3

Central Dobrogea

Casimcea Formation

Cekirgea Stromatolitic Algal Series

***Placothyris carsiensis* (SIMIONESCU).**

Figs. 1a–c; 2a–c; 3a–c:
LPB. III. B. 0121 – Coll. BĂRBULESCU.
Middle Oxfordian, Cekirgea valley.

***Dorsoplicathyris farcinata* (DOUVILLÉ).**

Figs. 4 a–c:
LPB. III. B. 0122 – Coll. BĂRBULESCU.
Middle Oxfordian, Cekirgea valley.

***Dorsoplicathyris petersi* n. sp.**

Figs. 5 a–c:
Paratype, LPB. III. B. 0123 – Coll. BĂRBULESCU.
The smallest specimen.

Figs. 6 a–c; 8 a–c:
Paratypes, LPB. III. B. 0125 – Coll. BĂRBULESCU.

Figs. 7 a–c:
Holotype, LPB. III. B. 0124 – Coll. BĂRBULESCU.

All figures – Uppermost Oxfordian, Veriga Arm (Danube) cliff, north of Topalu.

***Juralina subformosa* (ROLLIER).**

Figs. 9 a–c:
LPB. III. B. 0251 – Coll. BĂRBULESCU.
Uppermost Oxfordian, “La Vii” hill, north of Hârşova.

***Zeillerina delemontana* (OPPEL).**

Figs. 10 a:
LPB. III. B. 0252 – Coll. BĂRBULESCU.
Upper Oxfordian, Veriga Arm (Danube) cliff, north of Topalu.

Figs. 13 a–b; 14 a–c:
LPB. III. B. 0253 – Coll. BĂRBULESCU.
Middle Oxfordian, Cekirgea valley.

***Dictyothyris kurri* (OPPEL).**

Figs. 12 a–c:
LPB. III. 0254 – Coll. BĂRBULESCU.
Middle Oxfordian, Cekirgea valley.

Topalu Bioconstructed Coralgall Series

***Cheirothyris fleurieusa* (D’ORBIGNY).**

Figs. 11 d; 16 a–c:
LPB. III. B. 0255 – Coll. BĂRBULESCU.
Lower Kimmeridgian, Veriga Arm (Danube) cliff, north of Topalu.

***Zeillerina delemontana* (OPPEL).**

Figs. 15 a, c:
LPB. III. B. 0256 – Coll. BĂRBULESCU.
Lower Kimmeridgian, Veriga Arm (Danube) cliff, north of Topalu.

All figures natural size.

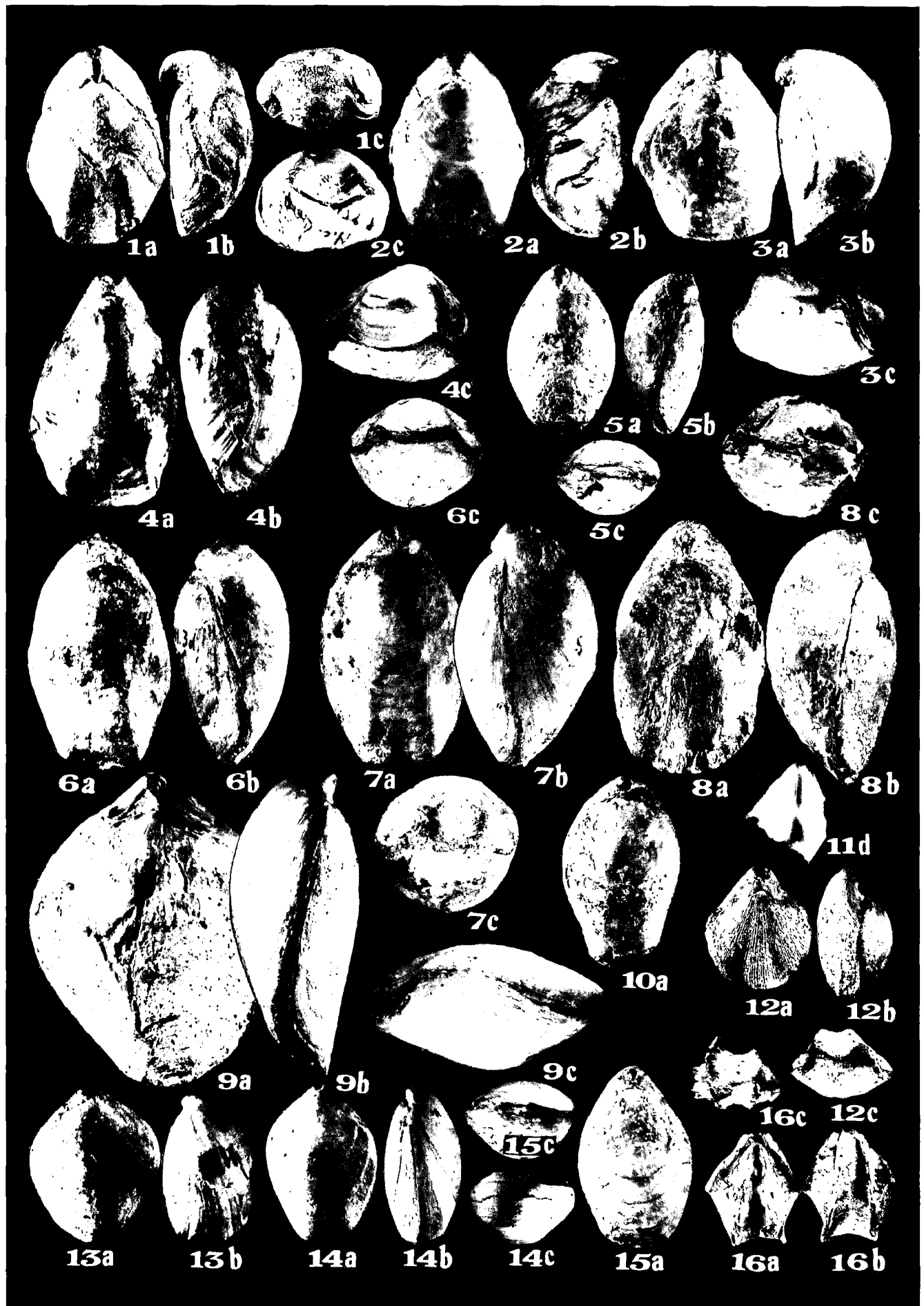


Plate 4

Central Dobrogea

Casimcea Formation

Topalu Bioconstructed Coralgall Series

***Septaliphoria moravica* (UHLIG).**

Figs. 1a–c:

LPB. III. B. 0257 – Coll. BĂULESCU.

Specimen with large arcuate anterior commissure.

Figs. 2 a–c:

LPB. III. B. 0258 – Coll. BĂULESCU.

Specimen with uniplicate anterior commissure, and quadrate median fold.

Figs. 3 a–c:

LPB. III. B. 0259 – Coll. BĂULESCU.

The largest specimen.

All figures – Lower Kimmeridgian, Veriga Arm (Danube) cliff, north of Topalu.

***Juralina bullingdonensis* (ROLLIER).**

Figs. 4 a–c:

LPB. III. B. 0260 – Coll. BĂULESCU.

Lower Kimmeridgian, Tătaru valley, Topalu.

***Juralina topalensis* (SIMIONESCU).**

Figs. 5 a–c:

LPB. III. B. 0261 – Coll. BĂULESCU.

Lower Kimmeridgian, Tătaru valley, Topalu.

***Juralina* sp.**

Fig. 6 a:

LPB. III. B. 0262 – Coll. BĂULESCU.

Lower Kimmeridgian, Tătaru valley, Topalu.

***Juralina kokkoziensis* (MOISEEV).**

Figs. 7 a–b:

LPB. III. B. 0263 – Coll. BĂULESCU.

Lower Kimmeridgian, Tătaru valley, Topalu.

***Juralina castellensis* (DOUVILLÉ).**

Figs. 8 a, d:

LPB. III. B. 0264 – Coll. BĂULESCU.

Lower Kimmeridgian, Veriga Arm (Danube) cliff, north of Topalu.

***Digonella* sp.**

Figs. 9 a–c:

LPB. III. B. 0265 – Coll. BĂULESCU.

Lower Kimmeridgian, Veriga Arm (Danube) cliff, north of Topalu.

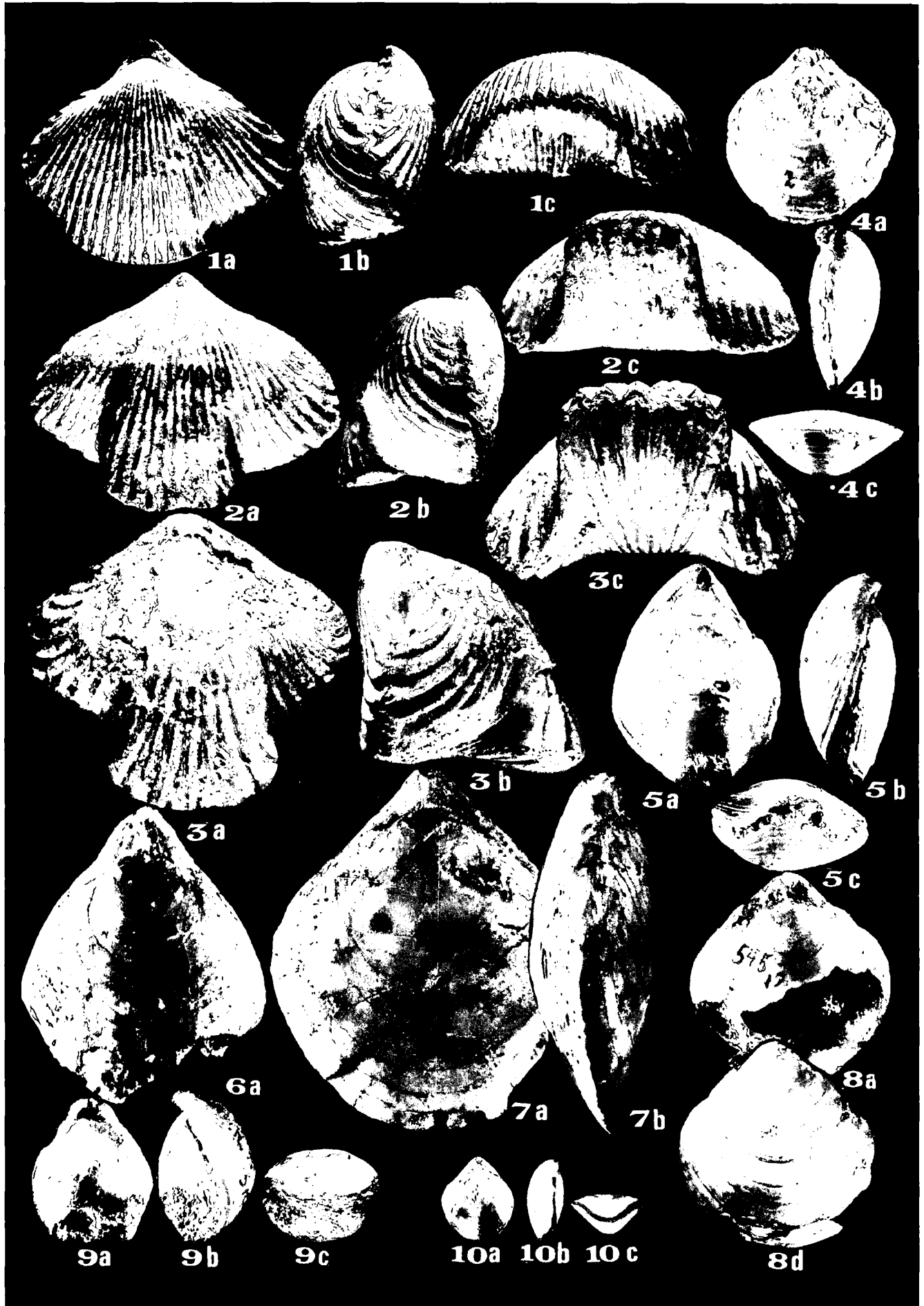
***Aulacothyris* sp.**

Figs. 10 a–c:

LPB. III. B. 0266 – Coll. BĂULESCU.

Lower Kimmeridgian, Veriga Arm (Danube) cliff, north of Topalu.

All figures natural size.



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Manuskript bei der Schriftleitung eingelangt am 22. Dezember 1993



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Zeitschrift/Journal: [Jahrbuch der Geologischen Bundesanstalt](#)

Jahr/Year: 1994

Band/Volume: [137](#)

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Artikel/Article: [Upper Jurassic Brachiopod Faunas of Central and North Dobrogea \(Romania\): Biostratigraphy, Paleoecology and Paleobiogeography 43-84](#)