Devonian and Carboniferous Brachiopods and Bivalves of the Djado Sub-Basin (North Niger, SW Libya)

Brachiopodi a mlži devonu a karbonu dílčí pánve Djado (severní Niger, jz. Libye)

(9 figs)

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A limited collection of brachiopods and bivalves was collected from the Djado sub-basin (southern extension of the Murzuq Basin: SW Libya and North Niger). Twenty brachiopod (mostly productids and spiriferids) and six bivalve species could be determined. Among the brachiopods, one is described as a new *(Rhynchopora magnifica* sp. nov.). Brachiopods reflect affinity to the North American faunas, especially among the productids.

Key words: Devonian, Carboniferous, Brachiopods, Bivalves, SW Libya, North Niger

Introduction

The upper Palaeozoic of the Djado sub-basin, a southwards extension of the Murzuq Basin in SW Libya, is not well known. Palaeontologic samples are very scattered and restricted (Plauchut – Faure 1959) in number and quality. Therefore, any new data from southern extension of the Murzuq Basin although imperfect and preliminary, have great stratigraphic as well as palaeogeographic value.

The first presence of the Carboniferous rocks situated south to the Djabal Fezzan was pointed by Beyrich (1852). In 1939, Carla Rossi reviewed and described Carboniferous faunas of the Serdeles Region (western flank of Murzuq Basin). One association (215 km from Ubari to Serdeles) is characterised by a syringothyrid, probably the species *Syringothyris jourdyi* Douvillé (= *Syringothyris cuspidata* and *S. elongata*: Rossi, Pl. 7, Fig. 8, Pl. 8, Figs 1–3) associated with a productid, probably of genus *Antiquatonia*. This fauna is probably of the late Visean to early Namurian age. Another association noted by Rossi (1939) is characterised by an absence of syringothyridids. Spiriferids are represented by one species of probably *Brachythyrina* (*Anthracothyrina*). Associated productids belong mainly to *Linoproductus* but Rossi (1939) noted also presence of other brachiopod taxa.

Geological setting of the Djado sub-basin

In Libya, the Murzuq Basin is a huge elongated triangular area with a broad apex pointing southwards. The portion extending into the Northern Niger is called sub-basin of Djado (Fig. 1). This appellation comes from the Djado-Chirfa oasis, located in the SW area. This sub-basin represents the southern extension of the Libyan Murzuq Basin, both forming the geological unit covering about 320 000 sq. km.

The edges of the basin are composed of Palaeozoic deposits. In the central portion, Mesozoic to Quaternary continental sediments are present. The outcrops of the Djado basinal part are succinctly illustrated in Fig. 1. This simplified document was prepared using the 1 : 500 000 scale geological map with the detailed Explanatory Booklet (Plauchut – Faure 1959).

Stratigraphy of Palaeozoic series

The geological sequence of Palaeozoic series is basically the same in surface and subsurface areas of the Djado sub-basin. However, an increasing continental influence can be noted in the southward direction, as previously recognised and defined also in the Ghadames and Murzuq Basins of western Libya (Bellini – Massa 1980, Massa 1988). Stratigraphical similarities exist between Murzuq and Djado areas. A schematic stratigraphical column, limited to the pre-Carboniferous units is presented on Fig. 2, as it is known and mapped along both margins of the Murzuq-Djado basin.

Cambrian and Ordovician

Basement rocks outcrop to the west of the Djado sub-basin (Eastern Hoggar) and the east (West Tibesti). The Cambro-Ordovician sequence consists of six formations. The total thickness is variable, ranging from 400 to 700 m. The Mourizidié Formation is the earliest Palaeozoic sequence resting unconformably on the Precambrian (Proterozoic) basement. It is correlated with lower Cambrian and is known only in the eastern margin of the Djado sub-basin. The Hassaouna Formation, representing middle and upper Cambrian, is built up of unfossiliferous, cross-bedded, mainly coarse-grained sandstones. The Acheybat Formation, referred to the Tremadocian has similar lithofacies but with common trace fossils. Both formations denote a fluvio-deltaic environment. The Haouaz Formation, referred to Llanvirnian is built up of fine to medium grained sandstones rich in trace fossils *Tigillites* and *Skolithus*. The

Fig. 1 Simplified geological map of the South Murzuq Basin and Djado sub-basin, with location of geological sections (lines) and boreholes (black rectangles). Explanations: 1 – Quarternary (Q); 2 – Mesozoic (M); 3 – Carboniferous (CF); 4 – Pre-Carboniferous Palaeozoic (PCP); 5 – Precambrian basement.

Melez Chograne and Memouniat Formations are sometimes difficult to differentiate because of their glacio-marine origin. The Melez Chograne is mainly shaly with often peculiar and typical microconglomeratic shales (diamictites). The macrofaunal data indicate upper Caradocian and Ashgillian age (Havlíček – Massa 1973). Presence of the Hirnantia Fauna in the Memouniat Formation, discovered in the Western Murzuq Basin (Havlíček – Massa 1973) confirms the Ashgillian age.

Silurian

The Silurian sequence outcropping on both sides of the Djado sub-basin is composed of two units. The lower unit, the Tanezzuft Formation, is mainly built up of a thick sequence of graptolitic shales bearing abundant graptoloids (Klitzsch 1968, 1970, Jaeger – Massa 1971). The upper unit, the Acacus Formation, is mainly composed of fine-grained micaceous sandstones and siltstones, outcropping in both flanks of the Djado sub-basin. Sandstones are rich in trace fossils of arthropods, such as *Harlania* (=*Arthrophycus*) and *Cruziana*. However, it is often difficult to separate these two formations. The total thickness of the Silurian varies, ranging between 150 to 300 m in the western Djado sub-basin. Thickness is more reduced along the eastern margin of the Djado sub-basin, with a maximum 120 m but Silurian rocks may be also totally absent. Presence of volcanic tuffs and dolerites suggest some pre-Caledonian extrusive igneous activity during the early Silurian (Plauchut – Faure 1959).

Devonian

A strong erosional disconformity occurs between the Silurian and Devonian. It underlies the classical Caledonian post anorogenic cycle. The Lower Devonian consists of the Tadrart and Ouan-Kasa Formations. These two Early Devonian units make up a single megacycle of Lochkovian, Pragian and Emsian age. The Lower Devonian extends over the Murzuq Basin and Djado sub-basin. Coarse-grained, cross-bedded sandstones with conglomerates characterise the basal Devonian sequence overlying the Silurian Tadrart Formation. The palaeoenvironment was fluvio-continental, with frequent plant fragments and rare trace fossils (*Spirophyton*). The Ouan-Kasa Formation occurs above this siliciclastic unit. Fine grained sandstones and calcareous sandstones (up to 25% carbonate), with several coquina horizons indicate wholly marine origin of the Ouan-Kasa Formation. In the type section of the Ouan-Kasa Formation (at the western Murzuq Basin on the territory of Libya), a rich and diversified marine fauna was collected and described, dating a late Pragian to Emsian interval (Mergl – Massa 1992). A similar fauna, collected in the SW part of the Djado sub-basin, was also described, (Mergl – Massa, 2000). The fossiliferous locality lies east of the Chirfa oasis (co-ordinates N 12˚43', E 20˚55'). The distance of both localities is approximately 400 km. Extended regional and continuous open marine character of the late Early Devonian is well established along the western margin of the Djado sub-basin.

The Aouinet-Ouenine Group represents the Middle and Upper Devonian. This group was previously defined in the outcrop belt along the southern margin of the Ghadames Basin. Four formations were described in ascending order: the Aouinet Ouenine I Formation, AO II Fm., AO III Fm., and AO IV Fm. Their stratigraphic interval comprising the Eifelian, Givetian, Frasnian, and Famennian in Europe is known in outcrops and subsurface of the Ghadames Basin (Massa 1988, Mergl – Massa 1992). In the Murzuq and Djado area, it was difficult to accept and differentiate the more detailed northern subdivisions. Southwards, continental influences are increasing with frequent fragments of lycophytes and lignite. In contrast, marine horizons are rare, with few bivalves and crinoids. The trace fossil *Spirophyton*, generally well preserved and covering the bedding planes of sandstones is a more frequent fossil. This ichnofacies is spread over the whole area and provides the basis for Devonian dating of sediments, because this trace fossil is unknown from Silurian and Carboniferous in the area. The present state of knowledge allows only use of the term Aouinet Ouenine Group for the Djado sub-basin.

Carboniferous

The Carboniferous crops out over the largest part of the Djado sub-basin (Fig. 1) This stage is characterised by several marine incursions between Hoggar – Tibesti. A frequent occurrence of fossiliferous units allows cor-

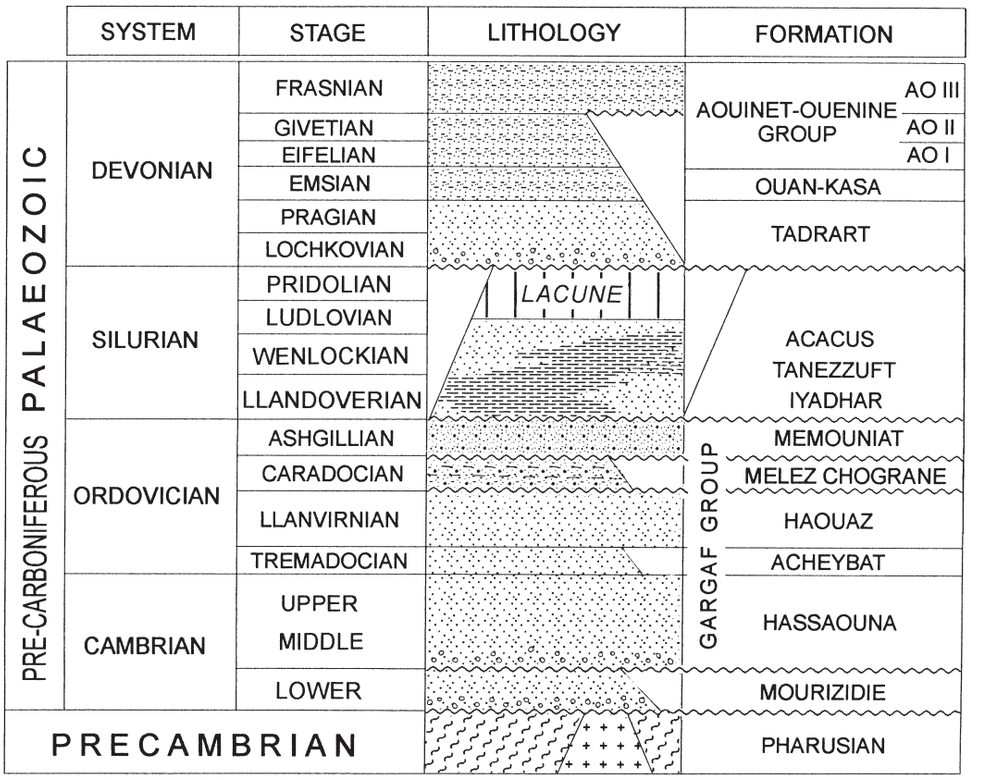

Fig. 2 Series and lithostratigraphy of the pre-Carboniferous units used in the South Murzuq Basin and in the Djado sub-basin.

rect age dating for the different parts of the Carboniferous. The maximum cumulative thickness, known from surface and subsurface is 1000 to 1100 m.

In ascending order, there are three units: the Mrar Formation, the Assedjefar Formation and the Dembaba Formation. Defined on outcrops south of the Ghadames basin (Bellini – Massa 1980), it was also possible to distinguish these units in the Murzuq basin. Faunal data and correlation were possible over the large southern areas, in spite of lithofacies changes. The facies sequence is progressive. The first, general paleontological study was just prepared recently (Mergl – Massa, 2000) so new complementary paleontological results are presented herein.

The Mrar Formation represents upper Tournaisian to Visean. The unit rest disconformably on sediments of the Aouinet Ouenine Group. Further to the South, the formation lies directly on the lower Devonian Tadrart Formation with a lacune of the Aouinet Ouenine Group. In the basal Mrar Formation, the lithology is highly diversified. The mainly green shales but either with dolomitic limestones or calcareous sandstones built up the formation, locally with ferruginous oolites. These basal fossiliferous horizons are excellent regional markers over the whole area of the Djado sub-basin. Rich and diversified fauna including brachiopods and goniatites indicates the first transgressive event in the upper Tournaisian. In the upper part of the Mrar Formation several fossil associations indicate an upper Visean age. This fossil-bearing calcareous sandstones and limestones alternate with shales and siltstones.

The Assedjefar Formation is correlated with the Namurian. The formation is made up of green shales, often with gypsum beds alternating with calcareous levels. The restricted marine to lacustrine environment is indicated by algal stromatolites and concretionary limestones ("Collenia" horizons and Caliche layers).

The Dembaba Formation represents the Moscovian. The formation is built up of red and white shales with few black limestones in the lower half of the unit. The upper half has a terrestrial origin and is unfossiliferous. Several evaporite levels with massive gypsum and sparse dolomite horizons are present. The final regression of the sea is marked by continental cross-bedded sandstones with chalcedonite, by palaeosols and red shales. The lagoonal and continental episode during the Moscovian closed the Carboniferous series in the Djado sub-basin. The Carboniferous sea definitely retreated after Moscovian time.

Faunal associations of Paleozoic series

Emsian: Ouan Kasa Formation

Devonian fossiliferous horizons are restricted in the area, being confined to Emsian. Samples R8 and R9 contain numerous but poorly preserved brachiopods of minute size, among which *Tropidoleptus* sp., *Leiorhynchus* (?)

sp. and *Spinella paulula* Mergl and Massa have been determined.

Carboniferous: Mrar Formation

The Carboniferous is more fossiliferous than the Devonian strata. The transgressive upper Tournaisian level, the base of the Mrar Formation, bears a distinct and abundant fauna with the medium-sized coarsely costate syringothyrid *Syringothyris* cf. *ahnetensis* Legrand-Blain, locally associated with a large rhynchonellid *Rhynchopora magnifica* sp. nov. Less abundant brachiopods near the base of the Carboniferous sequence are *Saharonetes* aff. *saharensis* Havlíček, *Schuchertella* sp. and *Syringothyris* sp. Bivalves occur rarely at this level. Another distinct, but low-diversity brachiopod association at the base of the Carboniferous (in south part of Djado sub-basin) flank of the basin is characterised by a giant globose rhynchonellid *Paurogastroderhynchus serdelesensis* (Massa et al.). These associations are also of late Tournaisian age. However, sandstones in the upper Mrar Formation yielded a productid *Fluctuaria undata* Defrance, the taxon indicating the Visean age.

Assedjefar Formation

The upper Visean and lower Namurian are generally poor in fossils. A weakly diversified brachiopod association near the base of the formation is characterised by the large syringothyrid *Syringothyris jourdyi* Douville and the terebratulid *Beecheria*. Calcareous sandstone yielded shells of large *Streptorhynchus*, sandy limestones bear locally abundant productids (*Antiquatonia, Flexaria* and *Ovatia*), with less abundant *Rhipidomella, Composita, Syringothyris, Anthracospirifer* and small rhynchonellids.

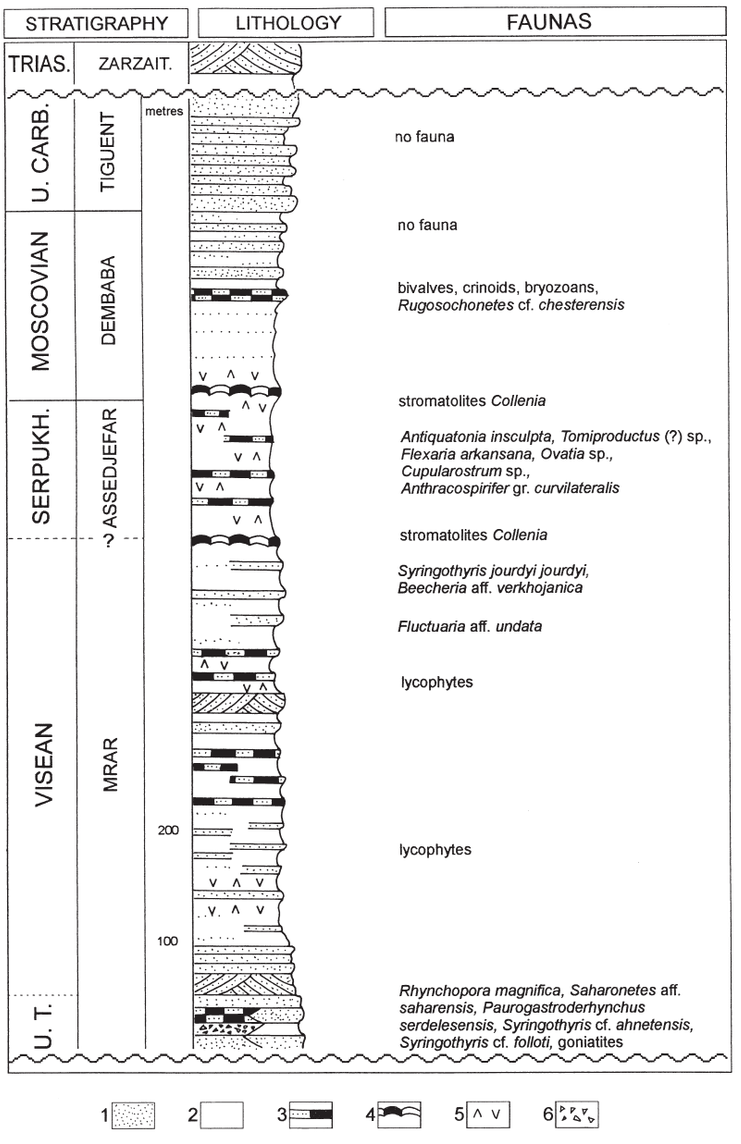

Fig. 3 Composite section of Carboniferous outcrops in the eastern Djado sub-basin. Explanations: 1 – sandstone; 2 – shale; 3 – limestone, carbonatic sandstone; 4 – stromatolitic limestone; 5 – evaporite; 6 – conglomerate; U. T. – Upper Tournaisian.

Dembaba Formation

The upper part of the marine Carboniferous (Moscovian) in the Djado sub-basin yielded an assemblage consisting of the chonetid *Rugosochonetes* cf. *chesterensis* (Weller) associated with Moscovian foraminifers (Mergl – Massa, 2000).

Conclusions

The Dinantian and early Silesian shelly assemblages of the Djado sub-basin are weakly diversified and represent shallow marine environments. The assemblages are dominated by productid brachiopods, coarsely ribbed rhynchonellids and spiriferids, with uncommon terebratulids or strophomenids. Fossil associations often show minimum of transport and reworking; brachiopod shells are often conjoined, associated in monospecific clusters or densely packed in the fossiliferous beds. Diversity is generally low, with only two or three species in samples.

As stated by previous authors (e.g. Legrand-Blain et al. 1987), some faunal elements in the Saharan area are closely related to some North American taxa (e.g. *Flexaria, Anthracospirifer, Rugosochonetes*). Most of the recorded taxa have a world-wide distribution (*Schuchertella, Ovatia, Cupularostrum, Syringothyris,*

Beecheria). Only a few elements are restricted to the Murzuq Basin and Djado sub-basin (*Saharonetes saharensis*, *Paurogastroderhynchus serdelesensis*).

Systematic paleontology

Superfamily Enteletoidea Waagen, 1884
Family Tropidoleptidae Schuchert, 1896

Genus *Tropidoleptus* Hall, 1857

Type species: *Strophomena carinata* Conrad, 1839

Tropidoleptus sp.
Fig. 4.1

1973 *Tropidoleptus* ?; Boucot et al., p. 98, Fig. 4 J, K.
1992 *Tropidoleptus* sp.; Mergl – Massa, p. 47, Pl. 3, Figs 17, 18.

Age: Emsian, Ouan Kasa Formation.
Locality: SW Djado sub-basin, section 8, samples R8, R9.

Remarks: A few newly gathered valves and their fragments belong to the same species, which has been described and figured by Mergl – Massa (1992). The best preserved unbroken dorsal valve is 9 mm wide and displays 22 angular plications with a median interspace wider than other interspaces. The morphology confirms a separation of this species from stratigraphically later species *Tropidoleptus carinatus freuloni* Boucot, Massa et Perry, as already indicated by Mergl – Massa (1992).

Superfamily Orthotetoidea Waagen, 1884
Family Schuchertellidae Williams, 1953
Subfamily Schuchertellinae Williams, 1953

Genus *Schuchertella* Girty, 1904

Type species: *Streptorhynchus lens* White, 1862

Schuchertella cf. *valentinae* Sokolskaya, 1963
Fig. 4.15

Age: Upper Visean/Namurian.
Locality: Djado sub-basin, section 70, sample D301.

Remarks: A single ventral valve is over 50 mm wide, poorly convex in both profiles, with a low, apsacline interarea. Cardinal extremities obtuse. Ornamentation formed by fine, rounded costellae, with new ones arising by intercalation. Prominent growth lamellae are crowded anteriorly. It is difficult to refer this valve to any known species, but the species *S. valentinae* Sokolskaya described by Sarytcheva et al. (1963) from the lower Tournaisian of the Kuznetsk Basin, Russia is most similar to Libyan shell.

Family Streptorhynchidae Stehli, 1954

Genus *Streptorhynchus* King, 1850

Type species: *Terebratulites pelargonatus* von Schlotheim, 1816

Streptorhynchus cf. *ruginosum* (Hall et Clarke, 1892)
Fig. 4.13, 14

Age: Upper Visean.
Locality: Djado sub-basin, eastern flank, section 95, sample B596.
Material: Four dorsal valves, several fragments of ventral valve.

Description: Shell large, conspicuously dorsi-biconvex, gently irregular in outline and with width exceeding 50–55 mm, rather thin-walled, pseudopunctate.

Ventral valve low, slightly irregular.

Dorsal valve is transversely oval, with obtuse cardinal extremities, strongly convex in lateral profile. Transverse profile highly convex, with flattened median sector forming weakly widening, shallow sulcus in anterior half of the valve. Anterior commissure rectimarginate. Internal details not observed.

Ornamentation consists of fine radial costellae, uniform in a size, 8–10 in number per 5 mm anteromedianly. Costellae are crossed by less distinct, fine concentric fila.
Remarks: Available shells are similar, mainly by weak but distinct sulcus, to specimens determined by Sarytcheva et al. (1963) as *Streptorhynchus ruginosum ruginosus* (Hall et Clarke), from the Visean of the Kuznetsk Basin, Russia.

Superfamily Chonetoidea Bronn, 1862
Family Rugosochonetidae Muir-Wood, 1962
Subfamily Rugosochonetinae Muir-Wood, 1962

Genus *Rugosochonetes* Sokolskaya, 1950

Type species: *Orthis hardrensis* Phillips, 1941

Rugosochonetes cf. *chesterensis* (Weller, 1914)
Fig. 4.2–9

1939 *Chonetes carbonifera* Keyserling: Rossi, p. 226, Pl. VI, Fig. 5a, 5b.
1993 *Rugosochonetes* cf. *chesterensis* (Weller): Racheboeuf – Schaff, p. 48, Fig. 3.

Age: Moscovian.
Locality: Djado sub-basin, upper part of the section 30, sample AC627.
Material: Some twenty shells and valves.

Description: Shell concavo-convex, 19 mm wide in the largest specimen. Ventral valve is subrectangular, about 77 % as long as wide, with maximum width slightly anterior to midlength. Lateral margins are evenly curved, anterior margin curved weakly. Cardinal extremities obtuse in adults. Umbo small, well defined, slightly erect posteriorly. Ventral interarea apsacline, low, with a large delthyrium, which is in its apical third covered by a highly convex, crescentic pseudodeltidium. Hinge spines not preserved along their length. There are seven to eight spines on each flank, the bases of spines are directed posterolaterally. Ventral interior with a large radially grooved hinge teeth. Septum is high, swollen in anterior part, about 30 % long as the valve. Adductor scars

small, situated in posterior quarter of the valve. Diductor scars large, 50 % as wide and 40 % as long as the valve, with a weak radial striation. Parallel vascular trunk deeply raised above the valve floor. Inner spine apertures large. Inner surface of the valve is densely covered by elongate, radially arranged endospines.

Dorsal valve gently concave, with a low, anacline interarea. Notothyrium filled by a posterior face of the cardinal process faced by a five lobes. Chilidial plates unknown. Inner socket ridges widely divergent, stout, hinge sockets deep and narrow. Alveolus well-defined. Median septum low, narrow but distinct, extending over two-third of the valve length. Anderidia narrow, short and subtending 60° each another. Brachial ridges defined by rows of large endospines. Periphery of the valve densely covered by finer, radially arranged endospines, diminishing toward the valve edge.

Ornamentation consists of fine, low capillae, about 12 per 2 mm.

Remarks: Growth pattern of the species has been studied by Racheboeuf – Schaaf (1993) but the specimens have not been described. Racheboeuf – Schaaf (1993) referred Libyan specimens, although expressing little doubt, to the rare species *R. chesterensis* (Weller) from the Mississippian of Illinois, U. S. A. However, Weller (1914) did not describe shell interior, therefore the exact systematic position of the specimens from the Djado area remains unclear. As noted by Racheboeuf – Schaaf (1993), shell exterior of *R.* cf. *chesterensis* bears unusually fine radial capillae, which distinguish this species from the typical members of the genus *Rugosochonetes* Sokolskaya. Rossi (1939) assigned a chonetid with fine ornamentation from the western flank of the Murzuq Basin (E of Serdeles) to species *Chonetes* (*Ch.*) *carboniferus* Kayserling, but figured specimens may be more probably referred to *R.* cf. *chesterensis*.

Species referred to *Rugosochonetes* by Sokolskaya (1950, in Sarytcheva et al, 1963) generally differ by smaller size and coarser ornamentation except of species *R. illinoisensis taidonensis* Sokolskaya, which differs from the Djado specimens only by less prominent dorsal median septum.

Family Anoplidae Muir-Wood, 1962

Genus *Saharonetes* Havlíček, 1984

Type species: *Saharonetes saharensis* Havlíček, 1984

***Saharonetes* aff. *saharensis* Havlíček, 1984**
Fig. 4.10–12

cf. 1974 *Chonetes mosensis* Demanet: Massa, Termier – Termier et al., Pl. 6, Fig. 5.
cf. 1984 *Saharonetes saharensis* sp. nov.: Havlíček, p. 65, Figs 30–33, 54.
cf. 1987 *Saharonetes saharensis* Havlíček 1984: Havlíček – Röhlich, Pl. XI, Figs 1–6, Pl. XII, Figs 6, 14–16, Pl. XIII, Fig. 1.
cf. 1989 *Saharonetes saharensis* Havlíček 1984: Racheboeuf et al., p. 225, Fig. 2B.
cf. 1992 *Saharonetes saharensis* Havlíček 1984: Mergl – Massa, Pl. 55, Pl. 8, Figs 1–9.

Age: Upper Tournaisian.
Locality: Djado sub-basin, section 91, sample D548.
Material: Seven ventral and nine dorsal valves, many fragments, all preserved in calcareous sandstone with the original shell substance.

Description: Shell concavo-convex, large, 14–16 mm wide in adults.

Ventral valve is transversely oval, about 73 % as long as wide, with evenly rounded lateral and less rounded anterior margins, widest at posterior third. Cardinal extremities obtuse. Valve is moderate and evenly convex in transverse profile, strongly curved in lateral profile. Maximum convexity lies at posterior length and equals to 20 % of the valve width. Ventral interarea low, apsacline. Spines of orthomorph oblique type at about 45–50°. There are three to four spines in each side. Ventral valve interior bears distinct, short myophragm.

Dorsal valve transversely oval, with very low interarea. Valve is evenly concave, with flattened posterolateral sector of the valve. Valve interior without median septum, cardinal process wide, its posterior face unknown. Dental sockets are short and low. Inner cristae are very short, subparalel to hinge line. Alveolus minute. Anderidia are short, low and acute ridges diverging at 80°. A pair of accessory septa originates between anderidia, anteriorly diverging at 20°. Inner surface of valve is covered by radial rows of rather coarse endospines.

Ornamentation of ventral valve with distinct acute costellae, separated by somewhat wider, rounded interspaces. New costellae originate by an intercalation in ventral valve, there are 2–3 costellae per 1 mm anteromedianly. Concentric ornamentation formed by weak fila.

Remarks: The species fit well to the concept of the genus *Saharonetes* Havlíček and is close to type species *S. saharensis* Havlíček from the Ashkidah and Mrar Formations (Tournaisian) of the Murzuq basin. The lower number of spines and weakly coarser costellation are the only differences of the Djado material, but these differences need further confirmation. *Saharonetes ghanaensis* described by Racheboeuf et al. (1989) from the lower Carboniferous of Ghana differs from the material from Djado sub-basin by higher angled spines, smaller size and shell interior bearing smaller and less frequent endospines.

Superfamily Productoidea Gray, 1940
Family Productidae Gray, 1940
Subfamily Productinae Gray, 1940
Tribe Retariini Muir-Wood et Cooper, 1960

Genus *Antiquatonia* Miloradovich, 1945

Type species: *Productus antiquatus* J. Sowerby, 1821

***Antiquatonia insculpta* (Muir-Wood, 1928)**
Fig. 5.1–8

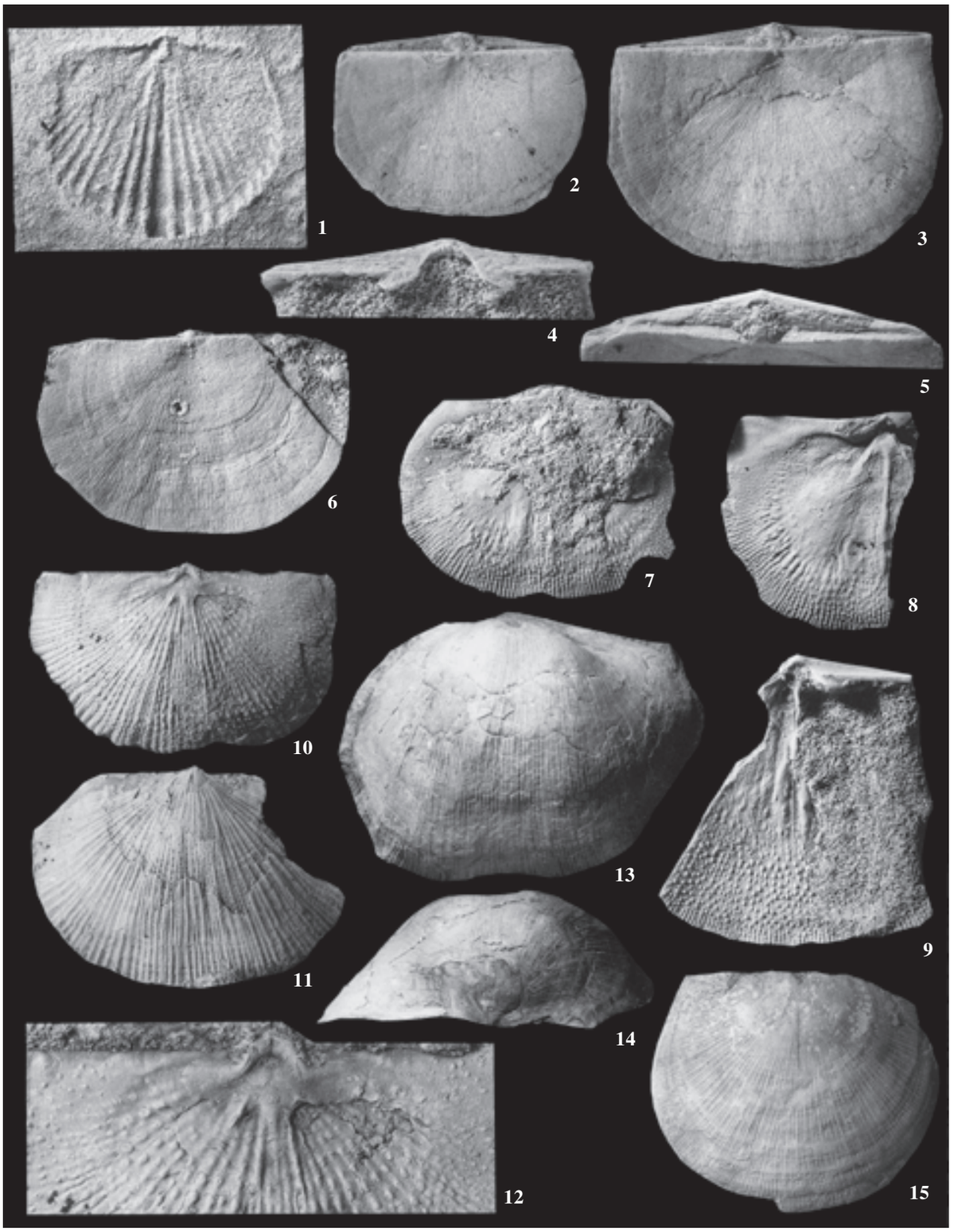

Fig. 4 1 – *Tropidoleptus* sp. internal mould of dorsal valve, x4.5; 2–9 – *Rugosochonetes* cf. *chesterensis* (Weller, 1914): 2 – complete shell, x4.0; 3 – complete shell, x4.0; 4 – ventral valve interarea, x4.0; 5 – posterior of complete shell, x4.0; 6 – dorsal valve exterior, x4.0; 7 – dorsal valve interior, x4.0; 8 – dorsal valve interior, x4.0; 9 – ventral valve interior, x4.0; 10–12 – *Saharonetes* aff. *saharensis* Havlíček, 1984: 10 – interior of dorsal valve, x3.8; 11 – exterior of ventral valve, x3.8; 12 – detail of cardinalia, x9.0; 13, 14 – *Streptorhynchus* cf. *ruginosum* (Hall et Clarke, 1892): dorsal valve and its posterior view; 13 – x1.2; 14 – x1.3; 15 – *Schuchertella* cf. *valentinae* Sokolskaya, 1963: interior of ventral valve, x1.3. Samples: R8 (1), AC627(2–9), D545 (10–12), B596 (13, 14), D301 (15).

1939 *Productus semireticulatus* Martin; Rossi, p. 229, Pl. 7, Fig. 4
1974 *Antiquatonia insculpta* Muir-Wood; Massa, Termier – Termier, p. 183, Pl. 7, Figs 9, 10.

Material: Four ventral valves, three dorsal valves.
Age: Lower Namurian.
Locality: Djado sub-basin, section 108, samples D77, D82.

Description: Shell large, 35–40 mm wide, concavo-convex, rather thin-walled.

Ventral valve is medially sulcate, with moderately convex visceral disc and flattened ears, the maximum width at hinge line. The umbo short, gently convex. Lateral profile regularly semicircular, with the umbo not overturned behind the hinge line. Transverse profile of visceral disc gently convex with a shallow sulcus, which may be distinct at midlength but vanish anteriorly. Interior of ventral valve with highly raised adductor scars.

Dorsal valve transversely subrectangular, widest at hinge line, with flat venter and short, strongly curved trail. Dorsal valve interior bears short, probably bilobed cardinal process, supported by a short median ridge. Brachial ridges large.

Ornamentation of ventral valve consists of well-defined rounded costae, weakly widening anteriorly, rarely branching into two smaller secondary costellae. Rugae distinct on visceral disc, trail without rugae. Fine concentric ornamentation of fine growth lines.

Dorsal valve ornamentation of costae and rugae on the venter, but trail is only costate. Spine bases scattered randomly over anterior half of the ventral valve except hinge line with a single row. The row at hinge line consists of five to six spines on each flank. Spines erect, at a high angle to the shell. Spines in dorsal valve not preserved.

Remarks: Shape and exterior of available valves are similar to *Marginatia* Muir-Wood – Cooper, and *Antiquatonia* Miloradovich. The latter genus has a shorter trail and more transverse outline with ears. Our specimens have a row of spines along the hinge margin and scattered spines on the summit of the costae, suggested as the typical features of *Antiquatonia* (Muir-Wood et Cooper, 1960). *Antiquatonia* is broadly distributed in the lower (Visean) and upper Carboniferous almost worldwide, but it is generally less common in the Mississippian of the United States (Muir-Wood – Cooper 1960). Our specimens are near to *A. pernodosa* Easton and *A. insculpta* Muir-Wood. The former is known from the upper Mississippian of Montana (Easton 1962), but differs by fewer spines in the ventral valve and in its maximum shell width is at midlength instead of at the posterior margin. *Antiquatonia insculpta* Muir-Wood is common in West Europe (British Isles, Germany) and in the territory of Russia (Moscow Basin, Donetsk Basin, the South Urals: Sarytcheva – Sokolskaya 1952). The only difference between the Djado specimens and *A. insculpta* is the more extended ears of typical specimens. Our specimens also show similarity to *A. wettonensis* (Muir-Wood), which differs only in a more reticulated ventral disc, while both species figured by Sarytcheva et al. (1963), although poorly illustrated, display finer radial ornamentation. Numerous other species referred to *Antiquatonia* (Sarytcheva 1949, 1952) are generally more coarsely costate.

Rossi (1939) poorly figured a productid that may belong to *Antiquatonia* from the upper Serpukhovian of the Serdeles area (western margin of the Murzuq Basin). Our specimens probably belong to the same species as the specimens from the upper part of the Assedjefar Formation, determined also as *Antiquatonia insculpta* Muir-Wood by Massa et al. (1974).

Family Buxtoniinae Muir-Wood et Cooper, 1960
Tribe Buxtoniini Muir-Wood et Cooper, 1960

Genus *Flexaria* Muir-Wood et Cooper, 1960

Type species: *Productus arkansanus* Girty, 1910

Flexaria arkansana (Girty, 1910)
Fig. 6.1–11

1974 *Flexaria arkansana* Girty: Massa, Termier – Termier, Pl. 7, Fig. 1.

Material: Six ventral and two dorsal valves, several fragments.
Age: Upper Visean or Lower Namurian.
Localities: Djado sub-basin, section 89, sample B666; section 97, sample D936; section 108, sample D77.

Remarks: The specimens from the Djado sub-basin are externally very similar to *F. arkansana* Girty. They attain the same size, convexity, and type of ornamentation. It is noteworthy, that the hinge margin of the dorsal valve bears numerous erect spines. There is, however, a weak difference in the transverse profiles between the type specimens from Missouri, USA and the specimens from the Djado sub-basin. The Libyan specimens have weak but distinct ventral sulcus and their flanks are steeply sloping while median sector of hypotypes from Missouri, figured by Muir-Wood – Copper (1960: Pl. 78, Figs 5, 8) are flat or convex and the flanks are not so steep. The interior of the Libyan specimens is poorly known.

Tribe Tolmatchoffiini Sarytcheva, 1963

Genus *Tomiproductus* Sarytcheva, 1963

Type species: *Productus elegantulus* Tolmatchow, 1924

Tomiproductus (?) sp.
Fig. 5.15–18

Age: Upper Visean or Lower Namurian.
Locality: Djado sub-basin, sample S32.

Remarks: Four rather small (some 20 mm wide) and incomplete valves show coarse, continuous rounded costae on the exterior of the ventral valve, the posterior of

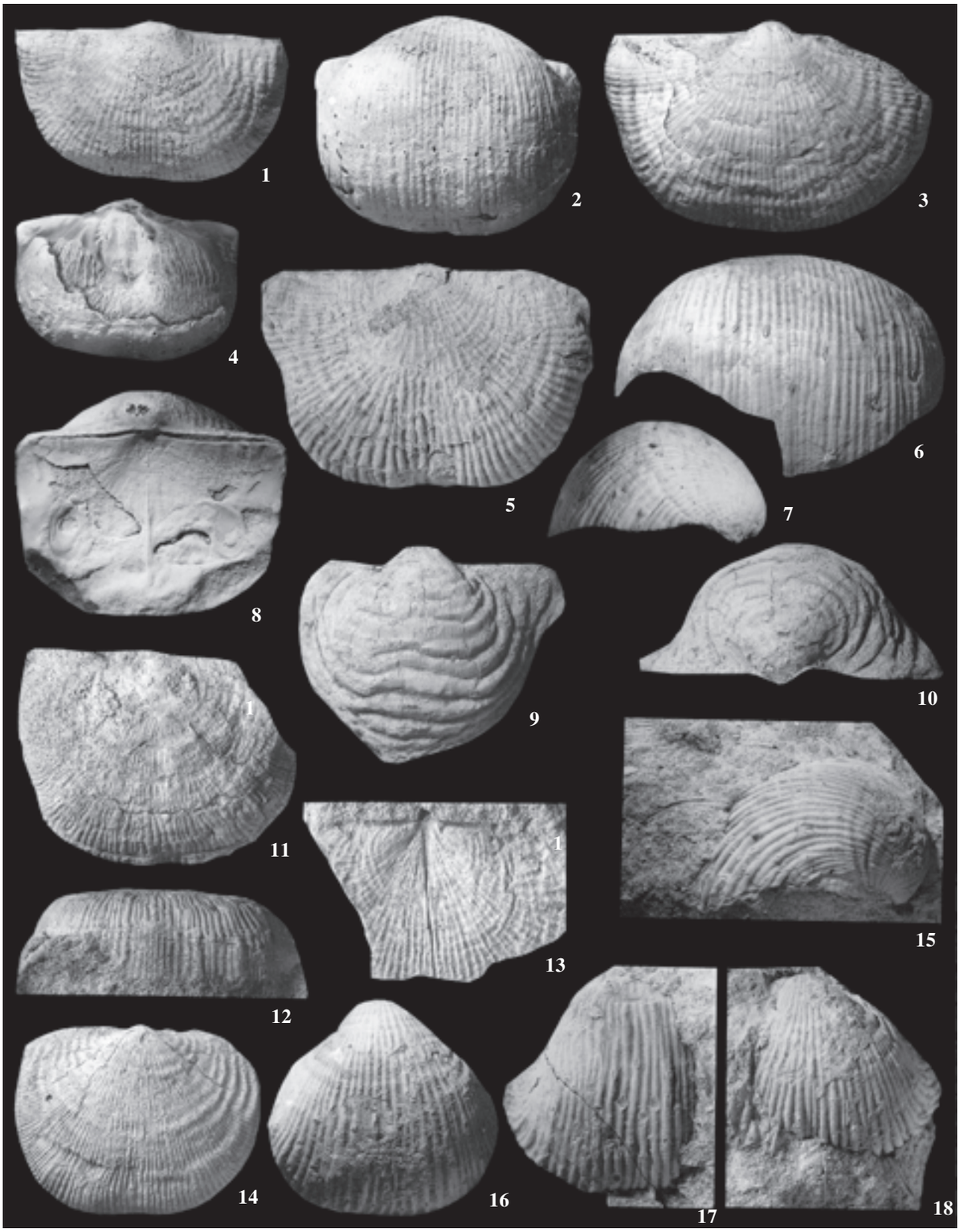

Fig. 5 1–8 – *Antiquatonia insculpta* (Muir-Wood, 1928): 1, 2, 8 – ventral valve exterior, and corroded interior of dorsal valve, x1.6; 3, 6, 7 – ventral valve exterior, x1.6; 4 – internal mould of ventral valve, x1.6; 5 – exterior of dorsal valve, x2.0; 9–14 – *Fluctuaria* aff. *undata* (Defrance, 1826): 9, 10 – ventral valve, x1.2; 11, 12 – exterior of dorsal valve, x1.2; 13 – internal mould of dorsal valve, x1.2; 14 – exterior of dorsal valve, x1.2; 15–18 – *Tomiproductus* (?) sp.: three incomplete ventral valves; note long recumbent spines (15, 18). Samples: D82 (1, 2, 4, 8), D77 (3, 5–7), M56 (9–14), S32 (15–18).

the valve with conspicuous rugellae. Recumbent spines long (Fig. 5: 15), strongly curved, sparsely distributed over whole shell surface. Species is poorly known and its exterior is similar to the species *Tomiproductus elegantulus* (Tolmatchow) and *T. duchkovae* Sarytcheva, both known in Tournaisian of the Kuznetsk Basin (Sarytcheva et al. 1963).

Superfamily Linoproductoidea Stehli, 1954
Family Monticuliferidae Muir-Wood et Cooper, 1960
Subfamily Auriculispininae Waterhouse, 1986

Genus *Ovatia* Muir-Wood et Cooper, 1960

Type species: *Ovatia elongata* Muir-Wood et Cooper, 1960

Ovatia sp.
Fig. 6.12–15

Material: Seven ventral valves.
Age: Lower Namurian,
Localities: Djado sub-basin, section 70/71, samples D308, D310, D311; section 108, sample D77.

Description: Ventral valve elongate, 30 mm long, highly convex with strongly incurved umbo, covered by fine rounded costellae, 12 in number per 5 mm anteromedianly. Flanks with a few rugae, anterior margin weakly sulcate.
Remarks: The genus *Ovatia* Muir-Wood et Cooper has world-wide distribution, with numerous, but often not well defined species from the North America (Muir-Wood – Cooper 1960, Carter 1987), Russia (Sarytcheva – Sokolskaya 1952, Sarytcheva et al. 1963, Bublitschenko 1963), Australia (Roberts 1971) etc. All Libyan specimens display a great resemblance to *Ovatia laevicosta* (White) from the Tournaisian and Visean of the Kuznetsk Basin (Sarytcheva et al. 1963), but differ by a more robust umbo. Libyan specimen differs from the type species *O. elongata* Muir-Wood – Cooper (Muir-Wood et Cooper 1960) by a less swollen ventral umbo and by diverging instead of converging costellation along the anterior margin.

Family Linoproductidae Stehli, 1954
Subfamily Linoproductinae Stehli, 1954

Genus *Fluctuaria* Muir-Wood et Cooper, 1960

Type species: *Productus undatus* Defrance, 1826

Fluctuaria aff. *undata* (Defrance, 1826)
Fig. 5.9–14

1974 *Fluctuaria undata* (Defrance): Massa, Termier – Termier, Pl. 4, Figs 2, 3.

Age: Upper Visean, and base Namurian.
Locality: Djado sub-basin, western flank, sections 32/34, samples M55, M56, M57.
Material: Two ventral and two dorsal valves, several fragments.

Description: Shell of medium size, 35 mm wide, transversely subrectangular to oval in outline, thin-walled, with maximum width at or slightly anterior to hinge line.

Ventral valve highly convex in transverse and lateral profiles, with flattened posterolateral parts. Maximum convexity posterior to midlength. Ventral umbo strongly curved. Ventral interior without distinct muscle impressions.

Dorsal valve moderately concave or with flattened visceral disc and prominent trail. Dorsal interior with prominent cardinal process. Its base continues anteriorly over the whole visceral disc as thin, low, and sharp median septum. Adductor scars dendritic, feebly impressed, about 30 % as long as visceral disc and less than 25 % as wide as the valve. The scars in the posterolateral part bordered by a low ridges.

Ornamentation of ventral valve with prominent rugae, increasing in size anteriorly, numbering 9 to 12 in available valves. Along the midsector, the rugae may be folded posteriorly. Dorsal valve exterior with less distinct rugae, but evenly spaced over the valve. Radial ornamentation of fine rounded costellae of uniform size, 6–10 per 5 mm anteromedianly. Spines not preserved, but their bases are distinct along the hinge line of ventral valve.
Remarks: Genus *Fluctuaria* Muir-Wood – Cooper is characterised by a small to medium-sized shell with prominent rugae and costellate surface. The genus is widely spread from upper Tournaisian with a core distribution in Visean of Europe (Sarytcheva – Sokolskaya 1952, Muir-Wood – Cooper 1960, Nalivkin 1979). Unlike the type species *F. undata* (Defrance), the specimens from Libya are larger and broader. The species *F. undatiformis* erected by Nalivkin (1979) differs in being much smaller in size.

Superfamily Rhynchotrematoidea Schuchert, 1913
Family Trigonirhynchiidae Schmidt, 1965
Subfamily Trigonirhynchiinae Schmidt, 1965

Genus *Cupularostrum* Sartenaer, 1961

Type species: *Cupularostrum recticostatum* Sartenaer, 1961

Remarks: The genus *Cupularostrum* Sartenaer is a "basket" genus widely used by the same way as the genus *Camarotoechia* Hall – Clarke by previous authors. Upper Devonian and Carboniferous rocks yield a plea of species referred to these two genera worldwide (e.g. Sarytcheva – Sokolskaya 1952, Sarytcheva et al. 1963). Formal description of any new species of this genus is hampered by the difficulty in confrontation with previously, but generally non adequately described species. Therefore, we prefer an open taxonomic position of *Cupularostrum*-like rhynchonellids from the Djado sub-basin.

As a supplement to previously described species from the Devonian and early Carboniferous strata of the Murzuq Basin (Havlíček – Röhlich 1987, Mergl – Massa 1992), additional species, which may be accommodated

Fig. 6 1–11 – *Flexaria arkansana* (Girty, 1910): 1, 2, 5, 6 – ventral valve exterior, x1.5; 3, 7, 8, 11 – ventral valve exterior; 4 – ventral valve, x1.5; 9, 10 – dorsal valve exterior, x1.5; 12–16 – *Ovatia* sp.: 12, 13 – ventral valve exterior, x1.5; 14–16 – ventral valve exterior, x1.0; 17–19 – *Paurogastroderhynchus serdelesensis* (Massa, Termier et Termier, 1974): 17 – dorsal valve interior, x1.2; 18, 19 – internal mould of complete shell, x1.2. Samples: D936 (1–13), D311 (14–16), Q9 (17–19).

into the genus *Cupularostrum* Sartenaer are distinguished.

***Cupularostrum* sp.**
Fig. 6.1, 2, 5, 6, 9, 10

Age: Upper Tournaisian (sample D651) to Namurian (samples D967, B/D581).
Localities: Djado sub-basin, section 94, sample D651; section 95, B/D581; section 99, sample D967.

Material: Several dozen specimens.

Description: The medium-sized, 15–16 mm wide, dorsibiconvex shell has a rather transverse outline with conspicuous ventral and obtuse dorsal beaks. Ventral valve with distinct, rather narrow sulcus, dorsal valve with low fold. Anterior commissure uniplicate and conspicuously serrate. Each valve bear 17–19 coarse costae, ventral sulcus with three, rarely four to five costae, dorsal fold with four costae. Interior unknown.
Remarks: This species from sample D967 is externally similar to specimens from Tournaisian of the Kuznetsk Basin. The only Carboniferous species hitherto reported from SW Libya is *C. minutum* Mergl et Massa, which differs by a smaller size, by only one or two costae in ventral sulcus, and by about 12–14 costae in ventral valve.

Subfamily Hemitoechiinae Savage, 1996

Genus *Paurogastroderhynchus* Sartenaer, 1970

Type species: *Camarotoechia nalivkini* Abramian, 1957

***Paurogastroderhynchus serdelesensis* (Massa, Termier et Termier, 1974)**
Fig. 6.17–19

1939 *Camarotoechia neapolitana* (Whidborne): Borghi, p. 148, Pl. II, Figs 4, 6–8, 13–17.
1974 *Septacamera serdelesensis* nov. sp.; Massa, Termier – Termier, p. 166, Pl. I, Figs 1, 2
1992 *Paurogastroderhynchus serdelesensis* (Massa, Termier – Termier, 1974): Mergl – Massa, p. 70–71, Pl. 132, Figs 16–23.

Age: Upper Tournaisian.
Locality: Djado sub-basin, locality SE from Djado, sample Q9.

Description: See Mergl – Massa (1992).
Remarks: One complete shell, and one dorsal valve show the same morphology as specimens from the type locality near Serdeles (Mrar Formation, Upper Tournaisian). The occurrence in the Djado sub-basin indicates much extended geographical distribution of the species, which was hitherto known only from the western margin of the Murzuq Basin.

Superfamily Rhynchoporoidea Muir-Wood, 1955
Family Rhynchoporidae Muir-Wood, 1955

Genus *Rhynchopora* King, 1965

Type species: *Terebratula geinitziana* de Verneuil, 1845

***Rhynchopora magnifica* sp. nov.**
Fig. 7.3, 4, 7, 8, 11, 12, 17

Holotype: Dorsal valve, figured in Fig. 7:8,12, deposted in Lyon University collection, Lyon, France.
Type horizon: Lower Visean, the equivalent of the base of Mrar Formation.
Type locality: Djado Basin, section 91, sample D550.
Age: Upper Tournaisian, base of the Mrar Formation.
Localities: Djado sub-basin, section 91, samples D542, D550.
Material: Fifteen valves and numerous fragments.

Description: Shell dorsi-biconvex, with deeply uniplicate and serrate commissure, large, 23 mm wide in adults, thick-walled. Shell substance punctate.

Ventral valve broadly subpentagonal in outline, about 73 % as long as wide, with beak angle 110°. Maximum width at midlength. Lateral margins evenly rounded, anterior margin almost straight. Sulcus broad, occupying about 30 % of valve width, with flat bottom, tongue long, flattened, anteriorly truncate. Transverse profile gently convex, with flattened flanks, but a narrow strip along posterolateral part of the large valves is geniculate. Palintrope well defined but small. Delthyrium open in all specimens available. Ventral valve interior bears thin, relatively large dental plates, moderately diverging anteriorly and dorsally. Their bases limit the border of the sulcus, and anteriorly continue into low, gradually faded ridges. Their bases are 13 % as long as valve. Muscle impressions poorly defined, restricted to umbonal chamber, bounded laterally by dental plates, poorly differentiated, with adductor scars extending anteriorly as narrowly triangular scar. Inner shell surface with distinct internal ribbing except for umbonal region where radially disposed rows of low pustules are developed.

Dorsal valve broadly oval in outline, slightly shorter than ventral valve. The maximum depth at about two-third of the valve length. Periphery of large valves strongly geniculate. Sulcus distinct since midlength of the valve, about 30 % as wide as valve at front margin. Dorsal valve interior with deep septalium, anteriorly supported by high and thin septum, which disappears at midlength of the valve. Dental sockets narrow, very deep and widely diverging, almost paralelling the posterior margin. Septalium probably open. Muscle scars poorly impressed, with a pair of narrow adductor scars laterally to median septum at midlength of the valve

Ornamentation of coarse radial ribs originating at umbo and evenly increasing in a size anteriorly, well distinct over whole shell surface. The crests of the ribs rounded, the bottom of interspaces angular. The crests of the ribs of large specimens become flattened along shell periphery. Surface of interspaces in valve interior along anterior periphery of large shells project into high, lamellose extension.

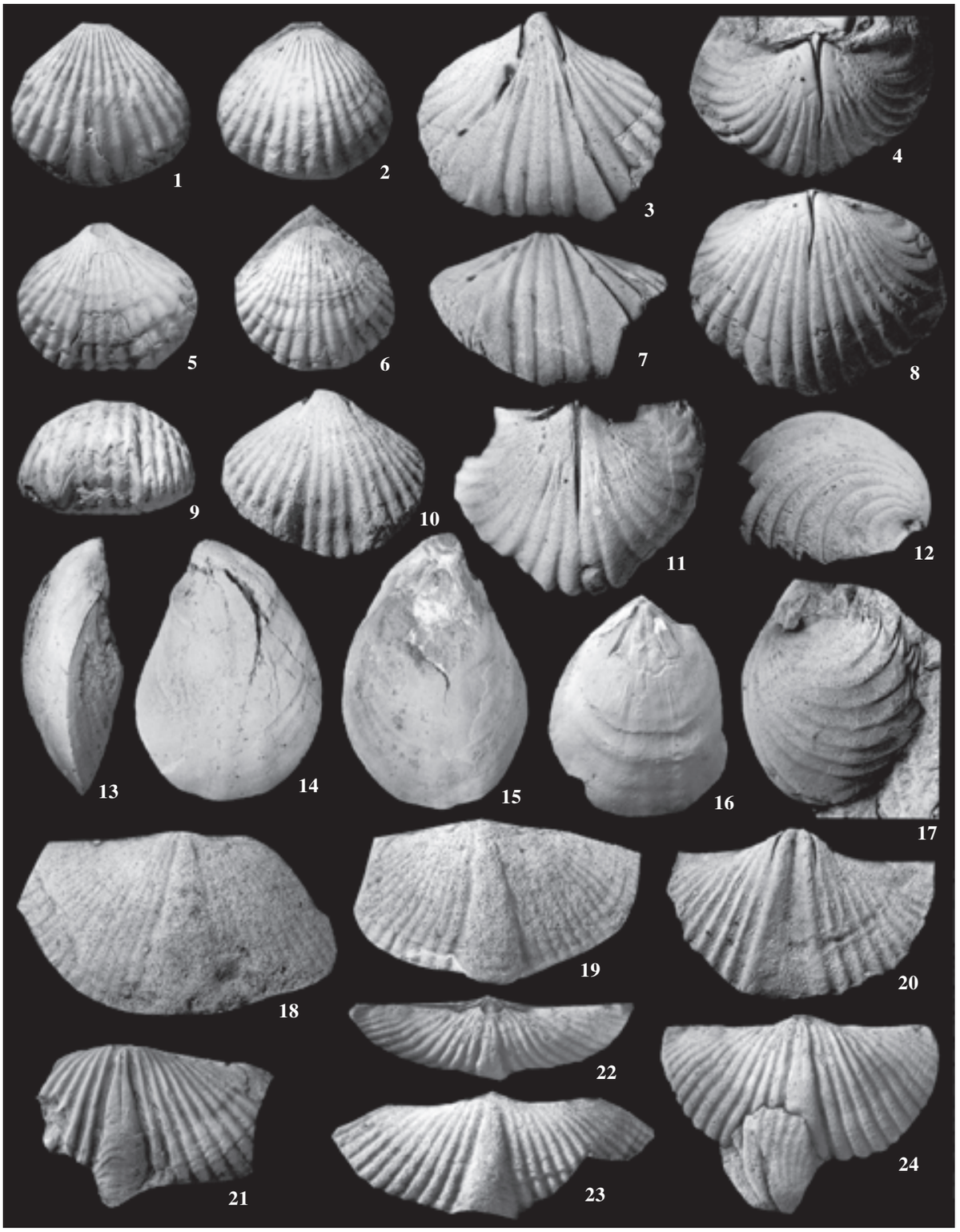

Fig. 7 1, 2, 5, 6, 9, 10 – *Cupularostrum* sp.: 1, 2 – complete shell exterior, x2.2; 5, 9 – complete shell exterior, x2.2; 6 – dorsal valve exterior, x2.2; 10 – internal mould of ventral valve, x2.2; 3, 4, 7, 8, 11, 12, 17 – *Rhynchopora magnifica* sp. nov.: 3, 7 – internal mould of ventral valve, x2.1; 4, 8, 12 – internal mould of dorsal valve, x2.1; 11, 17– internal mould of dorsal valve, x2.1; 13–16 – *Beecheria* aff. *verkhojanica* Abramov et Grigorjeva 1986: 13–15 – complete shell, x1.7; 16 – internal mould of dorsal valve, x1.7; 18, 19 – *Syringothyris* sp.: internal moulds of dorsal valves, x1.6; 20 – *Spinella paulula* Mergl et Massa 1992: internal mould of ventral valve, x5.6; 21–24 – *Syringothyris* cf. *ahnetensis* Legrand-Blain 1974: 21 – internal mould of dorsal valve, x1.7; 22, 24 – internal mould of dorsal valve, x1.7; 23 – internal mould of dorsal valve, x1.7. Samples: D 967 (1, 2, 5, 6, 9), D542 (3, 4, 7, 8, 11, 12, 17), D651 (10), D 645 (13–16), B639 (18, 19), R8 (20), D654 (21), D656 (22–24).

Endopunctation well developed over entire shell surface, distinct in original calcareous shell substance surface, but also evident by fine limonitic infillings normal to the surface of internal moulds, when calcareous matrix is removed.

Comparison: The shell is externally similar to *Rhynchopora triznae* Sokolskaya described in Sarytcheva et al. (1963) from Tournaisian of the Kuznetsk Basin. The new species differs by larger size and more distinct dorsal fold. *Rhynchopora persinuata* (Winchell) from the Kinderhook Formation differs from the new species by higher number of ribs in sulcus. The type species *R. geinitziana* (de Verneuil) differs by smaller, about half size. Carter (1988) gave a redescription of *Rhynchopora hamburgensis* Weller, which display high variability in outline, convexity and numerous ribs, but is about half size as new species. *Rhynchopora nikitini* Tschernyschew and *R. variabilis* Stuckenberg by Sarytcheva – Sokolskaya (1952) from the Moscow Basin differ by smaller size, and the former also by finer ribbing.

Superfamily Syringothyridoidea Fredericks, 1926
Family Syringothyrididae Fredericks, 1926

Remarks: Syringothyridids are common in the Lower Carboniferous, with many species worldwide (Weller 1914, Sarytcheva 1963, Abramov – Grigorjeva 1986 etc.). Several, commonly not well preserved syringothyridids have been reported from North Africa (Ficheur 1900, Douvillé 1909, Menchikoff 1930, Rossi 1939, Legrand-Blain 1970, 1974, Massa, Termier – Termier 1974, Havlíček – Röhlich 1987, Mergl – Massa 1992). Legrand-Blain (1970, 1974) gave descriptions or redescriptions of new or poorly known taxa and summarised their stratigraphical range and geographic distribution in the Saharan region. There, the syringothyridids are absent at the top of the Devonian. The Lower Tournaisian is characterised by *Syringothyris ahnetensis*, *Syringothyris* sp. 3 and *Verkhotomia* sp. Upper Tournaisian beds bear *Syringothyris folloti, S. sefiatensis* and *Histosyrinx vautrini*. The top of Tournaisian and lower Visean bear few syringothyridids and all known species belong to *Syringothyris* and *Histosyrinx.* The upper Visean is characterised by morphologically conspicuous species *Syringothyris jourdyi*; its upper stratigraphic range reaches the early Namurian.

Genus *Syringothyris* Winchell, 1863

Type species: *Syringothyris typa* Winchell, 1863

Syringothyris jourdyi jourdyi Douvillé, 1909
Fig. 8.1–14

1974 *Syringothyris jourdyi* Douvillé; Massa, Termier – Termier, Text-Pl. 3, Figs 7–9; Pl. 9, Figs 2–5.

Age: According Legrand-Blain (1970), the species ranges into lower Namurian (El Guelmouna Formation). In the Murzuq-Djado area, the species is known from the lower part of the Assedjefar Formation (upper Visean to lower Namurian).

Localitites: Djado sub-basin, section 89, sample B675, and SE Murzuq basin, section Fo14, sample NC8.

Synonymy: See Legrand-Blain (1970).

Material: One complete specimen, four dorsal and nine ventral valves, all favourably preserved in a sandstone.

Description: Specimens derived from western flank of the Murzuq Basin attain 80 mm width, and all display weak asymmetry. The shell is rather thin, even in the posterior part.

Ventral valve is hemipyramidal, strongly transverse, with obscuring or missing mucronations. Lateral profile weakly convex. Sulcus rapidly extends anteriorly, with borders subtend 30–35° angle, with flat bottom, dorsally elongated into very short tongue. Ventral interarea distinctly procline, flat or slightly concave apically, with large open delthyrium. The sides of delthyrium subtend 35–40° angle. Each side of delthyrium marked by narrow deep groove. Dethyrial cover not preserved. Ventral interior with long syrinx (Fig. 8:7, 11), dental plates short.

Dorsal valve transversely subpentagonal in outline, gently convex in midsector, and with flattened flanks in transverse profile. Maximum convexity umbonally in lateral profile. Beak inconspicuous. Interarea apsacline, low and weakly concave. Dorsal valve interior with large and deep dental sockets. Cardinal process large, transverse, comb-like. Crural bases massive, short. Internal ribbing distinct along valve periphery but obsolete apically.

Ornamentation of weak, flat costae, increasing in size toward front margin and laterally rapidly diminishing in size. Some 22–25 costae on each flank are distinct in well preserved valves. Sides of sulcus bear one or two pairs of weak plications. Concentric ornamentation of fine growth lines and more prominent growth lamellae, generally 3–5 in adults. Surface of interarea with distinct growth lines parallel to posterior margin, crossed by fine and tightly packed vertical striae; the latter are absent in marginal areas.

Comparison: Type species and both subspecies have been described in detail by Legrand-Blain (1970). The morphology of our valves is the same as specimens referred to the subspecies *Syringothyris jourdyi jourdyi* Douvillé by Legrand-Blain (1970). *Syringothyris jourdyi jourdyi* is a common taxon in the upper Visean and the lower Namurian of Western Sahara (Saoura, Reggane and Illizi regions). The localities situated in the western flank of Murzuq Basin (Massa, Termier – Termier 1974) and its presence in the Djado sub-basin are its most eastward known occurrence in North Africa. However, a syringothyridid figured and referred to *Syringothyris cuspidata* Martin by Kora (1995) from the Um Bogma Formation (Visean) of Sinai may belong to this species; its ventral interarea is also extremely high as well as in *S. jourdyi jourdyi* Douvillé.

Legrand-Blain (1970) gave detail description of the species and listed differences between *S. jourdy*i Douvillé and *Syringothyris cuspidata* (Martin). She noted the close relation of *S. jourdyi* to North American *S. typa*

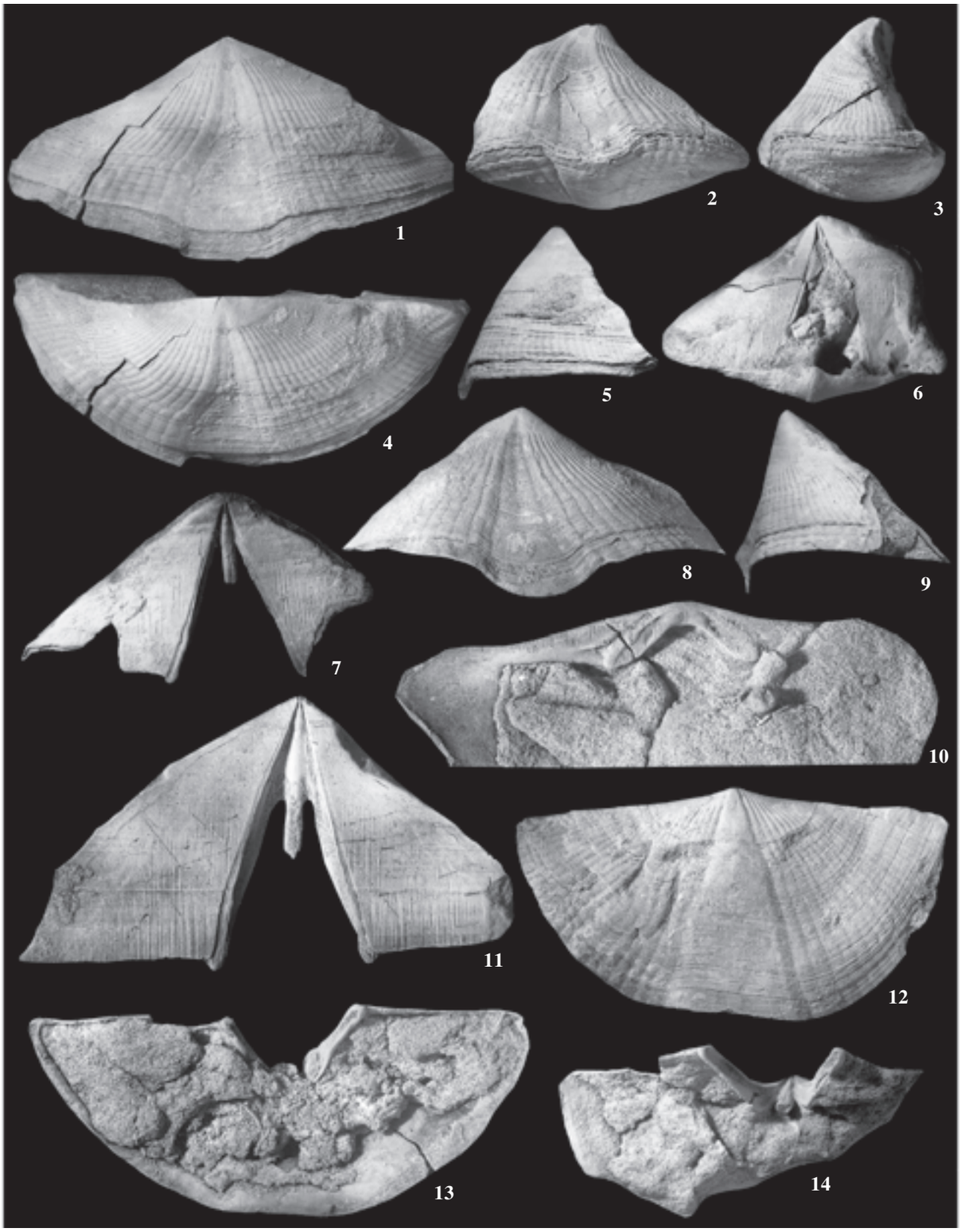

Fig. 8 1–14 – *Syringothyris jourdyi jourdyi* Douvillé, 1909: 1, 4, 5, 13 – ventral valve, x1.2; 2, 3, 6 – complete strongly asymmetric shell, x1.2; 7, 14 – incomplete ventral valve, x1.2; 8, 9 – ventral valve, x1.2; 10 – dorsal valve interior, x1.2; 11 – interarea of ventral valve; 14 – exterior of dorsal valve, x1.2. Sample: NC 8

Winchell and *S. hannibalensis* (Swallow). *Syringothyris texta* (Hall) differs by lower ventral interarea and more convex dorsal valve (Legrand-Blain 1970), more extended mucronations, more distinct lateral costae and less procline ventral interarea.

Syringothyris cf. *ahnetensis* Legrand-Blain, 1974

Fig. 7.21–24

cf. 1974 *Syringothyris ahnetensis* nov. sp.: Legrand-Blain, p. 100, Pl. I, Figs 1–3.
1992 *Syringothyris* sp. A; Mergl – Massa, p. 94, Pl. 24, Figs 15–18.

Age: Upper Tournaisian, basal Mrar Formation.
Localities: Djado sub-basin, section 94, samples D654, D655, D656.
Material: Five internal moulds of dorsal valves, four ventral valves and numerous fragments, well preserved in a fine sandstone.

Descriptions: Shell of moderate size, the largest specimen 50 mm wide.

Ventral valve hemipyramidal, steeply sloping anteriorly from the umbo. Sulcus deep, weakly widening anteriorly, extending into long tongue. Interarea procline, apically concave in lateral profile. Sides of delthyrium subtend about 30° angle. Perideltidium distintcly bordered. Ventral interior with short, thin and widely divergent, extrasinal dental plates posteriorly bounding weakly impressed ventral muscle field. Median septum absent, an incipient myophragm bisects posterior part of ventral muscle field. Structure of syrinx unknown.

Dorsal valve strongly transverse, maximum width immediately anterior to hinge line, rather convex in lateral profile. Transverse profile gently convex including the very lateral portion of the valve. Cardinal extremities rounded. Dorsal fold prominent, highly raised above lateral slopes. Dorsal valve interior with narrow, widely divergent dental sockets, incipient crural bases and transverse, comb-like cardinal process. A weak median ridge extends to the midlength of the valve.

Exterior with 12 to 14 strong, rounded costae, separated by deep interspaces, distinct over entire lateral sides. Fold and sulcus smooth. Concentric ornamentation formed by a few growth lamellae and much finer lines. Microornamentation on the ventral sulcus consists of flat, elongate and rectangular pustules, separated by narrow, short, and deep interspaces.

Remarks: New material probably represent the same species as described and illustrated by Mergl – Massa (1992) as *Syringothyris* sp. A. Newly gathered shells are of medium size, have procline ventral interarea and short, strongly divergent extrasinal dental plates. The typical specimens of *S. ahnetensis* Legrand-Blain also possess the rounded cardinal extremities, procline ventral interarea, prominent rounded costae and conspicuous, smooth sulcus and fold. The only difference is higher number of costae; typical specimens possess 16–20 costae (Legrand-Blain 1974) while our specimens possess only 12–14 costae. The age of our specimens (basal Mrar Fm., Upper Tournaisian) is roughly the same as typical *S. ahnetensis* (Lower Tournaisian). Otherwise externally similar species *S. hannibalensis* (Swallow) differs by more numerous costae. Specimens from the Lower Tournaisian (Taidonskyi Horizon) of the Kuznetsk Basin, referred to North American *S. hannibalensis* by Sarytcheva et al. (1963) probably belong to a different species (Legrand-Blain 1974), but they are remarkably similar to our material. The dorsal valves of the Kuznetsk species "*S. hannibalensis*" also have only 14–15 costae on each side of dorsal valve and rounded cardinal extremities.

Syringothyris cf. *folloti* Legrand-Blain, 1974

cf. 1974 *Syringothyris ahnetensis* nov. sp.: Legrand-Blain, p. 106, Pl. II, Figs 3–10.

Age: Upper Tournaisian.
Locality: Djado sub-basin, sample F404.
Material: Two deformed valves, preserved as internal moulds in sandstone.

Remarks: Both valves are strongly deformed, but their large size (more than 55 mm width, presence of apsacline ventral interarea and shallow and wide ventral sulcus are characteristic. There are about 20 costae on each flank. Ventral interior with strong, long and weakly divergent dental plates. Ventral muscle impressions weak.

Specimens are similar to *S. folloti* Legrand-Blain by less transverse outline, apsacline and apically concave ventral interarea and long dental plates, but both internal moulds differ by less divergent bases of dental plates and elongate instead of subcircular ventral muscle field.

Syringothyris sp.

Fig. 7.18, 19

Age: Upper Visean.
Locality: Djado sub-basin, section 89, sample B639.
Material: Six dorsal valves, poorly preserved in a sandstone.

Remarks: The valves are similar to *S.* cf. *ahnetensis* Legrand-Blain, but differ by more numerous lateral costae (the largest available valve haves 19 laterally rapidly diminishing costae on each flank), and acute cardinal extremities, while *S.* cf. *ahnetensis* haves rounded cardinal extremities.

Family Delthyrididae Waagen, 1883
Subfamily Spinellinae Johnson, 1970

Genus *Spinella* Talent, 1956

Type species: *Spinella buchanensis* Talent, 1956

Spinella paulula Mergl et Massa, 1992

Fig. 7, Fig. 20

1992 *Spinella paulula* sp. nov.; Mergl – Massa, p. 77–78, Pl. 15, Figs 10–18.

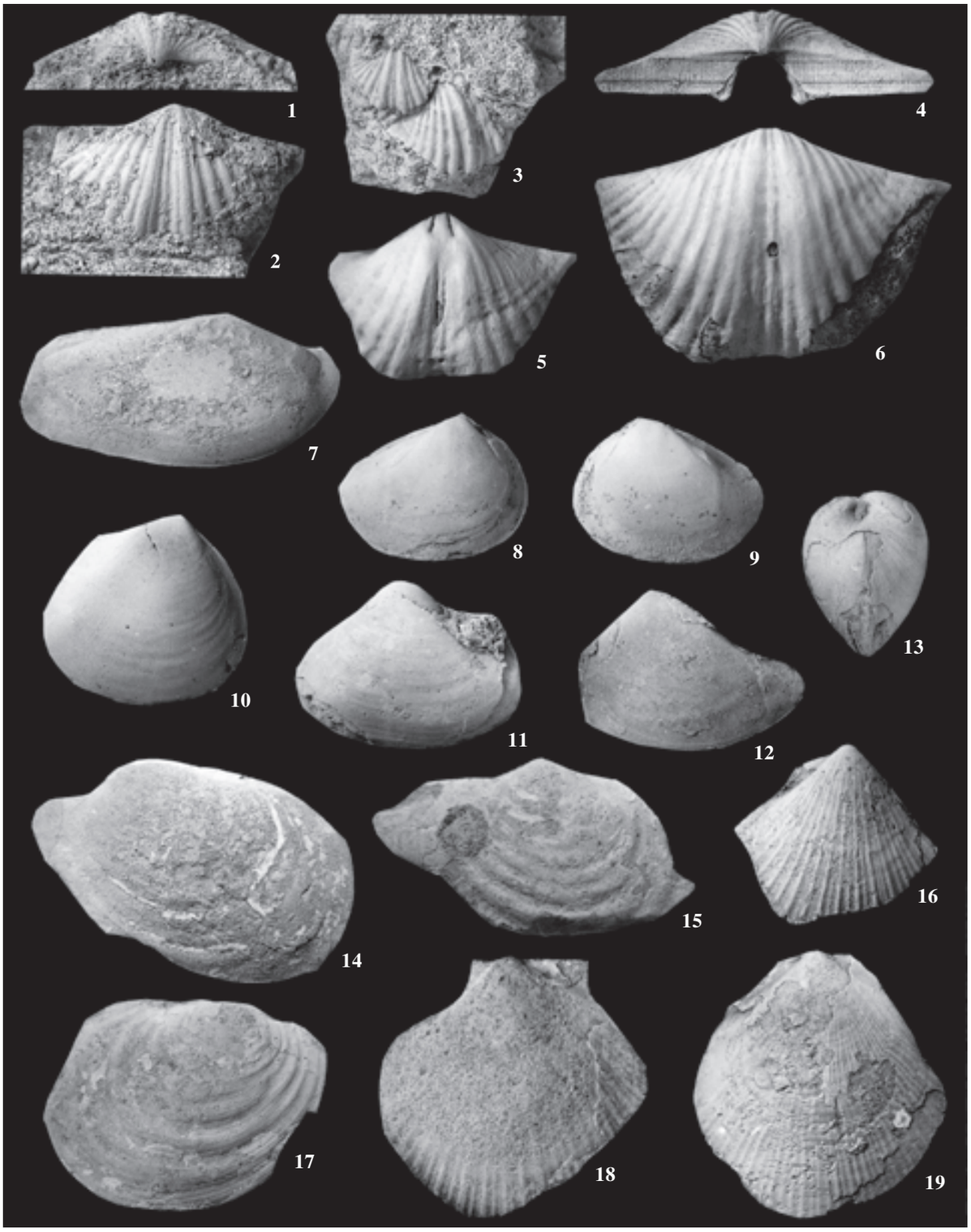

Fig. 9 1–6 – *Anthracospirifer* gr. *curvilateralis* (Easton, 1962): 1, 2 – exterior of ventral valve, x2.0; 3 – two small ventral valves, x2.0; 4–6 – two abraded ventral valves, x2.0; 7 – *Spathella* sp.: internal mould of right valve; 8–13 – *Schizodus* sp.: 8, 9 – internal mould of complete shell, x2.0; 10 – internal mould of right valve, x2.0; 11, 13 – exterior of left valve and anterior view of complete shell, x2.0; 12 – interior of left valve, x2.0; 14, 15, 17 – *Posidoniella* sp.: 14 – left valve, x2.0; 15 – right valve, x2.0; 16 – right valve, x2.0; 16, 18, 19 – *Pectenidae* gen. et sp. indet.: right valve, x2.4; right valve, x1.6; left valve, x2.4. Samples: D 309 (1–6), M56 (7,14,15,18), D250 (8–10,16), D967 (11–13), M54 (17), D303 (19).

Age: Emsian, Ouan Kasa Formation.
Locality: Niger, SW Djado Basin, section 8, sample R8, R9.
Material: Two slabs with several valves and some fragments.

Description: See Mergl – Massa 1992.
Remarks: Specimens are morphologically identical with shells collected in the Gour Iduka type section of western margin of the Murzuq Basin and are associated with the same fossils.

Family Spiriferidae King, 1946
Subfamily Prospirinae Carter, 1974

Genus *Anthracospirifer* Lane, 1963

Type species: *Anthracospirifer birdspringensis* Lane, 1963

***Anthracospirifer* gr. *curvilateralis* (Easton, 1962)**
Fig. 9.1–6

cf. 1986 *Anthracospirifer* gr. *curvilateralis* (Easton, 1962): Legrand-Blain, p. 42, Pl. 3, Figs 2–8.

Occurrence: Namurian.
Locality: Djado sub-basin, section 72, sample D223; section 70/71, samples D308, D309.
Material: Eight ventral valves (mostly abraded) and one external mould of dorsal valve.

Remarks: External morphology of our material is identical to specimens assigned by Legrand-Blain (1986) to the species *A.* gr. *curvilateralis* (Easton). Available shells are weakly mucronate, with bifurcating lateral costae, and five costae in ventral sulcus. *Anthracospirifer libycus* (Massa, Termier et Termier) from the Bashkirian (Assedjefar Formation) differs from our specimens by more frequently branching lateral costae, while our specimens only rarely show dichotomous branching.

Superfamily Dielasmatoidea Schuchert, 1913
Family Heterelasminidae Likharev, 1956

Genus *Beecheria* Hall et Clarke, 1893

Type species: *Beecheria davidsoni* Hall – Clarke, 1893

***Beecheria* aff. *verkhojanica* Abramov et Grigoryeva, 1986**
Fig. 7.13–16

Age: Upper Visean or base of Namurian, Assedjefar Formation.
Locality: Djado sub-basin, section 89, sample B675.
Material: One shell, one dorsal and one ventral valve.

Description: Shell equally biconvex, with elongate outline with width maximum anterior to midlength, length of species ranges between 25–28 mm. Anterior commissure weakly antiplicate, but plications poorly developed. Pedicle collar distinct, foramen mesothyridid. Dental plates well developed, gently diverging. Dorsal interior with imperforate cardinal plate, with V-shaped inner and outer hinge plates. Median ridge weak, resting on median plate which bears impression of muscles. Posterior adductors are deeply impressed while anterior paired scar is larger but having obscure borders. Cardinal process with radially diverging fine ridges, located at the posterior of cardinal plate.
Remarks: The species has some characteristic features of *Beecheria* Hall et Clarke, mainly V-shaped hinge plates and well-developed dental plates. From the revision of *B. hastata* (J. de C. Sowerby) given by Brunton (1982) is evident, that interiors of *B. hastata* and *B.* sp. are rather similar, but *B.* sp. has antiplicate commissure and a less convex profile. Sarytcheva el al. (1963) described several species of the genus *Beecheria* from Tournaisian and Visean of the Kuznetsk Basin, with species *B. khalfini* Besnosova in size and shape near to the Libyan specimens. Unlike the species from the Kuznetsk Basin, the species *Beecheria* aff. *verkhojanica* is distinct by well developed radial plications and less elliptical outline of the shell.

Abramov – Grigoryeva (1986) described from the Tchugutchansk Beds (Upper Visean) of the Verkhojansk area (NE Asia) new species *B. verkhojanica*, which is very similar in the size, shape, and convexity to Djado specimens. Nevertheless, the latter differ by three weak plication and weakly antiplicate commissure.

Superfamily Modiomorphoidea Miller, 1877
Family Modiomorphidae Miller, 1877

***Spathella* Hall, 1885**

Type species: *Spathella typica* Hall, 1885

***Spathella* sp.**
Fig. 9.7

Age: Lower Namurian.
Locality: Djado sub-basin, section 32/34, sample M56.
Material: Single valve.

Remarks: The single available internal mould is 30 m long, 50 % as high as long, extremely elongate posteriorly, with an edentulous hinge line, evenly convex moderate convex, with small umbone at anterior third, directed anterodorsally. Interior of right valve with ovoid anterior adductor scar and narrow, much longer posterior adductor scar. Valve is similar to forms generally referred to the genera *Spathella* Hall, *Lithophaga* Bolten and *Sphenotus* Hall, but confirmation of generic affinity needs additional material.

Genus *Schizodus* de Verneuil et Murchison, 1884

Type species: *Axinus obscurus* J. Sowerby, 1821

***Schizodus* sp.**
Fig. 9.8–13

Age: Namurian.
Locality: Djado sub-basin, section 73, sample D250; section 99, sample D967.
Material: Two complete shells, one left and two right valves.

Remarks: Shell about 30 mm long, 85–90 % as high as long, equivalved, inequilateral, umbones subcentral to anterior, directed dorsally. Valves rather convex, flattened ventrally. Hinge characters and dentition unknown. Interior with weakly impressed, smaller, elongate anterior adductor scar and almost linear posterior adductor scar. Pallial line entire, visceral area bears fine radial striation. Exterior with fine, obscure growth lines.

Species is externally similar to the Mississippian species *S. chesterensis* Meek et Worthen and *S. depressus* Worthen; unlike Libyan species, both species show more erect beaks (Hoare et al. 1989, Hoare 1993).

Superfamily Pectinoidea Rafinesque, 1815

***Pectinidae* gen. et sp. indet.**
Fig. 9.16, 18, 19

Age: Upper Visean to Lower Namurian.
Localities: Djado sub-basin, base of section 30, sample D303; section 32/34, sample M56; section 73, sample D250.

Remarks: Three incomplete valves (probably representing three separate species) have distinct radial ribbing. The largest, rather flat valve (Fig. 9.18), is 29 m long and bears flattened, rounded ribs. The second, smaller valve (Fig. 9.19) has fine, flattened radial ribs crossed by coarser, subangular ribs.

Superfamily Mytiloidea Rafinesque, 1815
Family Myalinidae Frech, 1891

Genus *Posidoniella* de Koninck, 1885

Type species: *Inoceramus vetustus* Sowerby, 1829

***Posidoniella* sp.**
Fig. 9.14, 15, 17

Age: Namurian.
Localities: Djado sub-basin, section 32/34, samples M54, M56.
Material: Five right and six left valves, several fragments.

Description: Shell 40 mm long, thin-walled, equivalved, inequilateral, with maximum height at posterior third. Beak prominent, anterior, weakly extended over hinge line.

Interior devoid of any distinct muscle impressions. Exterior of fine growth lines superimposed on regularly spaced conspicuous concentric rugellae.
Remarks: Species may by its thin shell, convexity and rugose concentric ornamentation by well referred to the genus *Posidoniella* Bronn. This genus is broadly distributed in marine sediments of Visean-Namurian age worldwide in Europe, Siberia and North America (Hind 1896–1900, Jackson 1927, Betekhtina 1979).

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Brachiopodi a mlži devonu a karbonu dílčí pánve Djado (severní Niger, jz. Libye)

V práci je popsána omezená kolekce brachiopodů a mlžů pocházející z dílčí pánve Djado (=jižní část murzucké pánve v jz. Libyi a severním Nigeru). Celkem dvacet druhů brachiopodů (většinou produktidních a spiriferidních) a šest druhů mlžů bylo rozlišeno v dostupném materiálu. Jeden druh brachiopoda je popsán jako nový (*Rhynchopora magnifica* sp. nov.). Brachiopodi, zejména produktidní, jeví zřetelné vztahy k faunám Severní Ameriky.