

New record of a Middle Devonian brachiopod fauna from the Northern Arabian Plate, Zap Anticline, Çukurca-Hakkari, Southeastern Turkey

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Brachiopods recently collected from the Zap River Valley area (SE Turkey) allow to establish a Middle Devonian (upper Givetian) age for the upper middle part of the Yığınlı Formation which was until now considered as Famennian on the basis of its micropaleontological contents and of its relative position in the series. • Key words: brachiopods, Devonian, Yığınlı Fm., Turkey.

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Geological and stratigraphic setting

The study area is located in southeastern Anatolia, along the northern margin of the Arabian plate of Gondwana (locality situated on the Northern limb of the Çukurca anticline, in Zap River Valley, Southeastern Turkey, GPS 37°17' N, 43° 30' E, Yığınlı Formation, approximate elevation 1280 m). A previous work on this area was conducted during the field-mapping projects of the Turkish Petroleum Company (Perinçek 1980). In southeastern Turkey, Devonian rocks crop out in the Hakkari Province, between the towns of Hakkari and Çukurca which are situated close to the Iran and Iraq borders and now accessible (Yalçın & Yılmaz 2010; Fig. 1). In the Hakkari area, the dominant Devonian-Lower Carboniferous lithology consists in brackish to marine, grey-black shale and shallow marine limestone (Bozdoğan & Ertuğ 1997, Yılmaz & Duran 1997). The outcrops are still poorly known from a palaeontological point of view due to the difficulty to obtain access to this region in the past (Hoşgör *et al.* 2011, Webster & Hoşgör, submitted).

Between Hakkari and Çukurca the Zap River incised a deep valley exposing two inliers of Cambrian and Ordovician deposits, mostly clastic, that form part of the Arabian Platform (Ghienne *et al.* 2010). Dean *et al.* (1981) demonstrated that shales and sandstones of Late Cambrian and Early Ordovician age representing the Seydişehir Formation described from the western

Taurus Mts, are widespread in the eastern Taurus, southeastern Turkey, and neighboring parts of Iraq. Disconformably overlying strata, mainly shales and siltstones, were named the Şort Tepe Formation and shown to be of Ashgillian age (Late Ordovician) (Dean & Zhou 1988, Ghienne *et al.* 2010). In the Zap Valley the thick Seydişehir Formation is unconformably overlain by a Lower and Upper Paleozoic succession comprising four formations, that are in ascending order: the Upper Ordovician Şort Tepe Formation, the Devonian Yığınlı Formation, the Upper Devonian-Lower Carboniferous Köprülü Formation and the Upper Permian Gomanibrik Formation (Harbol limestones) (Köylüoğlu & Altın 1989, Bozdoğan & Ertuğ 1997, Yılmaz & Duran 1997, Higgs *et al.* 2002, Hoşgör *et al.* 2011; Fig. 2).

The Yığınlı Formation, named by Açıkbaz (1978), consists of pink, dark red-coloured, cross-bedded, quartzitic sandstones, which occasionally alternate with yellowish green, grey mudstones and shales. Its thickness in the Hakkari-Çukurca area is between 200–295 m (Perinçek *et al.* 1991, Yalçın & Yılmaz 2010). Tunbridge (1988) in a sedimentological analysis, interpreted the Yığınlı Formation as a Famennian-age regressive-transgressive fluvio-deltaic clastic wedge and recognized five members within it. In ascending order the members include: dolomite and red shales, sandstones and grey shales, red sandstones and siltstones, sandstones and gray shales, and carbonates and grey shales.

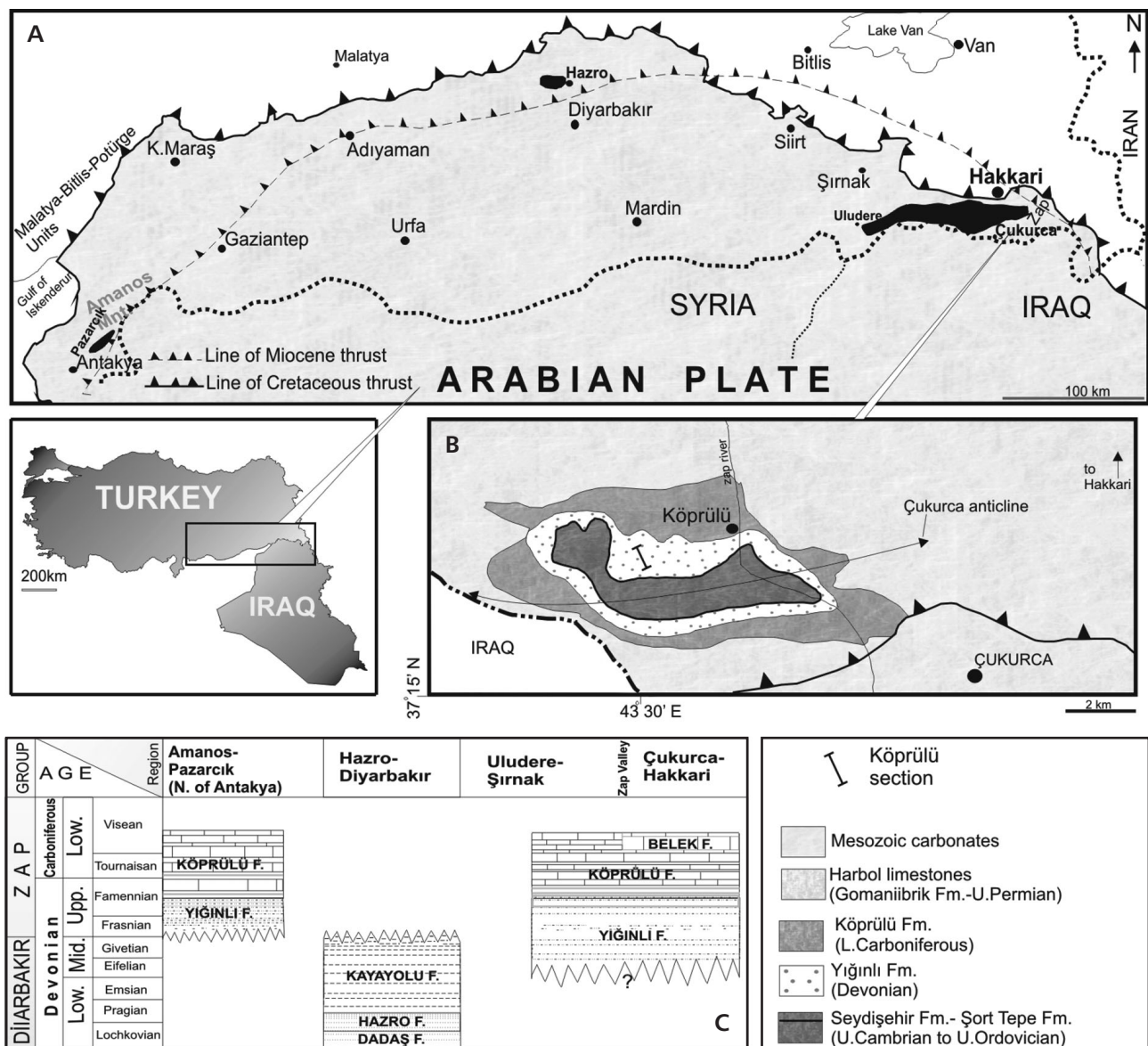


Figure 1. A – sketch map of Turkey showing location of the studied area on the North Arabian Plate. • B – geological map of the Zap Valley showing the position of the studied section. • C – generalized stratigraphic sections of the Devonian to Carboniferous rocks in southeastern Turkey (after Janvier *et al.* 1984, Hoşgör *et al.* 2011, Yılmaz & Duran 1997, Webster & Hoşgör, submitted).

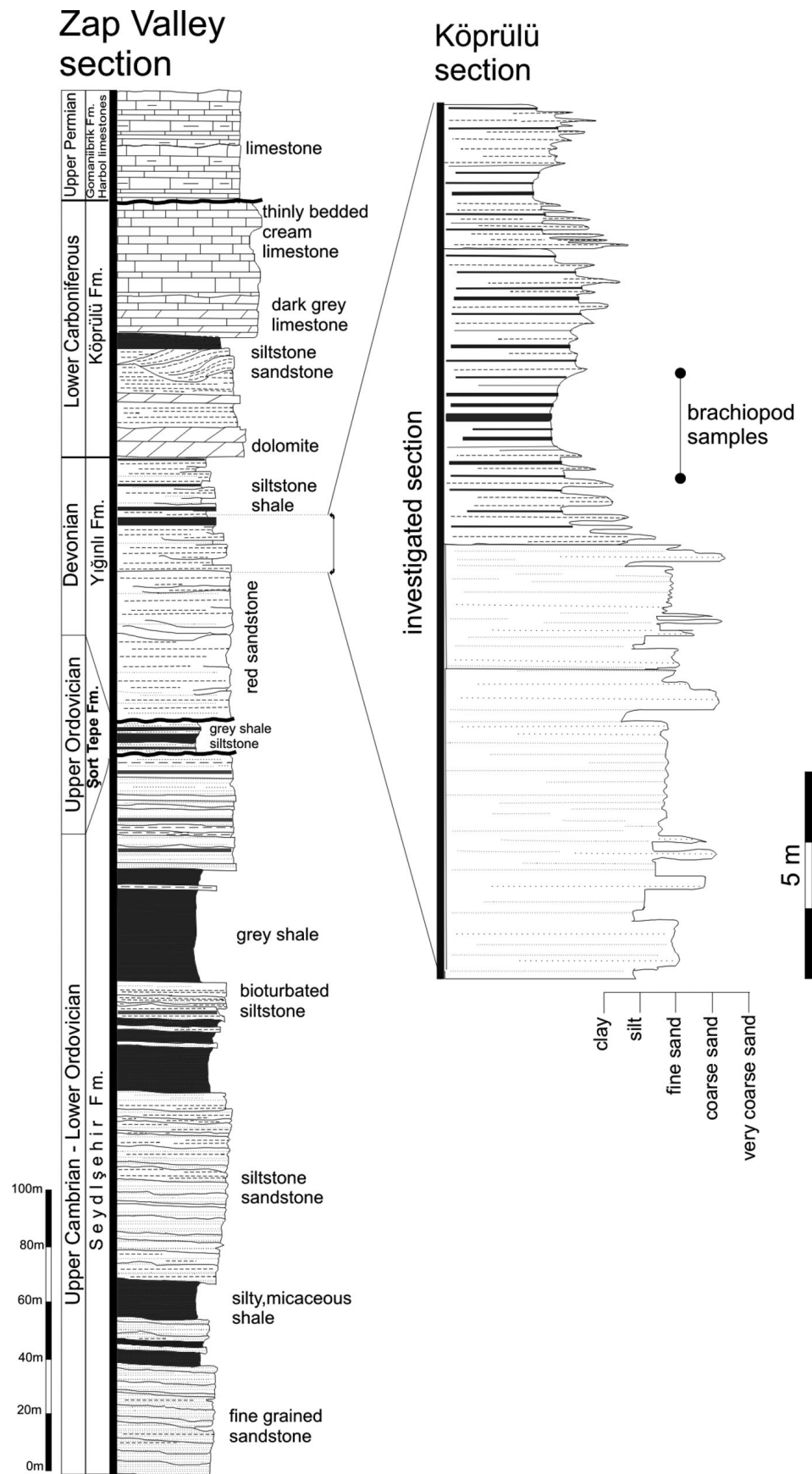
The fossil remains were discovered during field works undertaken by one of us (I.H.) in May 2010. The fossil material found in the Yığınlı Formation is scarce. Studied brachiopods come from shell concentrations of various thicknesses, some of which are clay-silt horizons. Most fossils, including the brachiopods, are well preserved in the middle part of the Köprülü section (Fig. 2). Echinoderms of similar age have been recently reported from the Şort Dere section (Webster & Hoşgör, submitted), located southeastern of the Köprülü section. So far, Devonian sequences were characterized by miospore taxa indicating a Famennian age and fish remains suggesting a Strunian age for the upper part of the Yığınlı Formation (Higgs *et al.* 2002,

Janvier *et al.* 1984) and the only mention of the presence of Middle and Upper Devonian brachiopods in SE Turkey concerned the Kayayolu Fm., in the Hazro area, about 200 km northwest of the zone studied here (Tolun 1949, Lebküchner 1976).

Systematic palaeontology

Although the material described below is generally well preserved (complete shells), each taxon, as mentioned above, is represented by few specimens, so that internal structures were not investigated. Such an examination would have led

Figure 2. Stratigraphic column of the studied units with detailed succession in the Köprülü section (after Janvier *et al.* 1984, Ghienne *et al.* 2010).



to the destruction of the specimens at hand. Further sampling in the area should allow more precise assignments and bring new light on Devonian faunas of Southeastern Turkey.

The material is housed in the Laboratoire de Paléontologie de Brest (LPB), Université de Bretagne Occidentale (France).

Order Productida Sarytcheva & Sokolskaya, 1959
Suborder Chonetidina Muir-Wood, 1955
Superfamily Chonetoidea Bronn, 1862
Family Chonetidae Bronn, 1862
Subfamily Dagnachonetinae Racheboeuf, 1981

Genus *Dagnachonetes* Afanas'eva, 1978

Dagnachonetes? sp.

Figure 3A–D

Material. – 2 ventral valves from level B6. No. LPB 19396.

Description. – The shell is small, slightly wider than long (length \approx 10 mm, width \approx 12 mm), convex (height \approx 5 mm) with a subtrapezoidal transverse section. The hinge is shorter than maximum width that is located approximately at mid-length. Numerous, very fine costellae covering the entire shell surface (about 80–90 costellae near the commissure), all identical in size and strength (no differentiated median costellae). New costellae appear either by intercalation or dichotomy. Very fine concentric fila can be seen locally on the shell, superposed to the radial ornament.

Interior unknown.

Remarks. – Due to the lack of dorsal valve and the impossibility to observe interior features, a generic assignment is very uneasy. Nevertheless, the micro-ornament of the shell and its overall shape is very reminiscent of *Dagnachonetes*, a genus known in the Middle Devonian (Eifelian–Givetian) of Europe, Russia and China.

Order Atrypida Rzhonsnitskaia, 1960
Suborder Atrypidina Moore, 1952
Superfamily Atrypoidea Gill, 1871
Family Atrypidae Gill, 1871
Subfamily Spinatrypinae Copper, 1978

Genus *Isospinatrypa* Struve, 1966

Isospinatrypa aspera Schlotheim, 1813

Figure 3E–I

Material. – 2 complete specimens from level B5. No. LPB 19395.

Description. – The shell is small (length \approx 18 mm, width \approx 18.5 mm), shield shaped to elongate, dorsibiconvex (Hd/Hv \approx 1.5), with a transapical foramen and a relatively short hinge, the maximum width being located at mid-length. Beak poorly developed. Delthyrium not visible. The anterior commissure is weakly plicate. Costae strong, rounded, about 15 on the entire shell dichotomizing near the commissure (3–4 costae per 5 mm there). Median costa slightly stronger and higher than lateral ones, dividing in early growth stage, each branch dividing again near the commissure. Growth lamellae relatively regularly spaced, bearing very fine concentric fila, and anteriorly developed in frills and hollow spines present on both valves.

Interior unknown.

Remarks. – The presence of well-developed frills and spines pleads in favor of an assignment to Spinatrypinae. The small size, general shape and slightly elevated median ribs are consistent with an assignment to *Isospinatrypa*, although interior remains unknown. The genus is known from the ?Lochkovian to the lower Givetian, worldwide. The general aspect of the shell, particularly the strong costae and the ornament is consistent with an assignment to the species *I. aspera* that is present *sensu lato* in upper Eifelian to Givetian deposits worldwide.

Subfamily Variatrypinae Copper, 1978

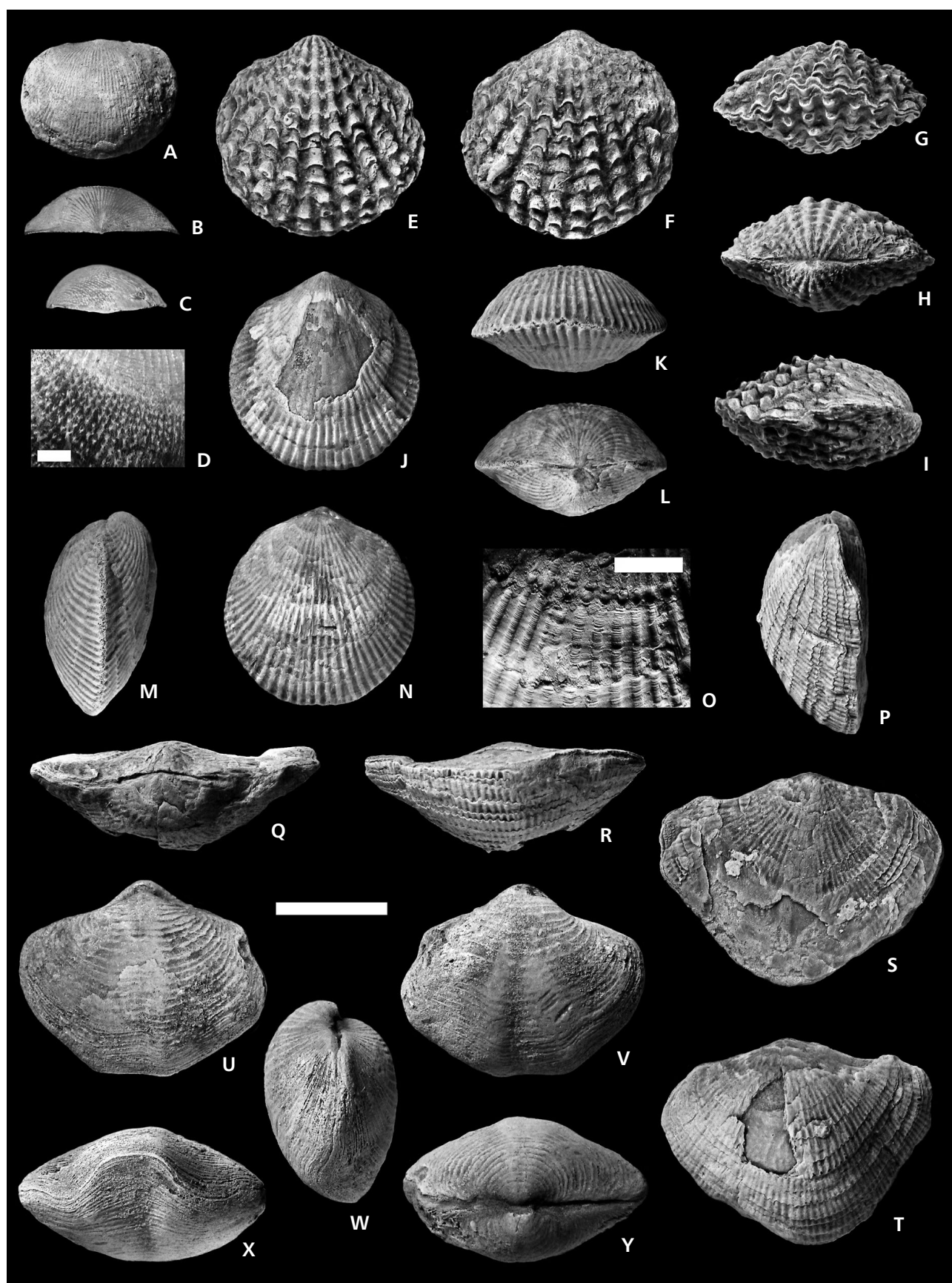
Genus *Variatrypa* Copper, 1966

Variatrypa sp.

Figure 3P–T

Material. – 1 complete specimen from level B7. No. LPB 19397d.

Figure 3. All specimens from KöprülÜ section, Yİğİnli Formation, SE Turkey. Scale bar = 1 cm, unless otherwise indicated. • A–D – *Dagnachonetes?* sp. Ventral, posterior and lateral views of a ventral valve; D – detail of the ornament (scale bar = 1 mm). LPB 19396a. • E–I – *Isospinatrypa aspera* Schlotheim, 1813. Ventral, dorsal, anterior, posterior and lateral views of a complete specimen. LPB 19395a. • J–O – *Desquamatia?* sp. Ventral, anterior, posterior, lateral and dorsal views of a complete specimen; O – detail of the concentric ornament (scale bar = 5 mm). LPB 19397a. • P–T – *Variatrypa* sp. Lateral, posterior, anterior, ventral and dorsal views of a complete specimen. LPB 19397d. • U–Y – *Athyris concentrica* (von Buch, 1834). Dorsal, ventral, lateral, anterior and posterior views of a complete specimen. LPB 19393a.



Description. – Shell of medium size, shield shaped to subtriangular, transverse (length = 18.5 mm, width = 24 mm), strongly dorsibiconvex with a long straight hinge. Maximum width slightly anterior to hinge. The dorsal valve is strongly convex, the ventral one almost plane (Hd/Hv = 5). The anterior commissure is rectimarginate. Numerous radial, very fine costae (about 80 costae on the commissure). The growth lamellae are weak, irregularly spaced and do not interrupt radial ornament, excepted near the anterior commissure where they develop short frills. They apparently bear traces of concentric fila but the shell surface is poorly preserved and this could be an artifact. The foramen is not exposed, hidden by the dorsal beak. Both ventral and dorsal areas are poorly developed.

Interior unknown.

Remarks. – The general shape of the shell, very long hinge, fine costae and the possible presence of concentric fila are consistent with an assignment to *Variatrypa*, despite the fact that the commissure is rectimarginate and interior features unknown. *Variatrypa* is cosmopolitan, present from the Emsian to the ?Frasnian. No known species presents a combination of characters similar to that observed in our material (subtriangular outline, almost flat ventral valve, etc.).

Genus *Desquamatia* Alekseeva, 1960

Desquamatia? sp.

Figure 3J–O

Material. – 3 complete valves from level B7. No. LPB 19397a–c.

Description. – Shell small, subcircular to slightly elongate (length = 17 mm, width = 16 mm), equivalve to slightly dorsibiconvex (Hd/Hv ≈ 1) with a short hinge. Both valves are poorly elevated. Anterior commissure rectimarginate. Ventral and dorsal areas low. Foramen transapical. Numerous, very fine costae appearing by dichotomy (about 50–60 costae in the vicinity of the commissure). Growth lamellae poorly expressed, long and regularly spaced, with very fine concentric fila (Fig. 3O). Frills apparently lacking (but surface of shells very poorly preserved).

Interior unknown.

Remarks. – This species is assigned with doubt to *Desquamatia*: the outline, low convexity and fine ornament are consistent with such an assignment. Nonetheless, the presence of fila is not reported in *Desquamatia* that in addition generally possess a plicate commissure. The genus is known from the Pragian to the Frasnian all around the world.

Order Athyridida Boucot, Johnson & Staton, 1964
Suborder Athyrididina Boucot, Johnson & Staton, 1964
Superfamily Athyridoidea Davidson, 1881
Family Athyrididae Davidson, 1881

Genus *Athyris* M'Coy, 1844

Athyris concentrica (von Buch, 1834)

Figure 3U–Y

Material. – 2 complete specimens, one of them strongly crushed, from level B3. No. LPB 19393.

Description. – Shell small to medium, equally biconvex, transverse (length = 17.5 mm; width = 22 mm) with widely rounded cardinal extremities, the maximum width being located at mid-length. Sulcus and fold, relatively wide (almost ½ width), trapezoidal in transverse section, poorly expressed except near the anterior commissure that is uniplicate to slightly parasulcate. Ventral beak well developed, curved and pierced by an apical foramen. Ventral area short, with well marked growth lines parallel to hinge. Dorsal beak small, hidden by its ventral counterpart. The shell is smooth. Growth lamellae regularly spaced, more concentrated in the vicinity of the commissure where they develop in wide frills.

On the juvenile specimen, the dorsal valve is clearly higher than the ventral one but this specimen is strongly crushed. It possesses very long frills (about 3 mm, the shell being 11 mm long).

Remarks. – The characteristics of this material are consistent with *A. concentrica* (*sensu lato*), a species widely distributed from the Middle Devonian to the Lower Carboniferous of the world. Nevertheless it should be noted that this species has never been firmly established. According to Alvarez *et al.* (1996) who revised the type species, the latter should be restricted to the material described by von Buch (1834), from the middle and upper Eifelian (Ahrdorf and Junkerberg formations, Eifel), but the name “*concentrica*” has been widely used to describe similar forms that are present up to the Carboniferous. It is to this informal group that we refer here.

Superfamily Meristelloidea Waagen, 1883
Family Meristidae Hall & Clarke, 1895

Genus *Dicamara* Hall & Clarke, 1893

Dicamara sp. cf. *D. prunulum* (Schnur, 1854)

Figure 4A–E

Material. – 2 complete shells from level B1. No. LPB 19391.

Description. – Shell small to medium, subquadrate to elongate (length respectively = 21 mm and 18 mm, width = 19 mm and 14 mm), with a strongly convex ventral valve and lower dorsal valve (Hd/Hv respectively = 0.33 and 0.57). Hinge astrophic. Maximum width located in the anterior third of the shell. Beaks robust on both valves strongly curved posteriorly on the ventral valve, hiding the dorsal one. Apical foramen present. Sulcus and fold lacking except in the immediate vicinity of the anterior commissure where they are only poorly expressed; the fold is slightly dorsally recurved at the commissure (Fig. 4C). Anterior commissure uniplicate with a wide subtrapezoidal tongue (sulcus width/width respectively 0.53 and 0.22). The shell is smooth. A few growth lamellae are visible, narrow posteriorly becoming gradually wider anteriorly.

Interior not observed. By transparency on one of the shells we can guess the presence of a thin, long dorsal median septum (about $\frac{1}{3}$ of L) and two straight, divergent, rather short dental plates (about $\frac{1}{4}$ of L).

Remarks. – This form is assigned to *Dicamara* after its external aspect and the presence of a long dorsal septum and short dental plates. It is also reminiscent of *Camarium* that often present a recurved fold in the vicinity of the commissure, or to a lesser extent to *Meristella*. Only a detailed study of the interior could help in this matter. Our material is externally very close to the species *D. prunulum*, at least its elongate variants (the nominal species shows a wide range of variations in its outline), sharing with the latter a strong convexity, elongate outline, the lack of sulcus/fold and a long septum. The genus *Dicamara* is widely distributed in the lower-middle Devonian; the species *D. prunulum* is restricted to the middle-upper Eifelian (Ahrdorf to Freilingen Schichten, Eifel), hence also the presence of a “cf.” here.

Superfamily Retzioidea Waagen, 1883

Family Neoretziidae Dagens, 1972

Subfamily Plectospirinae Alvarez, Rong & Boucot, 1998

Genus *Plectospira* Cooper, 1942

Plectospira ferita (von Buch, 1835)

Figure 4F–M

Material. – 2 complete shells from level B4. No. LPB 19394.

Description. – Minute shells with subquadrate to slightly elongate outline, flat, equibiconvex (length respectively 9 and 7.5 mm; width resp. 10 and 9 mm; height resp. 4 and 4.5 mm). Hinge short. Maximum width approximately at mid-length. Ventral beak robust strongly curved, acute,

with obscure apical foramen. Ventral area low. Fold flattened at top, poorly expressed in juvenile stage, shallower than adjacent costae, rapidly increasing in height and width towards anterior, reaching almost $\frac{1}{2}$ of width at anterior margin; it bears a shallow median groove on its distal extremity. Sulcus flat bottomed, slightly elevated above flanks, lower than adjacent costae in juvenile stage, bearing a median costa anteriorly. Costae strong, few (3 on each side), subangular in section, strongly projecting externally at the commissure. Microornament consisting of small tubercles giving to the shell surface a punctuate appearance (Fig. 4K).

Interior unknown.

Remarks. – The features observed in this form undoubtedly allow an assignment to the genus *Plectospira*. The shell outline, its size, the strong costae projecting outwards anteriorly, and the nature of fold and sulcus indicate that this form belongs to the species *Plectospira ferita*. The genus is known from the Silurian (upper Ludlow) to the Lower Carboniferous; although some references can be found indicating its presence as soon as Pragian, the true representatives of the species *P. ferita* appear to be restricted to the Eifelian–Givetian period.

Order Spiriferida Waagen, 1883

Suborder Spiriferidina Waagen, 1883

Superfamily Cyrtospiriferoidea Termier & Termier, 1949

Family Cyrtospiriferidae Termier & Termier, 1949

Genus *Cyrtospirifer* Nalivkin in Frederiks, 1924

Cyrtospirifer cf. *C. verneuili* (Murchison, 1840)

Figure 4S–Z

Material. – 2 complete shells from levels B8 and B9. No. LPB 19398–19399.

Description. – Shell medium to large (length respectively 23 and 25 mm; width 47 mm in both shells), entirely costate, transverse, subquadrate in outline, with subangular cardinal extremities (lateral commissure almost normal to the hinge). The maximal width is located slightly before the hinge. The dorsal valve is equal to or slightly higher than the ventral one. Ventral area curved, apsacline, with a robust, strongly curved beak. Delthyrium triangular, wide, with fine, relatively high deltidial plates. Dorsal area low, anacline to apsacline. Fold rounded in section, costate (about 13 costae on fold), well delimited by grooves deeper than lateral ones. Sulcus shallow, widely rounded, costate, moderately wide (sulcus width/width at anterior margin \approx 0.4). Costae rather fine, low, rounded, numerous (20–23 on each flank), separated by rounded grooves. Growth lamellae

fine, irregularly spaced, more densely distributed close to the commissure, and bearing concentric minute fila.

Interior unknown. One shell with broken apex shows a strong apical thickening in the ventral valve and the presence of a delthyrial plate. The dental plates, located on the edge of the sulcus, are divergent and straight.

Remarks. – The features observed in this species are those of *Cyrtospirifer verneuili* although cardinal extremities are generally more acute (eventually mucronate) in the nominal species than in our specimens. The status of *C. verneuili* and allied species is unclear and needs a thorough revision that is not under the scope of this paper. *Cyrtospirifer* is present during the upper Devonian in many areas of the world but many species referred (or close) to *C. verneuili* have been mentioned as soon as the Middle Devonian, particularly in North Africa: Algeria (Bitam *et al.* 1996), Morocco (Schindler & Wehrmann 2011), Mauritania (Racheboeuf *et al.* 2004), *etc.*

Order Spiriferinida Ivanova, 1972

Suborder Cyrtinidina Carter & Johnson, 1994

Superfamily Cyrtinoidea Frederiks, 1911

Family Cyrtinidae Frederiks, 1911

Genus *Cyrtina* Davidson, 1859

Cyrtina intermedia Oehlert, 1887

Figure 4N–R

Material. – 1 complete exfoliated shell from level B2. No. LPB 19392.

Description. – Shell punctate, small (length = 9 mm; width = 13.5 mm), transverse with suquadangular outline. Cardinal extremities widely rounded, hinge shorter than width that is located around mid-length. Ventral valve pyramidal, dorsal valve weakly elevated. Fold low, flattened at top, wide, well delimited by grooves slightly deeper than adjacent ones. Sulcus shallow, rounded in section, wide (almost $\frac{1}{2}$ shell width at anterior edge) with bounding costae stronger than lateral ones. Lateral costae few (5 on each flank), external ones much attenuated, low, rounded. Growth lamellae irregularly spaced, poorly expressed (on an eroded

shell surface). Ventral area high, triangular, asymmetric, topped by a poorly developed beak. Delthyrium closed at its base, open on the upper third, under the beak. Dorsal area very low, almost not expressed.

Interior unknown.

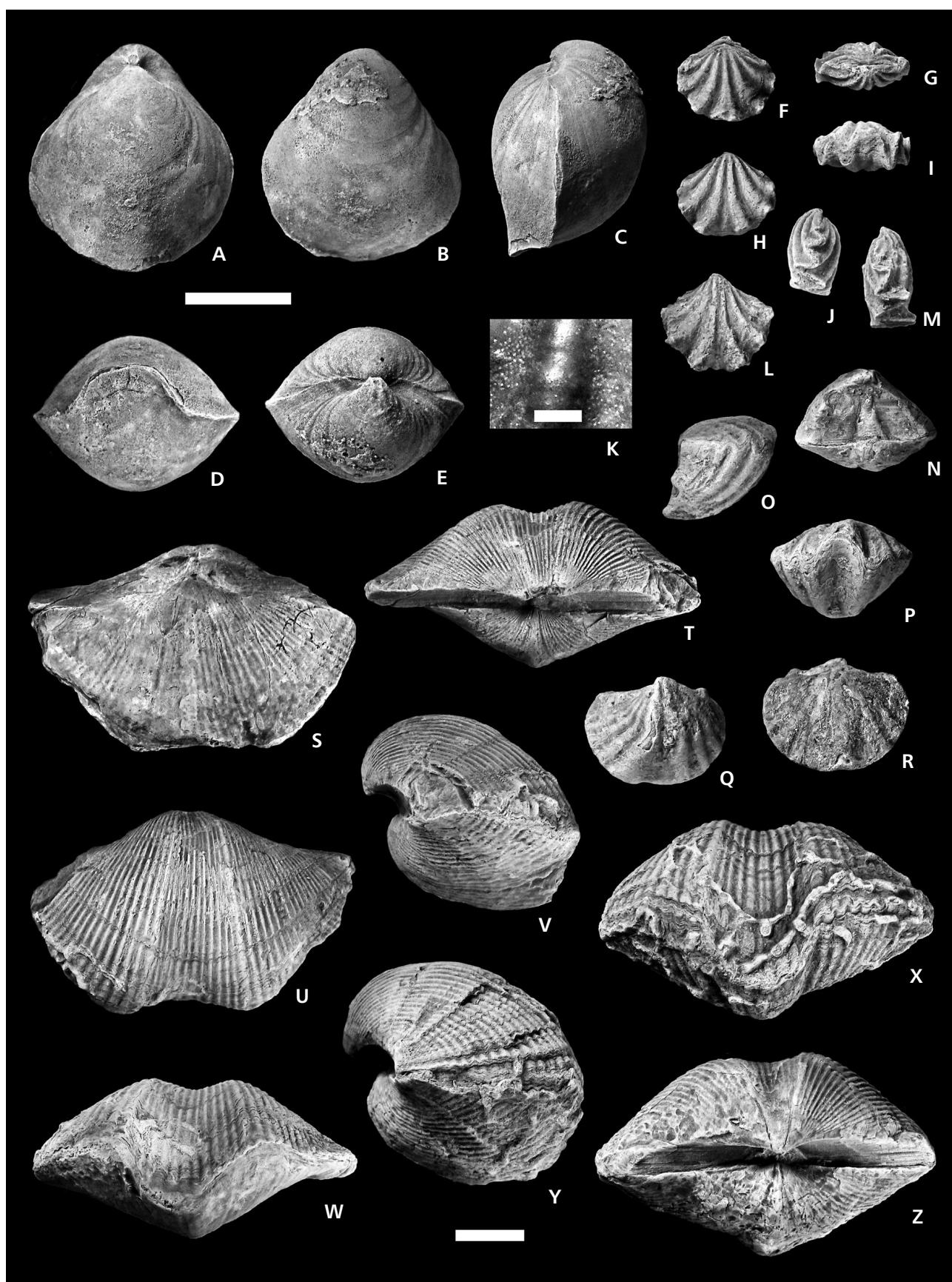
Remarks. – This form is assigned to *C. intermedia* after its general shape and number of costae. *C. multicostata* is very close to the present form but possesses more lateral costae. The species is known in Lower and Middle Devonian.

Discussion

Previously published data concerning this area deal with vertebrate faunas sampled in the top of the Yığınlı Formation and the lower part of the Köprülü Formation (Janvier *et al.* 1984). The top of the Yığınlı Formation was dated as Uppermost Devonian (Famennian), an age that was confirmed by the study of microflora (Higgs *et al.* 2002). In the latter study, two samples (respectively Zap 1 and Zap 2) were collected below the level yielding vertebrate remains and are possibly contemporaneous of our brachiopod fauna; they were dated as Famennian, with two identified palynomorph assemblages. Nevertheless, the lack of faunal control in the local sequences led the authors to correlate these assemblages with Western European ones, thereby introducing some uncertainty in the strength of the correlation and age estimation. The *Verruciretusispora lobziakii* assemblage was correlated with the *Vallatisporites hystricosus*-*Apiculiretusispora verrucosa* (VH) assemblage of Famennian age in Western Europe (Fa2c). The second one, namely *Retispora lepidophyta* assemblage, was correlated with the *Retispora lepidophyta*-*Knoxiosporites literatus* (LL) and *Retispora lepidophyta*-*Indotriradites explanatus* (LE) assemblages of Strunian (latest Famennian) age also in Western Europe.

As far as these levels are effectively contemporary of the levels studied here (middle part of the Köprülü section) these results are not compatible with those concerning brachiopods. Although the assignments are made only at the generic level for a significant part of the material examined here, an estimation of the age of this assemblage can be reasonably stated and it is older than that indicated in the studies mentioned above. Actually the presence of

Figure 4. All specimens from Köprülü section, Yığınlı Formation, SE Turkey. Top scale bar = 1 cm, for figures A–R, except figure K (scale bar = 0.5 mm); bottom scale bar = 1 cm, for figures S–Z. • A–E – *Dicamara* sp. cf. *D. prunulum* (Schnur, 1854). Dorsal, ventral, lateral, anterior and posterior views of a complete specimen. LPB 19391a. • F–M – *Plectospira ferita* (von Buch, 1835). F–J – dorsal, posterior, ventral, anterior and lateral and views of a small complete specimen; K – detail of the ornament of the same (scale bar = 0.5 mm), LPB 19394a; L, M – ventral and lateral views of another specimen, LPB 19394b. • N–R – *Cyrtina intermedia* Oehlert, 1887. Posterior, lateral, anterior, ventral and dorsal views of a complete, slightly damaged (exfoliated) specimen. LPB 19392. • S–Z – *Cyrtospirifer* cf. *C. verneuili* (Murchison, 1840). S–W – dorsal, posterior, ventral, lateral and anterior views of specimen LPB 19398; X–Z – anterior, lateral and posterior views of specimen LPB 19399.



Atrypids precludes an age younger than the lower Frasnian. Other elements such as *Dagnachonetes*, *Dicamara*, *Plectospira ferita* and *Cyrtina intermedia* do not cross the Middle–Upper Devonian limit. *Isospinatrypa aspera* is present from the upper Eifelian to the Givetian. On the other hand, *Cyrtospirifer* is rather known to be a representative of upper Devonian faunas, but many occurrences of the species *C. verneuili*, or closely related forms described as “*C. verneuili*”, *C. cf. verneuili* or *C. sp. e.g. verneuili*, have been recorded in many areas as soon as Middle Devonian (Givetian). Such a combination of genera of middle and upper Devonian affinities suggests a Givetian and most likely an upper Givetian age for this assemblage. This dating could probably be refined after sampling of complementary material that would allow the study of internal structures, but as mentioned above, brachiopod fauna is scarce in this formation. Anyway the age of this part of the Yığınlı Formation has thus to be modified in consequence. This is reinforced by a study of the echinoderms (Webster & Hoşgör, submitted) that suggests a middle Devonian age for crinoids remains from the Unit 4 of the Yığınlı Formation. Unfortunately these specimens were not sampled in place and their precise stratigraphic location is in need of a closer examination, but their presence is a further element in favor of a revision of the age of the series in the direction that we suggest herein. The exact position of the Köprülü section in the Yığınlı Formation remains to be clarified in order to reinforce our results, but it is clear that the earliest levels of this formation had already begun to settle since the Middle Devonian.

The Paleozoic evolution of Southeast Turkey was influenced by three main variables: global eustatic sea-level changes, regional tectonics related to major orogenic events and the formation of Neotethys and local tectonics related to intracontinental rifting and other subsidence variations (Carter & Tunbridge 1992). Paleogeographically the Late Ordovician to Early Carboniferous of northern Arabia suggests that North Africa and Arabia formed a broad stable continental shelf on the northern margin of the Gondwana supercontinent bordering the Paleo-Tethys Ocean. Studies of the Devonian–Early Carboniferous rocks in the north of Arabian plate show that they were deposited in either terrestrial or shallow marine environments (Beydoun 1991, Al-Juboury & Al-Hadidy 2009, Najafzadeh *et al.* 2010, Hoşgör *et al.* 2011). Typical shallow-marine deposits are recorded in southern Turkey (Carter & Tunbridge 1992), northern Syria (Best *et al.* 1993), northwest Iran (Najafzadeh *et al.* 2010) and northern Iraq (Wolfard 1981). The Devonian and Lower Carboniferous of the Arabian Plate is represented in Southeastern Anatolia (Fig. 1A, C) by sedimentary sequences observed from west to east in the Amanos Mountains, Hazro High and Hakkari area (Yalçın & Yılmaz 2010). The material described here is the first record of a Middle Devonian fauna in the Hakkari area.

From a paleontological point of view, the comparison with neighboring areas of Turkey, and more generally of the Middle East, is uneasy due to lack of data on brachiopods of this period. If faunas of Lower and Upper Devonian have been reported and/or described in several surrounding areas, the Middle Devonian period is much less documented. In SE Anatolia which belongs to the Arabian plate as mentioned above, a possible correlation should be considered between the base of Yığınlı Formation and the top of the Kayayolu Formation (Hazro area) which yielded some brachiopods (including *Atrypa*, *Cyrtospirifer verneuili*, *Athyris concentrica*, *Cyrtina*, *etc.*) (Tolun 1949, Lebküchner 1976) suggesting a broad Eifelian to Frasnian age (Fig. 1C). In other terranes constituting the rest of Turkey (Pontides and Taurides), considered as allochthon units, no fauna comparable to that described herein has been so far discovered, but Middle Devonian was recognized in the Pontides (Manastır Member of the Yılanlı Formation, Givetian) (Boncheva *et al.* 2009) and in Central and Eastern Taurides (Safak Tepe Formation, Eifelian–Givetian; Göncüoğlu *et al.* 2004, Sayar *et al.* 2009). No Givetian brachiopods fauna have been reported in neighboring areas belonging to the Arabian plate, respectively Syria, Jordan and Oman for which no deposit of the Middle Devonian has been recognized. In Iraq the Devonian is represented by the Pirispiki Formation that is devoid of fossils (Al-Juboury & Hadidy 2009). In Saudi Arabia, the Jubah Formation corresponds *pro parte* (lower part of the formation) to the series studied here, but has not yielded brachiopods and was dated on the basis of its palynomorphs contents (Marshall *et al.* 2007).

In northern Iran we do not know brachiopod communities precisely attributed to the Givetian, nor in SE Iran where Middle Devonian deposits are seemingly lacking. Brachiopods identified in Central Iran (Zefreh section, Brice 2006) differ of our material and appear to be older (probably Eifelian). In Afghanistan some fauna have been attributed to the Givetian (Brice 1971) but they are dominated by spiriferids and rhynchonellids, the latter being curiously absent from the assemblage collected in Zap Anticline, and this prevents meaningful comparisons between these regions. The same applies for the Russian platform and the Timan area and westwards, Libya and Algeria.

At the generic level, the taxa from Zap Anticline are known in many other areas of the world, a situation that was expected in the context of increasing cosmopolitanism observed during the Givetian and later. Among the most interesting genera, one can point out *Dagnachonetes* that is known in Europe (Poland, France, Spain), Russia and China, *Dicamara* also reported in Europe (Poland, France, Spain, Germany, Moravia), North Africa (Algeria) and Asia (Salair, Kazakhstan, India, China) and *Plectospira* known in Europe (Poland, Germany, Czech Republic),

Asia (Altai, Kuznetsk, Myanmar, Thailand, China) and Australia (New South Wales) during this period. The remaining genera are worldwide distributed. These data are consistent with the closure of the Rheic between Gondwana and Laurussia at this time and with a relatively narrow, incipient Palaeotethys.

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