Cambrian small shelly fossils from the Çal Tepe Formation, Taurus Mountains, Turkey

«Small shelly fossils» del Cámbrico en la Formación Çal Tepe, Montes Taurus, Turquía

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Abstract: Lower and Middle Cambrian carbonate rocks of the Çal Tepe Formation, cropping out in the western Taurus Mountains, yielded a large number of microfossil remains. Small shelly fossils from a single level in the upper Lower Cambrian represent a high diversity biota that could be related to the «Cambrian explosion». Microfossil association from the lower Middle Cambrian sediments of the Çal Tepe Formation is taxonomically very reduced and a dominant taxon is Hadimopanella Gediık. This sudden change could be attributed to a deepening of the basin during the early Middle Cambrian transgression.

Key words: Small shelly fossils, Taxonomy, Lower and Middle Cambrian, Çal Tepe Formation, Taurus Mountains, Turkey.

Resumen: Los sedimentos carbonatados de la Formación Çal Tepe (Montes Taurus occidentales) que corresponden al techo del Cámbrico Inferior y base del Cámbrico Medio, han proporcionado un gran número de restos paleontológicos. Los más antiguos, atestiguan la existencia de una paleobiota muy diversificada que puede vincularse a la «explosión cámbrica». En tanto que los sedimentos del Cámbrico Medio contienen una asociación de fósiles que se caracteriza por una diversidad muy baja en la cual el elemento dominante es Hadimopanella Gediık. Este cambio dramático registrado por los fósiles estudiados, puede atribuirse a una profundización de la cuenca que sería coincidente con la transgresión de la base del Cámbrico Medio.

Palabras clave: «Small shelly fossils», Taxonomía, Cámbrico Inferior y Medio, Formación Çal Tepe, Montes Taurus, Turquía.

INTRODUCTION

During the 1995 field trip of the 3rd International Meeting of the IGCP Project Nº 351, the Lower Palaeozoic carbonate rocks in southern Turkey were sampled for micropaleontological studies. In the last decades, the limestone rocks have been largely investigated for their content of phosphatic fossils by applying etching techniques with diluted organic acids. Most of the lower Palaeozoic rocks have yielded a large number of microfossils belonging to different systematic groups, and among them conodonts are the most useful for biostratigraphy. Furthermore, sclerites of the Class Palaeoescolecida (Conway Morris & Robison, 1986) and other of enigmatic origins have proved to be of value for regional correlation as well as being palaeoecological indicators.

In this contribution new observations on small shelly fossils (except conodonts, which have not been found) from the two limestone levels of the Çal Tepe Formation (Dean & Monod, 1970) in the type locality are provided. Previous data about fossils of this unit were published by Gediık (1989), who identified Scenella sp., Pelagiella sp., Microcornus sp., Hyolithes sp., Cowiella reticulata Hinz, Chancelloria sp. and six species of Hadimopanella Gediık, five of them described for the first time. Based on the latter species, Gediık (1989) established six regional biozones for the Cambrian rocks in Turkey. Other fossils such as trilobites, cystoid echinoderm plates, acrotertid brachiopods, paraconodonts and sponge spicules were mentioned by this author, and new taxa

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Humboldtochaeta anatoliensis Gedik and Konyasphaerulida celali Gedik were recognised.

Trilobites from the Çal Tepe Formation were studied by Dean & Monod (1970) and Dean (1975), who also reviewed and formally established some Lower Palaeozoic lithostratigraphic units. According to these authors, the age of the dolomite and limestone of this unit is upper Lower Cambrian to lower Middle Cambrian corresponding to the Protolenidae, Paradoxides and Pardailhania zones.

GEOLOGICAL SETTING

The Taurus Mountains extend subparallel to the southern coast of Turkey, from southwest of Antalya to the Karaman Maras and then to the east Tunceli. They are located between the Central Anatolia plateau in the north and the Mediterranean Sea, in the south.

The Taurus Mountains consist of numerous nappes or tectono-stratigraphic units, which were formed during the Alpine orogeny. It is generally accepted that a «Tauride-Anatolide continental microplate» surrounded by the Neotethyan oceanic branches was sliced and telescoped during the closure of these oceanic branches (Göncüoğlu et al., 1996). Most of these nappes possess in their pre-Mesozoic basement mostly continuous Palaeozoic successions (Fig. 1).

The Cambrian rocks in the Taurides are best exposed in the Geyikdağı Unit of Özgül (1976) which consists of the Hűdai Quartzite Formation and the Çal Tepe Formation (for a detailed review see Göncüoğlu & Közlu, 2000).

The Çal Tepe Formation is exposed in the southern Turkey, from the western and central Taurides, Amanos Mountains up to the Border Folds. The type section of this unit is located at the end of the southeastern area of the eponymous hill, approximately 2 km to the NW Seydisehir city, western Taurides (Dean & Monod, 1970) (Fig. 1). The carbonate rocks of the Çal Tepe Formation, about 150 m thick, Dean (1980) were formally subdivided during the Alpine orogeny.
Figure 2.-Geological section and stratigraphic succession of Çal Tepe Formation in its type locality (after Dean & Monod, pers. comm., November 1995). The levels with the small shelly fossils are indicated.

Figure 2.-Sección geológica y sucesión estratigráfica de la Formación Çal Tepe en su localidad tipo (según Dean & Monod, com pers., noviembre de 1995). Se indican los niveles con «small shelly fossils».
into four members. These are in ascending order: the Dolomite, Black Limestone, Light Grey Limestone and Red Nodular Limestone Member, the first one being absent at the type locality (Fig. 2). The red nodular limestone member of the Çal Tepe Formation is conformably overlain by an alternation of shales and bands/lenses of nodular limestones that mark the lower part of the overlying Seydisehir Formation (Fig. 3). An Upper Cambrian-Lower Ordovician age has been tentatively suggested for this part of the succession (GÖNCÜOGLU & KOZLU, 2000).

During the Cambrian and Ordovician times the southern area of Turkey was a flat and stable platform slightly deepening to the north, which received steady input of detrital materials from the south (MONOD et al., 1995).

BIOSTRATIGRAPHY AND PALAEOBIOGRAPHY

From the lower part of the Light Grey Limestone Member (CT-03), a diverse small shelly fossil assemblage is composed by: the cyanophyta Obruchevella delicata REITLINGER, poorly preserved Porifera, identified as Effelia cf. aramiformis (MISSARZHEVSKY), Taxaculum cf. volans BENGTSON, Dodecaactinella cf. cinodontota BENGTSON & RUNNEGAR, Calcihexactina sp., Nabaviella sp., Spicule Form A sensu CONWAY MORRIS, and polyactine spicules; Coeloscleritophorans as Archiasterella hirundo BENGTSON, Chancelloria cf. lenaica (MISSARZHEVSKY & MAMBETOV), Chancelloria spp., Halkieria spp., ?Eremactis sp.; bivalved organisms of possible brachiopod affinities related to Aroonia sp. and Apistoconcha sp.; Hyolithids as Conotheca cf. australiensis BENGTSON and ?Microcornus sp.; Cnidaria as Byronia sp.; phosphatic brachiopods; mollusc remains of helcionellids, Pelagiella MATTHEWS, and monoplacophora; spines of the crustaceous Isoxys? sp. A sensu BENGTSON (1990), abundant echinoderm plates; and fragmentary plates of Microdictyon sp.

This characteristic microfossil assemblage is well known from the Lower Cambrian rocks in many parts of the world (Australia, Antarctica, California, NW Canada, China, England, India, Iran, Mongolia, Morocco, Mexico, Newfoundland, Siberia). A late early Cambrian age for the level equivalent to the Çal Tepe lower assemblage is indicated by trilobites (DEAN & MONOD, pers. comm., November 1995). Furthermore, DEAN & OZGUL (1994) mention the presence of Acodararaxoides muroensis together with Corynexochella? robusta at a single level 1.8 m
above the base of the Light Grey Limestone Member at Çal Tepe type-area. These authors correlate it with the Acodoparadoxides mureroensis Zone of Spain and assign to an early Middle Cambrian age.

The second investigated level (CT-04), in the upper part of the Light Grey Limestone Member yielded a quite different microfossil association made up mainly by sclerites of the palaeoscolecid Hadimopanella oezgueli Gedik and sparse remains of brachio-pod phosphatic shells. Boogaard (1983) reported a very similar association from the Láncara Formation of the Cantabrian Mountains (NW Spain). The Iberian record lies between the Solenopleuropsidae and Cephalopyge zones of the Middle Cambrian (Loize & Szudy, 1961). At Çal Tepe section Hadimopanella horizon reported here have an early Middle Cambrian age (Dean & Monod, pers. comm., November 1995). H. oezgueli Gedik is widely distributed in several places of the NW Gondwana margin such as: Sardinia (Cherchi & Schroeder, 1985), Turkey (Gedik, 1977, 1989), Spain (Boogaard, 1983), Morocco (Boogaard, pers. comm., April 1997), and also in Kirgizia (Märrss, 1988). According to these findings, Fernández-Remolar (2001) suggests that H. oezgueli Gedik should be a good fossil-marker to infer the Lower-Middle Cambrian transition in Perigonwanan regions.

The fossil association of the late early Cambrian of the Taurus Mountains present characteristic genera of Gondwanaland. Pelagiella, Eremactus, Isoxys and Archiasterella have been described in most of the Lower Cambrian successions of Gondwanan regions. However, some genera of the Turkish association as Microcornus, Apistoconcha and Microdictyon, suggest affinities with the late early Cambrian Australasian associations, whereas species of Hadimopanella indicate an early Middle Cambrian connection with North Spain and Sardinia (Fernández-Remolar, in press). In fact, these three areas were affected by an early Middle Cambrian transgression that enabled the dispersal of open water benthos as palaeoscolecids in the Western Gondwanaland margin.

The microfossil assemblages that are found at the same section in the Çal Tepe locality reflect the clear change in the environmental conditions, related to a progressive deepening of the platform shelf.

Finally, late early Cambrian small shelly fossils represent a high diversity biota that could be related with the «Cambrian explosion», while the impoverished younger microfossil association reveals a sudden environmental change that is coincident with the early Middle Cambrian transgression.

SISTEMATICO PALAEONTOLOGIA

MATERIAL AND TAPHONOMY

Small shelly fossils reported here were extracted from two samples (CT-03 and CT-04) obtained from levels approximately 1 m and 10 m above the base of the Light Grey Limestone Member, which is 11 m of thickness. Limestone samples with a weight of 1700 gr (CT-03) and 1050 gr (CT-04) were dissolved in an 8% acetic acid solution and yielded an insoluble residue which almost totally consisted of fossil remains. Most of the fossils are poorly preserved, being them mechanically fragmented. The effects of an advanced diagenetic changes have been observed, such as recrystallization and/or dissolution. Therefore, the microornamentation has been obliterated in most of the specimens. Due to the state of preservation of the microfossils some of them have been left under an open nomenclature.

Skeleton remains are composed by silica, calcium phosphate and calcium carbonate. The presence of internal moulds is also common mainly of organisms with two valves.

SYSTEMATICO

The illustrated fossils are housed at the Department of Paleontology, Faculty of Geology, Complutense University of Madrid.

Division Cyanophyta Smith, 1938
Family Oscillatoriaceae Gomont, 1948
Genus Obruchevella Reitlinger, 1948

Type species: Obruchevella delicata Reitlinger, 1948

Obruchevella delicata Reitlinger, 1948
(Pl. 1, Figs. 1-2)

1990 Obruchevella delicata Reitlinger - in Bengtson et al., p. 23, Figs. 9A,B,E, H-K.

Material: 13 specimens from level CT-03.
Remarks: Ribbon-shaped after compression but originally tubular sheats with nearly circular cross-section, coiled in helical pattern, often irregular. This species has been reported from the Lower Cambrian Parara Limestone, Curramulka (South Australia).
Phylum Porifera GRANT, 1836
Class Calcarea BOWERBANK, 1864
Family unknown

Genus *Dodecaactinella* REIF, 1968

_Type species:* *Dodecaactinella oncera* REIF, 1968

*Dodecaactinella cf. cynodontota* BENGTSON & RUNNEGAR, 1990

(Pl. 1, Figs. 15,17)

(cf. 1990) *Dodecaactinella cynodontota* BENGTSON & RUNNEGAR – (in BENGTSON et al., 1990), p. 27, Fig. 11.

Material: 9 partly preserved and strongly recrystallized specimens from level CT-03.

Remarks: Spicules triradially symmetrical with irregular main rays. Characteristic bi- or trifurcating ends are poorly preserved in our material. All specimens displayed a high similarity with those from the Ajax Limestone in South Australia.

POLYACTINE SPICULES

(Pl. 2, Fig. 12)

Material: 7 specimens from the level CT-03.

Remarks: Spicules with several short rays. In general, they are robust and spherical in appearance. In our material the rays are usually broken, but in most of the specimens their insertion can be observed.

Order Heteractinida HINDE, 1888
Family Eiffeliidae RIGBY, 1986

Genus *Eiffelia* WALCOTT, 1920

_Type species:* *Lenastella araniformis* MISSARZHEVSKY, 1981

*Eiffelia cf. araniformis* (MISSARZHEVSKY, 1981)

(Pl. 2, Figs. 10-11)

(cf. 1990) *Eiffelia araniformis* BENGTSON (in BENGTSON et al., 1990), p. 27, 28, Figs. 12-13 (with previous references).

Material: 6 specimens from level CT-03.

Remarks: Spicules of the type 6+0 with rays diverging from nearly 90 to 55º have been assigned to this taxon. Some specimens display an angle between the plane of the central disk and the rays. Nodes on the convex side have not been observed.

*E. araniformis* has been reported from the Upper Atdabatian levels of the Siberian Platform, Mongolia, Europe, China and Australia.

Class Hexactinellida SCHMIDT, 1870

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PLATE 1
Figs. 1,2. - Obruchevella delicata REITLINGER, 1948. 1- CT-03-8851, x270. 2A- CT-03- (x150), 2B, (x500).
Figs. 3,7,11,14. - Byronia sp. 3- CT-03-8880, (X150); 7-CT-03-8864, (x190); 11- CT-03-8865, x160; 4A- CT-03-8846, (x140), 14B- detail of the wall, (x500).
Figs. 4,10, 13. - Conotheca cf. australiensis BENGTSON, 1990, 4- CT-03-8863, (x150); 10- CT-03-8859, (x200); 13- CT-03-8848, (x160).
Figs. 5-6.9.- ?Microcornus sp., 5-CT-03-8867, (x270); 6- CT-03-8842, (x160); 9- CT-03-8862, (x150).
Fig. 8.- ?Eremactis sp. CT-03-8842, (x220).
Fig. 12.- Helcionellidae genus and species indeterminate, CT-03-8886, (x120).
Figs. 15,17. - Dodecaactinella cf. cyonodontota BENGTSON & RUNNEGAR, 1990, 15- CT-03-8839, (x400); 17- CT-03-8845, (x350).
Fig. 16.- Halkieria sp., CT-03-8855, (x170).

LAMINA 1
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Fig. 16.- Halkieria sp., CT-03-8855, (x170).
PLATE I/ LÁMINA 1
Order Lyssakida ZITTEL, 1877
Family Hyalostellidae CHAPMAN, 1940

Genus *Calcihexactina* SDZUY, 1969

Type species: *Calcihexactina franca* SDZUY, 1969

*Calcihexactina* sp.
(Pl. 2, Figs. 6-7)

1987 *Calcihexactina* sp. indet. HINZ, p. 48, Pl. 15, Figs. 10, 15-16.

**Material:** 6 specimens from the level CT-03.

**Remarks:** Spicules with three axes forming 90º angles. Rays are apparently straight but in our material all are broken and it was impossible to establish if they were of equal length. Due to a poor preservation the specimens are identified only to a generic level.

Both known species of this genus have a wide stratigraphic range (Lower Cambrian to Lower - ?Middle Ordovician).

Order and Family unknown

Genus *Taraxaculum* BENGTSON, 1990

Type species: *Taraxaculum volans* BENGTSON, 1990

*Taraxaculum* cf. *volans* BENGTSON, 1990
(Pl. 1, Fig. 18)

**Material:** 5 specimens from the level CT-03.

**Remarks:** Small and broken siliceous spicules with one robust ray like a shaft, which carries at the end 4 to 5 radiating lateral rays. The lateral rays have different length and diameter. In their general aspect these spicules resemble those illustrated and described by BENGTSON (*in* BENGTSON et al., 1990, p. 34-35, Fig. 17) from the Lower Cambrian of South Australia.

Genus *Nabaviella* MOSTLER & MOSLEH-YAZDI, 1976

Type species: *Nabaviella elegans* MOSTLER & MOSLEH-YAZDI, 1976

*Nabaviella* sp.
(Pl. 2, Fig. 9)

**Material:** 7 specimens from the level CT-03.

**Remarks:** Spicules like clavules having one central ray pointed at one end, while the other carries robust recurved lateral rays. The state of preservation of the specimens unable the specific identification.

Spicule Form A sensu CONWAY MORRIS, 1990
(Pl. 2, Fig. 4)

1990 Spicule Form A CONWAY MORRIS (in BENGTSON et al., 1990), p. 37, Fig. 20.
Material: 11 specimens from the level CT-03.
Remarks: This type of spicule was recognized by Conway Morris (1990) in Lower Cambrian deposits (Ajax Limestone) of the Mt. Scott Range (South Australia). All the morphological features pointed out by Conway Morris (1990) are present in our material. Unfortunately, not complete specimens were found.

Hexactinellid spicules
(Pl. 2, Figs. 2-3)

Material: 27 specimens from the level CT-03.
Remarks: Several forms that cannot be included in known groups are here assigned to Hexactinellid s.l. The common feature of these specimens is the absence of uniform angles between the rays, consequently they lack diagnostic morphological pattern.

Coeloscleritophorados
Phylum Unknown
Class Coeloscleritophora Bengston & Missarzhevsky, 1981
Orden Chancelloriida Walcott, 1920
Family Chancelloriidae Walcott, 1920

Genus Chancelloria Walcott, 1920
Type species: Chancelloria eros Walcott, 1920

Chancelloria cf. lenaica Zhuravleva & Kordeh, 1955 (Plate 2, Fig. 8)
cf. 1955 Chancelloria lenaica Zhuravleva & Kordeh, p. 476-477, Pl. 1, Figs. u, y.
cf. 1985 Chancelloria lenaica, Brasier, Fig. 6c.

Material: 6 specimens from the level CT-03.
Remarks: Only incomplete and strongly recrystallized specimens occur in the sample CT-03. The sclerites have 6+1 rays, the vertical ray is robust and shorter than the others.

Chancelloria spp.

Material: 29 specimens from the level CT-03
Remarks: A large number of isolated rays and very poorly preserved sclerites (as internal moulds) are grouped into Chancelloria spp.

Genus Archiasterella Sdzuy, 1969
Type species: Archiasterella pentactina Sdzuy, 1969
Graciela N. Sarmiento & et al. Cambrian small shelly fossils from the Çal Tepe Formation, Taurus Mountains, Turkey

PLATE 3/LÁMINA 3
Archiasterella hirundo Bengtson, 1990
(Plate 2, Fig. 1)
2001 Archiasterella aff. hirundo Bengtson (in Bengtson et al.) – Fernández-Remolar, Lám. 1, Fig. 5.

Material: 15 sclerites were obtained from the level CT-03.
Remarks: Bengtson (1990) referred to A. hirundo sclerites with robust structure and flattened base. Our material is less robust than the specimens illustrated by this author, but they have flattened bases.

A. hirundo has been described from the Lower Cambrian of the Parara Limestone (Horse Gully, Curramulka and Kulpapa) and Ajax Limestone (Mt. Scott Ra) in South Australia.

Archiasterella cf. hirundo Bengtson, 1990
(Pl. 2, Fig. 5)
1990 Archiasterella cf. hirundo Bengtson (in Bengtson et al.), p. 54, Fig. 29 D-E.
1998 Archiasterella cf. hirundo, Fernández-Remolar, p. 181, Pl. XX, Fig. 3; Pl. XXV, Figs. 3, 5; Pl. XXXI, Fig. 2.

Material: 26 sclerites from the level CT-03.
Remarks: Sclerites of this taxa are one of the dominant components of the microfossil association obtained at level CT-03. They differ from A. hirundo by having slender and long rays. These sclerites are usually broken but their basal insertion can be observed in most of the specimens.

Genus Eremactis Bengtson & Conway Morris, 1990
Type species: Eremactis conara Bengtson & Conway Morris, 1990

Archiasterella hirundo Bengtson, 1990
(Plate 2, Fig. 1)
2001 Archiasterella aff. hirundo Bengtson (in Bengtson et al.) – Fernández-Remolar, Lám. 1, Fig. 5.

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Archiasterella cf. hirundo Bengtson, 1990
(Pl. 2, Fig. 5)
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1998 Archiasterella cf. hirundo, Fernández-Remolar, p. 181, Pl. XX, Fig. 3; Pl. XXV, Figs. 3, 5; Pl. XXXI, Fig. 2.

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Genus Eremactis Bengtson & Conway Morris, 1990
Type species: Eremactis conara Bengtson & Conway Morris, 1990

Lámina 4
Figs. 1-2.- Acrotretids indeterminate. 1- CT-03-1058, (x120); 2- CT-04-1082, (x180); 6- CT-03-1059, (x120).
Figs. 3-7.- Halkieria sp. Form A sensu Fernández-Remolar, 1998. 3- CT-03-1073, (x100); 7- CT-03-1051, (x120); 9- CT-03-1053, (x90); 12- CT-03-1047, (x140).
Figs. 4-11.- ?Aroonia sp., 4- CT-03-1060, (x90); 10- CT-03-1079, (x160); 11- CT-03-1068, (x100).
Figs. 8.- Apistoconcha sp., 5- CT-03-1064, (x130); 8- CT-03-1083, (x130).
Figs. 13-14.- Pelagiella sp., 13- CT-03-1069, (x170); 14- CT-03-1042, (x75).

Family Halkieriidae Poulsen, 1967
Genus Halkieria Poulsen, 1967
Type species: Halkieria obliqua Poulsen, 1967

Halkieria sp. Form A sensu Fernández-Remolar, 1998
(Pl. 4, Figs. 3, 7, 9, 12)
1998 Halkieria sp. Form A – Fernández-Remolar, p. 189-190, Pl. XXVI, Figs. 1-9; Pl. XXIX, Fig. 3.

Material: 10 sclerites from the level CT-03.
Remarks: Conical sclerites with rounded or oval outline and apical area inconspicuously developed. Although poorly preserved, the surface ornamentation shows the presence of tubercules and concentric
PLATE 4/LÁMINA 4

Graciela N. Sarmiento & et al. Cambrian small shelly fossils from the Çal Tepe Formation, Taurus Mountains, Turkey

Coloquios de Paleontología
2001, 52: 117-134
spaced ridges. Fernández-Remolar (1998) distinguished three different morphotypes within this form based on the ornamentation of the sclerites. The stage of preservation of our specimens unable more detailed identification.

These forms have been recognized in the Lower Cambrian Pedroche Formation, Córdoba (Spain).

Halkieria sp.  
(Pl. 1, Fig. 16)

**Material**: 5 sclerites from the level CT-03.  
**Remarks**: We refer to this genus four palmate sclerites with compressed blade and triangular shape, and one possible siculate element (not figured). This ?siculate element is very similar to those forms assigned by Conway Morris (in Bengtson et al., 1990, Fig. 40 F-I) to Halkieria sp. Ornamentation is not visible in our material.

Phylum unknown  
Class Hyolitha Marek, 1963  
Order Orthothecida Marek, 1966  
Family Circothecidae Syssoieiev, 1962

**Genus** Conotheca Missarzhevsky, 1969

**Type species**: Conotheca mammilata Missarzhevsky, 1969

*Conotheca* cf. australiensis Bengtson, 1990  
(Pl. 1, Figs. 4, 10, 13; Pl. 3, Figs. 2, 8, 9)

cf. 1990 *Conotheca australiensis* Bengtson (in Bengtson et al.), p. 216, Fig. 143.

**Material**: 11 conchs and one possible operculum from the level CT-03.

Remarks: Straight to slightly recurved conchs with circular or sub-circular cross-section. 

The apertural plane is perpendicular to the axis of the conch. The conch of most specimens exhibits the surface growth lines parallel to the aperture. Although not complete specimens were found, their general aspect and main features are in agreement with the description and illustrations given by Bengtson (in Bengtson et al., 1990). The only remarkable difference is that conchs in the Turkish collection seem to be shorter than those identified in Lower Cambrian rocks of South Australia.

Order Hyolithida Matthew, 1899  
Family unassigned

**Genus** Microcornus Mambetov, 1972

**Type species**: Microcornus parvulus Mambetov, 1972

? *Microcornus* sp.  
(Pl. 1, Figs. 5-6, 9; Pl. 3, Figs. 4, 12)

**Material**: 14 specimens from the level CT-03.  
**Remarks**: Narrow shells with rounded triangular or rounded quadrangular transverse cross section have been assigned with doubts to this genus. Surface ornamentation consists of fine growth lines parallel to the aperture. In the specimens preserved as internal moulds (Pl. 1, figs. 5-6) part of the bulbous protoconch can be observed. Due to the poor preservation, a clear distinction between the conchs of Microcornus and those from the genus Hyptiotheca Bengtson is impossible.

Phylum ?Cnidaria Hatschek, 1888  
Class Scyphozoa Götte, 1887
Subclass Scyphomedusae Lankester, 1881
Order Byroniida Bischoff, 1989
Family Byroniidae Bischoff, 1989

Genus Byronia Matthew, 1899

Type species: Byronia annulata Matthew, 1899

Byronia sp.
(Pl. 1, Figs. 3, 7, 11, 14; Pl. 3, Fig. 3)

Material: 17 specimens from the level CT-03.
Remarks: Phosphatic tubular or conical structures, irregularly curved and with circular or subcircular transversal section. Only in a few specimens the external surface ornamentation has been observed.

Based on a large number of specimens from Sierra Morena (South Spain), Fernández-Remolar (1998) recognized several morphotypes within this genus and discussed relationship with the genera Torellella and Hyolithellus. His conclusions has been followed in this paper.

Phylum Priapulida Lamarck, 1816
Class Palaeoscolecida Conway Morris & Robison, 1986
Family Palaeoscolocidae Whittard, 1953

Genus Hadimopanella Gedik, 1977

Type species: Hadimopanella oezgueli Gedik, 1977
**Hadimopanella oezgueli** Gedik, 1977  
(Pl. 3, Figs. 10, 13-15)

1983 Hadimopanella oezgueli Gedik - Boogaard, p.337, Figs. 3-5.  
2001 Hadimopanella oezgueli Gedik – Wróna & Hamedi, p. 104-105, Pl. 1, Figs. 1-6, Pl. 2, Figs. 1-8, Pl. 3, Figs. 1-5.  

**Material**: More than 100 sclerites from the level CT-04.  
**Remarks**: The most abundant phosphatic microfossils are button-like sclerites of *Hadimopanella*. They are characterized by one smooth and slightly convex side, while the other displays a central area with a variable number of nodes. A detail description of this taxon was given by Bengtson (1977) and Boogaard (1983).

Phylum Brachiopoda Duméril, 1806  
Class Inarticulata Huxley, 1869  
Order Acrotretida Köhne, 1949  
Suborder Acrotretidina Köhne, 1949  
Family Acrotretidae Schuchert, 1893

Acrotretids indet.  
(Pl. 4, Figs. 1-2; Pl. 5, Fig. 3)

**Material**: 16 specimens from the level CT-03, and 4 from the level CT-04.  
**Remarks**: Both phosphatic valves (brachial and pedicular), have been recognised in the association. The external ornamentation is easy to distinguish but the internal features of the valves were eroded or are masked by sedimentary particles.

Phylum Mollusca Cuvier, 1797  
Class Monoplacophora Knight, 1952  
Order Cyrtoneillida Hörny, 1963  
Superfamily Helcionelloidea Wenz, 1938  
Family Helcionellidae Wenz, 1938

Helcionellidae genus and species indet.  
(Pl. 1, Fig. 12)

**Material**: 1 phosphatic steinkern from the level CT-03.  
**Remarks**: This univalve specimen is bilaterally symmetrical and laterally compressed and in this aspect it differs from a typical cyrtoneillid. Corrugations can be recognized on the ends of the internal mould, while the middle part seems to be smooth. The node-like elements of ornamentation have also been observed in the cast.

Order Pelagielida RUNNEGAR & POJETA, 1985  
Family Pelagielidae Knight, 1956  
Genus *Pelagiella* Matthew, 1895

**Type species**: *Pelagiella atlantoides* (Matthew, 1895)

**Pelagiella sp.**  
(Pl. 4, Figs. 13-14)

**Material**: 21 specimens from the level CT-03.  
**Remarks**: Asymmetrical and dextral coiled shells with an oval aperture. Apical area looks like a hook and has smooth surface; only in a few specimens an antero-lateral crest is present. Pelagiellids are widely distributed in Lower and Middle Cambrian rocks of the Siberian Platform, China, Australia, Northern Africa, Europe and Laurentia.

Order, Family, Genus and species indeterminate

Phylum Monoplacophora Forma B sensu Fernández-Remolar, 1998  
(Pl. 3, Fig. 5)

1998 Monoplacophora Forma B Fernández-Remolar, p.160, Pl. XVI, Figs. 6,7,9,13,15; Fig. 39B.

**Material**: 4 specimens from the level CT-03.  
**Remarks**: Shells are subtriangular in shape, like a compressed bell. They have rounded apical region and a wide posterior central depression. The ornamentation is not visible because the specimens are strongly recrystallised.

BIVALVED FOSSILS  
Class and Order uncertain  
Family Tianzhushanellidae Conway Morris, 1990

Genus *Apistoconcha* Conway Morris, 1990

**Type species**: *Apistoconcha apheles* Conway Morris, 1990
Apistoconcha sp.  
(Pl. 4, Figs. 5, 8)

Material: 5 poorly preserved specimens from CT-03.  
Remarks: Our identification is based on the internal structures observed in dorsal and ventral valves as well as the characteristic features of the posterior margin. The growth lines are widespread on the external surface.

Genus Aroonia Bengtson, 1990  
Type species: Aroonia seposita Bengtson, 1990

Material: 11 specimens from the level CT-03.  
Remarks: Bivalved, biconvex and bilaterally symmetrical valves are included with some uncertainty in this genus. The posterior margin of the valves is straight and corresponds to the portion with maximal width. Two marks visible in an internal mould of one specimen (Pl. 4, fig. 4) could represent attachment surfaces of adductor muscles. External surface shows concentric growth lines. Bengtson (in Bengtson et al., 1990) discussed morphological features of these forms in comparison to inarticulate and articulate brachiopods. According to Conway Morris & Bengtson (1990, p. 184) they are not true brachiopods but probably they shared common ancestors.  

Our specimens exhibit some differences with those assigned to Aroonia seposita Bengtson, the only known species of the genus. The Tukish material could represent a new species of the genus or a different genus, but the preservation of the valves is not sufficient for a more detailed identification.

Genus Isoxys Walcott, 1890

Isoxys? sp. A sensu Bengtson, 1990?  
(Pl. 3, Figs. 1, 6)

Material: 5 specimens from the level CT-03.  
Remarks: Long and short spines with a thick phosphatic wall were interpreted by Bengtson (in Bengtson et al., 1990) as parts of the same organism. Based on the material from the Curramulka, Parara Limestone, this author attributed them with doubts to the genus Isoxys. The same criteria is followed here in respect to the material from the Çal Tepe Formation.

Subclass Ostracoda Latreille, 1806  
Order Phosphatocopida Muller, 1964  
Suborder, Family and Genus uncertain

Phylum Echinodermata Linne, 1758  
Echinoderms indeterminate  
(Pl. 5, Figs. 6-9)

Material: more than 100 plates from the level CT-03.  
Remarks: Very abundant, complete and fragmentarily preserved, undeterminate plates with characteristic wall of the echinoderms were isolated from the Çal Tepe. These plates display a great diversity of shape and size and will be studied in more detail in the forthcoming paper in order to establish their systematic position.

Genus Microdictyon Bengtson, Matthews & Missarzhevsky, 1981  
Type species: Microdictyon effusum Bengtson, Matthews & Missarzhevsky, 1981

Microdictyon sp.  
(Pl. 5, Figs. 1-2)

Material: 14 specimens from the level CT-03.  
Remarks: Subcircular plates with honeycomb pattern with hexagonal holes. Although not complete
plates have been recovered, it seems that the holes decrease in size towards the margins. Corroded nodes distributed on the walls between the holes were observed.

ACKNOWLEDGEMENTS

We thank to Dr. J.C. Gutierrez-Marco, Instituto de Geología Económica (CSIC, Madrid) for critically reading of the early version of the manuscript. Thanks are due to Dr. A. Perejón Rincón (CSIC-UCM, Madrid, Spain) for critically reviewing of the manuscript and an anonymous reviewer who provided constructive criticism on this paper and also made carefully linguistic corrections. The scanning electron microphotographs were taken at the Centro de Microscopía Electrónica «Luis Brú», Universidad Complutense de Madrid. We acknowledge sincerely Mr. C. Alonso for his photographic work. G.N. Sarmiento benefits with a grant of the Comunidad de Madrid (Spain).

Recibido el día 31 de mayo de 2001.
Aceptado el día 29 de octubre de 2001.

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