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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 H*adimopanella* GEDIK. 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* GEDIK. 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 GEDIK (1989), who identified *Scenella* sp., *Pelagiella* sp., *Microcornus* sp., *Hyolithes* sp., *Cowiella reticulata* HINZ, *Chancelloria* sp. and six species of *Hadimopanella* GEDIK, five of them described for the first time. Based on the latter species, GEDIK (1989) established six regional biozones for the Cambrian rocks in Turkey. Other fossils such as trilobites, cystoid echinoderm plates, acrotretid brachiopods, paraconodonts and sponge spicules were mentioned by this author, and new taxa

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H*umboldtochaeta 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 generaly accepted that a «Tauride-Anatolide continental microplate» surrounded by the Neotethyan oceanic branches was sliced and telescoped during the closure of these oceanic branches (GÖNCÜOGLU *et al*., 1996). Most of these nappes possess in their pre-Mesozoic basement mostly continuos Palaeozoic successions (Fig.1).

The Cambrian rocks in the Taurides are best exposed in the Geyikdagi Unit of ÖZGÜL (1976) which consists of the Hüdai Quartzite Formation and the Çal Tepe Formation (for a detailed review see GÖNCÜOGLU & KOZLU, 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

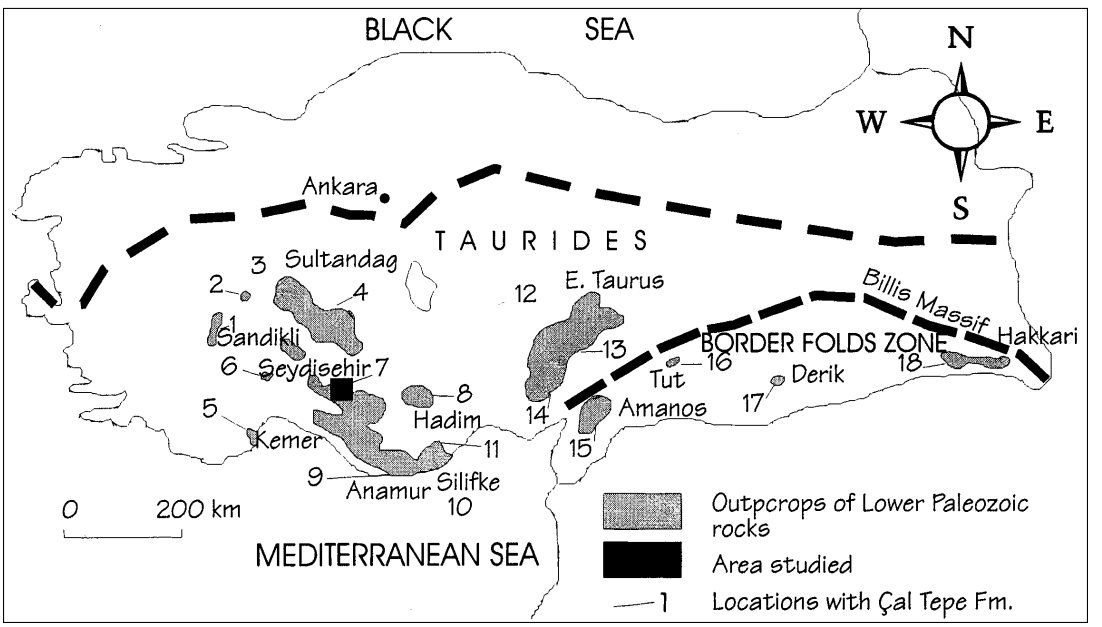

Figure 1.-Distribution of the Lower Palaeozoic rock-units in the Taurides and the Border Folds Zone. 1-14: localities with Çal Tepe Formation in the Taurides, 1- Sandikli, 2- Suhut, 3- Çay, 4- S Aksehir, 5- Kemer, 6- Karacahisar, 7- Çal Tepe type locality, 8- Hadim, 9- Anamur, 10- Silifke, 11-Kiliçtepe, 12- Sariz, 13- Feke, 14- Kozan. 15-18: localities with Çal Tepe Formation in the Border Folds Zone: 15- Amanos, 16- Tut, 17- Derik, 18- Zap Valley. (Modified from GÖNCÜOGLU, 1997).

Figura 1.-Distribución de las unidades litoestratigráficas del Paleozoico Inferior en los Montes Taurus y la Zona de los «Border Folds». 1-14: localidades en las que aflora la Formación Çal Tepe en los Montes Taurus: 1- Sandikli, 2- Suhut, 3- Çay, 4- S Aksehir, 5- Kemer, 6- Karacahisar, 7- Çal Tepe type locality, 8- Hadim, 9- Anamur, 10- Silifke, 11-Kiliçtepe, 12-Sariz, 13- Feke, 14- Kozan. 15-18: localidades en las que aflora la Formación Çal Tepe en la Zona de los «Border Folds»: 15- Amanos, 16- Tut, 17- Derik, 18- Zap Valley. (Modified from GÖNCUOGLU, 1997).

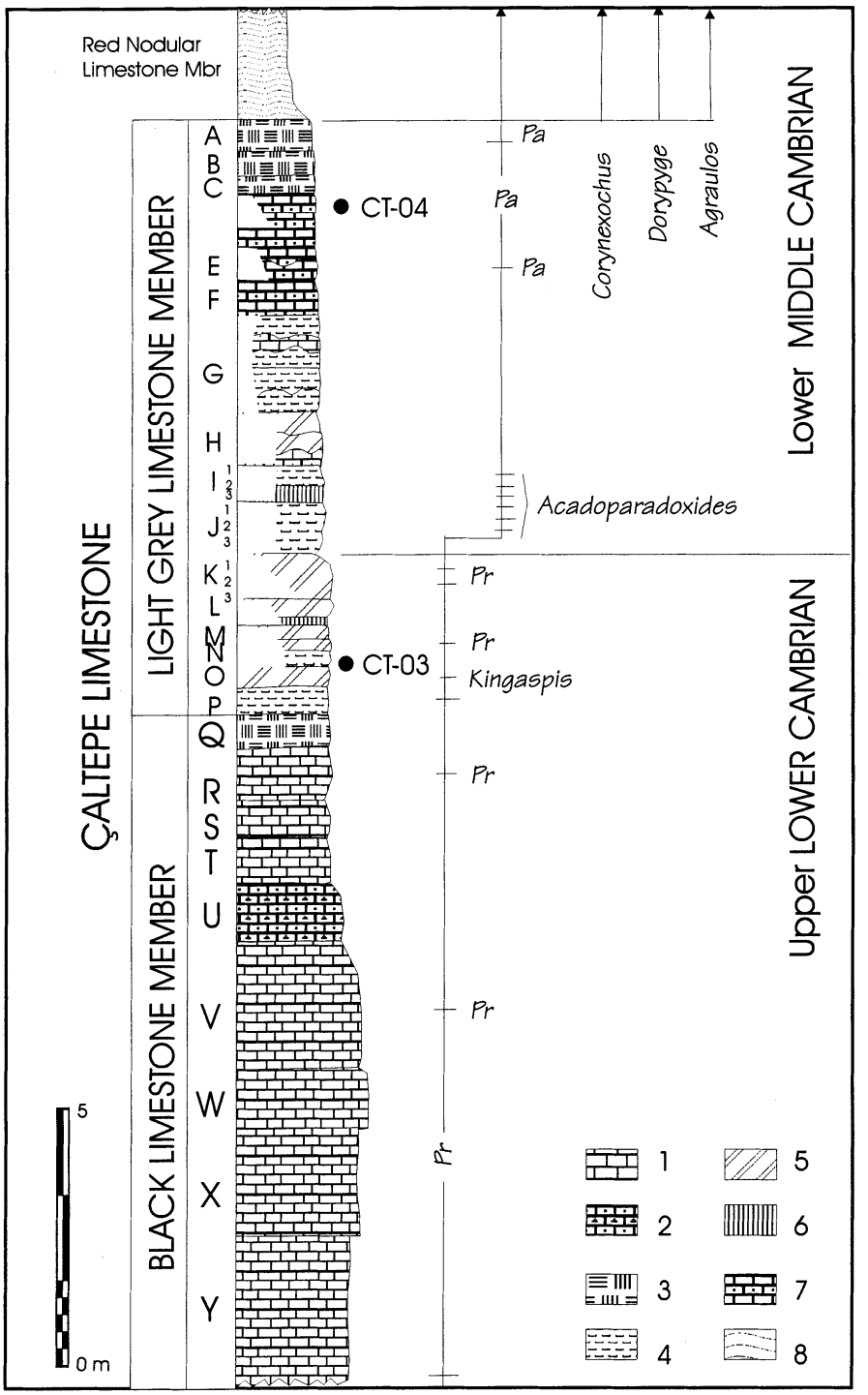

Figure 2.-Geological section and stratigraphic succession of Çal Tepe Formation in its type locality (after DEAN & MONOD, pers. comm., November 1995). The levels with the small shelly fossils are indicated.

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».

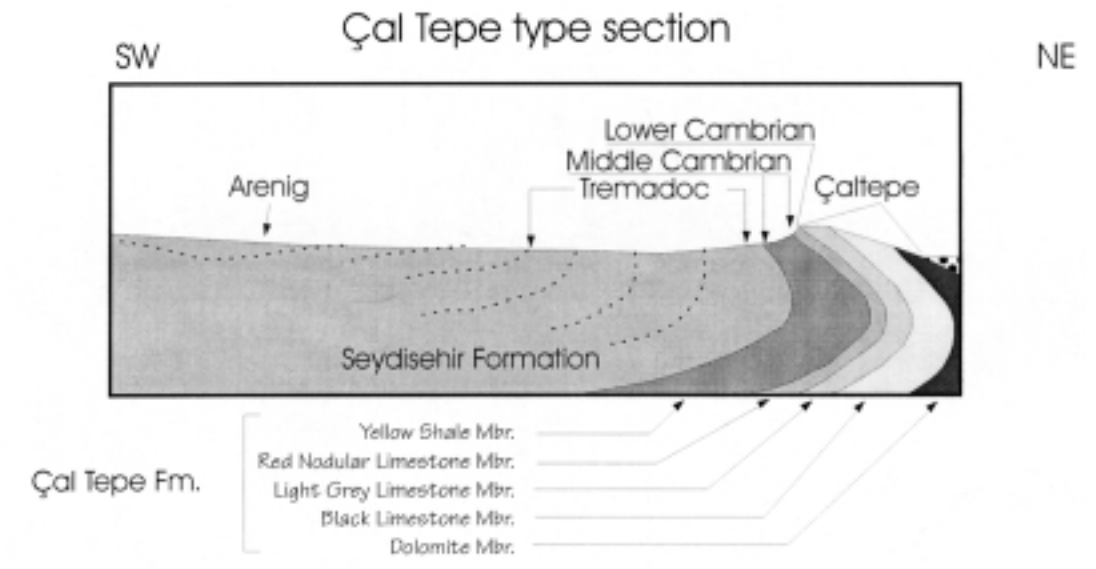

Figure 3.-Stratigraphic section of the Seydisehir and Çal Tepe formations in the type locality of the second unit (after DEAN & MONOD, pers. comm., November 1995).
Figura 3.-Sección estratigráfica de las formaciones Seydisehir y Çal Tepe en la localidad tipo de la segunda unidad (según Dean & Monod, com. pers., noviembre de 1995).

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 *Eiffelia* cf. *araniformis* (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; molluscan 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 & OZGÜL (1994) mention the presence of *Acadoparadoxides mureroensis* 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 *Acadoparadoxides 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 brachiopod 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 (LOTZE & SZDUY, 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 (MÄRSS, 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*, *Eremactis*, *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 paleoscolecids 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.

SISTEMATIC PALAEONTOLOGY

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 mechanical 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.

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

SYSTEMATIC

The illustrated fossils are housed at the Department of Palaeontology, 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 *Dodecaactinela* 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 trirradially symmetrical with irregular main rays. Characteristic bi- or trifurcating ends are poorly preserved in our material. All specimens diplayed 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

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.- ?*Erematctis* sp. CT-03-8842, (x220).
Fig. 12.- Helcionellidae genus and species indeterminate, CT-03-8861, (x120).
Figs. 15,17.- *Dodecaactinella* cf. *cynodontota* BENGTSON & RUNNEGAR, 1990. 15- CT-03-8839, (x400); 17- CT-03-8845, (x350).
Fig. 16.- *Halkieria* sp., CT-03-8855, (x170).

LÁMINA 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- detalle en la pared, (x500).
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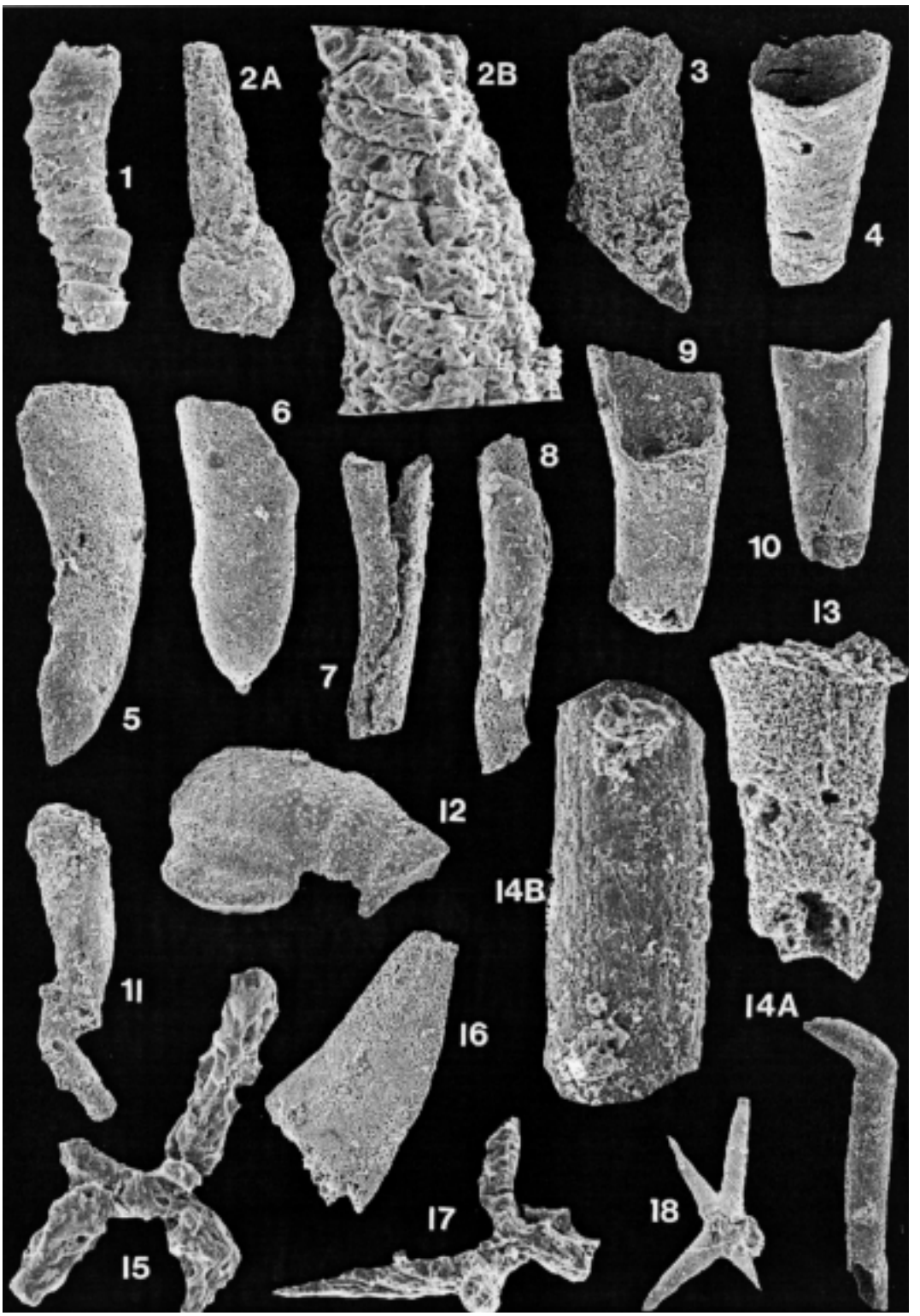
Fig. 16.- *Halkieria* sp., CT-03-8855, (x170).

PLATE 1/ LÁMINA 1



Order Lyssakida ZITTEL, 1877
Family Hyalostellidae CHAPMAN, 1940

Genus *Calcihexactina* SDZUY, 1969

Type species: *Calcihexactina franconia* 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 axis forming 90º angles. Rays are apparently straightbut 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 specie: *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.

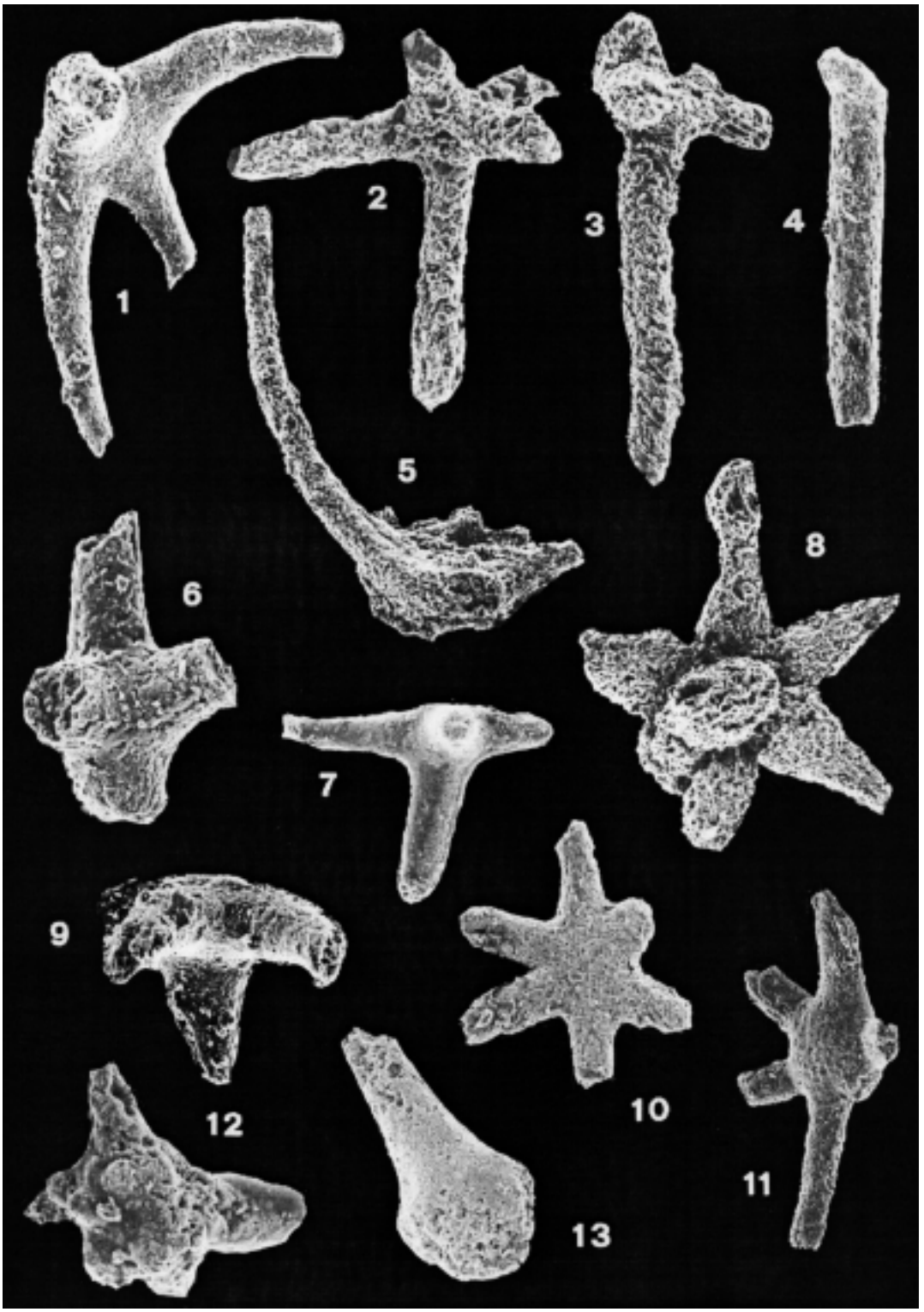
Spicule Form A *sensu* CONWAY MORRIS, 1990
(Pl. 2, Fig. 4)

1990 Spicule Form A CONWAY MORRIS (*in* BENGTSON *et al*.), p. 37, Fig. 20.

PLATE 2
Figs. 1,13.- *Archiasterella hirundo* BENGTSON, 1990. 1- CT-03-1074, (x130); 13- isolated ray, CT-02-1055, (x120).
Figs. 2-3.- Hexactinellid spicules. 2- CT-03-1050, (x120); 3- CT-03-1070, (x130).
Fig. 4.- Spicule Form A *sensu* CONWAY MORRIS, (in BENGTSON *et al*.,1990). CT-03-1067, (x110).
Fig. 5.- *Archiasterella* cf. *hirundo* BENGTSON, 1990. CT-03-1066, (x 80).
Figs. 6-7.- *Calcihexactina* sp., 6- CT-03-1044, (x300); 7- CT-03-1084, (x200).
Fig. 8.- *Chancelloria* cf. *lenaica* ZHURAULEVA & KORDEH, 1955. CT-03-1076, (x90).
Fig. 9.- *Nabaviella* sp., CT-03-1045, (x250).
Figs. 10-11.- *Eiffelia* cf. *araniformis* (MISSARZHEVSKY). 11- CT-03-1048, (x230); 11- CT-03- 1063, (x150).
Fig. 12.- Polyactine spicule, CT-031054, (x350).

LÁMINA 2
Figs. 1,13.- *Archiasterella hirundo* BENGTSON, 1990. 1- CT-03-1074, (x130); 13- radio aislado, CT-02-1055, (x120).
Figs. 2-3.- Espículas hexactinélidas. 2- CT-03-1050, (x120); 3- CT-03-1070, (x130).
Fig. 4.- Espícula Forma A *sensu* CONWAY MORRIS, (in BENGTSON *et al*.,1990). CT-03-1067, (x110).
Fig. 5.- *Archiasterella* cf. *hirundo* BENGTSON, 1990. CT-03-1066, (x 80).
Figs. 6-7.- *Calcihexactina* sp., 6- CT-03-1044, (x300); 7- CT-03-1084, (x200).
Fig. 8.- *Chancelloria* cf. *lenaica* ZHURAULEVA & KORDEH, 1955. CT-03-1076, (x90).
Fig. 9.- *Nabaviella* sp., CT-03-1045, (x250).
Figs. 10-11.- *Eiffelia* cf. *araniformis* (MISSARZHEVSKY). 11- CT-03-1048, (x230); 11- CT-03- 1063, (x150).
Fig. 12.- Espícula poliactina, CT-031054, (x350).

PLATE 2/LÁMINA 2



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 can not be included in known groups are here assigned to Hexactinellids *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* ZHURAULEVA & KORDEH, p. 476-477, Pl. 1, Figs. u, y.
cf. 1985 *Chancelloria lenaica*, BRASIER, Fig. 6c.
cf. 1987 *Chancelloria lenaica*, HINZ, p. 47-48, Pl. 2, Figs. 10-11.

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.

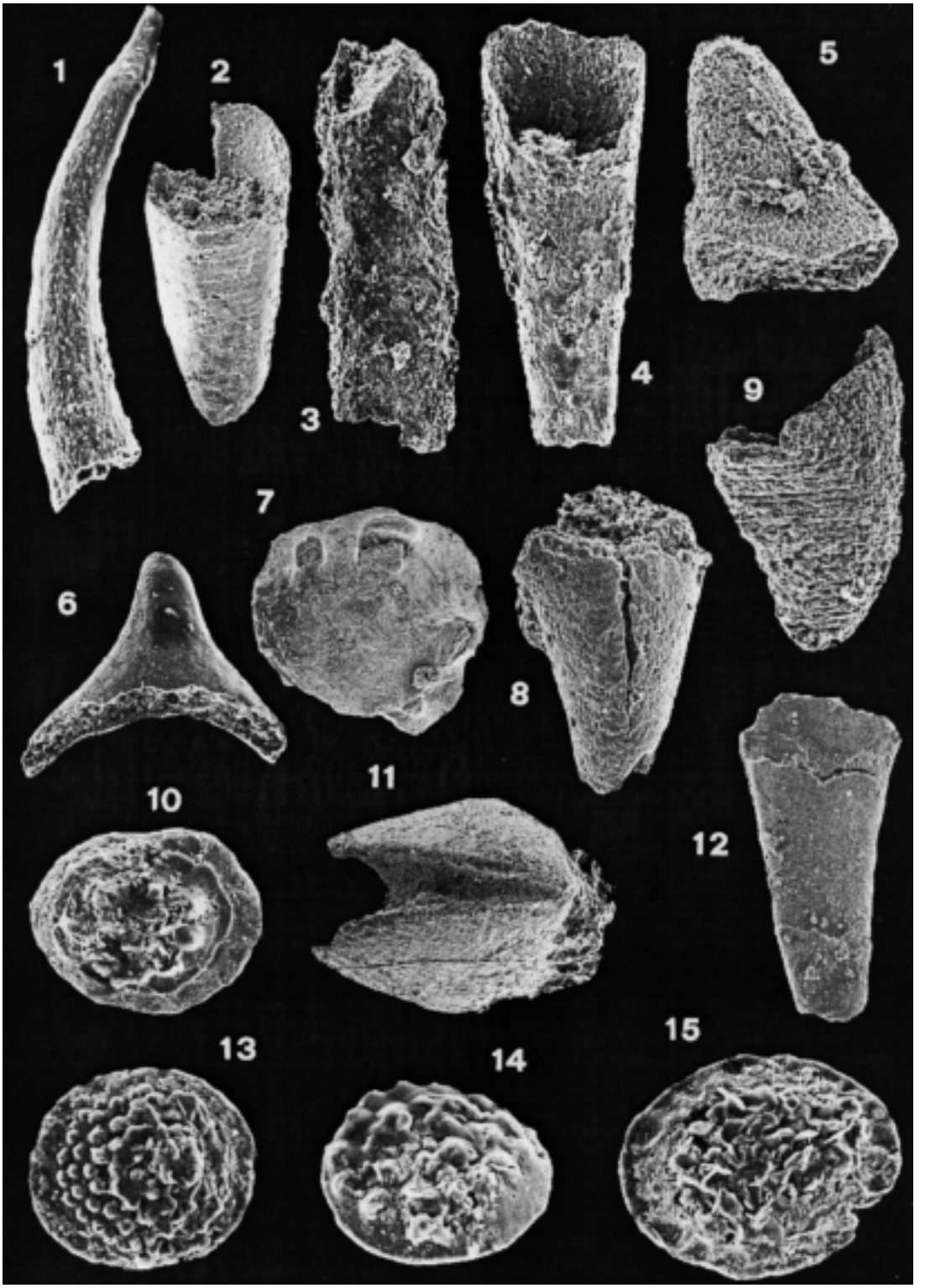
Genus *Archiasterella* SDZUY, 1969

Type species: *Archiasterella pentactina* SDZUY, 1969

PLATE 3
Figs. 1,6.- *Isoxys*? sp. A *sensu* BENGTSON? (*in* BENGTSON *et al*., 1990). 1- long spine, CT-03- 1051, (x190); 6- short spine, CT-03-1949, (x180).
Figs. 2,8,?9.- *Conotheca* cf. *australiensis* BENGTSON (*in* BENGTSON *et al*., 1990). 2- CT-03-1072, (x140);
Fig. 3.- *Byronia* sp., CT-03- 1010, (x140).
Figs. 4,12.- ?*Microcornus* sp., 4- CT-03-1056, (x130); 12- CT-03-1046, (x130).
Fig. 5.- Monoplacophora Form B *sensu* FERNÁNDEZ-REMOLAR, 1998. CT-03-1080, (x150).
Fig. 7.- Possible operculum of undeterminate hyolithid. CT-03-1043, (x40).
Figs. 10,13-15.- *Hadimopanella oezgueli* GEDIK, 1977. 10- CT-04-1061, (x500); 13- CT-04-1060, x 450); 14- CT-04-1059, (x500); 15- CT-04-1081, (x550).
Fig. 11.- Ostracoda, species D *sensu* HINZ, 1987, CT-03-1042, (x50).

LÁMINA 3
Figs. 1,6.- *Isoxys*? sp. A *sensu* BENGTSON? (*in* BENGTSON *et al*., 1990). 1- espina corta, CT-03- 1051, (x190); 6- espina corta, CT-03-1949, (x180).
Figs. 2,8,?9.- *Conotheca* cf. *australiensis* BENGTSON (*in* BENGTSON *et al*., 1990). 2- CT-03-1072, (x140);
Fig. 3.- *Byronia* sp., CT-03- 1010, (x140).
Figs. 4,12.- ?*Microcornus* sp., 4- CT-03-1056, (x130); 12- CT-03-1046, (x130).
Fig. 5.- Monoplacophora Form B *sensu* FERNÁNDEZ-REMOLAR, 1998. CT-03-1080, (x150).
Fig. 7.- Posible operculum de un hiolítido indeterminado. CT-03-1043, (x40).
Figs. 10,13-15.- *Hadimopanella oezgueli* GEDIK, 1977. 10- CT-04-1061, (x500); 13- CT-04-1060, x 450); 14- CT-04-1059, (x500); 15- CT-04-1081, (x550).
Fig. 11.- Ostracoda, especie D *sensu* HINZ, 1987, CT-03-1042, (x50).

PLATE 3/LÁMINA 3



Archiasterella hirundo BENGTSON, 1990
(Plate 2, Fig. 1)

1990 *Archiasterella hirundo* BENGTSON (*in* BENGTSON *et al.*), p. 54, Pl. 29, Figs. A-C; Pl. 30, Figs. A-H.
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 Kulpara) 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

? Eremactis sp.
(Pl. 1, Fig. 8)

Material: 4 sclerites from the level CT-03

Remarks: Sclerites with one elongate ray and circular cross-section. The specimens provisionally assigned to this genus have smooth surface. Both ends of the rays are broken in our material.

Orden Sachitida HE, 1980
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.

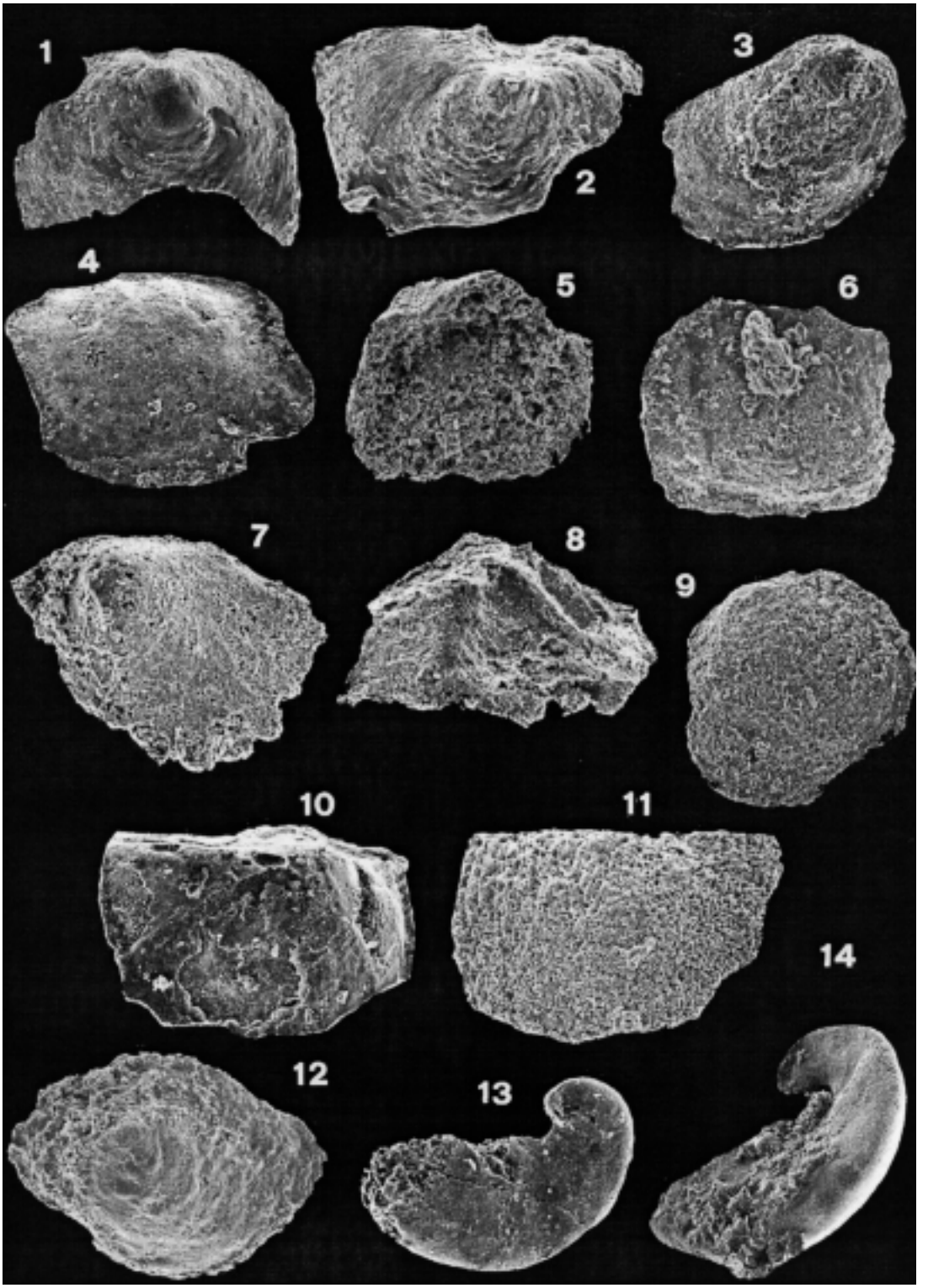
Material: 10 sclerites from the level CT-03.

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
Figs. 1-2,6.- Acrotretids indeterminate. 1- CT-03-1058, (x120); 2- CT-04-1082, (x180); 6- CT-03-1059, (x120).
Figs. 3,7,9,12.- *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. 4,10-11.- ?*Aroonia* sp., 4- CT-03-1060, (x90); 10- CT-03-1079, (x160); 11- CT-03-1068, (x100).
Figs. 5,8.- *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).

LÁMINA 4
Figs. 1-2,6.- Acrotrétidos indeterminados. 1- CT-03-1058, (x120); 2- CT-04-1082, (x180); 6- CT-03-1059, (x120).
Figs. 3,7,9,12.- *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. 4,10-11.- ?*Aroonia* sp., 4- CT-03-1060, (x90); 10- CT-03-1079, (x160); 11- CT-03-1068, (x100).
Figs. 5,8.- *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).

PLATE 4/LÁMINA 4



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 SYSSOIEV, 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.

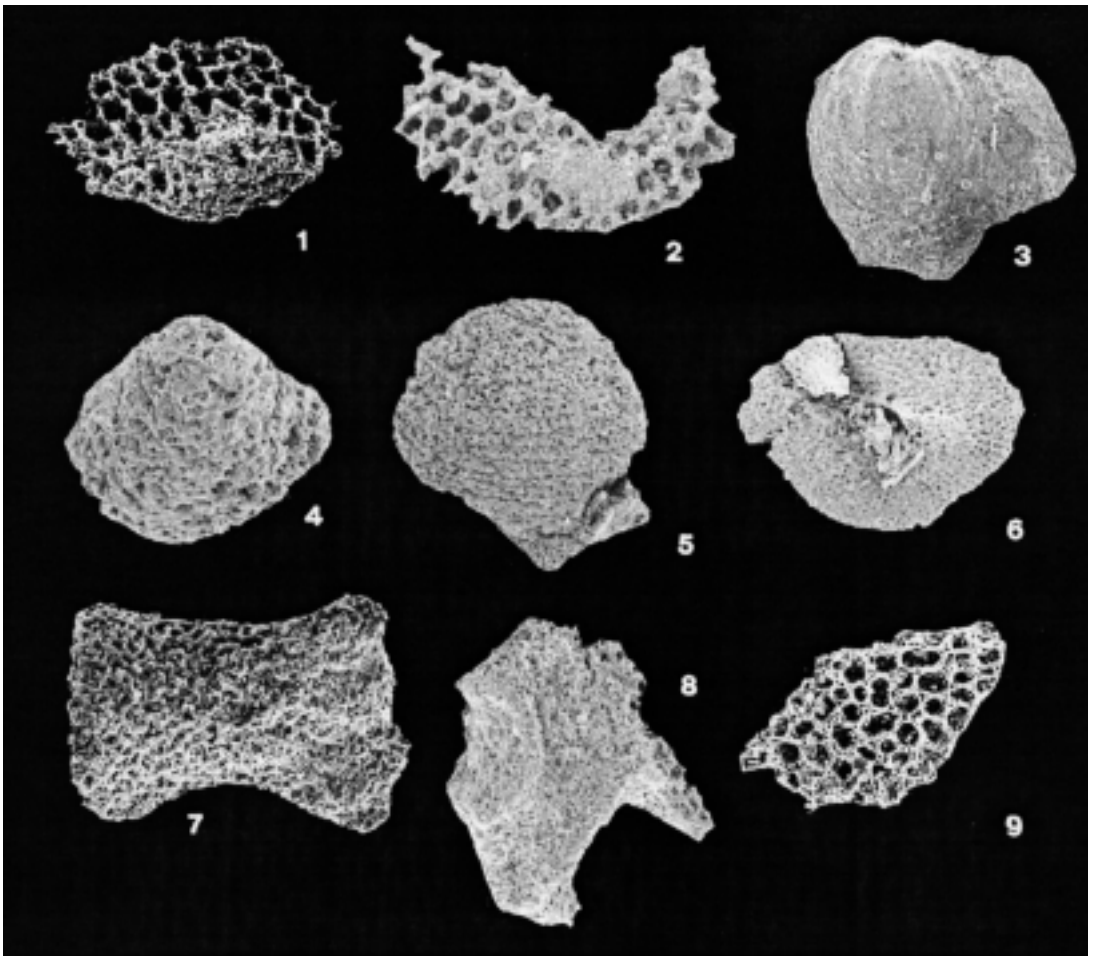
Remarks: Narrow shells with rounded triangular or rounded quadrangular transverse cross section have been assigned with doubts to this genus. Surface ornamentation consists of fine growth lines parallel to the aperture. In the specimens preserved as internal moulds (Pl. 1, figs.5-6) part of the bulbous 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

PLATE 5
Figs. 1-2.- *Microdictyon* sp., 1- CT-03-8899, (x70); 2- CT-03-8898, (x80).
Fig. 3.- Acrotretid indeterminate, CT-03-8857, (x150).
Figs. 4-5.- ?*Aroonia* sp., 4- CT-03-8005, (x170); 5- CT-03-8865, (x110).
Figs. 6-9.- Echinoderm plates. 6-CT-03-8860, (x120); 7-CT-03-8891, (x180); 8- CT-03-8898, (x140); 9- CT-03-8897, (x130).

LÁMINA 5
Figs. 1-2.- *Microdictyon* sp., 1- CT-03-8899, (x70); 2- CT-03-8898, (x80).
Fig. 3.- Acrotrétido indeterminado, CT-03-8857, (x150).
Figs. 4-5.- ?*Aroonia* sp., 4- CT-03-8005, (x170); 5- CT-03-8865, (x110).
Figs. 6-9.- Placas de equinodermos. 6-CT-03-8860, (x120); 7-CT-03-8891, (x180); 8- CT-03-8898, (x140); 9- CT-03-8897, (x130).

PLATE 5/LÁMINA 5



Subclass Scyphomedusae LANKESTER, 1881
Order Byroniida BISCHOFF, 1989
Family Byroniidae BISCHOFF, 1989

Genus *Byronia* MATTHEW, 1899

Type species: *Byronia annulata* MATHEW, 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.
1988 *Hadimopanella oezgueli* GEDIK - MÁRSS, p. 14-15, PL. 1, Figs. 1-8.
2001 *Hadimopanella oezgueli* GEDIK – WRONA & HAMEDI, p. 104-105, Pl. 1, Figs. 1-6, Pl. 2, Figs. 1-8, Pl. 3, Figs. 1-5.
2001 *Hadimopanella oezgueli* GEDIK – FERNÁNDEZ-REMOLAR, Lám. 1, figs. 1-4.

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 KHUN, 1949
Suborder Acrotretidina KHUN, 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 assocciation. 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 Cyrtonellida HORNY, 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 cyrtoconellid. 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 Pelagiellida RUNNEGAR & POJETA, 1985
Family Pelagiellidae 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 dextraly 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

Monoplacophora Form 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

? Aroonia sp.
(Pl. 4, Figs. 4, 10-11; Pl. 5, Figs. 4-5)

Material: 11 specimens from the level CT-03.

Remarks: Bivalved, biconvex and bilaterally symmetrical valves are included with some uncertainly 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 aductor? muscles. External surface shows concentric growth lines. BENGTSON (*in* BENGTSON *et a*l.,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 probable 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.

Phylum Arthropoda SIEBOLD & STANNIUS, 1845
Class Crustacea PENNANT, 1777
Order and Family Incertae Sedis

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 criterion is followed here in respect to the material from the Çal Tepe Formation.

Subclass Ostracoda LATREILLE, 1806
Order Phosphatocopida MÜLLER, 1964
Suborder, Family and Genus uncertain

Species D *sensu* HINZ, 1987
(Pl. 3, Fig. 11)

1987 species D HINZ, p. 60, Pl. 3, figs. 11-12,14

Material: 1 complete specimen from the level CT-03.

Remarks: Semi-symmetrical valves with maximum height approximately at the centre of each valve. Surface ornamentation is not visible. HINZ (1987) identified this Lower Cambrian ostracode from the *Protolenus* Limestone, Comley (England).

Phylum Echinodermata LINNEO, 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.

Phylum, Class, Order and Family incertae sedis

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 patterrn 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.

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