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Fossils from the basal levels of the Pedroche Formation, Lower Cambrian (Sierra Morena, Córdoba, Spain)

por

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RESUMEN.

Este trabajo constituye un avance de los primeros resultados obtenidos del estudio de los trilobites, arqueociatos, algas s. s. y estromatolitos de los niveles basales de la Formación Pedroche, así como la distribución estratigráfica de cada uno de los grupos fósiles.

ABSTRACT.

This paper constitutes an advance of the results obtained from the study of trilobites, archaeocyathans, algae s. s. and stromatolites from the basal levels of the Pedroche Formation and also the stratigraphic distribution of each fossil groups.

I. INTRODUCTION.

The Biostratigraphy of the Lower Cambrian base of the Iberian Peninsula is not yet known precisely because, on a local scale, facies show little variety and therefore the fossil groups found are not diverse. This means that the Biostratigraphy has to be identified, so far by one fossil group and also; on a regional basis, facies differ depending on location. From this we can deduce that reliable correlations are very difficult to determine.

In the Sierra of Córdoba, important outcrops of basal Cambrian rocks are found, with a cyclical successions of facies of carbonatic and terrigenous materials, which, favourable to evolution and life record, they mark at the same time a paleoenviroment whose conditions are more or less steady through the years. The repetition and alternation of these facies allow a simultaneous classification of fossils from different communities, consisting of trilobites, archaeocyathans, stromatolites, algae

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and trace fossils, which interrelate in space and time, and make possible the establishment of a more accurate date by comparison and contrast of ages deduced from the study of taxa in the different groups and also by their evolution in space and time. These aspects come together and can be observed in the series which break out in Arroyo of Pedroche, located along the road Córdoba-Badajoz between 1,9 and 2,5 km (fig. 1).

CARBONELL published in 1926 the first dates about the materials in Arroyo of Pedroche and he put them in the Carboniferous strata because of the similarity of facies. Later on, in 1929 CARBONELL found archaeocyathans on the same levels and he dated those beds to the Cambrian age. In 1930 CARBONELL mapped these levels in his fieldwork on El Majanillo and Mirabueno. CABANAS (1964) found

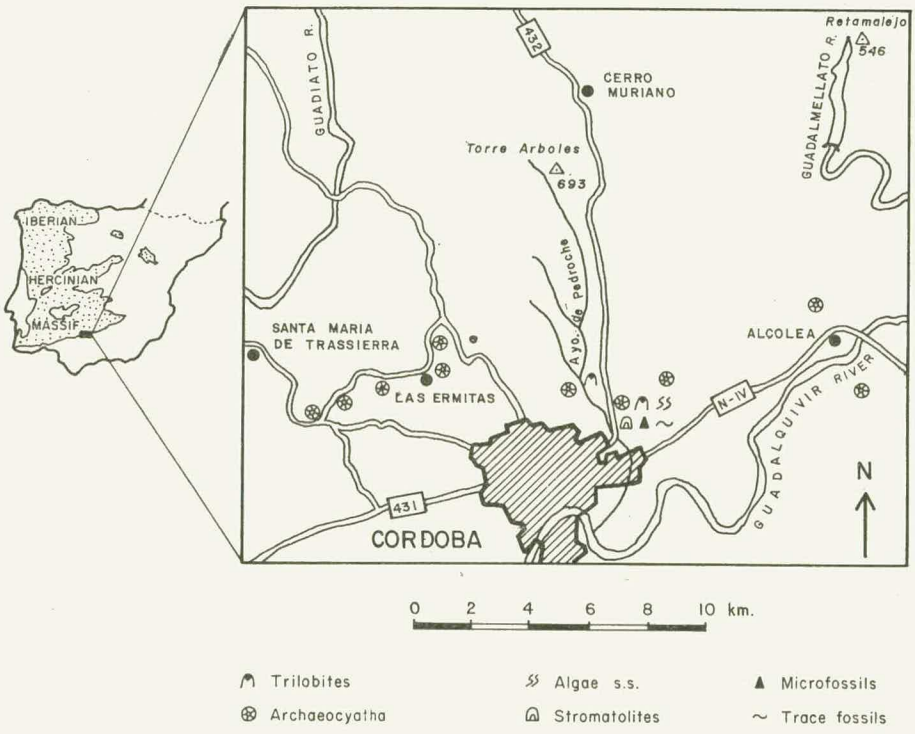

Fig. 1.—Geographic distribution of studied fossils localities and other near Córdoba.

archaeocyathans above the stream, under the iron bridge of the Córdoba-Almorchón railway. PEREJÓN (1974-1977) discovered new localities and studied the fauna of archaeocyathans previously found. LIÑÁN (1974) proposed the Cambrian type-section of the Sierra of Córdoba establishing three formations. LIÑÁN & DABRIO (1974) drew up in detail the lithologic section of the lower member of the Pedroche Formation, ZAMARREÑO (1977) studied some levels with algae on the Córdoba-Badajoz road. LIÑÁN (1978) carried out the cartography in the Sierra of Córdoba and made a study of the discovered trilobites. LIÑÁN & SDZUY (1979) published a systematic study of some genera of trilobites in Arroyo of Pedroche.

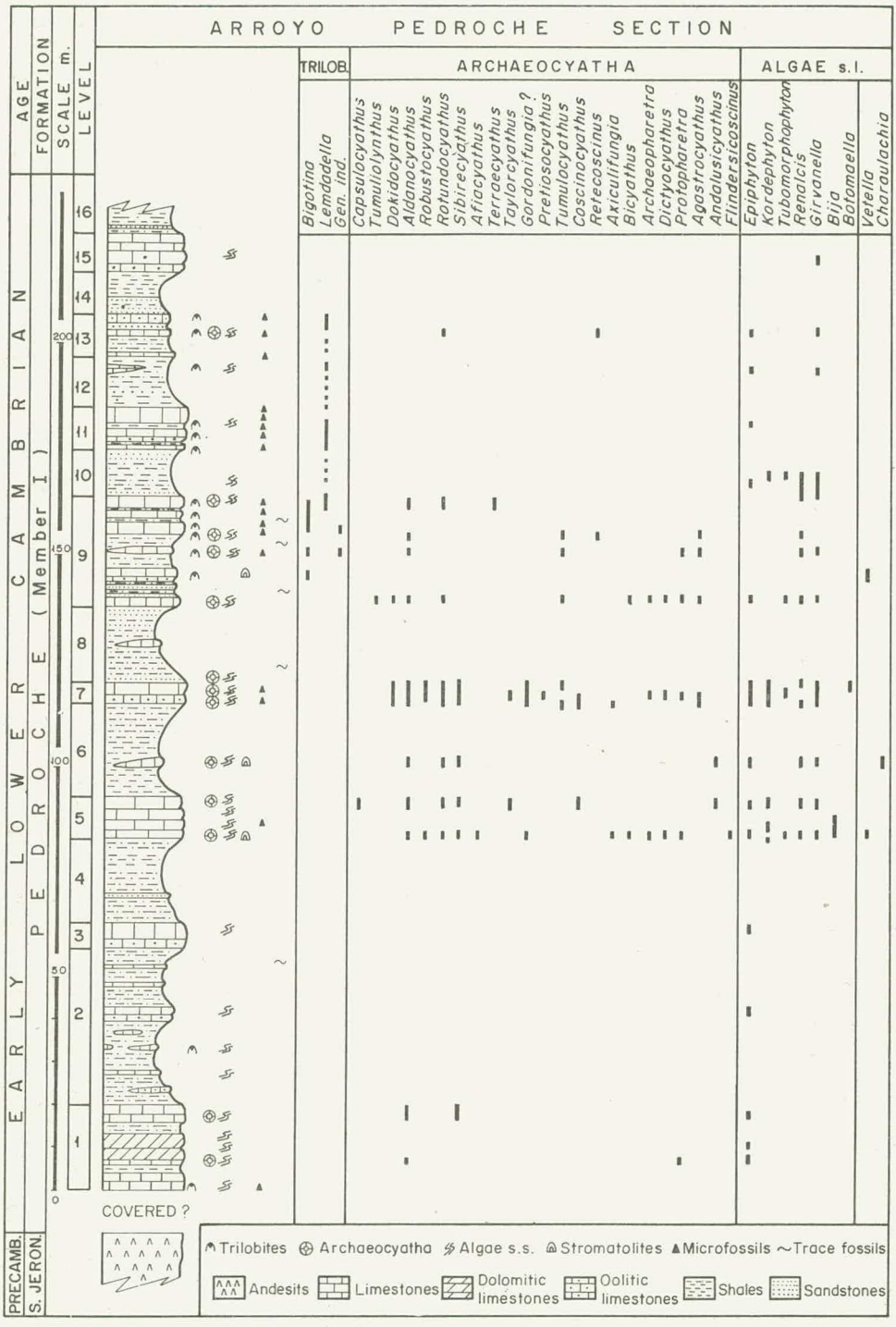

Fig. 2.—Biostratigraphic section of Pedroche Formation (Member I) of early Lower Cambrian.

Each author is responsible for a part of the study: E. LIÑÁN, for the date concerning trilobites, microfossils and ichnofossils; E. MORENO-EIRIS, for the algae s. s.; M. SCHMITT, for the stromatolites, and A. PEREJÓN, for the archaeocyathans.

The aim of this paper is to present the stratigraphic distribution of the taxa of trilobites, archaeocyathans, stromatolites and algae s. s., found in the Member I of Pedroche Formation.

II. STRATIGRAPHIC NOTIONS.

The Cambrian Series of the Sierra of Córdoba consists of three different formations: Pedroche, Santo Domingo, and Los Villares, in ascending stratigraphic order. This study is centred on the lower member of Pedroche Formation. The detailed lithologic column of the type section of this member was carried out by LIÑÁN & DABRIO (1974) and it has served as the basis for the present study.

As these authors have pointed out, concerning this series a certain repetition of carbonatic and terrigenous materials is noticed. Each sequence starts in theory with facies of sandstones and shales with trace fossils, then oolitic and oncolithic limestones facies in beds of decimetric thickness, followed by algae limestones and sometimes by archaeocyathans. In the upper part, microfossils, brachiopods, and trilobites are ussually found. The cycle ends with new deposits of sandstones, and shales with trace fossils.

In each cycle, algae limestones can be sustituted by stromatolitic limestones and algae mats limestones, depending on the geographic point where the series is cut. The usual lenticular shape of the carbonatic layers implies that they appear on a regional scale as discontinuous levels which are repeated in space and time.

The base of the series cannot be observed since it is covered in its last metters by the terraces of the Guadalquivir river. At 40 metres from the base andestic materials from San Jerónimo Formation (Upper Proterozoic) are found.

III. TAXA STRATIGRAPHIC DISTRIBUTION.

Although some other groups with problematic microfossils, brachiopods and ostracodes have seen recognized we shall only deal with the taxa distribution of trilobites, archaeocyathans stromatolites, and algae s. s.

TRILOBITES.—These are located in the calcareous levels, in its upper part or in the contact between the limestone and terrigenous materials: in this case the original carapace is not usually preserved. They are associated with archaeocyathans and algae s. s. at the calcareous levels; at terrigenous levels it is more frequently associated with brachiopods, pelagiellids, ostracodes and Chancelloriida in variable proportions, according to the level considered.

By means of limestone attack with formic acid 10 % diluted, several specimens of opistoparian trilobites have been extracted, rather scarce and incomplete. The distribution of classified genera can be seen in fig. 2. The *Bigotina* genus appear in the base of level 9 and are replaced by *Lemdadella* with which they coexist. Between one genus and another a progressive evolution is observed, and so there are intermediate forms which are difficult to include in one or other genus. The studied species are new, but given that the record of this section is continuous, it

is very difficult to establish their boundaries and because of this it has been decided to leave, for the moment, their specific systematic study. Allong with this transition, several cranidii of a new genus were found, but it was impossible to define such genus, because of the few specimens studied.

ARCHAEOCYATHANS.—This fossil group is well represented in nearly every calcareous stretch of Member I of the Pedroche Formation, this is due as much to the number of different genera, as to the quantity of specimens found. Fig. 2.

Archaeocyathans are always associated with algae forming the fundamental organic body of calcareous beds; when there are columnar stromatolitic structures the cups are arranged either in the inner empty spaces or on top of them. Only at the base of level 9 do the archaeocyathans constitute the main component of a bioherm 1,50 m thick and 2 m long, where algae are second to them in importance.

We have determined 267 specimens corresponding to 16 genera of the Class Regular and 490 specimens corresponding to 7 genera of the Class Irregular, scattered in levels 1, 5, 6, 7, 9 and 13. As can be observed en fig. 2, in each level there are one or some places where we have found archaeocyathans, and in all of them we can find genus of the Regular, while the Irregular are missing in four of them.

The relation between the number of genera of each Class in each level is very variable but the proportion always favour the Regular, except for the basal bed of level 9. On the other hand, the amount of Irregular specimens is higher than that of Regular, although in some places there are not Irregulares at all.

Considering the great quantity of Irregular specimens studied, especially those from level 9 base, we want to point out that in many longitudinal sections we have observed a gradual progression among the characteristic structures of genera *Bicyathus-Archaeopharetra-Protopharetra-Ardrossacyathus-Agastrocyathus*. This problem will be considered in a future study. So as not to complicate this, we have considered each one of this genera to be separate and independent.

Generally, depending on the place of appearance in the stratigraphic section, the archaeocyathans can be grouped in three units. The first one will include genera appearing in the lower levels of Member I (1 to 4) and among them can be found only *Aldanocyathus, Sibirecyathus* and *Protopharetra* associated with algae from genus *Epiphyton,* fragments of opistoparian trilobites and trace fossils.

The second archaeocyathans group appearing in the intermediate levels of Member I (5 to 9) would be constituted by 16 Regular genera, *Capsulocyathus, Tumuliolynthus, Dokidocyathus, Aldanocyathus, Robustocyathus, Rotundocyathus, Sibirecyathus, Afiacyathus, Terraecyathus, Taylorcyathus, Gordonifungia ?, Pretiosocyathus, Tumulocyathus, Retecoscinus, Coscinocyathus* and *Axiculifungia,* from which we have studied 258 specimens, 91 % of them falling between 0-6 mm in diameter and 7 Irregular genera, *Bicyathus, Archaeopharetra, Dictyocyathus, Protopharetra, Agastrocyathus, Andalusicyathus,* and *Flindersicoscinus,* with 489 specimens, 57 % of them, falling between 0-6 mm and a 11,5 % fall between 9-15 mm. In these levels the archaeocyathans are associated with trilobites of the genera *Bigotina* and *Lemdadella,* with the stromatolites *Vetella* and *Charaulachia* with many algae and Chancelloriida and some traces fossils.

The third group is located in the upper levels (10 to 15) and it consists of two genera of Regular, *Rotundocyathus* and *Retecoscinus* with 6 specimens, 3 of them measuring from 0-6 mm diameter and 3 other between 6 and 9, none of the Class Irregular were found. In these level archaeocyathans are associated with trilobites of *Lemdadella* and algae.

If we analize the appearing of the different morphologic structures of the archaeocyathans, we find the following:

In level 5 we find *Capsulocyathus,* with only one wall; genera with both simple walls appear in this and in every level, and among them, there is *Aldanocyathus* which is only missing in level 13. The inner wall with pore-tubes is found with *Afiacyathus,* restricted to the base of this level. The annulate inner wall is found in *Taylorcyathus* and *Gordonifungia* ? also present in level 7, and genera with tabulae like *Coscinocyathus* and *Axiculifungia.* Among the Irregular we find *Andalusicyathus* seen again in level 6 and *Flindersicoscinus* with tabulae restricted to this level only.

In level 7, we find the last specimen with annulate inner wall and genus *Pretiosocyathus* with double outer wall; and also cups whose outer wall presents tumuli, as in *Tumulocyathus* also present in level 9, and for the last time Regular genera are found with tabulae.

In level 9, we find *Tumuliolynthus* with only one wall with tumuli, and *Terraecyathus* with unconnected pore-tubes in the inner wall. *Retecoscinus* shows tabulae.

In level 13, only Regular genera *Rotundocyathus* with simple walls, and *Retecoscinus* with tabulae and no Irregular genus.

ALGAE S. S.—In every one of the carbonatic levels of the Member I of Pedroche Formation, algae remains are present, some of them are associated with stromatolitic structures as in levels 5 and 6 (fig. 2) and also with trilobites and microfossils remains. But those organisms with which they are frequently associated are the archaeocyathans and they form organic buildings with a variable arrangement either in space or time.

Therefore, within the same carbonatic level we can observed facies characteristic of bioherm and biostrom; only in the basal limestone of level 9 do we find a bioherm with a considerable volume and whose morphological features can be observed in field. In this carbonatic stretch both algae and archaeocyathans show a reduced generic variability, since it is in a bioherm that specific genera predominate. As for the algae (fig. 2) they are *Epiphyton, Tubomorphophyton, Renalcis* and *Girvanella*; and for the archaeocyathans there are the specimens belonging to this Class Irregular, with five genera, those which predominate netly upon the Regulars, with three genera. .

In contrast, there is mentioned level 7, where we find alternating facies belonging to bioherm and biostrom, with a great generic variability of archaeocyathans and algae.

Genus *Epiphyton* BORNEMANN, 1886, is one of the most frequent algae existing in the Pedroche Formation in its Member I. It is found scattered along the whole section from the lower levels, and constitutes together with the genera *Girvanella* and *Renalcis* the most abundant form.

These organisms show a great morphological variety whose specific classification we shall deal with in a future study. This genus is mainly found in those levels where archaeocyathans exist, as it is one of the main elements of the organic limestones; it is also associated with stromatolites, trilobites and microfossils.

The *Epiphyton* genus has been refered by the specialists to different algae types, to Chlorophyta (GORDON. 1921; MASLOV, 1956), to Cyanophyta (LUCHININA, 1971, 1975; WRAY, 1977), and to Rhodophyta (KORDE, 1955, 1958, 1959, 1961, 1969, 1973; VOLOGDIN, 1962; VORONOVA. 1976; DROZDOVA, 1980) and its inclusion

within Rhodophyta in the Epiphytaceae family (KORDÉ, 1959) is now accepted by most authors.

In the Rhodophyta, besides *Epiphyton,* we have recognized two other genera, *Kordephyton* RADUGIN & STEPANOVA, 1964, and *Tubomorphophyton* KORDE, 1973, the latter showing a great amount of specimens in the basal limestones of level 9.

Genus *Renalcis* VOLOGDIN, 1932. found scarcely is from level 5 to 8 of the section, whilst in level 9 it is very abundant with a great morphologic variety; it is worth pointing out that in some cases we observe a very intimate spatial relation among the forms *Renalcis, Girvanella* and *Epiphyton.*

This organism which appears from the Cambrian to the Upper Devonian and shows a branched multilocular shape with thick calcareous walls, has been usually considered as an algae by several authors (KORDÉ, 1961, 1965; VOLODGIN, 1962; JOHNSON, 1966; LUCHININA, 1971, 1975; VORONOVA, 1976; WRAY, 1977; DROZDOVA, 1980) and it is included by most in Cyanophyta. However other authors have refered to it as a benthic Foraminifera, ELIAS, 1950; KLOVAN, 1964; RIDING & BRASIER, 1975.

Genus *Girvanella* NICHOLSON & ETHERIDGE, 1878, in Member I of Pedroche Formation is distributed along the whole section; it is characterized by its tubular and non-branched calcified filamentous. In level 5 and 6 is scarcely found. while in levels 7 and 9, it is very abundant showing great morphological variety from isolated nodular forms, scattered in the microsparitic matrix, to elongated forms which surround and colonize the outer walls of the archaeocyathans cups.

This genus has now been reconsidered by DANIELLI, 1981 and he includes it in the Family Porostromata PIA, 1927, inside Cyanophyta, in this work the author offers a complete research on all the *Girvanella* specimens so for described.

Genus *Bija* VOLOGDIN, 1932 shows an irregular cellular structure of polygonal to rounded cells, considered by VOLOGDIN. 1962 and KORDÉ, 1969 as Rhodophyta; by LUCHININA, 1971 as Cyanophyta and by VORONOVA, 1976 as *incertae sedis.*

In the section of Member I we find it only in level 5, in its lower part it is associated with *Epiphyton, Turbomorphophyton, Renalcis,* and *Girvanella,* in the middle part only to *Kordephyton* and on the upper we find only *Bija.*

Genus *Botomaella* KORDÉ, 1958 alga Cyanophyta (KORDÉ, 1958, 1961, 1969; LUCHININA, 1971; DROZDOVA, 1980) constitutes with *Girvanella* the most abundant form of the upper stretches of level 7; it is found associated with *Epiphyton, Kordephyton,* and *Renalcis* genera whose appearances are somewhat sporadic in this level.

STROMATOLITES.—Stromatolites coexist with algae s. s., microfossils and archaeocyathans (this rarely) located between the columnar structure in facies of greater terrigenous upbringing, where cups are of a small size. In level 5 *Vetella* is found, *Charaulachia* in level 6. In level 9 a new form of *Vetella* is found coexisting with the older *Bigotina* species found, so that in the section, the columnar stromatolites are only seen below *Lemdadella.*

IV. STRATIGRAPHIC CONSIDERATIONS.

This preliminary study allows us to propose the division of the Lower Cambrian base in the Sierra of Córdoba in three clearly differentiated parts, according to the different fossils groups found.

The lower part would include the lowest levels of Member I from 1 to 4 and it is characterized by remains of opistoparian trilobites, archaeocyathans of the genera *Aldanocyathus, Sibirecyathus* and *Protopharetra,* algae from genus *Epiphyton* and traces fossils *Monocraterion* type.

The middle part includes from level 5 to 9 inclusive contains trilobites of genera *Bigotina* and *Lemdadella,* although the appearance moment of *Bigotina* is not well-known, besides the species of both genera overlap in time for a short period. Also all genera of archaeocyathans found: *Capsulocyathus, Tumuliolynthus, Dokidocyathus, Aldanocyathus, Robustocyathus, Rotundocyathus, Sibirecyathus, Afiacyathus, Terraecyathus, Taylorcyathus, Gordonifungia?, Pretiosocyathus, Tumulocyathus, Retecoscinus, Coscinocyathus, Axiculifungia, Bicyathus, Archaeopharetra, Dictyocyathus, Agastrocyathus, Andalusicyathus* and *Flindersicoscinus*; the stromatolites forms *Vetella* and *Charaulachia*; abundant algae with the presence of *Epiphyton, Kordephyton, Tubomorphophyton, Renalcis, Girvanella, Bija, Botomaella*; traces fossils, *Planolites, Monocraterion* and *Cruziana* ? and *Chancelloriida* very much frequent.

The upper part includes levels 10 to 15 it is characterized by presence of *Lemdadella,* the Regular archaeocyathans: *Rotundocyathus,* and *Retecoscinus* and all algae genera except *Bija* and *Botomaella.*

V. Correlations.

In Spain, *Lemdadella* and *Bigotina* have only been found up to now in Sierra Morena, so that correlations with other series are not very accurate. Liñán & Sdzuy (1979) have pointed out that for northern Spain the horizon with *Pararedlichia,* and *Bigotinops* of Concha of Artedo can probably be correlated with the upper levels containing the *Lemdadella* fauna, and for this reason the *Bigotina* fauna is older than any other in Spain.

The group of archaeocyathans genera found shows many resemblances to those of Las Ermitas, although up to now the genera *Terraecyathus, Gordonifungia* ?, *Pretiosocyathus,* and *Axiculifungia* have only been found in this localities and, on the other hand we have to take into account that genus *Andalusicyathus* in poorly represented here.

In Morocco, *Lemdadella* is found in Ounein and Tiout (Sdzuy, 1978; Liñán & Sdzuy, 1979) in this last place this genus coexist with specimens which could well be refered to *Bigotinops* and so, its age must be the Zone I of Hupe, the same as the lower horizon of Concha of Artedo.

The stromatolites found also show a low age in the Lower Cambrian. By the place they occupy in the Tiout series, *Vetella* should be more recent than the species of this genus appearing in Córdoba.

The archaeocyathans we have studied in this locality present a very similar genera association to that found in Tiout (Debrenne & Debrenne, 1978) except by *Tumulifungia* and *Neoloculicyathus* which are missing in Córdoba, therefore we think they must have a similar age.

In the French locality of Carteret, trilobites of genus *Bigotina* are also found whose age should not be very different to that of the Córdoba fauna and there are archaeocyathans of the genera *Aldanocyathus, Sibirecyathus, Retecoscinus* and *Protopharetra* (Debrenne & Debrenne, 1978) which are also present here. These

discoveries allow the comparison and correlation of these series with those of Morocco.

In Siberia there are only known species of *Bigotina* and this is the main reason for the difficulty experienced in correlating date with the Peninsula up to now. The discovery of associated faunas of *Lemdadella* and *Bigotina*, as well as the existence of 6 genera of common archaeocyathans in both regions: *Dokidocyathus, Aldanocyathus, Retecoscinus, Coscinocyathus, Taylorcyathus, Gordonifungia* ?, well be of great importance in future correlations with the siberian and the moroccan faunas in which Spain can represent an intermediary point of connection.

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