SKELETAL STRUCTURE, GROWTH, AND PALEOECOLOGY OF THE PATCH REEF-BUILDING POLYCHAETE WORM *DIPLOCHAETETES MEXICANUS* WILSON, 1986 FROM THE OLIGOCENE OF BAJA CALIFORNIA (MEXICO)

by

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ABSTRACT

Worm reeflets discribed here are composed of parallel and straight, curved, or bifurcated tubes, which are up to 10 cm long and have an average diameter of 1.4 mm. Their walls are composed of microgranular calcite and are multilamellar. The reef-builders settled on soft bottoms within the tidal or uppermost zone. They tolerated high water turbulence and a certain rate of sedimentation. Dead parts of the reef were recolonized by a new population. The reefs stabilized the sediment, produced biogenic debris, and offered new ecological niches for endo- and epilithic organisms. They mark a regional ecological event at the Oligocene/Miocene boundary. *Diplochaetetes mexicanus* as well *D. longitubus* demonstrate close relationships to a modern skeletal-forming polychaete worm, *Dodecaria. Diplochaetetes* is definitly not a sclerosponge and demonstrates a convergence with the chaetetid basal skeletons of sponges and favositid corals.

RÉSUMÉ

Le ver polychète *Diplochaetetes mexicanus* édifie de petits récifs sur des substrats sableux de la zone intertidale basse. Ces récifs se composent de tubes de forme droite, courbée ou ramifiée pouvant atteindre 10 cm de long. Les parois des tubes sont constituées de calcite microgranuleuse. Les constructeurs des récifs tolèrent une haute turbulence de l'eau et un certain taux de sédimentation. Les récifs stabilisent les sédiments et offrent de nouveaux milieux de vie pour des organismes épi- et endolithiques. Ils indiquent un évènement écologique régional à la limite Oligocène/Miocène en Basse Californie et peut-être aussi en Californie. *Diplochaetetes mexicanus* ainsi que *D. longitubus* présentent des similitudes avec le ver polychète actuel *Dodecaria* qui possède également un squelette basal calcaire agglutiné. Le genre *Diplochaetetes* n'est pas un spongiaire corallien. Son squelette basal chaetétide représente une convergence avec celui de certains spongiaires (p.ex. *Acanthochaetetes*) et des coraux favositidés.

ZUSAMMENFASSUNG

Der polychäte Wurm *Diplochaetetes mexicanus* baut auf sandigem Substrat des Gezeiten-Niedrigwasser-Bereichs kleine Riffkörper auf. Sie werden aus bis zu 10 cm langen Röhren, die gerade, gebogen und verzweigt sein können, zusammengesetzt. Die Röhrenwand besteht aus mikrogranulärem Kalzit. Die Riffbildner tolerieren hohe Wasserturbulenz und eine gewisse Sedimentüberdeckung. Die Riffe sind Sedimentstabilisatoren und Lebensraum für Epi- und Endolithen. Sie zeigen ein regionales ökologisches Ereignis an der Wende Oligozän/Miozän in Niederkalifornien und womöglich auch in Kalifornien an. *Diplochaetetes mexicanus* als auch *D. longitubus* zeigen Übereinstimmungen mit dem rezenten polychätem Wurm *Dodecaria*, der ebenfalls kalkige, agglutinierte Basalskelette aufweist. Das Genus *Diplochaetetes* ist kein coralliner Schwamm. Das chaetetide Basalskelett ist konvergent zu den chaetetiden Basalskeletten einiger Spongien (z.B. *Achantochaetetes)* und dem favositider Korallen.

KEY-WORDS : POLYCHAETA, AGGLUTINATED WORM TUBES, "CHAETETIDA", PATCH REEFS, PALEOECOLOGY, OLIGOCENE, SAN GREGORIO FORMATION BAJA CALIFORNIA, MEXICO.
MOTS-CLÉS : POLYCHAETA, TUBES DE VERS AGGLUTINÉS, "CHAETETIDA", BIO-CONSTRUCTIONS, PALÉOÉCOLOGIE, OLIGOCÈNE, FORMATION SAN GREGORIO BAJA CALIFORNIE, MEXIQUE.

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INTRODUCTION

Between La Paz and a point approximately 60 km farther north, the Oligocene San Gregoiro Formation crops out near the coast of Baja California (fig. 1). The sequence is characterized by conglomerates, siltstones, and coarse sandstones intercaleted with layers of oolithic phosphorites. Close to the top of the San Gregorio Formation, probable of Late Oligocene (Applegate 1986), only a few meters below the younger San Isidro Formation, there are small reeflets embedded in the conglomerates and coarse sandstones (fig. 2), which Wilson 1986 regards as being formed by sclerosponges. Very similar fossils have been reported from the San Lorenzo Series (Eocene to Oligocene) of California (U.S.A.) under the name of "*Serpula rectiformis* n.sp." (CLARK, 1918). Recent studies and newly collected material extend our knowledge about the skeletal structure and growth of the reef forming organisms, their systematic position, and their habitat and paleoecology.

Recently, Applegate (1986) proposed new statrigraphic names and units for the phosphoritic series and the overlaying marine sediments. The "San Gregorio Formation" of our paper coincides with the "San Hilario Member" and the "San Isidro-Formation" with the "Cerro Colorado Member" of Applegate "El Cien Formation".

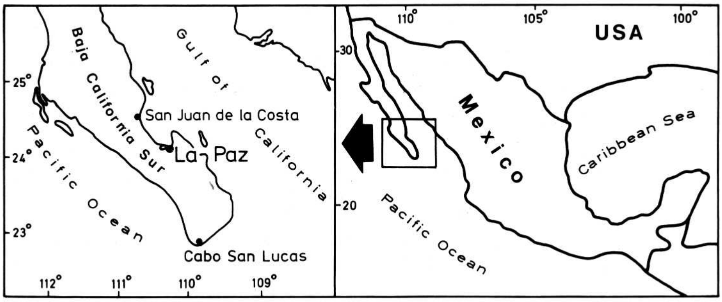

Fig. 1 - Sketch map of the area of investigation in the southern part of the California Peninsula.
Carte-croquis de la région étudiée dans la partie sud de la Péninsule californienne.

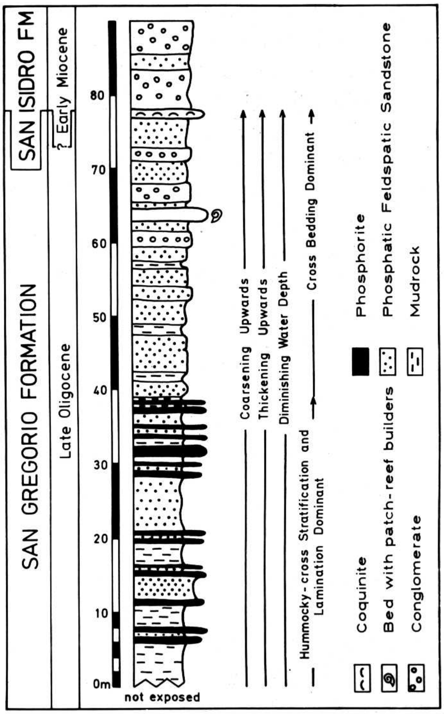

Fig. 2 - Stratigraphic section of the San Gregorio Formation near the Bay of La Paz, Baja California.
Coupe stratigraphique de la Formation San Gregorio près de la Baie de La Paz, Baja California.

MATERIAL AND METHODS

The material was collected in Baja California (R. Fischer & O. Galli). The specimens are deposited at the Institute of Geology and Paleontology of the University of Hannover. Further material was studied, which is housed in the collection of the "Geologìa Marina, Univ.Autónoma de Baja California Sur, La Paz.

Some of type material was studied by J. Reitner courtesy of E. Wilson. A small part of the collected material was studied by petrographic microscope (as well as the paratype material). From broken pieces of *Dodecaria* and *Diplochaetetes*, SEM (scanning electron microscope) and EDAX (Energy dispersive X-Ray Analyser) studies were performed in order to recognize the ultrastructure and cement mineralogy.

SKELETAL STRUCTURE OF *DIPLOCHAETETES MEXICANUS* WILSON

The small patch reefs consist of honeycomb-like infrastructure of tubes. The tubes are 15 to 100 mm long, have a rounded transverse section, and an average diameter of 1.4 mm. Neighboring tubes are fused by microcrystalline calcite. The interspaces may also be filled with sediment particles such as quartz, feldspar, and phosphatic ooids. The wall of the tubes is about 0.004 mm thick, consists of microcrystalline calcite in traverse sections and is lamellar (pl. 1, fig. 1). The lamellae are constructed of agglutinated grains of calcite, separated by thinner lamellae of densely packed micritic calcite (pl. 1, fig. 1,3 ; pl. 2, fig. 4)

In traverse sections the tubes are irregularly rounded or oblong internally but certainly subcerioid externally. The shape of individual tubes is always adapted to the available space. Some tubes show an initial partition of the lumen (pl. 1, fig. 2). This is indicated by a folding-in of a part of the wall. The fold, which in its early stages resembles a septum projection into the lumen, grows until it fuses with the opposite part of the wall and thus completes the partition.

In longitudinal section the narrow cyclindrical shape of the tubes becomes visible. The wall can be formed by one or several layers (pl. 1, fig. 3). The number of layers changes in the longitudinal direction. Particles of sediment can commonly be observed between the tubes (pl. 1, fig. 4). They have become completely enclosed by the growing tube walls. All tubes possess tabulae and a tube wall (pl. 1, fig. 6), or develop a proximal collar, which adds an additional layer to the tube wall (pl. 1, fig. 5). The tabulae may be multilamellar themselves (pl. 1, fig. 5-7) and sometimes vaulted in the opposite direction. In rare cases tabulae can be observed in which one or more concave lamellae raise from a convex lamellae as a base (pl. 1, fig. 7). The distance between the tabulae is normally some millimeters. Rarely, there are sequences of closely spaced tabulae with distances of less than one mm (pl. 1, fig. 8). These sequences preferentially occur where the tubes have been filled with sediment.

Growth

The tubes begin to grow on the surface of the sediment (pl. 1, fig. 9). Lack of bioturbation indicates that the soft parts of the organisms did not penetrate the sediment deeply. The tubes exclusively grow upward. The diameter of a tube remains constant over the entire length. Under normal circumstances the tubes appear to have grown continuously without limitations. Growth stopped only when the whole colony was buried by sediment.

After some time the basal part of the tube was cut off from the rest by the formation of a tabula. The formation of tabulae seems to have happened accidentally and cannot be related to the total length of the tubes at any stage of growth. Parts of the tube filled with sediment from below are also sealed off by tabulae. Open parts can reach maximum length of 5 cm, which give us an idea about the size of the adult organism. The ratio between bifurcating and undivided tubes is 1, 8-10. Bifurcating tubes are sometimes wider than undivided ones but do not differ otherwise.

All studied reef represent colonies of tube builders. Two structural types can be distinguished :

- carpets, characterized by lateral fusion of tubes. A colony of this type may extend over several to many square meters. Individual tubes within such a colony are arranged like organpipes (pl. 2, fig. 1).
- heads, formed by dome-like vaulted layers of tubes. The curvature of the layers results from different length of the tubes, with those in the center growing higher than those at the margin. Radial arrangement of the tubes was also observed (pl. 2, fig. 13). This type of growth leads to hemispherically shaped reef structures. In the San Juan de la Costa area the reef heads reach diameters up to 2,5 m and heights up to 1 m.

Systematic position of the genus *Diplochaetetes*

The fossils described above were regarded as skeletons of Tertara sclerosponges (Wilson 1986). However, the colony-like nature of the patch reefs, composed of individual tubes and the microcrystalline and lamellar structure of the tube walls, contradict this view. Additionally, a habitat with a high rate of clastic sedimentation does not match the ecological demands of modern sclerosponges (e.g. Reitner & Engeser 1987).

We group *Diplochaetetes mexicanus* in the class Polychaeta, taxon Sedentaria, which comprises organisms which build tubes of various types and materials ; i.e. mucus, sand grains (agglutinated), carbonate, etc. Reef-building of the kind observed in *Diplochaetetes mexicanus* occurs within the class Polychaeta, too (e.g. Kaester 1969 ; Storch 1971). Bifurcation of tubes indicates reproduction by budding (e.g. architomy; see Vogel & Angermann 1984, 147), which is known as a reproduction type in living polychaetes. Moreover, reef-building polychaetes are common in a habitat as reconstructed for *Diplochaetetes mexicanus* (see below).

It is impossible to decide which taxon of polychaete worms has constructed this simple type of skeletal tubes. It is probable that this character is highly convergent within the taxon Polychaeta. Further studies on this problem are planned.

FURTHER FOSSIL AND MODERN EXAMPLES OF *DIPLOCHAETETES* AND CLOSELY RELATED SKELETAL STRUCTURES

Diplochaetetes mexicanus exhibits nearly the same skeletal structure as observed in *Diplochaetetes longitubus* Weissermel (pl.3, fig.4) from the Eocene of Namibia. Both species are closely related and members of the same taxon. The specimen from the type locality, donated from Dr.Wilson, exhibits the same manner of agglutinated walls. The distances between the tabulae and the wall thickness is bigger. There is no doubt that a very close systematic and phylogenetic relationship exists between a modern polychaete worm species is known from California. It exhibits a diplochaetetid wall structure also. The modern genus *Dodecaria* (pl.3, fig.19 ; pl.4, A,B) seems to be also closely related to *Diplochaetetes*. But from the skeletals only it is impossible to decide, if these organsims are synonymous or not. Further studies on modern species with soft parts will prove this thesis. But there is no doubt on the relation to the taxon Polychaeta based mainly on the characteristic biomineralisation..

DIFFERENCES BETWEEN THE SKELETAL STRUCTURE OF *DIPLOCHAETETES* AND THE CORALLINE SPONGE *ACANTHOCHAETETES* AND TAXONOMIC CONSEQUENCES

The genus *Diplochaetetes* was first described by Weissermel (1913), assuming a close relationship to the order Chaetetida. He described and figured specimens with a granular microstructure. Fischer 1970 compared *Diplochaetetes* with the chaetetid genus *Acanthochaetetes* based on some similiarities of the shape of the chaetetid basal skeleton and the granular micritic microstructure. Based on this data Reitner & Engeser 1983 and Engeser *et al.* 1986 followed Fischers conclusions, because it was not possible for the authors to study the type material (which is deposited in East Berlin).

SKELETAL STRUCTURE OF THE CHAETETID SPONGE *ACANTHOCHAETES*

Acanthochaetetes is a hadromerid demosponge with chaetetid soft body organization closely related to the family Spirastrellidae (Reitner & Engeser 1987, Engeser *et alii.* 1986). This sponge has a spicular skeleton formed of tylostyle megascleres and spiraster microscleres (Hartmann & Goreau 1975, Reitner & Engeser 1983, 1987) and a basal skeleton formed by high Mg-calcite. The basal skeleton demonstrates three types of microstructures (pl. 2, fig. 3a,b) : (1) the primary wall structure , (2) the secondary tabulate structure, and (3) a later diagenetic backfill. The primary wall structure is "microlamellar" *sensu* Cuif *et al.* (1979) or "irregular" *sensu* Wendt (1979). The microlamellar structure is formed by more or less tangentially oriented very small (3-4 μm length), single, high Mg calcite crystals. The crystals were secreted within a narrow (1 μm) mucus layer between the basal skeleton and the exopinacoderm. The crystals are arranged in more or less randomly oriented aggregates. The random orientation results from the frequency of the spicules within the pinacoderm and fixing points of the soft tissue with the basal skeleton. The second type of microstructure is restricted to the tabulae. The tabulae are also formed by the pinacoderm, but the primary tabula is formed as a collagenous membrane. The calcification starts during the upward movement of the soft tissue. The microstructure of this type is totally irregular. No tangential orientation of the crystals is visible (Reitner & Engeser 1987, fig. 5). The third type, the so-called back fill, is a synvivo diagenetic product. The soft tissue, abandoning ontogentically older parts of the basal skeleton are mostly also covered by an irregularly oriented high Mg calcite. Mg values from the calcite of the second and the third type are significantly lower (up to 15 mol %), while the calcite of the primary wall shows a mean content of 18-19 mol % (Wendt 1979, Reitner 1987, Reitner & Engeser 1987). Other modern coralline sponges have also different skeletal structures and exhibit never characteristic chaetetid skeletons, which are only represented by *Acanthochaetetes* and *Merlia* (REITNER & KEUPP, 1989).

Agglutinated material is never observed in true *Acanthochaetetes* specimens.

There are sponges, the Dendroceratida (Keratosa), which have lost their entire spicular skeleton, which agglutinate quartz grains and other dedritus within their skeletal spongin fibers. This character is convergent to the agglutination behavior of the Polychaeta.

DIPLOCHAETETES MEXICANUS WILSON, 1986

The species described by Wilson 1986 has an irregular skeleton. In a few cases tubes are subdivided by tabulae only. The tabulae are convex, unlike acanthochaetetids. No horizontal spines exists, as observed within the acanthochaetetids. Superficial astrorhizae patterns (imprints of the exhalant channels of a sponge) are also absent. The microstructure of the wall is circumlamellar and composed of different lamellae. The lamellae are formed by agglutinated material (e.g. quartz grains, calcitic clasts) and bright layers (pl. 2, fig. 4a,b) and dense (dark in transmitted light) micritic calcite, probably low Mg calcite. In addition to primary lamallae, diagenetic calcite lamellae are common. These lamellae are often linked with shrinkage structures and have an average thickness of 60-70 m. Preferred crystal orientation is not observed (pl. 2, fig. 4a,b). This type of microstucture has never been observed within any coralline sponge. Circumlamellar skeletal structures with agglutinated material are known only from worm tubes.

Diplochaetetes mexicanus Wilson is definitely not a sponge. The convergent nature of the "chaetetid" skeletal structure is shown by its affiliation with different orders of sponges (Reitner & Engeser 1987, Kirkpatrick 1908), cnidarians (Favosites ; Copper 1985), and worm tubes (this paper).

PALEOECOLOGY OF *DIPLOCHAETETES MEXICANUS*

The habitat of *Diplochaetetes mexicanus* can be reconstructed from sedimentological and faunal evidence.

The **salinity** corresponds to normal marine conditions, because balanids ostracodes (Cypridae) and pholadid bivalves are also present.

The **substrate** on which the reefs grow is unconsolidated and consists of fine to coarse sand and conglomerates containing pebbles up to 1 cm in diameter.

The **bottom** is not completly smooth, but contains a relief. In places where the bottom forms a slope, marginal parts of the reef carpet break off and slide down. During the sliding process, the fragile tubes are differentiately fractured. Only the major ones buried the reef completely and prevented recolonization.

The habitat is located in a **high energy environment**. Water turbulence is indicated by reworking and redeposition of reef fragments, and cross-bedding with a wide range of grain sizes and poor sorting. Fluctuating turbulence is also reflected by varying degrees of erosion and sediment accumulation. **High turbulence** implies good oxygenation of the habitat.

Some hints on the **water temperature** are provided by the faunas in adjacent beds. The molluscs comprise genera like *Protothaca, Melongena, Anadara (Cunearca), Drillia, Crassilabrum, Knefastia,* etc., which characterize a tropical climate (see Durham 1950, Hertlein 1925, Hertlein & Jordan 1957, Smith 1984, 1987).

Balanids, boring bivalves and the polychaete reefs themselves indicate lower intertidal or upper subtidal zone. Despite irregularities within the individual beds, the most remarkable feature of the sediment is a well developed parallel bedding.

From the geographic distribution of the reefs (comp. Wilson 1986) in a NW-SE oriented strip, we conclude that they grew parallel to the Oligocene coast line. A near shore reef is also indicated by high quantities of detritic quartz and feldspars within the sediment. The preserved skeletons and their taphonomy also provide some hints on the **mode of life** of *Diplochaetetes mexicanus.*

The skeletons must have been exoskeletons because of the centripetal formation of the lamellae and the formation of the tabulae within the tubes. The primary mineralogical composition of the skeletons remains obscure. The fossil skeletons consist of microcrystalline calcite. This calcite may be primary or might have resulted from the recrystallization of Mg calcite or aragonite (B. Sedat, written comm.). The mode of tube formation also remains unclear. The tube could have been formed:

1. by agglutination of microcrystals selected from the sediment (sediment preserved within the tubes contains microcrystalline components (Pl. 3, fig. 2) or alternatively

2. by precipitation of microcrystallites and cementation of these particles by the organism itself. This mode is unknown in modern tubeworms.

The habitat of *Diplochaetetes mexicanus* was influenced by clastic sedimentation. As long as there was some sedimentation, the animals were only able to keep the surface of the colony clean by transporting sediment particles into interspaces between neighboring tubes. Increasing deposition of fine sand caused the surface of the colony to dome and finally resulted in a head-like colony shape. Sudden coverage with only a few mm of sediment is enough to smother the whole population. Increasing deposition of fine sand caused the surface of the colony to dome and finally resulted in a head-like colony shape.

The sediment sandwiched between the tube layers rarely filled the tubes themselves. From this fact we conclude that sudden sedimentary events buried reefs alive.

Besides being endangered by physical destruction, the reef of *Diplochaetetes mexicanus* were threatened by other animals. Pholads found in situ may have penetrated living reefs from the margins, but they appeared to move mainly attacked dead parts of the reef (pl. 3, fig. 3). Other invertebrates must have grazed on the reefs (? sea urchins, ? molluscs), producing abrasion surfaces which later on were covered by algal crusts.

The habitat and mode of life of *Diplochaetetes mexicanus,* help to understand the interaction of sedimentation processes and the mode of growth of these particular organisms. They were important sediment stabilizers by forming compact reef structures on sandy bottom, and after decomposition, by producing biogenic debris. This is evidenced by blocks and boulders of Oligocene reefal debris in recent arroyos (dry creeks) or shore deposits all along the northern Bay of La Paz

Finally, like all reefs, polychaete patch reefs have contributed many ecological niches for endo- and epilithic organisms and thereby increasing diversity. In the area under study, the reefs of *Diplochaetetes* mark an ecological event at the Oligocene/Miocene boundary. If *Diplochaetetes mexicanus* is identical with Seroula rectiformis (described by Clark 1918 from California (U.S.A.)), this event can be traced over a large area comprising all of Baja California and includinga part of California.

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PLATES

PLATE 1

Fig. 1-2 -Transverse sections of the skeleton of ***Diplochaetetes mexicanus*** WILSON, 1986
Sections transversales de squelette.

Fig. 1 : Multilamellar wall structure. Structure multilamellaire de la paroi

Fig. 2 : Tubes with different stages of partition.Tubes diffrents stades de croissance.

Fig. 3-9 - Vertical sections of the skeleton of ***Diplochaetetes mexicanus*** WILSON 1986.
Sections verticales du squelette

Fig. 3 : Multilamellar structured tube wall. Paroi tubulaire de structure multilamellaire.

Fig 3,4 : Sedimentary particles enclosed by the walls of neighboring tubes. Particules sdimentaires inclues dans les parois des tubes voisins.

Fig. 5-9 - Horizontal tabulae, unilamellar (8)) or multilamellar (5-7), simply added to the wall (5,8) or forming a collar (6). Concave convex structure of a bilamellar tabula (7). Narrowing of tabulation caused by sediment filling (9). Scale : 0,5 mm.

Tabulae horizontales, unilamellaires (8) ou multilamellaires (5-7), simplement fixes la paroi (5,8) ou bien formant un anneau (6). Structure concave convexe d'une tabula bilamellaire (7). Rtrcissement de la tabulation caus par un dpt de sdiments (9). Echelle : 0,5 mm..

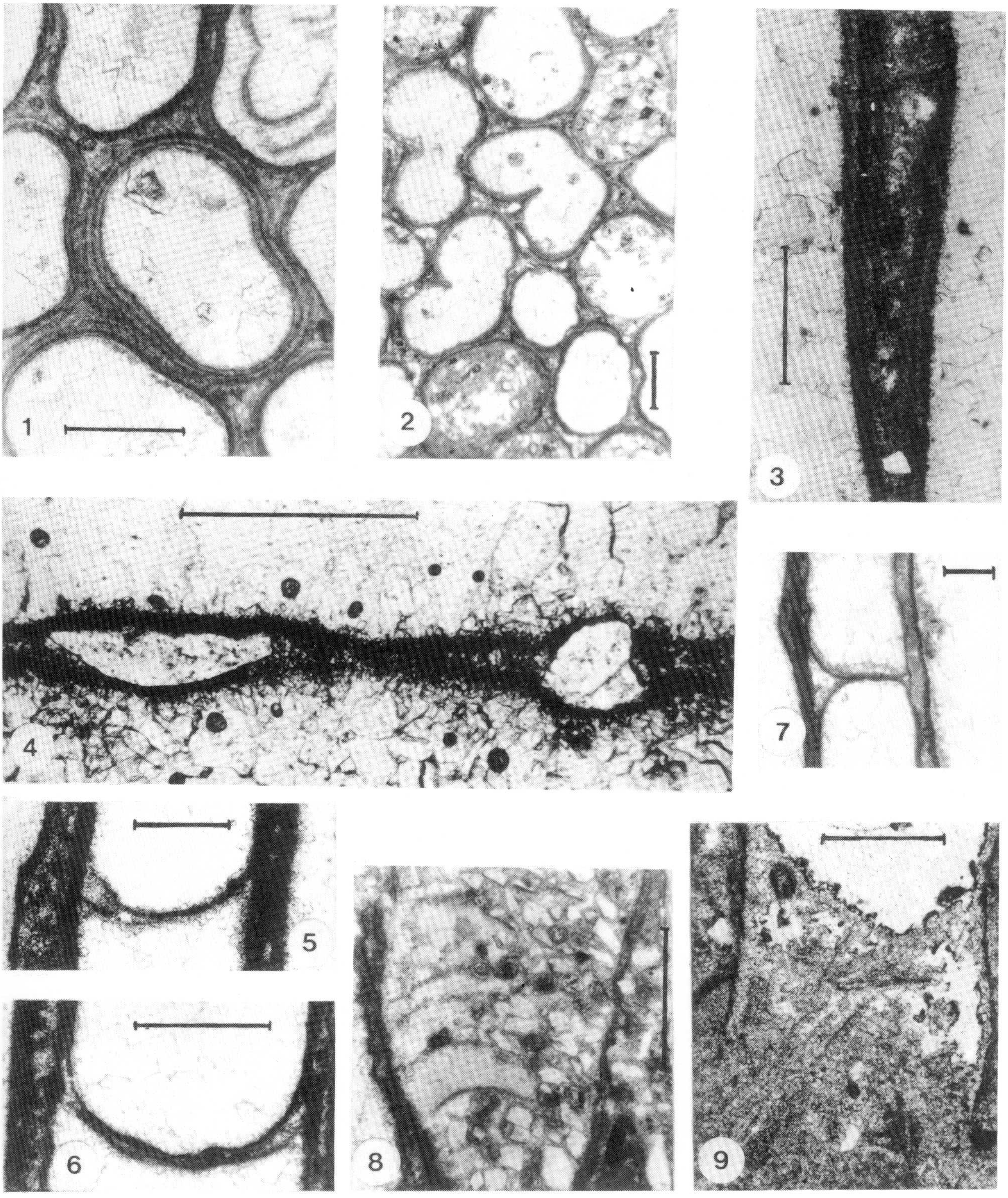
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PLATE 2

Fig. 1-2 - Mode of tube growth of ***Diplochaetetes mexicanus*** WILSON, 1986.
Mode de croissance des tubes de Diplochaetetes mexicanus WILSON, 1986.

Fig. 1 : Organ-pipe arrangement of the tubes generally present in carpet-like reefs (nat. size). Assemblage de tubes en tuyaux d'orgues, généralement présent dans les récifs en tapis (grandeur naturelle).

Fig. 2 : Radial arrangement of tubes in a head-like reef portion (diameter of the head : 30 cm).Assemblage radial de tubes dans une partie du récif en forme de tête (diamètre de la tête : 30 cm).

Fig. 3a,b - ***Acanthochaetetes seunesi*** FISCHER, 1970 ; Late Albian of northern Spain.
Albien tardif de l'Espagne du nord.

a : Internal structure showing the Mg calcite basal skeleton. Horizontal spines are characteristic for this genus (arrows). Scale 0,2 mm. Structure interne du squelette basal en Mg-calcite. Des épines horizontales sont caractéristiques (flèches) échelle : 0,2 mm. b : grossissement photographique.

b : Magnification of Fig. 3a. Primary wall structure (arrow) is microlamellar. The microstructure is formed by tangentially oriented high Mg calcite crystals. The dark microstructure of the tabulae is characterized by randomly Mg-crystals. Scale 0,2 mm. Agrandissement, la structure primaire de la paroi est microlamellaire (flèche). La structure microscopique est formée de longs cristaux de Mg-calcite d'orientation tangentielle. La structure microscopique sombre des tabulae se caractérise par des cristaux Mg d'orientation désordonnée.

Fig. 4a,b - ***Diplochaetetes mexicanus*** WILSON, 1986 (paratype No. 7195 ; figured in Wilson 1986, pl. 50, fig. 3,4)

a: Vertical section of a single tube with tabulae. The convex shape of the tabulae is characteristic. Microstructure of the wall is circumlamellar. The lamellae are formed by agglutinated material (bright lamellae) and micritic calcite (dark lamellae). The primary structures are modified by diagenesis. Some of the lamellae are of diagenetic origin (diagenetic granular calcite) (arrow). Scale 0,5 mm. Coupe verticale d'un tube isolé avec des tabulae. La forme convexe des tabulae est caractéristique. La structure microscopique de la paroi est circumlamellaire. Les lamelles sont composées de matière agglutinée (lamelles claires) et de calcite micritique (lamelles sombres). Les structures primaires ont été modifiées par diagénèse. Certaines lamelles sont d'origine diagénétique (calcite granuleuse diagénétique) (flèche).

b : detail of fig. 4a. Detailed circumlamellar microstructure of a tube wall of *Diplochaetetes mexicanus*. Scale 0,3 mm. Détail de la fig.4a. Structure microscopique circumlamellaire détaillée de la paroi d'un tube de *Diplochaetetes mexicanus*.

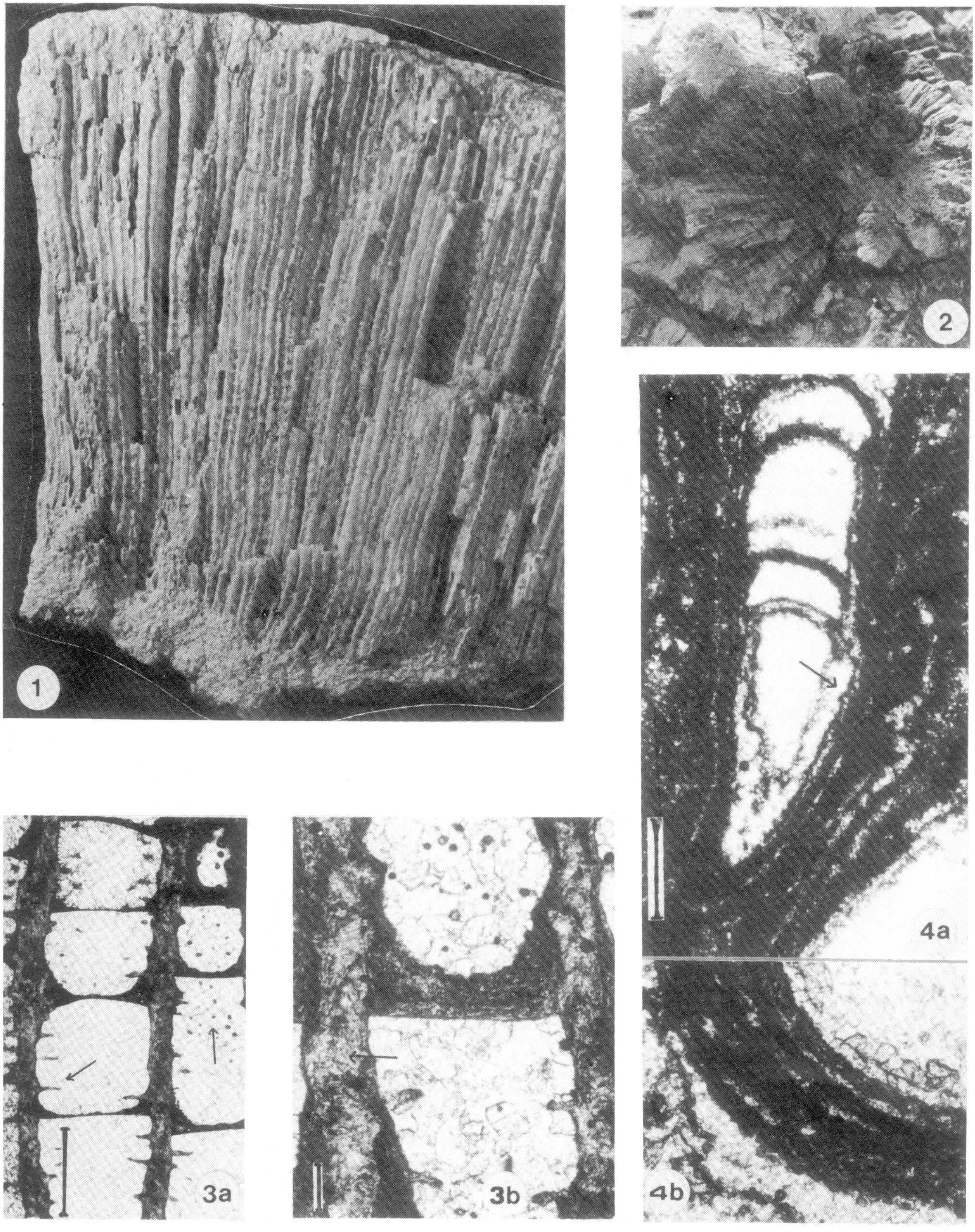

1
2
3a
3b
4a
4b

PLATE 3

Fig. 1 - Horizontal section of a colony of ***Diplochaetetes mexicanus*** WILSON,1968 showing fracture zones. Scale 2 mm.

Section horizontale d'une colonie de *Diplochaetetes mexicanus* WILSON, 1986 montrant les zones de fractures.

Fig. 2 - Vertical section of a tube of ***Diplochaetetes mexicanus*** showing internal calcitic sediment deposited on a bilamellar tabula. Tube cavity with cement of zoned crystals of calcite. Scale 0,1 mm. Photo : courtesy of B. Sedat, Bochum.

Coupe verticale d'un tube de *Diplochaetetes mexicanus* à l'intérieur duquel le sédiment calcitique s'est déposé sur une tabula bilamellaire. Cavité tubulaire avec ciment de cristaux de calcite zonés. Photo mise aimablement à notre disposition par B. Sedat, Bochum.

Fig. 3 - Negative print of a thin section showing a bore hole of a pholadid bivalve into a colony of ***Diplochaetetes mexicanus***. An accessory plate lies above the umbo. The structure below the umbo of the left valve represents the chondrophore (diameter of the pholadid : 2 cm). Scale 0,5 cm.

Tirage négatif d'une lame mince montrant le terrier d'un bivalve pholodide dans une colonie de *Diplochaetetes mexicanus.* Une plaque secondaire est posée sur le crochet. La structure sous le crochet de la valve de gauche représente le chondrophore (diamètre du pholadide : 2 cm)

Fig.4 - ***Diplochaetetes longitubus*** WEISSERMEL, 1913. Eocene from Namibia (type locality of Weissermel)

a. Transverse section exhibiting typical concave tabulae including secondary ones. The secondary tabulae are found in *D. mexcanus* and the modern genus *Dodecaria*. Quartz grains are entrapped within the calcareous wall. Section transversale montrant les tabulae concaves caractéristiques et les tabulae secondaires. Les tabulae secondaires se trouvent chez *D. mexicanus* et le genre actuel *Dodecaria*. Des grains de quarz sont incorporés dans la paroi calcaire.

b. Horizontal section exhibiting the crosscut calicles. The calicle walls show growth lamella structures. Scale 0.5 mm Section horizontale montrant les calicules coupés en travers. Les parois des calicules présentent des lamelles de croissance.

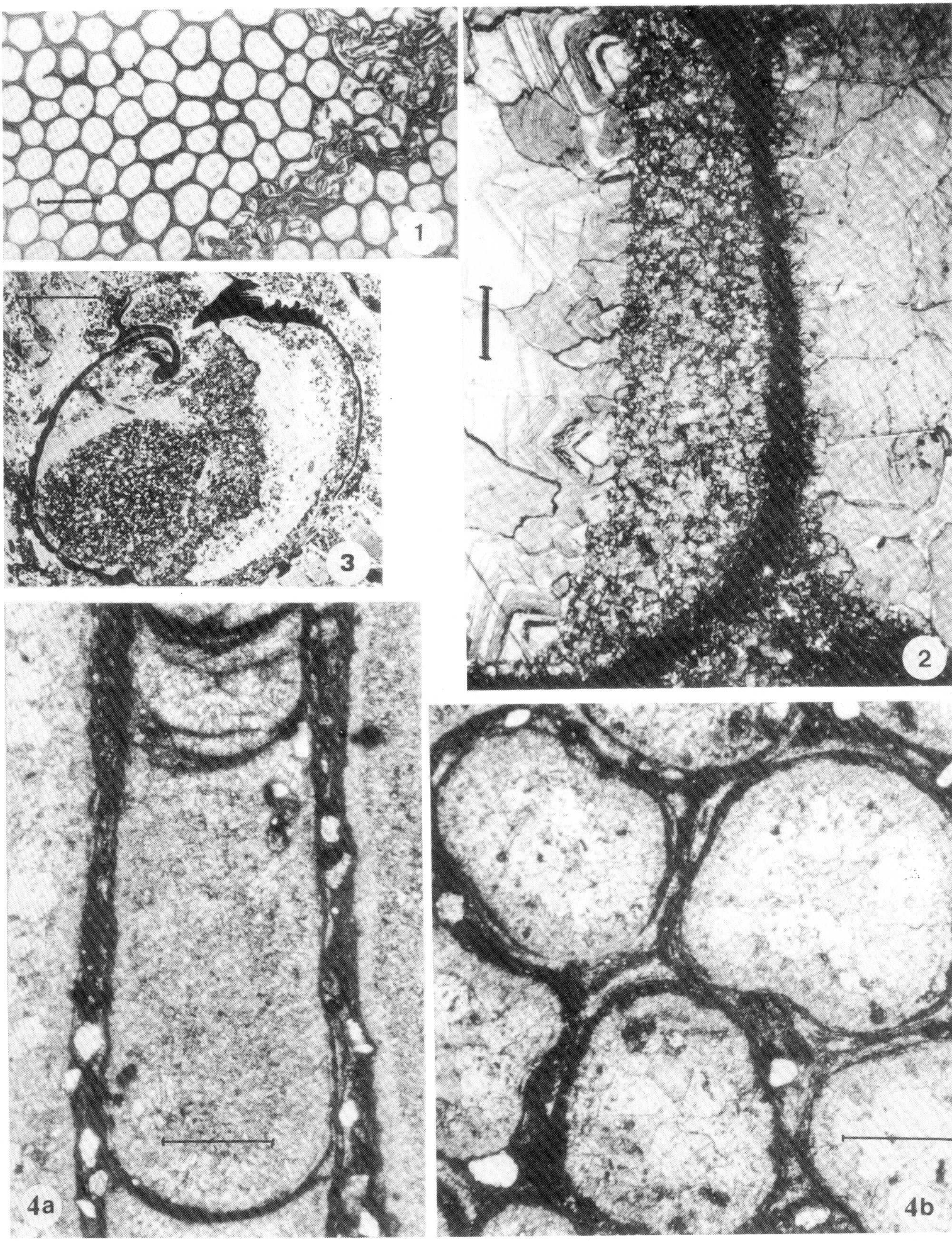
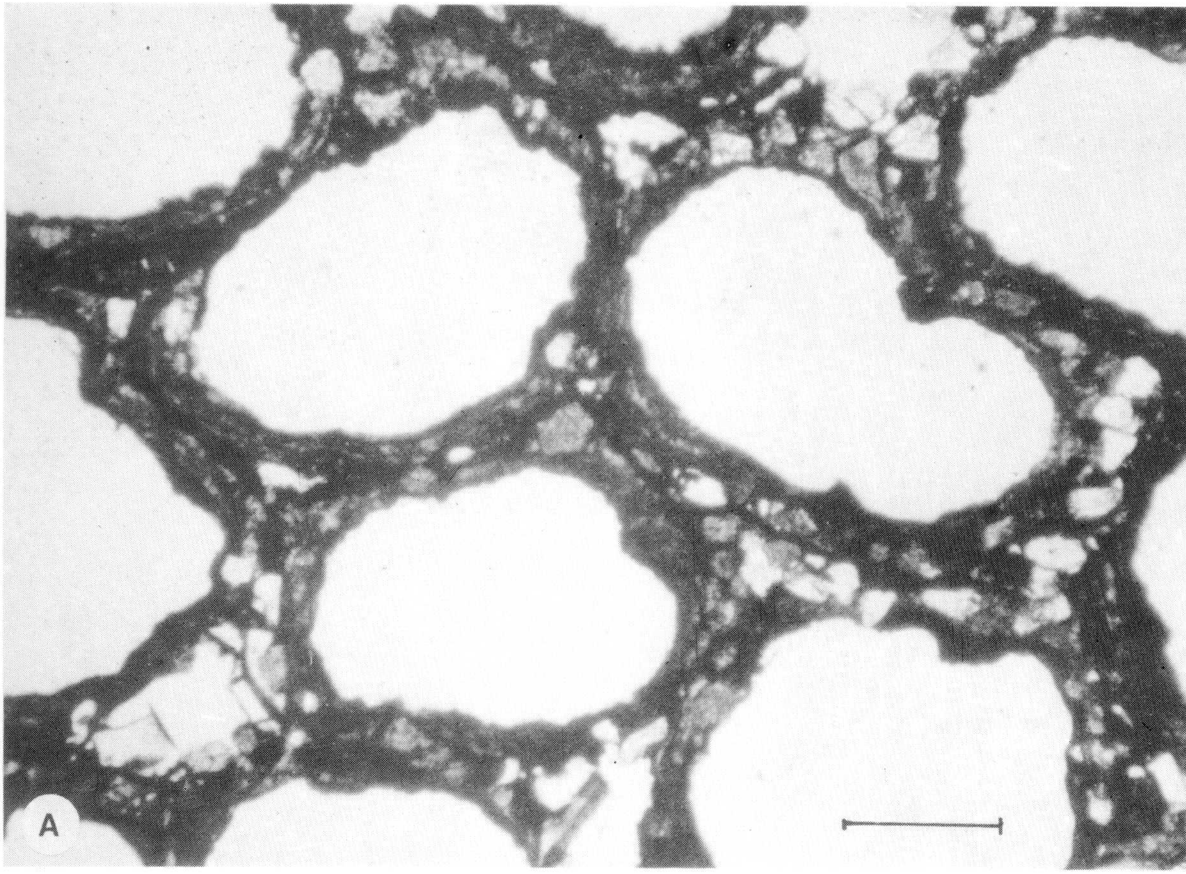

1
2
3
4a
4b

PLATE 4

***Dodecaria* sp..** Recent diplochaetetid worm tubes from the beach of Miraflores (Lima, Peru).
Tube d'un ver diplochaetétidé actuel provenant de la plage Miraflores (Lima, Pérou).

a: Horizontal section exhibiting the calicle shape and agglutinated quartz grains. Section horizontale montrant la forme des calicules et des grains de quarz agglutinés.

b.Transverse section demonstrating a tabula, which exhibits growth lamellae (Arrow-apertural direction) Scale : 0.5 mm Section transversale montrant une tabula qui présente des lamelles de croissance (flèche en direction de l'ouverture)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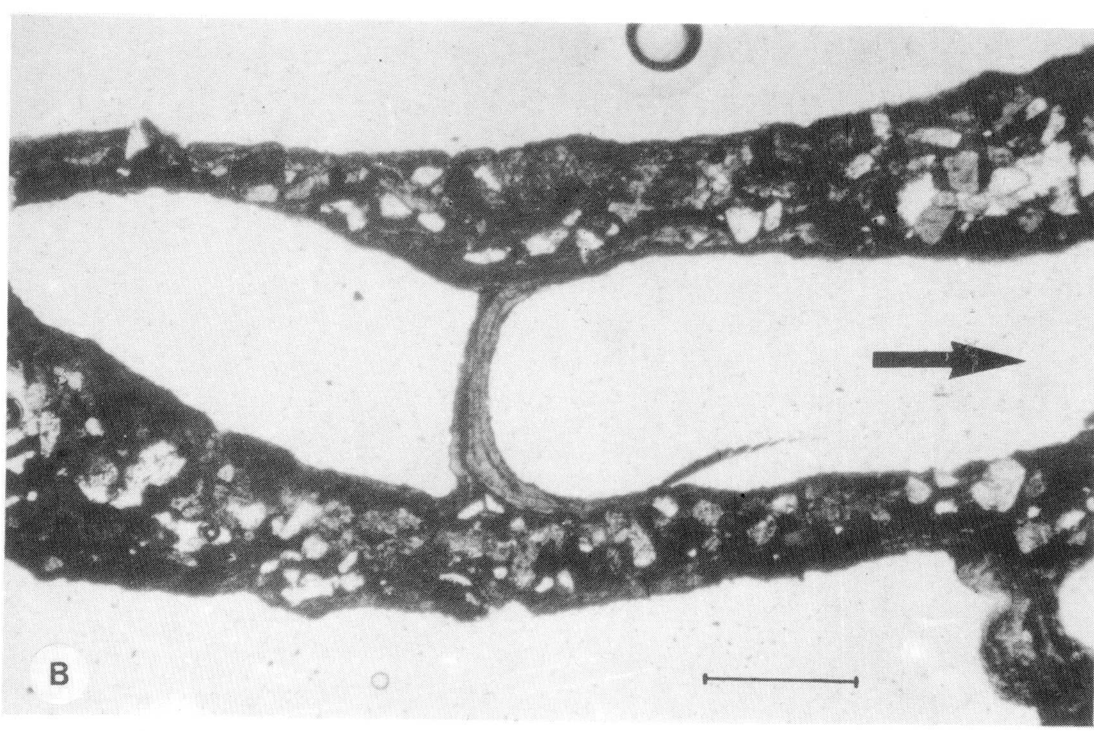
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