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MICROCODIUM, ITS EARLIEST OCCURRENCE AND OTHER CONSIDERATIONS

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Abstract. — It is generally accepted that *Microdium* ranges in time from late Cretaceous until late Pleistocene time. Review of the literature about *Microdium* (e.g. Bodergat 1974, Lucas and Montenat 1967 and Esteban 1973) and my own research suggest, however, that *Microcodium* did not appear until the Paleocene. It is extremely abundant in the Lower Paleocene of S.E. Spain. This may indicate that the climatologic circumstances were favourable for the development of *Microcodium* just after the extinction at the Cretaceous-Tertiary boundary. A mention is made of the occurrence of recent *Microcodium*-like organisms.

Résumé. — On admet généralement que *Microcodium* s'étend dans le temps du Crétacé terminal jusqu'au Pleistocène terminal.

Une étude de la littérature (voir entre autres Bodergat 1974, Lucas et Montenat 1967 et Esteban Cerda 1973) et des recherches personnelles suggèrent pourtant que *Microcodium* n'est apparu qu'à partir du Paléocène. Il se rencontre abondamment dans le Paléocène inférieur du Sud-Est de l'Espagne.

Ce fait peut indiquer que les circonstances climatologiques, peu de temps après l'extinction de nombreux organismes à la limite Crétacé-Tertiaire, étaient favorables au développement de *Microcodium*. Un exemple d'un organisme récent semblable au *Microcodium* est présenté.

INTRODUCTION

Microcodium is an organism which was first described by Glück (1912) from Miocene deposits near Baden, W Germany. It has since been discovered in many localities, especially in Southern France, and was discussed by many, mainly french, authors (e.g. Johnson 1953, Lucas and Montenat 1967 and Bodergat 1974). For the most thorough description and an excellent literature review, the reader is referred to A.M. Bodergat (1974).

Microcodium produced "colonies" consisting of aggregates of 100-700 µm long, prismatic to pyramidal monocrystalline laths of calcite, with a central cavity in each lath. Usually this cavity is filled with dark material. Two types of "colonies" may be distinguished, depending upon the arrangements of the prisms and pyramids. These may be radially distributed around a central axis, so that the "colony" looks like an ear of maize (Pl. 1, fig. 1) or they may be stacked parallel to each other, along axes which are branching in successive planes, thus forming crusts upon rocks that may be decimetres thick (Pl. 1, fig. 2) (Freytet 1969, Esteban 1973 and Bodergat 1974 a.o.).

Microcodium has travelled through the taxonomic system from the algae to the sponges, and occasionally even their organic origin has been doubted (See Bodergat p. 146).

It is now assumed to have been formed in and underneath paleosols or caliches, presumably by a group of calcite-secreting filamental bacteria, (actinomycetes ?) possibly in symbiosis with other organisms in the soil like fungae (Esteban 1973, Bodergat 1974). This is on account of the presence of very thin filaments within the prisms, described in detail by Lucas and Montenat 1967 for the first time.

Most records of *Microcodium* are from the Mediterranean area. In situ it occurs only in or below continental deposits. It is able to penetrate deeply into underlying carbonate-rocks, along karst-fissures, joints, pores in very coarse clastic rocks, or burrows. The carbonate wall rock along the

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penetrations is dissolved and redeposited as calcite prisms in the dissolution cavities (Lucas and Montenat 1967, Bodergat *et al.* 1975, Bodergat 1974).

It is the authors conviction that this penetration into older, commonly marine, rocks has led to incorrect age determinations of *Microcodium*.

MICROCODIUM IN S.E. SPAIN

In the Betic Cordilleras of Southern Spain *Microcodium* has been found in two essentially different environments (Fig. 1). In the Prebetic zone and in the Malaguide complex of the Betic zone it occurs almost exclusively "in situ", in, or associated with, continental deposits (Azéma 1961, Fernex 1968, Fourcade 1970 and Paquet 1967).

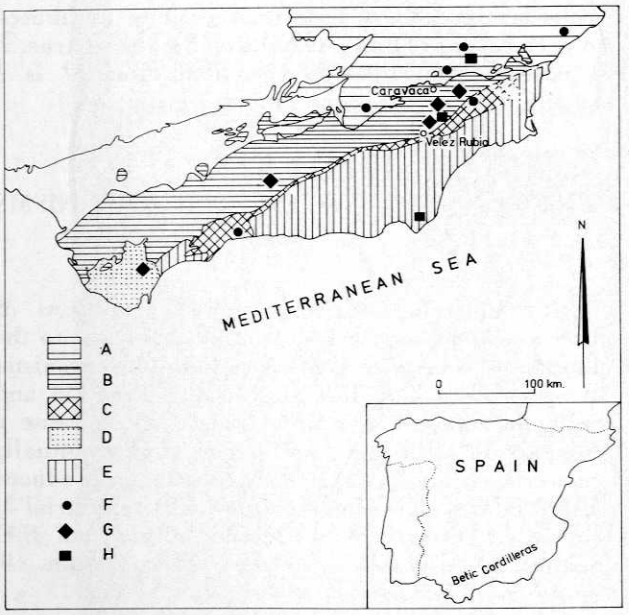


FIG. 1. — Occurrences of *Microcodium* and *Microcodium*-like recent organisms in the investigated area in S.E. Spain. A) Prebetic zone. B) Subbetic zone. C) Betic of Málaga. D) Flysch units of the campo de Gibraltar. E) Betic units. F) *Microcodium*, « in situ ». G) *Microcodium* in turbidites. H) Recent, *Microcodium*-like organisms.

In the Subbetic, the Dorsale, the Penibetic and the Flysch units *Microcodium* occurs only as detritus in turbidites and olistostromes. In these rocks they are usually completely fragmented and only the prismatic laths with the characteristic central cavity are found. Many turbidites consist of more than 90 % of *Microcodium* fragments (Pl. 1, fig. 3). In the Eastern Cordilleras between Vélez-Rubio and Caravaca I have studied these turbidites in detail. They are invariably intercalated with pelagic marls that can be dated with the aid of planktonic Foraminifera (Bolli 1966).

All occurrences of *Microcodium* are from the Paleogene and the most abundant from the Early Paleocene (Danian) deposits (*Gl. pseudobulloides* till *Gl. angulata* Zones (Wittink 1975). In post-Paleocene rocks of the same facies *Microcodium* is very rarely found.

The Upper Cretaceous of this area also consists of pelagic marls, locally with many turbidite intercalations, in which not a single fragment of *Microcodium* has been found.

In the investigated area considerable thicknesses of *Microcodium* bearing beds were deposited in a relatively short time: for example, 130 metres of practically amalgamated turbidites were deposited within a single planktonic Foraminiferal zone, the *Gl. uncinata* Zone, in the Melgoso section (Hermes 1977, Smit in prep.).

The activity of the *Microcodium* "bacteria" on the adjacent continent must have been considerable, to have produced such a large amount of prisms in such a short time in the Lower Paleocene.

THE EARLIEST OCCURRENCE OF MICROCODIUM

Since *Microcodium* was found to be an excellent index fossil for the Paleocene in the Subbetic zone, its range as reported in the literature has been checked. Most references indicate a Paleogene and only a few a Cretaceous age. References to younger ages are rare and often of a different type (Glück 1912, Bodergat 1974, Montenat and Echallier 1977). An exclusively Eocene s.l. age has been suggested by Cerda (1973) and Bignot (1974).

In all cases where *Microcodium* was reported from Cretaceous or older beds, these are covered by continental Paleogene formations (Esteban 1973, Bodergat 1974, Lucas and Montenat 1967 a.o.) and *Microcodium* invariably occurs in the top part of these older beds. Obviously, *Microcodium*, living in the Paleogene, may have penetrated into the Mesozoic subsurface.

A special case is the (rare) occurrence of *Microcodium* in continental beds of Rognacian or Garumnian age in Southern France.

These stages have been assigned to the Cretaceous on the presence of Dinosaurs. However,

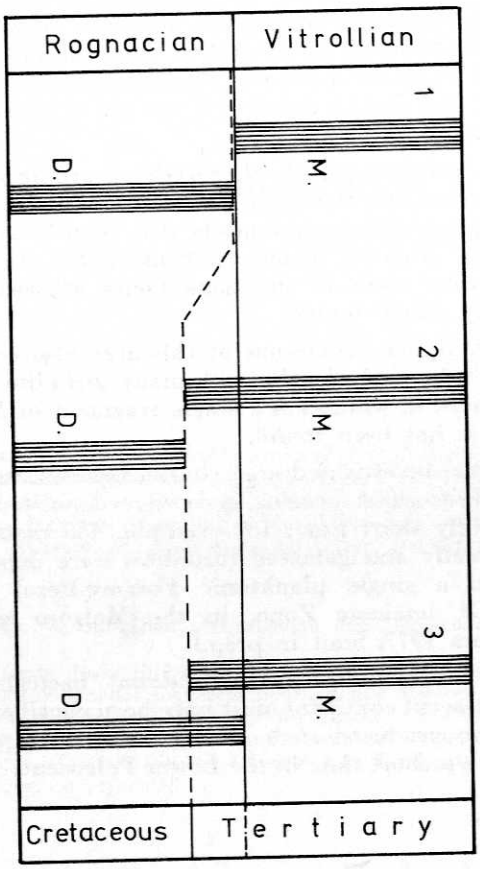


FIG. 2. — Three possibilities why *Microcodium* may be of Tertiary age while occuring in Rognacian beds.
1) It penetrates from the Vitrollian into the Rognacian.
2) The top part of the Rognacian is of Tertiary age.
3) The last dinosaur occurrences may be Tertiary.

several possibilities remain to explain the occurrence of Tertiary *Microcodium* in these Cretaceous beds (Fig. 2) :

— *Microcodium* may have penetrated into the Cretaceous from the overlying Tertiary Vitrollian, in which *Microcodium* abundantly occurs (Freytet 1969).

— *Microcodium* may occur only in the upper part of the Rognacian or Garumnian beds, which may be Tertiary in age, while Dinosaurs occur only in the lower, Cretaceous part: Dinosaurs and *Microcodium* have not been reported from the same bed;

— It may even be possible that the Dinosaurs of the Rognacian are partly of Tertiary age; the latest results in magnetostratigraphy and the radiometric age indicate a younger Cretaceous-Tertiary boundary for Dinosaurs than for marine organisms (Kent 1976, Butler *et al* 1977, Lerbeckmo *et al* 1978, and Shafiqullah *et al* 1964).

Considering the uncertainties in these matters at the moment, a further discussion about the age of *Microcodium* in these beds seems rather futile.

Summarizing, it may be concluded that so far no unequivocal occurences of *Microcodium* in Cretaceous or older beds have been described in the literature.

The mass occurrence of *Microcodium* in Early Paleocene time may point to favourable conditions in that time for the development of *Microcodium*. The as yet unsolved mass-extinctions at the Cretaceous-Tertiary boundary are sometimes attributed to exceptional climatic conditions: if this is true, it is possible that the "*Microcodium* climate" is a consequence of the same climatic evolution.

RECENT, MICROCODIUM-LIKE ORGANISMS IN S.E. SPAIN

In connection with the growth conditions of *Microcodium* I would like to draw attention to the abundant occurrence of *Microcodium*-like organisms in a recent caliche-like soil in the Prebetic and Subbetic zones (Fig. 1; Pl. 2, fig. 1-4), because a comparison with the fossil forms may eventually answer such questions as: What organism produced *Microcodium* ?; is *Microcodium* really terrestrial ?; and what aspects of the recent climate of S.E. Spain are comparable to the "*Microcodium* climate" as described above ?

Large lamisar « colonies » of calcite prisms have been found that are conspicuously similar to the

PLATE 1

1, 2. *Microcodium* colonies « in situ ».

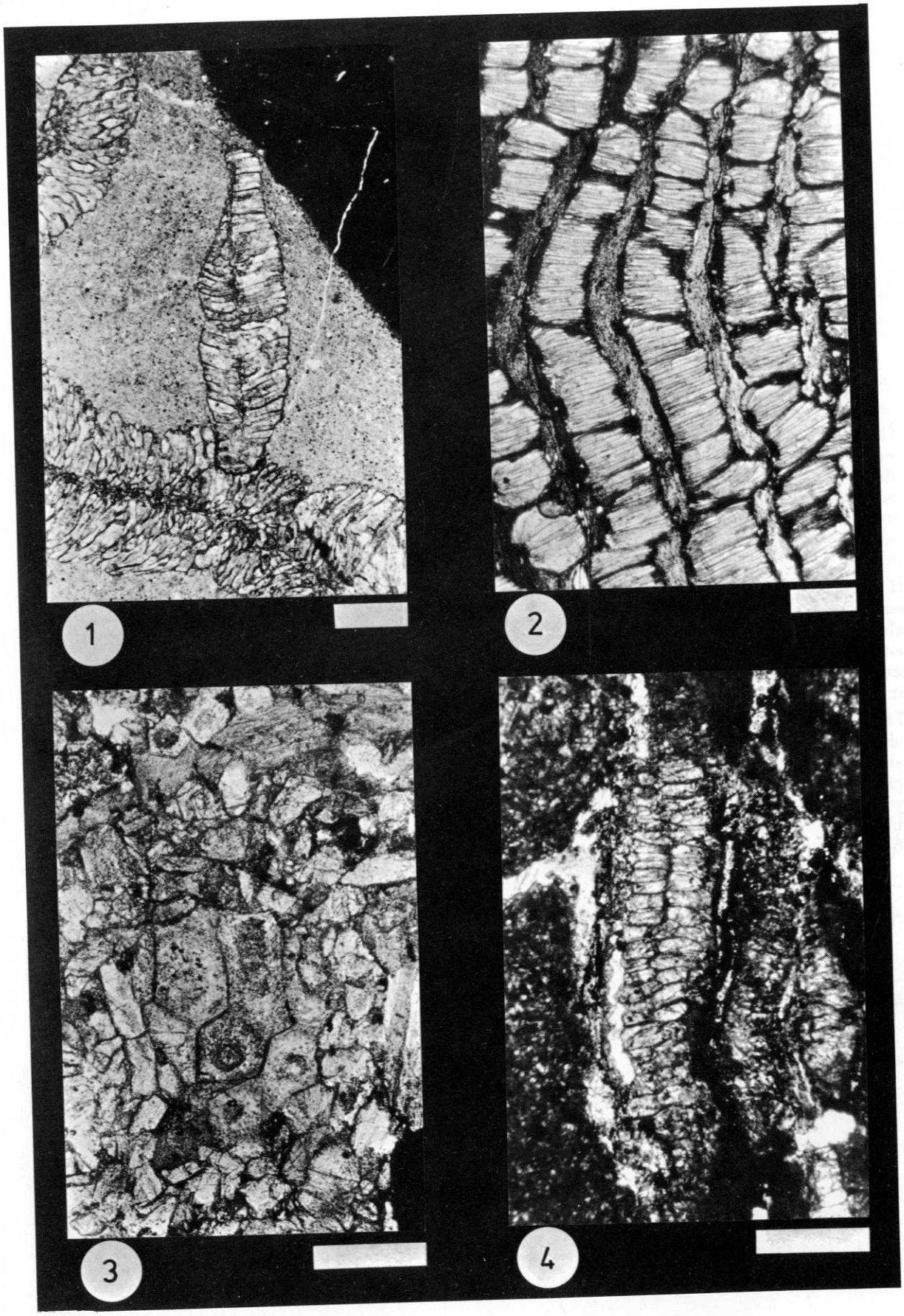
1 : The ear of maize form. From the lower Eocene of the Olivetta syncline. Near Ventimiglia, Italy. Bar = 0.5 mm.

2 : Laminar, crust-forming colonies. Poudingue d'Argens, Barrème syncline, along the road Barrème - Saint-André-les-Alpes, S.W. France. Age: Early to Middle Eocene. Bar = 1 mm.

3. *Microcodium* fragments in a Lower Paleocene turbidite, showing the central cavity in the prisms. Almoyas area, Subbetic zone, S.E. Spain. Bar = 0.5 mm.

4. Transverse section of a recent *Microcodium*-like « colony ». From a caliche crust in the Subbetic zone. S.E. Spain. Bar = 0.5 mm.

All samples from the authors collection.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fossil occurrences, both as regards the arrangement of the prisms and the way of growth; the "colonies" are formed and form approximately 20 centimetres below the surface and expand according to a branching system (Pl. 2, fig. 1-2) that Bodergat considered diagnostic for and only occurring in fossil *Microcodium* (See Bodergat 1974, pl. 6, fig. 5-8). However, all the prisms lack the central cavity which is so characteristic in the fossil *Microcodium* prisms (Pl. 2, fig. 3).

In an attempt to find an explanation for these *Microcodium*-like organisms the Scanning Electron Microscope was used. On high magnification graphs very small fungae hyphae were found in between the branches of a "colony".

"Needles" of even smaller size cover each prism in such a "colony".

These "needles" may be interpreted as cellulose macro-fibrilles that constitute the primary cell-walls of vascular plants (Th. M.G. van Kempen, pers. comm.). The prisms according to this interpretation of the "needles" would seem to be casts of plant root cells. How the calcite was deposited within these cells is still unclear.

If we make a comparison with fossil *Microcodium* prisms, than it is hard to imagine that they could be also the casts of plant root cells. Consequently the recent organisms in many ways do resemble *Microcodium*, but otherwise it is unlikely that they are the same.

The prisms of the recent "colonies" are easily eroded and accumulations have been found in dry-river beds at some distance from their place of origin. By analogy of their fossil counterparts they may be transported to the Mediterranean and form turbidites at the sea-bottom if their numbers are sufficient.

CONCLUSIONS

— The first indubitable appearance of *Microcodium*, at least in the Mediterranean area, is in the Lower Paleocene.

— The mass occurrence of *Microcodium* in lower Paleocene time may point to exceptional climatic conditions in that time.

— Recent organisms quite similar to the fossil forms are found in the soil of S.E. Spain and further specialized study of these forms may throw light on some of the problems concerning fossil *Microcodium*.

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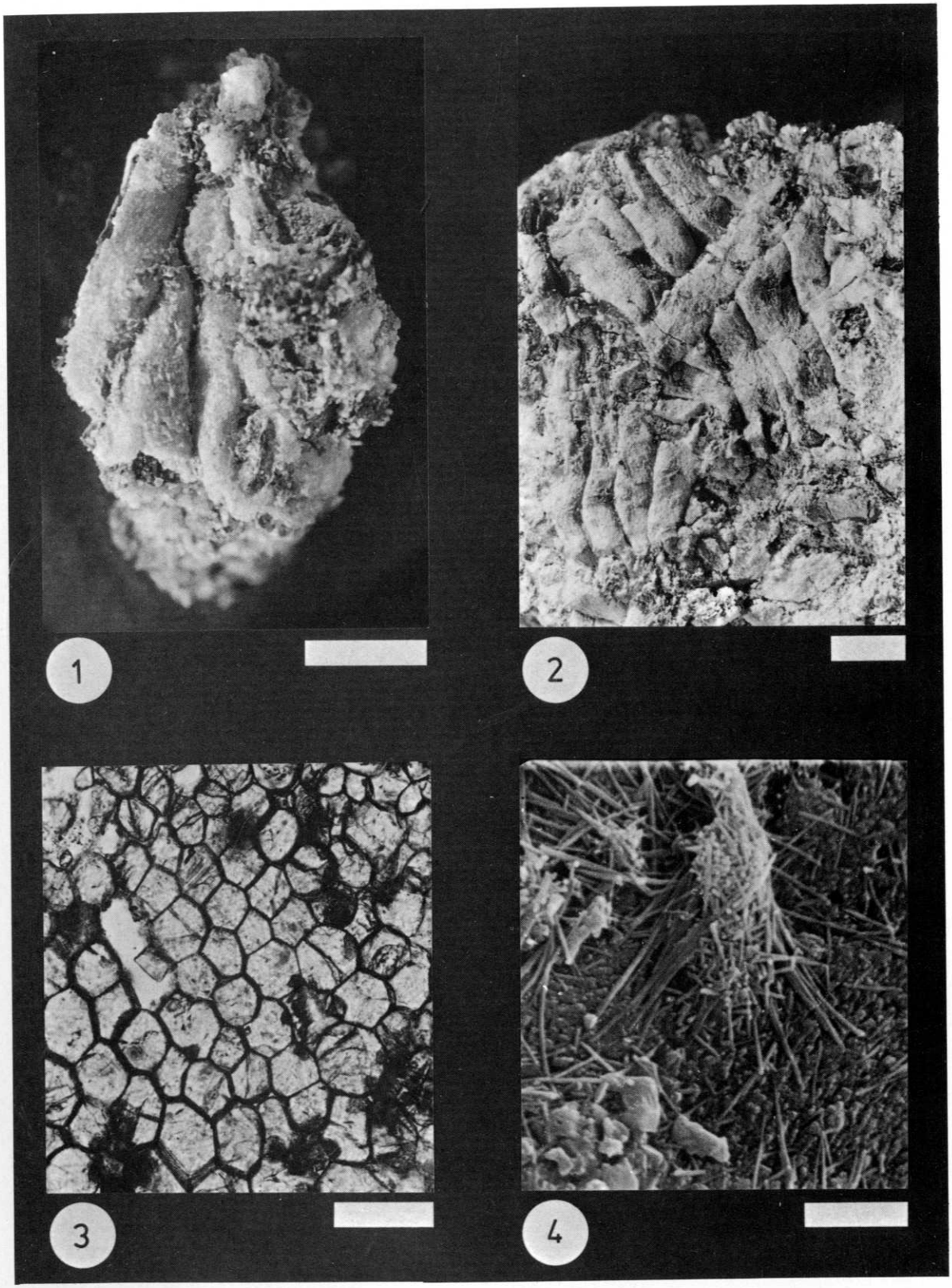
PLATE 2

1-4. Recent, *Microcodium*-like organisms, corroding Paleocene marls. from a road cut, Almoyas area, Subbetic zone, S.E. Spain.

1, 2 : Laminar, branching "colonies", viewed from above. Bar = 2 mm.

3 : Thin section perpendicular to the prisms. Not one of the prisms shows the central cavity characterictic for the fossil *Microcodium prisms.* Bar = 0.15 mm.

4 : Scanning Electron Micrograph, showing the « needles » that cover each prism in the colonies. These "needles" may be cellulose fibrilles of the cell-walls of vascular plants. Bar = 2 µm.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