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AN AGGLUTINATED FORAMINIFERA ASSOCIATION FROM A SANTONIAN HIPPURITID PATCHREEF-LAGOON (AUSTRIA).

by

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With 4 figures and 2 plates

ZUSAMMENFASSUNG

Aus oberkretazischen Mergeln des Salzkammergutes (Santon, Hochmoos-Schichten, *Dicarinella asymmetrica*-Zone) wird eine artenarme, aber individuenreiche epi- (z.T. endo-)benthonische *Bathysiphon-Reophax-Saccorhiza*-Assoziation bekannt gemacht, deren Vertreter überwiegend mit winzigen Pyritwürfeln agglutinierte Gehäuse aufweisen. Ihr Lebensraum war die vorübergehend anoxisch beeinflußte Lagune eines Hippuriten-Patchreefs. Neutrale bis negative Redoxpotentiale und eine infolge des saueren pH-Wertes gehemmte Karbonatbildung begünstigten eine bakteriell initiierte Pyritgenese. Die im Bodenschlamm angehäuften Pyritpartikel verwendeten die Sandschaler für die Agglutination ihrer Gehäuse.

Die nachgewiesenen Taxa und Morphotypen kennt man bisher vor allem aus flyschoiden Serien der ostalpinen Oberkreide und des Alttertiärs; in letzter Zeit mehrten sich jedoch Hinweise auf ein Auftreten in anoxisch beeinflußten Flachwasser-Environments.

ABSTRACT

The Upper Cretaceous (Santonian) of the Eastern Alps (Salzburg area, Austria) contains a rather monotypic agglutinated foraminiferal fauna which can be assigned to the shallow lagoonal milieu of a rudist patchreef complex. Nearly all foraminiferal tests show agglutination of pyrite crystals. Based upon modern models of pyrite formation, it is possible to associate this peculiar fauna with a temporary anoxic event. The paleoecological interpretation agrees with the widely accepted conclusion that physico-chemical parameters rather than paleobathymetric conditions, are responsible for the distribution patterns of these agglutinated foraminifera.

INTRODUCTION

Fossil benthic foraminiferal associations are important indicators of paleoceanographic conditions. Water depth *per se* is not an exclusive parameter controlling distributions of foraminifera. Over the past few years several cases have been reported of depth transgressive benthic assemblages. For example, Gradstein and Berggren (1981) show that Late Cretaceous and Paleogene flysch-type agglutinants of Alpine deep-sea basins also appeared in shallower continental margin basins (*e.g.* Labrador Shelf) and in intracratonic basins (*e.g.* North Sea). Løfaldli and Nagy (1983) as well as Hart and Bigg (1983) report on associations from Jurassic and Cretaceous bathyal and shallow-water environments. The latter were able to establish a clear dependence of these associations to anoxic events due to their presence in black shales, respectively in a "Black Band" intercalated in a white chalk succession. Similar observations have been presented by Moorkens (1976, 1984) concerning strata of the NW European Paleogene.

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Generally, the distribution of benthic foraminifera can be affected by changing different ecological factors such as substrate conditions, salinity, temperature and oxygen content, all of which change also with depth.

In this study, I report on an Alpine Late Cretaceous fossil assemblage with agglutinated foraminifera from a temporarily anoxic shallow lagoon environment whereby the taxa are characterized by a peculiar type of agglutination material. The particular taxa are also known from bathyal or deeper environments.

GEOLOGICAL SETTING

The material examined is from the Gosau Formation (Santonian) of the Abtenau Gosau region, some 30 km SE of Salzburg, Austria (figure 1). Stratigraphically, the samples belong to the Hochmoos Beds (*Dicarinella asymetrica* zone), which is a sequence of maximum 450 m thick marly shales with intercalated calcarenites (figure 2). In some of the horizons, single small rudist patchreef complexes occur, built up by *Hippurites* (*Vaccinites*) *sulcatus* Defrance. The deposits usually contain typical shelf-sea benthic assemblages with calcareous algae (corallinaceans, squamariaceans, codiaceans), "larger" foraminifera (lituolids, ataxophragmiids, miliolids, rotaliids, acervulinids) and "micro"-gastropods (Höfling 1985).

In the Unterbrein patchreef complex of NE Rußbach (figure 1), a dark coloured, silty band occurs, approximately 20 cm thick, that yielded an exclusively agglutinated foraminiferal association (figure 3B).

AGGLUTINATED FORAMINIFERA

1. Wall Texture

The taxa represented are, with few exceptions, agglutinated ones with idiomorphic or subhedral pyrite crystals of differing sizes. The cement seems to be composed of small framboidal pyrite grains but this is probably the result of diagenesis. Sections show that the tubular morphotypes present two cementation patterns (*sensu* Verdenius and Van Hinte 1983):

Masonry-type: most parts of the pyrite crystals jut out irregularly from the general wall surface, cement is restricted to intergranular parts (plate 2, figures 5-6);

Plastered type: most parts of the test show quite a smooth even surface; only a few pyrite crystals protrude through the cement (plate 2, figures 2-3).

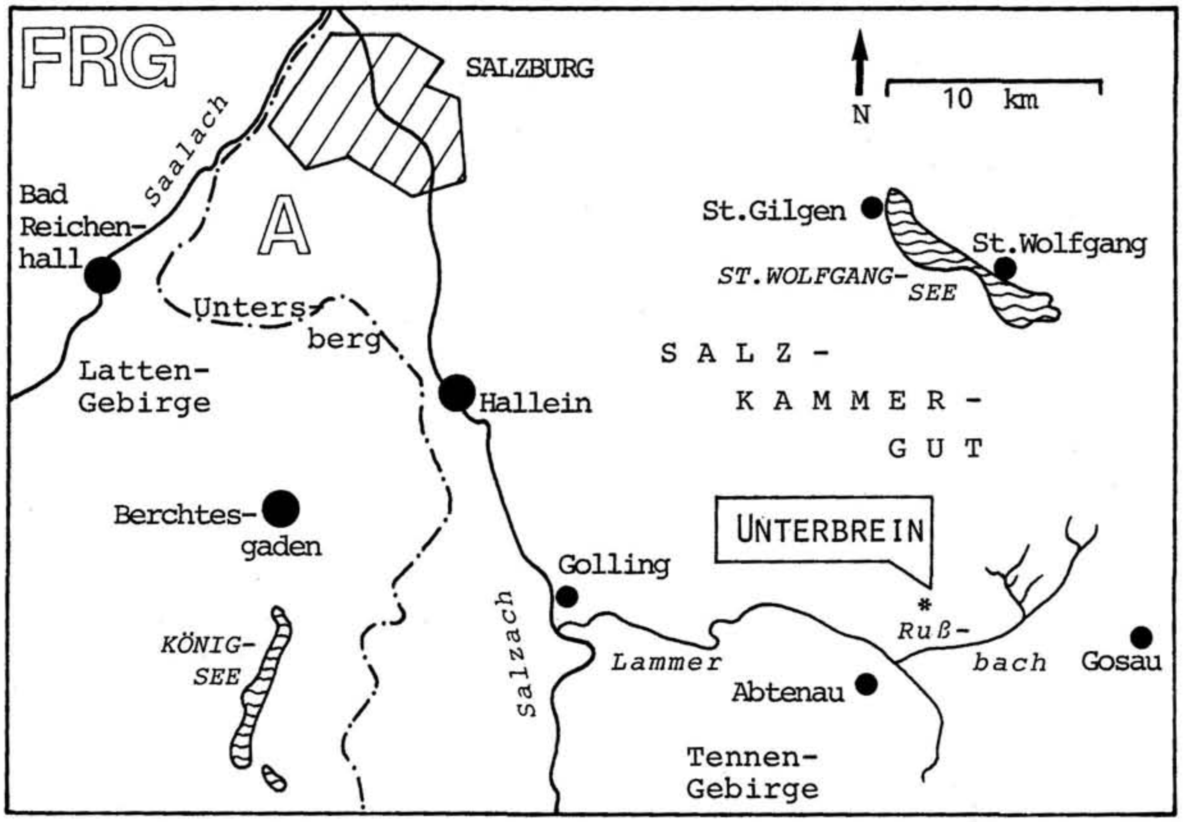

Fig. 1.
Location map of the Unterbrein rudist patchreef complex.

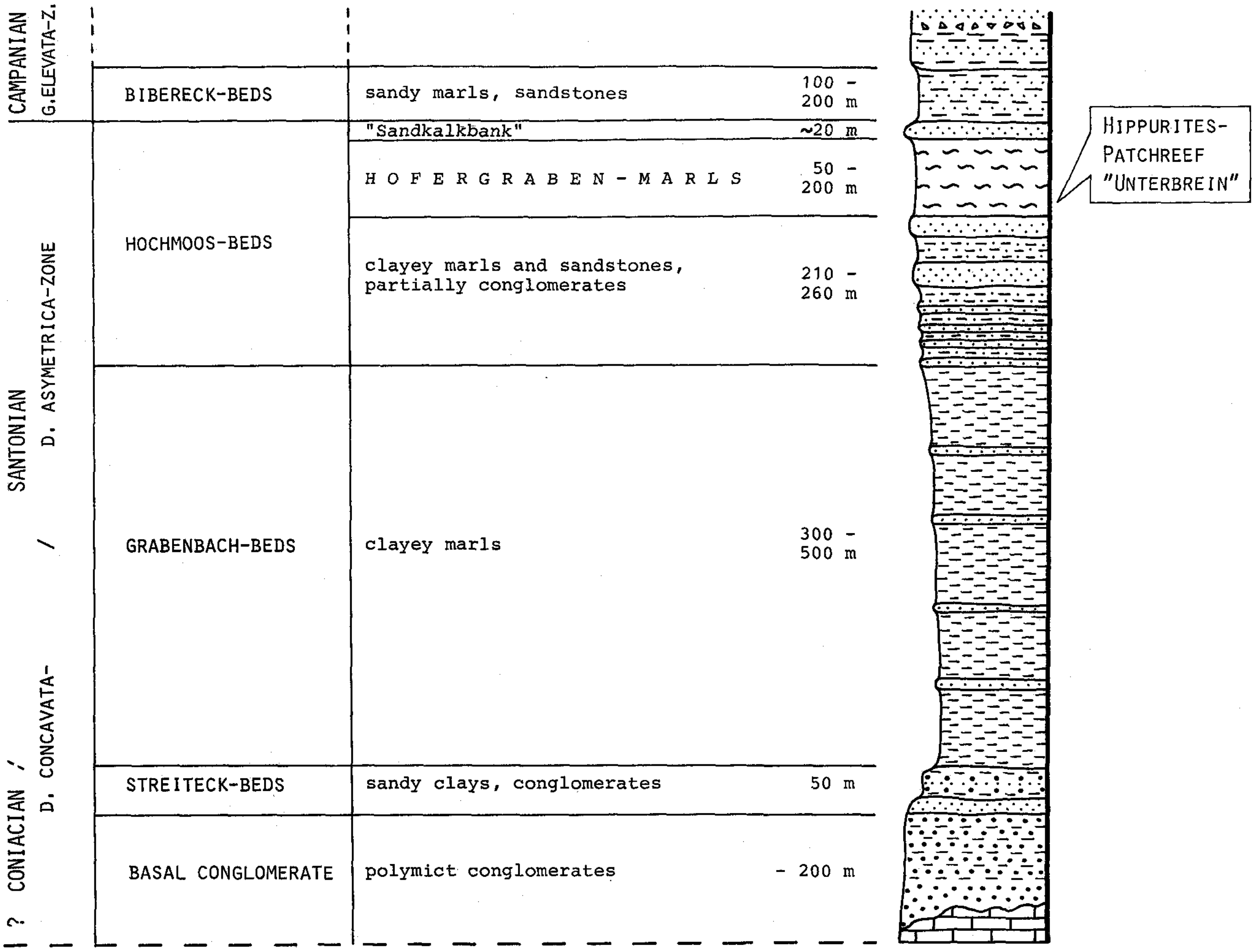

Fig. 2.
Columnar section of the Late Cretaceous Gosau Formation in the Abtenau – Gosau region.

A mixed wall texture type combining those mentioned above can occur. The globular morphotype is only represented by the masonry cementation pattern. The variability of particles in the test of agglutinated foraminifera is well known (*e.g.* Thalmann 1948; Switzer and Boucot 1955; Murray 1973). To the best knowledge of the author, there has been no mention so far of agglutination using pyrite crystals. This is largely due to the fact that pyritized tests are mostly associated with diagenetic processes. Thin sections indicate that small pyrite crystals assist in construction of the test walls. Diagenetically influenced accretive crystallization cannot be excluded (*comp.* Love 1964), and in the absence of a physico-chemical study of the sedimentary environment, the primary or secondary origin of the pyrite cement remains unclear.

2. Taxonomy

Generally, the taxonomy of Loeblich and Tappan (1964, 1981) is employed. Short morphological descriptions are given of the tests observed. Due to fragmentation of tests, several morphotypes are only determined in general.

Subfamily - Astrorhizinae Brady, 1881
Rhabdammina - morphotype (plate 1, figures 1-2): straight cylindrical, fragmented tubes, open at both ends, thin-walled.
Bathysiphon sp. (plate 1, figures 3-7): different morphotypes; straight or slightly curved tubular fragments, open at both ends; thick-walled; in some specimens pyrite grains arranged along the length of the test (plate 1, figures 5-6).

Subfamily - Hippocrepininae Rhumbler, 1895
Hyperammina - morphotype (plate 1, figure 8): slightly curved or rather straight cylindrical fragments; proloculus subglobular (seldom found attached to the tube); tubular chamber cylindrical or subcylindrical; test with wide range of grain sizes.
Saccorhiza cf. *ramosa* (Brady) (plate 1, figures 9-10): branched tubular fragments, approximately cylindrical, straight or curved; test rather thick-walled; proloculi rarely preserved.

Subfamily - Dendrophryinae Haeckel, 1894
Dendrophrya sp. (plate 1, figures 11-12): approximately cylindrical test fragments with a longitudinal groove; wall rather thin, with medium

to small pyrite grains; some longitudinal sections show equivalent of inner pseudo-chitinous lining.

Subfamily - Psammosphaerinae Haeckel 1894
Psammosphaera - morphotype (plate 2, figure 1): approximately globular chamber; no aperture visible; test coarse-grained.

Subfamily - Ammodiscinae Reuss, 1862
Ammodiscus ex gr. *cretaceus* (Reuss) (plate 2, figures 2-3): small discoidal test; outer wall surface smooth; pyritization rare.
Glomospira serpens (Grzybowski): test badly preserved; agglutination fine-grained; some tests pyrite-filled.

Subfamily - Hormosininae Haeckel, 1894
Reophax sp. (plate 2, figure 4): test flattened, slightly curved, generally fragmented; chamber sutures almost invisible; apertural neck not preserved; agglutination with coarse pyrite crystals of similar sizes. This morphotype resembles Cushman's (1946) taxon *R. dentalinoides*.

These agglutinants are associated with ataxophragmiids (mainly *Dorothia*), nubeculariids, nodosariids, osangulariids and smooth-shelled ostracods which show no evidence of pyritization. The latter were quite probably transported out of the patchreef area (figure 3D; post-mortem faunal mixture; Höfling 1985). The Astrorhizidae-Hormosinidae association of that type has been identified for the first time in an Alpine Late Cretaceous shallow marine depositional environment.

PALEOECOLOGICAL INTERPRETATION

The high amount of pyrite in the shales indicates that a temporary anoxic situation with stagnant bottom water may have dominated in the lagoonal environment (for more details about the whole patchreef complex see Höfling 1985). Special physico-chemical conditions, mainly linked to Eh/pH (low alkalic or slightly acidic pH values, negative or low positive Eh values), were responsible for subsequent biogeochemical reactions. These low redox-potentials together with O_2 depletion quite probably favored the bacterially initiated formation of pyrite which collected in the mud of the lagoon floor. In accordance with the biological pyrite synthesis models of Fenchel (1971) and Trudinger (1981), it may be concluded that depending on the addition of which organic material (*e.g.* phytoplankton, non-calcareous algae), sulphate in the pore space has been converted by sulphate-reducing bacteria into sulphide (firstly H_2S). In the presence of Fe^{2+}-ions, precipitation of pyrite came about. Furthermore the low pH values inhibited the formation of carbonate.

The redox discontinuity level must have lain just under or directly on the sediment/water interface.

The agglutinants of the environment in discussion may be thought of as a *Bathysiphon-Reophax-Saccorhiza* association (figure 3). Low diversity (figure 4), and a high number of individuals suggest that the environment only suited forms; it can therefore be referred to as an extreme or stress biotope. Moorkens (1976, 1984) states that modern tubular Astrorhizidae are also known to exist in H_2S-rich clayey mud. Similar to observations on

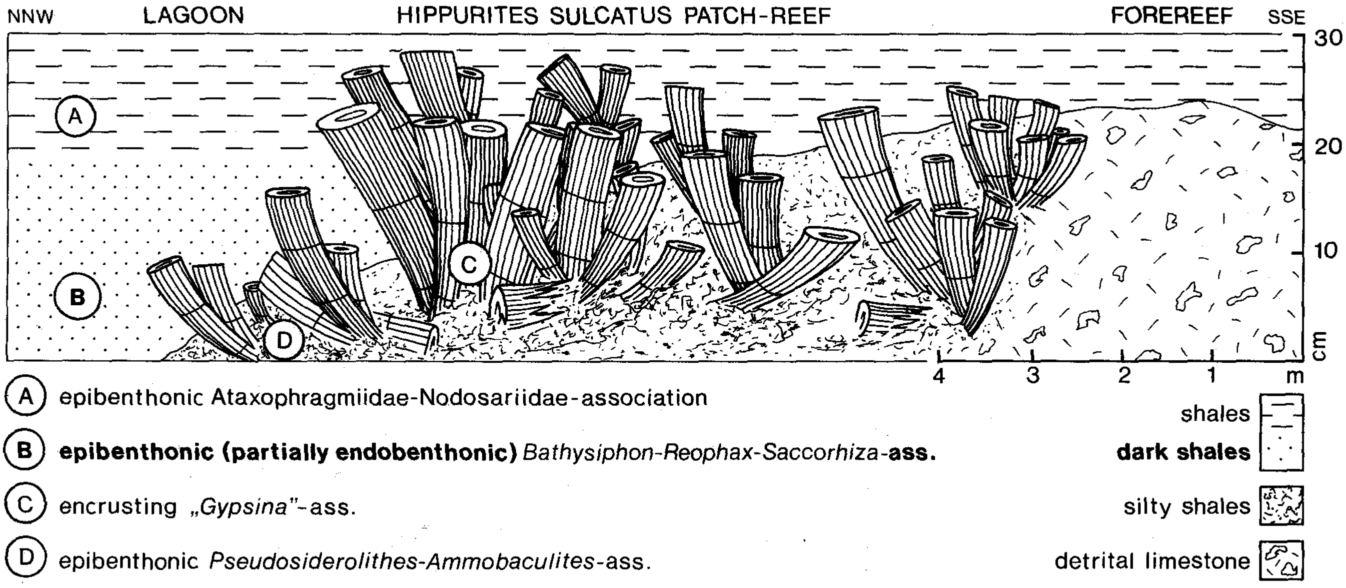

Fig. 3.
Schematic sketch of the Unterbrein rudist patchreef complex and its microbenthic associations.

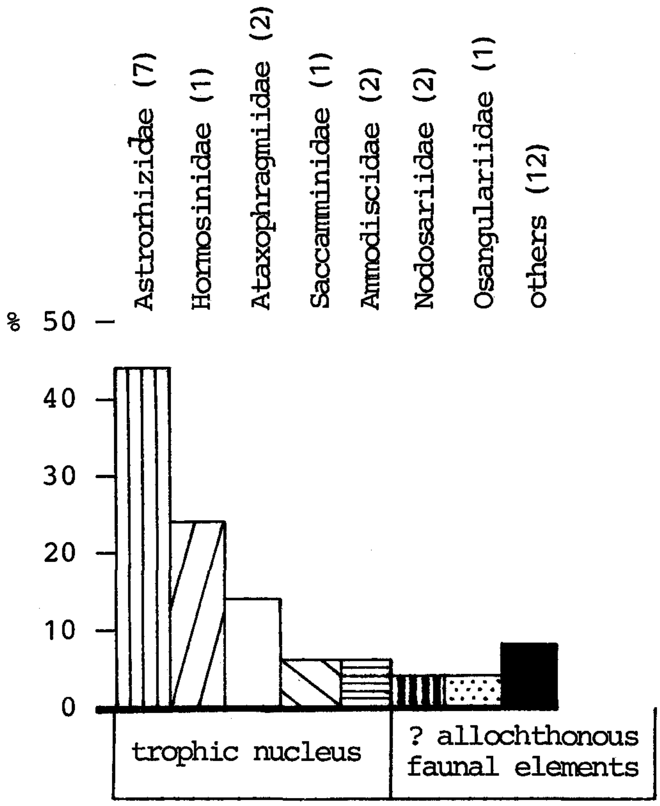

Fig. 4.
Histogram showing the quantitative distribution of the foraminiferal families in the patchreef lagoon representing the trophic nucleus and? allochthonous faunal elements.
Number of taxa or morphotypes in brackets.

modern "primitive" agglutinants (Nyholm 1957; Christiansen 1971; Lipps 1983; Jones and Charnock 1985), the dominating tubular morphotypes lived either epibenthic (*Dendrophrya*) or partially endobenthic, fixated by anastomosing pseudopodia (*Bathysiphon, Reophax*) as primarily suspension-feeders or totally endobenthonic in the uppermost part of the mud (*Rhabdammina, Bathysiphon, Hyperammina, Reophax*) as detrital/bacterial scavengers. The saccamminids can be interpreted as semi-infaunal passive deposit-feeders, the ammodiscids as epifaunal active deposit-feeders.

The fauna of the shales overlying the whole patchreef complex shows no sign of pyritization. The sediments contain "normal" shelf-type foraminifera (epibenthic Ataxophragmiidae-Nodosariidae association, figure 3, A).

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PLATE 1

Figures. 1-2	*Rhabdammina* - morphotype
Figures. 3-7	*Bathysiphon* sp., different morphotypes, figures 5-6 show pyrite grains arranged along the length of the test.
Figure. 8	*Hyperammina* - morphotype
Figures. 9-10	*Saccorhiza* cf. *ramosa* (Brady)
Figures. 11-12	*Dendrophrya* sp.

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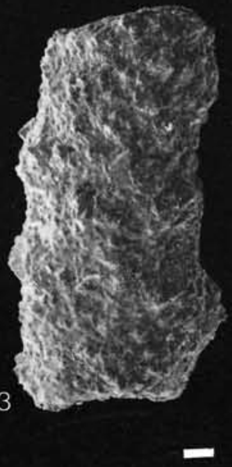
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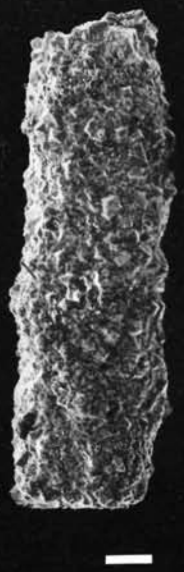
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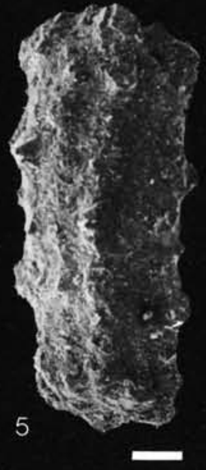
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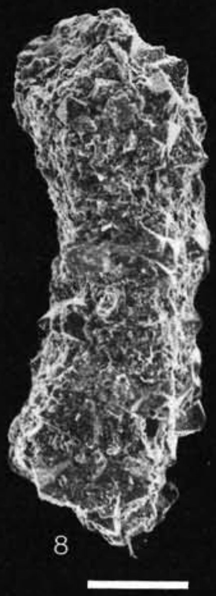
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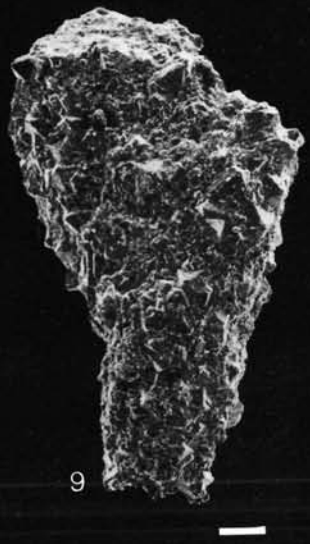
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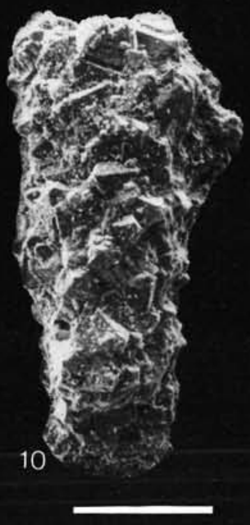
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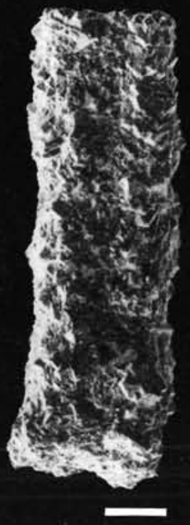
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PLATE 2

Figure. 1	*Psammosphaera* - morphotype
Figures. 2-3	*Ammodiscus* ex gr. *cretaceus* (Reuss)
Figure. 4	*Reophax* sp.
Figures. 5-6	Wall texture of tubular morphotypes in detail, to show the masonry-type cementation pattern.

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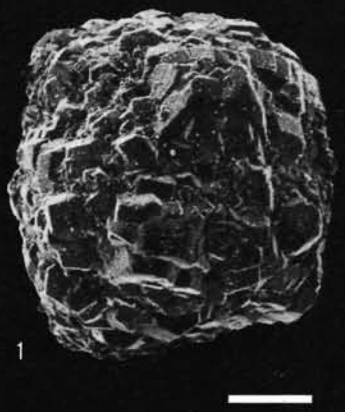
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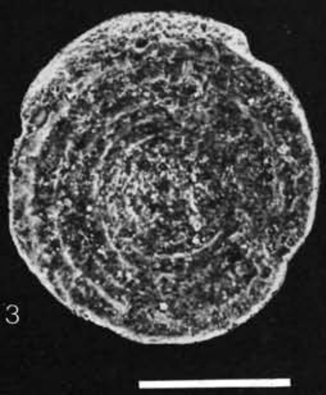
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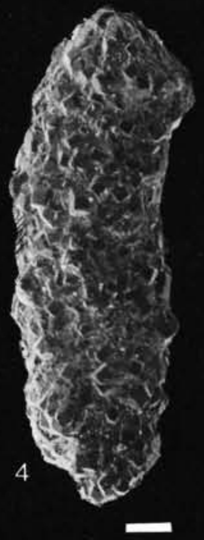
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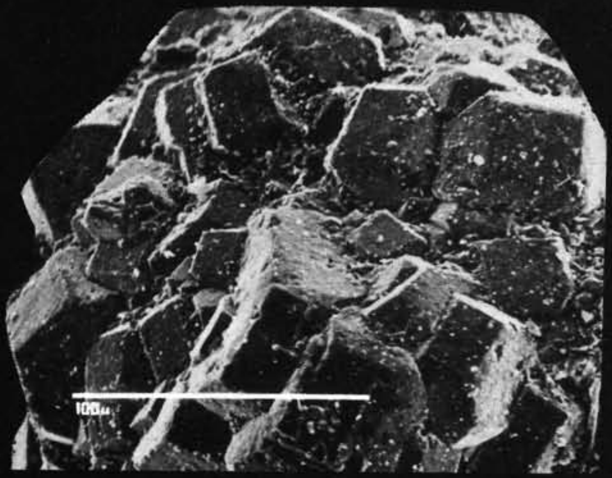

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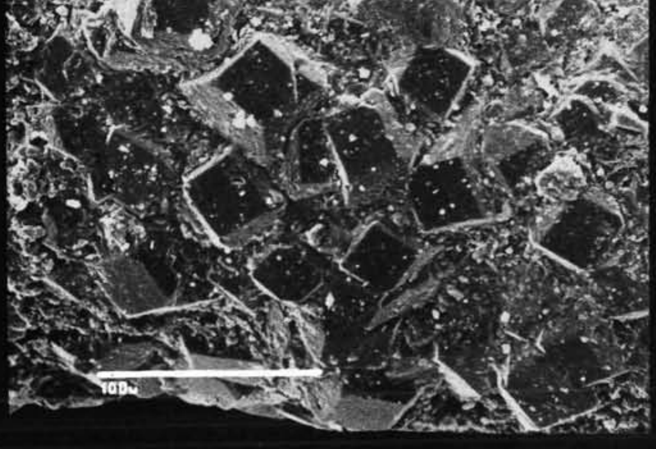

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