MEDDELELSER OM GRØNLAND
UDGIVNE AF
KOMMISSIONEN FOR VIDENSKABELIGE UNDERSØGELSER I GRØNLAND
Bd. **196** · Nr. **1**

GRØNLANDS GEOLOGISKE UNDERSØGELSE
Bulletin No. 100

DE DANSKE NÛGSSUAQ EKSPEDITIONER 1938–39
Under Ledelse af Alfred Rosenkrantz

SCLERACTINIAN CORALS FROM THE UPPER CRETACEOUS AND LOWER TERTIARY OF NÛGSSUAQ, WEST GREENLAND

BY

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WITH 16 FIGURES AND 1 TABLE IN THE TEXT, AND 8 PLATES

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1972

Abstract

Localities and deposits in north-west Nûgssuaq yielding fossil corals of the order Scleractinia are described. The age of the corals is Campanian ?, Maastrichtian and Lower Paleocene (Danian), on the basis of other marine fossils.

22 species are considered; 7 are described as new and are indigenous, 2 are possibly North American forms, 3 are known from Europe, and 10 are identifiable only to generic level. The following genera and subgenera are represented: *Haimesiastraea* (*Haimesiastraea*), *H.* (*Peruviastrea*) ?, *Discotrochus* ?, *Astrangia* (*Coenangia*) ?, *Oculina*, *Caryophyllia*, *Trochocyathus*, *Paracyathus*, *Stephanocyathus* (*Stephanocyathus*), *Desmophyllum* ?, *Lophelia* ?, *Parasmilia*, *Flabellum*, *Balanophyllia*, and *Dendrophyllia*. In addition, two new genera are described: *Kangiliacyathus* and *Faksephyllia*.

Certain Danian corals from Scandinavia are also revised.

In a survey of habitats, the lithology of the coral localities is considered together with bathymetric and thermal ranges known for scleractinian genera and species from other parts of the world. Depth and temperature of the Campanian and Maastrichtian seas in Greenland cannot be estimated with any accuracy. The Lower and Upper Danian seas were generally rather shallow. There is little evidence on which to judge the Danian climate.

Two species were perhaps hermatypic (no reef structures have been found). The remaining scleractinians are presumed to have been ahermatypic. A non-reef coral association has been found. Lower Danian rather sparsely populated polytypic coral thickets show signs of continual disturbance from water turbulence. The approximate depth of formation of these thickets appears to have been 80 m or shallower, which appears to be less than is usual for coral structures of this type.

Some Lower Paleocene species provide conclusive evidence of a direct connection between the Danian seas of West Greenland and of Scandinavia.

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INTRODUCTION

In Greenland, scleractinian corals of Upper Cretaceous and Lower Tertiary age have so far been found only in West Greenland. All the localities are situated in the north-western part of the peninsula called Nûgssuaq (Lat. 70° N–71° N).

Scleractinian fossils were noticed on Nûgssuaq for the first time by the Danish Nûgssuaq Expeditions (De Danske Nûgssuaq Ekspeditioner) 1938–39, which were led by Professor ALFRED ROSENKRANTZ, Copenhagen. The little material then collected (1939) has been supplemented since 1946 by large collections made during the current geological mapping of the peninsula under the auspices of the Geological Survey of Greenland (Grønlands Geologiske Undersøgelse, abbreviated as G. G. U.). Professor ROSENKRANTZ was also the leader and coordinator of the G. G. U. fieldwork on Nûgssuaq. A history of the fieldwork is given in ROSENKRANTZ, 1970. The present writer visited most of the coral localities in 1949, 1953, and in 1957.

The scleractinian material is housed in the Mineralogical Museum of the University of Copenhagen. It has, however, received little notice in the literature, a brief summary of which follows:

In 1940, ROSENKRANTZ *et al.* (p. 658) mentioned the occurrence of *Dendrophyllia* in Danian volcanic tuff on Nûgssuaq. It was on this information that POULSEN (in BØGGILD, 1945, p. 16) based his reference to the material. In 1951 (p. 156) and in 1953 (p. 31) ROSENKRANTZ briefly stated the existence of corals in the Danian of northern Nûgssuaq. On the basis of a personal communication from the author, ROSENKRANTZ later (1962, 1964 a) pointed out that the Greenlandic Danian dendroid genera and even species appeared to be identical with those of Europe (Denmark) and (1963 c) that the European *Dendrophyllia candelabrum* was recognized in the (Lower) Danian of Nûgssuaq. In the latter note he mentioned the existence of scleractinian fossils in the Greenlandic so-called Paleocene. In 1966, RASMUSSEN (p. 156) also mentioned this occurrence of *Dendrophyllia* in the Danian deposits. FLORIS (1967 a, b) presented preliminary results of his study on the fauna treated in this paper. These same preliminary results are quoted by ROSENKRANTZ & PULVERTAFT (1969). ROSENKRANTZ (1970) mentions the occurrence of *Dendro-*

phyllia candelabrum and makes use of short personal notes on the scleractinian fauna given to him by the present author in 1968 and 1969. RASMUSSEN (1969) and HENDERSON (1969) mentioned the same occurrence of *D. candelabrum*. On the basis of a personal communication from the author, HANSEN (1970) mentioned "corals" from certain concretions and SZCZECHURA (1971) mentioned "corals" from certain beds. BIRKELUND (1971) mentioned corals and the same occurrence of *D. candelabrum.*

In the stratigraphical placing of the Greenlandic material the present writer mainly depends on the results from other faunal elements, such as ammonites and other molluscs, by BIRKELUND (1965), ROSENKRANTZ & PULVERTAFT (1969), ROSENKRANTZ (1970), HANSEN (1970). The main part of the coral-bearing Greenlandic deposits can thereby be correlated with the Danian deposits of Denmark. For the division of the Danian, see ROSENKRANTZ (1970, p. 446).

The Danian is here considered lowermost Tertiary, in accordance with many authors (see for instance EL-NAGGAR, 1967, with discussion and references) and in contrast with the statement of DESOR (1847) that the Danian is the youngest stage of the Cretaceous. This common disagreement with DESOR's point of view is based principally on palaeontological revision and broadened study, particularly of molluscs (e. g. ROSENKRANTZ, 1960) and foraminifera. Generally, the Greenlandic scleractinians treated in this paper tend to draw the Danian into the Tertiary. The Danian is here considered a full stage constituting the Lower Paleocene. This consideration forms part of the Paleocene concept presented by EL-NAGGAR (1967), viz.:

Upper Paleocene: Landenian;
Middle Paleocene: Heersian (DUMONT, 1851); Montian (DEWALQUE, 1868) is a junior synonym;

Lower Paleocene: Danian.

(The lower part of the Selandian (ROSENKRANTZ, 1924), and in particular the Copenhagen Paleocene, is placed within the Middle Paleocene, or Heersian; see HANSEN, 1968.)

The placing of formations and groups of southern and eastern U. S. A. within the Paleocene and Eocene is in most cases in accordance with the scheme published by PALMER & BRANN, 1965. In general, for the stratigraphy of the Paleocene and Eocene of the Pacific Lower Tertiary of the U. S. A., use is made of the compilation chart in PAPP, 1959 (p. 318).

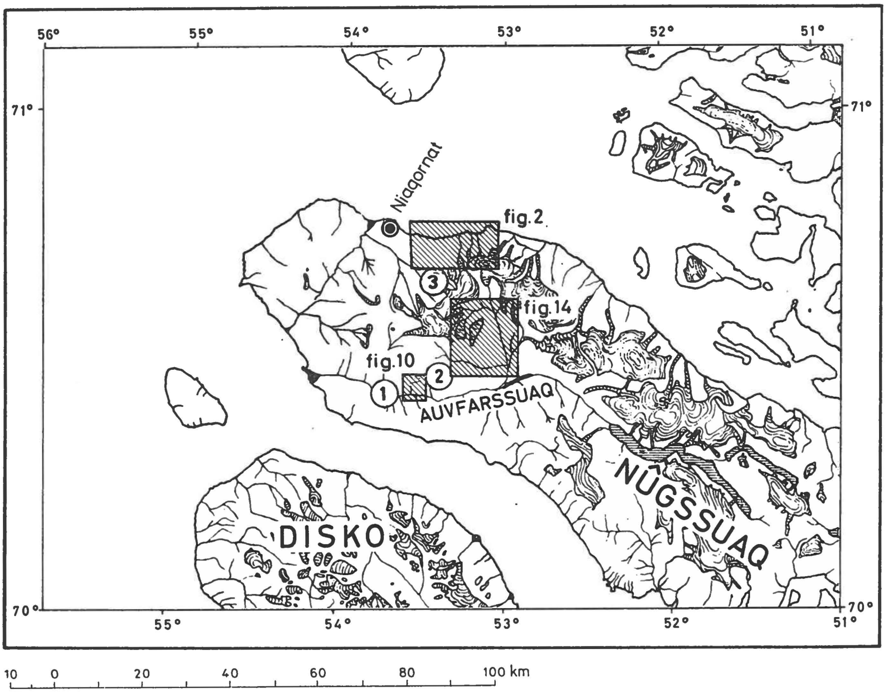

Fig. 1. Map of Nûgssuaq showing areas reproduced on a larger scale in Figs 2, 10 and 14, and coral localities outside these areas mentioned in the text. 1: Alluvial fan of the Quvnilik valley; 2: Locality in the Qilakitsoq valley; 3: Locality on the south-side of the Tunorssuaq valley. (Reproduced by permission (A.497/70) of the Geodetic Institute, Copenhagen).

DESCRIPTION OF THE LOCALITIES

Maps, see Figs 1, 2, 10, and 14

The fossils described in this paper were collected from localities in the north-western part of Nûgssuaq, partly on the northern coast and partly along the rivers of the interior (Fig. 1).

Most of the results of the field work carried out in this area have not yet been published. Some of the information given below is therefore based on the study of labels, on personal communications from Professor Rosenkrantz, and on field notes made in 1946 by Dr. Helge Gry, in 1953 by stud. mag. Gunnar Larsen and the author, and in 1957 by stud. mag. Knud Schou-Jørgensen and the author.

Relevant literature on the geology of the area is: Rosenkrantz *et al.*, 1940; Rosenkrantz, 1951, 1953, 1955, 1964 a, 1970; Rosenkrantz & Pulvertaft, 1969; Koch, 1959, 1963, 1964; Mathiesen, 1961; Birkelund, 1965; Bendix-Almgreen, 1969; Henderson, 1969; Hansen, 1970.

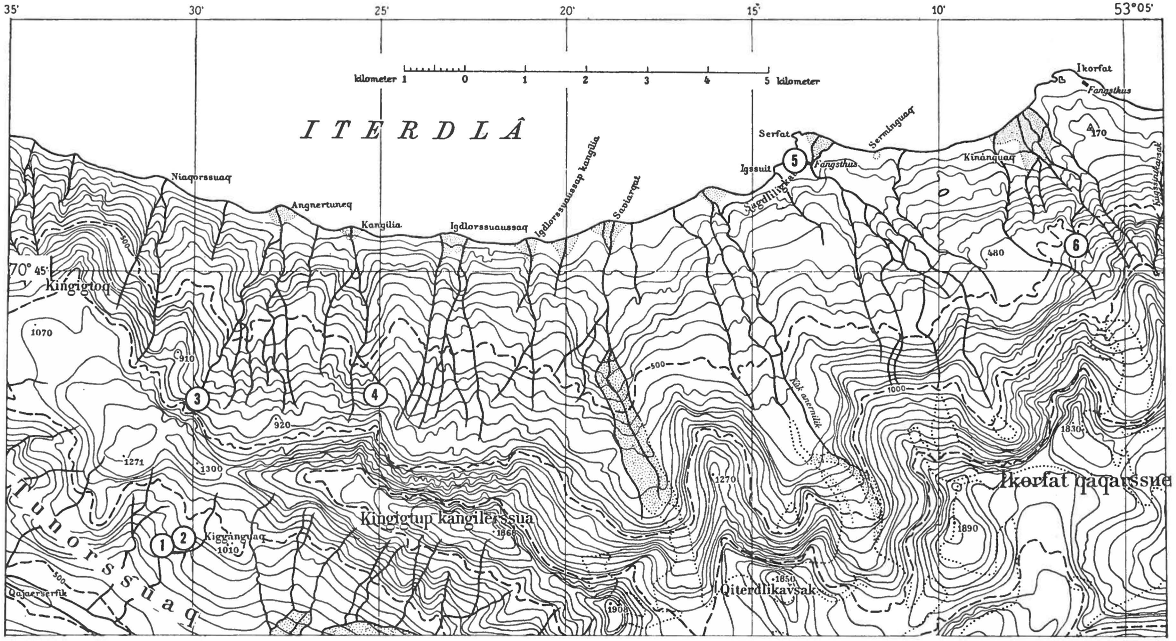

Fig. 2. Map of part of the Tunorssuaq valley and the northern coast of Nûgssuaq, showing coral localities: 1, 2: Coral-bearing sections ("Store Profil" and "Nordprofil" respectively) in Danienkløft; 3: Coral-bearing sandstone in Vestre Konglomeratkløft at Angnertuneq, 4: Danienrygge (Ryg A, Ryg B, Ryg C, Ryg D) at Kangilia; 5: Alluvial fan at Serfat; 6: Coral-find at Ikorfat. (Reproduced by permission (A.497/70) of the Geodetic Institute, Copenhagen).

General

The scleractinian fossils belong to the Cretaceous and Tertiary marine sediments which, in the ideal section of western Nûgssuaq, overlie limnic Cretaceous resting on Precambrian gneiss, and underlie several kilometres of Paleocene-Eocene basaltic volcanics (pillow lava and flood basalt lava).

In this ideal section the marine sequence is as follows:

(1) below, more than 1000 m of dark Upper Cretaceous (Coniacian-Maastrichtian) shales (and subordinate sandy shales and sandstones) with a predominantly pelagic fauna preferably preserved in calcareous concretions;

(2) resting unconformably on these shales, about 500 m of Lower Danian sediments, viz. a prominent basal conglomerate, which in places often contains derived Maastrichtian and also Campanian material (concretions), followed by a thick deposit dominated by concretion-bearing dark shale and nearly devoid of fossils in its lower part, but in its upper part with many fossils of benthonic organisms, mainly in subordinate beds of basalt tuff;

(3) and above, again unconformably, the Upper Danian deltaic-transitional Agatdal Formation (earlier referred to as "Lower Paleocene (Montian)", see Rosenkrantz, in Koch, 1959, p. 75; Koch, 1963, p. 13). This consists of up to 100 m of conglomerates, deltaic sandstones, dark bituminous shales with concretions and, in the uppermost part, numerous beds of basalt tuff.

The marine deposits have been dated mainly on the basis of ammonites and other molluscs (see Rosenkrantz *et al.*, 1940, pp. 657–658, 660–662; Poulsen in Bøggild, 1945; Rosenkrantz, 1951, esp. p. 156; 1953; 1962; 1963 c; 1964 a; 1970; Rosenkrantz & Pulvertaft, 1969; Birkelund, 1965; Hansen, 1970).

The fossil scleractinians date from the Campanian (?), Maastrichtian, Lower Danian and Upper Danian. Usually they were but rare finds but at some places they occurred in great quantities. Generally they were collected *in situ*. Only a minute portion of the material was collected from displaced blocks, mainly calcareous concretions from the dark shale series. All apparently belong to the north-west Nûgssuaq standard section described above.

Campanian (?) and Maastrichtian

One undeterminable solitary corallum filled with dark shale was collected at an altitude of 560 m from a locality at Ikorfat (Fig. 2, no. 6). The shale here dates from the younger part of the Campanian (Birkelund, 1965, p. 20) but the specimen found is badly weathered on all sides and may be displaced, and so may possibly be younger.

Upper Cretaceous scleractinians can be found in a Lower Danian basal conglomerate, which is coral-bearing at the so-called Oyster-ammonite Conglomerate localities I and II (altitude 410 m) and the Oyster-ammonite Conglomerate locality III (altitude 510 m), in Agatdalen, (see Fig. 14, nos. 6 and 7). The conglomerate at these localities is about 5 m thick and has yielded derived Campanian and Maastrichtian concretions from dark shales (see BIRKELUND, 1965, p. 18). The matrix of the conglomerate is shaly dark mud with a conspicuous content of quartz grains. In places, calcareous concretions have been formed within the conglomerate itself which belongs to the *Thyasira* Member (ROSENKRANTZ, 1970, p. 419).

Stephanocyathus (*Stephanocyathus*) ? sp. no. 1 was found in a derived concretion from Maastrichtian dark shales with some quartz grains (loc. III). The same species and a possible *Caryophyllia agatdalensis* were found at the same locality, in concretionary sandy bodies that may be either Campanian or Maastrichtian or Lower Danian. One further corallum (undetermined) was found at the locality, in a calcareous concretion, the age of which may be either Upper Cretaceous or Lower Danian.

Lower Danian

The Lower Danian conglomerate outcropping in Agatdalen also yielded some rare, unquestionably Lower Danian scleractinians. Thus *Caryophyllia agatdalensis* and *C.* sp. B were found at the Oyster-ammonite Conglomerate localities I and II (Fig. 14, no. 6).

Lower Danian scleractinians were found very commonly at some other localities. This was especially the case with a group of localities at Kangilia (map, Fig. 2), which yielded 15 species of scleractinians.

The Lower Danian at Kangilia is the type of ROSENKRANTZ's Kangilia Formation which is divided into 4 members (ROSENKRANTZ, 1970, p. 419). The scleractinians from the group of localities at Kangilia were largely collected *in situ*, either in or in intimate connection with two Lower Danian beds of basalt tuff within the dark shales. These deposits are here called Tuff I (the older) and Tuff II (referred to as tuff beds I and II by BENDIX-ALMGREEN, 1969). They are exposed in a group of small spurs, Ryg A, Ryg B, Ryg C, and Ryg D, together called the Danienrygge (Fig. 2, no. 4; Fig. 3) (see ROSENKRANTZ *et al.*, 1940, pp. 658, 661; ROSENKRANTZ, 1951, pp. 156, 158; ROSENKRANTZ, 1970, pp. 417–419, where the *Thyasira* Member is established on the two tuff beds with shale and sandstone in between. Each of the tuffs is up to 7 m thick at Kangilia, where the member is about 35 m thick. The same member was sketched by HANSEN (1970) as only *c.* 3 m thick).

In the case of Tuff I, corals have been found both in the tuff itself and in a weakly developed conglomerate immediately at its top.

Tuff II is exposed at altitudes of about 750 m. Scleractinian corals have from time to time been collected there in the following places:

Ryg A (Figs 4, 5). The tuff is greenish-grey, taking on a conglomeratic appearance through conspicuous, moderately to well-rounded fragments of shale (diameter up to at least 2 cm), which may sometimes be graphitized. The graphitized shale fragments, at least, may be redeposited "lapilli". The coarse sediment does not exhibit any distinct sorting or bedding. Scleractinians are common. Below the tuff is a thin quartz sandstone with plant detritus.

Ryg B and Ryg C. Tuff and coral content are generally like those of Ryg A.

Ryg D. Coral content like that of Ryg A. In 1957 the writer was unable to recognize any of the sub-localities found earlier.

Small portions of the material collected in 1939, 1946, 1947 and 1952, may have been found either in Tuff I or in Tuff II.

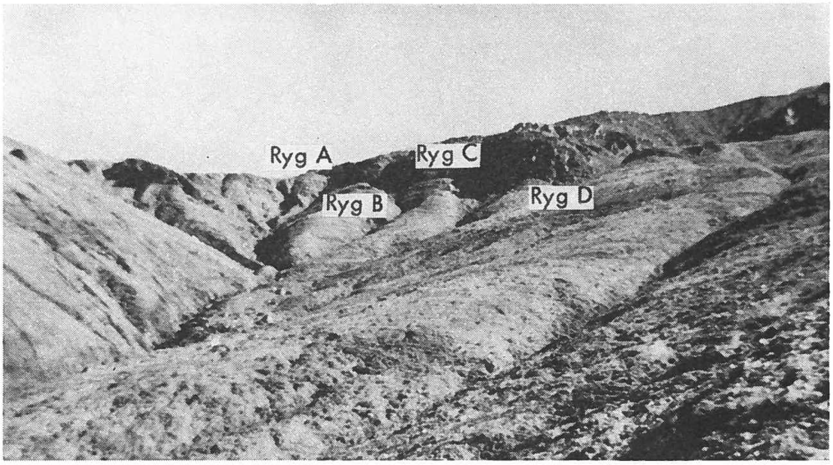

Fig. 3. Danienrygge at Kangilia photographed from the north and from an altitude of about 600 m. S. Floris photo, 1957.

Fig. 4. Tuff II of Ryg A (Danienrygge at Kangilia). S. Floris photo, 1957.

The majority of the scleractinian fossils were found in Tuff II. They are either remains of solitary corals or isolated fragments (reaching 10 or 15 cm) of branching forms. Apparently all the specimens were embedded without preferred orientation;

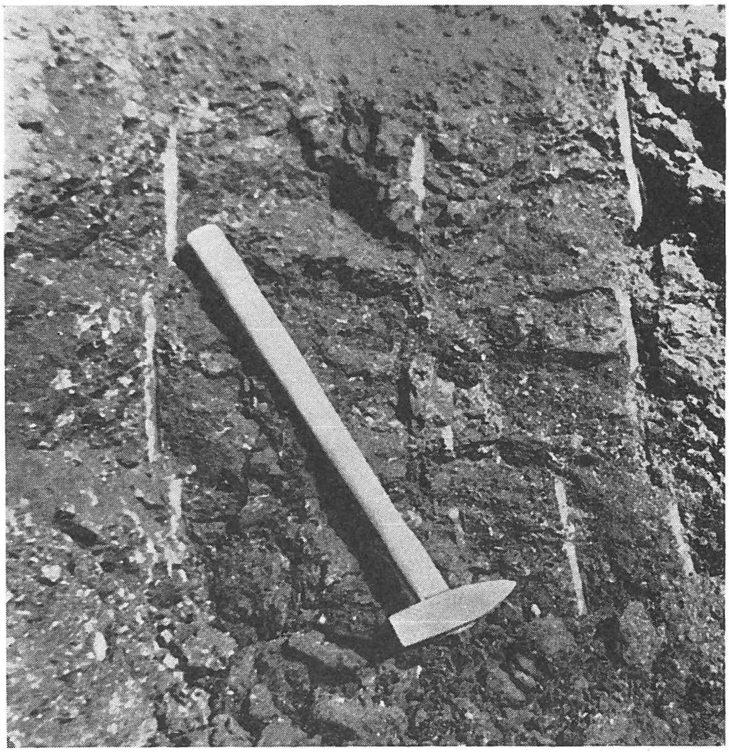

Fig. 5. Tuff II of Ryg A (Danienrygge at Kangilia). S. FLORIS photo, 1957.

one exception is the slightly preferred horizontal position in the uppermost part of the tuff as observed in Ryg C. The sediment filling the skeletons of Tuff II is identical with that surrounding them. Some bases contain sediment in a manner which demonstrates that the corals settled down and lived on a sediment dominated by rolled chips of shale and volcanic ash. Sorting and pronounced wear after death seem to have been negligible. Nevertheless, slight pre-embedding wear combined with later dissolution processes within the sediment generally have caused the removal of the finest sculptural elements of the surfaces.

In 1957 a 670 cm section was measured in Ryg C in order to study the distribution of corals in Tuff II. The top of the section was at an altitude of approximately 755 m and the dip (influenced by a nearby intrusive body ?) was about 30° to the south-west. Rock samples were collected at every half metre, while observations were made for the intervals.

The Ryg C succession is as follows: The greenish-grey Tuff II abruptly overlies 22 cm of greyish-violet unfossiliferous silty clay rich in muscovite which in turn unevenly overlies a light grey sandstone above dark shale. Tuff II is itself overlain by dark shale with calcareous concretions.

Almost throughout, concretionary bodies have been formed within the tuff itself, but these are very insignificant at some levels. In a thin horizon, 1.5 m above its base, the tuff has a rather clayey appearance. Apart from this horizon the tuff contains numerous very conspicuous small and moderately- to well-rounded pieces of shale (up to at least 5 mm, some graphitized).

Fig. 6. Part of the gorge complex of Vestre Konglomeratkløft at Angnertuneq. The two coral-bearing spurs are seen from the north and from an altitude of about 700 m. K. Schou-Jørgensen photo, 1957.

The basal tuff sample contained no macrofossils. All other samples contained macrofossils, although most of the upper third of the section appeared to be almost barren. Scleractinian remains were found at two levels in the sample series, viz. within a 210 cm thick zone in the middle of the section, and within the uppermost *c.* 25 cm, where the tuff has a certain content of clay.

The presence of more or less rounded grains in an unsorted or very poorly sorted sediment indicates that the marine Tuff II was deposited in water which was for the most part wave agitated.

The coral-bearing displaced blocks from the locality-complex either consist of basalt tuff (apparently displaced from Tuff II) or they are calcareous concretions from dark shales. The concretions probably belong to the Lower Danian. (Rosenkrantz (1970) appears to have referred the corals from these concretions to his *Propeamussium* Member).

At Angnertuneq there is a major group of gorges (map, Fig. 2) where *Caryophyllia* sp. B, *Stephanocyathus* (*S.*) sp., and probably *Faksephyllia faxoensis* were collected from displaced calcareous concretions (from dark shales), in the alluvial fan and in the gorge complex of Vestre Konglomeratkløft. Age is probably Danian (in part probably Lower Danian). Danian corals have been located *in situ* in the complex of gorges and spurs of Vestre Konglomeratkløft. They were observed here at altitudes between 750 m and 1,000 m in the years 1939 and 1946, in one or more beds of quartz sandstone cropping out in two small spurs (Fig. 6) in the upper part of the drainage system. In 1957 such a sandstone was visited at *c.* 750–760 m above sea level (Fig. 2, no. 3), and only specimens from that particular level have received attention in this study (*Flabellum groenlandicum*). They are considered to be of Lower Danian age.

A third place on the northern coast of Nûgssuaq, the alluvial fan at Serfat, to the west of the hunters' cabin (Fig. 2, no. 5), has yielded *Caryophyllia* sp. B, in a displaced calcareous concretion, probably of Lower Danian age.

In the Tunorssuaq river bed (Fig. 2) (downstream from the Danienkløft mentioned below) one displaced *Caryophyllia* sp. B was found (probably Lower Danian).

On the south side of the Tunorssuaq valley a displaced calcareous concretion yielded one specimen (*Stephanocyathus* (*S.*) sp.), also probably of Lower Danian age (Fig. 1, no. 3).

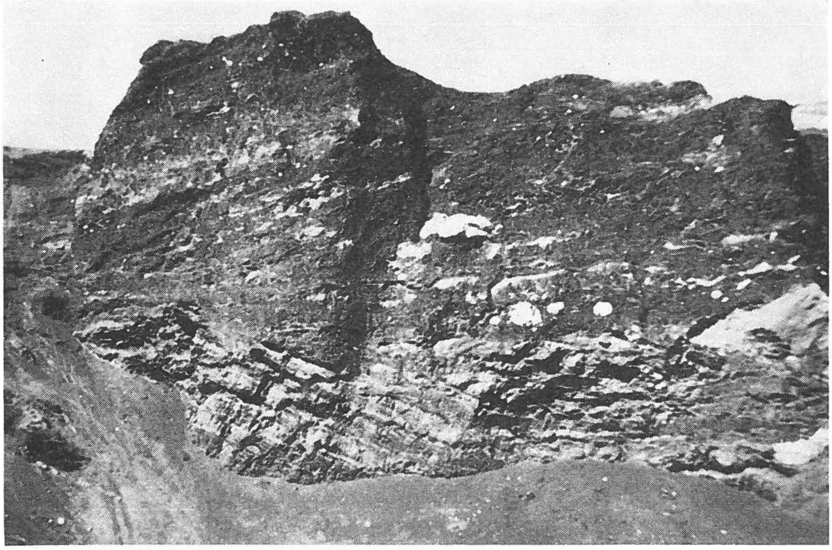

Fig. 7. "Store Profil" of Danienkløft, Tunorssuaq, seen from the south-east and from an altitude of about 825 m. Height of section *c.* 20 m. S. FLORIS photo, 1957.

Fig. 8. "Store Profil" of Danienkløft, Tunorssuaq. Details of tuff lens. S. FLORIS photo, 1957.

Lower Danian scleractinians have been found *in situ* in the Danienkløft, the main locality of which is the river section called "Store Profil" (Fig. 2, no. 1; Figs 7, 8). The sediments here consist of alternating shales and scleractinian-bearing basalt tuff in beds and lenses. The "Store Profil" tuff is found about 800 m above sea level and in

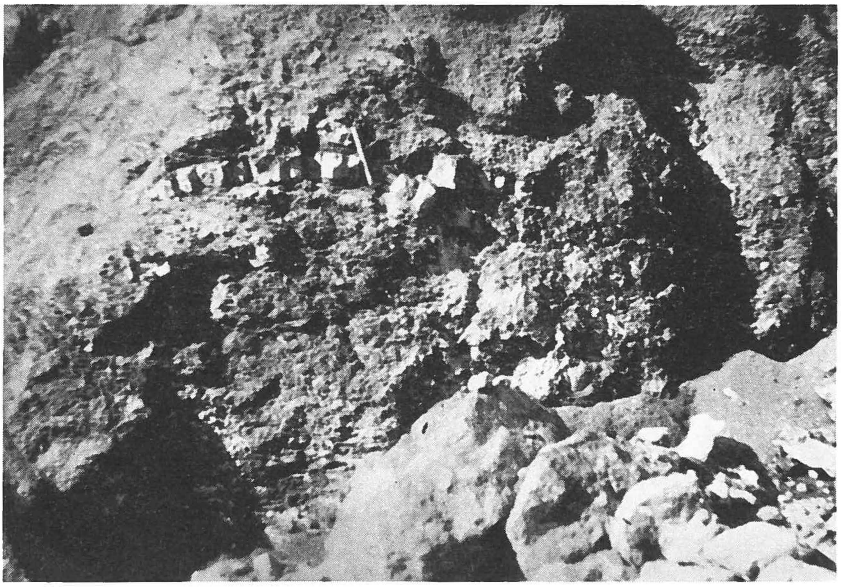

Fig. 9. "Nordprofil" of Danienkløft, Tunorssuaq. Calcium carbonate cemented shale with solitary corals. K. SCHOU-JØRGENSEN photo, 1957.

part, at least, presents a coarser sediment type than that observed at Kangilia. Thus, in the greenish grey unsorted tuff, up to hand-sized rounded pieces of shale can be observed within a lens. Scleractinians are rare. In 1957 the writer observed that the isolated skeleton fragments, found in a lens and damaged superficially by dissolution, apparently had no preferred orientation within the sediment. They did not appear to have been much worn before embedding. Apparently, at least a part of the tuffaceous sediment of "Store Profil" was deposited from fast and irregularly moving water (wave action).

Far upstream in the Danienkløft in the "Nordprofil" there is an exposure of shale of Lower Danian age with calcareous concretions (Fig. 2, no. 2). Here, at approximately 900 m above sea level, a slightly brecciated lens of dark shale, cemented by calcite and locally containing quartz grains, has yielded three specimens of *Caryophyllia* sp. B (Fig. 9).

A picrite body in the "Store Profil" has a single undeterminable scleractinian (Lower Danian ?).

Below the "Nordprofil" and downstream, corals were collected in the Danienkløft from displaced calcareous concretions found in the river bed (1952, 1957). The age is probably Danian (probably in part Lower Danian).

In 1957 Lower Danian scleractinian-bearing basalt tuff was found in the southern slope of the small gorge Koralravine (Figs 10, no. 2; 11, 12, 13). Fragments of the same rock type were sampled in the river bed of Koralkløft (Fig. 10, no. 1) in 1951, 1952, 1953, and 1957 (almost certainly displaced from the Lower Danian of Koralravine).

The base of the tuff lies at about 585 m above sea level. The tuff is dark, greenish grey and generally coarse grained. It contains somewhat rounded "lapilli" (?) of graphitized shale and what probably represents volcanic bombs, viz. calcareous concretions (from dark shales), some of which are orientated in the tuff with their longest axis vertical. Some large bodies of shale suggest that clay deposition took place

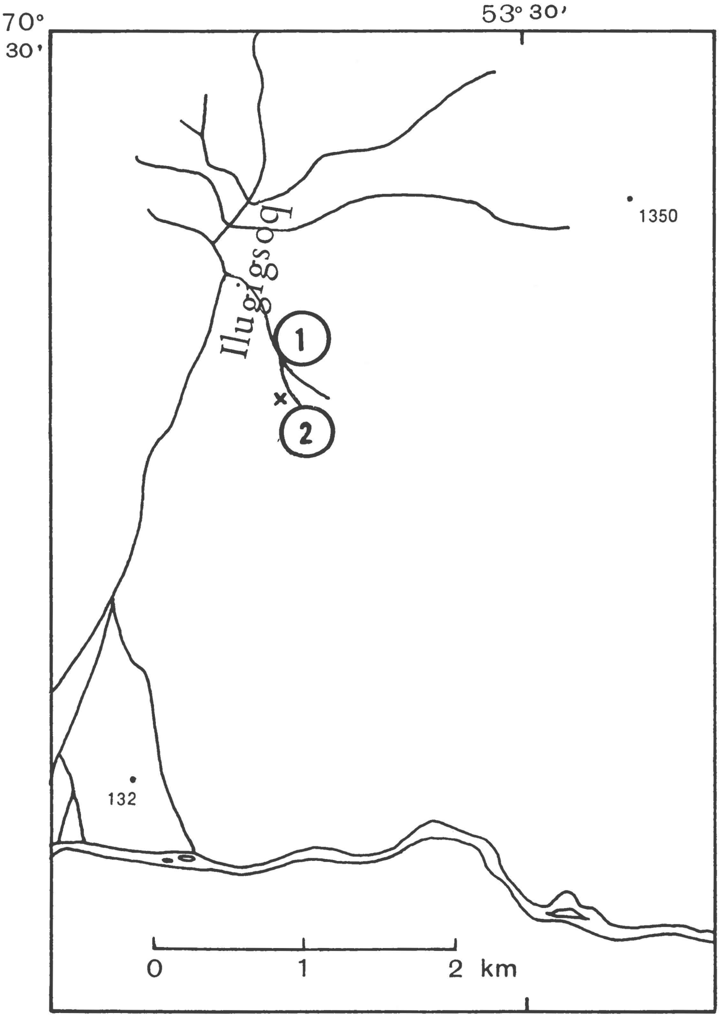

Fig. 10. Sketch-map of the river system of the Ilugigsoq valley, 1:50,000, indicating position of, 1: Koralkløft gorge, and 2: Koralravine gorge. Coral locality marked with cross. (Reproduced by permission (A. 497/70) of the Geodetic Institute, Copenhagen).

intermittently in small basins in the tuffaceous sea floors. In places the tuff has been solidly cemented with calcite at a later date.

The tuff is 4.8 m thick and lies between two shales. The upper shale contains tuffaceous matter and irregularly orientated fragments of coral skeletons in its basal part. The tuff contains numerous remains of a scleractinian fauna. The isolated skeleton fragments are apparently placed without any preferred orientation. They are either not worn, or only slightly so. Some fragments have been crushed within the sediment.

One specimen (*Caryophyllia* sp. B) was found in a displaced calcareous concretion in Koralkløft. Age is probably Lower Danian. Another specimen of *Caryophyllia* sp. B

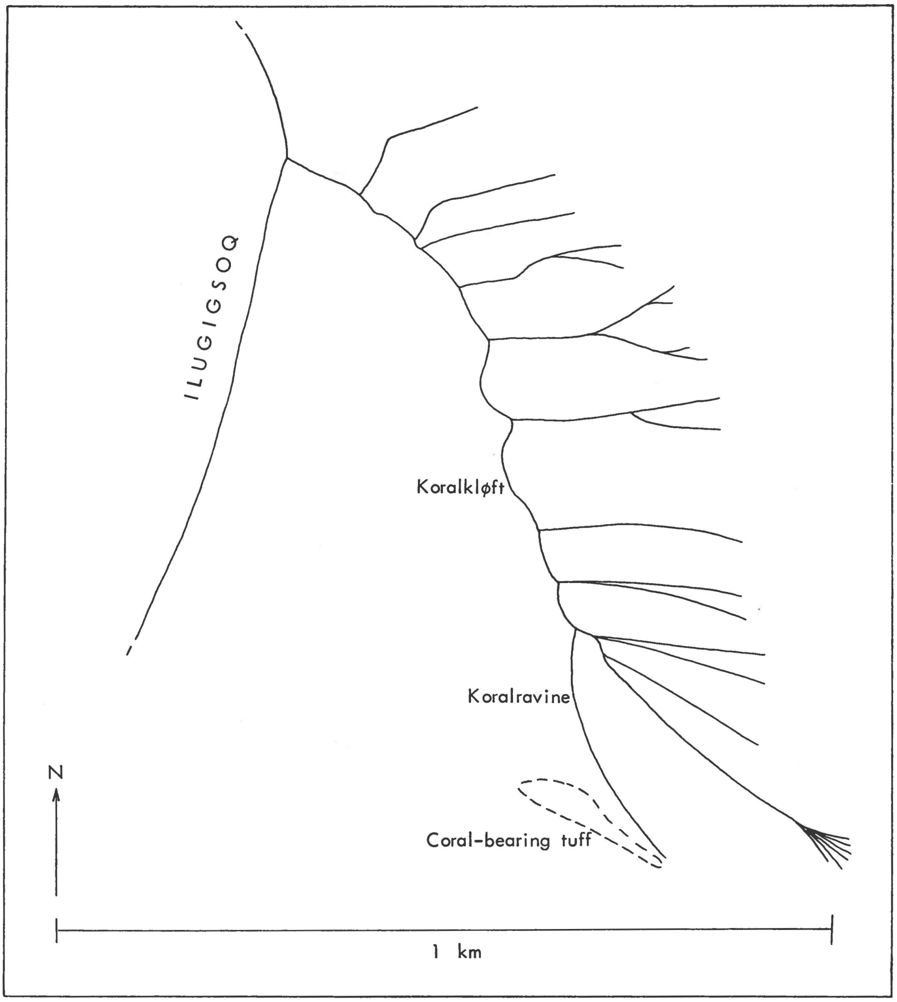

Fig. 11. Sketch-map showing coral-bearing tuff in southern slope of Koralravine. (From field notes by S. Floris, 1957).

was found displaced in a southern neighbouring gorge to Koralkløft (age probably Lower Danian). One undeterminable specimen was found in a displaced calcareous concretion in the next big gorge to the north of Koralkløft (Fig. 10); its age is probably Lower Danian. In the Qilakitsoq valley a displaced calcareous concretion was sampled in 1957 in the river bed at an altitude of about 740 m and was found to contain 2 individuals of *Caryophyllia* sp. B (probably Lower Danian) (see map, Fig. 1, no. 2). Quvnilik is a similar tributary (Fig. 1, no. 1). On its alluvial fan, which stretches into the Auvfarssuaq valley, a displaced calcareous concretion, probably Lower Danian, from dark shales, yielded an example of *Trochocyathus johannesi*. In the main river bed of the Kangersôq valley (Fig. 14) one specimen of *Caryophyllia* sp. B was collected in 1953 from a displaced calcareous concretion from dark shales, at an approximate alti-

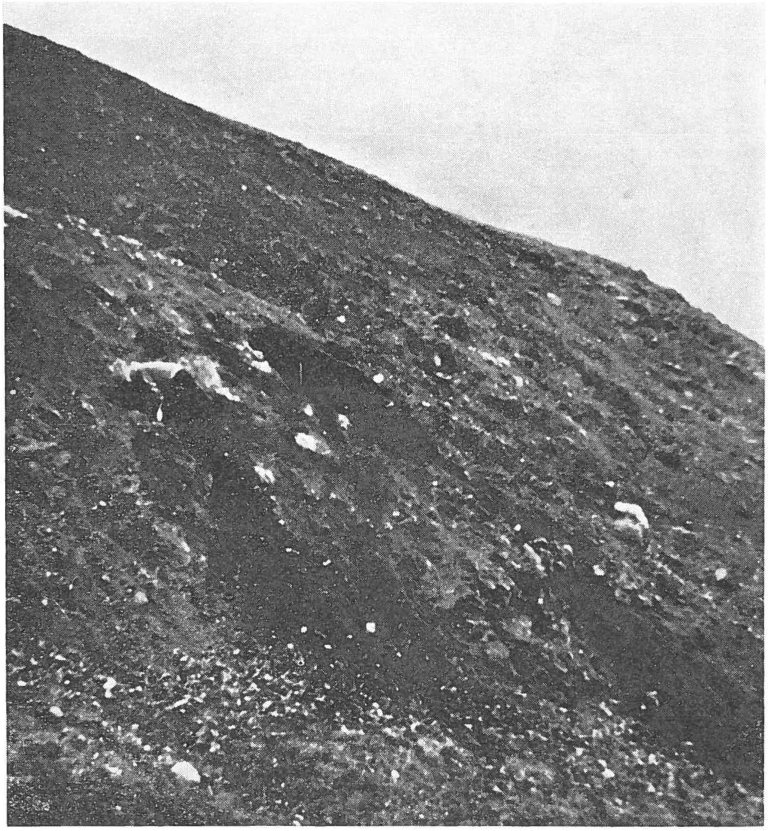

Fig. 12. Southern slope of Koralravine (of Koralkløft, Ilugigsoq), showing scleractinian-bearing tuff. Seen from the north and from an altitude of about 595 m. S. FLORIS photo, 1957.

tude of 500 m; age probably Lower Danian. Another individual of the same species was found in a displaced calcareous concretion in the river bed below the "Store Profil" of Agatkløft (Fig. 14); age is probably Lower Danian.

Upper Danian

Scleractinians have chiefly been found in quartz sandstones and in basalt tuff. Their remains demonstrate the presence of both solitary forms and colonial forms, but the skeletons of the latter are fragmented with the fragments scattered.

The Upper Danian sediments are exposed mainly in the sides and river sections of the three northerly gorges: Qaersutjægerdal, Agatkløft, and Turritellakløft. Each of these has a predominant section called the "Store Profil" (Figs 14, nos. 5, 4, 1; 15).

Among the minor sections two will be mentioned here because they are coral localities. The first is a small spur called Scaphitesnæsen (Fig. 14, no. 2) on the southern slope of Turritellakløft where a thick Upper Cretaceous sequence is overlain by dark

Fig. 13. Scleractinian-bearing tuff (scleractinians appear as white spots), Koralravine (of Koralkløft, Ilugigsoq). S. Floris photo, 1957.

shales of uncertain age which are in turn overlain by shale and sandstone belonging to the Upper Danian Agatdal Formation (555–560 m above sea level) (see Birkelund, 1965, Fig. 5, and p. 18). In this formation a *Haimesiastraea* (*H.*) *groenlandica* was found in a sandy sediment. The other minor coral-bearing (*Flabellum groenlandicum*) locality is a section in Konglomeratnæsen (Fig. 14, no. 3) on the northern slope of Turritellakløft. Collections were made in a sandy sediment (deltaic), in 1946 and 1951, at an altitude of approximately 550 m.

Based on observations on the type locality in Turritellakløft gorge in this northern part of the interior, Rosenkrantz (in Koch, 1959, p. 75) has divided his Agatdal Formation into three members: (1) a lower Turritellakløft Member (at the type locality 50 m of shale with sandstone lenses), (2) a middle Andreas Member (at the type locality at least 25 m of delta-sandstone), and (3) an upper Abraham Member (at the type locality a 12 m sequence of shales and coarse basalt tuff, the latter dominating in the upper part) (see Fig. 15).

All three members contain scleractinian remains. The Turritellakløft Member contains corals in Qaersutjægerdal ("Store Profil", in coarse concretionary clastics), and in Agatkløft ("Store Profil" (Sonja Member profile, or Sonja Section, in Hansen, 1970, pp. 15, 16), where corals were collected in the so-called Sonja Lens at an altitude

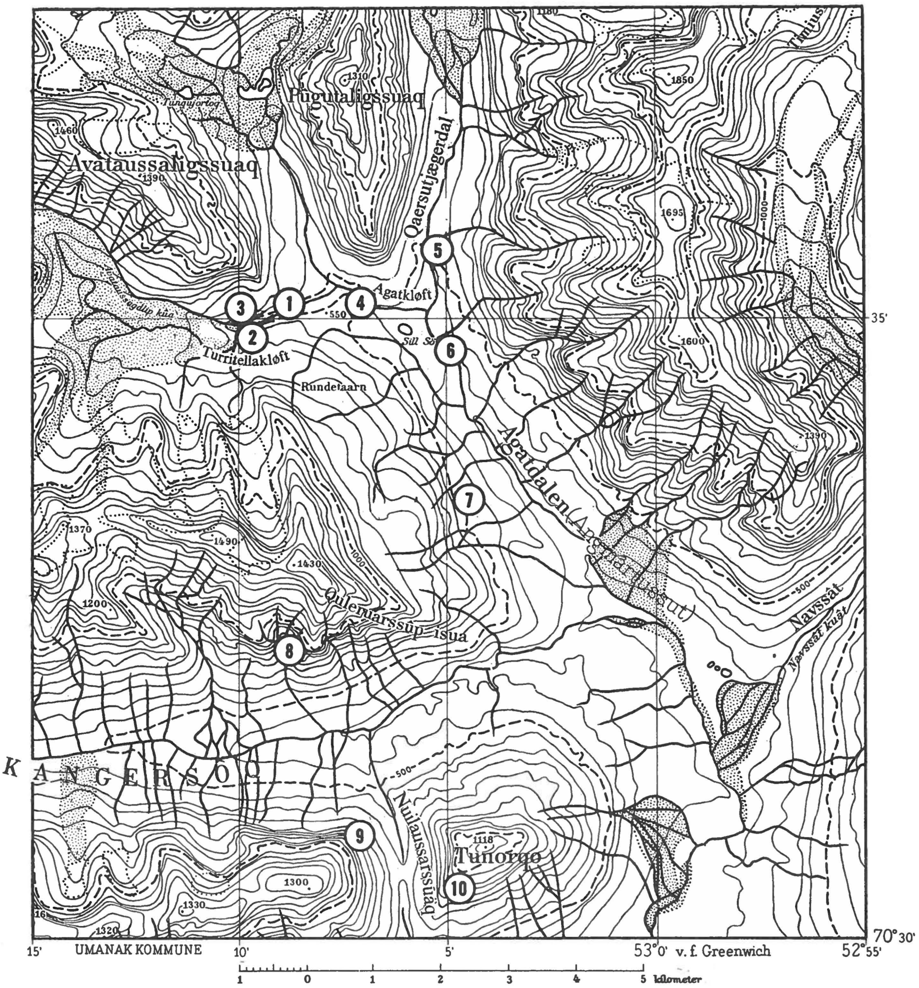

Fig. 14. Map of the Agatdalen and Nuilaussarssuaq valleys and part of the Kangersôq valley, showing coral localities: 1: "Store Profil" of Turritellakløft; 2: Scaphitesnæsen of Turritellakløft; 3: Konglomeratnæsen of Turritellakløft; 4: "Store Profil" of Agatkløft; 5: "Store Profil" of Qaersutjægerdal; 6: Oyster-ammonite Conglomerate localities I and II; 7: Oyster-ammonite Conglomerate locality III; 8: Coral locality of Kangersôq; 9: Coral locality of Nuilaussarssuaq; 10: Coral locality of Tunorqo. (Reproduced by permission (A.497/70) of the Geodetic Institute, Copenhagen).

of 460 m, almost six metric tons of rock have been washed. The lens consists of loose subarkosic sand (HANSEN, 1970) with apparently sorted fossils and fragments of fossils, and is part of the so-called Sonja Member of the Agatdal Formation (ROSENKRANTZ, in KOCH, 1959, p. 77); this coarse clastic deltaic member is correlated with the Turritellakløft Member, see ROSENKRANTZ, in KOCH, 1959, p. 77). Furthermore, the Turritellakløft Member contains scleractinians in Turritellakløft ("Store Profil", Scaphites-

Fig. 15. The Turritellakløft Member, the Andreas Member, and the Abraham Member exposed on the type locality, "Store Profil" of the Turritellakløft gorge, Agatdalen. Height of section *c.* 80 m. A. ROSENKRANTZ photo, 1949.

næsen, and possibly at Konglomeratnæsen). The Andreas Member and the Abraham Member contain corals in Turritellakløft ("Store Profil" and perhaps Konglomeratnæsen).

All these Upper Danian coral-bearing sediments are found at altitudes of about 500 m above sea level.

Further south, scleractinian fossils have been collected from corresponding deposits found in the valley Kangersôq (Fig. 14, no. 8), in the pass Nuilaussarssuaq (Fig. 14, no. 9) and on the southern slope of Tunorqo (Fig. 14, no. 10). In this area the deposits have been elevated to 700–800 m above sea level.

The corals were collected from coarse quartz sandstones. In Kangersôq they were collected at an altitude of approximately 744 m in the gorge that descends from the 1,430 m mountain to the north. In the pass Nuilaussarssuaq the material was collected at altitudes of 800–850 m. On the southern side of Tunorqo a coral (*Flabellum groenlandicum*) was collected at the altitude of 800 m, above the first big gorge to the east of Nuilaussarssuaq.

Scleractinians, probably of Upper Danian age, were found displaced in the following localities:

(1) Turritellakløft, *Flabellum groenlandicum* in quartz sandstone, and one dubious example, in concretionary dark shale;

(2) Agatkløft, conglomeratic quartz sandstone (possibly *Oculina becki*, and probably *Flabellum groenlandicum*);

(3) Kangersôq, in the western part of the double gorge just to the east of the gorge that descends from the 1,430 m mountain to the north, at an altitude of 710 m, quartz sandstone with *Flabellum groenlandicum* and dubious *Caryophyllia* sp. A;

(4) In the Ilugigsoq area: (a) quartz sandstone with pebbles and shell fragments (carbonate cemented) (probably *Haimesiastraea* (*H.*) *groenlandica*, dubious *Astrangia* (*Coenangia*) ? sp. cf. *A.* (*C.*) *cretacea*, *Flabellum groenlandicum*); (b) quartz sandstone (altitude of 600 m) (probably *Oculina becki*, possibly *Caryophyllia andreasi*, *Flabellum groenlandicum*); (c) quartz sandstone (Koralkløft) (dubious *Oculina becki*).

SYSTEMATIC DESCRIPTIONS

The earlier estimate of 43 (unnamed) species of Scleractinia from Greenland (FLORIS, 1967, a, b) is now seen to be excessive. In the present work the number has been reduced to 22.

The terminology and taxonomy followed in this study are, in general, those of WELLS, 1956.

The figured specimens are registered in the type collection of the Mineralogical Museum of the Copenhagen University (Københavns Universitets Mineralogiske Museum). Their numbers are cited with the prefix MMH.

Class **Anthozoa** EHRENBERG, 1834

Subclass **Zoantharia** BLAINVILLE, 1830

Order **Scleractinia** BOURNE, 1900

Suborder **Astrocoeniina** VAUGHAN & WELLS, 1943

Family **Stylinidae** d'ORBIGNY, 1852

Subfamily **Stylininae** d'ORBIGNY, 1852

Genus *Haimesiastraea* VAUGHAN, 1900 (b)

In 1956 WELLS placed this genus, together with *Peruviastrea* VAUGHAN, 1922, which was then considered a subgenus, with some doubt in the Stylininae. This doubtful classification is retained here. From the text it appears that an interpretation of septal microstructures was the basis for transferring the corals to a group among the Astrocoeniina. They were transferred from the Caryophylliicae GRAY, 1847, within which the Haimesiastraeidae had been established exclusively for them, as two distinct genera, by VAUGHAN & WELLS, 1943.

The type species is *H. conferta* VAUGHAN (1900 b). The columella of *Haimesiastraea* VAUGHAN (1900 b) is trabecular. It is substyliform in *Peruviastrea* VAUGHAN (1922), the type species of which is *P. peruviana* VAUGHAN, 1922. This solidity was suggested by WELLS (1941 b) to have been caused by secondary changes leading to possible synonymy with *Haimesiastraea*, but in 1956 he accepted *Peruviastrea* as a subgenus, differing from *H.* (*Haimesiastraea*) by its columella features.

Bathymetry is not known exactly for these extinct corals but a shallow-water habitat is indicated by the sediments. They were possibly hermatypic (the two species considered below were mentioned by FLORIS (1967 a, b) as "Two probably hermatypic species").

Subgenus *Haimesiastraea* VAUGHAN, 1900 (b)

Haimesiastraea (*Haimesiastraea*) *groenlandica* sp. n.

Pl. 1, Figs 1 A – 1 B

Holotype. MMH 12,631 (Pl. 1, Figs 1 A – 1 B). From Upper Danian quartz sandstone in Scaphitesnæsen, Turritellakløft, Agatdalen, Nûgssuaq, West Greenland. Two fragments of an incomplete but otherwise rather well preserved skeleton.

Diagnosis. Upper septal margins smooth, slight exsertation, massive coenosteum, the surface of which is plane or slightly depressed between calices and lacks dividing lines (intercorallite ridges); calice diameter about 1.6 mm; distinct granulation of septal plates; corallites not filling up with stereome.

Material. Besides the holotype, a weathered skeleton fragment probably belongs to the species. It displays a tangential typical section through a portion of the corallum but lacks indications of the surface sculpture.

Description of holotype. Corallum incrusts a small ball of fine-grained sandstone which lay on a sea floor consisting generally of coarser quartz sand. Protocorallite not distinguishable. Extratentacular budding produces a small plocoidally massive corallum with monocentric corallites. Corallum-surface between calices is plane or slightly depressed. No dividing lines (intercorallite ridges) between calices.

Distance between centres of calices ranges from 2.5 to 4.0 mm, height of winding subcylindrical corallites can exceed 8 mm, depth of calice about 0.5 mm, diameter of circularly outlined calice about 1.6 mm, diameter of preserved portion of corallum 22 mm and its height approximately 14 mm.

Where the corallum extended laterally, a thin epithecal layer was formed as a basis for either coenosteal formation or new corallites. The wall is an imperforate septotheca.

The corallite has 24 simply radiating septa, of which 12 reach to the axial structure. Apparently, newly formed corallites had the full septal number. Septal plate laminar. Septal construction of few simple and separate trabecules strongly inclined from the wall has been observed in a small part of one septum and was suggested in other septa. An axis of divergence was indicated in some places to be placed within the wall. The septal plate, particularly that of the 12 smaller septa, is conspicuously undulating. Septal sides with some small but distinct granules. A far more prominent sculpture consists of smooth ridges roughly following the directions of the upper septal margins. The ridges are very prominent on the largest septa. The inner septal margin is undulating and smooth; the upper margin is usually also smooth (occasionally and partially with a fine granulation similar to that found on the costae and coenosteal surface). Slight exsertation. No pali or paliform lobes. Columella trabecular, formed of 12 septa, diameter about 0.2 mm, not prominent.

Costae visible only as finely granulated (2 or 3 indistinct rows of granules) elements that over a distance of about 1 mm merge into the similarly granulated surface of the coenosteum. Each corallite has 24 equally developed costae. Smooth cristae ?. No synapticules. Rather few endothecal dissepiments, which are smooth and may or may not be connected with the septal ridges. Dense coenosteum with finely granulated surface. The superficial zone has a comparatively dense texture and a number of such zones can be recognized in the coenosteum. Sometimes it can be observed how new corallites were initiated in them. No internal stereome.

Affinities. *H. petrosa* (Gabb, 1864) was described from Cretaceous (?) or Eocene (?) rock (road-ballast ?), in California, see Vaughan, 1900 b, with synonymy; Nomland, 1916; Vaughan, 1922; Wells, 1933; Vaughan & Popenoe, 1933. The Greenlandic species differs from it at least in having generally smaller calices and in its minutely but distinctly granulated septal sides. The Greenlandic species differs from the following four species at least in its corallite dimensions and/or in the absence of dividing lines (intercorallite ridges) between the calices on its coenosteal surface: *H.* (*H.*) *anchistina* Squires, 1958 a, from New Zealand (Albian/Turonian – Upper Senonian); *H.* (*H.*) *conferta* Vaughan, 1900 b, from Paleocene in Texas and Maryland, from Paleocene-Lower Eocene in Alabama and from Lower Eocene in South Carolina and Louisiana (see Vaughan, 1900 b, 1922; Vaughan & Popenoe, 1933; Wasem & Wilbert, 1943); *H.* (*H.*) *humilis* Vaughan, 1922, and *H.* (*H.*) *peruviana* Vaughan, 1922, both from Peru (Lower and Middle Eocene or, rather, Paleocene-Lower Eocene, see Wells, 1941 b, pp. 3, 4, and Papp, 1959, pp. 349, 351).

The Greenlandic species shows very great similarity to *H.* (*H.*) *distans* Vaughan, 1922, from Peru (Lower-Middle Eocene or, perhaps rather, from Paleocene to Lower (and Middle ?) Eocene; see Wells, 1941 b, and Papp, 1959, pp. 349, 351). A difference is found, however, in that the corallites of the Greenlandic species do not fill up with stereome.

So far it has been thought reasonable to consider the Greenlandic coral as belonging to a new species.

Occurrence
Upper Danian
Agatdalen, Turritellakløft, Scaphitesnæsen, 1954, 1 example.
Displaced block: Ilugigsoq area, 1952, 1 probable example; probably Upper Danian.

Subgenus *Peruviastrea* Vaughan, 1922

Haimesiastraea (*Peruviastrea*) ? sp.

Pl. 1, Fig. 2

Material. Specimen A, collected in 1956, consists of two pieces of the basal portion of an apparently subcylindrical corallum. External sculpture is rather well preserved in places but generally has been destroyed. Specimen B, from the same locality, displays more than 10 corallites in a fragment of a worn, probably subcylindrical corallum. Finally, 5 fragments of very poor imprints of corallum surfaces doubtfully represent the same species.

Description, of Specimen A unless otherwise stated. Protocorallite cannot be certainly recognized among the four (?) equally developed corallites, each with 24 septa, that appear, naturally sectioned, in the damaged lower part of the corallum. This basal part has incrusted a small body of loose sandstone and anchored the erect part of the corallum. Budding is extratentacular, producing a plocoid and slightly curved subcylindrical (branching ?) corallum with monocentric corallites. No distinct dividing lines (intercorallite ridges) are observed between the corallites.

Height of preserved corallum fragment is 2 cm, diameter of incrusting disc about 13.5–17 mm, diameter of subcylindrical part of corallum about 8 mm, diameter of calices, of circular outline, about 1.9 mm (in Specimen B, 1.75 mm), depth of calice about 0.5 mm, diameter of calicular protuberance about 0.5 mm, distance between centres of calices about 3 mm (in Specimen B, 2.5 mm). Original basal plate and any traces of a common basal epitheca are either not or only indistinctly preserved. The incrusting disc of the corallum is mainly composed of massive coenosteum. Each corallite has a thin imperforate septotheca.

Septal number is 24, 12 septa reach to the columellar structure as seen in the calice. Septal plate laminar, with thin median dark line; trabecules probably simple, number and arrangement unknown. One fan system is suggested with its axis of divergence placed within the wall. Septal plate undulating, with sides sparsely and minutely granulated and with very prominent subhorizontal smooth ridges. Inner septal margins undulating and smooth, upper margins smooth, or possibly minutely granulated. Slight exsertation. No paliform lobes or pali were observed. Columella substyliform, in cross-section circular or elliptical, with a diameter of about 0.5 mm, projecting into the calice.

24 subequal costae merge with the coenosteal surface about 1 mm from the calice. Their sculpture, a minute granulation, cannot be studied in detail in the specimen. No synapticules. A few smooth tabular endothecal dissepiments. No intracorallite stereome. Coenosteum compact, ornamentation of surface is a fine granulation but is largely unknown. Intercorallite ridges may sometimes have been formed but at least were not developed between all corallites.

Affinities. The septa may well be typical of *Haimesiastraea* (*Peruviastrea*), but details are not fully known and so the assignment to *Peruviastrea* has to be made with a slight reservation.

The type species, *P. peruviana* VAUGHAN, 1922, was described originally with apparent stereomic filling, but later studies of topotypes (WELLS, 1941 b, p. 16) have shown that this is not always found. Accordingly, the Greenlandic coral appears to be very similar to *P. peruviana* (from Peru, Middle Eocene (see WELLS, 1941 b, pp. 3, 4) or either Paleocene or Lower Eocene (see PAPP, 1959, pp. 349, 351)). However, the generally larger calices in the Greenlandic coral indicate that it was a different form. Unfortunately, the state of preservation of the Greenlandic material does not allow a full study of specific characters.

Occurrence
Upper Danian
Agatdalen, Agatkløft, "Store Profil", Sonja Lens, 1956, 1958, 2 specimens; Nuilaussarssuaq, 1953, 1958, 5 dubious examples.

Suborder **Fungiina** VERRILL, 1865
Superfamily **Fungiicae** DANA, 1848
Family **Fungiidae** DANA, 1848

Genus *Discotrochus* EDWARDS & HAIME, 1848 (a)

Type species *D. orbignyanus* EDWARDS & HAIME, 1848 a. WELLS, 1956 (p. 388), expresses some doubt over the placing of the genus in the Fungiidae (earlier comments on the classification of the genus are found in WELLS, 1940 (p. 376) and in VAUGHAN & WELLS, 1943 (p. 139)). SQUIRES, 1958 a (p. 33) accepted *Discotrochus* as an independent genus among the Fungiidae without comment and this view is adopted here.

The genus probably ranges from the Danian to the Miocene.

Discotrochus ? sp.

Pl. 1, Figs 3 A – 3 B

Material. One fragment of a skeleton displaying the central basal part of the corallum. The rather well-preserved aboral face is the only demonstrated original outer surface.

Description. The preserved skeleton fragment clearly belongs to a free solitary coral. The fragment suggests a patellate corallum but the coral may well have developed into the discoid or cupolate form that is usually found in *Discotrochus*. The basal angle is about 140°. Height of specimen is 2.5 mm, dimensions of fragment of aboral surface are 4.6 mm and 3.7 mm. The fragment indicates a minimum diameter of 5 mm, in a circularly outlined low corallum. Calicular conditions unknown but the calice can reasonably be supposed to have had a circular outline. Aboral face shows evidence of neither an attachment nor of an epitheca. The theca is a non-sculptured and imperforate septotheca. Pits in the intercostal grooves suggest an earlier perforation, however, and thus possibly an early existence of a synapticulotheca. The imperfect specimen displays 42 septa in 6 systems, each of which contains 4 to 10 septa. At a distance of

1.5 mm from corallum centre 24 septa can be counted. The best preserved system corresponds to the septal number of 60 at a distance of 2.5 mm from centre of corallum. A fully grown individual may have had 96 septa. In varying degree septa of the 3rd cycle coalesce with those of the 2nd cycle, and 4th cycle septa with those of the 3rd. The points of union can be thickened. Septa appear laminar. (They may have been perforate along the unknown margins. A few questionable porous parts were unfortunately lost during preparation of the specimen). The traces of a dark median line doubtfully indicate a non-porous septum. Nothing definite is known of the nature of the trabecules or the details of their arrangement. The septal faces have a few coarse granules and, rarely, small irregular ridges. Septal margins and conditions of exsertation are unknown. It is not possible to state whether or not there were pali (or paliform lobes). Columella trabecular, with upper diameter in the fragmented specimen about 1.3 mm. In a complete, fully grown individual the ratio columella-diameter: corallum-diameter must have been considerably less than 0.26. Costae correspond to septa in number and position. The costae are ridges, which appear low and rounded (because of slight wear ?). The smallest of them are simple rows of rather stout granules. Even the large costae may have originated as such rows. Synapticulae are few but mostly strong and are supposedly compound. They display traces of a central dark string. They seem to be arranged in formations more or less completely encircling the columella at different levels. A similar arrangement is met with again in *D. vaughanianus* WELLS, 1945, and in *D. hoelzli* KÜHN, 1965 a. No dissepiments, tabulae or stereome.

Affinities. The coral probably belongs to *Discotrochus*. However, a full identification is prevented by the defective knowledge about some details of the septal structures and by the convexity of the aboral face of the skeleton, which suggests a patellate corallum. The latter feature, however, cannot be considered a serious objection. In the discoid type species the central area of the concave aboral face can be convex (figures in VAUGHAN, 1900 b) and a similar condition seems to exist in certain other species. (In fact, even a broadly attached trochoid *Discotrochus* has recently been reported: *D. vaughanianus* WELLS, 1945).

The Greenlandic Lower Danian specimen was compared with a number of species, which have been referred to *Discotrochus* and which are listed below:

Eocene species: *D. orbignyanus* EDWARDS & HAIME, 1848 a (see also VAUGHAN, 1900 b); *D. californicus* WELLS, 1940; *D. vaughanianus* WELLS, 1945; *D. astericus* SQUIRES, 1958 a; and *D.* sp. (in DURHAM, 1942).—Oligocene species: *D.* (?) *alternans* SOKOLOW, 1894.—Species (see KÜHN, 1965 a, b) of Miocene age: *D. michelottii* EDWARDS & HAIME, 1857; *D. duncani* REUSS, 1871, also in the Oligocene (GRUYTER, 1944); *D. cylindricus* (SISMONDA, 1871); *D. ottnangensis* PROCHAZKA, 1893; *D. hoelzli*

KÜHN, 1965 a; *D. minutus* VASIČEK, 1946; *D. pseudoduncani* VASIČEK, 1946; and *D. pausramensis* OPPENHEIM, 1922.

The Greenlandic fragment probably represents a new species, but the material is too poor for a full description and naming.

Occurrence
Lower Danian
Tunorssuaq, Danienkløft, "Store Profil", lens of basalt tuff, 1957, 1 specimen.

Suborder **Faviina** VAUGHAN & WELLS, 1943

Superfamily **Faviicae** GREGORY, 1900

Family **Rhizangiidae** d'ORBIGNY, 1852

Genus *Astrangia* EDWARDS & HAIME, 1848 (c)

Subgenus *Coenangia* VERRILL, 1869

(Sub-)genotype (genolectotype, VAUGHAN & WELLS, 1943, p. 177) *Coenangia conferta* VERRILL, 1869.

Astrangia (*Coenangia*) ? sp. cf. *A.* (*C.*) *cretacea* (BÖLSCHE, 1870)

Pl. 1, Figs 4–5

1967 a One species with massive skeleton: FLORIS, p. 152.

Synonymy of the American species:

1870 *Astraea cretacea* BÖLSCHE, pp. 216–217.

Pars ?: 1933 *Siderastrea cretacea* (BÖLSCHE) (non *S. c.* SÖHLE, 1897): WELLS, p. 144, probably not the Texas coral (Pl. 12, Fig. 13; Pl. 15, Fig. 26).

Pars ?: 1958 *Astrangia* (*Coenangia*) *cretacea* (BÖLSCHE): WELLS, p. 33, probably not the Texas coral cited (Pl. 3, Fig. 3).

Pars ?: 1958 b *Astrangia* (*Coenangia*) *cretacea* (BÖLSCHE): SQUIRES, pp. 2–3, Figs 1–2, probably not the Texas coral cited.

Material. 52 small corallum fragments, with internal skeleton elements well preserved. Preserved parts of original corallum surface nearly always badly worn. Additional material is one very dubious example, viz. a badly worn skeleton-fragment exposed on the weathered surface of a displaced block.

Description. The protocorallite has not been recognized for certain in the material. Budding extratentacular, corallites monocentric, corallum cerioid with convex surface and (always ?) incrusting base; exclusively incrusting habit is probable. Size unknown but probably small. Height at least 7.5 mm. Corallite number at least 7. Diameter of calice about 3–3.5 mm. Subhorizontal outline of calice polygonal (4–6 sided) or nearly circular. Depth of calice about 1 mm. In the material no indication of an epitheca is found. Wall of corallite is an imperforate septotheca. (In one specimen a basal plate structure common to several individuals is observed covering a mollusc shell). Features of protosepta have not been studied. Septal number in calice is 24. Septa of 1st and 2nd cycle reach the columellar region, septa of 3rd cycle are but about half as long and coalesce with those of the 2nd cycle. Septa laminar, yet with some very rare and irregular perforations. Trabeculae simple (?). Axis of divergence coincides with wall, one fan system per septum. Ornamentation of septa consists of spines or tubercles along trabeculae; sometimes striae or even ridges have been formed. Inner septal margins more or less distinctly spiny in accordance with the arrangement of the trabeculae. Slightly dentate upper septal margins are strongly indicated by the general septal structure but they were not actually observed in the worn material at hand. The material indicates that septa were non-exsert or almost non-exsert. No pali or paliform lobes. Columella trabecular, with upper surface appearing papillary and with diameter reaching 0.8 mm. Usually neither costae nor cristae can have developed. A few costae have been observed in the material, however, in locally developed coenosteum (see later). No synapticulae. Many endothecal thin tabular dissepiments. Often many of these are found at the same level within a corallite, most of them placed near the wall and most of them with the convex face up. Stereome without sculpture sometimes reinforced the walls and columella. Apparently the reinforcement took place at the surface of the corallum and at short intervals of growth. Contemporaneously, septa and coenosteal costae near the walls could also become covered with stereome. In the cerioid corallum a coenosteum is only developed very locally. It has no particular sculpture (?) and consists of exothecal tabular and often vertical dissepiments, of costae, and of smooth stereome sometimes covering dissepiments, costae, and walls. Apparently, new corallites could be founded in such coenosteal meshwork of costae and dissepiments.

Affinities. This material was considered an *Astrangia* (*Coenangia*) by FLORIS (1967 a). It does not seem referable to any other known genus (subgenus) than *Astrangia* (*Coenangia*) and would certainly have been referred to it had the indications of dentate upper septal margins and the probable existence of incrusting growth-form been ascertained. The coral species as known from Greenland is probably identical with *A.* (*C.*) *cretacea* (BÖLSCHE, 1870) until now known from older deposits in the U. S. A.

The original description of that species by BÖLSCHE (1870, pp. 216–217) was of New Jersey material and apparently was based on but a single, unfigured specimen of those observed and (in part ?) collected by CREDNER (CREDNER, 1870, pp. 193, 195, 205). According to the original text, BÖLSCHE's material has larger calices (4–5 mm) than the Greenlandic material. In 1958 (b) SQUIRES described material believed to be topotypic and conspecific with BÖLSCHE's and found a range of calice diameters from 2.7–4.6 mm. So far the Greenlandic material with diameters about 3–3.5 mm may well belong to the same species. (Squires records up to 6 calices per corallum in the diagnosis but contradicts himself with his figured corallum which displays a greater number).

The coral called *Siderastrea cretacea* (Bölsche) (non Söhle, 1897) (see Wells, 1933), from the Maastrichtian Navarro Formation in Texas (Wells, 1933, p. 144, Pl. 12, Fig. 13; Pl. 15, Fig. 26), was said to have the structure typical of *Siderastrea*. This suggests that a large number of synapticules had been observed and synapticules also appear to be figured in Pl. 12. This coral probably is a *Siderastrea* as was first proposed. If rich in synapticules, it cannot be identical with Bölsche's species as was suggested by Wells (1933) who, without material, redetermined Bölsche's New Jersey species to *Siderastrea*. (He was presumably misled by an unfortunate translation (1933, p. 144) of Bölsche's description (1870, p. 217) of the features of the granulation on the septal sides in some of the calices. That description does not concern synapticules so characteristic in *Siderastrea*. Synapticules seem not to have existed at all in Bölsche's specimen; at least they are not mentioned and it is evident that they cannot have been present in the quantity found in a genuine *Siderastrea*). The early, probably mistaken identification was the basis for two citations of the Texas coral as a form conspecific with Bölsche's species from New Jersey (Wells, 1958, and Squires, 1958 b). It would seem that Wells committed a *lapsus calami* when he used his early figure (1933, Pl. 12, Fig. 13) of the Texas coral to illustrate Bölsche's species, which in fact was then placed in *Astrangia* (*Coenangia*).

Occurrence
Upper Danian
Agatdalen: Agatkløft, "Store Profil", Sonja Lens, 47 fragments;
Qaersutjægerdal, "Store Profil", 5 fragments.
Displaced: Ilugigsoq area (1952), 1 dubious example; probably Upper Danian.

The species in Greenland seems to be restricted to the Upper Danian. In the U.S.A., Bölsche's species is known with certainty only from the Upper Cretaceous of New Jersey, and probably not from Texas. It can be supposed that the species in New Jersey is not younger than the Campanian.

Family **Oculinidae** Gray, 1847

Subfamily **Oculininae** Gray, 1847

Genus *Oculina* Lamarck, 1816

The type species is *Oculina virginea* Lamarck, 1816 (non *Madrepora virginea* Linné, 1758; nec Ellis & Solander, 1786) (= *O. diffusa* Lamarck, 1816; subsequent designation by Edwards & Haime, 1850 b).

The following are listed as synonyms in Wells, 1956 (p. 410): (a) *Dentipora* Blainville, 1830; (b) *Trymhelia* Edwards & Haime, 1849 a (*Trymohelia* Edwards & Haime, 1857); (c) *Coelohelia* Vaughan, 1900 b (pp. 125–126).

Oculina becki (Nielsen, 1922)

Pl. 1, Figs 6–17

With the growth of knowledge on Greenlandic fossil corals it was early recognized that this species was represented in strata on both sides of the Recent Atlantic Ocean and not on its eastern side alone. But this observation was not specifically reflected in the literature.

Selected references to literature on the occurrence of the species in northern Europe:

1864 *Oculina:* JOHNSTRUP, pp. 6, 25.
Non (pars ?): 1899 (*Oculina* sp.): HENNIG, pp. 5, 13–15, Pl. 1, Fig. 13.
1919 (nomen nudum) *Amphihelia Bechii; Amphihelia Bechi.* BR. N.: NIELSEN, pp. 28, 34.
1922 *Amfihelia Becki* NIELSEN, pp. 9, 31, Pl. 4, Figs 26–32.
1944 *Amphihelia becki:* ANDERSEN, p. 318, Text-fig. 263.

Remarks on the species in Europe (history, identifications, recent revision):

There is no serious doubt that material of the present species, from Fakse limestone quarry in Denmark (Middle Danian), was considered by JOHNSTRUP, in 1864. It was then observed how the corallites have no internal communication between their endothecal regions but it was not considered to what extent this was due to the way of budding or to internal filling up with stereome.

In 1899 HENNIG, apparently without a full investigation, claimed that what had been called *Oculina* from the Danish and Swedish Danian was but fossil remains of two other specified corals altered in particular ways. He did not report new finds of an *Oculina.*

NIELSEN, in 1919, mentioned the species in this way (here translated from Danish): "*Amphihelia Bechii* (previously identified as an *Oculina* but never described)". Even in 1919 no description, definition or figure of the species was given, and the name proposed for it remained a nomen nudum.

In 1922 the species was finally established by NIELSEN, who described it and for the first time figured some specimens, all of them from Fakse and all new. NIELSEN remarks that the "*Oculina* material" revised by HENNIG in fact does not confirm HENNIG's conception of an incorrectly identified Scandinavian *Oculina* (1899, see above) and really represents a new species. Both the old material and the new were then described. It cannot now be demonstrated why NIELSEN (1919, 1922) changed the generic identification and placed the species in *Amphelia* EDWARDS & HAIME, 1849 a (*Amphihelia* EDWARDS & HAIME, 1857; by NIELSEN spelled *Amphihelia* and *Amfihelia*), which is now considered a synonym to *Madrepora* LINNÉ, 1758 (see VAUGHAN & WELLS, 1943, p. 183). As now understood his material can belong to neither *Madrepora* nor *Amphelia,* inter alia because of its pali. On the contrary, the earlier identification with *Oculina* seems correct.

Recent study of the specimens (and in particular MMH nos. 2105, 2107 and 2111) figured by NIELSEN (1922), and of additional specimens, has now made it possible to choose a lectotype and to diagnose the species, as found in the type locality. (The large amount of material now known from Fakse demonstrates that the varying degree of granulation of the septal sides met with in NIELSEN's figured specimens (but not mentioned by him), grades into less common cases of almost spinose, but small, granules. Branching subplocoid portions of coralla, not described by NIELSEN, have also been found).

The lectotype. The specimen figured by NIELSEN (1922) on Pl. 4, Fig. 26, is chosen here as a lectotype. It is an unworn fragment of a corallum which displays 3 natural cross-sections through 3 corallites, and a portion of one calice. The skeleton is secondarily calcitic and is filled with soft calcareous mud. The specimen does not fully show the branching pattern, the depth of calice, or the appearance of the upper end of columella. In other respects, however, it characterizes the species satisfactorily.

The lectotype is kept in Copenhagen as MMH 2105. It is refigured here, Pl. 1, Fig. 6.

The stratum typicum is Middle Danian coral limestone (*Tylocidaris bruennichi* Zone).

The type locality is Fakse limestone quarry in Sjælland, Denmark.

Diagnosis (based on material from the type locality in Denmark). Corallum is in most cases slenderly dendroid with only a little coenosteum but, on the other hand, may be ramose (branching subplocoid) with conspicuous coenosteum. The alternate budding is either in one plane or with a tendency for calices to be placed sparsely in spirals all around the branches. The coenosteal surface of ramose branches is, like the surface of thinner branches, more or less distinctly granulated, with the granules often arranged in pseudocostae. (The surface of coenosteum may in some cases have been partially smooth ?). Costae, when developed, are narrow and rather inconspicuous. Calice subcircular. Calice diameter varies from 2 to 5 mm, but is most commonly 3 mm. Depth of calice 1–2 mm. Septal number 24. A single irregular palus crown contains 12 pali not forming a solid tube; pali often poorly developed. Columella papillose or subpapillose, not large or prominent. No internal filling with stereome. Dissepiments (endothecal, thin, tabular) are very rare.

Material. The skeleton substance is usually preserved in the Greenlandic material; only in a few cases are external and internal moulds the only indications left. The skeletal matter has become very much softened in some instances. The coral material generally consists of small skeleton fragments representing detached portions of coralla. The fragments usually are but 1 or 2 cm high and display 1–2 budding zones each. Many calices, and what appears to be 3 basal portions of coralla have been found. The material comprises about 1,600 fragments, on most of which the ornamentation is more or less destroyed. (Because of the fracturing and of different degrees of damage caused by dissolution and ordinary slight wear, hardly any of the specimens examined display all of the characters needed for a full description and determination. Nevertheless, this material from the Danian of Nûgssuaq is accepted here as belonging to one species, because all observed essential characters were found to be either constant or varying gradually).

Description (Greenlandic material). Extratentacular and alternate budding at angles generally between 30° and 45° closely below calices of monocentric corallites produced slightly branching, rather openly constructed and slenderly dendroid coralla. New corallites were founded either practically in the dark line zone of the mother corallites or at a greater distance from this zone, in the outer part of the wall. Branching occurred in all planes. Ordinary budding often appears to have been in one plane but there may also be a tendency for calices to be placed sparsely in spirals all around the branches. Thin fragment and thick fragments are often found together in a way suggesting the presence of only one species and the lack of any pronounced sorting. All degrees from thin to thick fragments are represented. The corallite features of the two branch types seem identical (however, the calice diameter may be slightly larger and the corallite height correspondingly a little taller in the thick branch fragments (subplocoid) than in those of the thin). The thick fragments of ramose branches may represent the normal, simply coenosteum-strengthened, comparatively basal regions of older colonies. They may also reflect extraordinary food supply or relatively hard life conditions. (This may apply to the stout specimens from the coarse sandstone in Nuilaussarssuaq but here the situation may have been masked to some degree by sorting). This combination of features agrees well with the characters of the species as now known from the type locality in Denmark.

Nothing is known concerning the "normal" size of the colony which was probably bush-shaped. The tallest fragments measure about 3 cm. Neither has a fully grown colony been met with in Europe, where even bases have not been definitely recognized. Three fragments of coralla from Kangilia demonstrate an apparent basal adherence to foreign objects. One of these fragments (Pl. 1, Fig. 10) displays remains of two corallites, both broken but clearly of the usual slender type and covered with thick coenosteum. The lower part of the supposed protocorallite has achieved in this way a diameter of 5 mm just above the imperfectly preserved basal disc. This fragment may be the base of a not particularly young corallum. The first bud is situated about 5 mm above the common base. Nothing definite is known about the substrate. The next fragment (Pl. 1, Fig. 11) demonstrates 8 or 9 slender corallites of the usual kind, without coenosteum thickening, budded from a broad basal extension which adheres to a *Dendrophyllia*. No protocorallite is distinguishable. This specimen may be supposed to be the basal part of a very young colony. Because no further budding from the crowded corallites is observed the specimen resembles a reptant corallum. The common base measures 10 by 6 mm, and the tallest of the broken corallites is about 2 mm high. The third fragment probably belongs to the present species but its nature as a base fragment is somewhat questionable. It adheres to an indeterminable coral and may be compared to a portion (2 or 3 corallites) of the second fragment described immediately above. A protocorallite cannot be safely demonstrated.

Height of corallite varies considerably and is usually between 5 and 8 mm. The calice, which is subcircular in outline, may be 2 mm in diameter, but is more commonly 3, and may reach about 5 mm. The cavity of the corallite is generally shaped like a curved cone, sometimes a little compressed. At the base the cavity is shaped individually according to the angle of budding from the mother corallite. Diameter of coenosteum-dominated branch is about 7 mm but such branches can coalesce to masses 1 or 2 cm across. Depth of calice is 1–2 mm. The same is observed in the material from the type locality where NIELSEN (1922) reported that "The calyx is not deep.". The basal plate of the protocorallite has not been identified for certain. No epitheca (the coenosteum of the type material was called epitheca by NIELSEN in 1922). Wall is a solid septotheca, on the outside reinforced with, in some cases, very thick coenosteum. The exterior of the wall of the corallite shows small, distinct granules often arranged in undulating rows (pseudocostae).

The septal number is 24. NIELSEN (1922), when establishing the species, gave the septal number as 27, but this must be a printer's error for 24. 27 septa have not been recognized by the present writer in the material from Scandinavia, and all sections found in NIELSEN's figured specimens demonstrate the septal number of 24.

The 12 septa of the 1st and 2nd cycles are almost equally developed. Immediately after budding the new corallite has very few septa but soon obtains the regular number of 12. Also in the newly formed corallite the septa are normal to the wall. Septum is laminar, with median dark line. One fan system and indications of simple trabecules are sometimes seen. Septal sides granulated to a varying degree, in accordance with growth-lines and trabecular directions. The inner margins of the 12 small septa are wavy. The inner margins of the 12 large septa are involved in the formation of the palar and columellar structures. Only in a very few cases were the upper septal margins so well-preserved that it was possible to observe how they are very minutely dentate; usually they appear to be smooth. Exsertation is poorly developed. 12 pali are developed in one irregular crown (composed of two) before the 1st and 2nd cycles of septa. Often pali are but poorly developed. Towards the corallite-axis there are processes, in some cases like paliform lobes, forming the lightly constructed, spongy, narrow, papillose or subpapillose, but not prominent columella. (Concerning the material from the type locality, NIELSEN (1922, p. 31) wrote that in some calices there "appear to be formations at the inner end of the septa which seem to indicate pali.". Placing the species in *Amphelia*, NIELSEN obviously had not fully realized that pali exist. They can be observed, however, in the specimens figured by him). Diameter of columella reaches 0.5 mm. In the lower part of the corallite the columella is often absent or at least apparently so, in the random sections. Costae are usually not observed. When found, on the corallites with thinnest walls, they consist of narrow, granulated and low ridges corresponding to all septa. Cristae are observed very rarely. No synapticulae. Endothecal dissepiments are extremely rare, thin and tabular.

Position of dark line in wall and also simple observations on the corallites demonstrate that there is no internal filling of the corallites with stereome. In the Scandinavian material a filling with stereome is extremely rare and when found is partial and very diminutive. Therefore earlier reports of internal stereomic fillings in the Scandinavian material need some explanation. It is clear that some features have been misidentified as regular fillings or have been mistaken for evidence of such. Thus NIELSEN (1922, p. 9) writes: "*Amfihelia Becki*, which like all Oculinae has a tendency to form compact endothecal fillings immediately under the calyces, yields thin, elongated, slightly crooked stone kernels, resembling single corals.". It appears, however, that young corallites of the species were founded regularly with a narrow lumen and that later thickening of the wall was coenosteal. The position of some traces of the dark median line in the wall also clearly demonstrates that the slender shape of internal moulds cannot be due to an endothecal stereome. The peculiar shape of the lower end of the internal mould is due merely to the particular way of budding with the new corallite springing from the compact wall of the old one. NIELSEN has made the following statement also (1922, p. 31): "A lengthwise cut through the stems shows that close under the calyx very compact endothecal formations are found which make the stems massive like those in other *Oculina* forms.". His Pl. 4, Fig. 28 displays a longitudinal section and it is most probable that he considered this particular figure to illustrate the "compact endothecal formations". The figured specimen has now been revised. It simply displays, in the large individual figured to the right, a hardened and somewhat recrystallized internal sediment-filling and, in that to the left, a transverse structure, which resembles a thick dissepimental floor but which in fact is in part an obliquely sectioned septum and in part a zone of what can easily be compared with other features in the same corallite as being diagenetically recrystallized calcareous sediment.

The dense coenosteum is granulated like the simple corallite wall and often displays pseudocostae. (The coenosteum may, in some cases, possibly be partially smooth). It unites the slender corallites and sometimes is quite extensively developed. Where two branches meet, coenosteal deposits may unite them firmly.

Identification and affinities. The Greenlandic coral appears identical with *Oculina becki* (NIELSEN, 1922), as far as that species is known from the type locality; see the diagnosis given above.

Concerning *Dentipora* BLAINVILLE (1830), no Upper Cretaceous to Oligocene species are known to the writer and it will therefore be omitted from consideration here. The oldest fossil *Trymhelia* appears to be the sole Oligocene representative, the Italian *T. solida* MICHELOTTI, 1861, which differs from the present species by having the usual solid tube made of pali.

The type species of *Coelohelia*, *C. wagneriana* VAUGHAN, 1900 b (pp. 127–128, Pl. 12, Figs 19–19 b), from the Lower Eocene (Greggs Landing) of Alabama, has features rather much in common with the present species. Calices are, according to the original description (concerned with but one specimen), almost exclusively disposed in two opposite rows; differences are found in budding ?, outline of calice (*C. wagneriana* has distinctly elliptical calices), in external sculpture (?), in the features of pali (*C. wagneriana* has one crown of pali, before the 2nd cycle of septa), in the features of columella (*C. w.* lacks columella), and lack of dissepiments (?) in *C. w.* In both species internal stereome is absent. However, in 1943 it was remarked by VAUGHAN & WELLS (p. 182) that recently discovered material apparently conspecific with *C. wagneriana* shows a well-developed columella and, in 1956 (WELLS, p. 410), *Coelohelia* was considered synonymous with *Oculina* which has pali in one irregular crown before the first two septal cycles and extratentacular budding. It seems probable, therefore, that *Oculina becki* and *C. wagneriana* were close relatives. They are different, at least in the outline of calices found on the dendroid corallum fragments. The writer has not been able to find references to or descriptions of any species referred to *Coelohelia* other than the type species, about which also he has seen no additional information.

While the present species thus seems to stand very close to *Coelohelia wagneriana* VAUGHAN, the following *Oculina* species as known from the literature and found in the Upper Cretaceous and the Paleogene, also have been compared with the Greenlandic-Scandinavian species:

O. nordenskjoldi FELIX, 1909, from the Upper Cretaceous of Snow Hill Island (Antarctis), has a (completely ?) slenderly dendroid corallum. It differs through long and broad, low, distinct costae, and also through having 32–48 septa;

O. osiris WANNER, 1902, from the Paleocene (Danian) of Egypt, has a (completely ?) slenderly built dendroid corallum. It differs through possessing a very feeble columella and proportionately coarse costae or pseudocostae on (upper) free parts of corallites (Fig. 8);

O. (?) *smithi* VAUGHAN, 1900 b, from the Paleocene (Midway limestone) of Alabama, is known from very poor material. The coral, as it seems typically, formed flabelliform masses of coalescing branches as is also, but rarely, observed in the present species. By its very few known characters it cannot be safely distinguished from that species. The corals are for the present considered to belong to two, possibly closely related, species;

O. peruviana VAUGHAN, 1922, from the Paleocene or Lower Eocene (but earlier dated as Middle Eocene) of Peru (see WELLS, 1941 b, pp. 3, 4; and PAPP, 1959, pp. 349, 351), so far known only from ramose branches with irregular budding, is similar in many specific characters to the present species but is different in the longitudinal striation of the coenosteal surface;

O. alabamensis VAUGHAN, 1900 b, with (exclusively ?) ramose coralla and apparently with calices rather densely placed on all sides of the branches, differs at least in its distinct, broad costae and in the somewhat different range of calice diameters (diameter range 1.5–2.5 mm, on average very slightly more than 2 mm);

O. olssoni WELLS, 1941 b, has corallum both subdendroid and ramose, and corallites tend to spiral on branches. Distinct differences are found in the septal number of 12, and in the internal filling with stereome;

O. oamaruensis PARK, 1917, (see SQUIRES, 1958 a), has (exclusively ?) ramose branches with calices densely placed all around the branch and also differs in, at least, the septal number of 32–38, and in the stereome-thickened tabular dissepiments;

O. singleyi VAUGHAN, 1900 b, has the corallum (exclusively ?) branching plocoid with corallites of different ages all around the branch and further differs by its prominent costae on free parts of corallites;

O. conferta EDWARDS & HAIME, 1850 b, which is characterized by irregular, subglobose, or lobated coralla with the corallites not arranged in a regular way, seems to be quite different from the present species;

O. incrustans DUNCAN, 1866, at least differs through its large number of septa and its large and prominent columella;

O. wetherelli DUNCAN, 1866, described on poor (dendroid ?) material, at least differs through its septal number of 48;

O. polyphylla ROEMER, 1863, at least differs through subphaceloid corallum and the costal number of 96;

"*Oculina* cf. *parvistella* REUSS n. sp.", in SOKOLOW (1894), is poorly known from one fragment (branching plocoid). This has calices irregularly all around the branches and differs from the present species at least in its calice diameters being 1.5–1.8 mm only. The younger *O. parvistella* REUSS (1871) has a (completely ?) branching plocoid corallum with calices all around the branches and differs from the present species at least through its peculiar anastomozing granulated ridges on the coenosteal surface;

O. harrisi VAUGHAN, 1900 b, known from one plocoid fragment only, has calices averaging 5 mm in diameter and placed in rather regular spirals, and differs also in having commonly 28 septa;

O. aldrichi VAUGHAN, 1900 b, with (totally ?) ramose coralla with calices in rather definite spirals at least differs in having usually 28 septa, and in having internal filling with stereome;

O. mississippiensis (CONRAD, 1847), (and *O. americana* EDWARDS & HAIME, 1850 a; see VAUGHAN, 1900 b), has (completely ?) ramose (branching plocoid and subplocoid) corallum with calices in dense spirals. It also differs in its specific character of a peculiar sculpture of the coenosteal surface.

Usually it has not proved easy, or even possible, to determine the degree of affinity between the present species and other *Oculina* species. This is mainly due to poor information on the species. Many have been established on incomplete coralla, and in some cases the descriptions do not give information on details like, e. g., presence or absence of stereome-filling of the corallites. Another difficulty arises from the general ignorance on the morphological reaction of the corals to different environments, even those environments which might be reflected in the sediments.

Among the species listed here, *Oculina becki* may have its closest relatives in *O. osiris*, and *Coelohelia wagneriana*. Rather close relationship may exist with *O. nordenskjoldi* and possibly with *O.* (?) *smithi* and *O. peruviana*.

Occurrence in Greenland

Lower Danian

Danienrygge at Kangilia:

Conglomerate immediately above Tuff I, Ryg B, 4 fragments, more or less worn (one appears certain);

Basalt tuff: Tuff I or Tuff II, 93 fragments, most of them with worn surface;

Tuff II: Ryg A, about 950 fragments, most of them with worn surface;
Ryg B, about 100 fragments, most of them with worn surface;
Ryg A + B, 52 fragments, most of them with worn surface;
Ryg C, 266 fragments, most of them with worn surface;
Danienrygge, 31 fragments, most of them with worn surface;

Tunorssuaq, Danienkløft, "Store Profil", 11 fragments, most of them with worn surface.

Upper Danian

Agatdalen: Qaersutjægerdal, "Store Profil", 1 fragment;
Agatkløft, "Store Profil", Sonja Lens, about 50 fragments, most of them with worn surface;
Turritellakløft, "Store Profil":
a) Turritellakløft Member, two lowermost sandstone beds, 1953, 3 probable examples;
b) Andreas Member, about 15 fragments probably and possibly of this species;
c) Abraham Member: Tuff beds, 50 fragments, most of them with worn surface;
Tuff beds in the upper part, 20 fragments, most of them with worn surface;
Tuff in the upper part (fallen material), 170 fragments, most of them with worn surface;
Tuff in the upper part below pillow lava, 10 fragments, most of them with worn surface;

Kangersôq, gorge descending from the 1,430 m mountain to the north, 2 (?) dubious examples;

Nuilaussarssuaq, about 100 fragments, of which the majority are represented by rough imprints only, while a few have left good imprints, and a few more display their skeleton substance, albeit weathered.

Displaced (probably Upper Danian)

Ilugigsoq, blocks of quartz sandstone: + 600 m (1952), 1 probable example;
Koralkløft, 1957, 1 dubious example;

Agatdalen, Agatkløft, conglomeratic quartz sandstone, 1 possible example.

Occurrence outside Greenland

Denmark: Danian, Zone of *Tylocidaris abildgaardi*, and Zone of *T. bruennichi* (i. e. in Lower and Middle Danian);
? Heersian;

Sweden: Danian, Zone of *Tylocidaris rosenkrantzi*, and Zone of *T. bruennichi* (i. e. in Lower and Middle Danian);
? Heersian.

Suborder **Caryophylliina** VAUGHAN & WELLS, 1943

Superfamily **Caryophylliicae** GRAY, 1847

Family **Caryophylliidae** GRAY, 1847

Subfamily **Caryophylliinae** GRAY, 1847

Genus *Caryophyllia* LAMARCK, 1801

The type species is *Madrepora cyathus* ELLIS & SOLANDER, 1786 (genolectotype, BRODERIP, 1828).

Eight genera are listed by WELLS (1956, p. 422) as synonyms. They will be commented on briefly in the following on account of the question of affinities or identity between possible representatives reported from the Senonian to Eocene and the Greenlandic *Caryophyllia* species of Maastrichtian (?) and Danian age: (1) *Anthophyllea* LINK, 1807. The writer is unaware of any Senonian-Eocene species referred to this genus. (2) *Anthophyllum* SCHWEIGGER, 1819. Only a few Senonian-Eocene species have been referred (and not by SCHWEIGGER) to *Anthophyllum*. They were later each transferred to some other genus than *Caryophyllia* (see FELIX, 1914; 1925). (3) *Cyathina* EHRENBERG, 1834. Some Senonian species were accepted at an early date as *Caryophyllia* (see FELIX, 1914) and are considered below. The one Eocene species referred (not by EHRENBERG) to *Cyathina* was later transferred to another genus than *Caryophyllia* (see FELIX, 1925). (4) *Amblocyathus* d'ORBIGNY, 1849. Apparently no Senonian-Eocene species has been referred to *Amblocyathus*. (5) *Paterocyathus* DUCHASSAING & MICHELOTTI, 1861. Likewise, no Senonian-Eocene species has been referred to *Paterocyathus*. (6) *Ceratocyathus* SEGUENZA, 1863. Two Eocene species, which have been referred by some authors (not by SEGUENZA) to *Ceratocyathus*, belong to other genera than *Caryophyllia* (see FELIX, 1925). (7) *Blastocyathus* REUSS, 1864, does not appear to have been reported from the Senonian-Eocene. (8) *Goniocyathus* YABE & EGUCHI, 1932 a, has, as far as is known, not been reported from the Senonian-Eocene (YABE & EGUCHI, 1932 a, b).

The similar genera, *Acanthocyathus* EDWARDS & HAIME, 1848 a, with large costal spines, and *Premocyathus* YABE & EGUCHI, 1942, with end costa of convex side of compressed corallum expanded, both may be interpreted as subgenera of *Caryophyllia* (see WELLS, 1956, p. 422). They have not been met with in the Greenlandic deposits.

Caryophyllia andreasi sp. n.

Pl. 2, Figs 1 A – 5

Derivation of the name. The species is named after the Greenlandic fisherman and reliable fossil-collector, Andreas Tobiassen, in Niaqornat.

Holotype. MMH 12,647 (Pl. 2, Figs 1 A – 1 B), from Lower Danian deposits, the basaltic Tuff II, Ryg A, Danienrygge at Kangilia, Nûgssuaq, West Greenland. The type specimen is a skeleton, with the outer surface somewhat damaged by dissolution and wear. It demonstrates a portion of the calicular margin, the bottom of the calice, and a fracture that probably is not far above the base. 72 septa are observed in calice. Sculpture of costae not well-preserved; for the most, only the surfaces of some older growth stages are visible. Actual height of type specimen is 14.5 mm, and the calice measures approximately 17 by 15.3 mm.

Diagnosis. Corallum subcylindrical-slenderly turbinate, cross-section circular or slightly oval, axis straight or slightly curved with curvature usually in plane of shorter diameter of a calice with oval outline, fixed (and possibly free ?), maximum height about 25 mm. Extremely compressed coralla with diameter-ratio 1.21; septal number (40–)44–72, most typically 48 (or 56, 58, 64, 66, and 68); 4 cycles; exsertation distinct, generally slight, in coralla about 8 mm broad not reaching 1.0 mm; 11 (possibly 10)–16 or 17 (possibly even 18) pali. Columella not heavy; costae subequal, flat or gently convex broad bands, for all septa, visible also in lower half of corallum, with densely but randomly placed granules standing three or four across and sometimes forming subhorizontal delicate ridges; intercostal bands, if present, very narrow and not smooth, but usually lacking; no dissepiments; outer stereome showing the costal pattern thinly coats wall; complete or partial internal basal stereomic filling rare, may be found in large coralla.

Material. The material comprises 350 individuals. 158 seem well-determined. 129 are either undoubtedly *Caryophyllia*, mainly topotypic, with faint costulation, the finer details of which have been destroyed, or they are probably *Caryophyllia*, mainly topotypic, with costulation like that of the species; these are all considered as probably belonging to the species. Finally, 63 specimens are dubiously determined, for instance because of crushing or weathering. Some bases and calices are preserved, and the majority of skeletons at hand are fairly complete and apparently were not much worn before embedding. But slight wear, dissolution processes within the sediment, and weathering have to a large extent destroyed the outer sculpture.

Description. Coralla range from subcylindrical to slenderly turbinate, have circular or slightly oval (very rarely faintly polygonal) cross-section, are straight or, particularly below, slightly curved, mostly with curvature in plane of shorter axis of an ovally outlined calice. Attachment is by broad basal disc, which may reach a diameter of 8 mm. The different growth-rates within any individual have been practically constant. In cases of most extreme compression the diameter-ratio is 1.21 (this seems confirmed for all uncrushed specimens examined). It was rarely possible to measure the height of complete coralla, e. g.: 11 mm, 13 mm, *c.* 11 mm. The tallest fragment measured was 22 mm. Taking account of all the material, the average height of a complete corallum would have been about 15 mm, and the maximum about 25 mm. Diameters of 12 calice margins (list below) ranges from 7.7 mm by 7.0 mm to 13.0 mm by 11.0 mm and in many cases are 8–11 mm. Larger calices obviously have been present, measuring for instance about 19 mm by 18 mm. 12 true diameter-ratios at calice margins range from 1.01 to 1.18, with a slight maximum at 1.11–1.13. 14 diameter-ratios from reconstructed calice margins (see list below) range from 1.00 to 1.18; the only values with more than one specimen are 1.06 (3), 1.11 (2), and 1.13 (2). Depth of calice not great, about 2 or 3 mm.

Basal plate is thin and with concentric lines. No epitheca. Wall is a compact septotheca rising from a prototheca of the monocyclic corallum as in the examples of *Caryophyllia* analyzed by DURHAM (1949). Outer side of wall reinforced with stereome, particularly below where the basal disc is formed. In many cases thin layers of this stereome have been partially detached, in certain examples evidently before embedding. This outer wall stereome throughout and apparently in full corallum height presents the pattern described later as costal-intercostal. Calicular margin is in one plane or, very rarely, undulates in accordance with differences in size of septa.

Septa arranged in 4 cycles. 29 more or less complete calices, all from Tuff II of Danienrygge at Kangilia, were investigated for septal numbers. These are listed below. The list also informs on corallum-shape, diameters of calicular margin (in brackets if estimated from reconstructed margin), and estimated height (h). All measurements are in millimetres.

44 septa, 1 specimen: Trochoid: 9 by 8 (h 13);

48 septa, 7 specimens: Subcylindrical: 8.4 by 7.4 (h 18); ceratoid: 7.7 by 7.0 (h 10), 8.0 by 7.9 (h 14 ?), 8.2 by 7.9 (h 14), (9.2 by 8.3) (h 14); trochoid: 9.0 by 8.2 (h 14), 9.3 by 8.4 (h 15);

52 septa, 2 specimens: Trochoid: ? by ? (h 12), (9.3 by 9.2) (h 15);

56 septa, 2 specimens: Subcylindrical: (11.5 by 9.9) (h 22); trochoid: ? by ? (h 15);

58 septa, 3 specimens: Ceratoid: (10.0 by 9.0) (h 15 ?), 11.0 by 10.5 (h 12); trochoid: (10.0 by 10.0) (h 15);

60 septa, 2 specimens: Trochoid: (10.2) by 10.0 (h 12), 11.2 by 10.1 (h 15);

64 septa, 4 specimens: Ceratoid: (8.0 by 7.0) (h 15); trochoid: (10.5) by 10.2 (h 14), 11.0 by 10.3 (h 17), 13.0 by 11.0 (h 15);

66 septa, 3 specimens: Ceratoid: (8.3 by 7.0) (h 15); turbinate: 9.0 by 7.9 (h 10), ? by ? (h 13);

68 septa, 3 specimens: Trochoid: (15.0 by 14.2) (h 20), (17.0 by 15.0) (h 20); turbinate: (16.8 by 15.8) (h 20);

70 septa, 1 specimen: Turbinate: (18.6 by 17.6) (h 17);

72 septa, 1 specimen: Trochoid: (18.0 by 16.0) (h 19).

The septal number ranges from 44 to 72. The most common value is 48. The values of 56, 58, 64, 66, and 68 also appear to be common. Numbers certainly higher than 72 have not been found in the whole material examined. Rarely, only 40 septa seem to be represented. Among the listed coralla, subcylindrical coralla display the number range of 48–56; the ceratoid, 48–66; the trochoid, 44–72; and the turbinate, 66–70. In the limited material especially investigated, the value of 48 was found in combination with diameters about 8–9 mm, the value of 56 with diameters of about 11 (?) mm, the value of 58 with diameters of about 10 (?)–11 mm, the value of 64 with diameters of about 8 (?)–13 mm, the value of 66 with diameters of about 8 (?)–9 mm, and the value of 68 with diameters of about 15 (?)–17 (?) mm. A calice 9 mm wide may show 44–66 septa, apparently independent of compression.

About 1 mm above the base, 6 protosepta, 6 2nd cycle septa, and 12 3rd-cycle septa are observed. Septum laminar, simple trabecules indicated, axis of divergence placed in the wall or close to its inner side. Septal sides with granulations arranged in accordance with growth-lines and trabecules. The granulations usually are small, pointed or, more commonly, rounded; similar granulations on the pali are bigger and often confluent sub-horizontally. Inner margin of septa undulating, upper margin appearing smooth. Exsertation distinct, generally slight; in coralla about 8 mm broad it has not reached 1.0 mm (this was ascertained through study of the whole material). Pali in one crown, 11 (or possibly 10) –16 or 17 (in some cases probably 18), before last-but-one septum cycle. No paliform lobes. Spongy columella composed of thin elements, its diameter varies from 1.5–4 mm.

Costae are found for all septa, subequal, flat or gently convex broad bands, more or less distinct also in lower half of corallum. They display densely but randomly placed granules standing up to 3–4 across the individual costa and sometimes confluent to form delicate sub-horizontal ridges. The very inconspicuous intercostal features range from the presence of very narrow bands to the presence of very faint and very shallow furrows, which in most cases become obliterated. The bands are not smooth. When widest, they are filled with more or less distinct small granules irregularly arranged in one row. Cristae are rarely observed. No synapticules, dissepiments, or tabulae. Outer stereome reinforces the wall in its full height but especially below. The costal-intercostal features just described are exposed throughout and apparently in the full height of the corallum. In the interior of corallum, complete or partial basal stereomic fillings are seen rarely; they have been found in a few large individuals.

Affinity. The specimens determined with certainty from the Tuff II exposures of the Danienrygge at Kangilia represent a close approach to a population unit. They demonstrate a species with a wide range of variation in shape, in septum number and palus number.

The polymorphous species differs from *C.* sp. A of this paper in its shape, from *C. agatdalensis* sp. n. at least in its dense granulation of costae, and from *C.* sp. B of this paper in its costae, which are not rib-formed.

The species appears to be new. It has been compared to the following *Caryophyllia* species as known from the literature and found in deposits from the Senonian-Eocene:

(It should be noticed, however, that information has not been available concerning the following semi-contemporaneous species: *C. affixa* Morren, 1828, from the Tertiary (see Vincent, 1921, p. 133; Felix, 1914, mentioned it as Cretaceous) of Belgium; *C. dachiardii* Angelis, 1903, Eocene in Argentina (see Felix, 1925); and also *C. capulus* Risso (1826) and *C. rugulosa* Risso (1826), both from the Eocene (?) of Southern France (see Felix, 1925). Kühn, 1960, p. 163, mentions a Danian "*Caryophyllia* nov. spec." from Austria without giving details. Too little is still known about the Senonian *C. debeyana* (Edwards & Haime, 1850 b), (see Felix, 1914), from Germany, for a comparison to be made; the same is true of the Upper Cretaceous *C. mississippiensis* Wells (1933), from the U.S.A., and both have had to be omitted from consideration).

C. decemplex Fromentel, 1862, differs in having costae as distinct ribs;

C. laevigata (Edwards & Haime, 1848 a), (see Felix, 1914), has the costae confined to the upper third of corallum;

C. lonsdalei Duncan, 1869, has subequal costae as flat ribs but these are nevertheless ribs and further they have a smooth appearance in Duncan's figures;

C. tennanti Duncan, 1869, differs in having smooth costae (such as are shown in Duncan's special figure);

Caryophyllia sp. (in Squires, 1962), of Piripauan age seems to be a comparatively small species, with a slightly cornute corallum and perhaps costated with single rows of strong granulations. Another *Caryophyllia* sp., probably of Haumurian age, is apparently but 4.5 mm high, has cornute corallum with remarkable costae as single rows of strong granulations, and may be conspecific with that just mentioned (see Squires, 1962);

"*C. bredae* (Edwards & Haime, 1850 b)", (synonymy in Felix, 1914), has but 48 septa and 6 pali;

"*C. cylindrica* (Edwards & Haime, 1850 b)", (synonymy in Felix, 1914), has but 48 septa and 6 pali;

C. compressa Duncan, 1880, differs in having small, compressed coralla, slightly bent in plane of minor axis of calice (diameter-ratio 1.4) and strong, rather coarsely granulated costae;

C. arcotensis (Forbes, 1846), (see Felix, 1914), differs from the present species in its costae which are distinct, narrow ribs;

C. feddeni Duncan, 1880, differs in having rib-like costae separated by broad bands, and in possessing an extremely feeble columella;

C. indica Duncan, 1880, differs in its strong, coarsely granulated costae and broad intercostal bands;

C. stephensoni Wells, 1933, differs in having a rather dominating columella, and acute costae separated by broad smooth intercostal bands;

"*C. konincki* (Edwards & Haime, 1848 a)", (see also Edwards & Haime, 1850 b; Felix, 1914), differs in having only 6 pali;

C. danica Nielsen, 1922, from the Paleocene (Middle Danian) of Denmark, somewhat resembles some specimens of the present species e. g. in its sub-conical shape and in the features of costulation. Nielsen stated that "single specimens ... are found." In his text he states the calice diameters of 10 by 8 mm (making a ratio of 1.25). According to his plate, calice diameters could also be about 6.8 by about 5.5 mm (with the ratio of 1.24). Only one specimen is now recognized that was certainly accepted as a *C. danica* by Nielsen at the time of establishment of the species. It was labelled by him for figuring. It has been registered (MMH 2080) as the original to his plate and this also is probably correct. However, the calice diameters of this slender and slightly curved corallum are different from those mentioned above, being 7.9 by

6.6 mm (giving a ratio of 1.2). The specimen has 48 septa and 12 pali, and its costae are practically identical with those found in the present Greenlandic species (there are no intercostal bands). But it differs from that in having the exsertation pronounced (1.0 mm), and in so far as Nielsen observed a specimen with calice diameters of 10 mm and 8 mm, *C. danica* had to some extent a more oval outline to the calice than is known for the Greenlandic species (ratios 1.2–1.25). *C. danica* and *C. andreasi* are here considered distinct but probably closely related species;

C. jasmundi Wanner, 1902, differs in that the 48 narrow costae are distinctly separated (Figs 2, 3);

Paleocene (Danian (?) and younger) *C. calcitrapa* (Koenen, 1885). The range and distribution of this species appears to be as follows: Danian (?) (Occurrence in the Danian of Russia is doubtful. The Danish occurrence mentioned by Nielsen (1922, 1926) depends on finds of virtually undeterminable specimens probably not belonging to this species (see Rosenkrantz, 1964 b, p. 523). A Danish occurrence is cited by Różkowska (1955) from Rosenkrantz (1920), but unfortunately she misunderstood his text on Paleocene (i. e. Heersian) specimens; Heersian, in Denmark and Russia; "Montian" in Poland (see Różkowska, 1955, and also discussion on the age-determination in Rosenkrantz, 1964 b). The species distinctly differs from the present Greenlandic species at least in its coralla, which are compressed and strongly curved in the plane of the longer axis of the calice. Since the longest costa is very prominent, winglike, and somewhat crenulate, the species in fact must be referred to the (sub)genus *Premocyathus*. For details of Koenen's species in Russia, see Arkhangelsky, 1904, and Ravn, 1903 (p. 93; referring to Pavlow, 1897);

C. kongieli Różkowska, 1955, differs in costae displaying single rows of granulations, and there is a sporadic occurrence of dissepiments;

C. crassicosta (Keferstein, 1859), (see Felix, 1925; Gruyter, 1944), differs from the Greenlandic species in that the slightly curved subconical compressed coralla, with internal filling up with basal stereome, have comparatively broad intercostal areas;

C. mediavia Vaughan & Popenoe, 1933, differs in that the costae are acute and coarsely granulated above;

C. dumblei Vaughan & Popenoe, 1933, differs in possessing conspicuous intercostal bands and pronouncedly rib-formed costae;

C. constricta Vaughan & Popenoe, 1933, differs through a peculiar fenestrate surface of the almost straight conical coralla and in having costae thin, ragged and widely spaced;

C. ? capayensis Bentson, 1943, has a more oval calice than has the present species;

C. texana Vaughan, 1900 b, is distinguished by its granulated costae being of two sizes, both types being rather acute;

C. mcglameryae Squires, 1957, differs in possessing a low bowl-shaped corallum;

C. clavus zelandiae Squires, 1958 a, differs through the development of a corallum distinctly facetted by the prominence of certain costae;

C. dalli Vaughan, 1900 b, differs through the presence of very prominent, acute costae;

C. brabantica Vincent, 1921, from the Eocene of Belgium, resembles the present species to some degree by its straight sub-conical corallum. Its costulation is very similar in some cases to that of the Greenlandic species, but costae in upper part of corallum are comparatively prominent. Furthermore, it would appear that the corallum is invariably more oval in cross-section than in the present species (diameter-ratios calculated from Vincent, 1921, are 1.25 and 1.38);

C. colei WELLS, 1945, differs from the present species in having distinct, rounded or sub-acute costal ribs and in the septal number, usually 53 (but ranging from 38 to 68).

These comparisons seem to indicate a close affinity with *C. danica*, and perhaps with *C. brabantica*. These two species unfortunately are not so well known as one would wish. The possibility for incorporation of *C.* sp. A of this paper in the present species is discussed under *C.* sp. A.

It appears that the corallum-shape generally is not of great use for the differentiation of *Caryophyllia* species. The development and ornamentation of costae so far have proved more useful characters; the features of costulation of *C. andreasi* sp. n. usually show small but, as far as is known, constant differences from those of the other species, of which the costulation is known. Septal number, on the other hand, is widely variable in the present species and the most common values observed are not uncommonly met with in other *Caryophyllia* species.

Results from studies of larger and possibly widely variable collections of fossil, and also living, *Caryophyllia* can be expected to give further evidence for affinities between species such as those quoted above. SQUIRES (1958 a, p. 42) has also stressed the general need for broad variation-studies on members of this genus.

Occurrence

Lower Danian

Danienrygge at Kangilia:
- Basalt tuff: Tuff I, Ryg C, 1 dubious example;
- Conglomerate immediately above Tuff I, Ryg B, 4 specimens, of which two are dubious;
- Basalt tuff: Tuff I or Tuff II, 12 specimens, of which 2 are probable and 3 are dubious;
  - Tuff II: Ryg A, 201 specimens, of which 78 are very probable while 26 are dubious;
    - Ryg B, 68 specimens, of which 31 are very probable while 9 are dubious;
    - Ryg A + B, 7 specimens;
    - Ryg C, 4 specimens, of which 2 are very probable;
    - Danienrygge, 12 specimens, of which 6 are very probable while 3 are dubious;

Tunorssuaq, Danienkløft, "Store Profil", 1 very probable example;

Ilugigsoq, southern slope of Koralravine, 12 specimens, of which 4 are probable and 5 are dubious.

Upper Danian

Agatdalen: Agatkløft, "Store Profil", Sonja Lens, 1 dubious example;
- Turritellakløft, "Store Profil", Abraham Member:
  - Tuff beds, 2 certain and 1 very probable examples;
  - Tuff beds in the upper part, 3 probable examples, and 1 dubious;
  - Tuff in the upper part (fallen material), 6 certain, 1 probable, and 9 dubious examples.

Displaced

Ilugigsoq, Koralkløft, basalt tuff, 1953, 1 certain example (age very probably is Lower Danian);

Ilugigsoq, quartz sandstone, + 600 m, 1952, 3 possible examples (bases) (probably Upper Danian).

Caryophyllia sp. A

Pl. 2, Figs 6–7 B

Material. 52 skeletons and 1 mould belonging to small coralla, all lacking base and only a few with a rather poorly preserved calicular margin. Outer sculpture is rarely well preserved, but is usually more or less destroyed by pre-embedding wear and later damage. 24 specimens seem well-determined. 24 further examples, of which the sculpture or some other diagnostic feature could not be well studied, are considered as probable representatives. 5 specimens are doubtfully determined because both sculpture and palus-conditions could not be studied.

Description. Corallum subcylindrical and curved about 90° in nearly one plane. Cross-section circular or slightly oval compression in plane of curvature. It is not known whether the corals were fixed or free. Sudden widenings of consistently subcylindrical corallum are observed in many coralla.

Estimated heights usually are about 1 cm but sometimes reach 2 cm. Diameters of the calice, which has a circular or slightly oval outline, are about 4–5 (but up to 7) mm. Ratio of diameters generally appears to be 1.0–1.13, and when it reaches as much as 1.4 or 1.5 in specimens from the Upper Danian basalt tuff, these high values evidently are due to crushing of the skeletons. Depth of calice is probably always less than 1 mm.

Basal plate and protosepta could not be studied. Epitheca has not been observed, it may have existed in lowermost portion of corallum. The wall is an imperforate septotheca.

Septal number varies considerably. Counts in definitely determined coralla resulted as follows (figures in brackets refer to septa not observed in calicular regions but slightly below them):

24 septa, 4 specimens;	(24 septa, 5 specimens);
26 septa, 1 specimen;	
28 septa, 1 specimen;	(28 septa, 5 specimens);
32 septa, 2 specimens;	(32 septa, 2 specimens);
	(36 septa, 2 specimens).

It appears that range of the septal number is from 24 to about 36. Septa generally are arranged in 3 distinct cycles with one crown of pali before 2nd cycle. Septum laminar, with dark line and indications of simple trabecules in one fan system, axis of divergence placed within the wall. Septal sides with a few small granules. Inner margins are undulating, particularly in septa reaching to the columella. Upper margins are deduced from other septal structures to have been smooth or at least nearly so. Exsertation slight. Pali distinct in calice, 6–8 or 9 in number, with rather big granules; no paliform lobes. Spongy columella feeble and appearing in calice with 2–3 tubercles.

Costae are found for all septa. They are subequal, flat or slightly convex bands, distinguishable also near the base. Costae display densely but randomly distributed granules standing 2–3 across the individual costa. In some examples the median zone of costae for some distance is like a faint rib, with 1–2 granules across it. An equivalent to this sporadical feature has not been observed in *C. andreasi* sp. n. No one costa on the convex side of the curved corallum differs morphologically from another. Intercostal features range from the presence of narrow bands to the presence of faint shallow furrows, which may be obliterated. The bands are not smooth. When broadest, they display more or less distinct, small granules. These are sometimes confluent to form a faint, uneven mound or they may be irregularly arranged in one row.

No synapticules, nor dissepiments, nor tabulae seem to have existed. No internal filling with stereome. Faint outer stereome apparently was found as a coating of wall in a few coralla, as far as is known retaining the costal sculpture. Stereome may possibly have normally formed a basal disc.

Affinities. By their shape these numerous tiny coralla can be distinguished from *Caryophyllia agatdalensis* sp. n. and from *C.* sp. B (of this paper), and also from the protean *C. andreasi* sp. n. Thus, no coralla in the collections demonstrate shapes (viz. 90° curvature in ceratoid coralla; *c.* 45° curvature in either subcylindrical or ceratoid coralla) that are intermediate between the shape of the present coral and the shape range of *C. andreasi.* It therefore seems justified to consider the present coral as a species distinct from the other Greenlandic species. Further, through its shape and the limited development of its longest costa, the coral is different from all of the Senonian-Eocene species, the details of which are listed under the discussion of *C. andreasi.* On this account it would be reasonable to treat the present coral as a new species.

However, another possibility exists. The present coral has a sculpture strongly reminiscent of and an occurrence almost identical with those of *C. andreasi* sp. n. It is therefore not impossible that it represents the narrowest specimens of subcylindrical *C. andreasi* which were regularly and completely overturned (with the likely provision that such specimens were able to prolong their calices almost regularly in the plane of curvature). In this respect it is worth noticing that straight, narrow (badly attached), subcylindrical coralla have not been recognized in the whole collection treated as *C. andreasi*.

Until this question of possible identity with *C. andreasi* has been finally solved, it is not fully advisable to name the present coral as a new species.

The corallum shape of the present coral may suggest some affinity with *C. calcitrapa* (Koenen, 1885) from the European Danian (?) and younger Paleocene, but in that species the longest costa is prominent and particularly sculptured. Furthermore, its corallum is more strongly compressed.

Occurrence

Lower Danian

Danienrygge at Kangilia:

Basalt tuff: Tuff I, Ryg C, 5 specimens, of which 1 is probable;
Conglomerate immediately above Tuff I, Ryg B, 5 specimens, of which 1 is probable;
Basalt tuff: Tuff I or Tuff II, 2 specimens;
Tuff II: Ryg A, 26 specimens, of which 15 are probable and 3 are dubious;
Ryg B, 6 specimens, of which 3 are probable and 1 is dubious;
Ryg A + B, 1 specimen;
Ryg C, 1 probable example;
Danienrygge, 1 probable example.

Upper Danian

Agatdalen, Turritellakløft, "Store Profil":

a) Turritellakløft Member, Lowermost sandstone bed, 1968, 1 specimen;
b) Abraham Member, Tuff beds, 1 specimen;
Tuff in the upper part (fallen material), 3 specimens, of which 2 are probable.

Displaced: Kangersôq, in western part of the double gorge just to the east of the gorge descending from the 1,430 m mountain to the north, 1 dubious mould; age is probably Upper Danian.

Caryophyllia agatdalensis sp. n.

Pl. 2, Figs 8 A – 9

Holotype. MMH 12,654 (Pl. 2, Figs 8 A – 8 B), from matrix of Lower Danian basal conglomerate, Oyster-ammonite localities I and II, Agatdalen, Nûgssuaq, West Greenland. The type specimen consists of one outer imprint and of several skeleton fragments and displays basal features and clear indications of calicular features. A portion of the internal mud-filling and skeleton has been lost, revealing some skeleton elements of the interior. The skeleton has not been worn but is weathered in part. Height about 13 mm, and calice-diameter about 10 mm.

Diagnosis. Trochoid corallum, broadly attached, with gently curved axis and with subcircular outline of the rather deep calice, height 12–

16.5 mm, diameter 9–11 mm; no epitheca, 48 septa in 4 cycles seem to be the norm but some additional septa of 5th cycle may be found; exsertation very distinct but slight; palus crown with presumably 12 pali; costae, which are not confined to the upper third of corallum, tend to develop for all septa and are subequal, broad and very slightly convex or even flat bands with a few rather widely spaced and rather small granules; intercostal bands hardly distinguishable, finely uneven and narrow, sometimes with single row of granules; cristae sometimes present; no dissepiments; outer stereome below forms basal disc; internal stereome is lacking or is negligible; no filling up of corallum.

Material. Five almost complete skeletons and portions of the wall of a sixth, all skeletons originally embedded complete and unworn (found in 1964). Three coralla, among them the type specimen, are still attached to their substrate, viz. pebbles of up to 10 mm (gneiss and quartzite). 6 calices and 6 bases, more or less complete, are present.—One additional specimen is provisionally referred to the same species. This specimen, which is evidently a *Caryophyllia*, consists of 4 fragments together showing an imperfect upper half, or 8 mm, of a corallum, with a poorly preserved outer sculpture.

Description (1964 material). Corallum broadly attached, trochoid, axis gently curved, with calice of subcircular outline. Height 12 mm (in 3 specimens) to 16.5 mm (the type specimen measures about 13 mm); diameter of calice 9–11 mm (in the type specimen about 10 mm); diameter of corallum just above basal disc is 2–3.5 mm; diameter of basal disc is 2.5–5 mm. Depth of calice not well known but apparently ranged between 3 and 6 mm.

No epitheca. Wall is a thin compact septotheca with a dark median line. It is normally not, but sometimes to a very slight degree, reinforced with inner stereome in its lowermost part. On the outside a stereome cover is found in the lowermost part where it expands to form the basal disc.

Septal number seems to be normally 48, with 4 cycles developed, but some additional septa of a 5th cycle may be found, as in the type specimen. At a level $2^1/_2$ mm above the substratum 12 septa are found in the type specimen; two of the septa, however, are very small. At the same level a spongy columella is formed by some septa from each of the 2 cycles concerned.

Septum laminar, simple trabecules indicated, axis of divergence is placed at or within the wall. Septal sides are faintly granulated with granulations arranged in accordance with the growth segments and trabecules and often drawn out a little in directions of the trabecules. Inner margins undulating, upper margins even and smooth (in type specimen they are deduced to have been so from other skeletal evidence).

Exsertation is slight but very distinct, as it must also have been in the type specimen as can safely be deduced from the exposed parts. One crown of pali, with palus number presumably 12, before 3rd cycle of septa, with granulations fewer than on septa but comparatively large. No paliform lobes. Spongy columella not very strong, and loosely constructed.

Costae are not confined to the upper third of corallum. They tend to develop for all septa and are subequal. They are broad and very slightly convex or even flat bands with a few rather widely spaced and rather small granules. These are scattered with 3–4 across (with room for 5 or 6 in total). Intercostal bands are hardly developed; they are finely uneven, very narrow bands, sometimes with a single row of granules indicating a new costa. Where the corallum suddenly gets a greater diameter, cristae and more acute costae develop, and intercostal uneven bands are comparatively conspicuous.

No synapticules, no dissepiments, and no tabulae. Stereome plays a rôle in the construction of the basal disc but internal stereome is either lacking or of minor importance and does not fill up the basal portion of the corallum.

Affinities. The present species differs from the other Greenlandic species considered in this paper as follows: From *Caryophyllia andreasi* sp. n. chiefly through the ornamentation of its costae; from *Caryophyllia* sp. A chiefly in its shape; from *Caryophyllia* sp. B chiefly in its costae, which are not rib-formed and in its lack of internal filling with stereome. It has been compared to the Senonian-Eocene *Caryophyllia* species, which are discussed above under *C. andreasi.* In characters listed in the diagnosis it differs from all of them, and it was decided to introduce the material as a new species.

The new species is a very generalized kind of *Caryophyllia* and falls well within the boundaries of the genus as understood by the Senonian to Eocene species. But it does not seem to have a close affinity with any one of the known species in particular.

Occurrence

Lower Danian

Agatdalen, Oyster-ammonite Conglomerate localities I and II, (concretionary body formed within the conglomerate), 1964, 6 specimens.

Lower Danian ? (or possibly Campanian or Maastrichtian)

Agatdalen, Oyster-ammonite Conglomerate locality III, 1961, 1 possible example.

Caryophyllia sp. B

Pl. 3, Figs 1–3

Material. 66 not too well preserved coralla. In addition 11 badly preserved coralla are doubtfully associated. Only parts of one upper calice-portion are safely recognized. The 4 bases recognized belong to dubious specimens. Usually, pre-embedding wear has destroyed the outer portions of the wall, and often later dissolution processes within the sediment, and weathering, have damaged the skeletons further. Only two rather well-preserved specimens (MMH 12,656 and MMH 12,657) yield useful information on wall and costulation. The skeletons are filled with sediment similar to that surrounding them.

Description. Corallum is trochoid to ceratoid or even subcylindrical. Axis is slightly curved, with curvature most pronounced in the lower portion of corallum. Cross-section is circular or, rarely, slightly oval. Apparently, the most oval cross-sections are recognized in the limited material from the Lower Danian basal conglomerate but details cannot be given because of the bad state of preservation of this material. Attachment was probably by means of a small basal disc but the only observed examples of such a disc belong to doubtfully determined specimens.

Height must have been generally about 3 cm and could reach at least 4 cm. Diameter usually varies between about 12 mm and about 20 mm. Depth of calice not well known but can be estimated to 3–5 mm.

Basal plate not studied. There was probably no epitheca. The wall generally is badly preserved because of pre-embedding wear and later weathering, and most of the specimens provide information only on what is interpreted to be that part of a septotheca which is on the inner side of the dark line of the wall. This interpretation of the damaged wall is based on investigation of two specimens (MMH 12,656 and MMH 12,657). MMH 12,656, which is a 3 cm high fragment representing most of the original corallum, and which has very conspicuous internal stereome, displays some inner parts of the worn outer portion of a septotheca. Any possible epitheca has been destroyed. MMH 12,657, which is a 21 mm high fragment of a probably 25 mm high corallum, and which has comparatively little filling with stereome, also gives evidence for a septotheca and probably had no epitheca.

Septal number usually is 48 but appears to be higher in the few comparatively broad individuals. In MMH 12,656 it is assumed to be 52, and in MMH 12,657 it is assumed to be 64. Typically 4 cycles appear. The protosepta are unknown. Septum laminar, with dark median line, axis of divergence is placed close to the wall or is enclosed within the wall. Septal sides with distinct granules arranged in rows with the directions of the growth segments and the trabecules. Where seen in cross-sections, such rows of coarsest granules may simulate sections through palus-like thickenings of median parts of the 1st and the 2nd cycle septa. Inner margins undulate. Upper margins are smooth or it can be deduced that they have been so. Exsertation generally can be assumed to have been slight: In MMH 12,657 an exsertation of 1 mm is indicated. Pali are found in one crown before 3rd cycle of septa, with numbers from 12–16 (MMH 12,656: 12 or 13 are assumed; MMH 12,657: 16 are assumed). No paliform lobes. The spongy columella is rather broad, with diameter ranging from $^1/_5$ to $^1/_3$ of the approximate diameter of the corallum.

Costae could be studied only in MMH 12,656 and MMH 12,657 and even here not very satisfactorily. The preserved features of MMH 12,656 reveal that its costae in full corallum height were formed as subequal, rounded, very distinct ribs; no intercostal bands seem to have existed in that specimen. Sculpture of costae is badly represented in the older growth-stages examined, perhaps it was a granulation with 3–4 granules across the individual costa. MMH 12,657 appears practically unworn in places and demonstrates quite similar rib-formed costae; intercostal bands are either lacking or are narrow, smooth or very finely granulated. Cristae not observed. No synapticules, dissepiments or tabulae have been observed. Some outer stereome may have reinforced the wall, particularly below, but nothing is known definitely.

Inner stereomic basal fillings play a varying but in many cases a large rôle; they can fill up the corallum completely in its lower half.

Affinities. In many cases the species shows a conspicuous internal filling with stereome, and it has rib-formed costae. Too little is known, however, for an extended comparison to be made with other species. It differs from the other Greenlandic species in these ways: From *C. andreasi* sp. n. in its costulation; from *Caryophyllia* sp. A in its shape and costulation; and from *C. agatdalensis* sp. n. in its features of stereome and costulation.

Occurrence

a) Material found *in situ*:

Lower Danian

Agatdalen, Oyster-ammonite Conglomerate localities I and II, (in matrix), 1964, 1968, 6 specimens, badly weathered in parts, of which 4 are dubious;

Danienrygge at Kangilia: Conglomerate immediately above Tuff I, Ryg B, 2 dubious examples;
Basalt tuff: Tuff II, Ryg B, 1 dubious example;
Ryg D, 1 dubious example;

Tunorssuaq, Danienkløft: "Store Profil", 2 specimens, of which 1 is a dubious example;
"Nordprofil", 3 specimens.

b) Material found in displaced blocks of concretionary dark shale. The shale concerned very often contains considerable amounts of quartz sand grains and quartz or feldspar gravel, and sometimes rolled pieces of quartzite and older hardened dark shale, with diameters of several cm:

Probably Lower Danian

Danienrygge at Kangilia, Ryg C, 1 specimen;

At Kangilia, altitude 610–730 m, 1939, 14 specimens; 1957, 11 specimens;

Angnertuneq, alluvial fan, 1939, 1 specimen;
gorge complex of Vestre Konglomeratkløft, 1946, 1957, 4 specimens, of which 2 are dubious;
Serfat, about 14 specimens (including MMH 12,656);
Tunorssuaq, Main valley, 1 specimen;
Danienkløft, 10 specimens;
Ilugigsoq, the southern neighbouring gorge to Koralkløft, 1 specimen (MMH 12,657);
Koralkløft, 1953, 1 specimen;
Qilakitsoq, 2 specimens;
Kangersôq, 1 specimen;
Agatdalen, Agatkløft, 1 specimen.

Remark: The author (FLORIS, 1967 a, b) noticed, with some reservation, the occurrence of a European Chalk species in the Upper Cretaceous of Greenland but no specific indication was given. The specimen concerned is now considered a Lower Danian dubious *Caryophyllia* sp. B.

Genus *Trochocyathus* EDWARDS & HAIME, 1848 (a)

The type species (genolectotype, EDWARDS & HAIME, 1850 b) is *Turbinolia mitrata* GOLDFUSS, 1826. In the concept of the genus presented by WELLS, 1956, p. 423, the corallum is turbinate to ceratoid, and the columella is fascicular, spongy, or crispate. KÜHN (1966, 1967) mentions and criticizes the fact that ALLOITEAU (1958, pp. 121–130) made a different designation of a type species. KÜHN also comments on the division of the genus by ALLOITEAU into three, viz. *Trochocyathus* EDWARDS & HAIME, 1848 (a), *Protrochocyathus* ALLOITEAU, 1958, and *Paratrochocyathus* ALLOITEAU, 1958. KÜHN thinks that these should rather be given the status of sub-genera based mainly on certain costal and columellar features. In the writer's opinion they should possibly not deserve even that rank because the features used in the differentiation are of a kind which might be influenced by variation in attachment and corallum shape, i. e. characters that are suspect even for differentiation at species-level. In this paper the concepts of ALLOITEAU and of KÜHN have not been followed.

Trochocyathus johannesi sp. n.

Pl. 3, Figs 4 A – 5

Derivation of the name. The species is named after the Greenlandic hunter and fossil-collector, JOHANNES TOBIASSEN, in Niaqornat.

Holotype. MMH 12,659 (Pl. 3, Figs 4 A – 4 B), from a displaced calcareous concretion from dark shales (probably Lower Danian), found at Kangilia, at altitude + 600 m, Nûgssuaq, West Greenland. An almost complete skeleton lacking the very base but showing calicular margin, outer sculpture (not well-preserved) of upper part, good evidence of the shape of the corallum, a section through part of the palus crowns, the septal apparatus, and the columella. Slightly worn and damaged by dissolution on outside. Actual height 9 mm, of which nearly 2 mm correspond to the exsertation, calice diameter 11 mm, depth of calice nearly 5 mm.

Diagnosis. Corallum low, turbinate, straight, with calice of circular outline. Probably either free or with minute scar resulting from attachment. Total height may exceed 10 mm, approximate heights 7 mm and 9 mm correspond to calice diameters 10 mm and 15 mm. Calice depth 3 mm to about 5.5 mm No epitheca ?. Septotheca thin, compact. 48 septa. 4 complete cycles. Young septa not bending toward the older. Strong exsertation by 1–2 mm. The two palus crowns with presumably 24 pali. Columella spongy, with circular cross-section. Costae for all septa, 2 sizes alternating. At the calice margin they are acute and sparsely granulated; below calice margin they are strong, rounded ribs, not serrate, with densely but irregularly placed granules lying up to 3–4 across and sometimes confluent subhorizontally. Intercostal furrows or very narrow intercostal bands. Cristae sometimes present. No dissepiments. No outer stereome ?. Inner stereome lacking or negligible.

Material. From one calcareous concretion from dark shales some skeleton remains (16 pieces) were obtained, representing 13 individuals, and in addition 5 pieces reasonably referred to a further 5 individuals. The calicular margins and upper portions of the wall generally are present but the lower portions of the wall and the very basal regions are missing. The outer sculpture of the skeletons generally has been damaged by wear and by dissolution processes within the sediment, and the study of costae therefore is often difficult or impossible. At least one specimen demonstrates the costal-intercostal features satisfactorily, however, and the type specimen evidently had identical features. There are no remains of any possible epitheca or outer stereome. In a similar concretion 1 skeleton was recognized in which was preserved the calicular margin, a partially weathered portion of the wall and also possibly a portion of the base.

Description. The low and broad corallum is turbinate, with straight axis, and with calice of circular outline. Preserved fragments strongly indicate that corallum was free or very poorly attached, and that no pedicle existed.

Height of fragment is, exclusive of exsertation, between 4 mm and 9 mm; height of two almost complete specimens is 7 mm and 9 mm (total heights), corresponding to calice diameters of 10 mm and 15 mm. Other specimens show calice diameters of 7 mm to 13 mm. It is obvious that the total height in some specimens must have exceeded 10 mm. Depth of calice (10 examples, inclusive of exsertation) ranges from 3 mm to about 5.5 mm. In holotype it is almost 5 mm.

Basal plate not studied. An epitheca is never preserved, and may not have been present. Wall is a thin, compact septotheca without a dark line.

Septal number is 48, 4 complete cycles. Young septa not bending toward the older. Conditions of protosepta unknown. Septum laminar, with median dark line, and with one fan-system; axis of divergence more or less parallel to the wall. Septal sides with granules, some rather prominent, arranged according to the directions of the growth-segments and trabecules, and often prolonged in trabecular directions. Inner margins undulating. Upper margins smooth or nearly so. Exsertation is prominent, up to 1–2 mm. Coarsely granulated pali, in 2 crowns before first 3 cycles of septa. The number of 24 is very strongly suggested by the large sections studied. They are prominent in calice. No paliform lobes. Columella spongy, diameter of circular cross-section can reach 2.5 mm, in the holotype it is about 1.5 mm.

Costae are found for all septa, 48. Two sizes alternate. At the calice margin they are acute and sparsely granulated. Below this margin they are strong, rounded ribs, not serrate, with densely but irregularly placed granules lying up to 3–4 across the individual costa and sometimes confluent subhorizontally. Intercostal furrows or very narrow intercostal bands. Cristae are sometimes found in uppermost portion of corallum. No synapticules, no dissepiments, no tabulae. No outer stereome is preserved, it may never have been present. Internal stereome is either lacking or negligible.

Affinities. The species has been determined to the genus *Trochocyathus* in the sense adopted by WELLS, 1956, and is compared with the following Senonian-Eocene *Trochocyathus* species as known from the literature.

The following 6 so-called *Trochocyathus* species have bowl-shaped coralla and thus differ from the present species: *T. mississippiensis* WELLS, 1933, (see also WELLS, 1941 a, p. 13); *T. taylorensis* WELLS, 1933; *T. hemisphaericus* NIELSEN, 1922; *T. epicharis* WANNER, 1902; *T. perarmatus* (TALLAVIGNES in ROUAULT, 1849), known from EDWARDS &HAIME, 1850 b, p. 66; and *T. renevieri* TOURNOUER, 1872.

The following 9 so-called *Trochocyathus* species have discoid or subdiscoid coralla and thus differ from the present species: *T.* sp. (in OPPENHEIM, 1915); *T. burnesi* HAIME in ARCHIAC, 1850, (known from DUNCAN, 1880); *T. californianus* VAUGHAN, 1900 b; *T. stantoni* VAUGHAN, 1900 b; *T. depressus* VAUGHAN, 1900 b; *T. nummuliticus* DUNCAN, 1880; *T. allonsensis* TOURNOUER, 1872; *T. nariensis* DUNCAN, 1880, (old individuals are cylindrical); and *T. nummiformis* DUNCAN, 1880.

Insufficient information was available concerning the following 6 species, which therefore had to be omitted from further consideration: It is uncertain what exactly was considered by DEWALQUE, who in 1863 mentioned "*Trochocyathus* (*Turbinolia*) *granulatus* GOLDF. sp." from the Landenian of Belgium (see VINCENT, 1921, who suggested that the coral was collected in the "Calcaire de Mons"). "*T. granulatus*" offers a mesh of problems so far concerning Oligocene or younger corals (see FELIX, 1925, and VAUDOIS-MIÉJA, 1964, pp. 18–19); *T.* (?) *mammilatus* GÜMBEL, 1861; *T.* sp. (in GREGORIO, 1890), (see VAUGHAN, 1900 b, p. 197); *T.* sp. (in WELLS, 1934 a); *T.* ? *giganteus* (ACHIARDI, 1866), (see FELIX, 1925). The original name, *Flabellum giganteum*, suggests a large and compressed corallum; *T.* (?) *bourgueti* (CATULLO, 1856), (see FELIX, 1925; with synonymy).

Concerning *Paratrochocyathus androiavensis* (ALLOITEAU, 1936), age, distribution, and earliest generic identification are not known to the writer. It is here considered a

Trochocyathus in the sense adopted by WELLS, 1956, but the writer is not in possession of many details. It differs from the present species in its feeble columella formed of separate subcylindrical pillars and possibly also in its wall, which is strongly developed (see VAUDOIS-MIÉJA, 1964); concerning *Protrochocyathus subarcuatus* (ALLOITEAU, year of establishment ?), age, distribution, and first generic identification are not known to the writer. It is here considered a *Trochocyathus* in the sense adopted by WELLS (1956) but the information available is scarce. The species is different from the present one in that the costae are in groups of 4 (see VAUDOIS-MIÉJA, 1964);

T. matleyi WELLS, 1934 b, from the Upper Cretaceous (Senonian ?), is different in possessing equal costae;

T. oregonensis NOMLAND, 1916, from the Upper Cretaceous (Senonian ?), differs from the present species through the form of the corallum which is curved in plane of minor axis of the calice which has an oval outline, and in the fact that the 48 costae are equal;

T. pergranulatus NOMLAND, 1916, from the Upper Cretaceous (Senonian ?), differs since its calice has an oval outline, and the outer side has 48 + 48 single rows of granulations;

T. carbonarius REUSS, 1854, differs because its compressed, slenderly conical corallum is curved in the plane of the minor axis of the calice, and every 4th of the delicate costae is comparatively dominant;

T. microphyes FELIX, 1903, at least differs through the bending of young septa toward older septa;

"*Parasmilia balanophylloides* BÖLSCHE, 1870" is perhaps a *Trochocyathus* (see WELLS, 1933, 1958; and SQUIRES, 1958 b). It differs from the present species in that young septa bend toward older ones and further differs in being broadly attached;

T. woolmani VAUGHAN, 1900 a, also differs in that young septa bend toward older ones, and in being broadly attached;

T. konincki EDWARDS & HAIME, 1848 a, is distinguished by slightly compressed, slender conical corallum with curvature in plane of the major diameter of the calice, and also by its equal costae;

T. egerius (WHITE, 1879), (as revised by WELLS, 1933), is distinguished by the acute, low, broad costae with narrow, beaded edges;

T. gardnerae WELLS, 1933, from the Maastrichtian of Texas, differs in that the 48 costae, which slightly alternate in size, are acute and faintly beaded, in its shallow calice, and in its faint exsertation;

T. lakii DUNCAN, 1880, differs in its very conspicuous intercostal areas, and its very prominent and very coarsely granulated costae;

T. speciosus (GABB & HORN, 1860), (see VAUGHAN, 1900 b, p. 196; 1902; and VAUGHAN & POPENOE, 1933), from the Paleocene of Tennessee, differs in having coarser costae;

T. dakotaensis VAUGHAN, 1920, from the Paleocene (Cannonball) of North Dakota, has a different corallum which is compressed (holotype has calice diameters 8 mm by 6.5 mm), and further, has 48 alternating costae with, in addition, 48 rudimentary ones;

T. ? neumani VAUGHAN, 1920, at least differs through its curved and distinctly compressed corallum, and steep sides of costae, which are beaded on the edges;

T. clarkeanus (VAUGHAN, 1895), (see VAUGHAN, 1900 b), is distinguished by elliptical cross-section of usually slightly curved conical corallum, by acute costae, by lack of exsertation, by apparent presence of rudimentary dissepiments, and possibly by shallow calice;

T. zitteli VAUGHAN, 1900 b, is distinguished by a compressed conical corallum which is curved in the plane of minor axis of calice, and by stereome thickening the wall and septa;

T. coloradoensis VAUGHAN & POPENOE, 1933, is distinct through its slightly curved sub-conical coralla, with equal and comparatively coarse costae (Fig. 6);

T. uber VAUGHAN & POPENOE, 1933, from the Paleocene Kincaid Formation of Texas, possibly differs through having (also in the upper part of the corallum) epithecal coatings and bands; and it at least differs in that certain young septa are fused to the faces of older ones and probably also in having a comparatively shallow calice;

T. haunsbergensis TRAUB, 1938, (see also KÜHN, 1967), differs by having a pronouncedly oval outline of calice, and through broad intercostal bands;

T. kroisbachensis TRAUB, 1938, (see also KÜHN, 1967), is distinct owing to a somewhat curved conical corallum with distinctly oval outline of calice, and probably also to strong inner stereomic thickening of septotheca;

T. sp. indet. (in KÜHN, 1967, "*T.* (*Protrochocyathus*) spec. indet."), owes its distinction from the present species to, at least, the pores found in the intercostal furrows;

T. cingulatus VAUGHAN, 1900 b, differs in the slightly compressed conical corallum being curved in plane of the minor axis of calice, and in having broad intercostal areas;

T. hyatti VAUGHAN, 1900 b, from the Paleocene of Alabama, possibly differs in its epithecal formations, and certainly in that certain septa are fused to older ones, and in its rather broad intercostal bands;

T. insignis DUNCAN, 1866, differs in that the conical corallum is curved and compressed, and that the subequal costae are very low ribs;

T. austeni DUNCAN, 1866, differs in its slender conical corallum, which is slightly curved and distinctly oval in its cross-section;

T. striatus (GABB, 1864), (see VAUGHAN, 1900 b), differs from the Greenlandic species in having curved slenderly conical coralla; at least the specimens treated additionally by VAUGHAN differ through sub-acute costae;

T. cupula (ROUAULT, 1848), (see EDWARDS & HAIME, 1850 b), is a small coral, which probably differs through its broad base and shallow calice, and certainly through the presence of rudimentary costae; the Belgian representative reported by EDWARDS & HAIME (1850 b) may be young *Caryophyllia brabantica*, as suggested by VINCENT (1921);

T. pyrenaicus (MICHELIN, 1846), (see also KÜHN, 1966), differs from the present species through a curved corallum with the cross-section pronouncedly oval and also in that the longest costa is particularly strong;

T. taramellii ACHIARDI, 1875, differs at least through the single rows of strong granules on the costae;

T. elongatus EDWARDS & HAIME, 1848 a, is distinguished by a subcylindrical corallum, which is curved, and by a distinctly oval outline of calice;

T. corbicula DUNCAN, 1880, differs in the oval outline of the calice and in the very slight exsertation of septa;

T. crooki MERRIAM & TURNER, 1937, differs through having a curved corallum and in that 10 costae are proportionately heavy;

T. imperialis NOMLAND, 1916, differs through having the conical corallum curved in the plane of the minor axis of a distinctly oval cross-section and in that the costae do not show a simple alternation in size;

T. nomlandi BENTSON, 1943, differs from the present species in its shape (the broadly conical (free) corallum is cuneiform at base), in the predominance of every 4th costa and in that the costal ornamentation is limited to single rows of granules;

T. (?) *perrini* Dickerson, 1913, differs at least in dominance of every fourth costa, and in having a compressed corallum;

T. affinis Reuss, 1870 (non Stoliczka, 1873; see Felix, 1914; 1925), at least differs in its curved and strongly compressed coralla;

T. concinnus Reuss, 1874, is distinguished by its corallum being rather strongly curved, and by the costal ornamentation being limited to single rows of granules;

T. conoides (Gabb & Horn, 1860), as in Vaughan, 1900 b, differs, e. g., through the oval outline of the calice, in a conical corallum curved in the plane of the minor axis of the calice, and in its outer sculpture;

T. crenulatus Mayer, 1877, differs in having horizontally and finely furrowed equal costae on the slightly compressed subconical corallum;

T. michelottii Mayer, 1877, differs in having equal costae, which are only slightly convex and have feeble horizontal furrows, and also in being slightly compressed;

T. lemniscatus Squires, 1958 a, possibly differs in its subhorizontal bands of densely and irregularly granulated stereome (also in its upper parts) and in the presence of a 1 mm high pedicel, and it certainly differs in that the exsertation is only slight and the costae are low and flat;

T. alpinus (Michelin, 1846), (see also Vaudois-Miéja, 1964), differs from the present species at least through its curved coralla;

T. haimei (Rouault, 1849), (see Fromentel, 1861), is distinguished by its shape resembling a compressed cone curved in the plane of the minor axis of the calice, and by its lamellar costae;

T. multisinuosus (Michelin, 1846), cited as "*multistriatus*" by d'Orbigny, 1850 a, and by Felix, 1925, differs markedly from the present species in having a flabelliform corallum;

T. paucicostatus Mayer-Eymar, 1887, differs in its slightly compressed and slightly curved subconical corallum with equal costae, which are densely and delicately furrowed across;

T. subundatus (Archiac, 1847), (see Vaudois-Miéja, 1964, description of neotype), differs in being slightly curved below and in having a compressed corallum (ratio of diameters of cross-section is 1.3);

T. thorenti d'Orbigny, 1850 a, (see also Vaudois-Miéja, 1964), as known from one French and a few (2 or 3) Austrian (Kühn, 1966) specimens, is distinct from the present species at least by having curved coralla.

On account of the differences stated, the present material is conconsidered to represent a new *Trochocyathus* species.

Close affinity seems to exist with the following: *T. gardnerae; T. speciosus; T. dakotaensis; T. uber;* and *T. hyatti.* The species which appear most similar to *T. johannesi* sp. n. are all from North America and most of them are approximately of the same age as *T. johannesi.* This corroborates the possibility of actual relationship.

Occurrence

Probably Lower Danian

Displaced: At Kangilia, calcareous concretion from dark shale, + 600 m, 1939, 13–18 specimens;
Alluvial fan of Quvnilik river, 1956, 1 specimen.

Genus *Paracyathus* EDWARDS & HAIME, 1848 (a)

The type species (genolectotype EDWARDS & HAIME, 1850 b) is *P. procumbens* EDWARDS & HAIME, 1848 a.

Paracyathus kangiliaensis sp. n.

Pl. 3, Figs 6 A – 9

Holotype. MMH 12,661 (Pl. 3, Figs 6 A – 6 B), from the Lower Danian basaltic Tuff II, Ryg A of the Danienrygge at Kangilia, Nûgssuaq, West Greenland. A skeleton showing base and most of the calice, including a minute portion of the calice margin. Outer surface is somewhat worn and damaged by dissolution, which makes observation of costal features difficult, yet not impossible, although it actually helps the study of stereomic covering of the wall. Height about 13 mm, diameter at calice 6 mm.

Diagnosis. Slenderly trochoid corallum; height approximately 13–14 mm; diameter of calice, of subcircular outline, 6 mm to at least 8.5 mm; depth of calice at corallum height about 13 mm is 1.2 mm; 46–48 septa; exsertation slight; costae equal, low, broad rounded ribs or sometimes nearly flat bands, with densely and irregularly placed simple and sometimes irregular granules lying about 3 across; faint, shallow and narrow intercostal grooves, which appear smooth; epitheca presumably not developed; thin deposit of layers of stereome, which form part of the basal disc and are sculptured with the complete costal pattern.

Material. Four skeletons. The holotype demonstrates base and most of the calice, while two additional specimens (MMH 12,662 and MMH 12,663) barely show portions of the base, and a third additional specimen (MMH 12,664) displays the base and a rejuvenation calice. All specimens are somewhat worn and damaged by dissolution processes within the sediment.

Description. The (slenderly) trochoid corallum has been fixed by a broad base, the diameter of which must have exceeded 5.5 mm.

The young stages are demonstrated to some extent by all four specimens. The holotype clearly shows indications of a polycyclic base. In MMH 12,662 it is seen how apparently a young corallum has been characterized by 5 successive thin walls, with the last formed developing to form the final adult wall. Some stereome and crushing phenomena make complete observation impossible but it would appear that inside the narrowest wall (the prototheca, incomplete ?) 6 protosepta developed, while inside the second wall there were 12 septa, and that inside the 3rd and 4th walls there were 24 septa. The septal number inside the 5th wall is uncertain. Inner diameter of the 5th wall is approximately 5.0 mm. In MMH 12,663, 4 or 5 wall rings are more or less distinct within a base 5 mm broad. Successive septal numbers appear to be 6, 12, 24, 24, and ?. In MMH 12,664, 5 wall rings are observed. These observations correspond fairly well to the polycyclic bases with 2–6, usually 5, thecal rings reported by DURHAM (1949), in the Recent *P. stearnsii* VERRILL. The only remarkable difference seems to be that in *P. stearnsii* 48 septa are found already inside the 4th wall. DURHAM (1949) found polycyclic bases also in 3 or 4 other species of *Paracyathus*.

Height of holotype is about 13 mm, of MMH 12,662 (fragment) about 10 mm, and of MMH 12,663 (a ground fragment) 6.2 mm. MMH 12,664 approximates 14.5 mm but the rejuvenation calice adds 3 mm. Diameter of the calice of the holotype, which has subcircular outline, is 6 mm. (The largest diameter of abruptly widened MMH 12,662 is 8 mm, and that of MMH 12,663 is 5.5 mm. MMH 12,664 has a diameter of 8.5 mm at lower calice margin, and 6.5 mm at margin of rejuvenation calice.) Diameter of corallum just above the base is about 4.5 to 5 mm. Depth of calice is 1.2 mm.

Basal plate not preserved. Epitheca not identified in the material, it is reasonably supposed never to have been present. Wall is a compact septotheca, which, particularly below, is slightly thickened by stereome.

Septal number is 46 in three specimens, and 48 in MMH 12,664 (oldest calice). Septal arrangement is in 4 cycles. A little below calice, 4th-cycle septa more or less regularly coalesce with 3rd-cycle septa. Septum laminar, with median dark line. Existence of but one fan system in each of the regular septal plates is suggested. Septal sides are granulated. The granules perhaps form some rare and incidental synapticules between the densely crowded septa. Inner septal margins have not been closely studied but seem to be rather straight. From other evidence it can be safely deduced that the upper margins have been smooth or almost so. Slight exsertation.

Pali are found before all but last cycle of septa. They are not arranged in distinct crowns and merge with the sparse columellar papillae, which presumably are paliform lobes. Columella is a loosely constructed spongy tissue, fascicular, narrow.

Costae are for the most part not well-preserved in the present material. However, close examination of their remains, and in particular of their rather well-preserved growth-stages sometimes exposed after loss of similarly patterned stereomic covering, reveals that costae were equal, low, broad and rounded ribs or sometimes nearly flat bands. They were covered by densely and randomly placed simple, and sometimes irregular, granules lying about 3 across the individual costa. Intercostal faint, shallow and narrow grooves, which appear smooth. Cristae not observed.

Synapticules lacking or perhaps formed incidentally, see above concerning septal granules. No dissepiments have been observed. Internal stereome is negligible or lacking. The outer side of the wall is thinly covered by layers of stereome, which forms part of the basal disc, and the layers of which are sculptured with the complete costal pattern.

Affinities. The species is compared with the Upper Cretaceous-Eocene species mentioned below, from North America, Central America, South America, Northwest Europe, and Austria, as known from the literature. It appears to be distinct from all of them and so it is introduced as a new species. (Comparison could not be made with "*P.* ? *serrulus*", said by CONRAD (1866) in a check list to be of Lower or Middle Eocene age, North America; see VAUGHAN, 1900 b.) The foreign species differ thus:

P. ? sp. (in TRECHMANN, 1929), from the Upper Cretaceous of Jamaica, has deeply and sharply cut intercostal grooves;

P. ? *vaughani* (WELLER, 1907), has calice almost reaching to the base (see also WELLS, 1933);

P. ravni KÜHN, 1930, at least differs either in costae being unequal or in presence of broad intercostal bands (Text-Fig. 14);

The calice of *P. lloydi* VAUGHAN, 1920, is strongly elliptical in outline and is 3.5 mm deep, in a corallum of 13.5 mm height;

The calice of *P. thomi* VAUGHAN, 1920, is also strongly elliptical in outline and is 5.5 mm deep, in a corallum of 13.5 mm height;

P. kayserensis VAUGHAN, 1920, from the Paleocene (Cannonball) of North Dakota, is comparatively broad, costae are subacute, and there is no exsertation;

P. bastropensis VAUGHAN & POPENOE, 1933, has costae ornamented with single rows of granules;

P. marylandicus VAUGHAN, 1901, has a subcylindrical corallum and slightly crested costae, which alternate above;

P. peruvianus VAUGHAN, 1922, at least differs in a broadly conical corallum and a very deep calice;

"*P. cylindricus* VAUGHAN, 1900 b", from the Paleocene (?) (Midway ?) of Alabama, has granulated and comparatively broad intercostal grooves. The name is a junior homonym to *P. cylindricus* DUNCAN, 1866;

P. haimei DUNCAN, 1866, has laminate costae and wide intercostal areas;

P. brevis EDWARDS & HAIME, 1848 a, has a low subturbinate corallum;

P. caryophyllus (LAMARCK, 1816), (see EDWARDS & HAIME, 1850 b), has rather broad and granulated intercostal areas;

P. cylindricus DUNCAN, 1866, has very distinct intercostal grooves;

P. crassus EDWARDS & HAIME, 1850 b, with unequal costae, has a calice about 6 mm deep to a corallum height of about 12 mm and at this stage the calice is of elliptical outline;

P. desnoyersi EDWARDS & HAIME, 1848 a, has a compressed corallum;

P. rugosus VAUGHAN, 1900 b, has peculiarly serrated costae;

P. granulosus VAUGHAN, 1900 b, is a subcylindrical coral, with costae more distinct than in the present species and slightly acute;

P. alternatus VAUGHAN, 1900 b, has elliptical outline of its calice and more pronounced and alternating costae;

P. bellus VAUGHAN, 1900 b, has only one row of granules on each of the costae;

P. bruxellensis GLIBERT, 1930, has a calice with an oval outline;

P. procumbens EDWARDS & HAIME, 1848 a, is curved, and the costae are acute (Pl. 10, Fig. 6).

The closest affinity seems to exist with the older representatives, such as TRECHMANN's *P.* ? sp., in particular *P. kayserensis*, which is rather similar to *P. kangiliaensis* in its sculpture and proportions, and also to VAUGHAN's *P. cylindricus*.

Occurrence
Lower Danian
Danienrygge at Kangilia, basalt tuff: Tuff II, Ryg A, 4 specimens.

Genus *Stephanocyathus* SEGUENZA, 1864

Subgenus *Stephanocyathus* SEGUENZA, 1864

The type species (genolectotype WELLS, 1936, p. 131) is *Stephanocyathus* (*Stephanocyathus*) *elegans* SEGUENZA, 1864. *Sabinotrochus* DUNCAN, 1873, and *Stephanotrochus* MOSELEY, 1881, are synonyms (WELLS, 1936; 1956).

Stephanocyathus (*Stephanocyathus*) sp.

Pl. 3, Fig. 10

Material. One fairly complete skeleton artificially sectioned (Specimen I); 8 less complete skeletons (Specimens II, III, IV, V, VIII, IX, X, and XI); 1 dubious badly preserved skeleton fragment with a minute portion exposed of its outer imprint (Specimen VI); and 1 very small skeleton fragment, which may belong to the species (Specimen VII).

Description. Patellate; apparently free (as evidenced by Specimen XI). Dimensions (all measurements in mm, figures in brackets are approximate):

	I	II	III	IV	V	VI	VIII	IX	X	XI
Corallum diameter...	(10)	(12)	(9)	(9)	(11)	7.2 ?	?	(10)	?	(8)
Wall diameter......	(9)	?	?	(8.6)	(10)	?	8	(9)	(6)	(6.8)
Corallum height.....	–	(4)	(2.8)	–	(3.8)	–	?	?	?	?
"Height of wall"....	(2.2)	–	–	(2)	(2)	1.8 ?	?	?	?	(1.2)

Calice with subcircular outline, depth 1.5–1.8 mm. Apex with small costal tubercles (Specimen XI). No epitheca. Compact, thin septotheca, almost smooth, without granules, sometimes with concentric constrictions marking alternations in growth-rate, not radially plicated. Total septal number is 58 in Specimen XI and would appear to be 64 in Specimens I, III–V, and X, 56 in Specimen IX, and 56+ in Specimens II and VIII. The same figures apply to the septa at a distance of 4mm from the centre (2 smaller specimens (X, XI) have septal numbers higher than 48); at 3 mm from the centre, a total of 56 septa is suggested in Specimens I–V, and in VIII–IX, while 64 or slightly fewer are suggested in Specimen X, and 56–58 are found in Specimen XI.

Septum laminar, with median dark line, one fan-system, "upper" margins smooth. Septal sides with a few medium-sized granules. Exsertation is about 0.5 mm; "exsertation" measured vertically is about 1.8 mm.

Pali, apparently in 2 crowns. Also paliform lobes, some of which are implied in the formation of the columella. Columella is trabecular, averaging 1 mm in diameter at the upper end where it is papillose. Costae are single rows of small granules and, predominantly, thin, pronounced laminae which appear to be smooth except for slightly uneven margins. The costae have had no very pronounced sculpture nor spines. No synapticules, no dissepiments, no tabulae or stereome.

Affinities. It seems reasonable to refer Specimen I, as well as Specimens II–V and VII–XI, to *Stephanocyathus* (*Stephanocyathus*) and also to consider them conspecific. Specimen VI only doubtfully belongs to the same subgenus and species.

The species represented differs at least in its features of the septal number from the two probable members of the subgenus which are described in this paper, and it is considered specifically distinct from them. But it seems too poorly known for a general comparison with other corals. The species is the oldest known certain member of the subgenus hitherto known from Eocene to Recent (WELLS, 1956, p. 424).

Occurrence
Lower Danian
Danienrygge at Kangilia, basalt tuff: Tuff II, Ryg B, 1 dubious example (VI).

Displaced (*probably Lower Danian*)
At Kangilia, calcareous concretions (+ 710 m, 1939, I; + 730 m, 1939, VII, VIII; II);
Angnertuneq, Vestre Konglomeratkløft, 1949, IX, X;
Tunorssuaq, Danienkløft, III, IV, and V;
South-side of Tunorssuaq (1952), XI.

Stephanocyathus (*Stephanocyathus*) ? sp. no. 1

Pl. 3, Figs 11 A – 12 B

Material. Two skeletons, both from reworked Upper Cretaceous concretions found as boulders (one of the concretions possibly may be Danian) in a Lower Danian basal conglomerate, and collected in 1956 and in 1958. Concerning the last-mentioned, Maastrichtian age is demonstrated by an accompanying *Discoscaphites*. The first-mentioned skeleton consists of two parts, viz. the septal apparatus filled with sediment (chiefly quartz sand) studiable in basal view, and a slightly damaged septotheca studiable from above. The latter skeleton is less informative and consists of a corallum cleaved into two parts along the median plane of the apparently otherwise well-preserved septotheca. Of both individuals the fragile elements of the interior skeleton presumably are preserved but they are concealed in hardened sediment.

Description, based on the specimen collected in 1956, unless stated otherwise. Corallum patellate and probably free, with greatest diameter about 9 mm and with diameter of wall about 8 mm (corresponding values in 1958 specimen are about 7 mm and about 6 mm). The height presumably about 3 mm. Calice subcircular in outline, its depth unknown. Basal plate not exposed in the material. Apparently no epitheca existed. Imperforate septotheca, apparently smooth except for a concentric wrinkling. 24 conspicuous septa; 6 + 6 septa form the first two, almost equal, cycles and 12 form the third (the same is the case in the 1958 specimen). Observed parts of septa are laminar, with median dark line. Observed small portions of "upper" margins are smooth; for the most, septal margins are not exposed in the material. Pali are suggested before 3rd-cycle septa and perhaps also before 2nd-cycle septa. The pali (?) as well as the normal septal plates bear a few granulations but the arrangement of these is unknown, as are features of fan-systems. Distinct exsertation. Columella presumably trabecular, its diameter and its appearance in the calice are unknown. Costae very distinct, thin. There cannot have been spines of the *Odontocyathus* type. The costae were presumably smooth. Those corresponding to the two first cycles of septa follow convex rays of the theca while those corresponding to the 3rd cycle of septa follow concave rays. No synapticules, dissepiments, tabulae, or stereome appear to have existed.

Affinities. Reference to *Stephanocyathus* (*Stephanocyathus*) very probably is correct but can as yet only be made with slight reservation, because we have no knowledge about some details of the septa and about the upper end of the columella.

The material is specifically distinct from the probable and the certain *Stephanocyathus* (*Stephanocyathus*) species otherwise known from Greenland and considered in this paper, through the small number of septa and the radially plicated theca. But the material is too poor for its relationship to other corals to be demonstrated satisfactorily.

Occurrence

Lower Danian ?, Maastrichtian, and perhaps Campanian

Agatdalen, Oyster-ammonite Conglomerate locality III, 1956, 1958, 2 specimens.

Stephanocyathus (*Stephanocyathus*) ? sp. no. 2

Pl. 4, Fig. 1

Material. 1 fragment of a skeleton crushed *in situ.* Demonstrates the basal portion of the corallum.

Description. Corallum patellate and probably free, with diameter suggested to be about 6 mm. Height must have exceeded the measured "wall height" of about $1^1/_2$ mm by the "height" of the septum-portions which are not preserved. Depth of the subcircularly outlined, possibly slightly six-lobate, calice is not known.

Basal plate not present. No epitheca. Imperforate septotheca without particular sculpture. The total septal number, at a distance of almost

3 mm from the centre of corallum, is suggested to be 48, with 4 complete cycles; about two systems can be studied. Septum is laminar, with median dark line, details of directions of the growth-segments and of the trabecules are unknown. Septal sides with a few but conspicuous granules. Septal margins unknown. Exsertation. There is slight evidence for two crowns of pali or paliform lobes following the septa of 2nd and 3rd cycle. Columella trabecular, rather stout, with diameter of 1 mm (?). Its upper end could not be observed. Costae prominent, granulated, with the granules often like short acute teeth, but without stout spines. No synapticules, tabulae, dissepiments, or stereome appear to have existed.

Affinities. Reference to *Stephanocyathus* (*Stephanocyathus*) probably is correct but must so far be made only with reservation, because we have no knowledge about the septal margins and some other details of septa, and about the upper end of columella. Through the septal number presumably being 48 in total, at a distance of almost 3 mm from centre of the corallum, this specimen differs from *S.* (*S.*) sp., and from *S.* (*S.*) ? sp. no. 1 of this paper and it is considered to represent a species separate from those. Closest affinity seems to exist with *S.* (*S.*) sp. A general comparison with other corals cannot be made for the present.

Occurrence
Upper Danian ?
Agatdalen, Agatkløft, "Store Profil", Sonja Lens (Upper Danian Agatdal Formation), 1 specimen, considered to be derived (belongs to a dark, fine-grained sediment, possibly a clay ball).

Genus *Kangiliacyathus* gen. n.

Derivation of the name. The genus is named after the Greenlandic locality, Kangilia, and cyathus, a cup.

Type species. Hologenotypicus monotypicus, *Kangiliacyathus groenlandicus* sp. n.

Diagnosis. Solitary septothecate trochoid coralla without dissepiments; with no pali, or paliform lobes; with upper margins of septa smooth; with costae rounded or almost flat; with columella composed of a few large elements, trabecularly spongy and not papillose.

Affinities. There is some similarity, and possible affinity, to the following genera: The Middle Cretaceous to Recent *Ceratotrochus* EDWARDS & HAIME, 1848 a, the large columella of which, however, is papillose fascicular; the Paleocene (Danian) to Recent *Cyathoceras* MOSELEY, 1881, the columella of which, however, is fascicular; and perhaps the Cretaceous (caryophylliin ?) *Epitrochus* FROMENTEL, 1862, the columella of which, however, is papillose.

Distribution
West Greenland

Range
Paleocene (Lower Danian)

Kangiliacyathus groenlandicus gen. n. & sp. n.

Pl. 4, Figs 2 A – 3

Holotype. MMH 12,669 (Pl. 4, Figs 2 A – 2 C), from Lower Danian conglomerate immediately above Tuff I, Ryg B, Danienrygge at Kangilia, Nûgssuaq, West Greenland. A fractured skeleton, practically unworn before embedding but partially a little crushed within the sediment, lacking some parts of calice, and the base. The specimen consists of two pieces together demonstrating a corallum portion 10 mm high and 9.3 by 8.0 mm broad (calicular margin deformed by pressure).

Diagnosis. Corallum slender or broad, straight or gently curved, with calice of subcircular outline normally 6–7 mm broad but in extreme cases from 5.5 to 9 mm across, with usual height suggested to be 10–12 mm, depth of calice at most a little more than 2 mm. Number of slightly exsert septa is assumed to range from 32 to 40, septal sides with few but rather large granules, diameter of columella 1–2 mm. Costae for all septa subequal, rounded ribs to almost flat bands, densely granulated with fine, irregularly distributed granules standing up to 3 across the individual costa. Cristae rather frequent. Intercostal narrow bands with single row of granules. Costal and intercostal ornamentation retained by the rather heavy outer stereome. Inner basal stereome rather heavy.

Material. 39 skeletons, of which 5 are determined with certainty, 9 with near certainty (lacking calicular margin), 21 are probable (worn but with at least some of the characteristic interior structures ascertained), and 4 are dubious. A few calices or fragments of calicular margins are preserved, and a few bases. Often the outer side of coralla is practically unworn but crushing of parts of the skeleton within the sediment apparently has occurred in several cases.

Description. Trochoid solitary coralla, slender or broad, with axis straight or gently curved, with calice of subcircular outline, attached by a rather broad basal disc.

The height of 10–12 mm is suggested to have been the general height reached in the species but the height could reach to more than 18 mm in the case of rejuvenation (observed once). Height of 5 certainly determined specimens: 8 +, 8.8 +, 9 +, 10 +, 11.5; height of 9 almost certainly determined specimens is: ?, ?, 8 +, 9.5 +, 10 +, 10 +, 11 +, 11.5 +, 18 + (rejuvenation). Diameter of calice is 5.5 mm to about 9 mm, apparently most often 6–7 mm. Breadth of basal disc varies considerably, from in general 3 or 4 mm, to about 7 mm in short, broad coralla. Depth of shallow calice may only slightly exceed 2 mm.

Basal plate not recognized. No epitheca. Wall is a compact septotheca, the first structure of which has medium thickness with a dark median line and becomes thickly covered on both sides by a stereome which may be distinctly layered in some cases. The costal pattern is observed throughout the stereome and in the full height of the latter.

Septal number in the calice region was in one case observed to be 32 (in a specimen determined with certainty) but otherwise had to be calculated only from crowns exposed partially. The values reasonably suggested in this way are: Certainly determined specimens, 32 (1), 40 (3); almost certainly determined specimens, 32 (4), 36 (1), 40 (4). It thus appears that 32–40 septa were the norm. Of these septa, 8–10 were considerably larger than the rest and alone reached to, and formed, the columella.

Septum laminar, with median dark line, simple trabecules indicated, with the axis of divergence placed in or close to the wall. Septal sides with a few rather large granules arranged according to the directions of growth-segments and trabecules. Inner margins undulating, with broad connections in larger septa where constructing the columella. Upper margins appeared smooth in the poor fragments studied; other structures of septa demonstrate that the upper margins must have been smooth in their full length. Exsertation slight. No pali, nor paliform lobes. Spongy columella of trabecular type and not papillose, composed of a few large elements from 8–10 larger septa; diameter 1–2 mm.

Costae correspond to all septa, are subequal at least above, and are densely granulated with fine, irregularly distributed granulations (up to 3 across the individual costa). Intercostal narrow bands display single rows of granulations. In different specimens costae may be conspicuously convex, as in the holotype, or nearly flat; intermediate forms have been observed. Cristae rather frequent, mainly corresponding to the larger septa.

No synapticules, no dissepiments, nor tabulae. Stereome showing the costal and intercostal ornamentation reinforces the outer side of septotheca, particularly below. Inner side of septotheca, and the septa, in the lower part of corallum are distinctly thickened with stereome which in some cases may even close the lumen.

Affinities. The species is the only known member of *Kangiliacyathus* gen. n.

Occurrence

Lower Danian

Danienrygge at Kangilia:

Conglomerate immediately above Tuff I, Ryg B, 35 specimens, of which 9 almost certain, 19 probable, and 2 dubious;

Basalt tuff: Tuff I or Tuff II, 1 probable example;
Tuff II, Ryg A, 1 probable and 1 dubious example;
Danienrygge, 1 dubious example.

Subfamily **Desmophyllinae** Vaughan & Wells, 1943

Genus *Desmophyllum* Ehrenberg, 1834

The type species is *D. dianthus* Ehrenberg, 1834 (non *Madrepora dianthus* Esper, 1797) = *D. cristagalli* Edwards & Haime, 1848 a; subsequent designation of type by Edwards & Haime, 1850 b. Synonyms, as listed by Wells, 1956, p. 426, *Coelosmilia* Edwards & Haime, 1850 b; *Psammosmilia* Fromentel, 1863; *Thalamophyllia* Duchassaing, 1870; *Javania* Duncan, 1876.

Desmophyllum ? sp.

Pl. 4, Figs 4 A – 4 C

Material. One incomplete skeleton, after transverse cutting preserved as 3 pieces. It demonstrates a rather well-preserved calice, but the very base of the corallum is missing. Skeleton is partially damaged by dissolution processes within the sediment, while before embedding it was somewhat worn.

Description. Corallum trochoid, appearing straight because of stereomic coating but fundamentally slightly curved. Apparently the corallum was fixed by a broad basal stereomic extension of the wall.

In early ontogenetic stages the coral was polycyclic. The lower portion of the broken corallum displays the origin of 3 cycles of septa. Any indication of columella is faint or absent. 1 protothecal and 3 thecal rings are suggested in the fracture, the thecal ones partially incorporated in stereomic masses of the final wall. The prototheca surrounds 6 protosepta and the first of the 6 septa of the 2nd cycle and has a diameter of about 1 mm. All 2nd cycle septa have appeared inside the 1st thecal ring, and at least some of the 3rd cycle septa are found inside the second thecal ring. The most basal portion of the fracture probably is within 1 mm from the basal plate. At a diameter of the septal apparatus of 2.4 mm, the adult wall alone is developed.

Diameter of the calice, with subcircular outline, is about 7 mm, height of preserved portion is about 9 mm. Depth of calice approximates 2.5 mm.

Conditions of basal plate unknown. No epitheca can be observed in the material and probably it did not exist at all. Imperforate septotheca.

Septal number is 54, 4 cycles. Septa of 1st and 2nd cycle reach to axial line of corallum or very close to it, septa of 3rd cycle reach four-fifths as far, and septa of 4th cycle reach about the half of that distance, as observed in a section about 2.5 mm below calicular margin. Septum is laminar, with median dark line. In the wall region there is considerable thickening of the septal plates. One fan system indicated, with axis of divergence subvertical. Septal sides with granules arranged according to directions of growth-lines and of trabecules. Upper margins unknown but are by other septal structures suggested to have been either smooth or finely granulated. Exsertation has been rather strong but cannot be studied in detail. Neither pali, nor paliform lobes appear to have developed. Columella is either lacking or, rather, is a very feebly developed trabecular structure as suggested by a very few, minute and variously orientated septal portions at the centres of the transverse sections studied.

Costae are badly preserved but apparently were broad and low bands with densely placed granules, fairly distinguishable near calice where cristae also existed.

No synapticulae. Dissepiments have not been observed; no tabulae. Heavy internal stereome did not develop but in the present specimen is imitated by masses of diagenetic calcium carbonate. Some stereome is found on the wall, however, and especially on its outer side, and below, where it is densely granulated.

Affinities. The seemingly most probable generic identification of the specimen is with *Desmophyllum.* In this genus, however, columella generally is thought to be lacking; but the type species, *D. cristagalli*, sometimes appears to develop a weak trabecular columella, see VAUGHAN and DURHAM, in DURHAM (1949, pp. 159, 163), and thus supposedly demonstrates a condition as that observed, with slight doubt, in the present specimen. But still the identification is to be made with reservation, partly because the few and deeply situated dissepiments to be found in the genus have not been demonstrated, and partly also on account of the observations made in early, polycyclic, stages in the present coral. These observations appear not to correspond to DURHAM's interpretation (1949, pp. 158–159, 162, Pl. 4, Figs 2, 4, 7, 8) of the basal structures in *D. cristagalli* (material accepted as this species even in the presence of a weakly developed columella; two monocyclic specimens). DURHAM found that in general it was indicated that the polycyclic and monocyclic characters apparently were features of at least specific importance. He further suggested that they might have generic value. If studies convincingly confirm this view, the present possible *Desmophyllum* should be removed from this genus.

The present species is too poorly represented for a specific identification, and a general comparison of the Greenlandic specimen with other corals will not be attempted.

Occurrence
Lower Danian
Danienrygge at Kangilia, basalt tuff: Tuff II, Ryg A or Ryg B, 1 specimen.

Genus *Lophelia* Edwards & Haime, 1849 (a)

The type species is ***Madrepora prolifera*** Pallas, 1766 (subsequent designation by Edwards & Haime, 1850 b). Wells (1956, p. 427) lists the synonyms *Lophohelia* Edwards & Haime, 1857, and *Scolangia* Tenison-Woods, 1880, and the bathymetric range, from 64–1,975 m. Squires (1964, p. 907) mentions the depth range as 50–3,383 m.

Lophelia ? sp.

Pl. 4, Fig. 5

Material. 1 fragment of a skeleton, displaying one lower cross-section through a corallite, and upper cross-sections of 5 or 6 corallites. Interior of corallites almost completely filled with coarse sediment and showing only septum parts. Other endothecal elements may possibly have existed. Surface of skeleton partially appears smoothened (damage by dissolution ?).

Description. No exact knowledge about the protocorallite exists. The corallum is formed by intratentacular budding, presumably distomodaeal, with type of linkage unknown, producing monocentric (subcylindrical ?) corallites, the length and further development of which is unknown (fascicular dendroid corallum ?).

Height of preserved fragment is 19 mm. Diameter of lowermost cross-section 11–12 mm; of smallest bud 2 mm; of next-smallest bud 4.5 mm; of the three larger "branches", 11–12 mm (axial corallite ?), 7.5 mm, and about 8 mm.

Calices unknown. Epitheca not observed in the preserved corallum portion and probably never existed. Wall is a compact septotheca covered with outer stereome.

The present portions of the septa are laminar, with median dark line. Septal number and other septal features are not known. Further, it is not known if pali, paliform lobes, columella, synapticules, dissepiments, or tabulae developed. At least some of these elements possibly existed but it may reasonably be assumed that the endothecal skeleton always was very weakly developed.

Costae are not observed in the fragment at hand. The outer side of the fragment displays a dense stereome that is thick and irregularly and densely granulated with minute granules. The stereome does not seem to have developed into a coenosteum.

Affinities. Too many details of the skeleton are unknown for more than a provisional generic determination to be made, and any discussion of specific relations must be omitted.

Occurrence

Lower Danian

Danienrygge at Kangilia, basalt tuff: Tuff II, Ryg A, 1 specimen.

Subfamily **Parasmiliinae** Vaughan & Wells, 1943

Genus *Parasmilia* Edwards & Haime, 1848 (c)

The type species is *Madrepora centralis* Mantell, 1822. Synonyms (according to Wells, 1956, p. 428): *Cylicosmilia* Edwards & Haime, 1848 c; *Cyclosmilia* d'Orbigny, 1849; *Monocarya* Lonsdale in Dixon, 1850; ? *Plesioparasmilia* Alloiteau, 1952, *Strobilosmilia* Alloiteau, 1952.

Parasmilia sp.

Pl. 4, Fig. 6

Material. One fragment of a skeleton. Calicular margin is lacking, and the basal disc is damaged. A portion of the wall is lacking and therefore the interior of the corallum is partially exposed. Surface of skeleton is somewhat worn and damaged by dissolution.

Description. Corallum trochoid, straight, fixed. Height of preserved fragment about 11 mm. Diameter of calice, with subcircular outline, unknown but probably has been 5–6 mm. Depth of calice unknown.

Basal plate unknown. Epitheca not recognized but may well have existed. Preserved wall is an imperforate septotheca. 38 septa, more or less distinctly in 4 cycles; 19 small, and 19 larger and almost equal. Arrangement of the laminar septa is normal. Median dark line. Axis of divergence subvertical. Only one fan system can be recognized. Septal sides with small but distinct granules seemingly arranged along growth-lines of septum. Upper septal margins are not preserved in the material. From preserved minor structures of septa and wall it is to be deduced, however, that the upper margins were smooth, and that they were exsert. Neither pali, nor paliform lobes. Columella trabecular, loosely built by at least 12 out of the 19 larger septa, diameter about one quarter of that of the corallum.

Costae are found for all septa but are badly preserved in the material. They appear broad and equally developed; details of sculpture and extension unknown. Synapticulae not observed. Endothecal dissepiments few. No internal filling with stereome. Outer stereome apparently diminutive.

Affinities. Attempts at a specific identification have not been made because of the poor state of preservation of, e. g. the costae, and also because nothing is known about possible variation of the septal number.

Occurrence

Lower Danian

Danienrygge at Kangilia, basalt tuff: Tuff II, Ryg A, 1 specimen.

Genus *Faksephyllia* gen. n.

Derivation of the name. In the generic name are combined the name of the Danish village, Fakse (earlier spelled Faxe, Faxoe, Faxoë, or Faxöe), and the Greek word meaning leaf, here septum.

Type species. Hologenotypus monotypicus, *Caryophyllia Faxoensis* BECK in LYELL (1837), established on material from Fakse limestone quarry in Denmark (Middle Danian) and now known from the Danian of both Europe and West Greenland.

Diagnosis (based on material from the type locality of type species). Distomodaeal intratentacular budding with trabecular linkage by repetition producing fasciculate dendroid coralla with monocentric cylindrical corallites which develop equally from each zone of budding; no epitheca; granulations of septal sides are small and rounded; neither pali nor paliform lobes; trabecular columella slightly to well developed; granulations on costae are small and rounded; no synapticules nor tabulae; dissepiments not vesicular; no coenosteum.

Affinities. The new genus despite its differing growth-pattern may have its closest relative in the Recent *Solenosmilia* DUNCAN, 1873.

Faksephyllia faxoensis gen. n. & BECK in LYELL (1837) sp.

Pl. 4, Figs 7–11; Pl. 5, Figs 1–5

With the growth of knowledge of Greenlandic fossil corals it was early accepted that the present conspicuous species was found in beds on both sides of the Recent Atlantic Ocean. But this was not reflected specifically in the literature.

Selected references to literature on the species in Europe:

1837 a	*Caryophyllia Faxoensis*, BECK: BECK in LYELL, p. 248, Text-Fig. 4 (p. 249).
"1847"	*Caryophyllia Faxoensis:* "BECK in LYELL" (according to d'ORBIGNY, 1850 b, p. 133).
"1847"	*Lithodendron Faxoense:* "BECK in LYELL" (according to EDWARDS & HAIME, 1851 a, p. 95).
1848	*Calamophyllia Faxoensis:* d'ORBIGNY (according to d'ORBIGNY, 1850 a, b).
1850 a	*Calamophyllia Faxoensis:* d'ORBIGNY, p. 295.
1850 b	*Calamophyllia Faxoensis:* d'ORBIGNY, p. 133.
1851 a	*Cladocora Faxoensis:* EDWARDS & HAIME, p. 95.

Non 1857 *Rhabdophyllia faxoensis:* EDWARDS & HAIME, (vol. 2) p. 352.
1899 *Lobopsammia faxensis*, BECK sp.: HENNIG (partim), pp. 11–13, 14, Pl. 1, Figs 13, 14 (non 15, 16), Pl. 2, Fig. 17.
1914 *Rhabdophyllia faxoënsis* BECK sp.: FELIX (partim), p. 176; *Lobopsammia faxensis* HENNIG: FELIX (partim), p. 206.
1919 *Haplophyllia faxensis.* BECH: NIELSEN, p. 34.
1922 *Haplophyllia faxensis*, BECK: NIELSEN, pp. 14–16, Pl. 1, Figs 1–7; in the plate-explanation the name *Calamophyllia faxensis* is used.
1929 *Calamophyllia faxensis* BECK: VOIGT, Pl. 9, Fig. 16;
Calamophyllia faxensis (*Dendrophyllia*): VOIGT, p. 84.
1933 *Calamophyllia* (*Haplophyllia*) *faxensis* BECK: HADDING, Text-Fig. 16.
1944 *Haplophyllia faxensis*: ANDERSEN, p. 317, Text-Fig. 262.
1948 *Haplophyllia faxensis*: POULSEN, p. 20, Pl. 11, Fig. 3 (after NIELSEN, 1922, Pl. 1, Figs 1, 2).
Non 1957 *Rhabdophyllia faxoensis*: ALLOITEAU, p. 181.
1966 *Haplophyllia faxoensis*: RASMUSSEN, Text-Fig. (p. 58).
1967 *Dendrophyllia* ("*Haplophyllia*") *faxensis* BECK 1837: VOIGT in HUCKE, p. 98, Pl. 42, Fig. 5.
1968 '*Haplophyllia*' *faxoensis* (BECH in LYELL): ASGAARD, p. 104.
1971 '*Haplophyllia*' *faxoensis*: FLORIS, p. 51 (Text-Fig.).

Notes on the species in Europe and on earlier attempts at a generic identification:

In 1834, CHARLES LYELL visited the type locality of this species. He published an account of the locality in 1836 (a, b), 1837 (a, b), and in 1838, but he mentioned the species only in 1837 (a). He stated here the abundant occurrence in the limestone of "*Caryophyllia Faxoensis*, BECK" and he offered a figure (a wood-cut from a "faithful drawing" which the Danish naturalist, HENRICK BECK, had had made and had given to him).

LYELL's figure seems to be a good one (reproduced here as Pl. 5, Fig. 1). The wood-cut obviously cannot be correct in certain details. Nevertheless, it essentially shows inner moulds and leaves no serious doubt that in fact the picture represents internal moulds of the present species, which is abundant (mainly as moulds) and easily distinguishable in the fauna of the classical and well-known type locality. Thus, in the same work, the species was named for the first time, by BECK, as *Caryophyllia Faxoensis.*

The figure gives information on the way of budding, proportions, size (presumably figured natural size), and suggested septal numbers in relevant places, all of which agree with the Fakse-material that later has been ascribed to BECK's species. Septal values of 28 ?, mainly 32 ?, 36 ?, 42 ?, and 48 ? are recognized along the figured fragments of branching moulds. Everywhere more than 24 septa are indicated. Where columella is indicated it seems to harmonize with the most poorly developed columellas in the known Fakse-material that later has been ascribed to the species; where it appears to be lacking, this reasonably is to be explained by the coarseness of the illustration technique. Unfortunately, information on calices and also on certain septal structures is missing, but nevertheless the figure can safely be accepted as representing a branching coral that is conspecific with the coral diagnosed in this paper.

D'ORBIGNY (1850 b) and EDWARDS & HAIME (1851 a) quoted the species from Fakse as from "BECK in LYELL (1847)", but these quotations must represent incorrect references to LYELL, 1837 a, since the Transactions concerned have no relevant text from 1847. Edwards & Haime's particular use of the name *Lithodendron* in this connection has not been explained and must represent a *lapsus calami*.

D'Orbigny (1850 a, b) states that the species was mentioned, as a *Calamophyllia* from Fakse, by d'Orbigny, in 1848. Probably the publication concerned was in fact d'Orbigny, 1850 a; see Felix, 1914, p. 8.

D'Orbigny (1850 a, b) mentioned the species from Fakse as a *Calamophyllia* without further comment. In 1851 (a) Edwards & Haime changed the generic determination of the Fakse-coral to *Cladocora*, without any particular explanation.

In 1857, Edwards & Haime placed Beck's species with *Rhabdophyllia* Edwards & Haime, 1851 a, and gave a description. Localities were given as Fakse and Vigny. The latter refers to Vigny Seine-et-Oise in France; the report of Beck's species from here seems to have been quoted only by Felix (1914), and there appears to have been no additional information on the French coral, see Soyer (1953) on d'Orbigny (1850 b), and Alloiteau (1957). Edwards & Haime cited Beck in Lyell (1837 a) and described fossils, from Vigny and, unlikely, from Fakse (where nothing similar has since been discovered). Their brief description concerns branching corals with 18–20 slightly unequal costae on 4–5 mm thick branches, and with a very low septal number, at most 24 (no septa of 4th cycle), 18–20 may be probable. In the septal number the corals differ markedly from Beck's figure and from the corresponding numbers met with in the mainly topotypic material which has been accepted as conspecific with Beck's specimen by the present writer (chiefly on the basis of the septal numbers) and also by earlier authors. The corals of Edwards & Haime therefore are here considered specifically distinct from Beck's species. Neither are they considered to be congeneric with it since these corals must have had well-developed columella (probably like that shown by Edwards & Haime, 1851 b, Pl. 15, Fig. 3 b) and dentate or spinose upper septal margins. It appears that Beck's specimen was only mistakenly placed with *Rhabdophyllia*.

Hennig, in 1899, gave an illustrated description of the species in Denmark and Sweden and stressed his concept of conspecificy between his material and the material considered in Lyell, 1837 a. He partially based his description on *Dendrophyllia* material (see Nielsen, 1922, p. 15) and therefore concluded that Beck's species is a *Lobopsammia*.

Felix in 1914 mentioned the species twice and placed it with two different genera, a mistake caused most probably by the growing confusion in quotation and new texts on Beck's species.

In 1919, Nielsen changed the generic determination to *Haplophyllia* without explanation.

In 1922, Nielsen revised the species in Scandinavia and argued against Hennig's generic determination. Apparently Nielsen preferred d'Orbigny's determination of the species as a *Calamophyllia* (1922, p. 15), but he mentioned the lack of collerettes and therefore found that the species should be classified with *Haplophyllia*. Later authors have not given particular explanations for their use of generic names.

In 1957, Alloiteau, from examination of a specimen considered to be a topotype (kept in Paris), found it impossible to refer the species to any known genus. However, his short description clearly reveals that his specimen cannot belong to Beck's species but very probably is a *Dendrophyllia candelabrum* Hennig, 1899, a species very common at Fakse.

In 1967, Voigt (in Hucke, 1967), presumably based on an unfortunate misunderstanding of a letter from the present writer, (1966), mentions and figures the species as '*Dendrophyllia* ("*Haplophyllia*") *faxensis* BECK 1837'.

Asgaard (1968, p. 104), advised by the present writer, and Floris (1971, p. 51), quoted the species as '*Haplophyllia*' *faxoensis*.

All earlier attempts at a generic determination of BECK's species can now be rejected for various reasons:

Caryophyllia LAMARCK (1801) since selection of genotype (1828) exclusively comprises solitary corals;

Lithodendron SCHWEIGGER (1819) as an objective synonym to *Mussa* OKEN (1815) (WELLS, 1936, p. 116; 1956, p. 418) differs from the present species in its dentation of septal margins and in its great number of dissepiments;

Calamophyllia BLAINVILLE (1830) differs from the present species in, e. g. having epithecal rings, synapticulotheca, and fenestrate septa (the two last-mentioned characters are rejected by ALLOITEAU, 1957, p. 176);

Cladocora EHRENBERG (1834) differs from our species in having extratentacular budding;

Rhabdophyllia EDWARDS & HAIME (1851 a) has been accepted as a synonym to *Calamophyllia* BLAINVILLE (1830) (see, e. g., WELLS, 1956, p. 380) which differs from the present species in synapticulotheca and fenestrate septa (see above for other characterization of *Calamophyllia*). However, ALLOITEAU (1957, pp. 179–183) in his revisional work found *Rhabdophyllia* to be clearly distinct, but in his concept, said to be based on that of EDWARDS & HAIME, the genus differs from the present coral in having costae with strong conical granulations, and spine-formed granulations on septal sides;

Lobopsammia EDWARDS & HAIME (1848 b) differs from BECK's coral in, e. g., having synapticulotheca;

Haplophyllia POURTALÈS (1868) (see *Gardineria* VAUGHAN (1907), in WELLS, 1956, p. 432) is not colony-forming like the present coral;

Aplophyllia d'ORBIGNY (1849) (*Haplophyllia* FROMENTEL, 1865, p. 13) differs from our coral in having extratentacular budding (see WELLS, 1956, p. 376);

Dendrophyllia BLAINVILLE (1830) differs from our coral in having synapticulotheca and extratentacular budding.

The neotype. The specimen figured in LYELL (1837 a) deserves the status of a (holo) type but unfortunately must be considered lost. The fossil, belonging to H. R. H. Prince CHRISTIAN, possibly together with conspecific topotype specimens must have been in BECK's charge in the Amalienborg castle in Copenhagen in 1837 and probably also in 1834. There is nothing to suggest that the material was not there also for a long time after 1837. It has not been particularly referred to by any author since then. In 1850 it was decided that geologically arranged fossils of the royal collections (such as the so-called Faxe collection) should be presented to the Mineralogisk Museum of Copenhagen University. Consequently, the BECK-LYELL material, together with other fossils, should have arrived at this museum long ago. However, a recent search of the various collections of the museum did not reveal the material, which is now considered lost. (See also LYELL, 1837 a; RAVN, 1902, 1903; CALLISEN, 1946; GARBOE, 1959, 1961). No author seems to have noticed the absence of the (holo)type and the fact that other possible members of a type-series could not be found.

Therefore, a neotype shall be designated here, preferably from among later figured specimens from the type locality. The one figured in HENNIG (1899), Pl. 1, Fig. 13, was stated to illustrate an uncommon condition and cannot now be recognized in the collections; and the one figured in Pl. 1, Fig. 14, cannot be recognized convincingly. Next to be considered are the specimens figured by NIELSEN in 1922; from these, specimen MMH 2043 is chosen and here designated as neotype for *Faksephyllia faxoensis*

(BECK in LYELL, 1837): it is figured as Pl. 1, Fig. 1, in NIELSEN (1922) and re-figured here (Pl. 4, Fig. 11). It was collected in Fakse limestone quarry (Middle Danian), in a soft coral limestone and is a secondarily calcitic skeleton fragment. The skeleton has been fractured *in situ* here and there but is far from seriously damaged.

The neotype demonstrates the characters mentioned diagnostically, with a few exceptions, viz. some characters that can be deduced from other features (depth of calice, smooth upper septal margins, slight exsertation). Variable specific characters are represented in the neotype as follows: 2 branches (5 mm thick) display 32 and 42 septa; the equal costae are granulated, columella diameter 1–1 $^1/_2$ mm, depth of calice 2 mm.

Diagnosis (based on material from the type locality in Denmark). Different septal numbers in simple parts of branches, *c.* 28–*c.* 52, roughly proportional to thickness of branch (*c.* 4 mm–*c.* 8 mm), and are most commonly 32, 36, or 42 (at the most common branch-diameters of 5–6 mm); budding with intervals of *c.* 1$^1/_2$–2 cm; angle between twin-branches about 30°–45°; depth of calice 2–4 mm; columella with diameter 1–2 mm, rather feebly constructed; slightly exsert septa, sparsely granulated on sides; costae broad or rather broad, for all septa or every second, equal to unequal, rather inconspicuous to almost indistinct, either almost smooth or densely and minutely granulated, commonly most distinct near calice; no stereomic filling of corallites.

Material. Usually, the skeleton substance is still preserved in the Greenlandic material; hollow mould preservation is uncommon. The material generally consists of rather small fragments representing detached corallum portions (observed in the field with length of 10 or more cm). The fragments usually are but 1$^1/_2$–2 cm high, a few of them without the conspicuous budding zones. A rather large number of calices, and perhaps one basal portion, are preserved. The material comprises almost 8,000 fragments, most of which have their outer sculpture somewhat damaged by slight wear and dissolution processes, but because inner structures and other characters appear uniform and because all stages of damage to sculpture have been studied, it is considered reasonable to include the specimens in one species. (A few specimens are so badly preserved that they are only doubtfully determined; this concerns mainly some crushed, softened skeletons and moulds from sandstone).

Description, of Greenlandic material. One fragment is believed to demonstrate the protocorallite but is badly preserved (protocorallites have not been recognized with certainty in material collected elsewhere). This find (Pl. 4, Fig. 7) suggests that the colony was initiated through budding from a tiny first corallite, only approximately $^1/_2$ cm high (internal diameter below: about 1 mm, and above: 3 by $4^1/_2$ mm). There is a complete lack of information about possible anchoring structures.

Intratentacular budding with distomodaeal or also tristomodaeal condition (rarely and by rapid distomodaeal budding), with trabecular linkage. The angle between new corallites usually is between 30° and 45°. The corallites are monocentric, mostly straight, and cylindrical, usually quite free laterally, and develop equally from each zone of budding. Corallum is formed by repeated budding; it is fasciculate and dendroid. No differences in dimensions of the corallites from the distal, and from the proximal end of the larger corallum fragments can be safely related to the level within the colony. (Concerning European material, NIELSEN (1922, p. 15) reports that the "branches in the same colony increase but slightly in circumference so that there is very little difference between the older and younger ones". And, on p. 16, he reports how the branches apparently are only slightly thicker in the lower portions of the corallum than in the upper. These features were not clearly recognized by the present writer during his study of NIELSEN's material).

Dimensions of the presumably bush-like corallum are unknown, but height may be estimated to have been about $^1/_2$ m. As a rule, the diameters of cross-sections of the corallites are from 4 mm to 8 mm; usually the corallite is 5 or 6 mm thick. In the zone of budding the cross-section is often pronouncedly oval, with axes about 5–6 mm by 9–10 mm. Budding generally takes place at every $1^1/_2$ or 2 cm but this interval may vary considerably.

The essentially dichotomous forking of corallites takes place in so many planes that a fan-shaped corallum apparently cannot be expected to have developed. NIELSEN (1922, p. 16) mentioned preferred budding in one plane for the Danish material but this has not been recognized by the present writer either in NIELSEN's or in other material from Europe. However, as NIELSEN (1922, p. 15) also stated, the corallum shape in the European material is "bushy".

The calice, of circular outline, is 2–3 mm deep. (NIELSEN's statement (1922, p. 15) that in the European material the calice has a "thickened sharply truncated edge" is clearly a misinterpretation).

Basal plate of protocorallite is unknown. Epitheca (e. g. collerettes) is missing. (Referring to the specimen figured by him as Pl. 1, Fig. 1, NIELSEN (1922) states that in the European material "occasionally plate-like formations uniting some of the branches appear". Such plates have been observed by the present writer among NIELSEN's and other material only in the specimen mentioned (viz. the neotype of *Faksephyllia faxoensis*) where they appear to be purely inorganic structures formed during diagenesis). Wall is a non-porous septotheca. It is not particularly heavy in the budding-zones and generally the thickness is uniform throughout the larger corallum fragments studied.

Septal numbers of the branches appear rather influenced by the budding-process and the exact septal number is of minor importance. To the most common branch-diameter of 5 or 6 mm corresponds a number-range of 32, 36, 38, 42. Septal number in the supposed protocorallite discussed above is 12 where diameter is about 1 mm; details of protosepta unknown. The septal arrangement occasionally displays coalescence but there is no indication of a regular substitution. The laminar septa with a median dark line each have one fan system of what is indicated to be simple trabecules and have on their sides a pattern of faint growth-lines and feeble striae along the trabecules. This pattern is made more distinct by sparse occurrence of small, rounded granulations. The upper septal margins are not too well-preserved but obviously must have been smooth or nearly smooth; this is corroborated by deductions from other septal features. (NIELSEN (1922, p. 16) mentions finely dentate upper septal margins in his European material, but this appears to be a misinterpretation of broken septa. Genuine dentations have not been observed by the present writer in NIELSEN's material). Slight exsertation. No pali, or paliform lobes. Columella trabecular, slightly to well developed but rather feebly constructed, 1–2 mm in diameter. (It was only on account of a differing concept of columella that NIELSEN (1922, p. 16) denied the presence of a columella in the European material studied by him; it in fact demonstrates trabecular columellae. Only occasionally the sections suggest such simple relations between septa as those shown in his Pl. 1, Fig. 3).

Costae may be quite distinct, particularly near calice, but usually are inconspicuous. They are equal or slightly unequal, and correspond to each or every second septum. They are low and usually broad bands, flat or slightly convex. Their ornamentation consists of fine and densely (but irregularly) placed rounded granules (with 4 or 5 at the same level); sometimes costae may appear smooth. Cristae usually are not developed. No synapticules. A few dissepiments, not vesicular. No tabulae. No coenosteum. Inner stereome usually reinforces septa and wall in a quite ordinary and very moderate way, and there is no filling up with stereome (such as is falsely suggested in some cases by diagenetically formed masses of calcium carbonate). (The filling up (with stereome ?) mentioned by NIELSEN (1922, p. 16) for his European material appears always to be with calcareous mud).

Identification and affinities. The Greenlandic material here described appears to be conspecific with *Caryophyllia Faxoensis* BECK in LYELL (1837 a) as this is known from the large material collected from the type locality and also elsewhere in Scandinavia. The species is the only known member of *Faksephyllia* gen. n.

Occurrence in Greenland

Lower Danian

Danienrygge at Kangilia: Basalt tuff:
Tuff I or Tuff II, 213 fragments, most of them with worn surface;
Tuff II: Ryg A, about 4,600 fragments, most of them with worn surface;
Ryg A or Ryg B, 15 fragments, most of them with worn surface;
Ryg B, about 1,750 fragments, most of them with worn surface;
Ryg C, 91 fragments, most of them with worn surface;
Ryg D, 1 fragment;
Danienrygge, 265 fragments, most of them with worn surface;
Tunorssuaq, Danienkløft, "Store Profil", 7 fragments, most of them with weathered surface;
Ilugigsoq, southern slope of Koralravine, about 580 fragments, some with worn surface.

Displaced: Ilugigsoq, Koralkløft, basalt tuff, 1951, 1952, 1953, 1957, about 400 fragments, presumably displaced from Koralravine. Probably Lower Danian.

Upper Danian

Agatdalen, Turritellakløft, "Store Profil":
a) Andreas Member, about 9 fragments (moulds), probable and dubious;
b) Abraham Member: Tuff beds, 4 fragments;
Tuff beds in the upper part, 1 probable example;
Tuff in the upper part (fallen material), 9 fragments;
Kangersôq, gorge descending from the 1,430 m mountain to the north, about 3 very dubious fragments;
Nuilaussarssuaq, about 4 dubious fragments.

Displaced: Angnertuneq, Vestre Konglomeratkløft, block of calcite-cemented conglomeratic shell-gravel from dark shales, 1957: 1 probable example. Probably Danian.

Occurrence outside Greenland

Denmark: Danian, Zone of *Tylocidaris bruennichi* (Middle Danian);
Sweden: Danian, probably Zones of *Tylocidaris rosenkrantzi* and *T. bruennichi* (i. e. in Lower and Middle Danian).

Superfamily **Flabellicae** BOURNE, 1905

Family **Flabellidae** BOURNE, 1905

Genus *Flabellum* LESSON, 1831

The type species is *F. pavoninum* LESSON, 1831. Synonyms (according to WELLS, 1956): *Phyllodes* PHILIPPI, 1841; *Blastotrochus* EDWARDS & HAIME, 1848 a; *Vasillum* TENISON-WOODS, 1879; *Lithomyces* PHILIPPI, 1887; *Placotrochides* ALCOCK, 1902; perhaps *Ulocyathus* SARS, 1856.

The genus (according to WELLS, 1956, p. 432) has a stratigraphic range from the Eocene in a broad sense, to Recent time. However, Cretaceous examples have been recorded from Alabama (GABB & HORN, 1860), and California (DURHAM, 1943); and a

Paleocene (Danian) example from Denmark. Further, Paleocene examples have been reported from the Heersian of Denmark (*Trochocyathus calcitrapa* Koenen, 1885), and from deposits in Alabama (Vaughan, 1900 b), Virginia (Vaughan, 1900 b), Texas (Vaughan & Popenoe, 1933), California (Gabb, 1864; Durham, 1943), and Austria (Kühn, 1967). But the record of a *Flabellum* (viz. *Trochocyathus calcitrapa* Koenen) in the Danian of Denmark (Nielsen, 1922, 1926) has proved to depend on poorly preserved and virtually undeterminable moulds. Moreover, Koenen's species (range, see above in the discussion of *Caryophyllia andreasi*, p. 45) is not a *Flabellum* but, as shown by Różkowska (1955), is a *Caryophyllia* (it more probably belongs to the (sub)genus *Premocyathus*, see p. 45).

Flabellum groenlandicum sp. n.

Pl. 5, Figs 6 A – 6 B; Pl. 6, Figs 1–33; Text-Fig. 16

Holotype. MMH 12,682 (Pl. 5, Figs 6 A – 6 B), from Lower Danian conglomerate immediately above Tuff I, Ryg B, Danienrygge at Kangilia, Nûgssuaq, West Greenland. It consists of two pieces of a skeleton which together demonstrate small portions of the calice, not the most basal region but nevertheless with indication of attachment disc. They also show the slightly developed pedicel of a compressed, trochoid to turbinate straight corallum, 48 septa (12 principal), columella, and stereome. Indistinct costae. A partial section in the corallum, where this is compressed turbinate and about 9 mm broad, clearly suggests the total septal number of 24 (3 complete cycles) (and also 24 rudimentary septa) with stereomic part of wall about 1 mm thick. Actual height 20 mm, diameters 11.3 mm by about 9 mm (slight crushing).

Diagnosis. Fixed corallum, often with pedicel. Shape may be trochoid, compressed trochoid, compressed turbinate (some cases with flabellate young stage), rather slenderly flabellate, cuneiform (some cases with flabellate young stage), or compressed subcylindrical (young stage flabellate or cuneiform). Faces of corallum are not concave. Axis of corallum is usually straight, or curved in one or another plane. Acute edges and even poorly developed small wing-like structures may be found in specimens with oval cross-section. Height rarely exceeds 25 mm, diameter-ratio 1–2.25 (common values 1.3 and 1.5), with diameters usually 9–10 mm by 6–8 mm. Calicular margin neither scalloped nor polygonal. Depth of calice 1–4.5 mm. At the basal plate 6 septa are developed, meeting at the centre. 12 principal septa, septal number 24 to 48, in big specimens, or even a few more. A cross-section of about 9 mm (major) diameter of compressed turbinate corallum shows at least 3 complete cycles of septa. Columella not very feeble, reached by only 12 septa. End-costae may develop into short and low wing-like structures; otherwise costae are inconspicuous; they never give corallum surface an undulating aspect, and they may even be lacking or "negative" (depressed); 24 or 48 equal ones or 12 big ones combined with 36 small; no particular sculpture. Internal stereome more or less fills the most basal part of corallum and almost regularly fills the lower third of the corallum.

Material. About 50 specimens found loose and about 1,275 specimens *in situ*. Skeletons by far dominate; some of them are softened. Nevertheless, a few of the corals are represented by outer and inner moulds only. Finest details of the outer surfaces are usually not very well-preserved because of slight wear and dissolution. The basal portions of coralla dominate the material, probably because of their reinforcement with internal stereome; basal discs are rather common, while few calice-margins are present.

Description. Coralla range from trochoid through compressed trochoid and compressed turbinate, or rather slenderly flabellate, to shapes characterized by flabellate young stage continued in a compressed turbinate, or a cuneiform (or series of flabellate stages), or a compressed subcylindrical stage, and to shapes characterized by cuneiform young stage continuing in a cuneiform or a compressed subcylindrical stage (see Fig. 16).

Faces of corallum not concave. Corresponding to the longer axis, where a cross-section is found with more or less oval outline, acute lateral edges on the corallum may be formed, which sometimes at different levels and over minute distances develop into small wing-like structures. These have no particular sculpture. Ordinary growth-lines on wall are not very conspicuous; they are almost horizontal on trochoid and compressed trochoid coralla but on flat sides of flabelliform coralla are distinctly convex upwards. Coarser restrictions of coralla caused by growth retardation are sometimes found and may be very pronounced. Coralla usually (in about 90 % of the material) are straight, or the axis curves gently in one or another plane. Corallum was fixed throughout life with a small base. A distinct pedicel is often observed, mostly in connection with flabellate stages where it may be very conspicuous. The cross-section of the pedicel is circular, with the diameter about 1.5 mm to a pedicel height of 1–1½ mm. Corallum height usually is 15–20 mm, but it can exceed 25 mm. Ratio of diameters of cross-section at calice varies from 1.0 to 2.25. Common values are 1.3 and 1.5. Major calice diameters are 6–14 mm (usually 9–10 mm), minor calice diameters are 4.0–10.5 mm (usually 6–8 mm). Calicular margin is neither polygonal in outline nor scalloped. Depth of calice 1–4.5 mm. Diameter of basal plate, with circular outline, about 1.5–3 mm; the plate normally is thickened with stereome. At the base of the pedicel 6 protosepta are found joining each other at the centre; 2nd-cycle septa are not observed. The protosepta regularly appear thick, and most or the whole of the interseptal spaces is filled with stereome. The monocyclic wall is formed by stereomic thickenings of outer septal portions and by a thin epitheca. Epitheca is only rarely preserved in more than small areas and sometimes has been completely removed by slight wear. It is shining, and has no particular sculpture or it appears sporadically and indistinctly granulated with minute granules. It often displays thin growth-lines or growth-segments.

Number of principal septa is 12. The septal number is 24 in small specimens and otherwise tends to be 48. Sometimes a few septa additional to 48 are developed near the ends of the longer axis in the largest coralla. In a cross-section about 9 mm broad at least 3 complete cycles of septa are found in compressed turbinate coralla. Septum is laminar, with median dark line, simple trabecules indicated, axis of divergence (one fan system) appears to be placed close to the epitheca. Septal sides are mainly sculptured only by faint growth-lines and faint trabecular striae but they also display a few small granules, which mainly are arranged along the trabecules. Inner margins undulating. Upper margins smooth. No exsertation. No pali nor paliform lobes. Columella trabecular, not very feeble, sometimes heavily constructed, made by 12 septa only; the shape of its cross-section corresponds to that of the corallum and hence is very often oval, with a maximum diameter at calice reaching 4 mm in larger coralla.

Costae are inconspicuous and may even be lacking or "negative" (depressed). When developed, common conditions are 48 equal costae, or 24 equal, or 12 big equal combined with 36 smaller equal ones. No special sculpture. Occasional development of end costae into low and short wing-like structures. Costae are never so coarse as to give the corallum surface an undulating aspect. In coralla showing indications of growth retardation the subsequent ontogenetic stages may show different forms of costation.

No synapticulae, no dissepiments, no tabulae. Stereome forms part of the wall in thickening the ends of septa, it more or less fills the most basal region of coralla and also almost regularly fills approximately the lower third of the adult coralla. Some small basal fragments lacking stereomic filling above the level of the pedicel but otherwise identical with larger fragments from the same localities are reasonably considered to belong to juvenile individuals. They are particularly common in the Upper Danian Sonja Lens (sampled by washing), where their abundance may be a result of sorting before embedding.

The material has many variable characters. The most conspicuous variation is that of the corallum shape. With this is connected the variation in curvature of growth-lines on the wall. The variation of the remaining characters does not seem to justify a differentiation of the material into two or more species. Concerning corallum shape, all recognized varieties are found to form a group or series, some spectacular members

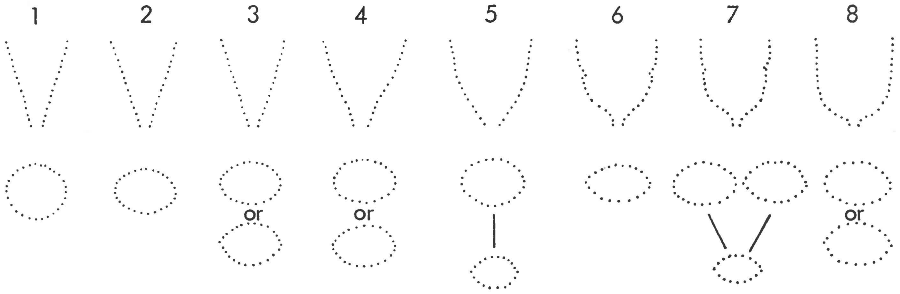

Fig. 16. Sketch of corallum shapes in *Flabellum groenlandicum* sp. n.

of which are sketched in Fig. 16. Occurrence (x = occurring; X = common occurrence; numbers refer to sketches in Fig. 16):

	1	2	3	4	5	6	7	8
Turritellakløft, "Store Profil", Abraham Member	–	x	X	X	x	x	x	–
Turritellakløft, "Store Profil", Turritellakløft Mb.	–	x	x	x	x	x	X	X
Agatkløft, Sonja Lens	x	x	X	x	x	X	X	x
Danienrygge, Tuff II	–	x	x	X	x	x	x	x
Danienrygge, Conglomerate immediately above Tuff I	x	X	x	x	x	x	x	x

The whole group or series, with intermediate shapes providing a gradual transition, is recognized in two of the five localities that have yielded the largest collections. In the remaining three of the rich localities, one or both of the two extreme members of the series have not been found. Material from other localities or horizons, found *in situ* or displaced, falls within the limits of the variation series.

Different shape varieties dominate among the adult or almost adult coralla in the five rich localities. The youngest association, about 80 specimens from coarse basalt tuff of the Abraham Member, is dominated by compressed trochoid to turbinate or flabellate coralla. The association (about 250 specimens) from the coarse sandstone of the deltaic Turritellakløft Member is dominated by a corallum which begins flabellate and continues as compressed subcylindrical or cuneiform, often with distinct retardations of growth. In this association the thick cuneiform type with continuation more or less evenly into a compressed subcylindrical or cuneiform adult stage is particularly common. The association (about 600 specimens) from the sandstone of the deltaic Sonja Lens is represented in the collection mainly by proximal portions of skeletons. The dominating shape of corallum is a strongly compressed trochoid one or a corallum which begins flabellate but continues as compressed subcylindrical or rather cuneiform (series of flabellate stages; restrictions caused by retardation of growth are common). The Lower Danian association (about

40 specimens) from the coarse basalt tuff, Tuff II, in Danienrygge at Kangilia is dominated by a compressed turbinate or flabellate corallum. The oldest large association, about 220 specimens from the conglomerate immediately above Tuff I in Danienrygge, as represented in the collection, is dominated by a slightly compressed trochoid corallum (axis ratio about 1.3). Indications of changes in growth are not conspicuous in this association.

Apart from the Sonja Lens collection, the collections cannot be assumed to contain a full representation of small, juvenile individuals belonging to the associations.

The gradual transition between forms at each stratigraphic level, and also the persistence of certain shape types through the Lower Danian and the Upper Danian within northwest Nûgssuaq, gives the impression that a specific unit is present. The other characters observed in the material are in agreement with this view.

The preponderance of certain forms at certain levels cannot immediately be explained as reflecting specific evolution. Dominance of certain shape types in certain formations could be explained by some post-mortem sorting but more probably is to be explained as mainly reflecting different and varying ecological conditions. Among these, variation in size of substrate particles of the bottom sediment, in erosional and depositional effects on this sediment, and differences in availability of food might well have caused variations like those observed in the shape of the corallum (ecophenotypes). Because the individuals often demonstrate changes in the form of corallum during their development, one should suppose that the environmental conditions sometimes changed rather suddenly and violently. This is corroborated by the nature of the sediments.

Affinities. This protean species is related to the *Flabellum rubrum* group (see SQUIRES, 1958 a, p. 63). Yet, so far, no specific identity with any early, certain or possible, member of the group has been ascertained.

The Greenlandic species is compared with the following Cretaceous to Eocene Flabellum species as known from the literature.

Neither *Lithomyces aequalis* PHILIPPI, 1887, nor *L. costatus* PHILIPPI, 1887, are well known to the present writer but are mentioned by VAUGHAN (1907, p. 50) as Tertiary species close to *F. pavoninum* and therefore can safely be assumed to have a shape of corallum very different from those met with in the Greenlandic species. The present writer knows of no additional species, from the Cretaceous-Eocene, which have been referred to any of the genera listed as synonyms of *Flabellum*. A comparison with "*F. striatum* GABB & HORN (1860)" from the Cretaceous of Alabama has not been made (VAUGHAN, 1900 b, found the original description and figures poor and the type material insufficient for specific characterization). *Flabellum* sp. (in ANGELIS, 1907) from the Eocene (Patagonico infer.) of Argentina is quoted in FELIX, 1925, p. 186, but otherwise is unknown to the present author and has to be omitted from consideration here. The Eocene *Flabellum* sp. (in TOULA, 1892, the unfigured one) from Bulgaria was said to be only feebly costate; a direct comparison cannot be made. The Eocene *Flabellum* sp. (in WELLS, 1945) from Barbados might be rather similar to the present species, but the material is so badly preserved as to prevent any further discussion. The Upper Eocene (?) *Flabellum* (?) *simplex* TENISON-WOODS, 1880, from New Zealand, does not appear to be well known and the type material is lost (see SQUIRES, 1958 a, p. 66); no comparison can be made.

F. fresnoense DURHAM, 1943, from the Upper Cretaceous of California, differs in having 16 principal septa to a total of 24, in a cross-section measuring 7.9 mm by 5.7 mm;

F. texense VAUGHAN & POPENOE, 1933, from the Paleocene Kincaid Formation of Texas, differs in having more pronounced wing-like processes and through being more coarsely costate;

F. remondianum GABB, 1864, (non VAUGHAN, 1900 b, see DURHAM, 1943), has a greater number of principal septa;

F. ? sp. (in DURHAM, 1943), differs in having about 72 septa in the poorly cuneiform corallum (basal fragment with largest diameter about 13 mm);

F. sp. (in VAUGHAN, 1900 b; 1901), is not well known but in its general shape it somewhat resembles some almost equally sized broadly flabellate Greenlandic specimens; the figured specimen (1901) differs from those in having 19 principal septa and more distinct costae;

F. primitivum KÜHN, 1967, from the Paleocene (Thanetian, see KÜHN & TRAUB, 1967) of Austria, is diagnosed on fragments of 3 coralla, which show only 2 complete septum cycles (columella-forming) and traces of a third (not columella-forming). Additional information is scarce. At least the holotype demonstrates the septal apparatus in a compressed turbinate corallum where this is about 9 mm broad and thus differs from relevant Greenlandic specimens;

Concerning *Flabellum conoideum* VAUGHAN (1900 b) and the "variety" *matthewsense* VAUGHAN (1900 b) more information would be desirable: *F. conoideum* VAUGHAN, from the Upper Paleocene (Naheola, Sucarnochee) of Alabama, and from the Paleocene of Texas (VAUGHAN & POPENOE, 1933), has obscure costae and, apart from the broadest specimens, is in size and shape similar to some of the Greenlandic specimens; however, it differs from the present species in having 16 principal septa. (DURHAM, 1949, found but 6 septa at the base of the pedicel, that is the same number as found in the present species). "*F. conoideum* var. *matthewsense* VAUGHAN" is of Paleocene age and has been reported from Alabama (Naheola age), Texas (Kincaid Formation; VAUGHAN & POPENOE, 1933), and (?) Arkansas (a specimen figured by HARRIS, 1894, was considered by VAUGHAN, 1900 b, as probably belonging to his variety). VAUGHAN (and also VAUGHAN & POPENOE) found the "variety" to differ from "typical" *F. conoideum* in having well-developed costae but also found that it graded directly into the "typical" form. Size and shape seem to fall within the range of "typical" *F. conoideum.* All the specimens that were examined by VAUGHAN had only 12 principal septa each. From VAUGHAN's text is inferred that the epitheca is different from that of "typical" *F. conoideum* (these features cannot be very well studied in the Greenlandic material). In its typical form each of the groups differs from the present material (in number of principal septa or in more developed costae). The specimens with distinct but weak costae, which were attributed to the "variety" *matthewsense* could be presumed to have 12 principal septa and to that extent might well be similar to some of the specimens of the Greenlandic material. But for the present too little is known for certain about them for a safe revision of their proper systematic position;

F. stantoni DURHAM, 1943, (description in VAUGHAN, 1900 b), differs from the present species at least in having wings and through being more coarsely costate;

F. bosniacum Oppenheim (1901), differs through being very broadly flabellate and also in having 24 principal septa;

F. sp. (in Toula, 1892, the figured one), differs in 16 very strong costae corresponding to the principal septa of only slightly compressed flabellate corallum;

F. sp. (*F. rubrum* species group) (in Wells, 1945), from the Eocene of Barbados, like the Greenlandic specimens has 12 principal septa; the corallum is about the same size and is cuneiform, but uncertainty exists concerning the base of the only known specimen, and this therefore cannot be compared directly with the Greenlandic cuneiform specimens. Too few other characters are known from the specimen for an evaluation of possibly close affinity with the present species;

F. antillarum Wells, 1945, has nodose ribs alternating with the septa, and about 20 septa reach the columellar region (holotype, where 11 mm wide);

F. appendiculatum (Brongniart, 1823), has distinct wings (and 16 principal septa are suggested by Brongniart's figure) and thus differs from the present species. Other material referred to Brongniart's species has 12 principal septa (as in the present species) but also has wings, in the lower third (see Kühn, 1966);

F. dufrenoyi (d'Archiac, 1846), (see Edwards & Haime, 1848 a), at least differs in having wings. *F. dentalinum* (d'Archiac, 1846) was based on juvenile *F. dufrenoyi*, according to Edwards & Haime, 1848 a;

F. clarki Bentson, 1943, differs in its somewhat different shape (faces of flabellate corallum concave) and in having a different number of principal costae (8 or 9 (16 or 18 ?)); the number of principal septa appears to be greater than in the Greenlandic species (Pl. 51, Fig. 15);

F. johnsoni Vaughan, 1900 b, differs in having 16 principal septa, in a corallum with polygonal cross-section;

F. lerchi Vaughan, 1900 b, differs through being far more coarsely costate;

F. renevieri Mayer, 1877, differs at least in having 18–20 costae, 9–10 of which are comparatively strong and can be assumed to represent 9–10 principal septa;

F. vaginale Michelin, 1846, at least differs in having wings;

F. mortoni Vaughan, 1900 b, differs at least in having a very feeble columella and only a small amount of stereome;

F. californicum Vaughan, 1900 b, from the Eocene of California, has flabellate to cuneiform coralla of a size equal to that of the Greenlandic material and, as in this, costae (12 principal) are not prominent. Another similarity is the septal number, 48 (about 52, according to Vaughan), with 12 major septa (Durham, 1943). A difference from the present species as a whole is that *F. californicum* usually has the corallum curved in plane of the shorter calicular axis (Vaughan; Nomland, 1916, figured two (worn ?) specimens, of which one was positively stated to be a straight one; Durham, 1943, did not figure any specimen, neither did he comment on the curvature). Unfortunately, the first and short description was made on poorly preserved specimens, and later authors (Nomland, 1916; Durham, 1943) have not given additional information on, e. g., possible stereomic filling of the corallum. A few of the Greenlandic specimens (less than 5 $^0/_0$) could possibly be connected with Vaughan's species, with its characteristic corallum shape. Costulation is different in some of them, however, and unfortunately is poorly known in the remainder. Thus, knowledge is imperfect about both the Greenlandic specimens concerned, and Vaughan's species in its typical form. The similarity observed is due to few and simple characters, and it may well be incidental. So far it seems most reasonable to keep the few specimens together with the remaining Greenlandic material, which is different from Vaughan's species in its typical form, and not to refer the few specimens, and with them the whole Greenlandic material, to Vaughan's not too well known Eocene species. Too little is known about the remaining

American specimens, in particular the straight specimen figured by NOMLAND, to decide their degree of affinity with the Greenlandic species. *F. californicum* and the Lower Paleocene Greenlandic species are here considered as separate (probably closely allied) species. There are notable differences in the number of coralla which possess certain shapes: *F. californicum* is flabellate to cuneiform and usually is curved in plane of the shorter axis (including the specimens figured by VAUGHAN); while *F. groenlandicum* usually (about 90 $^0/_0$) is straight (including holotype) and otherwise is curved in one or the other plane, and also has a large portion of coralla (approximately one third ?) which are neither flabellate nor cuneiform at any stage (which is the case with the compressed, trochoid to turbinate holotype);

"*F. californicum fiedleri* DURHAM (1943)", from the Eocene of California, with straight axis (?), appears to be very similar (yet larger) to a form that is common in the sandstone of "Store Profil" of Turritellakløft, but it differs from the present species in having 3 cycles of septa apparently reaching the columella, and also in a proportionately very deep calice;

F. circulare TENISON-WOODS, 1880, as known from SQUIRES (1958 a), who revised it as a subspecies to *F. pavoninum*, clearly is different from the present species through its corallum shape and its high septal number. *F. radians* TENISON-WOODS, 1880, was included by SQUIRES (1958 a) as a synonym differing from the present species through the same characters;

F. distinctum EDWARDS & HAIME, 1848 a, (see SQUIRES, 1958 a, who revised the corals as a subspecies to *F. pavoninum*). The Eocene members are distinctly different from the present species through their shape and high septal number;

F. apertum apertum MOSELEY, 1876. The Eocene members differ from the present species in their scalloped calicular margins and in their lack of internal stereomic fillings (see SQUIRES, 1958 a);

F. sphenodeum TENISON-WOODS, 1880, (see SQUIRES (1958 a), who revised the corals as a subspecies to *F. rubrum* (QUOY & GAIMARD, 1833)). According to SQUIRES, the corals have the septal number of 60–75, and the number of principal septa is 15 or higher;

The Middle Eocene-Lower Oligocene *F. cuneiforme* (LONSDALE, 1845) (in the sense of VAUGHAN, 1900 b, who recognized several "varieties", some of which had been described earlier as distinct species), occurring in Alabama, South Carolina, Mississippi, Louisiana, Arkansas (HARRIS, 1894, cited by VAUGHAN), Georgia, and Texas, generally has stereome filling in the lower portion and partially is rather similar to parts of the Greenlandic material in shape and often also in costulation; however, it differs in having 24 principal septa. It should be noted that DURHAM (1949) recognized the septal number of 12 at the base of the pedicel of a "variety" of *F. cuneiforme* and that stereome filling in the same began only at some distance above the base. None of the 12 septa met at centre. These observations are contrary to the conditions met with in the Greenlandic species;

F. sp. (in BERRY, 1929), differs at least in proportionately broad flabelliform shape;

F. idae TOULA, 1892, differs in its 6 very strong costae on flabellate corallum with 17 (16 ?) principal septa;

F. costatum MICHELIN, 1846, appears to differ from the Greenlandic species at least in having wings and may also differ in having proportionately coarse costae (as figured by MICHELIN);

F. bellardii HAIME in BELLARDI, 1850, as known from the information given by EDWARDS & HAIME, 1857, differs in having 16 larger septa;

F. oligophyllum REUSS, 1874, from the Priabonian of Italy, differs from the present species at least in its fewer septa.

The Greenlandic species can be distinguished from the species commented on above though doubt is indicated in some cases. It is here considered new.

It appears that morphologically the Greenlandic species agrees in a general way with many of the earliest known *Flabellum*-species as these are found in America and in Europe. However, the question of the closest affinities of the Greenlandic species must remain open. Too little is known about some characters and their variation in most of the penecontemporaneous species.

The closest affinities might be suggested to exist with the following corals: *F. fresnoense; F. conoideum*, and "*F. conoideum* var. *matthewsense*"; *F. texense; F. primitivum; F.* sp. of the *F. rubrum* group (in WELLS, 1945); Eocene "varieties" of *F. cuneiforme; F. californicum;* "*F. californicum fiedleri*"; and *F. oligophyllum.* Future studies of these may result in a new evaluation of some *Flabellum* species, including the Greenlandic, and their relationships.

Occurrence

Lower Danian

Danienrygge at Kangilia:

    Basalt tuff: Tuff I Ryg C, 3 specimens (1 is dubious);
    Conglomerate immediately above Tuff I, Ryg B, 223 specimens;
    Basalt tuff: Tuff I or Tuff II, 6 specimens;
        Tuff II, Ryg A, 35 specimens;
            Ryg B, 4 specimens;
            Ryg A + B, 2 specimens;
            Ryg D, 1 specimen;

Angnertuneq, gorge complex of Vestre Konglomeratkløft, 1957, 14 specimens;
Tunorssuaq, Danienkløft, "Store Profil", 2 specimens.

Displaced: At Kangilia, calcareous concretions from dark shale with quartz sand and also coarser particles of reworked material, about + 700 m, and + 730 m, 1939; 5 probable examples. Probably Lower Danian.

Upper Danian

Agatdalen:

    Qaersutjægerdal, "Store Profil", 4 specimens;
    Agatkløft, "Store Profil", Sonja Lens, about 600 specimens;
    Turritellakløft: Konglomeratnæsen, 4 specimens; "Store Profil":
    a) Turritellakløft Member: Lowermost sandstone bed (1948, 1956, 1958, 1961, 1964, 1968), 194 specimens; lowermost-but-one sandstone bed (1948), 1 specimen; two lowermost sandstone beds (1946, 1948, 1949, 1953, 1958), 75 specimens; sandstone bed no. 6 from below (1961), 13 specimens;
    b) Abraham Member: Tuff beds, 10 specimens; tuff bed no. 4 (1946), 3 specimens; tuff beds in the upper part, 8 specimens; tuff in the upper part (fallen material), 60 specimens; tuff in the upper part below pillow lava, 2 specimens;

Kangersôq, gorge descending from the 1,430 m mountain to the north, 16 specimens, of which some are dubious;
Nuilaussarssuaq, 14 specimens, of which one dubious;
Tunorqo, 1 specimen.

Displaced: Turritellakløft, 31 specimens, of which 1 is a dubious example;
Kangersôq, western part of the double gorge just to the east of the gorge descending from the 1,430 m mountain to the north, 6 specimens;
Ilugigsoq area, 1952, about 5 specimens; at +600 m, 1952, 14 specimens;
Agatdalen, Agatkløft, conglomeratic quartz sandstone, 3 specimens probably belonging to the present species.
This displaced material probably is of Upper Danian age.

Suborder **Dendrophylliina** VAUGHAN & WELLS, 1943

Family **Dendrophylliidae** GRAY, 1847

Genus *Balanophyllia* WOOD, 1844

The type species is *B. calyculus* WOOD, 1844. According to WELLS, 1956, *Osteodes* CONRAD (1855), *Leptopsammia* EDWARDS & HAIME (1848 b), ? *Clonotrochus* SCHAFHÄUTL (1863), and *Rhodopsammia* SEMPER (1872) are synonyms.

Balanophyllia sp., cf. *ponderosa texana* VAUGHAN & POPENOE, 1933

Pl. 6, Figs 34 A – 34 B

1933 *Balanophyllia ponderosa* var. *texana* VAUGHAN & POPENOE, pp. 341–343, Pl. 4, Figs 6–12.

Material. Seven individuals are represented by fragments of skeletons showing no calices and no bases. Outer surface is preserved partially but in many cases shows evidence of slight pre-embedding wear, of subsequent dissolution processes acting within the sediment, and of weathering.

Description, of Greenlandic material. Basal angle unknown, angles measured in preserved fragments are between 20° and 25°; probably the coralla were slenderly trochoid. In most coralla the cross-section is distinctly oval. Axis of corallum so far as is known almost straight or slightly curved in one or the other direction in relation to the oval cross-section. The shape of some of the fragments (also of the figured specimen, MMH 12,716) indicates that the corals were fixed by a broad base. Dimensions of the 7 fragments (all measurements in mm):

Height	15.5	22	17	14	11	20	11
Major diam., largest cross-section	*c.* 9.5	10.0	11.5	8.3	8.5	7.7	12
Minor diam., largest cross-section	*c.* 8.5	8.7	9.8	7.2	8.5	6.8	10
Major diameter: minor diameter	1.12	1.15	1.17	1.15	1.0	1.13	1.20

(The 15.5 mm high fragment is MMH 12,716). The diameter-ratio appears to be constant throughout each of the fragments.

Basal plate and calice unknown. The calice presumably had oval outline. Epitheca possibly present in the lower part of some of the fragments (not observed in the figured specimen), its sculpture, if any, is not known. Wall is a synapticulotheca, $^1/_2$–1 mm thick, and with many small lacunae. The pores to the outside between costae are obliterated by stereome (and epitheca ?) in some cases.

Septal number (48–) 72–about 90. Septal arrangement evidently in accordance with the Pourtalès plan. Septa are rarely porous, commonly they are laminar or apparently so, with traces of median dark line, probably with simple trabeculae. Axis of divergence coincides with the wall, one fan system. Septal sides sparsely granulated, inner margins slightly lacerate. Upper margins not observed, but in accordance with other septal structures they are reasonably assumed to have been either smooth or slightly dentate. Conditions of exsertation unknown. No pali or paliform lobes. Columella trabecular with an oval cross-section conforming to the oval cross-section of the corallum, diameters approximately one quarter of the corallum diameters. Costae correspond to all septa and in arrangement reflect the Pourtalès insertional scheme followed by the septa. Apparently the costae were subequal. They are low, finely granulated ridges. The granules are found 1–3 across, in an irregular arrangement. No cristae. Simple synapticules are present in the wall, in the columellar region, and in septal coalescing zones. Dissepiments occasionally have been observed. In some cases stereome seems to have played a rôle in filling the pores of the wall, and of the septa (?), but no trace of a filling up of the lower portion of the corallum has been recognized.

One or two specimens show a constriction at approximately half the height suggesting rejuvenation.

Affinities. The material shows the following differences from Paleocene-Eocene *Balanophyllia*-species as known from the literature.

It differs from *B. cowlitzensis* DURHAM, 1943; *B. desmophyllum desmophyllum* EDWARDS & HAIME, 1848 b, (see also VAUGHAN, 1900 b, 1901); *B. gravesii* (MICHELIN, 1844), (see also EDWARDS & HAIME, 1848 b); *B. inauris* VAUGHAN, 1900 b; *B. tenuistriata* EDWARDS & HAIME, 1848 b; *B. piuraensis* WELLS, 1941 b, (at least the holotype); *B. schlosseri* TRAUB, 1938; and *B. washingtonensis* DURHAM, 1942, owing at least to features of dimensions. It differs from *B. desmophyllum microcostata* VAUGHAN, 1900 b; *B. irrorata irrorata* (CONRAD, 1855), (see VAUGHAN, 1900 b); *B. irrorata coniformis* VAUGHAN, 1900 b; *B. irrorata dichotoma* (GABB & HORN, 1860), (see VAUGHAN, 1900 b); *B. irrorata mortoni* (GABB & HORN, 1860), (see VAUGHAN, 1900 b); and *B. haleana* (EDWARDS & HAIME, 1848 b), (see also VAUGHAN, 1900 b), from the Lower Eocene of Alabama, on the basis of at least its costal features.

It differs from *B. annularis* VAUGHAN, 1900 b, at least in its epitheca (?)-, and wall structures, and in the feature of, so far as is known, not being filled up with stereome; from *B. campanulata* DUNCAN, 1870, (see SQUIRES, 1958 a), Australia, where reasonably including *B. caliculata* DENNANT, 1904, see SQUIRES; and New Zealand (SQUIRES), in its shape; from *B. elongata* VAUGHAN, 1900 b, Eocene (a possible occurrence in the Netherlands, GRUYTER, 1944); Oligocene, U. S. A., through having no or at least less internal stereome filling; from *B.* sp. (in BERRY, 1929), in its weakly curved corallum; from *B. geniculata* (d'ARCHIAC, 1846), (see EDWARDS & HAIME, 1848 b), in having more septa in an equally large corallum; from *B. traubi* KÜHN, 1967, in its shape and less spongy wall; from *B. variabilis* NOMLAND, 1916, through having a more vesicular wall (unnamed "variety" described by MERRIAM & TURNER (1937) has less vesicular walls than NOMLAND's material); from *B. augustinensis* VAUGHAN, 1900 b, from the Middle Eocene of Texas, at least in not having septa heavily reinforced by stereome; from *B.* sp. cf. *irrorata* (CONRAD, 1855) (in WELLS, 1945), from the Eocene of Barbados, apparently in costal features, but the state of preservation of the American single specimen prevents any full discussion; and from *B. ponderosa ponderosa* VAUGHAN, 1900 b, Paleocene, Alabama, at least in that its coralla are not so large and coarse.

From the typical members of *B. ponderosa texana* VAUGHAN & POPENOE, 1933, from the Paleocene (Kincaid Formation) of Texas, it differs in, e. g., its more weakly curved coralla. However, some specimens of the small-sized American subspecies are nearly straight and they are also similar in many other respects to the Greenlandic material. The latter might belong to the subspecies, but the question cannot be solved so long as the Greenlandic fossils have given no detailed information on the most basal parts of corallum, the calice, or the epitheca.

(Information was not available concerning an Eocene coral reported from Argentina by ANGELIS (1903) (see FELIX, 1925) as *B. caulifera multigranosa* VAUGHAN, 1900 b, (i. e. a coral first described from the Oligocene of North America), and the Eocene *B.* sp. (in GERTH in MARTIN, 1922) from Java, see GERTH (1931). Comparative information was again lacking for the Eocene *B.* (?) *vermicularis* (SCHAFHÄUTL, 1863), Germany, see FELIX (1925, pp. 158, 286), with synonymy. This species seems to be the only representative of SCHAFHÄUTL's genus, *Clonotrochus* (1863), which WELLS (1956) also considered a questionable synonym to *Balanophyllia.* The species of two other of the synonymous genera appear to be exclusively modern and are here omitted from consideration. The fourth synonymous genus is *Osteodes* CONRAD, 1855. Very few species appear to have been classified at any time as *Osteodes.* Three seem to be more conveniently treated as two *Balanophyllia*-species (one Oligocene, and one Eocene commented on above), and one *Eupsammia*, see, e.g., VAUGHAN, 1900 b; *O. cyanthus* CONRAD, 1855, appears to be a nomen nudum, see VAUGHAN, 1900 b, p. 198.)

Among the species listed, *B. augustinensis; B. haleana; B.* sp. cf. *irrorata;* and *B. ponderosa ponderosa* seem to have rather close affinities with the species represented in the imperfect Greenlandic material. This possibly belongs to *B. ponderosa texana* VAUGHAN & POPENOE, 1933.

Occurrence
Lower Danian
Danienrygge at Kangilia, basalt tuff: Tuff II, Ryg A, 7 specimens.

Genus *Dendrophyllia* BLAINVILLE, 1830

The type species is *Madrepora ramea* LINNÉ, 1758 (subsequent designation by EDWARDS & HAIME, 1850 b). Several authors, and among them WELLS (1956, p. 435) mention the Recent *Brasseyia* WRIGHT, 1882, as synonymous with *Dendrophyllia.*

Dendrophyllia candelabrum HENNIG, 1899

Pl. 6, Figs 35–37; Pl. 7, Figs 1–6; Pl. 8, Figs 1 A – 1 B

The growth of knowledge on the occurrence in Greenland is sketched in the introduction (pp. 5–6). List of literature on the Greenlandic occurrence:

1940 *Dendrophyllia:* Rosenkrantz (in Rosenkrantz *et al.*), p. 658.
1945 *Dendrophyllia:* Poulsen in Bøggild, p. 16.
(1963c *Dendrophyllia candelabrum:* Rosenkrantz, p. 1, unpublished MS).
1966 *Dendrophyllia:* Rasmussen, p. 156.
1969 *Dendrophyllia candellabrum:* Rasmussen, p. 98.
1969 *Dendrophyllia candelabrum:* Henderson, p. 41.
1970 *Dendrophyllia candelabrum* Hennig*:* Rosenkrantz, pp. 412, 427, 444.
1971 *Dendrophyllia candelabrum:* Birkelund, p. 106.

Selected references to literature on the occurrence of the species in northern Europe:

1857 *Cladocora:* Karsten, p. 11.
1899 *Dendrophyllia candelabrum*, n. sp.: Hennig, pp. 8–11, Pl. 1, Figs 6–12;
  Dendrophyllia candelabrum, HNG.: Hennig, p. 14;
  Dendrophyllia: Hennig, pp. 3, 5;
  Lobopsammia faxensis, BECK sp.: Hennig (pars), pp. 11–13, Pl. 1, Figs 15, 16.
1922 *Dendrophyllia candelabrum*, Hennig: Nielsen, pp. 16–17, Pl. 1, Figs 8–22.
1933 *Dendrophyllia candelabrum* HNG.: Hadding, Text-Fig. 16.
1944 *Dendrophyllia candelabrum:* Andersen, p. 317, Text-Fig. 261.
Probably: 1957 *Rhabdophyllia faxoensis:* Alloiteau, with rejection of the generic identification, p. 181.
1960 *Dendrophyllia candelabra:* Rosenkrantz & Rasmussen, p. 9 (description of the type locality).
1966 *Dendrophyllia candelabra:* Rasmussen, p. 58 (figured); also (name not mentioned) p. 57 (no. 2 on the figure).
1967 *Dendrophyllia candelabra:* Rasmussen, p. 151, Fig. 128.
1968 *Dendrophyllia candelabrum* Hennig: Asgaard, pp. 103, 104, 105 (Fig. 1), 115.
1969 *Dendrophyllia:* Rasmussen, p. 97, Text-Fig. 7.
1971 *Dendrophyllia candelabrum*: Floris, p. 51 (Text-Fig.).

Remarks on the species in Europe:

The species cannot be referred to *Cladocora* Ehrenberg, 1834, as was costumary for decades, because that genus has phaceloid colonies with septotheca and paliform lobes. Hennig, who established the species reasonably referred it to *Dendrophyllia*. (Some material was mis-identified by him with another coral, see p. 75). In 1957, Alloiteau after examination of a fossil considered to be a topotype of "*Rhabdophyllia faxoensis*" as listed by Edwards & Haime, 1857, p. 352, found the fossil to be not assignable to any known genus, and he thought that it probably belonged to a new dendrophylliid genus. However, his description clearly reveals that the fossil examined cannot be a *Faksephyllia faxoensis* (Beck in Lyell, 1837 a) but very probably is a topotype of *Dendrophyllia candelabrum* Hennig. (It appears that Alloiteau did not know Hennig, 1899, and Nielsen, 1922).

Recent study of material published by Hennig (1899) and by Nielsen (1922), and of material such as that figured here (Pl. 7, Figs 4, 5) has now made it possible to choose a lectotype and to diagnose the species, as found at what has subsequently become the designated type locality.

This study has revealed that some parts of some of the colony fragments found at the type locality in Denmark do not display the Dendrophylliina characters very typically but, instead, imitate the corresponding ones of the Caryophylliina, viz. the arrangement of septa according to the Pourtalès plan appears reduced, and the thin wall is tending to function as a septotheca, without pores to the inner side. This particular development at least affects some of the narrow corallites. (Pl. 7, Fig. 4, shows a large corallum fragment (mould) from the type locality, with poor development of the Pourtalès plan and with a thin wall structure without pores opening to either side (though a certain porosity existed in some budding zones). Pl. 7, Fig. 5, shows a dendrophylliin branch (the thin synapticulotheca has no pores reaching to the outer side of the wall structure), the budded branches of which demonstrate a poor development of the arrangement of septa after the Pourtalès plan and have a thin wall structure that has been non-porous to either side (mould; wall structure and septa are present, more or less completely, but as a calcitic recrystallisation product). The specimen is from the type locality).

The lectotype. The specimen figured by HENNIG (1899) on Pl. 1, as Fig. 7, is chosen here as a lectotype. HENNIG referred to this figure when mentioning what he supposed to be particularly characteristic of the species. The type specimen is an internal mould of a portion of a colony, coated with small calcite crystals and preserved in limestone; the external imprints are not visible. The lectotype is kept in Copenhagen as MMH 1682 and is refigured here, Pl. 7, Fig. 6.

The stratum typicum is Middle Danian coral limestone (*Tylocidaris bruennichi* Zone).

The type locality is Fakse limestone quarry in Sjælland, Denmark.

Diagnosis (based on material from the type locality in Denmark). Subdendroid, with laterally free corallites, which at different intervals are budded from the parent corallites in any direction at angles more or less approaching 90°. As they grow, the lateral corallites soon parallel the essentially straight parent branch as slender (sub)cylinders with essentially no limit for their upward growth. Each branch may produce new ones. Common corallite diameter is 4–5 mm, the proximal end of the corallites in many cases is only 2–3 mm in diameter. The theca usually is quite thin and it is commonly more or less compact. Outside of the theca is concealed completely, or almost completely, by a dense deposit. Septa usually not porous. Septal number usually 24, 36, 48, or about 60. The Pourtalès plan may fail to develop typically. Weakly developed columella. Costae usually developed, equal to unequal, appear smooth or are finely granulated (with up to 3 granules across), and correspond to all distinct septa (they may appear somewhat vermiculate in a thick synapticulotheca). Endothecal tabular dissepiments not very uncommon. No internal filling up of corallites with stereome.

Material. The Greenlandic material comprises only skeleton fragments representing detached corallum portions. A few calices are known, but no basal part of a corallum has been definitely recognized. Very rarely is evidence for repeated budding present in the material that usually consists of fragments, which are only about $1^1/_2$ cm high and generally are small parts of slender branches, with or without buds. The fragments present in the collection often were parts of larger (about 5 cm high) corallum fragments buried intact in the sediment, but unfortunately this was rarely stated in the field labels concerned. Most specimens are moderately worn, but a few appear to be unworn. They often display the additional effect of dissolution within the sediment. Because their interior skeleton elements and also other characters appear to be fairly uniform or vary gradually, and because all degrees of sculpture damage have been observed, the smaller and larger fragments are here accepted as belonging to one species. The material comprises about 2,500 fragments.

Description (Greenlandic material). Protocorallite and basal plate not known. The same is true concerning the species as known from other localities. NIELSEN (1922, Pl. 1, Fig. 14) figured a "young colony" but it appears that in fact he figured a colony fragment without the protocorallite. Possibly, the protocorallites were rather small structures which after disintegration of the fragile colonies have easily been overlooked.

Corallum fasciculate and subdendroid, resembling a candelabra but with the slender cylindrical or subcylindrical branches given off in all planes, with the laterally free branches of monocentric corallites produced by extratentacular budding. (In the type locality (and also in HENNIG's Scanian locality) bilateral one-plane budding is not so nearly the rule as HENNIG obviously thought it to be). The buds spring with a mutual distance of zero to a couple of centimetres along the branches and may spring from $^1/_2$ mm to perhaps 1 or 2 cm below a calice margin. Each new branch may produce new ones.

Dimensions of the presumably bush-like corallum are unknown. In its type locality, *D. candelabrum* has been found with colony fragments measuring 30–50 cm in height. Diameter of proximal end of branch, at the budding zone, in many cases is only 2–3 mm, it may reach 5 mm (the maximum so far recognized in Scandinavia) or even 7 mm in the thickest branch fragments (with parent corallites 11–12 mm thick). The diameter usually reaches a fairly constant value of 4–5 mm at $^1/_2$ to 1 cm above the budding zone. Thicker branches with diameters of 6–9 mm (that is the maximum so far met with in Scandinavia) or even 10, 11 or 12 mm, also have been found; their rôle within the colony has not been fully recognized. (In specimens of *D. candelabrum* from the type locality it can be observed that sometimes the distal parts of the branches become thicker (at least 9 mm) while still giving off buds of a modest size (diameter at maximum 5 mm). Also in the type locality, the few comparatively complete coralla observed do not show any particularly thick branches near the supposed position of the protocorallite). Apparently the more or less straight corallites had unlimited growth upward.

Calice with circular or, more rarely, oval outline. Depth of calice ranges as widely as $1^1/_2$–6 mm; measured calice diameters were 4–5 mm.

Epitheca not recognized with certainty. Normally the wall is thin (and thickest in larger corallites), thus usually about $^1/_2$–1 mm. It is a synapticulotheca, which externally almost always becomes concealed at an early stage with a dense deposit which often displays costae. In most cases the synapticulotheca appears to be poorly developed as such; very commonly the lacunae of the wall are few and the wall compact on the inner side, especially in the thin branches. These small lacunae quite commonly have been filled up with stereome or diagenetical calcium carbonate. Only in rare cases can a synapticulotheca be readily demonstrated in the collection, and then especially in the walls about 1–2 mm thick found in the thicker branches (1 mm appears to be the maximum so far known in Scandinavia). But even here the lacunae, which are arranged in 1–2 (or 3) "layers", do not invariably open on either the inner or the outer ("perithecate") face of the wall structure. Only in young (?) portions of the thickest branches is it rather common to observe lacunae opening directly on the (original ?) exterior surface. Generally the wall structure has a smooth appearance or is finely and densely granulated (on costae, see later). In gross aspect the outer face of the wall is evenly rounded or sometimes slightly facetted.

About $^1/_2$ mm above the base of a newly formed corallite the septal number of approximately 24 is found. Usually, the inner widening of the corallite very soon allows for the introduction of a further 12 or 24 septa. These 36 or 48 septa of the nearly cylindrical straight corallites more or less conspicuously demonstrate the Pourtalès plan by coalescing, and this same plan is very evident in the thickest branches, which have *c.* 60 septa (Scandinavian maximum), or even *c.* 72 or *c.* 96 septa. In thin branches the Pourtalès plan may often not be easily distinguishable, however, and this, in connection with an apparent presence of a septotheca, may give to such branches a caryophylliin aspect.

In nearly all cases the septa are laminar, or in some cases perhaps only apparently so after the filling of pores with stereome. Septa may possess a few pores in the most distinctly dendrophylliin specimens. Generally the median dark line of the septa appears to be continuate. Trabeculae are probably simple. One fan system. Septal sides with a few and not very pronounced granulations arranged along the directions of the growth-lines and of the trabeculae. Inner septal margins are entire or, where implied in the formation of the columella, somewhat lacerate.

Upper margins are either smooth or, possibly, very minutely dentate. Slight exsertation. (HENNIG (1899) did not examine any calice; NIELSEN (1922) stated that the septa are not exsert (in his Scandinavian material), but actually septa are slightly exsert in the specimen figured by him as Pl. 1, Fig. 8).

No pali or paliform lobes. Columella trabecular, weak, loosely built of thin septal elements. Its diameter is usually one third of the corallite diameter but it varies as widely as from almost zero to about the half of the corallite diameter. Costae, when present, are equal to unequal, and correspond to all distinct septa. They are low and densely placed, with smooth appearance or are finely and densely granulated (with up to 3 granules across on the larger costae). Cristae have been observed in some specimens.

Simple synapticulae are present in the synapticulotheca and often in the columellar region. Endothecal tabular dissepiments not very uncommon. Stereome can be assumed to fill pores of septa and wall; apparently it does not play any additional rôle in the interior of the corallites. (Also in Scandinavia the species appears to lack internal stereomic fillings; see also NIELSEN's statement of lack of endothecal formation where obviously he did not mean dissepiments). Any coenosteum other than the thin, dense stereomic cover ("peritheca") on the wall has not been observed.

Identification and affinities. The Greenlandic material agrees so well with the diagnosis given above for *Dendrophyllia candelabrum* HENNIG (1899) (as known from the type locality) that it is considered to belong to that species. (11 fragments from Tuff II of the Danienrygge at Kangilia demonstrate a slightly wider range in certain characters than that known from Europe. They display thicker corallites than known from Europe, generally have a higher septal number and thicker vesicular wall tissue, and partially have broader buds).

Comparisons were made to the following Paleocene (?) - Eocene *Dendrophyllia* species as known from the literature. The foreign species often have been described on a very limited material, and it is not always possible to make simple comparisons. However, differences between the species have been recognized or at least seem probable, as follows:

D. peruviana VAUGHAN, 1922, from the Paleocene or Lower Eocene (but earlier dated as Middle Eocene) of Peru, (see WELLS, 1941 b (pp. 3, 4), and PAPP, 1959 (pp. 349, 351)), differs in very short corallites and in stereomic filling up;

D. lisbonensis VAUGHAN, 1900 b, differs in very short side branches;

D. striata VAUGHAN, 1900 b, of which only the basal portion is known, displays a broader and more conspicuous columella than *D. candelabrum*;

D. laevis LONSDALE, 1845, (see VAUGHAN, 1900 b, who found it based on indeterminable material), possibly had a solid wall; it differs from *D. candelabrum* at least in having very short side branches (side corallites);

D. pahiensis SQUIRES, 1962, of which is known only the basal portion, the calices of which are not elevated, probably differs in low septal number and in broad columella;

D. cowlitzensis DURHAM, 1942, differs in its narrow and short corallites;

D. tejonensis NOMLAND, 1916, at least seems to have had a comparatively large number of septa and also a different angle in budding;

D. dendrophylloides EDWARDS & HAIME, 1848 b, (see also EDWARDS & HAIME, 1850 b), differs in the general morphology of corallum;

D. italica SCHAUROTH, 1865, from the Eocene (?) ("Nummulithenkalk"), seems to differ from *D. candelabrum* at least in having fewer septa. (FELIX, 1925, may have been right in questioning the generic identification);

D. elegans DUNCAN, 1866, from the Eocene of England, has repeated budding and may be closely related to *D. candelabrum* but the broadly attached colonies were small (?), and with one axial corallite (?). Differences appear to be found in costal features and in the comparatively delicate arrangement of septa in *D. elegans*.

Occurrence in Greenland

Lower Danian

Danienrygge at Kangilia:
Basalt tuff: Tuff I or Tuff II, 53 fragments;
Tuff II, Ryg A, about 640 fragments;
Ryg A + B, 30 fragments;
Ryg B, about 250 fragments;
Ryg C, about 360 fragments;
Ryg D, 3 fragments;
Danienrygge, 50 fragments;
Tunorssuaq, Danienkløft, "Store Profil", 3 fragments;
Ilugigsoq, southern slope of the Koralravine, about 600 fragments.

Displaced: Tunorssuaq, Danienkløft, calcareous nodule, 1 dubious example, with solidified synapticulotheca, with no buds. Probably Danian;
Danienrygge at Kangilia, Ryg B (altitude about 685 m), basalt tuff, 1957, about 150 fragments, seemingly displaced from Tuff II. Probably Lower Danian;
Ilugigsoq, Koralkløft, basalt tuff, 1951, 1952, 1953, 1957, about 380 fragments, presumably displaced from occurrence in the Koralravine. Probably Lower Danian.

Occurrence outside Greenland

Denmark: Danian, Zone of *Tylocidaris abildgaardi* (Lower Danian) ?, Zone of *T. bruennichi* (Middle Danian), and Zone of *T. vexillifera* (Upper Danian);
Sweden: Danian, Zone of *T. rosenkrantzi*, and Zone of *T. bruennichi* (i. e. in Lower and Middle Danian);
Heersian. The record (ROSENKRANTZ, 1924, p. 28) may be based on a misidentified specimen (1970.931, Mineralogical Museum, Copenhagen).

Undetermined basal parts of Dendrophylliin coralla

Pl. 8, Figs 2–4

Material. Three skeleton fragments representing solitary or colonial dendrophylliins, with no calice preserved but presenting undoubted bases. All are somewhat damaged through fracturing and wear.

Description. Shape of corallum unknown, outline of cross-section circular or nearly so, basal plate not observed, no epitheca (?). Synapticulotheca is partially porous to the outside, but the remains of a thin, finely and densely granulated cover may possibly suggest that the lacunous tissue has been covered regularly. The septal arrangement demonstrates the Pourtalès plan; septa appear to be laminar, other details of septa are not well known. No pali or paliform lobes. The feeble columella is trabecular. Equal, low costae (which in the material probably are worn or corroded; they are now broad and smooth; probably they have been covered by a dense, finely granulated and thin deposit displaying their general pattern); no cristae have been observed. Synapticulae have been found at least in the wall. No coenosteum is observed. No internal stereome. Additional information on the same fragments, all measurements in mm:

	(Pl. 8, Fig. 2)	(Pl. 8, Fig. 3)	(Pl. 8, Fig. 4)
Height of fragment	$3^1/_2$ +	$7^1/_2$ +	$9^1/_2$ +
Diameter below	about 8	9 +	about 10
Diameter above	4	6	$7^1/_2$
Thickness of wall above	about $^1/_2$	about 1.1	about 1.1
Septal number	about 36–42	36–48	about 42
Dissepiments	?	few	?
Substrate	*Faksephyllia*	tuff	tuff

Remark: It is interesting to note that all three bases may belong to *Dendrophyllia candelabrum*. That species is common at the locality concerned, and the basal parts of its coralla have up to now not been recognized with certainty.

Occurrence
Lower Danian
Danienrygge at Kangilia, basalt tuff: Tuff II, Ryg A, 3 specimens.

Unidentified material

Due to poor preservation a number of Scleractinian remains in the collection from Nûgssuaq have not been identified. There follows a short review of their derivation and possible affinities.

Upper Campanian (?). Ikorfat, 1949. Solitary corallum (Pl. 8, Fig. 5). 58 septa. Probably a caryophylliin (not a *Caryophyllia*).

Lower Danian, or Campanian or Maastrichtian. Oyster-ammonite Conglomerate locality III, Agatdalen, 1961. Incomplete, crushed discoid corallum, with pali; Caryophylliina.

Lower Danian. a) Danienrygge at Kangilia: 1) Conglomerate immediately above Tuff I, Ryg B, 1 crushed solitary corallum (Caryophylliina ?); 2) Basalt tuff: Tuff I or Tuff II, solitary corallum (Caryophylliina ?); Tuff II, Ryg A, 1949, 2 solitary coralla (Caryophylliina ?); 1957, 4 solitary coralla (probably Caryophylliina) and 5 bases (probably belonging to Caryophylliina solitary corals, one apparently polycyclic);

Summary of localities with their

× Occurrence certain (×) Occurrence probable ? Occurrence dubious Summary of localities	U. Campanian. Ikorfat. (Coral may be younger ?).	Maastrichtian. Oyster-ammonite Conglomerate locality III, conglomerate-boulder.	Maastrichtian ? (Campanian ?, L. Danian ?). Oyster-ammonite Conglomerate locality III, conglom.-boulder ?.	L. Danian ? (Campanian ?, Maastrichtian ?). Oyster-ammonite Conglomerate locality III, conglom.-boulder ?.	Oyster-ammonite Conglomerate localities I and II, matrix of conglomerate.	Danienrygge at Kangilia. Tuff I.	Danienrygge at Kangilia. Conglomerate immediately above Tuff I.	Danienrygge at Kangilia. Tuff II.	Angnertuneq (Vestre Konglomeratkløft), quartz sandstone.
List of species					Lowe				
Haimesiastraea (Haimesiastraea) groenlandica sp. n.									
Haimesiastraea (Peruviastrea) ? sp.									
Discotrochus ? sp.									
Astrangia (Coenangia) ? sp. cf. *A. (C.) cretacea* (BÖLSCHE, 1870)									
Oculina becki (NIELSEN, 1922)						?	×	×	
Caryophyllia andreasi sp. n.						?	×	×	
Caryophyllia sp. A						×	×	×	
Caryophyllia agatdalensis sp. n.				?	×				
Caryophyllia sp. B					×		?	?	
Trochocyathus johannesi sp. n.									
Paracyathus kangiliaensis sp. n.								×	
Stephanocyathus (Stephanocyathus) sp.								?	
Stephanocyathus (Stephanocyathus) ? sp. no. 1		×	×						
Stephanocyathus (Stephanocyathus) ? sp. no. 2									
Kangiliacyathus groenlandicus gen. n. & sp. n.						?	×	(×)	
Desmophyllum ? sp.								×	
Lophelia ? sp.								×	
Parasmilia sp.								×	
Faksephyllia faxoensis gen. n. & BECK in LYELL (1837) sp.						?		×	
Flabellum groenlandicum sp. n.						×	×	×	×
Balanophyllia sp., cf. *ponderosa texana* VAUGHAN & POPENOE, 1933								×	
Dendrophyllia candelabrum HENNIG, 1899						?		×	
Undetermined basal parts of Dendrophylliin coralla								×	
Unidentified solitary coral, Caryophylliina ?	×								

epresentation of Scleractinia.

×	×	×				×		(×)	×		×			Danian	Tunorssuaq, Danienkløft, "Store Profil".
						×									Tunorssuaq, Danienkløft, "Nordprofil".
×		×						×							Ilugigsoq, Koralravine.
													×	Upper Danian	Scaphitesnæsen (Turritellakløft Mb.).
	×														Konglomeratnæsen (Turritellakløft Mb. ?, Andreas Mb. ?).
	×								×	×					Qaersutjægerdal, "Store Profil" (Turritellakløft Mb.).
	×		×					?	×	×		×			Agatkløft, "Store Profil", Sonja Lens (Turritellakløft Mb./Sonja Mb.).
	×						×		(×)						Turritellakløft, "Store Profil" (Turritellakløft Mb.), quartz sandstone.
		(×)							(×)						Turritellakløft, "Store Profil" (Andreas Mb.).
	×	×					×	×	×						Turritellakløft, "Store Profil" (Abraham Mb.), basalt tuff.
	×	?							?						Kangersôq.
	×	?							×			?			Nuilaussarssuaq.
	×														Tunorqo.
?		(×)												Displaced	Probably Danian. Concretions from dark shales.
	(×)			×	×	×									Probably L. Danian. Concretions from dark shales.
×		×						×							Probably L. Danian. Basalt tuff.
	×									?			?		Probably U. Danian. Block of carbonate cemented quartz sandstone with pebbles and shell fragments.
	×						?	?	(×)						Probably U. Danian. Quartz sandstone.
	(×)								?						Probably U. Danian. Conglomeratic quartz sandstone.
	?														Probably U. Danian. Concretion from dark shales.

Ryg B, 1956, 1 solitary corallum (probably Caryophylliina, with crushed interior); 1957, 2 solitary coralla (probably Caryophylliina) and 1 base (solitary coral ?, Caryophylliina ?); Ryg C, 1 base (solitary corallum ?, Caryophylliina ?) attached to larger indeterminable subcylindrical fragment of caryophylliin (?) corallum, a further corallum (solitary) and some fragments (Caryophylliina ?); Danienrygge, 1957, 2 solitary coralla (Caryophylliina ?); 1961, 1 base (solitary coral ?, Caryophylliina ?). b) Ilugigsoq, southern slope of Koralravine, 2 solitary, somewhat crushed coralla, apparently of one species, Dendrophylliina ?.

Lower Danian (?). In an occurence of so-called picrite, "Store Profil" of the Danienkløft gorge, Tunorssuaq valley, badly weathered skeletal portions of a solitary (?) coral were observed (1957).

Probably Lower Danian. Displaced calcareous concretion, from the next big gorge to the north of Koralkløft, Ilugigsoq valley-system, 1 solitary corallum (Caryophylliina ?).

Probably Danian. Displaced calcite-cemented, almost conglomeratic shell-gravel (concretion ?), Angnertuneq, Vestre Konglomeratkløft, 1957, 1 corallum (solitary ?, Caryophylliina ?).

Upper Danian. a) Quartz sandstone (Sonja Lens), "Store Profil" of Agatkløft, Agatdalen, 1952: 1 polycyclic base (6 mural rings, or more), solitary ?, Caryophylliina ?; 1956: 5 fragments of synapticulothecate corals (with epitheca ?), with perforate septa, one species ?, Dendrophylliina ?; and 2 bases (polycyclic, 5–6 mural rings), solitary corals ?, Caryophylliina ?; 1958: 1 polycyclic base (4–5 mural rings), solitary coral, Caryophylliina ?; and 1 solitary corallum, Caryophylliina ?. b) Quartz sandstone (Turritella conglomerate, to the east), Turritellakløft Member, "Store Profil" of Turritellakløft, Agatdalen, 1948, 1 solitary corallum (Caryophylliina ?). c) Basalt tuff (Uppermost tuff, fallen material), Abraham Member, "Store Profil" of Turritellakløft, Agatdalen, 1 solitary corallum (Caryophylliina ?). d) Quartz sandstone, gorge descending from the 1,430 m mountain to the north, Kangersôq, 1 solitary corallum, broadly attached, possibly polycyclic, Caryophylliina ?. e) Quartz sandstone, Nuilaussarssuaq, 1 inner mould of solitary (?) corallum (Caryophylliina ?).

Probably Upper Danian. Displaced: Quartz sandstone, Ilugigsoq area, + 600 m, 1952, 1 fragment of curved slender corallum (solitary ?); quartz sandstone with pebbles and shell fragments (carbonate cemented), Ilugigsoq area, 1952, 8 poorly preserved fragments of dendrophylliin coralla (probably 1 solitary species; 8 individuals ?), fragments measure up to 8 mm in height, and 96 septa are suggested.

PALAEOECOLOGY

Since the publication of Ravn (1918), certain groups of animals from coral-bearing parts of the marine deposits in West Nûgssuaq have received special treatment, mainly the crinoids (Rasmussen, 1961), the belemnites and the ammonites (Birkelund, 1956, 1965), the foraminifers (Hansen, 1970), and the ostracods (Szczechura, 1971). The nautiloids and the huge faunas of pelecypods and gastropods have been outlined and partially discussed by Rosenkrantz (e. g., in 1942, 1946, 1951, 1953, 1963 a, 1963 b, 1967, 1968, and 1970), who also (1970) gave a general summary of the faunas and floras. However, the special palaeoecological subjects mentioned in these works have no immediate relevance for the study of the corals. Preliminary notes on the palaeoecology of the scleractinians were published recently by Floris (1967 a, b).

Works on terrestrial floras (Koch; e. g., in 1963, 1967) have produced estimates of the palaeoclimate of the same area.

From the study of the faunas and sediments a general concept was achieved of the Upper Cretaceous-Lower Tertiary environment in West Greenland. This was presented sporadically in several of the works mentioned above and also in Rosenkrantz *et al.*, 1940, and Rosenkrantz & Pulvertaft, 1969.

Thus it is now well known that the Senonian sea transgressed over the western Nûgssuaq leaving thick deposits of dark euxinic mud. The facies changed, in Maastrichtian time, to a less anaerobic one as is suggested by the occurrence of numerous fine and coarse quartz sand grains in the calcareous concretions found in the dark shales.

The few Upper Cretaceous scleractinians found do not add much information to this picture. Of certain Maastrichtian age is a *Stephanocyathus* (*Stephanocyathus*) ?, originally buried in bituminous mud. Accompanying sand grains indicate a rather strong water movement and possibly a shallower depth than that at which the subgenus probably represented is known to live in Recent time, viz. 141–2,195 m. (Its temperature range today is from 3° C to 12° C or more. Temperatures are in this chapter generally cited from VAUGHAN & WELLS, 1943, while depth ranges are quoted mainly from WELLS, 1956). A possible specimen of *Caryophyllia agatdalensis* sp. n. was enclosed unworn in sediment dominated by quartz sand representing possibly Upper Cretaceous deposits or, more probably, a Lower Danian basal conglomerate. The sediment indicates rather shallow water, which is consistent with the modern bathymetric range of the genus, 0–2,743 m (temperature range 2.8° C–27° C).

The Lower Danian scleractinians lived in a number of rather different environments.

During quiet intervals in the formation of a Lower Danian conglomerate in the Agatdalen area, *C. agatdalensis* sp. n. and *C.* sp. B seem to have lived between the conglomerate boulders. At least *C. agatdalensis* settled on the gravel pebbles, which were incorporated in the dark muddy matrix. The conglomerate gives evidence for shallow-water conditions, which are consistent with the requirements of modern *Caryophyllia.*

Another Lower Danian coral habitat was sea floors of coarse quartz sand, which were inhabited by *Flabellum groenlandicum* sp. n. The genus occurs in modern time at depths between 3 m and 3,183 m (and has a temperature range from 1.7° C to 27.6° C). These ranges can hardly be in contradiction with the physical data of the Lower Danian environment. Related to the *F. rubrum* group, *F. groenlandicum* probably preferred shallow, warm waters.

On dark bituminous clay with sporadic sand grains and coarser particles lived *Caryophyllia* sp. B (Lower Danian and probably Lower Danian), *Trochocyathus johannesi* sp. n. (probably Lower Danian), and *Stephanocyathus* (*Stephanocyathus*) sp. (probably Lower Danian). This sediment was probably deposited in a sea shallower than the known upper limit (141 m) for modern *S.* (*Stephanocyathus*). *Trochocyathus* is rather indifferent as to depth and temperature (32–1,573 m; 4.7° C, or less, to 26.7° C, or less), and *T. johannesi* so far does not give clear evidence for the conditions of the dark-shale sea. Neither can the environment be well defined by the ranges of depth and temperature of modern *Caryophyllia*, or modern *S.* (*Stephanocyathus*). Probable finds of *Flabellum groenlandicum* (from probably Lower Danian dark shale with coarse particles of reworked material) possibly suggest a shallow, warm sea.

A probable example of *Faksephyllia faxoensis* and a dubious example of *Dendrophyllia candelabrum* have been recognized in conglomeratic shell-gravel from the shales (loose blocks, probably Danian). In this case, during the deposition of shale series, the corals may well have lived under local conditions similar to those on the main localities of those species, see the discussion below.

By far the richest of the Lower Danian coral-bearing beds known from Nûgssuaq are deposits dominated by basalt ash. At Kangilia, where two tuff beds have been recognized, a coral-bearing, weakly developed conglomerate is found immediately above the lower tuff bed (Tuff I) with a content of tuff particles together with quartz grains in its matrix.

This tuff-bearing conglomerate appears to have been inhabited by several species of scleractinians. Their skeletons are in most cases found broken but in general the fragments must have been buried without having suffered much wear. The skeletons are filled with tuff-bearing sediment. The corals from the conglomerate are: *Oculina becki; Caryophyllia andreasi; C.* sp. A; *C.* sp. B (dubious); *Kangiliacyathus groenlandicus;* and *Flabellum groenlandicum.* The ecological requirements of *Caryophyllia* and *Flabellum* may readily have been fullfilled by the conditions on the conglomerate sea floor. Modern *Oculina* is hermatypic and ahermatypic, and its range in depth from 0– about 100 m also agrees with the conglomerate environment. *Kangiliacyathus* gen. n. has no known living representatives. Its broad basal disc and stereomic strengthening of the skeleton made it well fitted to a life in disturbed waters.

Tuff I of the Danienrygge contains remains of the following scleractinians (not seriously damaged by wear): *Oculina becki* (in Tuff I ?); perhaps *Caryophyllia andreasi; C.* sp. A; *Kangiliacyathus groenlandicus* (determination probable; Tuff I ?); *Faksephyllia faxoensis* (in Tuff I ?); *Flabellum groenlandicum;* and *Dendrophyllia candelabrum* (in Tuff I ?). The four species occurring doubtfully in Tuff I are not considered here; the same species have been recognized certainly or probably in the younger Tuff II. *C. andreasi* is not considered because the one specimen certainly found in Tuff I is doubtfully determined and because the specimens determined with certainty only doubtfully derived from Tuff I. The generic data of the rest of the list give little information concerning local depth and temperature, but a warm shallow sea might be suggested by one of the species. It is unknown whether any coral structure, as for instance a thicket, developed in the possibly shallow Tuff I sea.

There are two Lower Danian coral-bearing deposits with a high content of basalt tuff in the Danienrygge at Kangilia (Tuff I and Tuff II), and one in the Danienkløft of Tunorssuaq as well as one in the Koralravine of the Ilugigsoq area. Possibly the deposits of Koralravine, Danienkløft, and one of the tuffs (probably Tuff II) of Danienrygge record the same volcanic eruptions.

The scleractinians from Tuff II and from the tuff deposits in Danienkløft and Koralravine are as follows:

	Tuff II	Danienkløft	Koralravine
A) Colony-forming, supposedly ahermatypic:			
Oculina becki	×	×	
Lophelia ? sp.	×		
Faksephyllia faxoensis	×	×	×
Dendrophyllia candelabrum	×	×	×
B) Solitary corals:			
Discotrochus ? sp.		×	
Caryophyllia andreasi	×	×	×
Caryophyllia sp. A	×		
Caryophyllia sp. B	?	×	
Paracyathus kangiliaensis	×		
? *Stephanocyathus* (*Stephanocyathus*) sp.	×		
Kangiliacyathus groenlandicus (probable)	×		
Desmophyllum ? sp.	×		
Parasmilia sp.	×		
Flabellum groenlandicum	×	×	
Balanophyllia sp., cf. *ponderosa texana*	×		

So far, Tuff II has yielded the richest coral fauna of the Lower Danian coral-bearing tuffs in Nûgssuaq. It was mainly this deposit which was briefly commented on by FLORIS, 1967 a, b. Everywhere in Tuff II the solitary coralla and colony skeletons examined are either unabraded or, more commonly, are slightly worn. They show no signs of having suffered lengthy transportation in the high energy environment suggested by the sediment. The colonial forms are branching types, the remains of which are broken. The fragments (up to 10 cm or more) are always found detached, and the coral remains as a whole show no preferred orientation (although at the top of the section in Ryg C most of the fragments lie horizontally). Sorting has been negligible. Skeletons in growth position of any of the corals have not been observed, but basal parts have been recognized in the tuff, including bases enveloping coarse sediment particles. The skeletons are filled with sediment of the same kind as that surrounding them. The tuffaceous deposit consists of volcanic ash and shale particles, at least some of which may be redeposited "lapilli", and there are indications that Tuff II was deposited in water, which was for the most part wave agitated.

The distribution of scleractinian fossils within Tuff II has been investigated in Ryg C only. However, a coral-rich level in Ryg A, Ryg B, and Ryg D (?) may correspond to the coral-rich level found midway up in the trench that was dug through Tuff II in Ryg C in 1957. (Here scleractinians were found in a series 210 cm thick just above the horizon that has a rather clayey appearance and is found about $1^1/_2$ m above the base of the tuff. See p. 13).

The upper and the lower scleractinian zones recognized in the special investigation in Ryg C both contain undeterminable fragments. Furthermore, both contain the branching corals, *Oculina becki*, *Faksephyllia faxoensis*, and *Dendrophyllia candelabrum*. The local faunal history began shortly after the abrupt beginning of the deposition of the ash and with the immigration of crustaceans, and soon several other animal groups became represented in the area (graphularians, crinoids, echinoids, annelids, pelecypods, gastropods, scaphopods, and fishes). The animals cannot be more closely determined from the poor remains collected in the samples from the trench, and the well preserved fossils found elsewhere in Tuff II generally have not been sufficiently analyzed to give a full picture of the fauna and of its possible partial dependence on the scleractinians.

The sudden appearance of a rich benthonic life in the tuff sea has been commented on by ROSENKRANTZ (e. g., ROSENKRANTZ *et al.*, 1940, p. 657). It was suggested that the tuff played the rôle of a tight seal over the anaerobic mud generally deposited in the earlier part of the Danian. Tuff particles should also have provided a better substratum for the benthos than mud.

A faunal decline is indicated within the horizon that has a rather clayey appearance. Above this horizon the tuff for about 2 m again contains a varied macrofauna, but now with an incursion of *Oculina becki*. The fragile colonies of this species apparently could endure the ash falls, and the species was later accompanied (1 m higher in the sediment) by *Faksephyllia* and *Dendrophyllia*. Their slenderly built, bushy skeletons must have been overturned, tumbled, and broken by the occasional load of ash, by direct water movement, and by stirring of the bottom sediment. The dead and dying fragments may have acted as sediment traps and were rapidly filled and covered with sediment, so becoming protected from wear, sorting and crushing. The overlying deposit is almost barren of fossils and may well represent redeposition of material from ash falls following in quick succession. The first catastrophic mortality probably resulted from burial by rapid sedimentation rather than from poisoning or heating of the sea water by volcanic eruptions. A change of sea level, possibly an effect of the volcanism, and a concomitant change in temperature may also have caused the decline of scleractinians. At the top of the section, scleractinians and their accompanying fauna return, and a mud fraction appears in the sediment.

This sketch is based on the results from the trench made in Ryg C, but it appears to be consistent with what is known of the tuff fauna elsewhere.

The Tuff II scleractinians to some extent form a natural unit. The three dominating branching forms also occur together in Europe, and most of the accompanying solitary genera form a suite known also from modern communities with branching corals. In Europe certain of the solitary genera are found fossil together with the branching forms mentioned.

The scleractinians of Tuff II have formed, practically on the spot where their remains are now found, at least two continually disturbed and not very densely populated polytypic coral thickets (see STETSON *et al.*, 1962; SQUIRES, 1964). The vertical and horizontal limits of the thickets are unknown. Obviously there has been no opportunity for an accumulation of coral-debris to develop on the thicket floor so as to allow the development here of a specialized fauna. Thus the coppice, the second ontogenetic stage of SQUIRES' "deep-water" (not light-dependant) coral structures (1964) was not reached.

In Europe, and principally in the Danish locality, Fakse limestone quarry, the three branching forms known from Tuff II have even reached the stage of bank construction (FLORIS, 1971) and they occur there with a highly diversified con-fauna. The depth of bank formation at Fakse has for long been a matter of discussion (earlier suggestions summarized in ASGAARD, 1968). The only critical evidence of bathymetry on which the present writer chiefly based his estimates (1962; 1967 a, b) is the rare occurrence of *Heliopora incrustans* NIELSEN (1917). Modern *Heliopora* is light-dependant and commonly lives in extremely shallow water, but it can be found so deep as within the interval from about 46 m to about 80 m (WELLS, 1954). The finds in Fakse then suggest a sea that was at least fairly shallow (the same was sketched by FLORIS, 1971). Penetrations that are probably algal (BROMLEY, in ASGAARD, 1968) might corroborate this estimate, and the present writer agrees with ASGAARD (1968, p. 117) that the depth of the Danian sea at Fakse was probably about 50–80 m.

The latest estimate of the depth of the sea at Fakse was made without special consideration of the scleractinians. However, a depth of about 50–80 m seems to be appropriate for *Dendrophyllia candelabrum*, *Faksephyllia faxoensis*, and *Oculina becki* while these flourished at Fakse (and also for the remaining of the known Fakse scleractinians, see also FLORIS, 1971). It also seems acceptable for their localities elsewhere in Europe. The lack of calcareous algae at the European localities does not necessarily mean a dark environment (see TEICHERT, 1958; FLORIS, 1971).

The bottom temperature of the sea at Fakse is still not well known (ASGAARD, 1968, pp. 117–118; FLORIS, 1971, p. 54). The present writer has mentioned the temperature of 15°–18° C (1967 a, b) but this estimate is now seen to be unreliable, though still possibly correct. (In 1967 (a) he concluded with some reservation, that the same temperature might have existed in the (Lower) Danian sea of West Greenland).

The Greenlandic Tuff II was deposited from wave-agitated water which is thought to have been at most 80 m deep. Calcareous algae have not been observed in the tuff. This may possibly mean a depth greater than 50 m at the latitude of Nûgssuaq (compare TEICHERT, 1958), and a sea-depth within the interval of 50 ?–80 m is here assumed for Tuff II. A not very shallow sea is suggested by the observation that the scleractinians of the thickets only rarely show signs of the activity of other organisms. (Borings of thallophytes, probably fungi, have been observed; BROMLEY, personal communication, 1968).

The bathymetry and temperature ranges of genera represented in Tuff II are listed in the following, together with data about a few species (* means probable or possible occurrence):

Oculina. 0 – about 100 m (see SQUIRES, 1958 a) (same species probably from about 50–80 m, in Fakse); temperature ?;

**Lophelia.* 50–3,383 m; temperature range at least is 2.5°–12° C (see ALLEN & WELLS, 1962);

Faksephyllia. Extinct (same species probably from about 50–80 m, in Fakse); temperature ?;

Dendrophyllia. 0–1,372 m (or 11–1,200 m, SQUIRES, 1964) (same species probably from about 50–80 m, in Fakse); temperature range at least is 11.2°–27.3° C;

Caryophyllia. 0–2,743 m; about 2.8°–27° C;

Paracyathus. 13–1,472 m; 4.7°–about 27° C;

**Stephanocyathus* (*Stephanocyathus*). 141–2,195 m, some fossil species occur in sandy sediments from probably shallow waters; temperature range 3°–12° C or more;

**Kangiliacyathus.* Extinct, probably a shallow-water form; temperature ?;

**Desmophyllum.* 0–2,286 m; most restricted temperature range is 2.7°–23.3° C;

Parasmilia. 313–366 m (some fossil species seem to have lived in shallower waters, thus at Fakse (report in NIELSEN, 1922)); 8.8°–12.5° C;

Flabellum. 3–3,183 m; 1.7°–27.6° C (the species concerned probably preferred a warm, shallow sea);

Balanophyllia. 0–1,100 m; about 6.7°–27.7° C (the species concerned possibly indicates temperate to subtropical climate).

The above data do not indicate any particular bathymetry for the Tuff II scleractinians. However, the possibility of a range of ? 50–80 m is not excluded. The depth range of modern ahermatypic scleractinians generally seems to depend on temperature. This is particularly the case with the banks (see, e. g., SQUIRES, 1964). The same combination of species of branching, supposedly ahermatypic corals occurred at possibly identical depths of sea in the Tuff II thickets and in the Fakse coral banks. If this identity were proved, it would be reasonable to assume that the same conditions of temperature existed at the sea floor in the two places. Unfortunately, the temperature at Fakse has not been judged with certainty, and the Tuff II temperature cannot be conclusively determined from the above tabulation.

In the coral thickets of Tuff II of the Danienrygge, and in the coral bank complex of Fakse in Denmark the same few, supposedly ahermatypic, colonial species were concerned with sediment trapping and were themselves producers of sediment. Similar to the Fakse occurrence are the bank complex at Limhamn in Sweden (see BROTZEN, 1959, for recent analysis and references) and possibly some other, less well-known south Scandinavian Danian coral localities. Below, the possible thicket nature of two further Greenlandic Lower Danian occurrences is discussed.

All these Danian coral structures seem to have been formed in rather shallow seas. In this way they differ from most of the coral structures of similar aspect which have been described of Recent age (many), Holocene (one), and Upper Tertiary (two) (see PRATJE, 1924; TEICHERT, 1958; ALLEN & WELLS, 1962; STETSON *et al.*, 1962; SQUIRES, 1964, 1965). These have generally been formed at depths of 100 or, more commonly, a few hundreds of metres. (The Fakse occurrence was briefly discussed in the same way, by FLORIS, 1971).

The Greenlandic colony corals listed on p. 106 were "framework corals" or, in one instance, a potential framework coral, in the Tuff II sea. The solitary corals listed were "associate corals". The genera represented form a non-reef coral association or group not unlike those of the Quaternary coral structures which are independant of light. The following relevant genera are met with in such groups: *Lophelia*, *Dendrophyllia*, *Caryophyllia*, *Paracyathus*, *Desmophyllum*, *Flabellum*, and *Balanophyllia*. *Faksephyllia* gen. n. may possibly have a descendent in the Recent *Solenosmilia*, which is known from banks on the European Continental shelf.

With rich occurrence of *Dendrophyllia* the above-mentioned Danian apparently rather shallow structures remind of *Dendrophyllia* structures on depths from 80 m and more, in the warm sea (bottom temperature up to 16° C) off Morocco. Another possible parallel may be found in the *Dendrophyllia*-rich Holocene structures on the Niger Delta (ALLEN & WELLS, 1962; SQUIRES, 1964)—2 or 3 genera of scleractinians are common to Tuff II and to the Niger structures, and *Dendrophyllia* and *Cyathoceras* are common to the Niger structures and to the bank complex of Fakse.

The Lower Danian tuff of Danienkløft records several volcanic eruptions. The local scleractinian history has not been investigated. Scleractinians are rather rare finds but those found can be looked upon as a poor copy of the Tuff II fauna and may well have lived under similar conditions. As far as is known, however, thickets did not develop in the Danienkløft area. The only extraordinary find is a *Discotrochus* ?. Certain species of this extinct genus were shallow-water types according to the sediments. This may also be considered true of the Greenlandic coral. At least some species seem to have lived in rather warm seas.

The Lower Danian sediments of Koralravine may suggest a number of distinct epochs of ash falls. The tuff contains a proportionately poor replica of the Tuff II fauna but the fauna was rich in individuals. There are many unworn scleractinian branch fragments, and the skeletons are rather commonly crushed within the sediment. This indicates that the corals were broken and buried quickly without reworking. The fauna is dominated by *Faksephyllia* and *Dendrophyllia candelabrum*. None of the corals has been found in growth position, but skeletal remains of both of the branching species are associated in large numbers in a manner which indicates the presence of at least one polytypic coral thicket. This probably existed under conditions rather similar to those of the Tuff II fauna.

In the Upper Danian, the sea again transgressed over the western part of Nûgssuaq.

A displaced block of probably Upper Danian conglomeratic quartz sandstone contained one possible example of *Oculina becki* and three probable examples of *Flabellum groenlandicum*, i. e. two species which are known to have occurred together in a weakly developed conglomerate elsewhere. A displaced concretion from dark shales (probably Upper Danian) contained a dubious example of *Flabellum groenlandicum*. If the determination is correct, this specimen is a rare example of the occurrence of this common species in shale facies.

The following corals were collected from young beds of coarse-grained basalt tuff: *Oculina becki*, *Caryophyllia andreasi*, *C.* sp. A, and *Flabellum groenlandicum*. Generally, the skeletons are at most moderately worn. The remains found so far of the colonial forms are detached branch fragments. *Dendrophyllia candelabrum* has not yet been recognized, but otherwise the faunule from the Upper Danian tuff corresponds quite well to the Lower Danian thicket fauna described before and may have lived under the same general conditions. It is unknown whether these Upper Danian corals formed any coral structures.

The remaining Upper Danian scleractinian faunas have been found in quartz-dominated sandy sediments indicating shallow-water conditions.

A rich coral locality is the deltaic Sonja Lens. Sorting may be responsible for the large representation in this locality of skeletons of presumably juvenile individuals of *Flabellum groenlandicum*. The coral fossils from the lens generally are fragmented, and the fragments are isolated but usually not much worn. This suggests a rather short or at least a gentle transportation before embedment. The interior of the coralla is filled with loose sandstone like that enclosing them, and the corals are presumed to have lived on a sandy sea floor close to the place of embedment and also to have been almost contemporaneous with the deposition of the Sonja Lens. One exception is *Stephanocyathus* (*Stephanocyathus*) ? no. 2, which is represented by one fragment filled and enclosed by dark fine-grained sediment and presumably derived from (Upper Danian ?) shale deposits. The immediate substratum for the corals can sometimes be studied. It consisted of quartz grains, mollusc shells, or balls of loosely cemented quartz sandstone.

The following scleractinians have been collected from the Sonja Lens: *Haimesiastraea* (*Peruviastrea*) ? sp.; *Astrangia* (*Coenangia*) ? sp. cf. *A.* (*C.*) *cretacea*; *Oculina becki*; *Caryophyllia andreasi* (dubious); *Stephanocyathus* (*Stephanocyathus*) ? sp. no. 2 (derived, see above); *Flabellum groenlandicum*. Discovery of *Astrangia* (*Coenangia*) ? in this shallow-water deposit is interesting because the coral concerned is probably related to corals from warm seas. (Modern *Coenangia* are ahermatypic shallow-water forms from warm temperate and subtropic areas. The temperature range of the type species is 15°–29° C, see DURHAM, 1947). The colonial form, *Haimesiastraea* (*Peruviastrea*) ? was perhaps hermatypic but apparently did not form anything like reefs. It was probably a relative to corals from seemingly fairly shallow seas of rather warm areas. The genera *Caryophyllia* and *Flabellum* in modern times have very wide thermal and bathymetric ranges, which cannot conflict with the present environment. *Flabellum groenlandicum* occurs in similar sediments elsewhere and probably preferred warm conditions. *Oculina becki*, which has been found in similar sediments elsewhere, provides no definite information about the temperature.

The remaining Upper Danian coral-bearing, quartz sand sediments appear to represent a shallow sea, and this seems to be substantiated by the corals. The sediments contain detached fragments of branching coralla together with rather complete coralla of compact colonial forms and solitary forms. The remains are not seriously damaged by wear, and they are filled with material resembling the surrounding sediment. This indicates that there has been little if any reworking or transport.

Flabellum groenlandicum is recognized, sometimes in great numbers, in most of the localities. *Oculina becki* also appears to be common. In the most coarsely grained sandstones the species is often represented by fragments of comparatively stout branches which may reflect rather strongly agitated waters. Discovery of a *Caryophyllia* (*C.* sp. A), of *Faksephyllia faxoensis* (rare and only determined as probable and dubious), and of a probable example of *Astrangia* (*Coenangia*) may also be consistent with the general impression of a shallow sea. *Haimesiastraea* (*Haimesiastraea*) was possibly hermatypic but, if so, appears not to have formed reef structures in this area. The species is closely related to American species, which lived in what apparently were rather shallow seas in areas with a temperate or subtropical climate. The few dubious examples of *H.* (*Peruviastrea*) ? do not add to our knowledge.

Concluding remarks.

Bathymetry and temperature are not well-known for the Upper Cretaceous scleractinians.

Concerning the Danian, at least the main part of the Greenlandic coral-bearing deposits seem to have been laid down in rather shallow seas. From the number of scleractinian species common to Lower Danian and Upper Danian seas it is possible that the faunas lived under somewhat similar climatic conditions. These conditions are but poorly defined. Two Upper Danian corals seem to provide the best evidence: *Astrangia* (*Coenangia*) ? probably is an indicator for a warm temperate or subtropical climate, and it seems likely that *H.* (*Haimesiastraea*) is an indicator of a temperate (most likely a warm temperate) or subtropical climate. These results agree with the conclusion drawn by Koch (1963) from studies of Upper Danian angiosperms of the same area (temperate and perhaps warm temperate climate) and, furthermore, with that drawn by Rosenkrantz (1970) from studies of certain molluscs of the Agatdal Formation.

Thus a warm, and most likely a warm temperate climate is indicated by the scleractinians for Upper and Lower Danian in West Greenland.

PALAEOGEOGRAPHY

The scleractinian fauna provides only a little information on palaeogeography.

Since 1967 (Floris, 1967 a, b) the present writer, in his continued study of the fauna, has found it necessary to change his view on the numbers of species involved in certain faunal relations. Of the 22 species accepted in this paper on the scleractinian fauna in Greenland, 7 are new and indigenous, 2 are perhaps known previously from North America, 3 are previously known from Europe, and 10 are identifiable only to generic level.

Eleven species, the affinities of which (with Upper Cretaceous-Eocene species elsewhere) could be studied and appeared to have some palaeogeographical significance, are listed below. (In Greenland, 10 are certainly of Lower Paleocene (Danian) age and one is probably (Lower) Danian (*Trochocyathus johannesi*); details of the foreign species are given in the chapter with systematic descriptions):

Upper Danian *Haimesiastraea* (*Haimesiastraea*) *groenlandica* sp. n. Closely related to a Cretaceous species in New Zealand, a Cretaceous ? (Eocene ?; Paleocene might be suggested ?) species in California, 3 Lower Tertiary species (all partially Paleocene ?) in Peru, and one species in the Gulf states and in the Atlantic coast area of the U. S. A. (Paleocene (Kincaid in Texas; Midway in Alabama; Aquia in Maryland) and Eocene (Louisiana, Alabama, South Carolina)).

Upper Danian *H.* (*Peruviastrea*) ? sp. Seems to be closely related to a Lower Tertiary (Paleocene ?) species in Peru.

Upper Danian *Astrangia* (*Coenangia*) ? sp. cf. *A.* (*C.*) *cretacea* (Bölsche, 1870). Perhaps identical with a species known from the Upper Cretaceous of the U. S. A. (New Jersey; hardly Texas).

Lower-Upper Danian *Oculina becki* (Nielsen, 1922). Also occurring in the Paleocene (Lower-Middle Danian, and possibly in the Heersian) of Scandinavia. May have close relatives in the Upper Cretaceous of Antarctis, in the Paleocene (Danian) of Egypt, in the Paleocene (Midway limestone) and the Eocene of Alabama, and in the Lower Tertiary (Paleocene ?) of Peru.

Lower-Upper Danian *Caryophyllia andreasi* sp. n. Seems to have very close relatives in a Paleocene (Middle Danian) species in Scandinavia and perhaps also in an Eocene species in Belgium.

(Probably Lower Danian) *Trochocyathus johannesi* sp. n. Seems closely related to certain species in the U. S. A., which are from the Maastrichtian (Texas) or from the

Paleocene (Cannonball in North Dakota; Kincaid in Texas; Midway in Tennessee; Black Bluff in Alabama).

Lower Danian *Paracyathus kangiliaensis* sp. n. Seems to have close relatives in certain species in North Dakota (Paleocene Cannonball) and in Alabama (Paleocene ? (probably Midway)).

Lower-Upper Danian *Faksephyllia faxoensis* gen. n. et BECK in LYELL (1837) sp. Also occurring in the Paleocene (Middle Danian; and Lower Danian ?) of Scandinavia.

Lower-Upper Danian *Flabellum groenlandicum* sp. n. Seems to have very close relatives in the Upper Cretaceous of California; in the Paleocene of Texas (at least partially in the Kincaid Formation), ? Arkansas, and Alabama; in the Paleocene (Thanetian) of Austria; in the Eocene of California, Barbados, Texas, Arkansas, Louisiana, Mississippi, Alabama, Georgia, and South Carolina; and in the Priabonian of Europe.

Lower Danian *Balanophyllia* sp., cf. *ponderosa texana* VAUGHAN & POPENOE, 1933. Might belong to a Paleocene (Kincaid Formation) species known from Texas. May have close relatives in the Paleocene of Alabama, and in the Eocene of Barbados, Texas, and Alabama.

Lower Danian *Dendrophyllia candelabrum* HENNIG, 1899. Also occurring in the Paleocene (Lower-Upper Danian, and the Heersian) of Scandinavia. It may have its closest known relative in the Eocene of England.

Astrangia (*Coenangia*) ? sp. cf. *A.* (*C.*) *cretacea* so far is considered as possibly identical with a species known from the Upper Cretaceous elsewhere. All of the remaining listed species either are identical with, or have apparently close relatives in, certain corals from deposits outside Greenland that more or less certainly have been dated as Paleocene; some of these species also have apparently close relatives in older or in younger deposits. It is interesting to see that Greenlandic corals from the Lower Paleocene (Danian) have a possibly identical form and also apparently close relatives (including a member of the rare and peculiar *H.* (*Haimesiastraea*)) in certain North American deposits that are contemporaneous or nearly contemporaneous with them, viz. deposits belonging to the Kincaid, the Aquia, and the Cannonball Formations. This suggests a certain connection between the areas concerned. The route of migration between the occurrences in the U. S. A. and in central West Greenland probably was the direct one along the eastern margin of the ancient North America (maps in SCHUCHERT, 1955). It should be stressed, however, that this concerns only a minor part of the coral faunas considered. Furthermore, studies of certain other invertebrate groups have suggested that the connection between West Greenland and localities in North America was rather weak (ROSENKRANTZ, 1951, 1953, 1964 a, 1970; ROSENKRANTZ & PULVERTAFT, 1969; HANSEN, 1970).

The presence of a possibly close relative to *Oculina becki* in the Danian of Egypt is interesting, but further study is needed before the palaeogeographic aspect can be evaluated.

Last to be considered is the Danian sea connection between the Nûgssuaq area and south Scandinavia that is indicated by the distribution of certain branching scleractinians. (Supporting evidence for the connection is provided by the two solitary species, *Caryophyllia andreasi* and the very similar *C. danica*).

Close affinities between other marine fauna elements of the geographically distant West Greenland and north Europe have been observed (ROSENKRANTZ, 1951, 1953, 1964 a, 1970; ROSENKRANTZ & PULVERTAFT, 1969; HANSEN, 1970), and it has been suggested (1969, ROSENKRANTZ, 1970), that a migration route passed through the Davis Strait. Marine Danian or younger Paleocene deposits have not been found in Greenland outside Nûgssuaq, and only a few relevant deposits have been recorded elsewhere in the Arctic region (see RAVN (1922), HÄGG (1925), OBRUTSCHEW (1926), MARTIN (1926), GRIPP (1927), ROSENKRANTZ (1951, p. 156), IMLAY & REESIDE (1954), KOROBKHOV & OVECHKIN (1959), BOBKOVA (1959), TOZER (1960, 1963), RAASCH (1961), THORSTEINSSON & TOZER (1962), FORTIER *et al.* (1963), and TOZER & THORSTEINSSON (1964)). The present writer has no information on corals in these deposits.

The suggested route through the Davis Strait seems quite probable also for the case of the Danian scleractinians. But no further evidence appears to have survived for tracing the migration route of the remarkable suite of three branching corals, which were apparently shallow-water forms.

It is possible that these corals and other invertebrates which migrated as planulae could have crossed the Atlantic Ocean step by step by making use of sea-mounts. Nothing definite is known about such sea-mounts but they may be thought to have been developed along the line of today's Faroe Islands and Iceland, during early phases of the Lower Tertiary Brito-Arctic basalt vulcanism (see also FLORIS, 1967 a, b). Indications of Lower Danian vulcanism have also been found in Scandinavia (ROSENKRANTZ, 1955).

In earlier discussions of similarities between European and West Greenlandic Danian invertebrate faunas, comparisons were also made elsewhere than to the Danian of south Scandinavia. Thus to (1) the Middle Paleocene Lower Selandian of Denmark; (2) the Lower Paleocene Middle Danian (see RASMUSSEN, 1965) Tuffeau de Ciply of Belgium; and (3) the Middle Paleocene (Heersian) of Belgium.

The Greenlandic scleractinian fauna appears to have at least one form possibly in common with the Middle Paleocene of Denmark; but it seems to have identical forms neither in the fauna from the Tuffeau de Ciply (four species reported from "Ciply" by EDWARDS & HAIME (1848 a, p. 290, and 1848 b, pp. 245, 246)) nor in the fauna from the Calcaire grossier de Mons (see BRIART & CORNET, 1865, p. 776, and ALLOITEAU & TISSIER, 1958).

DANSK SAMMENDRAG

Indledning

Scleractiniekoraller fra Yngre Kridt og Ældre Tertiær kendes i Grønland kun fra det nordvestlige Nûgssuaq, Fig. 1. Deres tilstedeværelse blev opdaget af De Danske Nûgssuaq Ekspeditioner 1938–39 (ledet af professor ALFRED ROSENKRANTZ). Et lille materiale fra 1939 er fra og med 1946 blevet suppleret med et meget stort, som er samlet under Grønlands Geologiske Undersøgelse's feltarbejde under ledelse af professor ALFRED ROSENKRANTZ. Korallerne har været meget lidt omtalt i litteraturen (kort bibliografi på siderne 5–6). I afhandlingen redegøres for 22 arter, som er påvist i materialet, der findes indlemmet i Københavns Universitets Mineralogiske Museum. Den stratigrafiske placering af materialet beror for en stor del på resultaterne af nyere vurderinger af andre dyregrupper (litteraturhenvisninger på side 6). Korallerne kan således for de flestes vedkommende dateres til Dan (om inddeling af Dan, se ROSENKRANTZ, 1970). (Dan-etagen betragtes her som Ældre Paleocæn, idet EL-NAGGAR's opfattelse (1967) følges. Ved den stratigrafiske indordning af nordamerikanske former følges PALMER & BRANN's skema (1965) suppleret med skema i PAPP (1959)).

Beskrivelse af lokaliteterne

Kort: Figurerne 1, 2, 10 og 14. Det geologiske kortblad med beskrivelse er endnu ikke publiceret, og lokalitetsbeskrivelserne er derfor bygget dels på relevante oplysninger i andre specialafhandlinger (liste på side 7) og dels på andres og forfatterens feltnoter. Efter en kort omtale af det geologiske idealsnit gennem Nûgssuaq's lagserie gennemgås i aldersfølge de koralførende aflejringer med omtale af de tilknyttede lokaliteter. Aflejringerne repræsenterer Yngre Kridt (Campan ?, Maastricht) samt Ældre Tertiær (Ældre og Yngre Dan). Materiale fra løstfundne blokke er medtaget med angivelse af sandsynlig alder. Tabellen på siderne 100–101 giver en oversigt over lokaliteterne.

Systematiske beskrivelser

Arterne er generelt klassificeret efter WELLS (1956). 7 er nye og kun kendt fra Grønland, 2 er måske identiske med arter kendt i Nordamerika, 3 kendes fra Europa, og 10 kan foreløbig kun slægtsbestemmes. Et materiale af ubestemte, dårligt bevarede fossiler er skitseret og opregnet i aldersfølge.

Følgende slægter er fundet (udover 2 nye): *Haimesiastraea* (*Haimesiastraea*), *H.* (*Peruviastrea*) ?, *Discotrochus* ?, *Astrangia* (*Coenangia*) ?, *Oculina*, *Caryophyllia*, *Trochocyathus*, *Paracyathus*, *Stephanocyathus* (*Stephanocyathus*), *Desmophyllum* ?, *Lophelia* ?, *Parasmilia*, *Flabellum*, *Balanophyllia* og *Dendrophyllia.*

Som led i behandlingen er bragt revisioner af nogle skandinaviske scleractinier (*Oculina becki* (NIELSEN, 1922), *Faksephyllia faxoensis* (BECK in LYELL, 1837), *Dendrophyllia candelabrum* HENNIG, 1899).

Arternes forekomst i Grønland er summeret i tabellen på siderne 100–101.

Palæoøkologi

Resultaterne bygger på undersøgelser af sedimenterne med deres indhold af koralfossiler og på de temperatur- og dybdekrav, der kendes for nutidige former eller kan antages for visse uddøde former. Øvre Kridtkorallernes dybde- og temperaturforhold er ikke godt kendt. Havet synes i Ældre og Yngre Dan for korallokaliteternes vedkommende i almindelighed at have været temmelig lavvandet. Det lokale Dan-klima er ikke godt belyst af scleractinierne; det har meget muligt været varmt (snarest varmt tempereret) i Yngre Dan.

To arter (*H.* (*Haimesiastraea*) *groenlandica* og *H.* (*Peruviastrea*) ? sp.) har måske været hermatype, men ingen revstruktur er fundet. Alle de øvrige scleractinier var antagelig ahermatype.

Der er påvist en ikke-revbyggende koral-association (liste på side 106), som i Ældre Dan dannede på samme tid (fortløbende) ødelagte, sparsomt befolkede polytypiske koral-krat. Dannelsedybden antages at have ligget i intervallet 50 ?–80 m, hvad der synes en mindre dybde end sædvanligt for koralstrukturer af et lignende udseende. Temperaturen ved bunden er ikke sikkert kendt. Tilstedeværelse af koral-krat er diskuteret for den basaltiske Tuf II i Danienrygge ved Kangilia på nordkysten (mindst to krat), for basalttuffen i Danienkløft (Tunorssuaq-dalsystemet) (ingen krat påvist) og for basalttuffen i Koralravine (Ilugigsoq-dalsystemet) (mindst eet krat er indiceret). I forbindelse dermed diskuteres forholdene i Dan-tid i Fakse, idet der er fundet identiske former blandt de kolonidannende scleractinier i Skandinavien (først og fremmest i Fakse) og på Nûgssuaq.

Palæogeografi

Mens palæoklimatologiske udsagn er behandlet i foregående kapitel, behandles her kort nogle faunaforbindelser. Elleve koralformers identitets- og andre slægtskabsforhold kunne nærmere undersøges; ti er kendt fra Dan-etagen i Grønland, og en er sandsynligvis fra Ældre Dan i Grønland (liste på siderne 114–115). Nogle af dem synes at have nære slægtninge (og i et tilfælde en muligvis identisk form) i nordamerikanske lag (Kincaid, Aquia og Cannonball Formationerne i Texas, Maryland og North Dakota), som er jævnaldrende eller meget nært jævnaldrende med de grønlandske former. Det ligger nærmest at antage en vandringsvej mellem de amerikanske og de grønlandske forekomster lige øst om det nordamerikanske fastland. Ligheden med nordamerikanske faunaer er dog begrænset til en lille del af de undersøgte scleractinier. Forbindelse til Europa (Danmark-Sverige) i Dan-tid er meget kraftigt betonet af visse af korallerne (kombinationen af tre grenede arter (formodentlig lavvandsformer), som blandt andet er hovedbjergartsdannere i koralkalken i Fakse). Nær forbindelse med Europa er tidligere påvist for andre invertebratgrupper i Vestgrønlands Dan, og en ligeledes tidligere foreslået vandringsrute gennem Davis Strædet virker også ganske sandsynlig for scleractiniernes vedkommende.

Notes added in proof

1) Note on p. 7:

A geological map of Nûgssuaq was published in 1971 (Sheet Søndre Strømfjord–Nûgssuaq, 1:500,000) by the Geological Survey of Greenland (Copenhagen).

2) Note on p. 108:

Since the publication of FLORIS (1971) a paper by CHEETHAM (1971) has appeared which directly concerns the present study in its analysis of the Fakse limestone quarry. The writer may not be in agreement with CHEETHAM's bathymetric results. CHEETHAM appears to consider even the Fakse "mounds" as probably formed at depths approximating the shelf edge (pp. ii, 36). However, it must be stressed that the existence of a thicket (or coppice, or bank) of corals which are not light-dependant cannot form the basis of any estimate of living-depth of the corals.

CHEETHAM, A. H. 1971: Functional Morphology and Biofacies Distribution of Cheilostome Bryozoa in the Danian Stage (Paleocene) of Southern Scandinavia. *Smithson. Contr. Paleobiol.* **6**, i–iv, 1–88.

ACKNOWLEDGEMENTS

For his permission to study the collection of Nûgssuaq fossil scleractinians in the Mineralogical Museum of the Copenhagen University, and for his kind and instructive advice I sincerely wish to express my thanks to Professor Alfred Rosenkrantz, Copenhagen University. I am indebted also to Professor Arne Noe-Nygaard, director of the Mineralogical Museum of the Copenhagen University, for his permitting me to study the collections and for the facilities made available to me.

I further wish to thank the leaders and staffs of the following Swedish institutes for permission to study the collections: Paleontologiska Institutionen, Lund; Paleontologiska Institutionen, Uppsala; Riksmuseets Paleozoologiska Avdelning, Stockholm; and Sveriges Geologiska Undersökning, Stockholm.

The maps were prepared for publication by the drawing office of the Geological Survey of Greenland. Mr. Knud Schou-Jørgensen and Professor Alfred Rosenkrantz provided some of the field photographs, while photographic work in the laboratory was carried out by Mrs. Bente Bang Soltau (the plates) and Mr. P. Nielsen. For this help I owe my sincere thanks.

I wish to thank the director of the Geological Survey of Greenland for permission to publish this work. During the early part of the study I gratefully received financial support from the Danish State Research Foundation.

Lastly, I wish to thank Dr. Richard G. Bromley for improving the English text.

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Note: Some of the works have not been consulted in the original.

Færdig fra trykkeriet den 30. august 1972.

PLATES

BENTE BANG SOLTAU photo.

Plate 1

Figs 1 A – 1 B. *Haimesiastraea* (*Haimesiastraea*) *groenlandica* sp. n. (p. 24).

Fig. 1 A. Larger fragment (MMH 12,631 A) of the holotype. Surface sculpture. ×6. Upper Danian. Turritellakløft, Scaphitesnæsen.

Fig. 1 B. Same fragment. Cross-section of corallites. ×8 $^2/_3$.

Fig. 2. *Haimesiastraea* (*Peruviastrea*) ? sp. (p. 25). Specimen A. MMH 12.632. ×2. Upper Danian. Agatkløft, "Store Profil", Sonja Lens.

Figs 3 A – 3 B. *Discotrochus* ? sp. (p. 27).

Fig. 3 A. MMH 12,633. From above. ×4. Lower Danian. Tunorssuaq, Danienkløft, "Store Profil".

Fig. 3 B. Same specimen. From below. ×4.

Figs 4–5. *Astrangia* (*Coenangia*) ? sp. cf. *A.* (*C.*) *cretacea* (Bölsche, 1870). (p. 29).

Fig. 4. MMH 12,634. Corallum fragment from above. ×4. Upper Danian. Agatkløft, "Store Profil", Sonja Lens.

Fig. 5. MMH 12,635. Fragment of incrusting corallum, from above. ×8. Upper Danian. Agatkløft, "Store Profil", Sonja Lens.

Figs 6–17. *Oculina becki* (Nielsen, 1922). (p. 31).

Fig. 6. Lectotype. MMH 2105. ×2. Middle Danian. Fakse limestone quarry (Denmark).

Fig. 7. MMH 12,636. Corallum fragment. ×2. Lower Danian. Danienrygge at Kangilia, Ryg A, Tuff II.

Fig. 8. MMH 12,637. Surface sculpture. ×10. Upper Danian. Agatkløft, "Store Profil", Sonja Lens.

Fig. 9. MMH 12,638. ×4. Photograph taken in xylene, shows the pali. Lower Danian. Danienrygge at Kangilia, Ryg A, Tuff II.

Fig. 10. MMH 12,639. Supposed basal fragment of corallum. ×2 $^2/_3$. Photograph taken in xylene. Lower Danian. Danienrygge at Kangilia, Ryg A, Tuff II.

Fig. 11. MMH 12,640. Basal fragment of corallum. ×3. Lower Danian. Danienrygge at Kangilia, Ryg A, Tuff II.

Figs 12–16. MMH 12,641–12,645 respectively. Different degrees of development of coenosteum. ×2. Upper Danian. Turritellakløft, "Store Profil" (Abraham Mb.), basalt tuff in the upper part (fallen material).

Fig. 17. MMH 12,646. External mould, in sandstone. ×2. Upper Danian. Nuilaussarssuaq.


1 A


1 B


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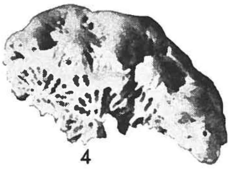
3 A


3 B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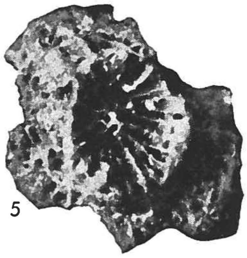
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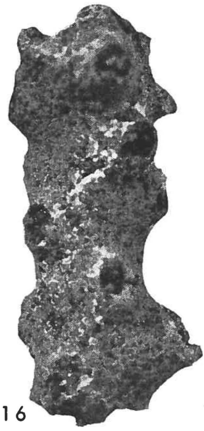
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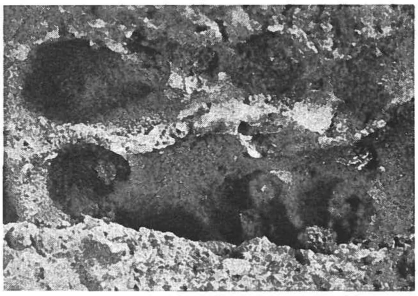
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Plate 2

Figs 1 A – 5. *Caryophyllia andreasi* sp. n. (p. 40).

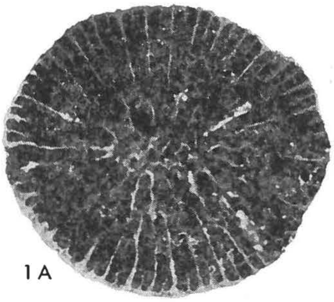
- Fig. 1 A. Holotype. MMH 12,647. From above. ×$2^1/_2$. Photograph taken in xylene. Lower Danian. Danienrygge at Kangilia, Ryg A, Tuff II.
- Fig. 1 B. Same specimen. Outer sculpture. ×8 $^2/_3$.
- Fig. 2. MMH 12,648. ×2. Lower Danian. Danienrygge at Kangilia, Ryg A, Tuff II.
- Fig. 3. MMH 12,649. ×2. Lower Danian. Danienrygge at Kangilia, Ryg A, Tuff II.
- Fig. 4. MMH 12,650. Outer sculpture. ×10. Lower Danian. Danienrygge at Kangilia, Danienrygge, Tuff II.
- Fig. 5. MMH 12,651. Outer stereome. ×8. Photograph taken in xylene. Upper Danian. Turritellakløft, "Store Profil" (Abraham Mb.), basalt tuff.

Figs 6–7 B. *Caryophyllia* sp. A. (p. 47).

- Fig. 6. MMH 12,652. Outer sculpture. ×10. Upper Danian. Turritellakløft, Store Profil (Turritellakløft Mb.), quartz sandstone (Lowermost sandstone bed, 1968).
- Fig. 7 A. MMH 12,653. ×2. Lower Danian. Danienrygge at Kangilia, Ryg A, Tuff II.
- Fig. 7 B. Same specimen. ×4. Photograph taken in xylene.

Figs 8 A – 9. *Caryophyllia agatdalensis* sp. n. (p. 49).

- Fig. 8 A. Part (MMH 12,654 A) of holotype. ×2. Lower Danian. Oyster-ammonite Conglomerate localities I and II, matrix of conglomerate.
- Fig. 8 B. Remaining part (MMH 12,654 B) of holotype. ×2.
- Fig. 9. Possible example. Cross-section of the largest of the fragments (MMH 12,655 A). ×2 $^2/_3$. Photograph taken in xylene. Lower Danian ? (Campanian ?, Maastrichtian ?). Oyster-ammonite Conglomerate locality III, conglomerate-boulder ?.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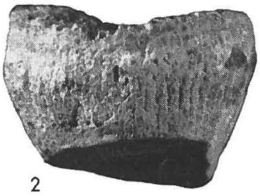
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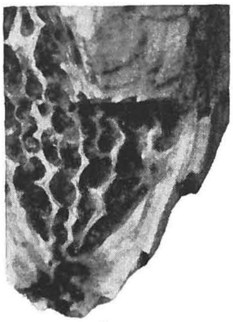
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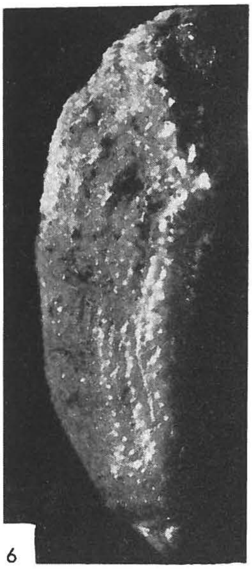
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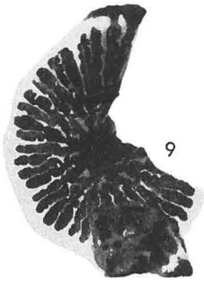
7 A


8 A


7 B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8 B

Plate 3

Figs 1–3. *Caryophyllia* sp. B. (p. 51).

Fig. 1. MMH 12,656. ×2. Probably Lower Danian. Serfat (displaced concretion from dark shale).

Fig. 2. MMH 12,657. ×2. Probably Lower Danian. Ilugigsoq, the southern neighbouring gorge to Koralkløft (displaced concretion from dark shale).

Fig. 3. MMH 12,658 A. Cross-section. ×2. Photograph taken in xylene. Probably Lower Danian. Serfat (displaced concretion from dark shale).

Figs 4 A – 5. *Trochocyathus johannesi* sp. n. (p. 54).

Fig. 4 A. Holotype. MMH 12,659. ×2 $^2/_3$. Photograph taken in xylene. Probably Lower Danian. At Kangilia (displaced concretion from dark shale).

Fig. 4 B. Same specimen. ×1 $^2/_3$.

Fig. 5. MMH 12,660. Outer sculpture. ×10. Probably Lower Danian. At Kangilia (displaced concretion from dark shale).

Figs 6 A – 9. *Paracyathus kangiliaensis* sp. n. (p. 60).

Fig. 6 A. Holotype. MMH 12,661. ×2. Lower Danian. Danienrygge at Kangilia, Ryg A, Tuff II.

Fig. 6 B. Same specimen. Calicular view. ×4. Photograph taken in xylene.

Fig. 7. MMH 12,662. Cross-section. ×2 $^2/_3$. Photograph taken in xylene. Lower Danian. Danienrygge at Kangilia, Ryg A, Tuff II.

Fig. 8. MMH 12,663. Cross-section. ×4 $^4/_5$. Photograph taken in xylene. Lower Danian. Danienrygge at Kangilia, Ryg A, Tuff II.

Fig. 9. MMH 12,664. ×2. Lower Danian. Danienrygge at Kangilia, Ryg A, Tuff II.

Fig. 10. *Stephanocyathus* (*Stephanocyathus*) sp. (p. 63). Specimen I. MMH 12,665. From below. ×4. Probably Lower Danian. At Kangilia (displaced concretion from dark shale).

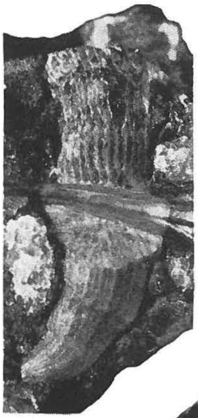
Figs 11 A – 12 B. *Stephanocyathus* (*Stephanocyathus*) ? sp. no. 1. (p. 64).

Fig. 11 A. Part (MMH 12,666 A) of 1958-specimen. ×4. Maastrichtian. Oyster-ammonite Conglomerate locality III, conglomerate-boulder.

Fig. 11 B. Remaining part (MMH 12,666 B) of the same specimen. ×4.

Fig. 12 A. Part (MMH 12,667 A) of 1956-specimen. ×4. Maastrichtian ? (Campanian ?, L. Danian ?). Oyster-ammonite Conglomerate locality III, conglomerate boulder ?.

Fig. 12 B. Remaining part (MMH 12,667 B) of the same specimen. ×4.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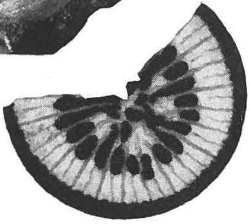

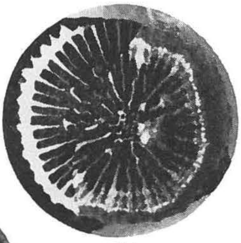
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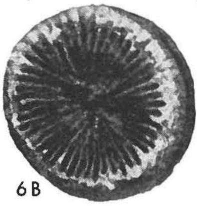
6A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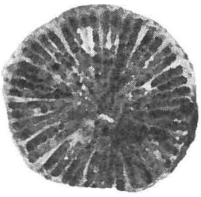
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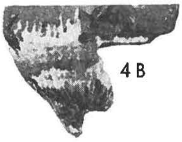
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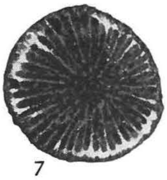
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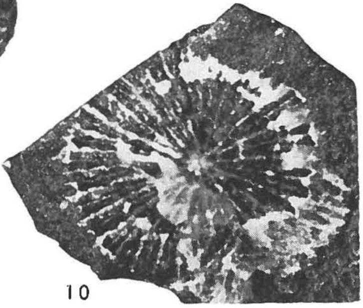
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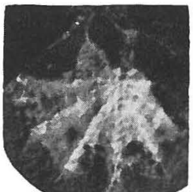
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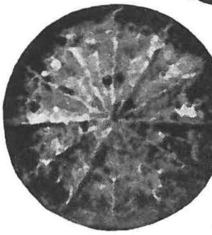
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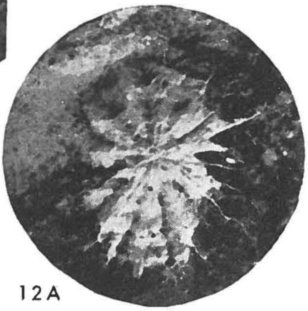
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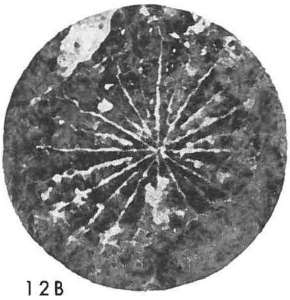

12B

Plate 4

Fig. 1. *Stephanocyathus* (*Stephanocyathus*) ? sp. no. 2. (p. 65). MMH 12,668. From below. ×8. Upper Danian ?. Agatkløft, "Store Profil", Sonja Lens (probably derived).

Figs 2 A – 3. *Kangiliacyathus groenlandicus* gen. n. & sp. n. (p. 67).

- Fig. 2 A. Larger fragment (MMH 12,669 A) of holotype, with outline of the remaining fragment (MMH 12,669 B). ×2. Lower Danian. Danienrygge at Kangilia, Ryg B, Conglomerate immediately above Tuff I.
- Fig. 2 B. The same larger fragment, from below. ×4. Photographed in xylene.
- Fig. 2 C. The same larger fragment. Outer sculpture. ×10.
- Fig. 3. MMH 12,670. Cross-section about 2 mm below calicular margin. ×4. Photographed in xylene. Lower Danian. Danienrygge at Kangilia, Ryg B, Conglomerate immediately above Tuff I.

Figs 4 A – 4 C. *Desmophyllum* ? sp. (p. 69)

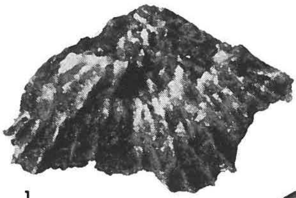
- Fig. 4 A. Calicular view. MMH 12,671 A. ×4. Photographed in xylene. Lower Danian. Danienrygge at Kangilia, Ryg A or Ryg B, Tuff II.
- Fig. 4 B. Cross-section 2.5 mm below calicular margin. MMH 12,671 B. ×4 $^2/_3$. Photographed in xylene.
- Fig. 4 C. Basal fracture. MMH 12,671 C. ×4. Photographed in xylene.

Fig. 5. *Lophelia* ? sp. (p. 71). MMH 12,672. ×2. Lower Danian. Danienrygge at Kangilia, Ryg A, Tuff II.

Fig. 6. *Parasmilia* sp. (p. 72). MMH 12,673. ×2 $^2/_3$. Photographed in xylene. Lower Danian. Danienrygge at Kangilia, Ryg A, Tuff II.

Figs 7–11. *Faksephyllia faxoensis* gen. n. & Beck in Lyell (1837) sp. (p. 73; also on pl. 5).

- Fig. 7. Presumably a proctocorallite. MMH 12,674. ×3. Lower Danian. Danienrygge at Kangilia, Ryg A, Tuff II.
- Fig. 8. Cross-section. MMH 12,675. ×4. Photographed in xylene. Lower Danian. Danienrygge at Kangilia, Tuff II.
- Fig. 9. Outer sculpture. MMH 12,676. ×10. (The fragment was photographed upside-down). Lower Danian. Danienrygge at Kangilia, Tuff II.
- Fig. 10. Cross-section. MMH 12,677. ×4. Photographed in xylene. Lower Danian. Danienrygge at Kangilia, Tuff II.
- Fig. 11. Neotype. MMH 2043. ×2. Middle Danian. Fakse limestone quarry (Denmark).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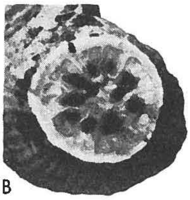
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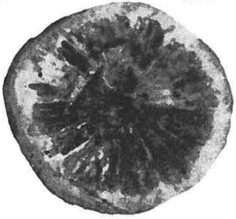
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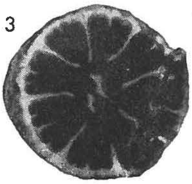
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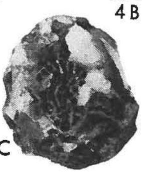
4A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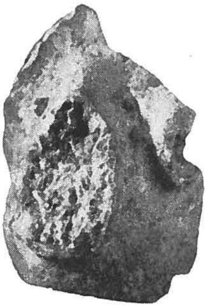
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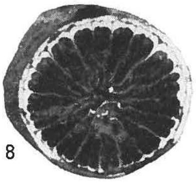
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Plate 5

Figs 1–5. *Faksephyllia faxoensis* gen. n. & Beck in Lyell (1837) sp. (p. 73; also on pl. 4).

Fig. 1. Reproduction of Fig. 4 (p. 249) in Lyell (1837 a). ×1 $^1/_3$.

Fig. 2. Calice. MMH 12,678. ×4. Lower Danian. Danienrygge at Kangilia, Tuff II.

Fig. 3. Calice. MMH 12,679. ×4. Lower Danian. Danienrygge at Kangilia, Tuff II.

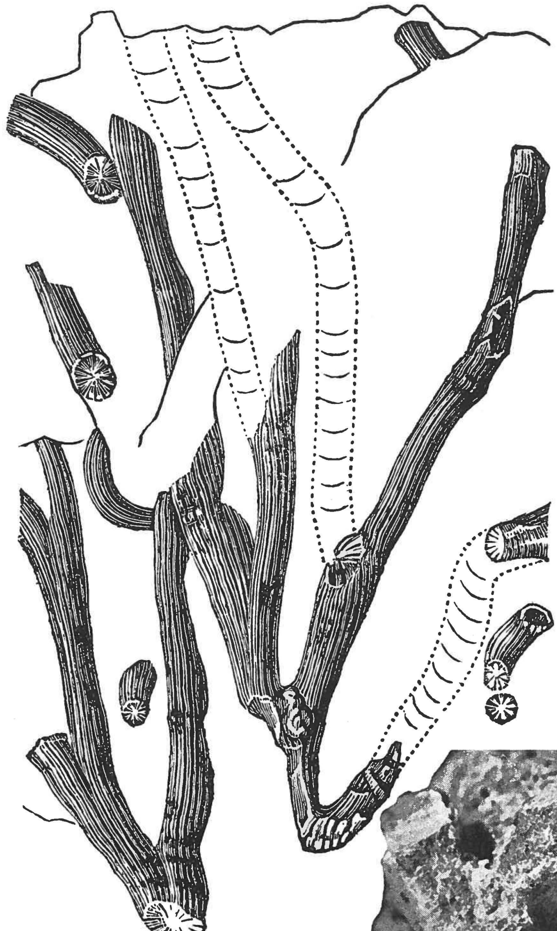
Fig. 4. Calices. MMH 12,680. ×4. Lower Danian. Danienrygge at Kangilia, Tuff II.

Fig. 5. MMH 12,681. ×2. Lower Danian. Danienrygge at Kangilia, Ryg A, Tuff II.

Figs 6 A – 6 B. *Flabellum groenlandicum* sp. n. (p. 81; also on pl. 6).

Fig. 6 A. Holotype. MMH 12,682 A, B. ×2. Lower Danian. Danienrygge at Kangilia, Ryg B, Conglomerate immediately above Tuff I.

Fig. 6 B. Larger fragment (MMH 12,682 A) of holotype. From above. ×4. Photographed in xylene.



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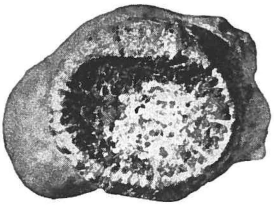

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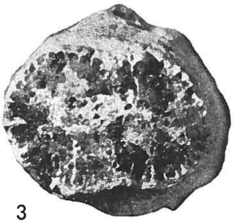

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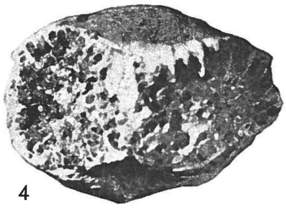

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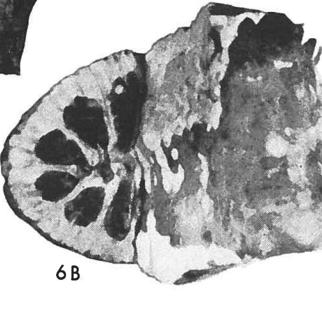


6B

Plate 6

Figs 1–33. *Flabellum groenlandicum* sp. n. (p. 81; also on pl. 5).

Fig. 1. Cross-section of compressed turbinate corallum, with 48 septa. MMH 12,683. ×4. Photographed in xylene. Lower Danian. Danienrygge at Kangilia, Ryg B, Conglomerate immediately above Tuff I.

Fig. 2. Cross-section, approximately $^1/_2$ cm above the base and more than 8.5 mm below calicular margin. MMH 12,684. ×4. Photographed in xylene. Lower Danian. Danienrygge at Kangilia, Ryg B, Conglomerate immediately above Tuff I.

Fig. 3. MMH 12,685. ×2. Upper Danian. Turritellakløft, "Store Profil" (Turritellakløft Mb.), quartz sandstone (Two lowermost sandstone beds, 1946).

Figs 4–25. Corallum shapes. MMH 12,686–12,707 respectively. ×1 $^1/_3$. Lower Danian. Danienrygge at Kangilia, Ryg B, Conglomerate immediately above Tuff I. Compare text-fig. 16.

Figs 26–33. Corallum shapes. MMH 12,708–12,715 respectively. ×1 $^1/_3$. Upper Danian. Agatkløft, "Store Profil", Sonja Lens. Compare text-fig. 16.

Figs 34 A – 34 B. *Balanophyllia* sp., cf. *ponderosa texana* VAUGHAN & POPENOE, 1933. (p. 90).

Fig. 34 A. Fragment from above. MMH 12,716. ×2 $^4/_5$. Photographed in xylene. Lower Danian. Danienrygge at Kangilia, Ryg A, Tuff II.

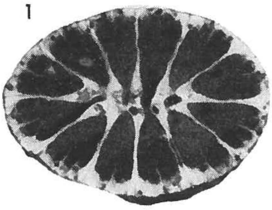
Fig. 34 B. Same specimen, outer sculpture, ×10. Photographed in xylene.

Figs 35–37. *Dendrophyllia candelabrum* HENNIG, 1899. (p. 92; also on plates 7, 8).

Fig. 35. Side-view of calice. MMH 12,717. ×2. Lower Danian. Danienrygge at Kangilia, Ryg A, Tuff II.

Fig. 36. Cross-section. MMH 12,718. ×4 $^4/_5$. Fragment photographed from below and in xylene. Lower Danian. Ilugigsoq, Koralravine.

Fig. 37. Cross-section. MMH 12,719. ×4 $^4/_5$. Photographed in xylene ("up" is to the right). Lower Danian. Ilugigsoq, Koralravine.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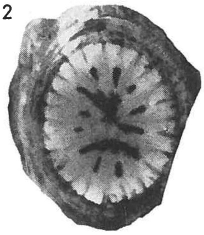
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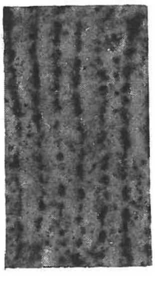
34A


34B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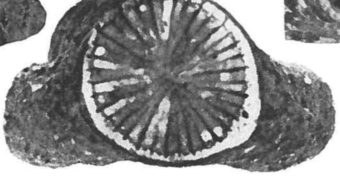
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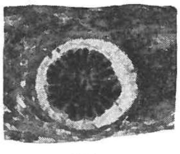
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Plate 7

Figs 1–6. *Dendrophyllia candelabrum* Hennig, 1899. (p. 92; also on plates 6, 8).

Fig. 1. Cross-section. MMH 12,720. ×4 $^4/_5$. Photographed in xylene. Lower Danian. Danienrygge at Kangilia, Ryg A, Tuff II.

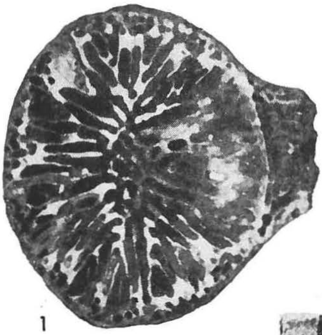
Fig. 2. Cross-section. MMH 12,721. ×4 $^4/_5$. Photographed in xylene. Lower Danian. Danienrygge at Kangilia, Ryg A, Tuff II.

Figs 3 A – 3 B. Large corallum fragment. MMH 12,722. Lower Danian. Danienrygge at Kangilia, Ryg A, Tuff II. Fig. 3 A, Cross-section of widest corallite, ×2 $^1/_3$, photographed in xylene. Fig. 3 B, ×2.

Fig. 4. MMH 12,723. ×1 $^1/_3$. Middle Danian coral limestone. Fakse limestone quarry (Denmark).

Fig. 5. MMH 12,724. ×2. Middle Danian coral limestone. Fakse limestone quarry (Denmark).

Fig. 6. Lectotype. MMH 1682. ×2. Middle Danian. Fakse limestone quarry (Denmark).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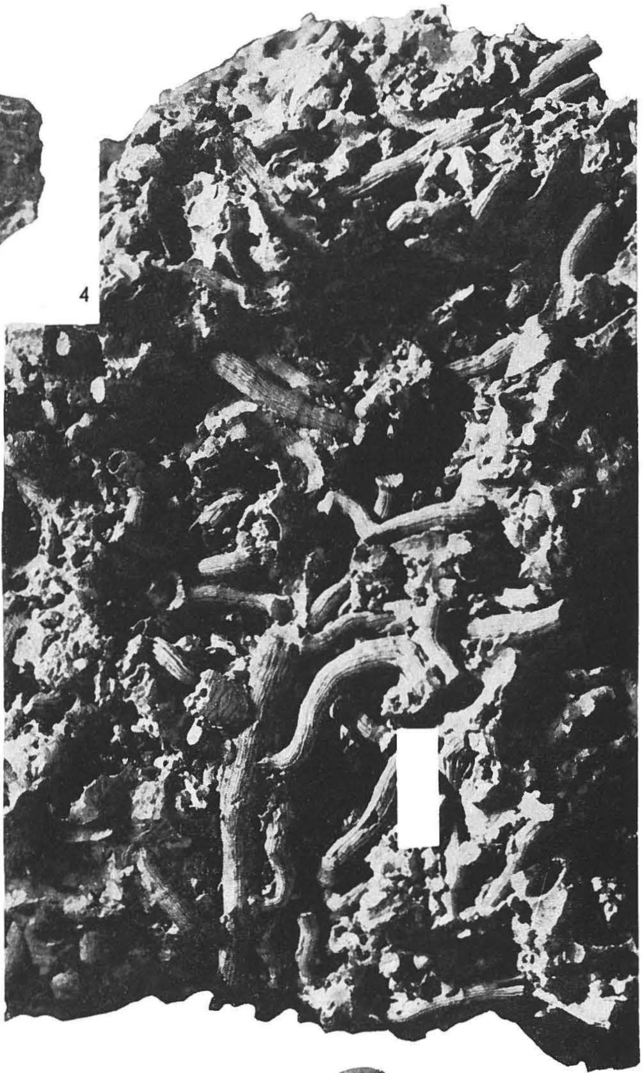
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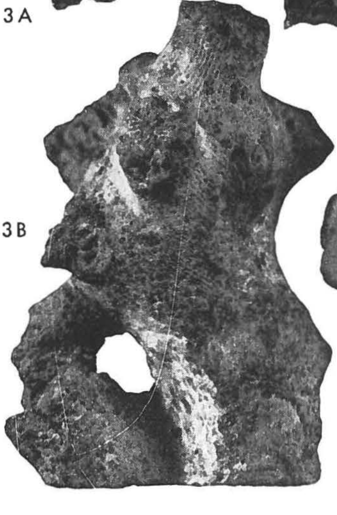
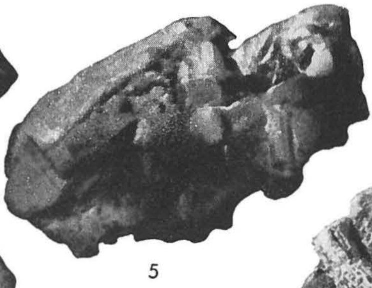
3A


3B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6

Plate 8

Figs 1 A – 1 B. *Dendrophyllia candelabrum* HENNIG, 1899. (p. 92; also on plates 6, 7).

Fig. 1 A. MMH 12,725. ×2. Probably Lower Danian. Ilugigsoq, Koralkløft (basalt tuff presumably displaced from Koralravine).

Fig. 1 B. Same fragment. Outer sculpture. ×10.

Figs 2–4. Undetermined basal parts of Dendrophylliin coralla. (P. 98).

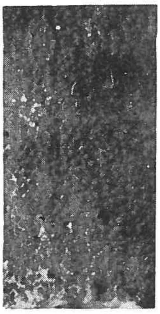
Fig. 2. MMH 12,726. ×3. Lower Danian. Danienrygge at Kangilia, Ryg A, Tuff II.

Fig. 3. MMH 12,727. ×5. Photographed in xylene. Lower Danian. Danienrygge at Kangilia, Ryg A, Tuff II.

Fig. 4. MMH 12,728. ×3. Lower Danian. Danienrygge at Kangilia, Ryg A, Tuff II.

Fig. 5. Unidentified solitary corallum. (pp. 9, 99). MMH 12,729. ×2. Upper Campanian (?). Ikorfat.


1 A


1 B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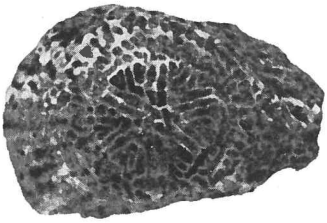
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