Upper Maastrichtian? – lower Paleocene dinoflagellate cysts and pollen from turbidites in the Itilli region, Nuussuaq, central West Greenland – first dating of the sediments

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Dinoflagellate cysts are recorded for the first time from two sections representing the uppermost part of the more than two kilometre thick turbidite succession exposed on the south-east side of the Itilli valley in Nuussuaq, central West Greenland. The cysts were recovered from sections situated immediately below the Tertiary pillow breccia at Ilugissorsuaq and at Qaasersut. The dinoflagellate cysts are rare in these sediments and the diversity appears to be low in both sections. The species *Palaeocystodinium* cf. *P. australinum* is rare whereas *Phelodinium kozlowskii* is very common in the uppermost sample from Ilugissorsuaq. A similar acme of *P. kozlowskii* has been recovered from the lower Paleocene part of the Kangilia section on the north coast of Nuussuaq. The presence of *P.* cf. *P. australinum* and the pollen *Wodehousia spinata* at Qaasersut indicates the presence of uppermost Maastrichtian to lowermost Paleocene sediments.

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The most extensive and varied exposures of Cretaceous–Tertiary sediments in central West Greenland occur on the Nuussuaq (previously spelt Nûgssuaq) peninsula (Fig. 1). In the Itilli (previously spelt Itivdle) valley in western Nuussuaq these sediments consist of organic-rich slope mudstones alternating with coarse- to very coarse-grained submarine fan sandstones. These sandstones occur in 30–100 m thick megacycles internally composed of fining-upward cycles a few metres thick deposited from high-density turbidite currents (Christiansen *et al.*, 1992).

It has not hitherto been possible to correlate the turbidite succession with any other exposed section in the area. Ehman *et al.* (1976) believed that the succession was Cretaceous while Hansen (1980) thought it was Tertiary (for further discussion see also Pulvertaft, 1987). One of the reasons why the correlation of these sediments is of importance is that if they are also found offshore they could act as excellent source and reservoir rocks for hydrocarbons.

The turbidites are overlain by the Tertiary volcanic rocks of the Vaigat Formation (Hald & Pedersen, 1975; Piasecki *et al.* 1992). The base of the turbidite succession is not exposed.

Previous palynological studies of the more than two kilometre thick turbidite succession in the Itilli region have only occasionally yielded badly preserved dinoflagellate cysts, spores and pollen (Croxton, 1976, 1978, 1980; Ehman *et al.*, 1976; Hansen, 1980). All previously analysed samples have been thermally postmature due to volcanic and hydrothermal activity in the area.

In one sample (GGU 210427) from the lowermost part of a section (M 24) in the Anariartorfik valley, Croxton (1978, 1980) recorded two battered specimens of *Aquilapollenites* (Plate 1, Figs 1–2) and one triporate specimen of the Normapolles group. Trilete, tricolpate and monolete specimens were also recorded. Based on these records Croxton (1978) concluded that strata of Maastrichtian age occur in the Itilli valley. It should, however, be noted, as Hansen (1980) did, that these pollen and spores could represent reworked Maastrichtian material. Sample GGU 210427 represents a level situated approximately at 800 m in the more than 2 km thick turbidite succession at Itilli (G. Dam & M. Sønderholm, personal communication, 1993).

An indication of the minimum age of the Itilli turbidite succession was provided by Jürgensen & Mikkelsen (1974) who, on the basis of coccoliths, placed a basalt conglomerate with matrix of fossiliferous marine limestone from the oldest part of the basalt at Marraat Killiit

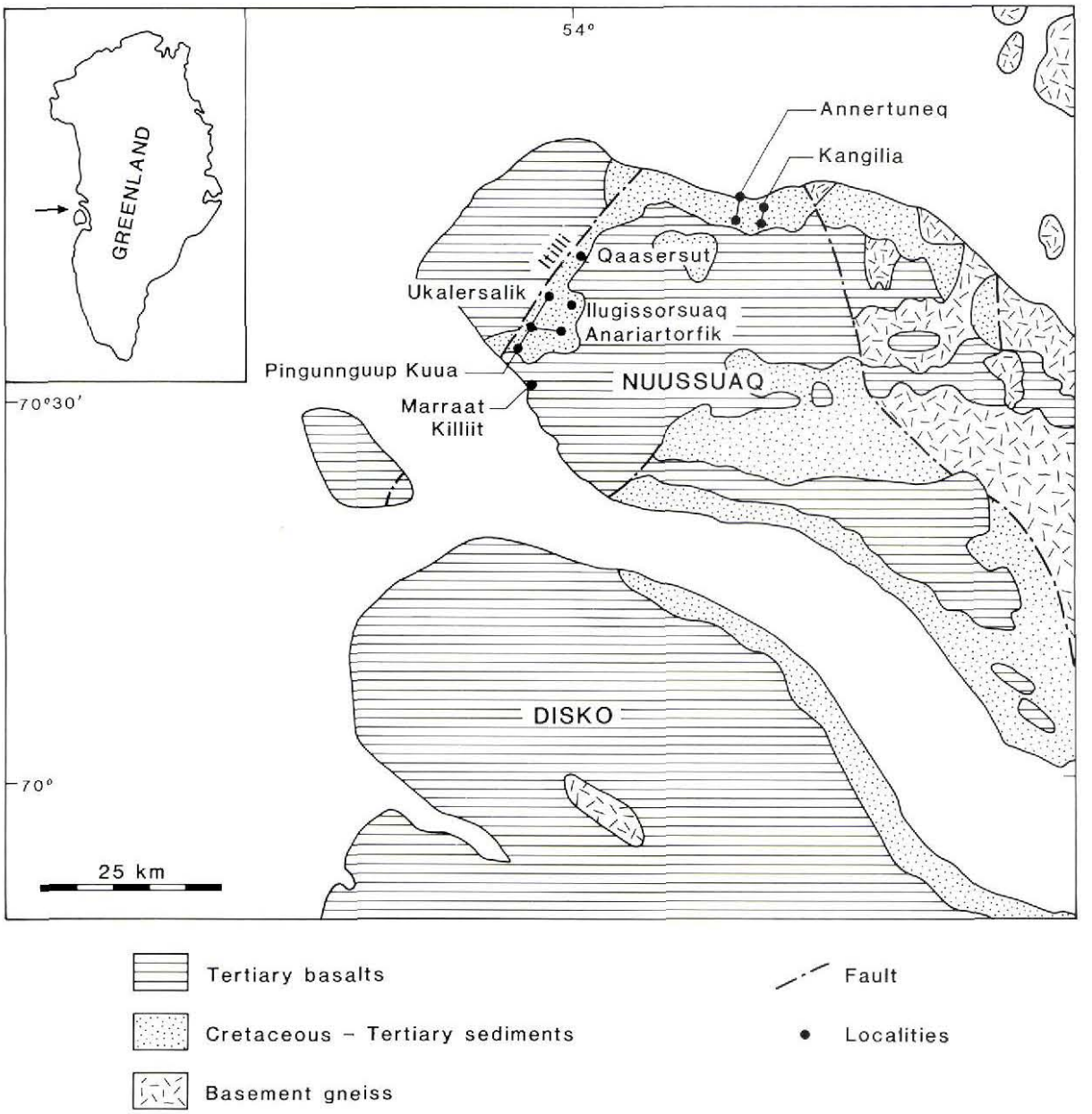


Fig. 1. Geological sketch map showing main outcrops of Cretaceous–Tertiary sediments on Nuussuaq and the localities mentioned in the text.

(Fig. 1) in nanoplankton zone NP3. The authors obtained a similar NP3 dating of a tuff bed just below the pillow breccia at the Kangilia section on the north coast of Nuussuaq.

In the present study 27 samples from 6 sections (GD 19910723/1, Ukalersalik; GD 19910808/1, Anariartorfik; GD 19910809/2, Anariartorfik; MS 19910810/1, Ilugissorsuaq; GD 19910811/1, Pingunnguup Kuua and GD 19920811/1, Qaasersut – Fig. 1) have been analysed for dinoflagellate cysts, spores and pollen. Of these samples, 21 from the lower 2 km of the succession are barren, whereas 5 samples from section MS 19910810/1 at Ilugissorsuaq (Fig. 2) and one sample from section GD 19920811/1 at Qaasersut yielded dinoflagellate cysts. Initial searches for radiolaria gave negative results.

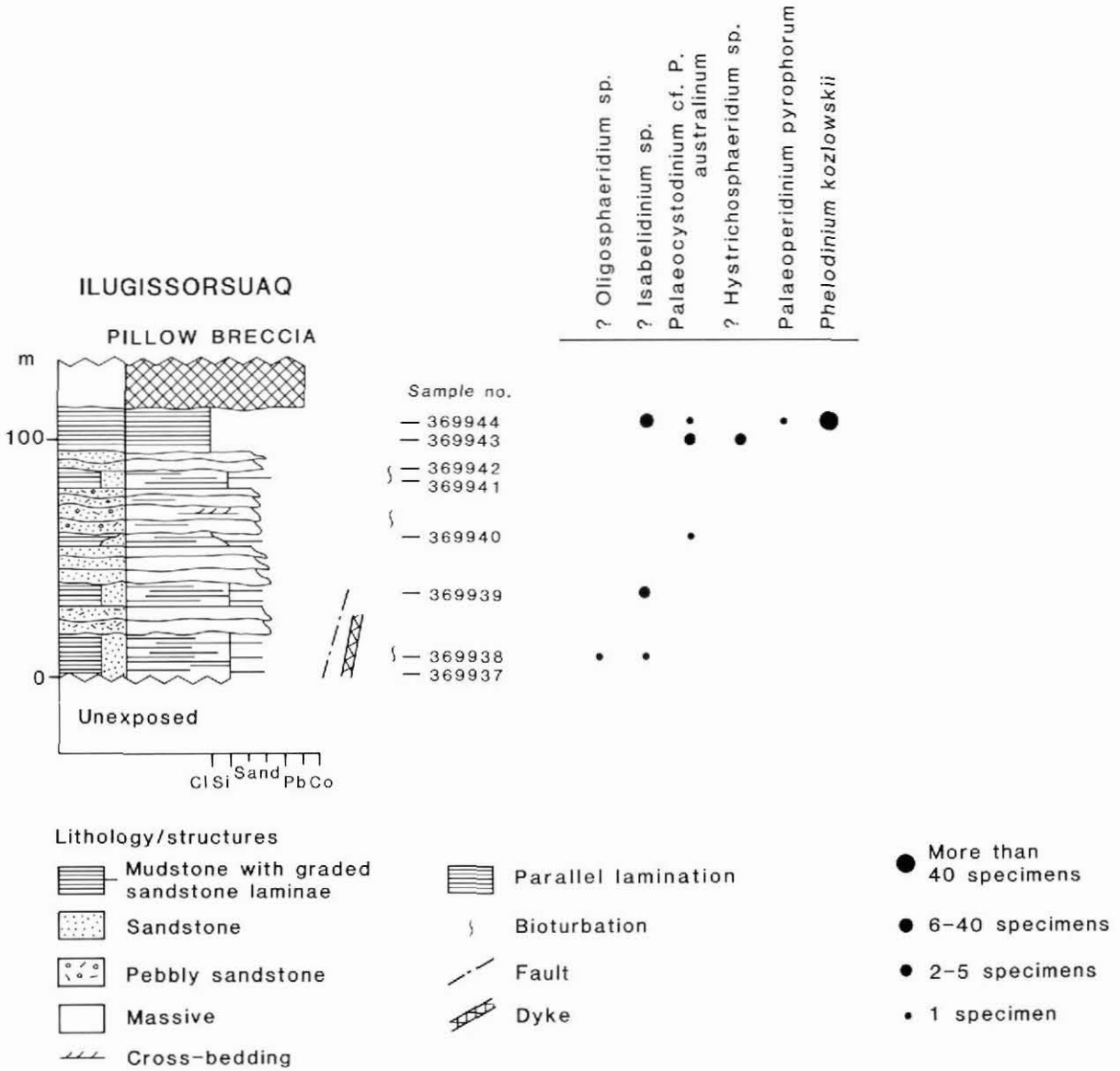


Fig. 2. Sedimentological log and dinoflagellate range chart for the uppermost turbidite succession at Ilugissorsuaq, Itilli valley (MS 19910810/1).

Palynology of section MS 19910810/1 and comparison with other localities

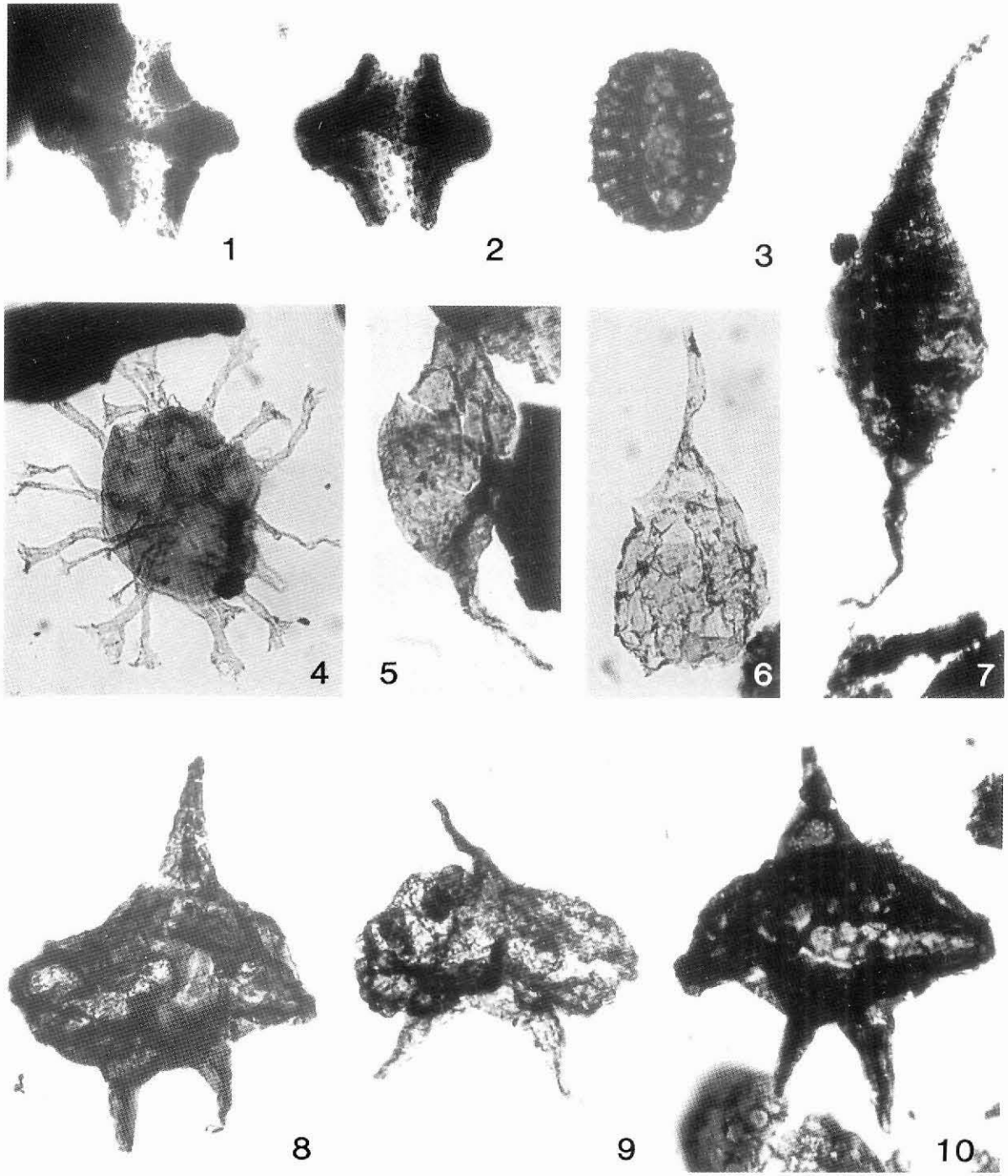
The uppermost part of the turbidite succession at Ilugissorsuaq is situated just below the Tertiary pillow breccia (Figs 1 & 2). This section is the first from the Itilli area that has been found to have a relatively low thermal alteration index (TAI 2^{+}–3). Eight samples from the section have been analysed for dinoflagellate cysts. In all samples the organic content is dominated by strongly degraded, structured organic material, coal fragments and brown tracheids, while spores and pollen constitute a minor part. Dinoflagellate cysts are badly preserved and very rare or absent in the lower seven samples, while they are abundant in the uppermost sample (Fig. 2). It should be noted that the colour and degree of degradation of the dinoflagellates are similar to the rest of the organic matter, which may indicate that no contamination has taken place.

The lower samples have yielded ?*Isabelidinium* sp., ?*Oligosphaeridium* sp. and poorly preserved specimens of *Palaeocystodinium australinum*/*P.* ?*bulliforme* which in the present study have been referred to as *Palaeocystodinium* cf. *P. australinum* (Plate 1, Fig. 5).

In general the genus *Isabelidinium* ranges from the Late Cretaceous to Eocene while the genus *Oligosphaeridium* ranges from the Jurassic to Eocene.

Palaeocystodinium australinum was originally described from the Paleocene in Australia by Cookson (1965). Williams & Bujak (1985) illustrated a latest Campanian to late Paleocene (NP 8) 'world-wide' range for the species. The species has been reported from the late early Paleocene to early late Paleocene (NP4 to NP7) in the North Sea area by Powell (1992). Heilmann-Clausen (1985) reported *P. bulliforme* (as *P. australinum*) from the Danian and Selandian (early and early late Paleocene age) in Denmark.

Palaeocystodinium bulliforme was originally de-



scribed from the lower Paleocene on Bylot Island in north-east Canada by Ioannides (1986), but Ioannides also illustrated on his range chart (fig.4) that the species may range down to the uppermost Maastrichtian in the area.

Hansen (1980) recorded both *P. bulliforme* (as '*P. klintholmense*') and *P. australinum* in mudstones above a conspicuous conglomerate in his compiled section from Kangilia and Annertuneq on the north coast of Nuussuaq. According to Hansen (1980), the top of this conglomerate is situated at about 370 m above sea level in the Annertuneq section. *Palaeocystodinium bulliforme* was recorded from 60 m above the conglomerate right up to 787 m a.s.l. (i.e. *c.* 415 m above the conglomerate), just below the Tertiary pillow breccia. *Palaeocystodinium australinum* was recorded by Hansen (1980) from approximately 280 m above the conglomerate up to 787 m a.s.l.

In the Annertuneq and Kangilia sections on the north coast of Nuussuaq the Cretaceous–Tertiary boundary has for many years been supposed to be at the base of the conspicuous conglomerate referred to above – the so called 'basal Danian conglomerate' of Rosenkrantz (1970). However, during field work in 1992, loose concretions containing ammonites were found in the scree at 20 and 50 m respectively above this conglomerate. This indicates that the conglomerate and the mudstones up to at least 50 m above it are of Late Cretaceous age; it cannot, therefore, be equalled with the Cretaceous–Tertiary boundary.

Piasecki *et al.* (1992) recorded *P. australinum* and *P. bulliforme* from intrabasaltic Lower Tertiary sediments on Nuussuaq, and interpreted these to correlate with NP4 to NP5/?NP6.

The present author has recorded the first occurrence of *P.* cf. *P. australinum* in a sample collected at 342 m a.s.l. (approximately 30 m above the conspicuous conglomerate) at Annertuneq.

In the Ilugissorsuaq section, the second highest sample (GGU 369943, Fig. 2) contains a few fragments of *P.* cf. *P. australinum* (Plate 1, Fig. 6) and a chorate species, ?*Hystrichosphaeridium* sp. (Plate 1, Fig. 4).

The uppermost sample at Ilugissorsuaq (GGU 369944, Fig. 2) is dominated by the species *Phelodinium kozlowskii* (Plate 1, Figs 8–10); 43 battered specimens have been recorded in one slide.

Phelodinium kozlowskii was originally described from the upper Maastrichtian in Poland (as *Lejeunia kozlowskii*) by Górka (1963).

In the Mackenzie district, North Western Territories, Canada, *P. kozlowskii* ranges from the late Campanian to the 'middle' Maastrichtian according to McIntyre (1975).

Harker & Sarjeant (1975) considered *P. kozlowskii* to be a junior synonym of *P. tricuspis*. According to Williams & Bujak (1985) *P. tricuspis* ranges from earliest Maastrichtian to early late Paleocene (NP4) 'worldwide'. Costa & Davey (1992) recorded the range for *P. tricuspis* from the late Campanian to latest Maastrichtian in England and the North Sea area, but mentioned that the species may range across the Cretaceous–Tertiary boundary.

Piasecki *et al.* (1992) recorded *P. kozlowskii* from sediments in the lower part of the pillow breccia in southern Nuussuaq, West Greenland and interpreted these as belonging to NP4 to NP5/?NP6.

Hansen (1980) recorded *P. kozlowskii* as ranging from 392 m a.s.l. (approximately 20 m above the conglomerate) to 787 m a.s.l., just below the pillow breccias, in his compiled Kangilia and Annertuneq section on the north coast of Nuussuaq.

The present author has recorded the first occurrence of *P. kozlowskii* in a sample collected at 282 m a.s.l. (approximately 12 m above the conglomerate) at Kangilia, north coast of Nuussuaq. *Phelodinium kozlowskii* is very rare in the lower part of its range, whereas the species becomes abundant at a level situated approximately 130 m above the conglomerate.

Plate 1. Dinoflagellate cysts and pollen species from the uppermost Maastrichtian to lowermost Paleocene sediments on western Nuussuaq.

All stage co-ordinates are from Leitz Dialux 22 microscope 057691, Geological Survey of Greenland.

MGUH denotes the type collection of the Geological Museum, Copenhagen.

Fig. 1. *Aquilapollenites* sp. GGU 210427–3; 39.7–95.9; MGUH 22072. × 1000.

Fig. 2. *Aquilapollenites* sp. GGU 210427–3; 33.4–107.5; MGUH 22073. × 1000.

Fig. 3. *Wodehousia spinata* GGU 401251–4; 33.5–107.0; MGUH 22074. × 500.

Fig. 4. ? *Hystrichosphaeridium* sp. GGU 369943–4; 37.5–96.2; MGUH 22075. × 500.

Fig. 5. *Palaeocystodinium* cf. *P. australinum* GGU 369940–4; 41.5–108.1; MGUH 22076. × 500.

Fig. 6. *Palaeocystodinium* cf. *P. australinum* GGU 369943–4; 32.0–114.2; MGUH 22077. × 500.

Fig. 7. *Palaeocystodinium* cf. *P. australinum* GGU 401251–7; 46.9–98.0; MGUH 22078. × 500.

Fig. 8. *Phelodinium kozlowskii* GGU 369944–4; 26.4–100.0; MGUH 22079. × 500.

Fig. 9. *Phelodinium kozlowskii* GGU 369944–4; 39.4–97.4; MGUH 22080. × 500.

Fig. 10. *Phelodinium kozlowskii* GGU 369944–4; 51.4–103.0; MGUH 22081. × 500.

This level has been recorded at two localities in the Kangilia area.

The sample (GGU 369944) also contains a single *Palaeocystodinium* cf. *P. australinum* specimen, a few specimens of *Isabelidinium*, a fragment of *Palaeoperidinium pyrophorum* (known range from Cenomanian (Late Cretaceous) to Selandian (early late Paleocene)) and a few chorate specimens.

Discussion of section MS 19910810/1

At a level approximately 130 m above the conglomerate in the Kangilia section *P. kozlowskii* becomes quite abundant and occurs together with the diagnostic Paleocene species *Cerodinium striatum* and *C. speciosum*. The abundance of *P. kozlowskii* and the presence of *P.* cf. *P. australinum* in the uppermost part of the Ilugissorsuaq section (MS 19910810/1) may indicate that this part of the section corresponds to the above mentioned level at Kangilia, implying that this part of the Ilugissorsuaq section cannot be older than Paleocene.

Palynology of section GD 19920811/1 and comparison with other localities

Four samples representing the upper 200 m of the turbidite succession at Qaasersut have been searched for palynomorphs. Only the uppermost sample (GGU 401251), situated 20 m below the Tertiary pillow breccia, yielded any fossils. Due to thermal alteration, the sample contains only few specimens of *Palaeocystodinium* cf. *P. australinum* (Plate 1, Fig. 7) and one specimen of the pollen *Wodehousia spinata* (Plate 1, Fig. 3). The presence of *W. spinata* indicates a rather restricted stratigraphic interval. Previously *W. spinata* has been recorded from the uppermost Maastrichtian in Alberta, Canada by Srivastava (1970), from the uppermost Maastrichtian to the lowermost Paleocene in western Canada (Jerzykiewicz & Sweet, 1986; Sweet *et al.*, 1990) and from the uppermost Maastrichtian to lowermost Paleocene in the western United States of America (Nichols & Fleming, 1990; Nichols & Brown, 1992).

Wodehousia spinata has never been reported below the previously presumed Cretaceous–Tertiary boundary conglomerate on the north coast of Nuussuaq. Croxton (1980, fig. 2) recorded the species from an interval situated between 83 m and approximately 118 m above the conglomerate at Annertuneq. The present author recorded the first occurrence of the species 12 m above the conglomerate at Kangilia, where it occurs together with a presumed Late Cretaceous dinoflagellate assemblage. *Wodehousia spinata* and Late Cretaceous dinoflagellates are common in sediment from the concretion that surrounds the ammonite sampled 50 m above the conglomerate at Annertuneq. The species seems to be less frequent in its upper range at Annertuneq (approximately 90–120 m above the conglomerate) where it occurs together with early Paleocene species such as *Cerodinium striatum* (see Croxton (1980) fig. 2) and *C. speciosum*.

Discussion of section GD 19920811/1

The occurrence of *W. spinata* in the uppermost part of the Qaasersut section indicates the presence of uppermost Maastrichtian to lowermost Paleocene deposits. *Wodehousia spinata* and *P.* cf. *P. australinum* have their first occurrence above the conglomerate in the Annertuneq region on the north coast of Nuussuaq, where they occur in assemblages both with and without characteristic Paleocene species. *Wodehousia spinata* is most common in the Upper Cretaceous sediments at Annertuneq. However, this cannot be used as a basis for direct correlation with the single record of *W. spinata* at Qaasersut, but it may justify the provisional conclusion that sample GGU 401251 represents upper Maastrichtian.

Conclusion

The very low species diversity and the rather poor preservation make it difficult to determine the precise relationship of the Ilugissorsuaq and Qaasersut sections. However, comparison with the better known Annertuneq and Kangilia sections indicates that the Ilugissorsuaq section, or at least the uppermost sample from this, is of early Paleocene age. The underlying samples may just as well be of Late Cretaceous age. The uppermost sample from the Qaasersut section is probably slightly older (late Maastrichtian) than the uppermost sample at Ilugissorsuaq but not necessarily older than the rest of the samples from the Ilugissorsuaq section.

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