might thus have some potential for gas generation (see also Croxton, this report) there is a lack of any good reservoirs in this critical section.

The oldest sediments above basement were found to be of Paleocene age and quite contrary to expectations there were no Cretaceous or older sediments.

These concession areas cover only about 2 per cent of the Greenland shelf. However the region in which they are located was regarded as being very promising. Although only five wells have been drilled the results from these extend beyond the immediate vicinity of the wells. Moreover, results from the Labrador shelf have not been as encouraging as was hoped for in the early days of exploration, and only gas with small amounts of gas condensate has so far been discovered.

The exploration on the West Greenland shelf has thus greatly reduced, but not entirely eliminated, the possibilities for finding commercial petroleum deposits south of Disko. The prospects for Melville Bugt are as yet untested, while much work will be required on the East Greenland shelf before areas of potential interest can be delineated.

Acknowledgements

Thanks are due to the numerous companies concerned for permission to use unpublished data in the production of fig. 15.

References

Geological Survey of Greenland 1978: Well data summary sheets. August 1978. Kangâmiut 1.

Henderson, G. 1976: Developments in petroleum exploration offshore West Greenland during 1975. *Rapp. Grønlands geol. Unders.* **80**, 29–31.

Henderson, G. 1978: Developments in petroleum exploration offshore West Greenland during 1977. *Rapp. Grønlands geol. Unders.* **90**, 32–36.

Manderscheid, G. 1978: West Greenland offshore basin. *In* Facts and principles of world oil occurrence. Can. Soc. petr. Geol. conference abstracts 1978, 78–79.

Manderscheid, G. in press: West Greenland offshore basin. *In* Facts and principles of world oil occurrence. *Mem. Can. Soc. petr. Geol.*

Palynological studies offshore West Greenland with preliminary results from the Kangâmiut 1 well

Catherine A. Croxton

During the summers of 1976 and 1977 a total of five wells were drilled offshore West Greenland (Henderson, 1978). GGU received samples of cuttings from all the wells while drilling was in progress and at a later date received the remnants of sidewall core material.

Palynological preparations have been made from cuttings of all five wells at approximately 30 m intervals. Preparation of sidewall core samples is now in progress. To date the total number of preparations made of offshore material is of the order of 500, representing the last three years' investigations.

Preparation technique

'Unwashed' samples of cuttings were generally preferred to the 'washed' samples which were often of poor quality. These 'unwashed' cuttings were thoroughly washed in the GGU laboratory on a fine mesh sieve to remove the drilling mud. Any larger than average unequidimensional fragments occurring with the cuttings were discarded due to the high probability that they originated from a higher horizon than was currently being drilled. Although it is impossible to completely remove so-called cavings and drilling mud contaminants their numbers can be greatly reduced by careful pre-treatment of the cuttings.

Standard palynological preparation procedures were then followed.

Preliminary results from Kangâmiut 1

Palynostratigraphic and thermal alteration index (TAI) studies based on preparations of cuttings made in GGU have been made of all five wells but at the time of writing only the data for Kangâmiut 1 has been released from confidential status (see Henderson, this report).

TGA-Grepco Kangâmiut 1, drilled in 180 m of water on the West Greenland continental shelf, 150 km south-west of Holsteinsborg reaches the Precambrian basement at approximately 3700 m and bottoms at 3874 m. A summary of the lithologies of the sediments overlying basement taken from the Well Data Summary Sheet released in August 1978 is incorporated in fig. 17. From 500 m to approximately 1700 m shaly sandstones were encountered while from 1700 m to approximately 2600 m medium- to coarse-grained sandstones are predominant. From 2600 m downwards occur montmorillonitic clays and shales based by a conglomerate with an associated black shale lying directly on altered basement.

Palynostratigraphy

The palynostratigraphy of Kangâmiut 1 is similar to that described from the Labrador shelf wells. Williams & Bujak (1977) propose ten informal biostratigraphic assemblages based on the stratigraphic distribution of palynomorphs in the Labrador shelf wells and these assemblages are assigned provisional ages. The preliminary biostratigraphic breakdown of Kangâmiut 1 is based on the recognition of these Labrador assemblages, (fig. 17). Some of the more age diagnostic forms recorded from these assemblages are listed below.

Recovery from the upper 2600 m of sandstone lithologies is very poor and at this stage comparison with the Labrador assemblages is tentative. Palynological assemblages within the interval are thought to be comparable to some or all of the series of assemblages to which Williams & Bujak (1977) provisionally assign Pleistocene to Oligocene ages. The lower interval of coarse- and medium-grained sandstones may be included with strata provision-

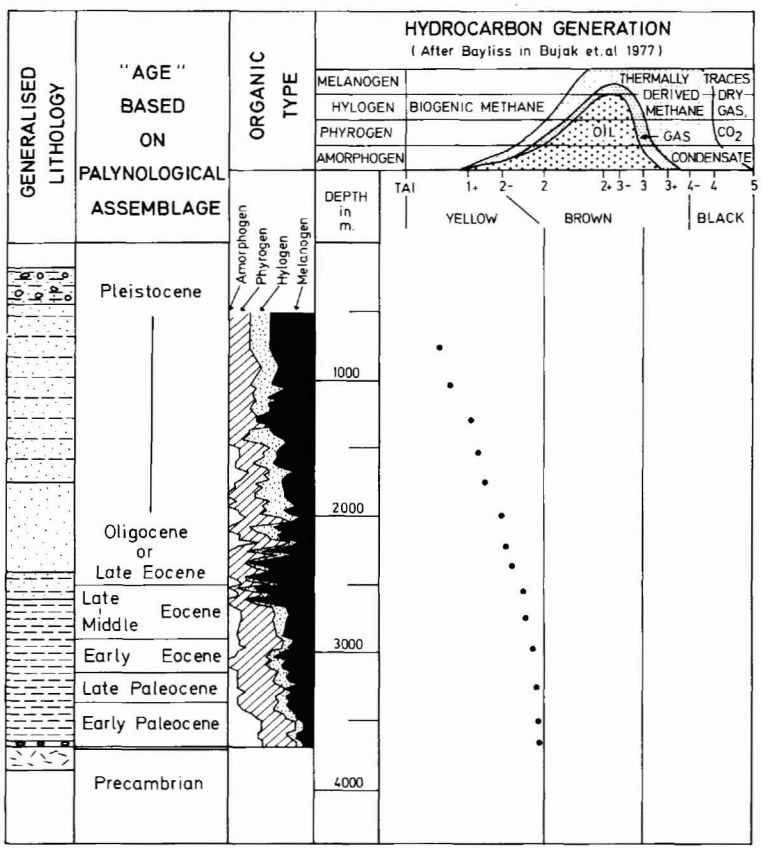

Fig. 17. Summary of preliminary palynostratigraphy, organic type and TAI for Kangâmiut 1.

ally dated Late Eocene in this report. The Kangâmiut 1 assemblages from the upper 2600 m are generally non-marine, dinoflagellate cysts being recorded from very few levels. *Tsugaepollenites igniculus* (Potonié) Potonié & Venitz occurs in the upper part of the interval and *Bombacacidites* sp. A Williams & Brideaux 1975 below 760 m. Horizons with reworked Eocene and Paleocene forms are recorded respectively around 878 m and 1725 m.

From the lower shaly lithologies of Kangâmiut 1 well preserved assemblages were recovered. The following four Labrador assemblages are recognised.

The *Wetzeliella lunaris* Assemblage (middle – late Eocene) from 2500 m to 2900 m. Forms recovered include *Wetzeliella lunaris* Gocht, *W. articulata* Eisenack, *W. hampdenensis* Wilson, *Cyclonephelium ordinatum* Williams & Downie, *Lingulodinium machaerophorum* (Deflandre & Cookson) Wall, *Hystrichokolpoma rigaudae* Deflandre & Cookson, *Deflandrea spinulosa* Alberti, *Thalassiphora pelagica* (Eisenack) Eisenack & Gocht and species of *Caryapollenites, Pterocaryapollenites* and *Tiliapollenites.*

The *Areoligera senonensis* Assemblage (early Eocene) from 2900 m to 3135 m. This

assemblage includes *Wetzeliella condylos* Williams & Downie, *W. hyperacantha* Cookson & Eisenack, *Cordosphaeridium gracile* (Eisenack) Davy & Williams and *Membranilarcia ursulae* (Morgenroth) De Coninck.

The *Deflandrea speciosa* Assemblage (late Paleocene) from 3150 m to 3440 m. The assemblage includes *Deflandrea speciosa* Alberti and *Areoligera medusettiformis* (Wetzel) Lejeune – Carpentier. A reworked horizon occurs within this interval at 3351 m which includes species of *Densosporites* and *Triquitrites* of most probably Carboniferous age.

The *Paleoperidinium pyrophorum* Assemblage (early Paleocene) from 3400 m to ±3700 m. Palynomorphs recorded include *Paleoperidinium pyrophorum* Sarjeant, *Areoligera* sp. and *Alnipollenites* sp.

Associated with the basal conglomerate of the sedimentary sequence of Kangâmiut 1 is a distinctive black organic rich shale. Fragments of this were picked by hand and processed separately. Palynomorphs recovered include *Deflandrea speciosa, Areoligera medusettiformis, Paleocystidinium* sp. and *Alnipollenites* sp. The black shale is therefore considered Paleocene in age. A number of apparently reworked palynomorphs were also recorded from preparations of fragments thought by their lithology to be exclusively from this horizon. They include *Chatangiella* sp. (Santonian–Campanian), *Trilobosporites* sp. (Cretaceous) and *Densosporites* sp. (?Carboniferous). As well as these identifiable reworked forms brown/black fragments of palynomorphs occur and these can only be recorded as reworkings of unknown age.

Hydrocarbon potential as inferred from organic matter type and thermal alteration index (TAI)

The organic matter type and thermal alteration index study, a technique used for determining the thermal history and hydrocarbon potential of sediments by examining the coloration and type of dispersed organic material has also followed the definitions and format used by the Canadian Survey geologists offshore eastern Canada (Bujak, Barss & Williams, 1977).

The colour of certain types of organic matter changes predictably with exposure to increased temperatures and these colour differences can be observed under the microscope and plotted on the so-called TAI scale (Staplin, 1969). The hydrocarbon potential of sediments is also dependent on the type of dispersed organic matter present since different types of organic matter respond differently to heating. The four categories of organic type recognised in Kangâmiut 1 are those defined by Bujak *et al.* (1977). The way in which the four types respond to heating have been graphically illustrated by Bayliss (*in* Bujak *et al.*, 1977) and this is incorporated in fig. 17 against the TAI scale.

For Kangâmiut 1 the relative abundances of the organic types are plotted in columnar format (fig. 17). Differing relative abundances may reflect changes in depositional environment. Bujak *et al.* (1977) found melanogen predominant in shallow water deposits and amorphogen generally absent from non-marine strata. In Kangâmiut 1 this general pattern fits well with the palynological assemblages recorded.

The upper 2600 m of sediments, predominantly sandstones, give rise primarily to melanogen, hylogen and phyrogen, the relative abundances of these organic types being

variable throughout the interval. The TAI values are recorded only to reach just above 2-. According to Bayliss's hydrocarbon generation scheme there is no potential for thermally derived hydrocarbons for the three organic types primarily present in this interval.

From 2600 m to 3700 m, the predominantly shaly sequence, a marked change can be seen in the organic type profile. Phyrogen is primary with melanogen secondary and amorphogen and hylogen present. The TAI is recorded as 2- to 2. From the hydrocarbon generation diagram amorphogen would have significant potential for the recorded TAI of 2- to 2. Gaseous and liquid hydrocarbons could be generated. Phyrogen indicates at this TAI value some potential for thermally derived methane. Although amorphogen is recorded in rather higher relative abundance especially in the lower part of this interval, not too much emphasis should be placed on this as the degradation of phyrogen may have given rise to some of the organic material identified as amorphogen. However in the lower part of the interval, provisionally dated Paleocene, the TAI is high enough for the generation of gas from the predominant phyrogen.

These preliminary results infer that in Kangâmiut 1 only the lowest (Paleocene) strata are thermally mature enough source lithologies and their generating potential is for gas. This data compares well with results from the Labrador shelf and with the inferences made by Schiener & Leythaeuser (1978) for the West Greenland shelf.

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References

Bujak, J. P., Barss, M. S. & Williams, G. L. 1977: Offshore eastern Canada. Part I & II. Organic type and color and hydrocarbon potential. *Oil Gas J.* **75,** (14), 198–202 & (15), 96–100.

Geological Survey of Greenland 1978: Well data summary sheets. August 1978. Kangâmiut 1.

Henderson, G. 1978: Developments in petroleum exploration offshore West Greenland during 1977. *Rapp. Grønlands geol. Unders.* **90,** 32–36.

Schiener, E. J. & Leythaeuser, D. 1978: Petroleum potential off West Greenland. *Oil Gas J.* **76,** (40), 223–234.

Staplin, F. L. 1969: Sedimentary organic matter, organic metamorphism, and oil and gas occurrence. *Bull. Can. Pet. Geol.* **17,** 47–66.

Williams, G. L. & Bujak, P. J. 1977: Cenozoic palynostratigraphy of offshore Eastern Canada. *Am. Assoc. Strat. Palynol., Contrib.* **5A,** 14–47.