ANALYSIS OF SURFACE AND BOREHOLE SAMPLES FROM THE WEST GREENLAND BASIN

N. B. H. Stevens*

Introduction

During the summer of 1971 a programme of shallow core-drilling was undertaken on the Nûgssuaq peninsula using a Craelius Prosper 25 core drill belonging to the Danish Atomic Energy Commission, Risø. This drill provides cores with a diameter of 16 mm. The object of the programme was to obtain fresh samples of the Cretaceous-Tertiary shales in this part of the West Greenland Basin for stratigraphic and source rock analysis. Source rock analysis of surface samples collected during 1968 (see Stevens *in* Henderson, 1969) had indicated the desirability of obtaining fresher material than can be collected in the active zone or at the immediate top of the permafrost zone. For various reasons the coring programme did not provide the amount of cores hoped for. The core samples sent for analysis were therefore supplemented by surface samples (mainly from Nûgssuaq). This report gives a brief account of the results of the analysis of 21 surface and borehole samples. The sample localities are shown in fig. 10.

Micropalaeontological and microlithological results

Fourteen samples were analysed, ranging in age from Lower Santonian to probable Upper Danian. The chronostratigraphy in this area was previously established on the basis of marine macrofossils and fossil plants (Rosenkrantz, 1970). All the samples were shales. Most of them are of a dark colour. Some contain quartz grains. Others are calcareous. Gypsum was noted in some samples. Organic matter is present. Feldspar and mica in minor quantities were observed.

A microfauna was found in four samples stated to be of Upper Campanian to Upper Danian age. A single specimen of *Hedbergella* present in an Upper Campanian sample is indicative of a Cretaceous age only, no closer age determination being possible. The other eight Foraminifera encountered are mainly arenaceous, pointing to a rather shallow marine environment of deposition. They do not permit

* Olexcon International N. V., The Hague.

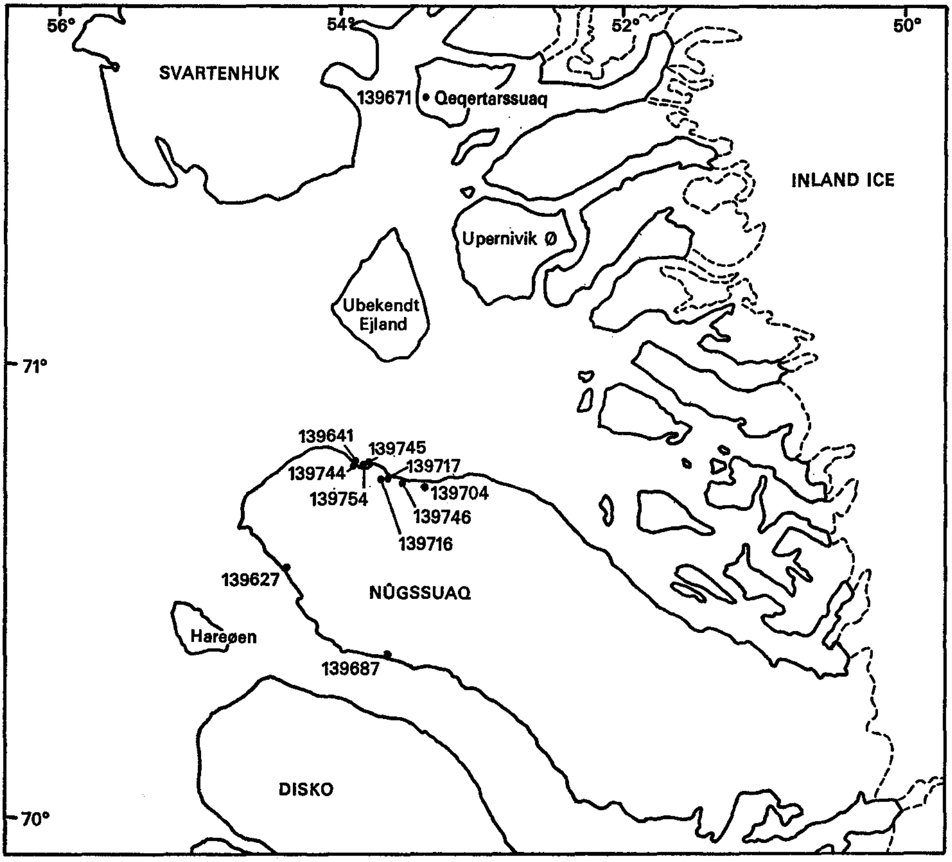

Fig. 10. Map showing localities of sedimentary samples collected for various types of analysis.

an age determination owing to their long range. The sample collected from the Lower Santonian is of non-marine origin.

Samples of Upper Campanian and Lower Danian age contain sand grains derived from two different sources, which in both cases points to contemporaneous erosion of two different formations at varying distances from the place of deposition of the erosional products.

The present results indicate that analysis of more samples could provide more information on the stratigraphy and tectonics of the area. Diagnostic microfossils may be found in the marine strata and in marine intercalations in the non-marine deposits.

Results of the visual porosity and microlithological analysis

Seven sandstone samples were analysed. The purpose was not to obtain representative information on potential reservoir rocks in the area as a whole, but to obtain an impression of the visual porosity and microlithology of some scattered samples.

Only sample 139661 (Barremian-Aptian) shows a fair to good porosity. A poor porosity was noted in samples 139745 (Upper Campanian or slightly older), core sample 139744 (a) (Lower Santonian) and sample 139687 (probably Lower Senonian). In sample 139687 and in sample 139661 the porosity is different in thin sections taken in planes perpendicular to each other.

The degree of sorting varies. Good sorting was noted in sample 139745 (Upper Campanian or slightly older) and in sample 139687 (probably Lower Senonian), fair sorting in sample 139744 (b) (Lower Santonian) and in sample 139671 B (Upper Cretaceous), poor sorting in sample 139744 (a) (Lower Santonian) and in sample 139661 (Barremian-Aptian).

There is thus considerable variation in both the porosity and the degree of sorting, which is only to be expected in this estuarine type of environment.

The quartz grains present in some samples, viz. 139744 (a) and 139671 B are cracked. In almost all the samples undulatory extinction of the quartz was noted under crossed polars. This points to cataclasis: the source rocks for these grains must have been metamorphic rocks or rocks which had been exposed to strong stress before the erosion took place that made these grains available for redeposition elsewhere.

The locality from which sample 139671 B was collected was studied in some detail. The brecciated sandstone showed inclusions of claystone nodules. Bitumen was observed along fault planes generally together with calcite and at one place around a claystone nodule. Disseminated black spots were noted in the sandstone at some places. Bitumen was also noted within calcite infillings.

Palynological results

Twelve samples were analysed. A number of microfossils proved to be present in the following samples: 139627 (a) and (b) (probably Upper Danian), 139704 (Lower Danian), 139716, 139717, 139746 (a), (b), (c) and (d) (Upper Campanian). No microfossils were found in the samples 139754 (Upper Campanian or slightly older), 139641 and 139744 (c) (Lower Santonian).

The ages quoted are based on the chronostratigraphy established previously (Rosenkrantz, 1970). The ages obtained from the palynological analysis were different. On the basis of palynological evidence a closer determination than Cretaceous age for sample 139627 was not possible. Sample 139704 is considered to be Turonian. A closer age determination than Mesozoic for sample 139716 was not possible. In samples 139716, 139717 and 139746 (b) species characteristic of Triassic sediments were found. The age of samples 139746 (a-d) is probably Cenomanian.

The fact that the microfossils indicate ages different from those established on macrofossil evidence may be attributable to the following circumstances. Owing to migration of angiosperms from the south, ages based on triporate pollen differ with latitude. However, triporate pollen was only identified with certainty in one sample. A number of microfossils observed in the samples may be reworked. Taking the tectonic picture at the basin rim into account slumping has probably occurred and perhaps on various occasions. In the field slumping was noted at more than one locality. However, the lack of microfossils indicating a younger age along with those that were found remains to be explained. This lack could be due to the type of environment of deposition. The presence of Triassic microfossils indicates reworking. Another noteworthy question is that Triassic sediments must be or must have been present somewhere in or near the area from where the samples have been collected.

Results of the source rock analysis

Ten samples were analysed. Samples 139704 and 139716, of Lower Danian and Upper Campanian age respectively, were shown to be source rocks. These results thus confirm earlier results (see Stevens, *in* Henderson, 1969) showing that source rocks are present at these levels. These particular samples were collected at a considerable distance from the earlier samples.

In both samples 139704 and 139716 one of the extracts had a high sulphur content. In general this factor detracts from the quality of these rocks as source rocks. However, it appears that (judging from the limited number of samples analysed so far) no secondary enrichment of the sulphur has taken place. The higher contents of sulphur in extracts were found in samples with higher extract values. It is assumed that a large part of the hydrocarbons formerly present in these rocks has migrated from the rocks leaving most of the sulphur behind, this resulting in a concentration of the sulphur in the rocks.

More evidence will be required for confirmation of these preliminary conclusions. This will require analysis of additional samples. Such analysis is also necessary to determine variations in quality and extent of the source rocks.

Possible origin of the sulphur

Proteins are the predominant nitrogenous constituents of animal and plant tissue. Organic radicals forming part of the proteins may contain elements such as phosphorus and sulphur. Proteins have undoubtedly played an important part in the development of source rocks.

Sulphur may have been released from the proteins to form sulphates. The fact that anaerobic bacteria break down sulphates on the one hand and organic matter or hydrocarbons on the other hand is well known. It is probable that under favourable circumstances large quantities of proteins were accumulated and preserved in the West Greenland Basin and have resulted in high sulphur contents in several samples.

The sulphate-reducing bacteria are believed to get their energy from the organic matter, including hydrocarbons, and their oxygen from the sulphate radical. The process in which the bacteria are involved results in reduction of the sulphate and oxidation of organic matter or hydrocarbons, with production of carbon dioxide and water.

If hydrocarbons are more easily attacked by the bacteria than organic matter in general, a high sulphur content could be expected in extracts of source rocks.

Burning of the shales is probably due to the highly sensitive character of elemental sulphur, perhaps in the presence of phosphorus, also derived from protein constituents. Furthermore, the burning could well be promoted by the presence of either organic matter or hydrocarbons. This would explain why both source rocks and non-source rocks catch fire in this area.

The probable part played by clay minerals as "catalysts" in the development of hydrocarbons should also be mentioned. Only a few workers have studied reactions taking place between e. g. montmorillonite and amino acids (resulting from the breaking down of proteins). This all adds to the complexity of the processes which have affected or could affect organic matter.

References

Henderson, G. 1969: Oil and gas prospects in the Cretaceous-Tertiary basin of West Greenland. *Rapp. Grønlands geol. Unders.* **22**, 63 pp.

Rosenkrantz, A. 1970: Marine Upper Cretaceous and lowermost Tertiary deposits in West Greenland. *Bull. geol. Soc. Denmark* **19**, 406–453.