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Project 'Nordolie': hydrocarbon source rock investigations in central North Greenland

F. G. Christiansen and F. Rolle

The project 'Nordolie' was initiated under the Danish Ministry of Energy's Research Programme 1983. The aim of the project is to obtain general knowledge about the source rock geology of central North Greenland. Similar investigations have previously been carried out in eastern North Greenland (Rolle, 1981; Rolle & Wrang, 1981).

The main purpose of the project is to study the presence and distribution of potential hydrocarbon source rocks in the region and to evaluate the thermal maturity pattern. Studies of reservoir properties, trapping possibilities, and other aspects of petroleum geology will accordingly have a much lower priority.

Field work was carried out by two geological field teams from June to August 1984 and

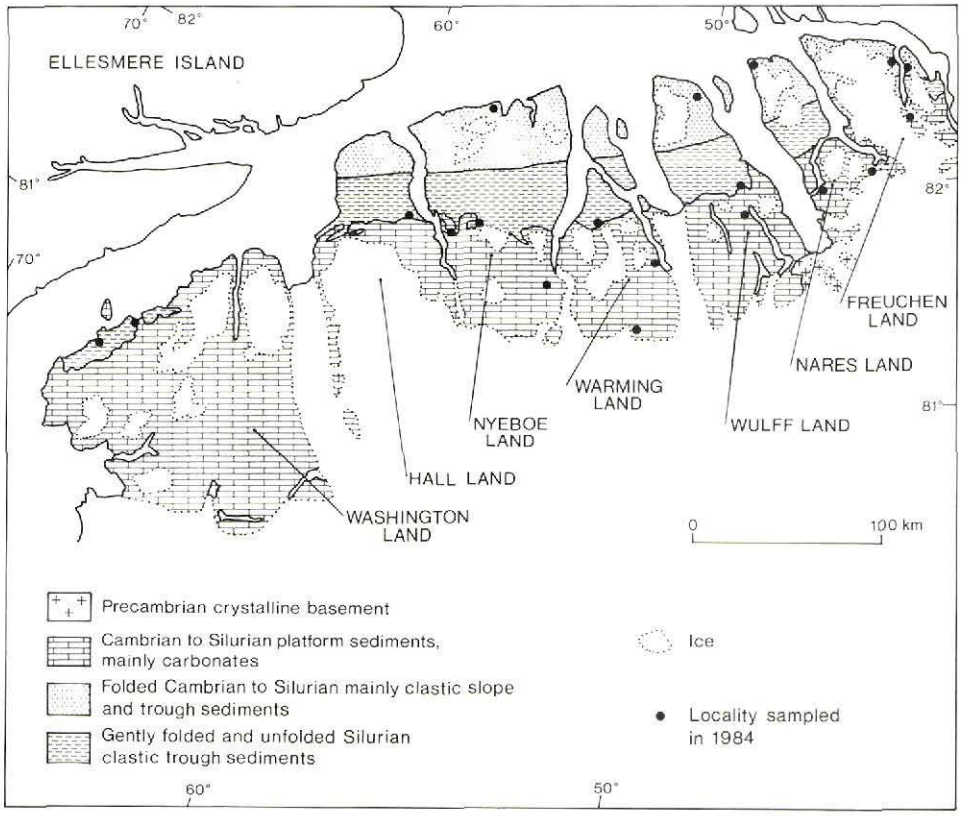

Fig. 5. Simplified geological map of central North Greenland showing camp site locations. Based on maps published by Dawes (1976).

will continue in 1985, and include a shallow drilling programme. The work is a fully integrated part of GGU's other activities in the region (see Henriksen, this report).

Geological background

North Greenland comprises a Precambrian to Lower Palaeozoic carbonate shelf and clastic deep water basin sequence. The platform sediments were deposited as shallow marine carbonates with minor sandstones and shales during the Lower Cambrian to Lower Silurian. Today they are exposed in an 800 km long east–west trending zone with a thickness of probably more than 4 km (Dawes, 1976) and a width of at least 200 km (Hurst, 1980). North of the platform a deep-water trough of Cambrian to Silurian age with up to 8 km of turbidites and shales is present (Friderichsen *et al.*, 1982; Hurst & Surlyk, 1982; Surlyk & Hurst, 1984). The margin between the platform and the trough seems structurally controlled (Hurst & Surlyk, 1984). Several phases of basin widening by southward backstepping of the margin occurred during the Cambrian to Silurian. Periods of compression and folding occurred in the Devonian and/or Early Carboniferous (Dawes, 1976; Higgins *et al.*, 1982). The intensity

of deformation and metamorphism increases progressively northwards from the non-metamorphic platform carbonates and eventually reaches amphibolite facies within the northernmost part of the fold belt. Late Cretaceous to Tertiary faulting have also affected the area.

Field work 1984

The main objective during the 1984 season was the systematic sampling of organic-rich sediments. A total of more than 600 samples were collected, covering the main parts of the sequence throughout the region. About 35 sections, from eastern Freuchen Land to Washington Land (fig. 5), have been studied in detail from 19 different camp sites. During helicopter reconnaissance additional sampling has been performed in areas not covered by the detailed work. Most samples were collected from what appeared to be the most organic rich sequences, but less promising formations were also sampled. Organic geochemical data can thus be supplemented with thermal maturity parameters derived from petrographic studies of organic matter, diagenetic microstructures, and clay mineralogy.

Detailed sedimentological and structural work has been carried out in the boundary zone between shelf carbonates and trough clastics. The structurally complex northern part of the region was also studied in an attempt to understand the sequence underlying the Silurian clastics and the relationship between structural style and thermal maturity.

Possible hydrocarbon source rocks

It is not possible to evaluate the source rock potential directly in the field. However, information about the depositional environment, grain size, colour and to some extent the smell of rocks has outlined some promising formations in both the carbonate shelf sequence and the clastic basin sequence.

The Henson Gletscher Formation of the Brønlund Fjord Group (carbonates and shales), which is known to be a high quality source rock in western Peary Land (Rolle & Wrang, 1981), has been traced to western Freuchen Land where it decreases in thickness and eventually disappears. Higher in the carbonate sequence the limestones and dolomites of the Nunatami Formation and the Morris Bugt Group are relatively dark and often quite stinking. The pervasive bioturbation of these sediments suggests a fairly low organic content but due to their great thickness and lateral extent throughout the region they are nevertheless regarded as interesting. The Washington Land Group has only been cursorily examined because it forms the present erosion level.

In the basin sequence the black, often stinking, shales and lime mudstones of the Cape Schuchert and Lafayette Bugt Formations seem to be promising throughout the region. In Washington Land samples of the Cape Schuchert Formation have previously proved to have a source rock potential (Perregaard, 1979). They outcrop along the Silurian shelf margin and show a highly variable thickness and facies development, depending on the steepness of the margin and the position of carbonate build-ups. It has not been possible to differentiate the two formations east of Washington Land. The siltstones of the associated Wulff Land Formation, which occur more distally to the shelf margin, are less interesting. The dark Thors Fjord Member has, however, been found as far west as Nares Land where it outcrops with a

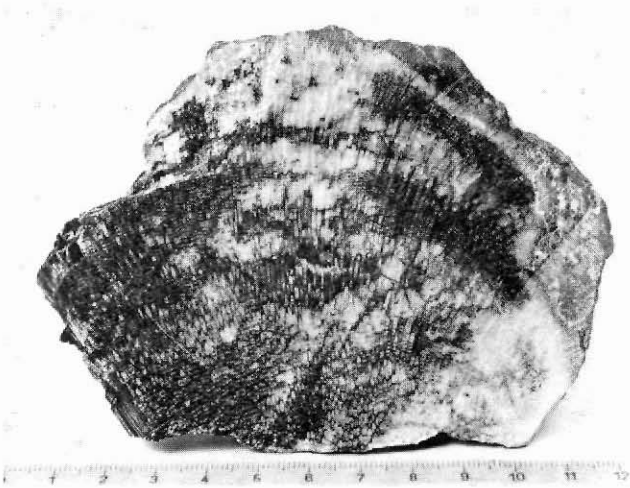

Fig. 6. Pyro-bitumen filled corals from conglomerate in the Lafayette Bugt Formation. Sample locality: Lafayette Bugt, Washington Land.

thickness of approximately 15 m, and it may contribute to the potential of the westernmost part of the region. The black, often chertified, shales of the Amundsen Land Group have only been studied in areas that are thermally overmature.

Maturity and migration

Previous geochemical analyses have indicated a favourable thermal maturity of both Silurian rocks in Washington Land (Perregaard, 1979) and Cambrian rocks in eastern Freuchen Land (Rolle & Wrang, 1981).

The occurrence of low metamorphic slates with a greasy appearance, and a commonly developed new (axial plane) cleavage in the shales of northern Freuchen Land, Nares Land and Nyeboe Land observed during this summer's work suggest that most of the fold belt is overcooked. This is in full accordance with the metamorphic zonation of Dawes (1976) but the degree of control of the thermal pattern by the change in structural style from north to south is not yet understood.

Pyro-bitumen has been observed as vug, pore and fracture fillings at several locations, suggesting favourable maturity as well as generation and expulsion of petroleum. The most important showings are in the Cambrian carbonates of southern Freuchen Land, Warming Land and Wulff Land. The bitumen seems not directly related to known source rocks which may imply that large-scale migration has occurred. In western Washington Land impressive bitumen filled corals (fig. 6) have been found in conglomerates and calcarenites of the Lafayette Bugt Formation, where the source is presumed to be the local interbedded shale and lime mudstones.

Laboratory work and 1985 field season

Geochemical analyses of apparently fresh surface samples often show severe degradation and pollution of the organic material. To overcome this problem six to eight slim-hole cores

will be drilled in the 1985 field season to depths of approximately 60 m using a GGU constructed drilling unit (Surlyk, 1983). The final positions of the drilling sites will be fixed after preliminary screening of the collected material with LECO and Rock Eval analyses. A total of 200 samples have been analysed i 1984 giving a first approximation of the maturity and source rock potential of most of the studied formations. Furthermore, kerogen concentrates from these samples will be studied by optical methods with respect to type and colour (thermal alteration index) of the organic matter. The composition of hydrocarbons from a limited number of samples will be analysed by gas chromatography and mass spectroscopy. In addition, standard lithological studies will be performed on polished and thin sections of a large number of rock samples.

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