Project SYD VEST SEIS – 3285 km of multichannel seismic data acquired on the southern West Greenland shelf

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During the three years since 1988, there has been renewed activity within the Geological Survey of Greenland (GGU) to reassess the geology and petroleum prospectivity of the southern West Greenland offshore area (Chalmers, 1989; Chalmers, 1990; Chalmers & Pulvertaft, in press; Ottesen, 1991). Pulvertaft (1991) gives a summary of the present state of the re-evaluation.

This work has shown that the geology of the northern Labrador Sea and offshore southern West Greenland is poorly understood. A number of questions about the area's petroleum prospectivity remain unanswered despite re-interpretation and in some cases reprocessing of the existing seismic data. These problems derive from limitations in both the quality and extent of the existing seismic coverage.

Project SYD VEST SEIS

In an attempt to resolve some of the problems a seismic survey, project SYD VEST SEIS, was undertaken in 1990. The survey was partly funded by GGU but mainly by the Mineral Resources Administration for Greenland.

South of 64° 20′N the main problem was lack of seismic data (Fig. 1). Therefore, a substantial part of the survey was placed in a grid between 62° and 65°N. In Phase I of Project VEST SOKKEL Chalmers (1990, fig. 2C) identified fault blocks containing thick, probably pre-Tertiary sedimentary seismo-stratigraphic sequences. The northern part of the Project SYD VEST SEIS grid was designed to overlap with these interesting sequences and trace them south. Similar structures and sequences were also identified in the Pilot Project (Chalmers, 1989). However there was a gap of about 100 km in seismic data coverage between the two areas (Fig. 1) and the grid was designed to bridge this gap. South of the Pilot Project area, there again was no seismic coverage, so the SYD VEST SEIS grid was extended southwards until seabed topography just north of 62°N suggested that basement may be at the sea floor over the whole shelf. The NE–SW lines were extended into the deep water area to obtain a tie with lines from a survey shot by Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) in 1977 (Hinz *et al.*, 1979) which GGU has recently reprocessed (Pulvertaft, 1991).

The remaining lines of the survey are more widely spaced and were planned for a number of reasons. The two lines between 64° 30′N and 66°N are reconnaissance lines in an area of fairly deep water. There were no previous seismic data in this area, but the area is on trend with the Kangâmiut Ridge to the north and the block-faulted terrain in the southern part of the VEST SOKKEL Phase I area to the south-east. One of the lines also ties into the Nukik-1 well.

The lines between 66°N and 68°N (Fig. 1) are test lines in an area where there is good data coverage from the 1970s. The new lines were shot in order to find out how much data quality can be improved when obtained with modern acquisition technology. Two of the lines pass through the wells Kangâmiut-1 and Ikermiut-1 where there are still possibilities for untested plays (Chalmers & Pulvertaft, in press). The area between 67°N and 68°N, 54°W and 56°W contains interesting deep structures and possible stratigraphic traps in the lowermost Tertiary – Upper Cretaceous sediments (Chalmers & Pulvertaft, in press, fig. 8). The lines have been extended westwards to the boundary between Canadian and Greenland waters to obtain information about an area not investigated in the 1970s.

In the area between 68°N and 70° 30′N (Fig. 1), it is known that there are thick basalt flows, although their westward extent is unknown. Under the basalts on the west side of the island of Disko are black shales which could act as hydrocarbon source rocks. It is hoped that the four lines in this area will allow us to 'see through' the basalts using modern technology and interpret structures and sedimentary sequences below them.

Contractor, ship and equipment

After a competitive tender and discussions with a number of seismic contractors, a contract to acquire and process Project SYD VEST SEIS data was awarded to Halliburton Geophysical Services of Calgary, Alberta,

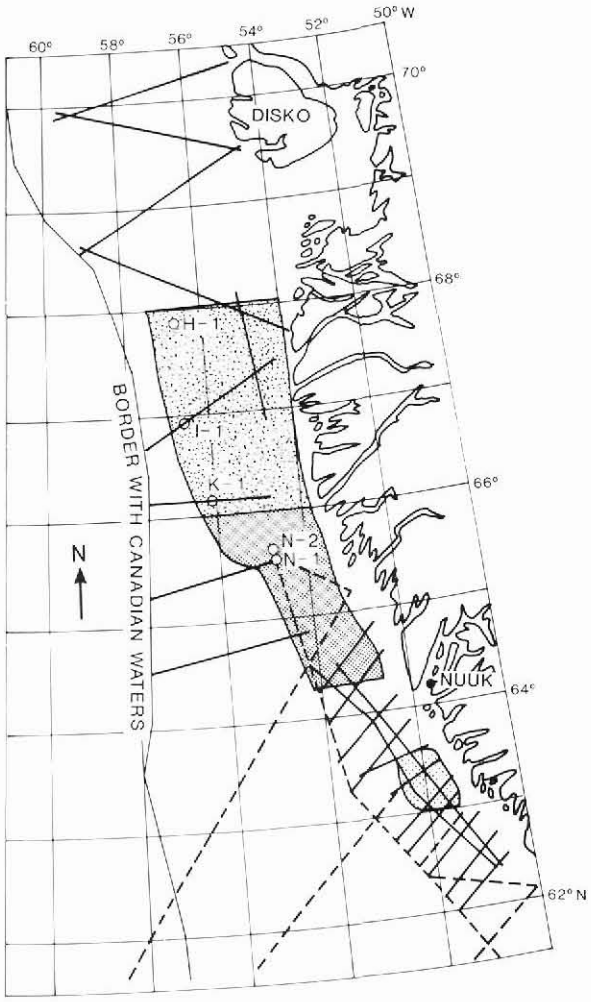

Fig. 1. Map showing the locations of the Project SYD VEST SEIS seismic lines. Lines from the survey acquired by Bundesanstalt für Geowissenschaften und Rohstoffe (BGR) in 1977 (Hinz *et al.*, 1979) which have recently been reprocessed by GGU are also shown. The areas where seismic data exist from the 1970s are shown in tone. An interpretation of data in the Pilot Project area has been published (Chalmers, 1989) and interpretation of data in the VEST SOKKEL Phase I area is nearing completion. Open circles indicate wells drilled in 1976–77: H-1 = Hellefisk-1, I-1 = Ikermiut-1, K-1 = Kangâmiut-1, N-1 and N-2 = Nukik-1 and 2.

Canada. Their ship, the *Fred J. Agnich*, was used for the survey. The ship is a specialised seismic survey vessel used exclusively for this type of work.

Operations

Acquisition of Project SYD VEST SEIS took place from 3rd August to 21st September, 1990, a total of 50 days. The survey started and finished in Nuuk. The total length of seismic lines recorded was 3285 km, a mean of 65.7 km/day, but there were large variations in the daily totals. On the best day, 170 km of data were acquired. The main acquisition parameters were:

Source: 3616 cu.in. (59.3 litre) tuned air-gun array with 59 individual air-guns. Air pressure was 2000 psi (138 bar). Shot interval was 25 m and firing accuracy ± 1 ms. The air-gun array was towed at a depth of 6 m.

Receiver: 3000 m analogue streamer with 120 groups each of 25 m. The streamer was towed at 8 m depth and the offset from the guns to the first group was 175 m.

Recorder: DSF V
sample interval 2 ms
record length 8 sec.
field filter 3.5–125 Hz

Navigation: Transit satellites and GPS.

A statistical breakdown of time used during the survey is given in Table 1. Some comments on these figures are required.

Weather. Nearly 20% of the time was spent 'down for weather'. This was due not only to local high winds but often to large swells. Even in light winds the swell could cause high amplitude noise bursts on the streamer.

Travel. The substantial percentage of time devoted to travel was because the survey consists of long lines spread thinly over a large area. Unproductive time was spent travelling to and from the survey area and moving from one line to another.

Navigation. While shooting seismic lines, the position of the ship must be known to an accuracy of at least 200 metres. This is normally done by observing special navigation satellites of which there are two systems, the older Transit system and the newer GPS (Global Positioning System).

For SYD VEST SEIS a dual system of Transit and GPS satellites was used. Transit satellites are widely spread and give an 'update' (a correction to position) about every hour. The GPS system is capable of giving continuous updates, provided at least three satellites are in view and are traced by the ship at any time. The GPS system enables the speed and direction of the ship to be determined accurately.

Most of the 'down for navigation' time occurred because the navigational system lost track of GPS satellites. As a result, by the time a good GPS position was

Table 1. Breakdown of survey time during Project SYD VEST SEIS

Activity	hours:mins	%
Recording	418:48	35.8
Weather	224:13	19.2
Travel (line change, transport to/from survey area)	141:11	12.1
In port	26:15	2.2
Navigation problems	136:46	11.7
Other instruments/ship problems	100:43	8.6
Fishing interference	8:26	0.7
Ice interference	21:12	1.8
Other (test, deploy and recover equipment etc.)	93:01	7.9
Total	1170:35	100.0

re-established, the ship had moved too far off the seismic line, which made it necessary to break off recording and circle back before continuing.

Other instrument and ship problems. A variety of events can cause the recording of a seismic line to be interrupted. They range from specific problems such as loss of the constant supply of high pressure air, or loss of accuracy in timing of the firing of 59 air-guns at the technical 'seismic' end, to more general problems such as loss of electrical power.

Fishing interference. Prior to the start of seismic operations, information about the survey had been published through the Greenland media, newspapers and radio. Fishermen were informed that the ship was relatively unmanoeuvrable and contact radio frequencies were published. This warning seems to have had the desired effect, as fishing trawlers operating in the area were very cooperative and on a number of occasions gave the seismic ship free passage by moving off its track. Thus an anticipated loss of time due to fishing activities turned out to be essentially no loss at all.

The start of the survey coincided with the beginning of the salmon fishing season in Greenland. As this fishery takes place with long drift nets, there was some concern that there could be interference between the two activities. In the event, however, the seismic ship never sighted a drift net.

Sea ice. Ice caused the ship to deviate off line only a few times, while pack-ice encountered in the very northwestern part of the survey area caused one line to be cut short, and another to be slightly repositioned.

Processing. At the end of the survey, the seismic data were shipped to Calgary, Canada, where processing by Halliburton Geophysical Services is currently (November 1990) taking place. Priority has so far been given to initial testing to identify which methods should be included in the processing sequence in order to obtain the best results.

One of the characteristics of the data is the presence of multiples. This is caused by energy from the air-gun shot reflecting back and forth between the seafloor and the water surface. This energy then obscures the weaker reflections from the subsurface that the survey was intended to record. Offshore Greenland the seafloor is very 'hard' making the reflection coefficient high and giving 'ideal' conditions for multiples. Thus one of the important steps in the processing sequence is to remove the multiple energy and reveal the primary reflections underneath. At the time of writing this step is being carried out with reasonable success, judging from the tests performed.

Interpretation

It is expected that final processed versions of the Project SYD VEST SEIS data will be available during the first quarter of 1991. The data will be available for sale at commercial rates.

During 1991 an interpretation of the data will be undertaken and the results incorporated in GGU's continuing reassessment of the offshore area of southern West Greenland.

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