A possible new hydrocarbon play, offshore central West Greenland

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The discovery of extensive seeps of crude oil onshore central West Greenland (Christiansen *et al.* 1992, 1994, 1995, 1996, 1997, 1998, this volume; Christiansen 1993) means that the central West Greenland area is now prospective for hydrocarbons in its own right. Analysis of the oils (Bojesen-Koefoed *et al.* in press) shows that their source rocks are probably nearby and, because the oils are found within the Lower Tertiary basalts, the source rocks must be below the basalts. It is therefore possible that in the offshore area oil could have migrated through the basalts and be trapped in overlying sediments.

In the offshore area to the west of Disko and Nuussuaq (Fig. 1), Whittaker (1995, 1996) interpreted a few multichannel seismic lines acquired in 1990, together with some seismic data acquired by industry in the 1970s. He described a number of large rotated fault-blocks containing structural closures at top basalt level that could indicate leads capable of trapping hydrocarbons. In order to investigate Whittaker's (1995, 1996) interpretation, in 1995 the Geological Survey of Greenland acquired 1960 km new multichannel seismic data (Fig. 1) using funds provided by the Government of Greenland, Minerals Office (*now* Bureau of Minerals and Petroleum) and the Danish State through the Mineral Resources Administration for Greenland. The data were acquired using the Danish Naval vessel *Thetis* which had been adapted to accommodate seismic equipment.

The data acquired in 1995 have been integrated with the older data and an interpretation has been carried out of the structure of the top basalt reflection. This work shows a fault pattern in general agreement with that of

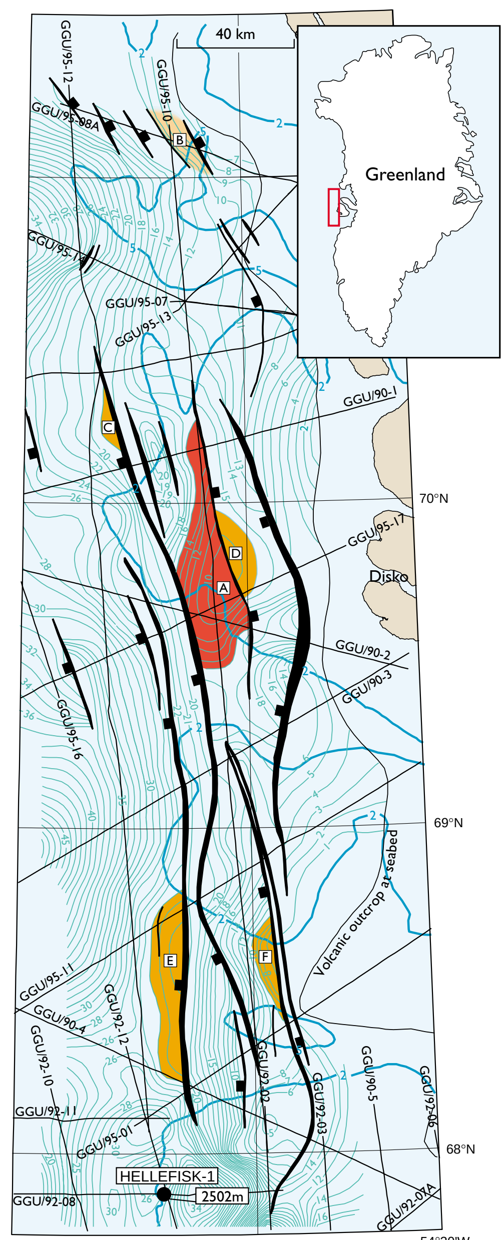

Fig. 1. Location map of the studied area showing the seismic lines, the five structural closures (structures A and C–F) and an additional lead (structure B), with structure A as the most prominent. Water depth shown by blue lines (only 200 and 500 m) and depth to top of the basalts by green lines (in hundreds of metres). The depth to the top of the Tertiary basalts at the Hellefisk-1 well is marked. Ticks on downthrow side of faults.

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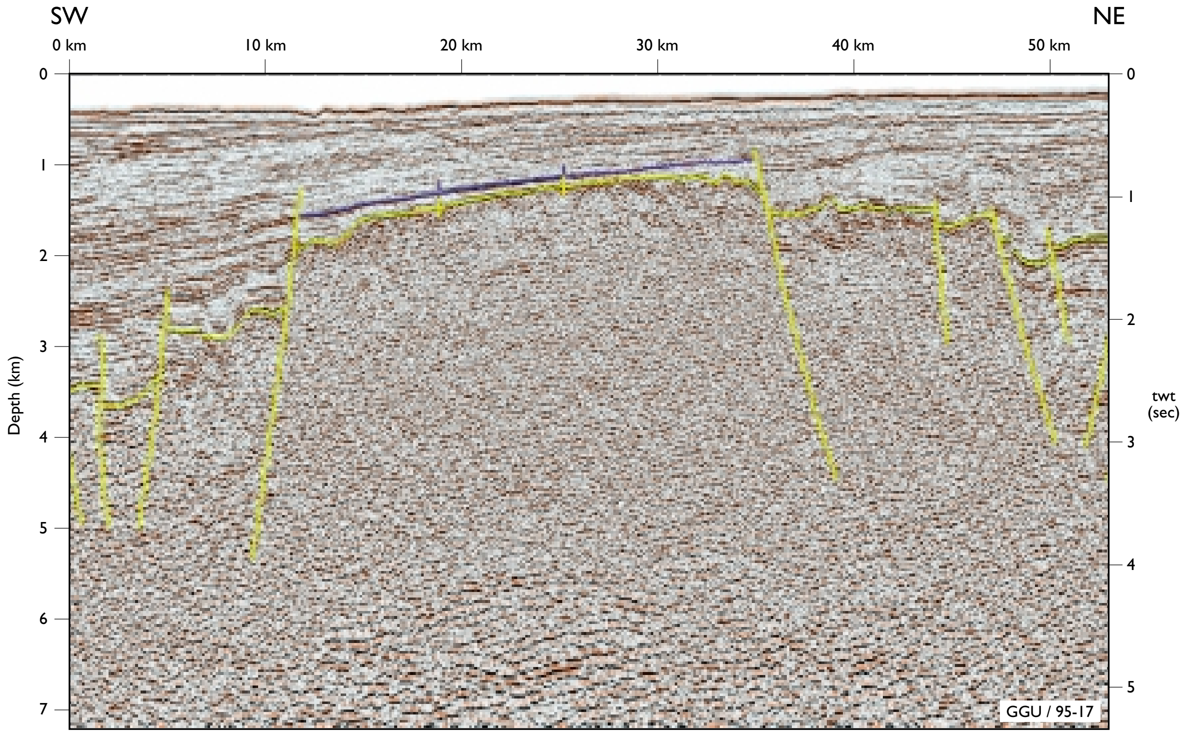

Fig. 2. Seismic section GGU/95-17 showing structure A as the horst block at top basalt level (yellow marker) bounded by faults to its east and west. Above the structure the 'bright spot' (blue marker) is shown. The post-basaltic sediments are seen to onlap structure A, indicating that deposition was controlled by topography. Below the centre of the structure some reflections are seen which are interpreted to be the base of the basaltic section. At depths of 5.5 km and 6.5 km strong reflections are seen which are tentatively interpreted to be from pre-basaltic sediments.

Whittaker (1995, 1996), although there are differences in detail. In particular the largest structural closure reported by Whittaker (1995) has not been confirmed. Furthermore, one of Whittaker's (1995) smaller leads seems to be larger than he had interpreted and may be associated with a DHI (direct hydrocarbon indicator) in the form of a 'bright spot'.

Interpretation

The seismic data used in this study were interpreted on a Sun work-station using Landmark SeisWorks-2D software.

The succession has been divided into intervals of different seismic character. The uppermost interval is present in most of the studied area, except east of 55°W where stratigraphically lower units crop out at seabed (Fig. 1). The uppermost unit is interpreted as sediments that can be tied to the Tertiary sediments in the Hellefisk-1 well (Rolle 1985). Throughout the study area the sediments lap onto top basalt level and indicate that the sedimentation was controlled by topographic structures (Fig. 2).

The top of the basalt unit is, except for the seabed, the most prominent reflector in the study area, and can also be tied to the Hellefisk-1 well (Rolle 1985). In many places reflections are visible from below the top of the basalts probably indicating that there are different seismic facies within the basalts and that sedimentary units may be found below the basalts. Work is continuing to determine the geological significance of the deeper, pre-top basalt reflections as well as the position of the base of the basalts.

Structure of the top basalt reflection

Whittaker (1995, 1996) showed that the top of the basalts is dissected by a complex system of steep, roughly N–S trending faults between 55°30′W and 57°W, south of 70°30′N. He suggested that this fault system consists of strike-slip faults related to oblique sea-floor spreading in Baffin Bay. The new data confirm Whittaker's (1995, 1996) interpretation in general terms. Steep faults with throws in places in excess of 1 km can be followed from seismic line to seismic line throughout most of the area

(Fig. 1). The faults define rotated blocks, and grabens have developed between the major faults. Complex minor faulting is commonly found within the grabens.

Farther north, the fault system shows a more NW–SE trend (Fig. 1). The coverage by 1990s data is very sparse in this area, but the older data used by Whittaker (1995, 1996) clearly shows this trend.

Prospectivity

Several structural closures at the top basalt level are shown on Figure 1 (structures A and C–F) and an additional lead (structure B) is indicated on the seismic lines.

The most promising structure, structure A, is situated west of Disko (Fig. 1). Structure A is bounded by faults to its east and west and closed by structural dip to the north and south. Figure 2 shows part of seismic line GGU/95-17 on which structure A can be seen as the horst block at top basalt level. Structural closure is mapped at about 1500 m depth and the shallowest part of the horst is at less than 1000 m depth. The structure is covered by 800–1300 m of sediments and approximately 200 m of water.

Above structure A a horizon within the sediments exhibits increased reflectivity (a 'bright spot'; Fig. 2) that approximately coincides with the structural closure mapped at top basalt level. The bright spot is seen on four seismic lines (Fig. 1) and is situated at a depth between 1000 and 1300 m below sea level, dipping from east to west. The bright spot has an extent of approximately 55 km in the N–S direction and from 7 to 23 km in the E–W direction, which gives an area of approximately 1000 km^2, so it could indicate the presence of large quantities of hydrocarbon. Preliminary results from an AVO (Amplitude Versus Offset) study on the bright spot on two seismic lines indicate that it is a Type 3 AVO anomaly in the sense of Castagna & Swan (1997), a typical gas-sand overlain by shale.

Several other small closures have been mapped and are shown and labelled on Figure 1. Whittaker (1995, 1996) mapped a large closure around the location of structure C in an area of sparse data coverage. Unfortunately the new data do not confirm Whittaker's (1995, 1996) mapping. Structure B can be seen on two seismic lines. However the structure is at the northern limit of seismic coverage, and there are no data to define its limits to the north. It is therefore unclear whether structure B is closed. All of these structures apart from B, are on the downthrown sides of faults, so their trapping potential is uncertain.

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