P-Wave Modelling of the East Greenland Volcanic Margin North of the Jan Mayen Fracture Zone

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Introduction

Between the Jan Mayen and Greenland Senyua Fracture Zone the continent-ocean transition off East Greenland is less well known. In contrast to the well explored and studied volcanic rifted margin off Norway, the deeper structure of the East Greenland margin adjacent to the Voring Plateau is of special interest. One of the main targets is to estimate the amount of magmatic material which intruded into the crust or underplated compared to the Voring Plateau, which is a large magnetic complex off the Norwegian margin. Existing gravity and magnetic data off East Greenland do not support the presence of a feature like the "Voring Marginal High" yet. Although MCS and potential field data exist along the East Greenland margin, the data density is insufficient to image lateral variations in the deeper structure, which can be expected from comparison with the conjugate margin off Norway.

The Expedition ARK XIX/4-Fig. 1-2

In 2003 new seismic reflection data were acquired on four profiles by "RV Polaris I" to investigate the deep structure of the East Greenland continental margin and its transition from continental to oceanic crust (Fig. 1). The three profiles shown in Fig. 1. Most transects were located in the prolongations of the fixed profiles of earlier investigations between 72°N and 76°N. Parallel to the deployment of ocean-bottom hydrophones (OBH) and seismometers (OBS), MCS data were recorded with a 3000m long streamer along the profiles.

One striking feature, which most likely was connected with the initial break-up, is marked by a pronounced negative anomaly (Fig. 2) between black dashed lines. The anomaly runs parallel to the coast for more than 400km between Kong Oscar Fjord at 72°N and south of Bear Island at 76°N (Schildwein, 1998). Its shallow and linear structure was not known before the expedition. Thus, the reflection profiles were extended landward to better image its deeper seismic structure. In addition, high resolution aeromagnetic and ship borne gravity data were gathered to resolve crustal anomalies on geologic boundaries.

Magnetic Anomalies - Fig. 2

The aeromagnetic survey HELMAG 2003 was operated during the expedition ARK XIX/4 and performed by helicopter in 100m altitude and with a line spacing of 50m. In total 7500 km were flown and cover the area over the seismic reflection profiles AMG 2003/040 and AMG 2003/050. The data yield high frequency variations within the pronounced negative anomaly and eastward. The wavelengths of the variations are approx. 10km with amplitudes of roughly 100nT. The negative anomaly extends eastward over a distance of 50km and a correlation with a basement high is assumed (see Fig. 3).

Crustal Structure - Fig. 3-4

Along profile AMG 2003/040 the crustal thickness changes from the western continental crust of 2980m to oceanic crust of approx. 9km. The transitional crust extends over almost 194km and appears as well as the continental crust high magnetic structure, intruded in the sanded transitional crust termination is equivalent to correlate with the eastern end of the magnetic anomaly. On the eastern end it is assumed that the transitional crust includes the magnetic high, which appears in the slope, and terminates with the onset of the oceanic crust. This is determined by the velocity-depth function in combination with the magnetic spreading anomaly C22. The basement high is in excellent agreement with the general trend of the magnetic and gravity data. A Cenozoic/Miocene sediment basins is bordered by the basement high in the west and a magnetic high in the east, which is derived from MCS data and reflection data as well.

Fig. 2

In Fig. 2 the four selected sections of OBH show the interpreted phases and the fit of the forward modelling procedure as well as the ray coverage.

- OBH432 (left) represents a registration unit on the continental side of the profile with offsets of almost 200km.
- OBH422 and OBH442 (middle) were located in the continent-ocean transition zone and show the complex structure of the basement high in the west and the magnetic high in the east. All three stations have also nearly penetrating a lower crustal body which has p-wave velocities of 6.9 km/s. This high velocity body (HVB) extends beneath the entire continent-ocean transition zone and reaches thickness of up to 15km.
- OBH402 (shaded as a typical section from the oceanic crust.

Almost all stations have recorded reflections from the Moho (PmP) but only a few give us an insight into mantle velocities.

Fig. 3

Conclusions and Outlook - Fig. 5-6

A p-wave model of the seismic reflection profile AMG 2003/040 shows a striking correlation with the additional acquired aeromagnetic data. The entire profile can be divided into three parts - continental crust, transitional crust and oceanic crust. The evidence for strong magnetic activity can be assumed due to the strong variations in the velocity-depth function and a high velocity body extending under the entire transitional zone.

In Fig. 5 the two prior models of the crustal margins are faced to each other. These profiles are not exactly conjugate profiles. They have more or less a shift of approx. 50km in the north-south direction but are used here for a first order comparison of both margins.

The profile along the Voring Plateau is shown in the same colour and dimensions and is modified after Mølje et al. 2001. The ocean crust along both profiles is almost equal in thickness and also the thickness of the continental margin is 27% including the top of the high velocity body at both margins. The rest of both models differ significantly in their shape and structure, e.g. the high velocity body off East Greenland is almost twice as thick as the section off Norway. With the continent-ocean transition on the Voring Plateau extending over 30-50km the transitional crust on the East Greenland side have a extension of about 190km.

During processing of the seismic reflection data a suspicious phase appeared in some sections (examples shown in Fig. 6). This uninterpreted phase is shown by blue ticks and appears on shots from both directions. From the traveltime it is assumed that the termination of the high velocity body on the ocean side (marked with "X") might be more complex than modelled. All attempts to interpret this signal were in vain so far or stood in conflict with the signals recorded from other registration units.

Further work will be done on this profile and on the southern profile AMG 2003/050.