Marine seismic investigation of the shelf around the Faroe Islands

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Nielsen, P. Hedebol, Waagstein, R. Rasmussen, J. and Larsen, B.: Marine seismic investigation of the shelf around the Faroe Islands. *Danm. Geol. Unders., Årbog 1981:* 101–109, København, 1 okt. 1982.

Shallow seismic profiling shows that the basaltic shelf around the Faroe Islands extends roughly to the 200 m depth contour. Outside the basaltic shelf the basalts are overlain by sediments of presumed Tertiary age which dip outwards at a low angle.

Previously published in Fródskaparrit 27 (1979): 102–112.

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The Faroe Islands are surrounded by a broad shelf which is part of the Faroe-Iceland-Greenland ridge in the northern Atlantic Ocean. It is generally assumed that the ridge consists largely of volcanic rocks surrounded by sediments. More than 3 km of Lower Tertiary basalt lavas are exposed on the Faroe Islands (Rasmussen and Noe-Nygaard 1969). Based on gravimetric and deep reflection seismics it seems likely that the Faroe shelf rests on continental crust (Bott and Watts 1971, Bott and others 1974, Nielsen 1976).

The shelf around the Faroe Islands has been subject to several investigations in the last few years. A detailed bathymetric survey has been performed inside the 200 m depth contour (Rasmussen 1977). The shelf, including the banks to the southwest, has been sampled by dredging (Waagstein and Rasmussen 1975, Waagstein 1977). A magnetic and bathymetric survey covering the shelf including Bill Bailey Bank and Lousy Bank (Nielsen 1977) is complete and the results are now being compiled. This survey supplements earlier studies by Dobinson (1970), Schrøder (1971) and Fleischer and others (1974). The shallow structure of the shelf has also been investigated by a few seismic reflection profiles (Stride and others 1967, Talwani and Eldholm

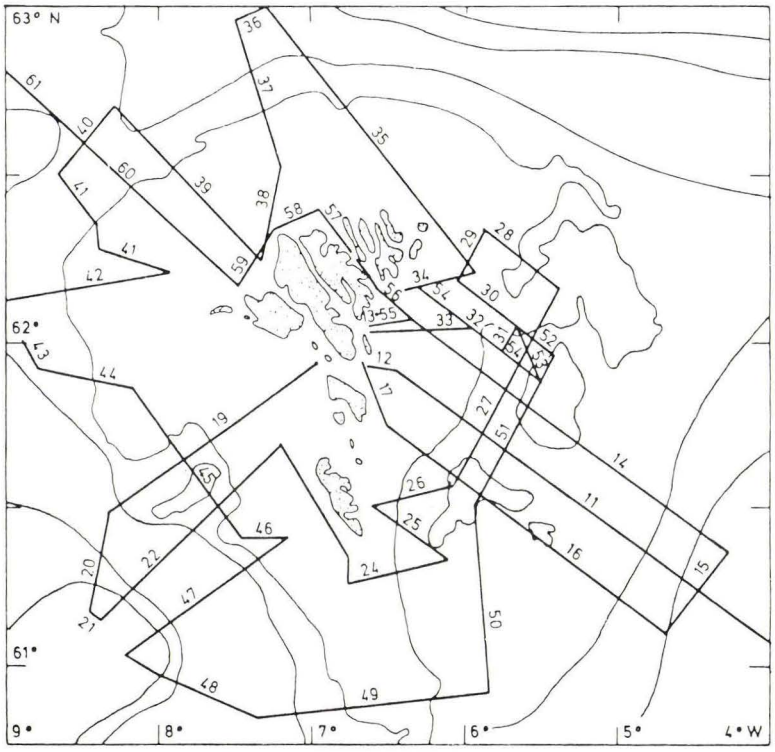

Fig. 1. A sketch of the survey lines made by »Dana« around the Faroe Islands during the summer 1979. (Line 18 in the sounds Nólsoyarfjørður and Skopunarfjørður has been omitted for clarity).

1972, Himsworth 1973, Korsakov 1974, Talwani 1974). Some of the above studies have been reviewed by Bott (1975) and Waagstein (1977).

In order to further elucidate the geological structure of the upper parts of the shelf, and especially to map the extent of basalts on the sea floor, the Faroese government and the Geological Survey of Denmark carried out a seismic survey on the research vessel »Dana«, 6–22 July 1979, with equipment on loan from the Geological Survey of Greenland. About 2300 km of shallow seismic profiles were obtained (Fig. 1).

This initial report describes the survey and presents some preliminary results.

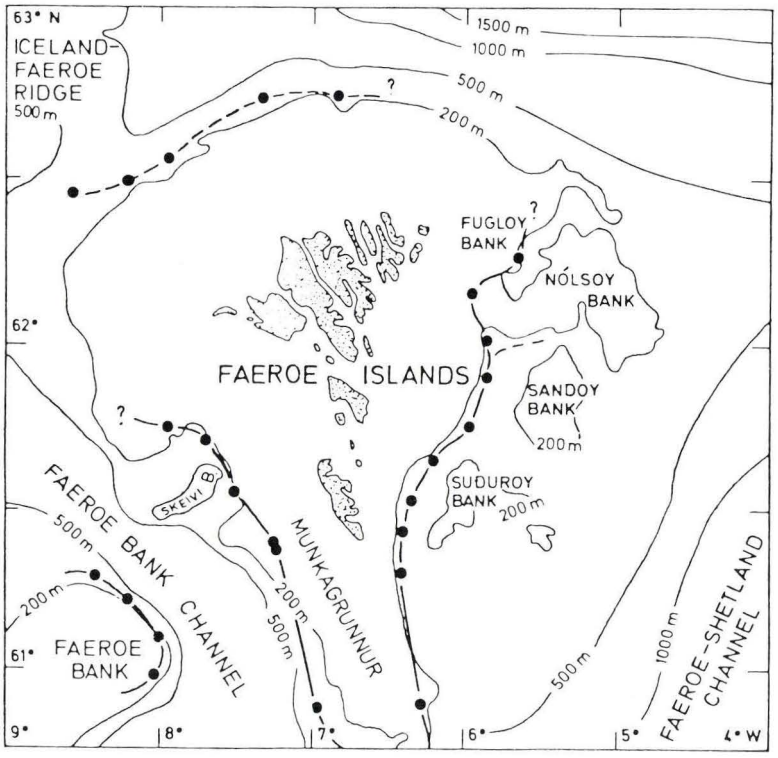

Fig. 2. The map shows the boundary of the Faroese basalt areas according to the measurements made on board »Dana«; see the text for details.

Methods

The sea bottom was investigated chiefly by seismic methods, using the principles of the recording echo sounder. A 10–20 cu inch airgun (Bolt), operated at 120 atm, or a 4 KJ nine electrode sparker array (EG & G 402), was used as a sound source. The sound signal reflected from the sea floor or from layers in the substrate was detected by a short hydrophone streamer (EG & G 265). After amplification and filtering of the seismic signal, the reflections were recorded on a facsimile recorder (EPC 3200 and 4500). An example of the records is shown in Fig. 4. The depth was measured by a Simrad SM50 sounder. The local morphology of the sea bottom was also investigated by side-scan sonar (Edo Western 515T/606), but the side-scan system was operative only on the last day of the survey. The magnetic field was measured by a proton magnetometer (Geometrics G803). Position was determined by

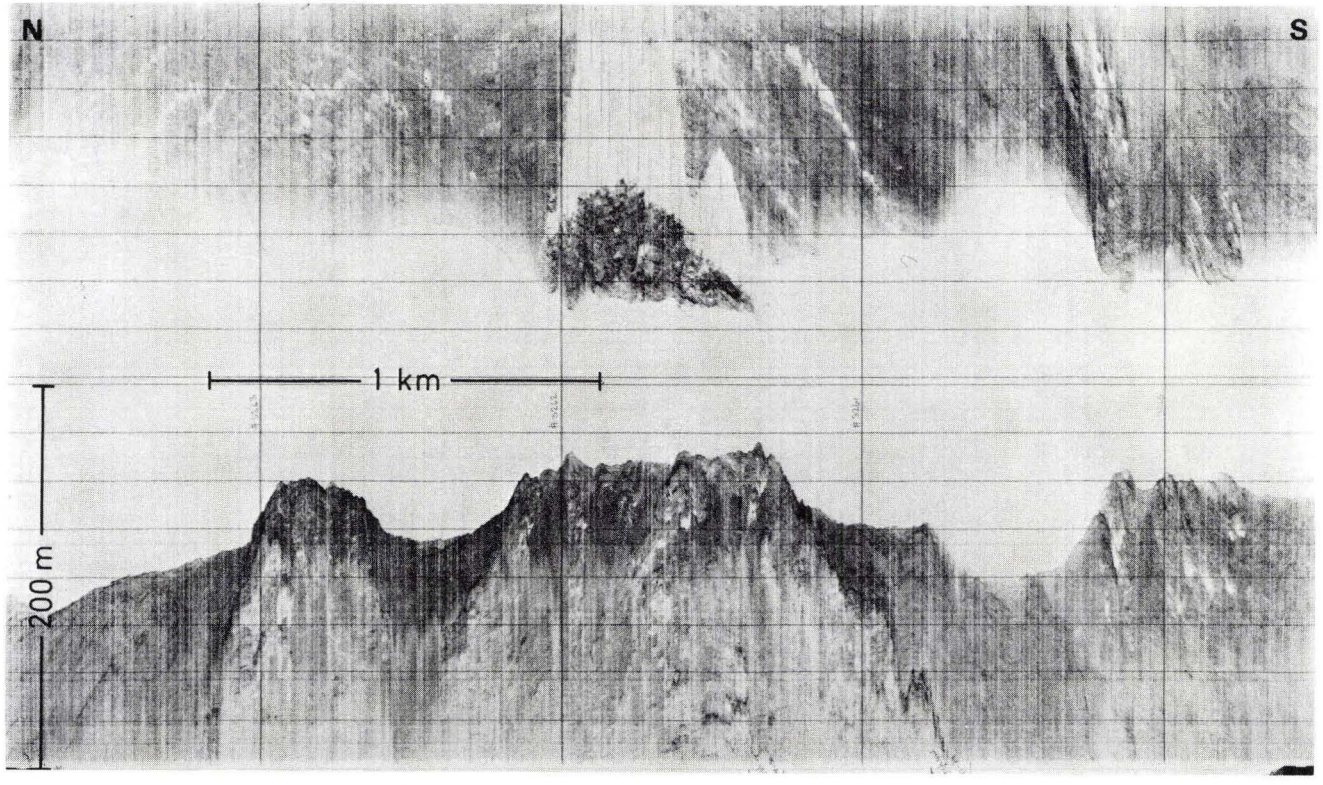

Fig. 3. Side-scan record from Djúpini (line 57).

The side-scan emits a narrow sound beam perpendicular to the course of the ship just above the sea floor. The sound reflected (or rather scattered) from the obstacles on the sea floor is recorded. The record resembles a negative photograph of the sea bottom as illuminated by a projector just above the sea floor.

The darker areas mark the parts of the sea bottom which protrude or for other reasons reflect more sound energy than average. The white area in the upper central part marks the acoustic shadow behind a protruding feature. The lower half shows the bottom on the port side (west) of the ship. Interpreted geologically, the picture probably shows an outcrop of basalt, with an outline controlled by intersecting joints. The dark areas between the outcrops possibly indicate a rather coarse-grained sediment.

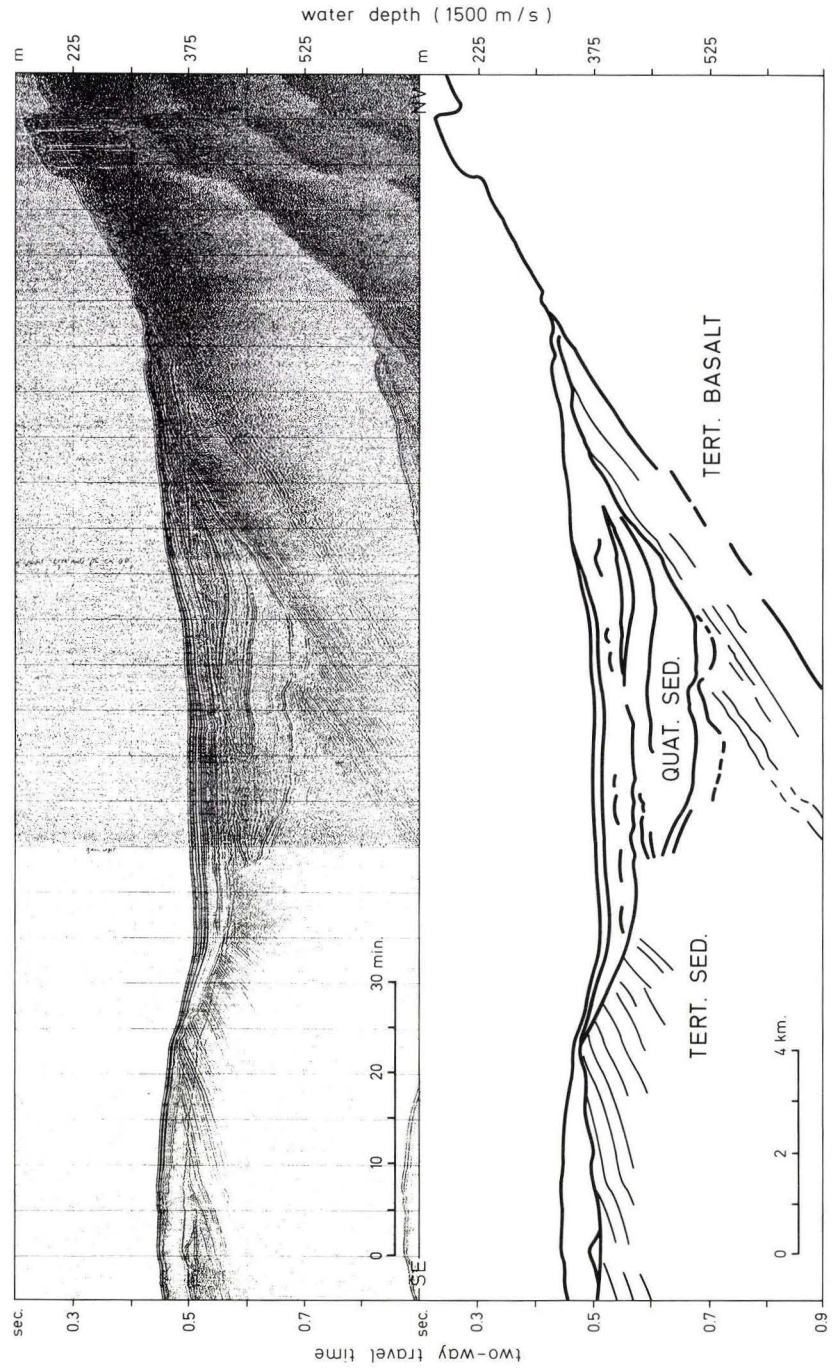

Fig. 4. A part of the seismic recording of line 11 and its interpretation showing the basalt-sediment boundary (east of the Faroe Islands).

an integrated satellite navigator sonar doppler system (Magnavox). The positional accuracy is well within 200 m when the system is working properly, but in many cases the navigator system caused troubles. A description of such marine investigations is given by, i.a. McQuillin and Ardus (1976).

Results

The basaltic shelf. Most of the wide shelf around the Faroe Islands consist of basalt like the Faroe Islands themselves. The submerged basalt area is characterized by strong, short-waved magnetic anomalies and a lack of seismic penetration. The eroded basalt flows often form inclined steps clearly visible on bathymetric and seismic profiles and side-scan records (Fig. 3). The inclination of such steps, and of rare internal reflections in the basalts, suggests that the flows dip towards the limit of the basalts east and west of the islands (Fig. 4).

The top of Faroe Bank to the southwest also consists of basalt.

Young sediments partly fill shallow depressions on top of the basalt but rarely exceed a thickness of 50 m. Glacial overdeepened depressions occur in the fiords between the islands and may be empty (e.g. Skopunarfjørður) or filled with 50–150 m of sediment (e.g. Nólsoyarfjørður, Djúpini).

The limit of the basaltic shelf

The basalt disappears below sediments on the outer shelf or slope around the Faroe Islands (Fig. 2). The basalt contact with the sediments varies in character. To the sourtheast, south and southwest, the top of the basalt falls 2–10°, seldom more, beneath the sediment sequence. The estimated depth of seismic penetration of the overlying sediments is 200–500 m, and the basalt drops below this depth within a few kilometres. The contact is mostly straight and seems to follow the stratification of the basalt (Fig. 4). North of 62° N, the eastern contact becomes flat and irregular. The basaltic basement thus occurs at less than a few hundred metres depth below Nólsoy Bank and is possibly exposed somewhere on the bank. North and northwest of the Faroe Islands (lines 35, 37, 39 and 60), the outermost part of the shelf has an irregular topography (cf. Fleischer and others 1974). The irregular zone is 10–15 km wide and seems to consist of sediments. The sediments show little or no seismic penetration and their thickness is unknown. However, the magnetic data suggest that the basaltic basement occurs at shallow depth until the edge of the shelf. Just beyond the shelf edge a wedge of transparent sediments overlies a basement reflector which is presumed to be basalt. The

strong reflector is lost a few kilometres downslope beneath several hundred metres of sediments. The supposed limit of shallow basaltic basement is shown as a stippled line on Fig. 2. Exposures of basalt reappear on the Iceland-Faroe Ridge. Due west of the northern Faroe Islands, shallow basaltic basement extends farther to the west than the survey lines.

The sedimentary shelf

Thick sediments occur on the outer shelf east of the Faroe Islands and can be divided into two major stratigraphic units.

The lower unit consists of well-bedded sediments which dip outwards at a low angle. The oldest strata overlie the sloping basalt sediment contact conformably or nearly so (Fig. 4). The lower unit is clearly seen along the western sides of Sandoy Bank and Suðuroy Bank, and in the channel between the banks. In this area the inclined beds apparently crop out on the sea floor in many places. The channels (broad valleys) separating Sandoy and Suðuroy Banks from each other and from the basaltic inner shelf are cut down into the lower sediments. These channels resemble the marginal and transverse channels described from many glaciated shelves.

The upper sediment units rests unconformably on the lower unit or directly on the basalt. The upper sediments are irregularly bedded and can attain a thickness of up to a few hundred metres in the channels, but in most places they are much thinner. The channel fillings show a high or moderate seismic transparency and probably consist dominantly of fine-grained sediments. The internal structure of the channel fillings indicats several stages of erosion and deposition (Fig. 4). The thin sediment cover on top of Sandoy and Suðuroy Banks and farther east is much less transparent and probably includes a large fraction of coarse-grainedd glacial material. In this area the underlying series is barely visible. The low-transparency layer continues a little down the slope towards the Faroe-Shetland Channel.

Thick sediments also occur on the outer shelf west of the islands in a small area facing the Faroe Bank Channel (Fig. 2). A lower series of outward-dipping sediments also exists here beneath a cover of younger sediments (cf. Stride and others 1967).

Discussion

The regularity of the contact between basalts and lower sediments suggests that the contact follows the bedding of the basalt flows. This impression is supported by observations of the dip of flows on the basaltic shelf. The dip of

the contact, i. e. flows, is steeper than the probable original dip of the flows. The basalts are therefore tilted, a finding consistent with the idea of updoming of the basalt plateau (Schrøder 1971, Waagstein 1977).

The conformable contact between basalts and sediments (Fig. 4) indicates that the oldest parts of the lower sediments have also been tilted. Asssuming an early date of doming (Waagstein 1977), the oldest sediments only slightly postdate the basalts dated at 50–60 mill. years, i.e. Lower Tertiary (Tarling and Gale 1968). Some of the sediments are probably tuffaceous (Waagstein and Rasmussen 1975).

The lower sediment unit attains a thickness of roughly 2 km in the vicinity of Sandoy and Suðuroy Banks, according to gravity (Bott and Watts 1971) and seismic evidence (Korsakov 1974).

The sediments of the upper unit are supposed to be of Quaternary age. The Faroese ice sheet probably reached the 400 m depth contour to the southeast of the Faroe Islands (Waagstein and Rasmussen 1975). The large areas of poor seismic penetration on the eastern sedimentary shelf are therefore probably covered by glacial drift.

Acknowledgements. The paper is reprinted with permission from Fróðskaparrit. The authors wish to thank the Geological Survey of Greenland for the opportunity to make the survey around the Faroe Islands. We also wish to thank all on board the »Dana« for fine cooperation. One of the authors, P. H. Nielsen, acknowledges a grant from »Statens Naturvidenskabelige Forskningsråd«.

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