DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2001/18

Seismic data acquisition in the offshore part of the Nuussuaq Basin during summer 2000 – Cruise report

Christian Marcussen, Holger Lykke Andersen, James A. Chalmers, Per Trinhammer, Rasmus Rasmussen and Egon Hansen

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF ENVIRONMENT AND ENERGY

G E U S

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EFP - Project NuussuaqSeis 2000:
Structure and hydrocarbon potential of the Nuussuaq Basin:
Acquisition and interpretation of high-resolution multichannel seismic data – ENS J.nr. 1313/99-0024

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1. Background

Knowledge of the Nuussuaq Basin in central West Greenland has increased dramatically since the discovery of extensive oil seeps on western Nuussuaq in 1992. A wealth of geological and geophysical studies have been published and data from slim core drilling and exploration wells are also available. They indicate that the Nuussuaq Basin is a petroleum basin in its own right, and not merely an accessible analogue to potential petroleum basins offshore. Furthermore, seismic data acquired in 1995 in the fjords south and north of Nuussuaq and gravity interpretation have contributed to the general understanding of the structure of the basin.

The project NuussaqSeis 2000 – acquisition of high-resolution multichannel seismic data in the waters around Nuussuaq and Ubekendt Ejland – was designed in order to improve further understanding of the shallow structure of the Nuussuaq Basin. Data from the NuussuaqSeis 2000-project will increase the seismic coverage in the region considerably and the new data will also have direct implications for the evaluation of the hydrocarbon potential of the onshore areas.

Based on experience from seismic acquisition in earlier years in the same waters, it was anticipated that ice conditions (many icebergs) would prevent the use of a long streamer (e.g. 3000 m). Usage of a short streamer would make it impossible to remove seabed multiples by traditional methods (e.g. F/K filtering). On the other hand the relatively large water depths in the area of interest – between 400 and 800m - would make it possible to see up to 1.5 km of sediments before the first seabed multiple would distroy the data. It was therefore decided to use shallow seismic equipment with a considerably smaller source but better resolution than a conventional marine seismic equipment.

Seismic acquisition took place from 18 July to 2 August 2000 using the Danish research vessel '*Dana*' (fig. 24) with seismic equipment from the Geological Institute, Aarhus University. Funding for the project was provided by the Danish Energy Research Programme, the Greenland Bureau of Minerals and Petroleum, the Geological Institute, Aarhus University and GEUS.

2. Survey planning

Prior to arriving in Greenland, the planned survey consisted of 2013 km of Priority 1 lines in Vaigat and Uummannaq Fjord plus 290 km of Priority 2 lines in the volcanic areas west of Nuussuaq and Ubekendt Ejland (see fig. 1).

A total of 18 days was planned for the entire survey, an average of 112 km per day if only the Priority 1 lines were acquired and of 128 km per day if we managed to acquired the Priority 2 lines as well. This planning was based on the expectation that we would have some downtime for bad weather, plus significant amounts of time spent reconnoitring areas with icebergs. In the event of iceberg reconnoitring, we expected to have to retrieve and redeploy the seismic gear, which would take additional amounts of time. In addition, we had planned 2 days of downtime for equipment problems.

The bathymetry of parts of the planned survey area was poorly known. Therefore all available bathymetric data were compiled and plotted together with the preplanned lines as overlays to the published charts from the area. These overlays proved to be very useful in the line-to-line planning of the survey.

In the event, we had superb weather for seismic acquisition. Wind speeds were low all the time, and we had effectively calm weather much of the survey, so our time lost because of weather was zero. Icebergs were either relatively sparse, in which case it was possible to acquire data around them without significant problems other than the occasional move slightly off line, or they were packed so densely that it was impossible to penetrate those areas at all. The amount of time lost for equipment downtime was also small, a total of approx. 10 hours, thanks to the splendid and untiring work of our two technicians Per Trinhammer and Egon Hansen. In general maintenance of equipment was done during extended line shifts.

The result was that we acquired data much faster than anticipated, and had the luxurious problem of having to extend the survey to fill the ship-time we had available. The programme extensions and alterations were done in four areas and four out of five phases of the survey (see map of acquired lines – fig. 2).

2.1 **Phase 1. Vaigat**

The first phase of the survey in Vaigat was carried out mostly on pre-planned lines. We started west of the fjord entrance then shot two lines (GEUS00-01 and GEUS00-03) the entire length of the fjord plus a tie line (GEUS00-02) at the eastern end of Vaigat. We found no sea-ice at all (as expected) and a low concentration of icebergs.

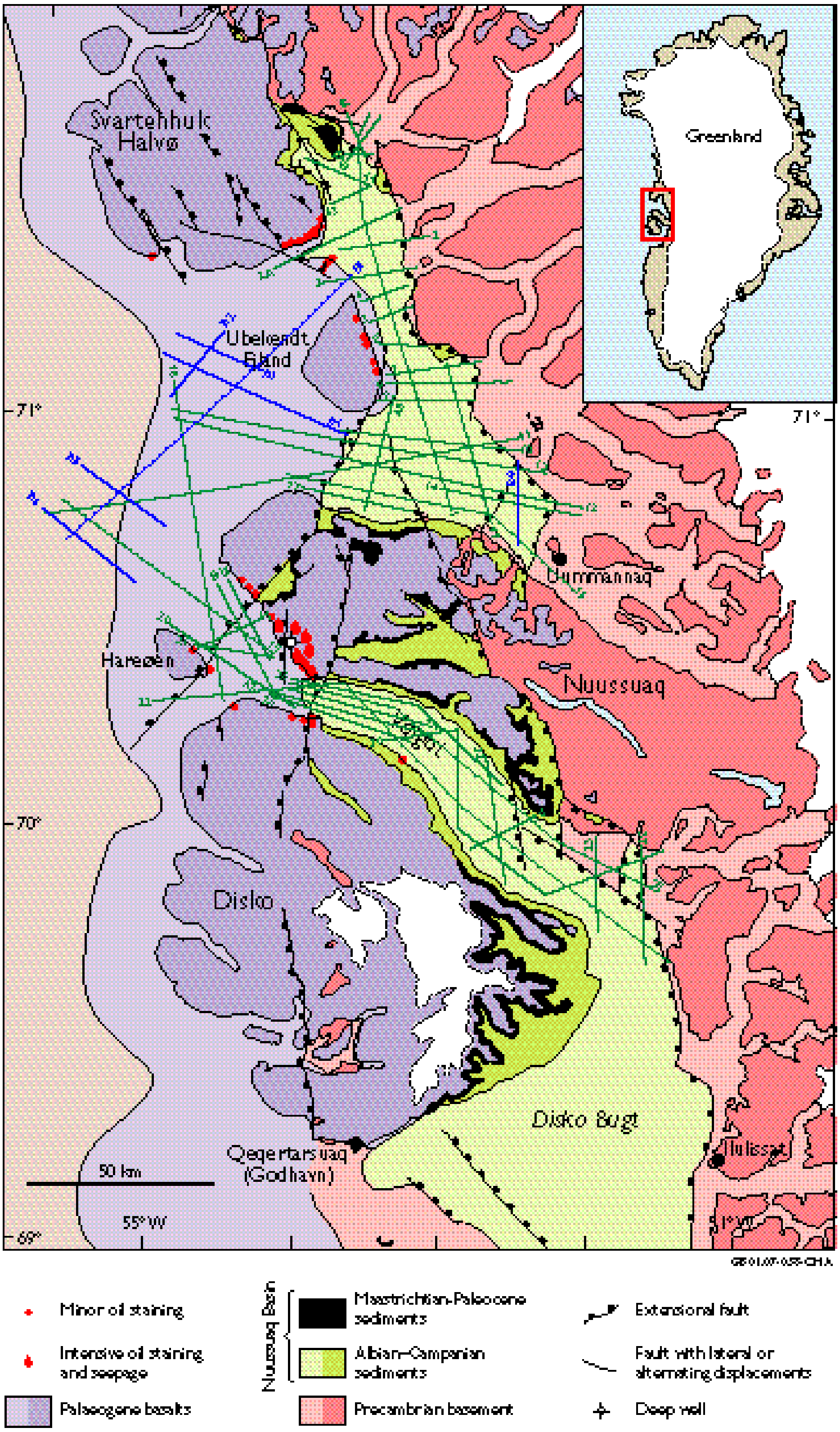

Fig. 1: Preplanned seismic lines of the NuussuaqSeis 2000 survey: priority A in green and priority B in blue. All line names have the prefix DANA-.

Because of the low iceberg density, we decided to obtain what we regarded as the strategically most important data first, so we concentrated on acquiring lines over the known area of fault-blocks in western Vaigat. Lines GEUS00-04 to GEUS00-07 inclusive were acquired there. It became apparent during the acquisition of these lines that the quality of the data we were acquiring was good to excellent in the areas without sills or large moraines at the seabed.

Once this phase of the survey was complete, we concentrated on the area off Maarrat between Nuussuaq and Hareøen, and acquired lines GEUS00-09 to GEUS00-11 there.

With this complete, we felt that we had covered the most important parts of the Vaigat survey, so moved to Uummannaq Fjord via two long transects out into the basalt area and back to north of Nuussuaq, lines GEUS00-12 and GEUS00-13.

2.2 Phase 2. Uummannaq Fjord north to Svartenhuk Halvø

GEUS00-13 was a long transect from out in the basalt area west of Nuussuaq to finish above basement outcrop west of Appat Ø. On the way into and across Uummannaq Fjord, it became apparent that the outer fjord had a similarly low density of icebergs to that found in Vaigat, but that they were packed tight in the inner fjord around Uummannaq Ø itself.

The next part of the programme was two long transits (GEUS00-14 and –15) back across Uummannaq Fjord and out into the basalts again. Line GEUS00-15 was terminated early because of dense concentrations of icebergs, and it was then apparent that we had to abandon acquisition of the planned lines east of 52° 30'W (the eastern ends of planned lines DANA-13 and –15, and we abandoned DANA-14 entirely). Instead new lines were planned in this area to make best use of where we could work. Lines GEUS00-15 to –18 were acquired in southern Uummannaq Fjord in two different directions to optimise fault crossings. N–S tie lines GEUS00-19 and –21 were then acquired together with the first dip line in the northern part of Uummannaq Fjord (GEUS00-20).

On our way south on GEUS00-21, it became apparent that the icebergs in inner Uummannaq Fjord were moving out westwards, at a time when the wind had shifted to easterly. We had planned to shoot next planned line DANA-1 all the way to east of Svartenhuk Halvø, but because of the movement of the ice, decided to complete all acquisition in Uummannaq Fjord first, before moving north of the southern tip of Upernivik Ø. Lines GEUS00-22 to –26 were then acquired to finish our work there.

It is worth remarking at this point that some of the lines were acquired only because of excellent work by Captain Peter Østrin and the bridge officers in using the radar to discover sneaky routes through iceberg concentrations into open areas beyond. The eastern ends of several of the lines in Uummannaq Fjord were acquired only because of this. In particular, line GEUS00-25, which is important to study the location and structure of the eastern margin of the basin, is an excellent example of this work.

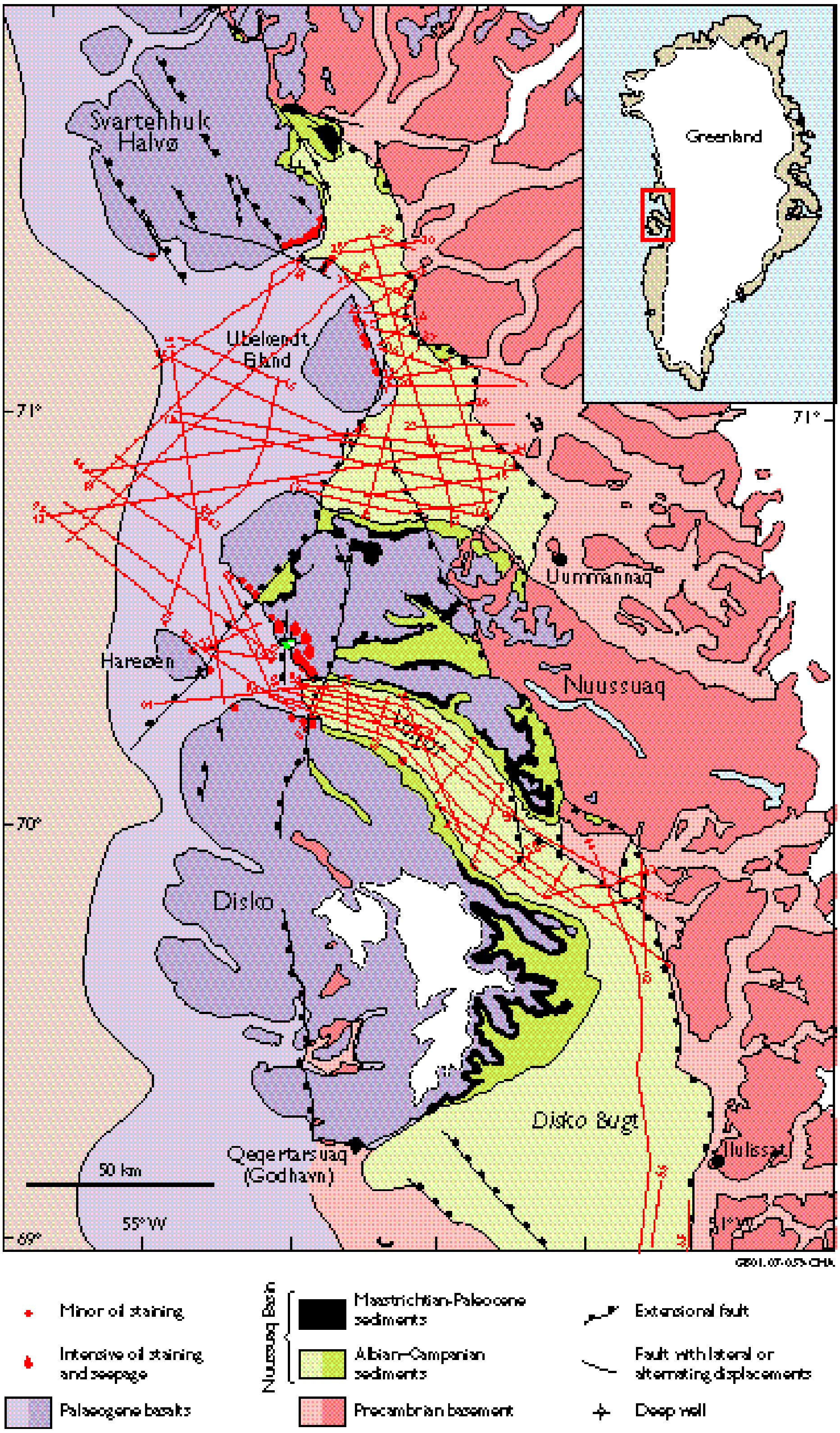

Fig. 2: Seismic lines acquired during the NuussuaqSeis 2000 survey are shown in red. All line names have the prefix GEUS00-. Line numbers placed at start of line.

We then resumed the transit north between Ubekendt Ejland and Upernivik Ø, to be stopped by large concentrations of icebergs at 71° 27'N (fig. 36). It was apparent that there was no possibility of proceeding farther north, and that the entire programme east of Svartenhuk Halvø had to be cancelled.

We zigzagged south between Ubekendt Ejland and Upernivik Ø, then back north again on zigzags that were on the opposite phase to those on the transit south. We did not tie lines at the turns, but proceeded with short line changes close to the coast in the overall direction of travel.

2.3 **Phase 3. The basalt areas west of Nuussuaq and Ubekendt Ejland**

Our preplanned programme was that we would acquire lines west of Nuussuaq and Ubekendt Ejland only as a second priority programme. However, we now found ourselves with substantial amounts of shiptime available and a completed programme in the accessible areas that was more than originally planned. We wanted some more data in Vaigat, but felt that 2–3 days would be more than adequate for that, so we decided to use the time available to study the areas west of Ubekendt Ejland and Nuussuaq where the basalts are near seabed, and where water depths are large enough that would could hope to achieve significant penetration of the basalts above the first seabed multiple. We knew from GGU/95 and even Brandal 1971 lines that there are reflections from below the top of the top basalt reflection. However the significance of those reflections is not well understood. Different interpretations of the area have also been published in the literature, which would have substantially different implications about the area's prospectivity. The existence of a bright spot on the some of the GGU/1995 lines indicates that the area is interesting from the point of view of hydrocarbon prospectivity, so we planned an expanded programme in the area where the basalts are near the seabed. Some information on the lines already acquired caused us to adjust the location of some of the preplanned lines and to extend others.

We had considered that it would be necessary to take in all our equipment to find a way through the icebergs north of Ubekendt Ejland. However, the captain thought it should be possible to find a route near one of our planned lines. And so it was. We proceeded southwest along the long transit GEUS00-40 out into the basaltic areas west of Ubekendt Ejland and Nuussuaq.

During the next 3½ days we acquired lines GEUS00-41 to GEUS00-52 (approx. 710 km incl line GEUS00-40) in a broad grid extending from the mouth of Vaigat in the south to Svartenhuk Halvø in the north. Reflections were received in many areas from up to and over 500 msec below the top of the basalts. Preliminary interpretations showed several distinct areas, and the programme was adjusted to optimise coverage of these areas.

2.4 **Phase 4. Vaigat again**

Preliminary interpretation of the lines acquired during Phase 1 in Vaigat showed that, in western Vaigat, the interpretation shown in Chalmers et al. (1999) was essentially correct, but that alterations were necessary in eastern Vaigat. Detailed images of the Cretaceous sediments in western Vaigat were now available, so a number of lines were planned that crossed the western part of the fjord within each fault block to give horizon ties between the lines along the fjord. It was also apparent, on the Ramesses displays and also on the preliminary ProMax stacks, that reflections were not visible from below large moraines, so lines were planned to avoid those areas. In eastern Vaigat, lines were adjusted to optimise interpretation of structure.

2.5 **Phase 5. Disko Bay**

It was decided to use the last cruise day for a long N-S transect from the eastern end of Vaigat across the mouth of Jakobshavn Isbræ and further to acquire to short N-S lines just south of Ilulissat in order to study the southern extension of the sedimentary basin and also to provide the coring project with some useful data.

3. Summary of results

Due to excellent weather conditions (mostly calm and only few periods with fog) and favourable ice conditions approx. 20% more data than planned were acquired between 18 July and 2 August totalling 2740 km (see table 1 and 2 and fig. 2).

Source:	4 x 40 cu. inch TI SG-I sleeve guns	Spacing between individual guns: 50 cm centre to centre
	Pressure: 120 bar	Depth: 3.5 m to centre of cluster
Streamer:	Length: 593.75 m (active section)	Towing cable length: 90 m
	96 groups	6.25 m group interval
	3.125 m group length	Depth: 3 m
Shotpoint interval:	5 sec ≈ 12.5 m	Near offset: 53 m
Recording system:	2 Geometrics R48	Sample rate: 1 msec
	Record length: 3072 msec	Delay: 0 msec
	Filters: Low cut: 10 Hz slope 24 db/oct	Filters: High cut: 300 Hz anti-aliasing
	Data format: SEG-D 8048 revision 0	Output media: IBM 3490 cartridge
Navigation:	GPS	Ashtech G12 receiver
Magnetometer:	Geometrics G866	
Echosounder:	Simrad EK 400	

Table 1: Acquisition parameters

Cruise participants:

Christian Marcussen, chief-scientist, GEUS
Holger Lykke Andersen, co-chief scientist, Aarhus University
James A. Chalmers, senior researcher, GEUS
Rasmus Rasmussen, senior adviser, GEUS
Per Trinhammer, technician, Aarhus University
Egon Hansen, technician, GEUS
Britt Jessen, student, Aarhus University

Peter Østrin, captain of R/V *Dana* and the crew of R/V *Dana*

Table 2: Line summary

Line name	AREA	Date	SOL Lat N	SOL Long W	EOL Lat N	EOL Long W	FF#	LF#	FR#	LR#	Length (nominal)	Remarks
GEUS00-A	Ikermiut	16-07-00	66 03.4	57 00.0	66 11.3	57 00.1	1	1111	1	2	13,89	
GEUS00-01	Vaigat	18-07-00	70 18.7	55 01.1	69 41.0	51 22.5	1	13251	3	21	165,64	
GEUS00-02	Vaigat	18-07-00	69 41.0	51 32.7	69 57.5	51 33.3	1	2419	22	25	30,24	event # starts with #7
GEUS00-03	Vaigat	19-07-00	69 51.7	51 28.4	70 21.8	54 01.4	1	8957	26	38	111,96	
GEUS00-04	Vaigat	19-07-00	70 22.5	54 02.6	70 07.0	52 31.3	1	5136	39	46	64,20	
GEUS00-05	Vaigat	20-07-00	70 04.2	52 32.9	70 20.1	54 12.2	1	5458	47	55	68,23	event # starts with #3
GEUS00-06	Vaigat	20-07-00	70 20.9	54 14.3	70 14.6	53 01.4	1	3836	56	61	47,95	event # starts with #2
GEUS00-07	Vaigat	20-07-00	70 16.1	53 04.7	70 21.4	54 07.5	1	3220	62	66	40,25	
GEUS00-08	Vaigat	20-07-00	70 21.1	54 11.1	70 35.9	54 35.5	1	2492	67	70	31,15	
GEUS00-09	Vaigat	21-07-00	70 36.7	54 30.9	70 25.3	54 12.1	1	1930	71	73	24,13	
GEUS00-10	Vaigat	21-07-00	70 25.7	54 11.0	70 17.1	54 42.9	1	1595	74	76	19,94	event # starts with #1943
GEUS00-11	Vaigat	21-07-00	70 26.9	54 41.8	70 31.0	54 16.6	1	1350	77	78	16,88	event # starts with #3552
GEUS00-12	Vaigat	21-07-00	70 26.0	54 10.2	70 47.5	55 45.9	1	5576	79	86	69,70	
GEUS00-13	Uummannaq	21-07-00	70 45.2	55 52.1	70 57.3	52 28.3	1	9939	87	101	124,24	
GEUS00-14	Uummannaq	22-07-00	70 53.2	52 24.6	71 01.2	54 57.4	1	7450	102	112	93,13	
GEUS00-15	Uummannaq	22-07-00	70 59.8	54 56.9	70 50.1	52 33.2	1	7079	113	122	88,49	
GEUS00-16	Uummannaq	23-07-00	70 46.8	52 40.1	70 52.0	54 06.1	1	4252	123	128	53,15	event # starts with #14
GEUS00-17	Uummannaq	23-07-00	70 50.4	54 00.3	70 48.9	52 35.8	1	4182	129	134	52,28	
GEUS00-18	Uummannaq	23-07-00	70 52.4	52 34.4	70 49.6	53 32.5	1	2834	135	138	35,43	
GEUS00-19	Uummannaq	24-07-00	70 47.9	53 30.8	71 03.7	53 19.1	1	2393	139	143	29,91	
GEUS00-20	Uummannaq	24-07-00	71 05.5	53 19.6	71 05.7	52 24.7	1	2636	144	147	32,95	event # starts with #18
GEUS00-21	Uummannaq	24-07-00	71 18.1	52 55.7	70 46.3	52 36.9	1	3231	148	152	40,39	
GEUS00-22	Uummannaq	24-07-00	70 47.2	52 53.8	71 00.9	53 06.6	1	2109	153	156	26,36	
GEUS00-23	Uummannaq	24-07-00	70 59.8	53 08.3	71 00.0	52 25.4	1	2052	157	159	25,65	
GEUS00-24	Uummannaq	25-07-00	70 55.7	52 22.6	70 58.7	53 45.0	1	3984	160	165	49,80	
GEUS00-25	Uummannaq	25-07-00	71 06.7	53 21.8	71 05.7	52 20.0	1	3109	166	170	38,86	
GEUS00-26	Uummannaq	25-07-00	71 03.0	53 25.1	71 03.0	53 25.1	1	1997	171	173	24,96	
GEUS00-27	Uummannaq	25-07-00	70 58.3	53 04.3	71 27.6	53 31.9	1	4508	174	180	56,35	
GEUS00-28	Uummannaq	26-07-00	71 26.0	53 42.4	71 27.3	53 25.9	1	839	181	182	10,49	event # starts with #4512
GEUS00-29	Uummannaq	26-07-00	71 27.1	53 24.2	71 25.4	53 10.4	1	689	183		8,61	
GEUS00-30	Uummannaq	26-07-00	71 26.6	53 08.0	71 24.7	53 45.3	1	1798	184	186	22,48	event # starts with #692
GEUS00-31	Uummannaq	26-07-00	71 20.7	53 37.3	71 22.2	53 10.5	1	1277	187	188	15,96	
GEUS00-32	Uummannaq	26-07-00	71 21.5	53 10.5	71 16.8	53 33.4	1	1293	189	190	16,16	
GEUS00-33	Uummannaq	26-07-00	71 16.2	53 12.3	71 15.6	53 12.3	1	983	191	192	12,29	
GEUS00-34	Uummannaq	26-07-00	71 14.6	53 18.9	71 11.5	53 27.1	1	856	193	194	10,70	
GEUS00-35	Uummannaq	26-07-00	71 10.9	53 26.1	71 07.8	52 53.7	1	1627	195	197	20,34	
GEUS00-36	Uummannaq	26-07-00	71 06.1	53 22.2	71 11.4	53 08.4	1	1030	198	199	12,88	

Table 2 (cont.)

Line name	AREA	Date	SOL Lat N	SOL Long W	EOL Lat N	EOL Long W	FF#	LF#	FR#	LR#	Length (nominal)	Remarks
GEUS00-37	Uummannaq	27-07-00	71 12.6	53 09.7	71 14.0	53 30.3	1	1011	200	201	12,64	event# starts with #4
GEUS00-38	Uummannaq	27-07-00	71 14.8	53 30.0	71 17.3	53 12.6	1	897	202	203	11,21	event# starts with #3
GEUS00-39	Uummannaq	27-07-00	71 18.3	53 13.4	71 22.7	53 43.2	1	1581	204	206	19,76	
GEUS00-40	W. Nuussuaq	27-07-00	71 21.9	53 35.8	70 41.7	55 42.9	1	8558	207	219	106,98	
GEUS00-41	W. Nuussuaq	27-07-00	70 46.0	55 53.6	70 32.0	54 35.8	1	3461	220	224	43,26	
GEUS00-42	W. Nuussuaq	28-07-00	70 32.2	54 56.9	70 46.0	54 45.0	1	2122	225	228	26,53	event# starts with #3465
GEUS00-43	W. Nuussuaq	28-07-00	70 45.6	54 41.5	70 54.6	55 23.1	1	2380	229	232	29,75	
GEUS00-44	W. Nuussuaq	28-07-00	70 52.2	55 36.3	70 41.5	54 47.1	1	2839	233	236	35,49	event# starts with #2385
GEUS00-45	W. Nuussuaq	28-07-00	70 44.6	54 47.9	71 06.7	54 11.4	1	3927	237	242	49,09	event# starts with #5221
GEUS00-46	W. Nuussuaq	28-07-00	71 05.9	54 10.2	71 12.0	54 57.2	1	2396	243	246	29,95	
GEUS00-47	W. Nuussuaq	29-07-00	71 09.2	55 02.8	70 57.9	53 40.0	1	4254	247	252	53,18	
GEUS00-48	W. Nuussuaq	29-07-00	70 58.7	53 38.8	70 51.8	55 37.0	1	5749	253	261	71,86	
GEUS00-49	W. Nuussuaq	29-07-00	70 50.7	55 31.9	71 23.9	54 02.5	1	6716	262	271	83,95	
GEUS00-50	W. Nuussuaq	30-07-00	71 23.2	54 03.4	71 07.0	55 09.1	1	3934	272	277	49,18	
GEUS00-51	W. Nuussuaq	30-07-00	71 10.0	55 00.0	70 19.1	54 31.7	1	7601	278	288	95,01	
GEUS00-B	W. Nuussuaq	30-07-00	70 21.5	54 33.0	70 22.8	54 33.7	1	200	289		2,50	
GEUS00-52	Vaigat	31-07-00	70 27.8	54 45.1	70 18.3	54 00.6	1	2595	290	293	32,44	
GEUS00-53	Vaigat	31-07-00	70 17.9	53 54.3	70 22.3	53 47.3	1	734	294	295	9,18	
GEUS00-54	Vaigat	31-07-00	70 21.3	53 38.0	70 15.7	53 38.2	1	812	296	297	10,15	
GEUS00-55	Vaigat	31-07-00	70 15.1	53 25.8	70 20.5	53 21.3	1	812	298	299	10,15	
GEUS00-56	Vaigat	31-07-00	70 19.4	53 13.0	69 59.7	52 47.3	1	3191	300	304	39,89	
GEUS00-57	Vaigat	31-01-00	70 01.1	53 13.9	69 51.3	52 13.9	1	2361	305	308	29,51	
GEUS00-58	Vaigat	01-08-00	69 59.0	52 14.0	69 54.5	52 34.5	1	1221	309	310	15,26	
GEUS00-59	Vaigat	01-08-00	69 57.5	52 43.8	70 08.1	52 32.1	1	1663	311	313	20,79	
GEUS00-60	Vaigat	01-08-00	70 12.6	52 45.4	70 06.6	53 00.5	1	1199	314	315	14,99	
GEUS00-61	Vaigat	01-08-00	70 04.1	52 56.5	69 51.3	51 31.2	1	4982	316	323	62,28	
GEUS00-62	Vaigat	01-08-00	69 54.9	51 32.9	69 51.9	52 10.1	1	1948	324	326	24,35	
GEUS00-63	Vaigat	01-08-00	69 52.7	52 10.7	69 56.3	52 04.5	1	628	327		7,85	
GEUS00-64	Vaigat/Ilul	02-08-00	69 57.8	51 53.4	68 59.9	51 37.5	1	8679	328	341	108,49	
GEUS00-65	Ilulissat	02-08-00	68 59.9	51 17.9	69 07.3	51 17.2	1	1065	342	343	13,31	even# starts with #8687
GEUS00-66	Ilulissat	02-08-00	69 10.2	51 27.9	69 00.4	51 32.7	1	1416	344	345	17,70	
Total											2742,6	

SOL, EOL: start and end of line coordinates; FF#, LF#: first and last file number; FR#, LR#: first and last reel number.

4. Seismic equipment – technical details

4.1 Streamer and acquisition instruments

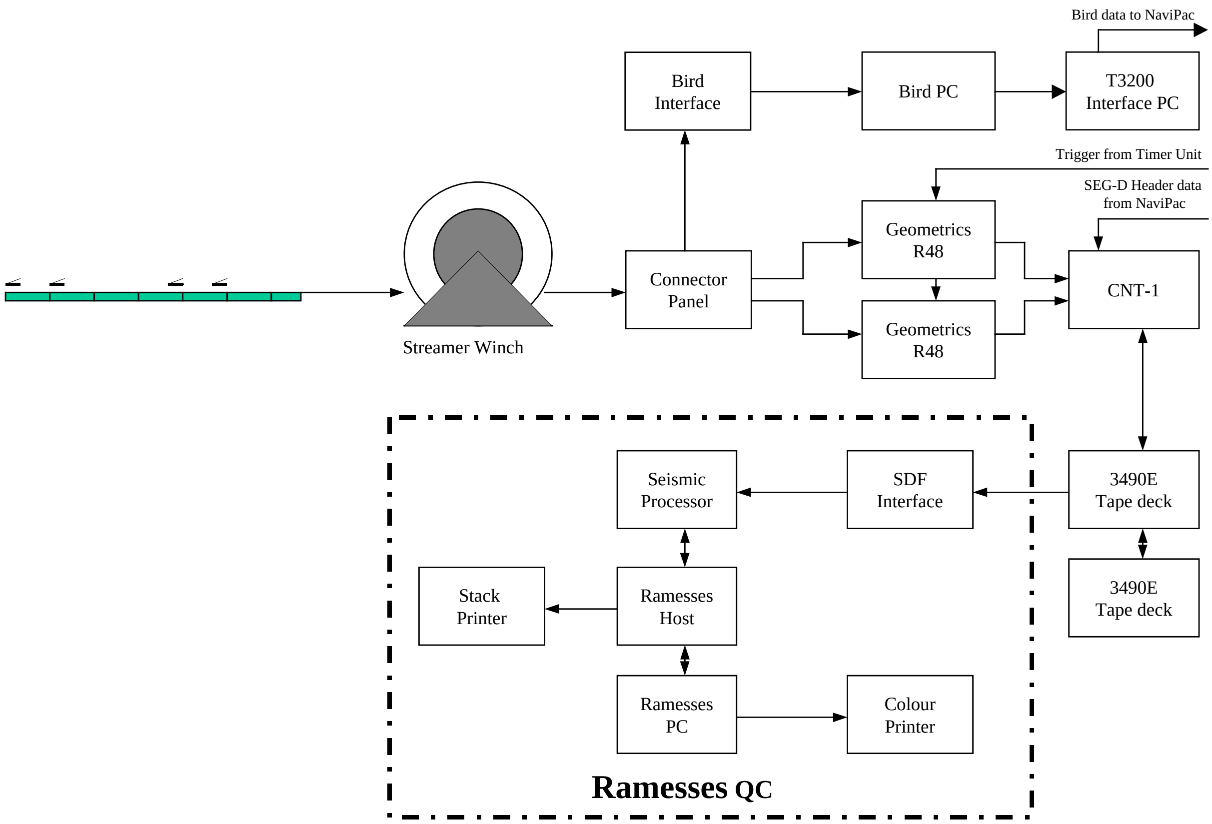

Fig. 3: Block diagram of the 96 channel. marine seismic acquisition equipment on board *H/S Dana*

Streamer (fig. 27):

96 channel HydroScience streamer, consisting of 6 active sections and with total active length of 593.75 m, 1 (one) 50 m stretch section and 50 m towcable :

<u>Active section specification :</u>
3.125 m channel length
7 x Benthos RDA hydrophones in each channel
6,25 m channel interval, centre to centre

DigiCourse communication coil, in each section, rear end

<u>50 m Stretch section :</u>
DigiCourse communication coil in front end

Streamer winch (fig. 26):

Hydraulic winch, placed in a 10” container, with remote control. The winch has following specifications :

Powered from 3x380 V, 32 Amp.
Drum size, inner diameter 1.3 m, outer diameter 2.1 m, and width 1.2 m
Break 2.0 ton, pulling force 1.0 Ton
Weight 4 Ton

Connector Panel :

Panel to distribute signal from streamer deck cable, to acquisition unit and bird control.

Bird interface :

Interface unit for birdcontrol (type DigiCourse Model 272), used to communicate between bird PC and bird 1 to 4, placed on the streamer. Bird 1 is placed at the end of first active section, bird 2 is placed at the end of 2nd active section, bird 3 is placed at 2nd last active section, bird 4 is placed at the tail of the last active section.

Bird PC :

PC used to download data to each bird. When data is downloaded, the *Run* programme is used to monitor the actual fin angle and depth. The *Log* programme is set to send a serial string every 10 sec, to T3200 interface PC. Format is *DigiCourse*, see page 70 in “DigiSCAN 293A PC Edition Operator’s Manual” for detailed format specification. With the *Diagnostics* programme the battery status of each Bird can be checked. This is done every 2nd day or at EOL.

T3200 Interface PC :

PC to generate a bird string to NaviPac each second because the NaviPac programme can not run without getting an update each sec. A new interface driver for the NaviPac would be appreciated.

Geometrics R48 (fig. 30):

Two 48 channel acquisition units, acting as slaves for CNT-1, where all recording parameters are set up. The two units each have an 18 bit Sigma-Delta, 4 bit IFP A/D converter, and each unit sends a data- set to the CNT-1, via the 100Mbit net card. Each R48 unit gets its own trigger, from the timer-unit.

CNT-1 :

This is a 200 Mhz PC, with two net cards (100Mbit), one for each acquisition unit, and a Fast Wide SCSI interface to the two 3490E tape decks. The PC runs the programme CNT-1 where line name, tape no. and recording parameters can be set up.

Recording parameters:

Sample interval :	1 msec
Record length :	3072 msec (in Seg-D 8048 format, RL = mutipla of 512 msec)
Delay:	0 msec
Low cut filter:	10 Hz, slope 24 db/oct.
High cut filter:	300 Hz (anti-alias filter set automatically corresponding to sample interval)
Data format:	SEG-D 8048 revision 0

During data acquisition the program generates a log file which contains the following data:

First line is read from the serial input from NaviPac (not all numbers are readable in the log file, but all data are sent to the SEG-D header). The format of the string is: time HH:MM:SS (UTC), event no, X pos, Y pos (UTM Zone 21, WGS 84, Sleeve Gun Position), depth (in ms, ships draft of 5.5 m to be added), magnetic data (nT*0.1), bird data <CR> <LF>. Second line is file no., exact CNT-1 trigger time, size in Kbyte and Reel no.

During data acquisition several windows can be displayed on the PC:

The *shot gather window* is displayed, with varying display settings changed as appropriated on the fly.
The *noise window* shows all 96 ch noise values in μbar, as a “snapshot”, calculated between shots.
The *trigger window* shows the time interval between shots and the energy of a specified hydrophone (in our case ch 1).

When the NaviPac programme sends a trigger, it also sends a string to communication port 1 on the CNT-1. The string contains time, event, position , water depth, magnetic data, and bird data, and is transferred to the SEG-D external header on tape.

3490E Tape deck :

Data is recorded on two 3490E tape decks. The CNT-1 programme automatically changes drive when one tape is filled up. The capacity of one tape cartridge is 800 Mbyte, and with the recording parameters used, one tape cartridge is filled in about one hour.

The tape deck (Fujitsu M2488C), has a SDF option, *Seismic Data Function*, this is a Read After Write function, where data is send to an external SCSI port (8 bit). During a write operation the data is read simultaneously and a SEG-D data set is transferred to this port. This facility is used as QC, by means of the Ramesses program.

SDF interface :

This interface unit listens on the SDF interface on the 3490E tape deck currently in use. Data from the SDF port is transferred to the Ramesses Seismic processor.

Seismic Processor :

This processor, together with all components in the Ramesses QC system, produces an on-line brute stack, during the survey. The Ramesses PC sets up all the parameters.

Ramesses Host :

The host distributes processing, recording and shot set-up. During a line the stack and sail line is stored temporarily. The host also prints on the on-line stack printer during a survey.

Stack Printer :

The on-line stack printer, a 14 inch IBM b/w ink printer.

Ramesses PC :

The control unit of the Ramesses system, used to set up processing parameters. Some parameters can be changed and sent to the host during the acquisition of a line, but if the velocity tables has to be changed, the processing has to be re-started. During acquisition of a seismic line, every 4^{th} CMP or shot gather can be displayed. This display can also calculate a F-K spectrum, FFT spectrum or RMS signal/noise ratio. Also a velocity analysis can be performed in order to obtain correct stacking velocities for processing. This can be done both on-line and off-line.

When a sail-line is transferred, it is possible to display/print the RMS signal and noise on all 96 channel vs. SP number. This gives a good overview of the physical condition of the streamer.

Colour Printer :

Used to print single shot gather, CMP shot gather, sail-line and velocity spectrum. The printer is a Cannon A3 ink printer.

4.2 Source and air supply

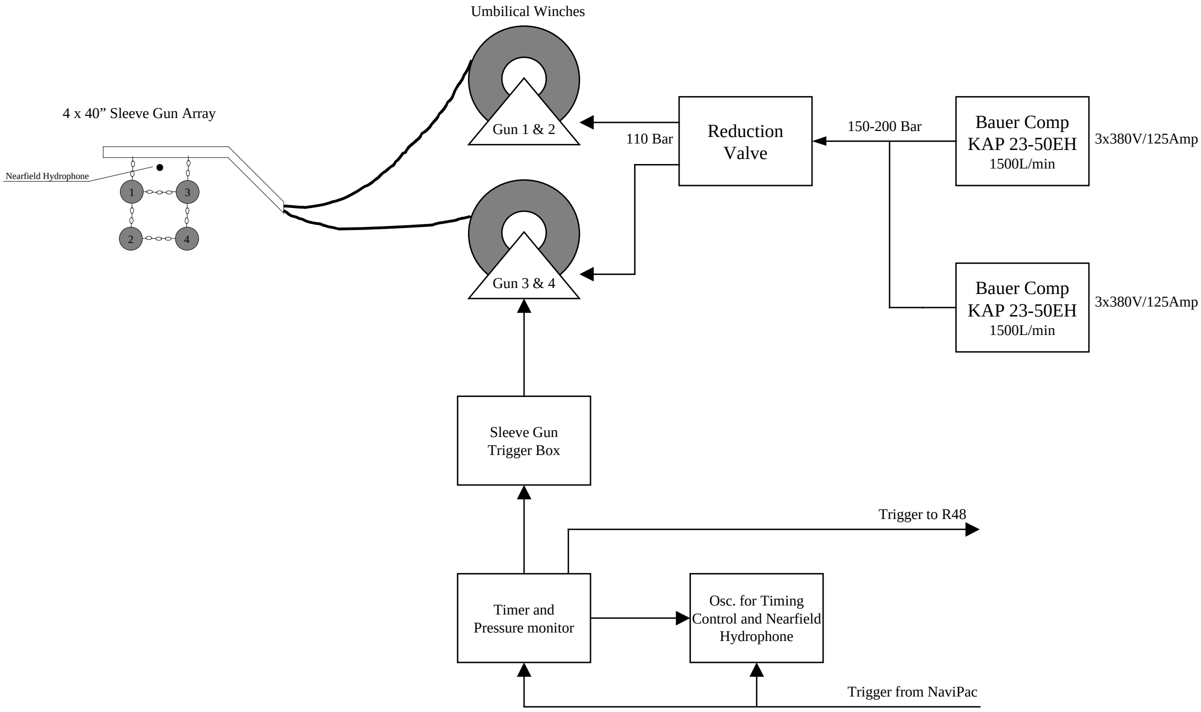

Fig. 4: Block diagram of sleeve gun source and air supply

Sleeve gun array (fig. 29):

Sleeve gun array consisting of four 40 cu. inch TI SG-I, placed in a cluster. They are chained together with a spacing of 50 cm, centre to centre.

A Ref-Tek57 hydrophone is placed at the top of the array in order to monitor the nearfield. The signal from the nearfield hydrophone is not recorded, only displayed on an oscilloscope, and a few shots are stored in a spreadsheet format.

The array is towed using a 12 mm steelwire on port side.

Umbilical winch :

Two umbilical winches supply two sleeve guns each. Every gun needs an air hose, a trigger and a timing coil conductor. The winch has a slipring and a swivel to supply air for each gun. This makes it possible to pressurise the guns before deployment.

Sleeve gun trigger box :

From the umbilical winch, the electrical connection goes to the Sleeve gun trigger box. The guns are triggered individually, and each trigger delay can be set with a small potentiometer. From a reading of the timing coil signal, the delay of all guns is adjusted to have a leading edge at 8mS after the trigger from the Timer Unit.

Timing and pressure monitor :

Unit to distribute triggers to the sleeve gun trigger box and to take out each timing coil signal, to be measured on the oscilloscope. With a switch each coil can be selected, and displayed.

The actual pressure of gun pair 1 & 2 and 3 & 4 is measured and displayed. The output pressure from the compressor is measured and displayed as well. The monitor has an alarm that will alert in case the pressure of the gun is below 80 bar or above 130 Bar. If the pressure of the compressor output is below 130 Bar or above 220 Bar the alarm with alert as well.

Oscilloscope for timing control :

Digital oscilloscope to measure the timing coil and nearfield hydrophone.

Reduction valves :

Two reduction valves are distributing air to the guns. The outlet is set to 110 bar. On each valve is placed a temperature controlled heating element, to prevent ice clogs. The inlet can vary from 150 to 200 bar.

There is also one valve to reduce pressure to 8 Bar in this box. This working pressure is used to calibrate the depth transducer on the birds, cleaning air and special tools from the sleeve gun tool kit.

Air compressors:

Two electrical driven Bauer Compressor KAP23 50EH rented from the Danish Navy. The air capacity is 1500 litre/min for each compressor. The compressor automatically starts when pressure is below 150 bar, and stops when pressure reaches 200 bar. A 400-litre air bottle bank is placed inside each compressor unit. This bank is used as a buffer in situations where we have to turn off all compressors i.e. for maintenance work. With this bank we are able to shoot for about 30 min. without compressors running. During the complete survey the two compressors worked without major problems for approx. 280 hours each.

4.3 Navigation and Magnetometer

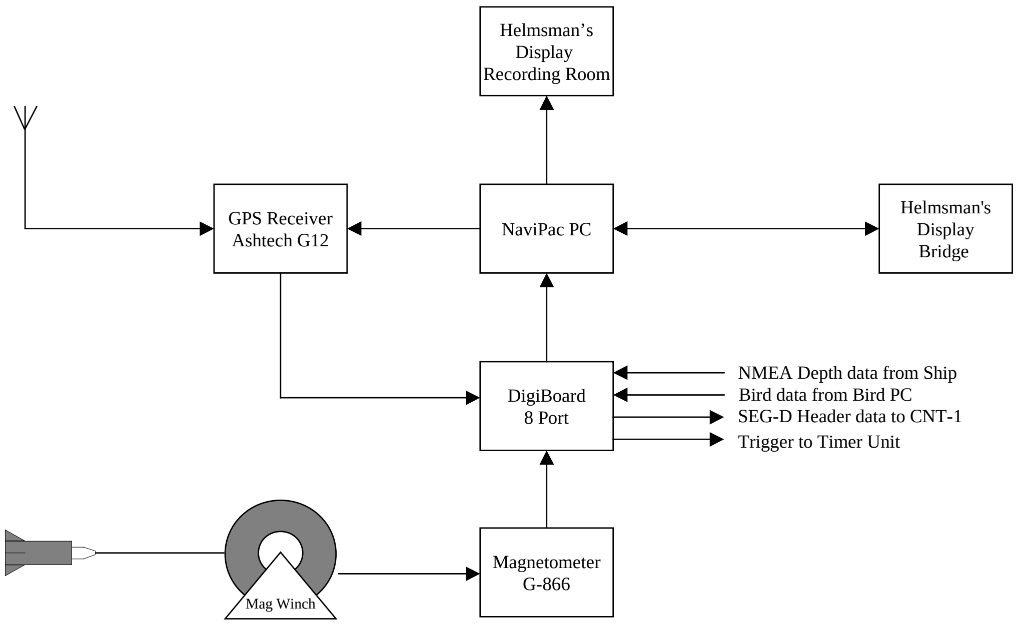

Fig. 5: Block diagram of navigation and magnetometer

NaviPac PC (fig. 31):

NaviPac is a navigation and datalogging programme running on a PC with NT4.0 (Service pack 5). In order to provide enough input/output ports the PC is extended with a “digiboard” with 8 extra serial ports.

Input to the navigation system is send from the Ashtec G12 GPS-receiver. The other input data are: Magnetometer data from the G-866, depth from the ship echosounder (NMEA

183) and data from the birds. Output data are : trigger to the Timer Unit, data to the CNT-1 controller and data to a custom log file. Data sent to the CNT-1 controller were recorded on the trace header. Referencepoint for the GPS data was the position of the gun cluster.

The Helmsman's display in the recording room controls the survey, where the operator can choose a preplanned line as the curent active line and start and stop acquisition. Runline data is distributed to the remote Helmsman's display on the bridge via coaxial TCP/IP network.

This version of NaviPac is fairly new and much improved compared to older versions of the software. However two minor improvements are suggested here: the event number should always be sey to zero at the start of a new line and it should be possible to design the custom log file in UKOOA format (i.e. linename, eventnumber, X, Y, waterdepth.

Furthermore we observed an error when Navipac was writing to the custom log file in the event of an alarm for missing input data e.g. from the magnetometer. I this case the postion written to the log file is not updated before the alarm was cancelled. However, the correct position was send to the G-866.

WGS84 datum and UTM zone 21 were used as cartographic reference system.

GPS Receiver G12:

The G12 is a 12 channel GPS receiver. As there are no differential reference stations available in the survey area, the G12 runs in the non-differential mode. It delivers positions in NMEA 183 format to NaviPac (GGA string).

The NaviPac PC is running the evaluate programme, used to set up and monitor the G12 receiver. The HDOP mask is set to 8, and the evaluation mask is set to 5.

At the start of the survey a GG24 GPS/GLONASS receiver was used to rake advantage of the improved accuracy of the combined receiver. However we experienced some periods where the receiver or the software in the receiver not were able to give any position. The cause of this malfunctioning was not found and it was decided to use the G12 receiver for the rest of the survey.

Helmsman's Display on the bridge:

A notepad PC is running the Helmsman's display in slave mode. It receives runline data and cross track information from the NaviPac PC. This display makes it possible for the navigator to see where the ship is with respect to the preplanned line.

Echosounder:

The ships 18-kHz-echosounder (Simrad Ekko Sounder EK400) was used during the survey. The echosounder transmits depth to NaviPac in NMEA183 format every 7-8 sec.

Magnetometer G-866 (fig. 34):

EG&G Geometrics proton magnetometer with marine sensor and approx. 300 m long tow-cable. Self-triggered every 10 sec and data sent to NaviPac as RS232 serial data. Resolution on the G-866 is 0.1 gamma, but due to low signal strength the 1-2 less significant digits are not reliable.

We encountered various problems with the magnetometer at the start of the survey. Not before the acquisition of line GEUS00-18 the magnetometer was able to record some usefull data however a lot of errors did occur during the rest of the survey (see chapter 10 for data example). At several occasions the magnetometer cable got tangled with the streamer. This problem was solved when the towing arrangement was changed to the starboard crane (see fig. 35)

5. Receiver and source set-up and performance

5.1 Streamer set-up and performance - details

The streamer (Hydrosciences Inc.) is composed of 6 active sections each with 16 channels in total 96 hydrophone groups (fig. 6). Group length 3.125 m with 7 equally spaced hydrophones. Group distance 6.25 m. Total length of active streamer 593.75 m. In the front end: 50 m stretch section. Towing cable length on this cruise: 40 m.

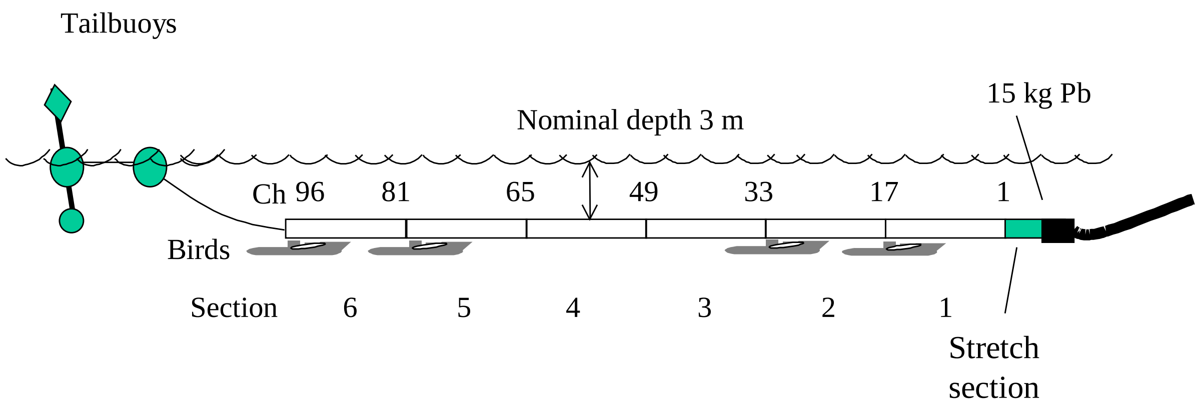

Fig. 6: Streamer set-up during the NuussuaqSeis 2000 survey

The streamer was dragged in the centre line of the ship with the nearest hydrophone group centre (measured along the cable) at 90 m behind the reference line as shown in fig. 7. (Distances in direction of the ship's long axis are measured from the front end of the trawl ramp as indicated on the figs. 7, 9 and 11)

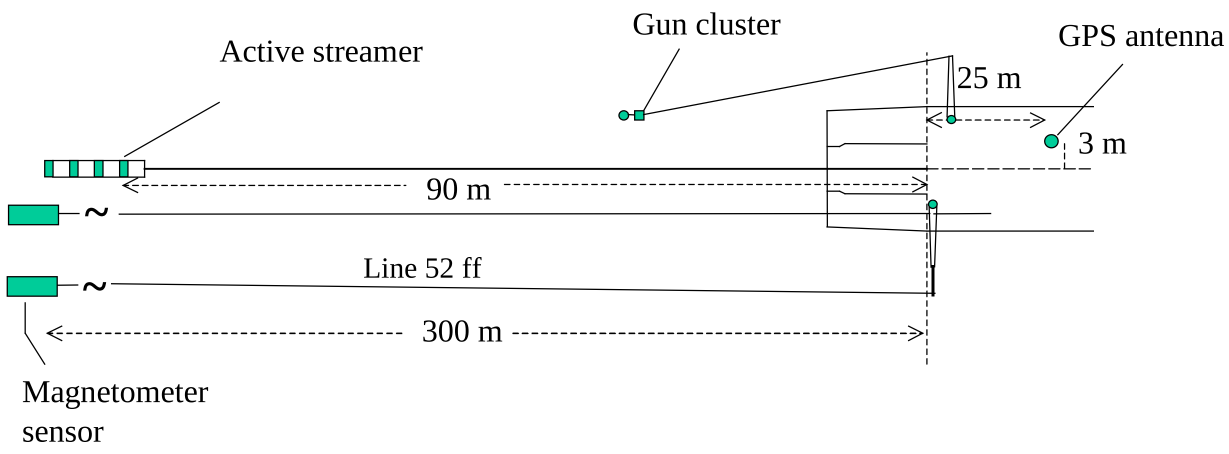

Fig. 7: General arrangement of the seismic equipment

On lines GEUS00- 01 through – 03 a Norwegian buoy was dragged as a tail buoy in a ca. 25 m long rope. Four active birds (DigiCourse) were located as follows: one in the front end of the stretch section and one in rear ends of active sections 1, 5 and 6. With this configuration the front end and the rear end of the streamer was generally dragged too close to the surface. Therefore, before start of line GEUS00-04 some modifications were made in order to stabilise the front and rear end at the target depth 3 m. The front-end bird was replaced by 15 kg lead and the four birds were placed at the rear ends of section 1, 2, 4 and 5. Furthermore, the normal tail buoy was mounted ca. 10 m behind the Norwegian buoy (fig. 28). The normal tail buoy is built of a Norwegian buoy mounted with a vertical steel pipe with an anchor in the lower end and a radar reflector in the upper, visible end. With the resulting increased depth of the drag-point in the front end and the increased drag in the tail end a satisfactory balance was obtained. Streamer depth was maintained close around 3 m with exceptions occurring in (rare) periods with wind (up to ~8 m/s) and/or relatively strong currents.

In general all 96 channels were functioning. Few cases with periods of malfunction were observed for channel 53.

5.2 Sleeve gun set-up and performance - details

A cluster of four 40-cubic inch sleeve guns (Texas Instruments Type I sleeve guns) was prepared for the cruise. The cluster was build with the guns placed in the corners of a regular square with sides 0.5 m long as shown in fig. 8. The guns are each carried by two 0.5 m long chains under a steel frame. Horizontally the two pairs of guns are connected by two 0.5 m long chains and connected with the front part of the frame by two helical springs. The depth of the gun-cluster was controlled by a ca. 4 m long chain/wire connected with three Norwegian buoys (fig. 29). For monitoring purposes a near-field hydrophone was mounted on the frame above the guns.

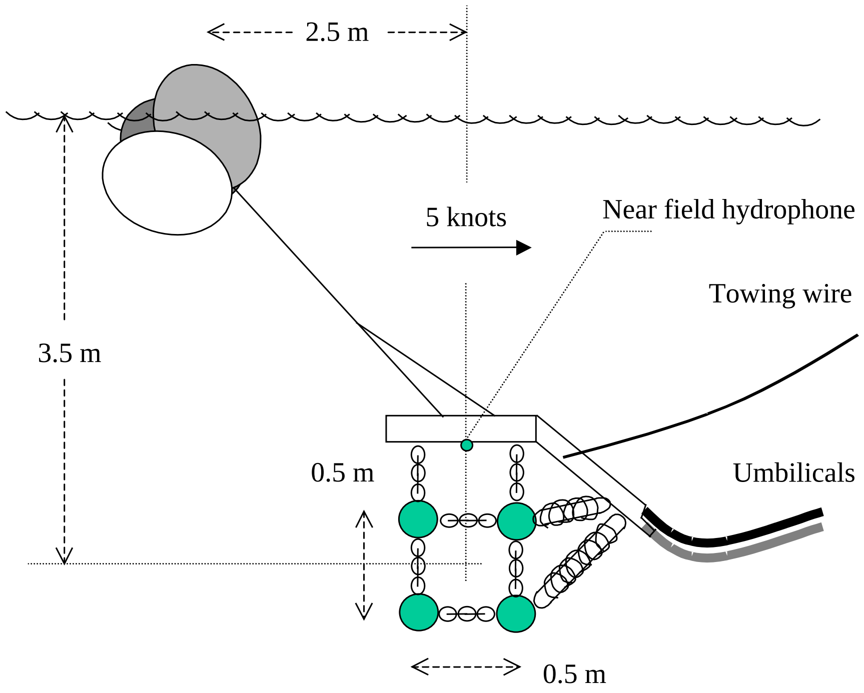

Fig. 8: Sleeve gun cluster

The gun-cluster was dragged in a wire from the crane in the port side of the ship (cf. fig.7). The horizontal co-ordinates of the Norwegian buoys carrying the gun-cluster were calculated from measurements of distances from the port and starboard side of the stern (fig. 9). Distances were measured by a laser instrument with an expected error < +/- 1 m. In addition to that, the distance between the near-field hydrophone and a hydrophone in the hull close above the propeller was calculated from measurements of the time difference between first arrivals at the two hydrophones (cf. fig. 10 and 12).

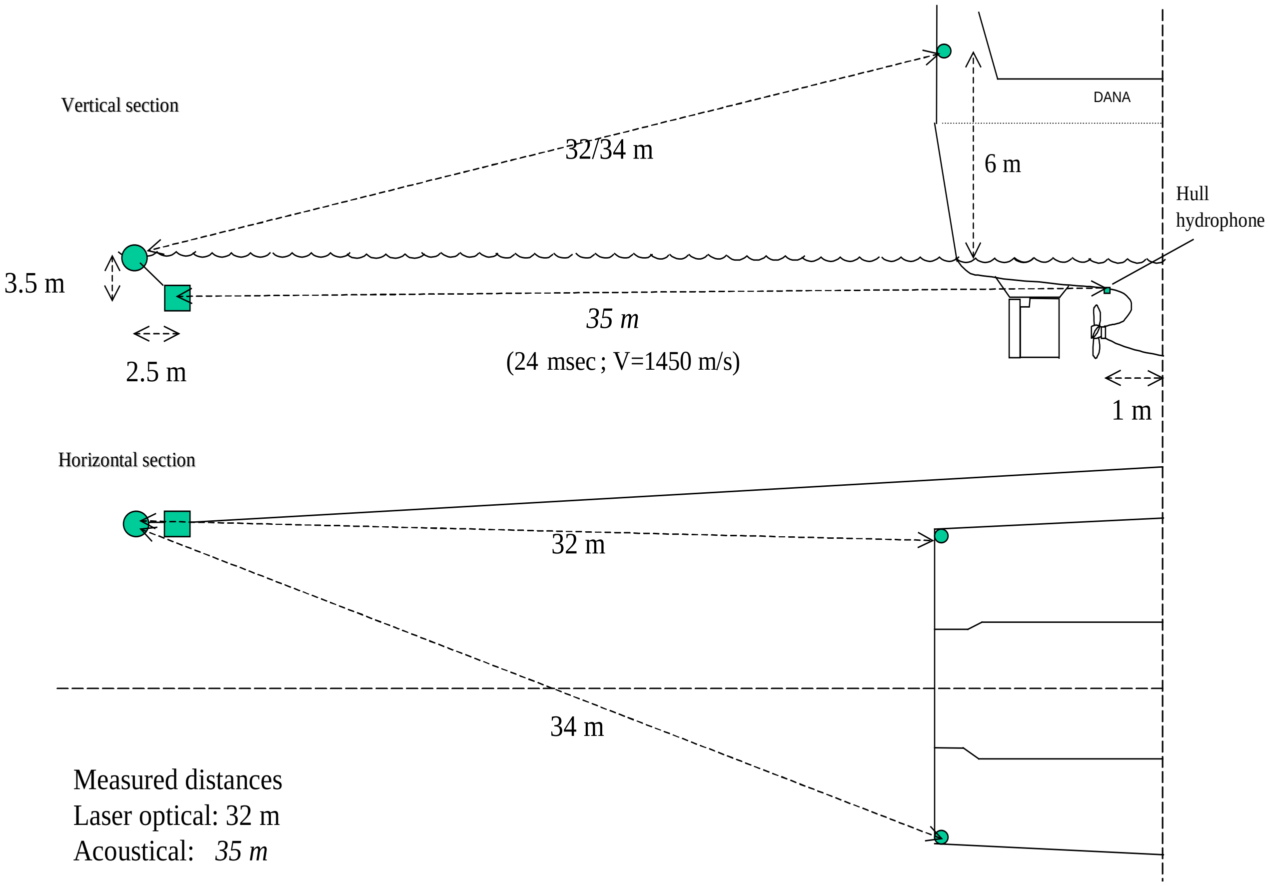

Fig. 9: Measurements of distances to the sleeve gun cluster

The calculated horizontal co-ordinates for the centre of the gun-cluster was 37 m behind the reference in the ship's axis and 6 m offset from the axis to the port side (fig. 11). The depth of the centre gun-cluster (3.5 m) was measured directly with a string attached to the frame. The length of the string – to the sea surface – was measured from a rubber boat with a speed equal to the ships speed of 5 knots. At the same time the hrizontal lag (2.5 m) between theguns and the Norwegian buoys was measured. The lag was needed in order to correct the laser-distances to the centre of the gun-cluster.

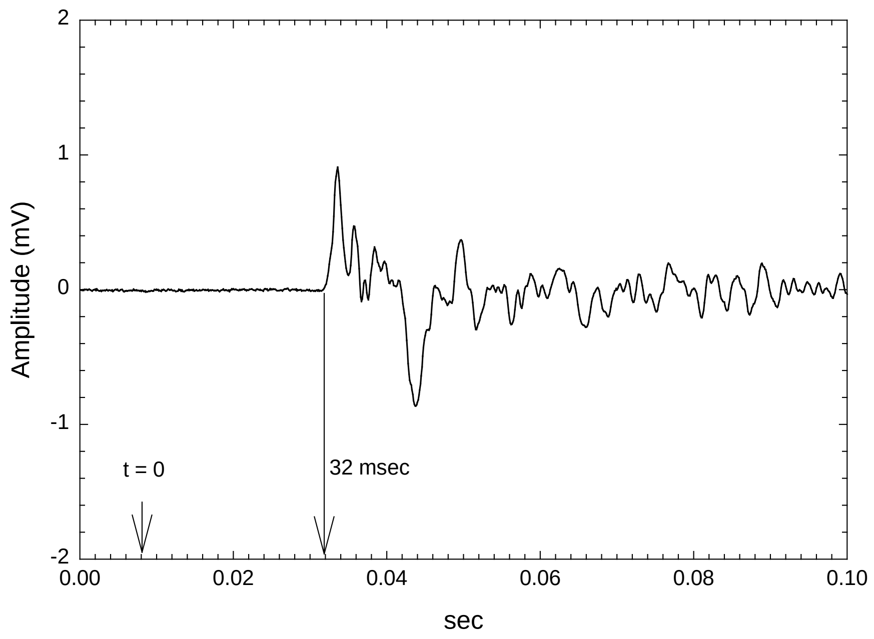

Fig. 10: Hull hydophone signal

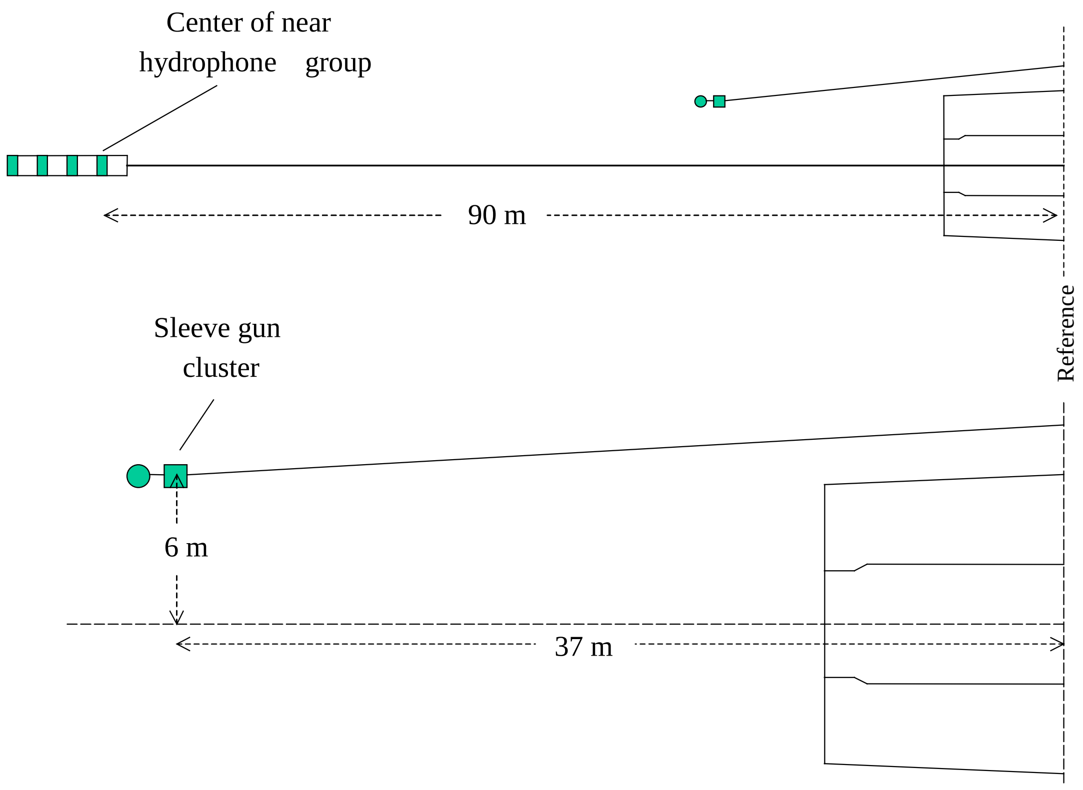

Fig. 11: Gun and streamer layout

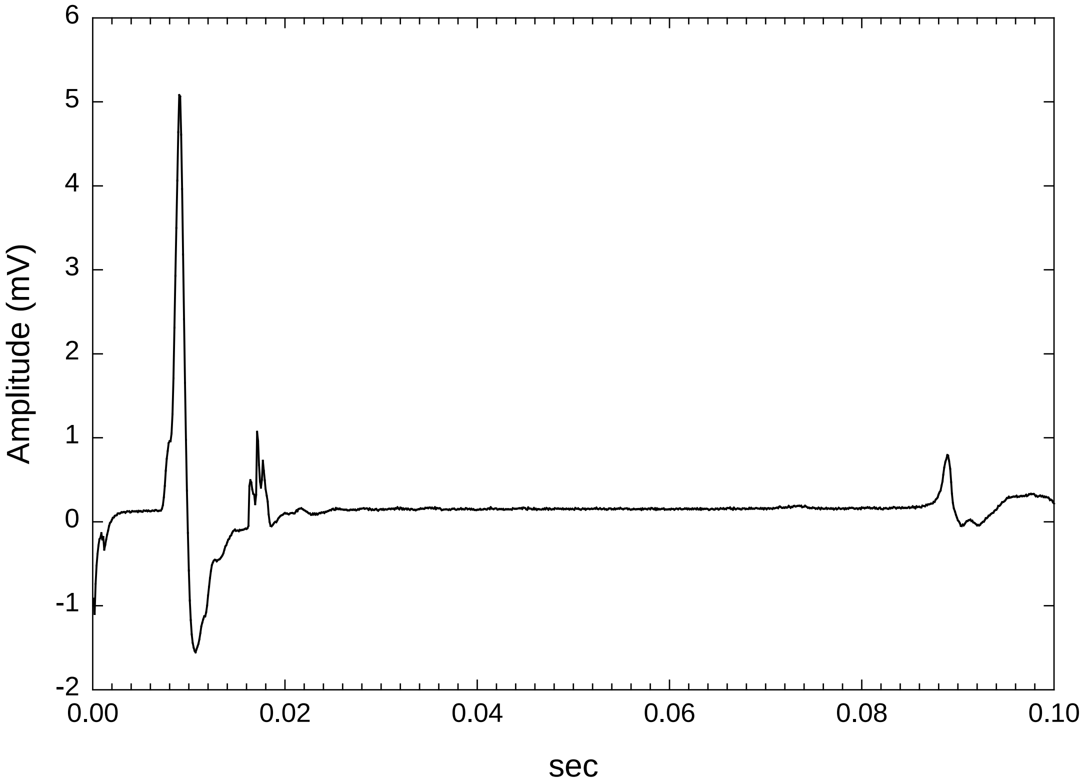

Fig.12: Near field hydrophone 4 x 40 cubic inch cluster

The gun-cluster pulse was permanently monitored (lines GEUS00-01 through 56) by the signal received from the near-field hydrophone (fig. 12). Generally the signature of the gun-cluster behaved fairly stably with peak amplitudes of the primary pulse of 5-6 volts and with an amplitudes of the first bubble pulse close to 0.4 -0.6 volts. Except for a few gun failures, mostly due to damages on supply hoses, all four guns have been in operation with the pressure maintained at 110 bar. In cases where a gun had to be closed this was partly compensated for by increasing the pressure to 120 bar.

During acquisition of line GEUS00-57 the umbilicals were damaged by collision with an ice floe. Only one of the umbilicals could be repaired on the spot. Two guns and the near field hydrophone were removed from the cluster, and all lines from GEUS00-57 and onwards were acquired by two guns at a pressure of 120 bar.

5.3 Signal/noise conditions

Thanks to the generally very calm weather, the signal-noise ratio has been generally satisfactory. A representative example of a shot gather, monitored by the RAMESSES QC-system, is shown in fig. 13.

The mean frequency band as measured by RAMESSES on all 96 channels for one randomly chosen shot on line GEUS00-58 is shown in fig 14. It should be noted that the high frequency cut off is controlled by an antialias filter corresponding to the re-sampling rate of 2 msec applied by the RAMESSES-system. An “unlimited” frequency spectrum is observed by the hull-hydrophone as displayed in fig. 15. The spectrum is almost flat up till about 300 Hz.

The ship noise was minimised by keeping the propeller pitch high (ca. 2) and the rotational speed low (80-100 rpm). The frequency spectrum of the ship noise as monitored by the hull-hydrophone is displayed in fig. 16. The noise peak at low frequency (ca. 8 Hz) is generated by the four propeller blades.

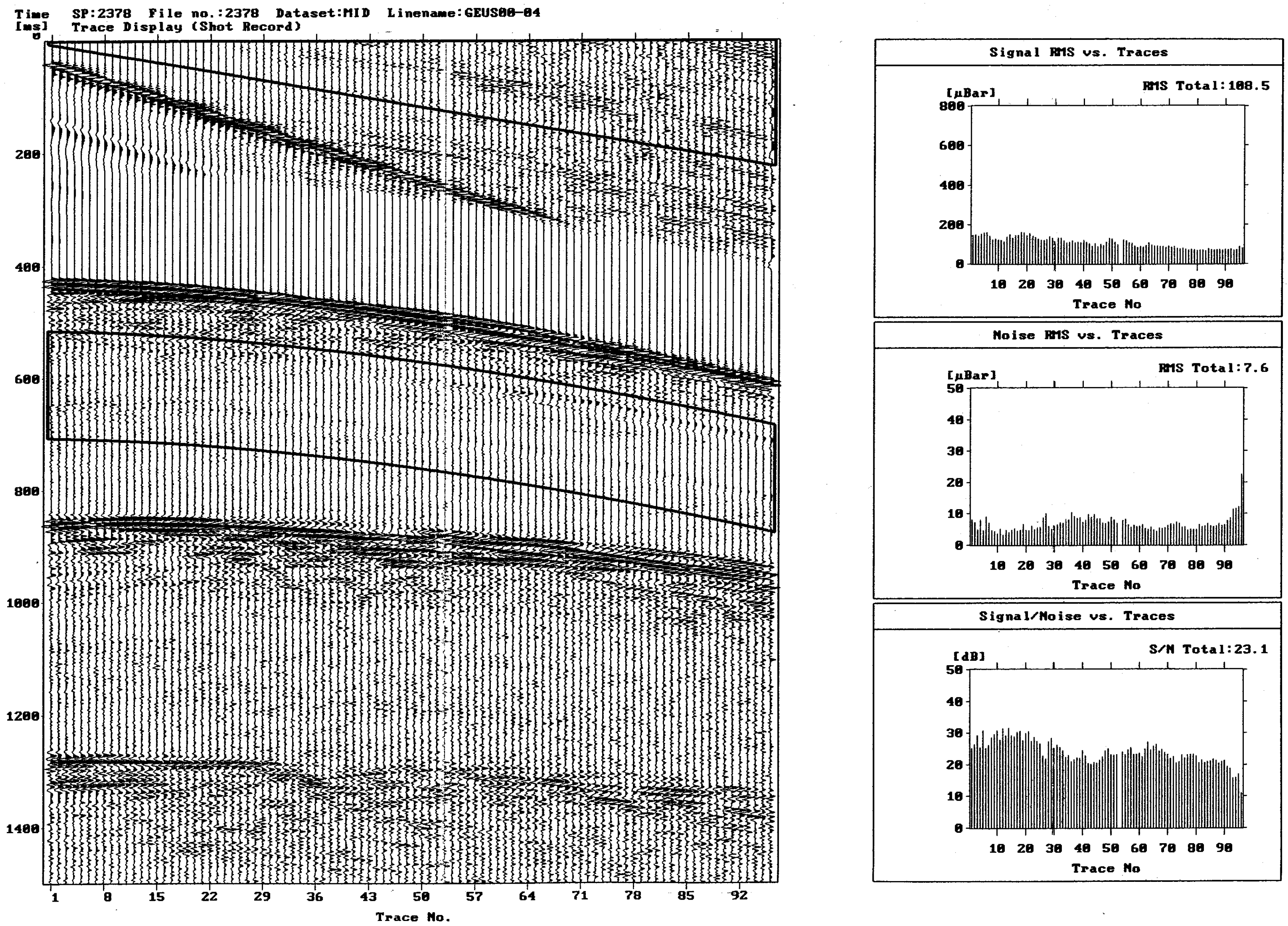

Fig. 13: Shot gather monitored by the RAMMESSES QC-system

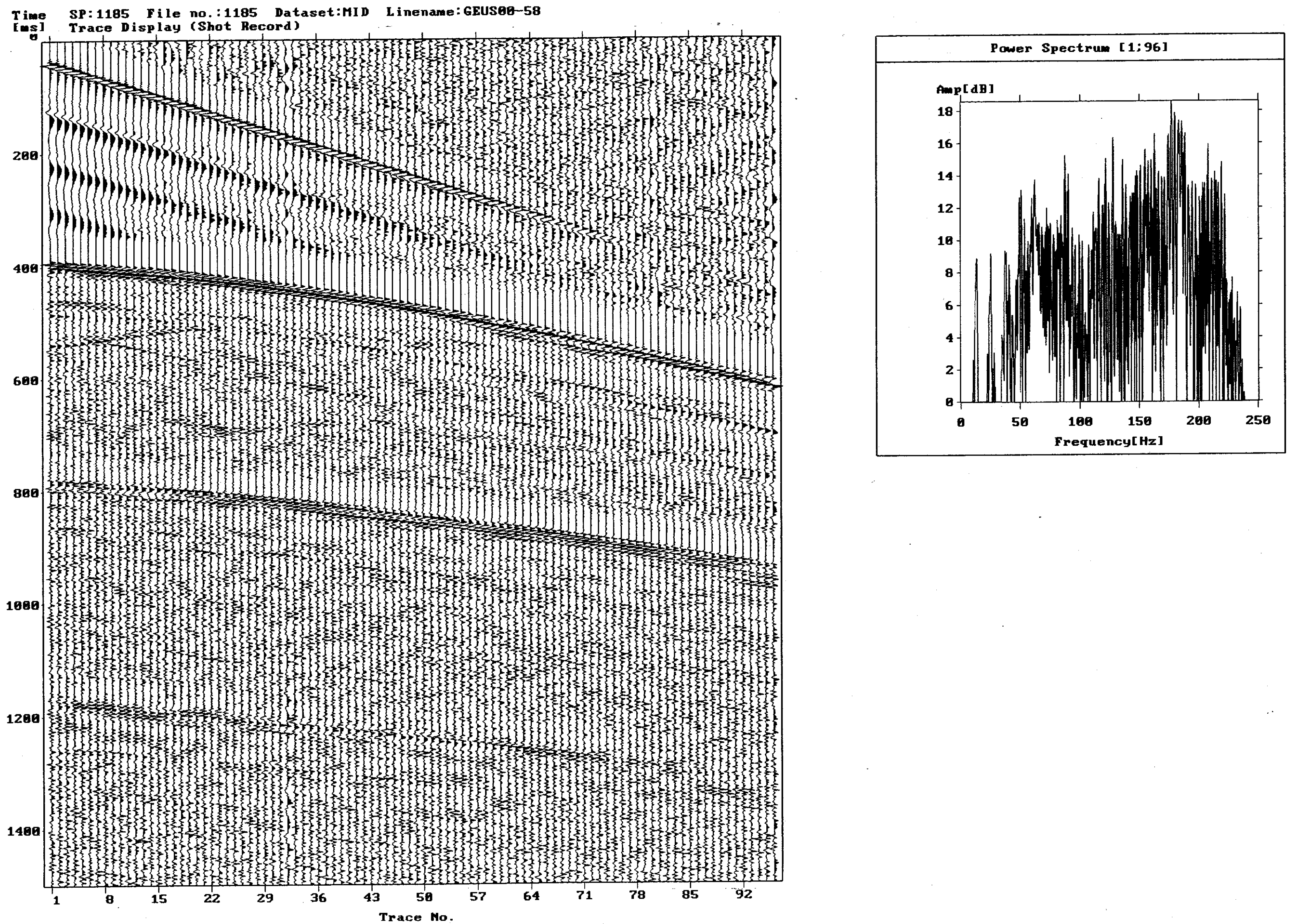

Fig. 14: Mean frequency band of one randomly chosen shot on line GEUS00-58

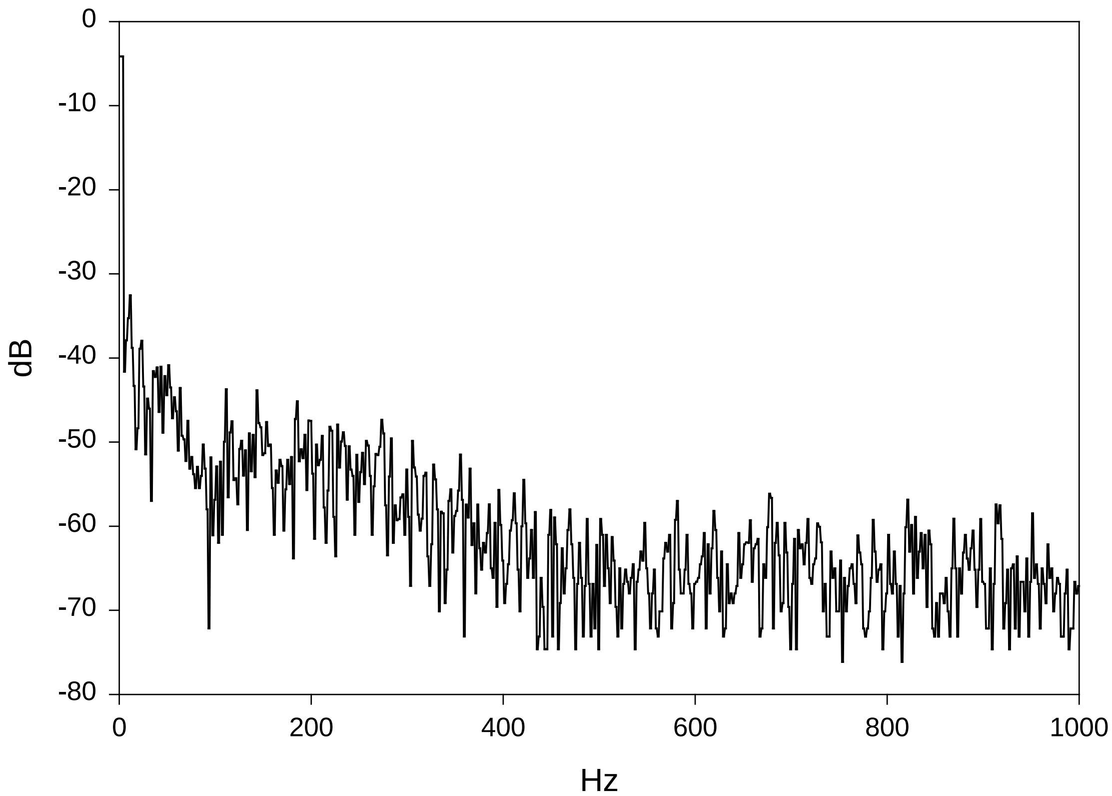

Fig. 15: Hull hydrophone: shot and ship noise spectrum – line GEUS00-41

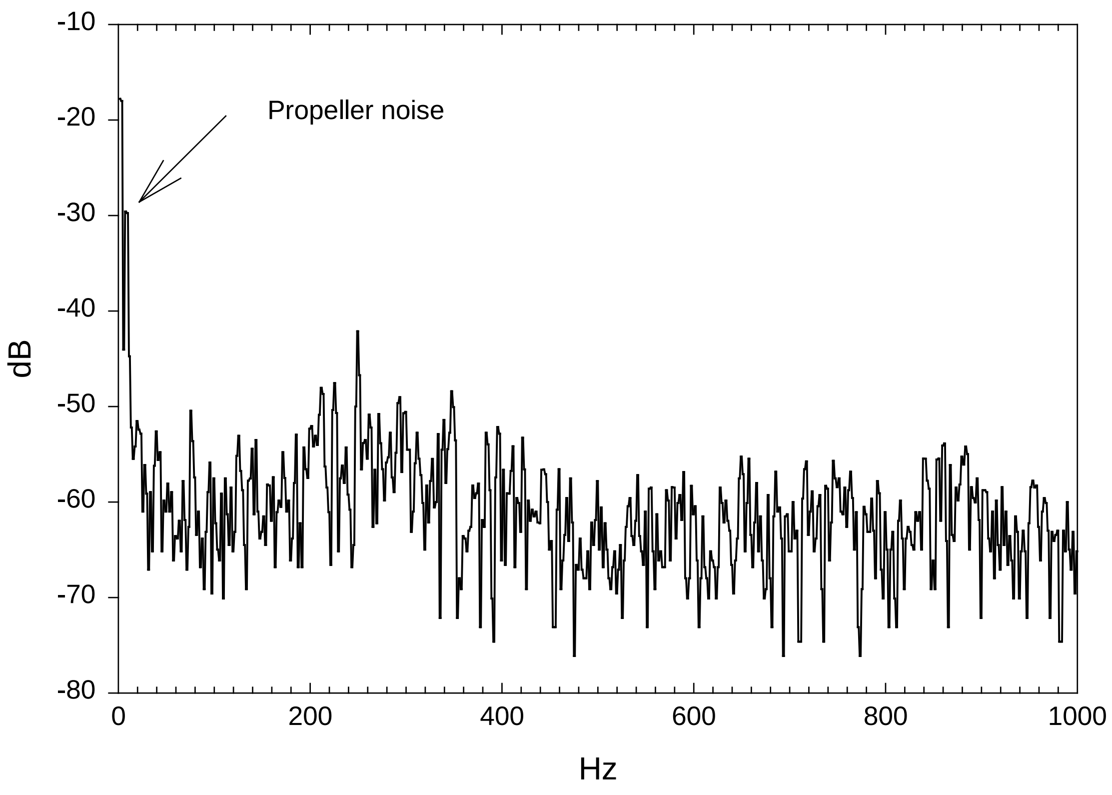

Fig. 16: Hull hydrophone: ship noise

6. On board processing with ProMax

In the survey planning phase of the NUUSEIS2000 survey it was decided to include the PROMAX processing facilities from GEUS as part of the onboard equipment for the survey. The PROMAX processing equipment (fig. 32) used during the acquisition included:

- SUN workstation, model: ultra 60
- 3480/3490 tape drive
- Exabyte tape drive
- Lexmark A3/A4 printer

Immediately after arrival at the vessel on 14 July the processing equipment was installed. Underway to the survey area, the set-up of the processing facilities was tested in order to make sure that everything was working properly. The first line from the survey area was acquired on 18 July and the test processing of a segment from this line was initiated. Based on the results from the test trials a pre-stack processing sequence was established. It was decided to concentrate the processing efforts onboard the vessel to the pre-stack processing in order to get started as soon as possible with the bulk processing. During the acquisition period approximately 800 km was processed up to raw stack.

The experience from the survey showed that it was very useful to include the PROMAX seismic processing system as part of the field equipment. The processing system worked without any problems during all the acquisition period and valuable input for adjusting the survey program was obtained.

Room for improvement:

Because of budgetary reasons no large plotter (A0) and plotting software were brought on board *Dana*. The A3-printer could – because of lack of suitable software – only print screen dumps of marginal quality. If the PROMAX processing facility should be used on board a ship in the future it is recommended that a large plotter and the necessary software is included.

7. Preliminary interpretation

A preliminary interpretation of the data was made as it became available throughout the survey (fig. 33). The primary purposes of the interpretation were to provide information for any necessary alteration of survey plans, to judge quality of data, to provide input to processing on ProMax and, of course, to obtain a first set of new ideas for subsequent more detailed interpretation.

7.1 Vaigat

As was shown in Chalmers et al. (1999), Vaigat can be divided into three areas. West of about 54°W, basalt is exposed at seabed. Between 54°W and 53°W are three large fault blocks where thick, dipping Cretaceous sediments can be seen and the centre of the bathymetric channel is partly filled by flat-lying Quaternary sediment (fig. 17). East of 53°W are complex areas with both large moraines (fig. 18) and sills (fig. 19) at and under the seabed. Reflections are not generally visible on the Ramesses processing from below either of these shallow features, but improvement may be achieved with ProMax processing. Easternmost Vaigat is structured in a complex way, and the interpretation shown in Chalmers et al. (1999) needs to be altered. Part of the later part of the survey was planned to optimise interpretation here.

7.2 Uummannaq Fjord and the strait between Ubekendt Ejland and Upernivik Ø

Good reflections were obtained over most of this area. There are few areas of moraine or large sills. The area is structured, and good images of many of the faults were obtained (fig. 20). Along the eastern margin of the area, several crossings onto basement were achieved (fig. 21). Dense concentrations of icebergs in south-eastern Uummannaq Fjord prevented crossings over the eastern margin of the basin there. For the same reason, it was not possible to record north of 71°27’N, so no new information is available about that area.

7.3 The basalt areas west of Ubekendt Ejland and Nuussuaq

We appear to have obtained excellent images of reflections from below the top of the basalts in may areas. Our technicians finally made the magnetometer work at about the time we started to record data from this area, so there is also adequate to good magnetic data to use.

There has been some on-board discussion of the significance of the sub-top basalt reflections. Some of them certainly come from lithology variations within the basalt sequences (fig. 22), and a continuation and possibly more detailed extension of Nina Skaarup's basalt stratigraphy work should be possible. Preliminary correlation of the magnetic with the seismic data suggests that it may be possible to develop a magnetostratigraphy of these sequences. Other reflections seem to come from half-grabens (fig. 23). It is possible that they are syn-magmatic sequences, as has been discussed by e.g., Geoffroy et al. (1998), but it is also possible that we may be seeing through thin basalt to westward-dipping Cretaceous or lower Paleocene sediments west of Nuussuaq. Quantitative interpretation of the magnetic data may resolve this question.

7.4 References:

Chalmers, J. A., Pulvertaft, T. C. R., Marcussen. C. & Pedersen, A. K. 1999. New insight into the structure of the Nuussuaq Basin, central West Greenland. Marine and Petroleum Geology, **16**, 197-224.

Geoffroy, L., Gelard, J.P., Lepvier, C. & Olivier, P. 1998: The coastal flexure of Disko (West Greenland), onshore expressionof the 'obligue reflectors'. Journal of the Geological Society, London, **155**, 463-473.

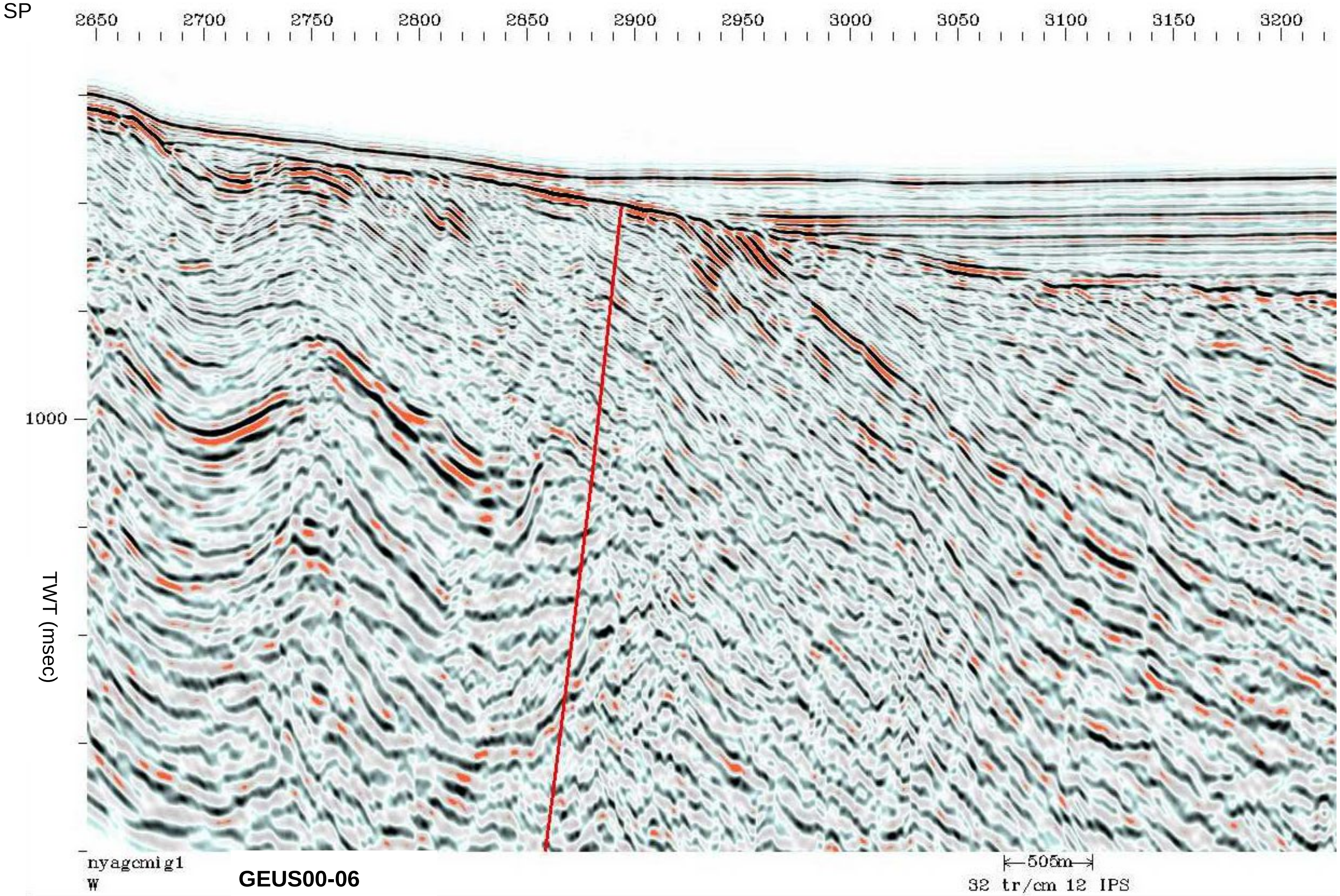

Fig. 17: Part of line GEUS00-06 (W → E, left to right) in western Vaigat showing easterly-dipping Cretaceous sediments divided by a westerly-throwing fault. Flat-lying Quaternary sediments that partially fill the channel in central Vaigat can be seen east of about SP 2850.

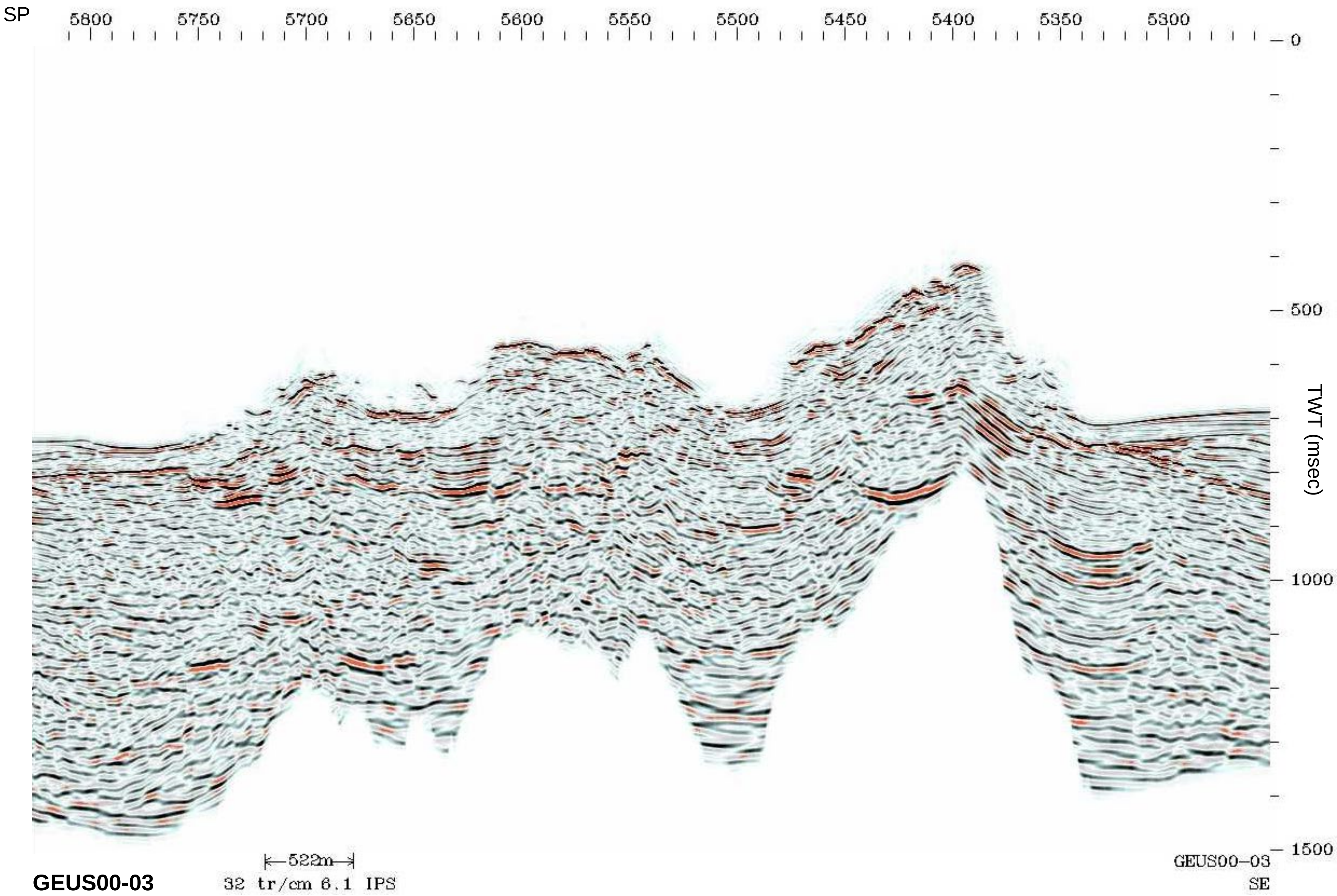

Fig. 18: Part of line GEUS00-03 (W → E, left to right) in eastern Vaigat showing large moraines, Reflections from Cretaceous sediments can be seen from below the moraines.

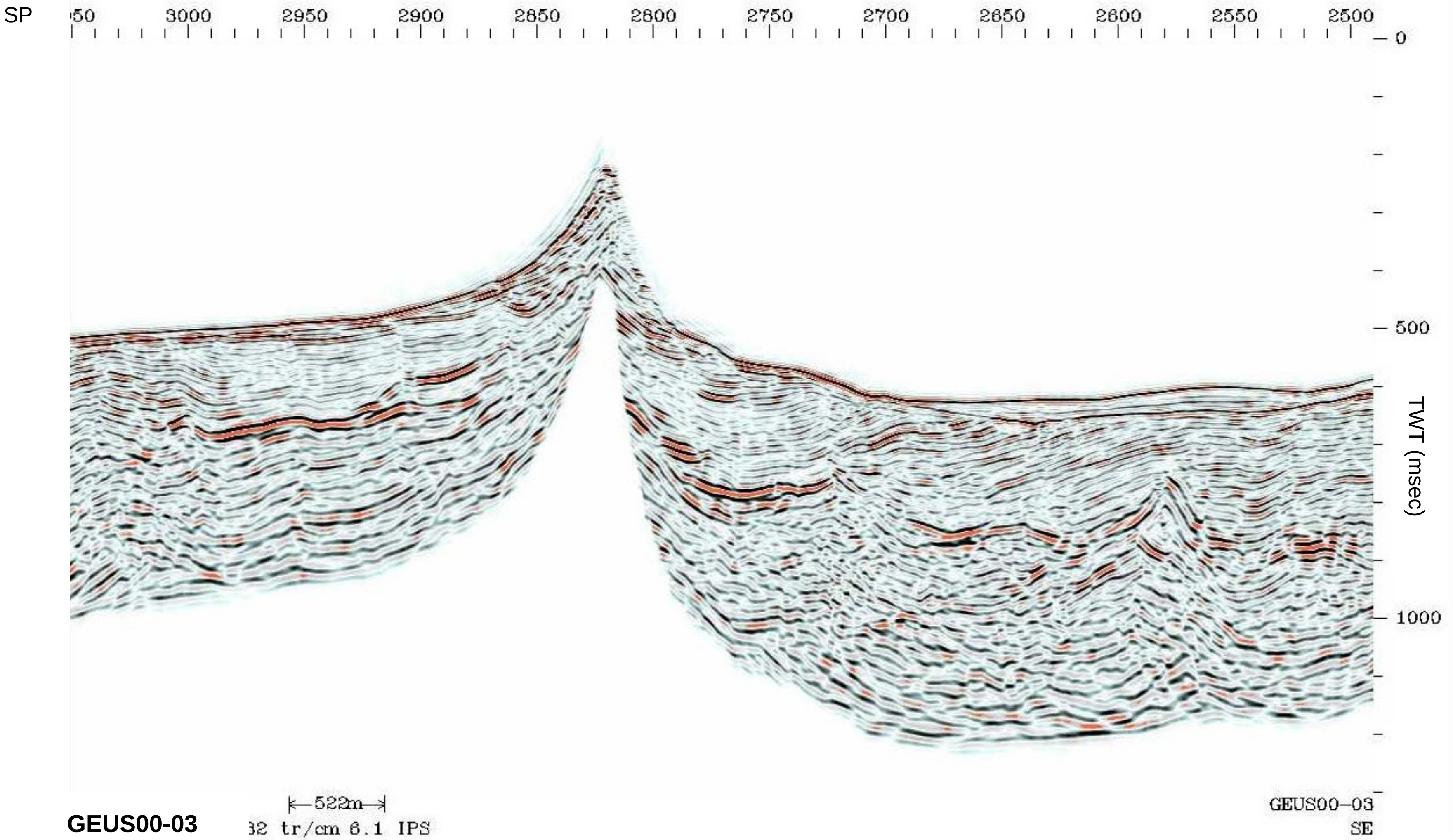

Fig. 19: Part of line GEUS00-03 (W → E, left to right) in eastern Vaigat showing a ridge at the seabed formed by a sill (probably one of the Tartunaq swarm) that is more resistant to erosion than the surrounding sediments. Reflections from other sills can be seen from within the sediments east of SP 2780.

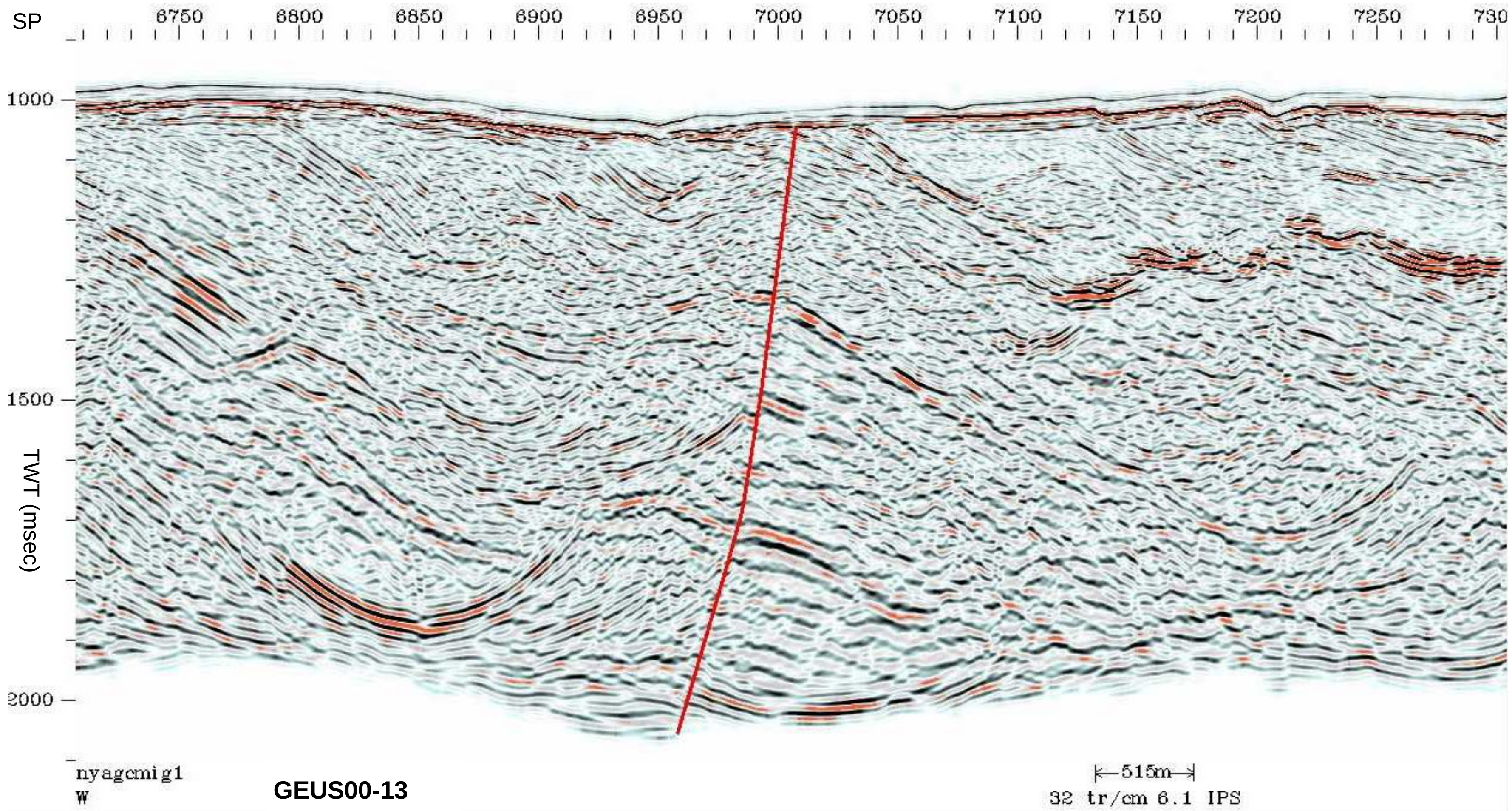

Fig. 20: Part of line GEUS00-13 (W → E, left to right) in Uummannaq Fjord showing easterly-dipping Cretaceous sediments divided by a westerly-throwing fault.

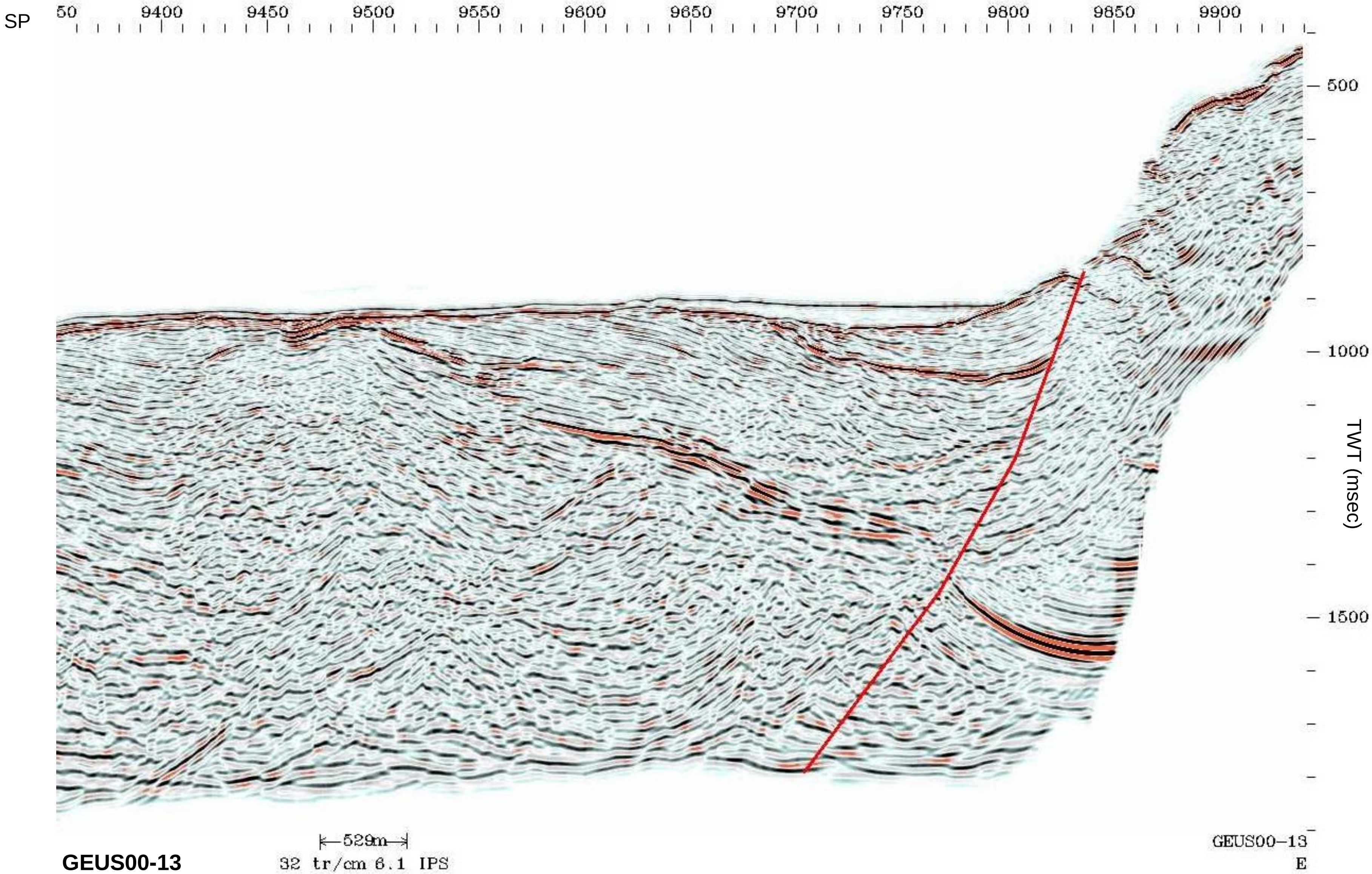

Fig. 21: Part of line GEUS00-13 (W → E, left to right) in Uummannaq Fjord. A fault block containing Cretaceous sediment can be seen west of SP 9840 and basement is exposed at the seabed east of this SP.

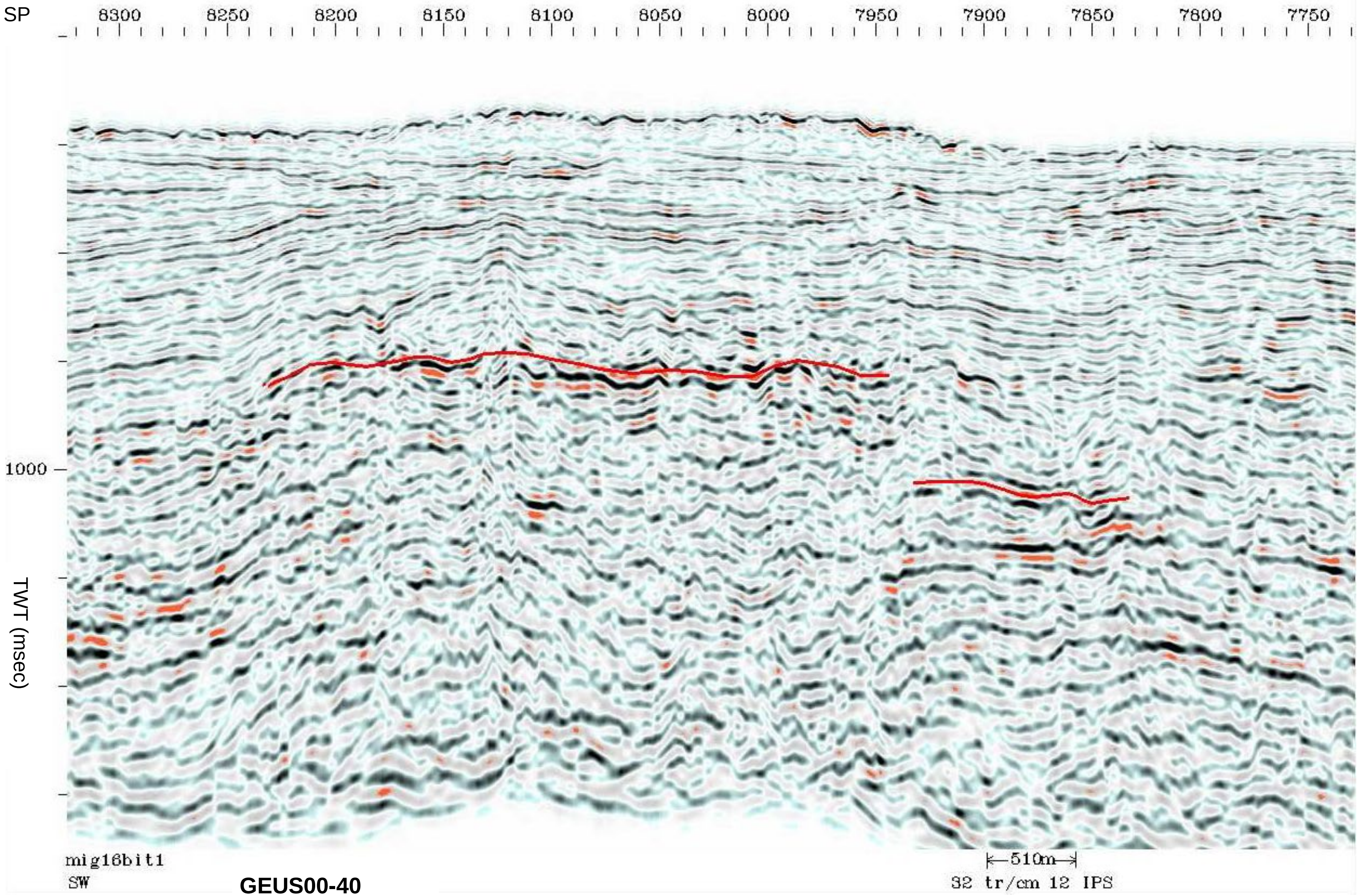

Fig. 22: Part of line GEUS00-40 (SW → NE, left to right) west of Nuussuaq. Post-basaltic Cenozoic sediments lie on top of the basalts (red horizon) within which at least three flat-lying sequences can be seen.

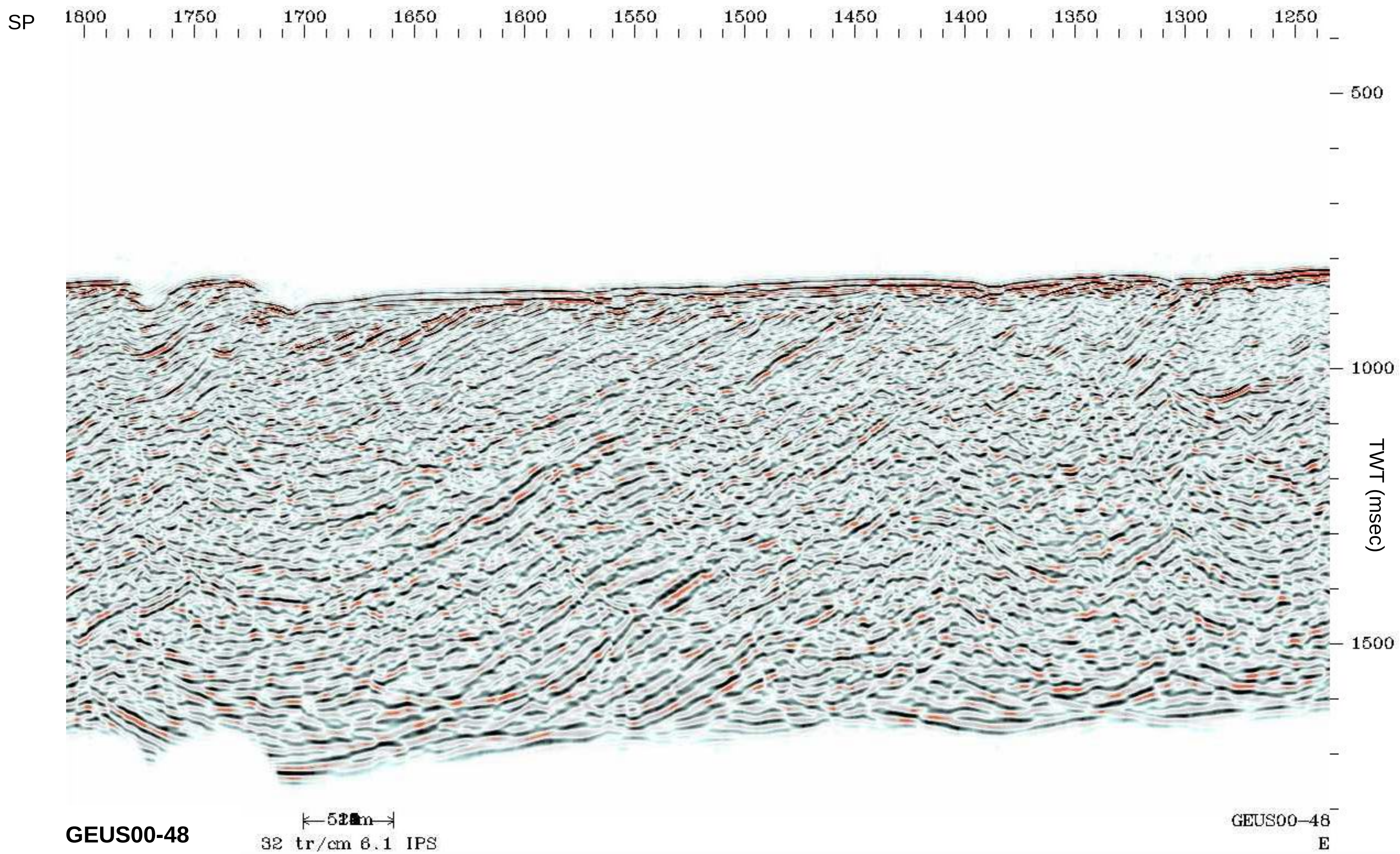

Fig. 23: Part of line GEUS00-48 (W → E, left to right) west of Nuussuaq. Dipping reflections can be seen below the top basalt horizon. These may be reflections from within the basalt pile, possibly from sedimentary horizons separating basalt or hyaloclastite flows, or they could be from Cretaceous sediments under a very thin basalt section.

8. Future use of *H/S Dana*

Once again *H/S Dana* proved to be very well suited for this kind of survey. The Aarhus equipment has now been used several times on *Dana*, which means that mobilisation and demobilisation can be done without major problems and very smoothly. The crew on board *Dana* has gained a lot of experience in acquisition of seismic data, therefore the cooperation between the seismic and the ships crew is very efficient which has been essential for the success of this cruise.

Room for improvements:

- The fax and e-mail facilities on board *H/S Dana* are completely out of date. New modern facilities should be installed before any future cruise to Greenland.

- If a redesign of the backdeck is planned it is suggested that some of the permanent winches etc. are removed in order to give more and safer workspace for seismic and drilling operations.

- The installation of a gravimeter platform on one of the lower decks in the centre of the ship would be highly appreciated

9. Photos from the cruise

Fig. 24: *H/S Dana* in Ummannaaq Fjord

Fig. 25: The bridge of *H/S Dana*

Fig. 26: Containerised streamer reel (Aarhus University) on the back deck of H/S Dana

Fig. 27: Deployment of streamer – installation of bird (depth controlling device)

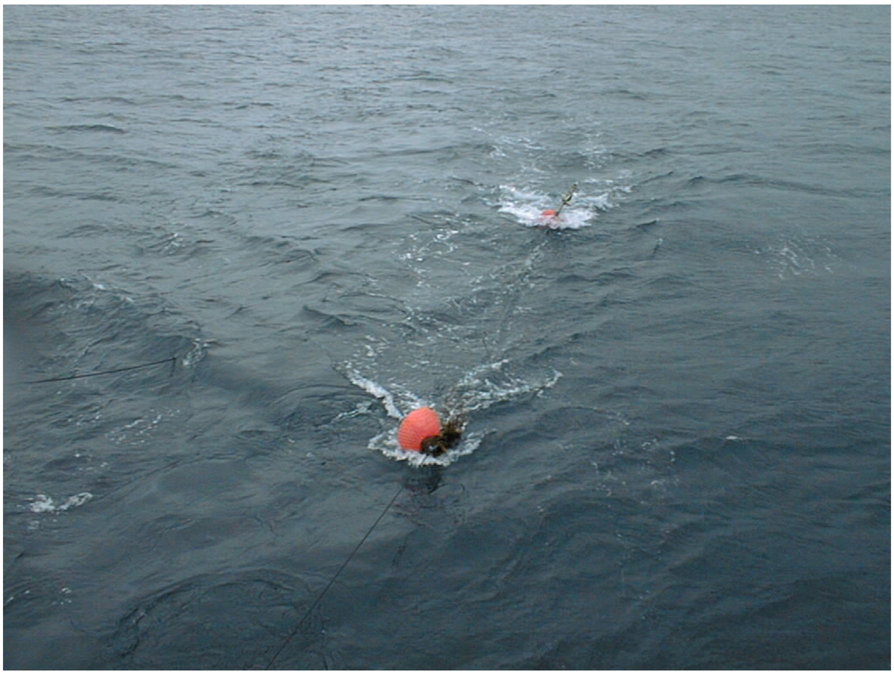

Fig. 28: Tailboy at the far end of the streamer

Fig. 29: Deployment of airgun array (4 x 40 cu. inch sleeve guns)

Fig. 30: Recording room on board H/S Dana

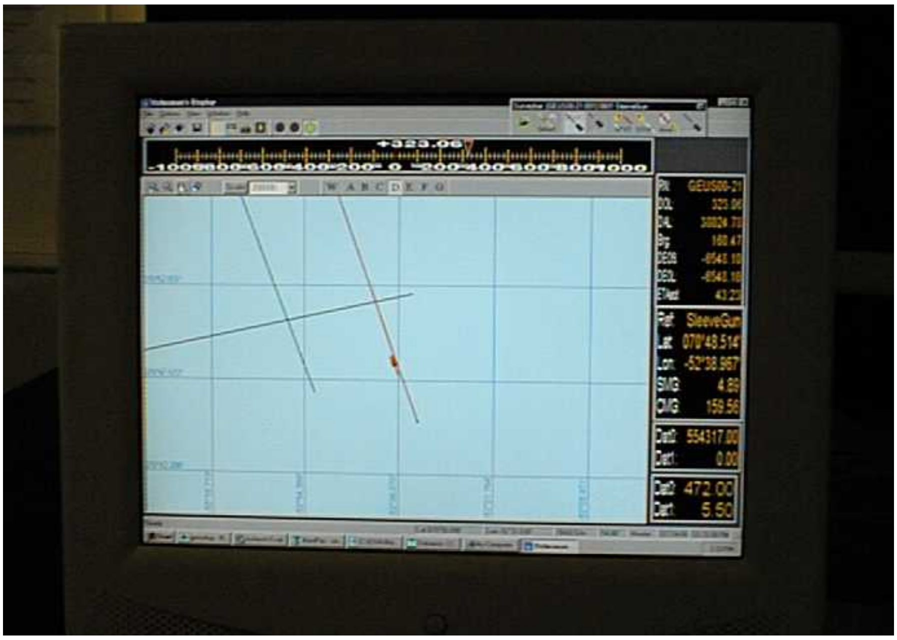

Fig. 31: Navipac – screen display

Fig. 32: Processing facilities on board H/S Dana

Fig. 33: Preliminary interpretation of the seismic data was necessary in order to refine the survey program

Fig. 34: Magnetometer used on board H/S Dana

Fig. 35: Modified towing arrangement for the magnetometer sensor

Fig. 36: Ice situation looking north towards Svartenhuk Halvø 26 July 2000

Fig. 37: Ice situation in the eastern part of Vaigat 1 August 2000

10. Magnetic profiles obtained during the cruise

Some data examples:

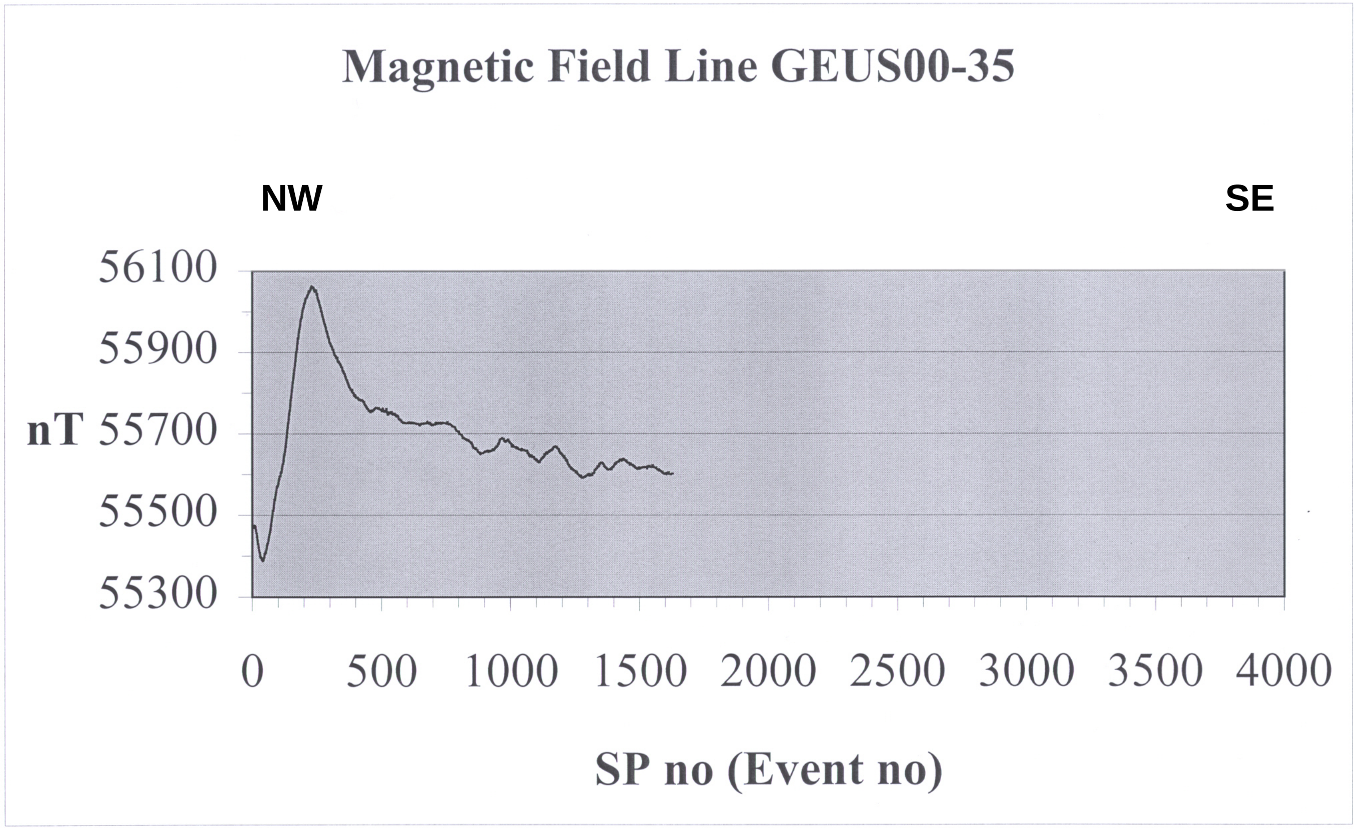

Fig. 38: Profil east of Ubekendt Ejland (see fig. 2). The magnetic anomaly is believed to represent the contact between basalts and sediments.

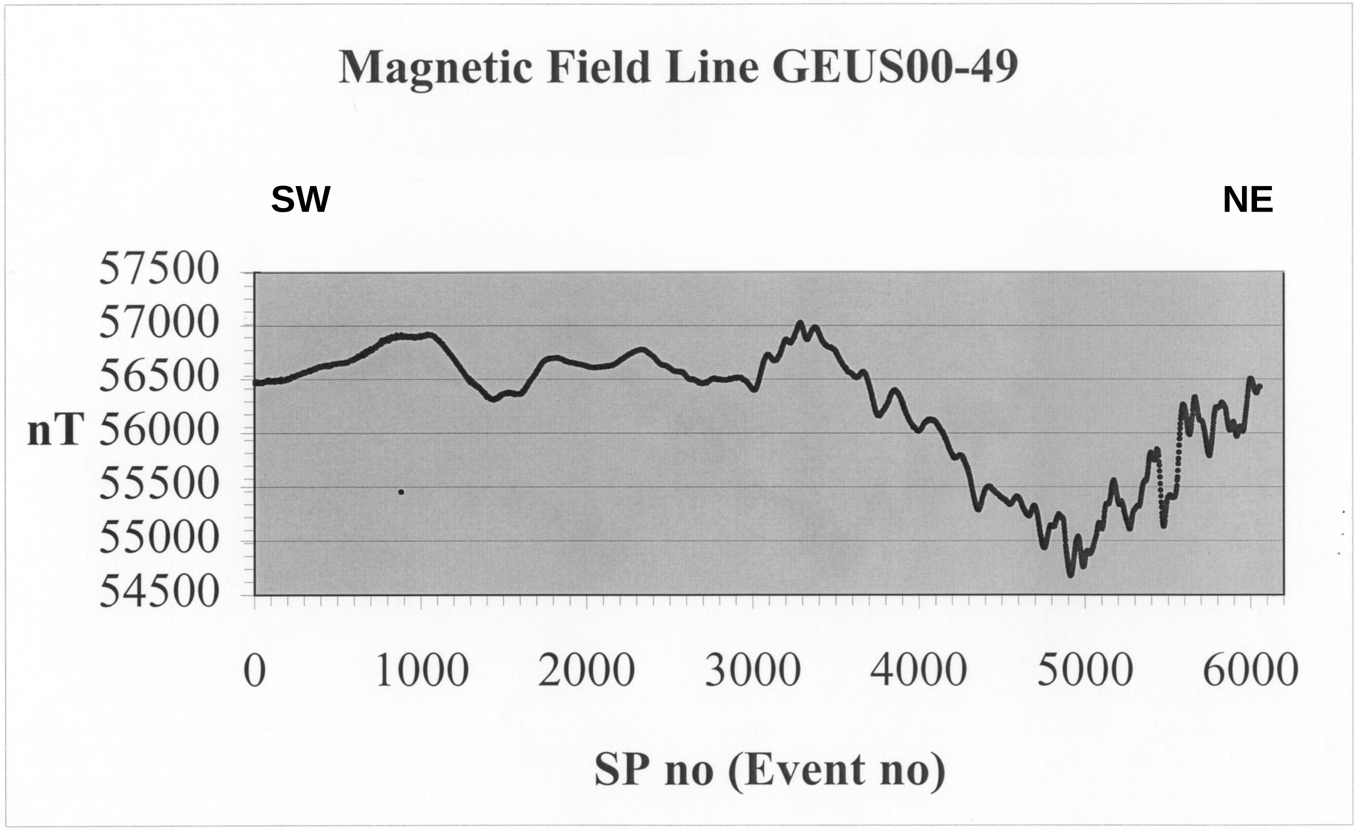

Fig. 39: Profile in the basalt area west of Ubekendt Ejland (see fig. 2). The change in the magnetic field around SP 3000 might be due to the transition from dipping reflections of unknown origin to flatlying basalts.

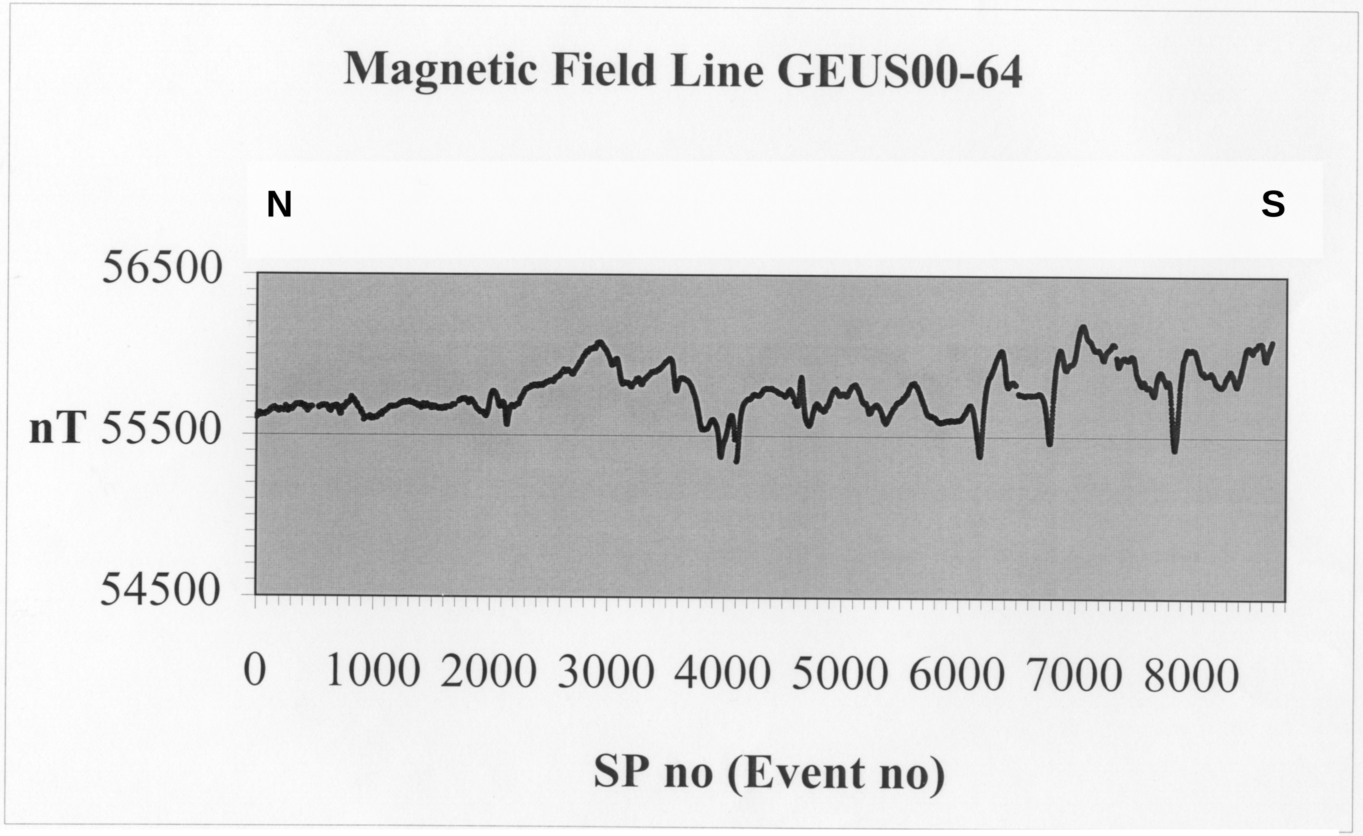

Fig. 40: Profile in the northern part of Disko Bugt (see fig. 2). Anomalies are believed to be caused by intrusions.

11. Communication from DANA (in Danish)

11.1 FAX – Weekly reports

Til: GEUS fax nr.: 38 14 20 50

Att: Flemming G. Christiansen / Jens Jørgen Møller

(send venligst kopi af denne fax til Martin Sønderholm i Råstofdirektoratet)

Projekt NuussuqSeis 2000

Rapport nr. 1 fra DANA - onsdag, 19.7.2000

Efter planmæssig afgang fra Nuuk den 14.7.2000 ved 18-tiden, indsamlede DANA ADCP (accoustic dobbler current profiler) transekter for DFU i et døgns tid. Efter yderligere halvanden døgns transit med en kortvarig storm startede vi indsamlingen af seismiske data fra tidlig midnat (GMT), den 18.7.2000. Vi har nu indsamlet vores to første seismiske profiler på i alt 200 km (planlagte linier DANA-22 og 37) og vi vurderer, at isforholdene i Vaigat er så gode, at vi kan gennemføre store dele af de planlagte linier. Processeringen af den første linie er også kommet godt i gang. Der er udvalgt et testområde og de første testresultater er på vej.

Vejret er også gunstig for indsamling af seismiske data: om natten næsten havblik og om dagen en frisk fjordvind. Ellers er her overskyet med enkelte lave skyer og en nysnegrænse (?) på ca. 800m.

Mange hilsner fra de 7 seismikkere om bord på DANA

Til: GEUS fax nr.: 38 14 20 50

Att: Flemming G. Christiansen / Jens Joergen Moeller

(send venligst kopi af denne fax til Martin Soenderholm i Raastofdirektoratet)

Projekt NuussuqSeis 2000

Rapport nr. 2 fra DANA - mandag, 24.7.2000

Vi er stadigvaek heldige med vejr- og isforhold. Efter at have indsamlet ca. 700 km seismiske data i Vaigat omraadet, hvor der nu resterer en 2 dages arbejde paa tilbagevejen til Ilulissat er vi draget videre nordpaa til Ummannaq Fjorden. Ogsaa her har isforholdene vist sig at vaere gunstige, saa kun de oestligste dele af programmet ikke kan gennemfoeres. Isfronten i form af en hoej koncentration af isfjelde ligger ca. paa en linie fra 70 53.2'N, 52 24.6'W til 70 50.1'N, 52 33.2'W. I loebet af i aften og nat vil vi saa bevaege os nordpaa langs linie DANA-1, for at se paa isforholdene i Iglorsuit og ved Svartenhuk Halvoe.

Vi har nu indsamlet ca. 1200 km data

Vejret har de sidste dage vaeret perfekt: naesten vindstille og skyfri himmel. Kun en smule taage har drillet lidt. Alle paa togtet er fascineret af den storslaaede natur heroppe.

Liste over indsamlede linier:

DANA-22, DANA-37, DANA-29, DANA-23, DANA-25, DANA-42, DANA-24, DANA-40, DANA-39, DANA-21, DANA-41, DANA-19, DANA-11, DANA-12, DANA-13 (- 20 km iden oestlige ende), DANA-15 (kun det vestligste ben), DANA-17 (forlaenget mod ENE),ny linie GEUS-18, DANA-48 og DANA-8.

Mange hilsner fra de 7 seismikkere om bord paa DANA

Til: GEUS   fax nr.:   38 14 20 50

Att: Flemming G. Christiansen / Jens Joergen Moeller

(send venligst kopi af denne fax til Martin Soenderholm i Raastofdirektoratet)

Projekt NuussuqSeis 2000

Rapport nr. 3 fra DANA - soendag, 30.7.2000

Kort tid efter jeg skrev rapport no.2 aendrede vi taktik med hensyn til indsamling af data i Uummannaq Fjord. I stedet for at gaa nord over mod Svartenhuk Halvoe valgte vi at goere indsamlingen i Uummannaq Fjord faerdig, idet vi var bange for at isfjeldene der laa inde ved Uummannaq ville bevaege sig mod vest pga. af en oestlig vind. Programmet i Uummannaq Fjord blev saa afsluttet om aftenen den 25.7., hvorefter vi fortsatte med at indsamle linien mod nord mod Svartenhuk Halvoe. Tidlig om morgenen den 26.7. viste det sig, at det ikke var muligt at indsamlede data nord for 71N 27’ pga. af et taet baelte af isfjelde. I stedet for indsamlede vi et taet net af linier i Igdlorssuit sundet mellem Ubekendt Ejland og Upernivik OE. Det lykkedes herefter at indsamle DANA-B1 syd for Schades oeer langs NW kysten af Ubekendt Ejland. De sidste dage har vi nu indsamlet et udvidet DANA-B program i basaltomraadet ud for kysten. De sidste tre dage vil blive brugt til at indsamle supplerende data i Vaigat (ca. 350 km)

Vi har nu indsamlet ca. 2300 km data.

Vi forventer at vaere i Ilulissat torsdag, den 3. august kl.11:00.

Vejret har i den foerste del af den forloebne uge stadigvaek vaeret perfekt: naesten vindstille og skyfri himmel. De seneste dage er det blevet overskyet med regn og taagebanker men generelt set rolige vindforhold. Her tidlig mandag morgen er vi dog endnu en gang heldig i mundingen af Vaigat: naesten havblik og sol paa de hoejeste toppe paa Disko.

Mange hilsner fra de 7 seismikkere om bord paa DANA

11.2 Logs from the captain of Dana

Fra: 421938410@inmc.eik.com
Sendt: 21. juli 2000 20:32
Til: danatur@dfu.min.dk

Skippers log: Den 16. juli kl. 0015
Dana befinder sig paa positionen 65.50 N 64.14 W, hvilket svarer til 78 soemil sydvest for Sisimiut/Holsteinsborg. Vejret i i oejeblikket fint med svag vind og vi har et flot udsyn over de hoeje kystfjelde med sne paa toppen, men i morgen lover meteologerne stormvejr.

Vi naede frem til Nuuk til tiden idet vi ankom den 14. juli kl 1104, men det skyldtes kun at maskinfolkene knoklede hele natten for at reparere den bagbord hovedmotor, hvor en bolt i et topstykke var spraengt, men kl fire om morgenen havde vi igen fuld maskinkraft, hvilket vi havde meget brug for.

Vi fortoejede ved at Atlantkajen og de folk, der skulle hjem naaede ders fly, og deres aflosere og forskerholdet kom ombord og kl. 1850 afgik vi igen efter et altfor kort ophold, da nogle af os lige skulle have tid til et dejligt gensyn med gamle venner. Samtidig skulle vi lige holde en lille reception for en raekke af charterens (GEUS) indbudte gaester, og togtlederen og jeg skulle interviewes af Groenlands radio, saa det blev en meget hektisk dag inden Dana med tre stoed i floejten sagde farvel til Nuuk og gled ind i taagen paa Godthaabsfjorden.

Vi gik samme aften i gang med vores ADCP-maalinger, hvor vi med lydboelger maaler stroemmen hele vejen ned til 500 meter dybde. Dette er en del af et samarbejdsprojekt mellem DFU og Groenlands Naturinstitut, der har til formaal at kortlaegge forholdene for plankton og fiskelarver i Davisstraedet.

Paa vej indtil Nuuk boed en pukkelhval os velkommen ved at slaa med sine 5 meter lange luffer saa vandet stod omkring den og soekonger, tejster og edderfugle stroeg rundt om skibet. Vores hvalobservatoer fra Nordsoemuseet Anders Oesterby, der som planlagt gik i land i Nuuk, fik saaledes en flot afslutning paa sin tur - isaer da Godthaabsfjorden var fuld af store flokke af Groenlandssaeler, der fik vandet til at koge.

Paa gensyn

Peter Oestrin, skipper

Fra: 421938410@inmc.eik.com
Sendt: 21. juli 2000 20:35
Til: danatur@dfu.min.dk

Skippers log den 17. juli 2000

Danas position idag kl 2258 dansk tid er 69.19 N 55.55 W og vi kan nu skimte Disko-oens stejle fjelde i disen. Vi regner med at begynde vores seismiske opmaalinger i Vaigat, der er et dybt smalt sund nord for Disko ved midnat med en lang transekt hele vejen igennem, saa vi ogsaa faar rekognoseret for isfjeldskoncentrationer, hvilke kan goere arbejdet til lidt af en udfordring.

Vi fik gennemfoert 4 af den 5 adcp transekter vi skulle inden den betalte skibstid for dette loeb ud. Denne aktivitet var dog afbrudt af en test af det seismiske maaleudstyr og en lille rask storm, der betoed at vi maatte dreje skibet op i stormen og vente et par timer til vejret bedredes - ogsaa fordi en af vores store udstyrscontainere rev sig loes og skulle surres fast igen.

Det vil vare lidt foer vi sender den naeste log, da de over tusind meter hoeje fjelde omkring Vaigat goer at vores antenner ikke kan se de satellitter vi sender til, saa vi maa vente til vi dukker frem af kloeften igen.

Vi har nu passeret polarcirklen, der ligger paa 66.30 N og er endnu en gang tilbage i midnatssolens land. Vi har set et par finhvaler, en hel del saeler og en lille flok grindehvaler, der passerede taet forbi skibet.

Paa gensyn
Peter Oestrin

Fra: 421938410@inmc.eik.com
Sendt: 21. juli 2000 20:37
Til: danatur@dfu.min.dk

Skippers log den 18. juli 2000

Danas position er nu 69.46 N - 51.42 W. Vi mangler et par timer i at vaere faerdige med vores foerste 180 kilometers seismiktransekt gennem Vaigat og har lige passeret Disko-oens nordoest punkt. Det er gaaet perfekt hele vejen igennem, og vi har stort set ikke vaeret generet af isfjeldene selv om de var ganske store. Det vil sige at den del der er over vandet er omkring 5 gange Dana og saa er der omkring 7 gange saa meget is under vandet. Vores isrecognosering tyder paa at det bliver relativt let at gennemfoere arbejdet i Vaigat, men de groenlandske vejraander er jo kendt for at lave om tingene temmelig hurtigt, saa lad os nu se...

Udstyret koerer fint bortset fra at teknikerne har lidt problemer med et magnetometer, der skulle maale styrken af jordens magnetfelt, hvilket kan fortaelle noget om de bjergarter der gemmer sig nede i havbunden. I modsaetning til vores normale undersoegelser, hvor vi undersoger forholdene i selve havet, drejer dette togt sig om de dybe lag under havbunden. Det foregaar ved at vi slaeber en trykluftkanon og et cirka 700 meter langt kabel med hydrofoner(undervands-mikrofoner) efter os. Trykluftkanonen skyder hvert 10 sekund og lyden bevager sig ned gennem havet og langt ned i havbunden, hvor den reflekteres af de forskellige bjergartslag, hvorefter vi samler den reflekterede lyd op med hydrofonerne i kablet. Dette signal tegner saa - efter en stoerre tur igennem geologers computere - et billede af de forskellige lag, og dette kan dels fortaelle noget om i hvilken dybde lagene befinder sig og hvad de bestaar af samt om der er mulighed for at finde olie og det er det det hele drejer sig om.

Veret har vaeret fint selv om det nu er lidt overskyet, men da vi i formmidags gled ind mellem isfjeldene ud for den forladte bygd Qutligssat i solskin og let vind med Sarah Brightman paa broens ghettoblaster kunne det naesten ikke blive bedre.

Paa gensyn

Peter Oestrin
skipper

Fra: 421938410@inmc.eik.com
Sendt: 21. juli 2000 20:45
Til: danatur@dfu.min.dk

Skippers log den 20. juli 2000 2155 groenlandsk tid

Danas position er nu 70.34 N - 54.34 W og vi er ved at skyde seismik i Hareloebet mellem Hare-oeen og Nugsuaq. Vi er blevet faerdige med foerste del af arbejdet i Vaigat, hvilket svarer til ca 20 procent af vores arbejdsprogram, saa det gaar ganske godt.

Verjet er stadig perfekt med sol og svag vind og isfjeldene har stort set ikke generet os selvom vi ind i mellem glider taet forbi dem. Det skal dog goeres med forsigtighed, da vi har set et par stykker bryde sammen og saa er det ikke saerlig heldigt at vaere i nabolaget.

Dagens fugl blev en lille kjove, saa nu har vi set alle kjovearterne i Nordatlanten paa togtet, og ellers var der en lille flok hvidvingede maager, der gav en flot flyveopvisning omkring et stort isfjeld sammen med mallemukkerne. Sent i gaar aftes kunne vi foelge en groenlandsk fanger i en lille jolle paa saeljagt mellem isfjeldene og det lykkedes ham at faa ram paa en af fjordens mange saeler, saa vi keder os ikke.

Paa gensyn

Peter Oestrin

Fra: 421938410@inmc.eik.com
Sendt: 23. juli 2000 01:28
Til: danatur@dfu.min.dk

Skippers log Den 22. juli 2000

Danas position kl 2310 dansk tid er 71.00 N - 54.57 W. Vi er lige ved at gaa ind paa vores tredje lange seismiktransekt i Umanak Fjord langs nordkysten af Nussuaq. Vejret er perfekt med havbklik og hoj sol og de store isfjelde ligger saa spredt at de stort set ikke genere arbejdet herude. I oestenden af vores arbejdsomraade er situationen helt anderledes for her lukker isfjeldene fra Store Gletcher helt for adgangen, saa vi svinger taet ned langs kanten af isfeltet naar vi gaar ind paa transektet for at faa maalt saa meget som muligt. Vi er godt forud for programmet paa grund af det gode vejr og de meget fine isforhold.

Her er utroligt smukt og i det klare vejr kan vi se de let sneklaedte kystfjelde paa 100 kms afstand. For et ojeblik siden styrtede der en isblok paa stoerrelse med et parcelhus ned fra toppen af et af de store isfjelde - heldigvis paa god afstand - og vi vugger nu let i bolgerne fra plasket. Ellers har vi har besoeg af et par flokke af groenlandssaeler og saa havde vi eller et godt lille mysterie i morgens da vi laa nord for bygden Qasut. Inde langs kysten kom Dana nemlig sejlende i modsat retning, og vi mente da ellers vi havde styr paa skibet. Efter intense kikkertstudier fandt vi dog en rimelig forklaring. Det var det gamle groenlandsskib Disko, der nu sejler med turister, og det er blevet malet om saa det ligner Dana paa afstand, saa en masse snedige teorier om luftspejlinger og fata morgana blev kasseret.

Bemaerk at vi ikke naede at sende rejsebrev igaar. Vi havde vist ldt for travlt med at nyde udsigten blandt andet. Der har vaeret lidt problemer med rejsebrevene paa grund af en forkert email adresse, men nu har vi rettet fejlen og DFU INFO skulle gerne kunne laegge de fleste af rejsebrevene ud paa nettet i naeste uge.

Paa gensyn

Peter Oestrin

Fra: 421938410@inmc.eik.com
Sendt: 24. juli 2000 01:09
Til: danatur@dfu.min.dk

Skippers log Den 23. juli 2000 groenlandsk tid

Danas position er 71.51 N - 54.52 W.

Vi sender lidt sent i aften, da vi har vaeret taet inde ved Nussuaqs nordkyst og der skygger de hoeje fjelde for de satelliter vi sender over.

Vi skyder stadig seismiktransekter i Umanak Fjord langs nordkysten af Nussuaq, og har stadig perfekt vejr og meget fine isforhold. I loebet af natten, hvor overhovedet ikke bliver moerkt paa grund af midnatsol, begynder vi at arbejde os nordover mod Ubekendt Eilande.

Sidste nat kom taagen rullende ned fra fjeldene paa Nuusuaq, og da den naaede ud til os gik sigtbarheden fra 100 kilometer til 30 meter paa 5 minutter, saa det var lidt taet, men taagen lettede igen, da vi naermede os isfronten, saa vi kunne vende uden problemer.

Paa gensyn Peter Oestrin

Fra: 421938410@inmc.eik.com
Sendt: 25. juli 2000 21:30
Til: danatur@dfu.min.dk

Skippers log den 25. juli 2000.

Danas position kl 2115 dansk tid 71.00 N - 53.13 W.

Vi af nu afsluttet opmaalingerne i Umanak Fjord, og begynder i aften efter en mindre reparation paa maaleudstyret gaa op i sundene oest og nord for Ubekendt Eilande. Det kan blive ganske spaendende for her er en del af dybderne ikke opmaalt, men vi har lidt ekkolodninger fra en kutter fra sidste aar og saa holder vi ellers godt oeje med vores eget ekkolod.

Det sidste doegn har det vaeret lidt overskyet med regn og frisk fjordvind, men nu er det ved at klare op igen. Isfjeldene har ogsaa opfoert sig paent og vi kunne traenge langt ind langs Alfreds Wegners Halvoe i formiddags uden isproblemer. Vi havde nu ellers et par snedige planer i baghaanden, men dem fik vi ikke brug.

Paa gensyn Peter Oestrin

Fra: 421938410@inmc.eik.com
Sendt: 27. juli 2000 00:44
Til: danatur@dfu.min.dk

Skippers log den 26. juli 2000.

Danas position i dag 2115 dansk tid 71.12 N 53.23 W

Vi de sidste de sidste 24 timer lavet opmaalinger i sundet Igdlorsuit mellem Ubekendt Eilande og fastlandet. Vi naaede dog ikke op i de uopmaalte nordlige dele, da omraadet var helt spraerret af isfjelde, saa vi har lavet et taet net zigzag-transekt i selve sundet, og gaar i nat nord om Ubekendt Eilande for at fortsaette paa havsiden.

Vjeret er overskyet men klart og vi har havblik. Det vrimler sjovt nok med havterner i sundet, saa det er lidt forandring i forhold til de andre omraader, men vi ser stadig mange saeler.

Paa gensyn

Peter Oestrin

Fra: 421938410@inmc.eik.com
Sendt: 28. juli 2000 14:55
Til: danatur@dfu.min.dk

Skippers log den 28. juli 2000

Danas position i dag kl.1430 dansk tid 70.50 N - 55.25 W

Vi naaede ikke at sende i gaar. Vi afsluttede arbejdet i Idlorsuit Sund mellem Ubekendt Eilande og fandt et hul mellem isfjeldene saa vi kunne lave et transekt nord om oeen ud gennem Karrat Fjord gennem daarligt kortlagt farvand, saa vi listede igennem paa ekkoloddet og der var ikke meget overensstemmelse mellem hvad det og kortet viste, saa det var ganske spaendende. Samtidig sendte Groenlands Radio en udsendelse om togtet og Dana baseret paa interviews med togtlederen og undertegnede under det korte havneophold i Nuuk og det slap vi nu ogsaa ganske godt fra og skibet fik en masse gratis reklame.

Vi har siden i gaar formiddags arbejdet i aabent vand i Nordoest-bugten, hvor vi er gaaet i gang med de transekter, der havde 2. prioritet, da vi er fint forud for programmet. Herude ligger

isfjeldene meget spredt, saa navigatoerene kan slappe lidt af indtil
vi skal op og arbejde langs isfronten ved Svartenhuk Halvoeen om et
doegns tid.

Vejret er stadig godt selv om det nu er overskyet, og det hele gaar
stille og roligt efter planen. Bortset fra lidt tejster, mallemukker
og graamaager er der ikke meget liv herude.

Paa gensyn

Peter Oestrin

Fra: 421938410@inmc.eik.com
Sendt: 30. juli 2000 20:22
Til: danatur@dfu.min.dk

Skippers log den 30. juli 2000

Danas position kl 1602 groenlandsk tid 70.35 N - 54.40 W.

Vi er nu paa vej sydover mellem Hareoen og Nussuaq paa det sidste
aabentvandstransekt inden vi paabegynder de afsluttende transekter i
Vaigat.

I nat lykkedes det os at naa 30 km laengere mod nordoest end vi havde
regnet med, da isfjeldene mere spredt end vi havde forventet.
Muligvis skyldtes det at vi fulgte en undervandskloeft og de helt
store isfjelde stod strandet paa begge sider af den. Paa grund af
lavthaengende skyer, der i nogle tilfalde skjulte toppen af
isfjeldene og meget diset vejr var det et helt spoegelsesagtigt
sceneri vi bevaegede os langsomt igennem, hvor det nogen gange saa ud
som isfjeldene svaevede.

Bortset fra to omraader med meget taette iskoncentrationer ved Umanak
og den nordlige ende af Igdlorsuit Sund har vi gennemfaoert hele
programmet og lidt til nord for Nuusuaq, saa det er indtil nu gaaet
over forventning.

Paa Gensyn

Peter Oestrin

Fra: 421938410@inmc.eik.com
Sendt: 1. august 2000 01:44
Til: danatur@dfu.min.dk

Skippers log den 31. juli 2000 kl 2130 groenlandsk tid

Dans position er nu 69.57 N - 52.35 W. Vi arbejder nu i oestenden af Vaigat efter en ufrivillig pause paa 5 timer, idet vores luftkanon-rig, der skaber de lydpulser vi sender ned i havbunden, under en manoevre kolliderede med en isskodse og blev beskadiget. Vores to teknikere fik dog to af de fire kanoner til at virke, saa vi fortsaetter med nedsat signalstyrke, men faar stadig gode data hjem.

Isfjeldssituationen har aendret sig siden var var her sidst, saa vi forventer at faa lidt problemer med isfjelde i Diskobugtens nordoest hjoerne i nat. Vejret er stadig godt arbejdsvejr, men vinden er frisket lidt og skyerne haenger lavt paa fjeldene omkring os, og vi har haft lidt smaaregn, saa det er ikke ligefrem turistbrochurevejr men her er stadig utroligt flot.

Paa gensyn

Peter Oestrin

Fra: 421938410@inmc.eik.com
Sendt: 1. august 2000 21:11
Til: danatur@dfu.min.dk

Skippers log den 1. augus 2000 kl 1700 groenlandsk tid

Dans position er nu 69.52 N - 51.31 W. Vi arbejder forsat i oestenden af Vaigat og i Diskobugtens nordoest hjoerne. Vejret er stille med regn, regndis og taage med sigt ned til nul meter, saa det gaar meget stille og langsomt, og vi holder os godt vaek fra isfjeldsomraaderne, da selv smaa stykker kalvis kan skade vores to tilbagevaerende kanoner.

Paa gensyn

Peter Oestrin

Fra: 421938410@inmc.eik.com
Sendt: 2. august 2000 20:59
Til: danatur@dfu.min.dk

Skippers log den 2. august 2000 kl 1640 groenlandsk tid

Dans position er nu 69.01 N - 51.28 W. Vi befinder os lige syd for Isfjeldsbanken ud for Jakobshavn Isfjord, hvor enorme isfjelde ligger stuvet sammen. Vi har lige bjaerget udstyret efter den sidste seismiktransekt og er nu paa vej op til Ilullisssat/Jakobshavn, hvor vi skal skifte forskerhold og et par enkelte besaetningsmedlemmer. Vi kan ikke komme til kaj paa grund af anden trafik, saa hvis is- og vejrsituationen tillader det, ligger vi for anker inat og sender gummibaaden ind. Ellers maa vi ligge og kredse uden for isen.

Vi har gennemfoert hele programmet for denne del af groenlandstogtet bortset fra et par mindre omraader hvor isfjeldene sagde stop, saa vi er godt tilfredse og siger paent tak til vores groenlandske hjaelpe-aander.

I morgen forsaetter vi med tre doegns pistoncoring, hvor vi skal tage proever af havbunden, inden vi den 6 om aftenen satter kurs mod syd, saa vi kan vare paa Faeroerne den 13. august

Paa gensyn

Peter Oestrin

Fra: 421938410@inmc.eik.com
Sendt: 5. august 2000 01:24
Til: danatur@dfu.min.dk

Skippers log den 3. august 2000 kl 2100 groenlandsk tid

Danas position er nu 68.50 N - 53.09 W. Vi befinder os syd for oeen Hunde Eilande efter en dags vellykket pistoncoring mellem denne og Arveprinsens Eilande, idet vi fik et par sedimentkerner paa 8,7 og 11 meter op fra op fra 850 meters dybde. Vejret er igen vidunderligt med vindstille og havblik og naesten 10 graders varme og hernede syd for Diskooeen er der kun faa isfjlede og der er langt i mellem dem.

Vi sendte ikke igaar, da dagen blev saerdeles livlig. Isfjorden ved Ilullissat havde skudt ud, og vinden var sprunget i sydvest, saa adgangen til havne var blokkeret af isfjelde, da vi var oppe og kigge paa forholdene den 2. om aftenen, saa vi laa og sejlede langs iskanten og ventede. Om morgen lettede ispresset saa meget at gummibaaden kunne smutte ind og ud mellem isskodserne med forskere og besaetning til afloesning, saa efter en masse boevl med forsinkede fly og forskere der var blevet vaek, havde vi klokken et et komplet hold ombord. Vi sejlede derefter ned til hvad der i det nu meget smukke vejr, maatte vaere en af verdens smukkeste arbejdspladser nemlig sydsiden af Jakobshavn Isfjeldsbanke, og gjorte klar til foerste forsoeg med pistoncoringudstyret. Dette er kort fortalt et hult bor som man trykker 10 meter ned i havbunden ved hjaelp af et 1000 kg tungt lod og saa kan man faa en soejle af havbunden med op inden i boret. Hele systemet ligner noget Storm P ville have elsket og kraever en hel del kreativ taenkning og en masse knoklen for at det virker men det lykkedes at lave et teknisk perfekt skud....Der var dog den lille hage ved at det, at vi 10 meter nede i havbunden havde ramt en sten med med saa stor fart at spidsen af boreroeret blev knust og hele bundproeven gik tabt, men det er hvad der kan ske naar man leger med mudder paa 350 meters dybde.

Paa gensyn

Peter Oestrin