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2016.038

Transforming analogue sparker records from the Norwegian continental shelf into SEG-Y format - technical report, SPARDIG project

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REPORT

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Title:
Transforming analogue sparker records from the Norwegian continental shelf into SEG-Y format - technical report, SPARDIG project

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Summary:

Analogue seismic lines (sparker) acquired mainly by IKU during 17 surveys in the period 1970-1984 have been transformed to SEG-Y format. The old data, which make up a regular seismic grid from 60°N (Northern North Sea) to ca. 71°30'N (Tromsøflaket; SW Barents Sea), are of medium to good quality.

A total of 31 261 km of sparker lines were processed and transformed. Compared to conventional seismic lines the resolution of sparker is better. An integrated interpretation of SEG-Y transformed sparker together with available 2D seismic data and high resolution bathymetric data sets will have a large potential for improved geological regional mapping of the upper layers of the seabed.

Keywords: Marine Geology	IKU Sparker	SEG-Y
Processing	SeisTrans	Caldera software
Shallow Seismic	Analogue seismic	Regional grid

CONTENTS

1. INTRODUCTION

SPARDIG – 'Transforming analogue sparker records from the Norwegian continental shelf into SEG-Y format and application of the data to re-interpret the basement-sediment contact in the Møre-Trøndelag area' is a two year project being initiated in 2014 by the Geological Survey of Norway (NGU).

The old IKU sparker data are unique due to the regularity of the extensive data grid, and also because the sparker has much higher seismic resolution than ordinary 2D seismic lines. An integrated interpretation of SEG-Y transformed sparker together with available 2D seismic data and high resolution bathymetric data sets, will have a large potential for improved geological mapping, particularly of the Quaternary strata. Further, by transforming the data to SEG-Y format, the data will be secured for future use.

In this report we inform shortly about the data background (acquisition and later data management), and present the technical procedures and quality control applied. The technical part of the project, scanning of old paper rolls of reflection seismic data and transforming them to SEG-Y format, have been carried out by CNRS (public scientific and technological establishment acting with University of Strasbourg on behalf of the Institut de Physique du Globe de Strasbourg). The selection and management of original paper rolls, as well as the quality control of the SEG-Y versions, have been carried out at NGU. The project also includes a scientific part, where the SEG-Y versions of IKU sparker are interpreted together with other available data in the Møre-Trøndelag area to study the interface between sedimentary and crystalline rocks and improve the geological mapping in the coast near area. This study will be reported separately (Rise et al., 2016).

2. HISTORY AND CONDITIONS OF THE ORIGINAL DATA

The sparker data were acquired during the years 1970-1982, first by the NTNF's kontinentalsokkelkontor which later became Institutt for kontinentalsokkelundersøkelser (IKU; Continental Shelf Institute, Norway; and later IKU Petroleum Research). At present the institute has been reorganized, now being part of the SINTEF group (Sintef Petroleum Research as). As the navigation on parts of the old data off Troms was missing, Sintef Petroleum Research kindly offered the Spardig project to include sparker acquired in an industry project off Troms (Sættem et al., 1985).

The sparker lines make up a regular regional grid from 60°N (Northern North Sea) to ca. 71°30'N (Tromsøflaket; SW Barents Sea), commonly with 10 km distance between E-W lines and 25 km between lines in the perpendicular direction (Fig. 1). Totally around 33 000 km of shallow seismic profiling with sparker were shot (IKU, 1984). Simultaneously with the sparker also side-scan sonar and penetration echosounder have commonly been used. On Trænabanken (area E, see Fig. 1), Huntec Deep Towed Boomer was partially used.

Various large fishing vessels were applied during data acquisition, and mobilizing of portable survey equipment was necessary on every survey. The EG&G three electrode sparker was the main acoustic source on all seismic surveys (Fig. 1). Only off Mid Norway, where the grid is twice as dense in the inner shelf area, every second line are a boomer line. The sparker was mainly operated at 1000 joule, which in most of the mid- to inner shelf areas gave sufficient energy to provide penetration beyond the regional bedrock unconformity underlying the Quaternary section. A one channel streamer was applied, and after filtering at 50-500 Hz the data were recorded on an EPC graphic recorder, usually with a scale of 0.5 s. On some lines, a scale of 0.75 s. or 1 s. have been used. The survey speed was commonly between 4 and 5 knots. The penetration varies from 100 to 500 ms. TWT, and the quality of most lines varies from good to acceptable, commonly reflecting the survey weather. The resolution (pulse length) of the sparker records is ca. 10-12 ms.

The original EPC-records were copied into negative transparent film in half scale (25 cm width). From these, half scale paper copies were made and folded. The original sparker rolls have all the time been stored in closed boxes.

Shot point maps (sp-maps) in the scales 1:100 000 and 1: 250 000 were plotted (datum ED 50), commonly together with 10 m bathymetric contours, and used as basis for various geological interpretations. Later, due to reading problems of the original navigation tapes, all sp-maps had to be re-digitized, securing positions at every 5 minutes along the seismic line as well as start/stop.

The data were in the early eighties subdivided in 6 data packages (A-F, see Fig. 1 and Table 1), and later into another small package G defined in the Møre area. The packages were offered for sale to oil companies as half scale folded paper copies (25 cm width). Navigation sets for each data package were made.

The responsibility of analogue seismic data base acquired in the period 1970-1982 was transferred from IKU Petroleum Research to NGU in 1998. This included storage of the physical data (i.e. original paper rolls and half-scale film copies), and safe storage of the corresponding digital navigation database.

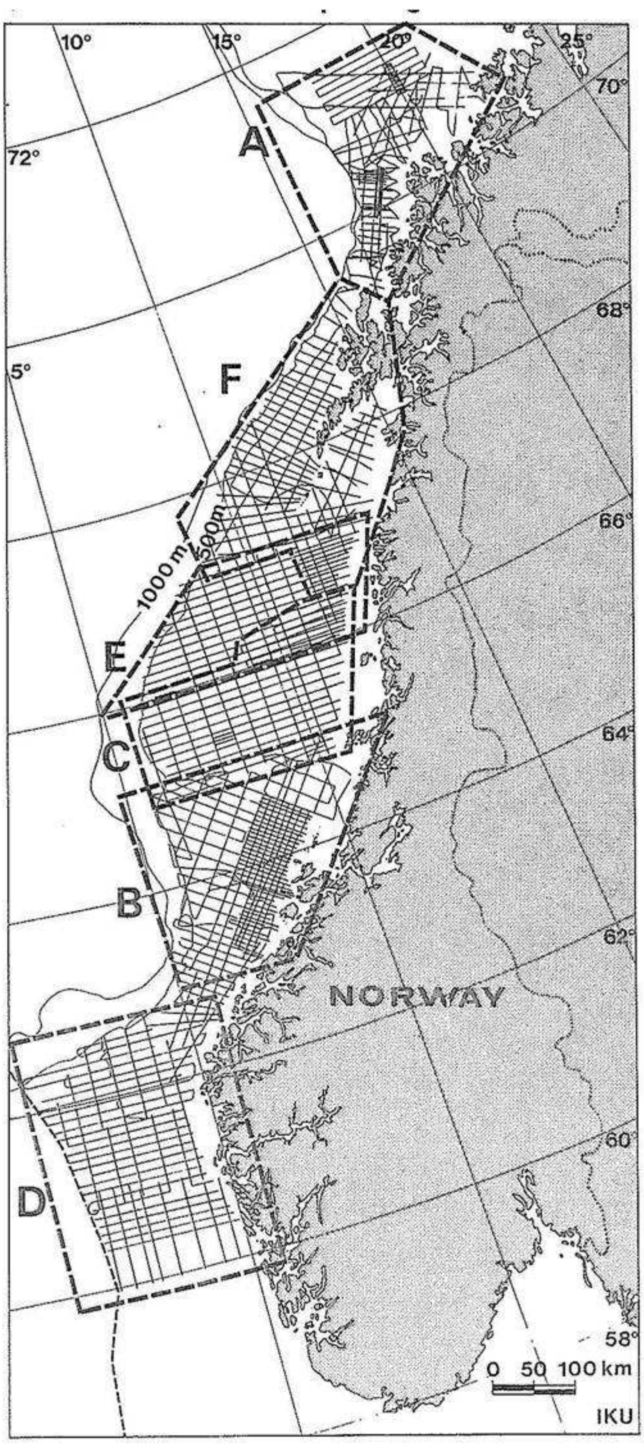

Figure 1. The IKU sparker grid was acquired during the years 1970-1982. IKU subdivided the lines into data packages (letters A-F) which were offered for sale. Every second line in the dense grid close to the coast in package B is boomer data (IKU 1984).

3. NAVIGATION SYSTEMS APPLIED DURING DATA ACQUISITION

The Decca receivers compare the phase difference between one Master beacon and two or three Slave beacons (Red, Green, Pink). Generally the best 'slaves' to use would have Decca signals (Lanes) crossing each other at a largest possible angle. Five different Decca Main Chains have been applied in the various survey areas (Table 1). Compared to the GPS applied today, the Decca system has a variable and low accuracy. However, IKU used the same slave combinations during both the seismic survey and the following sampling survey, which secured a good relative accuracy (the main goal was to sample a target observed on a seismic line). Listings of the slave combinations applied on the various seismic lines were available during planning of the IKU sampling surveys, but were seldom presented in the survey reports. In Vestfjorden and off Lofoten (survey 8210), however, the slave combinations applied to calculate the positions are given (Fig. 2) (Rise & Gunleiksrud, 1983). From the surveys run in 1970 and 1971, i.e. 8 lines with prefix C70 and C71 (ca. 950 km length) we have no information about the navigation.

The deviation between Decca Main Chain and GPS is mainly in the order 50-200 m, but much larger errors may occur depending on the geometry of the applied lane combinations (Pers. comm., Mr. Sølvberg, Norwegian Hydrographic Office). Sølvberg also refers to deviations due to the 'night effect'. Decca Main Chain alone is sensitive for disturbances in the atmosphere, often causing unstable signals. It also varies over the day, having the best quality during daylight hours.

During some surveys it was necessary change between two neighbour Decca Chains in order to obtain an optimal lane geometry. This could locally introduce navigation jumps, particularly at some long N-S lines. Large errors occurred in the boundary area between the Helgeland Chain (9E) and the Lofoten Chain (3E), which resulted in large navigation steps (1-3 km) at locations where the chain was shifted on N-S lines (Rise & Gunleiksrud, 1982). The Helgeland Chain (9E) was used from line B82-131 and southwards, whereas the Lofoten Chain (3E) was used from line B82-132 and northwards. Also in the boundary area between the Lofoten Chain (3E) and the Finnmark Chain (7E) it is reported large navigation errors (NTNF, 1972, 1974). Under survey 8110 the Helgeland Chain worked fine (Bugge and Tegdan, 1981).

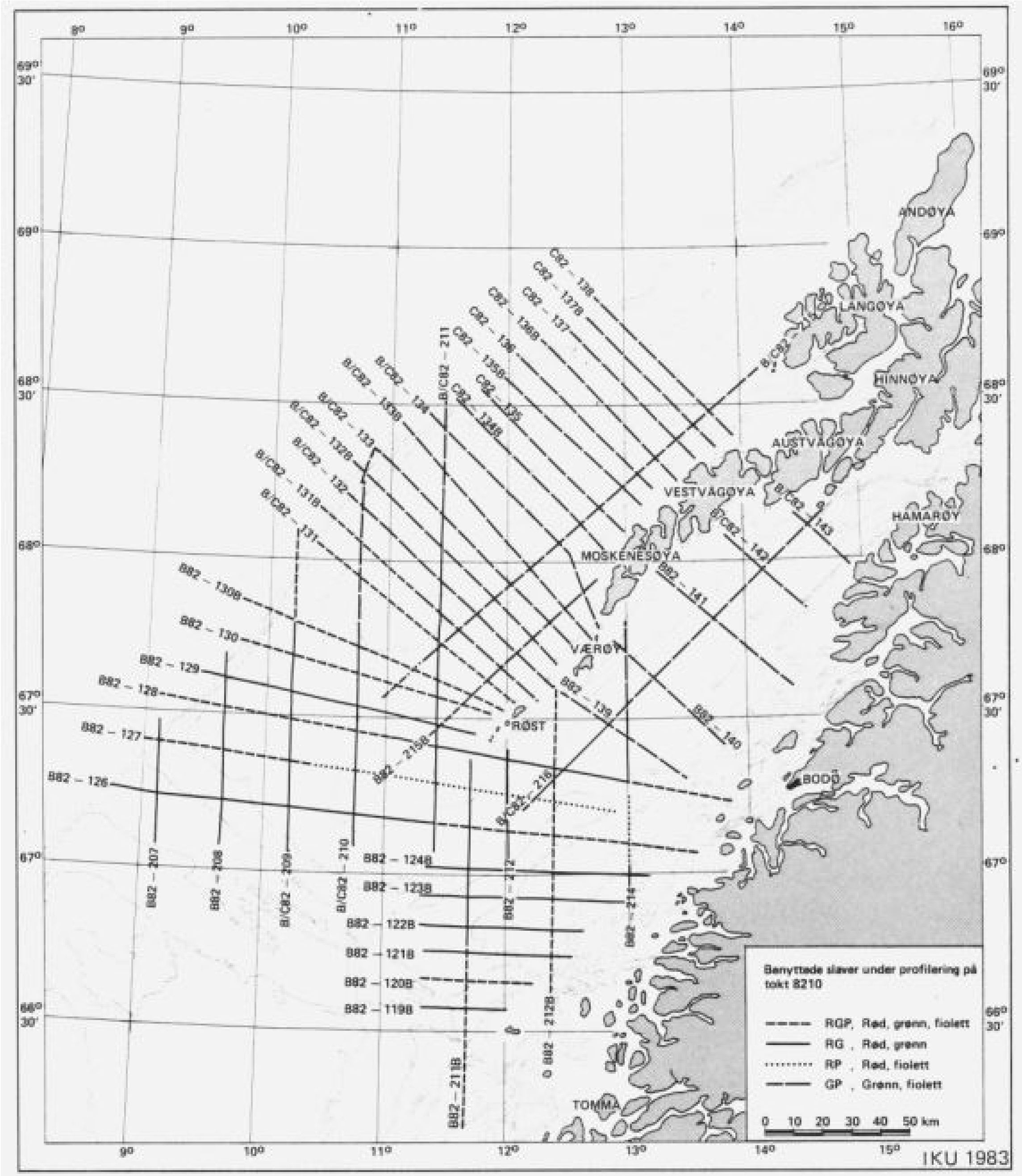

Figure 2. Map showing different slave combinations applied using Decca Main Chain navigation system on survey IKU 8210 (from Rise & Gunleiksrud, 1983). Note: Prefix is now B82- for all lines acquired during this survey

Logging of Loran C signals indicates that both the Trøndelag Chain (4E) and the Vestlandet Chain (0E) give good data in most of the survey areas. IKU's integrated positioning system (IPS) was used in Nordsjøen (survey 7910), applying a combination of data from Decca Main Chain, Loran C, satellite, gyro and log. IPS gives a better absolute positioning accuracy, but as Decca Main Chain was used earlier,this one was applied when plotting the shot point maps. The importance to take samples exactly at the location pinpointed from the seismic interpretation was probably the background for this choice.

During interpretation using both 2D lines and sparker, it appears that the seafloor as well as characteristic reflections mainly correspond fairly well. This shows that navigation errors are within an acceptable window limit for regional interpretations in most of the area. On some line intersections we have observed deviations, which may indicate fairly large navigation errors. Most likely this occurs mainly in local areas where the slave beacons make up a poor geometry. After receiving the new SEG-Y transformed data set we have performed only a limited amount of seismic interpretation of these data together with conventional 2D lines. So far most lines appear to correspond fairly well, but during future work sparker segments with large navigation errors will be noted.

4. SCANNING OF THE ORIGINAL RECORDS

The original records (paper or film) are scanned with a Contex scanner in 600 dpi greyscale 8 bits. Images are rotated (90° plus fine rotation to make the image horizontal), clipped to keep the useful area, converted into black & white 1bit, and saved as TIF images using a name convention. Scanner glass is regularly checked and cleaned, and scanned images are regularly checked to avoid loss of information. There is a scanning long roll limitation: it is not possible to scan length >5 m due to file size limitation of image at 2 Gb. The rolls were scanned starting on both sides when length <10 m, and cut roll when >10 m.

5. TRANSFORMATION INTO SEG-Y FORMAT

SeisTrans (Caldera software) is used to transform images into seismic traces. SeisTrans was developed during EC Seiscanex project EVR1-CT-2001-40016 and one application is resurrecting vintage paper seismic records (Miles et al., 2007).

SeisTrans uses interactive, iterative and repeatable steps in a dedicated graphics window. A first step allows definition of axes and scales, than record time lines (horizontal twt times and navigation times lines down the record) are picked and removed, and traces are defined. At this step, control tools are available to ensure the quality of the traces. A first SEG-Y file is created.

Post processing is done later: merge of files (one per image) into one file per line; extract shots on GMT time lines; link to date & time, interpolation of date & time for all shots; extraction of navigation from excel files, creation of file shot - date & time – position, correction of delay, adding navigation information into trace headers, and finally write file into SEG-Y format.

Table 1. Summary of IKU survey information and navigation applied

Survey no.	Area	Profiles (i.d.)	Navigation	Ref. / Comment
7205/7206	Troms, Lofoten-Vesterålen, Vestfjorden	V72-x ; S72-x; Q72-x; C72-x	Decca Main Chain Lofoten (3E) & Finnmark (7E)	NTNF 1972. Large chain navigation errors
7303/7304	Møre-Trøndelag	B73-x	Decca Main Chain Trøndelag (4E) + Loran C	NTNF 1973. Good navigation.
7410	Troms og Finnmark	C74-x	Decca Main Chain Lofoten (3E) Finnmark (7E)	NTNF 1974. Large chain navigation errors
7412	Møre-Trøndelag	B74-x	Decca Main Chain Trøndelag (4E) + Loran C (for testing)	NTNF publ. 60. Loran C data indicates that chain 4E is good.
7510	Møre-Trøndelag	B75-x	Decca Main Chain Trøndelag (4E) + Loran C (for testing, see comments in report)	Bugge, T., 1975
7610	Midtnorge Møre Nordsjøen	B76-x B76-x; AB76-x A76-x; AB76-x; B76-x	Decca Main Chain + Loran C for testing	Rokoengen, 1976 Moum, J. (Ed.), 1978
7710	Nordsjøen	A77-x; AB77-x	Decca Main Chain Vestlandet (0E), good chain). Log and gyro. Loran C logged and stored.	Bugge, 1977 Moum, J. (Ed.), 1978.
7810	Helgeland	B78-x; C78-x	Decca Main Chain Helgeland (9E), log and gyro (relative accuracy good). Loran C and satellite data logged and stored.	Dekko, 1978
7910	Nordsjøen	A79-x	Decca Main Chain Vestlandet (0E). Integrated positioning system; data stored	Bugge, 1979
7911	Trænabanken	B79-x	?	?
8110	Helgeland/Trænabanken	B81-x	Decca Main Chain Helgeland (9E)	Bugge & Tegdan, 1981
8210	Vestfjorden/Lofoten	B82-x	Decca Main Chain. Helgeland (9E) and Lofoten (3E)	Rise & Gunleiksrud, 1982.
Geoteam 84	Troms	C84-x	Syledis Chain Troms I	Sættem et al., 1985

6. QUALITY CONTROL AND CHECK OF DATA IN PETREL

The digital data is received from CNRS through their ftp site. The data was quickly checked using SeisSee software for locations in UTM coordinates and delay corrections. After this quick check the data was loaded into Petrel with other datasets and culture data to check for the location and any other problems associated with SEG-Y file headers. The data was opened as composite line with cross over lines for checking the correctness of location and delay. The colour scale chosen is White - Grey - Black since the data is mainly a positive sided reflection. The negative half is clipped since it is converted from a black and white image.

Most of unforeseen problems and deviations occurred during the first period of the project. Parts of this resulted from the early history of the old data, including reorganization of storage, navigation and partly deviating identity (i.d.) on line rolls and navigation listings. This resulted in misunderstandings both internally and between NGU and CNRS. The first storage and listing was based on survey numbers, but later the data were reorganised in order to make sale packages in various geographical areas. Some surveys and also lines ended therefore up in two neighbour packages, which also resulted in splitting of the original navigation files. This resulted in back and forth communication to sort out various deviations, particularly during the first phase of the project. Figure 3 gives a map view of all the IKU sparker lines transferred to SEG-Y format.

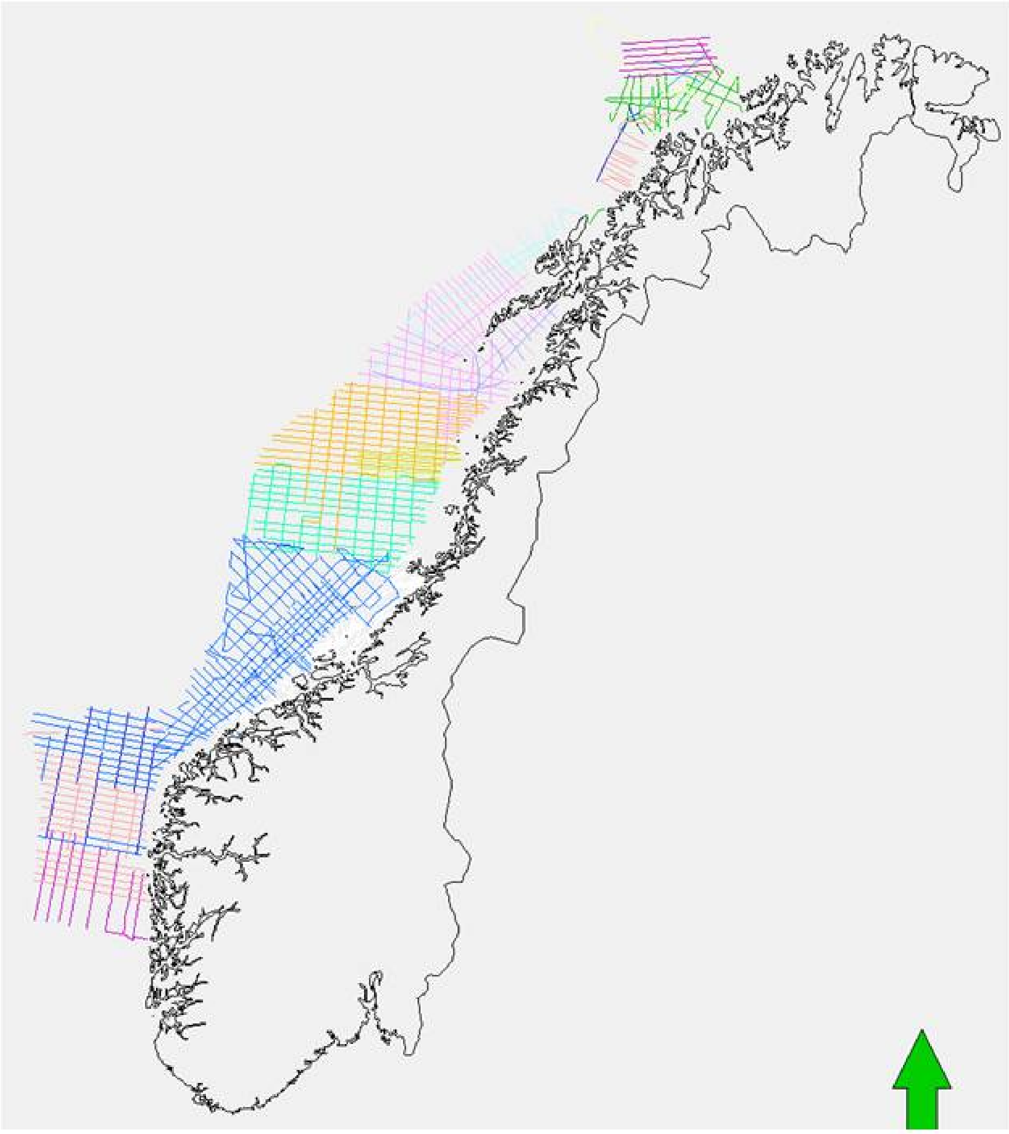

Figure 3. Map showing the location of all IKU sparker lines been transformed to SEG-Y format in the SPARDIG project. Different surveys are imaged with varying colours.

7. COMPARISON OF IKU SPARKER AND 2D SEISMIC

IKU sparker lines have commonly a higher resolution than 2D lines image, but the penetration is limited. Sparker and conventional data image the subsurface differently, and figures 4-9 demonstrate that the data sets are suplementary to each other. This is well illustrated in figure 5, where the interpretation of the base Quaternary on the sparker is uncertain due to limited penetration or very low acoustic contrasts. Although a parallel and closely spaced 2D line was of poor quality, an erosional surface was evident and improved the interpretation of the sparker (Figs. 5, 6). Conventional seismic lines are of very variable quality with respect to delineating units in the upper part of the records. Some lines gives hardly no details of the Quaternary stratigraphy (Fig. 7), but others have nearly of same resolution as sparker (Fig. 9).

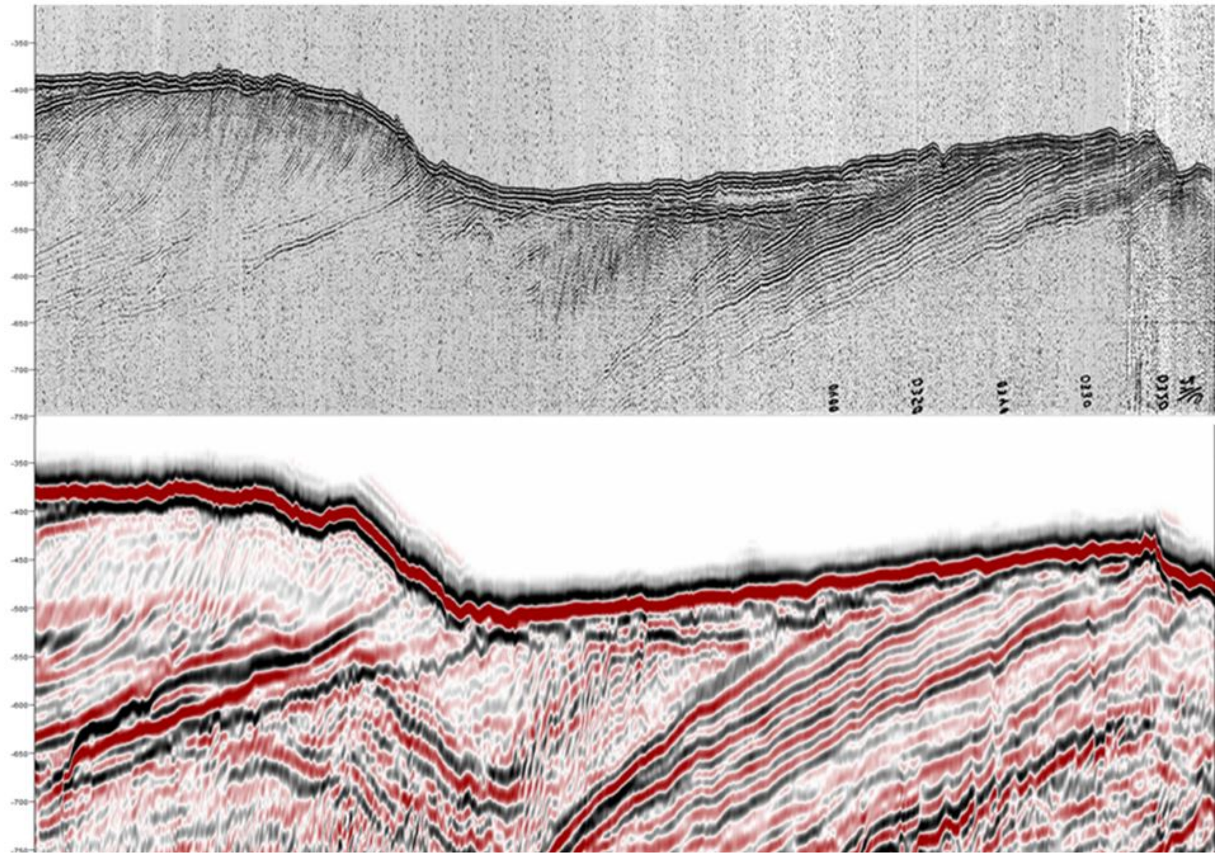

Fig. 4. The NW-SE sparker line B73-153 off mid Norway shown together with the parallel 2D line MND84NHR01 imaged in the same scale (lines ca. 500 m apart). The deltaic Molo Formation to the left. Note the thin Quaternary overburden.

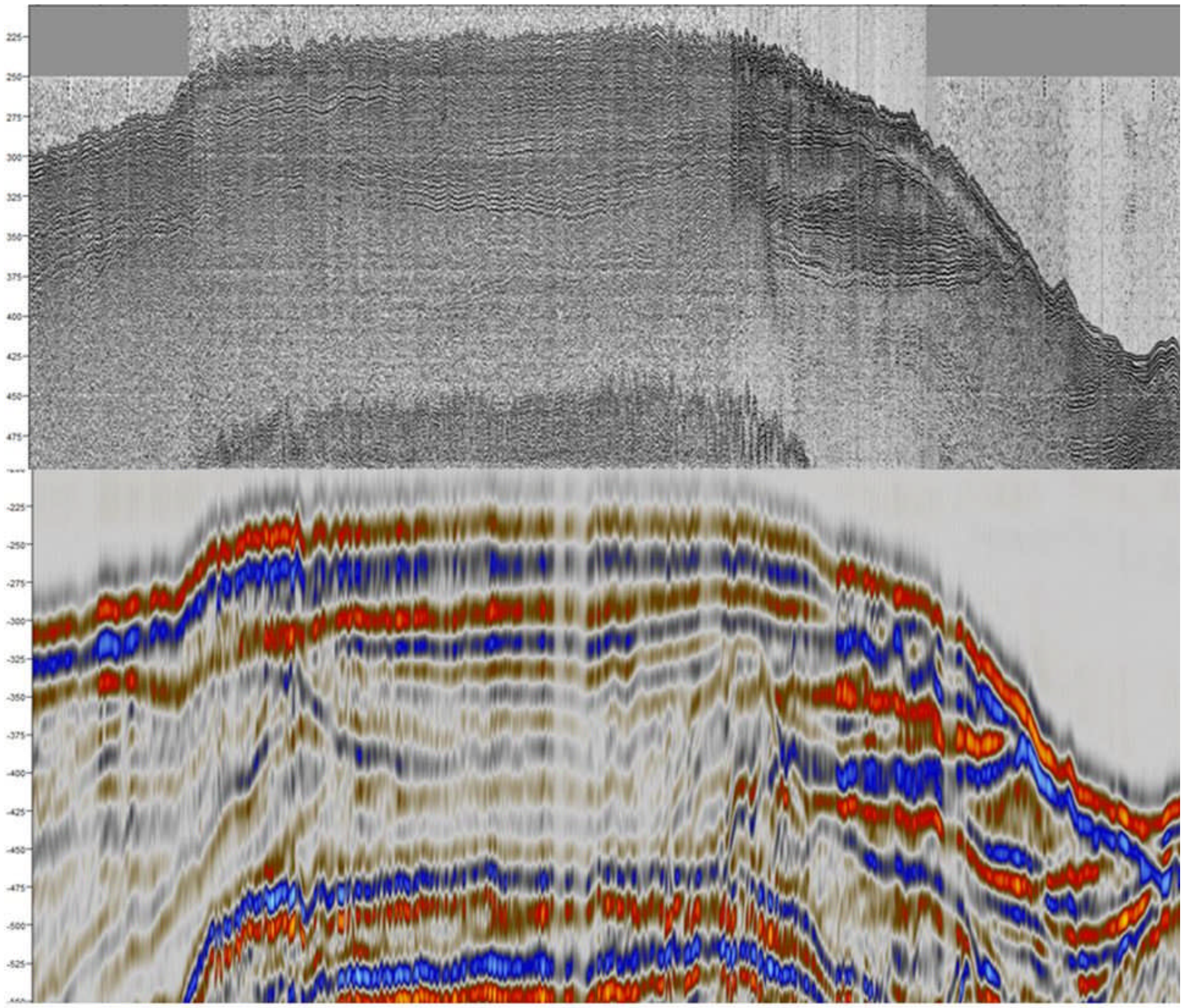

Fig. 5. Sparker line B75-141 (SE-NW) crossing Frøyryggen west of Frøya, here shown together with the parallel 2D line NPD-FB-84 (Mig Raw MB20-84) imaged in the same scale (lines ca. 300 m apart). The sparker line shows a thick Quaternary sequence comprising several units, but the base Quaternary is difficult to trace. Although the 2D line is of poor quality and low resolution, it was useful in order to "guide" the interpretation of base Quaternary (see Fig. 6).

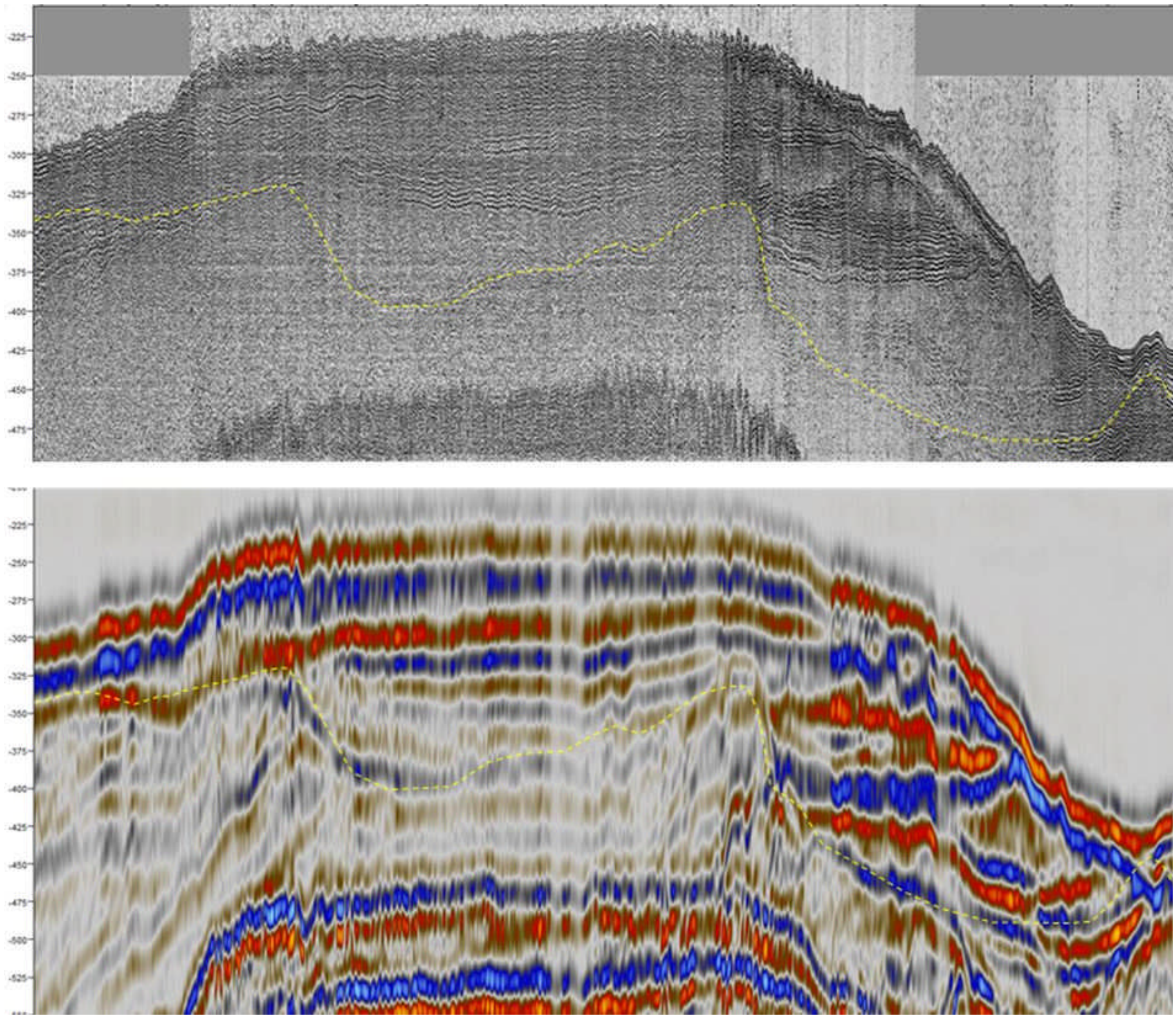

Fig. 6. Both sparker line B75-141 and the parallel 2D line of low resolution were useful in order to improve the interpretation base Quaternary (yellow stippled line).

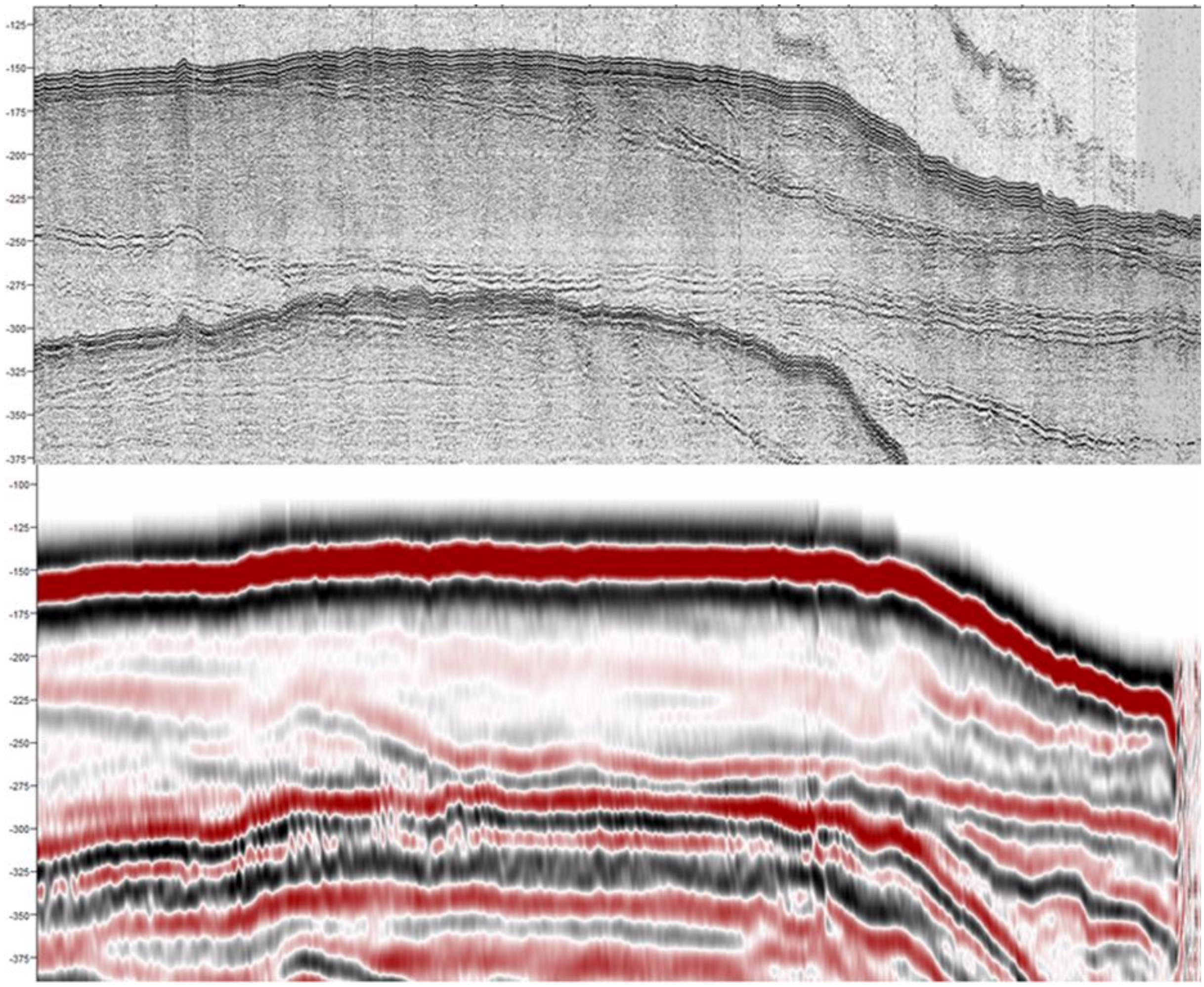

Fig. 7. Sparker line B74-112 located at the shallow northeastern part of Haltenbanken (SW to the left) shown together with the parallel 2D line MND84NHR01 16 (lines ca. 500 m apart). Note that the Quaternary stratigraphy is poorly imaged on the 2D line compared to the sparker. The Quaternary sediments are >100 m thick, and the top bedrock surface is hidden below the seabed multiple.

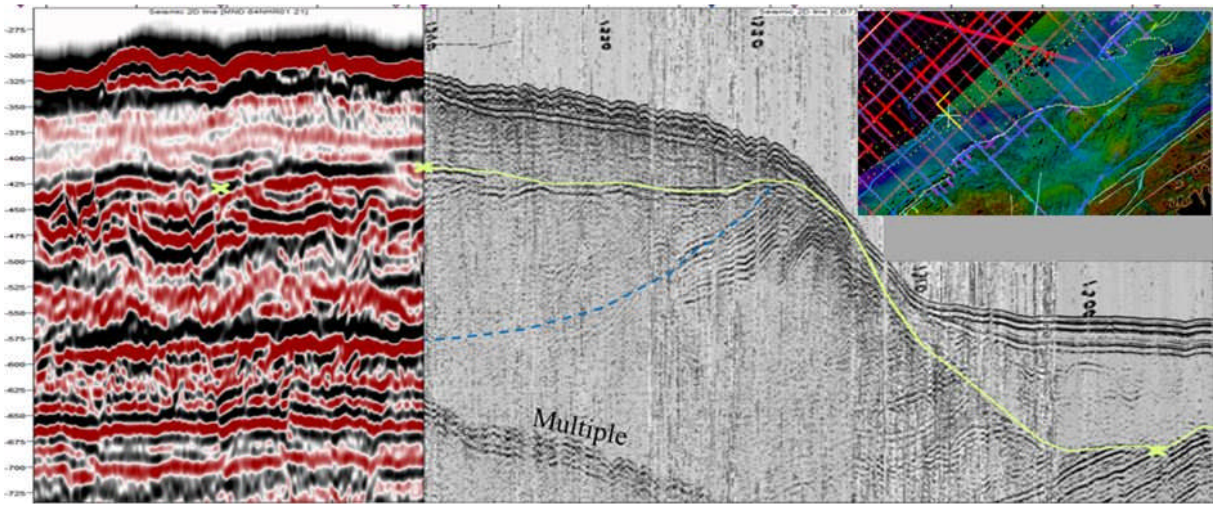

Fig. 8. Composite line showing B73-162 (SE-NW, see yellow line at inset map) and the 2D line MND84NHR01 21 in the perpendicular direction. Bedrock strata are truncated at base Quaternary (yellow line on IKU sparker). Note that the Quaternary appears as a very transparent unit on the 2D seismic, and that the uppermost layer also can be vaguely imagined. The westward continuation of the reflection which is marked with a stippled blue line is unclear from the sparker, but shows up as a very strong and characteristic reflection on the 2D line (possibly representing base Cretaceous).

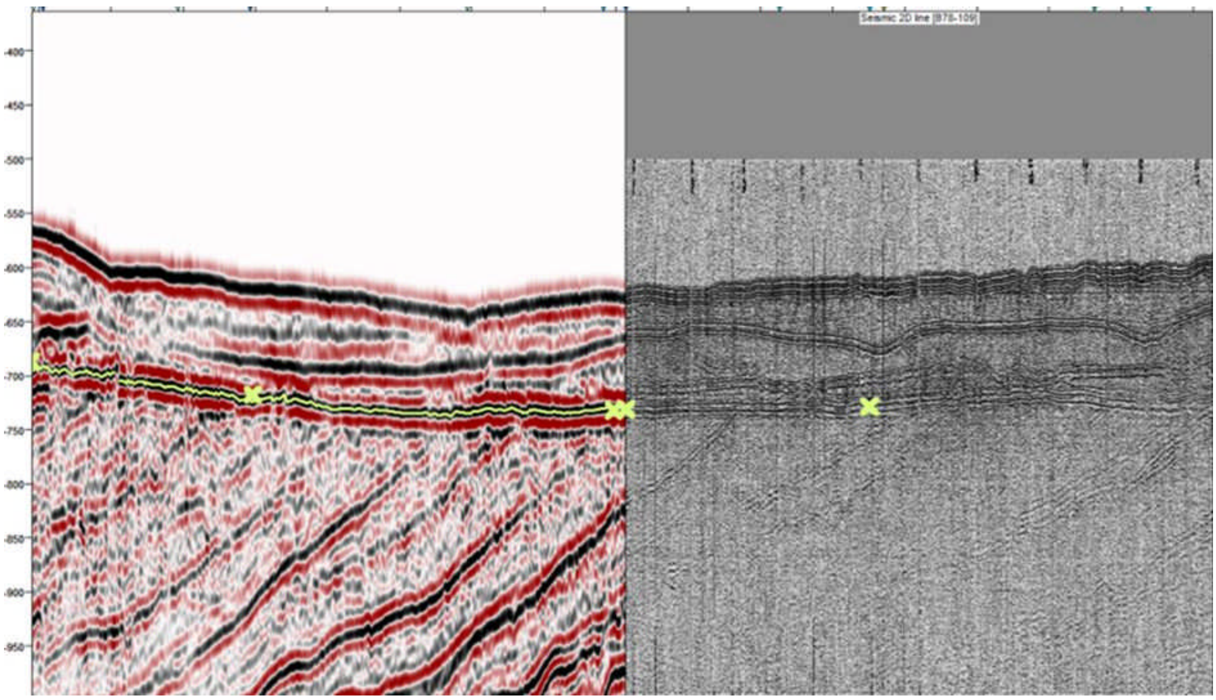

Fig. 9. Composite line off Helgeland showing B78-109 (E-W) and the 2D line ST8808-800.-000058 towards NW. The reflections line up very nicely. A lower Quaternary unit seen on the sparker line is difficult to trace on the 2D line, but most likely this unit pinches out towards NW.

8. SUMMARY OF WORK ACCOMPLISHED

The data included in this project were originally acquired in 17 different surveys in the period 1970-1984. 374 analogue sparker lines have been scanned, processed and transformed to SEG-Y format. The total length of survey lines is 31 261 kilometer (Table 2). Details for all processed lines are attached in Appendix 1, and the map in figure 3 shows the location of the lines.

Table 2. Summary of work done to transform analogue IKU sparker into SEG-Y format

Line prefix	# Lines	#Traces	Length (km)
C70	5	66 994	789,3
C71	3	13 171	166,8
C72	3	19 436	236,0
Q72	4	10 609	113,3
S72	11	69 529	876,7
V72	8	47 309	617,4
B73	37	278 927	2347,9
C74	32	167 347	1426,2
B74	32	176 063	1795,9
B75	28	236 928	1813,9
A76	3	42 248	310,9
AB76	6	106 414	789,9
B76	26	316 893	2404,9
A77	24	298 280	2559,6
AB77	1	7 685	63,2
B78	33	429 993	3752,1
C78	7	97 409	792,8
A79	9	103 972	966,0
B79	7	92 857	649,7
B81	31	438 029	4205,5
B82	46	420 485	4057,0
C84	18	67 458	525,7
Total	**374**	**3 508 036**	**31 260,7**

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APPENDIX 1. SPARDIG SUMMARY REPORT (IPGS-CNRS REPORT)

SPARDIG is a project initiated by NGU and supported by Det norske oljeselskap ASA, Lundin Norway AS and Statoil ASA to transform analogue sparker records into SEG-Y format to revitalize the legacy of shallow seismic data from the Norwegian continental shelf.

CNRS is collaborating to this project by converting paper rolls into (1) images and (2) SEG-Y files, according to a services contract signed between NGU and CNRS.

This report is a summary of the four period reports given to NGU (Spardig reports 01-04). A total of 374 Sparker lines (31 261 km) were processed and transformed to SEG Y format.

SUMMARY OF PERIOD OF WORK

During the 1st period (Oct 2014 - March 2015), we built and improved the processing workflow. We discussed with NGU to solve several problems encountered. First data delivery was provided to NGU.

During the 2nd period (March - August 2015), the first datasets (Shipment 1 from NGU) were returned to NGU and validated. We processed the next datasets sent in Shipment 2, and continued to improved our workflow.

During the 3rd period (September 2015 - March 2016), the datasets from Box 2 were returned to NGU and validated. Datasets of Box 3 were processed, validated ans returned to NGU. We started the work with the datasets of Box 4.

During the 4th period (April 2016 - October 2016), the datasets from Box 3 were returned to NGU and validated. Datasets of Boxes 4 and 5 were processed, validated and returned to NGU.

DATES/MILESTONES THROUGHOUT THE PROJECT

2014-10-13 : Contract between NGU and CNRS signed
2014-10-17: Receipt of box(see fig below) from NGU containing lines with the prefix B73 (38 rolls), B74 (32 rolls) and B75 (27 rolls). Note that the navigation files had the prefix B73, B74 and B75 and that this prefix have been used in Annex 1.

2014-11-01: Hiring of Marco-Bruce Raharimalala by CNRS
2014-12-01 : Steering committee at NGU, Trondheim

2015-04-03 : Receipt of 2nd box from NGU containing lines with the prefix A76, A77, A79, AB76, B76 (from Norskerenna).
2015-05-28&29 : Visit of Leif Rise and Shyam Chand to CNRS, IPGS, Strasbourg.
2015-07-07: Returned 1st box to NGU.
2015-08-26 : Receipt of 3rd box from NGU containing lines with the prefix B78 (32 rolls), B79 (9 rolls) and B81 (3 rolls).

2015-10-29 : Returned 2nd box to NGU.
2015-11-25 : 2nd steering committee at NGU, Trondheim.
2015-12-14 : Receipt of 4th box from NGU containing lines with the prefix B81 (21 rolls), B82 (41 rolls).
2016-03-29 : Returned 3rd box to NGU.

2016-06-13: Receipt of 5th box from NGU containing lines with prefix B82 (3 lines), V72 (8 lines), S72 (11 lines), C84 (16 lines), C74 (31 lines), Q72 (4 lines), C72 (3 lines), C71 (3 lines), C70 (5 lines), C78 (7 lines).
2016-07-13 : Visit of Leif Rise to CNRS, IPGS, Strasbourg
2016-09-08 : Returned 4th box to NGU.
2016-10-25 : Box 5 ready to return to NGU.

WORKFLOW

The main steps of the workflow are:

- scan (by parts) of the paper rolls to produce TIF images
- conversion of (parts of) the image of the seismic section in SEG-Y traces
- post-processing of the SEG-Y file correct time shifts, add navigation.

Details of the workflow are summarized below :

0. Inventory of shipment.
1. Digitisation of documents :
   - scan in 600 dpi Greyscale 8 bits (Contex scanner),
   - rotation 90° and fine rotation (Geometry),
   - selection of useful area (Display),
   - conversion in Greyscale 1bit (TypeMan),
   - naming and comments (Info),
   - save as TIF format (FileMan).

   Scanner windows has to be regularly checked and cleaned.

   Regular QC.
2. Conversion into SEG-Y traces (SeisTrans):

   Save in Seismic Unix .su format (SEG-Y without header blocks)

3. Post-processing

   3.0: merge of .su (1 per image) in one .su profile per line

   3.1: extract shots on GMT time lines; link to date&time

   3.2: interpolation of date&time for all shots; extraction of navigation from excel files

   3.3: creation of file shot - date&time - position

   3.4: correction od delay

   3.5: adding navigation information into trace headers

   3.6: write SEG-Y files

4. Reporting and statistics on the data.

After return to NGU, SEG-Y data have a quality control, and were loaded into Petrel software. This led to some additional corrections: mis-correction of the delay, and navigation corrections.

SUMMARY OF WORK ACCOMPLISHED

The table below shows the line prefixes applied during various surveys in the period 1970-1984. Number of lines and digitized traces as well as the length of processed lines are also shown. Table 1 in the report gives reference to the location of lines. Details are given in Annex 1.

Line prefix	# Lines	#Traces	Length (km)
C70	5	66 994	789.3
C71	3	13 171	166.8
C72	3	19 436	236.0
Q72	4	10 609	113.3
S72	11	69 529	876.7
V72	8	47 309	617.4
B73	37	278 927	2 347.9
C74	32	167 347	1 426.2
B74	32	176 063	1 795.9
B75	28	236 928	1 813.9
A76	3	42 248	310.9
AB76	6	106 414	789.9
B76	26	316 893	2 404.9
A77	24	298 280	2 559.6
AB77	1	7 685	63.2
B78	33	429 993	3 752.1
C78	7	97 409	792.8
A79	9	103 972	966.0
B79	7	92 857	649.7
B81	31	438 029	4 205.5
B82	46	420 485	4 057.0
C84	18	67 458	525.7
Total	**374**	**3 508 036**	**31 260.7**

Annex1 : Summary of processed lines

Cruise NTNF 1970

Line prefix	#Traces	Length (km)
C70-4	4 916	58.9
C70-5	14 006	153.3
C70-6	12 363	116.0
C70-7	18 018	230.3
C70-8	17 691	230.8
C70: 5 lines	**66 994**	**789.3**

Cruise NTNF 1971

Line prefix	#Traces	
C71-16	3 517	48.1
C71-2	7 943	96.4
C71-3	1 711	22.3
C71: 3 lines	**13 171**	**166.8**

Cruises IKU 7205/7206

Line prefix	#Traces	Length (km)
C72-2	5 510	73.0
C72-4	12 517	146.2
C72-5	1 409	16.8

C72: 3 lines	**19 436**	**236.0**

Line prefix	#Traces	Length (km)
Q72-15	4 341	42.5
Q72-16	2 649	28.0
Q72-17	1 852	21.7
Q72-18	1 767	21.1
Q72: 4 lines	**10 609**	**113.3**

Line prefix	#Traces	Length (km)
S72-1	3 214	39.1
S72-2	2 108	25.9
S72-3	1 513	19.1
S72-4	2 017	26.7
S72-5	2 161	34.0
S72-6	3 075	39.3
S72-7	3 309	46.8
S72-8	4 370	58.2
S72-9	21 901	232.3
S72-10	4 610	58.9
S72-11	21 251	296.4

S72: 11 lines	**69 529**	**876.7**

Line prefix	#Traces	Length (km)
V72-1	5 044	60.7
V72-2	13 740	178.8
V72-3	1 473	20.1
V72-4	2 349	31.0
V72-5	3 000	37.3
V72-6	4 379	58.6
V72-7	3 829	49.5
V72-8	13 495	181.4
V72: 8 lines	**47 309**	**617.4**

Cruise IKU 7303/7304

Line prefix	#Traces	Length (km)
B73-104	15 614	137.1
B73-105	6 013	49.9
B73-106A	17 024	126.6
B73-106	10 003	90.5
B73-108-D	9 182	60.5
B73-109	5 531	46.9
B73-110	19 361	134.9

B73-111-A	16 462	131.5
B73-111	7 755	59.7
B73-112A	12 493	115.8
B73-112B	5 098	48.2
B73-113	12 017	112.5
B73-119	2 459	19.4
B73-120	4 190	42.6
B73-122	6 863	66.8
B73-128	5 072	41.5
B73-130	4 969	47.2
B73-131	4 699	42.5
B73-133	3 493	34.5
B73-135	4 092	37.9
B73-137	4 160	37.3
B73-140	3 494	34.1
B73-141	4 597	38.0
B73-143	4 600	41.6
B73-145	6 961	65.5
B73-147	6 323	59.9
B73-149	6 237	58.4
B73-151-2	6 387	54.5
B73-151	2 281	20.1
B73-153-2	5 342	37.9

B73-153	3 079	24.4
B73-155	6 691	62.6
B73-157	11 759	13.3
B73-159	6 930	69.1
B73-161	6 612	62.7
B73-162	13 418	99.2
B73-169	7 666	72.0
B73: 37 lines	**278 927**	**2 347.9**

Cruise IKU 7410/7412

Line prefix	#Traces	Length (km)
C74-100	3 772	30.6
C74-106	8 266	59.8
C74-107	4 353	34.2
C74-108	5 857	55.2
C74-109	7 398	63.8
C74-110	7 550	69.7
C74-111	10 232	80.3
C74-112	10 243	74.6
C74-128	3 839	29.5
C74-130	1 119	7.9
C74-132	2 136	15.4
C74-134	1 153	8.4

C74-135	8 837	92.6
C74-136	2 753	21.3
C74-138	9 711	76.3
C74-139	4 610	48.2
C74-140	9 243	83.6
C74-141	12 295	87.2
C74-142	6 252	63.2
C74-143	1 546	15.0
C74-144	1 880	20.5
C74-145	1 203	13.8
C74-146	2 516	18.4
C74-147	4 438	42.5
C74-148	1 810	14.8
C74-150	2 765	22.0
C74-152	10 239	86.3
C74-153A	1 945	13.1
C74-153	12 036	108.4
C74-156	2 686	26.2
C74-157	1 475	14.1
C74-159	3 189	29.3
C74: 32 lines	**167 347**	**1 426.2**

Line prefix	#Traces	Length (km)
B74-102	3 357	33.6
B74-103	6 192	65.8
B74-104	12 795	145.3
B74-105	3 682	35.1
B74-108	4 797	41.5
B74-109	9 065	97.1
B74-110	8 430	91.1
B74-111	8 591	91.9
B74-112	5 396	56.4
B74-113	1 566	14.2
B74-114	1 875	18.7
B74-115	4 137	42.3
B74-116	2 754	29.1
B74-117	1 527	15.1
B74-118	2 277	20.8
B74-119	1 138	11.3
B74-120	7 545	76.9
B74-121	1 298	11.3
B74-122	1 271	12.0
B74-123	1 252	13.9
B74-124	2 252	22.5
B74-130	3 401	29.2

B74-133	7 295	66.7
B74-136	8 166	76.8
B74-139	8 968	99.2
B74-143	6 515	68.9
B74-144	8 188	83.6
B74-147	9 516	99.8
B74-150	11 471	112.1
B74-153	12 573	121.3
B74-162	6 306	64.5
B74-169	2 467	27.9
B74: 32 lines	**176 063**	**1 795.9**

Cruise IKU 7510

Line prefix	#Traces	Length (km)
B75-105	4 953	39.7
B75-106	24 428	133.1
B75-107A	11 368	85.8
B75-107	3 390	28.9
B75-108	11 486	90.3
B75-109	8 265	78.2
B75-110	8 072	59.6
B75-111	4 576	43.0
B75-112	9 234	98.9

B75-113	7 615	68.0
B75-114A	5 417	47.8
B75-114B	4 928	36.8
B75-115	10 606	91.0
B75-116	11 241	92.9
B75-117	11 583	93.6
B75-118	16 361	106.4
B75-119	10 559	67.0
B75-131	2 077	6.3
B75-132	2 833	22.5
B75-141	8 780	79.5
B75-142	2 214	20.6
B75-143	6 360	45.1
B75-151	15 505	134.6
B75-152-1	18 708	117.4
B75-152-2	10 214	76.2
B75-152C	3 436	26.4
B75-155	1 674	15.9
B75-157	1 045	8.4
B75: 30 lines	**236 928**	**1 813.9**

Cruise IKU 7610

Line prefix	#Traces	Length (km)
A76-110	10 899	81.5
A76-118	12 849	82.8
A76-119	18 500	146.6
A76: 3 lines	**42 248**	**310.9**

Line prefix	#Traces	Length (km)
AB76-126	21 397	160.4
AB76-127	11 485	110.2
AB76-128	15 809	131.2
AB76-129	12 269	108.0
AB76-130	24 834	122.6
AB76-131	20 620	157.5
AB76: 6 lines	**106 414**	**789.9**

Line prefix	#Traces	Length (km)
B76-101	14 372	96.4
B76-102	3 618	29.5

B76-103	12 061	97.2
B76-104	25 979	195.4
B76-105A	13 135	103.2
B76-105	7 277	55.6
B76-106A	10 426	97.6
B76-106	10 324	93.1
B76-107	25 606	181.4
B76-108	10 269	84.8
B76-109	11 805	83.1
B76-113	27 757	215.0
B76-114	3 555	37.4
B76-115	19 503	145.4
B76-116	13 641	95.0
B76-117	10 161	91.2
B76-128	10 063	58.8
B76-150	25 555	177.9
B76-155	16 011	122.5
B76-157	13 644	105.5
B76-159	11 336	90.6
B76-201	5 017	26.9
B76-202	4 657	34.7
B76-203	6 146	40.5
B76-204	682	6.1

B76-205	4 293	40.1
B76: 26 lines	**316 893**	**2 404.9**

Cruise IKU 7710

Line prefix	#Traces	Length (km)
A77-108	10 192	92.6
A77-109	10 858	89.5
A77-110	9 409	83.9
A77-111A	14 056	110.8
A77-111B	2 853	19.8
A77-111	3 276	27.8
A77-112	18 640	148.7
A77-113	17 456	148.6
A77-114	20 312	145.7
A77-115	20 623	146.3
A77-116	16 069	149.8
A77-117	14 664	148.7
A77-118	6 791	65.5
A77-120A	7 679	55.6
A77-120B	4 366	39.0
A77-120	3 339	26.9
A77-121	16 131	153.7
A77-122	16 893	154.0

A77-123	18 949	151.5
A77-124	13 946	158.4
A77-125	14 750	162.4
A77-152	13 502	92.6
A77-154	11 932	94.5
A77-155	11 594	93.3
A77: 24 lines	**298 280**	**2 559.6**

Line prefix	**#Traces**	**Length (km)**
AB77-150	7 685	63.2
AB77: 1 line	**7 685**	**63.2**

Cruise IKU 7810

Line prefix	**#Traces**	**Length (km)**
B78-100	2 711	24.4
B78-101A	9 119	68.1
B78-101	5 686	49.6
B78-102B	2 457	23.6
B78-102	19 311	144.1
B78-103B	15 555	153.2
B78-103	4 428	41.4
B78-104	24 507	212.3

B78-105	26 487	225.6
B78-106A	2 381	23.5
B78-106	25 979	228.5
B78-107	26 021	243.4
B78-108	27 917	248.1
B78-109	30 136	244.5
B78-110	28 032	254.4
B78-111	27 434	251.9
B78-112	27 401	252.4
B78-113A	3 687	30.2
B78-113B	7 096	59.2
B78-113C	2 189	20.0
B78-113D	2 617	23.4
B78-201	13 956	102.2
B78-202	11 382	101.5
B78-203	11 999	113.3
B78-204A	1 971	15.4
B78-204	5 239	46.0
B78-205	5 482	51.9
B78-207	15 728	125.5
B78-208	14 736	130.3
B78-209	15 091	133.8
B78-210	10 869	90.5

B78-211A	2 389	19.9
B78: 32 lines	**429 993**	**3 752.1**

Line prefix	#Traces	Length (km)
C78-115	6 949	56.0
C78-201	15 156	120.4
C78-202	16 290	127.6
C78-203	15 715	130.3
C78-204	13 558	118.7
C78-205	15 641	118.6
C78-206	14 100	121.2
C78: 7 lines	**97 409**	**792.8**

Cruise IKU 7910/7911

Line prefix	#Traces	Length (km)
A79-130	8 024	59.8
A79-201	12 064	127.1
A79-202	12 130	126.9
A79-203	12 390	125.7
A79-204	11 860	115.3
A79-205	12 998	116.2
A79-206	13 511	114.6

A79-207	9 784	89.8
A79-208	11 211	90.6
A79: 9 lines	**103 972**	**966,0**

Line prefix	#Traces	Length (km)
B79-101	18 431	117.3
B79-102	14 439	115.3
B79-103	16 795	121.4
B79-104A	14 683	102.1
B79-104	5 868	44.0
B79-105	12 907	93.1
B79-106	9 734	56.5
B79: 7 lines	**92 857**	**649,7**

Cruise IKU 8110

Line prefix	#Traces	Length (km)
B81-106B	2 597	24.9
B81-113A	19 156	172.1
B81-113	4 024	38.1
B81-114	24 007	250.4
B81-115	25 820	252.2
B81-116	24 295	260.4

B81-117B	21 097	178.9
B81-117	8 934	82.3
B81-118A	7 426	76.3
B81-118	17 887	167.7
B81-119A	10 877	101.6
B81-119	12 776	126.5
B81-120	23 765	227.3
B81-121	22 546	211.6
B81-122	20 812	199.3
B81-123	21 079	210.8
B81-124	21 413	204.8
B81-125A	10 151	99.6
B81-125B	2 833	24.8
B81-125	3 844	34.3
B81-204	16 725	159.1
B81-205	18 928	182.4
B81-206	26 408	236.8
B81-207	12 361	124.2
B81-208B	3 644	33.1
B81-208	10 152	89.7
B81-209	11 931	118.7
B81-210	13 007	120.5
B81-211	11 741	122.5

B81-212	5 384	52.2
B81-213	2 409	22.4
B81: 31 lines	**438 029**	**4 205.5**

Cruise IKU 8210

Line prefix	#Traces	Length (km)
B82-119B	3 870	33.9
B82-120B	5 384	39.9
B82-121B	6 223	53.6
B82-122B	5 380	56.9
B82-123B	7 165	74.2
B82-124B	7 901	78.1
B82-126A	9 436	94.9
B82-126	11 774	117.0
B82-127	21 732	204.3
B82-128A	12 510	115.9
B82-128	10 637	94.6
B82-129	10 008	99.4
B82-130B	9 469	99.0
B82-130	11 535	93.3
B82-131B	10 116	103.8
B82-131	8 363	92.9

B82-132B	9 970	103.2
B82-132	11 127	101.6
B82-133B	9 830	104.1
B82-133	9 768	95.5
B82-134B	7 717	74.1
B82-134	9 246	97.4
B82-135B	6 391	66.5
B82-135	8 597	69.2
B82-136B	7 373	69.7
B82-136	8 227	69.1
B82-137B	6 643	66.9
B82-137	6 544	62.5
B82-138	7 315	73.5
B82-139	5 762	59.7
B82-140	6 931	56.6
B82-141	6 342	64.9
B82-142	4 216	39.7
B82-143	2 487	27.7
B82-207	4 051	44.8
B82-208	6 547	68.5
B82-209	10 779	113.9
B82-210	13 950	142.0
B82-211B	15 398	132.7

B82-211	14 929	164.5
B82-212B	11 910	106.5
B82-212	4 295	40.2
B82-214	11 439	89.5
B82-215B	6 910	74.4
B82-215	18 051	177.8
B82-216	16 237	148.6
B82: 46 lines	**420 485**	**4 057.0**

Cruise IKU Geoteam 84

Line prefix	#Traces	Length (km)
C84-301	4 351	34.1
C84-303	4 066	34.4
C84-3041	3 041	22.2
C84-30421	1 399	9.2
C84-3042	1 738	12.6
C84-305	5 095	42.6
C84-306	5 530	43.9
C84-308	4 980	38.8
C84-309	4 759	37.4
C84-310	4 514	38.4
C84-3121	3 679	27.1
C84-3122	2 413	18.1

C84-313	5 309	47.1
C84-3152	4 316	33.2
C84-318	6 269	41.9
C84-319	2 360	13.8
C84-3521	2 069	15.8
C84-363	1 570	15.1
C84: 18 lines	**67 458**	**525.7**

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