DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 2004/37

# Seismic Experiments at Glyvursnes June - December 2003
# Aquisition report

Contribution to the SeiFaBa project
funded by the Sindri Group

Morten S. Andersen (UFI/GEUS), Michael Worthington (OU),
Nick Mohammed, Robert S. White (CU)
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# Contents

# Introduction

In 2003 Cambridge University, Oxford University and the University of the Faroe Islands acquired seismic data on and around Glyvursnes, the Faroe Islands. The data were acquired as part of a larger project addressing the petrophysic and seismic properties of Faroes basalts. The SeiFaBa Project, sponsered by the Sindri Group.

Data were acquired for four different experiments, which in combination with analysis of the logs from the and petrophysical analyses of plugs from the core from the Glyvursnes-1 borehole provide a unique dataset for detailed analysis of seismic wave propagation through the Faroese basalts at different scales. The data acquired are:

VSP, offset VSP's and multilevel offset VSP's (June-July 2003)

Surface seismic reflection data (September 2003)

Wide-angle multi-channel seismic data for investigation of lateral anisotropy using both high resolution geophones and autonomous seismometers for the recording (September 2003)

Broadband data for seismic tomography (June-December 2003)

This report covers the acquisition of seismic data at Glyvursnes in June-July and September 2003. The main report provides the crucial facts about the VSP experiments carried out in June-July 2003 and the high resolution surface seismic experiments carried out in September 2003. Details concerning recording with the autonomous seimometers (Guralp 6TD's) are provided in a separate report "Sindri: Petrophysical and seismic properties of Faroese basalts, 6TD Technical Field Report" included as an appendix to the main report:

Autonomous_seismometers_report_and_site_info\6TD_faroe_2004_final_report.pdf

Detailed information needed for further work with the data is included in the digital appendixes to this report.

# General information

The survey area is the Glyvursnes south of Tórshavn, the Faroe Islands, and the neighbouring part of Nolsoya Fjorð (Figs 2 and 3). It is centred around the Glyvursnes-1 well with the geographical co-ordinates (WGS-84):
51° 58’ 57.94” N, 6° 44’ 35.56” W, altitude 16.5 m (top of casing)
For mapping purpose we use UTM co-ordinates, zone 29 with reference to WGS-84
Easting(X): 618254, northing(Y): 6874316, altitude(Z): 16.5 m

Other fixed installations:
Streamer winch: Easting(X): 618244, northing(Y): 6874413, altitude(Z): 3.1
VSP pit positions,
Zero offset: Easting(X): 618242, northing(Y): 6874307, altitude(Z): 19
242m offset: Easting(X): 618254, northing(Y): 6874973, altitude(Z): 46.5
415 m offset: Easting(X): 618281, northing(Y): 6873901, altitude(Z): 50.5

Detailed survey data for VSP pit positions are in file
VSP_observer_logs_and_position_data\VSP_pos.xls


**Figure 1.** *Overview of survey area. Key to symbols: Red cross: autonomous seismometers; blue lines (onshore): geophone strings for vertical component reflection seismic profiles; red lines geophone strings for mixed 1C and 3C onshore-offshore seismic profiles; red lines offshore: approximate streamer positions during onshore-off seismic experiments; yellow and green crosses shot positions for two suites of marine reflection profiles with lateral offsets.*

## Timing

The experiments were co-ordinated so that any shot could be used in most or all of the experiments above. This required that all shots were shot at a precisely known time. The GPS time signals were used as the common reference. The shots were triggered at GPS minute signals, and the GPS time code were recorded by the surface seismic and VSP recording units.
For the VSP data, the GPS time code is recorded on channel 5. For the surface seismic data, the GPS time code is recorded on channel 121 (when only onshore data are recorded) or channel 217 (when both onshore and offshore data are recorded).

## Positions and distances

As we are working within a fairly small area and want to calculated seismic velocities with high accuracy. Positioning has to be of consistent and of high precision. All positions are thus logged as co-ordinates in UTM zone 29 using the WGS-84 reference system. As far as possible positions were measured with a differential GPS using a local reference station operated by Landsverkfrøðingurin, which was set up for this purpose. The precision is thus significantly better than 0.25 m (two measurements of the position of the top of the casing in Glyvursnes-1 was all within 0.05 m). The position of the gunboat and the position of the tail of the streamer were measured using standard mobile differential GPS system (Astech G12 GPS + Shipmate RS5660 on the gun boat and Astech BR2G at the tail of the streamer). As the height relative to the geoid is well known, these systems provide an accuracy of ca. 1-2 m.
The position of individual streamer groups can be determined either from the know positions of the two ends of the streamer or relatively to the gun boat using the arrival time for the direct arrival of individual shots, which provide the most stable solution is yet to be decided.
Copies of files with positional data for geophones, seismometers and dynamite shots are found as digital appendixes as directory
Multichannel_observers_logs_and_positiondata\positions.onshore.seismic.reflection\.
Copies of files with the logged shot positions and streamer-tail position for the marine part of the experiments are found in the directories
Multichannel_observers_logs_and_positiondata\NavipackGunboat\ and
Multichannel_observers_logs_and_positiondata\NavipackTugboat\.
Table 1 provides a key to combining the diverse files with positional data for the multichannel seismic data.

**Table 1.** *List of acquired multichannel seismic data and navigation files*.

| File name | Line name, reflection profiles | rec. stat. | Shots | date | Layout | | Position files | | | Orientation |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | geoph. | Streamer | Geophones | Streamer tail | gun shot | |
| Gax.sgy | - | 80 | 24 | 16-09-03 | ga | - | gp_GA_UTM.dat | - | 030916C006.npd | 200° |
| gax200.sgy | - | 80 | 32 | 16-09-03 | ga | - | gp_GA_UTM.dat | - | 030916C011.npd | 270° |
| gax201.sgy | - | 80 | 16 | 16-09-03 | ga | - | gp_GA_UTM.dat | - | 030916C012.npd | 90° |
| gax202.sgy | - | 80 | 19 | 16-09-03 | ga | - | gp_GA_UTM.dat | - | 030916C016.npd | 247° |
| gax300.sgy | - | 80 | 28 | 17-09-03 | ga | - | gp_GA_UTM.dat | - | 030917C005.npd | Arc 800 m |
| gax301.sgy | - | 80 | 28 | 17-09-03 | ga | - | gp_GA_UTM.dat | - | 030917C010.npd | Arc 600 m |
| gax302.sgy | - | 80 | 29 | 17-09-03 | ga | - | gp_GA_UTM.dat | - | 030917C011.npd | Arc 1000 m |
| Gax401.sgy | - | 80 | 64 | 17-09-03 | ga | - | gp_GA_UTM.dat | - | 030917C008.npd | 21° |
| gax402.sgy | - | 80 | 43 | 18-09-03 | ga | - | gp_GA_UTM.dat | - | 030918C003.npd | 62.2° |
| gax402a.sgy | - | 80 | 43 | 18-09-03 | ga | - | gp_GA_UTM.dat | - | 030918C005.npd | 341° |
| gax403.sgy | - | 80 | 43 | 18-09-03 | ga | - | gp_GA_UTM.dat | - | 030918C006.npd | 221° |
| gax404.sgy | - | 80 | 25 | 18-09-03 | ga | - | gp_GA_UTM.dat | - | 030918C007.npd | 311° |
| gax405.sgy | - | 80 | 26 | 18-09-03 | ga | - | gp_GA_UTM.dat | - | 030918C012.npd | |
| gax406.sgy | - | 80 | 27 | 18-09-03 | ga | - | gp_GA_UTM.dat | - | 030918C015.npd | |
| gax407.sgy | - | 80 | 27 | 18-09-03 | ga | - | gp_GA_UTM.dat | - | 030918C016.npd | |
| Gax408.sgy | - | 80 | 16 | 18-09-03 | ga | - | gp_GA_UTM.dat | - | 030918C017.npd | |
| Gax409.sgy | - | 80 | 22 | 18-09-03 | ga | - | gp_GA_UTM.dat | - | 030918C018.npd | 313° |
| Gax410.sgy | - | 80 | 8 | 18-09-03 | ga | - | gp_GA_UTM.dat | - | 030918C020.npd | 180° |
| gax411.sgy | - | 80 | 72 | 18-09-03 | ga | - | gp_GA_UTM.dat | - | 030918C021.npd | 21° |
| gax412.sgy | - | 80 | 20 | 18-09-03 | ga | - | gp_GA_UTM.dat | - | 030918C022.npd | 124° |
| gax413.sgy | - | 80 | 42(36) | 18-09-03 | ga | - | gp_GA_UTM.dat | - | 030918C023.npd | 230° |
| gax414.sgy | - | 80 | 34 | 18-09-03 | ga | - | gp_GA_UTM.dat | - | 030918C024.npd | 330° |
| gax50.sgy | - | 80 | 41 | 17-09-03 | ga | - | gp_GA_UTM.dat | - | 030917C009.npd | 201° |
| gbx500.sgy | - | 80 | 43 | 19-09-03 | gb | ga-ext (312m) | gp_GB_UTM.dat | 030919C002.nvd | 030920C000.npd | 180° |
| gbx501.sgy | gbx-501 | 128 | 152 | 19-09-03 | gb | ga-ext (312m) | gp_GB_UTM.dat | | 030920C002.npd | 200° |
| gbx502.sgy | gbx-502 | 128 | 96 | 19-09-03 | gb | ga-ext (312m) | gp_GB_UTM.dat | | 030920C003.npd | 21° |
| Gbx503.sgy | - | 128 | 29 | 19-09-03 | gb | ga-ext (312m) | gp_GB_UTM.dat | | 030920C004.npd | 199° |
| gbx504.sgy | - | 128 | 44 | 19-09-03 | gb | ga-ext (312m) | gp_GB_UTM.dat | | 030920C005.npd | 200° |
| gbx505.sgy | - | 176 | 30(24) | 19-09-03 | gb | ga-ext (625m) | gp_GB_UTM.dat | | 030920C006.npd | |
| gbx505a.sgy | - | 176 | 24(26) | 19-09-03 | gb | ga-ext (625m) | gp_GB_UTM.dat | | 030920C008.npd | Arc 1100 m |
| gbx506.sgy | - | 176 | 17(??) | 19-09-03 | gb | ga-ext (625m) | gp_GB_UTM.dat | | 030920C009.npd | 160° |
| gbx507.sgy | - | 176 | 28 | 19-09-03 | gb | ga-ext (625m) | gp_GB_UTM.dat | | 030920C010.npd | 190° |
| gbx508.sgy | - | 176 | 18 | 19-09-03 | gb | ga-ext (625m) | gp_GB_UTM.dat | | 030920C011.npd | 190° |

*continues on next page*

**Table1.** *List of acquired multichannel seismic data and navigation files. (continued from previous page).*

| Seismic File name | Line name, reflection profiles | rec. stat. | Shots | date | Layout | | Position files | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | geoph. | Streamer | Geophones | Dynamite Shots | Streamer tail | gun shot | Orientation |
| gbx600.sgy | - | 80 | 58 | 20-09-03 | gb | gb-ext(625) | gp_GB_UTM.dat | - | 030920C000.nvd | 030921C003.npd | 340° |
| gbx601.sgy | gbx-601 | 176 | 14 | 20-09-03 | gb | gb-ext(625) | gp_GB_UTM.dat | - | | 030921C005.npd | 160° |
| gbx602.sgy | gbx-602 | 176 | 60 | 20-09-03 | gb | gb-ext(625) | gp_GB_UTM.dat | - | | 030921C007.npd | 340° |
| gbx603.sgy | gbx-603 | 176 | 90 | 20-09-03 | gb | gb-ext(625) | gp_GB_UTM.dat | - | | 030921C008.npd | 160° |
| gbx604.sgy | gbx-604 | 176 | 64 | 20-09-03 | gb | gb-ext(625) | gp_GB_UTM.dat | - | | 030921C009.npd | 340° |
| Gbx605.sgy | gbx-605 | 176 | 62 | 20-09-03 | gb | gb-ext(625) | gp_GB_UTM.dat | - | | 030921C010.npd | 160° |
| Gbx606.sgy | gbx-606 | 176 | 71 | 20-09-03 | gb | gb-ext(625) | gp_GB_UTM.dat | - | | 030921C011.npd | 340° |
| Gbx607.sgy | - | 176 | 59 | 20-09-03 | gb | gb-ext(625) | gp_GB_UTM.dat | - | | 030921C012.npd | 160° |
| Gbx608.sgy | - | 176 | 4 | 20-09-03 | gb | gb-ext(625) | gp_GB_UTM.dat | - | | 030921C013.npd | 340° |
| gbxdyn.sgy | gb/gbx-dyn | 176 | 7 | 20-09-03 | gb | gb-ext(625) | gp_GB_UTM.dat | - | | - | |
| Gcx700.sgy | - | 80 | 216 | 21-09-03 | gc | - | gp_GC_UTM.dat | - | - | 030922C007.npd | 75° |
| Gcx701.sgy | - | 80 | 81 | 21-09-03 | gc | - | gp_GC_UTM.dat | - | - | 030922C008.npd | Arc 400 m |
| gcx702.sgy | - | 80 | 32 | 21-09-03 | gc | - | gp_GC_UTM.dat | - | - | 030922C010.npd | 75° |
| gcx703.sgy | - | 80 | 36 | 21-09-03 | gc | - | gp_GC_UTM.dat | - | - | 030922C011.npd | Arc 800 m |
| Seifaba_1 | Seifaba_1 | 120 | 25 | 04-09-03 | S-1 | - | gp_S1_UTM.txt | ep_S1_UTM.dat | - | - | |
| Seifaba_1(A) | Seifaba_1 | 120 | 12 | 04-09-03 | S-1 | - | | | - | - | 160° |
| Seifaba_2 | Seifaba_2 | 120 | 1 | 05-09-03 | S-2 | - | gp_S2_UTM.txt | ep_S2_UTM.dat | - | - | |
| Seifaba_2(A) | Seifaba_2 | 120 | 31 | 05-09-03 | S-2 | - | | | - | - | 70° |
| Seifaba_3W | Seifaba_3W_mid | 48 | 12 | 06-09-03 | S-3Wb | - | gp_S3Wb_UTM.txt | ep_SW3_UTM.dat | - | - | 160°, offset/50 |
| Seifaba_3W | Seifaba_3W_near | 48 | 12 | 06-09-03 | S-3Wa | - | gp_S3Wa_UTM.txt | | - | - | 160°, offset/25 |
| Seifaba_3W | Seifaba_3W_far | 24 | 12 | 06-09-03 | S-3Wc | - | gp_S3Wc_UTM.txt | | - | - | 160°, offset/75 |
| Seifaba_4W | Seifaba_4W_far | 48 | 12 | 06-09-03 | S-4Wc | - | gp_S4Wc_UTM.txt | ep_SW4_UTM.dat | - | - | 160°, offset/75 |
| Seifaba_4W | Seifaba_4W_mid | 48 | 12 | 06-09-03 | S-4Wa | - | gp_S4Wa_UTM.txt | | - | - | 160°, offset/50 |
| Seifaba_4W | Seifaba_4W_near | 24 | 12 | 06-09-03 | S-4Wb | - | gp_S4Wb_UTM.txt | | - | - | 160°, offset/25 |
| Seifaba_5W | Seifaba_5W_mid | 48 | 12 | 08-09-03 | S-5Wb | - | gp_S5Wb_UTM.txt | ep_SW5_UTM.dat | - | - | 160°, offset/50 |
| Seifaba_5W | Seifaba_5W_near | 48 | 12 | 08-09-03 | S-5Wa | - | gp_S5Wa_UTM.txt | | - | - | 160°, offset/25 |
| Seifaba_5W | Seifaba_5W_far | 24 | 12 | 08-09-03 | S-5Wc | - | gp_S5Wc_UTM.txt | | - | - | 160°, offset/75 |
| Seifaba_5W | Seifaba_5Wx_mid | 48 | 12 | 08-09-03 | S-5Wb | - | gp_S5Wb_UTM.txt | | - | - | 160°, offset/50-325 |
| Seifaba_5W | Seifaba_5Wx_near | 48 | 12 | 08-09-03 | S-5Wa | - | gp_S5Wa_UTM.txt | | - | - | 160°, offset/25-300 |
| Seifaba_5W | Seifaba_5Wx_far | 24 | 12 | 08-09-03 | S-5Wc | - | gp_S5Wc_UTM.txt | | - | - | 160°, offset/75-350 |

Notes:

Positions of geophones and dynamite shots are found as digital appendixes in the directory Multichannel_observers_logs_and_positiondata\positions.onshore.seismic.reflection\.

The files with the location of streamer tail are found in the directory Multichannel_observers_logs_and_positiondata\NavipackTugboat\

The files with the location of gun-shots are found in the sub-directories of Multichannel_observers_logs_and_positiondata\NavipackGunboat\

# VSP

Three VSP surveys was carried out at the Glyvursnes-1 borehole between 26 June and 19 July 2003. The source/borehole offsets for the three surveys were 14m, 242 m and 415 m. The source was a 150 cubic inch Sodera airgun fired in specially constructed ponds each with an average water depth of 1.5 metres. A hydrophone was positioned at approximately 10 metres depth immediately beneath the source ponds (within 5cm diameter drill holes) so that the repeatability of the source wavelet could be monitored.
The receiver was an Input/Output 3 component downhole sonde with three orthogonally arranged SM-7M 10 Hz geophones. This was attached to a custom made hydraulic clamping system.
Data were recorded on CD in SEG-Y format with a Geometrics Geode seismic recording system. Sample rate was 0.125 msec. The following data were recorded:

Ch. 1 Vertical component registered on downhole tool.
Ch. 2 Horizontal component 1 registered on downhole tool.
Ch. 3 Horizontal component 2 registered on downhole tool.
Ch. 4 Near field hydrophone
Ch. 5 GPS time code.
Ch. 6 Airgun time break.

The layout of the VSP experiment is illustrated in Figure 2. For exact data for the survey geometry and data files see appendices:
(1) VSP_observer_logs_and_position_data\VSP.July_Notes_and_Info.xls and
(2) VSP_observer_logs_and_position_data\VSP_pos.xls

## Vertical VSP

Shots were fired in pit 1: offset 14 metres.
The receiver was clamped at depths: 50 m to 600 m at 10 m intervals.
Each data file consists of one vertical and two horizontal downhole geophone signals, a source monitor hydrophone signal, a GPS time signal and a gun time break. Shots were always fired on a GPS minute.

## 242 m multi level offset VSP

Shots were fired in pit 2: offset 242 m.
The receiver was clamped at depths: 50 m to 350 m at 10 m intervals. The shot location was positioned just to the borehole side of a prominent dyke, with the line between borehole and pit 2 making a right angle with the strike of the dyke.

## 415 m multi level offset VSP

Shots were fired in pit 3: offset 415 m.
The receiver was clamped at depths: 50 m to 350 m at 10 m intervals. The shot location was in line with the borehole and pit 2, approximately 100 m beyond the dyke.

## Fixed level offset VSP's

During the September field experiment, the downhole receiver was clamped permanently at 400 m depth and all shots fired during the GA and GB surveys were recorded.

# Seismic reflection  data

Two set of surface seismic reflection data was acquired, one onshore the other offshore. The two data set are quite different in character and will complete each other. An overview of all reflection seismic data including the wide-angle seismic data are found in table 1. The instrumentation is illustrated in figures 2 and 3. For printing and viewing in larger scales. digital copies of figures 2 and 3 are included as the files:
Figures_illustrating_recording_configuration\Dynamite_Setup_2003.pdf and
Figures_illustrating_recording_configuration\Gun_Setup_2003.pdf.

## Onshore seismic reflection data

All onshore surface seismic data were acquired using 250g charges, as this appear to provide the best compromise between penetration and resolution (Fig. 4).
The onshore reflection seismic dataset comprises five layouts of 120 vertical geophones (Fig. 5). Two layouts were 600 m long profiles, while three layouts was designed to record seismic signal from three depth profiles at the time (Fig. 6), thus providing a dense coverage of depth points (2.5 m ·12.5 m) within an area of (240 m · 47.5 m for each setup).

| | |
|---|---|
| Geophones: | 120 (GS20D / SM7/9; 14 Hz) placed at 5 m intervals (one on each recording channel) preferably drilled into bedrock and covered with turf, alternatively placed in holes, which in the overburden and covered. As far as possibly the holes were digged through the peat constituting the upper part of the overburden. In a few instances, it was not possible to dig through the peat, either because the peat is thick at the geophone position or because the lower part of the peat is filled with boulders. The geophones were thus placed in the peat at these sites. |
| Recording: | The data were recorded on CD in SEG-Y format with a Geometrics StrataView recording system with a modified analog anti-alias filter, which eliminates the noise from the Loran-C transmitter in Eiði. The folowing channels were recorded. |
| | Ch. 1-120 Geophone data |
| | Ch. 121 GPS time code |
| Sample interval | 0.5 ms |
| Record length | 3 sec. |
| Trigger: | External, derived from GPS-clock. |
| Storage: | 32 bits, SEG-Y. |
| Source: | 250 g in 3 m deep hole. |

The holes were drilled less than two weeks before they were used. A few charges were positioned at shallower depth, as the shot holes at these locations were collapsed. For the layout Seifaba-5W three lines were acquired re-using shot holes that had been used previously.

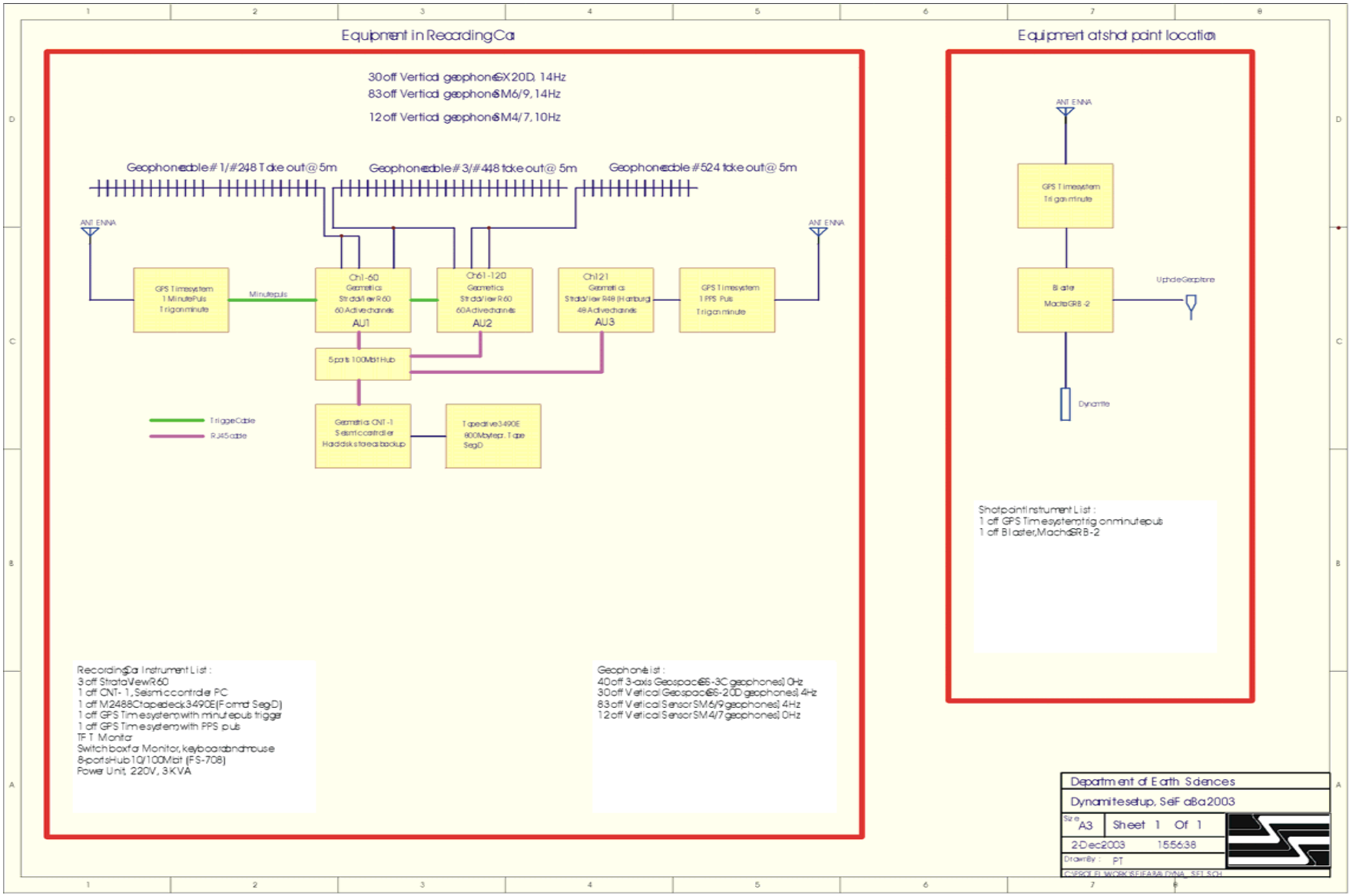


**Figure 2**. *Schematics of instrumentation during onshore seismic recording (see digital appendixes for more detailed copy of this figure).*

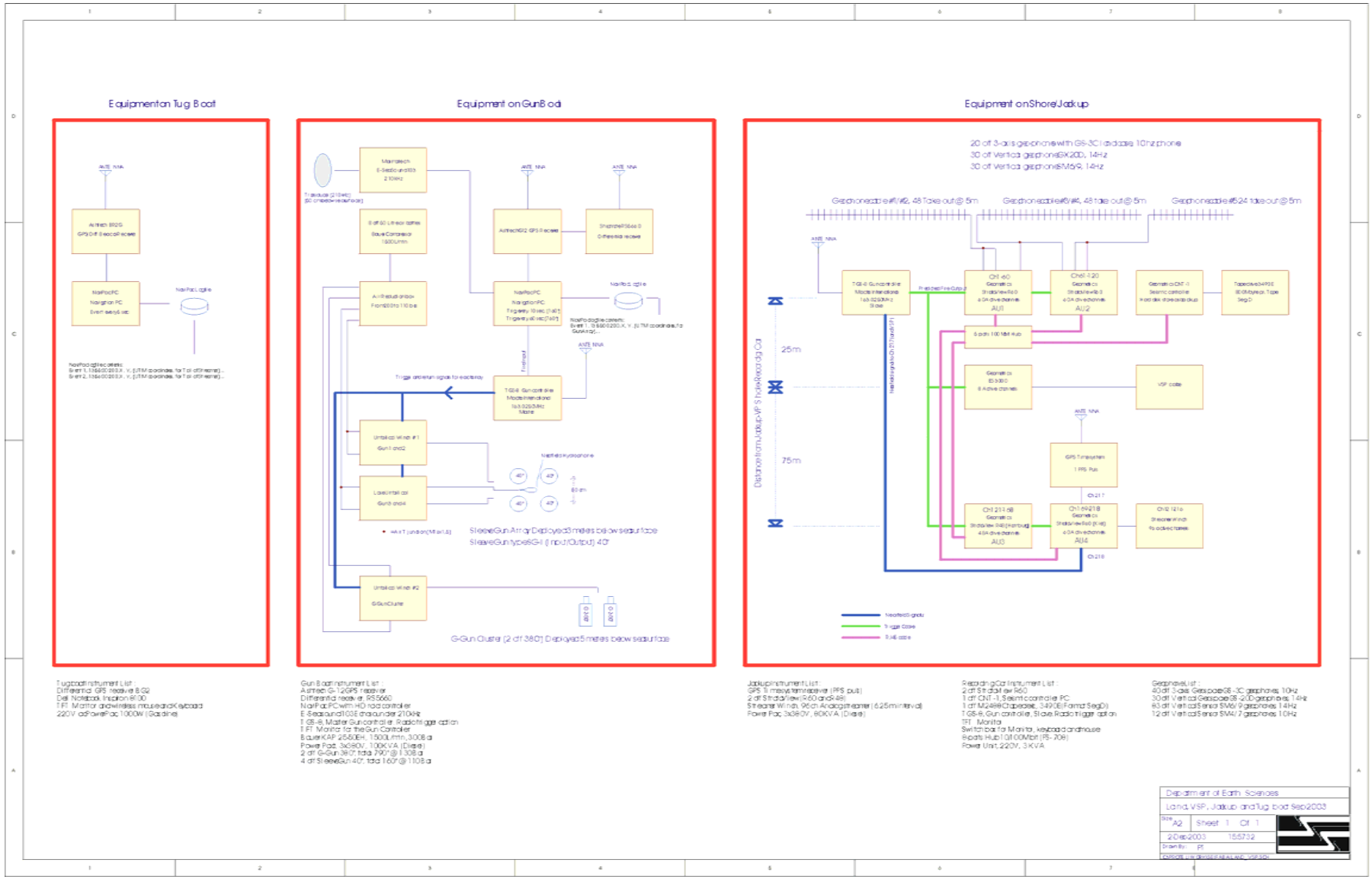


**Figure 3.** *Schematics of instrumentation during offshore and onshore-offshore seismic recording (see digital appendixes for more detailed copy of this figure).*

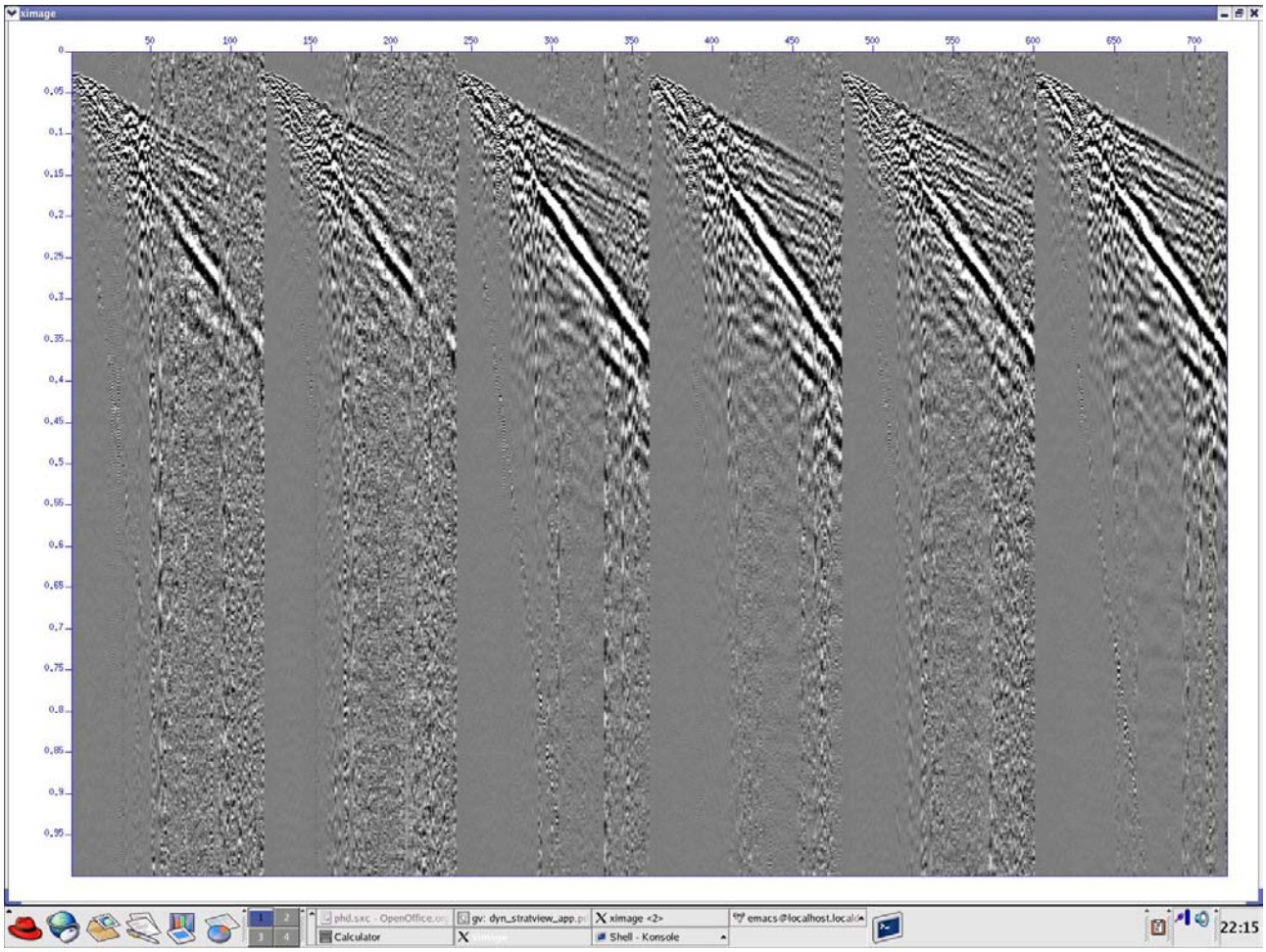


**Figure 4.** *Test shots fired close to northern end of line S1. The charges are 32 g, 60g, 90g, 125g, 250g and 350g. Reflections around 0.15 sec and below, are evident on the gathers with the larger charges. 250g charges were used for all production shots.*

The trigger signals were derived from a GPS-clock. For shots on layouts Seifaba-4W and Seifaba-5W the "up-hole" travel time was recorded successfully, and was between 48 and 52 ms. Details concerning the recording are found in the recording sheets. Copies are found in the files Multichannel_observers_logs_and_positiondata\StratView.observers.log.part.I.pdf and Multichannel_observers_logs_and_positiondata\StratView.observers.logs.part.I.app.pdf.

## Offshore seismic reflection data

The offshore shore seismic dataset comprises two layouts of the 96 channel streamer, with 6.5 m group interval. Five passes with offsets varying from 50-250 m were made for each layout (Fig. 3) with a 160 cu. inches airgun cluster and one with the 760 airgun cluster. We have thus two 100 m broad zones of marine depth points with overlap between the two zones.

Recording: The streamer data were recorded together with onshore wide-angle seismic data on CD or tape in SEG-Y format with a Geometrics StrataView recording system connected to the onshore recording unit through a net cable. The following channels were recorded.

| | |
|---|---|
| Ch. 1-120 | Geophone data |
| Ch. 121-176 | Streamer data |
| Ch. 177-216 | Empty |

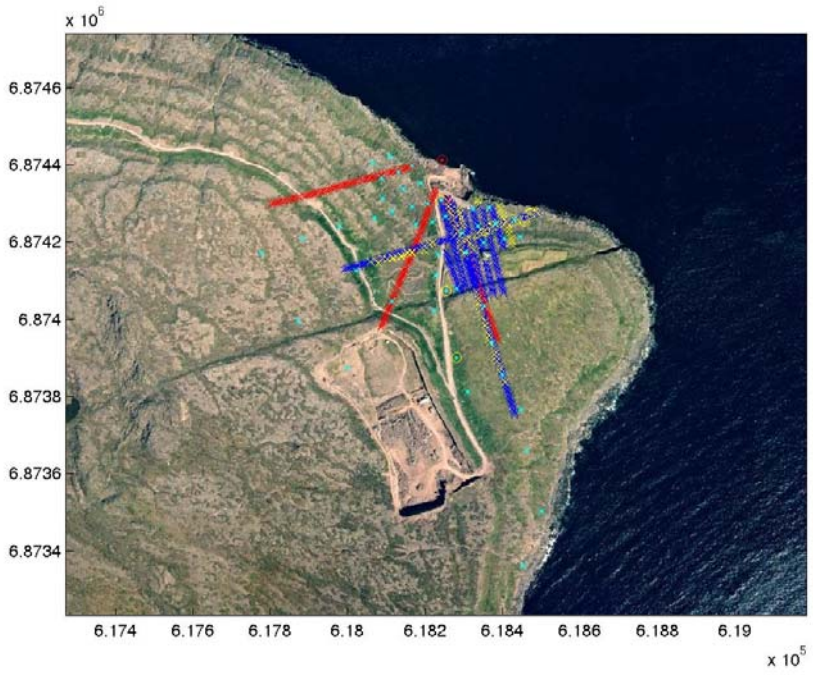


**Figure 5.** *The study area at Glyvursnes. All onshore recording stations and shots are displayed. Signatures: blue x: geophone location for onshore reflection seismic experiment; yellow x, yellow o: shot locations for onshore reflection seismic experiment; cyan x: fixed autonomous seismometers; yellow ring with cyan dot: VSP pits; red x: geophone location for azimuthal experiment; black dot the Glyvursnes-1 well.*

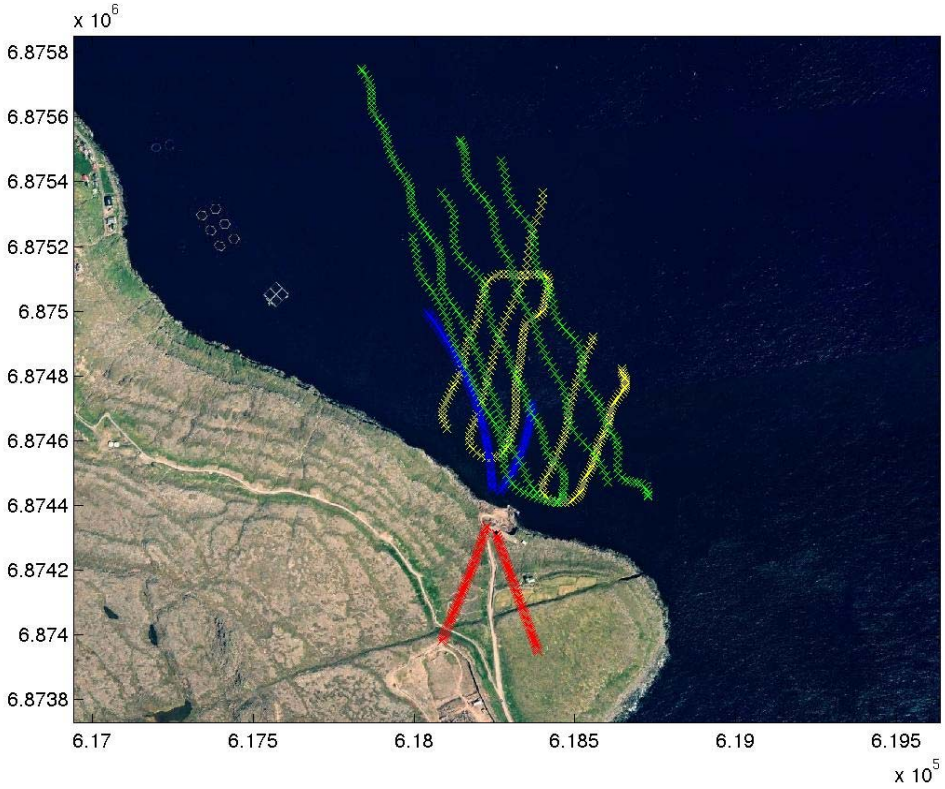


**Figure 6.** *Marine reflection shot and receiver positions for seismic reflections. Location of streamer groups represents average positions during each set of shots.*

| | | |
|---|---|---|
| | Ch. 217 | GPS time code |
| | The header keyword “trid” is used to indicate the type of data on a given channel (trace), trid=42 is hydrophone, trid=43 is vertical geophone, trid=44 is first horizontal component (north) and trid=45 is second horizontal component. | |
| Sample interval | 0.5 ms | |
| Record length | 3 sec. | |
| Trigger External | Derived from GPS-clock. | |
| Storage: | 32 bits, SEG-Y. | |
| Source: | Two airgun clusters, only one fired at the time. | |
| Small cluster: | 4 x Haliburton 40 cu. inches sleeveguns. | |
| Big cluster: | 2 x Sodera 380cu. inches airguns. | |

Details concerning the recording is found in the recording sheets. Copies are found in the files Multichannel_observers_logs_and_positiondata\Stratview.observers.log.part.II.pdf and Multichannel_observers_logs_and_positiondata\StratView.observers.log.part.II.app.pdf.

## Wide-angle multi-channel seismic data

The wide-angle data was shot using the same offshore configuration as for the offshore seismic reflection data. Onshore recording was made on a combination of 1C- and 3C-geophones:

| | | |
|---|---|---|
| Recording: | The data were recorded on CD or tape in SEG-Y format with a Geometrics StrataView recording system connected to the onshore recording unit through a net cable. The folowing channels were recorded. | |
| | Ch. 1-120 | Geophone data |
| | Ch. 121-176 | Streamer data |
| | Ch. 177-200 | Empty |
| | Ch. 217 | GPS time code |
| Geophones | 80 placed at 5 m intervals. Every 4th geophone being a 3C-geophone (GS-3C; 10 Hz) with the first horizontal component oriented towards nortth. The 3C-geophones were preferably cemented onto bedrock and otherwise treated as the vertical geophones (see above - onshore seismic reflection data). | |

Other parameters as described above (onshore seismic reflection data).
Details concerning the recording is found in the recording sheets. Copies are found in the files Multichannel_observers_logs_and_positiondata\Stratview.observers.log.part.II.pdf and Multichannel_observers_logs_and_positiondata\StratView.observers.log.part.II.app.pdf.

# Broad band seismic data

Forty-five autonomous seismic stations (Guralp DT6) were deployed in the survey area. The seismometers were all positioned on a small concrete platform directly on bedrock in the bottom of 10-100 cm deep holes and covered by turf. The main power supplies were solar panels with 12V car batteries as backup.
Data were recorded continuously. During active acquisition data were recorded with 4 ms sample interval. All shots fired during the above mentioned experiments were recorded. During periods where no active data acquisition was going on, the sample interval was reduced to 8 ms. Further details about the data acquisition for the tomography and lateral anisotropy experiments is provided in a separate report, “Sindri: Petrophysical and seismic properties of Faroese basalts, 6TD Technical Field Report”, included as an appendix to the main report:
Autonomous_seismometers_report_and_site_info\6TD_faroe_2004_final_report.pdf.
Details concerning deployment and servicing of the autonomous seismic stations are found in Autonomous_seismometers_report_and_site_info\guralp_sites_info_printable.xls

# Digital appendixes

Data documenting the acquisition are included in digital form as this is most suitable for further work. Filenames of the digital documents and the directory structure should provide help finding the relevant data. The following can be used to find specific data:

Multichannel_observers_logs_and_positiondata\: Directory containing observers logs for the multichannel experiment. The following are found in the root of this directory:

- Multichannel_observers_logs_and_positiondata\gunboat.log.pdf: Gunners log: All operational data concerning the gun arrays.
- Multichannel_observers_logs_and_positiondata\StratView.observers.log.part.I.pdf: Observers log for the onshore recording of reflection seismic data.
- Multichannel_observers_logs_and_positiondata\StratView.observers.logs.part.I.app.pdf: Sketches and additional notes concerning the onshore-offshore recording of reflection seismic data.
- Multichannel_observers_logs_and_positiondata\StratView.observers.log.part.II.app.pdf : Sketches and additional notes concerning the onshore-offshore recording of reflection seismic data and wide angle multichannel seismic data.
- Multichannel_observers_logs_and_positiondata\StratView.observers.log.part.II.app.pdf: Observers log for the onshore-offshore recording of reflection seismic data and wide angle multichannel seismic data.
- Multichannel_observers_logs_and_positiondata\key.to.position.files.table.sefaba.lines.xls: This is copy of table 1 providing a key to combining files with shot positions to files with geophone locations.

Multichannel_observers_logs_and_positiondata\positions.onshore.seismic.reflection\: Directory containing the files with the positions of onshore shot mentioned in table 1. The **.dat** files in this directory are tabulator-separated files. Each row contains the following fields: station number, easting, northing and altitude.

Multichannel_observers_logs_and_positiondata\NavipackGunboat\: Directory containing the files with the positions of offshore shot mentioned in table 1. The files are stored in sub-directories, one for each day. All recorded navigation files are included. Use table 1 to combine files with positions of the gun-arrays, with positions of streamer-tail and the seismic data file. Examples of files containing marine position data is given in the two next sections (Example and format of NaviPack C-file and Example of Navipack S-file).

Multichannel_observers_logs_and_positiondata\NavipackTugboat\: Directory containing the files with the positions of the streamer tail mentioned in table 1. Use table 1 to combine files with positions of streamer-tail with positions of the gun-arrays, and the seismic data file. Examples of files containing marine position data is given in the two next sections (Example and format of NaviPack C-file and Example of Navipack S-file).

Autonomous_seismometers_report_and_site_info\: Directory containing data specific to the autonomous seismometers.

- Autonomous_seismometers_report_and_site_info\guralp_sites_info_printable.xls: Log of all operations (including deployment and recovering of instruments) on the autonomous seismometers.

VSP_observer_logs_and_position_data\: Directory containing data specific to the VSP and offset VSP experiment.

- VSP_observer_logs_and_position_data\VSP.July_Notes_and_Info.xls: Observers log for VSP data acquisition.

VSP_observer_logs_and_position_data\VSP_pos.xls: File with copy of original position data for the VSP experiment.

## Example and format of NaviPack C-file

The NaviPack C-files contain positions of the activated gun-array at trigger times.

The first two lines is the file header. The first line contain a description of the comma-separated data fields. The second line contain runline information: The start and end point of the line. All following lines are data lines giving time of trigger signal, and the positions of the two gun arrays and the antenna position on the boat with reference to WGS-84 (easting, northing (UTM zone 29), latitude and longitude and height of array relative to sealevel). First for the GGun and then the for the sleevegun array. The last field (chan. 1 is the logged water depth). Additional survey data can be found in the NaviPack-S files.

Time,Events,GGun: East,North,Lat,Long,Height,SleeveGun: East,North,Lat,Long,Height,Ref. Pos. (group 1): East,North,Lat,Long,Height,Marimatech: input 1: ch1,End Of Line (EOL),
Runlineinfo: id: 6, name:NONEC001, longname: , start: 618828.00, 6873798.00 end: 617847.00, 6875035.00

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11:44:06.693, | -9999, | 617940.4713,6875138.2057, | 061°59.413978', -006°44.918906', -5.0000, | 617953.2372,6875146.3156, | 061°59.418104', -006°44.903976', -3.0000, | 617961.0393,6875146.3038, | 061°59.417952', -006°44.895049', | 0.0000, | 37.3300 |
| 11:44:33.693, | 1024, | 617990.7284,6875146.9144, | 061°59.417726', -006°44.861052', -5.0000, | 618004.9632,6875152.0242, | 061°59.420210', -006°44.844560', -3.0000, | 618012.5724,6875150.3001, | 061°59.419140', -006°44.835922', | 0.0000, | 37.8900 |
| 11:45:29.693, | 1023, | 618097.8421,6875143.1250, | 061°59.413684', -006°44.738634', -5.0000, | 618111.1900,6875150.2365, | 061°59.417262', -006°44.723077', -3.0000, | 618118.9684,6875149.6289, | 061°59.416789', -006°44.714201', | 0.0000, | 37.0500 |
| 11:46:33.687, | 1022, | 618194.7892,6875188.0603, | 061°59.436053', -006°44.625911', -5.0000, | 618208.6357,6875194.1443, | 061°59.439068', -006°44.609824', -3.0000, | 618216.3461,6875192.9516, | 061°59.438282', -006°44.601049', | 0.0000, | 36.2800 |
| 11:47:35.693, | 1021, | 618297.2793,6875179.0741, | 061°59.429298', -006°44.508990', -5.0000, | 618311.6723,6875183.7196, | 061°59.431528', -006°44.492335', -3.0000, | 618319.2216,6875181.7496, | 061°59.430326', -006°44.483775', | 0.0000, | 38.2200 |
| 11:48:40.691, | 1020, | 618396.1166,6875165.5095, | 061°59.420145', -006°44.396433', -5.0000, | 618411.0783,6875163.2987, | 061°59.418675', -006°44.379401', -3.0000, | 618416.9739,6875158.1884, | 061°59.415814', -006°44.372858', | 0.0000, | 41.1600 |
| 11:49:39.681, | 1019, | 618492.4468,6875132.6423, | 061°59.400650', -006°44.287516', -5.0000, | 618507.3500,6875135.2179, | 061°59.401756', -006°44.270360', -3.0000, | 618514.5473,6875132.2060, | 061°59.400000', -006°44.262244', | 0.0000, | 44.6100 |
| 11:50:39.682, | 1018, | 618592.6401,6875117.9591, | 061°59.390866', -006°44.173454', -5.0000, | 618607.7197,6875116.7991, | 061°59.389959', -006°44.156245', -3.0000, | 618613.9579,6875112.1133, | 061°59.387320', -006°44.149295', | 0.0000, | 47.4500 |
| 11:51:45.690, | 1017, | 618680.1234,6875063.6046, | 061°59.359970', -006°44.075523', -5.0000, | 618694.9844,6875060.7957, | 061°59.358179', -006°44.058631', -3.0000, | 618700.6703,6875055.4531, | 061°59.355197', -006°44.052338', | 0.0000, | 51.4500 |
| 11:52:55.691, | 1016, | 618760.7940,6875004.5485, | 061°59.326671', -006°43.985578', -5.0000, | 618773.5091,6874996.3591, | 061°59.322025', -006°43.971357', -3.0000, | 618776.7696,6874989.2709, | 061°59.318149', -006°43.967910', | 0.0000, | 53.1100 |
| 11:53:57.679, | 1015, | 618828.3162,6874931.6068, | 061°59.286145', -006°43.911237', -5.0000, | 618842.1389,6874925.4689, | 061°59.282582', -006°43.895666', -3.0000, | 618846.4500,6874918.9660, | 061°59.279001', -006°43.890994', | 0.0000, | 53.5400 |
| 11:55:02.688, | 1014, | 618906.5505,6874870.6758, | 061°59.251881', -006°43.824161', -5.0000, | 618918.0609,6874860.8651, | 061°59.246385', -006°43.811384', -3.0000, | 618920.3479,6874853.4058, | 061°59.242327', -006°43.809066', | 0.0000, | 53.9600 |
| 11:56:12.685, | 1013, | 618946.7324,6874776.8592, | 061°59.200635', -006°43.781943', -5.0000, | 618958.7371,6874767.6599, | 061°59.195458', -006°43.768577', -3.0000, | 618961.4085,6874760.3294, | 061°59.191463', -006°43.765814', | 0.0000, | 54.0900 |
| 11:57:16.680, | 1012, | 619012.7231,6874697.5412, | 061°59.156705', -006°43.709619', -5.0000, | 619025.0357,6874688.7583, | 061°59.151746', -006°43.695884', -3.0000, | 619027.9565,6874681.5235, | 061°59.147797', -006°43.692832', | 0.0000, | 55.3700 |
| 11:58:22.678, | 1011, | 619056.5014,6874607.3422, | 061°59.107337', -006°43.663147', -5.0000, | 619063.5313,6874593.9512, | 061°59.099998', -006°43.655641', -3.0000, | 619062.8764,6874586.1766, | 061°59.095826', -006°43.656702', | 0.0000, | 53.2900 |
| 11:59:29.673, | 1010, | 619057.3594,6874506.2845, | 061°59.052934', -006°43.666215', -5.0000, | 619061.3153,6874491.6868, | 061°59.045004', -006°43.662275', -3.0000, | 619058.9885,6874484.2398, | 061°59.041040', -006°43.665235', | 0.0000, | 45.5500 |
| 12:00:45.684, | 1009, | 619037.4787,6874405.1481, | 061°58.998880', -006°43.693012', -5.0000, | 619047.2390,6874393.5949, | 061°58.992479', -006°43.682309', -3.0000, | 619048.2814,6874385.8628, | 061°58.988298', -006°43.681426', | 0.0000, | 42.6700 |
| 12:02:17.680, | 1008, | 619070.0934,6874306.2588, | 061°58.945046', -006°43.659663', -5.0000, | 619064.5962,6874292.1691, | 061°58.937567', -006°43.666517', -3.0000, | 619058.2981,6874287.5641, | 061°58.935207', -006°43.673906', | 0.0000, | 37.4800 |
| 12:03:58.673, | 1007, | 619048.1413,6874210.6050, | 061°58.893981', -006°43.688608', -5.0000, | 619051.5159,6874195.8622, | 061°58.885984', -006°43.685339', -3.0000, | 619048.8959,6874188.5131, | 061°58.882078', -006°43.688630', | 0.0000, | 29.9700 |
| 12:05:33.667, | 1006, | 619033.1739,6874111.2913, | 061°58.840816', -006°43.709708', -5.0000, | 619032.6885,6874096.1749, | 061°58.832690', -006°43.710869', -3.0000, | 619028.2859,6874089.7337, | 061°58.829306', -006°43.716163', | 0.0000, | 23.6300 |
| 12:06:43.671, | 1005, | 618975.8169,6874028.3020, | 061°58.797234', -006°43.778642', -5.0000, | 618972.1036,6874013.6408, | 061°58.789413', -006°43.783477', -3.0000, | 618966.4230,6874008.2926, | 061°58.786642', -006°43.790189', | 0.0000, | 16.7400 |
| 12:07:42.667, | 1004, | 618918.8965,6873950.0319, | 061°58.756183', -006°43.846885', -5.0000, | 618914.7221,6873935.4953, | 061°58.748438', -006°43.852241', -3.0000, | 618908.8754,6873930.3291, | 061°58.745768', -006°43.859136', | 0.0000, | 12.9300 |
| 12:09:04.666, | 1003, | 618920.7017,6873805.9774, | 061°58.678622', -006°43.850584', -5.0000, | 618928.9745,6873793.3164, | 061°58.671653', -006°43.841628', -3.0000, | 618929.0626,6873785.5148, | 061°58.667452', -006°43.841839', | 0.0000, | 21.0900 |

# Example of Navipack S-file

First few lines of a NaviPack-S file. This file contains all data recorded by the navigation system. It is retained to allow evaluation of possible conspicuous trigger positions stored in the NaviPack-C files. The first data record are highlighted. Description of the data record is found in the header. More detailed description of these files are found in the NaviPack manual.

H0; 2003:09:22:13:39:48.813; 3.4.0; D:\NaviPacData\SeiFaBa2003\030922\030922S008.npd; NaviEdit(NT) Interpreter Format /H0
H0; P; O; no; Time; E; N; height; stddev; ; ; ; kp; dal; dol; fix /H0
H0; P; D; no; Time; E; N; height; stddev; dx; dy; dz; kp; dal; dol /H0
H0; D; no; insttype; index; channel_number; Time; BathyDepth; NumOfDepths; Depth1; TimeAge1../H0
H0; A; no; index; Time; Roll; Pitch; Heave /H0
H0; G; no; index; type; Time; Gyro; CMG /H0
H1; UTM (north); 5; 0.999600000000; 0.575958653158; 0.785398163397; -0.157079632679; 0.000000000000; 500000.000000000000; 0.000000000000; 29 /H1
H11; POS; 1; metric; 1.0000000000; m /H11
H12; DEP; 1; metric; 1.0000000000; m /H12
H2; WGS 84; 298.257223563000; 6378137.000000 /H2
H3; 0.0000; 1.#INF; 0.0000; 0.000000000000; 0.000000000000; 0.000000000000; 0.0000 /H3
H4; Anschutz NMEA 0183; 153; 1; 0; 0.000; 0.000; 0.000 /H4
H5; Anschutz NMEA 0183; 153; 1; 0; 1; 0.000 /H5
H4; GGun; 801; 2; 0; 2.150; -22.000; -5.000; 0 /H4
H4; SleeveGun; 802; 3; 0; -2.150; -7.500; -3.000; 0 /H4
H4; Marimatech; 710; 4; 0; 0.000; 0.000; 0.000 /H4
H41; input 1: ch1; 710; 4; 7100; -3.500; -2.500; -0.190 /H41
H7; Number of objects = 6 /H7
H7; Vessel; 0; -1; 0; 0.000; 0.000; 0.000; -1 /H7
H7; input 1: ch1; 7100; 710; 0; -3.500; -2.500; -0.190; 0/H7
H7; input 1: ch2; 7101; 710; 0; 0.000; 0.000; 0.000; 0/H7
H7; input 1: ch3; 7102; 710; 0; 0.000; 0.000; 0.000; 0/H7
H7; GGun; 801; 801; 0; 2.150; -22.000; -5.000; 0 /H7
H7; SleeveGun; 802; 802; 0; -2.150; -7.500; -3.000; 0 /H7
H4; /H4
H6; 1; GPS1 (NMEA): G12_Diff_ZDA - Diff /H6
H7; Runlineinfo: id: 9; name:NONEC002; longname: ; start: 618006.30; 6874658.20; end: 618575.32; 6874001.18;/H7
P; O; 1; 2003:09:22:13:39:49.578; 617998.4021; 6874752.5741; 0.0000; 5.00; ; ; ; 0.1896; 1342.13; 78.13; -9999
G; 0; 1; 2003:09:22:13:39:49.578; 225.8588; 221.8514
V; 0; 0; 2003:09:22:13:39:49.578; 0.0000; 0.0000; 0.0000; 1.9914
P; X; 801; 2003:09:22:13:39:49.578; 618012.0988; 6874769.9241; -5.0000; 61.9869073; -6.7475263; 0.40; 0.000; 0.00; 0.00; -9999
P; X; 802; 2003:09:22:13:39:49.578; 618005.1498; 6874756.4909; -3.0000; 61.9867890; -6.7476677; 0.71; 0.000; 0.00; 0.00; -9999
P; X; 7100; 2003:09:22:13:39:49.578; 618002.6578; 6874751.9507; -0.1900; 61.9867490; -6.7477182; 0.82; 0.000; 0.00; 0.00; -9999
D; 0; 710; 4; 1; 2003:09:22:13:39:48.567; 0.1900; 10;25.7900; 0;25.8100; 148;25.7900; 210;25.7300; 280;25.6900; 450;25.6900; 510;25.6500; 591;25.7100; 781;25.6900; 832;25.6100; 902;
S; 44; 2003:09:22:13:39:48.989; 4; 5.00; 59.96; 0.00; 0.00; 0.00; 0.00; 0.00; 0.00; 0.00; 0.00; 0.00; 0.00; -0.00; 0; 0; 61.986698; -6.74794550; 0
P; O; 1; 2003:09:22:13:39:50.578; 617997.7119; 6874750.8975; 0.0000; 5.00; ; ; ; 0.1883; 1343.44; 77.18; 1
G; 0; 1; 2003:09:22:13:39:50.578; 223.8397; 219.8723
V; 0; 0; 2003:09:22:13:39:50.578; 0.0000; 0.0000; 0.0000; 1.9660
P; X; 801; 2003:09:22:13:39:50.578; 618010.7888; 6874768.7193; -5.0000; 61.9868969; -6.7475521; 0.32; 0.206; 1325.78; 84.25; 1
P; X; 802; 2003:09:22:13:39:50.578; 618004.3174; 6874755.0496; -3.0000; 61.9867763; -6.7476845; 0.64; 0.195; 1336.83; 76.68; 1
P; X; 7100; 2003:09:22:13:39:50.578; 618001.9869; 6874750.4245; -0.1900; 61.9867356; -6.7477320; 0.75; 0.191; 1340.74; 74.28; 1
D; 0; 710; 4; 1; 2003:09:22:13:39:49.619; 0.1900; 10;25.5900; 0;25.6500; 57;25.6100; 128;25.5700; 289;25.5200; 347;25.4700; 430;25.4700; 620;25.4500; 679;25.3900; 750;25.3900; 889;
S; 44; 2003:09:22:13:39:49.989; 4; 5.00; 60.08; 0.00; 0.00; 0.00; 0.00; 0.00; 0.00; 0.00; 0.00; 0.00; 0.00; -0.00; 0; 0; 61.986681; -6.74795567; 0
P; O; 1; 2003:09:22:13:39:58.578; 617995.6518; 6874736.7282; 0.0000; 5.00; ; ; ; 0.1796; 1352.14; 67.07; 2

# SINDRI: Petrophysical and seismic properties of Faroese basalts

## 6TD Technical Field Report

**June – December 2003**

**Nick Mohammed**

**Email: nm341@cam.ac.uk**

A dense array of 45 autonomous Guralp (6TD) seismometers was deployed within the Glyvursnes region of Streymoy; the Faroe Islands. The following technical field report contains details of the following:

- Sensor ID, GPS ID, Easting, Northing, Height.
- 6TD sensors
- Sampling rates
- External battery voltages
- Downloading
- Damages
- Additional (non-Glyvursnes) 6TD sensors
- Acknowledgements
- Schematic of seismometer array and photo of individual site layout
- Spreadsheet of entire 6TD history

**SINDRI: Petrophysical and seismic properties of Faroes basalts**

**Summary of Fieldwork:**

**Acquisition of onshore array and onshore-offshore airgun data**

A dense array of 45 autonomous Guralp (6TD) seismometers was deployed within the Glyvursnes region of Streymoy; the Faroe Islands. Deployment of the forty-five seismometers began in June 2003 and extended through to July 2003. During periods of controlled source seismic shooting, all sites maintained a sampling rate of 200 samples.sec$^{-1}$. For intervening periods when they were recording earthquakes, a sampling rate of 100 samples.sec$^{-1}$ was used. GPS coverage (for the time base) for each site was initially set to update at 1-hour intervals; however, this was increased to continuous to avoid (apparent) large time excursions observed during discrete acquisition (*see Figures 1 and 6*).

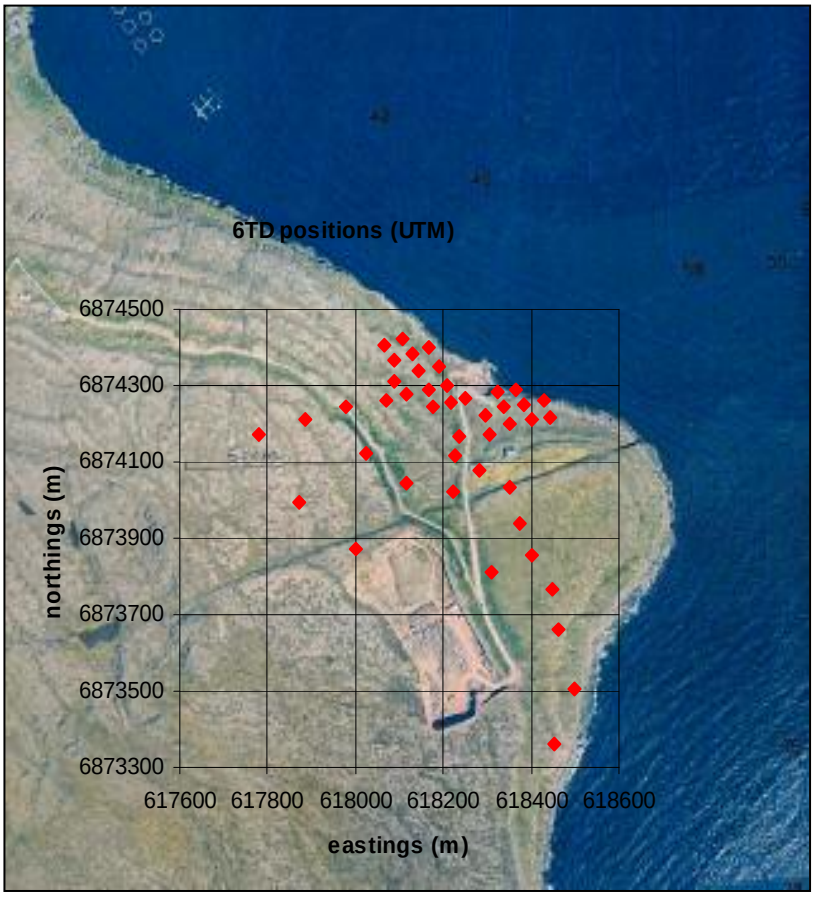


***Figure 1. Location of 45 Guralp (6TD) seismometers on Glyvursnes, Streymoy; the Faroe Islands •. UTM coordinates are given (wgs84, zone 29V) and scaled to aerial photograph. Locations were governed by bedrock distribution and accessibility. The seismometer array includes radial extensions required for wide-angle acquisition, plus a dense array for potential tomographic studies.***

Nick Mohammed and Bob White

Appendix A summarises the servicing of the Guralp seismometers and comments on the basic characteristics of the recorded data. External battery voltages were checked regularly to ensure optimum power supply and the general site attributes monitored (*see Appendix A*). The seismometer array will be run until mid-December 2003 to continue recording earthquake data.

Three 400-m-long (120 channel) independent temporary land arrays were set up combining three- and one-component geophones. The three-component geophones were cemented to bedrock, and wherever possible the one-component sensors were set in drilled holes in bedrock. The three radial profiles converge at the VSP hole (Glyvursnes-1) and are shown schematically in Figure 2.

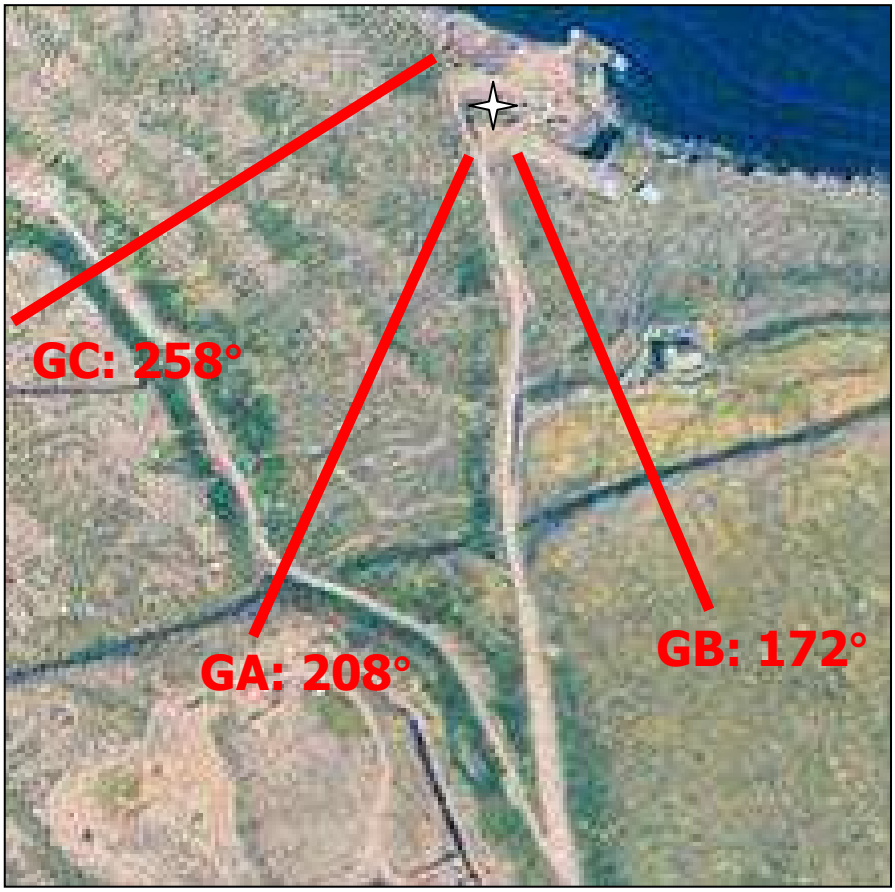


***Figure 2. Approximate positions of geophone profiles GA, GB and GC; star represents position of Glyvursnes-1. A combination of three-component and one-component geophones were utilised such that, within any profile, a single three-component geophone was always followed by three one-component geophones. Total profile lengths were (5 x 80 m) 400 m, with a geophone spacing of 5 m. All geophones were buried to reduce the effects of wind-induced noise and drilled directly into basalt where possible. The majority of three-component geophones were cemented to bedrock permitting greater practical flexibility in orientation and levelling.***

Shooting of line GA commenced on 16th September 2003 and continued for three days. A large (2 x 380 cu in G-gun cluster) and smaller sleeve-gun cluster (4 x 40 cu in) were fired such that line extension and wide-angle (azimuthal) onshore-offshore data were acquired. Figure 3 illustrates the total distribution of firing over the three days. Sleeve-gun firing positions have been omitted, since the inherent high resolution (10-second firing interval) dataset obscures the G-gun dataset (*see Figure 3*). Figures 4 and 5 illustrate G-gun shot locations for line GB (19th-20th September 2003) and GC (21st September 2003) respectively.

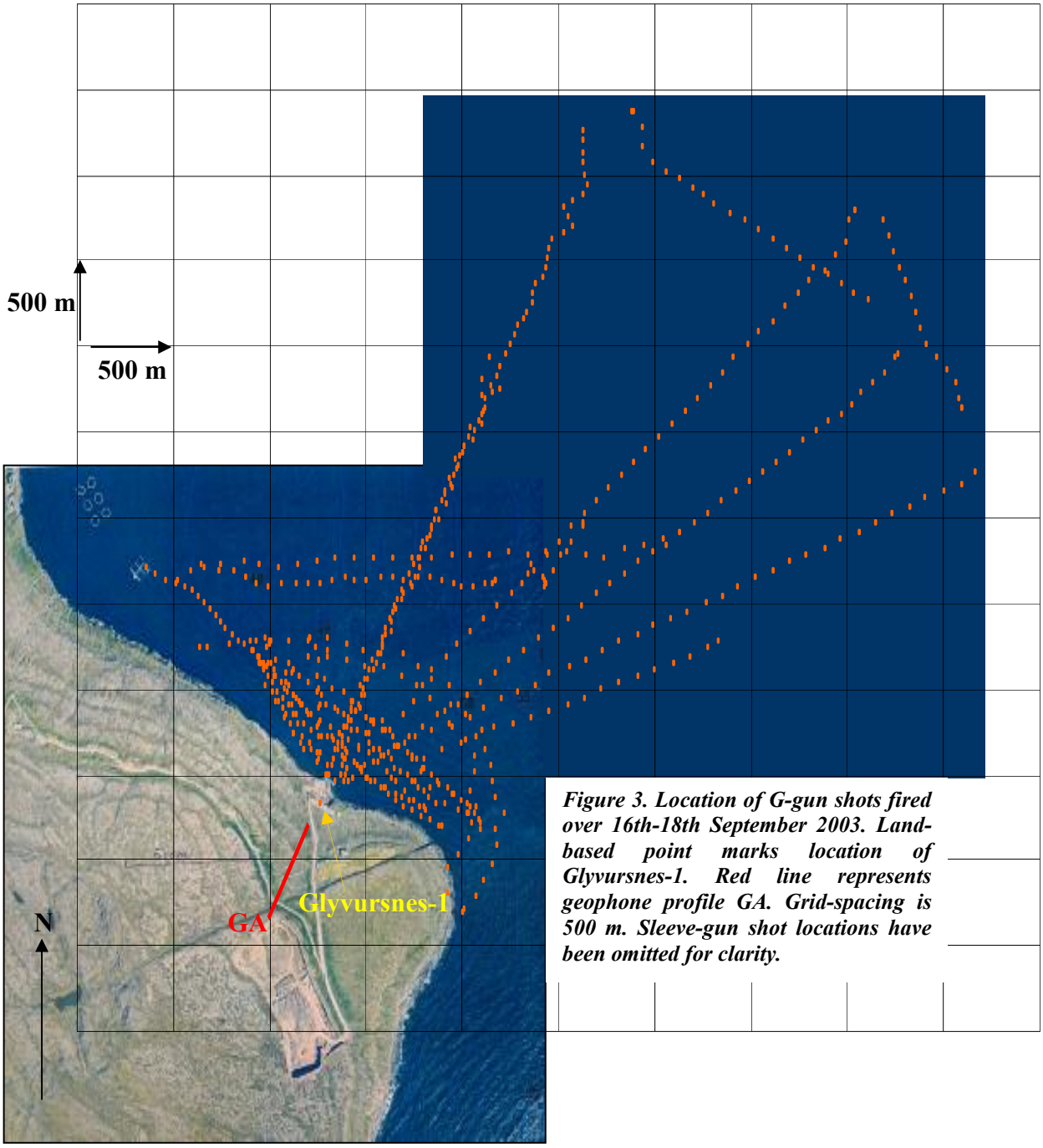


***Figure 3. Location of G-gun shots fired over 16th-18th September 2003. Land-based point marks location of Glyvursnes-1. Red line represents geophone profile GA. Grid-spacing is 500 m. Sleeve-gun shot locations have been omitted for clarity.***

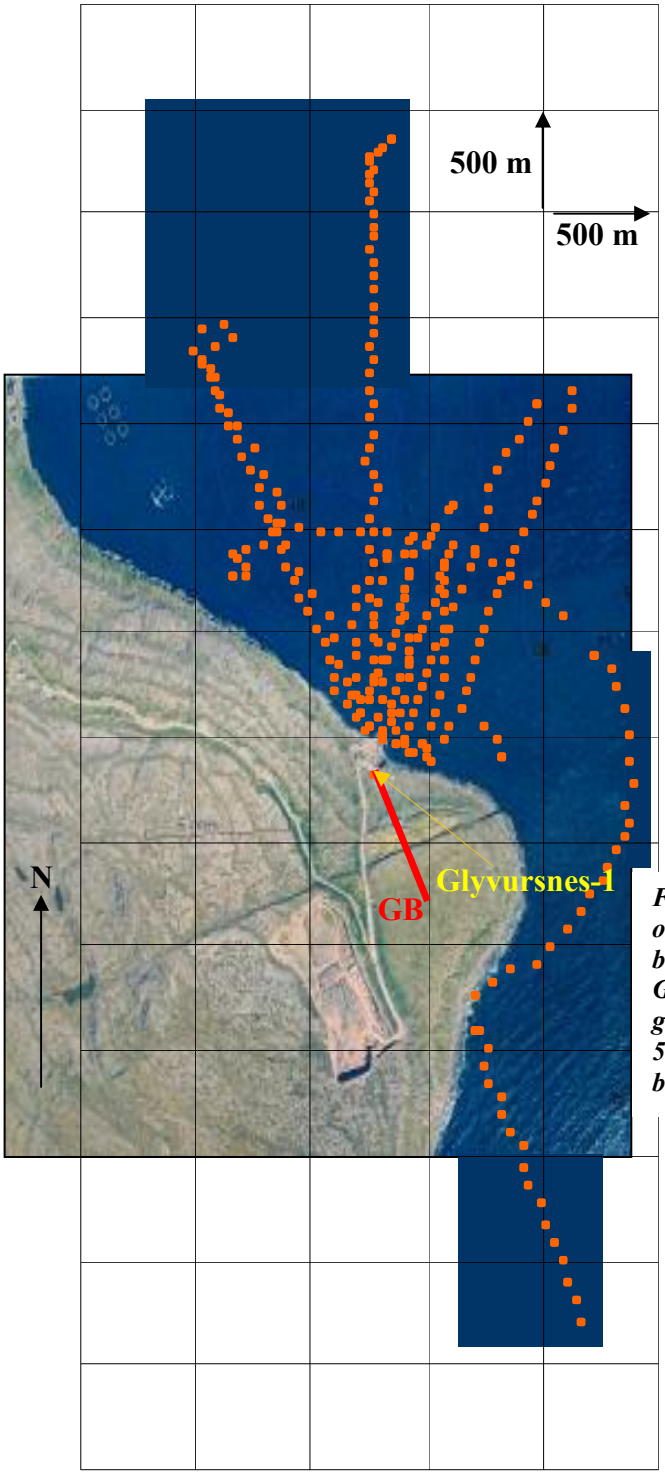


*Figure 4. Location of G-gun shots fired over 19th-20th September 2003. Land-based point marks location of Glyvursnes-1. Red line represents geophone profile GB. Grid-spacing is 500 m. Sleeve-gun shot locations have been omitted for clarity.*

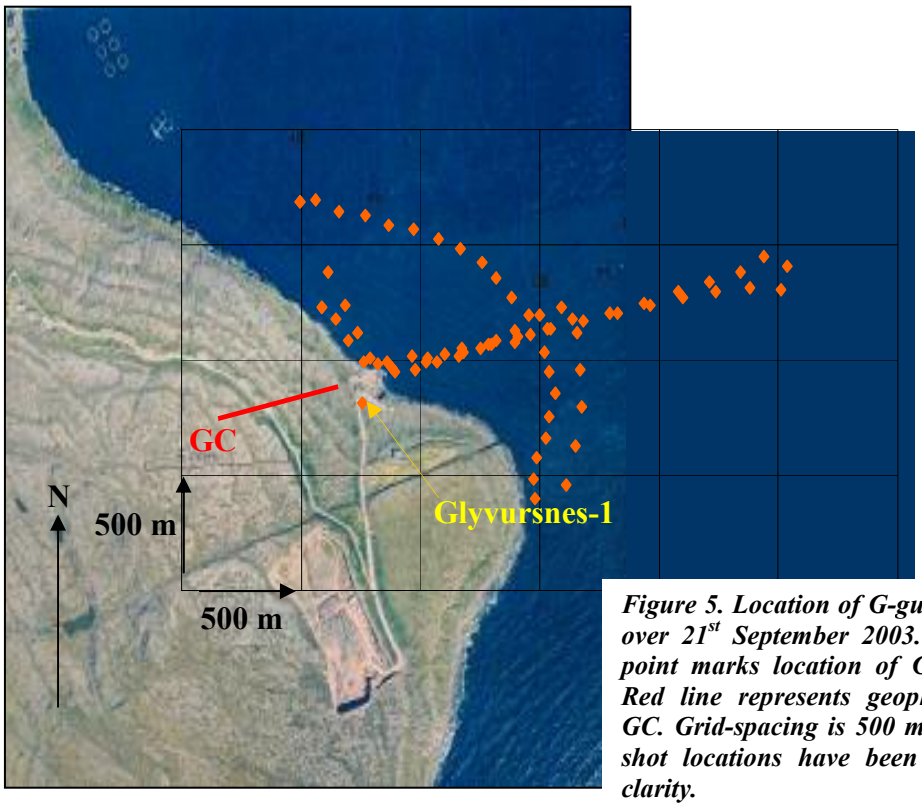


***Figure 5. Location of G-gun shots fired over 21st September 2003. Land-based point marks location of Glyvursnes-1. Red line represents geophone profile GC. Grid-spacing is 500 m. Sleeve-gun shot locations have been omitted for clarity.***

Throughout the shooting, the three-component borehole seismometer was held clamped at 400 m in the borehole, in the Middle Series basalts. By combining the surface recordings of wide-angle arrivals, measured by both the temporary and autonomous arrays, with the three-component borehole seismometer, we will be able to investigate the characteristics of wave propagation through the medium, including P- and S-wave response, anisotropy, absorption and scattering.

Several temporary Guralp sites were maintained on the islands of Nólsoy and Vágar during the shooting to provide data at greater offsets and to record local quarry blasts.

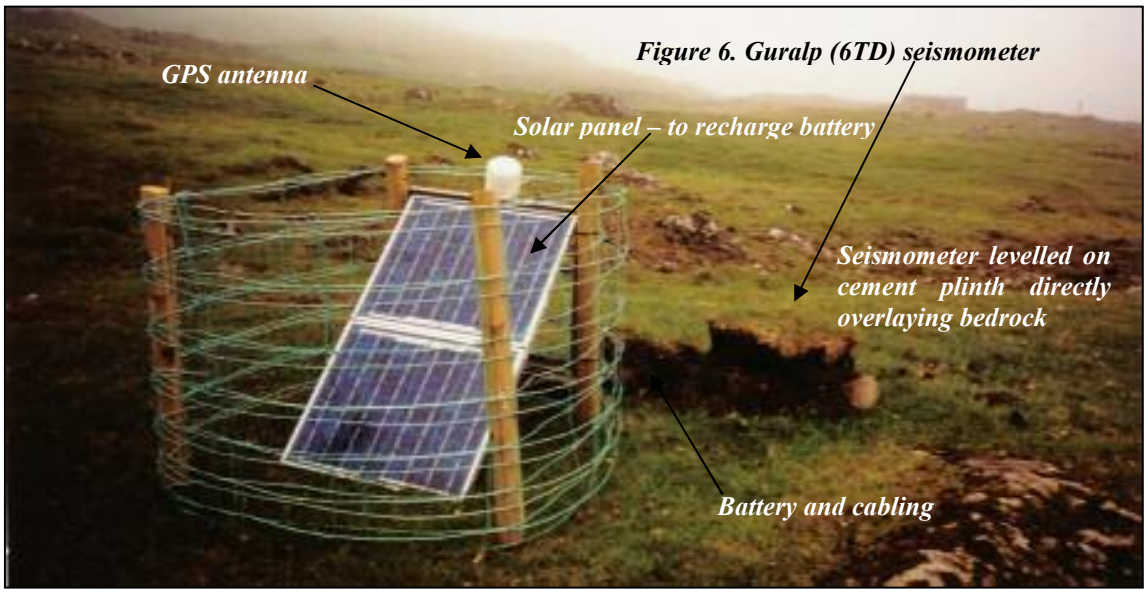


*Figure 6. Guralp (6TD) seismometer*

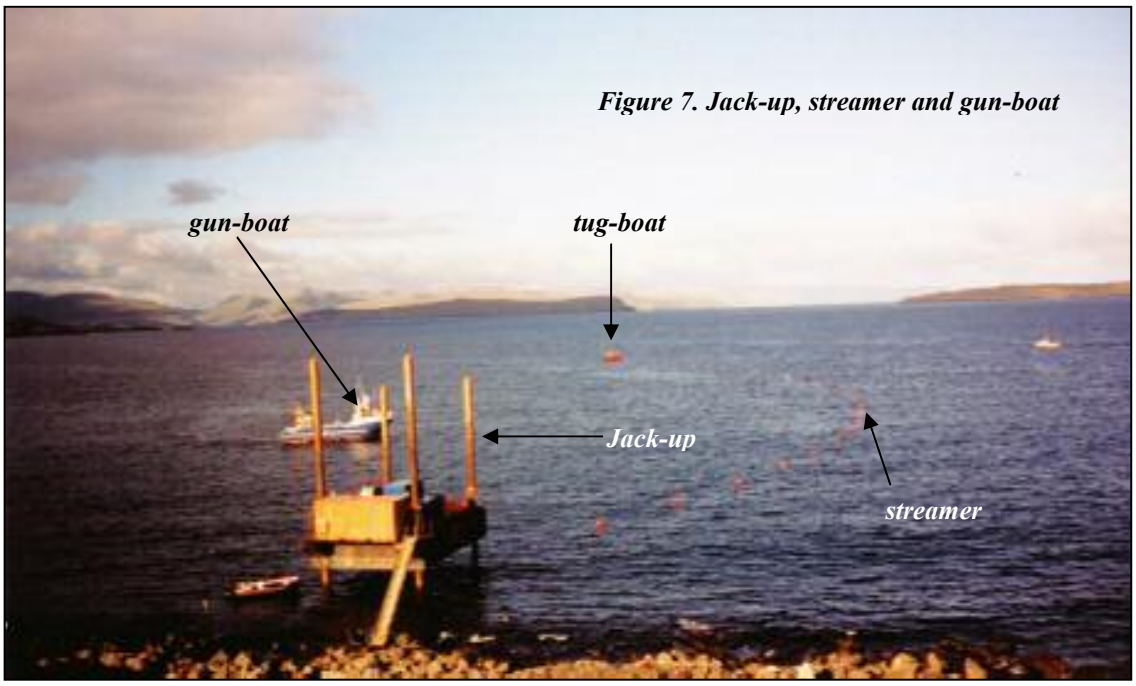


*Figure 7. Jack-up, streamer and gun-boat*

**Acknowledgements**

We are grateful for the assistance in the field from Morten-Sparre Andersen, Rannvá M. Arge, Michael Arnhild, Niels K. Breiner, Alex Brisbourne, Neil Hurst, Zoe Lunnon, Jenny Maresh, Nick Mohammed, Uni Peterson, Alan Roberts, Dan Rowlands, Felicia Shaw, Lindsey Smith, Roman Spitzer, Per Trinhammer, Bob White and Mike Worthington.

| Site ID | Sensor ID | GPS ID | Easting (m) | Northing (m) | Height (m) |
|---|---|---|---|---|---|
| 1 | 6019 | G3024 | 618207 | 6874300 | 23.275 |
| 2 | 6142 | G2815 | 618165 | 6874291 | 30.400 |
| 3 | 6193 | G2771 | 618114 | 6874278 | 46.450 |
| 4 | 6196 | G3021 | 618069 | 6874262 | 55.270 |
| 5 | 6131 | G3032 | 617979 | 6874242 | 78.744 |
| 6 | 6126 | G2714 | 617884 | 6874209 | 94.375 |
| 7 | 6039 | G2964 | 617778 | 6874171 | 114.717 |
| 8 | 6189 | G2722 | 618268 | 6874270 | 22.461 |
| 9 | 6077 | G2814 | 618294 | 6874223 | 28.277 |
| 10 | 6022 | G2176 | 618305 | 6874175 | 30.225 |
| 100 | 6161 | G2992 | 618500 | 6873503 | 24.414 |
| 101 | 6079 | G2991 | 618461 | 6873659 | 35.397 |
| 102 | 6186 | G3013 | 618446 | 6873765 | 30.145 |
| 103 | 6162 | G#### | 618454 | 6873363 | 18.011 |
| 11 | 6156 | G3023 | 618281 | 6874079 | 42.755 |
| 12 | 6058 | G2712 | 618353 | 6874035 | 47.871 |
| 13 | 6076 | G2694 | 618373 | 6873940 | 45.209 |
| 14 | 6095 | G2683 | 618400 | 6873855 | 37.358 |
| 17 | 6176 | G3003 | 618175 | 6874246 | 36.700 |
| 20 | 6214 | G3034 | 618022 | 6874124 | 77.027 |
| 22 | 6091 | G3035 | 617871 | 6873995 | 106.933 |
| 27 | 6025 | G2697 | 618115 | 6874047 | 61.925 |
| 28 | 6178 | G3006 | 618323 | 6874284 | 17.851 |
| 29 | 6212 | G#### | 618336 | 6874242 | 21.264 |
| 30 | 6166 | G2996 | 618252 | 6874267 | 23.940 |
| 32 | 6202 | G3038 | 618234 | 6874167 | 37.925 |
| 33 | 6167 | G2997 | 618228 | 6874115 | 42.325 |
| 34 | 6220 | G2670 | 618224 | 6874021 | 53.780 |
| 35 | 6028 | G2960 | 618350 | 6874198 | 31.576 |
| 36 | 6211 | G2772 | 618382 | 6874248 | 20.546 |
| 37 | 6197 | G3027 | 618404 | 6874210 | 27.857 |
| 38 | 6179 | G3005 | 618431 | 6874259 | 17.772 |
| 39 | 6140 | G2982 | 618444 | 6874214 | 27.624 |
| 40 | 6182 | G3008 | 618364 | 6874290 | 13.833 |
| 42 | 6201 | G2670 | 618189 | 6874352 | 20.050 |
| 43 | 6045 | G3031 | 618166 | 6874399 | 13.075 |
| 44 | 6029 | G2753 | 618143 | 6874339 | 28.375 |
| 45 | 6074 | G2700 | 618131 | 6874382 | 24.325 |
| 46 | 6012 | G3218 | 618107 | 6874423 | 22.500 |
| 47 | 6188 | G3013 | 618090 | 6874313 | 45.159 |
| 48 | 6204 | G2750 | 618088 | 6874366 | 34.225 |
| 49 | 6037 | G3217 | 618064 | 6874405 | 31.825 |
| 81 | 6066 | G2698 | 618309 | 6873813 | 47.363 |
| 82 | 6170 | G3019 | 617999 | 6873875 | 96.598 |
| 99 | 6165 | G2995 | 618219 | 6874253 | 27.600 |

The sensor and GPS serial numbers above are those recorded on recovery only. Several sites incurred instrument and/or GPS receiver replacements at certain stages within the project and these are discussed more fully below.

**UTM coordinates** – zone 29V, datum: wgs84. Heights (above sea level) are an average of four differential GPS (DGPS) measurements corrected for antenna elevation above ground surface.

**6TD sensors** were deployed on cement plinths, directly overlying bedrock and protected in accordance with the SEIS-UK recommended field procedure. In addition, 1m high fencing was constructed around the solar panels to discourage the local (domestic) wildlife (*see figure 1*). In general, the seismometer array was designed to produce several radial extensions required for wide-angle acquisition, plus a dense array for potential tomographic studies. Sleight deviations from the ideal layout were primarily governed by local bedrock distribution. Only, site 103 (*see figure 2*) was deployed significantly off-strike in attempt to reduce the degrading effects of wave-induced noise.

During periods of controlled source seismic shooting, all sites maintained a **sampling rate** of 200 samples/sec. For intervening periods when they were recording earthquakes, a sampling rate of 100 sample/sec was used. GPS coverage (for the time base) for each site was initially set to update at 1-hour intervals; however, this was increased to continuous – and at the expense of greater power usage – to avoid (apparent) large time excursions observed between updates. Despite this, several sites experienced coverage limitations either as result of topographic shadowing or (perhaps) as a result of the receivers not being configured to suit Faroese circumstances. Sites 01, 03, 04, 05, 09, 11, 20, 27, 34 & 44 gained new GPS receivers in mid-August and were found to work much better.

In general, downloading of all the sites took place either before the start of any controlled source seismic shooting, to ensure maximum recording space; or before any prolonged periods of teleseismic recording. Whilst maintaining a sampling rate of 100 samples/sec, it was found that instruments could record for approximately 40 days before downloading was required. For a sampling rate of 200 samples/sec,

instruments were downloaded approximately every 14 days. GPS coverage, battery voltage and general site attributes were also monitored at these stages. In particular, (spatial) variation in the magnitude of **external battery voltages** is most evident. This is most likely due to the positioning of certain sites with respect to shadows cast by the landscape and/or buildings and thus preventing substantial solar recharge. During Faroese winter, however, daylight hours are so short, that the amount of solar recharge may be regarded as negligible. It is possible that the sensors went through a series of on/off cycles, particularly from October onwards, in conjunction with rising and falling power supply. The official low-voltage disconnect on the 6TDs should operate between 9.2-9.6V and similarly reconnect when battery voltages reach between 11.2-11.6V. Whether these criteria are affected by the extreme cold, as prevailed during the last few months of the project, is unknown. Since monitoring of the sites was relatively coarse (maximum – twice a month) it is possible that these cycles may have gone by unnoticed in the field, being essentially aliased. (Note that the data itself is a record of when the instruments were functioning and can obviously be checked to provide a more complete record). This may help to explain the fact that, on recovery for example, certain sites had seemed to 'maintain' relatively 'high' voltages, when in truth the sensor may have just restarted after a period of recharge.

**Downloading** of all sensors occurred on: 09/06/03, 20/06/03, 08/07/03, 21-22/07/03, 29-31/08/03, 13-14/09/03, 22/09/03, 31/10/03-01/11/03 and 13-15/12/03. All downloads up until 22/09/03 occurred without problems.

During the **penultimate download** (31/10/03-01/11/03), it was discovered that 8 sensors (**6022, 6028, 6037, 6131, 6140, 6156, 6196 & 6197**) would not communicate with the palmtop computer and thus download not permitted. It was not clear at the time whether this was a result of low battery voltage or independent instrument failure, because we did not try a new battery: see below.

It was decided that due to decreasing daylight hours (and thus minimal solar recharge of batteries) a full **battery replacement** scheme be instigated. This was carried out between 15-17/11/03 and it was hoped that the new batteries would provide enough power for the sensors to record until recovery in mid-December. On gaining a fully charged battery, 6 of the 8 sensors (above) began to function again, suggesting power

loss as the cause of failure recorded during 31/10/03-01/11/03. The remaining two instruments (**6037 & 6140**), however, would not function despite replacing with fully charged batteries, and furthermore an additional 8 sensors (**6045, 6074, 6079, 6165, 6189, 6211, 6212 & 6220**) failed, all of which had been *functional* (and thus successfully downloaded) during the penultimate download. These instruments had therefore failed between the penultimate download (31/10/03-01/11/03) and the servicing period (15-17/11/03). In this case, lack of power could obviously not be advocated as a reason for instrument failure because fully charged batteries had been installed.

After recovery, and during the **ultimate download** (13-15/12/03), a reduced total of 7 sensors (**6079, 6126, 6170, 6189, 6193, 6196 & 6220**) were now recorded as non-functional. Surprisingly, only *three* (**6079, 6189 & 6220**) of these had been previously recorded as non-functional during the battery replacement scheme in November. Another (**6196**) had been registered as non-functional during the penultimate download, but, on gaining a fully charged battery in November, had powered up again. None of the remaining 3 had been observed as non-functional at any stage throughout the project.

Evidently, there seems to be little or no pattern in this behaviour apart from that it took place toward the latter stages of the project when conditions were poor (cold/wet) and battery power limited. None of the 6TDs was superficially damaged. The 7 sensors that were ultimately non-functional have been brought to the attention of Guralp who are to download in January 2004.

In addition to the 6TD sensors listed above, several other **damages** were incurred during the project:
1 x large rucksack spoilt by battery acid
3 x palmtop computers damaged by rain
1 x download cable, 1 x power cable, 4 x GPS cables: damaged by wildlife.

**10 spare 6TD sensors** were also available throughout the project: 6018, 6032, 6044, 6071, 6107, 6164, 6192, 6194, 6216 & 6217. During the acquisition of controlled source seismic shooting, several temporary sites were constructed on the islands of Vágar and Nolsoy, and on the Streymoy peninsular opposite Glyvursnes (Kirkjubøur). The Nolsoy sites were primarily deployed to monitor local quarry activity, whereas those deployed on Vágar and Kirkjubøur were used to achieve greater offset than that offered solely by the permanent Glyvursnes array. All 10 sites were recovered and downloaded at the end of September.

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We are grateful for the assistance in the field from Morten-Sparre Andersen, Rannvá M. Arge, Michael Arnhild, Niels K. Breiner, Alex Brisbourne, Neil Hurst, Zoe Lunnon, Jenny Maresh, Nick Mohammed, Uni Peterson, Alan Roberts, Dan Rowlands, Felicia Shaw, Lindsey Smith, Roman Spitzer, Per Trinhammer, Bob White and Mike Worthington.

***Figure 1. Schematic location of 6TD sensors on Glyvursnes. UTM coordinates: zone 29v, datum: wgs84***

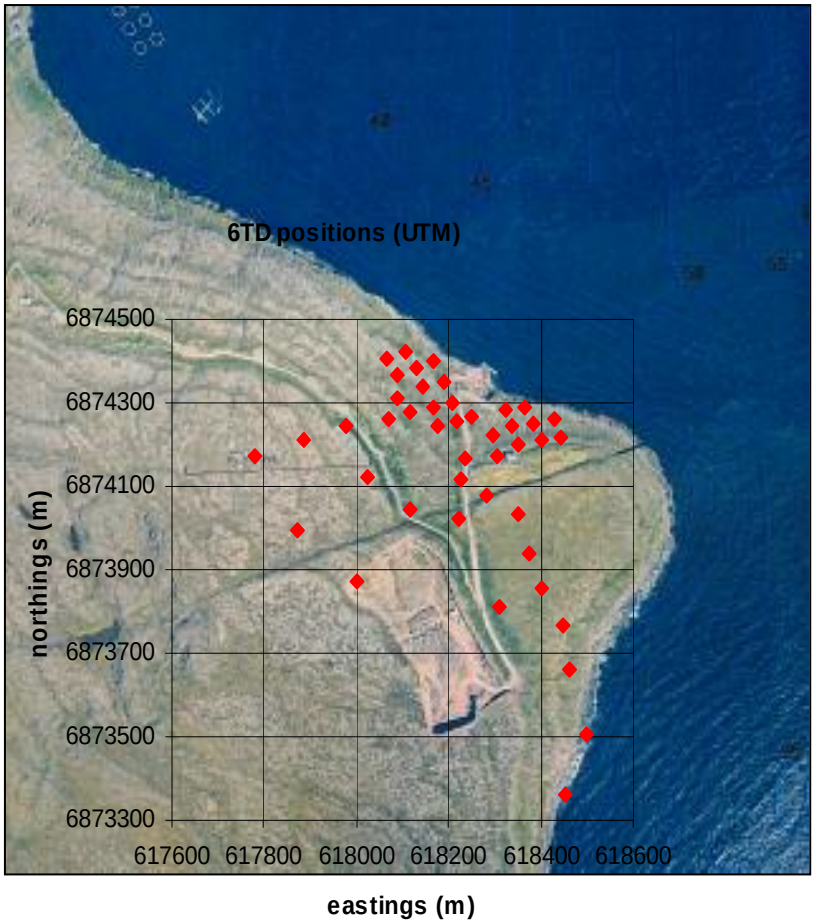


***Figure 2. A typical Glyvursnes site: complete with 6TD sensor, battery and cabling, GPS receiver, solar panel and 1 m high protective fencing.***