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Data of the active and passive seismic experiments on Bornholm in the framework of the GASH project (October 2010 and June 2012)

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Abstract

SEG-Y and other supplementary data of the near surface active and passive seismic experiments on Bornholm, Denmark, with the aim of investigating the Alum Shale black shale formation. Presented are data of active weight drop measurements, P-wave and S-wave vibroseis experiments and of ambient noise recordings of two locations in the southern part of Bornholm. The corresponding experiments were carried out in October 2010 and in June 2012.

Supplementary data:

DOI: 10.5880/GIPP.201015.1 (October 2010)
DOI: 10.5880/GIPP.201222.1 (June 2012)

Coordinates: Billegrav: 55°01' N, 15°00' E
Skelbro: 55°02' N, 14°53' E

1. Introduction

Black shales are sedimentary rocks with a high content of organic carbon, which leads to a dark grayish to black color. Because of their potential to contain oil or gas, black shales are of great interest for the support of the worldwide energy supply. In Scandinavia, black shales are widely spread geographically, have a high maturity and a high TOC content. Furthermore, on the Danish island Bornholm, these hydrocarbon source rocks occur at shallow depth (< 50 m) which makes this location applicable to our shallow seismic investigation in the framework of the GASH project.

The GASH project (GAs SHales in Europe) is an interdisciplinary, multinational shale gas research initiative started in 2009 with a duration of three years. It focuses on potential gas shales in Europe, especially on the Alum Shale (Denmark) and the Posidonia and Carboniferous Shales (Germany), with the aim to predict shale gas formation and occurrence in time and space.

In October 2010 and in June 2012 we carried out measurements in the southern part of Bornholm at two locations (Billegrav, Skelbro) to study the seismic properties of the shallow black shales of the Alum Shale Formation. The profiles were located as near as possible to existing well locations which enabled us to correlate the seismic data with the logging information of the boreholes (Schovsbo, 2011). The seismic lines were arranged perpendicular to each other to achieve a three-dimensional impression of the subsurface in this area. The analysis of the data at the Skelbro location (traveltime tomography) revealed the Alum Shale black shale layer with reduced seismic velocities between a limestone layer on top and a sandstone layer below the black shale (Baumann-Wilke et al., 2012; Baumann-Wilke, 2013). The different lithological formations were all found dipping southward.

2. Data Acquisition

2.1 Experiment design and schedule

At two different locations (Billegrav, Skelbro) in the southern part of Bornholm, active and passive seismic measurements were conducted. For the active seismic experiment 6 seismic lines were deployed at the two locations (Figure 1). The three lines of the Billegrav location and the first two lines of the Skelbro location were carried out with a weight drop source between 04.10. and 12.10.2010 and had a length of 700 m each. The active experiments at the third line of the Skelbro location took place between 18.06. and 22.06.2012. Therefore, both weight drop and mini-vibrator were used as a source along the 700 m long profiles. The mini-vibrator could be operated as either P-wave or S-wave source. At each shot point the sources were initiated ten times.

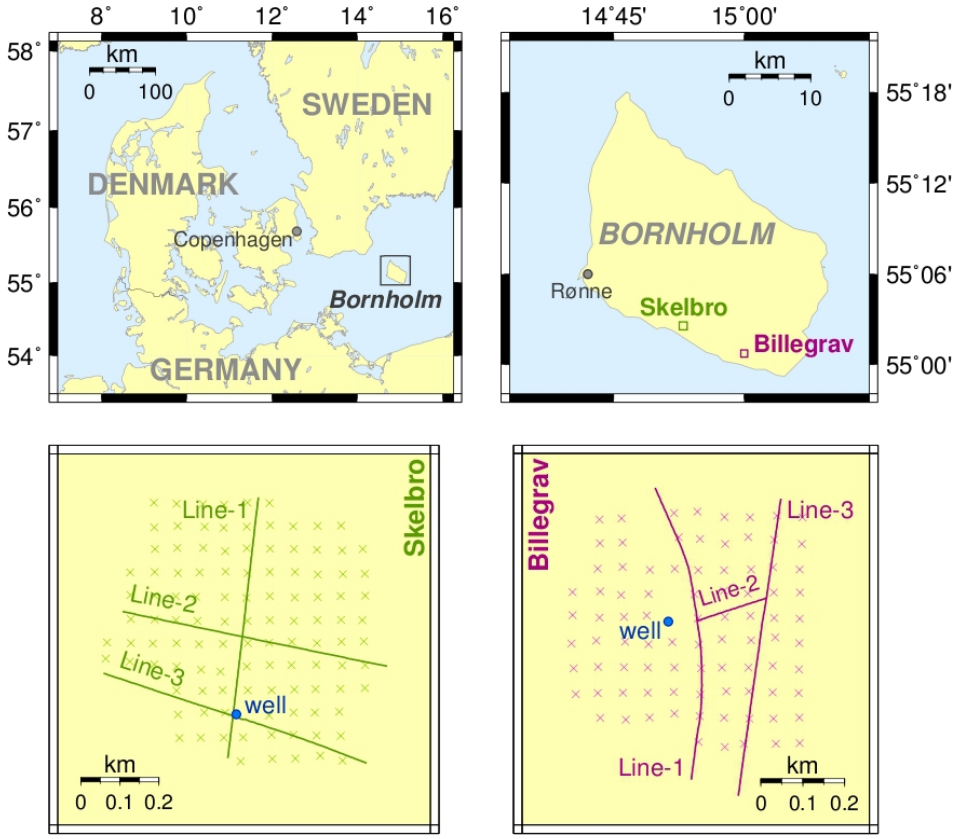

Figure 1: Location maps of the GASH seismic experiments on Bornholm, Denmark. The lines indicate the active seismic profiles and the crosses represent the locations of the stations for the ambient noise measurement. The Skelbro Lines 1 and 2, all Billegrav lines and the ambient noise measurements were conducted in October 2010, the experiments at the Skelbro Line 3 were carried out in June 2012. At both of the locations the positions of the scientific wells are inserted.

The weight drop experiments were carried out with a fixed receiver spread and the vibroseis lines had a roll-along configuration with an overlap of 120 m. The central parts of all profiles were equipped with geophones of the Geode system, where 10 Geodes each with 24 geophones were arranged with a receiver distance of 2 m. At the outer edges of each profile stand-alone digital data recorders (DSS Cubes) were spread every 2 m to reach the full extend of the line.

The vibroseis lines covered only the inner part of the third seismic profile at the Skelbro location (distance 120 – 600 m) but were arranged with a smaller receiver spacing of 1 m again using the Geode system (10 Geodes, 24 channels each). In the near field area around the source position the

stand-alone digital data recorders were deployed between the Geode geophones to decrease the receiver spacing to 0.5 m. For the weight drop and P-wave vibroseis experiments vertical geophones were used and for the S-wave viboseis experiment three-component geophones were arranged.
The stations for the ambient noise recordings at the Skelbro location were running continuously between 01.10. and 04.10.2010 and at the Billegrav location between 13.10. and 16.10.2010. The recorders were spread with a distance of 60 m between two adjacent stations over an area of approximately 700 x 700 m.

2.2 Geometry/Location

The shot and receiver coordinates of all profiles and the coordinates of the ambient noise stations are listed in the folder *info/geometry*.

2.3 Instrumentation

The Geode (Geometrics Inc.) seismic multichannel system (240 channels) was used in connection with 10 Hz vertical or three-component geophones. Additionally, up to 205 stand-alone digital data recorders (DSS Cubes, Geophysical Instrument Pool Potsdam GIPP) with 4.5 Hz geophones were spread to reach the full extend of each seismic profile.
A PEG-40 (R. T. Clark Companies, Inc.) was used as the weight drop source and the vibroseis experiments were conducted with a mini-vibrator (ElViS – Electrodynamic-Vibrator System by Geosym). A sweep length of 10 s was used with linearly increasing frequency from 20 to 160 Hz.
The ambient noise measurements were realized with the DSS Cubes and 4.5 Hz geophones.

2.4 Acquisition parameters

	spread	***total profile length (m)***	***source type***	***number of sources***	***number of receivers***	***source distance (m)***	***receiver distance (m)***
Billegrav Line-1	fixed	716	weight drop	61	359	12	2
Billegrav Line-2	fixed	190	weight drop	31	187	6	1
Billegrav Line-3	fixed	716	weight drop	61	359	12	2
Skelbro Line-1	fixed	690	weight drop	58	340	12	2
Skelbro Line-2	fixed	714	weight drop	61	359	12	2
Skelbro Line-3	fixed	716	weight drop	61	360	12	2
Skelbro Line-3 Vib-P	roll-along	480	vibrator	71	445	6/12	0.5/1
Skelbro Line-3 Vib-S	roll-along	480	vibrator	72	319/325	6/12	0.5/1

3. Data Processing

The archived data were basically processed, including

- bandpass filtering (Butterworth, zero phase, 1-6-500-6),
- vertical stacking (Diversity stack based on amplitude, operator length of 100 ms),
- restitution filtering (equalization of the different geophones used, convolution of 4.5 Hz data

with filter to equalize with 10 Hz data),
- geometry installation and
- resampling to 1ms.

4. Data Description

For all active seismic lines one SEG-Y file contains the recordings of all receivers and all weight drop sources along the lines. Additionally, two SEG-Y files with the vibroseis recordings of all receivers of each P-wave and S-wave source can be found. The ambient noise recordings are only available as raw (unprocessed) data.

4.1 File format

The data are stored in SEG-Y format (e.g., Barry et al., 1975). The header words are set as listed in the following table.

Seismic Unix header	***SEG-Y header bytes***	***description***
tracl	1 – 4	trace number within line
tracr	5 – 8	trace number within this file
fldr	9 – 12	field record number = shot point number
tracf	13 – 16	receiver channel number
ep	17 – 20	shot point number (= fldr)
cdp	21 – 24	CDP ensemble number
trid	29 – 30	trace identification code
nhs	33 – 34	number of horizontally stacked traces
offset	37 – 40	distance from source to receiver (in m)
gelev	41 – 44	elevation at receiver location
selev	45 – 48	elevation at source location
scalel	69 – 70	scale factor of gelev and selev
scalco	71 – 72	scale factor of sx, sy, gx and gy
sx	73 – 76	source coordinate (utm x)
sy	77 – 80	source coordinate (utm y)*
gx	81 – 84	receiver coordinate (utm x)
gy	85 – 88	receiver coordinate (utm y)*
counit	89 – 90	coordinates unit code
muts**	111 – 112	start of mute time
mute**	113 – 114	end of mute time
ns	115 – 116	number of samples per trace
dt	117 – 118	sampling interval in microseconds
year	157 – 158	year data recorded

d1	181 – 184	X CDP coordinate
f1	185 – 188	Y CDP coordinate
* the utm y coordinate was subtracted by 6000000 beforehand ** not set in all files		

4.2 Data content and structure

The data of the two corresponding experiments are stored separately according to their date of registration. The folder “201015-bornholm/” contains the data of the measurements in October 2010 and the folder “201222-bornholm2/” contains the data of the June 2012 experiment. The content of the two folders is listed in the following tables.

201015-bornholm/

file name	*sources*	*traces*	*size (bytes)*	*acquisition date*	*comment*
segy/Billegrav_Line-1_Weightdrop.sgy	61	21899	618431360	08.10.2010	
segy/Billegrav_Line-2_Weightdrop.sgy	31	5797	117334880	12.10.2010	
segy/Billegrav_Line-3_Weightdrop.sgy	61	21876	617781840	09. + 11.10.2010	
segy/Skelbro_Line-1_Weightdrop.sgy	58	19720	556896400	04. – 05.10.2010	
segy/Skelbro_Line-2_Weightdrop.sgy	61	21899	618431360	06.10.2010	
raw/*					raw data (unprocessed)
info/geometry/*					geometry files
info/README_201015					readme file
info/GASH_seismics_Bornholm.pdf					project report
info/Billegrav.las					borehole logging data
info/Skelbro.las					borehole logging data
* content described in readme file (/info/README_201015)					

201222-bornholm2/

file name	*sources*	*traces*	*size (bytes)*	*acquisition date*	*comment*
segy/Skelbro_Line-3_Vibro_P.sgy	71	31595	323662780	19. – 20.06.2012	
segy/Skelbro_Line-3_Vibro_S.sgy	72	23352	239221488	21. – 22.06.2012	
segy/Skelbro_Line-3_Weightdrop.sgy	61	21960	488394000	18.06.2012	
raw/*					raw data (unprocessed)
info/geometry/*					geometry files
info/README_201222					readme file
info/GASH_seismics_Bornholm.pdf					project report
info/Skelbro.las					borehole logging data
* content described in readme file (/info/README_201222)					

5. Data Quality/Accuracy

For the weight drop experiments the recording system was triggered by a trigger switch with an accuracy of 34.7 µs. The coordinates were measured with a differential GPS system with a location accuracy of about 1 m.

6. Data Availability/Access

The data are archived at the *GIPP Experiment and Data Archive* where they are freely available for further use. The DOI numbers of the supplementary data are 10.5880/GIPP.201015.1 and 10.5880/GIPP.201222.1. When using the data, please give reference to this data publication and to Baumann-Wilke et al. (2012). Recommended citation for this publication is:

> Baumann-Wilke, M., Bauer, K., Stiller, M., and Schovsbo, N. H. (2014) Data of the active and passive seismic experiments on Bornholm in the framework of the GASH project. Scientific Technical Report STR Data 14/04; DOI: 10.2312/GFZ.b103-14046; Potsdam.

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