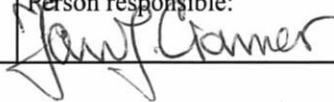


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Title: Cruise report- Sandwaves and sand transport on the Barents Sea continental margin offshore Norway			
Authors: Monica Winsborrow, Reidulv Bøe, Leif Rise, Shyam Chand		Client: Norwegian Deepwater Programme (NDP)	
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Summary:			
<p>Sandwaves are common on many continental shelves indicating the operation of strong currents which lead to erosion, transportation and deposition of sediment on the seabed. Their dynamic nature means that they can pose challenges to seafloor installations such as pipelines.</p> <p>Sandwaves were identified on the Barents Sea continental margin by the MAREANO programme (www.mareano.no). A project entitled "Sandwaves and sand transport on the Barents Sea continental margin", within the Norwegian Deepwater Program, NDP, was set up with the aim to provide a detailed study of the nature and characteristics on sandwaves on the Barents Sea continental slope.</p> <p>A marine geological cruise to the south-western Barents Sea slope was carried out by R/V G.O. Sars, 11-18 April 2012, to acquire datasets for use in this project. The primary data collected were TOPAS and grab/gravity core samples. In addition, ADCP data was collected for analysis by the Institute for Marine Research. In total, 1144 km of TOPAS data were collected, along with sampling at 38 grab stations and 14 gravity core stations.</p> <p>This report provides a summary of the equipment used and the datasets collected during this cruise.</p>			
Keywords: Sandwaves	Sand transport	Grab	
Gravity core	Shallow seismic	Continental slope	
Sampling	Seabed sediment	ADCP	

CONTENTS

1. INTRODUCTION	4
2. BACKGROUND	4
3. EQUIPMENT	5
3.1 TOPAS (Parametric Sub-bottom Profiler System).....	5
3.2 Grab	5
3.3 Gravity corer.....	6
4. SEA STATE AND WEATHER CONDITIONS	8
5. EQUIPMENT PERFORMANCE.....	9
6. PRELIMINARY RESULTS	11
6.1 TOPAS data.....	11
6.2 Grab samples	13
6.3 Gravity cores.....	14

FIGURES

Figure 1. Deployment of the van Veen grab.

Figure 2. On deck preparation of the gravity corer.

Figure 3. Deployment of the gravity corer.

Figure 4. TOPAS data collected during rough seas.

Figure 5. Summary of data collected during cruise G12104.

Figure 6. Large sandwaves.

Figure 7. Small sandwaves.

Figure 8. Stratigraphic setting of sandwaves.

TABLES

Table 1. Overview of grab samples collected.

Table 2. Overview of gravity cores collected.

APPENDICES

Appendix 1. Cruise log.

Appendix 2. Onboard sample descriptions.

1. INTRODUCTION

A marine geological cruise to the south-western Barents Sea slope was carried out by R/V G.O. Sars, 11-18 April 2012, as a scientific contribution to the project "Sandwaves and sand transport on the Barents Sea continental margin" (Contract No. 4502202750 between Statoil Petroleum AS (Statoil) and Geological Survey of Norway, with Statoil representing the Seabed Project within the Norwegian Deepwater Program, NDP).

The primary aim of the cruise was to undertake geological and geophysical investigations of sandwaves and sand transport on the continental slope in the south-western Barents Sea. The primary data collected were TOPAS and grab/gravity core samples. In addition, ADCP data was collected for analysis by the Institute for Marine Research. In total, 1144 km of TOPAS data were collected, along with sampling at 38 grab stations and 14 gravity core stations.

2. BACKGROUND

Sandwaves are common on many continental shelves indicating the operation of strong currents which lead to erosion, transportation and deposition of sediment on the seabed. Their dynamic nature means that they can pose challenges to seafloor installations such as pipelines. Sandwaves were identified on the Barents Sea continental margin by the MAREANO programme (). This project aims to provide a detailed study of their nature and characteristics, and represents the first such study of sandwaves along the Norwegian continental slope.

Key objectives of the project, which will be addressed using data collected on this cruise, are:

1. What are the sedimentary processes leading to sandwave formation?
2. What is the mode of evolution of the sandwaves?
3. What role do seabed currents play in the formation and maintenance of the sandwaves?

Scientific party on the cruise were:

Reidulv Bøe	NGU	Cruise leader
Leif Rise	NGU	Researcher
Shyam Chand	NGU	Researcher
Monica Winsborrow	NGU	Researcher
Martin Dahl	IMR	Survey Engineer
Ann-Kristin Abrahamsen	IMR	Survey Engineer

3. EQUIPMENT

The research vessel G.O. SARS (owned by the Institute of Marine Research and the University of Bergen) was used. The ship is 77.4 m long, 16.4 m wide and has a displacement of 4067 tonnes. She has a top speed of 17.5 knots, and the noise-reduced engines give a 99% reduction in underwater noise emission, compared with conventional research vessels. R/V G.O. Sars is fitted with a range of acoustic and sampling equipment for operations in fisheries, geology and environmental research. Those used during this cruise were:

- Kongsberg TOPAS PS18 sonar, hull-mounted
- Echo sounder (EK 60)
- van Veen Grab 2500 m²
- 2 R.D.I. ADCP, acoustic doppler current profiler, 75 and 150 kHz

- In addition, a gravity coring equipment from the Geological Survey of Norway was onboard. This has an approximate weight of 300 kilograms and the capacity to retrieve 3 m long samples.

3.1 TOPAS (Parametric Sub-bottom Profiler System)

R/V G.O.Sars operates a hull-mounted Kongsberg TOPAS PS 18 parametric sub-bottom profiler. It is designed for sub-bottom profiling at very high spatial resolution, using a narrow, low frequency beam and wide bandwidth. The acoustic beam is electronically stabilised for roll, pitch and heave. Several types of pulses can be used. The Ricker pulse was used throughout this cruise. This generates a single pulse wavelet and is optimised for high-resolution operation. The raw, unprocessed data was stored for processing onshore while a crude processing was applied for onboard display and grabbing screen dumps of interesting features.

3.2 Grab

A 2500 m² van Veen Grab was used to acquire samples of the upper c. 15 cm of the seabed (Fig. 1). Once the grab sample was on deck, a 30 cm clear plastic tube was pressed into the sample to obtain an “undisturbed” mini-core. These were sealed and labelled onboard. A sample of the surface sediment was also taken, stored in a plastic bag, labelled and stored. The grab was then opened and further samples were taken of any other distinct layers. A visual description of the samples was made onboard according to the SOSI-classification.



Figure 1. Deployment of the van Veen grab.

3.3 Gravity corer

The gravity corer was used to obtain sediment cores up to 3 m long for stratigraphic purposes (Figs. 2 and 3). Once onboard the gravity cores were cut into 1 m sections, labelled and sealed. Any material recovered in the core catcher was put into a plastic sample bag and inserted into the core base.



Figure 2. On deck preparation of the gravity corer.



Figure 3. Deployment of the gravity corer.

4. SEA STATE AND WEATHER CONDITIONS

A log was kept during the whole cruise period providing a complete record of onboard operations. This is found in Appendix 1.

The first one and a half days of the cruise were affected by high winds and rough seas, with wind speeds reaching 45- 50 knots, and maximum wave heights of 14 m. During this time sampling was not possible and the quality of TOPAS data were affected. In rough seas, TOPAS data were only collected when travelling in the direction of the waves. Some interference in the data remained (Fig. 4), however the quality was reasonable.

For the remaining 5 days of the cruise the weather and sea conditions were good, allowing collection of high quality TOPAS data and sampling.

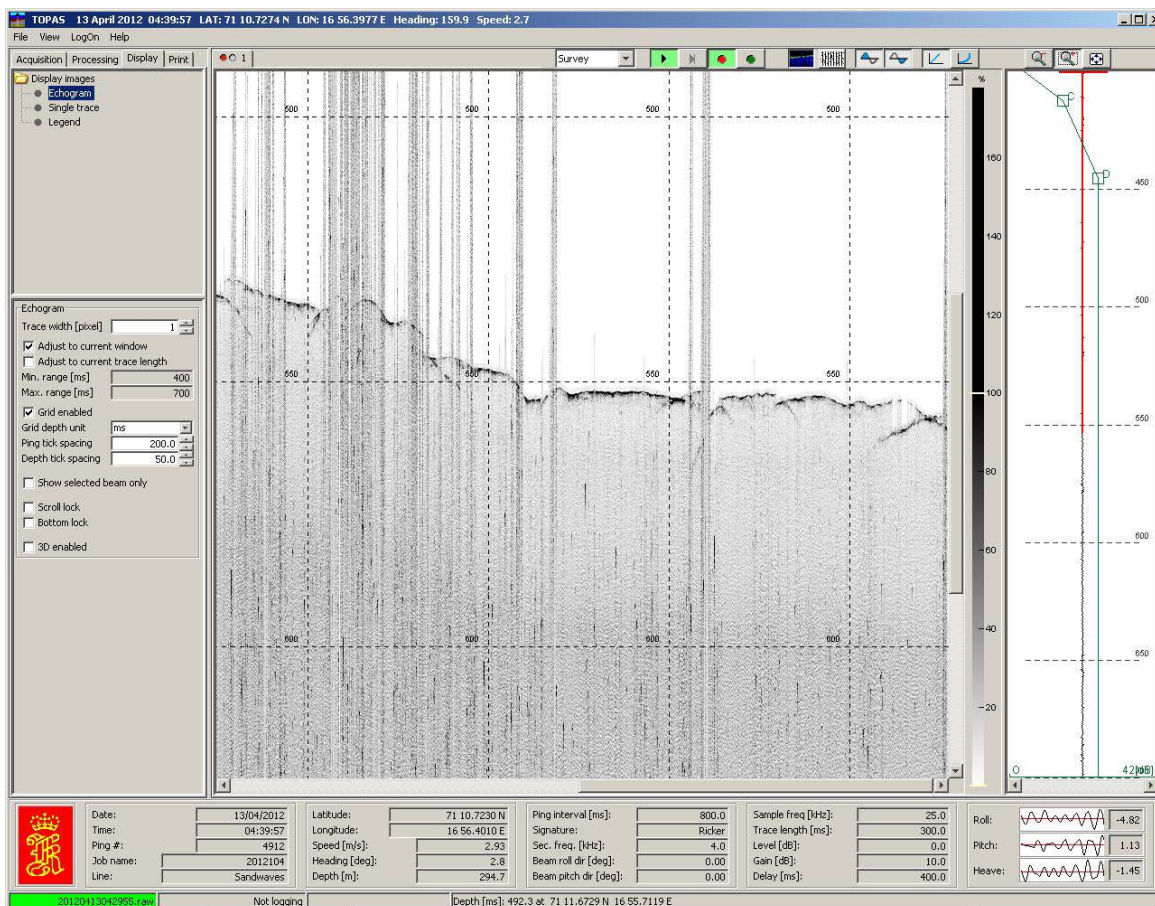


Figure 4. TOPAS data collected during rough seas had a reasonable quality, although some interference is clearly visible.

5. EQUIPMENT PERFORMANCE

The TOPAS parametric profiler generally performed well, however the software crashed fairly regularly. This could be quickly restarted, ensuring minimal loss of data.

The van Veen grab performed extremely well throughout the cruise. Of the 38 sampling stations, 35 produced good samples, a further 2 produced no or very small samples, and one retrieved a large granite boulder.

The gravity corer performed well in the areas outside the sandwaves. Of the 14 sampling stations, good samples were obtained in 10. In addition, one sample was lost at the sea surface during recovery (GC5), and three samples retrieved no sediment.

Figure 5 shows the data collected during the cruise. In total, 1144 km of TOPAS data were collected, providing extensive, high resolution coverage of the sandwave fields and adjacent areas. A total of 38 grab samples were attempted, with samples recovered in 35 of these (see appendix 2 for preliminary onboard descriptions). Gravity coring was attempted at 14 locations, with good samples obtained in 10 of these (see Appendix 2 for preliminary onboard descriptions).

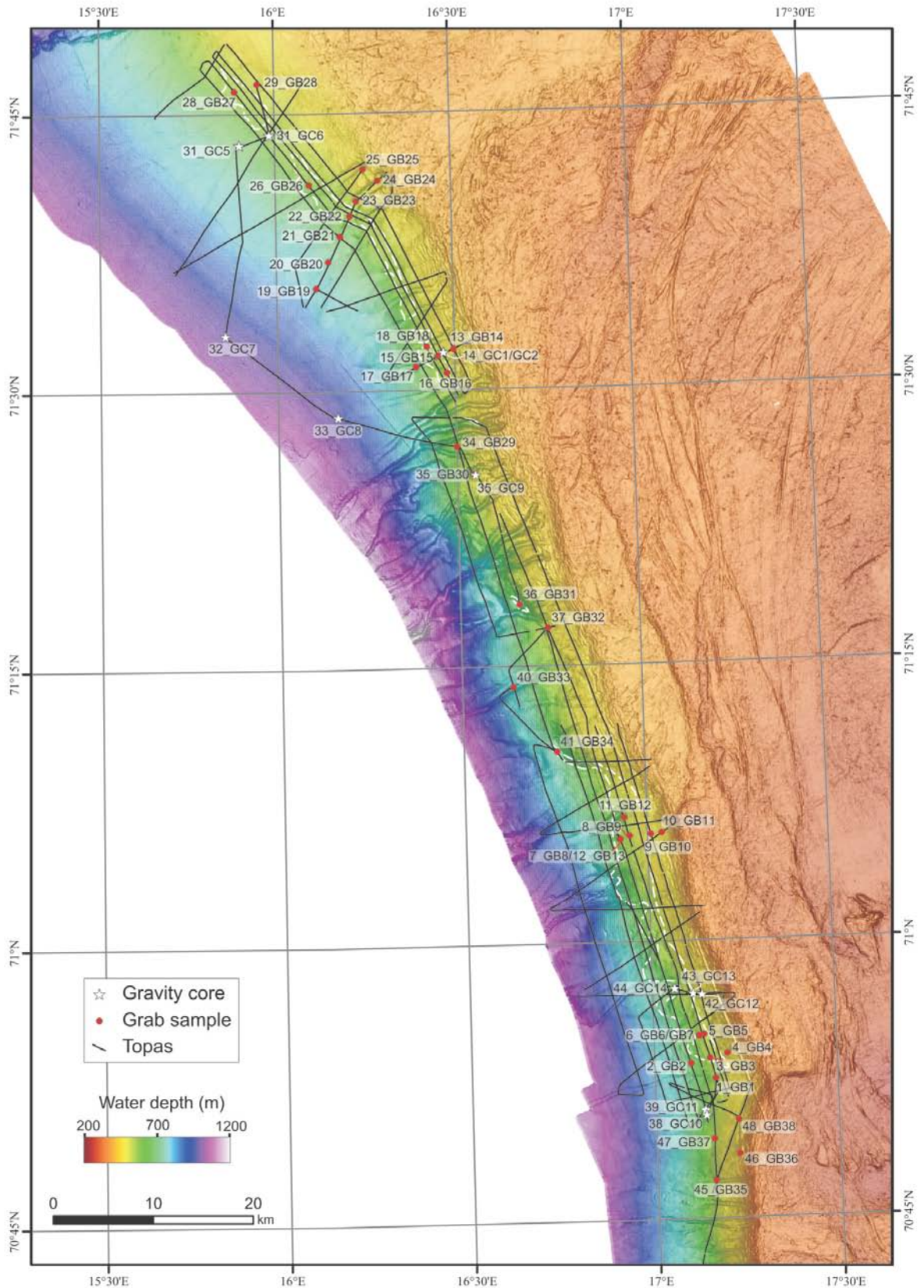


Figure 5. Summary of data collected during cruise G12104 to the continental slope in the south-western Barents Sea. The dashed white line indicates the estimated extent of sandwave fields mapped prior to the cruise from MAREANO bathymetry data. TOPAS data collected on the cruise suggests that this mapping underestimates their extent.

6. PRELIMINARY RESULTS

6.1 TOPAS data

Here we present some initial findings based on the unprocessed data. Sandwaves were readily identifiable on the TOPAS data (Fig. 6).

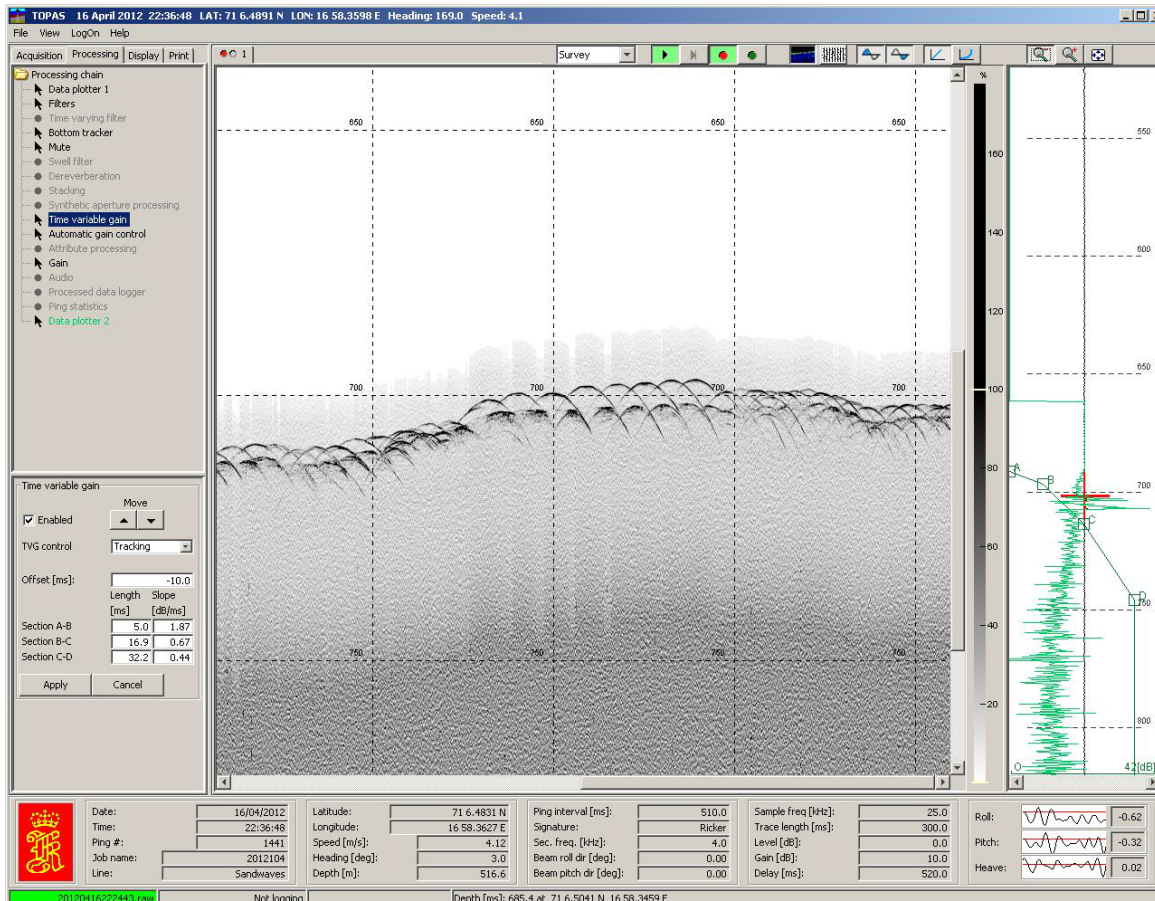


Figure 6. Large sandwaves within the southern sandwave field. These features are approximately 5 m high and are readily identifiable on both TOPAS and bathymetry datasets. Processing of the data should reduce hyperbolas and improve the imaging of these features.

In addition to the large sandwaves previously mapped from MAREANO multibeam bathymetry datasets, small sandwaves were identified on the TOPAS data (Fig. 7). Based on our initial viewing of the data, these appear to be fairly extensive, suggesting that the extent of sandwave fields mapped from bathymetry datasets represents an underestimation.

The TOPAS also gives information on the stratigraphic setting of the sandwaves. Figure 8 shows an infilled channel, overlaid by laminated sediments and then small sandwaves.

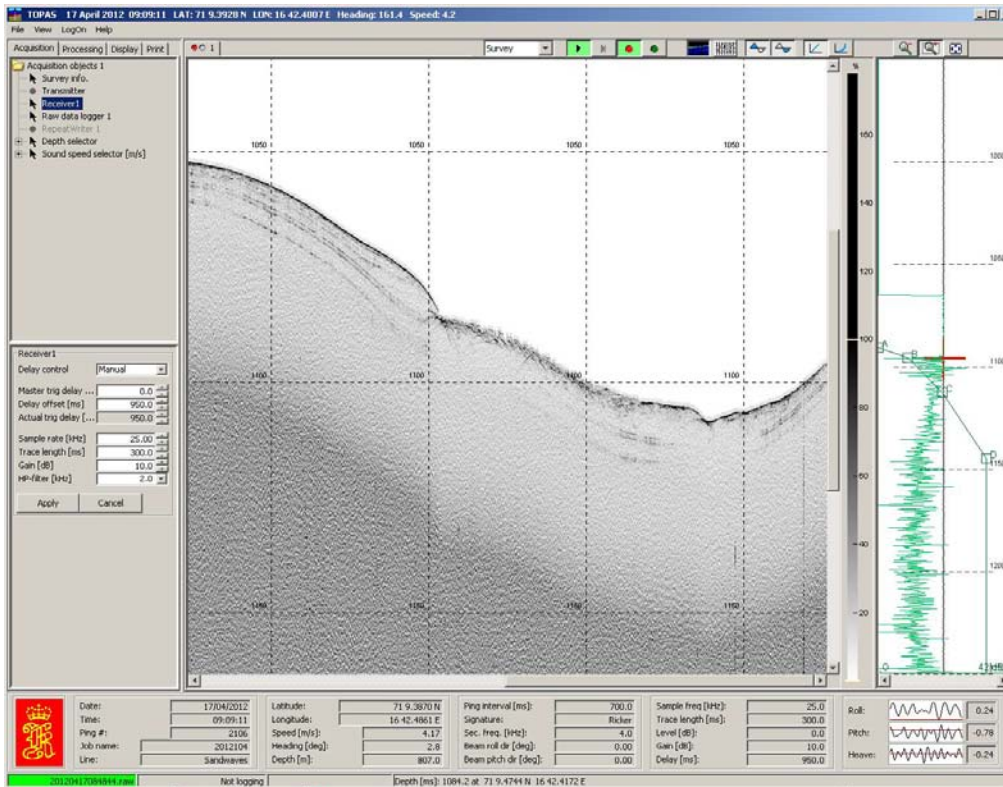


Figure 7. Small sandwaves identified southwest of the northernmost sandwave field in approximately 800 m water depth.

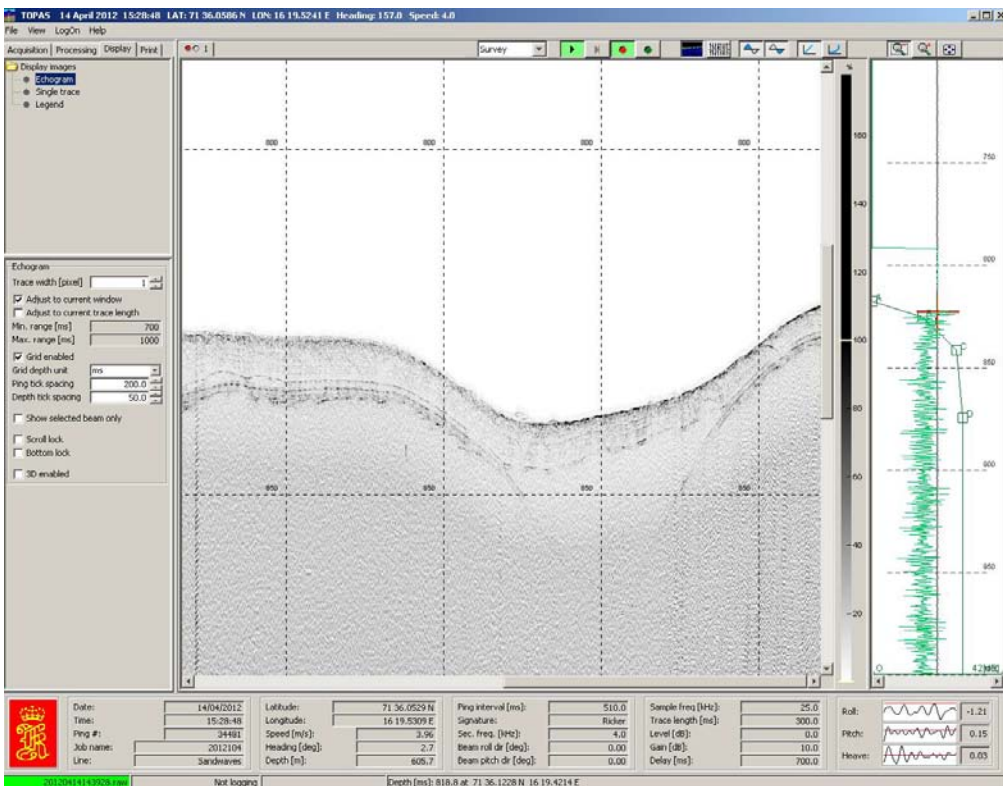


Figure 8. Stratigraphic setting of sandwaves. Small sandwaves in the southern part of the northernmost sandwave field overlay laminated sediments and an infilled channel.

6.2 Grab samples

Onboard a preliminary description of each grab sample was written (Appendix 2). A total of 38 grab samples were attempted, with samples recovered in 35 of these. Table 1 shows the location of each grab sample, water depth and retrieved sample length.

Table 1. Overview of grab samples collected

Core number	Location		Water depth (onboard echosounder)	Water depth (from bathymetry data)	Core length (cm)
1-GB1	70 52,54	17 09,96	567	571	8
2-GB2	70 53,38	17 06,03	658	664	17
3-GB3	70 53,64	17 09,16	566	571	3
4-GB4	70 53,88	17 12,02	484	486	8
5-GB5	70 54,94	17 08,31	555	558	15
6-GB6	70 54,86	17 07,45	580	584	0,5
6-GB7	70 54,86	17 07,45	580	584	14
7-GB8	71 05,56	16 55,46	603	609	12
8-GB9	71 05,73	16 57,10	559	565	15
9-GB10	71 05,80	17 00,62	480	485	11
10-GB11	71 05,87	17 02,42	441	445	16
11-GB12	71 06,72	16 56,30	564	571	17
12-GB13	71 05,56	16 55,55	602	606	16
13-GB14	71 32,21	16 29,83	505	508	23
15-GB15	71 31,84	16 27,21	579	585	18
16-GB16	71 30,93	16 28,66	556	560	9
17-GB17	71 31,27	16 23,45	659	663	0
18-GB18	71 32,35	16 25,33	583	586	11
19-GB19	71 35,58	16 06,74	785	790	22
20-GB20	71 37,00	16 08,88	721	725	13
21-GB21	71 38,35	16 10,95	665	669	0
22-GB22	71 39,45	16 12,66	605	612	21
23-GB23	71 40,26	16 13,79	569	574	17
24-GB24	71 41,35	16 17,52	495	498	17
25-GB25	71 41,97	16 15,02	478	481	15
26-GB26	71 41,16	16 05,80	615	620	17
28-GB27	71 46,24	15 53,26	587	591	15
29-GB28	71 46,64	15 57,13	547	550	15
34-GB29	71 26,94	16 30,04	602	606	13
35-GB30	71 25,43	16 32,75	548	552	5
36-GB31	71 18,34	16 39,91	659	666	15
37-GB32	71 17,07	16 44,58	539	543	16
40-GB33	71 13,89	16 38,50	788	793	15
41-GB34	71 10,36	16 45,47	705	709	17
45-GB35	70 47,04	17 09,49	566	570	20
46-GB36	70 48,45	17 13,52	411	412	6
47-GB37	70 49,29	17 09,45	565	569	44
48-GB38	70 50,30	17 13,51	446	450	15

Preliminary results from the grab samples suggests that within the sandwave fields samples tend to comprise well-sorted, fine-to-medium grained sand. Both up- and down-slope of the sandwave fields samples were coarser and more poorly sorted. Initial onboard descriptions suggest that samples from areas of large sandwaves showed similar grain sizes and degrees of sorting as those from areas of small sandwaves. An increase in quartz content was noted towards the north.

6.3 Gravity cores

Gravity coring was attempted at 14 locations, with good samples obtained in 10 of these. Where possible a preliminary description of the top and base of each core was written onboard (Appendix 2). Table 2 shows the location of each gravity core, water depth and retrieved sample length.

Table 2. Overview of gravity cores collected

Core number	Location		Water depth (onboard echosounder)	Water depth (from bathymetry data)	Core length (cm)
14-GC1	71 31,99	16 28,24	543	551	0
14-GC2	71 31,99	16 28,21	545	552	0
27-GC3	71 43,93	15 59,00	615	619	151
30-GC4	71 43,93	15 59,00	615	619	239
31-GC5	71 43,32	15 53,68	671	676	0
31-GC6	71 43,32	15 53,68	671	676	67
32-GC7	71 33,11	15 50,97	953	956	113
33-GC8	71 28,53	16 09,90	940	947	301
35-GC9	71 25,43	16 32,75	548	552	>50
38-GC10	70 50,64	17 08,17	631	639	110
39-GC11	70 50,76	17 08,09	626	630	286
42-GC12	70 57,12	17 07,83	508	512	262
43-GC13	70 57,16	17 06,75	534	539	220
44-GC14	70 57,42	17 03,82	613	618	250

APPENDIX 1
CRUISE LOG

SANDWAVES CRUISE April 11th – 18th 2012

Date	Time (UTM)	St. nr.	Activity	Position (geographic coordinates from the bridge)	Water depth (m)	Core length (cm)	Comments (number of samples, analysis type..)
11/04	1200						Departure from Tromsø. Safety briefing and fire training.
	1800		Topas				Attempt to collect Topas data, but high waves gave rise to very poor quality data. Decided to transit to the northern part of the southern sandwave area and try profiling southwards in the direction of waves.
12/04	0617		Topas				Restart Topas data collection. Average wave height 6 m, maximum 9 m, but now we are travelling in the direction of the waves the data quality is improved, although some noise from the waves is visible.
	0744		Topas				Stopped Topas line to go north and collect an IMR current meter which has been released from its position in the sandwave area.
	10:56			71 15.4763 15 59.7609			Current meter onboard.
	1301		Topas				Re-start Topas data acquisition. Wave height 4-5 m, but OK data quality because travelling in the direction of the waves.
	1642		Topas				Topas acquisition program crashed and was re-started after 2 minutes.
	1812		Topas				Finished line across slide scar
	2106		Topas				Start of line north of southern sandwave area. Wind up to 45-50 knots and average wave height 6-7 m with maximum 14 m.
	2350		Topas				Stop of line.
13/04	0000		Topas				Started to run second priority line in northerly direction. Weather improved but still rough.
	0031		Topas				Stopped line due to poor data quality.
	0430		Topas				Start of new line in southerly direction after having travelled back to northern part of southern sandwave area. Poor data quality due to high waves (mean 4.5 m, max 7 m), wind (gale) and strong currents along the shelf break.
	0457		Topas				New line because Topas stopped. OK data quality.
	0543		Topas				New line because Topas stopped. OK data quality.
	0617		Topas				New line because Topas stopped. Reduced data quality.
	0648		Topas				New line because Topas stopped. OK data quality.
	0726		Topas				End of line
	0829		Topas				Start of line to be run during transit. Bad weather and poor quality.
	0900		Topas				Start of line
	1004		Topas				Start of new line after crash
	1054		Topas				New line towards the Grab GB3
	1122		Topas				Reached location of Grab GB3
	1132	1-GB1	Grab	70 52,54	17 09,96	567	8
	1258	2-GB2	Grab	70 53,38	17 06,03	658	17
	1430	3-GB3	Grab	70 53,64	17 09,16	566	3

SANDWAVES CRUISE April 11th – 18th 2012

Date	Time (UTM)	St. nr.	Activity	Position (geographic coordinates from the bridge)		Water depth (m)	Core length (cm)	Comments (number of samples, analysis type..)
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	1533	4-GB4	Grab	70 53,88	17 12,02	484	8	
	1631	5-GB5	Grab	70 54,94	17 08,31	555	15	
	1726	6-GB6	Grab	70 54,86	17 07,45	580	0,5	Very small sample
	1756	6-GB7	Grab	70 54,86	17 07,45	580	14	
	1840		Topas					Topas start
	1900		Topas					New line start
	2007		Topas					New line start
	2210		Topas					New line
14/04	0004	7-GB8	Grab	71 05,56	16 55,46	603	12	
	0046	8-GB9	Grab	71 05,73	16 57,10	559	15	
	0133	9-GB10	Grab	71 05,80	17 00,62	480	11	
	0236	10-GB11	Grab	71 05,87	17 02,42	441	16	
	0402	11-GB12	Grab	71 06,72	16 56,30	564	17	
	0425	12-GB13	Grab	71 05,56	16 55,55	602	16	Same location as GB8
	0520		Topas					Start of line
	0703		Topas					End of line
	0708		Topas					Start of line
	0748		Topas					End of line
	0749		Topas					Start of line
	0930		Topas					Start of new line
	1036		Topas					Start of new line
	1204		Topas					Start of new line
	1305		Topas					Start of new line
	1311		Topas					Start of new line
	1626		Topas					End of line
	1633		Topas					Start of line
	1640		Topas					Restart line after system crash
	1810		Topas					End line due to drift from line
	1814		Topas					New line in correct course.
	1839		Topas					Line crashed. New line
	2002		Topas					New connecting line
	2009		Topas					New line
15/04	2254		Topas					New line
	0112		Topas					Crash and new line
	0153		Topas					End of line
	0154		Topas					Start of line

SANDWAVES CRUISE April 11th – 18th 2012

Date	Time (UTM)	St. nr.	Activity	Position (geographic coordinates from the bridge)	Water depth (m)	Core length (cm)	Comments (number of samples, analysis type..)
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	0233		Topas				End of line	
	0235		Topas				Start of line	
	0332		Topas				End of line	
	0338		Topas				Start of line	
	0509		Topas				End of line	
	0511		Topas				Start of line	
	0634		Topas				End of line	
	0638		Topas				Start of line	
	0739		Topas				End of line	
	0741		Topas				Start of line	
	0834		Topas				System crash and new line started	
	0844		Topas				End of line	
	0848		Topas				Start of line	
	0944		Topas				End of line	
	0947		Topas				Start of line	
	1203		Topas				End of line	
	1223	13-GB14	Grab	71 32,21	16 29,83	505	23	
	1315	14-GC1	Gravity core	71 31,99	16 28,24	543	0	Lowered too fast. Try again in same location
	1336	14-GC2	Gravity core	71 31,99	16 28,21	545	0	Gravel in core catcher
	1421	15-GB15	Grab	71 31,84	16 27,21	579	18	
	1514	16-GB16	Grab	71 30,93	16 28,66	556	9	
	1613	17-GB17	Grab	71 31,27	16 23,45	659	0	Small sample retrieved
	1709	18-GB18	Grab	71 32,35	16 25,33	583	11	
	1808		Topas					Start of line
	1825		Topas					End of line
	1831	19-GB19	Grab	71 35,58	16 06,74	785	22	
	1930	20-GB20	Grab	71 37,00	16 08,88	721	13	
	2018	21-GB21	Grab	71 38,35	16 10,95	665	0	Large granite boulder retrieved
	2114	22-GB22	Grab	71 39,45	16 12,66	605	21	
	2157	23-GB23	Grab	71 40,26	16 13,79	569	17	
	2241	24-GB24	Grab	71 41,35	16 17,52	495	17	
	2331	25-GB25	Grab	71 41,97	16 15,02	478	15	
16/4	0026	26-GB26	Grab	71 41,16	16 05,80	615	17	
	0128	27-GC3	Gravity core	71 43,93	15 59,00	615	151	
	0234	28-GB27	Grab	71 46,24	15 53,26	587	15	
	0328	29-GB28	Grab	71 46,64	15 57,13	547	15	

SANDWAVES CRUISE April 11th – 18th 2012

Date	Time (UTM)	St. nr.	Activity	Position (geographic coordinates from the bridge)	Water depth (m)	Core length (cm)	Comments (number of samples, analysis type..)
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	0356		Topas				Start of line
	0418		Topas				End of line
	0425	30-GC4	Gravity core	71 43,93	15 59,00	615	239
	0459		Topas				Start of line
	0515		Topas				End of line
	0545	31-GC5	Gravity core	71 43,32	15 53,68	671	0
	0634	31-GC6	Gravity core	71 43,32	15 53,68	671	67
	0711		Topas				Start of line
	0809		Topas				End of line
	0815	32-GC7	Gravity core	71 33,11	15 50,97	953	113
	0953		Topas				Start of line
	1030		Topas				End of line
	1101	33-GC8	Gravity core	71 28,53	16 09,90	940	301
	1139		Topas				Start of line
	1217		Topas				End of line
	1227	34-GB29	Grab	71 26,94	16 30,04	602	13
	1258		Topas				Start of line
	1309		Topas				End of line
	1316	35-GB30	Grab	71 25,43	16 32,75	548	5
	1355	35-GC9	Gravity core	71 25,43	16 32,75	548	>50
	1430		Topas				Start of line
	1458		Topas				End of line
	1458		Topas				Start of line
	1522		Topas				End of line
	1522		Topas				Start of line
	1531		Topas				End of line
	1536	36-GB31	Grab	71 18,34	16 39,91	659	15
	1643	37-GB32	Grab	71 17,07	16 44,58	539	16
	1716		Topas				Start of line
	1724		Topas				End of line
	1726		Topas				Start of line
	1831		Topas				End of line
	1833		Topas				Start of line
	1906		Topas				End of line
	1907		Topas				Start of line

SANDWAVES CRUISE April 11th – 18th 2012

Date	Time (UTM)	St. nr.	Activity	Position (geographic coordinates from the bridge)	Water depth (m)	Core length (cm)	Comments (number of samples, analysis type..)
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	1916		Topas				End of line
	1916		Topas				Start of line
	1932		Topas				End of line
	1933		Topas				Start of line
	1947		Topas				End of line
	1948		Topas				Start of line
	2014		Topas				End of line
	2014		Topas				Start of line
	2041		Topas				End of line
	2042		Topas				Start of line
	2106		Topas				End of line
	2107		Topas				Start of line
	2204		Topas				End of line
	2204		Topas				Start of line
	2224		Topas				End of line
	2224		Topas				Start of line
	2313		Topas				End of line
	2315		Topas				Start of line
	0034		Topas				End of line
17/4	0034		Topas				Start of line
	0046		Topas				End of line
	0052	38-GC10	Gravity core	70 50,64	17 08,17	631	110
	0135	39-GC11	Gravity core	70 50,76	17 08,09	626	286
	0221		Topas				Start of line
	0550		Topas				End of line
	0552		Topas				Start of line
	0630		Topas				End of line
	0653	40-GB33	Grab	71 13,89	16 38,50	788	15
	0726		Topas				Start of line
	0811		Topas				End of line
	0815	41-GB34	Grab	71 10,36	16 45,47	705	17
	0848		Topas				Start of line
	1120		Topas				End of line
	1120		Topas				Start of line
	1221		Topas				End of line
	1222		Topas				Start of line

SANDWAVES CRUISE April 11th – 18th 2012

Date	Time (UTM)	St. nr.	Activity	Position (geographic coordinates from the bridge)	Water depth (m)	Core length (cm)	Comments (number of samples, analysis type..)
------	------------	---------	----------	---	-----------------	------------------	---

	1232		Topas				End of line
	1234		Topas				Start of line
	1257		Topas				End of line
	1304	42-GC12	Gravity core	70 57,12	17 07,83	508	262
	1348	43-GC13	Gravity core	70 57,16	17 06,75	534	220
	1419		Topas				Start of line
	1435		Topas				End of line
	1437		Topas				Start of line
	1438		Topas				End of line
	1503	44-GC14	Gravity core	70 57,42	17 03,82	613	250
	1536		Topas				Start of line
	1806		Topas				End of line
	1825	45-GB35	Grab	70 47,04	17 09,49	566	20
	1838		Topas				Start of line
	1917	46-GB36	Grab	70 48,45	17 13,52	411	6
	2002	47-GB37	Grab	70 49,29	17 09,45	565	44
	2048	48-GB38	Grab	70 50,30	17 13,51	446	15
	2145		Topas				End of line
	2146		Topas				Start of line
	2153		Topas				End of line
	2154		Topas				Start of line
	2203		Topas				End of line
	2203		Topas				Start of line
	2300		Topas				End of line
	2301		Topas				Start of line
18/04	0102		Topas				End of line
	0103		Topas				Start of line
	0159		Topas				End of line
	0202		Topas				Start of line
	0224		Topas				End of line
	0225		Topas				Start of line
	0304		Topas				End of line
	0323		Topas				Start of line
	0331		Topas				End of line
	0331		Topas				Start of line
	0340		Topas				End of line

SANDWAVES CRUISE April 11th – 18th 2012

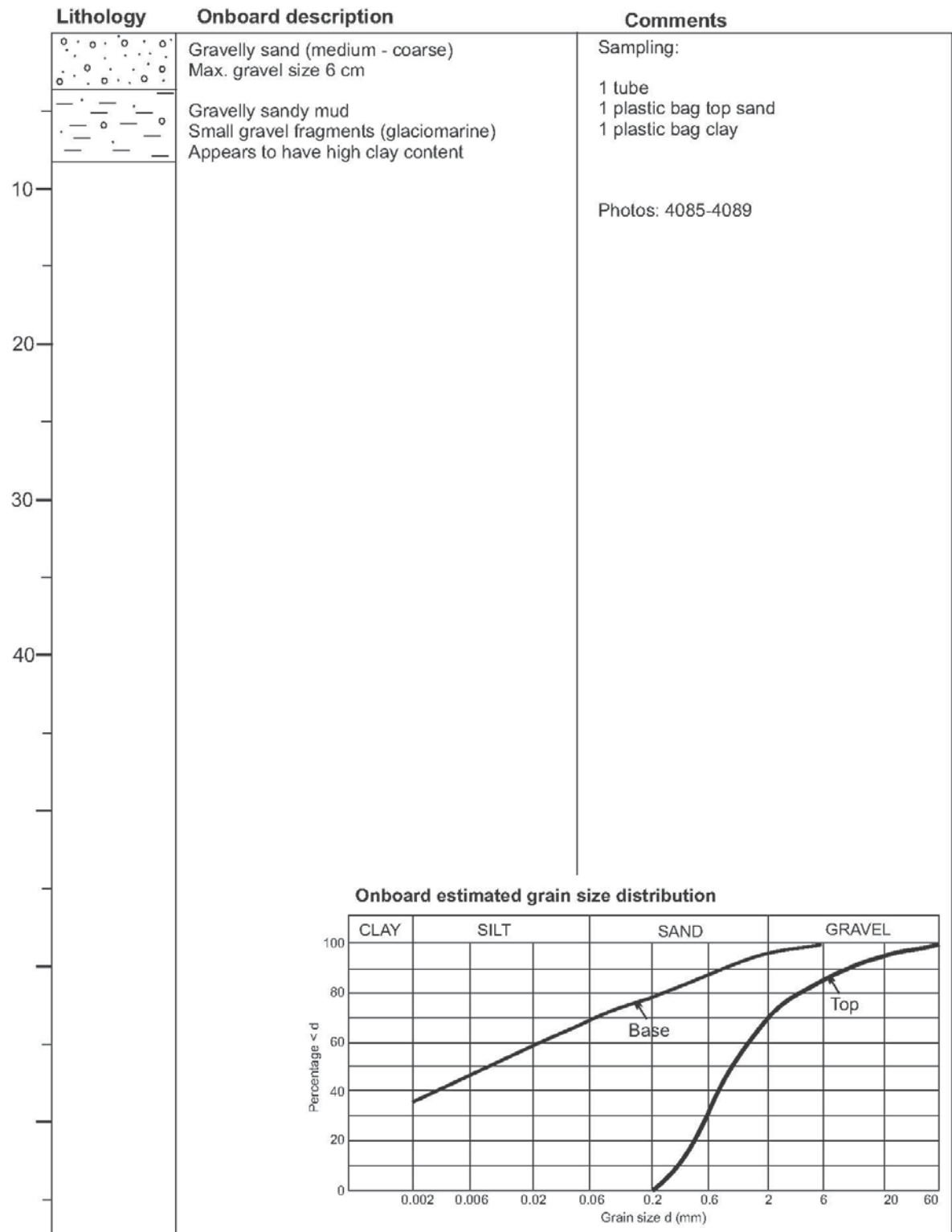
Date	Time (UTM)	St. nr.	Activity	Position (geographic coordinates from the bridge)	Water depth (m)	Core length (cm)	Comments (number of samples, analysis type..)
------	------------	---------	----------	---	-----------------	------------------	---

	0341						Start transit to Tromsø
	0900						Arrival Tromsø

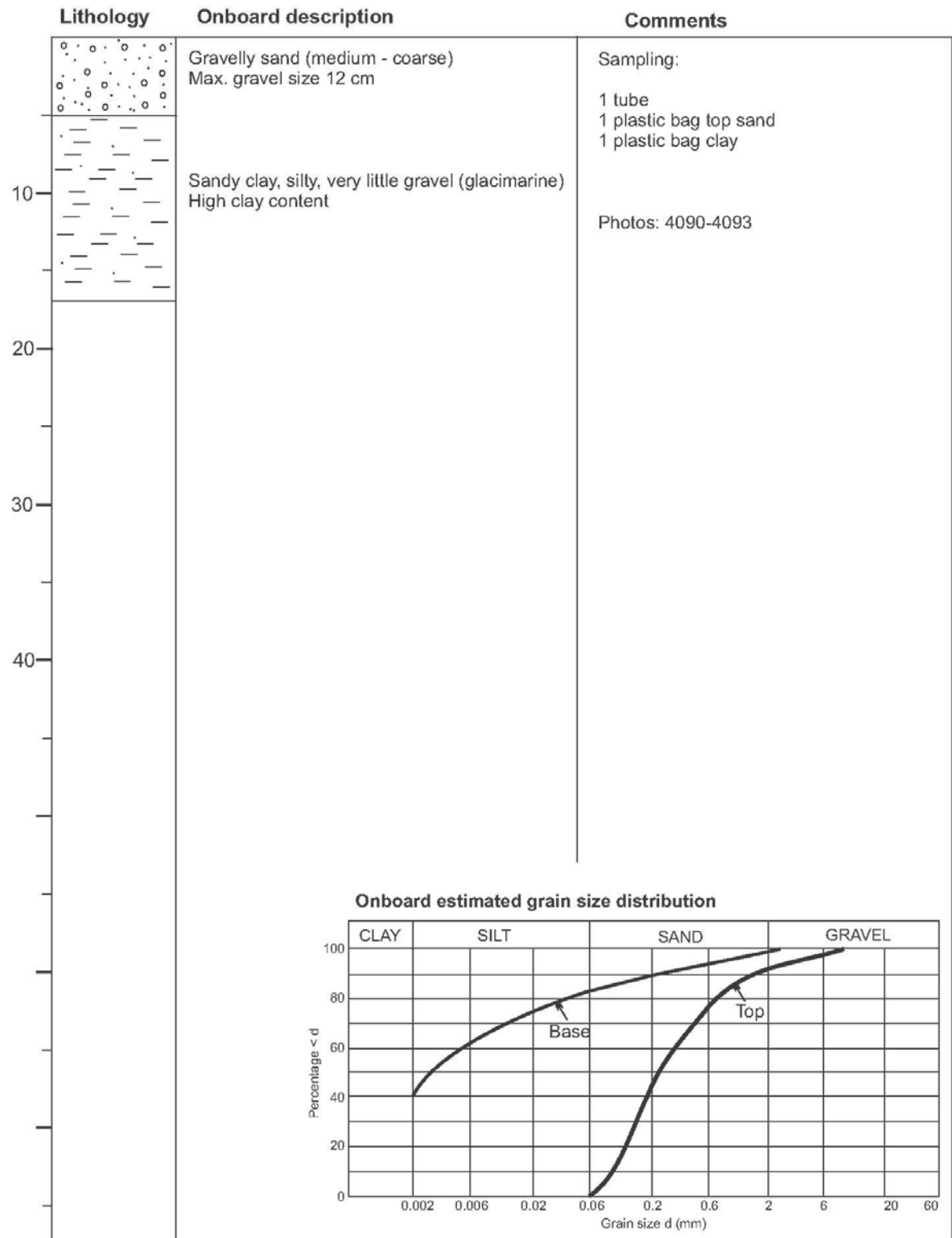
APPENDIX 2

ONBOARD SAMPLE DESCRIPTIONS

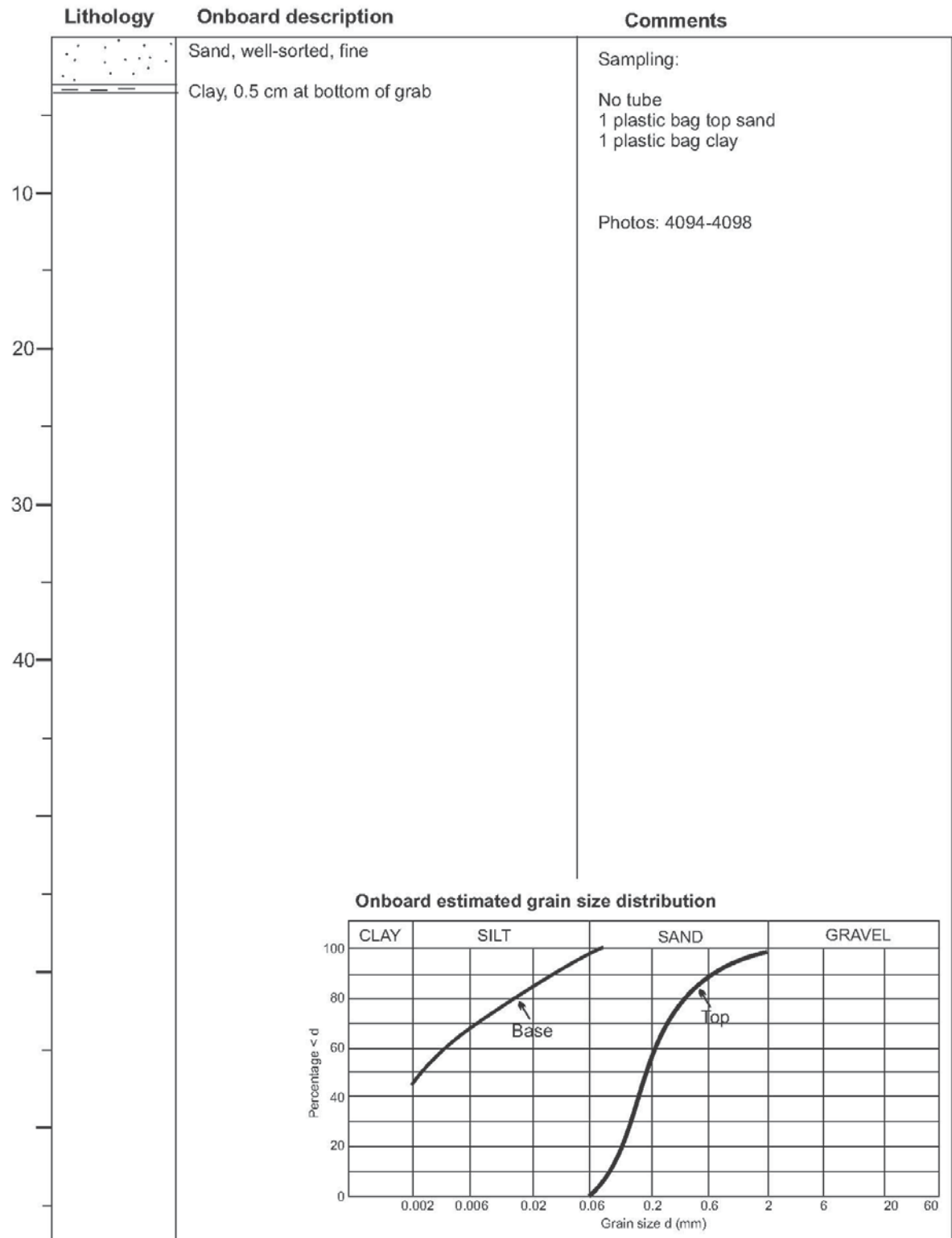
Project number: 3420.00 ('Sandwaves')	Sample number: GS12104-1-GB1
Notes (operation, etc): 3-5 m waves	Equipment: Van Veen grab
	Date- time: 13/4- 2012
	Length (penetration): 8 cm



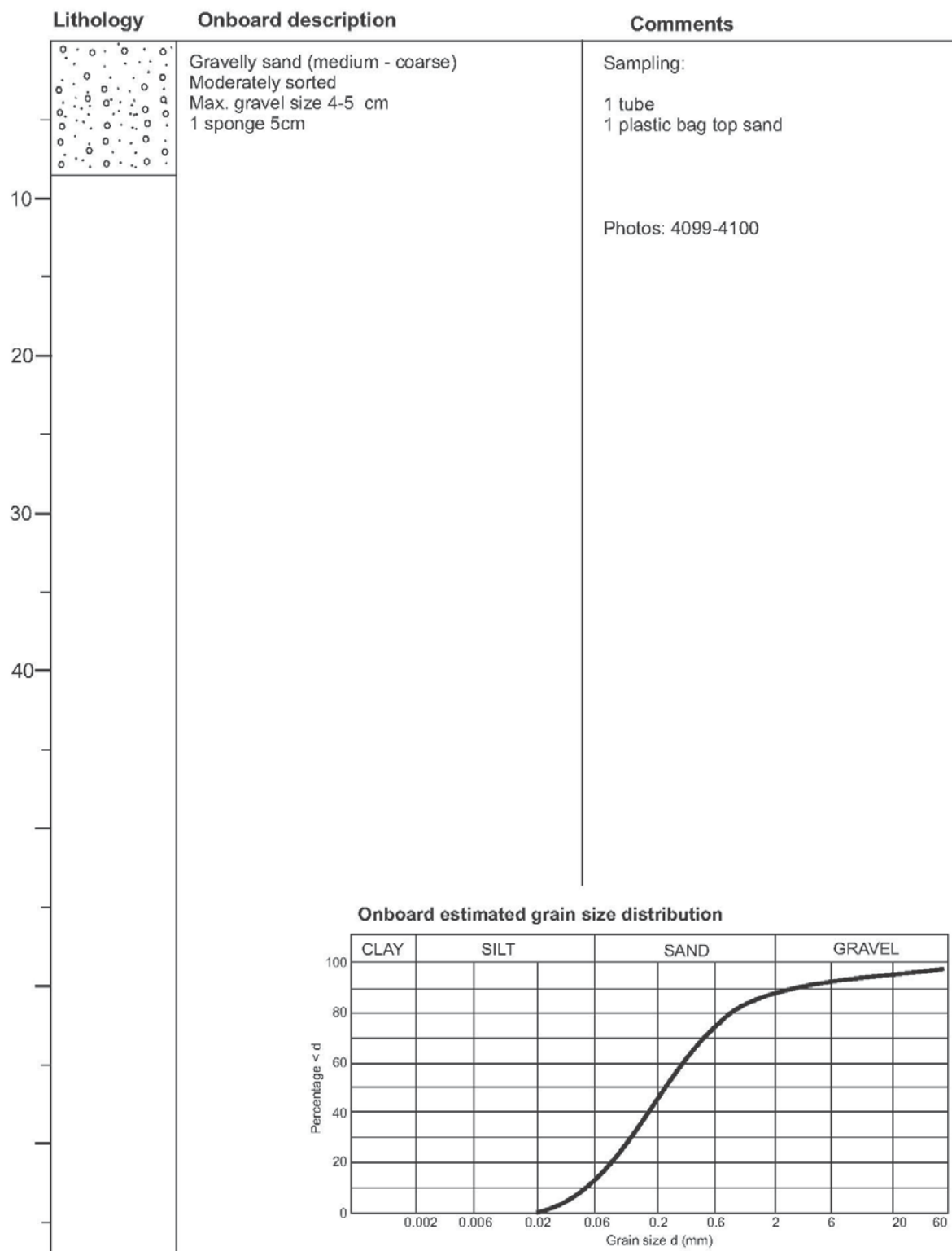
Project number: 3420.00 ('Sandwaves')	Sample number: GS12104-2-GB2
Notes (operation, etc): 2-4 m waves	Equipment: Van Veen grab
	Date- time: 13/4- 2012
	Length (penetration): 17 cm



Project number: 3420.00 ('Sandwaves')	Sample number: GS12104-3-GB3
Notes (operation, etc): 3-5 m waves	Equipment: Van Veen grab
	Date- time: 13/4- 2012
	Length (penetration): 3 cm



Project number: 3420.00 ('Sandwaves')	Sample number: GS12104-4-GB4
Notes (operation, etc): 2-4 m waves	Equipment: Van Veen grab
	Date- time: 13/4- 2012
	Length (penetration): 8 cm



Project number: 3420.00 ('Sandwaves')

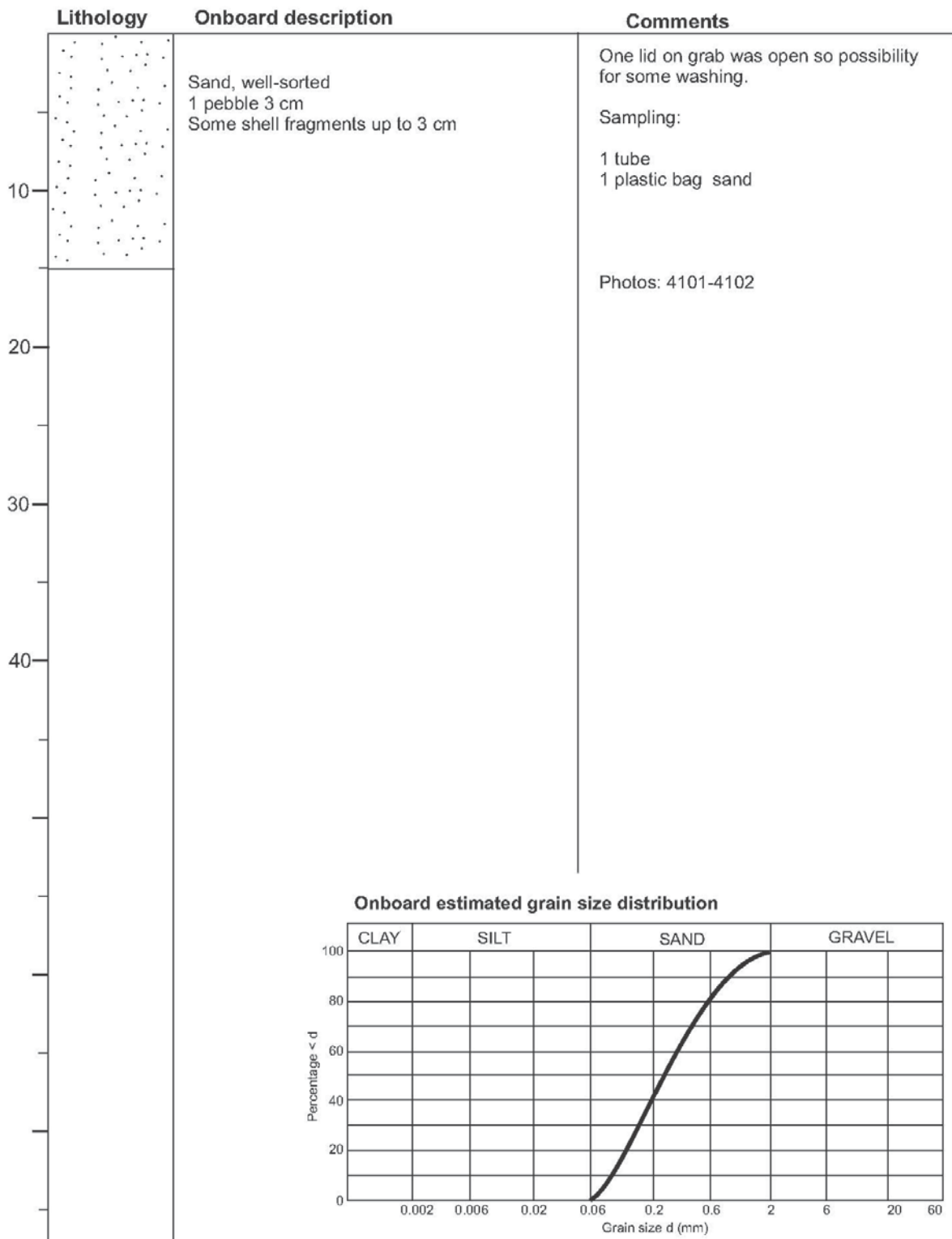
Sample number: **GS12104-5-GB5**

Notes (operation, etc): 2-4 m waves

Equipment: Van Veen grab

Date- time: 13/4- 2012

Length (penetration): 15 cm



Project number: 3420.00 ('Sandwaves')

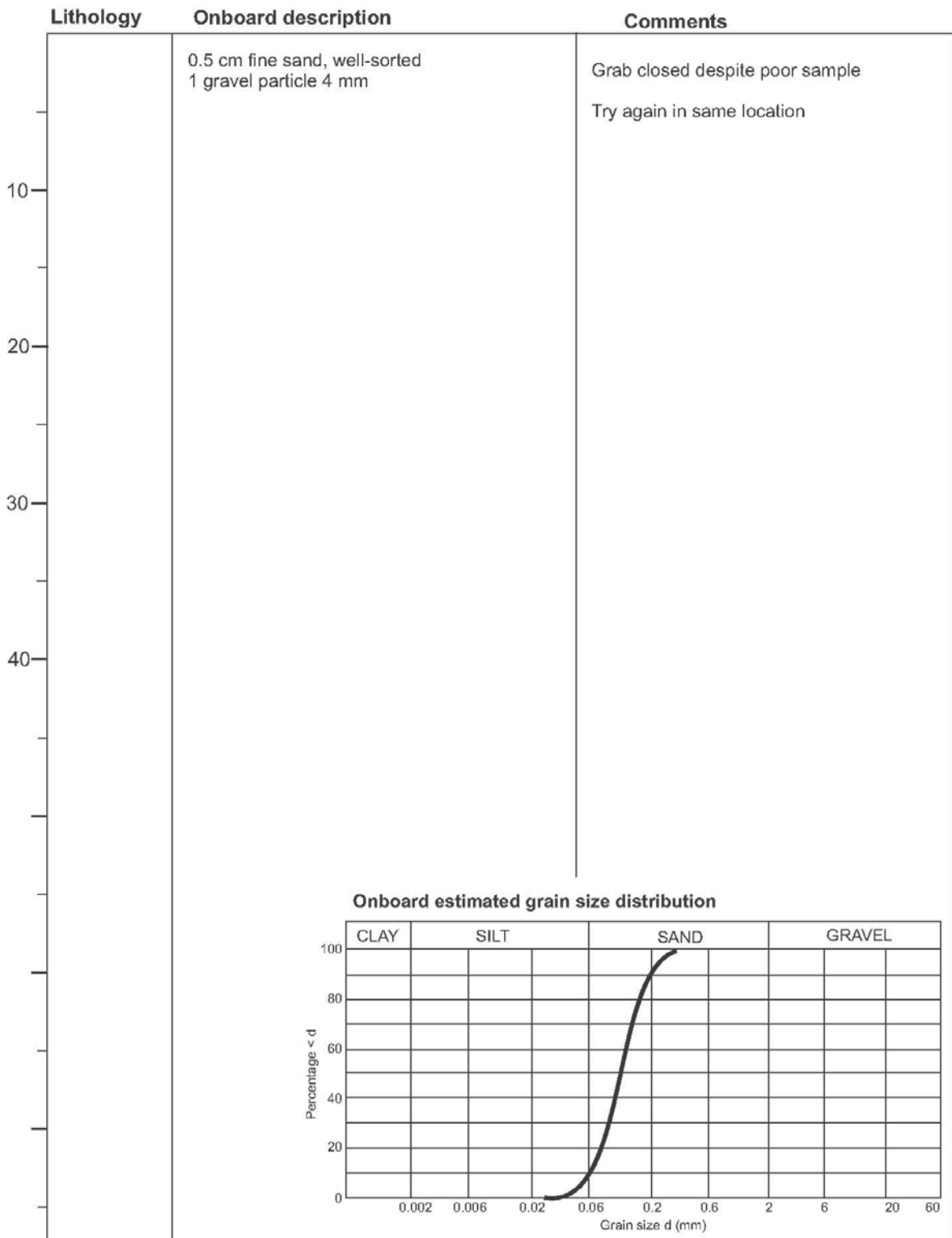
Sample number: **GS12104-6-GB6**

Notes (operation, etc): 2-4 m waves

Equipment: Van Veen grab

Date- time: 13/4- 2012

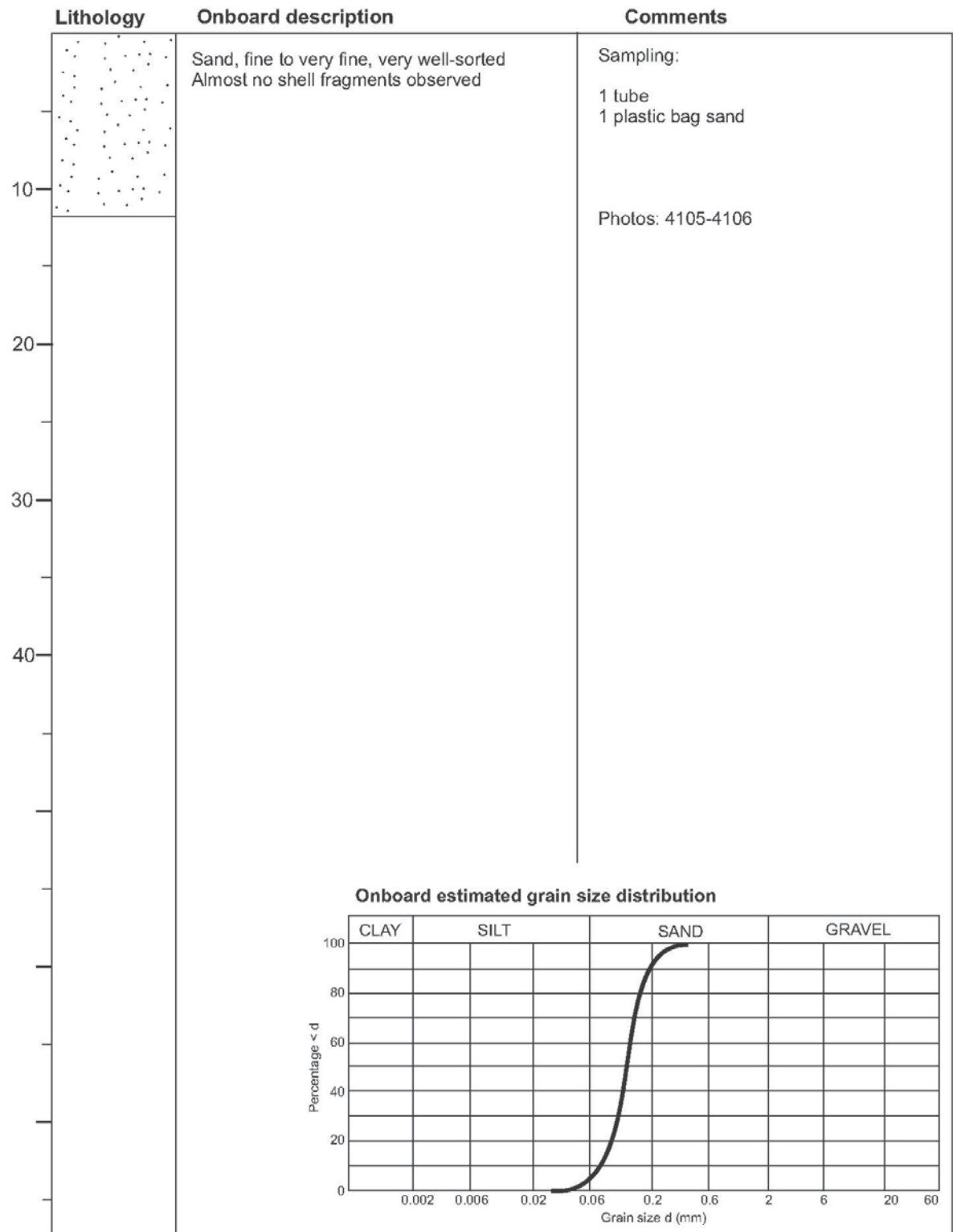
Length (penetration): 0.5 cm



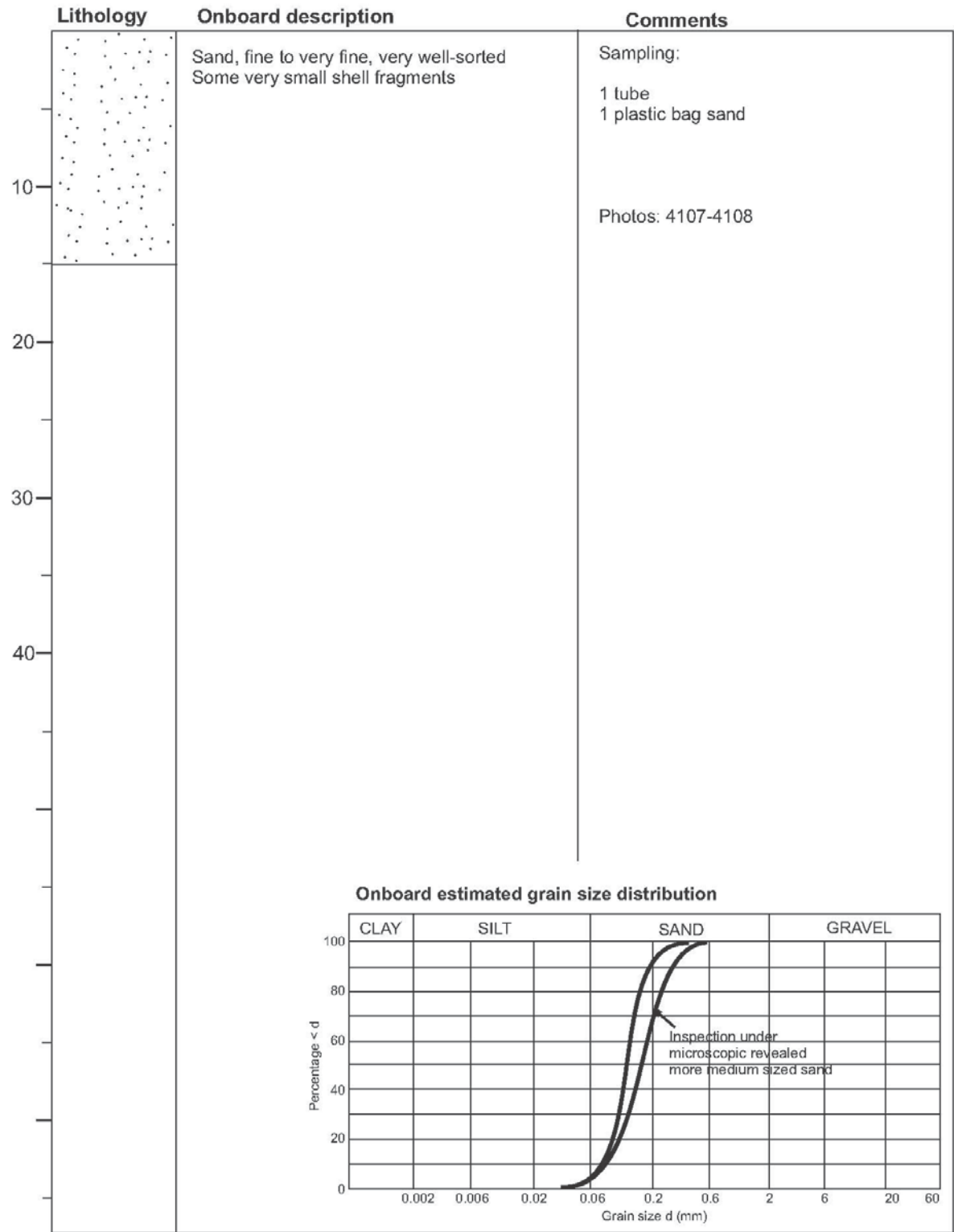
Project number: 3420.00 ('Sandwaves')	Sample number: GS12104-6-GB7
Notes (operation, etc): 2-4 m waves	Equipment: Van Veen grab
	Date- time: 13/4- 2012
	Length (penetration): 14 cm

Lithology	Onboard description	Comments																						
	<p>Sand, fine to very fine, very well-sorted Homogenous sample Small shell fragments</p>	<p>Sampling: 1 tube 1 plastic bag sand</p> <p>Photos: 4103-4104</p> <div> <p>Onboard estimated grain size distribution</p> <table border="1"> <thead> <tr> <th>Grain size d (mm)</th> <th>Percentage < d</th> </tr> </thead> <tbody> <tr><td>0.002</td><td>0</td></tr> <tr><td>0.006</td><td>0</td></tr> <tr><td>0.02</td><td>0</td></tr> <tr><td>0.06</td><td>~10</td></tr> <tr><td>0.2</td><td>100</td></tr> <tr><td>0.6</td><td>100</td></tr> <tr><td>2</td><td>100</td></tr> <tr><td>6</td><td>100</td></tr> <tr><td>20</td><td>100</td></tr> <tr><td>60</td><td>100</td></tr> </tbody> </table> </div>	Grain size d (mm)	Percentage < d	0.002	0	0.006	0	0.02	0	0.06	~10	0.2	100	0.6	100	2	100	6	100	20	100	60	100
Grain size d (mm)	Percentage < d																							
0.002	0																							
0.006	0																							
0.02	0																							
0.06	~10																							
0.2	100																							
0.6	100																							
2	100																							
6	100																							
20	100																							
60	100																							

Project number: 3420.00 ('Sandwaves')	Sample number: GS12104-7-GB8
Notes (operation, etc): 1-2 m waves	Equipment: Van Veen grab
	Date- time: 14/4- 2012
	Length (penetration): 12 cm



Project number: 3420.00 ('Sandwaves')	Sample number: GS12104-8-GB9
Notes (operation, etc): 1-2 m waves	Equipment: Van Veen grab
	Date- time: 14/4- 2012
	Length (penetration): 15 cm



Project number: 3420.00 ('Sandwaves')

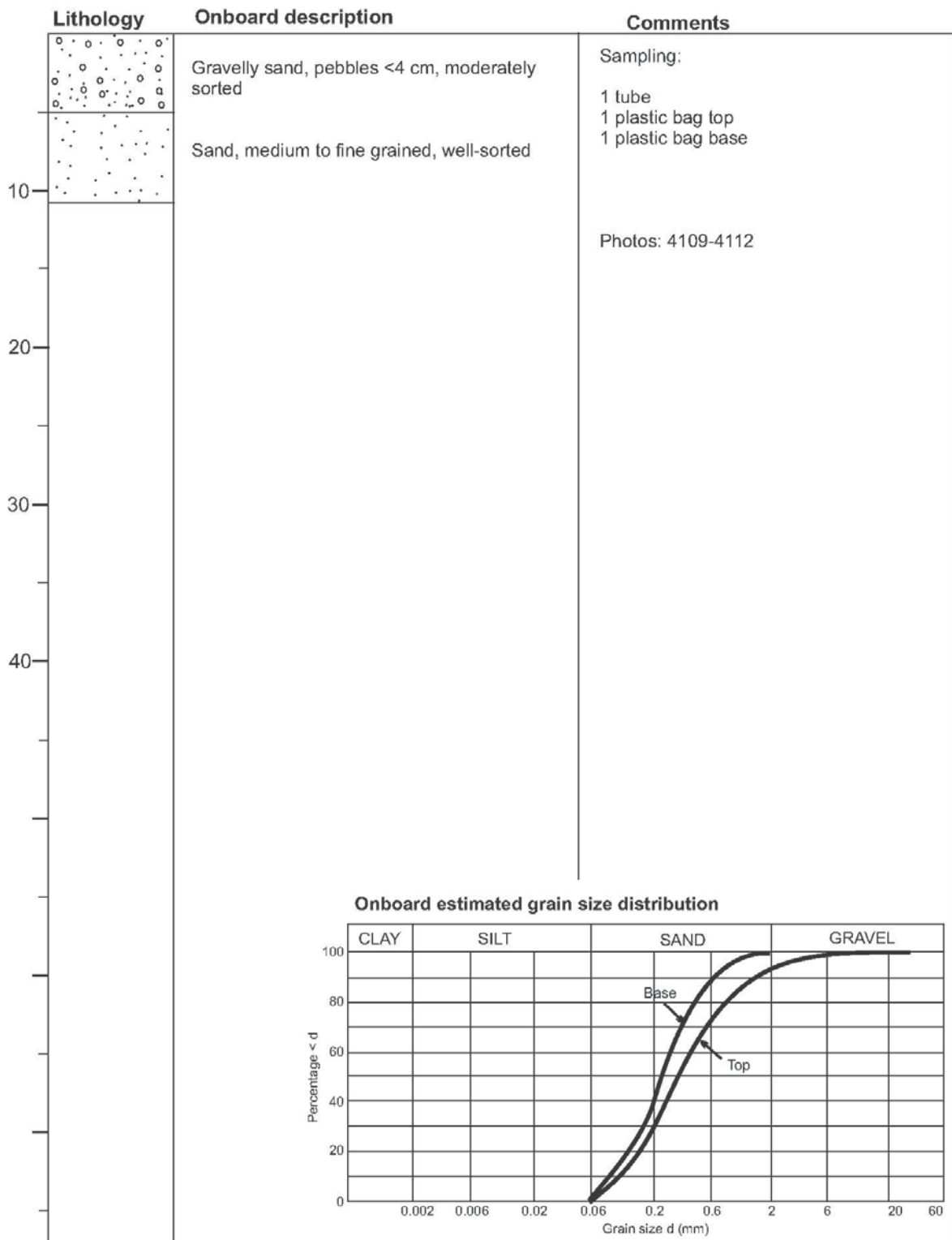
Sample number: **GS12104-9-GB10**

Notes (operation, etc): 1-2 m waves

Equipment: Van Veen grab

Date- time: 14/4- 2012

Length (penetration): 11 cm



Project number: 3420.00 ('Sandwaves')

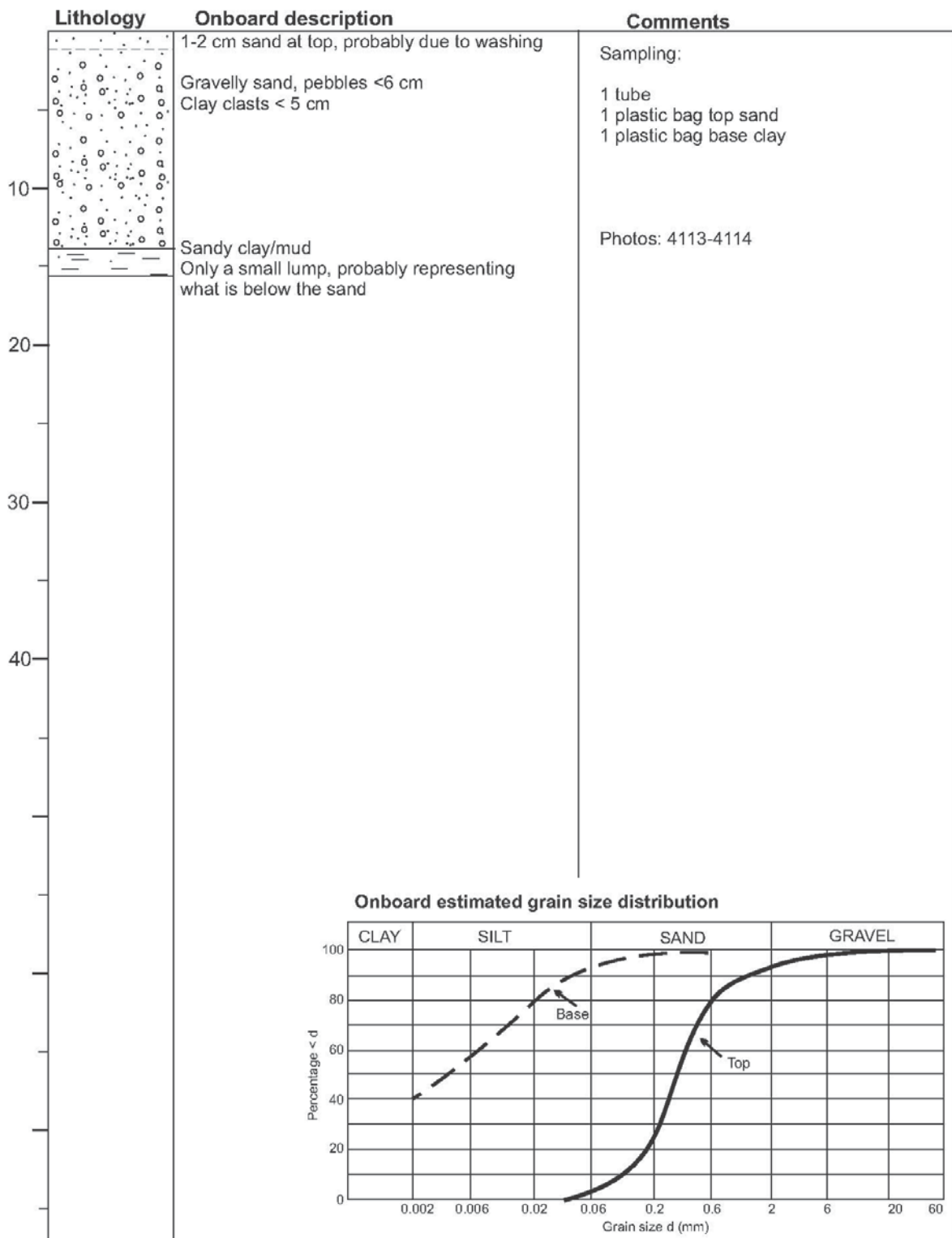
Sample number: **GS12104-10-GB11**

Notes (operation, etc): 2 m waves

Equipment: Van Veen grab

Date- time: 14/4- 2012

Length (penetration): 16 cm



Project number: 3420.00 ('Sandwaves')

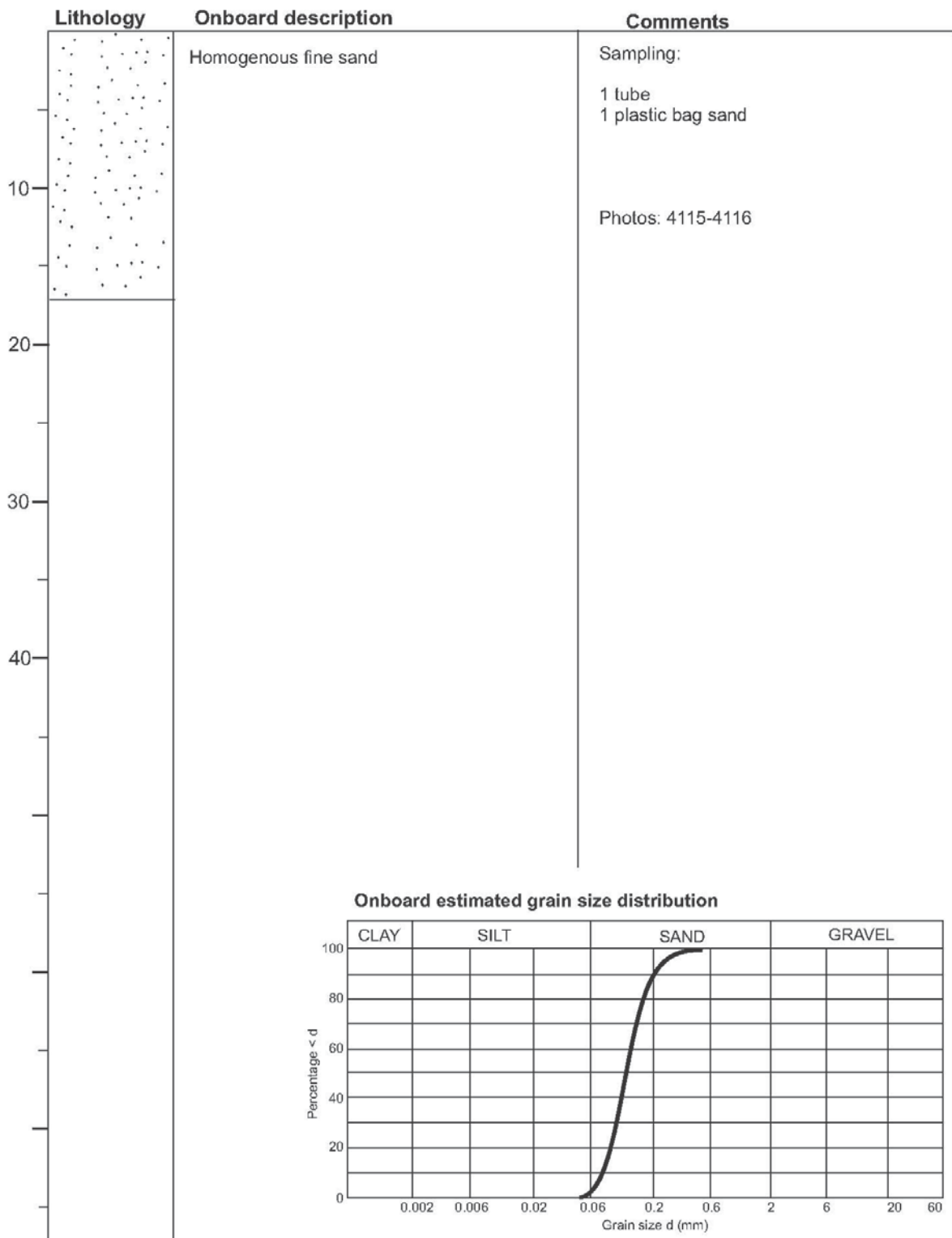
Sample number: **GS12104-11-GB12**

Notes (operation, etc): 1-2 m waves

Equipment: Van Veen grab

Date- time: 14/4- 2012

Length (penetration): 17 cm



Project number: 3420.00 ('Sandwaves')

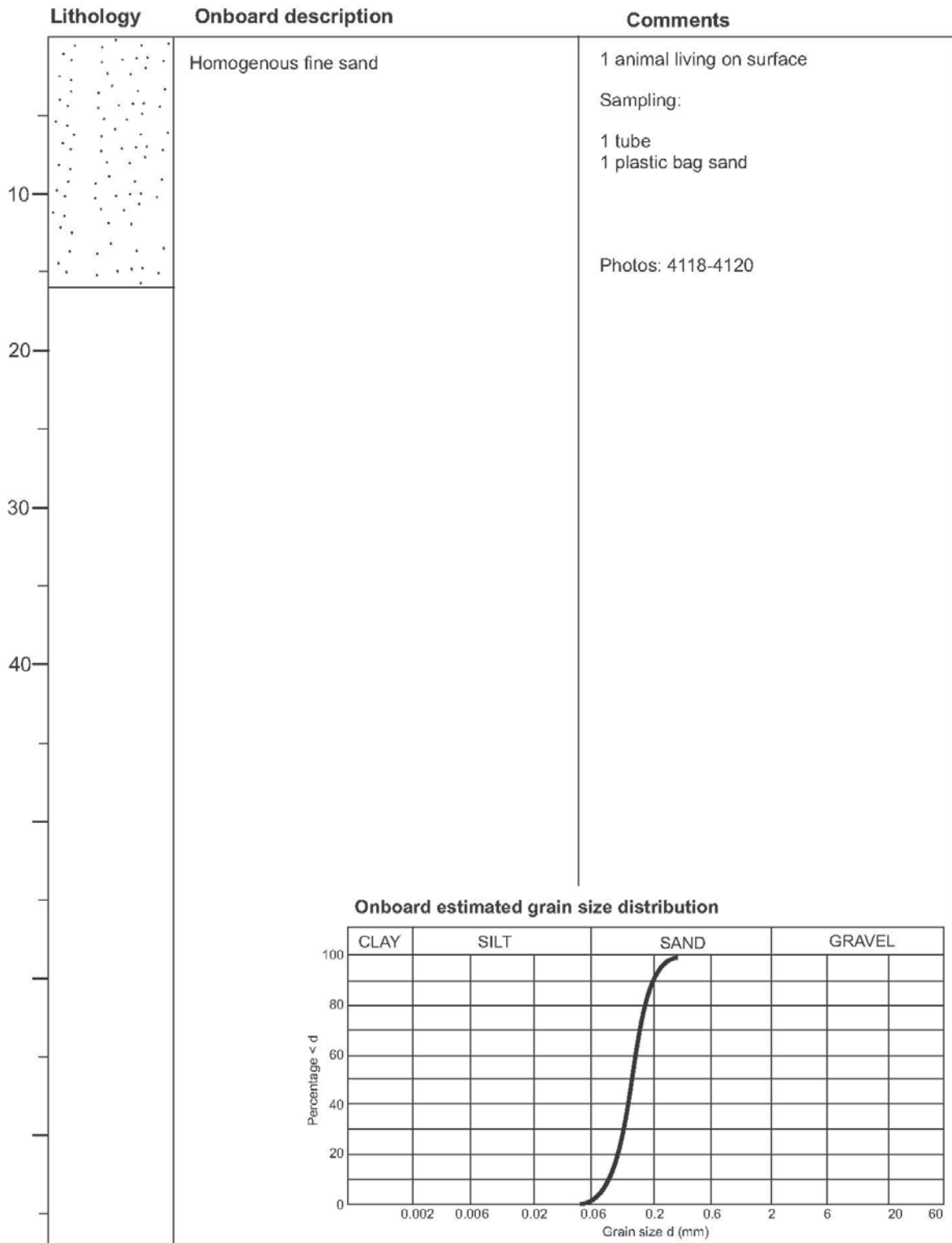
Sample number: **GS12104-12-GB13**

Notes (operation, etc): 1-2 m waves

Equipment: Van Veen grab

Date- time: 14/4- 2012

Length (penetration): 16 cm



Project number: 3420.00 ('Sandwaves')

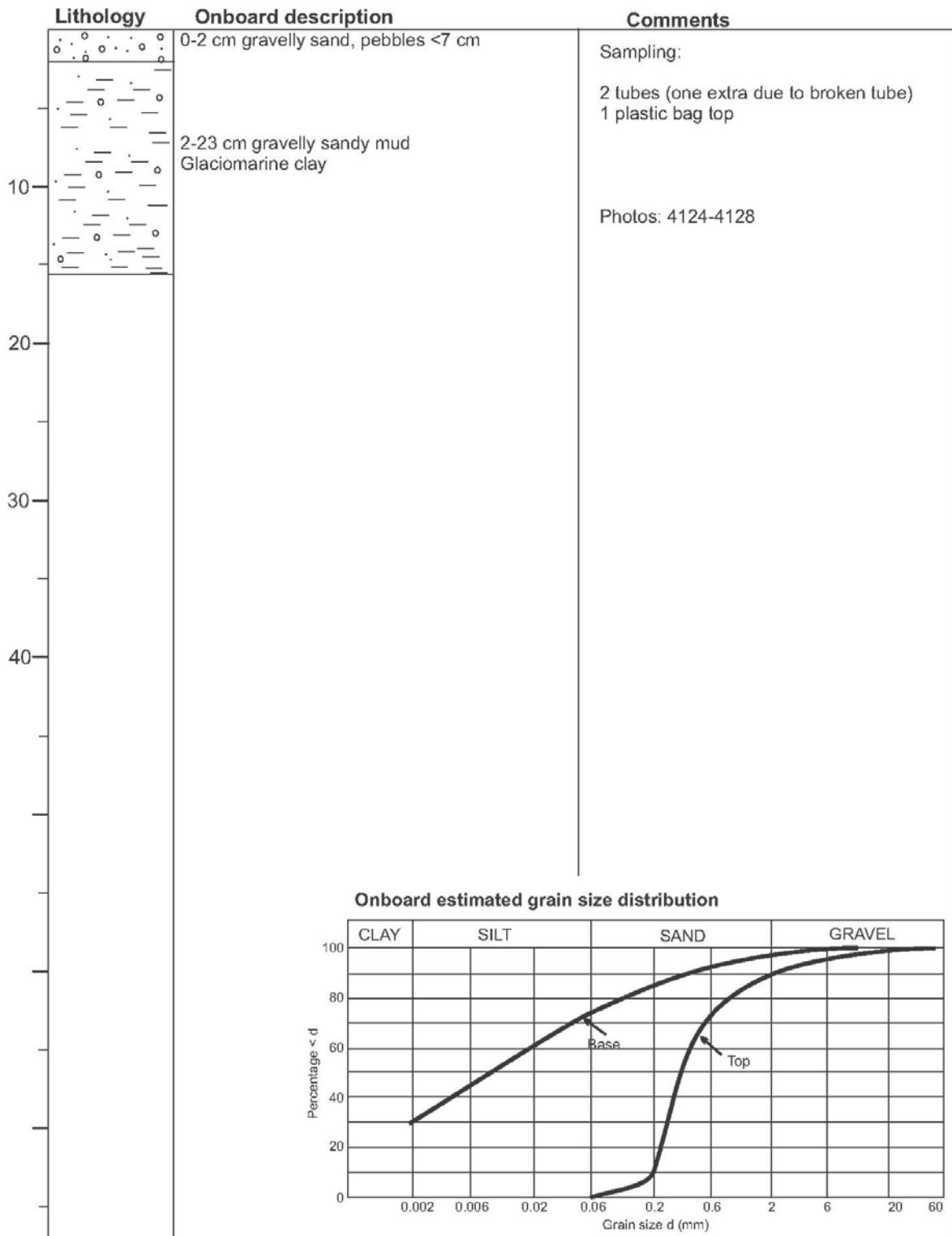
Sample number: **GS12104-13-GB14**

Notes (operation, etc): 1-2 m waves

Equipment: Van Veen grab

Date- time: 15/4- 2012

Length (penetration): 23 cm



Project number: 3420.00 ('Sandwaves')

Sample number: **GS12104-15-GB15**

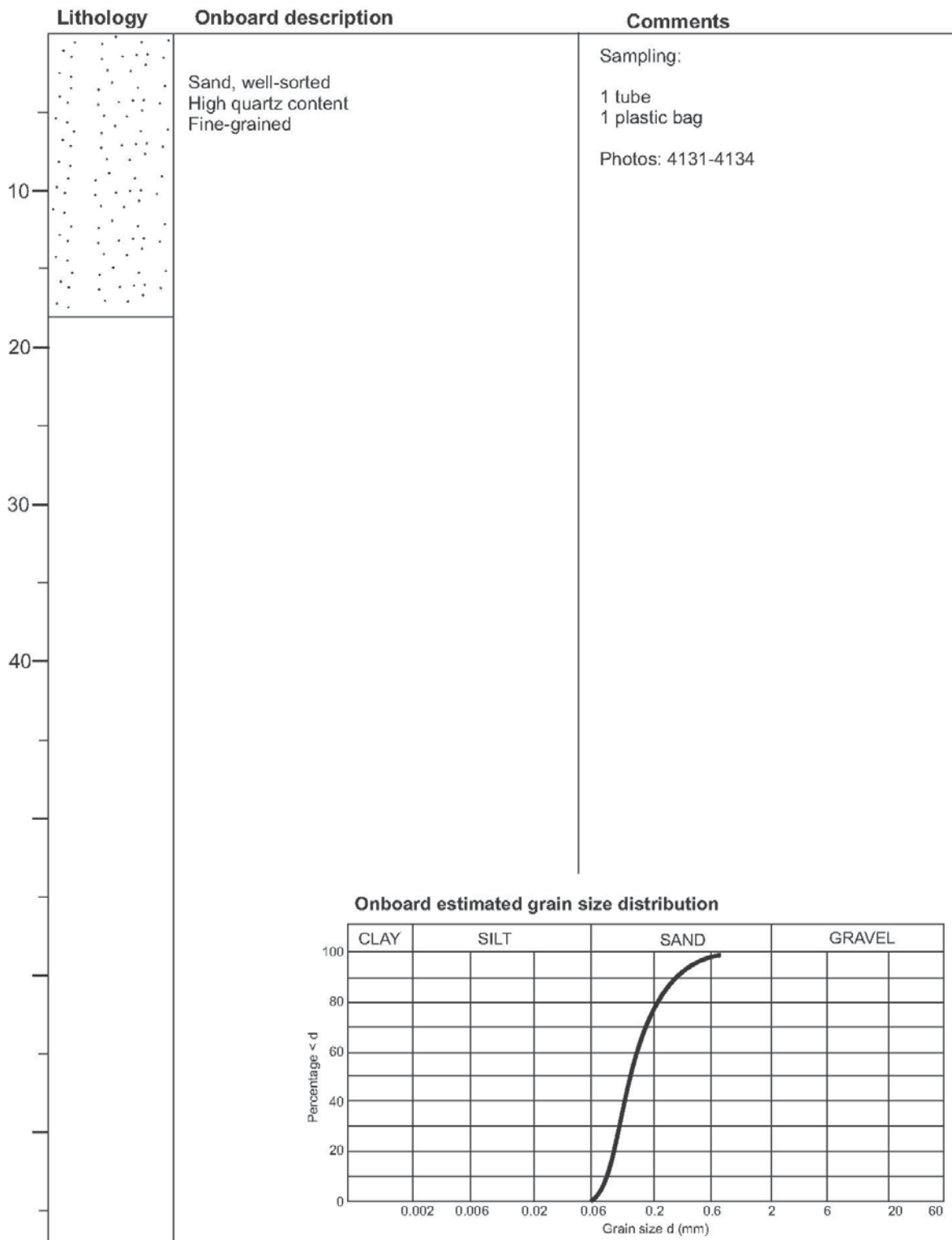
Notes (operation, etc): 1 m waves

Equipment: Van Veen grab

Strong current towards south

Date- time: 15/4- 2012

Length (penetration): 18 cm



Project number: 3420.00 ('Sandwaves')

Sample number: **GS12104-16-GB16**

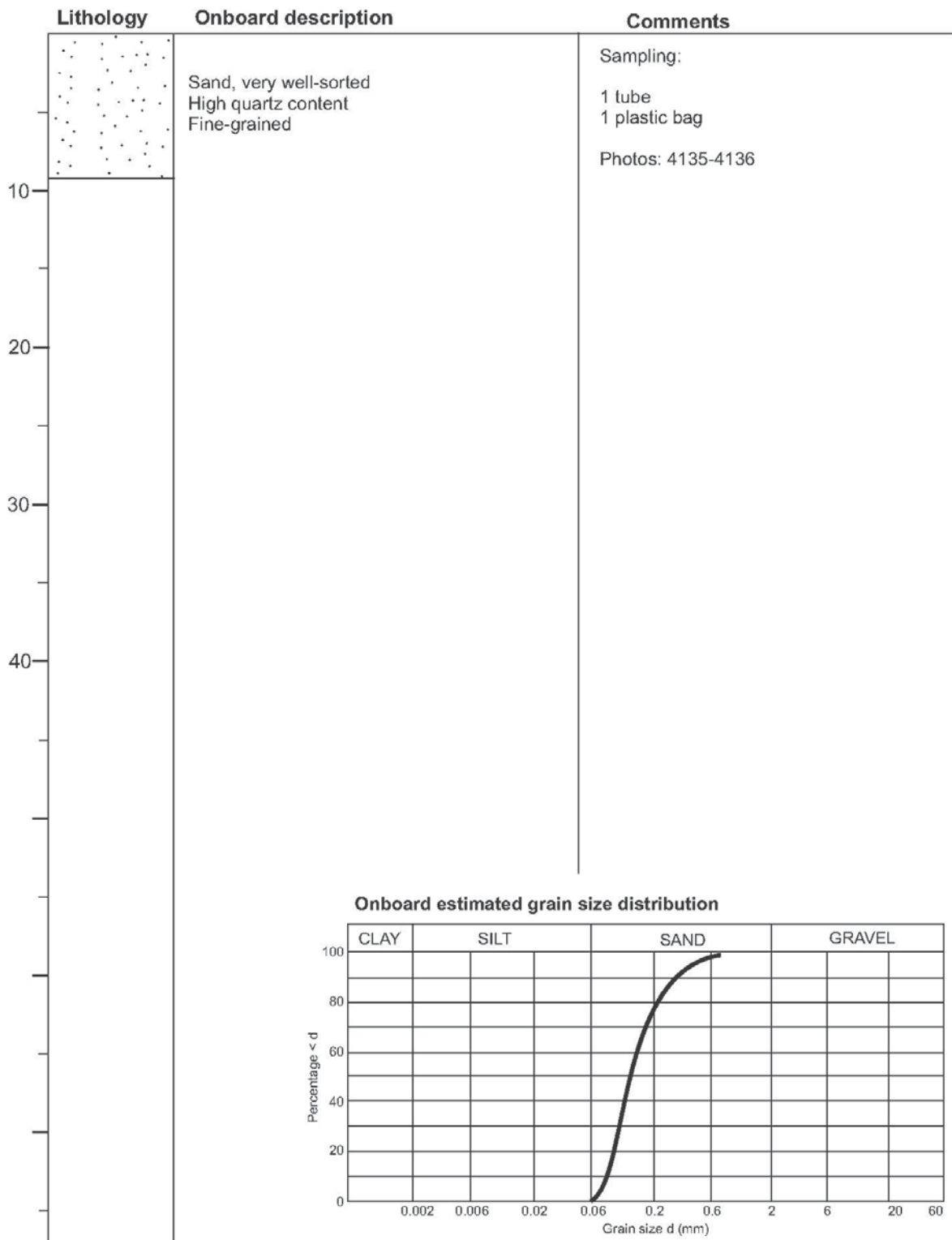
Notes (operation, etc): 1 m swell

Equipment: Van Veen grab

Current towards south

Date- time: 15/4- 2012

Length (penetration): 9 cm



Project number: 3420.00 ('Sandwaves')

Sample number: **GS12104-17-GB17**

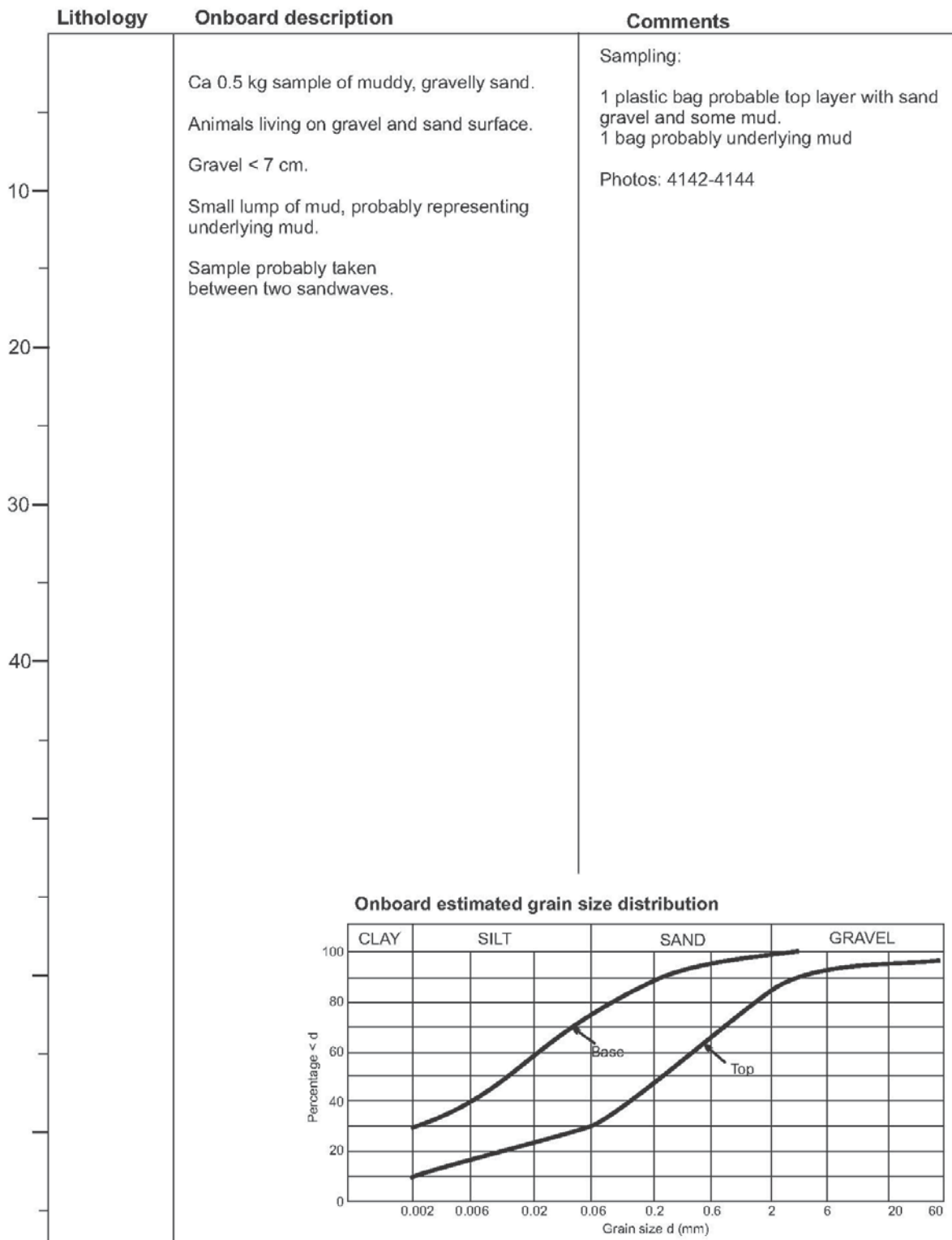
Notes (operation, etc): 1 m swell

Equipment: Van Veen grab

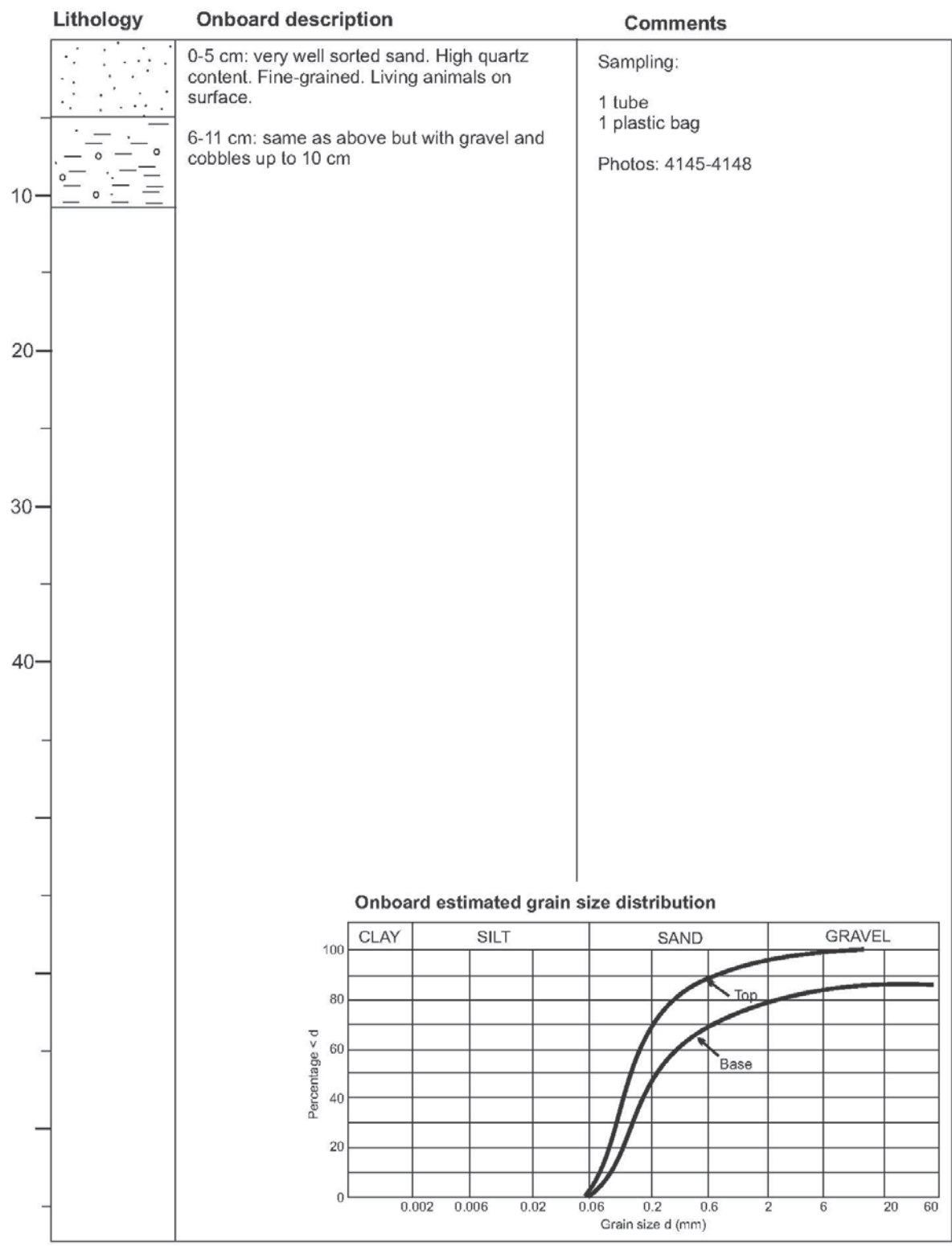
Strong current towards south

Date- time: 15/4- 2012

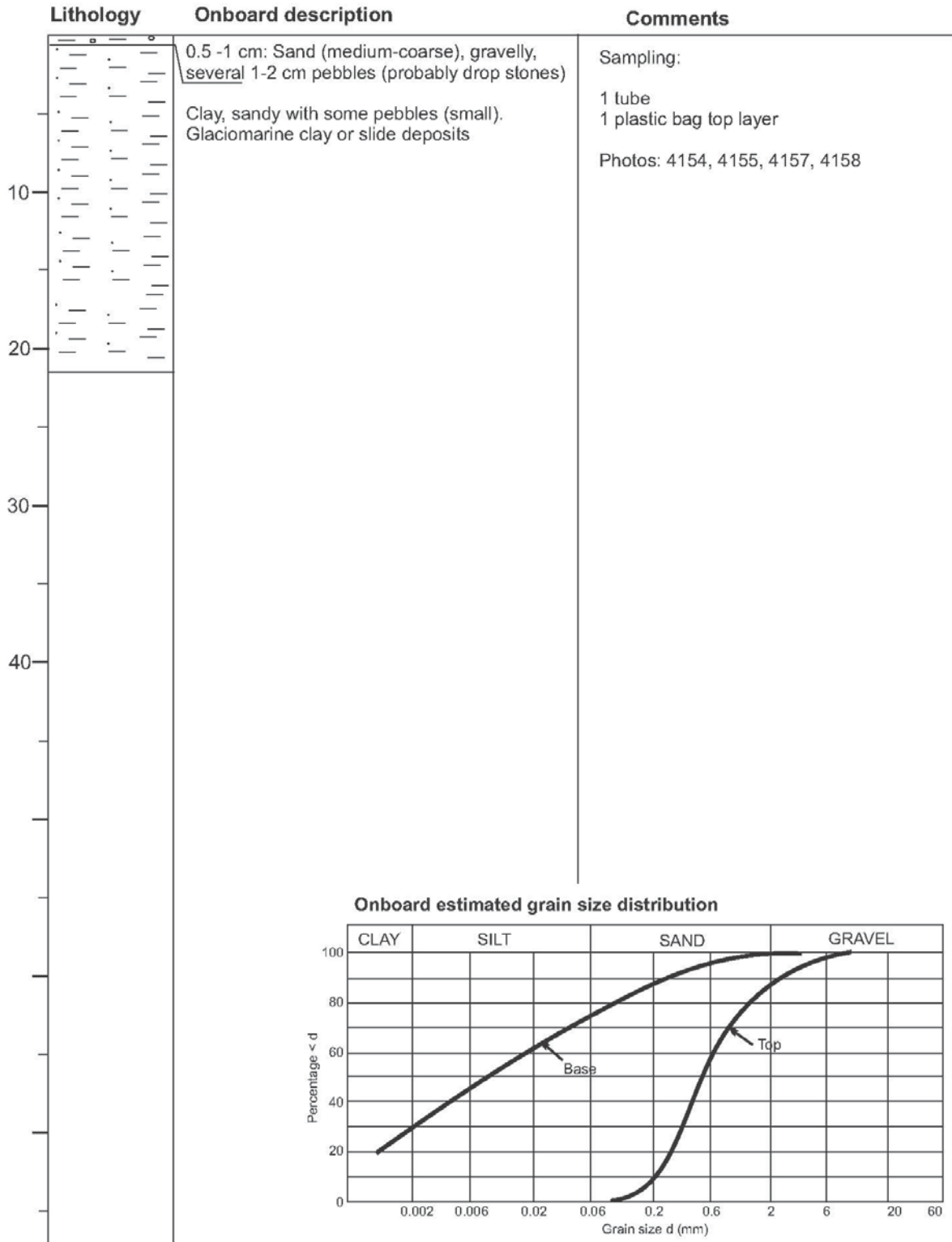
Length (penetration):



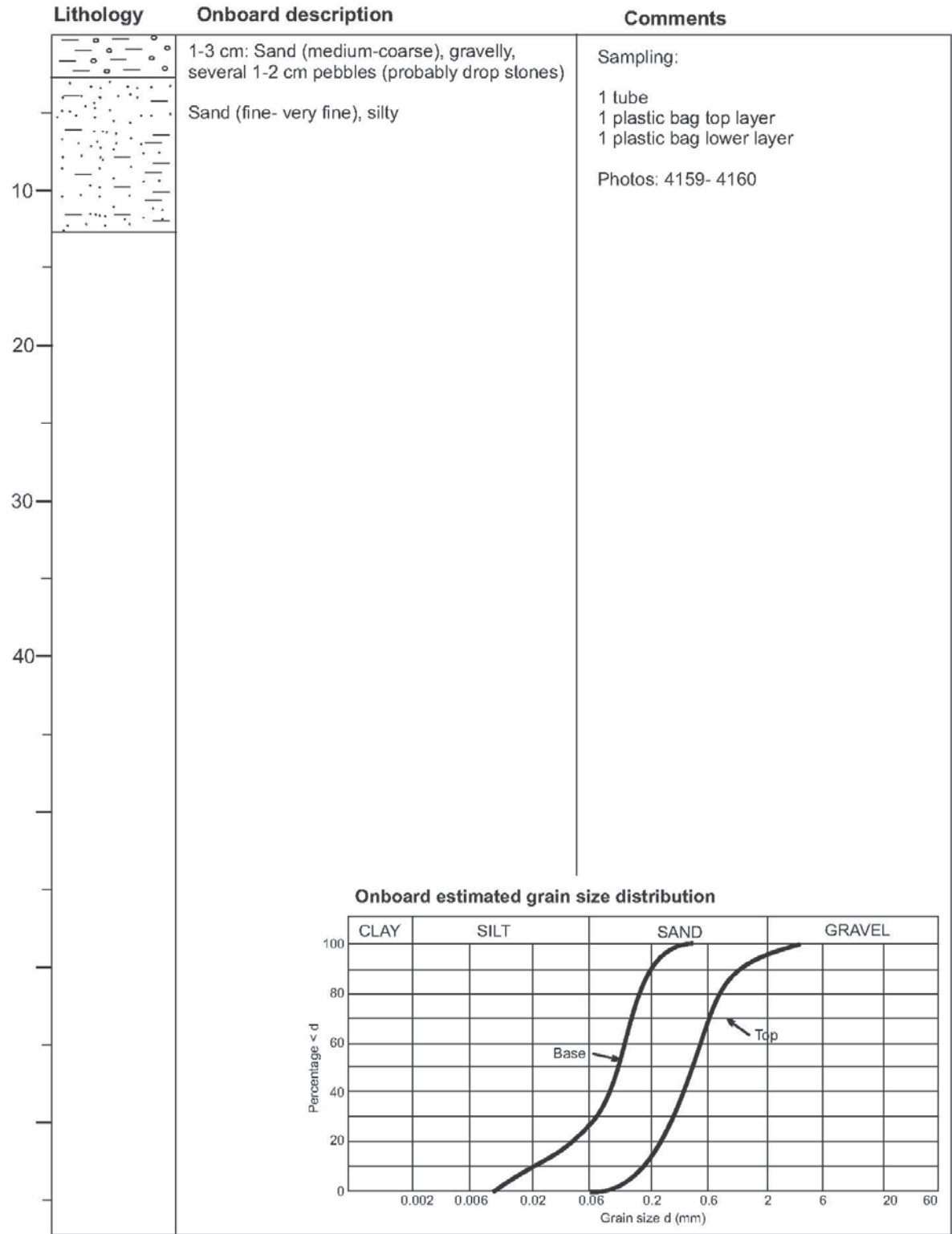
Project number: 3420.00 ('Sandwaves')	Sample number: GS12104-18-GB18
Notes (operation, etc): 1 m swell	Equipment: Van Veen grab
Strong current towards south	Date- time: 15/4- 2012
	Length (penetration): 11 cm




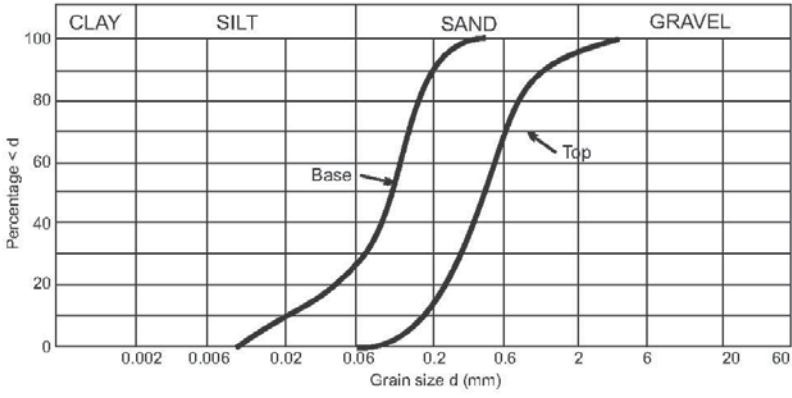
Project number: 3420.00 ('Sandwaves')	Sample number: GS12104-19-GB19
Notes (operation, etc): 1 m swell	Equipment: Van Veen grab
From TOPAS location appears to be in slide deposits	Date- time: 15/4- 2012
Current towards south	Length (penetration): 22 cm



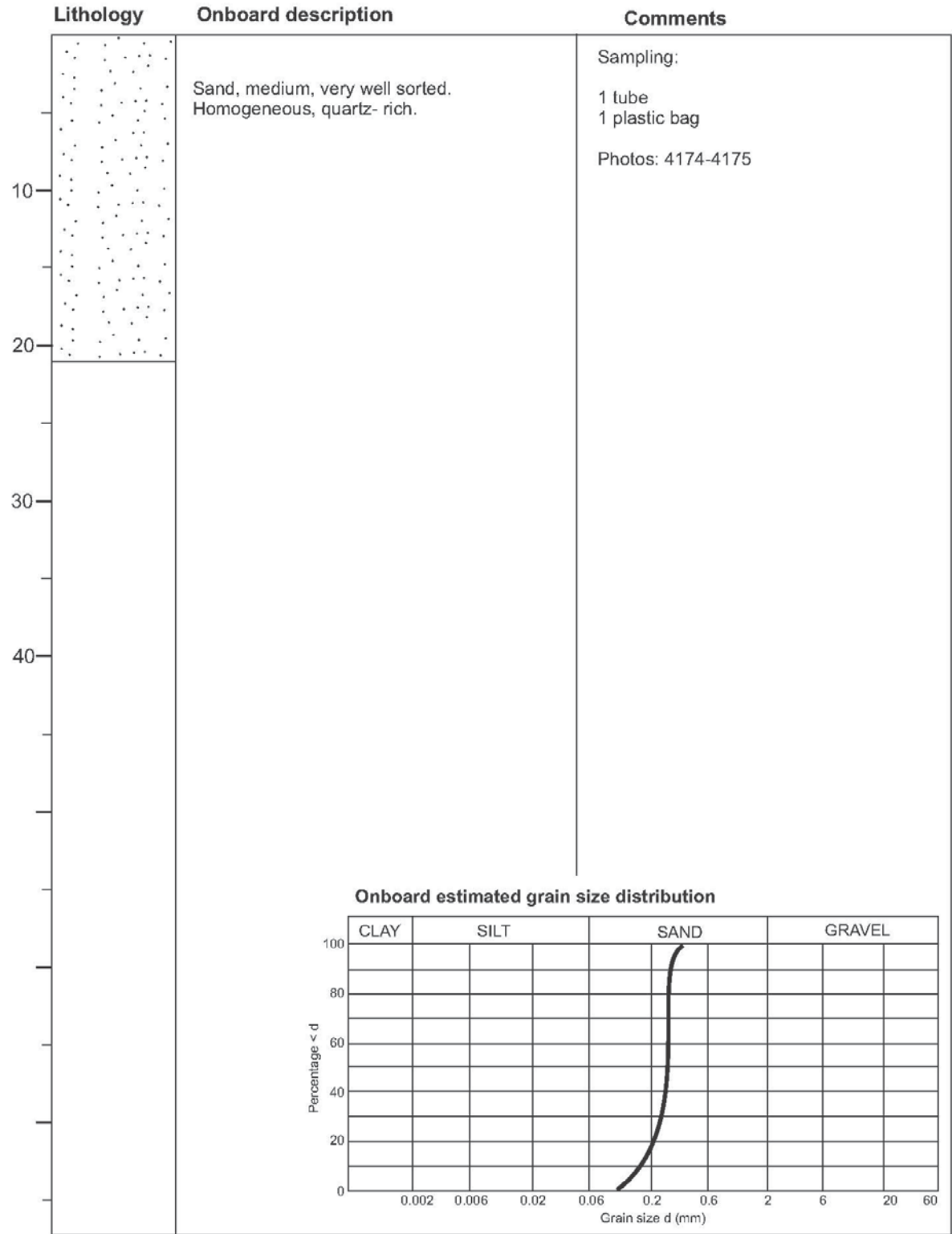
Project number: 3420.00 ('Sandwaves')	Sample number: GS12104-20-GB20
Notes (operation, etc): 1 m swell	Equipment: Van Veen grab
Current towards south	Date- time: 15/4- 2012
	Length (penetration): 13 cm



Project number: 3420.00 ('Sandwaves')	Sample number: GS12104-21-GB21
Notes (operation, etc): 1 m swell	Equipment: Van Veen grab
No damage	Date- time: 15/4- 2012
	Length (penetration):

Lithology	Onboard description	Comments																																	
	<p>One 30 x 45 cm large boulder of granite in the mouth of the grab.</p> <p>At least 100 different species present on the upper part of the boulder.</p> <p>No growth on the lower part of the boulder suggesting that it was imbedded in sand? probably not clay.</p>	<p>Photos: 4161- 4171</p>																																	
<p style="text-align: center;">Onboard estimated grain size distribution</p>  <table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Grain size d (mm)</th> <th>Base (%)</th> <th>Top (%)</th> </tr> </thead> <tbody> <tr><td>0.002</td><td>0</td><td>0</td></tr> <tr><td>0.006</td><td>0</td><td>0</td></tr> <tr><td>0.02</td><td>10</td><td>0</td></tr> <tr><td>0.06</td><td>25</td><td>0</td></tr> <tr><td>0.2</td><td>60</td><td>10</td></tr> <tr><td>0.6</td><td>95</td><td>50</td></tr> <tr><td>2</td><td>100</td><td>85</td></tr> <tr><td>6</td><td>100</td><td>95</td></tr> <tr><td>20</td><td>100</td><td>100</td></tr> <tr><td>60</td><td>100</td><td>100</td></tr> </tbody> </table>			Grain size d (mm)	Base (%)	Top (%)	0.002	0	0	0.006	0	0	0.02	10	0	0.06	25	0	0.2	60	10	0.6	95	50	2	100	85	6	100	95	20	100	100	60	100	100
Grain size d (mm)	Base (%)	Top (%)																																	
0.002	0	0																																	
0.006	0	0																																	
0.02	10	0																																	
0.06	25	0																																	
0.2	60	10																																	
0.6	95	50																																	
2	100	85																																	
6	100	95																																	
20	100	100																																	
60	100	100																																	

Project number: 3420.00 ('Sandwaves')	Sample number: GS12104-22-GB22
Notes (operation, etc): 1 m swell	Equipment: Van Veen grab
Very strong current towards north (20°)	Date- time: 15/4- 2012
	Length (penetration): 21 cm



Project number: 3420.00 ('Sandwaves')

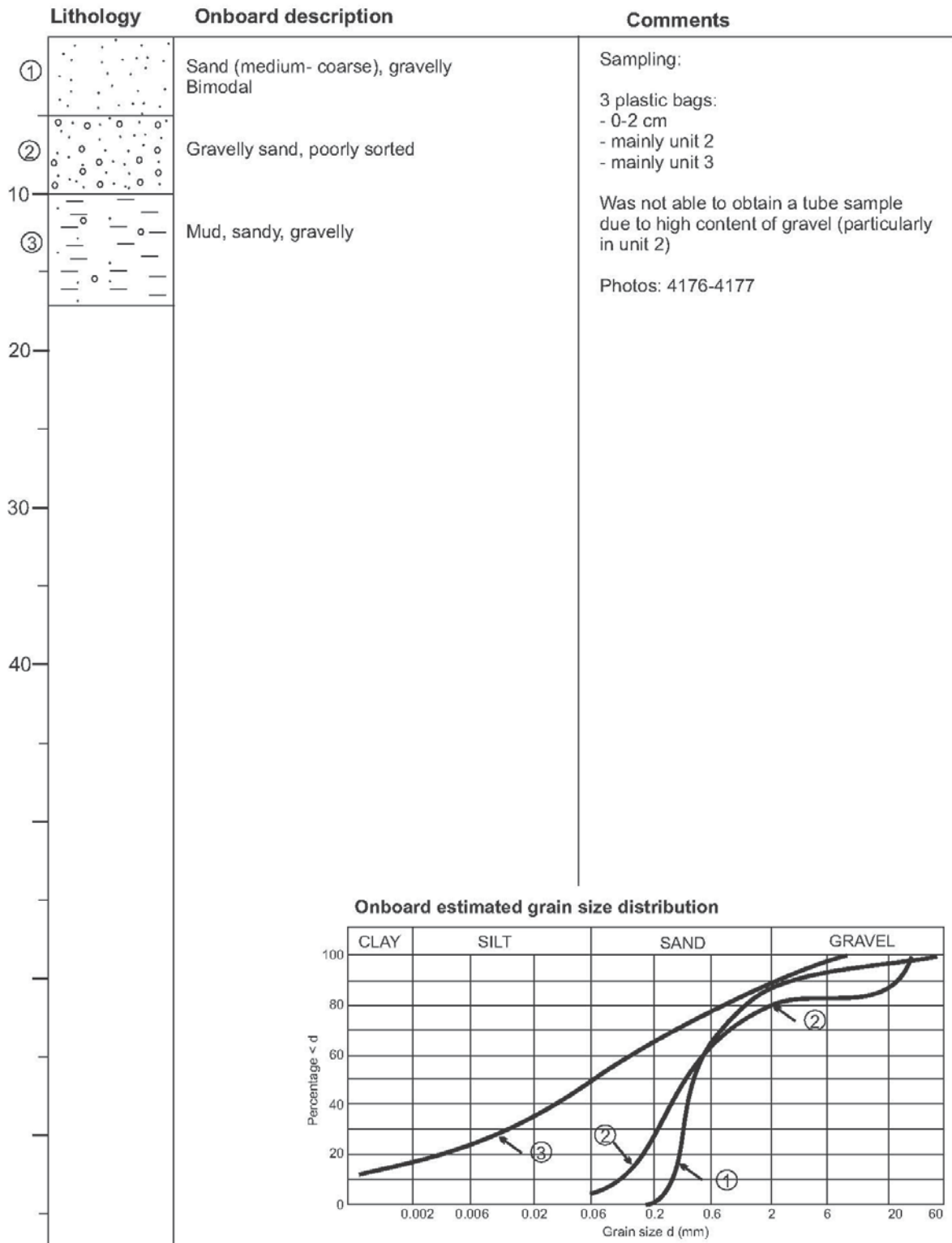
Sample number: **GS12104-23-GB23**

Notes (operation, etc): 1-2 m swell

Equipment: Van Veen grab

Date- time: 15/4- 2012

Length (penetration): 17 cm



Project number: 3420.00 ('Sandwaves')	Sample number: GS12104-24-GB24
Notes (operation, etc): 1- 2 m waves, snowing	Equipment: Van Veen grab
	Date- time: 15/4- 2012
	Length (penetration): 17 cm

Lithology	Onboard description	Comments																																	
	<p>Gravelly sand, poorly sorted (max 6cm)</p> <p>Clay, sandy with gravel fragments (appear to be consolidated compared to normally consolidated clays)</p> <p>Penetrometer: Strength (unconf.): 1.5 kg/cm³ (1 loc) 0.9 kg/cm³ (2 loc)</p> <p>Not homogeneous in strength</p>	<p>Sampling:</p> <p>1 tube 2 plastic bags</p> <p>Photos: 4179-4181</p>																																	
<p>10</p> <p>20</p> <p>30</p> <p>40</p>																																			
		<p>Onboard estimated grain size distribution</p> <table border="1"> <caption>Estimated data from grain size distribution graph</caption> <thead> <tr> <th>Grain size d (mm)</th> <th>Base (%)</th> <th>Top (%)</th> </tr> </thead> <tbody> <tr><td>0.002</td><td>10</td><td>0</td></tr> <tr><td>0.006</td><td>35</td><td>0</td></tr> <tr><td>0.02</td><td>55</td><td>0</td></tr> <tr><td>0.06</td><td>70</td><td>0</td></tr> <tr><td>0.2</td><td>80</td><td>0</td></tr> <tr><td>0.6</td><td>85</td><td>10</td></tr> <tr><td>2</td><td>90</td><td>40</td></tr> <tr><td>6</td><td>95</td><td>75</td></tr> <tr><td>20</td><td>98</td><td>95</td></tr> <tr><td>60</td><td>100</td><td>100</td></tr> </tbody> </table>	Grain size d (mm)	Base (%)	Top (%)	0.002	10	0	0.006	35	0	0.02	55	0	0.06	70	0	0.2	80	0	0.6	85	10	2	90	40	6	95	75	20	98	95	60	100	100
Grain size d (mm)	Base (%)	Top (%)																																	
0.002	10	0																																	
0.006	35	0																																	
0.02	55	0																																	
0.06	70	0																																	
0.2	80	0																																	
0.6	85	10																																	
2	90	40																																	
6	95	75																																	
20	98	95																																	
60	100	100																																	

Project number: 3420.00 ('Sandwaves')

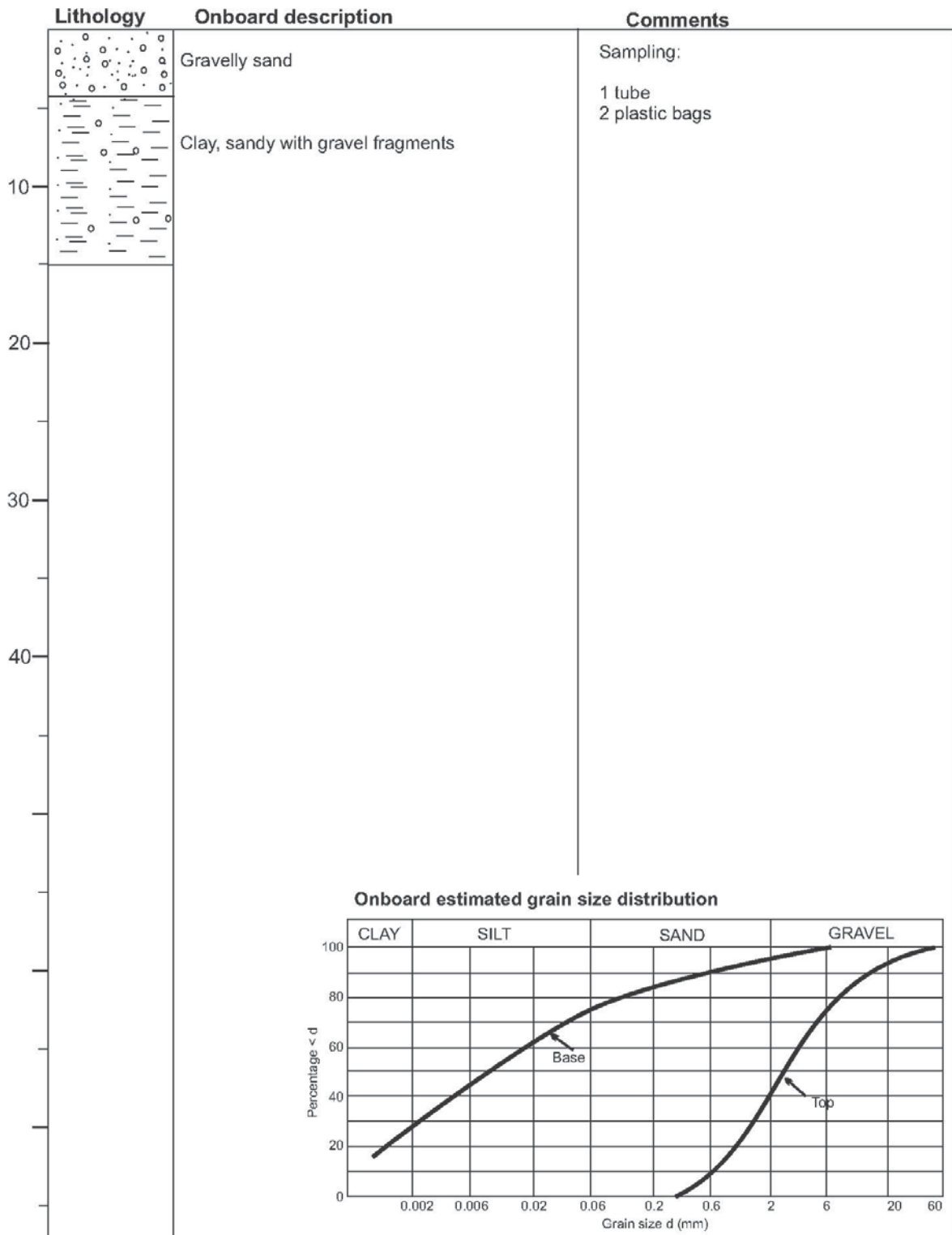
Sample number: **GS12104-25-GB25**

Notes (operation, etc): 1- 2 m waves

Equipment: Van Veen grab

Date- time: 15/4- 2012

Length (penetration): 15 cm



Project number: 3420.00 ('Sandwaves')

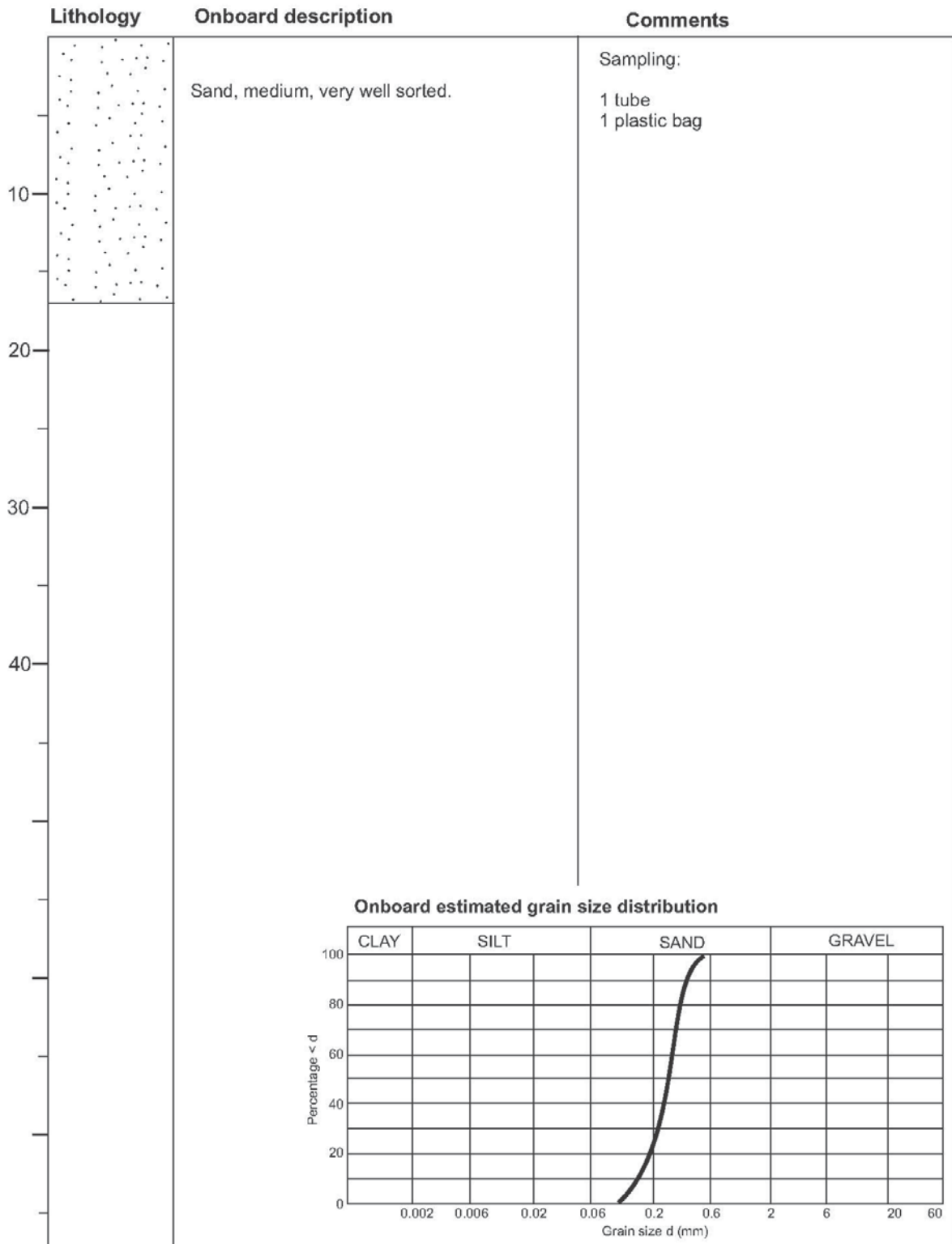
Sample number: **GS12104-26-GB26**

Notes (operation, etc): 2-3 m swell

Equipment: Van Veen grab

Date- time: 16/4- 2012

Length (penetration): 17 cm



Project number: 3420.00 ('Sandwaves')

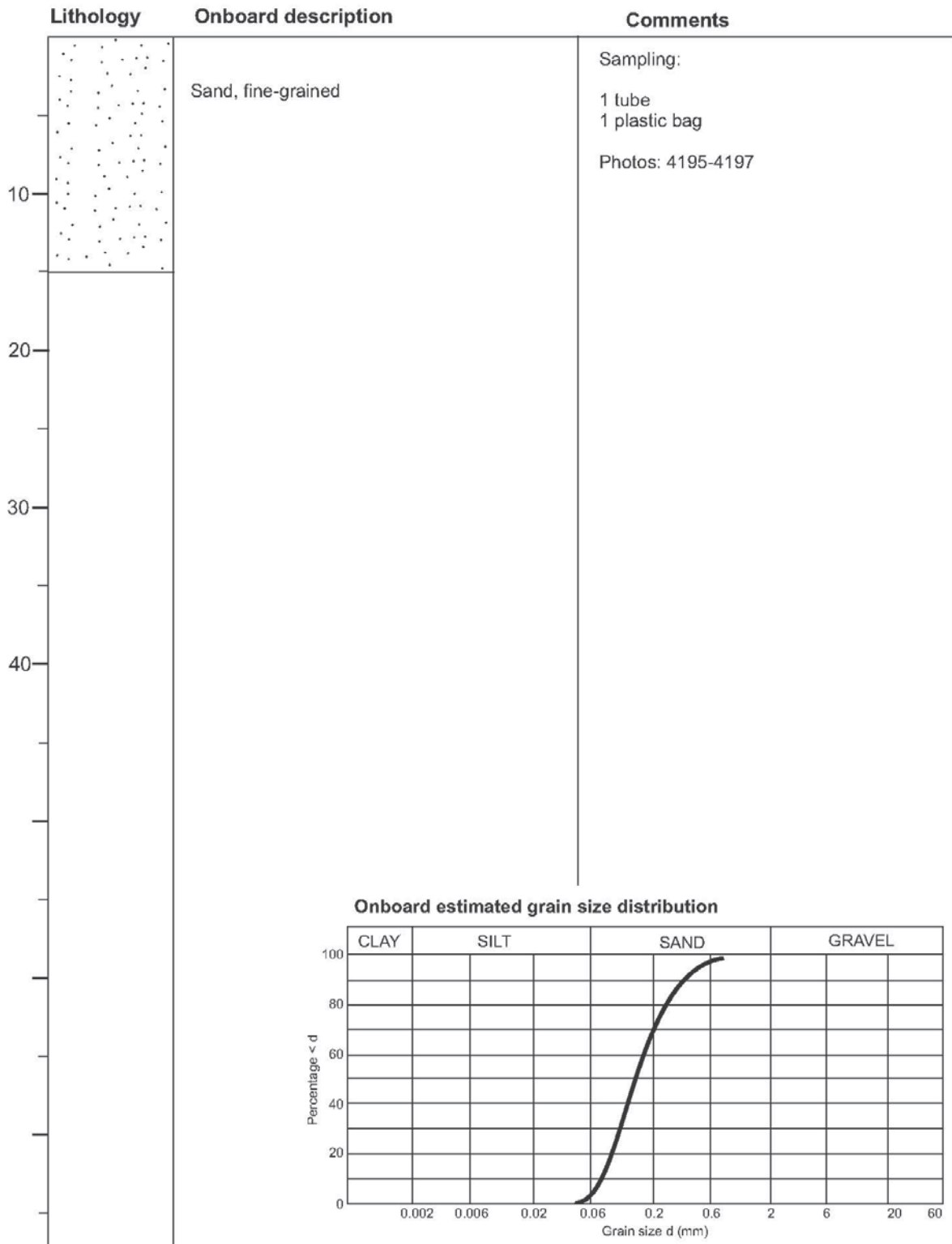
Sample number: **GS12104-28-GB27**

Notes (operation, etc): 1-2 m waves

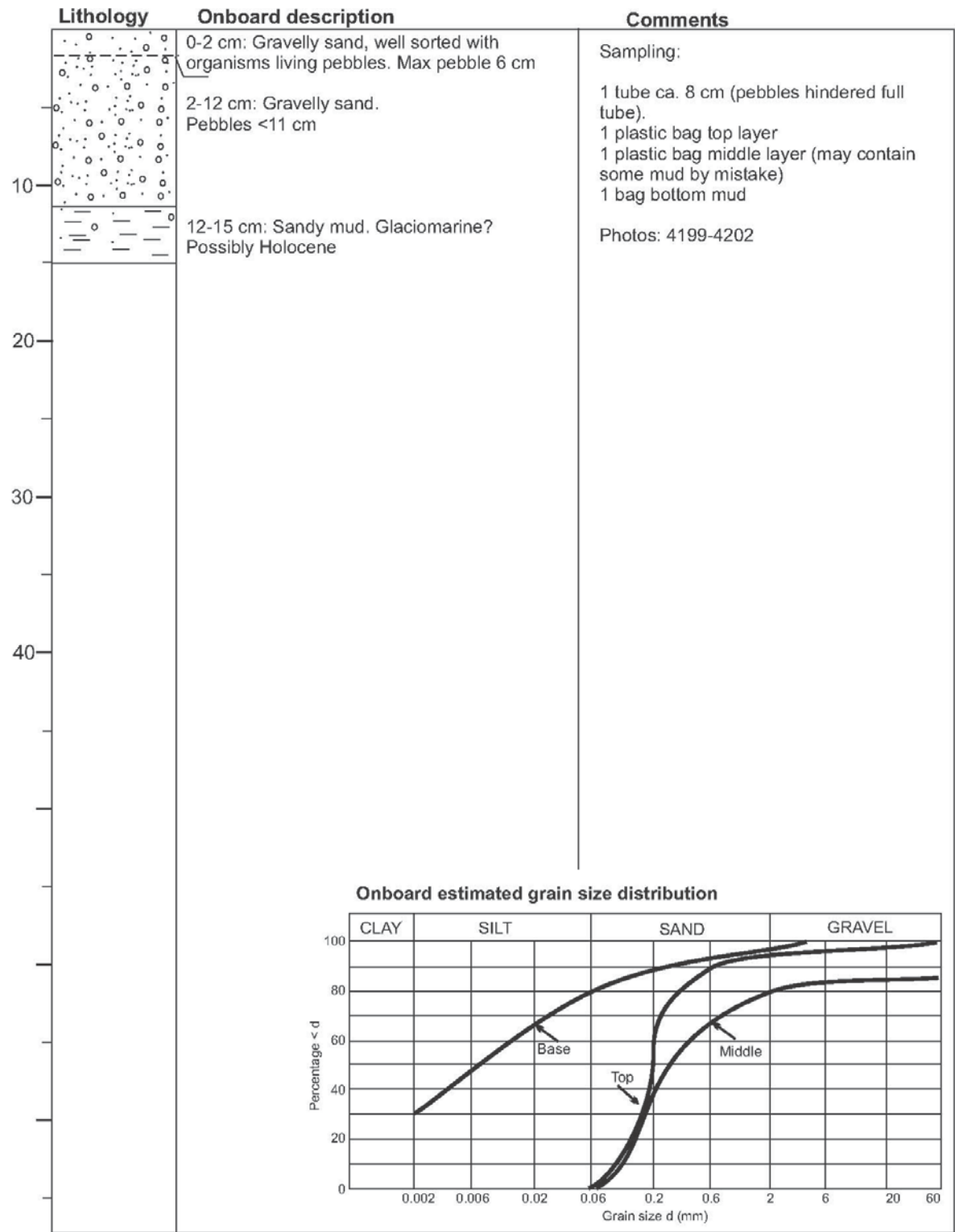
Equipment: Van Veen grab

Date- time: 16/4- 2012

Length (penetration): 15 cm



Project number: 3420.00 ('Sandwaves')	Sample number: GS12104-29-GB28
Notes (operation, etc): 1 m waves	Equipment: Van Veen grab
	Date- time: 16/4- 2012
	Length (penetration): 15 cm



Project number: 3420.00 ('Sandwaves')

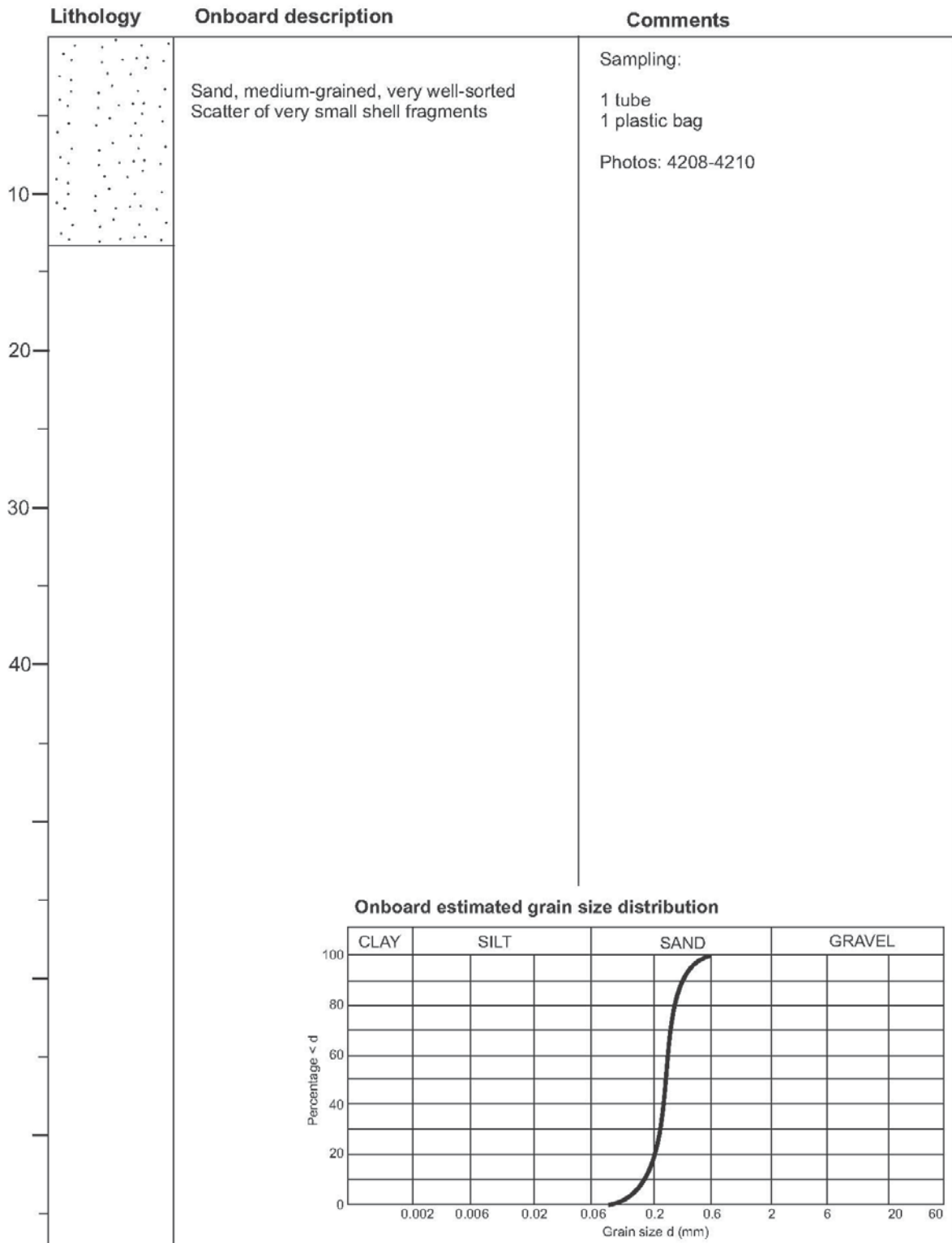
Sample number: **GS12104-34-GB29**

Notes (operation, etc): 2-3 m waves

Equipment: Van Veen grab

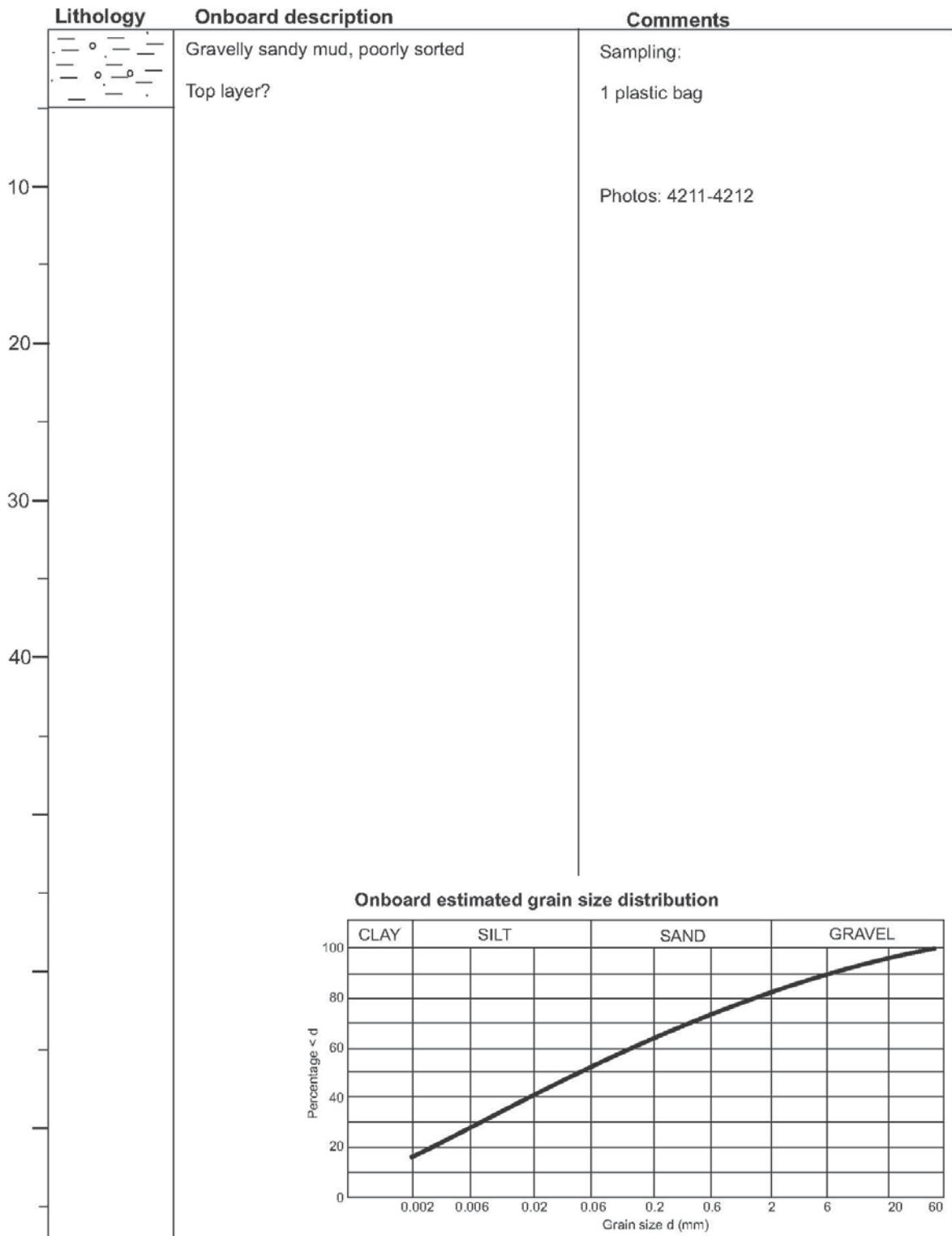
Date- time: 16/4- 2012

Length (penetration): 13 cm



Project number: 3420.00 ('Sandwaves')
 Notes (operation, etc): 1- 2 m waves, snowing

Sample number: **GS12104-35-GB30**
 Equipment: Van Veen grab
 Date- time: 16/4- 2012
 Length (penetration): 5 cm



Project number: 3420.00 ('Sandwaves')

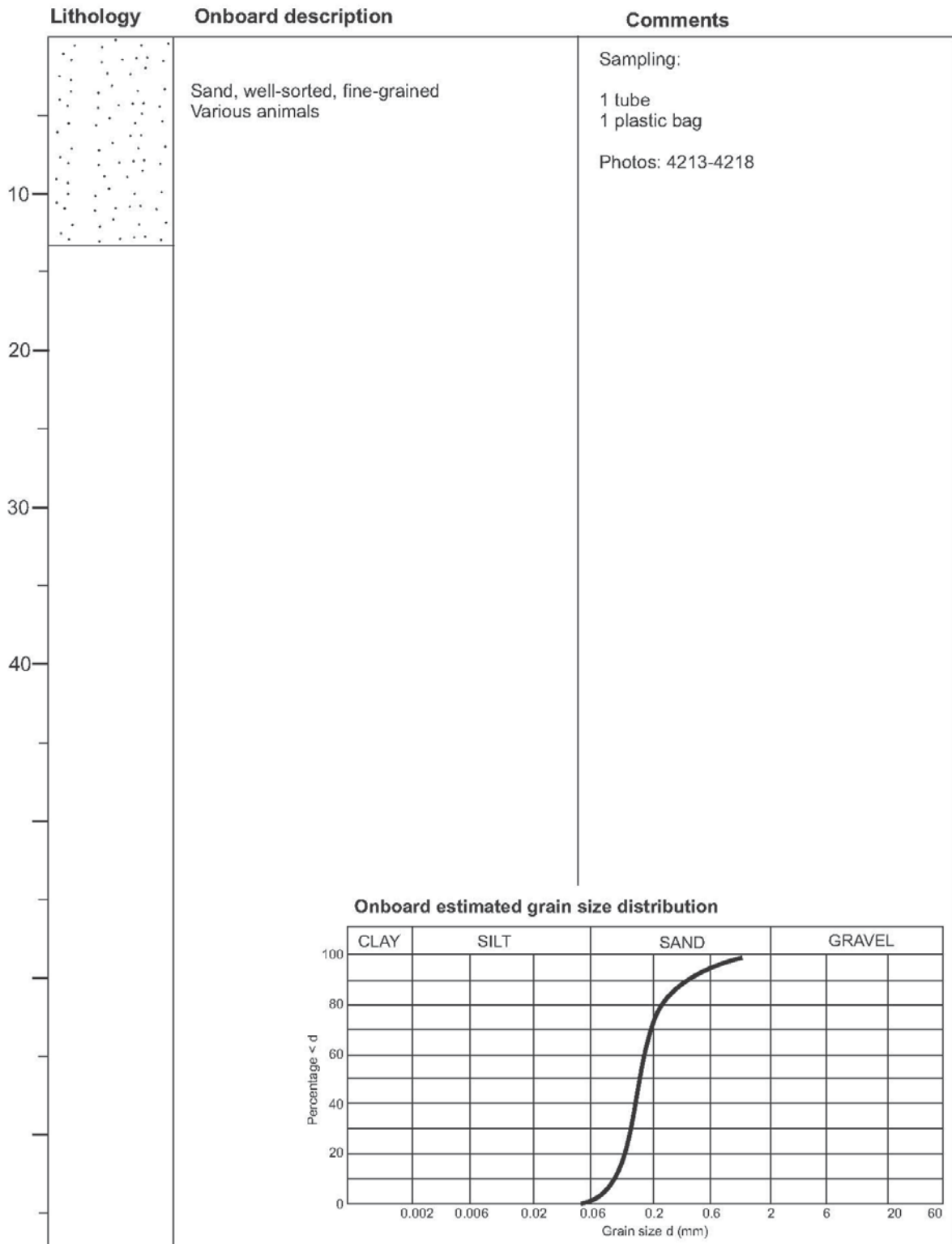
Sample number: **GS12104-36-GB31**

Notes (operation, etc): 1-2 m waves

Equipment: Van Veen grab

Date- time: 16/4- 2012

Length (penetration): 15 cm



Project number: 3420.00 ('Sandwaves')

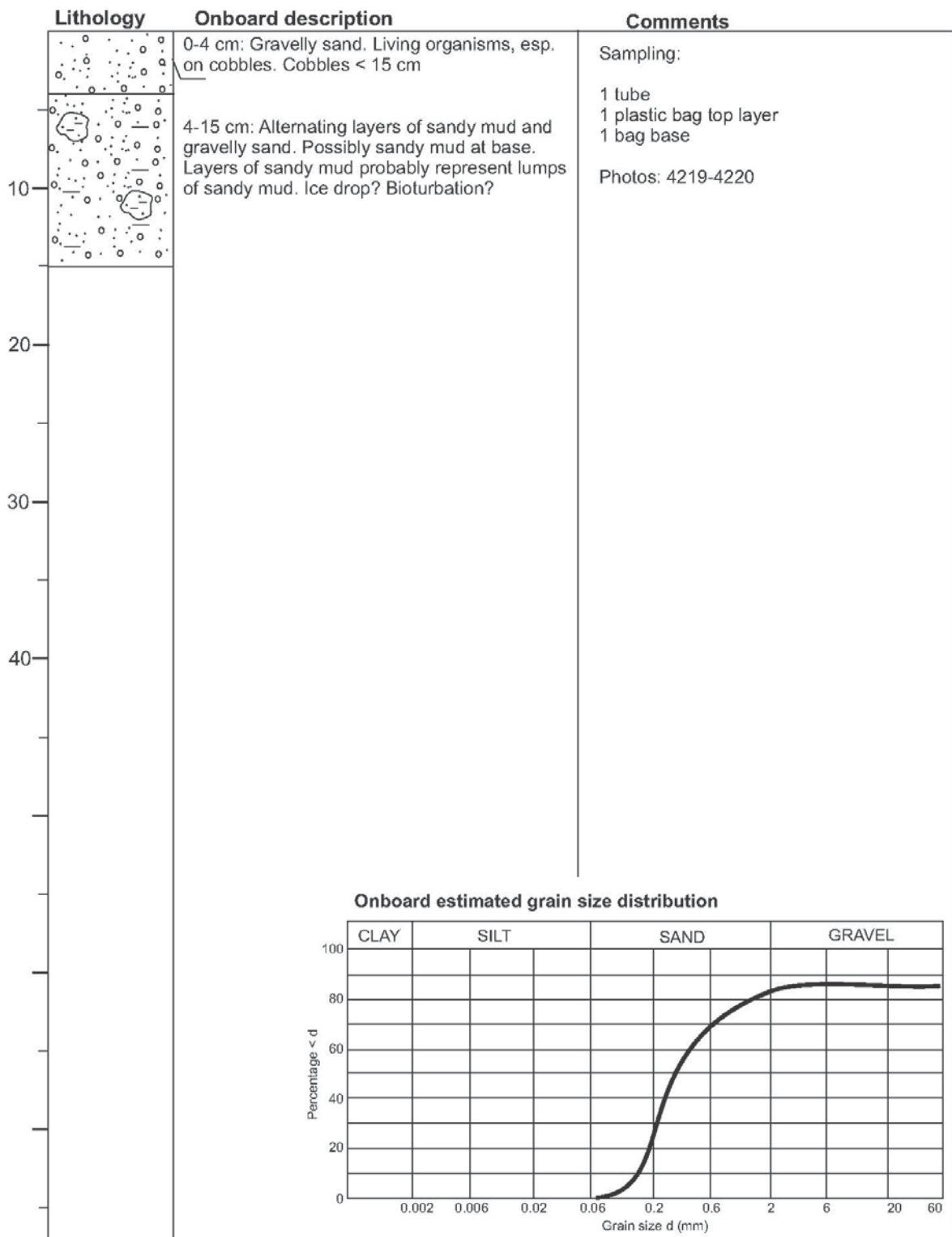
Sample number: **GS12104-37-GB32**

Notes (operation, etc): 1-2 m waves

Equipment: Van Veen grab

Date- time: 16/4- 2012

Length (penetration): 16 cm



Project number: 3420.00 ('Sandwaves')

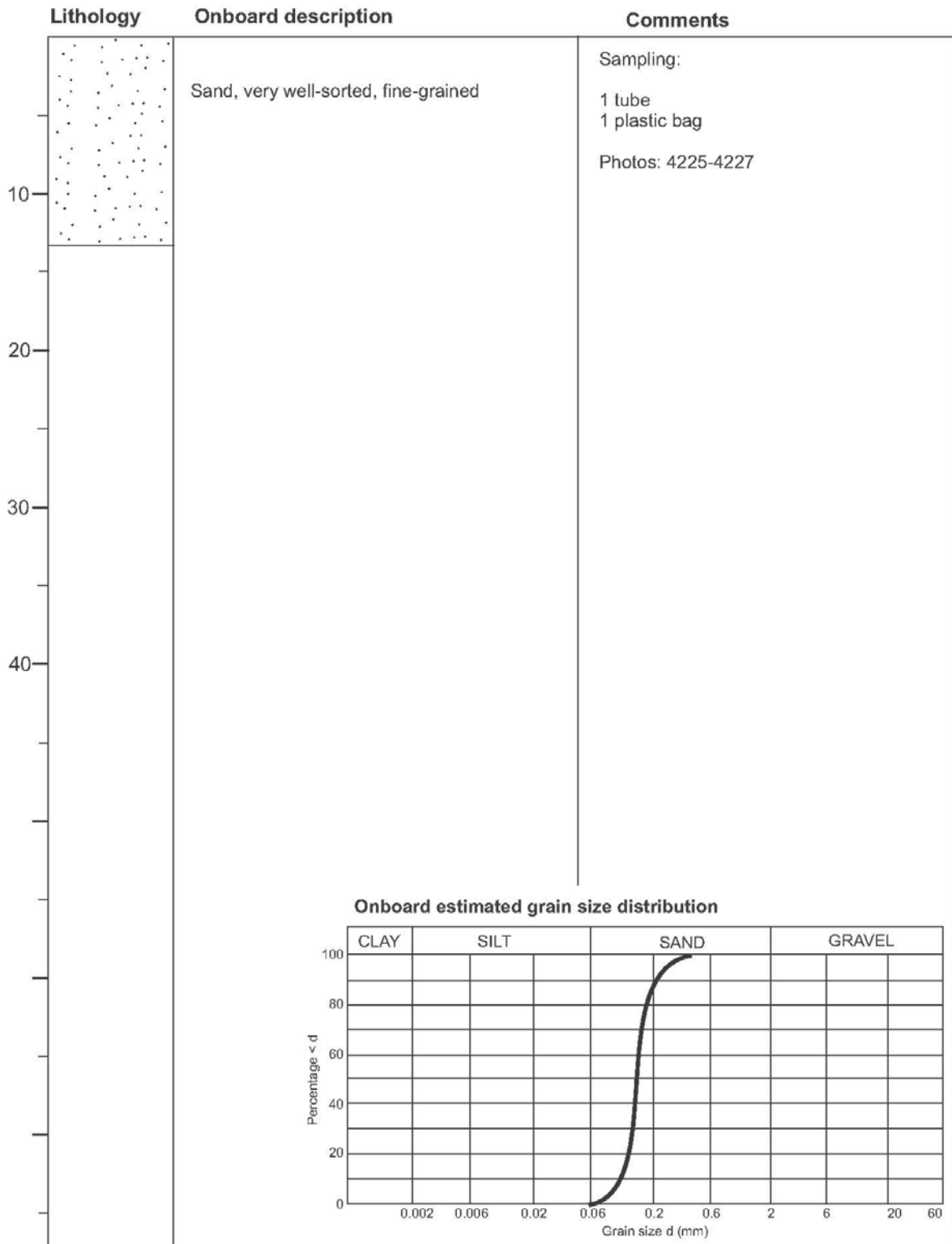
Sample number: **GS12104-40-GB33**

Notes (operation, etc): 1-2 m waves

Equipment: Van Veen grab

Date- time: 17/4- 2012

Length (penetration): 15 cm



Project number: 3420.00 ('Sandwaves')

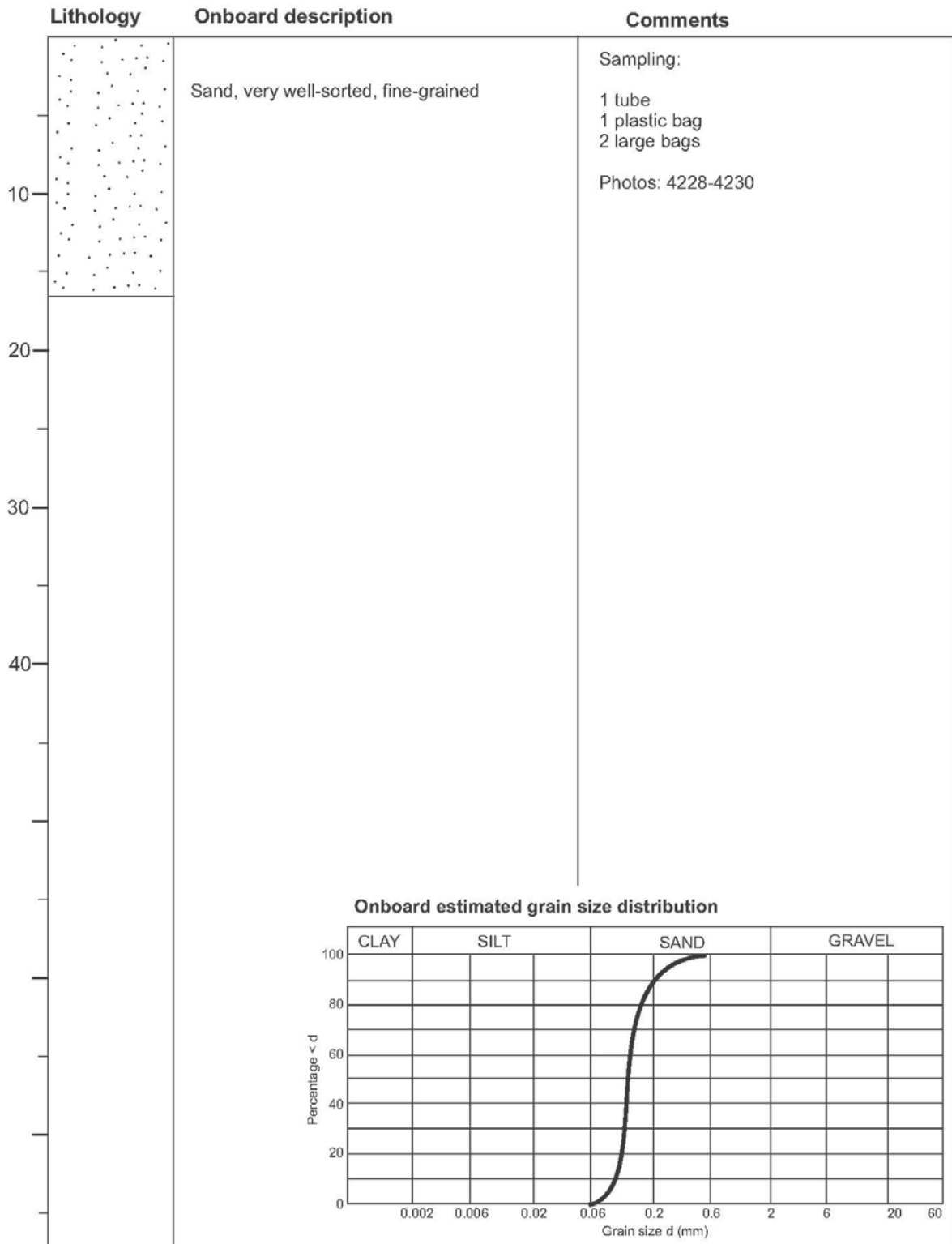
Sample number: **GS12104-41-GB34**

Notes (operation, etc): 1-2 m waves

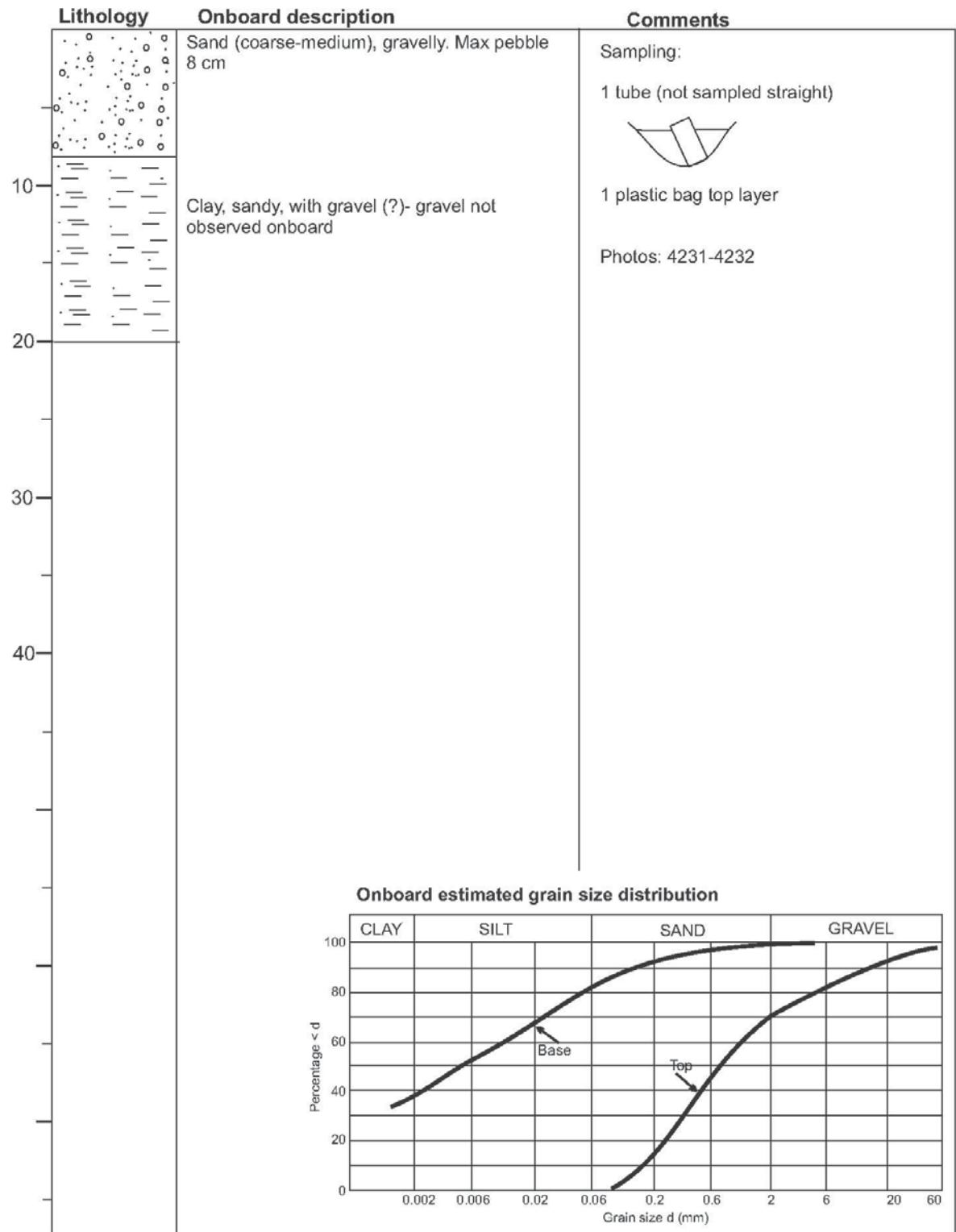
Equipment: Van Veen grab

Date- time: 17/4- 2012

Length (penetration): 17 cm



Project number: 3420.00 ('Sandwaves')	Sample number: GS12104-45-GB35
Notes (operation, etc): 2-3 m waves	Equipment: Van Veen grab
Strong current, 25° inclination to north	Date- time: 17/4- 2012
	Length (penetration): 20 cm



Project number: 3420.00 ('Sandwaves')

Sample number: **GS12104-46-GB36**

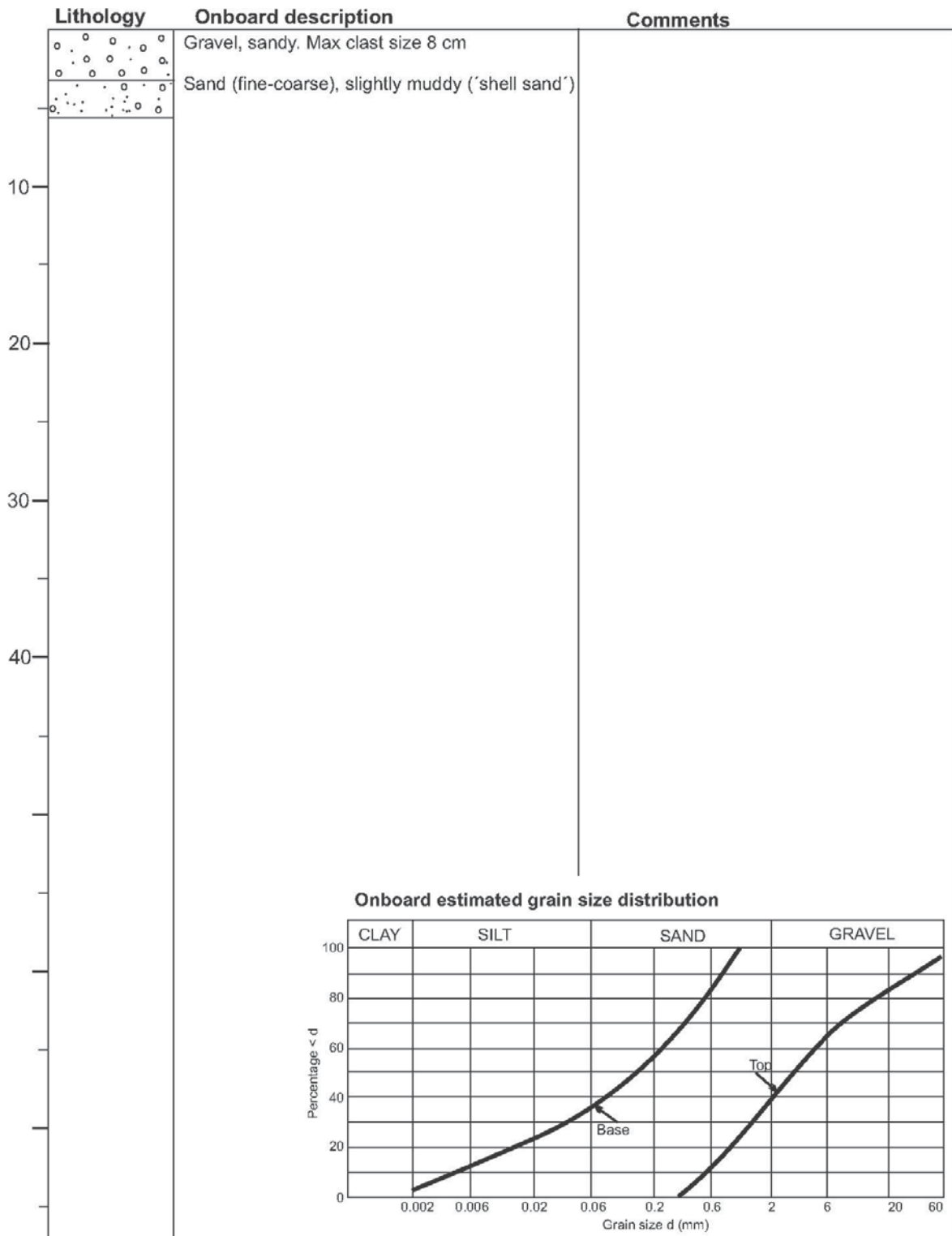
Notes (operation, etc): 2-3 m waves

Equipment: Van Veen grab

Strong current

Date- time: 17/4- 2012

Length (penetration): 6 cm



Project number: 3420.00 ('Sandwaves')

Sample number: **GS12104-47-GB37**

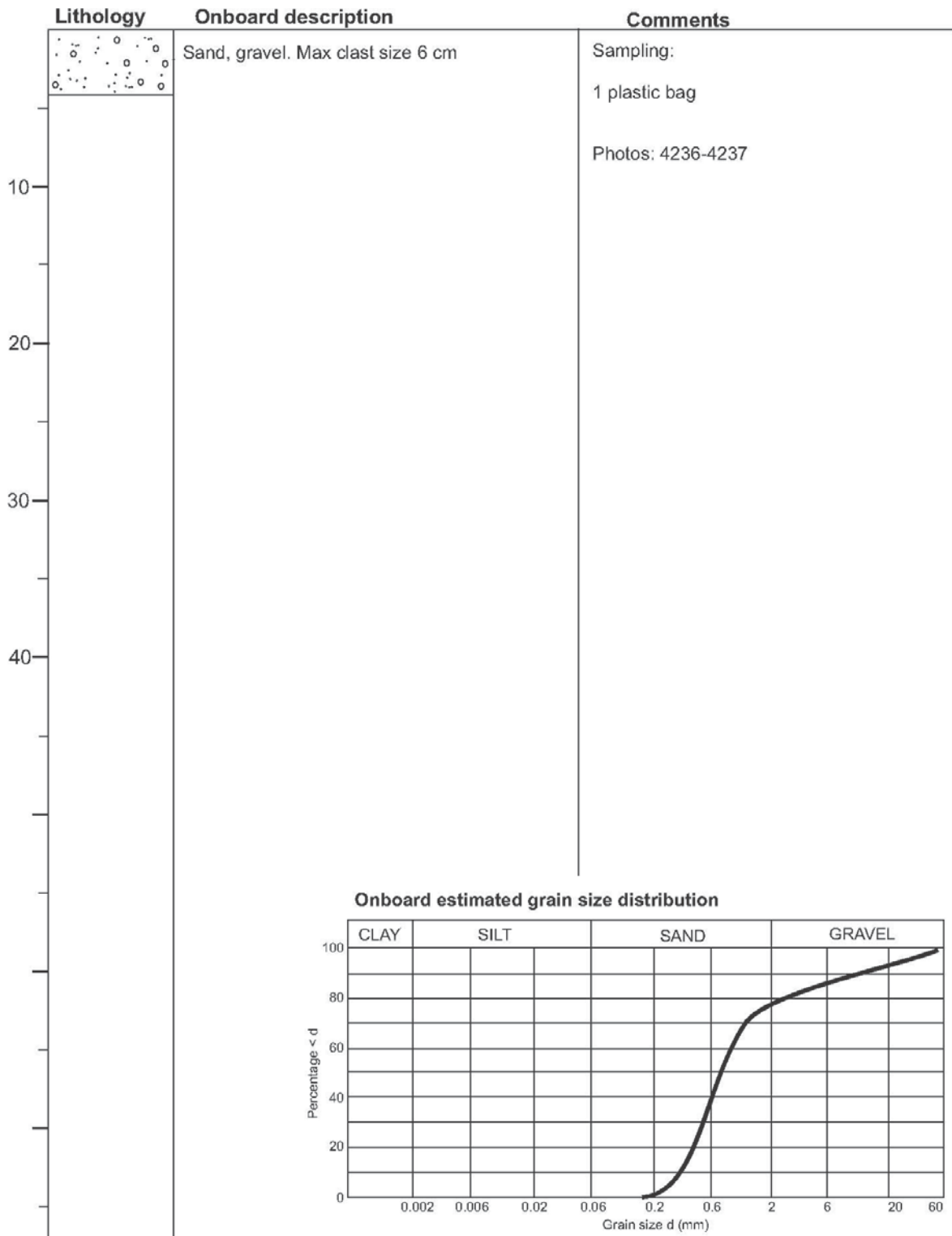
Notes (operation, etc): 2-3 m waves

Equipment: Van Veen grab

Strong current

Date- time: 17/4- 2012

Length (penetration): 4 cm



Project number: 3420.00 ('Sandwaves')

Sample number: **GS12104-48-GB38**

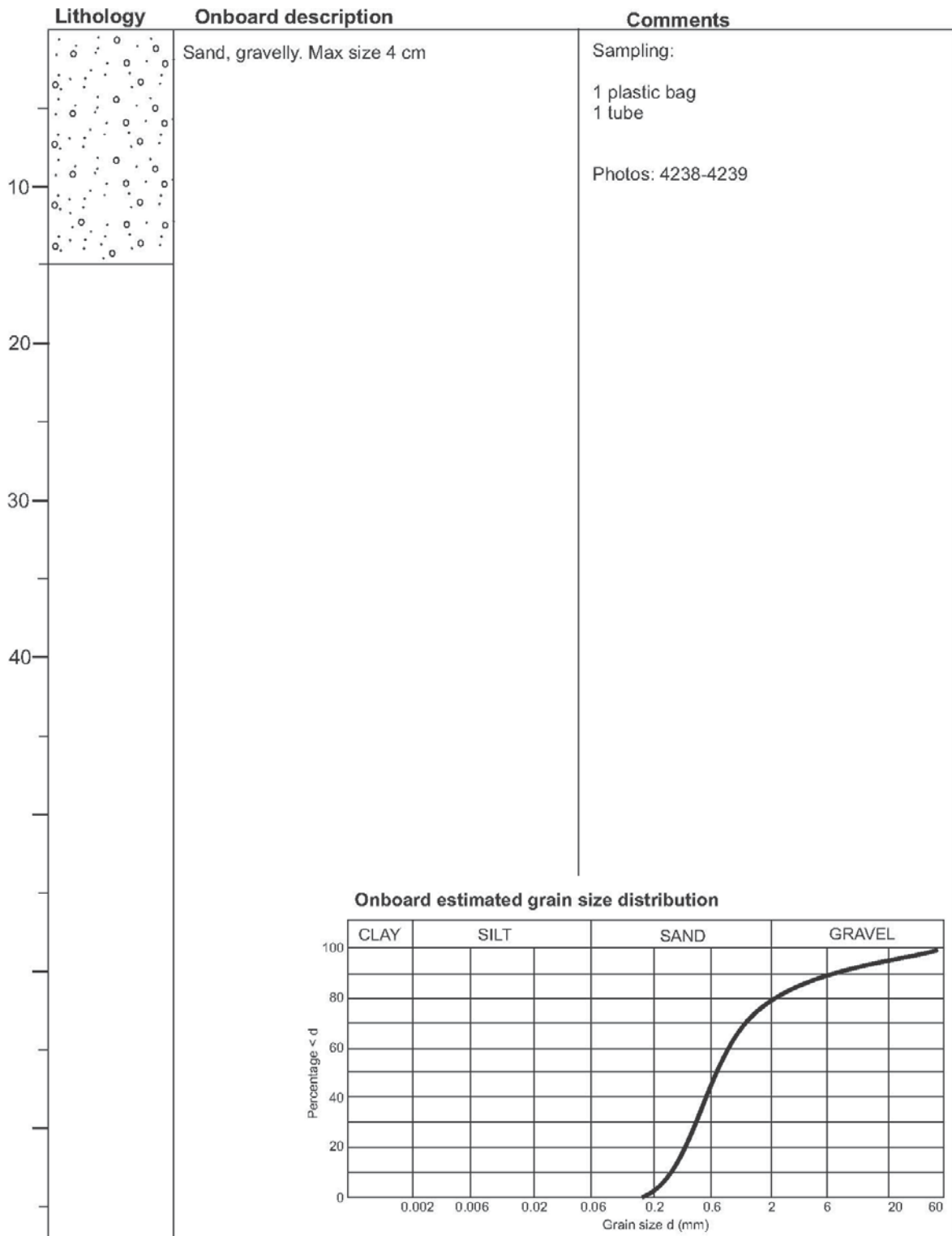
Notes (operation, etc): 2-3 m waves

Equipment: Van Veen grab

Strong current

Date- time: 17/4- 2012

Length (penetration): 15 cm



Project number: 3420.00 ('Sandwaves')

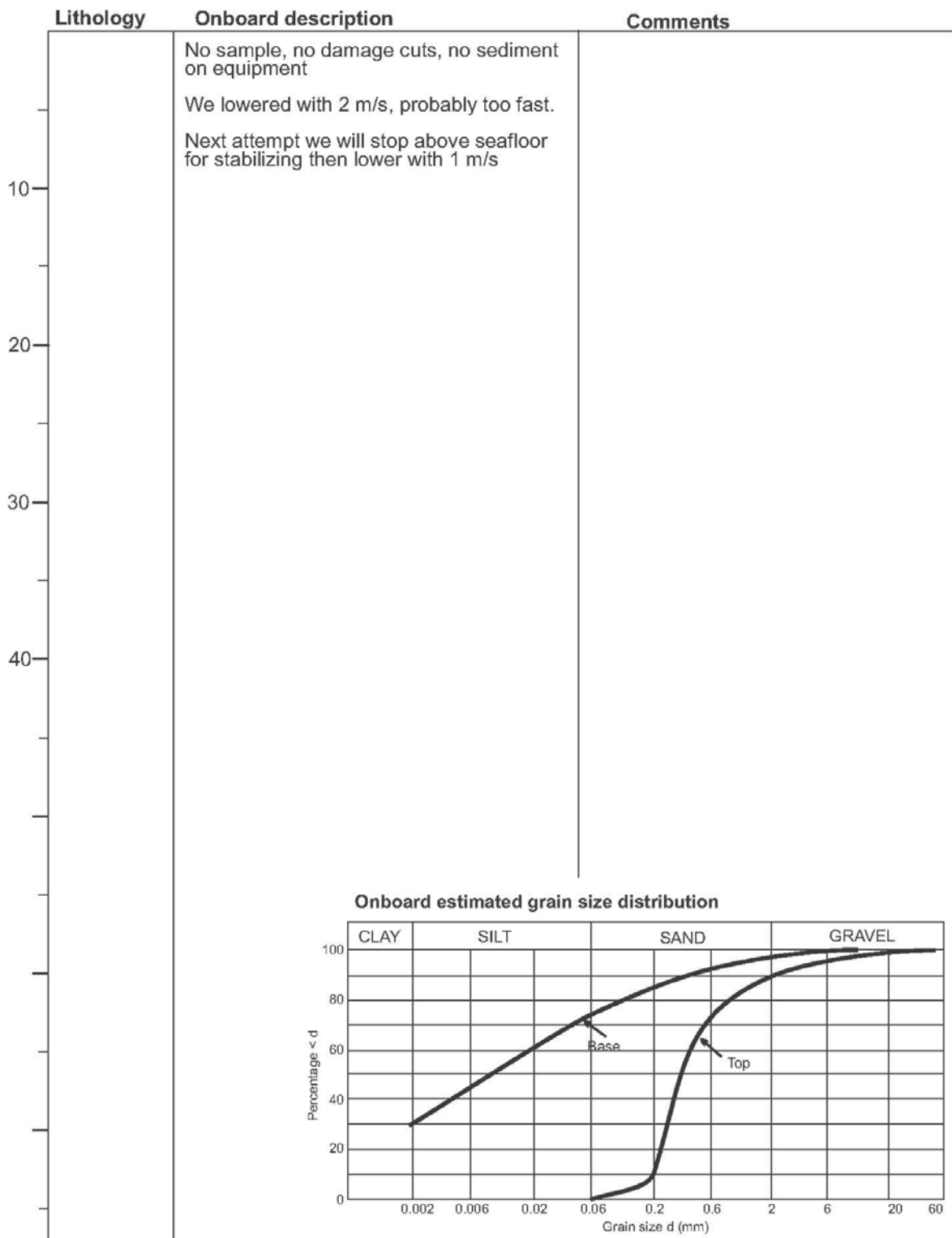
Sample number: **GS12104-14-GC1**

Notes (operation, etc): 1m swell

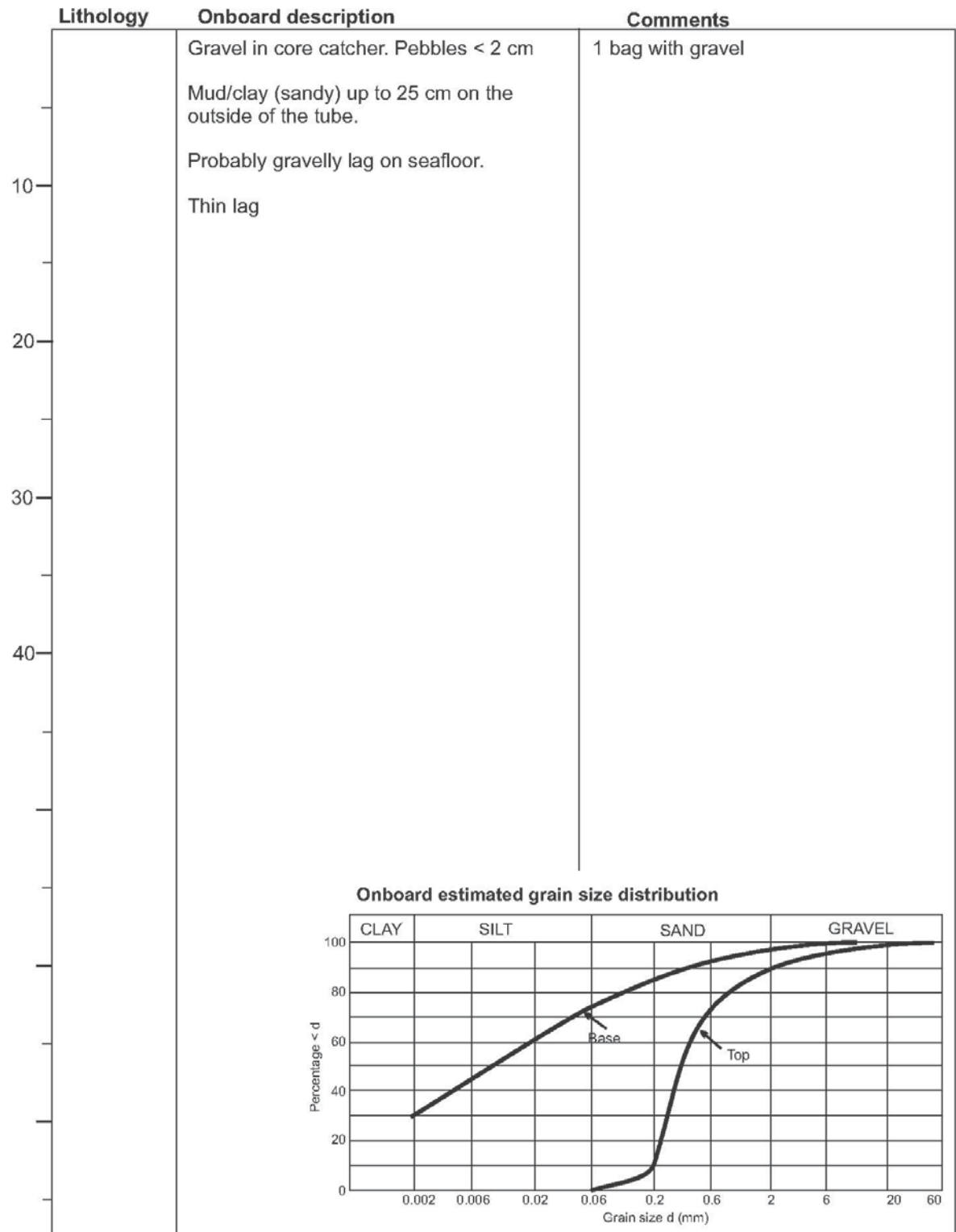
Equipment: Gravity core

Date- time: 15/4- 2012

Length (penetration): 0 cm



Project number: 3420.00 ('Sandwaves')	Sample number: GS12104-14-GC2
Notes (operation, etc): 1m swell, drifting wire 10-15° towards south	Equipment: Gravity core
	Date- time: 15/4- 2012
	Length (penetration): 0 cm



Project number: 3420.00 ('Sandwaves')

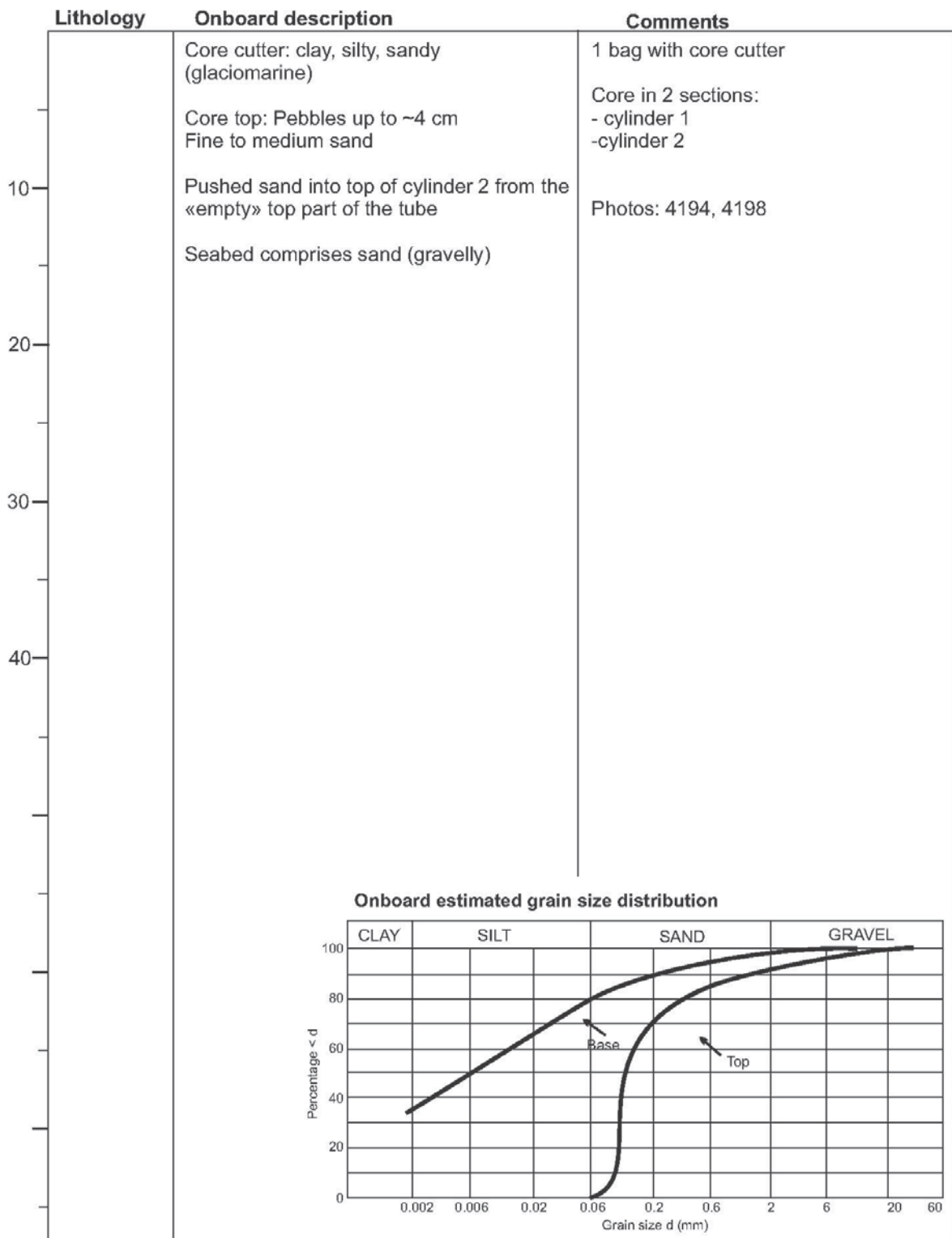
Sample number: **GS12104-27-GC3**

Notes (operation, etc): 2-3 m

Equipment: Gravity core

Date- time: 16/4- 2012

Length (penetration): 151 cm



Project number: 3420.00 ('Sandwaves')

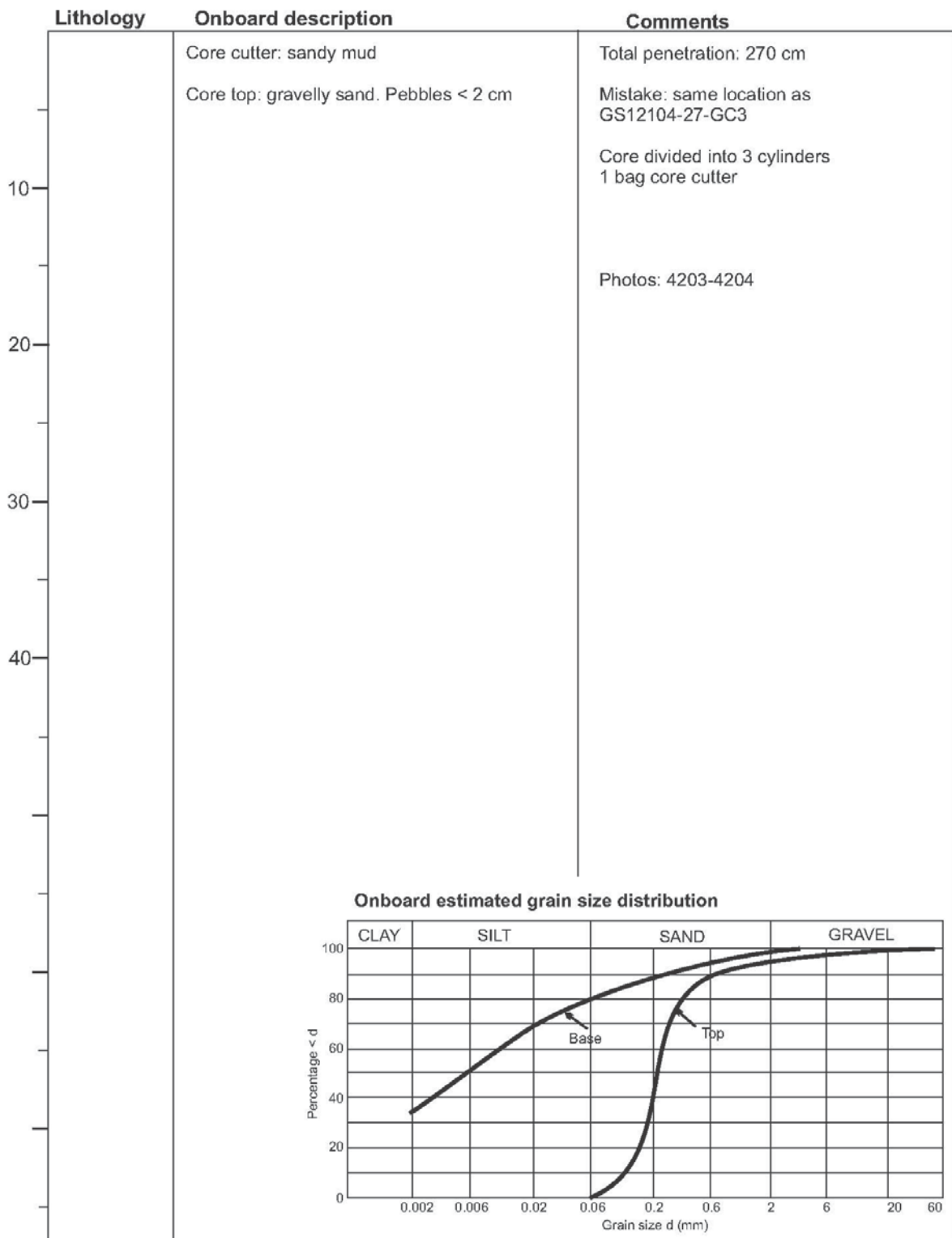
Sample number: **GS12104-30-GC4**

Notes (operation, etc): 1m waves

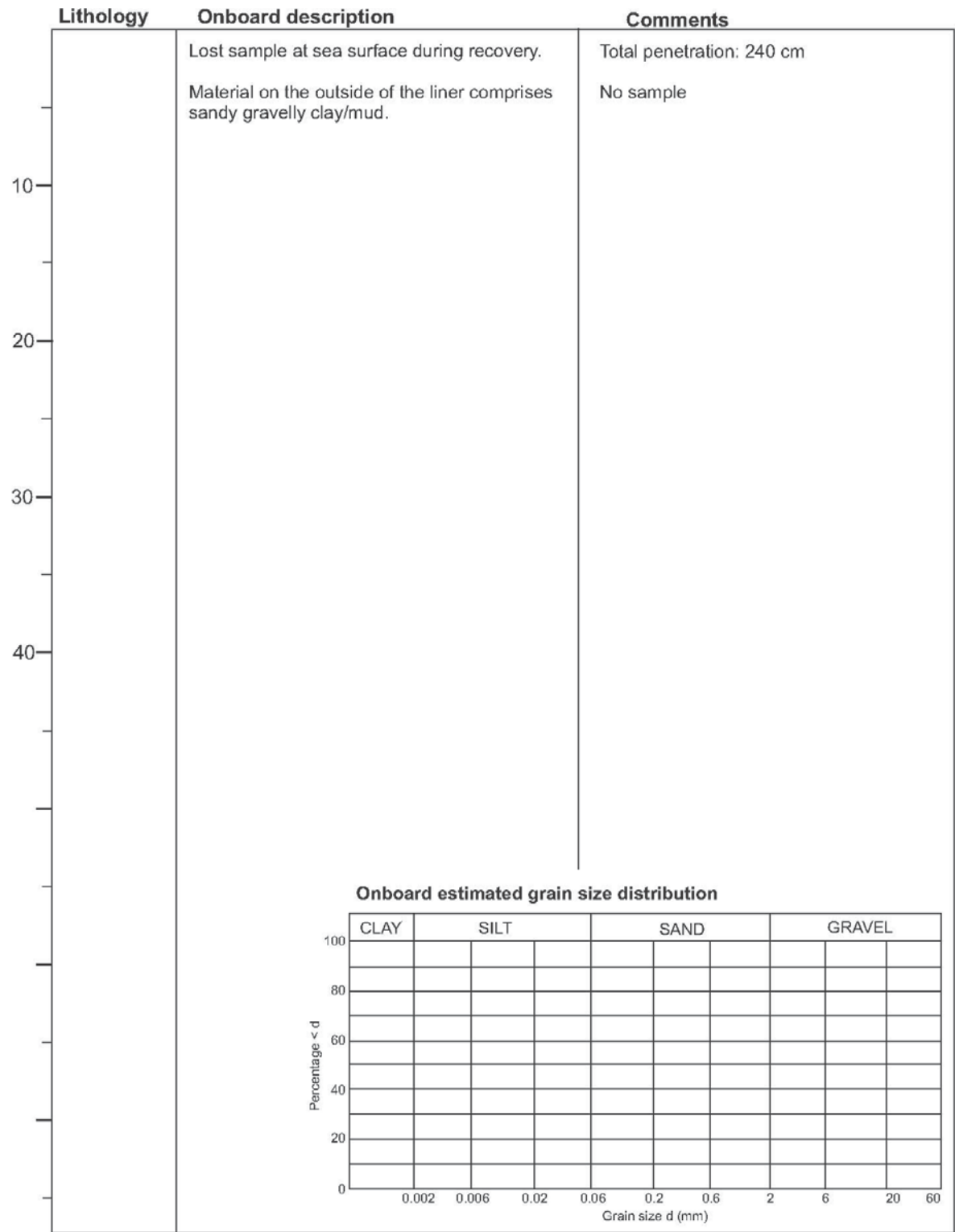
Equipment: Gravity core

Date- time: 16/4- 2012

Length (penetration): 239 cm



Project number: 3420.00 ('Sandwaves')	Sample number: GS12104-31-GC5
Notes (operation, etc): <1m waves	Equipment: Gravity core
	Date- time: 16/4- 2012
	Length (penetration): 0



Project number: 3420.00 ('Sandwaves')

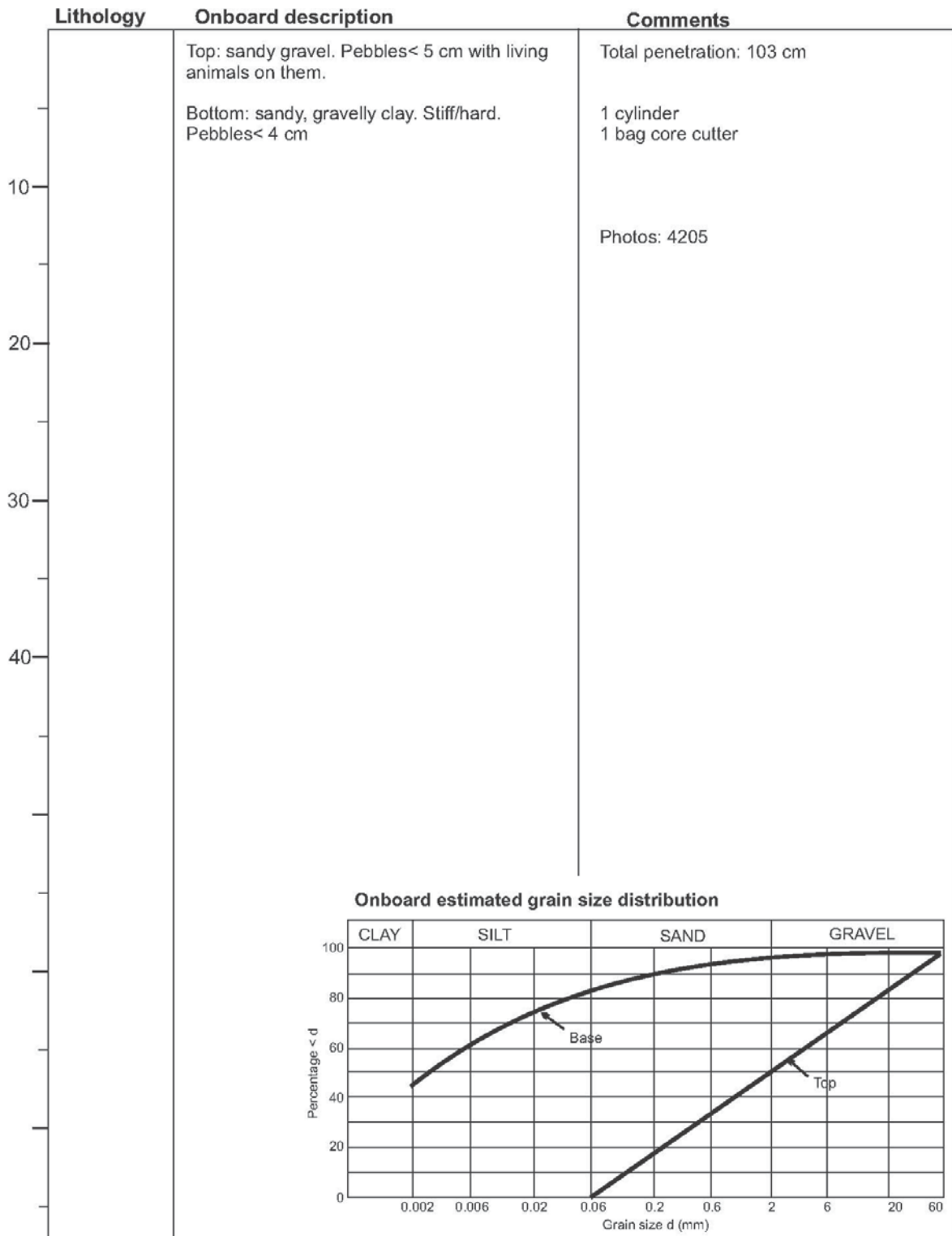
Sample number: **GS12104-31-GC6**

Notes (operation, etc): <1m waves

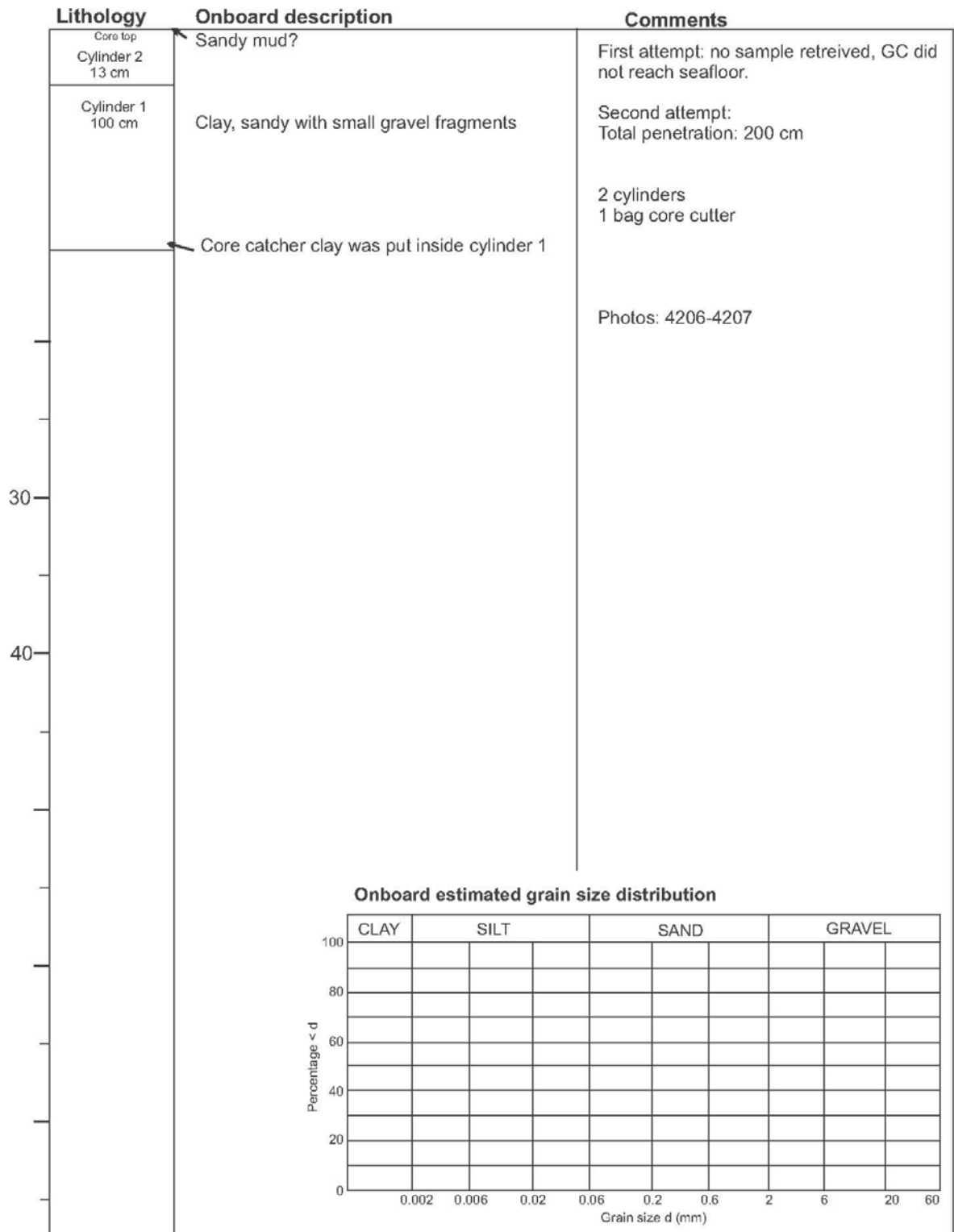
Equipment: Gravity core

Date- time: 16/4- 2012

Length (penetration): 67 cm



Project number: 3420.00 ('Sandwaves')	Sample number: GS12104-32-GC7
Notes (operation, etc): <1m waves	Equipment: Gravity core
	Date- time: 16/4- 2012
	Length (penetration): 113 cm



Project number: 3420.00 ('Sandwaves')

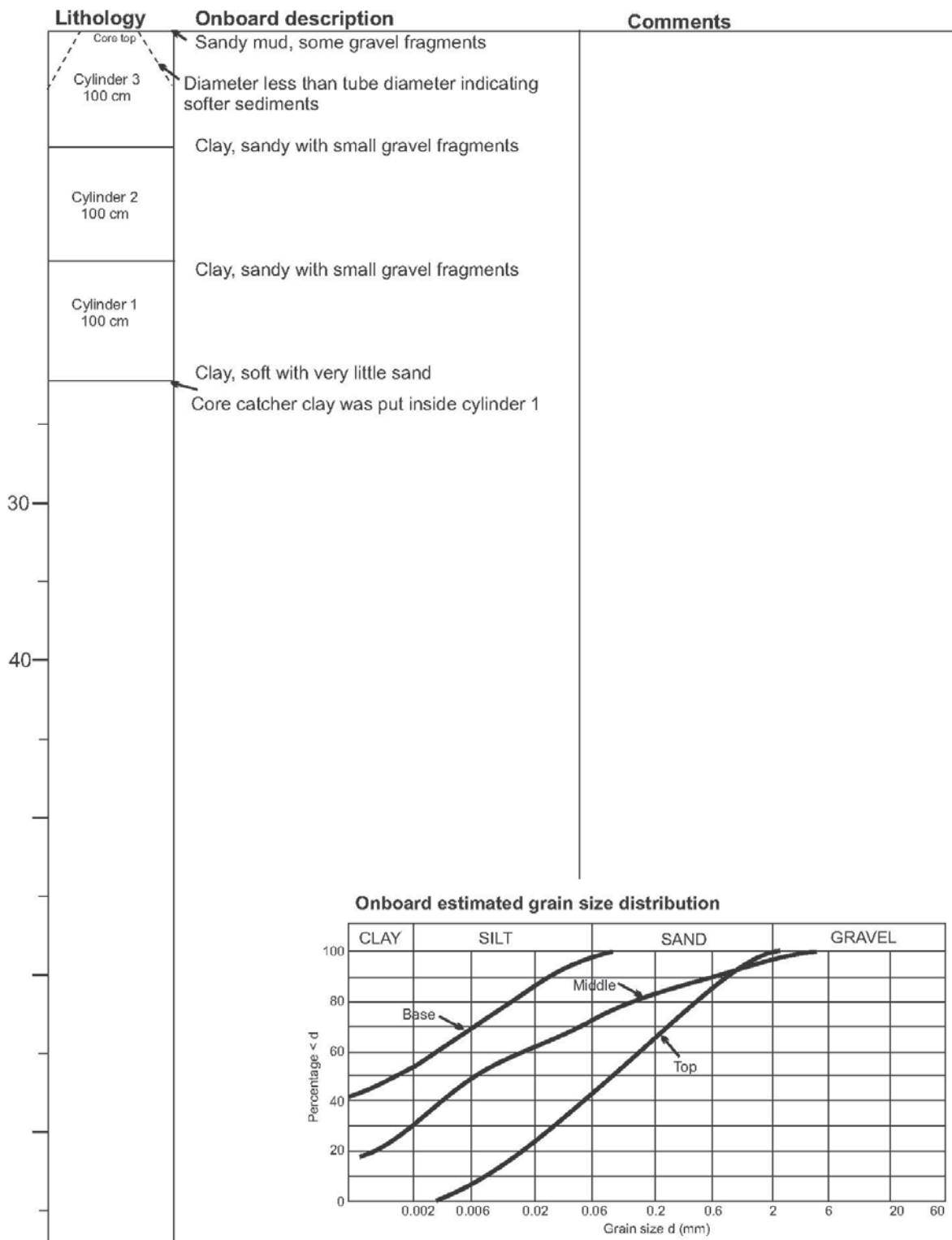
Sample number: **GS12104-33-GC8**

Notes (operation, etc): 2-3 m waves

Equipment: Gravity core

Date- time: 16/4- 2012

Length (penetration): 301 cm



Project number: 3420.00 ('Sandwaves')	Sample number: GS12104-35-GC9
Notes (operation, etc): 1- 2 m waves	Equipment: Gravity core
	Date- time: 16/4- 2012
	Length (penetration): 5 cm

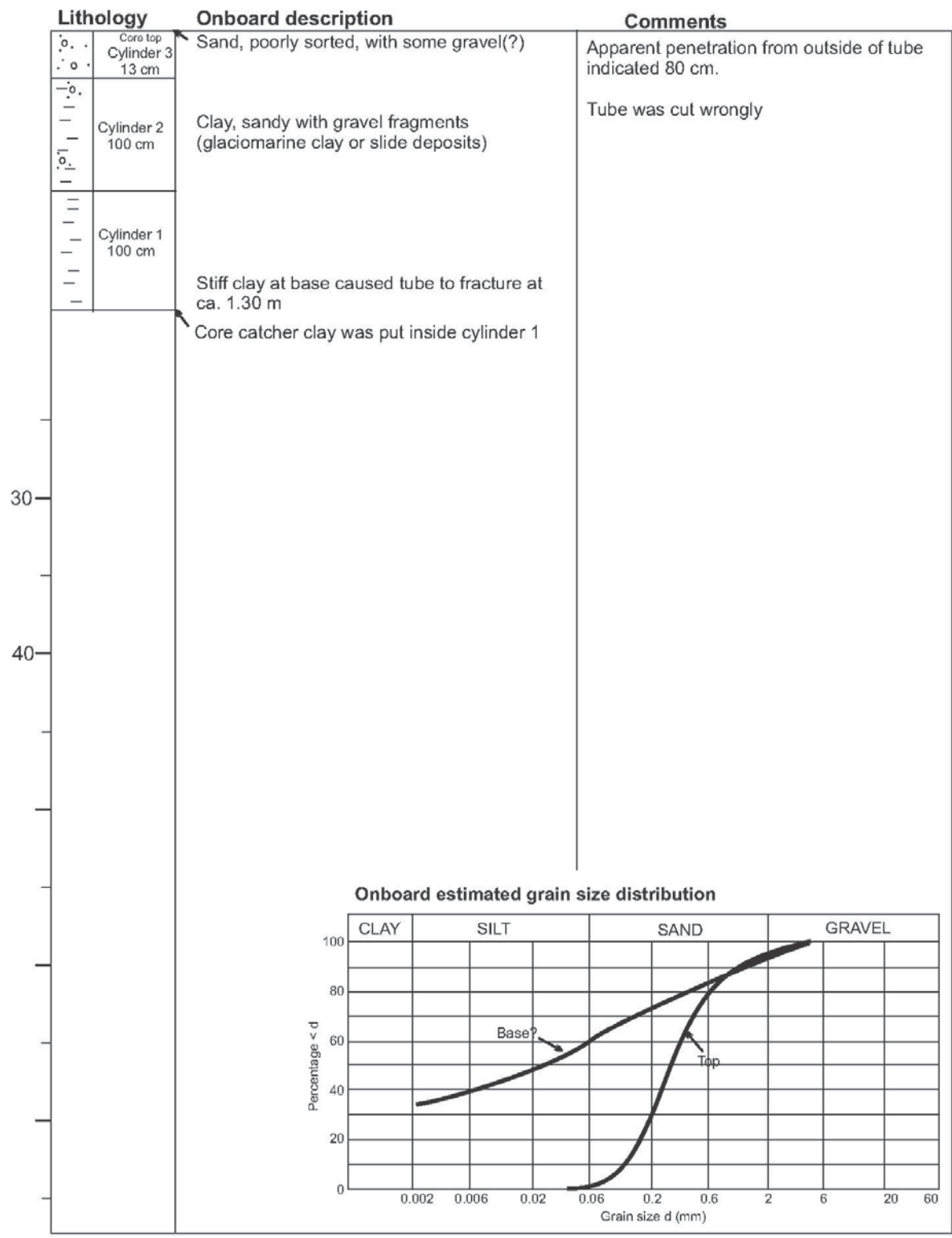
Lithology	Onboard description	Comments
<div style="display: flex; flex-direction: column; align-items: center;"> <div style="margin-bottom: 10px;">10</div> <div style="margin-bottom: 10px;">20</div> <div style="margin-bottom: 10px;">30</div> <div style="margin-bottom: 10px;">40</div> </div>	<p>Empty tube. Had penetrated at least 50 cm.</p> <p>Soft gravelly sandy mud on outside of tube</p>	<p>Sampling:</p> <p>1 plastic bag</p>

Onboard estimated grain size distribution

	CLAY	SILT	SAND	GRAVEL
100				
80				
60				
40				
20				
0				

Grain size d (mm)

Project number: 3420.00 ('Sandwaves')	Sample number: GS12104-38-GC10
Notes (operation, etc): 2 m waves	Equipment: Gravity core
Tube half broke 1.30m above base, lost parts (10-20 cm?)	Date- time: 17/4- 2012
	Length (penetration): 110 cm



Project number: 3420.00 ('Sandwaves')

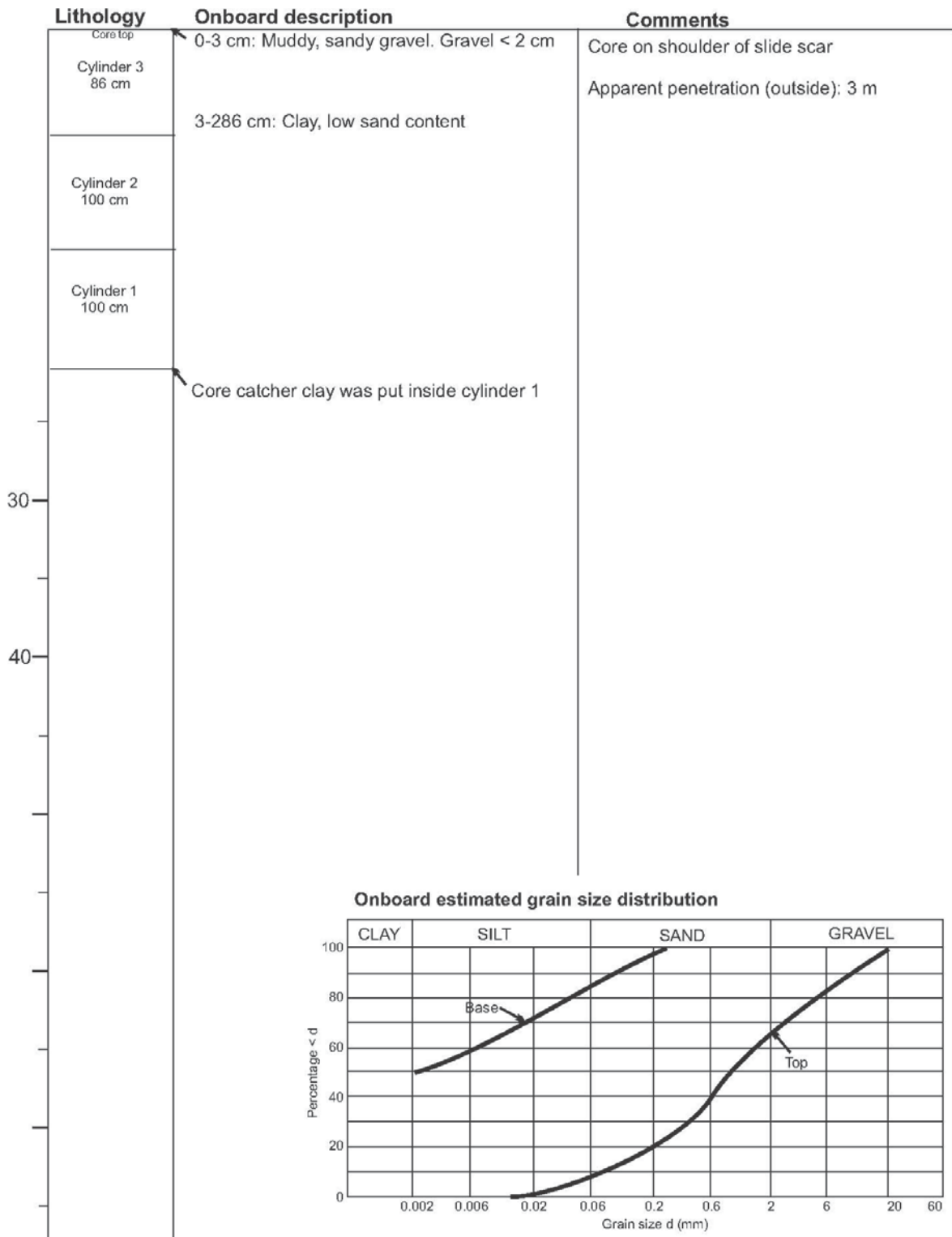
Sample number: **GS12104-39-GC11**

Notes (operation, etc): 1- 2 m waves

Equipment: Gravity core

Date- time: 17/4- 2012

Length (penetration): 286 cm



Project number: 3420.00 ('Sandwaves')

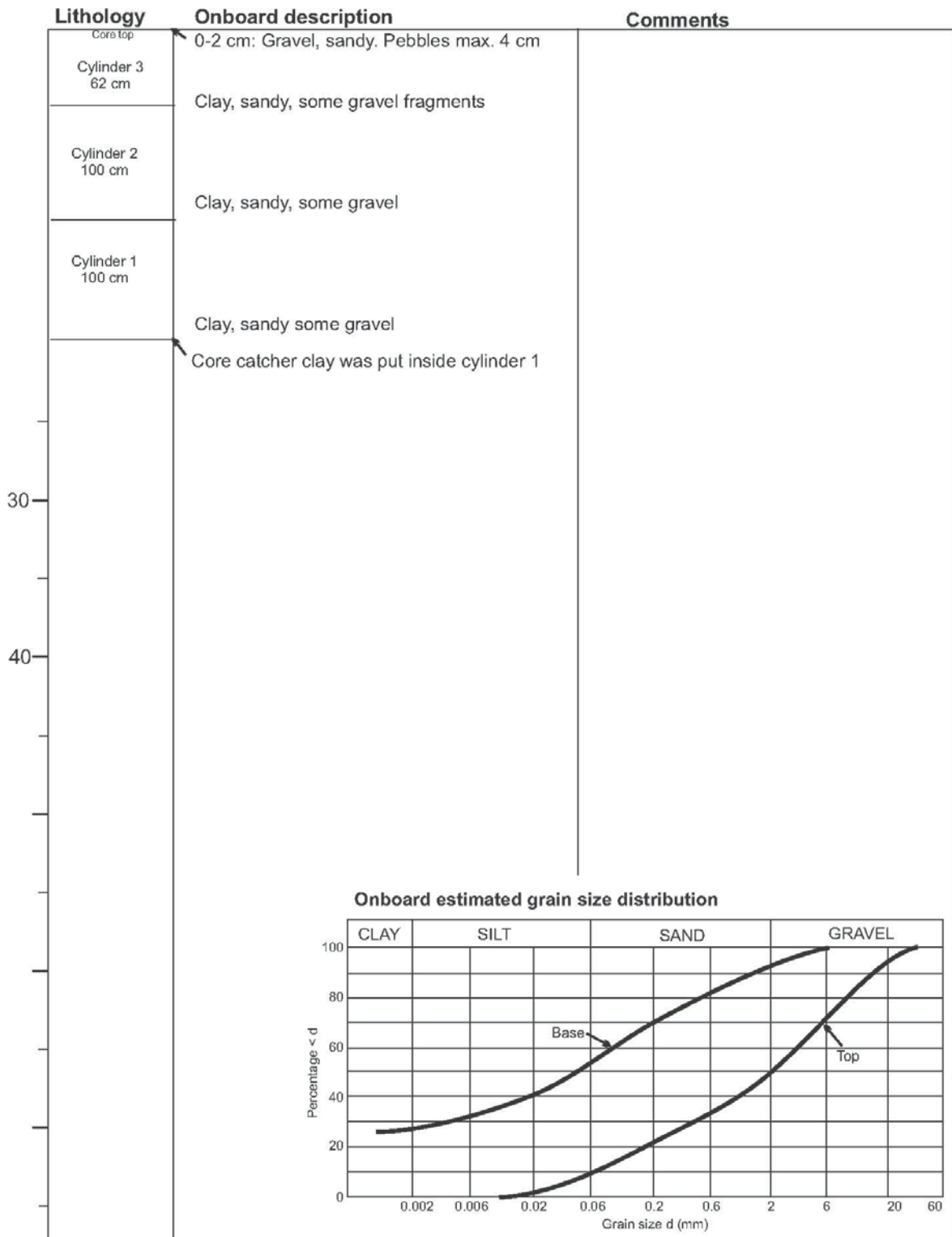
Sample number: **GS12104-42-GC12**

Notes (operation, etc): 2 m waves

Equipment: Gravity core

Date- time: 17/4- 2012

Length (penetration): 262 cm



Project number: 3420.00 ('Sandwaves')

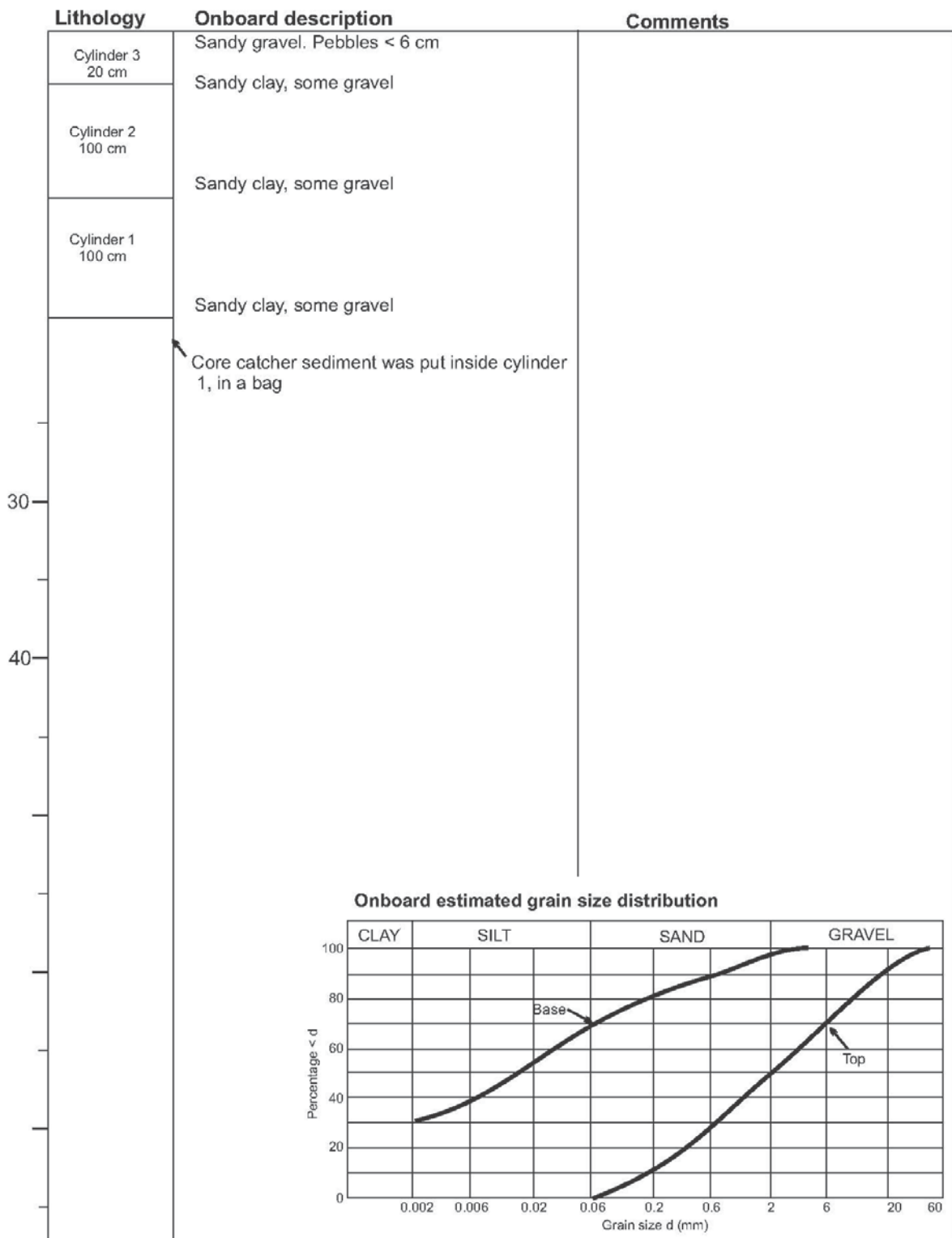
Sample number: **GS12104-43-GC13**

Notes (operation, etc): 2 m waves

Equipment: Gravity core

Date- time: 17/4- 2012

Length (penetration): 220 cm



Project number: 3420.00 ('Sandwaves')

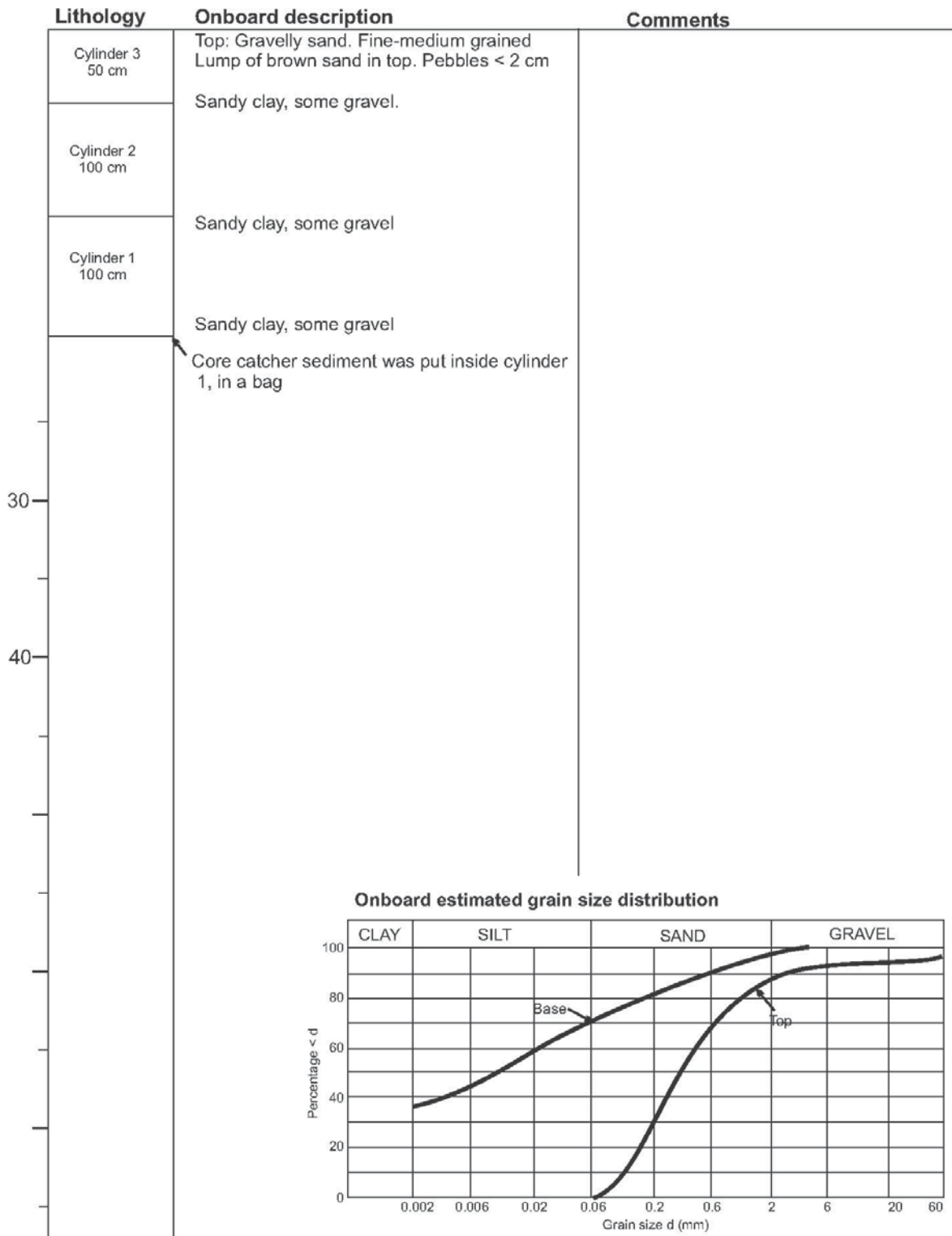
Sample number: **GS12104-44-GC14**

Notes (operation, etc): 1- 2 m waves

Equipment: Gravity core

Date- time: 17/4- 2012

Length (penetration): 250 cm





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