

FFI RAPPORT

ANALYSIS OF BOTTOM SAMPLES FROM VESTFJORDEN COLLECTED DURING RUMBLE FIRST SEA TRIAL

JENSERUD Trond, OTTESEN Dag (NGU)

FFI/RAPPORT-2002/05018

FFIBM/821/116

Approved
Horten 30 December 2002

Tor Knudsen
Director of Research

**ANALYSIS OF BOTTOM SAMPLES FROM
VESTFJORDEN COLLECTED DURING RUMBLE
FIRST SEA TRIAL**

JENSERUD Trond, OTTESEN Dag (NGU)

FFI/RAPPORT-2002/05018

FORSVARETS FORSKNINGSINSTITUTT
Norwegian Defence Research Establishment
P O Box 25, NO-2027 Kjeller, Norway

P O BOX 25
 NO-2027 KJELLER, NORWAY
REPORT DOCUMENTATION PAGE

SECURITY CLASSIFICATION OF THIS PAGE
 (when data entered)

1) PUBL/REPORT NUMBER FFI/RAPPORT-2002/05018 1a) PROJECT REFERENCE FFIBM/821/116	2) SECURITY CLASSIFICATION UNCLASSIFIED 2a) DECLASSIFICATION/DOWNGRADING SCHEDULE -	3) NUMBER OF PAGES 41
4) TITLE ANALYSIS OF BOTTOM SAMPLES FROM VESTFJORDEN COLLECTED DURING RUMBLE FIRST SEA TRIAL		
5) NAMES OF AUTHOR(S) IN FULL (surname first) JENSERUD Trond, OTTESEN Dag (NGU)		
6) DISTRIBUTION STATEMENT Approved for public release. Distribution unlimited. (Offentlig tilgjengelig)		
7) INDEXING TERMS IN ENGLISH: IN NORWEGIAN: a) <u>Seabed sample</u> a) <u>Bunnsedimentprøve</u> b) <u>Grain size analysis</u> b) <u>Kornfordelings analyse</u> c) _____ c) _____ d) _____ d) _____ e) _____ e) _____		
THESAURUS REFERENCE: 8) ABSTRACT <p>As a part of the RUMBLE first sea trial 15 sediment samples were taken from two areas in the inner and outer Vestfjorden, respectively. This report presents the results of the analysis of the sediment samples.</p> <p>The seabed samples have been classified according to grain size analysis. In the inner area (A), five samples are classified as clay (silty/sandy) and two samples as sand (silty/clayey). In the outer area (B), three samples are classified as clay and six samples as sand.</p>		
9) DATE 30 December 2002	AUTHORIZED BY This page only Tor Knudsen	POSITION Director of Research

ISBN-82-464-0709-0

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE
 (when data entered)

CONTENTS

	Page
1 INTRODUCTION	7
2 MEASUREMENTS	7
3 RESULTS AND DISCUSSION	10
4 CONCLUSIONS	14
A GRAIN SIZE ANALYSIS	16
B CUMULATIVE GRAIN SIZE DISTRIBUTION	21
References	39
DISTRIBUTION LIST	41

ANALYSIS OF BOTTOM SAMPLES FROM VESTFJORDEN COLLECTED DURING RUMBLE FIRST SEA TRIAL

1 INTRODUCTION

Project RUMBLE is concerned with measuring bottom roughness by use of low frequency active sonar. During the spring of 2001, the project carried out a sea trial in the Vestfjorden area. As a part of the sea trial 15 sediment samples were taken from two areas in the inner and outer Vestfjorden, respectively. The bottom samples constituted part of the ground truth collected during the sea trial. The bottom samples have been analysed by the Geological Survey of Norway (NGU), and the results are reported in the present document

2 MEASUREMENTS

The RUMBLE first sea trial took place in the Vestfjorden area of Norway from 28 May to 5 June 2001. Two areas were selected for the measurements as shown in figure 2.1. Both areas are squares of 15 by 15 nm. Area A is located in the inner fjord and has a flat bottom with soft sediments. Area B is located at the entrance of the fjord, and is expected to contain harder sediments as well as glacial scouring. The trial plan for the first sea trial is given in [1].

As a part of the trial grab samples were collected in order to investigate surface sediment properties. A total of 15 samples were collected, see figure 2.2. The locations of the samples are listed in table 2.1.

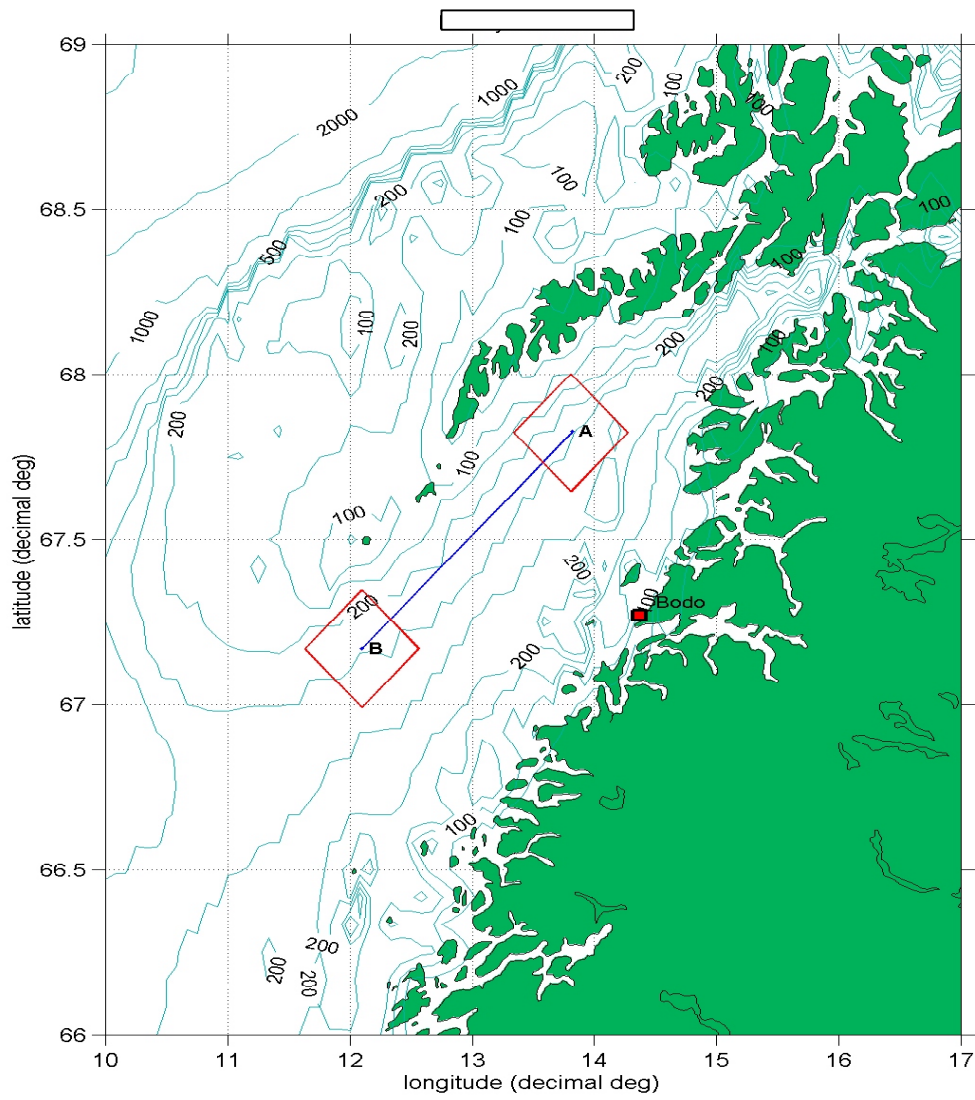


Figure 2.1. RUMBLE first sea trial – working areas.

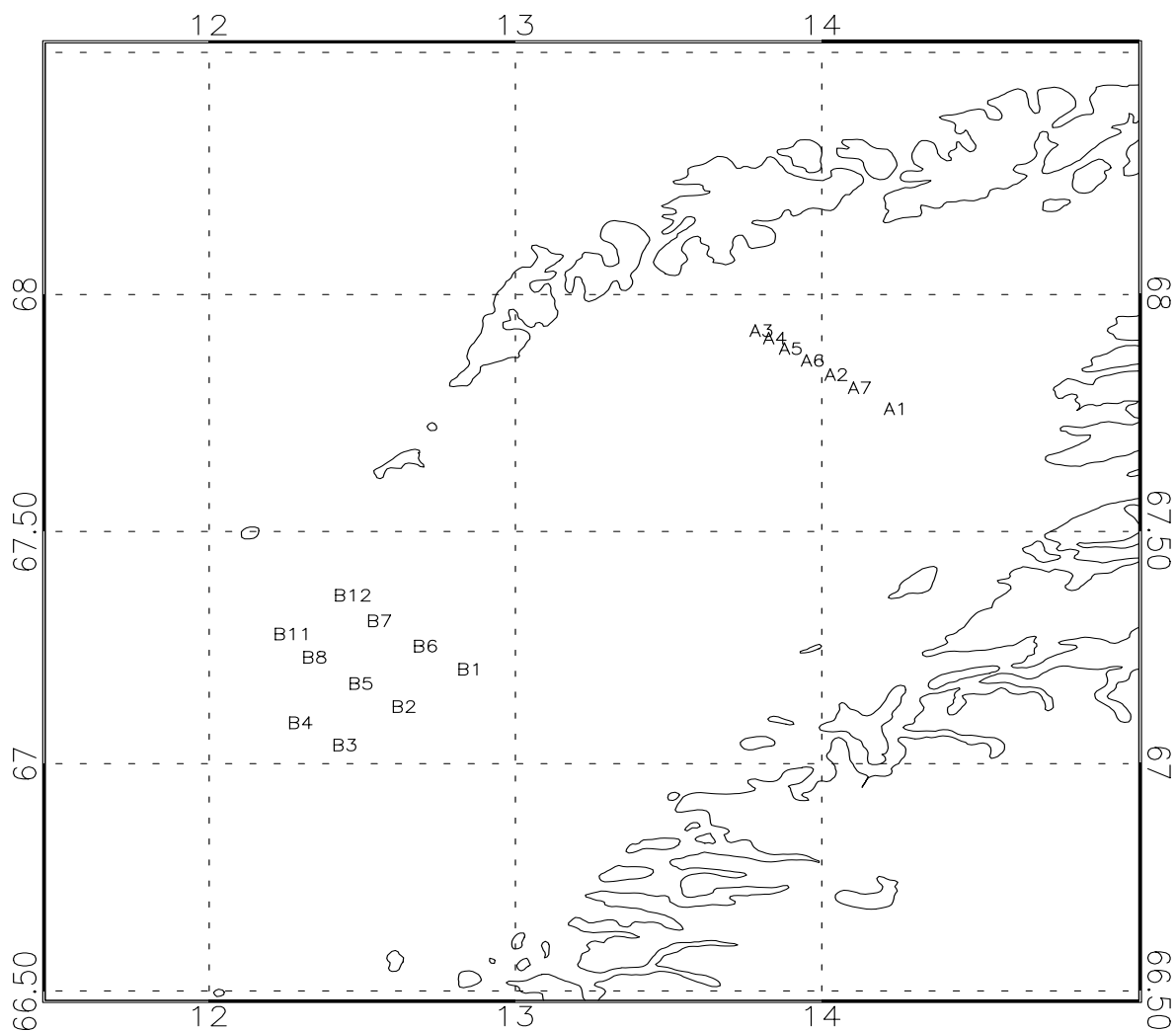


Figure 2.2. Location of grab samples in areas A and B.

Sample no.	Position (Lat, Long)	Sample no.	Position (Lat, Long)
A1	67° 44.80N, 14° 07.53E	B01	67° 11.45N, 12° 43.48E
A2	67° 49.11N, 13° 55.95E	B02	67° 06.60N, 12° 30.60E
A3	67° 54.65N, 13° 41.25E	B03	67° 01.60N, 12° 19.00E
A4	67° 53.70N, 13° 43.90E	B04	67° 04.50N, 12° 10.30E
A5	67° 52.40N, 13° 47.00E	B05	67° 09.60N, 12° 22.15E
A6	67° 50.90N, 13° 51.30E	B06	67° 14.45N, 12° 34.80E
A7	67° 47.45N, 14° 00.52E	B07	67° 17.70N, 12° 25.80E
		B08	67° 13.00N, 12° 13.10E
		B09	Not collected
		B10	Not collected
		B11	67° 16.00N, 12° 05.00E
		B12	67° 21.00N, 12° 16.80E

Table 2.1: Location of grab samples.

3 RESULTS AND DISCUSSION

The grab samples were first roughly classified according to sediment type, and then analysed for grain size distribution [2]. NGU (Geological Survey of Norway) performed the analysis. The method used for the analysis is based on laser diffraction and is described in [3].

A preliminary classification of the grab samples is given in table 3.1. The classification was performed by inspection.

Due to destroyed markings two of the samples (B5 and B8) could not be distinguished with certainty. The samples are denoted by X and Y in the analysis.

Sample no.	Sediment description
A1	Clay
A2	Clay, 1 cobble (10cm)
A3	Silt, sandy
A4	Silt, sandy
A5	Clay
A6	Clay
A7	Clay with gravel (<0.5cm)
B01	Clay
B02	Sand, silty with gravel and 1 cobble (10cm). Shell-fragments
B03	Clay with gravel (<3cm)
B04	Sand, fine. Some gravel (<0.5cm)
B06	Clay
B07	Sand, medium with gravel and cobbles (< 7cm). Shell-fragments
B11	Clay with gravel and cobbles (3-10cm). Shell-fragments
B12	Sand, coarse/medium with gravel/cobbles (<10cm). Shell-fragments
X	Clay
Y	Clay

Table 3.1 Preliminary classification of grab samples.

The results of the grain size analysis [2] are summed up in tables 3.3 and 3.4. Table 3.3 gives the relative content of clay, silt, sand and gravel in the samples, as well as a general description of the sediment type. The relative amount of the different sediment categories within a sample is found from the cumulative grain size distributions, Appendix A and B, by using the sediment categories defined in table 3.2.

Another sediment property of interest is mean grain size. This quantity is extracted from table A.2, and listed in table 3.4.

Sediment category	Grain size (mm)
Clay	< 0.002
Silt	0.002 – 0.060
Sand	0.060 – 2.0
Gravel	> 2.0

Table 3.2 Definition of sediment categories.

Further details of the grain size analysis are given in Appendix A and B. Appendix A contains tables of cumulative grain size distribution and volume statistics. The results are also presented as plots of the cumulative grain size distribution in Appendix B.

The Coulter Counter grain size analyses normally gives a clay content much less than both the Hydrometer and the Sedigraph methods. This is important to have in mind when the different grab samples are classified. We have tried to compensate for this (at least partly) in the classification of the samples on the basis of the Coulter Counter analysis.

Sample no.	Clay %	Silt %	Sand %	Gravel %	Sediment type
A1	15	82	3		Clay, very silty
A2	12	72	16		Clay, very silty, slightly sandy
A3	6	51	33		Silt, sandy, clayey
A4	7	37	51	5	Sand, silty, clayey
A5	10	64	24	2	Clay, very silty, sandy
A6	11	70	17	2	Clay, very silty, slightly sandy
A7	12	73	14	1	Clay, very silty, slightly sandy
B01	12	75	13		Clay, very silty, slightly sandy
B02	5	23	61	11	Sand, silty, clayey
B03	8	34	55	3	Sand, silty, clayey
B04	5	27	65	3	Sand, silty, clayey
B06	13	75	12		Clay, very silty, slightly sandy
B07	5	24	65	6	Sand, silty, clayey
B11	8	36	47	9	Clay, silty, sandy
B12	2	11	76	11	Sand, silty, gravelly
X	8	43	47	2	Clay, silty, sandy
Y	11	70	19		Clay, very silty, slightly sandy

Table 3.3 Results of the grain size analysis: Relative content of clay, silt, sand and gravel.

Sample no.	Grain size (mm) d_{50}	
	Mean	Median
A1	0.016	0.01
A2	0.066	0.016
A3	0.09	0.054
A4	0.39	0.075
A5	0.18	0.026
A6	0.18	0.018
A7	0.10	0.015
B01	0.028	0.019
B02	1.15	0.16
B03	0.3	0.08
B04	0.3	0.13
B06	0.027	0.018
B07	0.59	0.14
B11	0.79	0.077
B12	0.67	0.26
X	0.2	0.059
Y	0.034	0.023

Table 3.4 Results of grain size analysis: Mean grain size.

Figures 3.1 and 3.2 show detailed topographic maps of areas A and B. The sediment types of the grab samples collected in the areas are plotted in the maps. Some correlation of sediment type and terrain is found from the figures, although not consistent. In general the flat parts contain the softer sediments, while the sloping parts contain the harder sediments.

The seabed of the area A, figure 3.1, comprises elongated ridges and depressions that were formed under an ice flowing towards southwest along the main axis of Vestfjorden. The ridges and depressions consist of till material, whereas on top of the till surface a rather thin layer of layered sediments (marine/glaciomarine clays) may be found.

The sea bottom of area B, figure 3.2, consists of till material with elongated forms (ridges and depressions) formed under ice flowing towards southwest. In the central, deepest part of the area a few rather circular depressions may be found. The depressions are formed by ice erosion in the underlying till material or bedrock. In the northern part of the area the outer part of a large moraine ridge crossing Vestfjorden (The Tennholmen ridge) is found. This moraine ridge is up to 100 m high, 60 km long and 20 km wide.

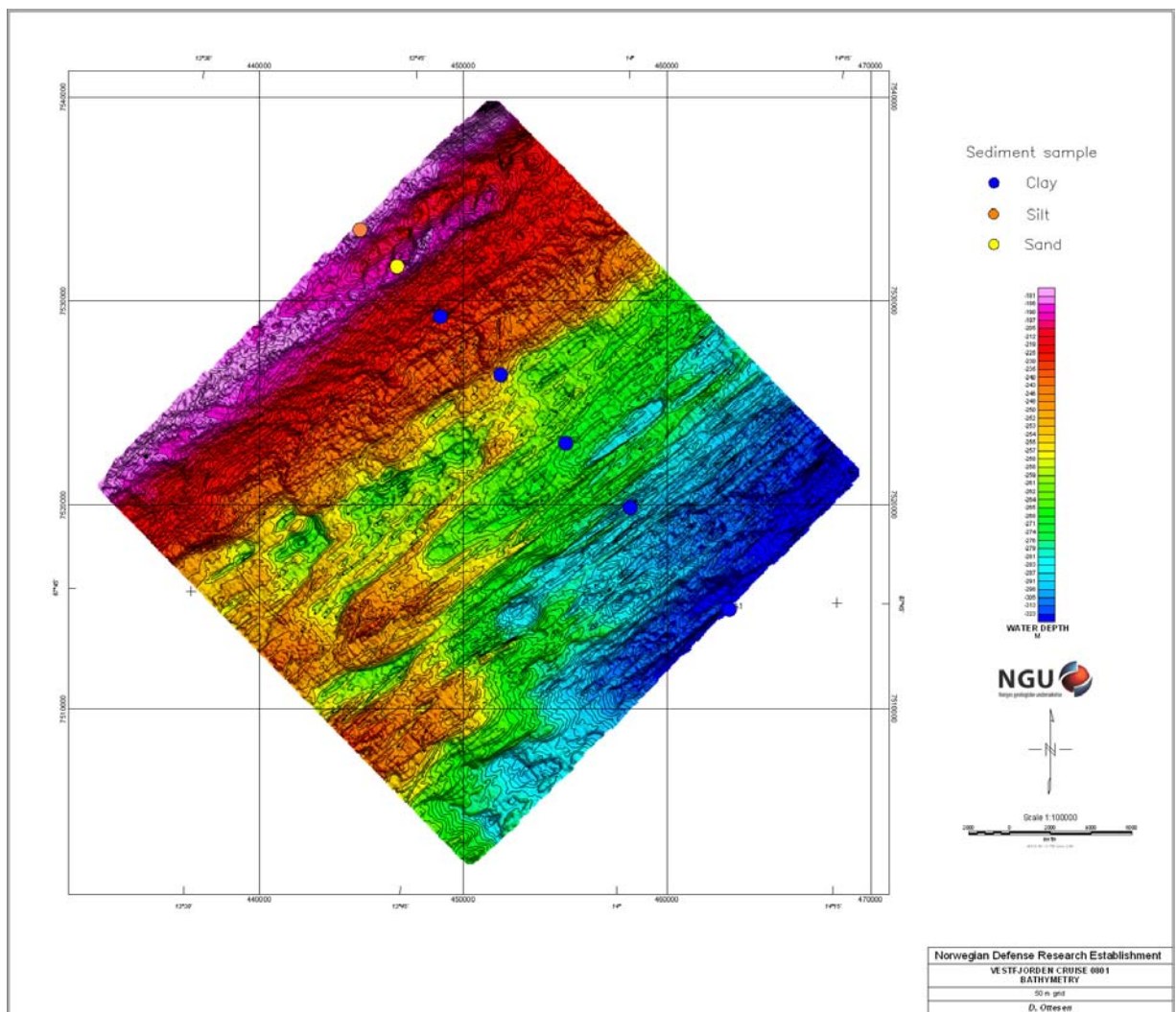


Figure 3.1 Topographic map of area A. Sediment category of grab samples are plotted in the map.

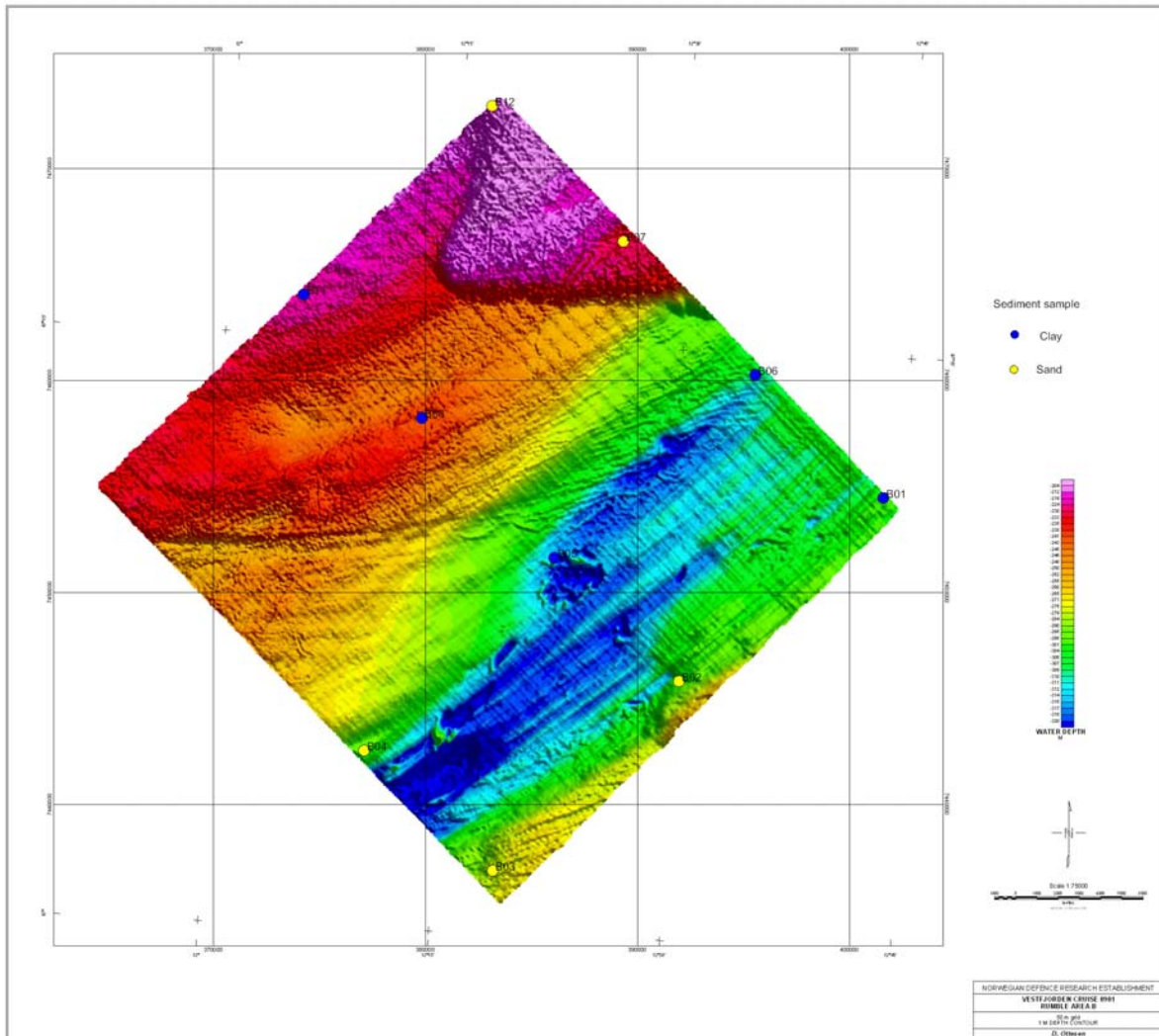


Figure 3.2 Topographic map of area B. Sediment samples, as classified in table 3.3, are plotted in the map.

4 CONCLUSIONS

15 samples from the sea bottom from two areas of Vestfjorden have been collected in June 2001, see figure 2.2. Based on grain size analysis, five samples in area A (inner Vestfjorden) have been classified as clay and two samples as sand (silty, clayey). In area B (outer Vestfjorden) three samples have been classified a clay and six as sand.

APPENDIX

A GRAIN SIZE ANALYSIS

Sample no. Diameter (μm)	A1	A2	A3	A4	A5	A6	A7	B01	B02	B03	B04	B06	B07	B011	B012	x	y
0.375	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.412	0.15	0.11	0.052	0.062	0.097	0.11	0.12	0.12	0.042	0.084	0.045	0.13	0.044	0.089	0.018	0.079	0.11
0.452	0.41	0.32	0.14	0.17	0.27	0.31	0.33	0.35	0.12	0.23	0.13	0.36	0.12	0.25	0.049	0.22	0.32
0.496	0.79	0.61	0.28	0.33	0.52	0.61	0.64	0.67	0.23	0.45	0.24	0.69	0.24	0.48	0.096	0.43	0.61
0.545	1.34	1.03	0.47	0.57	0.88	1.02	1.08	1.13	0.39	0.75	0.41	1.17	0.40	0.80	0.16	0.72	1.03
0.598	2.01	1.55	0.72	0.85	1.32	1.53	1.62	1.70	0.58	1.13	0.63	1.75	0.60	1.19	0.25	1.08	1.55
0.657	2.78	2.15	1.00	1.18	1.83	2.13	2.25	2.36	0.81	1.56	0.87	2.43	0.84	1.65	0.35	1.49	2.15
0.721	3.65	2.82	1.31	1.55	2.40	2.79	2.95	3.09	1.08	2.04	1.16	3.19	1.11	2.15	0.46	1.96	2.82
0.791	4.60	3.56	1.67	1.96	3.03	3.52	3.72	3.89	1.37	2.56	1.47	4.02	1.41	2.70	0.60	2.46	3.56
0.869	5.61	4.35	2.05	2.40	3.70	4.29	4.54	4.74	1.68	3.11	1.81	4.91	1.74	3.28	0.74	3.00	4.34
0.953	6.66	5.17	2.45	2.86	4.40	5.10	5.40	5.63	2.02	3.67	2.17	5.83	2.09	3.87	0.90	3.55	5.16
1.047	7.74	6.01	2.86	3.33	5.12	5.93	6.27	6.53	2.36	4.24	2.55	6.76	2.45	4.46	1.07	4.11	5.99
1.149	8.82	6.86	3.29	3.81	5.84	6.77	7.16	7.44	2.72	4.81	2.94	7.71	2.82	5.05	1.25	4.68	6.83
1.261	9.92	7.71	3.72	4.30	6.57	7.61	8.05	8.35	3.09	5.38	3.33	8.66	3.21	5.64	1.44	5.24	7.68
1.385	11.0	8.57	4.16	4.78	7.30	8.46	8.94	9.25	3.45	5.94	3.74	9.60	3.59	6.22	1.64	5.80	8.53
1.520	12.1	9.43	4.60	5.27	8.03	9.31	9.84	10.1	3.82	6.50	4.14	10.5	3.99	6.79	1.85	6.35	9.37
1.669	13.2	10.3	5.03	5.76	8.76	10.2	10.7	11.0	4.19	7.05	4.55	11.5	4.38	7.35	2.06	6.89	10.2
1.832	14.3	11.2	5.47	6.24	9.50	11.0	11.6	11.9	4.57	7.61	4.96	12.4	4.77	7.91	2.27	7.43	11.1
2.010	15.4	12.0	5.91	6.74	10.2	11.9	12.6	12.8	4.94	8.18	5.37	13.3	5.17	8.49	2.49	7.98	11.9
2.207	16.6	13.0	6.35	7.24	11.0	12.8	13.5	13.7	5.32	8.76	5.79	14.3	5.58	9.08	2.72	8.53	12.8
2.423	17.8	13.9	6.80	7.76	11.8	13.7	14.6	14.7	5.70	9.37	6.21	15.3	6.00	9.68	2.94	9.10	13.7
2.660	19.1	14.9	7.26	8.30	12.6	14.7	15.6	15.6	6.10	10.0	6.65	16.3	6.42	10.3	3.17	9.69	14.6
2.920	20.5	16.0	7.72	8.86	13.5	15.8	16.7	16.6	6.51	10.7	7.10	17.4	6.86	11.0	3.41	10.3	15.6
3.206	22.0	17.2	8.20	9.44	14.4	16.9	17.9	17.7	6.93	11.4	7.56	18.6	7.32	11.7	3.65	10.9	16.6
3.519	23.6	18.4	8.69	10.0	15.4	18.1	19.2	18.8	7.37	12.1	8.04	19.8	7.80	12.4	3.89	11.6	17.7
3.862	25.3	19.7	9.19	10.7	16.4	19.3	20.6	20.0	7.83	12.9	8.55	21.0	8.30	13.2	4.13	12.3	18.9

4.241	27.1	21.1	9.70	11.3	17.4	20.7	22.1	21.3	8.31	13.7	9.07	22.4	8.81	14.0	4.38	13.1	20.1
4.656	29.0	22.6	10.2	12.0	18.5	22.1	23.6	22.6	8.80	14.6	9.61	23.7	9.35	14.8	4.62	13.8	21.3
5.111	31.1	24.1	10.8	12.7	19.7	23.5	25.2	24.0	9.32	15.5	10.2	25.2	9.90	15.7	4.88	14.6	22.6
5.611	33.3	25.8	11.3	13.5	20.9	25.1	27.0	25.4	9.84	16.4	10.7	26.7	10.5	16.5	5.13	15.5	23.9
6.158	35.5	27.5	11.9	14.2	22.1	26.7	28.8	26.9	10.4	17.3	11.3	28.3	11.0	17.4	5.38	16.3	25.3
6.761	37.9	29.3	12.5	14.9	23.4	28.4	30.6	28.4	10.9	18.1	11.9	29.9	11.6	18.3	5.63	17.2	26.7
7.421	40.4	31.2	13.0	15.7	24.7	30.1	32.6	29.9	11.5	19.0	12.5	31.5	12.2	19.1	5.88	18.0	28.1
8.147	42.9	33.1	13.6	16.4	26.1	31.9	34.5	31.5	12.0	19.9	13.1	33.2	12.8	20.0	6.13	18.9	29.5
8.944	45.5	35.1	14.2	17.1	27.4	33.7	36.6	33.1	12.5	20.7	13.7	34.9	13.4	20.8	6.37	19.8	30.9
9.819	48.2	37.2	14.8	17.9	28.8	35.6	38.7	34.8	13.1	21.6	14.2	36.6	14.0	21.7	6.62	20.7	32.4
10.78	51.0	39.3	15.5	18.6	30.3	37.6	40.9	36.5	13.6	22.4	14.8	38.4	14.5	22.5	6.86	21.6	33.9
11.83	53.9	41.5	16.1	19.3	31.8	39.6	43.1	38.2	14.1	23.2	15.4	40.3	15.1	23.3	7.10	22.5	35.4
12.99	56.8	43.8	16.8	20.1	33.4	41.7	45.4	40.1	14.7	24.0	16.0	42.2	15.7	24.2	7.34	23.5	37.0
14.26	59.8	46.3	17.6	20.9	35.1	43.9	47.9	42.0	15.3	24.8	16.7	44.3	16.3	25.1	7.59	24.5	38.6
15.65	63.0	48.8	18.5	21.8	37.0	46.3	50.4	44.1	15.9	25.7	17.3	46.5	17.0	26.0	7.84	25.6	40.4
17.18	66.2	51.6	19.4	22.8	39.0	48.8	53.1	46.4	16.6	26.7	18.1	49.0	17.7	27.0	8.10	26.8	42.4
18.86	69.6	54.4	20.5	23.8	41.2	51.4	55.9	48.9	17.3	27.7	18.9	51.6	18.4	28.1	8.38	28.0	44.5
20.70	72.9	57.3	21.7	24.9	43.5	54.1	58.7	51.6	18.0	28.7	19.7	54.3	19.2	29.2	8.67	29.4	46.8
22.73	76.2	60.2	23.0	26.1	45.9	56.9	61.6	54.3	18.7	29.7	20.6	57.2	19.9	30.4	8.96	30.8	49.2
24.95	79.3	63.1	24.5	27.3	48.5	59.7	64.4	57.2	19.5	30.7	21.5	60.1	20.7	31.5	9.26	32.3	51.7
27.38	82.2	65.9	26.2	28.6	51.1	62.4	67.1	60.1	20.3	31.7	22.4	63.1	21.5	32.6	9.56	33.8	54.3
30.07	84.9	68.6	28.2	30.0	53.7	65.0	69.7	63.1	21.0	32.7	23.3	66.1	22.2	33.7	9.86	35.3	57.0
33.00	87.2	71.2	30.4	31.5	56.5	67.5	72.2	66.1	21.8	33.8	24.3	69.1	23.0	34.9	10.2	37.0	59.9
36.24	89.4	73.6	33.1	33.1	59.2	69.9	74.5	69.2	22.7	34.8	25.4	72.2	23.8	36.0	10.5	38.6	62.8
39.77	91.2	75.8	36.2	34.8	62.0	72.1	76.7	72.3	23.5	35.9	26.5	75.2	24.6	37.3	10.8	40.4	65.8
43.66	92.8	77.8	39.8	36.6	64.7	74.3	78.7	75.4	24.4	37.1	27.6	78.2	25.4	38.6	11.2	42.4	69.0
47.93	94.3	79.8	44.0	38.6	67.4	76.3	80.6	78.6	25.4	38.4	28.9	81.2	26.3	40.1	11.6	44.5	72.4
52.63	95.7	81.6	48.7	40.8	70.2	78.2	82.5	81.9	26.4	39.8	30.3	84.1	27.3	41.7	12.1	46.9	75.8
57.77	96.9	83.4	53.8	43.1	72.8	80.0	84.3	85.1	27.6	41.4	31.8	87.0	28.4	43.6	12.6	49.5	79.4
63.41	98.0	85.1	59.2	45.6	75.4	81.7	86.1	88.1	28.9	43.3	33.5	89.6	29.7	45.6	13.3	52.4	82.9
69.62	98.9	86.7	64.5	48.1	77.8	83.3	87.6	90.8	30.3	45.5	35.2	92.0	31.2	47.7	14.1	55.3	86.2
76.43	99.5	88.0	69.5	50.7	79.9	84.7	89.0	93.1	31.8	47.9	37.1	93.9	32.9	50.0	15.1	58.3	89.2
83.90	99.9	89.2	73.8	53.2	81.6	85.8	90.1	94.8	33.4	50.6	39.0	95.4	34.8	52.2	16.1	61.2	91.6
92.09	100.0	90.2	77.5	55.5	83.0	86.7	90.9	96.1	35.1	53.5	41.0	96.4	36.9	54.4	17.4	63.9	93.5
101.1	100.0	91.0	80.5	57.8	84.2	87.5	91.6	96.9	36.9	56.5	43.0	97.2	39.3	56.6	18.9	66.4	95.0

111.0	100	91.8	82.9	60.0	85.3	88.2	92.2	97.6	38.9	59.7	45.3	97.8	41.9	58.7	20.6	68.8	96.1
121.8	100	92.6	84.9	62.1	86.3	89.0	92.8	98.1	41.1	63.0	47.7	98.4	44.7	60.8	22.6	71.2	97.1
133.7	100	93.5	86.6	64.2	87.3	89.8	93.5	98.6	43.5	66.2	50.4	98.9	47.7	63.0	24.9	73.4	97.9
146.8	100	94.4	88.2	66.2	88.2	90.7	94.2	99.1	46.0	69.3	53.3	99.3	50.8	65.1	27.6	75.7	98.7
161.2	100	95.2	89.6	68.2	89.2	91.5	94.8	99.6	48.7	72.1	56.4	99.7	53.9	67.1	30.6	77.9	99.3
176.8	100	95.8	90.8	70.0	89.9	92.1	95.3	99.8	51.4	74.7	59.5	99.9	56.9	69.1	33.9	79.9	99.7
194.2	100	96.3	91.8	71.6	90.5	92.6	95.7	100.0	54.1	77.0	62.6	100.0	59.8	70.9	37.5	81.8	99.9
213.2	100	96.6	92.6	73.2	91.0	92.9	95.9	100.0	56.7	79.0	65.5	100.0	62.7	72.6	41.4	83.4	100.0
234.1	100	96.8	93.2	74.6	91.4	93.2	96.1	100.0	59.3	80.7	68.2	100	65.4	74.2	45.5	84.9	100.0
256.8	100	97.0	93.8	75.9	91.6	93.4	96.3	100	61.7	82.3	70.7	100	67.9	75.6	49.5	86.2	100
282.1	100	97.1	94.3	77.2	91.9	93.6	96.4	100	64.0	83.8	73.0	100	70.3	77.0	53.5	87.4	100
309.6	100	97.2	94.8	78.4	92.1	93.9	96.6	100	66.1	85.0	75.1	100	72.5	78.3	57.4	88.5	100
339.8	100	97.3	95.4	79.7	92.3	94.1	96.7	100	68.0	86.2	77.1	100	74.6	79.5	61.0	89.6	100
373.1	100	97.5	95.9	81.0	92.6	94.4	96.9	100	69.9	87.3	79.1	100	76.6	80.6	64.3	90.6	100
409.6	100	97.6	96.5	82.2	92.9	94.7	97.1	100	71.6	88.3	81.0	100	78.5	81.7	67.4	91.6	100
449.7	100	97.7	97.0	83.5	93.2	95.0	97.3	100	73.4	89.3	82.8	100	80.3	82.7	70.3	92.6	100
493.6	100	97.9	97.4	84.8	93.6	95.3	97.5	100	75.2	90.3	84.6	100	82.0	83.7	72.8	93.6	100
541.9	100	98.1	97.8	86.0	93.9	95.6	97.7	100	76.9	91.3	86.3	100	83.7	84.5	75.2	94.6	100
594.9	100	98.3	98.0	87.1	94.3	95.9	97.8	100	78.7	92.1	87.8	100	85.2	85.2	77.3	95.3	100
653.0	100	98.5	98.3	88.1	94.7	96.1	97.9	100	80.3	92.9	89.2	100	86.6	85.8	79.1	95.9	100
716.9	100	98.6	98.5	88.9	95.1	96.3	97.9	100	81.7	93.5	90.5	100	87.8	86.2	80.6	96.3	100
786.9	100	98.7	98.7	89.7	95.5	96.4	98.0	100	82.9	93.9	91.6	100	88.8	86.6	81.9	96.5	100
863.9	100	98.9	98.9	90.3	95.8	96.5	98.0	100	83.9	94.3	92.6	100	89.6	87.0	82.9	96.6	100
948.2	100	99.0	99.1	90.8	96.2	96.5	98.1	100	84.6	94.6	93.6	100	90.1	87.4	83.7	96.7	100
1000	100	99.1	99.3	91.3	96.5	96.5	98.1	100	85.2	94.9	94.4	100	90.5	87.9	84.3	96.8	100
2000	100	99.4	99.6	95.0	97.6	97.2	98.7	100	88.9	96.6	96.8	100	93.6	90.5	89.2	97.8	100
4000		99.8	100	97.6	98.9	98.1	99.0		91.9	98.3	99.1		96.5	93.4	97.5	99.1	
8000		100		100	100	100	100		93.3	99.7	100		98.3	96.5	100	100	
16000									100	100			100	100			

Table A.1. Cumulative grain size distribution

**Statistics
Preferences**

	A1	A2	A3	A4	A5	A6	A7	B01	B02	B03	B04	B06	B07	B011	B012	X	Y
From	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375	0.375
To	2000	8000	4000	8000	8000	8000	8000	2000	16000	16000	8000	2000	16000	16000	8000	8000	2000
Volume	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Mean:	15.59	66.50	95.47	387.3	177.5	184.6	106.9	28.82	1146	301.9	327.7	26.92	588.5	794.6	668.3	202.1	33.78
Median:	10.43	16.30	53.94	74.61	26.39	17.97	15.43	19.60	168.8	82.34	131.8	17.85	143.5	76.54	259.7	58.69	23.43
D(3,2):	3.782	4.786	9.830	8.944	5.759	4.915	4.614	4.704	12.39	7.478	11.32	4.519	11.75	7.284	24.21	7.571	5.058
Mean/Median Ratio:	1.495	4.079	1.770	5.191	6.725	10.28	6.925	1.470	6.790	3.667	2.486	1.508	4.100	10.38	2.573	3.444	1.442
Mode:	19.76	21.69	60.52	1414	37.96	21.69	21.69	50.23	11314	116.3	168.8	34.58	153.8	11314	2828	72.95	55.14
95% Conf. Limits:	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
95% Conf. Limits:	46.65	711.1	515.2	2295	1530	1786	1254	87.93	6736	2192	1686	83.43	3848	5239	2837	1439	101.3
S.D.:	15.84	328.9	214.2	973.3	690.2	816.8	585.4	30.16	2852	964.5	693.1	28.83	1663	2268	1107	631.3	34.43
Variance:	251.1	108.1e3	45862	947.2e3	476.4e3	667.2e3	342.7e3	909.7	8.134e6	930.2e3	480.4e3	831.3	2.766e6	5.142e6	1.224e6	398.5e3	1185
C.V.:	101.6	494.5	224.3	251.3	388.9	442.4	547.9	104.7	248.8	319.4	211.5	107.1	282.6	285.4	165.6	312.3	101.9
Skewness:	1.630	12.82	8.779	4.211	6.477	6.011	8.616	1.760	3.078	6.916	5.109	1.832	5.107	3.781	2.900	6.761	1.522
Kurtosis:	2.690	191.9	98.67	18.56	45.10	36.11	76.41	4.074	7.988	58.90	31.47	4.332	27.91	13.83	8.783	50.71	2.668
d10:	1.270	1.619	4.474	3.494	1.952	1.642	1.547	1.498	5.774	2.656	4.972	1.443	5.200	2.541	31.44	2.792	1.632
d50:	10.43	16.30	53.94	74.61	26.39	17.97	15.43	19.60	168.8	82.34	131.8	17.85	143.5	76.54	259.7	58.69	23.43
d90:	37.46	90.78	166.9	828.6	178.7	136.1	83.23	67.76	2716	480.5	692.4	64.41	932.0	1813	2203	353.2	79.00
Specific Surf. Area % <	15864	12536	6104	6708	10418	12208	13004	12756	4843	8023	5301	13279	5104	8237	2478	7925	11863
10	1.270	1.619	4.474	3.494	1.952	1.642	1.547	1.498	5.774	2.656	4.972	1.443	5.200	2.541	31.44	2.792	1.632
25	3.806	5.378	25.63	20.86	7.575	5.578	5.045	5.469	46.36	14.55	35.10	5.048	41.88	14.15	134.1	14.90	6.039
60	14.34	22.58	64.33	111.1	37.26	25.23	21.60	27.28	241.1	111.9	179.6	24.86	195.2	117.6	331.4	80.83	33.16
75	21.99	38.54	86.54	241.2	62.54	45.25	37.07	43.12	489.6	179.2	308.0	39.55	346.0	246.8	537.9	142.7	51.49
90	37.46	90.78	166.9	828.6	178.7	136.1	83.23	67.76	2716	480.5	692.4	64.41	932.0	1813	2203	353.2	79.00

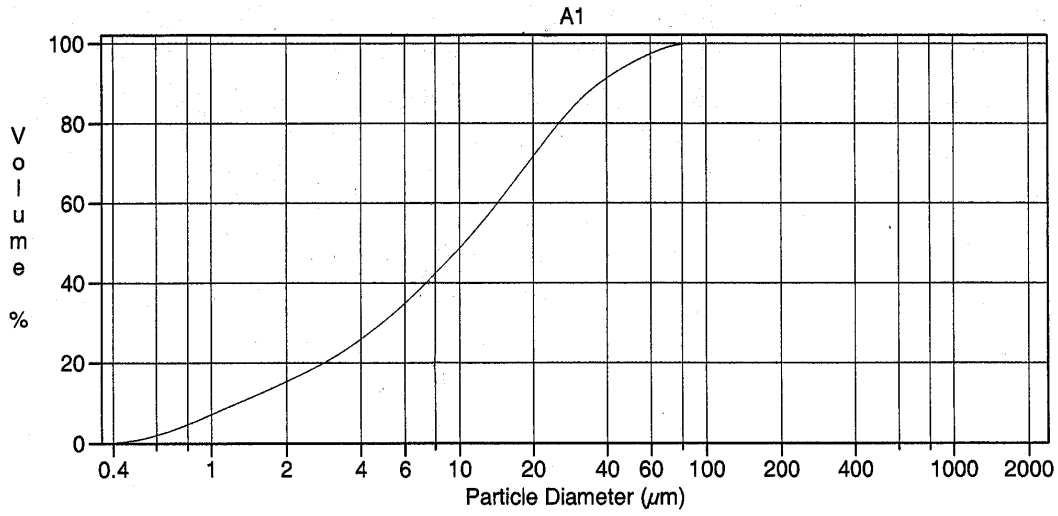
Table A.2. Volume statistics

Interpolation Preferences

	A1	A2	A3	A4	A5	A6	A7	B01	B02	B03	B04	B06	B07	B011	B012	X	Y
Particle Diameter μm	Volume %	Volume %	Volume %	Volume %	Volume %	Volume %	Volume %	Volume %	Volume %	Volume %	Volume %	Volume %	Volume %	Volume %	Volume %	Volume %	Volume %
1.000	8.17	6.41	3.23	3.61	5.44	6.33	6.69	6.68	2.73	4.19	2.99	7.00	2.88	4.29	1.49	4.11	6.29
2.000	15.2	11.7	4.76	5.85	9.21	11.3	12.3	10.9	4.27	7.11	4.69	11.6	4.61	7.00	2.33	6.49	10.4
5.000	18.2	13.8	4.31	5.43	9.70	12.8	14.3	11.4	3.98	6.45	4.32	12.1	4.30	6.38	1.85	6.40	10.4
10.00	12.7	10.1	3.11	3.41	6.99	9.17	10.1	8.06	2.44	3.58	2.67	8.53	2.63	3.74	1.06	4.24	6.91
15.00	10.1	8.54	3.14	3.09	6.50	7.95	8.44	7.42	2.10	3.00	2.36	7.78	2.20	3.23	0.84	3.80	6.35
20.00	7.72	6.99	3.35	2.85	5.91	6.64	6.81	6.69	1.81	2.45	2.10	6.92	1.84	2.70	0.71	3.42	5.85
25.00	11.9	12.7	11.8	7.55	13.6	12.5	12.3	15.2	4.03	5.25	5.03	15.2	3.88	5.85	1.57	8.25	14.2
40.00	3.60	4.68	9.67	4.67	6.52	4.82	4.69	7.61	2.28	3.00	2.98	7.12	2.10	3.44	0.97	5.02	7.88
50.00	2.44	3.50	9.93	4.52	5.21	3.59	3.55	6.20	2.29	3.18	2.97	5.54	2.19	3.55	1.11	5.09	6.89
60.00	1.61	2.68	8.83	4.19	4.04	2.70	2.70	4.68	2.28	3.43	2.88	4.05	2.37	3.51	1.26	4.85	5.60
70.00	0.46	1.01	3.63	1.87	1.53	1.00	1.00	1.66	1.10	1.78	1.36	1.42	1.25	1.64	0.69	2.18	2.15
75.00	0.29	0.84	3.12	1.72	1.27	0.82	0.81	1.31	1.08	1.79	1.30	1.11	1.27	1.54	0.72	1.99	1.78
80.00	0.25	1.31	5.00	3.07	1.98	1.27	1.20	1.83	2.09	3.55	2.46	1.56	2.60	2.81	1.51	3.51	2.69
90.00	0.047	10.1	23.5	45.1	17.3	13.5	9.27	4.26	65.3	47.3	59.5	3.83	63.6	46.2	82.9	36.8	6.98

Table A.3. Cumulative grain size, Interpolation results

B CUMULATIVE GRAIN SIZE DISTRIBUTION



Volume Statistics (Arithmetic)

a1#.\$02

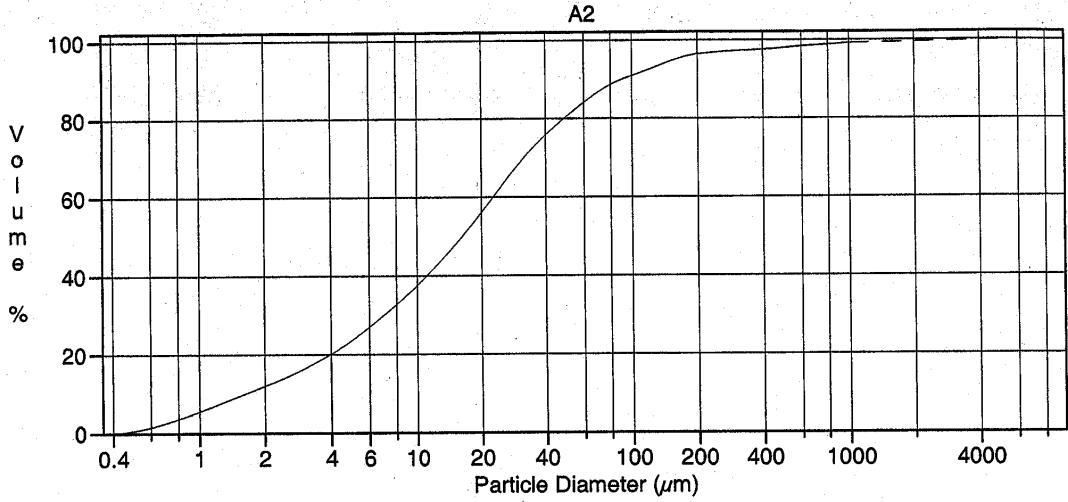
Calculations from 0.375 µm to 2000 µm

Volume	100.0%			
Mean:	15.59 µm	95% Conf. Limits:	0-46.65 µm	
Median:	10.43 µm	S.D.:	15.84 µm	
D(3,2):	3.782 µm	Variance:	251.1 µm ²	
Mean/Median Ratio:	1.495	C.V.:	102%	
Mode:	19.76 µm	Skewness:	1.630 Right skewed	
d ₁₀ :	1.270 µm	Kurtosis:	2.690 Leptokurtic	
d ₅₀ :	10.43 µm			
d ₉₀ :	37.46 µm			
Specific Surf. Area	15864 cm ² /ml			

% <	10	25	60	75	90
Size µm	1.270	3.806	14.34	21.99	37.46

a1#.\$02

Particle Diameter µm	Volume %
1.000	8.17
2.000	15.2
5.000	18.2
10.00	12.7
15.00	10.1
20.00	7.72
25.00	11.9
40.00	3.60
50.00	2.44
60.00	1.61
70.00	0.46
75.00	0.29
80.00	0.25
90.00	0.047



Volume Statistics (Arithmetic)

a2.\$0a

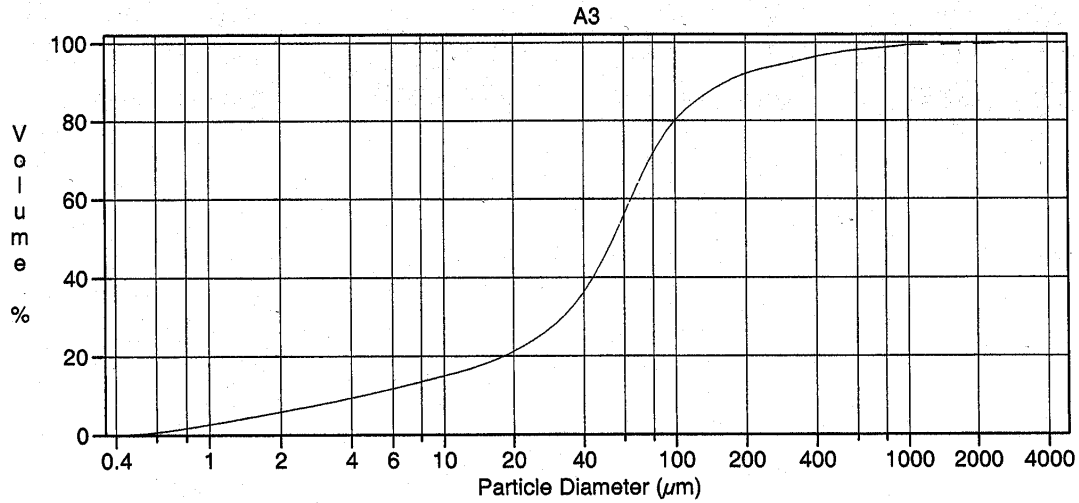
Calculations from 0.375 µm to 8000 µm

Volume	100.0%	95% Conf. Limits:	0-711.1 µm
Mean:	66.50 µm	S.D.:	328.9 µm
Median:	16.30 µm	Variance:	108149 µm ²
D(3,2):	4.786 µm	C.V.:	495%
Mean/Median Ratio:	4.079	Skewness:	12.82 Right skewed
Mode:	21.69 µm	Kurtosis:	191.9 Leptokurtic
d ₁₀ :	1.619 µm		
d ₅₀ :	16.30 µm		
d ₉₀ :	90.78 µm		
Specific Surf. Area	12536 cm ² /ml		

% <	10	25	60	75	90
Size µm	1.619	5.378	22.58	38.54	90.78

a2.\$0a

Particle Diameter µm	Volume %
1.000	6.41
2.000	11.7
5.000	13.8
10.00	10.1
15.00	8.54
20.00	6.99
25.00	12.7
40.00	4.68
50.00	3.50
60.00	2.68
70.00	1.01
75.00	0.84
80.00	1.31
90.00	10.1



Volume Statistics (Arithmetic)

a3.\$0a

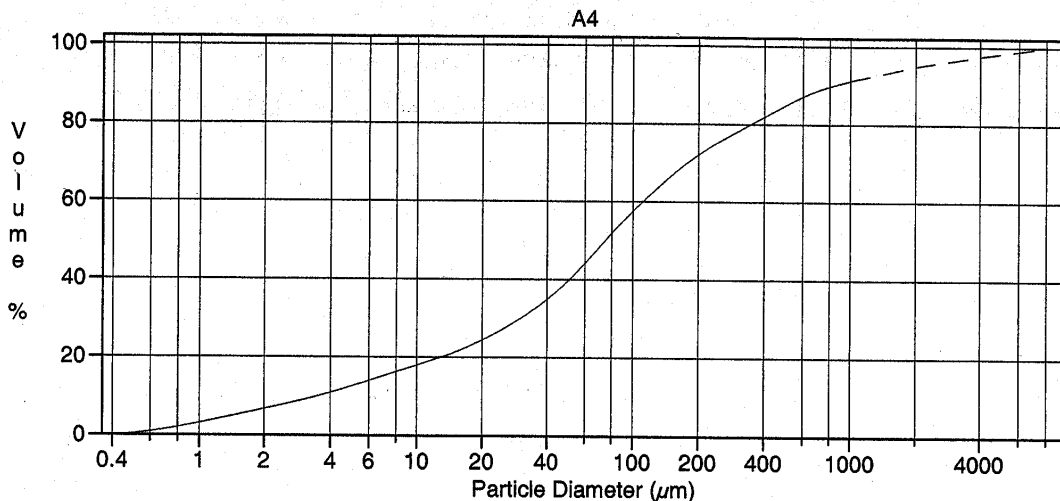
Calculations from 0.375 µm to 4000 µm

Volume	100.0%			
Mean:	95.47 µm	95% Conf. Limits:	0-515.2 µm	
Median:	53.94 µm	S.D.:	214.2 µm	
D(3,2):	9.830 µm	Variance:	45862 µm ²	
Mean/Median Ratio:	1.770	C.V.:	224%	
Mode:	60.52 µm	Skewness:	8.779 Right skewed	
d ₁₀ :	4.474 µm	Kurtosis:	98.67 Leptokurtic	
d ₅₀ :	53.94 µm			
d ₉₀ :	166.9 µm			
Specific Surf. Area	6104 cm ² /ml			

% <	10	25	60	75	90
Size µm	4.474	25.63	64.33	86.54	166.9

a3.\$0a

Particle Diameter µm	Volume %
1.000	3.23
2.000	4.76
5.000	4.31
10.00	3.11
15.00	3.14
20.00	3.35
25.00	11.8
40.00	9.67
50.00	9.93
60.00	8.83
70.00	3.63
75.00	3.12
80.00	5.00
90.00	23.5



Volume Statistics (Arithmetic)

a4#.\$0a

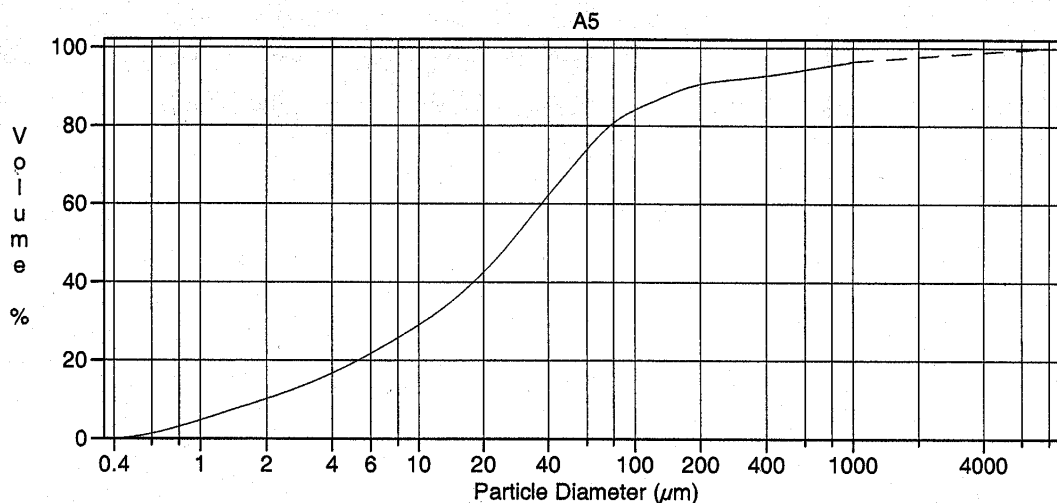
Calculations from 0.375 µm to 8000 µm

Volume	100.0%		
Mean:	387.3 µm	95% Conf. Limits:	0-2295 µm
Median:	74.61 µm	S.D.:	973.3 µm
D(3,2):	8.944 µm	Variance:	947246 µm ²
Mean/Median Ratio:	5.191	C.V.:	251%
Mode:	1414 µm	Skewness:	4.211 Right skewed
d ₁₀ :	3.494 µm	Kurtosis:	18.56 Leptokurtic
d ₅₀ :	74.61 µm		
d ₉₀ :	828.6 µm		
Specific Surf. Area	6708 cm ² /ml		

% <	10	25	60	75	90
Size µm	3.494	20.86	111.1	241.2	828.6

a4#.\$0a

Particle Diameter µm	Volume %
1.000	3.61
2.000	5.85
5.000	5.43
10.00	3.41
15.00	3.09
20.00	2.85
25.00	7.55
40.00	4.67
50.00	4.52
60.00	4.19
70.00	1.87
75.00	1.72
80.00	3.07
90.00	45.1



Volume Statistics (Arithmetic)

a5.\$0a

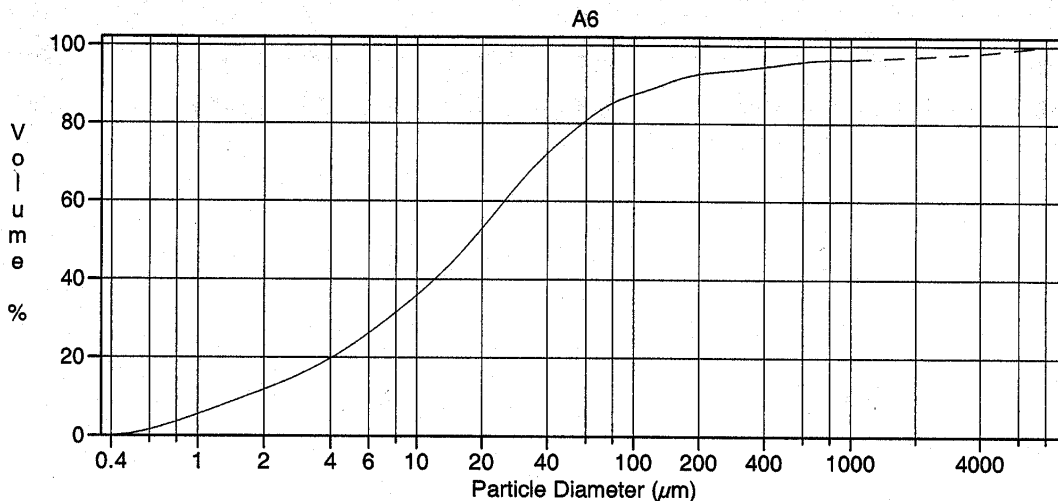
Calculations from 0.375 μm to 8000 μm

Volume	100.0%			
Mean:	177.5 μm	95% Conf. Limits:	0-1530 μm	
Median:	26.39 μm	S.D.:	690.2 μm	
D(3,2):	5.759 μm	Variance:	476357 μm ²	
Mean/Median Ratio:	6.725	C.V.:	389%	
Mode:	37.96 μm	Skewness:	6.477 Right skewed	
d ₁₀ :	1.952 μm	Kurtosis:	45.10 Leptokurtic	
d ₅₀ :	26.39 μm			
d ₉₀ :	178.7 μm			
Specific Surf. Area	10418 cm ² /ml			

% <	10	25	60	75	90
Size μm	1.952	7.575	37.26	62.54	178.7

a5.\$0a

Particle Diameter μm	Volume %
1.000	5.44
2.000	9.21
5.000	9.70
10.00	6.99
15.00	6.50
20.00	5.91
25.00	13.6
40.00	6.52
50.00	5.21
60.00	4.04
70.00	1.53
75.00	1.27
80.00	1.98
90.00	17.3



Volume Statistics (Arithmetic)

a6.\$0a

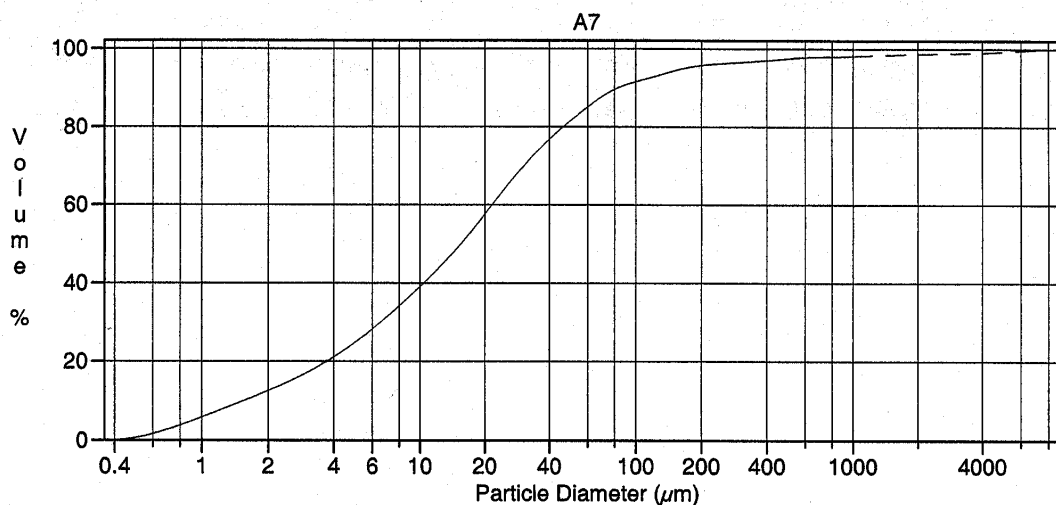
Calculations from 0.375 μm to 8000 μm

Volume	100.0%			
Mean:	184.6 μm	95% Conf. Limits:	0-1786 μm	
Median:	17.97 μm	S.D.:	816.8 μm	
D(3,2):	4.915 μm	Variance:	667191 μm ²	
Mean/Median Ratio:	10.28	C.V.:	442%	
Mode:	21.69 μm	Skewness:	6.011 Right skewed	
d ₁₀ :	1.642 μm	Kurtosis:	36.11 Leptokurtic	
d ₅₀ :	17.97 μm			
d ₉₀ :	136.1 μm			
Specific Surf. Area	12208 cm ² /ml			

% <	10	25	60	75	90
Size μm	1.642	5.578	25.23	45.25	136.1

a6.\$0a

Particle Diameter μm	Volume %
1.000	6.33
2.000	11.3
5.000	12.8
10.00	9.17
15.00	7.95
20.00	6.64
25.00	12.5
40.00	4.82
50.00	3.59
60.00	2.70
70.00	1.00
75.00	0.82
80.00	1.27
90.00	13.5



Volume Statistics (Arithmetic)

a7.\$0a

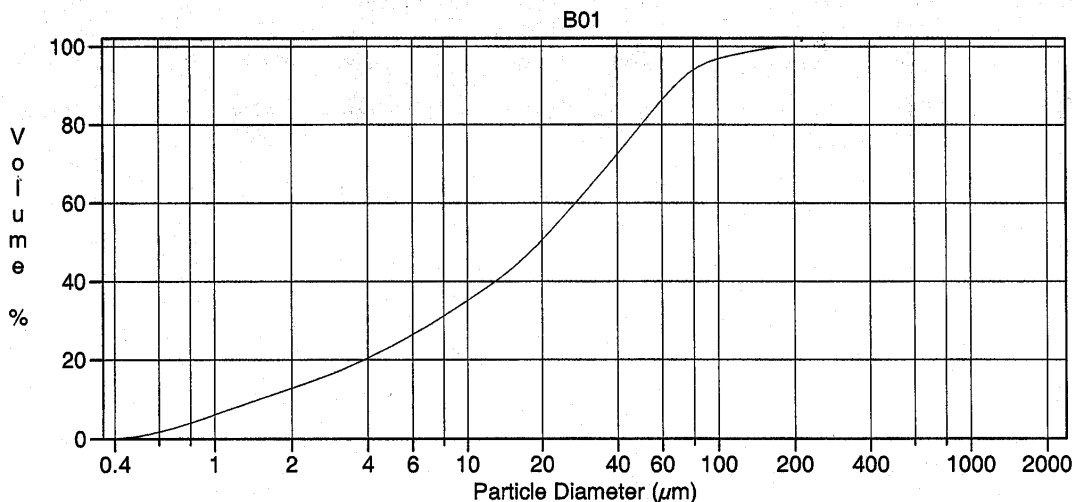
Calculations from 0.375 μm to 8000 μm

Volume	100.0%			
Mean:	106.9 μm	95% Conf. Limits:	0-1254 μm	
Median:	15.43 μm	S.D.:	585.4 μm	
D(3,2):	4.614 μm	Variance:	342731 μm^2	
Mean/Median Ratio:	6.925	C.V.:	548%	
Mode:	21.69 μm	Skewness:	8.616 Right skewed	
d ₁₀ :	1.547 μm	Kurtosis:	76.41 Leptokurtic	
d ₅₀ :	15.43 μm			
d ₉₀ :	83.23 μm			
Specific Surf. Area	13004 cm^2/ml			

% <	10	25	60	75	90
Size μm	1.547	5.045	21.60	37.07	83.23

a7.\$0a

Particle Diameter μm	Volume %
1.000	6.69
2.000	12.3
5.000	14.3
10.00	10.1
15.00	8.44
20.00	6.81
25.00	12.3
40.00	4.69
50.00	3.55
60.00	2.70
70.00	1.00
75.00	0.81
80.00	1.20
90.00	9.27



Volume Statistics (Arithmetic)

b01.\$02

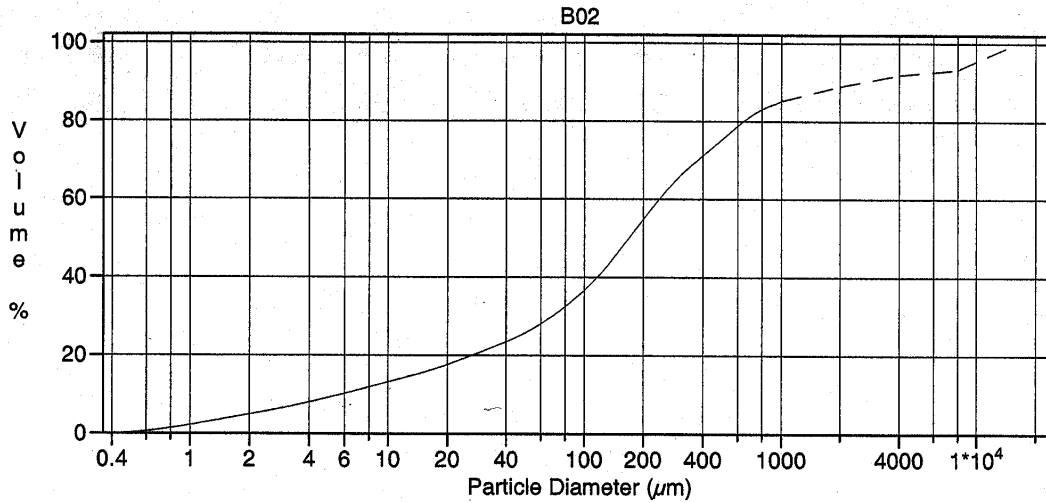
Calculations from 0.375 μm to 2000 μm

Volume	100.0%			
Mean:	28.82 μm	95% Conf. Limits:	0-87.93 μm	
Median:	19.60 μm	S.D.:	30.16 μm	
D(3,2):	4.704 μm	Variance:	909.7 μm^2	
Mean/Median Ratio:	1.470	C.V.:	105%	
Mode:	50.23 μm	Skewness:	1.760 Right skewed	
d ₁₀ :	1.498 μm	Kurtosis:	4.074 Leptokurtic	
d ₅₀ :	19.60 μm			
d ₉₀ :	67.76 μm			
Specific Surf. Area	12756 cm^2/ml			

% <	10	25	60	75	90
Size μm	1.498	5.469	27.28	43.12	67.76

b01.\$02

Particle Diameter μm	Volume %
1.000	6.68
2.000	10.9
5.000	11.4
10.00	8.06
15.00	7.42
20.00	6.69
25.00	15.2
40.00	7.61
50.00	6.20
60.00	4.68
70.00	1.66
75.00	1.31
80.00	1.83
90.00	4.26



Volume Statistics (Arithmetic)

b02#.\$0a

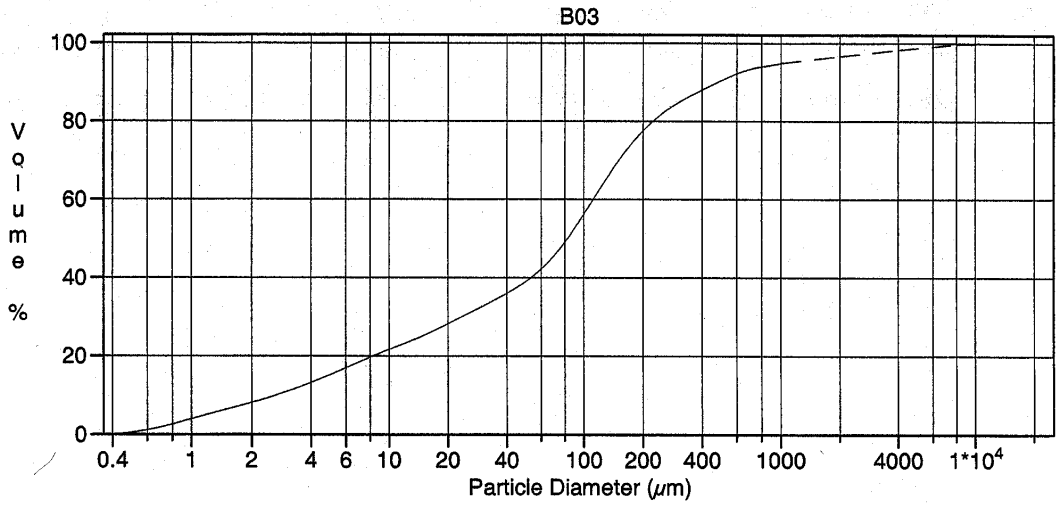
Calculations from 0.375 μm to 16000 μm

Volume	100.0%			
Mean:	1146 μm	95% Conf. Limits:	0-6736 μm	
Median:	168.8 μm	S.D.:	2852 μm	
D(3,2):	12.39 μm	Variance:	8134010 μm^2	
Mean/Median Ratio:	6.790	C.V.:	249%	
Mode:	11314 μm	Skewness:	3.078 Right skewed	
d ₁₀ :	5.774 μm	Kurtosis:	7.988 Leptokurtic	
d ₅₀ :	168.8 μm			
d ₉₀ :	2716 μm			
Specific Surf. Area	4843 cm^2/ml			

% <	10	25	60	75	90
Size μm	5.774	46.36	241.1	489.6	2716

b02#.\$0a

Particle Diameter μm	Volume %
1.000	2.73
2.000	4.27
5.000	3.98
10.00	2.44
15.00	2.10
20.00	1.81
25.00	4.03
40.00	2.28
50.00	2.29
60.00	2.28
70.00	1.10
75.00	1.08
80.00	2.09
90.00	65.3



Volume Statistics (Arithmetic)

b03.\$0a

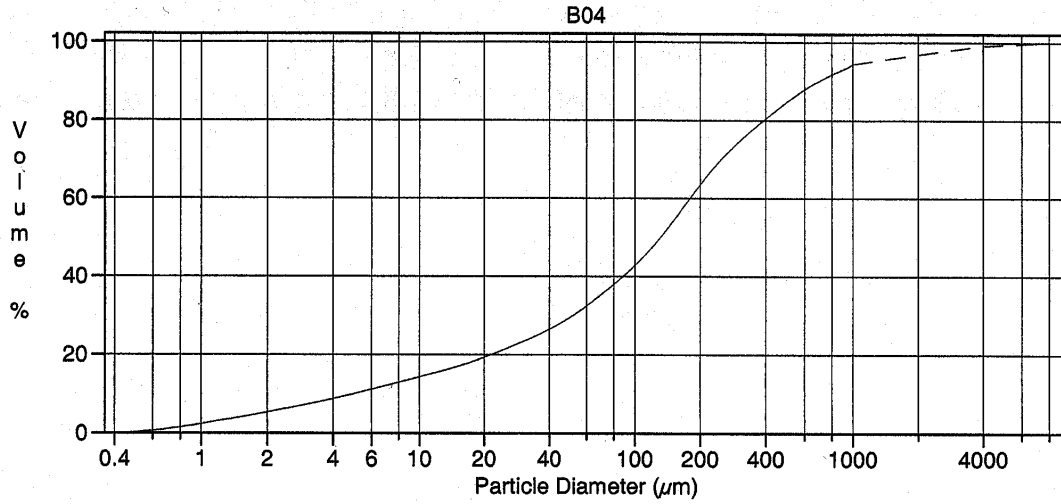
Calculations from 0.375 µm to 16000 µm

Volume	100.0%		
Mean:	301.9 µm	95% Conf. Limits:	0-2192 µm
Median:	82.34 µm	S.D.:	964.5 µm
D(3,2):	7.478 µm	Variance:	930238 µm ²
Mean/Median Ratio:	3.667	C.V.:	319%
Mode:	116.3 µm	Skewness:	6.916 Right skewed
d ₁₀ :	2.656 µm	Kurtosis:	58.90 Leptokurtic
d ₅₀ :	82.34 µm		
d ₉₀ :	480.5 µm		
Specific Surf. Area	8023 cm ² /ml		

% <	10	25	60	75	90
Size µm	2.656	14.55	111.9	179.2	480.5

b03.\$0a

Particle Diameter µm	Volume %
1.000	4.19
2.000	7.11
5.000	6.45
10.00	3.58
15.00	3.00
20.00	2.45
25.00	5.25
40.00	3.00
50.00	3.18
60.00	3.43
70.00	1.78
75.00	1.79
80.00	3.55
90.00	47.3



Volume Statistics (Arithmetic)

b04.\$0a

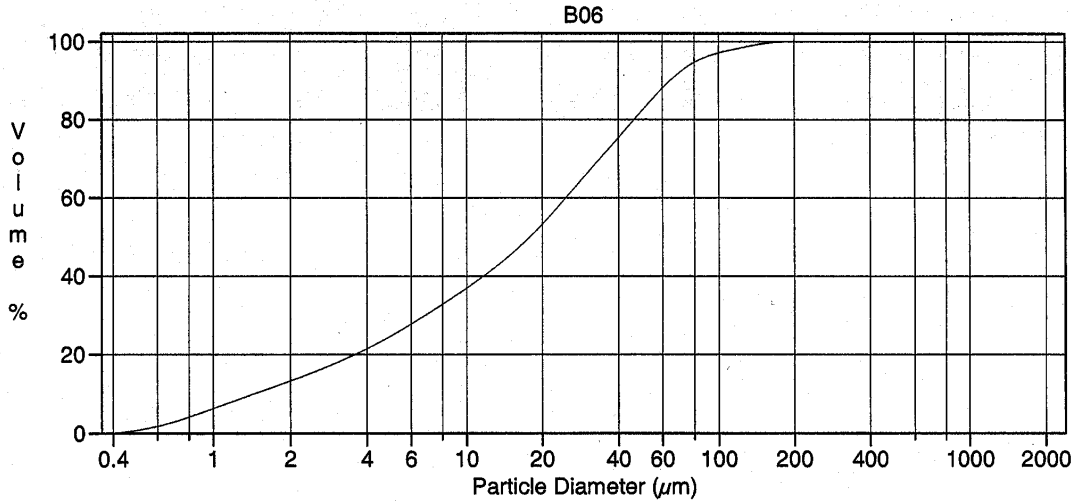
Calculations from 0.375 µm to 8000 µm

Volume	100.0%	95% Conf. Limits:	0-1686 µm
Mean:	327.7 µm	S.D.:	693.1 µm
Median:	131.8 µm	Variance:	480382 µm ²
D(3,2):	11.32 µm	C.V.:	212%
Mean/Median Ratio:	2.486	Skewness:	5.109 Right skewed
Mode:	168.8 µm	Kurtosis:	31.47 Leptokurtic
d10:	4.972 µm		
d50:	131.8 µm		
d90:	692.4 µm		
Specific Surf. Area	5301 cm ² /ml		

% <	10	25	60	75	90
Size µm	4.972	35.10	179.6	308.0	692.4

b04.\$0a

Particle Diameter µm	Volume %
1.000	2.99
2.000	4.69
5.000	4.32
10.00	2.67
15.00	2.36
20.00	2.10
25.00	5.03
40.00	2.98
50.00	2.97
60.00	2.88
70.00	1.36
75.00	1.30
80.00	2.46
90.00	59.5



Volume Statistics (Arithmetic)

b06.\$02

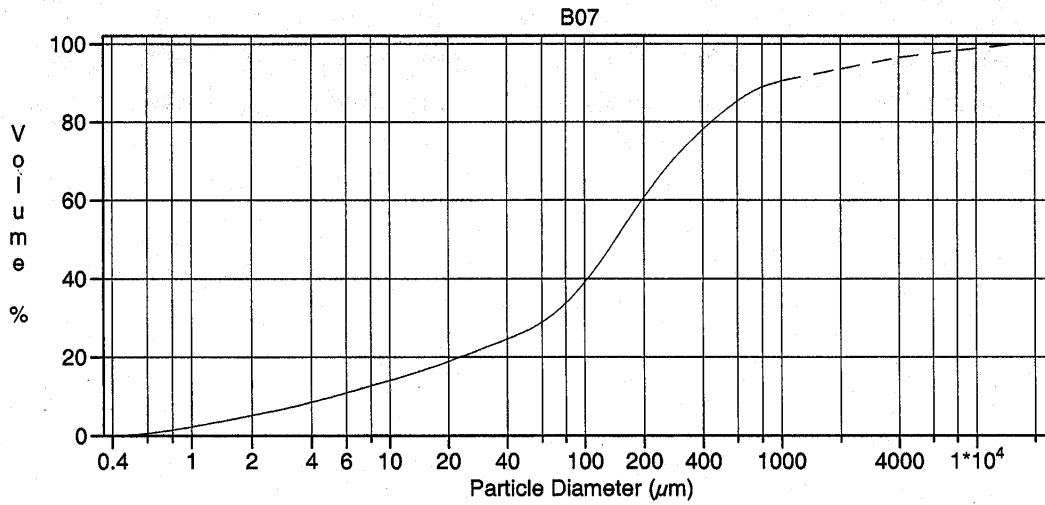
Calculations from 0.375 μm to 2000 μm

Volume	100.0%			
Mean:	26.92 μm	95% Conf. Limits:	0-83.43 μm	
Median:	17.85 μm	S.D.:	28.83 μm	
D(3,2):	4.519 μm	Variance:	831.3 μm^2	
Mean/Median Ratio:	1.508	C.V.:	107%	
Mode:	34.58 μm	Skewness:	1.832 Right skewed	
d ₁₀ :	1.443 μm	Kurtosis:	4.332 Leptokurtic	
d ₅₀ :	17.85 μm			
d ₉₀ :	64.41 μm			
Specific Surf. Area	13279 cm^2/ml			

% <	10	25	60	75	90
Size μm	1.443	5.048	24.86	39.55	64.41

b06.\$02

Particle Diameter μm	Volume %
1.000	7.00
2.000	11.6
5.000	12.1
10.00	8.53
15.00	7.78
20.00	6.92
25.00	15.2
40.00	7.12
50.00	5.54
60.00	4.05
70.00	1.42
75.00	1.11
80.00	1.56
90.00	3.83



Volume Statistics (Arithmetic)

b07.\$0a

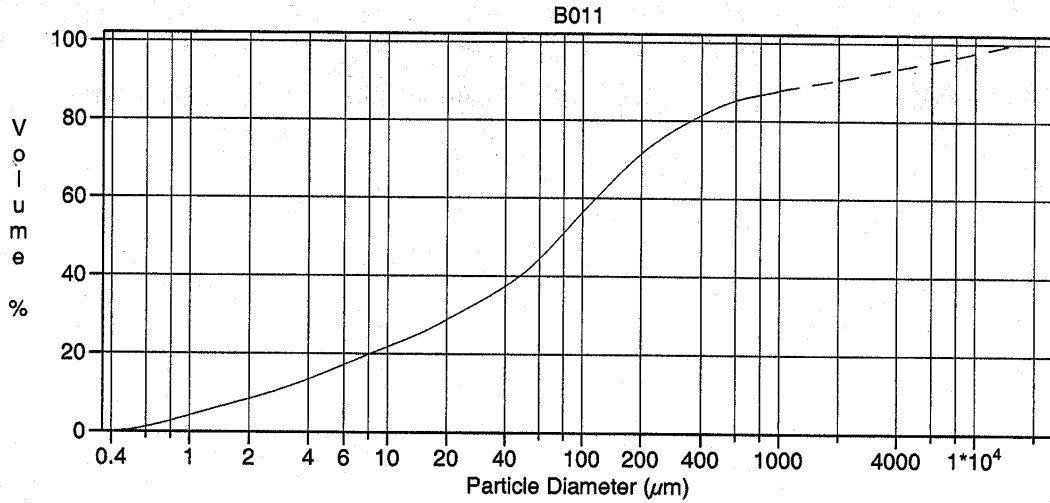
Calculations from 0.375 µm to 16000 µm

Volume	100.0%			
Mean:	588.5 µm	95% Conf. Limits:	0-3848 µm	
Median:	143.5 µm	S.D.:	1663 µm	
D(3,2):	11.75 µm	Variance:	2766191 µm ²	
Mean/Median Ratio:	4.100	C.V.:	283%	
Mode:	153.8 µm	Skewness:	5.107 Right skewed	
d ₁₀ :	5.200 µm	Kurtosis:	27.91 Leptokurtic	
d ₅₀ :	143.5 µm			
d ₉₀ :	932.0 µm			
Specific Surf. Area	5104 cm ² /ml			

% <	10	25	60	75	90
Size µm	5.200	41.88	195.2	346.0	932.0

b07.\$0a

Particle Diameter µm	Volume %
1.000	2.88
2.000	4.61
5.000	4.30
10.00	2.63
15.00	2.20
20.00	1.84
25.00	3.88
40.00	2.10
50.00	2.19
60.00	2.37
70.00	1.25
75.00	1.27
80.00	2.60
90.00	63.6



Volume Statistics (Arithmetic)

b011.\$0a

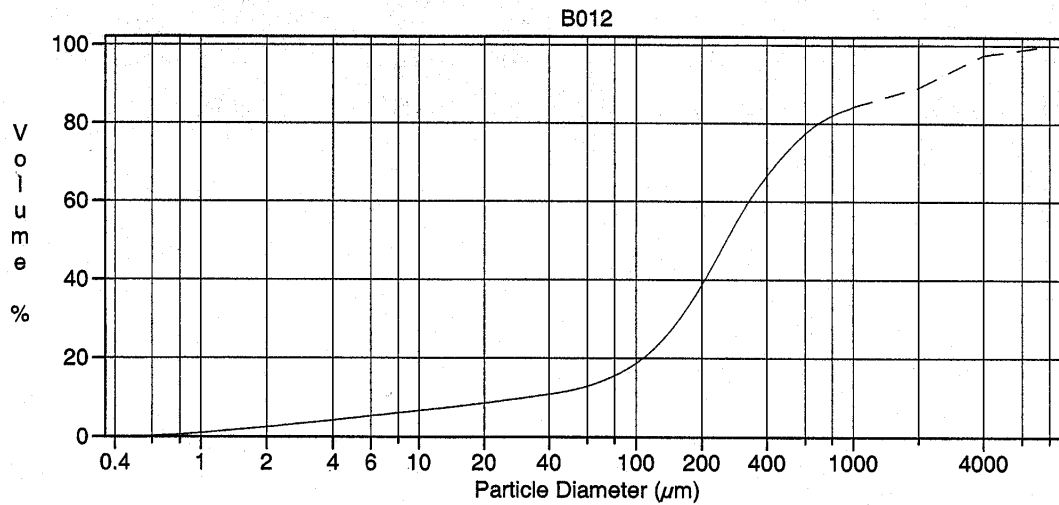
Calculations from 0.375 µm to 16000 µm

Volume	100.0%			
Mean:	794.6 µm	95% Conf. Limits:	0-5239 µm	
Median:	76.54 µm	S.D.:	2268 µm	
D(3,2):	7.284 µm	Variance:	5142304 µm ²	
Mean/Median Ratio:	10.38	C.V.:	285%	
Mode:	11314 µm	Skewness:	3.781 Right skewed	
d ₁₀ :	2.541 µm	Kurtosis:	13.83 Leptokurtic	
d ₅₀ :	76.54 µm			
d ₉₀ :	1813 µm			
Specific Surf. Area	8237 cm ² /ml			

% <	10	25	60	75	90
Size µm	2.541	14.15	117.6	246.8	1813

b011.\$0a

Particle Diameter µm	Volume %
1.000	4.29
2.000	7.00
5.000	6.38
10.00	3.74
15.00	3.23
20.00	2.70
25.00	5.85
40.00	3.44
50.00	3.55
60.00	3.51
70.00	1.64
75.00	1.54
80.00	2.81
90.00	46.2



Volume Statistics (Arithmetic)

b012.\$0a

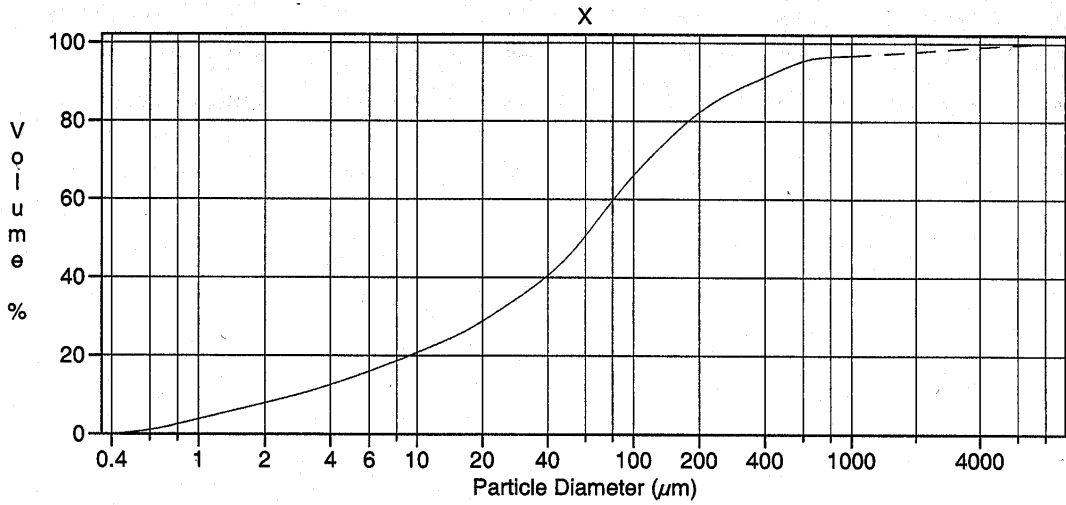
Calculations from 0.375 µm to 8000 µm

Volume	100.0%			
Mean:	668.3 µm	95% Conf. Limits:	0-2837 µm	
Median:	259.7 µm	S.D.:	1107 µm	
D(3,2):	24.21 µm	Variance:	1224403 µm ²	
Mean/Median Ratio:	2.573	C.V.:	166%	
Mode:	2828 µm	Skewness:	2.900 Right skewed	
d ₁₀ :	31.44 µm	Kurtosis:	8.783 Leptokurtic	
d ₅₀ :	259.7 µm			
d ₉₀ :	2203 µm			
Specific Surf. Area	2478 cm ² /ml			

% <	10	25	60	75	90
Size µm	31.44	134.1	331.4	537.9	2203

b012.\$0a

Particle Diameter µm	Volume %
1.000	1.49
2.000	2.33
5.000	1.85
10.00	1.06
15.00	0.84
20.00	0.71
25.00	1.57
40.00	0.97
50.00	1.11
60.00	1.26
70.00	0.69
75.00	0.72
80.00	1.51
90.00	82.9



Volume Statistics (Arithmetic)

x.\$0a

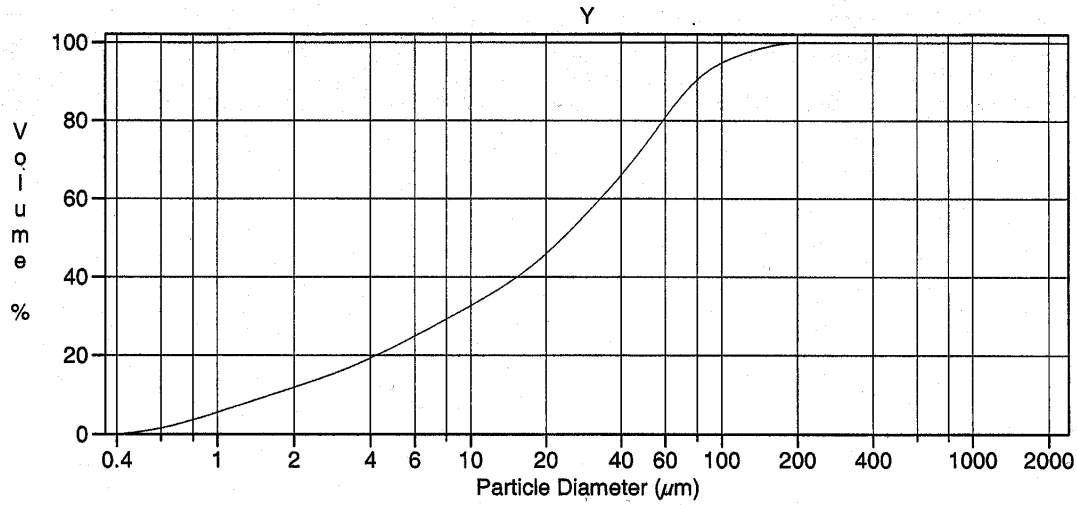
Calculations from 0.375 µm to 8000 µm

Volume	100.0%		
Mean:	202.1 µm	95% Conf. Limits:	0-1439 µm
Median:	58.69 µm	S.D.:	631.3 µm
D(3,2):	7.571 µm	Variance:	398544 µm ²
Mean/Median Ratio:	3.444	C.V.:	312%
Mode:	72.95 µm	Skewness:	6.761 Right skewed
d ₁₀ :	2.792 µm	Kurtosis:	50.71 Leptokurtic
d ₅₀ :	58.69 µm		
d ₉₀ :	353.2 µm		
Specific Surf. Area	7925 cm ² /ml		

% <	10	25	60	75	90
Size µm	2.792	14.90	80.83	142.7	353.2

x.\$0a

Particle Diameter µm	Volume %
1.000	4.11
2.000	6.49
5.000	6.40
10.00	4.24
15.00	3.80
20.00	3.42
25.00	8.25
40.00	5.02
50.00	5.09
60.00	4.85
70.00	2.18
75.00	1.99
80.00	3.51
90.00	36.8



Volume Statistics (Arithmetic)

y.\$02

Calculations from 0.375 μm to 2000 μm

Volume	100.0%		
Mean:	33.78 μm	95% Conf. Limits:	0-101.3 μm
Median:	23.43 μm	S.D.:	34.43 μm
D(3,2):	5.058 μm	Variance:	1185 μm^2
Mean/Median Ratio:	1.442	C.V.:	102%
Mode:	55.14 μm	Skewness:	1.522 Right skewed
d ₁₀ :	1.632 μm	Kurtosis:	2.668 Leptokurtic
d ₅₀ :	23.43 μm		
d ₉₀ :	79.00 μm		
Specific Surf. Area	11863 cm^2/ml		

% <	10	25	60	75	90
Size μm	1.632	6.039	33.16	51.49	79.00

y.\$02

Particle Diameter μm	Volume %
1.000	6.29
2.000	10.4
5.000	10.4
10.00	6.91
15.00	6.35
20.00	5.85
25.00	14.2
40.00	7.88
50.00	6.89
60.00	5.60
70.00	2.15
75.00	1.78
80.00	2.69
90.00	6.98

References

- (1) T. Jenserud, D. Simons and A. Plaisant (2001): RUMBLE first sea trial Plan
- (2) NGU Kornfordelingsanalyse. Analysekontraktsnr. 2001.0479
- (3) NGU-SD 5.11a
- (4) R. Tiele (1997): Data input to operational sonar forecast models. In E. Pouliquen, A.D. Kirvan and R.T. Pearson, editors, *Rapid environmental assessment*, SACLANTCEN Conference Proceedings CP-44.

DISTRIBUTION LIST

FFIBM **Dato:** 30 December 2002

RAPPORTTYPE (KRYSS AV)		RAPPORT NR.	REFERANSE	RAPPORTENS DATO	
<input checked="" type="checkbox"/> RAPP	<input type="checkbox"/> NOTAT	<input type="checkbox"/> RR	2002/05018	FFIBM/821/116	30 December 2002
RAPPORTENS BESKYTTELSESGRAD			ANTALL EKS UTSTEDT	ANTALL SIDER	
Unclassified			26	41	
RAPPORTENS TITTEL			FORFATTER(E)		
ANALYSIS OF BOTTOM SAMPLES FROM VESTFJORDEN COLLECTED DURING RUMBLE FIRST SEA TRIAL			JENSERUD Trond, OTTESEN Dag (NGU)		
FORDELING GODKJENT AV FORSKNINGSSJEF			FORDELING GODKJENT AV AVDELINGSSJEF:		
Tor Knudsen			Jan Ivar Botnan		

EKSTERN FORDELING

INTERN FORDELING

ANTALL	EKS NR	TIL	ANTALL	EKS NR	TIL
1		IA Erwan BERNI (Chairman) DGA/DSA/SPN/ST/LSM 8, Bd Victor 00303 PARIS ARMEES, France	9		FFI-Bibl
1		Frans Jansen MSc Directorate of Material Royal Netherlands Navy Dep of Weapon and Communication Systems Underwater Sensor- and Weapon Systems branch Van der Burchlaan 31 P.O. Box 20702 2500 ES The Hague, The Netherlands	1		FFI-Ledelse
1		Wessel GROOT WEAO Research Cell Rue de la Régence 4 1000 BRUXELLES, Belgique	1		FFIE
1		Alain PLAISANT Thomson Marconi Sonar 525 Route des Dolines BP 157, Valbonne 06903 Sophia Antipolis Cedex, France	1		FFISYS
1		Johnny Dybedal Kongsberg Defence Aerospace P.O. Box 55 7501 Stjørdal Norway	1		FFIBM
1		Dick Simons, TNO-FEL	1		FFIN
1		Michael Ainsley, TNO-FEL P O Box 96864 2509 JG The Hague, The Netherlands	1		Forfattereksemplar(er)
1		NGU, Dag Ottesen Leiv Eirikssonsvei 39, 7491 Trondheim	2		Restopplag til FFI-Bibl
			1		Avd ktr FFIBM/Horten
					Elektronisk fordeling:
					FFI-veven
					Jarl K Johnsen (JKJ)
					Tor Knudsen (TKn)
					Trond Jenserud (TJe)
					Elling Tveit (ETv)

FFI-K1 Retningslinjer for fordeling og forsendelse er gitt i Oraklet, Bind I, Bestemmelser om publikasjoner for Forsvarets forskningsinstitutt, pkt 2 og 5. Benytt ny side om nødvendig.