The Geological Survey of Norway has taken over 252 Norwegian Petroleum Directorate (NPD) gravity cores. This report is a compilation of different activities within the project. The following topics are included:

- A quality assessment report including four cores.
- A list of the cores transferred to NGU Geodata Centre from NPD December 2001.
- A digital map showing the locations of the retrieved gravity cores in the Barents Sea.
- A CD with all photo-documentation from the visits to the core storage facility in Stavanger.
- Correspondence with NPD staff was undertaken concerning the handling and use of cores after the cores had been sampled in 1976 – 1979.

The original purpose for the cores was exploration for oil and gas in the Barents Sea using surface organic geochemistry. Several hundred cores were taken during the period 1976 – 1979, and later submitted for geochemical hydrocarbon gas analysis at Horovitz Laboratory in Houston, Texas. Unfortunately NPD has not been able to track the results from these analyses.

The quality assessment report shows that the cores appear to be in good condition, which will allow use of the gravity cores for different types of investigations. The core material can be used for logging methods as well as geochemistry. The total of 252 cores vary from approx. 100 cm to approx. 200 cm in length. The cores encompass a large geographical area in the Barents Sea.

The transfer of the gravity cores to NGU and the assessment of core quality provide opportunities for future regional studies in the Barents Sea, without the need for a re-sampling programme. The cost of a new sampling programme to collect a similar number of gravity cores would be in the order of several Mill. Norwegian kroner.
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1. INTRODUCTION

In 2000, the Norwegian Petroleum Directorate (NPD) offered the Geological Survey of Norway (NGU) to take over a large number of gravity cores from the Barents Sea. These cores were sampled during the late 1970s during a campaign for oil and gas exploration. NGU for its part decided to undertake a quality assessment of the core material prior to taking over cores stored in a former bomb shelter in Stavanger city, in order to determine whether more than 20 years of storage had done harm to the cores.

This document includes the report on quality assessment of the cores undertaken by NGU together with the Geological Institute, University of Tromsø, a list of the 252 gravity cores transferred to NGU, and maps showing the sampling locations for the gravity cores in the Barents Sea. All 252 gravity cores transferred to NGU (Table 1.1) are now stored at NGU's Geodata Centre in Løkken, south of Trondheim. In addition, four of these cores were used for the quality assessment presented in Chapter 2.

Table 1.1. Overview of the 252 gravity cores taken over by NGU from the NPD for the sampling years 1976, 1977 and 1978.

<table>
<thead>
<tr>
<th>Sampling year</th>
<th>Number of cores sealed in PVC tubes</th>
<th>Number of cores with co-ordinates</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976</td>
<td>79</td>
<td>67</td>
</tr>
<tr>
<td>1977</td>
<td>134</td>
<td>133</td>
</tr>
<tr>
<td>1978</td>
<td>39</td>
<td>39</td>
</tr>
</tbody>
</table>

The gravity cores have mainly been sampled along latitude and longitude lines, and have been labelled accordingly in most cases. Table 1.2 lists the different sampling lines and the number of cores collected from each line. The gravity core locations are shown on the maps in Appendix 1 - firstly on an overview map and thereafter on maps with line number and core number for the years 1976, 1977 and 1978 respectively. The complete list of gravity cores taken over by NGU is presented in Appendix 2.

Previous reporting from the NPD-cores is included in Elverhøi and Solheim (1983a, 1983b). These reports mainly deal with surface sediment distribution as well as Quaternary stratigraphy.
Table 1.2. Sampling year, sampling line and number of cores retrieved from each line. The name of the line and gravitation core numbers are shown in the maps in appendix 1.

<table>
<thead>
<tr>
<th>Sampling year</th>
<th>Line</th>
<th>Number of cores</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976</td>
<td>T1</td>
<td>7</td>
</tr>
<tr>
<td>1976</td>
<td>T2</td>
<td>11</td>
</tr>
<tr>
<td>1976</td>
<td>T3</td>
<td>6</td>
</tr>
<tr>
<td>1976</td>
<td>Z1</td>
<td>17</td>
</tr>
<tr>
<td>1976</td>
<td>Z3</td>
<td>35</td>
</tr>
<tr>
<td>1976</td>
<td>No code</td>
<td>3</td>
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<td>1977</td>
<td>BGR16</td>
<td>14</td>
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<tr>
<td>1977</td>
<td>BG2100</td>
<td>4</td>
</tr>
<tr>
<td>1977</td>
<td>BG2600</td>
<td>4</td>
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<tr>
<td>1978</td>
<td>VG 33</td>
<td>1</td>
</tr>
</tbody>
</table>
2. INVESTIGATIONS OF NORWEGIAN PETROLEUM DIRECTORATE GRAVITY CORES FROM THE BARENTS SEA

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August 2001
Introduction

The aim of the investigation of four selected Norwegian Petroleum Directorate (NPD) gravity cores from the Barents Sea has been to evaluate the quality of the cores after more than 20 years of storage under cold and moist conditions in a hard rock bomb shelter room. The gravity cores were sampled in the period from 1976 to 1979 from the Barents Sea. In total approximately 950 cores are stored in Stavanger in the bomb shelter owned by the municipality. The cores constitute unique Quaternary sample material from the Barents Sea, from the Finnmark coast in the south to Svalbard to the north. The potential value of the cores is several million NOK if sampling were to be carried out again.

The following features have been studied:

- Core recovery
- Core sealing
- The degree of alteration of sediments due to oxidation during storage
- Quaternary stratigraphy through application of different logging techniques
- Carbonate dissolution
- A first indication of how the gravity cores can be used in future projects

Application of up to date core logging techniques in collaboration between the Department of Geology, University of Tromso and the Geological Survey of Norway have given good indications for what the sediments consist of as well as a qualitative evaluation of the core material.

Location

The Barents Sea is an Arctic epicontinental sea (Fig. 2.1) bounded by a Tertiary sheared and rifted margin to the west (Eldholm et al. 1984). The bathymetry of its southwestern part is characterised by a central broad, west-east channel called the Bear Island Trough, which reaches a depth of 500 m. To the north is the shallow (ca. 100m) Spitsbergenbanken and to the south are bank areas of 300 to 200 m depth separated by the Ingøydjupet Trough running perpendicularly to the Norwegian coast. A large fan is situated in the front of the Bear Island Trough, typical for many glaciated shelves (Vorren 1992). The Barents Sea has been repeatedly glaciated during the Quaternary. During this period considerable erosion occurred on the Barents Sea shelf and a correspondingly high sediment accumulation occurred on the continental margin. In the southern Barents Sea a total thickness of ca. 1-km was eroded.
The investigated sediment cores are located along the east-west axis of the Bear Island Trough in the western Barents Sea (Fig. 2.1).

Fig. 2.1. Location map of the western Barents Sea showing the location of the investigated sediment cores. Bathymetry contours are in meters.
Material and methods

Four of the gravity sediment cores collected by the Norwegian Petroleum Directorate along 73°10' north latitude in 1977 were selected for the quality investigation (Table 2.1).

<table>
<thead>
<tr>
<th>Core number</th>
<th>Latitude (N)</th>
<th>Longitude (E)</th>
<th>Ocean depth (m)</th>
<th>Length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BG7310-77 117-1</td>
<td>73° 11' 09.4&quot;</td>
<td>16° 59' 41.8&quot;</td>
<td>not reported</td>
<td>154</td>
</tr>
<tr>
<td>BG7310-77 131-1</td>
<td>73° 12' 45.5&quot;</td>
<td>19° 19' 36.3&quot;</td>
<td>not reported</td>
<td>118</td>
</tr>
<tr>
<td>BG7310-77 146-1</td>
<td>73° 12' 06.6&quot;</td>
<td>21° 40' 41.1&quot;</td>
<td>not reported</td>
<td>183</td>
</tr>
<tr>
<td>BG7310-77 172-1</td>
<td>73° 10' 09.7&quot;</td>
<td>25° 42' 55.2&quot;</td>
<td>not reported</td>
<td>201</td>
</tr>
</tbody>
</table>

Table 2.1. Investigated sediment cores from the western Barents Sea: latitude, longitude and core length.

The inner diameter of the gravity corer is 10 cm. The sealed cores were opened by splitting them longitudinally in two equal parts. One half was subjected to various geotechnical and sedimentological analysis: X-radiography; colour determination by using the Munsell Colour Charts; shear strength by the fall-cone test (Hansbo 1957); multi sensor core logging and investigation of the 100-1,000 µm fraction using a binocular microscope.

A Multi-Sensor Core Logger (MSCL) is an automated logging device that can measure p-wave travel time, bulk sediment density and magnetic susceptibility (Weber et al. 1996; Gunn and Best 1998). P-wave velocity measurements are made by using simple transmission geometry with two vertically mounted compressional wave transducers located on opposite sides of the core. In order to derive sediment bulk densities the MSCL uses the technique of gamma ray attenuation. This method has the advantage of being non-destructive to the core. Magnetic susceptibility is a measurement of how easily a substance can be magnetised (Gunn and Best 1998). A loop sensor remains stationary as the core is moved through it. The sensor measures the magnetisation of the material. Susceptibility data may be used to detect structures and events that are not easily seen through visual inspection of the core.
Results

The sediment core is 154 cm long and can be divided into two main lithological units. The upper 30 cm consists of a sandy pelite with scattered clasts. The unit is laminated in the lower part. In the 15-20 cm interval a c. 2 cm long clast of sedimentary origin was observed. This clast contains fossil gastropods of unknown pre Quaternary age. Most probably this clast was eroded from pre Quaternary sedimentary strata in the Barents Sea. There is a marked boundary to the lower unit, which constitutes the rest of the core 30-154 cm. This lower unit is characterised by a pelite with scattered clasts and strongly folded sandy and pelitic layers. These structures were observed both by visual inspection of the core and in the X-radiographs (Fig. 2.3A, D).
Fig. 2. X-radiographs of sediment core BG 7310-77 117-1. A) 0-45 cm core interval; B) 40-85 cm core interval; C) 80-125 cm core interval; D) 120-ca. 165 cm core interval.

The upper unit probably represents the Holocene relatively high energetic bottom environment during which the larger clasts are relicts from previous glaciogenic environments. The lower unit may represent either a glaciogenic and/or a gravity flow environment. The folding structures may be created e.g. during sediment gravity flows or by glaci-tectonism.

The sediments are slightly oxidised in the lower and upper part. In general it looks "fresh" and shows no direct effects of the long (24 years) of storing.
This sediment core is 183 cm long and consists of two main lithologic units. The upper unit (0-100 cm) is a massive, bioturbated, soft, olive grey mud. Scattered zones with more brownish chroma, probably due to increased oxidation, are observed in the lower part of the unit. Magnetic susceptibility and shear strength are relatively low, P-wave velocity shows large variation. The lower unit is a laminated to massive very dark grey mud with scattered clasts (Fig. 2.5A-5E).

The boundary to the upper unit is sharp and lamination is particularly pronounced in the lower part. P-wave velocity shows stable values, magnetic susceptibility shows a down core increasing trend. Shear strength values are relatively low. The upper unit probably represents a post glacial environment in the Barents Sea, probably mainly the Holocene. The lower unit represents a glaciomarine environment, probably for the last deglaciation. The scattered clasts we assume are rafted by ice bergs originating from the waning Barents Sea Ice Sheet.
Most of the Barents Sea deglaciated between 15,000 and 10,000 $^{14}$C years BP (Vorren and Laberg 1996).

![Fig. 2. 5. X-radiographs of sediment core BG 7310-77 146-1. A) 0-45 cm core interval; B) 40-85 cm core interval; C) 80-125 cm core interval; D) 120-ca. 165 cm core interval, E) 140-180 cm core interval.

The sediments are slightly oxidised in the lower and upper part. In general it looks ”fresh” and shows no direct effects of the long (24 years) of storing.
The sediment core is 201 cm long and consists of two lithologic units. The upper unit (0- ca. 80 cm) is a massive, bioturbated, soft mud. The upper 50 cm has a dark greyish brown colour. The lower part of this unit varies between dark greyish brown and dark grey colours. In the interval 60-80 cm there is a gradual transition towards the lower unit. This unit consists of massive, dark grey mud with scattered clasts. The frequency of clasts decreases up-core in the unit. P-wave velocity and magnetic susceptibility show slightly elevated values compared to the upper unit. The upper unit is interpreted to represent a post glacial environment and the lower unit a glaciomarine environment from the later part of the last deglaciation. The scattered clasts of the lower unit, interpreted to reflect ice berg rafting (IRD), appear to terminate at c. 40 cm in the core. The Barents Sea Ice sheet and the Fennoscandian ice sheet
retreated to the fjord areas around 13,000 $^{14}$C years BP of Svalbard and Norway respectively.

Younger Dryas cold spell (11,000-10,000 $^{14}$C years BP). Thus, the 40 cm interval in this core may be close to the Weichselian/Holocene boundary.

![Fig.2. 7. X-radiographs of sediment core BG 7310-77 172-1. A) 0-45 cm core interval; B) 40-85 cm core interval; C) 80-125 cm core interval; D) 120-ca. 165 cm core interval; E) 160-ca. 210 cm.](image)

The lithostratigraphy of this core resembles that of core BG 7310-146-1 (Fig. 2.4), although the latter has a somewhat coarser texture as is also indicated by the higher magnetic susceptibility values. The sediments are slightly oxidised in the lower and upper part. In general it looks “fresh” and shows no direct effects of the long (24 years) of storing.
This core is 120 cm long and contains two lithologic units. The upper unit, 0-20 cm, is characterised by olive brown lag gravel, with a sandy to silty-clay matrix. There is a sharp boundary to the lower unit, which is a very dark grey, massive diamicton with frequent clasts = 1 mm in diameter. The shear strength values are moderate to high for glaciomarine sediments. The upper unit is evidently a lag deposit derived by winnowing of Quaternary glaciogenic diamictons. It contains both sediments from an earlier glacial environment as well as from the modern environment. This unit is typical from shallow to deep bank areas in the Barents Sea and on the Norwegian shelf (Vorren et al. 1978; 1984; Hald and Vorren 1984). This unit probably reflects an increasing bottom current energy regime established by the full onset of the West-Spitsbergen Current, a northern extension of the North Atlantic Current, since the early Holocene. The lower unit represents a glaciomarine environment, with frequent ice berg rafting, probably from the last deglaciation. The sharp boundary between the two units may represent a hiatus.
Fig. 2.9. X-radiographs of sediment core BG 7310-77 131-1. A) 0-45 cm core interval; B) 40-85 cm core interval; C) 75-120 cm core interval.
Microscopy of the 100-1000 µm fraction

The following sediment samples were sieved and the 100-1000 µm fraction was inspected using a binocular microscope:

- BG7310-77 117-1, 0-2cm
- BG7310-77 117-1, 100-102cm
- BG7310-77 131-1, 50-52cm
- BG7310-77 172-1, 20-22cm
- BG7310-77 172-1, 120-122cm
- BG7310-77 146-1, 20-22cm
- BG7310-77 146-1, 120-122cm
- BG7310-77 146-1, 180-182cm

The inspection was done mainly to investigate if the long storing of the sediment cores had led to dissolution of the carbonate fossils (foraminifera, ostracodes, bivalve shells, etc.). Such dissolution is common in sediment cores from Arctic waters, if the sediments have been stored unsealed and exposed to room temperature (Hald et al. 2001). The inspected samples mainly consist of a minerogenic component dominated by quartz grains. A few benthic foraminifera were observed, but none of them showed any sign of carbonate dissolution. Thus we conclude that the long storing of the sediment cores have not led to increased carbonate dissolution, probably because the cores have been completely sealed within the PVC-tube.
Conclusions

Geo-scientific conclusions

Detailed stratigraphical studies including visual core description, shear strength, multi core sensor logging, x-radiography and microscopy of the sand fraction, show that the four sediment cores contain five lithostratigraphic units, representing various sedimentary environments. These are: Unit 1) Holocene/post glacial pelite; Unit 2) Sandy-gravely lag deposits; Unit 3) Bioturbated pelite with scattered IRD; Unit 4) Massive pelite with frequent IRD; Unit 5) Folded/deformed sediments. Unit 1, Holocene/postglacial pelite, represents the modern environment in low energetic settings on the shelf, for example glacial troughs. Unit 2, sandy-gravely lag deposits, is frequent on the shallower banks today in the Barents Sea area. Units 3 and 4 represent glaciomarine settings, probably from the last deglaciation. The deformation structures seen in Unit 5 may be formed by sediment instability such as mass wasting or they could be due to deformation by an overriding glacier.

Quality of the Barents Sea gravity cores

The quality evaluation suggests that the gravity cores can be used for geo-scientific projects. From a cost – benefit evaluation point of view it is concluded that a significant part of the cores should be stored under any circumstance due to that the cores represent a high value. If a similar set of samples were to be collected again from the Barents Sea, the costs would amount to several million NOK for a comparable sampling program. It is not likely that it will be possible to have a similar set of gravity cores available for use without any restrictions. Additionally, generation of new projects might attract external sources for funding if the existing NPD cores are included in new projects.

Recommendations

The investigations of the four gravity cores have so far shown, that the cores have not suffered particularly during more than 20 years of storage in a hard rock bomb shelter room with constant low temperature and moist conditions. The authors of the report therefore recommend that the NPD gravity cores should be considered as a highly valuable and useful sample material from the Barents Sea.
**References**


Vorren, T.O. and Laberg, J.S., 1996. Late glacial air temperature, oceanographic and ice sheet interactions in the southern Barents Sea region. In: J.T. Andrews, W.E.N. Austin, H. Bergsten and A.E. Jennings (Editors), Late Quaternary Palaeoceanography of the


APPENDIX 1. Location map for the gravity cores taken over by NGU
Gravity core locations

Scale 1: 7 000 000
Gravity core locations, those sampled in 1976 are numbered.
Gravity core locations, those drilled in 1977 are numbered
Gravity core location, those drilled in 1978 are numbered.
APPENDIX 2. List of cores taken over by NGU
### Norwegian Petroleum Directorate Barents Sea gravity cores updated July 31st 2002

<table>
<thead>
<tr>
<th>Year</th>
<th>Code</th>
<th>Sub-no.</th>
<th>Latitude N</th>
<th>Longitude E</th>
<th>UTM-lat.</th>
<th>UTM-long.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1976</td>
<td>T1</td>
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<td>no data</td>
<td>no data</td>
<td>no data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16</td>
<td>no data</td>
<td>no data</td>
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<td></td>
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<td>no data</td>
<td>no data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
<td>71 05 30</td>
<td>30 31 30</td>
<td>1055792</td>
<td>7959561</td>
</tr>
</tbody>
</table>

**Explanation of columns and data**

- **Year**: Sampling year of the gravity cores.
- **Code**: Each core has been sampled.
- **Sub-no.**: Core numbers are numbered in appendix 1 together with the location and sub-numbers are limited to the cores taken in 1976.
- **Latitude N**: Latitude north.
- **Longitude E**: Longitude in degrees, minutes and seconds.
- **UTM-lat.**: UTM latitude, zone 33.
- **UTM-long.**: UTM longitude, zone 33.

### T1

<table>
<thead>
<tr>
<th>No.</th>
<th>Sub-no.</th>
<th>Latitude N</th>
<th>Longitude E</th>
<th>UTM-lat.</th>
<th>UTM-long.</th>
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<tr>
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<tr>
<td>T2</td>
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<td>1018027</td>
<td>7958641</td>
</tr>
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<td>T2</td>
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<td>28 30 00</td>
<td>1078027</td>
<td>7958641</td>
</tr>
<tr>
<td>T2</td>
<td>5</td>
<td>71 10 00</td>
<td>27 30 00</td>
<td>962712</td>
<td>7962079</td>
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### Z1

<table>
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<th>No.</th>
<th>Sub-no.</th>
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<th>Longitude E</th>
<th>UTM-lat.</th>
<th>UTM-long.</th>
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<tbody>
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<td>18 04 00</td>
<td>597279</td>
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<td>8</td>
<td>73 31 30</td>
<td>20 49 30</td>
<td>684132</td>
<td>8168257</td>
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<tr>
<td>Z2</td>
<td>9</td>
<td>73 30 00</td>
<td>21 23 30</td>
<td>702283</td>
<td>8167315</td>
</tr>
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<td>Z2</td>
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