The Upper Palaeozoic succession on the Finnmark Platform, Barents Sea

TOM BUGGE, GUNN MANGERUD, GEIR ELVEBAKK, ATLE MØRK, INGER NILSSON, STEIN FANAVOLL & JORUNN OS VIGRAN


During the Late Palaeozoic, sediments were deposited in the proto-Barents Sea along the northern margin of the Fennoscandian Shield. These sediments have no outcrops onshore Norway, but a condensed Upper Palaeozoic succession occurs on the Finnmark Platform close to the present coast of Norway. During 1987 and 1988, IKU Petroleum Research cored most of the condensed, 600–700 m thick sedimentary section, and except for about 100 m, the entire Carboniferous–Permian succession was cored. Using high resolution multichannel seismic data, fourteen seismic units have been defined in the cored succession. These are grouped into four stratigraphic intervals and discussed in a stratigraphic context based on seismic, sedimentological and biostratigraphic data. The dating is based on palynomorphs in the clastic-dominated Lower Carboniferous succession, by fusulinids in the carbonate-dominated Upper Carboniferous/Lower Permian succession, and by palynomorphs in the clastic-dominated Upper Permian and lowermost Triassic succession. A major transgression affected the Finnmark Platform in the Early Carboniferous (Viséan), and marine shale was deposited in the east, while a local basin in the west was filled by flood plain deposits up to 650 m thick. An overall transgressive trend through the Bashkirian to Kasimovian (Mid-Late Carboniferous) gave flood plain to shoreface deposits on the southern Finnmark Platform. A carbonate platform with significant clastic input existed from the Late Carboniferous (Gzhelian) to Late Permian, with Palaeoetoxyinae–phylloid algal buildups forming during the Gzhelian–Asselian and beyoozoan buildups during the Sakmarian–Artinskian (Early Permian). The clastic input increased during the Late Permian, and at the Permian/Triassic transition the carbonate shelf was transgressed and covered by clastic sediments prograding from the east and southeast.

Exploration for oil and gas on the Barents Shelf started in the early 1980s and, to date, 53 deep hydrocarbon exploration wells have been drilled by oil companies. Stimulated by the need for more geological information, a shallow stratigraphic drilling programme was initiated by IKU Petroleum Research in 1984 and up until now 57 stratigraphic drillings (Fig. 1) with continuous coring have given 3700 m core from the Barents Sea. Eleven of these drillings are from the Palaeozoic succession, three from the Svalis Dome and 8 from the Finnmark Platform (Fig. 2).

The present study area is situated offshore northern Norway, on the eastern part of the Finnmark Platform, which parallels the coastline of the Troms and Finnmark counties. The platform is bounded to the northwest by the Harstad and Tromsø Basins and to the north by the Hammerfest and Nordkapp Basins (Fig. 1). The 'disputed area' between Norway and Russia is adjacent to the east. The eight stratigraphic cores on the Finnmark Platform were drilled before any deep wells were drilled in this area and provide a valuable data 'point' with an almost fully cored succession. They were drilled in offset positions in order to cover most of the Upper Palaeozoic succession vertically as well as laterally. Being located on the southern part of the platform, the cored succession is condensed and probably has more breaks in deposition compared to the northern, more basinward part of the platform.

To date, 13 hydrocarbon exploration wells have been drilled into Palaeozoic rocks on the Barents Shelf, but with the exception of three wells, which are still confidential, these are located outside the Finnmark Platform and have limited coring programmes. The amount of published Palaeozoic data from the Barents Shelf is limited and primarily based on seismic data, some released wells on the Loppa High and on correlations with Bjørnøya/Svalbard and Novaya Zemlya, where Upper Palaeozoic rocks are exposed (e.g., Rønnevik 1981; Faleide et al. 1984; Gramberg et al. 1988; Gérard & Buhrig 1990; Alsgaard 1992; Bruce & Toomey 1992; Cecchi 1992; Nilsen et al. 1992; Nettvet et al. 1992a). Some of these publications refer to the shallow stratigraphic drillings, but with the exception of publications by Nilsson (1993), Mangerud (1994) and Stemmerik et al. (in press) little direct documentation or use of the data has so far been published.

This article presents the results from the IKU shallow stratigraphic drillings in the Upper Palaeozoic succession on the Finnmark Platform. The Carboniferous to Lower Triassic succession was divided into fourteen seismic units, which are grouped into four main intervals. These four intervals are discussed in a stratigraphic context based on seismic, sedimentological and biostratigraphical data. Regional correlation of each of the units is discussed, and implications for palaeogeographic reconstruction are included.
Fig. 1. Map of the Barents Shelf showing the position of the 57 shallow stratigraphic cores drilled by IKU in the Barents Sea. The cores have a total length of ca. 3700 m and cover the Lower Carboniferous to Upper Tertiary succession. The present study describes the eight Palaeozoic cores on the Finnmark Platform in the southeast (geological base map modified from Sigmond 1992).

Data base

The study is based on data acquired during the shallow stratigraphic drilling programme on the Finnmark Platform in 1987 and 1988 (Table 1). In addition to the eight bedrock cores with a core recovery of 91% (Table 2), 1100 km of high resolution seismic data have been acquired (Fig. 2); 780 km representing multichannel data, while single channel data were acquired on all lines.

The cores discussed here cover the 600–700 m thick Carboniferous–Permian and lowermost Triassic succession: about 100 m in the Lower/Middle Carboniferous succession was not drilled (Figs. 3, 4). Some of the

<table>
<thead>
<tr>
<th>Core no.</th>
<th>Year drilled</th>
<th>Geographical coordinates</th>
</tr>
</thead>
<tbody>
<tr>
<td>7128/12-U-01</td>
<td>1988</td>
<td>71°14'25.5&quot;N 28°50'28.9&quot;E</td>
</tr>
<tr>
<td>7129/10-U-01</td>
<td>1987</td>
<td>71°09'35.5&quot;N 29°16'42.8&quot;E</td>
</tr>
<tr>
<td>7129/10-U-02</td>
<td>1987</td>
<td>71°07'13.5&quot;N 29°13'23.1&quot;E</td>
</tr>
<tr>
<td>7029/03-U-01</td>
<td>1987</td>
<td>70°48'36.2&quot;N 30°44'31.1&quot;E</td>
</tr>
<tr>
<td>7029/03-U-02</td>
<td>1988</td>
<td>70°56'07.0&quot;N 29°58'53.6&quot;E</td>
</tr>
<tr>
<td>7127/10-U-03</td>
<td>1988</td>
<td>71°10'55.0&quot;N 27°11'02.4&quot;E</td>
</tr>
<tr>
<td>7127/10-U-02</td>
<td>1988</td>
<td>71°09'39.5&quot;N 27°05'26.8&quot;E</td>
</tr>
<tr>
<td>7029/03-U-01</td>
<td>1988</td>
<td>70°54'10.2&quot;N 29°54'15.1&quot;E</td>
</tr>
</tbody>
</table>
Table 2. Eight Palaeozoic cores were drilled on the Finnmark Platform in 1987 and 1988, with a total length of ca. 800 m. Average core recovery was 91%.

<table>
<thead>
<tr>
<th>Core no.</th>
<th>Seismic line</th>
<th>Shotp.</th>
<th>Water depth (m)</th>
<th>Quat. overburden (m)</th>
<th>Penetr. in bedrock (m)</th>
<th>Tot. penetr. below seabed (m)</th>
<th>Core length (m)</th>
<th>Core recovery (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7128/12-U-01</td>
<td>IKU-01-88 (dig)</td>
<td>998.8</td>
<td>409</td>
<td>62.5</td>
<td>97.7</td>
<td>160.2</td>
<td>73.8</td>
<td>75.6</td>
</tr>
<tr>
<td></td>
<td>IKU-01-87 (an)</td>
<td>256.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7129/10-U-01</td>
<td>IKU-03-87 (dig)</td>
<td>1295.0</td>
<td>382</td>
<td>55.4</td>
<td>37.9</td>
<td>93.3</td>
<td>34.9</td>
<td>92.3</td>
</tr>
<tr>
<td></td>
<td>IKU-03-88 (an)</td>
<td>358.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7129/10-U-02</td>
<td>IKU-03-87 (dig)</td>
<td>1683.0</td>
<td>336</td>
<td>30.3</td>
<td>89.6</td>
<td>119.9</td>
<td>85.7</td>
<td>95.6</td>
</tr>
<tr>
<td></td>
<td>IKU-03-88 (an)</td>
<td>466.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7030/03-U-01</td>
<td>IKU-103-88 (an)</td>
<td>ca 10160.0</td>
<td>308</td>
<td>26.3</td>
<td>147.4</td>
<td>173.7</td>
<td>143.6</td>
<td>97.4</td>
</tr>
<tr>
<td></td>
<td>IKU-10-87 (dig)</td>
<td>164.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7029/03-U-02</td>
<td>IKU-07-88 (dig)</td>
<td>ca 1692.8</td>
<td>308</td>
<td>11.9</td>
<td>189.1</td>
<td>201.0</td>
<td>180.9</td>
<td>95.7</td>
</tr>
<tr>
<td></td>
<td>IKU-07-87 (an)</td>
<td>461.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7127/10-U-03</td>
<td>IKU-102-88 (dig)</td>
<td>2919.9</td>
<td>264</td>
<td>74.9</td>
<td>78.1</td>
<td>153.0</td>
<td>56.8</td>
<td>72.6</td>
</tr>
<tr>
<td></td>
<td>IKU-102-88 (an)</td>
<td>2916.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7127/10-U-02</td>
<td>IKU-102-88 (dig)</td>
<td>ca 3245.0</td>
<td>279</td>
<td>69.0</td>
<td>131.2</td>
<td>200.2</td>
<td>126.5</td>
<td>96.4</td>
</tr>
<tr>
<td></td>
<td>IKU-102-88 (an)</td>
<td>ca 3242.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7029/03-U-01</td>
<td>IKU-07-88 (dig)</td>
<td>2060.4</td>
<td>366</td>
<td>71.2</td>
<td>93.4</td>
<td>164.6</td>
<td>83.6</td>
<td>89.5</td>
</tr>
<tr>
<td></td>
<td>IKU-07-87 (an)</td>
<td>560.1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sum average       864.4  1265.9  785.8  90.9

Fig. 2. Geological map of the Finnmark Platform based mainly on 1100 km of high resolution seismic data and on the IKU shallow drillings. Annotated seismic lines are shown in other figures.
drilled cores overlap stratigraphically and give information about lateral facies changes in the area. Two of the eight Palaeozoic cores (7128/12-U-01 and 7129/10-U-01) penetrated the Permian/Triassic contact. Core 7029/03-U-01 was drilled through Lower Carboniferous rocks and some metres into the underlying Precambrian basement. During the drilling in 1988, downhole petrophysical logging was performed in all holes, including gamma, sonic, density and neutron porosity. In addition, dipmeter logging was done in holes 7127/10-U-02 and 7128/12-U-01. The three cores drilled in 1987 (7030/03-U-01 and 7129/10-U-01 & -02) were only logged in the laboratory by direct measurements on the cores. These analyses included spectral and total gamma, horizontal sound velocity and thermal conductivity.

The 16 biozones established for the present study (Table 3) are based on palynology for the Lower Carboniferous succession. The zones referred to are all correlated to the European miospore zonation of Clayton et al. (1977), which proved to be a useful tool in the study area. The Middle/Upper Carboniferous and Lower Permian succession is dated by fusulinids. The fusulinid assemblage zones referred to are defined by Nilsson (1993), who also provides circum-arctic correlations. For the Upper Permian and lowermost Triassic succession, palynostratigraphic zones are defined by Mangerud (1994), who correlates these with established palynostratigraphic zones in the Sverdrup Basin in the Canadian Arctic.

**Definition of seismic units**

The shallow seismic data, recorded to 2.5 seconds, have a vertical resolution of 5–7 ms, allowing identification of seismic units down to thicknesses of 7–10 m. Using the core description and analyses of the petrophysical logs, a detailed correlation between each of the cores and the high resolution seismic data has been made. Regional seismic units and reflectors have been correlated through most of the area; other seismic units have been followed only locally.

Seismic interpretation in combination with sedimentological and biostratigraphical correlation has made it possible to arrange the eight Palaeozoic cores in stratigraphic order and to identify overlaps and non-cored gaps. The resulting composite log of the overall cored succession shows the main seismic units and regional reflectors (Fig. 3). The same reflectors are shown on seismic line IKU-07-88 (Fig. 4), where cores 7029/03-U-01 & -02 were drilled. The four other cores have been projected onto this line to show their relative position and the total stratigraphic coverage. Two Lower Carboniferous (Viséan) cores (7127/10-U-02 & -03, Fig. 5) were drilled in a local sedimentary basin in the western part of the study area and could not be projected onto this line.

**Viséan I seismic unit**

The lower boundary of this unit gives strong reflections in the inner part of the study area and weaker reflections farther out (red–brown, Figs. 4, 5, 6, 7). These are caused by a slight increase in sound velocity and a more abrupt increase in density. The lower boundary corresponds to the top of the basement. The upper boundary is a strong seismic reflector in the inner part of the study area, but is not possible to identify in the outer part. It corresponds to the top of an upper Viséan limestone (blue), which represents a high velocity and high density layer.

In the east this seismic unit is slightly thinner downdip and is too thin to reveal any internal reflection pattern. In the west it is thicker and shows a progradational pattern with an ENE dip. The corresponding cored unit mainly comprises continental deposits, but in the east the lower part of the marine upper Viséan succession of core 7029/03-U-01 is also included. The cored succession is about 20 m thick in the east, but approximately 650 m near drill sites 7127/10-U-02 and -03 in the west (Fig. 7), due to local basin development (Fig. 8).

**Viséan II seismic unit**

The seismic reflections from the top of this unit are caused by marked peaks in sound velocity and density and correspond to the top of an upper Viséan marine shale (orange reflector, Fig. 3). The reflector can only be identified locally around drill site 7029/03-U-01 in the eastern part of the study area (Fig. 6).

This seismic unit is acoustically transparent and shows some thickness variations close to subcrop. The unit continues basinwards, but is there more diffuse, due to weakening of the top reflector. It corresponds to a 25 m thick unit of upper Viséan marine shale in core 7029/03-U-01 and is restricted to the eastern parts of the study area (Fig. 8), but probably extends northwards and eastwards into the Russian Barents Sea and Timan–Pechora area.

**Viséan III seismic unit**

The top of this unit is defined by a fairly strong and continuous seismic reflector (purple), caused by downward decrease in density. It corresponds to the top of upper Viséan shoreface sandstones in core 7029/03-U-01 (Figs. 3, 4, 6). The reflector can be traced laterally for about 10 km northwestwards and for more than 50 km towards the southeast.

The unit appears with scattered, parallel seismic reflections and shows a thickening trend downdip. The corresponding cored unit is 20 m thick in the eastern part of the study area, where it subcrops below Quaternary sediments (Fig. 6). Westwards, the unit is truncated by a Kasimovian erosional event and therefore subcrops (below younger Carboniferous rocks) farther offshore in the
Fig. 3. Composite log showing the cored Carboniferous–Permian succession on the Finnmark Platform. With the exception of about 100 m in the mid-Carboniferous, the entire sedimentary succession has been cored. Some laterally equivalent cores display local variations. The colours separating the seismic units correspond to colours used on seismic reflectors in other figures. Colours are also used to enhance the lithological subdivision: green, yellow, orange for clastics, blue for carbonates, purple for evaporites. Lithological legend in Fig. 5.
Fig. 4. Seismic line IKU-07-88 showing the defined seismic units (see location in Fig. 2 and correlation with Fig. 3). Cores 702-03-U-01 & -02 were drilled on this line, while the remaining cores have been projected in accordance with their stratigraphic position. Most of the seismic units can be correlated throughout the study area.
The Lower and Middle Carboniferous seismic units cannot be resolved in the west, due to lack of core control.

**Serpukhovian seismic unit**

The seismic unit is bounded upwards by a regional seismic reflector representing an angular unconformity (brown reflector, Figs. 4, 6). This boundary has not been cored and can only be observed in seismic data in the eastern part of the area.

The unit is characterized by several scattered reflections and by a few discontinuous reflections, subparallel to the top and base of the unit. Total thickness is approximately 50 m in the east, where the lower part is represented by coastal plain deposits in core 7029/03-U-01 (Fig. 3). The upper part comprises some of the undrilled interval between cores 7029/03-U-01 & -02.

**Bashkirian seismic unit**

The upper boundary gives partly discontinuous seismic reflections (green, Fig. 6), traceable only in the eastern part of the study area. It is represented by the top of Middle Carboniferous flood-plain deposits in the cored section.

The seismic unit is approximately 60 m thick and becomes slightly thicker downdip. In common with the three Lower and Middle Carboniferous units, it is truncated in the central part of the study area by the Late Carboniferous (Kasimovian) erosional event and cannot be followed continuously from east to west. This unit and the overlying Middle Carboniferous seismic unit are characterized by a few continuous and several short and discontinuous reflections, which become stronger and more continuous basinwards (Figs. 3, 4). The upper part of the unit corresponds to the lowermost part of core 7029/03-U-02, comprising flood-plain sandstone deposits.

**Middle Carboniferous seismic unit**

The upper reflector (yellow) of this unit represents an angular unconformity caused by the regional Kasimovian erosional event (Figs. 4, 9). It corresponds to the top of a conglomerate at 102.7 m in core 7029/03-U-02 (Fig. 10) displaying velocity and density peaks.

The unit has a similar appearance to the underlying Bashkirian seismic unit, with some continuous and several short and discontinuous reflections. It is approximately 90 m thick in core 7029/03-U-02 (Fig. 10) in the east where it was penetrated at subcrop. A seismic reflector is observed within the middle part of the unit (at 134 m in core 7029/03-U-02, orange in Figs. 4, 6). Owing to extensive erosion of the top of this seismic unit, the thickness of the succession above this internal seismic reflector increases more than three times basinwards. The thickness of this wedge-shaped Middle Carboniferous seismic unit increases accordingly from 90 m in the inner part to more than 150 m 10 km farther out.

**Kasimovian-Gzhelian seismic unit**

The upper boundary is a strong and continuous seismic reflector corresponding to a surface later described as a karst surface on top of open marine boundstones (pink reflector, Figs. 3, 6). The boundstone has sound velocities in excess of 6000 m/s (cores 7029/03-U-02 and 7030/03-U-01, Fig. 10). This marked reflector probably masks the reflections from the clastic/carbonate transition, approximately 20 m below the karst surface.

The unit is approximately 40 m thick in the eastern part of the area and is there too thin to reveal any internal reflection pattern. It increases to about twice the thickness in the west, and several irregular and discontinuous reflections can be observed. Some mounded seismic features interpreted as buildups occur in the upper part in the outer part of the study area (Fig. 11). The corresponding cored unit comprises the transition from dominantly clastic rocks to carbonates (Figs. 3, 10).

**Gzhelian seismic unit**

The upper bounding reflector (red) is strong and can easily be traced laterally throughout the study area, but becomes weaker downdip (Figs. 4, 11). The boundary corresponds to the top of an anhydrite layer (Fig. 3), and the attenuated reflections downdip are interpreted to represent change in facies.

This carbonate-dominated unit has a constant thickness of 50–60 m throughout the area. Some irregular and discontinuous reflections occur in the updip parts of this unit, while several buildup-like features can be seen downdip (Fig. 11). The upper boundary formed by the anhydrite layer seems to disappear in the area where the buildups occur, and this seismic unit cannot therefore be distinguished from the overlying unit in the outer part of the Finnmark Platform.

**Asselian I seismic unit**

The upper bounding reflector is characterized by strong and continuous seismic reflections (blue, Fig. 3), caused by a marked velocity contrast on top of carbonate-dominated Asselian rocks (88 m in core 7129/10-U-02, Fig. 10).

Internal reflectors are partly discontinuous in updip parts, but become more even and continuous downdip (Fig. 14). Buildups occur downdip in the lower part of the unit (Fig. 11). The cored section (cores 7030/03-U-01 and 7129/10-U-02) of this seismic unit is 50 m thick in the east and increases to 100 m westwards. Downdip it may be up to 500 m thick.
Asselian II seismic unit

The upper boundary gives strong and continuous seismic reflections (light brown, Figs. 4, 11), which are caused by a marked drop in sound velocity corresponding to the downward transition from carbonate to shale-dominated Sakmarian rocks (64 m in core 7129/10-U-02, Fig. 10).

A fairly strong and continuous reflector can occasionally be observed within this unit, which is generally characterized by its strong lower and upper bounding reflectors. The corresponding cored unit is dominated by clastic rocks, but with some carbonate influence. The thickness of 25 m in the middle part of the area, where the unit was cored, seems to be constant throughout with only a minor increase eastwards.

Sakmarian–Artinskian seismic unit

Strong and continuous seismic reflections on top of this unit (dark blue, Figs. 4, 11) are caused by an increase in sound velocity of more than 3000 m/s from the overlying rocks. This coincides with the top of the Artinskian limestone (Fig. 3).

No internal reflections can be observed between the strong reflections from the lower and upper bounding surfaces. The unit is penetrated by cores 7129/10-U-02, 7129/10-U-01 and 7128/12-U-01 and is dominated by limestones with some clastic rocks occurring in the lower part (Figs. 10, 12, 13). The seismic unit is about 45 m thick at the drilling location and shows only a slight increase in thickness eastwards. The upper boundary of this seismic unit corresponds to the Gipsdalen/Templefjorden Group transition and represents a mid-Permian tectonic event that can be recognized throughout the Arctic (e.g. Doré 1991).

?Kungurian–Ufimian seismic unit

The seismic reflections defining the top of this unit are caused by a negative impedance contrast, i.e., lower sound velocity and density below the boundary. The reflector (green) corresponds to the transition from ?Kungurian–Ufimian clastic rocks to overlying Kazanian limestone (Fig. 13).

Owing to the thickness of only 7 ms two-way time (9 m), this unit can only be resolved in the single channel seismic data. It was penetrated by the laterally equivalent cores 7129/10-U-01 and 7128/12-U-01 (Fig. 14) and seems to have a constant thickness throughout the area.

Kazanian–Tatarian seismic unit

The top reflector (purple, Figs 4, 11) coincides with a slight downward increase in sound velocity (at ca. 119 m in core 7128/12-U-01, Fig. 13). Immediately below (ca. 124.5 m), there is a more drastic increase which seems to cause stronger reflections. The reflections from these two levels generally tend to coincide, but in some places downdip the upper reflector tends to split and form mound-like features (Fig. 11).

The upper boundary corresponds to the top of Kazanian–Tatarian limestone (Fig. 13), close to top Permian, and is a good seismic reflector which can be observed over most of the Barents Sea. The lower boundary can be identified in the high resolution single channel seismic data, but is commonly masked by the top Permian reflector in multichannel seismic data.

Lower Triassic seismic unit

In updip parts the upper boundary is a strong reflector (dark brown) which follows the top of a prograding seismic unit (Fig. 4). It becomes more diffuse downdip.

The unit comprises a series of cliniforms that downlap on the basal surface (Fig. 4). Total thickness of the unit is approximately 120 m, and it was penetrated only in the lower part (cores 7128/12-U-01 and 7129/10-U-01, Figs. 13, 14).

Description of cored units

Early Carboniferous (Viséan) land-shelf transition

Lower Carboniferous rocks were cored in three of the shallow drillings on the Finnmark Platform. Core 7029/03-U-01 was drilled in the eastern part of the study area and penetrated 93.5 m of bedrock (Fig. 5), below 70 m of Quaternary glacial clay and till. The lower 15 m in this core consisted of low grade (green schist) metamorphic sandstones correlated to the allochthonous Precambrian Berlevåg Formation of the Kalak Nappe Complex present on the neighbouring mainland (Anna Siedlecka, pers. comm. 1989). The upper 12 m of the metamorphic sandstone are weathered, with kaolinite development in the uppermost few metres, reflecting humid tropical/temperate climatic conditions. Cores 7127/10-U-02 & -03 in the west (close to Nordkapp, the northernmost point in Norway) indicate the presence of a local Carboniferous basin on the downfaulted side of a SSW–NNE striking fault (Fig. 2).

The oldest part of the sedimentary succession on the Finnmark Platform is recorded in core 7029/03-U-01 (Fig. 7). The unit, representing the lower part of the Viséan I seismic unit (Fig. 3), is 15 m thick and consists of continental conglomerates, sandstones and siltstones directly resting on and onlapping the basement. This clastic succession has an overall fining-upward trend comprising stacked fining-upward units, a few metres thick, interrupted by one coarsening-upward unit. The succession is interpreted to represent braided river deposits (Fig. 9a), where the coarsening-upward unit may be infill of a local pool on the braid plain. The rocks are virtually barren of microfossils, but palynomorphs suggest a general Viséan age (biozone I, Table 3).
Fig. 5. Logs showing the three Lower Carboniferous cores from the Finnmark Platform. For location, see Figs. 2 and 8. The internal stratigraphic relation between these cores is shown in Fig. 7.
Lateral equivalents to these continental deposits were probably encountered in cores 7127/10-U-02 & -03, which were drilled 100 km further to the northwest (Fig. 2). These cores are separated by a non-cored stratigraphic interval of approximately 175 m (Fig. 7), and both comprise poorly lithified coarse to fine-grained quartz-arenitic sandstone beds separated by siltstone and coal beds (Fig. 9b). Massive to laminated fine-grained sandstone beds are commonly strongly disrupted by root structures. The cores represent crevasse channel and crevasse splay sediments deposited in a flood-plain setting in a humid and tropical climate. Dipmeter readings of cross-stratifications show an ENE dip. The flood plain was probably governed by a meandering river sourced from the mainland, flowing northeastwards parallel to the basin axis. From seismic data it can be inferred that the same depositional regime probably also existed during deposition of the succession between the two cores, implying that the flood-plain deposits comprise at least 380 m of the 650 m thick Lower Carboniferous succession here. A local palaeogeographic reconstruction shows a northeast-flowing river creating the flood plain represented by cores 7127/10-U-02 and -03 (Fig. 8). The river entered the sea immediately east of Nordkapp, where the local palaeo-coastline roughly paralleled the present coastline with probably only minor fluctuations through Late Palaeozoic time. From palynology a late Viséan age is indicated for these flood-plain deposits (biozone II, Table 3). A chronostratigraphic correlation with the lowermost part of the marine succession in core 7029/03-U-01 is suggested (Fig. 7).

On top of the upward-fining continental clastic unit in the lower part of core 7029/03-U-01 is a 10 cm thick shale bed (at about 135 m), seen as a peak (> 300 API) in the gamma log (Fig. 5). This unit forms the base of a 5 m thick carbonate unit and represents a transgression that marks the onset of marine conditions in the area. The basement reflector and the top of the limestone unit can be determined on the seismic profiles. This lower...
Viséan I seismic unit (below top carbonate) is hard to trace downdip, where the resolution of the seismic data is reduced (see Fig. 4). The carbonate unit comprises intensely bioturbated sandy dolomites, partially dolomitized mudstones and wackestones, and mud-/wackestones with thin shale partings. Large oncolites (up to 5 cm) are common in the limestone (Fig. 9c). They commonly show a complex structure resulting from repeated vertical growth and collapse of columnar stromatolites. The wackestone contains cement-filled moulds of (?sponge) spicules as well as algal laminae, gastropods, brachiopods, bivalves, trilobites, foraminifera and crinoids. Both the palynomorphs and the microfauna suggest a middle to late Viséan age. The limestone unit is interpreted to represent a low-energy shelf environment within the photic zone, deposited during the continued transgression.

The carbonates are overlain by a 23 m thick coarsening-upward succession of dark grey silty shale (Fig. 9d) representing the Viséan II seismic unit (Fig. 3). The lowermost part of the shale contains a low density and low diversity ichnofabric, dominated by the ichnogenus *Chondrites*, which may indicate low oxic conditions (e.g., Bromley & Ekdale 1984). Upwards, the shale is characterized by high diversity and high density fully marine ichnofabric. Some of the burrows were filled by early diagenetic pyrite and siderite nodules. The shale also contains abundant bivalves, different types of brachiopods, ammonoids, gastropods, trilobites, crinoids and rugose corals. The organic matter content is 3–4%, with a dominance of terrestrially derived plant material. The depositional environment of this shale unit is interpreted to have been a quiet marine basin with a stratified anoxic/dysoxic to oxic water column with a strong influx of terrestrial plant debris derived from a nearby land area. The palynomorph dating suggests a late Viséan age for the shales (biozones II and III, Table 3), which is supported by brachiopod ages (C.H.C. Brunton, written comm. 1988).

The slight regressive trend recorded in the shale unit continues upwards with a rapid shift to sand deposition on top of the shale (Fig. 9c). This boundary corresponds to a seismic reflection (orange, Figs. 4, 6) that can be traced basinwards for a distance of 8–10 km. The sandstone unit, which is 22 m thick, represents the Viséan III seismic unit. It consists of two coarsening-upward successions separated by dark grey siltstones. The sandstone contains horizontal and low-angle trough cross-lamination and wave ripples. These primary structures are sometimes cut by escape burrows, probably developed during periods of rapid deposition. The depositional environment is believed to represent a continued regression from a lower shoreface to upper shoreface/foreshore setting.

The shallow marine sandstone is abruptly overlain by yellowish and greyish brown, mottled silty shales with abundant root structures and coaly beds and thin, fining-upward sandstone units, representing deposition on a
coastal, partly vegetated, plain with small creeks in a semi-arid climatic setting (Fig. 9f). This interval represents the lower part of the Serpukhovian seismic unit (Fig. 3). Palynomorphs indicate an early Serpukhovian age (biozone V, Table 3).

The succession in cores 7127/10-U-02 & -03 and parts of core 7029/03-U-01 (Fig. 5) is comparable to the Billefjorden Group in Svalbard. The Billefjorden Group is characterized by quartz arenites, black shales and coals (Harland et al. 1976; Gjelberg 1981; Gjelberg & Steel 1981; Steel & Worsley 1984), deposited in various types of alluvial settings in a humid and tropical climatic environment. Lacustrine deposits of the Viséan Svenbreen Formation on Spitsbergen are exceptionally rich on kerogen type I and II (40% TOC), making them an excellent source rock for hydrocarbons (Nettvedt et al. 1992b). A major difference between Svalbard and the study area is, however, that a late Viséan transgression reached the latter area from the east/northeast, resulting in the marine carbonate and shale succession in core 7029/03-U-01 (Fig. 5). No signs of marine incursions are recorded in this part of the succession on Spitsbergen or Bjørnøya, while the transgression probably opened the seaway from the Timan–Pechora Basin to the Finnmark Platform. Furthermore, it also probably established open marine conditions in the Nordkapp Basin area where organic-rich facies may also have been deposited. The organic matter of the shale is dominated by kerogen type IV, due to its proximal position (Fig. 8). In a more distal setting, however, this shale could represent a possible source rock for hydrocarbons. The continental deposits of the Serpukhovian seismic unit (above 86 m in core 7029/03-U-01) probably do not have any equivalents on Bjørnøya/Spitsbergen. They seem to represent a more continuous sedimentary succession on the southern Finnmark Platform than on Bjørnøya/Spitsbergen (Fig. 15). They also contain sedimentary elements characteristic both for the Billefjorden Group (coal and common root structures) and the Gipsdalen Group (brownish-mottled sediments) reflecting a probable gradual transition between the two groups.

Carboniferous coastal clastics to carbonate transition

The clastic Middle/Upper Carboniferous succession on the Finnmark Platform is represented by part of the undrilled interval between cores 7029/03-U-01 & -02 and the lower 120 m of core 7029/03-U-02 (Figs. 3, 10). The whole interval has been divided into three seismic units, with the base defined by a strong and regional reflector corresponding to an angular unconformity recognized throughout the east of the study area (brown reflector, Fig. 4). The unconformity probably represents a tectonic event, and although the datings are poor in this part of the succession, it is tentatively correlated with the Bashkirian rifting event described from the western Barents Sea and the Norwegian–Greenland Sea (Harland et al. 1974; Gjelberg & Steel 1981; Håkansson & Stemmerik 1984; Cippitelli 1990; Nøttvedt et al. 1992a).

A thick syntectonic sediment package related to this rifting is observed in seismic data elsewhere in the Barents Sea (seismic unit K2 of Nøttvedt et al. 1992a). The Bashkirian seismic unit is represented by the lower 10 m of core 7029/03-U-02 (201.0–190.6 m) which comprises fining-upward medium to coarse-grained, often cross-bedded sandstones (Fig. 10), separated by red-brown and greenish mottled siltstones (Fig. 9g). The depositional environment is interpreted as a semi-arid flood plain with coarse-grained, probably braided-river deposits.

The clastic succession continues up to 84.3 m in core 7029/03-U-02 (Fig. 10), but a change to a marginal marine depositional environment takes place at 190.6 m. The overlying 105 m thick clastic succession belongs to the Middle Carboniferous and Kasimovian–Gzhelian seismic units (Fig. 3). Up to 118.7 m (Fig. 10) the succession consists of repeated 2–7 m thick fining-upward channel filling units. Mud and basement clasts occur at the bases of the fining-upward sandstone (Fig. 9h), while dolomite clasts, sometimes with concentric structures resembling pisolithic structures, occur with increasing abundance from approximately 145 m. Similar dolomite nodules are widespread in the siltstones and shales which separate the sandstones and thus document the erosive nature of the channel sandstones. Brachiopod fragments, Chondrites burrows and flaser bedding indicate a marine-influenced environment for these sediments, most likely a fan delta system with adjacent fine-grained embayment fill.

A conglomerate with common metamorphic basement clasts at 118.7 m represents a transition to a 16 m thick, more heterolithic facies comprising both fining- and coarsening-upward sandstone units with horizontal laminae and ripple and trough cross-bedding. Siltstones between the sandstones contain bivalve and brachiopod fragments and a high diversity ichnofabric including Chondrites. These sediments were probably deposited in a more distal marine environment compared to the sediments below, and the coarsening-upward units probably represent prograding delta lobes, while the fining-upward sandstones represent tidal flat/embayment fill or distributary channel fillings of a delta system.

The clastic succession of core 7029/03-U-02 is divided in two parts by a boundary at 102.7 m (Figs. 9i, 10). It seems to represent a regional tectonic event, recognized as an angular unconformity in the seismic data (yellow reflector, Fig. 4). Based on Kasimovian dating of the sediments above the unconformity, a Kasimovian age is suggested for the erosion, although a late Moscovian age cannot be excluded. The seismic reflection marks the boundary between the Middle Carboniferous and the Kasimovian–Gzhelian seismic units. The erosion related to this event was most extensive on the south of the Finnmark Platform, with a hiatus in the central part of the study area. In the core, this erosion is probably
Table 3. Biozones for the Upper Palaeozoic succession on the eastern Finnmark Platform.

<table>
<thead>
<tr>
<th>Biozone</th>
<th>Characteristics</th>
<th>Age</th>
</tr>
</thead>
</table>
| I       | Lycospora pusilla assemblage  
Characteristic species: L. pusilla and Compsatitoxa labiata  
Comments: The association has a very low diversity  
Age: Indeterminate Visean, possibly late Visean |
| II      | Peritritles tessellatus, Schulzospora campylotoidea – Diatomozonotrites saetousus and Raistrickia nigra – Potoniespore delicatus assemblage zones  
Characteristic species: Crassispora aculeata, P. tessellatus, P. delicatus, R. nigra, S. campylotoidea, Triquitrites marginatus, Verrucosporites baccatus, Waltzispora planispinula  
Comments: The biozone includes two concurrent range palynomorph assemblages that are correlated with the European TC & NM miospore zones of Clayton et al. (1977). Brachiopods including Tornquistia polita and Eomarginifera trispina  
Age: late Visean |
| III     | Raistrickia nigra – Triquitrites marginatus and Tripartites vetustus – Rotaspora fracta zones  
Comments: The biozone seems to correlate with the VF miospore zones of Clayton et al. (1977). |
| IV      | late Visean |
| V       | Tripartites/Triquitrites, Schulzospora spp., Waltzispora spp. abundance zone.  
Characteristic species: Common occurrences of Tripartites, Triquitrites, Schulzospora spp. and Waltzispora spp.  
Comments: The zone seems to correlate with the European NC miospore zone of Clayton et al. (1977)  
Age: late Visean to early Serpukhovian |
| VI      | early Serpukhovian |
| VII     | Rugosofusulina ex. gr. priscac – Pseudofusulinella usvae zone  
Characteristic species: Rugosofusulina ex. gr. priscac, Pseudofusulinella usvae  
Age: late Kasimovian/early Gzhelian |
| VIII    | Schellwienia sp. A – Rugosofusulina praevia zone  
Characteristic species: Schellwienia sp. A, Rugosofusulina praevia, Jigulites longus mukronatus, Pseudofusulinella usvae, Rugosofusulina flexuosa  
Age: middle –late Gzhelian |
| IX      | Schellwienia sp. A – Rugosofusulina praevia zone  
Characteristic species: Schellwienia sp. A, Rugosofusulina praevia, Jigulites longus mukronatus, Pseudofusulinella usvae, Rugosofusulina flexuosa  
Age: middle –late Gzhelian |
| X       | Rugosofusulina ex. gr. priscac – Pseudofusulinella usvae zone  
Characteristic species: Rugosofusulina ex. gr. priscac, Pseudofusulinella usvae  
Age: late Kasimovian/early Gzhelian |
| XI      | early Serpukhovian |
| XII     | late Asselian |
| XIII    | late Asselian |
| XIV     | late Asselian |
| XV      | late Asselian |
| XVI     | late Asselian |
| XVII    | late Asselian |
| XVIII   | early Sakmarian |
| XIX     | early Sakmarian |
| XX      | early Sakmarian |
| XXI     | early Sakmarian |

Continued over →
represented by two conglomerate beds with extrabasinal clasts. It is overlain by a one-metre-thick dolomite bed with anhydrite-filled moulds, which probably represents a sabkha environment that developed during the initial stage of transgression. The top of this bed represents the seismic marker recognized as the regional erosional event in seismic data, although the base of the conglomerate three metres below (105.9 m in core 7029/03-U-02) probably represents the onset of erosion.

The carbonate bed at 102.7 m is overlain by a coarsening-upward unit with bioturbated siltstones at the base, and further by fossiliferous medium-grained, carbonate-cemented sandstones. Brachiopods, bivalves, corals and crinoids as well as fusulinids occur in the upper 3 m of the clastic part of the Kasimovian–Gzhelian seismic unit (biozone VI, Table 3). Similar rocks are recorded in the lower part of core 7030/03-U-01 (from TD at 173.7 m to 155.4 m; Fig. 10). The upper boundary of the Kasimovian–Gzhelian seismic unit is represented by a seismic reflection (pink) which is so strong that it masks the reflection from the base of the carbonates. It coincides with a karst surface approximately 20 m above the base of the carbonate-dominated Upper Carboniferous succession (Fig. 9). These 20 m of rock show a complex lithofacies development and consist of fossiliferous, coarsening-upward shales to sandstones representing prograding shoreline deposits. Algal-laminated dolomites with enterolithically folded anhydrite beds probably represent sabkha deposits. Furthermore, Palaeoaplysina-phyllloid algal boundstone reefs occur in a few metres thickness. Dating of the Kasimovian–Gzhelian seismic unit is based on fusulinids (biozone VI, Table 3), and the unit is interpreted to represent progradation from shallow shelf to shoreline environment following the Kasimovian transgression.

The succession in the lower part of core 7029/03-U-02, corresponding to the ?Bashkirian seismic unit, closely resembles the Landnordingsvika and Ebbadalen Formations on Bjørnøya and Spitsbergen, respectively (Fig. 3). The base of the unit seems to correspond to the Bashkirian rifting event. As on Bjørnøya and Spitsbergen, the transition from the underlying succession represents a dramatic shift which reflects change from a humid to a semi-arid climate (Gjelberg 1981; Gjelberg & Steel 1981; Johannesen & Steel 1992), but it is also important to note that the transition from the Billefjorden Group to the red bed facies is gradual, and therefore not easy to distinguish exactly, even in outcrop exposures (Gjelberg 1981).

The succession corresponding to the Middle Carboniferous and the Gzhelian–Kasimovian seismic units (Fig. 3) reflects a slow and overall transgressive development, coinciding with flattening of the hinterland and resulting in a gradual change from proximal fan delta deposits to subtidal mudstones and shoreface/tidal flat sandstones, sabkha dolomites and Palaeoaplysina-phyllloid algal reefs. Similar development is seen in the Carboniferous strata on Spitsbergen (Gjelberg & Steel 1981; Johannesen...
Upper Palaeozoic, Finnmark Platform
& Steel 1992). The clastic succession from 190.6 m up to the unconformity at 102.7 m in core 7029/03-U-02 (Middle Carboniferous seismic unit) is probably time equivalent with the Kapp Kåre Formation on Bjørnøya (Fig. 15). However, the lithology is different, as carbonates dominate on Bjørnøya (Worsley & Edwards 1976).

The boundary between the Kapp Kåre Formation and the overlying late Moscovian–Kasimovian Kapp Hanna Formation on Bjørnøya is represented by intraformational conglomerates overlain by extraformational conglomerates of the Kapp Hanna Formation (Worsley & Edwards 1976). We suggest the regional erosional event recorded at the base of the two conglomerate beds below Kasimovian-dated strata in core 7029/03-U-02 on the Finnmark Platform to correspond to this boundary (Fig. 15). This implies that the clastic part of the Kasimovian–Gzhelian seismic unit corresponds to the Kapp Hanna Formation. The Middle Carboniferous unit is probably time equivalent with the Kapp Kåre Formation, but with a different lithology, while the lower seismic unit correlates with the Landnøringsvika Formation (Figs. 3, 15).

Late Carboniferous–Early Permian lagoonal to shelf carbonates

The Upper Carboniferous–Lower Permian carbonate-dominated succession on the Finnmark Platform has been penetrated by the upper part of core 7029/03-U-02, core 7030/03-U-01, core 7129/10-U-02 and the lowermost parts of cores 7129/10-U-01 and 7128/12-U-01 (Figs. 10, 13). The succession has been divided into four seismic units bounded by strong and continuous seismic reflections, although more discontinuous in the updip parts (Figs. 3, 4, 11).

The lower of the four seismic units in the Upper Carboniferous–Lower Permian succession, the Gzhelian seismic unit (Fig. 3), is represented by two cores, 7029/03-U-02 and 7030/03-U-01, and has thicknesses of 53 and 64 m, respectively. The basal reflector (pink) coincides with the karst surface 20 m above the base of the carbonate succession (Fig. 9). The carbonate rocks below this reflector consist of two buildups separated by a thin clastic interval. The upper bounding reflector of this lowest carbonate (Gzhelian) unit represents the top of an anhydrite layer which is 7–8 m thick (Fig. 3). Fusulinids indicate a middle/late Gzhelian to late Gzhelian/early Asselian age for this seismic unit (biozones VII and VIII, Table 3).

The carbonate-dominated Asselian I seismic unit (Fig. 3) is approximately 50 m thick and has its base on top of the anhydrite layer. Its upper boundary is represented by a strong and consistent reflector (blue) corresponding to the change from dolomites to clastics at 88.3 m in core 7129/10-U-02 (Fig. 10). This seismic unit has been dated by fusulinids (Fig. 9q) and a latest Gzhelian/early Asselian to late Asselian age is indicated (biozones VIII–XI, Table 3).

The rocks forming the two lower seismic units comprise limestones, dolomites, evaporites and clastics and contain calcitic and dolomitic phylloid algal-Palaeoaplysina buildups. They represent shallow marine depositional environments related to arid shorelines like hypersaline lagoons, tidal flats/sabkhas as well as sheltered areas with clastic deposition on the landward side of Palaeoaplysina-phylloid algal buildups.

The following sedimentary facies are recognized in the Gzhelian and Asselian I seismic units:

Marine clastics occur primarily in the lower 20–40 m, mainly as a few metres thick, stacked, coarsening-upward units grading from shales to fine-grained sandstones. Fragments of brachiopods, crinoids, small foraminifers and fusulinids together with a high diversity ichnofabric, including the ichnogenus Zoophycos, suggest repeated shoreline progradations on a few metres deep lagoon/shelf.

Palaeoaplysina-phylloid algae buildups occur in thicknesses ranging from a few decimetres up to 4 m in the cored upper Kasimovian to upper Asselian succession (Figs. 9j, k), and some of the reefs are stacked on top of one another with total thickness of up to 10 m. Seismic data show that the reefs were probably formed on small structural highs close to the local shelf breaks. Further offshore, larger mounds interpreted as buildups can be recognized on seismic sections of the two lower carbonate-dominated seismic units (Fig. 11). Most of the cored reefs consist of wackestone and packstones, while boundstones are only present locally, particularly in the upper part of the individual buildup. The fossil faunas in the buildups include, in addition to phylloid algae and the enigmatic fossil Palaeoaplysina, brachiopods, fenestellid and ramose bryozoans, bivalves, scattered fragments of tubular algae fusulinids and tabular encrusting foraminifera, echinoids, gastropods, ostracods, Tubiphytes and algal laminae. This highly diverse fossil assemblage reflects shallow, open, low-energy, marine conditions. In this type of environment, sediments were trapped and stabilized by baffling of phylloid algae and bryozoans. Some marine cement occurs within the reefs, as isopachous fringes of inclusion-rich fibrous calcite replacement of probable former aragonite cement and as calcite neomorphism of peloidal high magnesium calcite cement. In addition, encrusting by tabular foraminifera, Tubiphytes and probably also Palaeoaplysina may have contributed to the stabilization of the reefs.

In the cored succession, the Palaeoaplysina-phylloid algal reefs are associated with open marine siliciclastics.

Fig. 10. Logs of three Carboniferous–Lower Permian cores. The relative stratigraphic positions of the cores are shown in the upper left sketch. For location of the cores, see Fig. 2. Legend in Fig. 5.
Upper Palaeozoic, Finnmark Platform

7029/03-U-02
Gamma
(Sonic
velocity mls)

7030/03-U-01
Gamma
(Sound velocity
(km/sec))
Fig. 11. High resolution multichannel seismic section of the Carboniferous-Permian succession. Buildups (blue) probably consisting of Palaeoaplysina-phylloid algae are abundant in the Gzhelian-Asselian succession. The origin of the mound-like features (purple) at top Permian level is uncertain. A subglacial channel is seen in the upper left. (See location of the line in Fig. 2).

(Fig. 9r), fossiliferous lagoonal dolomites, subaquatic anhydrite and sabkha dolomites with anhydrite nodules and beds. These facies associations reflect inner shelf conditions associated with arid shoreline deposits. They form shoaling-upward units, each a few metres thick, capped by subaerially exposed surfaces. Several of these units are vertically stacked and form regressive intervals less than 10 m thick. Seismic data show that the Gzhelian sequences form an overall prograding unit, while the Asselian I seismic unit is characterized by onlap. This

Fig. 12. Selected core photos of the Permian succession. Core width is approximately 5.0 cm and length of photos 17 cm. a: Crinoid-rich, bioturbated shelf wackestone, late Asselian (7129/10-U-02, 80.6 m); b: Crinoid-rich, high energy shelf packstone, Sakmarian (7129/10-U-02, 52.6 m); c: Shallow shelf grainstone, Artinskian (7129/10-U-01, 86.4 m); d: Subaerially exposed conglomerate with brachiopods, 'Kungurian–Ufimian' (7129/10-U-01, 74.8 m); e: Shallow shelf packstone overlain by a condensed phosphorite bed, Kazanian (7129/10-U-01, 66.5 m); f: Porous, spiculitic chert and a bluish chert nodule, Kazanian (7128/12-U-01, 119.9 m).
trend is interpreted to represent a shift from overall regression in the Gzhelian to transgression in the Asselian. The buildups of middle to late Gzhelian age have been subject to pervasive, early dolomitization. In these buildups the porosity is high and occurs as moulds after fossils and evaporite nodules, and as intercrystalline porosity and vugs and fractures in sucrosic dolomite. In limestone buildups the porosity is low because of extensive late diagenetic calcite cement.

Dolomitized wackestones/packstones are widespread in the Gzhelian seismic unit (Fig. 9m) and the lower half of the overlying Asselian I seismic unit. The dolomites are bioturbated and contain fragments of crinoids, fusulinids, brachiopods, bivalves and tabular algae as well as peloids and a few percent of sand and silt. Anhydrite nodules are common in this facies (Fig. 9n), which probably represents lagoonal to tidal flat environments in the protected areas between the buildups and the sabkhas.

Coarsening-upward skeletal dolomitic packstones occur in the upper half of the Asselian I seismic unit and are particularly common in the lower 30 m of core 7129/10-U-02. Rocks of this facies contain a diverse fossil assemblage including crinoids, brachiopods, fusulinids, tabular algae, corals and bryozoans. There are five coarsening-upward units, each 2–5 m thick, which are recognized by transition from wackestone to grainstones. This facies probably represents a shallow shelf environment.

Anhydrite occurs as a 7–8 m thick layer separating the Gzhelian and Asselian I seismic units in cores 7029/03-U-02 and 7030/03-U-01 (Figs. 9p, 10) and extends from a subcrop position close to the seabed out to the buildups farther out on the Finnmark Platform (Fig. 11), where it seems to fade out, most likely due to lateral facies shift. Anhydrite also occurs as nodules throughout the cored Gzhelian–middle Asselian interval. The facies probably represents subaqueous anhydrite replacement of former gypsum precipitated in lagoonal environments between the buildups.

Dolomite peloidal mudstones with anhydrite nodules/beds are common in both the Gzhelian and Asselian I seismic units and show a gradual transition from the underlying fossiliferous lagoonal dolomite. Algal laminae are common, while fossil fragments occur sporadically and are most commonly preserved as anhydrite-filled moulds. Anhydrite is present as nodules, locally replaced by calcite and native sulphur (Fig. 9o), and as enterolithically folded beds. This facies probably represents sabkha deposits.

In addition to the Gzhelian and Asselian I seismic units in the carbonate dominated succession, an additional unit has been recognized between the Asselian I and II seismic units in the eastern part of the study area. It is represented by two metres of wacke-/packstone in the top of core 7030/03-U-01, but seems to occur only locally in this part of the area.

The Asselian II seismic unit (Fig. 3) is approximately 25 m thick and corresponds to the clastic-dominated interval between 88.3 m and 63.7 m in core 7129/10-U-02 (Fig. 10). The lower boundary is represented by the abrupt change from limestones to calcareous shales in the upper Asselian succession. The upper boundary coincides with a level where the clastic content decreases significantly. The unit consists of greyish green bioturbated calcareous shales and marls in association with coarsening upward and fining-upward clayey wackestones (Fig. 12a). Based on fusulinids the seismic unit has been assigned a late Asselian–Sakmarian age (biozones XI and XII, Table 3). The abrupt change from shallow shelf carbonates with algae in the underlying Asselian I unit to calcareous shales and marls without algae reflects a change to a deeper basin setting with increased clastic input. The onset of the clastic sediments represents a transgression which resulted in establishment of generally deeper marine conditions during the Sakmarian throughout most of the Barents Shelf, and a shallow, warm water, marine biotic assemblage was replaced by more temperate water assemblages. This also resulted in the end of evaporite accumulation on the southern Barents Shelf, while evaporites were still precipitated on Spitsbergen (Steel & Worsley 1984).

The Sakmarian–Artinskian seismic unit extends to the top of the Artinskian carbonates. This interval is approximately 45 m thick and comprises most of the Sakmarian and the entire Artinskian succession. Dating is based on fusulinids (biozones XII and XIII, Table 3). The top Artinskian seismic reflector (dark blue) is strong and continuous in the entire area and corresponds to an unconformity representing the change from carbonate facies to deposition of marls, shales, silt- and sandstones. This unconformity correlates with the mid-Permian unconformity which can be recognized across the western Arctic (Steel & Worsley 1984). It is represented by a strongly diagenetically altered surface which may be of karst origin. Owing to limited vertical resolution in conventional seismic data, this top Artinskian reflector in places interferes with the top Permian reflector. The dominant lithology within this seismic unit is crinoid–brachiopod-bryozoan packstone and grainstone (Fig. 12b, c), which is bedded and typically has shale partings in the lower part. Occasional siliciclastic input and a dominance of highly fragmented fossils show that deposition probably took place in a high-energy, storm-influenced shelf environment.

The four Upper Carboniferous–Lower Permian seismic units can generally be correlated with the Gipsdalen Group on Spitsbergen/Bjørnøya (Figs. 3, 15). The two lower seismic units (Gzhelian and Asselian I) contain algal and palaeoaplysinsid buildups probably equivalent to those of the Kapp Dunér Formation on Bjørnøya. On Spitsbergen, time-equivalent buildups occur in the Tyrrfelljellet Member of the Nordenskiöldbreen Formation (Skag et al. 1982). Palaeoaplysina buildups were widespread throughout the Arctic during Moscovian to Sakmarian times where they mainly were distributed.
along the Laurentian borderlands (Watkins & Wilson 1989). There are three principal types of *Palaeopllysina*-phyllloid algal reefs: small isolated patch reefs on the inner shelf, tabular banks on the outer platform areas and large mound-like bodies along the platform margin and upper slope (Davies et al. 1989; Chuvashov 1983; Beauchamp et al. 1989; Beauchamp 1992). In the Barents Sea basin, only patch and the tabular bank type buildups have been documented so far (Skaug et al. 1982; Lønøy 1988; Stemmerik & Larsen 1993; Stemmerik et al. in press). The buildups encountered in the cored succession are interpreted as patch reefs, but seismic data indicate that larger mounds are present along rims of highs farther out on the platform and as isolated reefs on the platform (Bruce & Toomey 1992; Nilsen et al. 1992). These features may be represented, as seen on Bjørnøya, by vertically stacked *Palaeopllysina* buildups forming buildup complexes several tens of metres thick (Lønøy 1988; Stemmerik & Larssen 1993).

The Asselian II seismic unit has a dominantly shaly lithology and does not have any lithological equivalent on Bjørnøya or Spitsbergen. It is, however, time equivalent to the uppermost part of the Nordenskiöldbreen Formation on Spitsbergen. The basal boundary may chronostratigraphically correspond to the major karst surface seen on top of both the Kapp Dünér Formation on Bjørnøya (Worsley & Edwards 1976) and the Kim Fjelde Formation in North Greenland (Stemmerik & Elvebakk 1994).

The Sakmarian–Artinskian seismic unit has a lithological equivalent in the Hambergfjellet Formation on Bjørnøya, and is also time equivalent to parts of the Gipshuken Formation on Spitsbergen. The Gipshuken Formation, however, contains restricted dolomites/evaporites reflecting a proximal platform position. On the Barents Shelf, this seismic unit corresponds to a major carbonate platform development where *Tubiphytes*-bryozoan cementstone reefs are widespread (Bruce & Toomey 1992; Cecchi 1992; Nilsen et al. 1992). Similar reef development also occurs in the Sverdrup Basin (Beauchamp et al. 1989; Davies et al. 1989) and in North Greenland (Stemmerik 1992).

**Late Permian–Early Triassic shelf carbonates and clastics**

The Upper Permian–lowermost Triassic succession on the Finnmark Platform was penetrated by cores 7128/12-U-01 and 7129/10-U-01 (Fig. 13). Two Upper Permian seismic units have been defined on the high resolution seismic data, but due to the limited thickness the boundary between them cannot be resolved in the multichannel data (Figs. 3, 14).

The lower of these two Upper Permian seismic units was dated as *Kungurian–Ufimian* based on palynomorphs (biozone XIV, Table 3). The unit has a sharp contact with the underlying limestone (Fig. 13), corresponding to the very strong and continuous seismic reflector (dark blue), marking the base of this unit. Dark grey and grey clay/marl and siltstones compose the lower part of the unit which is rich in partially sideritized or calcified glauconite ooids. Bioturbation is intensive with a high diversity and density ichnofabric including common *Zoophyces* burrows. The unit is interrupted by a glauconite bed at about 79 m in core 7129/10-U-01 (Fig. 13). In core 7128/12-U-01, lower gamma radiation above 144.5 m corresponds to a dark grey clayey siltstone with pyrite concretions and fossil fragments of sponge spicules, bryozoans, brachiopods and ostracods. The *Kungurian–Ufimian* unit was deposited in a low-energy, well-oxygenated deep shelf environment showing an overall transgressive development. The glauconitic ooids in the lower part were deposited during the initial transgression in sufficiently high energy to roll the glauconite on the sea floor (snowball effect). In the upper part of this seismic unit ferruginous ooids and the brownish colouring in core 7129/10-U-01 are interpreted to reflect subaerial exposure (Fig. 12d).

The upper of the two Upper Permian seismic units is dated by palynomorphs as Kazanian–*Tatarian* (biozone XV, Table 3) and shows a westwards thickening from 10 m in core 7129/10-U-01 to about 20 m in core 7128/12-U-01. It is bounded at its base by a medium–strong, continuous reflection (green), corresponding to a matrix-supported mudclast conglomerate in cores 7129/10-U-01 and 7128/12-U-01 (Fig. 13). This conglomerate contains dark greenish and yellowish glauconitic clasts as well as brownish-coloured shale clasts, probably derived by erosion in the immediately underlying unit. The interval overlying the pebbly siltstone consists of bedded marly wackestone and grainstone, partially silicified, and contains fragments of spiriferid brachiopods, bryozoans, crinoids, trilobites and sponge spicules. This limestone was probably deposited on a shallow, storm-influenced carbonate platform. Only the lower 3.5 m was recovered in core 7128/12-U-01, but from the log character it is interpreted to continue up to the high-gamma peak at 124 m (Fig. 13), which implies a thickness of 14 m for this limestone. It is 8 m thick in core 7129/10-U-01.

In core 7129/10-U-01, this wacke-/packstone is overlain by a 50 cm thick bed of black, micritic phosphorite with common sponge spicules and moulds after sponge spicules as well as scattered glauconite grains (Fig. 12e). It also contains a 10 cm deep and up to 3 cm wide structure filled by clayey sediments with pebbles of cherts, black phosphorite, and reddish-brown and green glauconite from the overlying rocks. This crack may have formed during subaerial exposure. The high-gamma peak at 124 m in the non-cored interval of borehole 7128/12-U-01 is interpreted to represent a similar phosphorite bed. In core 7129/10-U-01 this bed is overlain by spiculitic chert consisting of light greenish-grey glauconitic chert where sponge spicules dominate totally (Fig. 12f). This chert unit is 4 m thick and extends up to 119.3 m (Fig. 13). The upper part was cored and consists of two different lithofacies: porous friable chert with abundant...
Fig. 13. Logs of two Upper Permian–Lower Triassic cores showing rapid changes from Artinskian grainstone, through ?Kungurian–Ufimian clastics and Kazanian–?Tatarian partly silicified wackestone/packstone, to Griesbachian clastics. Legend in Fig. 5.

spiculitic mouldic porosity in a fine-grained cherty porous matrix, and well-cemented bluish grey early diagenetic (pre-compactional) chert nodules. The homogeneous distribution of mouldic porosity in the chert indicates early, syndepositional diffusion of the silica from the dissolving sponge spicules into the seawater and partially causing silification of the original lime matrix. During shallow burial, dissolution of sponge spicules continued and the excess silica migrated into the cherty matrix and precipitated as chert nodules. The spiculitic chert unit was deposited in deeper-water environments than the underlying shallow carbonate platform deposits, probably in an outer shelf/break type of setting where upwelling resulted in a high biogenic production. The phosphorite bed may thus represent a condensed bed developed during the transgression between deposition of the limestone and the chert unit. A similar spiculitic chert is not found in core 7129/10-U-01, probably due to a period of erosion that eroded down to the phosphorite bed.

Directly resting on the phosphorite bed in core 7129/10-U-01 is a 1.5 m thick succession of greyish- to reddish-brown, pebbly shale with clasts of chert, glauconite, greyish and brownish shale and black phosphorite. A similar layer, but without phosphorite, is approximately 3 m thick in core 7128/12-U-01 (Fig. 13). Palynological dating of the matrix of this unit indicates a Late Permian age (Mangerud 1994). The clasts within this layer seem to have been derived from the underlying sediments and thus indicate an erosional unconformity within the Upper Permian succession. This erosion probably developed during the suggested subaerial exposure, as indicated from the karstic development seen on top of the phosphorite layer in core 7129/10-U-01.

The two Upper Permian seismic units equate with the Tempelfjorden Group. The base of the group is a major unconformity probably coinciding with the subaerial exposure of the Finnmark Platform as observed on top of the Artinskian limestone in cores 7129/10-U-01 and 7128/12-U-01. This boundary also represents a significant shift in climate, as the temperate climate chloro­zoan fossil assemblage of the underlying Gipsdalen
Group sediments was abruptly overlain by cooler water silica-rich sediments (e.g. Stemmerik & Worsley 1989). The boundary coincides with the mid-Permian rifting event, and the observed shift across the boundary could therefore partly be influenced by a shift in ocean circulation pattern. The lowermost Upper Permian shaly unit and the subaerial exposure surface on top of it, may correlate in time with the karst development seen on top of the Hambergfjellet Formation on Bjørnøya (Worsley & Edwards 1976). The bedded limestone unit overlying the shales correlates lithologically with the Miseryfjellet Formation on Bjørnøya, while the spiculitic chert correlates with the Kapp Starostin Formation on Spitsbergen (Fig. 15, cf. Steel & Worsley 1984).

The Lower Triassic seismic unit is dated to the Griesbachian by palynomorphs (biozone XVI, Table 3). The base of this unit closely coincides with the most prominent seismic reflector in the area, and the unit is in general characterized by a seismic prograding pattern. The upper boundary is an erosional unconformity in the inner part and becomes a conformity farther out in the basin, representing a type 1 sequence boundary as defined by, e.g., Van Wagoner et al. (1988), and further discussed by, e.g., Helland-Hansen & Gjelberg (1994). This siliciclastic unit consists, in the lower part, of sandstones and siltstones fining upwards to silty shales, with both ripple and horizontal laminae as well as water escape structures. In core 7129/10-U-01 the rocks are reddish- to greyish-green, while core 7128/12-U-01 contains more grey-coloured deposits grading into greyish-green, reflecting the more proximal position of core 7129/10-U-01. There is low density bioturbation. The rocks are interpreted to have been deposited in a shallow marine environment. The youngest of the cored Griesbachian sediments are recorded in core 7128/12-U-01 and consist of silty shales, with sandstone and siltstone beds, representing a shallow and storm-influenced shelf. Bioturbation is generally of low density and low diversity, but a few beds are totally bioturbated. The uppermost part includes red beds and caliche, interpreted as shoreface and coastal plain deposits.

The seismic unit belongs to the Havert Formation as defined by Worsley et al. (1988) in the Hammerfest Basin and consists of shales with minor interbedded siltstones and sandstones in two coarsening upwards sequences. In age, this seismic unit correlates with the lower part of the
Sassendalen Group in Svalbard, which was dated as early Griesbachian by ammonoids (Tozer & Parker 1968; Korchinskaya 1986). The lithological development, colour and facies clearly resemble the lowermost part of the Sassendalen Group of Svalbard (Mørk et al. 1982) and the Blind Fiord Formation of the Sverdrup Basin (Embry 1986).

Palaeogeography

The palaeogeographic development of the Finnmark Platform is summarized below and includes comments on similarities/differences with the rest of the western Arctic (Fig. 15). The palaeogeographic maps (Fig. 16) and the discussion are based on in-house IKU data and on various published sources for the remaining areas, including Gjelberg (1981), Steel & Worsley (1984), Worsley et al. (1986), Gramberg et al. (1988), Stemmerik & Håkansson (1988), Ziegler (1989), Doré (1991), Alsgaard (1992), Nettvedt et al. (1992a), Beauchamp (written comm. 1993), Sobolev & Nakrem (in press) and Stemmerik & Worsley (1994).

After the Devonian suturing of the Iapetus Sea, the Barents shelf was situated on the northern part of the Laurussian Plate with an opening to the Ural Ocean and Sakmarian back-arc basin to the east. There was no marine connection to the west, but during the Carboniferous, the seaway between the Arctic area and the Proto-Arctic Ocean to the northwest was established. By the end of the Permian, the Ural Orogeny, with collision between the Siberia/Kazakhstan continents and the eastern margin of the Laurussia Plate, closed the seaway to the east, while it was still open from the northwest. A marine connection southward to the Proto-Atlantic and to the Zechstein Sea was probably established along the Late Permian rift system between Greenland and Norway (Doré 1991). During the Late Palaeozoic the Arctic sedimentary basin included the Svalbard Platform and a series of basins and highs in the Barents Sea as well as the Wandel Sea Basin in North Greenland, the Sverdrup Basin in Canadian Arctic, the Alaska North Slope, and offshore Chukotka and Siberia. The basin extended eastwards into the Timan–Pechora area. The southern boundary of the sedimentary basins is well defined, while the northern boundary is poorly understood, although a
northern land area has been proposed to have existed during most of this period (Ziegler 1989; Embry 1992).

The Finnmark Platform was situated close to the palaeo-coastline during the Carboniferous–Permian period. There were no major orogenic events after the Silurian–Early Devonian Caledonian orogeny, but during the Late Devonian graben systems were developed and huge swamp areas with prograding fans existed over most of the Barents Shelf, North Greenland and the Sverdrup Basin (Beauchamp et al. 1989; Stemmerik & Worsley 1989). On the Finnmark Platform, Lower Carboniferous braided river sandstones onlap metamorphic basement in the east and represent the oldest sedimentary rocks recorded. During the Late Devonian–Early Carboniferous the depositional environment throughout the western Arctic was dominated by continental deposits including braided rivers, swamps and fans. In late Viséan time the sea transgressed the Finnmark Platform from the east (Fig. 16a) and deposited dark grey shales with TOC-content of 3–4% as recorded in core 7029/03-U-01. How far west this transgression reached is not known, but it is likely that the Nordkapp Basin and surrounding areas were flooded (e.g. Alsgaard 1992). Both on Bjørnøya and Spitsbergen, as well as in the Sverdrup Basin, the Viséan succession is of continental origin (Fig. 16a). The eastern part of the Barents Shelf was dominated by carbonate deposition. In the Sverdrup Basin, lacustrine shales and other clastic sediments occurred in local downfaulted basins (Davies & Nassichuk 1988; Beauchamp et al. 1989). Similar basins were formed on Spitsbergen and in the Wandel Sea Basin in North Greenland (Stemmerik & Worsley 1989).

During the last part of the Early Carboniferous, the sea regressed from the Finnmark Platform and deposition of marine sediments was gradually replaced by coastal plain sandstones and coals. A Bashkirian rifiting event recorded between Greenland and Norway and on the western Barents Shelf (Gjelberg & Steel 1981; Håkansson & Stemmerik 1984; Cippitelli 1990) probably also influenced the eastern Finnmark Platform. It resulted in formation of series of rotated fault blocks which followed the Caledonian WSW–ENE trend west of 28°E and the Baikalian ESE–WNW trend east of 28°E (Dengo & Røsland 1992). The initial filling of these half grabens was by continental red beds and associated coarse-grained fluvial deposits, probably equivalent to the Landnødingsvika Formation on Bjørnøya (Gjelberg 1981). These continental deposits were followed by stacked fan delta complexes successively overlain by more distal marine deposits. Parts of Spitsbergen and the Sverdrup Basin became transgressed by the end of the Early Carboniferous, and evaporitic environment prevailed in parts of Spitsbergen and in the Sverdrup Basin, where carbonate deposition also occurred. By Moscovian time, the Sverdrup Basin, North Greenland and most of the Barents Shelf, with the exception of the southern areas and parts of Spitsbergen, had become a carbonate platform (Fig. 16b), with an opening established to the Proto-Arctic Ocean in the northwest. Contemporaneously with this, deposition of evaporites, mainly salt, started in the Nordkapp Basin and in the Hammerfest/Tromsø Basins, extending northeastwards to the Maud Basin and the Svalis Dome area. Large amounts of clastic sediments were deposited on the East Greenland and Mid-Norway continental shelves. The previously formed rift basins on the Barents Shelf became filled and a shallow shelf environment was established throughout most of the area. As a result of reduced relief of the hinterland and drowning of the former highs during the ongoing sea-level rise, clastic deposition gradually decreased and was replaced by carbonate deposition. This coincided with the Kasimovian transgression that introduced an extensive carbonate and evaporite platform over most of the present western Arctic area. The carbonate deposition continued to dominate until the mid-Permian, also accompanied by formation of Palaeoaplysina–phylloid algal reefs. Deposition of evaporites still continued in the Nordkapp, Maud, Hammerfest and Tromsø Basins (Fig. 16c) (Johansen et al. 1992), at least until the late Asselian, when a major transgression is indicated by the cored succession on the Finnmark Platform. This transgression was followed by progradation of a high-energy carbonate platform during Sakmarian–Artinskian time. Bryozoan–Tubiphytes reefs were formed on the Finnmark Platform and are widespread elsewhere on the Barents Shelf and in the Arctic (Bruce & Toomey 1992; Cecchi 1992; Nilsen et al. 1992). During late Asselian to Artinskian time sediment deposition on the Barents Shelf was characterized by increase in thickness from platforms to basins (Nøttvedt et al. 1992a). Some parts of the Loppa High and the Stappen High were probably uplifted in late Asselian/Sakmarian time (Worsley et al. 1990; Stemmerik & Larssen 1993), and prominent karst surfaces were developed between the Kapp Dunér and Hambergfjellet Formations on Bjørnøya (Worsley & Edwards 1976). On Spitsbergen, the Billefjorden Fault may still have been active as it affected facies patterns (Steel & Worsley 1984). A major mid-Permian tectonic event can be recognized throughout the Arctic as well as off Mid-Norway and on East Greenland. This event caused a shift in deposition to generally deeper marine environments, reflected on the Finnmark Platform by clastic sediments being deposited during the Kungurian–Ufimian time. This mid-Permian event also led to a seaway being established southwards between Norway and East Greenland (Surlyk et al. 1984; Đoré 1991). This shift in ocean circulation pattern could also have influenced the onset of clastic deposition in the Barents Sea.

During the Late Permian, the Ural orogeny caused increased deposition of clastic sediments from the southeast and east into the Barents Sea. On the Finnmark Platform, bryozoan limestone and spiculitic chert were deposited, while silicified spiculitic shales are found in the Upper Permian succession in the Hammerfest Basin and probably also in the Nordkapp Basin, the Loppa High,
Early Carboniferous (Viséan)

- Siliciclastic shelf
- Carbonate platform
- Basinal shales/carbonates
- Deltaic/shallow marine clastics
- Continental clastics
- Land
- Algae buildups
- Thrust fault

Middle Carboniferous (Moscovian)

- Mixed siliciclastic/carbonate shelf
- Carbonate platform
- Basinal shales/carbonates
- Evaporites
- Deltaic/shallow marine clastics
- Continental clastics
- Land
- Bryozoan buildups
- Phylloid algae - Palaeoaplysina buildups

Early Permian (Asselian - Sakmarian)

- Siliciclastic shelf
- Carbonate platform
- Basinal shales/carbonates
- Evaporites
- Deltaic/shallow marine clastics
- Land
- Bryozoan buildups
- Phylloid algae - Palaeoaplysina buildups
- Thrust fault

Late Permian (Kazanian)

- Siliciclastic shelf
- Carbonate platform
- Deeper marine (spiculitic shales)
- Deltaic/shallow marine clastics
- Continental clastics
- Land

Fig. 16. Palaeogeographic reconstructions of the Arctic for the Early Carboniferous to Late Permian. The compilation is based on published and in house IKU data (e.g. Steel & Worsley 1984; Worsley et al. 1986; Gramberg et al. 1988; Stemmerik & Håkansson 1989; Ziegler 1989; Doré 1991; Alsgaard 1992; Beauchamp written comm. 1993; Nættvedt et al. 1992; Sobolev & Nakrem in press; Stemmerik & Worsley 1994). SvB = Sverdrup Basin, SpB = Spitsbergen, B = Bjørnøya, LH = Loppa High, FP = Finnmark Platform, NZ = Novaya Zemlya.
Svalbard and in the Sverdrup Basin (Fig. 16d). Subaerial exposure during the Ufimian–Kazanian reflects a relatively short and probably tectonically induced lowering of sea level on the Finnmark Platform. Clastic deposits gradually prograded across the carbonate platform in most of the Arctic during the Late Permian. In the eastern Barents Sea, clastic deposition mainly prograded from the Ural Mountains rising in the east and the Novaya Zemlya further north, while the clastics prograded mainly from the south on the Finnmark Platform and both east- and westwards from the Fedynsky High–Central Barents High (Pchelina 1988; Gading 1994). By Griesbachian time (earliest Triassic), deposition of clastic sediments dominated the entire Arctic area.

Conclusions

The studied Lower Carboniferous–Lower Triassic sedimentary succession was deposited on the northern margin of the Fennoscandian Shield. The palaeo-coastline followed that of the present day with only minor variations, and most of the sediments were deposited in a shallow and marginal marine environment. The cored succession represents a 600–700 m thick condensed clastic and carbonate succession.

Fourteen seismic units have been identified and most of these units can be recognized throughout the study area on the Finnmark Platform. The six units defined in the Lower and Middle Carboniferous are truncated in a westward direction. They are, however, probably present with increased thickness in the westernmost part of the area, but due to lack of core control here, a detailed correlation of these units from east to west is not possible. The younger seismic units are all bounded by strong reflectors and can be traced throughout the area.

In late Viséan time rivers deposited sands across the study area, and later the sea transgressed the platform from the east, resulting in limestones and shales being deposited. The seismic data give no indication of older sedimentary rocks on the Finnmark Platform. In the westernmost parts of the study area, a local downfaulted basin was supplied with clastic sediments from a river which ran northeastwards and deposited up to 650 m of Lower Carboniferous (Viséan) flood-plain sandstones. In the eastern part of the study area, a partly continental and partly marine succession only 60 m thick was deposited. A regional erosive event which took place in the Late Carboniferous (probably Kasimovian) time, eroded much of the Lower and Middle Carboniferous succession in the central part of the study area.

The Viséan transgression was followed by deposition of Serpukhovian–?Bashkirian sandstones in a coastal plain/flood-plain environment showing a regressive trend. During the Middle Carboniferous and until Gzhelian time (Late Carboniferous), deposition of fining-upward sandstones in fan delta complexes dominated deposition on the Finnmark Platform.

By late Kasimovian time, most of the present Arctic area was transgressed and a huge carbonate platform existed on most of the Barents Shelf. In the marginal setting on the southern Barents Shelf and on the southern Finnmark Platform, the transition from clastic to carbonate deposition was delayed until the early Gzhelian. The cored Upper Carboniferous–Lower Permian carbonate succession (mid-Gzhelian–upper Asselian) is dominated by *Palaeoaplysina*-phylloid algae buildups associated with arid shoreline deposits. The buildups consist of up to 4 m thick units of boundstone, packstone and wackestone and may form up to 10 m thick stacked units. From seismic data, thicker buildups are interpreted to occur farther out on the Finnmark Platform. Contemporaneously, anhydrite was formed in lagoonal environments, resulting in an 8 m thick anhydrite bed in the middle part of the cored carbonate succession.

A relative rise in sea level caused change to open marine environments in the late Asselian with deposition of predominantly calcareous shales, which were gradually replaced by limestones during the Sakmarian–Artinskian. The break with change from carbonate deposition during the Artinskian to deposition of siliciclastics during the Kungurian–Ufimian observed in the cored succession, corresponds to the regional mid-Permian tectonic event traced throughout the Arctic. These clastic sediments were probably subaerially exposed before a new transgression resulted in deposition of Kazanian–?Tatarian bryozoan limestones, which form the youngest Permian carbonate unit.

The Lower Triassic sediments are recognized by a characteristic progradational pattern and comprise fining-upward sandstones, siltstones and shales. These represent the major shift from dominantly carbonate deposition which took place during the Late Carboniferous and Permian, to dominantly clastic deposition which continued to take place throughout the Mesozoic and Cenozoic on the Barents Shelf.

Acknowledgements. – The study presented here is part of the Barents Sea mapping programme performed by IKU Petroleum Research. All the oil companies participating in the shallow drilling programmes on the Finnmark Platform in 1987 and 1988 are gratefully acknowledged. Thanks are due to our colleagues at IKU for their contribution to the programmes and to the crew of M/S 'Bucentaur' for their skill and enthusiasm. The authors also thank Berit Fossum and Ingrid Brandslet for help with the illustrations and John Gjelberg and reviewers, Arvid Nøttvedt, Anthony M. Spencer and Lars Stemmerik, for valuable comments.

Manuscript received March 1994

References


