Upper Carboniferous cyclic shelf deposits, Kapp Kåre Formation, Bjørnøya, Svalbard: response to high frequency, high amplitude sea level fluctuations and local tectonism

Lars Stemmerik & David Worsley

The upper Bashkirian–Moscovian Kapp Kåre Formation is well-exposed in coastal cliff sections along the west coast of Bjørnøya, Svalbard. It is composed of stacked cycles of mixed siliciclastics and carbonates in the lower Bogevika Member and of cyclic shelf carbonates in the overlying Efuglvika Member. The uppermost Kobbebukta Member consists of shelf carbonates and syntectonic conglomerates and sandy turbidites. The shift in cycle types reflects an overall transgression of the region during the Moscovian combined with renewed tectonic activity and uplift of eastern Bjørnøya during the late Moscovian. Twelve carbonate facies and 6 siliciclastic facies are distinguished. The carbonate facies range from intertidal dolomitic mudstones with pseudomorphs after gypsum to sub-wavebase, intensely bioturbated wackestones. Most carbonates are deeper subtidal facies and shallow marine carbonate facies are only common in the transgressive part of mixed siliciclastic–carbonate cycles of the Bogevika Member. Incorporating the effects of high amplitude, high frequency glacioeustacy and active extensional tectonism, a dynamic model is developed to explain the spatial variability of facies observed within the Kapp Kåre Formation. Observations from Bjørnøya are placed within the context of the regional structural and stratigraphic framework so that significance of the study to ongoing exploration efforts in the Barents Sea can be evaluated. Most important, our observations suggest that dolomitized, porous carbonate buildups are most likely to be found in the upper Moscovian succession in areas where accommodation space increased temporarily due to local tectonism.

L. Stemmerik, Geological Survey of Denmark and Greenland, Thoravej 8, DK-2400 Copenhagen NV, Denmark; D. Worsley, Saga Petroleum, Box 490, N-1301 Sandvika, Norway (current address: Saga Petroleum, Mabruk, Libya).

Mixed carbonate–siliciclastic cycles and carbonate cycles characterize the upper Bashkirian–Moscovian marine successions of Bjørnøya, Spitsbergen, northern Greenland and equivalent offshore successions of the western Barents Sea (Figs. 1, 2) (Stemmerik & Worsley 1989; Pickard et al. 1996; Stemmerik 1996; Stemmerik, Håkansson et al. 1996). Deposition of these cyclic sediments took place during the latter stages of mid-Carboniferous rifting, and during an overall, second order rise in sea level. Superimposed on these long-term patterns were high frequency and high amplitude glacioeustatic sea level fluctuations thought to be triggered by glaciations in the Southern Hemisphere (e.g. Veevers & Powell 1987). The changes in composition of the cyclic sediments are believed to reflect the interplay between long- and short-term sea level fluctuations and the local, often tectonically controlled, supply of siliciclastic material (Stemmerik, Elvebakk et al. 1998). On-

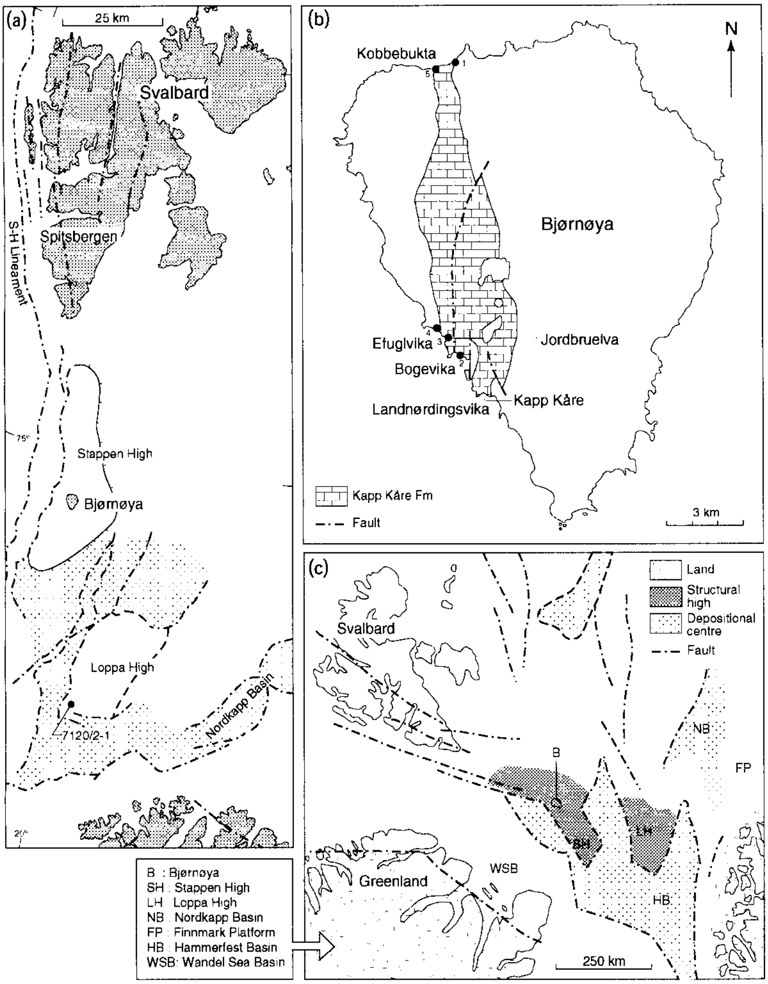

Fig. 1. (a) Simplified map of the south-western Norwegian Barents Sea, showing location of Bjørnøya and major structural elements mentioned in the text. (b) Map of Bjørnøya showing the distribution of the Kapp Kåre Formation and locations, 1–5, of investigated sections. (c) Pre-drift reconstruction of the western Barents Sea and northern Greenland showing depositional centres and major structural lineaments. Note that Bjørnøya is located on a late Palaeozoic structural high.

going regional rise in sea level gradually led to flooding of structural highs that had acted as siliciclastic source areas, so the shift from mixed siliciclastic and carbonate cycles to cyclic carbonate deposition is highly diachronous within the region, depending on the timing of the cut-off of siliciclastic material (see Fig. 2). On Bjørnøya this shift took place during the early Moscovian at the transition from the Bogevika Member to the Efuglvika Member (Fig. 2). There, cycles are composed of interbedded inner- to mid-shelf carbonates and shoreface to foreshore siliciclastics in the upper Bashkirian to lower Moscovian part of the succession (Bogevika Member) and cyclically interbedded shelf carbonates in the middle to upper Moscovian part of the succession (Efuglvika Member). However, renewed input of coarse-grained siliciclastic material (Kobbebukta Member) occurred following a local, late Moscovian tectonic event that led to extended subaerial exposure and erosion of the eastern parts of Bjørnøya (Worsley et al. in press).

The upper Bashkirian–Moscovian Kapp Kåre Formation on Bjørnøya provides an example of cyclic sedimentation on a tectonically active block during the later stages of regional rifting. The importance of local and regional processes for changes in depositional style is reflected in the lithostratigraphic subdivision of the formation (Worsley et al. in press) but so far the sediments have not been subjected to a detailed facies analysis. This paper focuses on the carbonate facies of these cyclic deposits. Twelve carbonate facies have been identified, ranging from intertidal dolomitic mudstone with pseudomorphs after gypsum to deep subtidal, bioturbated wackestone.

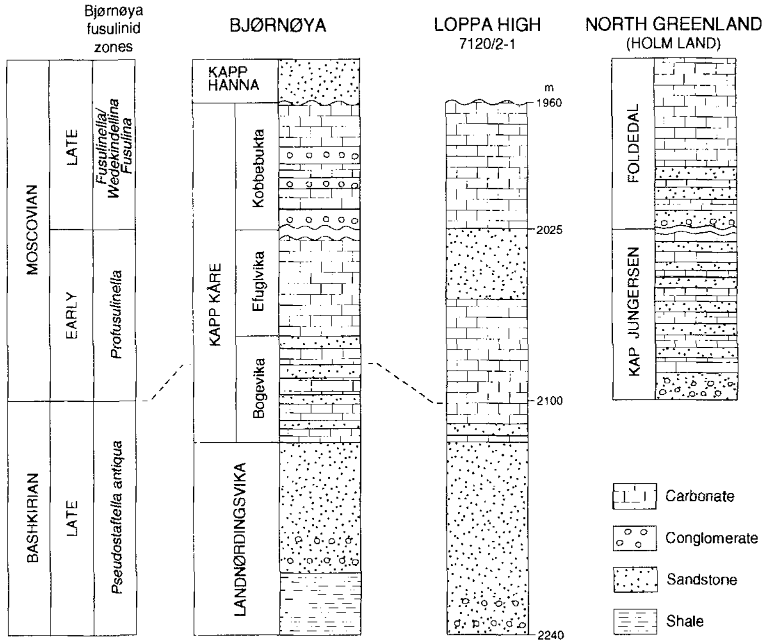

Fig. 2. Correlation of the Bashkirian–Moscovian depositional units of Bjørnøya, Loppa High and northern Greenland. Data from Stemmerik (1996) and Stemmerik, Elvebakk et al. (1998).

Carbonate buildups are rare; small lenticular buildups occur in the basal part of the Kobbebukta Member. The facies analysis shows that subtidal carbonates dominate and that shallow marine carbonates are limited to the transgressive parts of mixed siliciclastic–carbonate cycles of the Bogevika Member and to the basal part of the Efuglvika Member. We propose that the change in depositional style through time reflects availability of siliciclastic material from the adjacent structural high and a change in shelf profile from a high energy ramp to a deeper, rimmed shelf.

The Kapp Kåre Formation forms an important analogue to the thick time equivalent offshore successions in the western Barents Sea where hydrocarbon exploration is presently going on. There cyclic shelf deposits are proposed to be widespread but they have only been described from well 7120/2-1 from the Loppa High (Stemmerik, Elvebakk et al. 1998). The present study may therefore contribute towards a better understanding of the regional facies development of the Bashkirian–Moscovian succession in the western Barents Sea.

Regional setting

The Barents Sea region formed a complex rift-related system of rapidly subsiding basins and more stable platforms during the late Palaeozoic. The outcrop area of Bjørnøya is located on the Stappen High in the westernmost part of the Barents Sea, near the eastern margin of the late Palaeozoic rift system between Greenland and Spitsbergen (Fig. 1). The central axis of the rift contains thick halite accumulations of proposed late Carboniferous and earliest Permian age as seen in its southward extension on the East Greenland Shelf. Similarly, the halite-filled Nordkapp Basin defines a north-eastward trending rift axis further to the east in the Barents Sea. The study area formed part of a zone of structural weakness along which plate movements took place from the Caledonian Orogeny and onwards, and it is therefore expected to show some unusual tectonic and depositional developments compared to the areas further to the east (Steel & Worsley 1984; Dore 1991; Gudlaugsson et al. 1998; Worsley et al. in press).

On Bjørnøya, the Upper Carboniferous sediments are included in the Bashkirian Landnørdingsvika Formation, the upper Bashkirian–upper Moscovian Kapp Kåre Formation, the uppermost Moscovian–(?)Kasimovian Kapp Hanna Formation (Fig. 2), and the Gzelian–Asselian Kapp Duner Formation (Worsley & Edwards 1976; Kirkemo 1979). Deposition took place in a

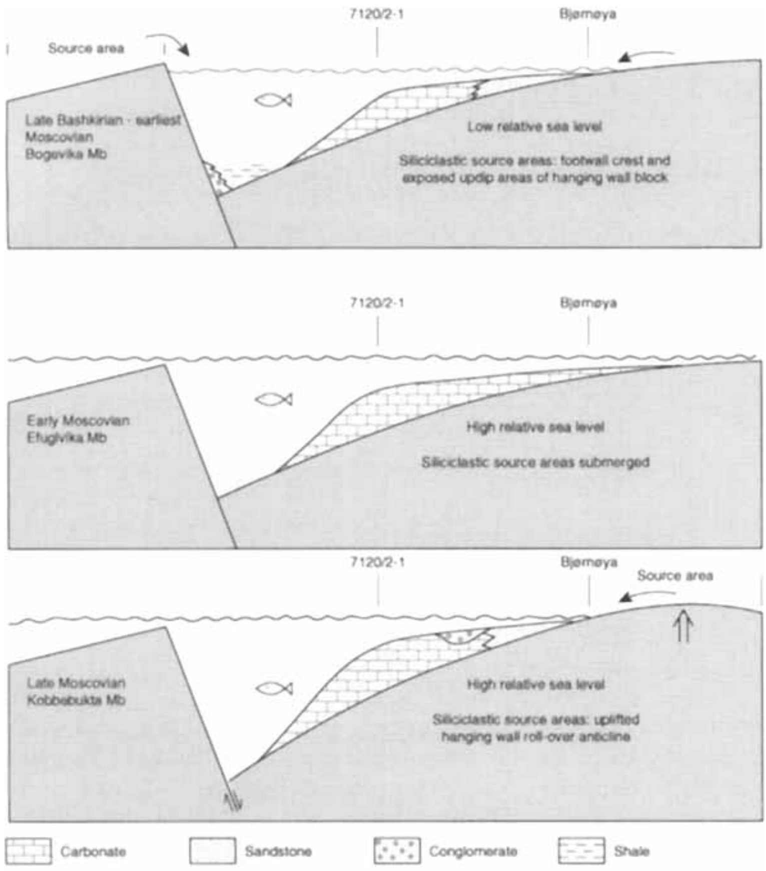

Fig. 3. Schematic evolution of the Bjørnøya area during late Bashkirian–Moscovian times. The proposed structural position of well 7120/2-1 relative to Bjørnøya is shown. Note, however, that the Loppa High, where well 7120/2-1 is located, has a different tectonic history. For location of well 7120/2-1, see Fig. 1a.

westward tilted half-graben bounded to the west by a major fault zone that appears to have been active throughout the late Palaeozoic (Fig. 3) (Worsley et al. in press). Marine transgression of the region occurred during the late Bashkirian and interbedded shelf siliciclastics and carbonates of the Bogevika Member were deposited on the hanging wall block during the late Bashkirian and early Moscovian. Further relative sea level rise is thought to have cut off the siliciclastic source areas as the footwall block and the rollover anticline of the hanging wall block were drowned, so that shelf carbonates of the Efuglvika Member were deposited (Fig. 3). The change in sedimentation and the general fining upwards trend shown by these two members is interpreted to reflect both a regional rise in sea level and more stable tectonic conditions (Worsley et al. in press).

The Stappen High and other positive features along the margins of the Barents Sea (Fig. 1) experienced renewed tectonic activity during the late Moscovian as indicated by a marked erosional break between the Efuglvika and Kobbebukta members (Fig. 2). Faulting took place along north–south and NNE–SSW trending lineaments and led to differential uplift of eastern and southern Bjørnøya that at this time was located on the roll over anticline of the hanging wall block (Fig. 3) (Worsley et al. in press). Following a late Moscovian break in sedimentation, interbedded carbonates and siliciclastics were deposited in small syn-depositional half-grabens. Pulses of coarse-grained material suggest that the eastern part of the island was still exposed at this time (see e.g. Fig. 3).

Stratigraphy

The Kapp Kåre Formation is dated by fusulinids. The upper part of the underlying Landnørdingsvika Formation and the main part of the basal Bogevika Member contain a late Bashkirian fusulinid fauna with *Pseudostaffella antiqua*

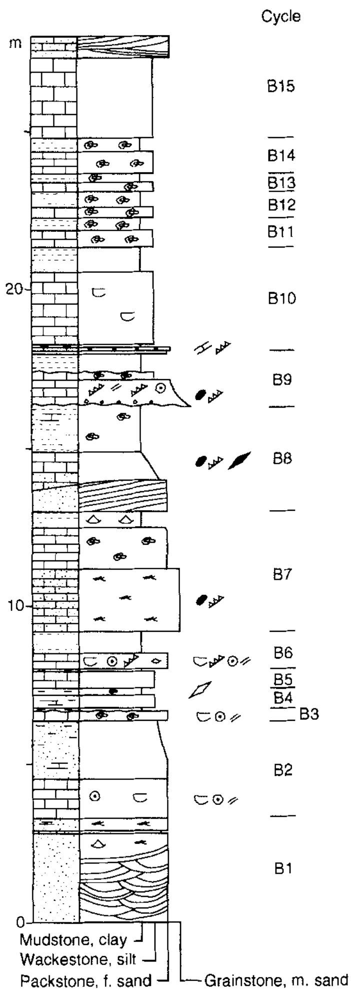

Fig. 4. Sedimentological log of the Bogevika Member at Bogevika, locality 2 in Fig. 1b. For legend, see Fig. 5.

(Fig. 2) (Stemmerik, Elvebakk et al. 1998). The uppermost part of the Bogevika Member and the Efuglvika Member contain a fusulinid fauna that is regarded as early Moscovian in age based on the presence of *Profusulinella prisca* and *Neostaffella* cf. *sphaeroidea* (Stemmerik, Elvebakk et al. 1998). The Kobbebukta Member contains three local fusulinid assemblages of late Moscovian age; the youngest of these are also found in the lowermost Kapp Hanna Formation (Simonsen 1988).

Bogevika Member

The upper Bashkirian–lower Moscovian Bogevika Member consists of cyclically interbedded carbonates and siliciclastics. It is exposed in coastal cliffs at Landnørdingsvika and Bogevika on the south-west coast and in Kobbebukta in the north (Fig. 1); significantly, the facies development in these two areas is quite different. The exposed section in Bogevika represents the uppermost 30 m of the Bogevika Member that is 95 m thick (Fig. 4) (Kirkemo 1979). In the Bogevika area the member consists of stacked shallow marine sandstones and carbonates capped by red siltstones with abundant caliche nodules. The studied succession consists of 15 caliche-capped cycles, each 0.5–4 m thick (B1–B15 in Fig. 4). The approximately 45 m thick section in Kobbebukta is also suggested to represent the upper part of the member (Kirkemo 1979). The Bogevika Member is here quite different and is composed of more complicated, siliciclastic-dominated cycles (K0-KIV in Fig 5). These cycles are 8.5–12 m thick, each consisting of 3–4 higher order subcycles (K1.1–K4.4 in Fig. 5), some of which resemble the cycles seen at Bogevika. The transgressive part of the cycles at Kobbebukta consists of thin higher order cycles of interbedded carbonates and siliciclastics whereas the regressive part is usually composed of one large shoaling upward siliciclastic unit of offshore shales to upper shoreface or foreshore sandstones (Fig. 5).

Efuglvika Member

The Efuglvika Member is composed of cyclically interbedded limestones with abundant chert and is some 75 m thick in the type section in Landnørdingsvika (Fig. 6) (Worsley & Edwards 1976). The member has been studied in detail in Efuglvika and along the lower part of the Jordbruelva ("Earth-bridge" River) where the 52 m thick section through the uppermost part of the member is composed of 11 complete and two incomplete cycles, each 1–8 m thick (E1–E11 in Fig. 7). The member appears to be very uniform throughout the island and variations in cycle stacking patterns like those seen in the Bogevika Member are not apparent.

Kobbebukta Member

The Kobbebukta Member was introduced by Kirkemo (1979) to include the upper part of the Kapp Kåre Formation at Kobbebukta and around Kapp Kåre. It was originally considered missing

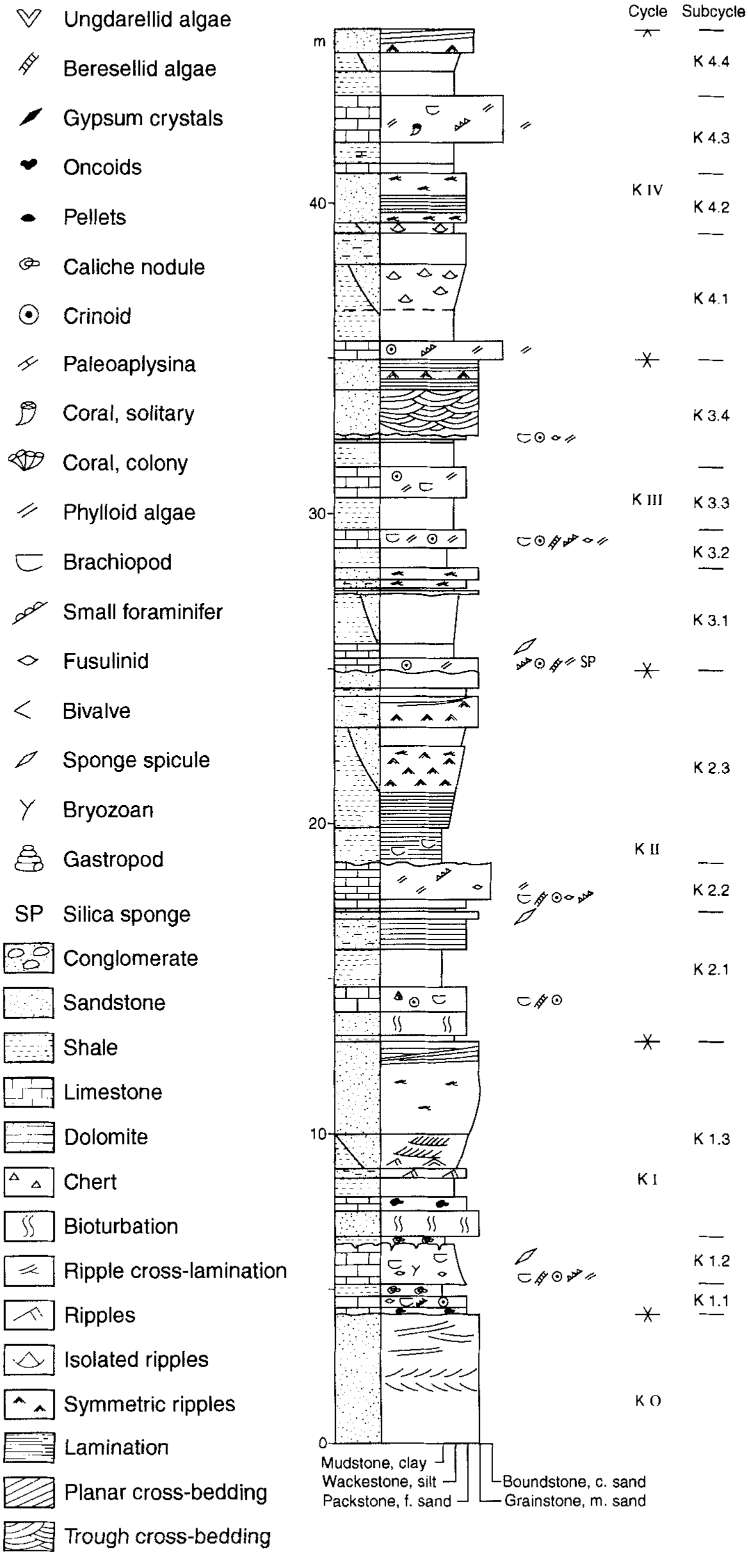

Fig. 5. Sedimentological log of the Bogevika Member at Kobbebukta, locality 1 in Fig. 1b. Legend explains symbols used in Figs. 4, 5, 7, 8, 9 and 17.

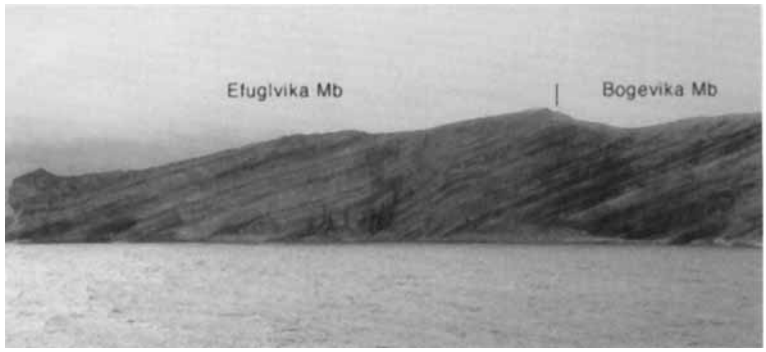

Fig. 6. The lower part of the Kapp Kåre Formation in the coastal cliffs at Kapp Kåre. Note the transition from interbedded carbonates and red siliciclastics to pure carbonates, corresponding to the boundary between the Bogevika and Efuglvika members. Cliff is approximately 25 m high.

around Efuglvika but subsequent fieldwork indicates that it is also present in this area (Stemmerik, Elvebakk et al. 1998). Sections through the Kobbebukta Member and the transition to the overlying Kapp Hanna Formation have been studied in detail both in Efuglvika and in the

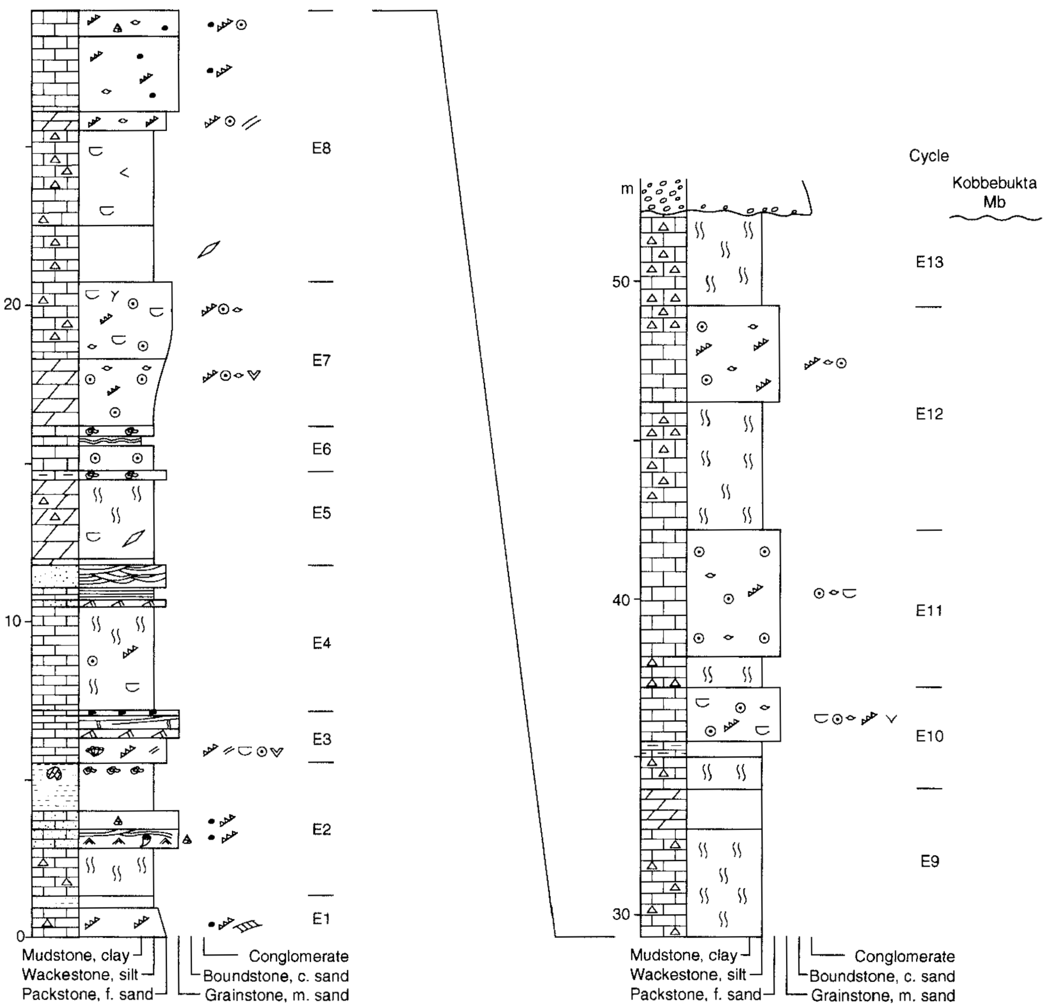

Fig. 7. Sedimentological log of the Efuglvika Member at Jordbruelva-Efuglvika, locality 3 in Fig. 1b. For legend, see Fig. 5.

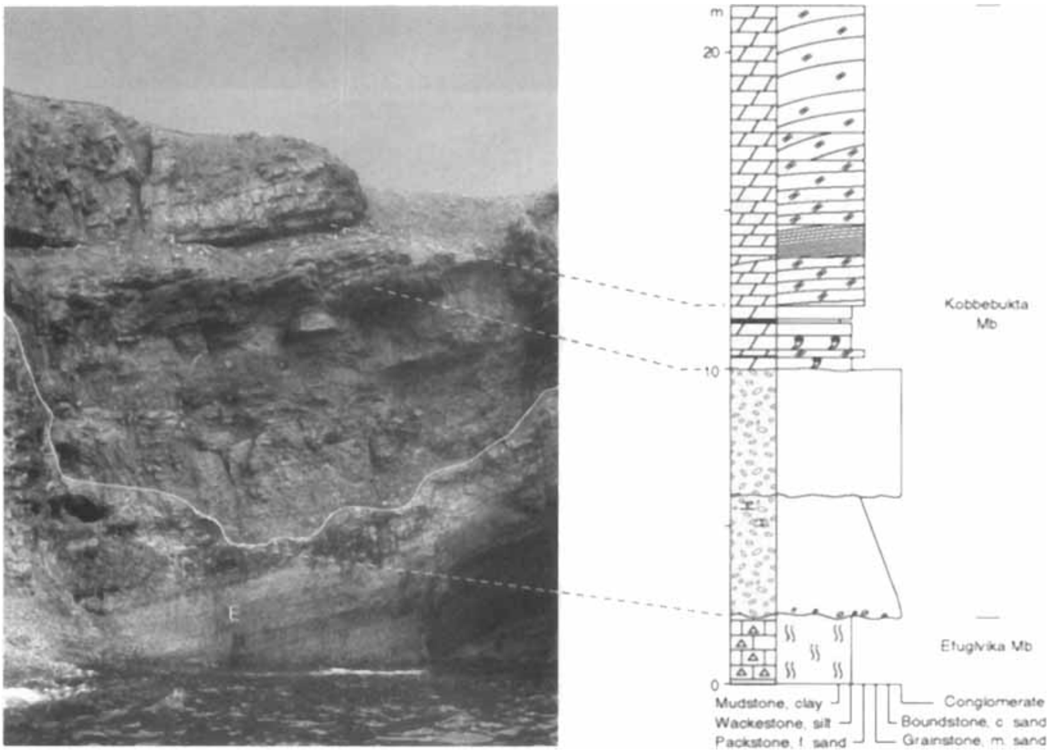

Fig. 8. Erosional disconformity between the Efuglvika Member (E) and the Kobbebukta Member at Efuglvika, locality 4 in Fig. 1b. Note the karstified erosional lower surface and the conglomerate-filled channel. The upper part of the succession is a carbonate buildup shown in more detail in Fig. 14. The sedimentological log of the Kobbebukta Member at this locality is shown to the right. For legend, see Fig. 5.

area west of Kobbebukta (Figs. 8, 9), and additional observations have been made in the coastal cliffs towards the south-west. The boundary between the Efuglvika and Kobbebukta members is defined by a well-developed karstic surface with evidence of fluvial erosion and up to 5 m of local relief (Fig. 8). The Kobbebukta Member is thin (2–3 m) to locally absent in the Bogevika–Landnørdingsvika area. It thickens to approximately 20 m in Efuglvika where a basal conglomerate is overlain by a few metres of bedded shelf carbonates followed by westward migrating phylloid algal buildups. In the Kobbebukta area, the member is approximately 30 m thick and composed of shelf carbonates abruptly intercalated vertically and laterally with thick submarine conglomerates. Evidence of syndepositional growth faulting is seen in association with one of these conglomerates. This resulted in a local 10–20 m deep and several hundred metres wide half-graben filled with turbiditic and slumped sandstones and shales. The top surface of the member is highly erosive with evidence of valley incision at several places.

Depositional facies

The Kapp Kåre Formation displays large variations in depositional facies reflecting deposition during times of high amplitude glacioeustatic fluctuations of sea level and active local tectonism (Stemmerik, Elvebakk et al. 1998; Worsley et al. in press). Both carbonate and siliciclastic facies show a range from offshore facies deposited well below wavebase to facies deposited in shallow subtidal and supratidal environments. However, most facies are only present in one of the three members, and we have therefore chosen to describe the facies of each member separately. The carbonate facies description is based on field

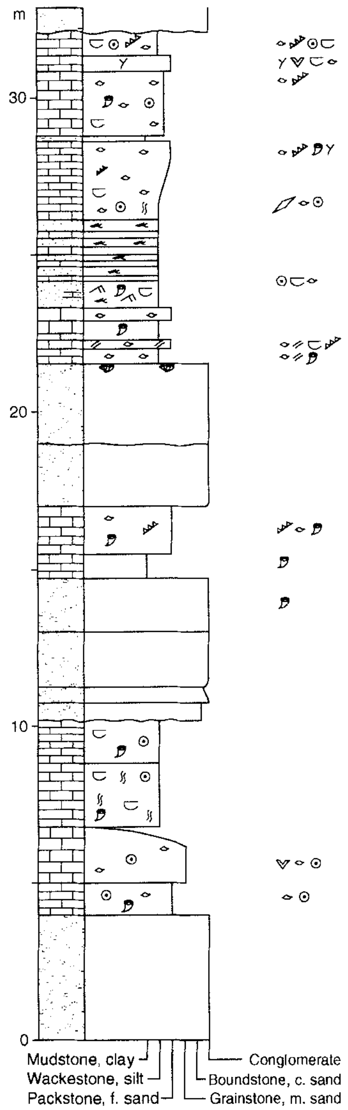

Fig. 9. Sedimentological log of the Kobbebukta Member in the type area west of Kobbebukta, locality 5 in Fig. 1b. For legend, see Fig. 5.

observations and microfacies analysis of more than 80 thin sections.

Bogevika Member

The Bogevika Member includes six common carbonate facies and three well-defined siliciclastic facies. In addition to the carbonate facies described below, dolomitic mudstone with pseudomorphs after gypsum are present locally (cycle B8 in Fig. 4).

Phylloid algal grainstone

Description. – This facies is dominated by whole and fragmented plates – up to several centimetres long – of phylloid algae in a clotted peloidal cement (Fig. 10a). Also present in this facies are abundant encrusting foraminifers various types of other small foraminifers and beresellid algae. Fusulinids and ostracods are rare whereas fragments of echinoderms are common. Intraclasts up to several centimetres long are a common constituent in this facies. Locally, encrusting red algae appear to have bound sediment grains together. This facies is restricted to thin – less than 10 cm thick – transgressive layers directly overlying subaerially exposed carbonates or sandstones (e.g. base of cycles B9 and B10 in Fig. 4).

Interpretation. – The presence of gravel-size intraclasts and the relatively coarse size of the algal fragments suggest deposition in a shallow, high energy environment developed during initial transgressions.

Sandy peloidal grainstone

Description. – The sandy peloidal facies occurs as ripple cross-bedded sandy grainstone with up to 30% fine-sand-size siliciclastic rains. The carbonate grains are almost exclusively well-rounded to elongate, 0.05 to 0.2 mm long peloids and single layered apterinellid foraminifers (Fig. 10b). The sandy peloidal grainstones occur immediately over the siliciclastic unit (e.g. cycles B7 and B8 in Fig. 4). The upper part of this facies is often completely altered and well-developed caliche features are present.

Interpretation. – Sediments of this facies were deposited in shallow, moderately high energy and biologically stressed environments. The absence of large-scale sedimentary structures and ooids is taken as evidence for a moderately high energy setting, and this facies most likely formed in shallow lagoons. The stratigraphic position immediately above siliciclastic sediments suggests that the sandy grainstones formed during the early stages of transgression and the incorporated siliciclastic material is reworked from the underlying siliciclastic unit. Water depth never exceeded a few metres and the caliche a top of this facies was formed during a subsequent sea level fall.

Oncolitic packstones

Description. – This facies consists of closely packed subrounded oncolites that range in size

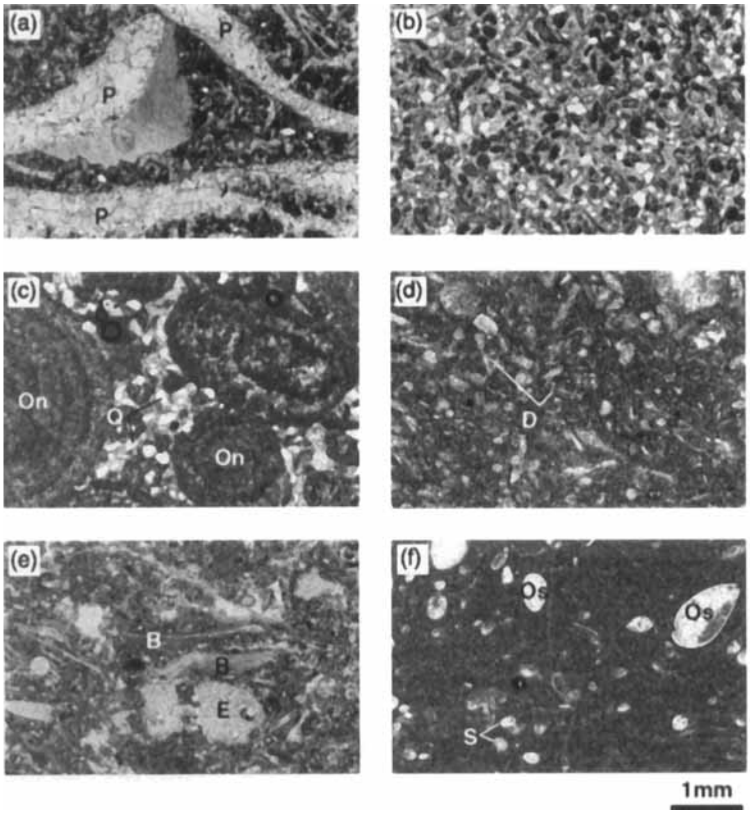

Fig. 10. Microphotographs in plane polarized light of carbonate facies from Bogevika Member: (a) phylloid algal (P) grainstone, Bogevika; (b) sandy peloidal packstone, Bogevika; (c) oncolitic (On) packstone, Kobbebukta, Q = quartz sand; (d) beresellid (B) boundstone, Kobbebukta; (e) brachiopod-dominated packstone, Kobbebukta, B = brachiopod, E = echinoderm; and (f) spiculitic wackestone with ostracods (Os) and dissolved spicules (S) filled by calcite, Kobbebukta.

from less than 2 mm to more than 20 mm (Figs. 10c, 11). The oncolites nucleated on sand-size quartz grains, ostracods or brachiopod fragments. They consist of a clotted peloidal core and a well-laminated outer rim. Encrusting foraminifers and the red algae *Asphaltina* sp. occur in the outer laminated part. Sand-size quartz grains are common between the oncolites together with rare

Fig. 11. Oncolitic packstone directly overlying shallow marine, shoreface sandstone, Kobbebukta. Hammer is 35 cm long.

fragments of ostracods. This facies forms 20–40 cm thick beds that rest on sandstones of the preceding cycle and are overlain by biogenic wackestone or marine shale (e.g. subcycle K1.1 in Fig. 5).

Interpretation. – The complete dominance of oncoids in the oncolitic packstone facies suggests deposition in an environmentally stressed setting. Oncoids require a periodically turbulent environment, and the presence of sand-size grains indicate reworking of the underlying sandstones. The oncolitic packstones always grade into relatively deep shelf deposits and this facies possibly represents a fairly deep environment near storm wavebase. One explanation for the complete absence of normal marine fossils in this transgressive facies is that supersaturated water from adjacent deep halite basins migrated across the shelf during early sea level rise and that a chemocline was maintained in the deeper parts of the shelf for some time, excluding the immigration of a normal marine fauna. Comparable oncolitic packstones are also common in the transgressive part of the well-known Pennsylvanian cycles of the US mid-continent (Wilson 1975).

Beresellid boundstone

Description. – This facies forms 60–150 cm thick massive units completely dominated by the beresellid algae *Donzella* sp. The *Donzella* fragments are up to 0.7 mm long; they occur together with rare fragments of phylloid algae, rare small foraminifers, fusulinids and calcispheres and variable amounts of echinoderm fragments (Fig. 10d). The red algae *Ungardella* sp. is locally common as up to 2 mm long fragments in this facies. The beresellid boundstone most commonly forms the regressive part of mixed carbonate–siliciclastic subcycles (e.g. subcycles K2.2 and K3.3 in Fig. 5). The boundstones found in this position show evidence of subaerial exposure in form of up to 10 cm deep erosional features. In one case it forms the transgressive part of a cycle.

Interpretation. – In the Sverdrup Basin of Arctic Canada, beresellid algae are present in a variety of open marine, inner shelf facies and occasionally form thin biostromes in the Moscovian and Lower Permian part of the succession (Beauchamp 1987; Morin et al. 1994). The buildups are suggested to have formed in a shallow shelf setting at or near the fair weather wavebase. The stratigraphic position of the beresellid boundstones at, or near, cycle tops or during transgressions suggests a similar environment of deposition for the Bjørnøya facies.

Brachiopod-dominated packstone/ wackestone

Description. – The brachiopod-dominated packstones form 25–80 cm thick massive beds dominated by productid brachiopods and fragments of brachiopods, echinoderms and bivalves (Fig. 10e). Beresellid and ungdarellid algae, small foraminifers and fusulinids are also present. Brachiopod-dominated wackestones are less common; they form up to 100 cm thick beds that occasionally grade up into spiculitic wackestone (e.g. subcycle K1.2 in Fig. 5). In Bogevika the upper part of this facies is completely altered and well-developed caliche features are present (e.g. cycle B3 in Fig. 4).

Interpretation. – The relatively diverse fauna indicates deposition in a normal marine environment. The dominance of brachiopods and echinoderms over foraminifers and calcareous algae suggests that deposition took place in a deeper subtidal environment and the absence of wave generated structures indicate deposition below storm wavebase. This facies is therefore suggested to represent open marine deeper shelf conditions during times with low siliciclastic input. The caliche found in the upper part of this facies at Bogevika reflects subaerial exposure during the following sea level fall.

Spiculitic wackestone

Description. – This facies forms 0.1–0.5 m thick beds of spiculitic wackestone with rare laminae of concentrated ostracods (e.g. base of subcycle K2.2 and middle of subcycle K3.1 in Fig. 5; Fig. 10f). It is dominated by pseudomorphs after silica spicules in a muddy carbonate matrix. The spicules are dissolved and replaced by finely crystalline calcite. The ostracods are bivalved.

Interpretation. – The spiculitic wackestone facies resembles the sponge facies of the Paradox Basin of Pray & Wray (1963) and Goldhammer et al. (1990) in the mid-western US. In the Paradox Basin this facies formed during initial transgression in environmentally stressed, apparently hypersaline environments. The absence of normal marine fossils points towards deposition in a restricted marine environment for the Bjørnøya facies. Deposition took place well below storm wavebase; the absence of bioturbation suggests anaerobic bottom conditions.

The spiculitic wackestone most commonly occurs immediately below organic-rich laminated shale and are therefore suggested to represent maximum flooding, and deposition at relatively deep water comparable to what is described from the Paradox Basin and the Moscovian of northern Greenland (Stemmerik 1996).

Red siltstone

Description. – This facies is particularly common at Bogevika, where it forms 5–170 cm thick layers (top of cycles B3–B14 in Fig. 4). The siltstone is red, usually massive and often contains caliche nodules. Mud cracks and rare roots are also seen and in one layer small current ripples were found. The siltstone always overlies highly altered carbonates and occasionally it fills cracks in the underlying carbonate.

Interpretation. – The red siltstone facies represent deposition in protected marginal marine to fluvial environments that were subsequently exposed. The presence of well-developed caliche nodules indicates deposition in a warm and arid climate.

Sandstone

Description. – In the Kobbebukta area, up to 450 cm thick upward coarsening units of fine- to medium-grained sandstone form the upper part of coarsening upward cycles (e.g. the intervals from ca. 9–13 m and 20–25 m in Fig. 5). Sedimentary structures change from small isolated wave ripples in the lower, more shaly part of these units over ripple cross-laminated fine-grained sandstone to large-scale trough and planar cross-bedded medium-grained sandstone, occasionally with large-scale herringbone cross-beds (Fig. 12). The uppermost sandstones often show low angle planar lamination. Palaeocurrent directions based on trough cross-bedded sandstone indicate flow towards the SSW (200°–220°), current ripples indicate flow towards the south and symmetrical ripples indicate a north-south flow direction. Beds, up to 50 cm thick, of bioturbated fine- to medium-grained sandstone are also present in the Kobbebukta area. In the Bogevika area, sandstones are more fine-grained. They consist of large-scale trough and planar cross-bedded, fine-grained sandstone often showing bimodal flow directions. Palaeocurrent directions are towards the WNW (280°–320°) and the ESE (100°–160°), respectively.

Interpretation. – The shallowing upward units resemble typical prograding shoreface successions with basal lower shoreface ripple cross-laminated sandstone overlain by coarser grained cross-bedded sandstone representing the upper shoreface (e.g. Walker & Plint 1992). The low angle planar cross-bedded sandstones are interpreted as beach deposits. The lack of hummocky cross-bedding suggests limited storm influence whereas the bimodal flow directions are taken as evidence for some tidal influence during deposition.

Shale

Description. – Black to grey laminated shale with a sparse fauna of bivalves and small brachiopods forms beds up to 100 cm thick in the Kobbebukta area (e.g. base of subcycle K2.3 in Fig. 5). Most commonly, this facies forms the basal part of coarsening upwards units where the laminated shale gradually passes into shales with small symmetrical sand ripples and, finally, ripple cross-bedded sandstone.

Interpretation. – This facies formed below storm wavebase. The lamination and local evidence of high organic content indicate anaerobic bottom conditions during deposition. The gradual transition of this facies into heterolites with small sand wave ripple indicates that at least the upper part of the shale was deposited close to storm wavebase. This facies apparently formed in outer shelf environments from near storm wavebase and outward.

Efuglvika Member

The Efuglvika Member is dominated by carbonates with some rare siliciclastic beds in the lower part at Jordbruelva. We have distinguished three common carbonate facies. The siliciclastic facies are red mudstones with caliche nodules similar to those described from the Bogevika Member and nearshore cross-bedded sandstones.

Peloidal grainstone

Description. – The peloidal-dominated facies consists mainly of fine-grained grainstones where the grains are almost exclusively peloids and small foraminifers (cycles E1, E2 and E8 in Fig. 7; Fig. 13a). The relative proportion of the grain compo-

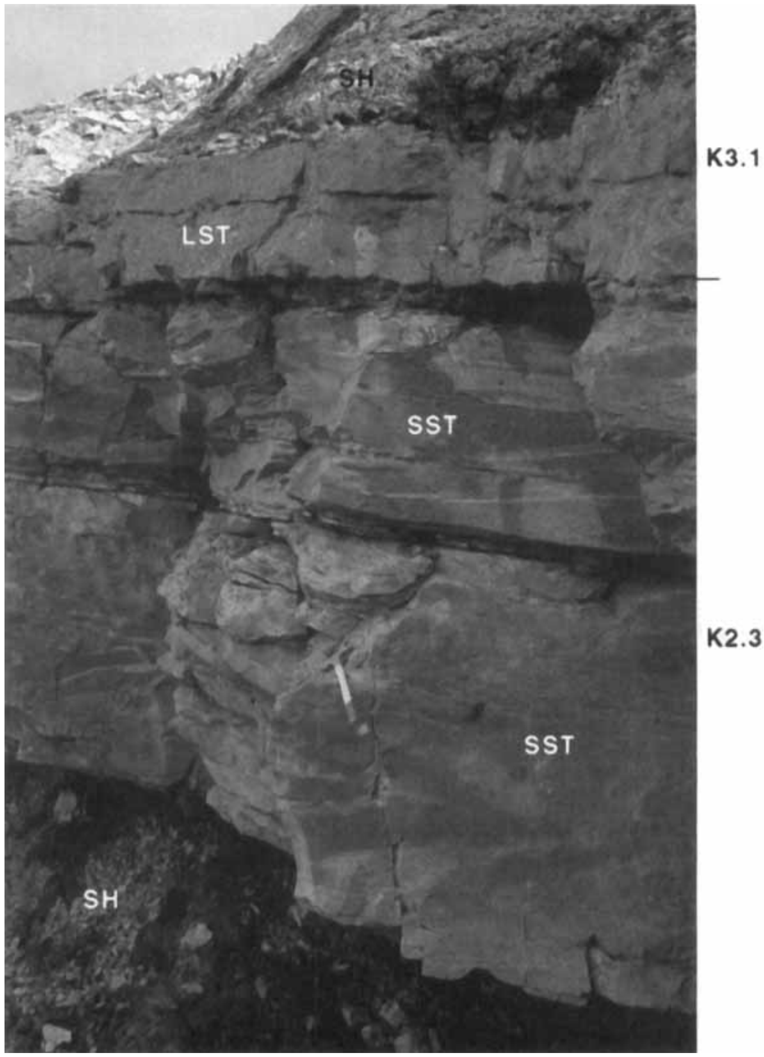

Fig. 12. Large-scale cross-bedded sandstone (SST) from top of cycle KII at Kobbebukta. Note the sharp lower boundary to the underlying shales (SH) and to the overlying transgressive carbonates (LST) of the following cycle. K 2.3 and K3. 1 refer to subcycles in Fig. 5. Hammer is 35 cm long.

nents ranges from almost completely dominance of peloids to sediments where foraminifers dominate. The peloids are well-rounded to elongate, 0.05 to 0.2 mm long, and show a gradual transition from grains with a micritic envelope to completely micritized grains. The foraminifers are mainly single layered apterinellids. Additional biogenic components include rare calcispheres, and fragments of bivalves, ostracods, and echinoderms. Occasionally, this facies shows small-scale cross-bedding and contains pisoids in its upper parts.

Interpretation. – Sediments of this facies were deposited in shallow, moderately high energy and biologically stressed environments. The low diversity fauna with dominance of primitive foraminifers suggests deposition in biologically stressed environments and the intense micritization points towards a shallow marine environment. The absence of large-scale sedimentary structures and ooids is taken as evidence for a moderately high energy setting, and this facies most likely formed in shallow lagoons that subsequently became subaerially exposed. The carbonate grain composition resembles that of the peloidal facies of Morin et al. (1994) from the Permian of the Sverdrup Basin, also interpreted as a shallow lagoonal facies.

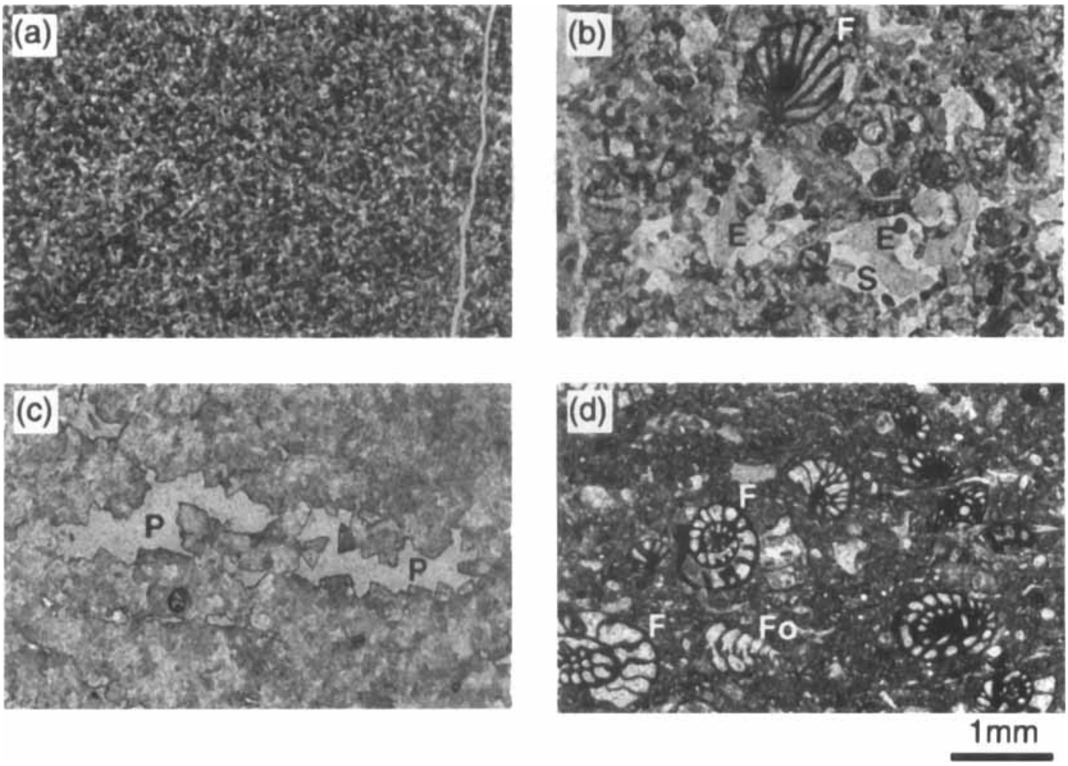

Fig. 13. Microphotographs in plane polarized light of carbonate facies from the Efuglvika and Bogevika members: (a) peloidal packstone, Efuglvika Member; (b) biogenic facies, Efuglvika Member, F = fusulinid, E = echinoderm, S = syntaxial calcite; (c) dolomitized phylloid algal buildup, Kobbebukta Member, P = pore space after dissolved (?)phylloid algae; and (d) fusulinid facies, Kobbebukta Member, F = fusulinid, Fo = small foraminifer.

Biogenic facies

Description. – Bioclastic packstones and grainstones with syntaxial cement are common in the upper part of the Efuglvika Member where they form the upper part of shallowing upwards carbonate cycles (e.g. cycles E7, E10–E12 in Fig. 7). This facies forms 1–4 m thick, massive units composed of poorly sorted, 0.5–2 mm fragments of echinoderms, brachiopods, bryozoans and foraminifers with abundant micritized grains (Fig. 13b). The foraminifer fauna is more diverse than seen in the peloidal facies and includes abundant apterinellids and globivalvinid forms as well as fusulinids. Also, many of the micritized grains appear to be altered foraminifers. Fragments of phylloid and beresellid algae are rare in these rocks. The carbonate cement is dominantly syntaxial and there is no evidence of pervasive early marine cementation.

Interpretation. – The relatively diverse fauna found in this facies point towards deposition in a normal, open marine environment. The grain abrasion and micritization suggest deposition in a relatively shallow environment whereas the scarcity of algal fragments points towards deposition in the deeper parts of the inner shelf. This facies is suggested to represent the deep part of the inner shelf between fair weather and storm wavebase.

Bioturbated biogenic wackestone

Description. – Intensely bioturbated biogenic wackestones are common in the Efuglvika Member (base of cycles E2, E4, E5 and E8–E13 in Fig. 7). They are generally poorly preserved due to later dolomitization and chertification. Identified biogenic components include rare brachiopods, crinoids and ostracods and more common sponge spicules. The bioturbation is dominantly by large *Thalassinoides* burrows that were later filled or replaced by chert.

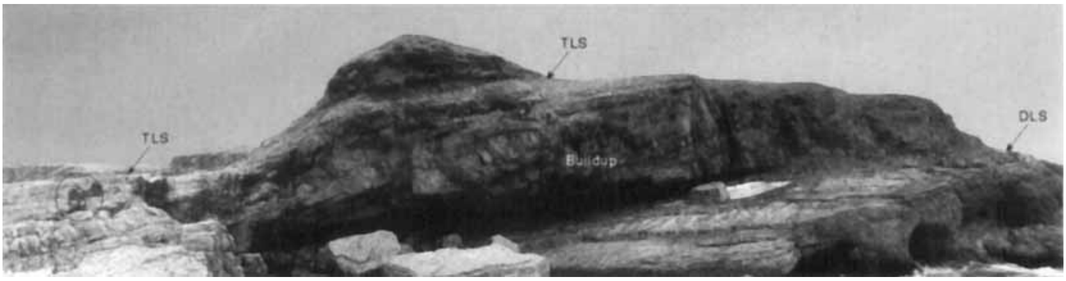

Fig. 14. Phylloid algal buildup in the upper part of the Kobbebukta Member at Efuglvika. Note that the buildup prograded towards the left (west). DLS = downlap surface. TLS = toplap surface. Person for scale encircled. The buildup corresponds to the upper part of the log in Fig. 8.

Interpretation. – The intense bioturbation and absence of primary sedimentary structures indicate deposition in relatively deep water with limited sediment supply. The sparse fauna suggests deposition in normal marine conditions most likely well below storm wavebase on an open shelf.

Hummocky and swaly cross-bedded sandstone

Description. – This facies consists of 60–70 cm thick fine-grained sandstone layers with erosive bases. The sandstone rests directly on bioturbated biogenic wackestone. The sandstone displays a range of sedimentary structures of which hummocky and swaly cross-bedding are most common. Wave ripples and parallel lamination are also occasionally seen. This facies is restricted to cycles E1–E3 in the basal part of the measures section at Jordbruelva (Fig. 7).

Interpretation. – Hummocky and swaly cross-bedded sandstones are generally believed to represent deposition at or immediately below storm wavebase (Walker & Plint 1992).

Kobbebukta Member

The Kobbebukta Member includes two carbonate facies of which the fusulinid facies is very broadly defined. The siliciclastic facies is dominated by conglomerates, and locally sandy turbidites.

(?)Phylloid algal buildups

Description. – Up to 5 m thick lenticular and tabular buildups are locally present in the lower part of the Kobbebukta Member as well as exposed at Efuglvika (Figs. 8, 14). They are massive or have a massive core surrounded by inclined flank beds with a relief of up to 4 m. The buildups are composed of vuggy, brownish weathering, coarsely crystalline dolomite (Fig. 13c). The dolomite has completely destroyed all primary textures and the origin of these buildups is highly speculative. However, many vugs have a platy, irregular shape corresponding to that of a phylloid algal plate, and it is therefore suggested that phylloid algae played an important role in the formation of the buildups.

Interpretation. – Phylloid algal buildups are believed to represent a wide range of shelf environments from storm wavebase to near the limit of the photic zone (e.g. Beauchamp 1993; Morin et al. 1994). The destruction of the primary fabric in this facies prevents a more precise interpretation within this depth range.

Fusulinid facies

Description. – Facies dominated by fusulinids are common particularly in the Kobbebukta Member at Kobbebukta (Fig. 9). They display a relatively large variation in composition but are dominated by wackestones and packstones. They consist of abundant fusulinids together with small foraminifers and fine fragments of brachiopods, crinoids, corals and ostracods (Fig. 13d). Also present are beresellid and ungdarellid algae. The fusulinid-dominated facies are interbedded with ripple cross-bedded, fine-grained sandstone or form the upper part of shallowing upwards carbonate beds separated by thick conglomerates.

Interpretation. – Fusulinids are common in late Palaeozoic mid-shelf deposits and their dominance points towards deposition in open marine, low energy mid-shelf environments below fair weather wavebase but within the photic zone. The facies

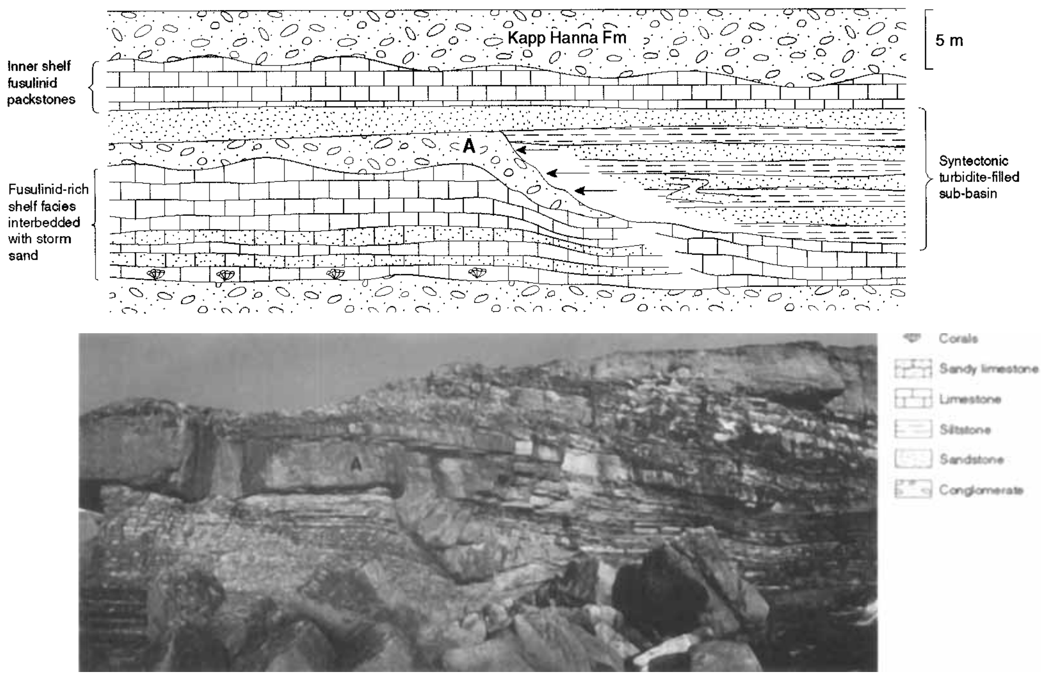

Fig. 15. Small graben structure filled by interbedded turbidites and red claystone of the Kobbebukta Member in the area west of Kobbebukta. Note syntectonic deformation of the conglomerate.

resembles the Permian mid-shelf fusulinacean facies of the Sverdrup Basin described by Morin et al. (1994).

Intraformational conglomerates

Description. – The intraformational conglomerates are 50–450 cm thick and often have slightly erosive bases (Fig. 9). They are poorly sorted, matrix-supported with 30–40% clasts of grey chert and limestone, usually 2–15 cm in size. The chert clasts are angular in shape while the carbonates often are more well-rounded. The matrix consists of poorly sorted sand- to mud-size carbonate and chert. Resedimented rugose corals are often present. The conglomerates appear non-graded and are dominantly massive although irregular horizontal bedding occasionally occurs. The top surface of the conglomerates is often colonized by 30–40 cm large colonies of *Chaetetes*, still in growth position. Furthermore, Kirkemo (1979) has reported reverse grading of the basal part of some units and irregular top surfaces with large clasts. At Kobbebukta, one of these conglomerate beds is seen to be associated with syndepositional faulting (Fig. 15).

Interpretation. – The conglomerates are interpreted as subaqueous debris flows in accordance with Kirkemo (1979). The presence of in situ *Chaetetes* colonies on top of several conglomerates indicates that deposition took place subaqueously apparently in relatively deep water since there is no evidence of colonization by calcareous algae. The clasts appear mostly to be derived from the underlying parts of the Kapp Kåre Formation whereas clasts in the overlying Kapp Hanna Formation conglomerates are mostly sandstones. This indicates that conglomerates were deposited as the result of syndepositional tectonic uplift of southeastern Bjørnøya (Worsley et al. in press), and that chertification of the underlying parts of the Kapp Kåre Formation took place early.

Graded beds

Description. – The graded beds consist of thin bedded, 2–40 cm, sandstones. Most beds are massive, poorly sorted fine-grained sandstone with an erosive base (Fig. 16). Some beds have planar bases with striations or flutes. The sandstone beds are most commonly tabular within the

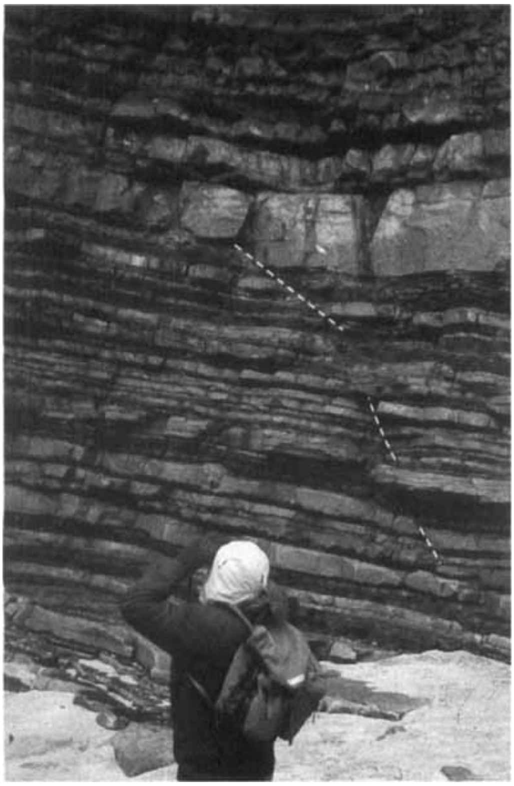

Fig. 16. Interbedded turbidites and red claystone of the Kobbebukta Member. Detail of Fig. 15 showing erosional base of most sandstones and small growth faults in the graben fill. Person for scale.

limits of the exposures, although some beds wedge out laterally both to the east and the west. Individual beds may show reverse grading at the base occasionally with some coarse material, including rugose corals. They are massive or laminated in the central part and commonly fine upward into the overlying shale. The tops of many sandstone beds are rippled with assymetric flat-crested ripples. This facies is interbedded with dark brownish to red, massive claystone (Fig. 16).

Interpretation. – The sandstone beds resemble classical turbidites and are interpreted as such. The preservation of asymmetric ripples at the top of the beds and the lack of wave generated structures indicate deposition well below storm wavebase The turbidites are restricted to a localized syntectonic graben west of Kobbebukta (Fig. 15). Flow directions based on data from the ripples indicate flow towards the west parallel to the axis of the graben.

Depositional model

The carbonate facies of the Kapp Kåre Formation represent a range of shelf environments from intertidal mudflats to deep subtidal shelf. Shallow marine carbonate facies are only well-documented in the transgressive part of mixed carbonate–siliciclastic cycles of the Bogevika Member, and in the lowermost Efuglvika Member. Deposition apparently took place on a moderately high energy shelf with a ramp-like profile during late Bashkirian time, whereas it occurred on a more protected, possibly slightly deeper rimmed platform during most of the Moscovian. The late Moscovian tectonic uplift of the area only influenced carbonate sedimentation temporarily and intermittently, and most of the Kobbebukta Member was also deposited on a protected shelf.

The depositional models presented below are based on the assumption that all the facies represented in the high frequency cycles were deposited simultaneously on the shelf but moved laterally with time as a result of fluctuations in sea level.

Late Bashkirian ramp sedimentation (Bogevika Member)

During early Bashkirian times there was a lateral trend from thick sandstone-dominated cycles at Kobbebukta in northern Bjørnøya to thin siltstone-dominated cycles at Bogevika in south-western Bjørnøya (Fig. 17). The two areas were located at different positions in the north-west-trending half-graben to which sedimentation was restricted at this time.

Kobbebukta area. – The Kobbebukta succession consists of four complete sand-dominated cycles (KI–KIV in Fig. 5), each composed of a basal succession of higher order mixed carbonate–siliciclastic subcycles overlain by a relatively thick shallowing and coarsening upward succession that passes from offshore shales into heterolithic lower shoreface sandstone and finally upper shoreface and foreshore sandstone (Fig. 5). Each of these cycles reflects deposition during a glacioeustatic sea level cycle and represents a high frequency depositional sequence with the maximum flooding interval in the basal part of the laminated shales (Fig. 5). The carbonate–siliciclastic subcycles in the transgressive systems tract

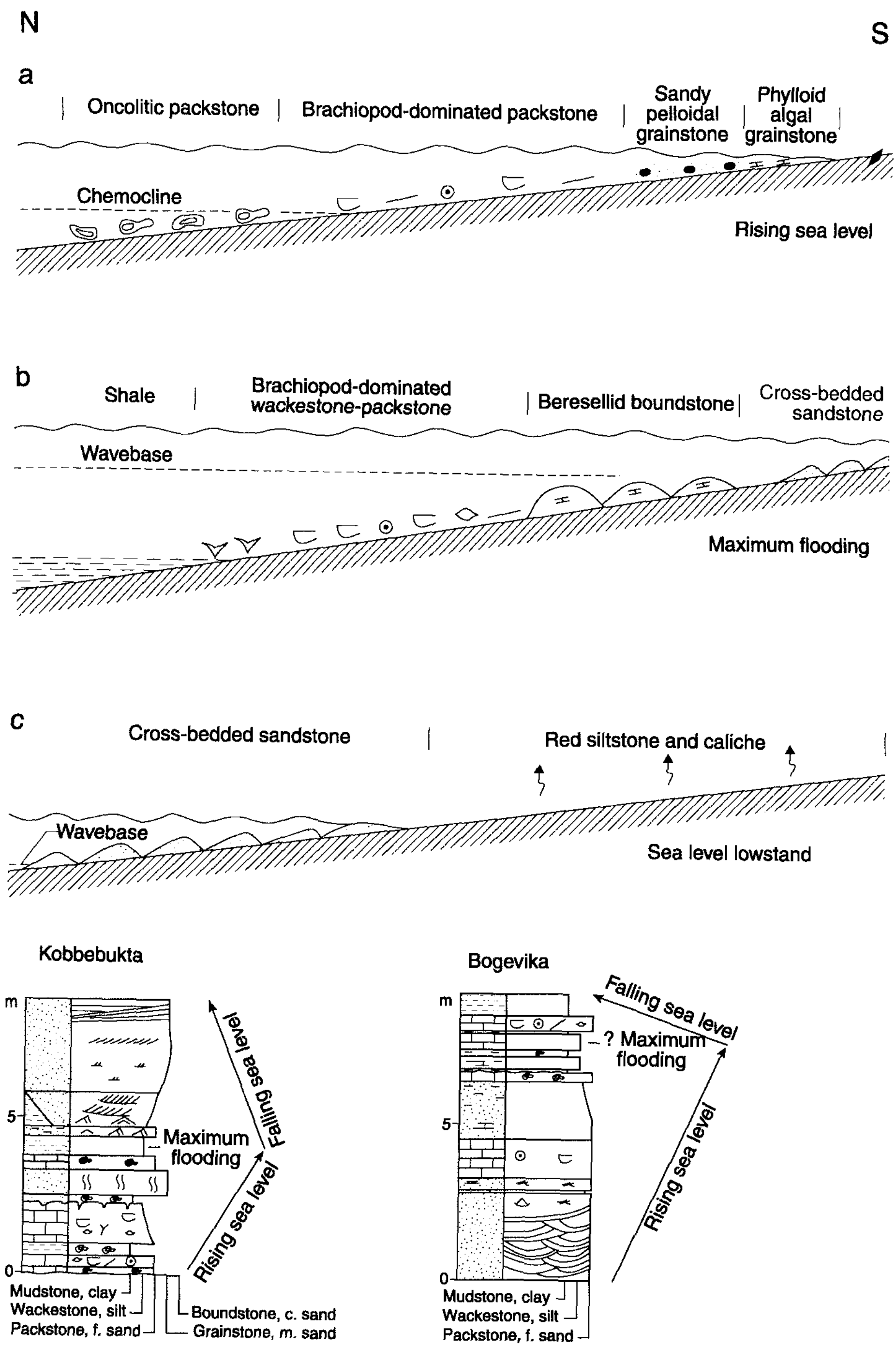

Fig. 17. Schematic depositional model for the Bogevika Member showing facies distribution during (a) sea level rise; (b) maximum flooding; and (c) sea level lowstand. The logs show the depositional response to one full glacioeustatic sea level cycle corresponding to a high frequency sequence at Kobbebukta and Bogevika, respectively, and correspond to the intervals 0–9 m in Fig. 4 and 13–25 m in Fig. 5.

of these high frequency sequences are highly variable in composition.

In the two basal high frequency sequences (KI and KII in Fig. 5), the transgressive systems tract is composed of thin mixed subcycles followed by a clearly defined maximum flooding interval of black, laminated shales, and then a thick regressive sand-dominated unit. In the lowermost high frequency sequence, the transgressive systems tract is composed of two subcycles and the basal part of the third subcycle (K1.1–1.3 in Fig. 5). The basal two consist of transgressive, upward deepening carbonates directly overlain by red lagoonal mudstone with caliche nodules. The third subcycle starts with transgressive reworked sand followed by oncolitic packstone and offshore marine shale, representing maximum flooding. The regressive part consists of shallowing upward shoreface to foreshore sand-dominated facies. The second high frequency sequence starts with a subcycle of transgressive reworked sand, brachiopod-dominated packstone and shale overlain by a thin regressive unit of shallow marine sandstone (K2.1 in Fig. 5). It is followed by a shallowing upward carbonate subcycle of spiculitic wackestone, brachiopod-dominated packstone and beresellid boundstone capped by a subaerial exposure surface. The last subcycle is siliciclastic with open marine shales (maximum flooding interval) overlain by shoreface to foreshore sand-dominated facies (Fig. 5).

The two uppermost high frequency sequences are less clearly organized. The third consists of four subcycles (K3.1–3.4 in Fig. 5). The lower subcycle starts with a thin transgressive algal grainstone that passes up into spiculitic wackestone followed by a thicker shallowing upward unit of shoreface shale to foreshore sandstone. The three following subcycles consist of a transgressive shale overlain by brachiopod-dominated packstone and wackestone. In the topmost subcycle the carbonate is erosively overlain by a relatively thick shallow marine sandstone. The uppermost high frequency sequence consists also of four subcycles (K4.1–4.4 in Fig. 5). The lower has a thin transgressive beresellid boundstone unit overlain by upward coarsening shoreface shales to fine-grained sandstone. It is overlain by a siliciclastic subcycles of shoreface shales and sandstones followed by a mixed subcycle of interbedded carbonate mudstone and shale overlain by a thick beresellid boundstone unit. The upper subcycle is also siliciclastic and consists of shoreface shales and sandstones that grade into foreshore sandstone at the top (Fig. 4).

Bogevika area. – The Bogevika cycles are silt-dominated and comparable in thickness to the Kobbebukta subcycles. However, they show no evident lower order stacking like that seen in Kobbebukta subcycles. They consist of carbonate-rich sandstone, shallow marine carbonates and red siltstone. Each cycle shows evidence of subaerial exposure at the top in form of red siltstone with abundant caliche nodules, mud cracks and roots. The overlying transgressive sandstone and sandy limestone display bi-directional, large-scale planar cross-bedding and small-scale ripple structures. They were deposited in tidally influenced, shallow marine environments and record transgressive reworking of sand that was brought out onto the shelf during sea level lowstand. The overlying carbonates are mainly sandy peloidal packstones and phylloid algal grainstones indicative of deposition in nearshore and lagoonal, moderately high energy environments; open marine brachiopod-dominated packstones are rare.

Facies model. – Detailed facies models of the Bogevika Member are somewhat speculative as individual cycles can not be correlated between the two outcrop areas; however, lateral variations in depositional facies between the two areas are most easily explained if deposition took place on a slightly northward sloping ramp (Fig. 17). The condensed siltstone-dominated cycles seen at Bogevika formed updip in areas with low subsidence rates whereas the thicker, sandstone-dominated cycles at Kobbebukta formed in areas with higher subsidence rates. One assumption is that each of the siltstone-capped cycles in Bogevika corresponds to one of the large cycles in Kobbebukta. Alternatively and more likely, the siltstone-dominated Bogevika cycles are subcycles like those seen in Kobbebukta, and they can be grouped into thicker, poorly defined cycles, each characterized by having a transgressive sandstone or a thin layer of reworked limestone clasts at the base (Fig. 17).

The overall facies composition of the Bogevika Member indicates that carbonate deposition mainly took place in deeper shelf environments below storm wavebase. Shallow marine carbonate facies are confined to thin transgressive units in the Bogevika cycles while they are missing at

Kobbebukta. In contrast most siliciclastic sediments were deposited above storm wavebase with the black shales as the only exception. The gross pattern therefore best fits a model where carbonate deposition took place in shallow, high energy environments during initial transgression and was otherwise confined to the deeper parts of the ramp. Deposition of siliciclastic sediments mainly took place above storm wavebase on the inner part of the ramp. Outer shelf, dysoxic or anoxic shale deposition possibly took place during maximum transgression and in the early stage of sea level highstand in areas with high sediment supply.

The cyclic facies patterns show that each flooding event forced the siliciclastic system landward and led to widespread carbonate deposition on the ramp whereas the following fall in sea level led to seaward progradation of shallow marine and fluvial siliciclastics and subaerial exposure of the updip areas. During peak transgressions the Kobbebukta area was too deep for carbonate sedimentation and offshore shales were deposited there whereas shallow marine algal and peloidal carbonates were deposited further updip on the ramp.

Early Moscovian inner platform cycles

The lower Moscovian Efuglvika Member is composed of cyclically interbedded deep subtidal, bioturbated wackestone and biogenic packstones and grainstones. In one cycle, the biogenic packstones pass upward into peloidal packstones of proposed lagoonal origin. This is the only evidence of shallow subtidal, algal-rich facies in these cycles; however, cycle tops often show evidence of subaerial exposure. The cycles are typically 5–8 m thick (Fig. 7). The basal, 1.5–3.5 m thick units of bioturbated wackestones with abundant chert-filled/replaced *Thalassinoides* burrows form the transgressive part of these cycles. The intense bioturbation indicates that deposition was relatively slow and took place when the sea floor was located below storm wavebase. The shift towards biogenic packstone and grainstone of the upper part of the cycles is usually abrupt, with little evidence of facies gradations across the boundary. This is interpreted to reflect lowering of sea level and deposition above storm wavebase without any significant facies progradation.

The absence of a vertical facies gradation and well-developed prograding intertidal and supratidal depositional units suggests that the Efuglvika Member cycles formed on a very broad relatively deep shelf far from any land area. The shelf profile must have been extremely flat since there is no evidence of facies progradation in these cycles, in contrast to the underlying Bogevika Member cycles where the sea level falls forced shoreface to foreshore sandstones out on top of sub-storm-wavebase shales. This indicates a change from a moderately high energy shelf with a ramp-like profile to a more protected, possibly rimmed platform. The early Moscovian drowning of the entire region and consequent reduction of siliciclastic supply apparently allowed widespread barrier-like reef complexes to form. There is no evidence of such reefs on Bjørnøya itself, but they have been documented on seismic sections from the western Barents Sea; some highly silicified units within the Efuglvika Member may, however, consist of reef debris from a nearby graben margin.

Late Moscovian syntectonically influenced platform sedimentation

The deep shelf sedimentation of the Efuglvika Member was terminated during the late Moscovian as the result of renewed tectonic activity in the graben that extended over present-day Bjørnøya. The top surface of the member is a well-developed karst surface with up to 5 m of local relief (Fig. 8). The thickness variations and facies stacking patterns of the overlying Kobbebukta Member indicate that deposition took place during differential subsidence of the study area that is related to active faulting (Worsley et al. in press). The north-western part of the island was subsiding more rapidly than the south-western part, and most likely the eastern part of the island was uplifted above sea level.

The basal karst surface is overlain by thick, (?)fluvial conglomerates with a variable clast composition that reflects the exposed sediments in the uplifted eastern part of the island. The matrix is siliciclastic. It is overlain by a prograding carbonate buildup in the southern, slowly subsiding Bogevika area (Fig. 18). Further to the north sedimentation is characterized by deposition of shelf carbonates and thick submarine conglomerates. In this area there is faint evidence of cyclic or rhythmic deposition of fusulinid wackestones and more algal-rich packstones both in the upper and the lower part of the succession. The picture is, however, disturbed by the repeated occurrence of thick conglomerates or thinner sandstones. These

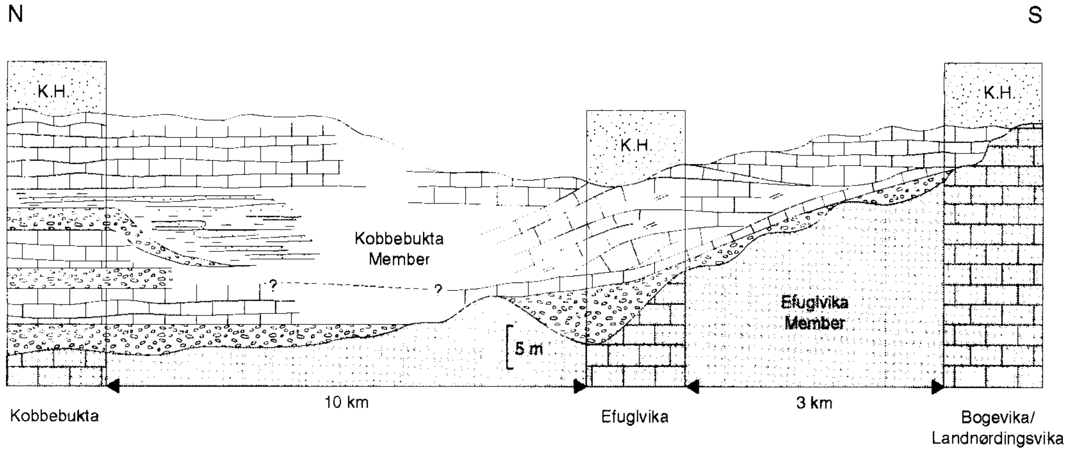

Fig. 18. Schematic north-south section showing the facies distribution within the Kobbebukta Member. Note the uplifted southern margin that may have acted as siliciclastic source area during early Kobbebukta Member time. Carbonate buildups are confined to a narrow zone along the margins of the high.

siliciclastic beds are clearly not part of a sea level driven cyclic pattern as seen lower in the formation. The conglomerates occur randomly in the section both above deeper water wackestones and shallower water packstones. There is no evidence of marine reworking of the top surfaces of these conglomerates, suggesting that they were deposited below wavebase. Rather, the top surfaces represent condensed surfaces colonized by large syringoporid coral colonies possibly indicating rapid deepening associated with deposition of these conglomerates. More direct indication of syn-depositional growth faulting is seen in association with one of these conglomerates. It resulted in a local 10–20 m deep and several hundred metres wide half-graben filled with slumped sandstones and shales deposited by currents flowing along the axis of the structure (Fig. 15).

Discussion

The 1–10 m scale cyclic pattern of sedimentation seen in the Kapp Kåre Formation compares to that of other late Carboniferous sedimentary successions in the northern Greenland–Barents Sea area and elsewhere in the Northern Hemisphere. The primary control on the cyclic depositional pattern is believed to be glacioeustacy triggered by glaciations in the Southern Hemisphere whereas the internal composition of the cycles is controlled by regional and local factors such as climate, relative sea level, tectonic activity and subsidence patterns and distances to siliciclastic sources.

The three members of the Kapp Kåre Formation show different examples of the sedimentary response of mixed carbonate–siliciclastic systems on footwall highs to late Carboniferous glacioeustatic sea levels fluctuations in a warm water shelf setting. Deposition took place in a warm and arid climate and there is no evidence for any major climatic shift during the late Bashkirian and Moscovian that could explain the observed changes in depositional facies. The change from siliciclastic-dominated cycles in the late Bashkirian to carbonate-dominated cycles in the Moscovian primarily reflects decreasing availability of siliciclastic material accompanying ongoing regional sea level rise. The sandstone-dominated cycles of the Bogevika Member were deposited in graben areas with a moderate supply of siliciclastic material from adjacent, subaerially exposed graben margins. The transgressive part of the cycles consists of carbonates or a mixture of carbonates and siliciclastics. Thick sandstones are limited to the regressive part of the cycle. In areas with a high siliciclastic influx, such as the Billefjorden Trough on Spitsbergen immediately adjacent to the Billefjorden Lineament or well locations on the Loppa High (Fig. 1) (Steel & Worsley 1984; Johannesen & Steel 1992; Stemmerik 1996), both the transgressive and regressive parts of the cycle are composed of siliciclastics. Carbonates, if present, are limited to the maximum flooding interval of the cycle (Stemmerik, Elvebakk et al. 1998). Deposition of sandy nearshore sediments was forced seawards during sea level falls, and sandstone-dominated mixed cycles are limited to the more distal areas away from graben margins. In more proximal areas, siltstone-dominated cycles formed. The siltstones were deposited during sea level lowstand in ephemeral lakes or shallow lagoons behind the sandy shorelines and were repeatedly subaerially exposed. The sandstone-dominated Bjørnøya cycles are shale-rich and show well-developed higher order cyclicity compared to time equivalent cycles in well 7120/2-1 located further south on the Loppa High (Fig. 1). Differences between siliciclastic-dominated cycles in these two areas are found primarily in the transgressive to maximum flooding interval of the cycles. The Bjørnøya cycles generally have more thickly developed transgressive deposits and a more well-defined maximum flooding interval with deposition of organic-rich shales. The highstand deposits are very similar in the two areas. The observed differences are most likely controlled by the distance from the siliciclastic source and by subsidence rates. The Bjørnøya cycles formed in a rapidly subsiding area with a limited siliciclastic source whereas well 7120/2-1 cycles are thought to characterize a more stable graben margin but nearer to a siliciclastic source area.

The Efuglvika Member carbonate cycles were deposited during second order sea level highstand and flooding of siliciclastic source areas. At this time tectonic influence on sedimentation was more subtle and depositional cycles are more similar. The Efuglvika Member cycles show no lateral variations on Bjørnøya. They are very like age equivalent cycles described from 7120/2-1 on the Loppa High and from the Foldedal Formation in Peary Land, northern Greenland, and possibly characterize sedimentation over huge, relatively stable platform areas. They differ from buildup dominated cycles like those described from Spitsbergen and Amdrup Land, northern Greenland, and the cycles deposited immediately adjacent to these buildups (Pickard et al. 1996; Stemmerik 1996).

The cyclicity in the Kobbebukta Member is poorly developed compared to the two previous members. The overall depositional conditions in northern Bjørnøya resemble those of the Efuglvika Member. However, repeated tectonic events followed by deposition of conglomerates are interpreted to have disturbed the pattern and no predictable cyclicity is apparent.

Exploration significance

The Landnørdingsvika Formation and the lower Bogevika and Efuglvika members of the Kapp Kåre Formation show a transgressive development typical for the late Bashkirian–early Moscovian of the western Barents Sea. The succession forms the transgressive part of a second order sequence where Bashkirian red beds are gradually replaced by cyclically interbedded siliciclastics and carbonates as sea level rose. The Bogevika cycles show overall similarities to age equivalent cycles in well 7120/2-1 from the Loppa High and the Kap Jungersen Formation at Depotfjeld, northern Greenland (Stemmerik, Elvebakk et al. 1998). In all these areas, the carbonates are preserved as tight limestones with no reservoir potential, supporting prognoses that the transgressive late Bashkirian–early Moscovian succession is non-prospective in most platform areas.

Carbonates with reservoir quality porosity are limited to the upper Moscovian dolomitized carbonate buildups of the Kobbebukta Member around Efuglvika. These correlate to a thick, highly porous dolomitized succession in well 7120/2-1 from the Loppa High (Stemmerik, Elvebakk et al. 1998) and comparable, although slightly older Moscovian dolomitized buildups are also found at Kap Jungersen, northern Greenland (Stemmerik 1996). It appears that the Moscovian carbonate buildups are limited to areas where the rate of accommodation space increased temporarily due to local tectonism. Based on the observations from Bjørnøya and well 7120/2-1, it is therefore likely that upper Moscovian dolomitized carbonates are present around structural highs in the western Barents Sea. Comparison between Bjørnøya and well 7120/2-1 suggests that these potential reservoir rocks will be most thickly developed somewhat downdip on the hanging wall block, corresponding to the proposed location of well 7120/2-1 (Figs. 3, 17, 18).

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Geological Survey of Denmark and Greenland (LS) and Saga Petroleum ASA (DW).

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