and undulatory lower set boundaries (Visser, 1980; Boersma & Terwindt, 1981; Terwindt, 1988). Bipolar foreset dip directions are common throughout most of the central fjord zone and combined with the features noted above the deposits are considered to be of tidal origin (Sønderholm *et al.*, 1989; Tirsgaard, 1993). The sand sheet deposits observed south of Geologfjord represent shallow, poorly defined, high energy tidal channels laid down in a dominantly intertidal environment. The multi-storey sandstone sheets represent larger tidal channel complexes, with the interbedded, heterolithic deposits rich in desiccation cracks recording deposition on inter- to supratidal flats, which developed during periods of abandonment of the tidal channel complexes when depositional activity was shifted to other parts of the coastline (Tirsgaard, 1993).

North of Geologfjord, the tidal deposits most likely represent a dominantly subtidal environment, with sets of cross-bedding having formed in response to landward migrating, medium-scale dunes which may have formed in a back-barrier setting, possibly as part of tidal-delta or shoal complexes (e.g. Boersma & Terwindt, 1981; Sha & de Boer, 1991).

Depositional model

Correlation strategies in Precambrian rocks

The development of depositional models of Precambrian successions is invariably hampered by the absence of proper dating. Biostratigraphic resolution is at best low and consequently correlations rely to a very large extent on lithostratigraphic principles. Since sequence stratigraphic concepts began to be addressed more directly towards outcrop studies (e.g. Posamentier & Vail, 1988; Posamentier *et al.*, 1988; Galloway, 1989; Van Wagoner *et al.*, 1990), it has become apparent that extensive lithostratigraphic correlations are hazardous and in many cases lead to false conclusions (Van Wagoner *et al.*, 1990). However, since the identification and correlation of chronostratigraphic surfaces, or units, provide the fundamental building blocks in sequence stratigraphic models (Allen & Posamentier, 1994), and constraining biostratigraphic data nearly always are absent, limitations are placed on the applicability of sequence stratigraphy in Precambrian successions. Surfaces and units with chronostratigraphic significance will have to be inferred on the basis of an interpretation of the surrounding successions. In most cases, correlation and the subsequent generation of depositional models will therefore have to rely on a combination of lithostratigraphic and sequence stratigraphic principles and methodologies. Application of sequence stratigraphic methods may necessitate making such assumptions as constant sediment influx, uniform distribution of sediment along the shelf, or constant and uniform regional subsidence (Tirsgaard, 1996).

Recognition of regional unconformities (i.e. sequence boundaries) is often problematic in Precambrian successions (e.g. Harris & Eriksson, 1990), which are therefore often regarded as thick, conformable stratigraphic successions and sequence stratigraphic principles can only be applied to these successions with difficulty (Christie-Blick *et al.*, 1988). The problem is reduced where substantial fluvial incision has occurred and is marked by visible lithological variations (e.g. Christie-Blick *et al.*, 1988), or where regional, transgressive conglomerates are developed. Where grain size variations are small and indications of fluvial incision absent, sequence boundaries may be difficult to locate. However, the formation of sequence boundaries, particularly on gently dipping shelves and ramps, is very often characterised by an associated, significant basinward translation of facies (van Wagoner *et al.*, 1988; Posamentier & James, 1993) resulting in major palaeogeographic reorganisations of the shelf.

In some successions, flooding surfaces are more readily defined and, where these can be confidently correlated and placed in a sequence stratigraphic framework, they may provide a better basis for the subdivision of a succession and the subsequent definition of genetic stratigraphic packages (e.g. Galloway, 1989).

In the establishment of the depositional evolution of the Lyell Land Group biostratigraphic data are not available. Neither continental deposits nor levels of fluvial incision have been observed and unequivocal evidence of regional unconformities is absent. However, it is apparent that major palaeogeographic reorganisations took place several times on the shelf during the deposition of the group. It therefore seems improbable that the approximately 3 km of sediment comprising the Lyell Land Group should form an entirely conformable succession.

Characteristic of the Lyell Land Group is a large-scale cyclic pattern of the five facies associations described above. In order to divide this large-scale cyclic development into genetically related packages to create an understanding of the shelf architecture and evolution through time, sequence boundaries have been placed where the main regional unconformities are considered to be present. Since direct evidence of major hiati is not available, sequence boundaries have to be inferred from the succession of facies. On this basis, sequence boundaries are considered to be located where the main regional basinward translation of facies have occurred. In all cases this also appears to be associated with laterally extensive erosion of the underlying deposits.

Flooding surfaces have also been defined within the Lyell Land Group to help define the sequences and provide a basis for the subdivision of the sequences into systems tracts. The precise location of maximum flooding surfaces is difficult to determine, but within each of the interpreted sequences the maximum flooding surface has been placed in the middle of the most fine-grained interval, which is commonly 20–50 m thick.

The widespread nature of the major lithostratigraphic units (formations) and their component facies within the window of exposure suggest that depositional conditions, including sediment influx and subsidence rates were uniform and parallel to basin strike for most of the time during deposition of the Lyell Land Group. It is therefore assumed that units showing consistent stacking patterns within each sequence, which are correlatable throughout the entire central fjord zone, have chronostratigraphic significance and formed in response to regional changes in relative sea-level.

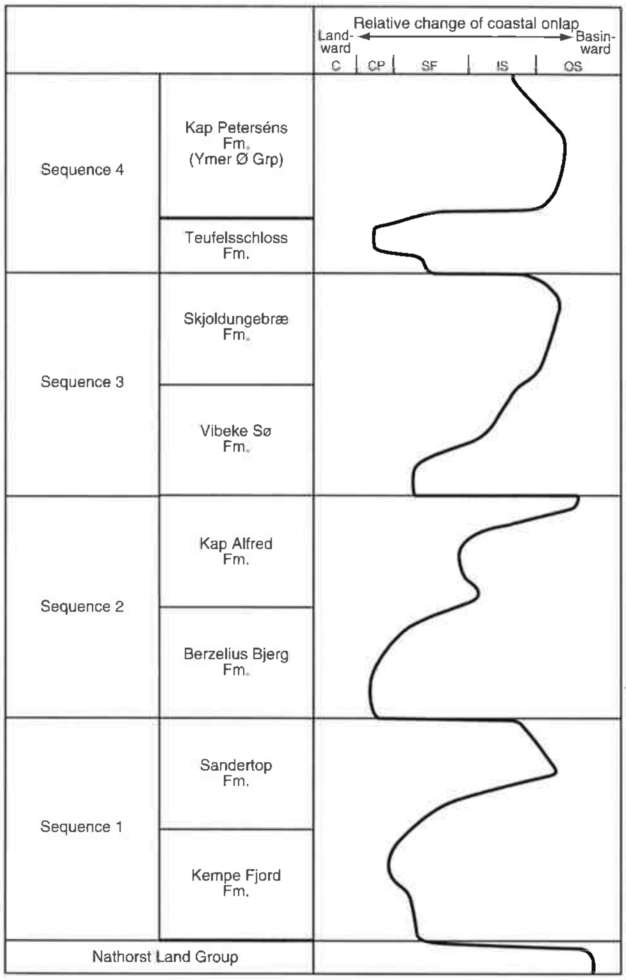

Fig. 53. Relative coastal onlap curve for the four sequences constituting the Lyell Land Group and lowermost part of Ymer Ø Group. The curve is drawn such that each sequence represents the same time span and assumes that no major hiati are present. These assumptions are naturally speculative. The figure should therefore be used with caution, but helps to illustrate that variations in coastal onlap show similar trends in all four sequences. C: continental deposits (not recognised in outcrops), CP: tidally dominated coastal plain association, SF: shoreface associations, IS: storm- and wave-dominated inner shelf association, OS: outer shelf association.

Sequence stratigraphic framework

The deposits of the Lyell Land Group can be subdivided into four, large-scale sequences which overall show the same general sedimentary evolution through time (Fig. 53). The sequences vary in thickness from 400 to 1100 m and are readily traceable for 300 km parallel to the inferred palaeocoastline in the central fjord zone and 100 km basinward to Canning Land.

The sequence boundaries (the bases of all four sequences) are placed where a sharp change occurs from deposits of the outer shelf association, or of the storm-dominated inner shelf association, to deposits of the shoreface or coastal plain association (Figs 9, 14, 18, 26, 30). The vertical development of facies associations indicates that a major regional translation of facies is associated with the abrupt transition from shelf mudstones to shoreface or coastal plain sandstones (Figs 12, 20, 44). This translation is also interpreted to be associated with regional erosion and appears to have formed in relation to a large-scale forced regression. The location of the sequence boundary thus lies at the base of the forced regressive wedge (Posamentier *et al.*, 1992; Kolla *et al.*, 1995).

The lowest 80–500 m of the four sequences consist of progradational to aggradational depositional patterns, which reflect a low rate of relative sea-level rise. In the middle part of the sequences a retrogradational depositional trend reflects a deepening of the shelf related to a rapid relative rise in sea-level. In the upper part of the sequences aggradation dominates, but is sometimes succeeded by very weak progradation indicating a reduced rate of relative sea-level rise (Fig. 53). The maximum flooding surface within each sequence is placed within mudstone intervals where the retrogradational depositional patterns are succeeded by aggradational or progradational patterns (Figs 10, 18, 19, 25, 26).

Evidence of highstand deposition is only present in two of the four sequences, in which progradation patterns become visible in the upper part (Sandertop and Skjoldungebræ Formations), while deposition during the transgressive phase constitutes the middle part of the sequences (Figs 10, 16, 18, 25, 26).

In addition to the regionally developed sequence boundaries, which can be traced throughout the entire central fjord zone and to Canning Land, higher order sequence boundaries can be inferred at the base of a number of sandstone bodies of the shoreface association as these are considered to have formed in response to forced regressions. However, it was not possible with confidence to trace these across the region because of inadequate exposure. More detailed studies and correlations are required if a meaningful sequence stratigraphic model is to be established for higher order sequences.

Sedimentary sequences

Each of the four sequences formed in response to large-scale, cyclic changes in relative sea-level (Fig. 53). Although the overall trends within each sequence are similar, variations occur which show that the palaeogeography varied with time. Each sequence is inferred to represent a package of genetically-related strata.

Galloway (1989) suggested that major palaeogeographic reorganisation occurs during the maximum flooding of the basin, implying that the palaeogeography of a basin may be significantly different during a lowstand and the ensuing highstand. Lowstand shorelines may be characterised by different depositional processes and environments than highstand shorelines. Since the exposures of the Lyell Land Group are nearly all located parallel to basin strike, there is very little control on the variations of the facies associations during sea-level changes (e.g. highstand shorelines are not preserved within the window of exposure).

Sequence 1

This sequence is represented by the Kempe Fjord and Sandertop Formations (Fig. 5) and ranges in thickness between 800 and 1000 m in the central fjord zone. The sequence boundary is marked by a change from outer shelf mudstones to sandstones of the shoreface and coastal plain associations (Fig. 10). The shift corresponds to the contact between the Nathorst Land Group and the Lyell Land Group (Fig. 6).

This initial, abrupt shallowing is followed by a more gradual shallowing, reflected in the lower 200 m of the Kempe Fjord Formation (Figs 9, 53), where deposits of the storm- and wave-dominated shoreface association are overlain by subtidal sandstone deposits of the tidally dominated coastal plain association. Towards the top these grade into a 300 m thick succession of predominantly intertidal deposits. The intertidal channel deposits are succeeded by approximately 100 m of sandstone of mainly subtidal origin. This change implies a subtle rise in relative sea-level.

This weak deepening trend observed in the upper part of the Kempe Fjord Formation becomes more pronounced in the Sandertop Formation (Figs 10, 53). The deepening of the shelf is reflected in a change in the lower 80 m of the Sandertop Formation where deposits of the storm-dominated inner shelf association gradually give way to deposits of the outer shelf association. The latter represent the maximum flooding of the basin and form a roughly 40 m thick succession (Fig. 10). Above this unit, deposits of the storm- and wave-dominated inner shelf association gradually become more important, signifying renewed progradation.

A poorly developed, overall shallowing is signified by the overlying 320 m of sediment, which constitutes the rest of the Sandertop Formation (Figs 10, 53). Sharp-based shoreface deposits occur within the storm-dominated inner shelf deposits and reflect minor progradational events, possibly caused by forced regressions.

Sequence 2

This sequence is represented by deposits of the Berzelius Bjerg and Kap Alfred Formations; it varies in thickness between 750 and 1200 m in the central fjord zone (Fig. 5). The sequence boundary is located at the contact between the Sandertop Formation and the Berzelius Bjerg Formation (Figs 12, 14), defined by an abrupt shift from heterolithic mudstone deposits of the storm- and wave-dominated inner shelf association to sandstones of the tidally dominated coastal plain association. In contrast to sequence 1, shoreface deposits are only a few metres thick and coastal plain deposits are present almost directly above the sequence boundary (Fig. 12). Within the lower 400 m of the sequence, a development similar to the lower part of sequence 1 is seen reflecting the low rate of relative sea-level rise, following the abrupt fall inferred at the base (Fig. 53).

An increased rate of relative sea-level rise is indicated by the deepening trend at the top of the Berzelius Bjerg Formation, where the coastal plain association passes up into 80 m of fine-grained sandstone of the shoreface association (Fig. 14). This trend continues into the Kap Alfred Formation, where the shoreface association passes into the storm- and wave-dominated inner shelf association, which forms a relatively uniform 130 m thick succession (Figs 15, 16). Above follows a 400 m thick succession consisting of interbedded deposits of the tidally influenced shoreface and the storm- and wave-dominated inner shelf association which marks a shift towards a more tidally dominated shelf. The uppermost 100 m of the sequence consists entirely of mudstone of the outer shelf association and represents the culmination of the overall deepening (Figs 16, 53).

The presence of tidally dominated coastal plain deposits in both sequences 1 and 2 suggests that tidal activity was a permanent, rather than a periodic feature on the shelf. The shift from a storm- to a tide-dominated shelf as a result of a change in the basin palaeogeography (which may have led to increased tidal ranges and stronger tidal currents) is therefore unlikely. It is more likely that the change resulted from a period of subdued storm activity on the shelf. This allowed better preservation of tidally induced features within the shoreface deposits where previously storm-induced wave activity and currents resulted in complete reworking of the tidal features.

Sequence 3

Sequence 3 comprises the sediments of the Vibeke Sø and the Skjoldungebræ Formations (Fig. 5); it reaches a thickness of almost 550 m in the central fjord zone and in Canning Land. Sequence 3 is initiated by an abrupt shift from mudstone of the outer shelf association to mature, structureless sandstone of the storm- and wave-dominated shoreface association (Figs 18, 30). Following the initial pronounced sea-level fall, the sequence records shoreface aggradation during a slow relative rise in sea-level followed by a gradual deepening related to an increased rate in relative sea-level rise (Fig. 53). The lower 150 m of the sequence consists primarily of deposits of the shoreface association. However, in the central fjord zone, 10–20 m of heterolithic deposits of the storm- and wave-dominated inner shelf association occurs 20–25 m above the base, reflecting minor, high-frequency variations in relative sea-level (Fig. 18). In Canning Land, shoreface deposits appear to comprise the entire basal 80 m (Fig. 19), but the exact correlation of the shoreface sandstone units is uncertain. It is possible that the 80 m of shoreface deposits in Canning Land should be correlated with only the basal 25 m of the sequence in the fjord zone; the variation in thickness reflecting the distribution of accommodation space on the shelf during the sea-level lowstand.

Above the shoreface deposits follows approximately 150 m of sediment showing a recurrent interbedding of 1–5 m thick shoreface packets and 5–40 m thick units of storm-dominated inner shelf deposits (Fig. 18), reflecting repeated episodes of regression followed by transgression. An overall deepening is manifested by the gradual upward thinning of the sandstone beds and a gradual thickening of the heterolithic deposits (Figs 18, 19, 23). In the uppermost 200 m of the sequence, storm-dominated inner shelf deposits give way to mudstones of the outer shelf association and here, thin sharp-based shoreface sandstone beds directly overlie outer shelf deposits. A weak upward coarsening trend is present in the uppermost 50 m, where there is a return to interbedded deposits of the inner shelf and shoreface (Figs 18, 25, 26).

The repeated episodes of forced regression seen throughout most of this sequence reflects the superimposition of high-frequency relative sea-level variations upon the overall relative sea-level rise. The high frequency sea-level oscillations give rise to 20-50 m thick regressive-transgressive cycles, similar to those observed in the sequences below. The cycles cannot, with confidence be correlated between outcrops and their lateral extent is unknown. Cyclic regressive-transgressive events on a scale of 70–120 m are also visible within the sequence and appear to be correlatable throughout the fjord zone and eastwards to Canning Land. The cyclic pattern is produced by stacked successions of upward thickening sandstone units (Figs 18, 19, 26).

Sequence 4

Sequence 4 is initiated by the Teufelsschloss Formation and continues into the overlying Kap Petersén̈s Formation of the Ymer Ø Group (Figs 23, 30, 53). The sequence attains a thickness between 250 and 350 m in the central fjord zone, showing a gradual thinning towards the south. From Steno Land to northern Lyell Land (Fig. 1), the sequence boundary is marked by a shift from heterolithic mudstone deposits of the storm-dominated inner shelf association to sandstones of the storm- and wave-dominated shoreface association (Figs 27, 30, 44). The shoreface deposits form 30–50 m thick successions which contain a 2–5 m thick heterolithic unit in the middle part.

From Strindberg Land to Lyell Land, the shoreface deposits are erosively overlain by sandy tidal channel deposits of the coastal plain association, similar to those observed in sequences 1 and 2, reflecting continuous but modest progradation of the coastline (Figs 30, 44, 53). The coastal plain association forms a 60–70 m thick succession. A slight deepening of the shelf is implied by the regional presence of 1–6 m thick shoreface deposits above the tidal channel sand sheets (Figs 28, 30A). This also constitutes the top of the Teufelsschloss Formation and thus the Lyell Land Group. A dramatic flooding event occurs immediately above the Teufelsschloss Formation (Figs 30, 31, 44, 53), where mudstones of the outer shelf association abruptly overlie shoreface deposits. These outer shelf deposits, which are part of the Kap Petersén̈s Formation, form a very uniform succession 120–180 m thick which near the top gradually passes up into a 50–100 m thick succession of storm-dominated inner shelf deposits (Fig. 53).

In the northernmost part of the central fjord zone, and in southern Lyell Land, Scoresby Land and Canning Land, the coastal plain association is absent, and instead the lower part of the sequence consists of interbedded deposits of the storm- and wave-dominated shoreface and inner shelf associations (Figs 26, 27). In the southern part of the central fjord zone and in Canning Land, where the coastal plain association is absent, the lower more coarse-grained part of the sequence thins dramatically and is only 30 m thick in Canning Land and in Scoresby Land (Fig. 19). It is still recognisable as stacked 8–10 m thick shoreface sandstone successions interbedded with storm-dominated inner shelf deposits (Figs 26, 27). In the southern and eastern part of the shelf, the abrupt deepening of the shelf, marked by the contact to the Kap Petersén̈s Formation is defined by an abrupt shift from storm-dominated inner shelf deposits to mudstones of the outer shelf association (Figs 26, 27).

Palaeocoastline orientation

Because of the lateral homogeneity of the various formations, unequivocal data regarding the orientation of the coastline during the formation of the Lyell Land Group is not available. However, lithological variation and sedimentary structures in combination can be used to give an indication of the palaeocoastline orientation.

Typically, all formations preserved in the Bredefjord – Ardencaple Fjord region can be readily traced more than 300 km south to Scoresby Land without showing any major variations in lithology and thickness. In contrast, the formations show more variations, albeit still small, in an eastward direction across a distance of only 100 km to Canning Land. These variations are seen as a tendency for formations to become more sand-rich towards the west and more fine-grained towards the east. Such regional lithological variations suggest a roughly north–south running palaeocoastline, with the basin deepening in an eastward direction.

Palaeocurrent directions potentially provide good evidence of coastline orientation, but their value is entirely a function of the validity of the inferred depositional model. Within the storm- and wave-dominated inner shelf and shoreface associations of all four sequences, foreset dip directions indicate a strong dominance of northerly flowing currents. These are here interpreted to have formed in response to shore-parallel geostrophic currents. This interpretation is supported by studies of Recent shelf currents and shelf dispersal systems (e.g. Duke, 1990; Snedden & Nummedal, 1991; Swift & Thorne, 1991), but there are gaps in the understanding of Precambrian shelf circulation systems, particularly on very wide and shallow shelves (cf. Cant & Hein, 1986) and palaeocurrent evidence must therefore always be treated with caution.

Foreset dip directions from intertidal channels suggest general NW–SE palaeocurrent directions, which implies that the palaeocoastline was probably oriented NE–SW (Tirsgaard, 1993). The most reliable indication of coastline orientation is perhaps provided by the large-scale wave ripples, observed in the shoreface association. Large-scale wave ripples are generally accepted as indicators of coastline orientation as they form in response to steady, high energy, oscillatory wave movements with crestlines orientated parallel with the coastline (Leckie, 1988). In nearly all cases, ripple-crests are orientated N–S or NNW–SSE, suggesting an orientation of the coastline similar to that suggested by the palaeocurrents.

The evidence from palaeocurrent data combined with regional lithological variations thus consistently suggests a general N–S, possibly NNE–SSW, orientation of the coastline, with the basin deepening in an eastward direction. Deflection of the geostrophic currents in a northerly, i.e. anticlockwise direction suggests a palaeolatitude in the southern hemisphere. This configuration appears to have existed during deposition of the entire Lyell Land Group.

Sequence stratigraphic model

As a result of the sequence stratigraphic interpretation of the sediments in the central fjord zone and the inferred north–south palaeocoastline orientation a sequence stratigraphic model is suggested for the shelf during the formation of the Lyell Land Group. The model has tentatively been extended 100 km to the west to include the Petermann Bjerg region (Fig. 1). A sequence stratigraphic cross-section showing the characteristic stacking patterns of the systems tracts of all four sequences is shown in Figure 54.

The model depicts a broad and gently dipping ramp where the central fjord zone was located in a relatively distal position dominated by lowstand and transgressive deposits. Further landward, highstand deposition dominated while lowstand periods were characterised by erosion and bypass.

Sequences 1 and 2 (Fig. 54A) were characterised by relatively high sediment input during lowstand periods. Combined with the creation of considerable accommodation space this led to the development of thick, regionally uniform, sandy shallow marine lowstand wedges. Sediments most likely were conveyed to the lowstand wedges via braided stream systems located west of the central fjord zone, possibly in the Petermann Bjerg region. During the ensuing transgression drowning of the ramp resulted in the sharp transition from shallow marine to outer shelf deposits. The highstands were characterised by aggradation and subsequent progradation of the coastline, manifested in the central fjord zone as a gradual transition from an outer to an inner shelf environment.

Sequence 3 contains a relatively larger proportion of outer shelf and mudstone-rich inner shelf deposits than the previous two sequences. It is initiated by a significant seaward translation of facies and the formation of a lowstand wedge in the central fjord zone (Fig. 54B) which shows a less uniform lithological development than the previous lowstand wedges, possibly because less coarse material was available. The transgression and highstand periods show a similar development to the two underlying sequences, but contain a larger proportion of mudstone.

Sequence 4 shows an even more limited coarse clastic input than sequence 3, although this sequence is also initiated by a significant basinward translation of facies and the formation of a lowstand wedge (Fig. 54C). The lowstand wedge is thinner than in the previous sequences and shows considerable variations in lithology. During the subsequent transgression, the coastline was rapidly translated to the west and only fine-grained outer shelf sediments were deposited. In the central fjord zone, the ensuing highstand is manifested only as a shift to mudstone-rich inner shelf deposits.

Because of the limited evidence available to constrain the sequence stratigraphic model in an east–west direction, it can serve only as a first approximation which must await further substantiation from sedimentological studies of the Petermann Bjerg Group as sedimentological evidence from this group is not available at present. However, based on the sequence stratigraphic model of the central fjord zone and the limited lithological and stratigraphical information available from the Petermann Bjerg Group tentative sequence stratigraphic correlation schemes are shown in Figure 55 compared with the lithostratigraphical correlation originally suggested by Wenk & Haller (1953).

Basin physiography and cyclic sea-level changes

It is characteristic of the Lyell Land Group deposits that the individual facies associations form successions which may be many tens, sometimes hundreds of metres thick within each sequence, without showing any major variations in facies, grain size or bed thickness. The facies associations are also readily traceable throughout the central fjord zone for more than 300 km showing only minor thickness variations. The depositional patterns can likewise be correlated 100 km eastwards into the basin to Canning Land.

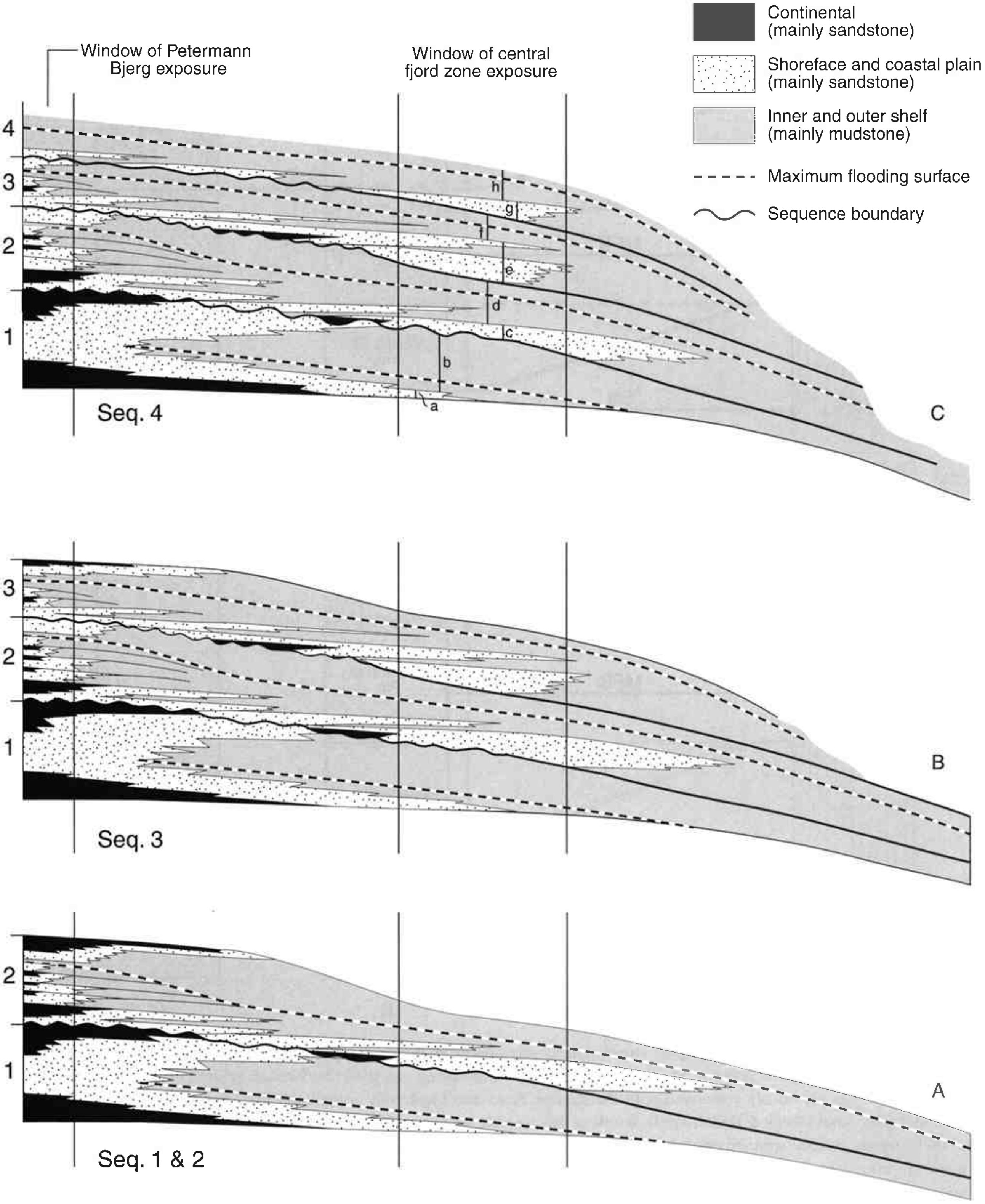

Fig. 54. Tentative sequence stratigraphic cross-section showing the characteristic stacking patterns of the lowstand, transgressive and highstand systems tract deposits for a broad ramp setting as envisaged for the different stages during the evolution of the Lyell Land Group. Window of central fjord zone and Petermann Bjerg exposures is indicated. Top of Kempe Fjord Formation (a), Sandertop Formation (b), Berzelius Bjerg Formation (c), Kap Alfred Formation (d), Vibeke Sø Formation (e), Skjoldungebræ Formation (f), Teufelsschloss Formation (g), Kap Peterséns Formation (h). See text for further explanation.

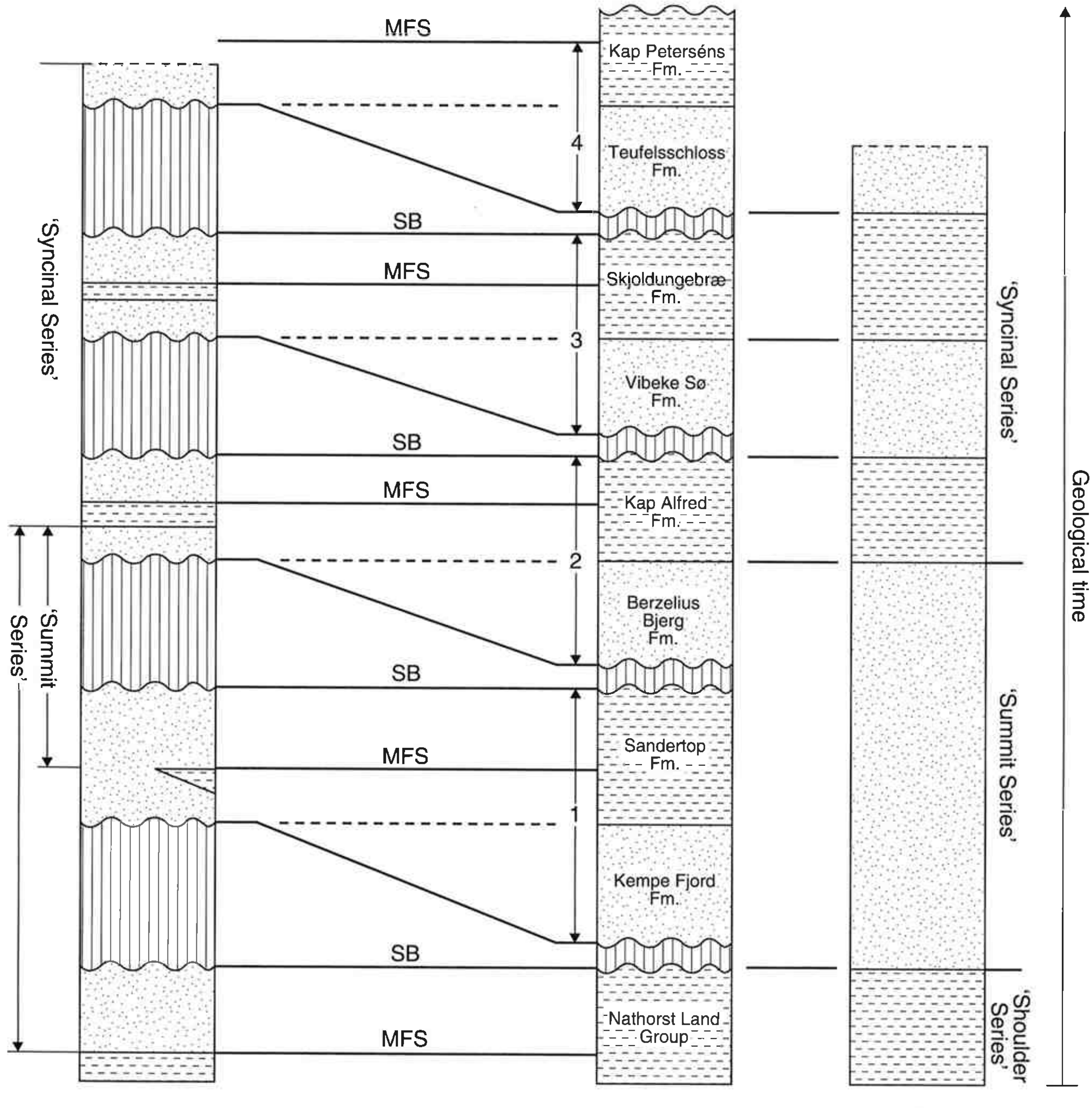

Fig. 55. Two possible sequence stratigraphic correlation schemes between the successions in the Petermann Bjerg region (**A**) and in the central fjord zone (**B**); see also Fig. 53. The lithostratigraphic correlation suggested by Wenk & Haller (1953) is shown in **C**. The 'Summit Series' was previously correlated with the Kempe Fjord and Sandertop Formations ('bed-groups 1 and 2') on a strictly lithostratigraphic basis (Wenk & Haller, 1953). In one of the possible sequence stratigraphic correlations the 'Summit Series' is coeval with both coarse- and fine-grained deposits of 5 units (uppermost part of the Nathorst Land Group, the Kempe Fjord Formation, the Sandertop Formation, the Berzelius Bjerg Formation and the lower part of the Kap Alfred Formation) and includes two major sequence boundaries. The 'Summit Series' may also be coeval with only the upper part of the Sandertop Formation, the Berzelius Bjerg Formation and the lower part of the Kap Alfred Formation and only include one major sequence boundary.

Similar sedimentation patterns appear to be common in many Precambrian and Cambrian successions (e.g. Anderton, 1976; Levell, 1980; Føyn, 1985; Dott *et al.*, 1986; Hein, 1987; Nystuen & Siedlecka, 1988; Eriksson *et al.*, 1993) where thick, laterally very extensive and extremely homogeneous shelf sandstone or mudstone units can reach thicknesses of more than 2 km without showing indications of marked cyclic development or significant changes in depositional environment. Part of this may be explained by the diminished environmental resolution resulting from the low preservation of fine-grained material caused by the absence of land vegetation (e.g. Dalrymple *et al.*, 1985; Dott *et al.*, 1986; Pettijohn *et al.*, 1987; Tirsgaard, 1993). However, the general picture of substantial deposition of homogeneous facies in Precambrian and Cambrian successions depicted by Cant & Hein (1986) can be considered valid; these authors suggested that increased tidal amplitudes or reduced chemical weathering due to the absence of land plants were possible causes. None of these explanations are, however, appropriate for the deposits of the Lyell Land Group. Although environmental resolution in the coastal depositional environments of the Lyell Land Group is reduced there are compelling indications of only a modest tidal amplitude (Tirsgaard, 1993). It seems therefore more plausible that the stable nature of the individual facies belts is a result of a particular combination of basin physiography, subsidence rates, eustasy, sediment influx and shelf circulation systems.

The consistent vertical and lateral development of facies associations seen in the four sequences of the Lyell Land Group imply that subsidence rates parallel to basin strike must have been highly uniform and that sedimentation rates over long periods must have balanced relative sea-level change. No evidence of significant tectonic activity has been observed within the Lyell Land Group suggesting that the major sea-level falls and consequent shelf reorganisations were a result of eustasy.

There are no indications of point sourcing of sediment to the shelf and sourcing of sediment appears to have been evenly distributed along the coast. This in combination with effective dispersal systems driven by consistent coast parallel geostrophic currents which were periodically supplemented by tidal current systems probably helped to create the wide lateral distribution of the facies associations.

The thick development of the individual facies associations also suggests that facies belts were extensive, both parallel to and perpendicular to the basin strike and that they migrated only slowly and over relatively short distances. During deposition of each of the four sequences, periods existed when outer shelf or coastal plain deposits were laid down across large areas within the window of exposure, forming facies belts at least 50–100 km wide. Such a distribution of facies suggests an extremely flat basin physiography. The thickness of the facies associations is dependent upon the combined effect of subsidence, eustasy and sediment input. To preserve thick successions of a single facies association requires prolonged periods with relatively uniform rates of creation of accommodation space on the shelf. Major eustatic changes in sea-level would lead to variations in accommodation space and consequently result in significant lateral translation of facies. This would be particularly conspicuous on a gently dipping shelf, where even small variations in sea-level lead to submergence or exposure of large areas of the shelf. Since major translations of facies are mainly associated with the formation of the four sequence boundaries, and thus lower order cyclic sea-level changes, it implies that high order sea-level cycles during most of the time must have been of small amplitude. The only exception to this occurred during deposition of sequence 3 when recurrent episodes of forced regression led to major shifts in facies belts and to the formation of near coastal shoreface deposits directly above outer shelf deposits.

Palaeogeographic reconstruction

On the basis of the facies development within the four sequences, a general palaeogeographic model of the shelf can be made. The model assumes that no major palaeogeographic reorganisation of the basin occurred in association with the shifts in relative sea-level within each sequence. This is likely to be an over-simplification, but with the minor amount of east–west data on the shelf and the poorly developed highstand deposits, a more detailed model is not achievable. Once integration of data from the Petermann Bjerg area becomes possible, a more refined model may be established.

A reconstruction of the shelf during formation of all four sequences depicts a shelf orientated north–south and deepening towards the east (Fig. 56). Coastal plain deposits formed in the most proximal parts. These were dominated by wide, shallow sandy tidal channels and, to a lesser extent, by tidal flats formed within a micro- to mesotidal regime (Tirsgaard, 1993). Seaward, the coastal plain deposits passed into shoreface deposits

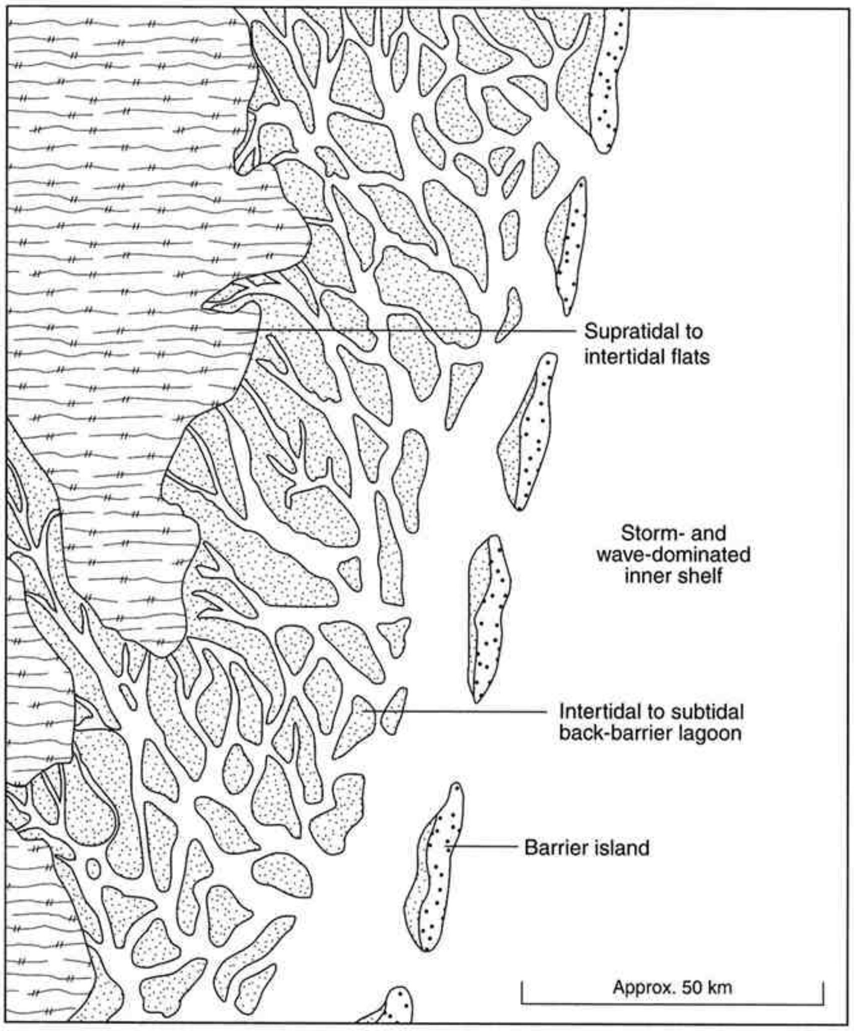

Fig. 56. Simplified, tentative reconstruction of the shelf during formation of the four sequences. Coastal plain tidal channels and supra- to intertidal flats formed at the landward side (these are not developed in the window of exposure of sequence 3, but are suggested to exist west of the central fjord zone). Towards the east, these pass into a series of barrier islands, which seawards pass into storm-dominated inner shelf and eventually outer shelf environments. The coastline was orientated roughly north–south, with the main transport direction on the shelf being towards the north.

which, during most of the time, were strongly influenced by storm and wave activity. Northerly flowing, shore-parallel geostrophic currents were the dominant transport agent. During formation of sequence 2, however, tidal activity became more prominent, probably because of reduced storm- and wave activity in the shoreface environment or, alternatively, because tidal currents periodically became stronger. Similar hydrodynamic changes on shelves have been recorded from late Precambrian deposits by Lindsey & Gaylord (1992). A climatic change towards a more calm environment or palaeogeographic reorganisation on the shelf leading to enhanced tidal amplitudes are both mechanisms likely to have caused such changes (see also discussion of this under the description of sequence 2).

Considering the recurrent evidence of tidal activity both within the coastal plain deposits, and periodically within the shoreface deposits, it is likely that barrier islands formed on the shelf (Fig. 56; Reinson, 1992). However, as previously discussed, direct evidence of their occurrence such as tidal inlet or tidal delta deposits has not be observed. Basinward, the shoreface deposits passed into storm-dominated inner shelf deposits which, further seaward, graded into an outer muddy shelf.

In sequence 3 coastal plain deposits do not occur and evidence of tidal activity is missing throughout the sequence. This does not necessarily imply that tidal channels did not form on the coastal plain, which may have existed further west. Since storm- and wave-dominated shoreface deposits form the most proximal deposits it is likely that the fall in relative sea-level which initiated all four sequences was smaller in sequence 3 than in the other three sequences.

During the final stages of deposition of the Lyell Land Group, indications from sequence 4 suggest that a more diverse depositional pattern developed on the shelf, where sediment influx and coastal progradation were more localised. The tidally dominated coastal plain deposits became localised to the middle part of the central fjord zone, while deeper water developed on the shelf in the southern part of the central fjord zone and in Canning Land. This may reflect a diminishing siliciclastic sediment supply which eventually was reduced to the point at which a carbonate ramp (represented by the deposits of the overlying Ymer Ø Group) began to develop across the entire shelf.

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