CHAPTER 6

Eocene to early Oligocene deltas in the Southern North Sea Bight, Belgium

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ABSTRACT: The Southern North Sea Bight is a shallow marine, siliciclastic and intracratonic basin with gently dipping sediment packages indicative for a ramp-type basin margin. Four cored wells near the Belgian coast contain together a nearly continuous, 200 m thick sediment succession of Eocene till early Oligocene age. Facies analysis suggests that part of these sediments are deposited in delta systems and part on muddy shelf. A sedimentation model for the delta complex is presented. Sequence stratigraphic analysis provides new clues for the reconstruction of relative sea-level changes and for the genetic interpretation of the various lithologic units and the large-scale architecture of the ramp-type margin.

6.1 INTRODUCTION

The shallow, intracratonic Southern North Sea Bight (SNSB) Basin is a basin without a pronounced continental shelf-edge. The large-scale architecture of the basin is dominated by gently dipping sediment packages indicative for a ramp-type margin setting. Northwestern Belgium is situated on the continental shelf of the southern basin margin (Fig. 1), where siliciclastic shallow-marine Tertiary beds dip gently to the NNE (less than 0.5%) in a series of onlapping parallel, WNW-ESE orientated units. Singularities at the top of these units are related to late Tertiary and Quaternary erosion.

Onshore northwestern Belgium, the stratigraphy of the Eocene succession has been established by Rutot (1882, 1883), Mourlon (1888), Leriche (1912, 1922) and by Gulinck (1965, 1969a, 1969b). More recently, the lithostratigraphy of the layers forming the transition between the Eocene and the Oligocene has been modified by Jacobs (1975). The Palaeogene lithostratigraphy (Table 1) is a summary from Maréchal and Laga (1988), based on contributions by various authors. In spite of this fragmentary information of the Palaeogene depositional environments of the SNSB Basin, up to now no attempt was made to forward an integrated sequence-stratigraphic approach.

In the SNSB Basin 16,000 km high-resolution seismic reflection profiles have been shot by the Renard Centre of Marine Geology (RCMG) Seismostratigraphy Unit. On basis of these profiles a number of seismic stratigraphic units of Eocene till early Oligocene age have been introduced by De Batist (1989). To further identify age and sedimentology of these units, four wells (GR1, SWB, SEWB and VR1) were drilled in front of the Belgian coast roughly along a SW-NE to S-N down-dip section (Fig. 2). The cores contain the expected Eocene till early Oligocene deltaic succession, which has a composite thickness of up to about 200 m (Fig. 3).

In this paper a detailed description of the cores' lithology is given. The well data allow the reconstruction of a sequence-stratigraphic model of the delta complex based on sedimentary facies analysis, grain-size trends and genetic relationships of the facies. Biostratigraphical control was provided by data obtained from equivalent sediment series in nearby onshore cored holes 11E138 and 22W276 (Fig. 2; King, 1990; Steurbaut, 1990).

6.2 GR1 WELL

The lithology of well GR1 is dominated by grey-green coloured clay (Fig. 4). The clay is often bioturbated, and contains mm-sized, sand-filled burrows and local concentrations of sideritized, fine-sandy laminae. There is a gradual decrease in grain size from the base towards the top of the well.

At the base (Unit 1) the clay contains mm-thick silty laminae, fine sandy patches and some jarosite and pyrite concretions. At about 73 m well depth the clay is overlain by a disturbed, highly-organic black clay layer with jarosite veins and pyritized fossils. The transition from the organic-rich layer into the under- and overlying units is gradual, probably through the loss of organic carbon by oxidation. The overlying Unit 2 has a higher organic carbon content then the basal clay unit and contains rare, mm-thick silt and fine sand in both laminae and patch structures. Around fossils jarosite and pyrite-rimmed concretions occur. Variations in organic carbon occur across the fine, mm-thick horizontal laminae.

The monotonous clayey facies in well GR1 suggests a quiet depositional environment with important fine-grained sediment supply into the early Eocene basin (Jacobs & Sevens, 1988). The dispersed silty to fine-sandy patches indicate intense biogenic sediment reworking. The few horizons with reworked allochtonous fossil material and the very thin, fine-sand laminae point to

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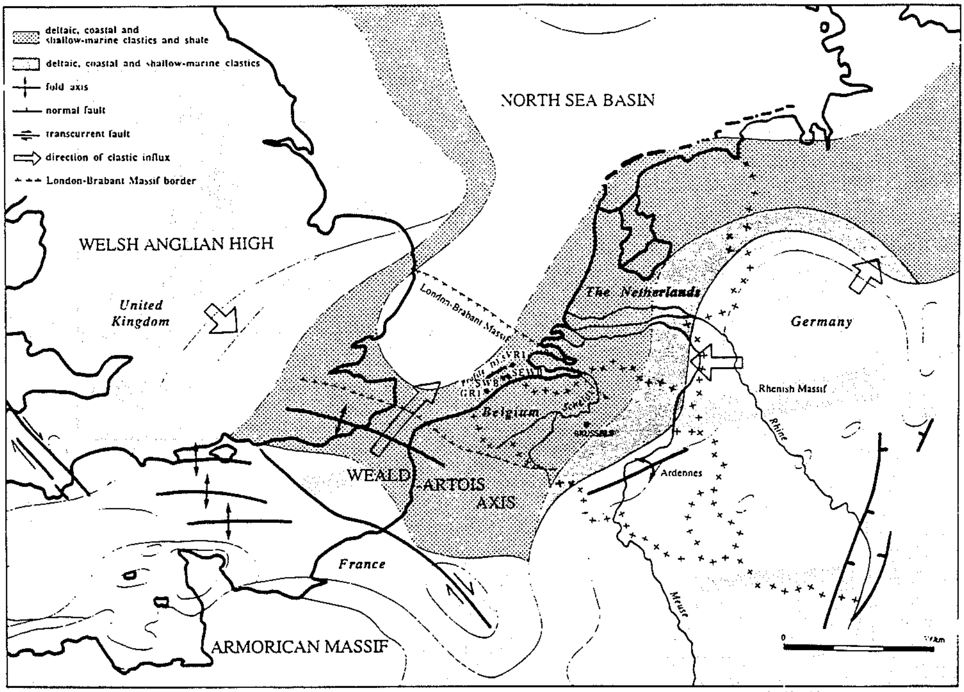

Figure 1. Sketch of the late Eocene palaeogeography of the Southern North Sea Bight Basin with the positions of the cored wells GR1, SWB, SEWB and VR1 (after Ziegler 1982).

short periods of high-energy conditions possibly related to storm events. The envisaged environment may be compared with a modern, offshore mudshelf under microtidal conditions. The intercalated organic-rich horizon is inferred to represent a period of sea-bottom anoxia (Van Bavinchove, 1993).

6.3 SWB WELL

At the base of the SWB well (Unit 4), offshore shelf muds have been correlated with the top of the clays in well GR1 (see Fig. 2). Unit 5 in well SWB is characterized by lenticular grey-green clay with burrows and cm-thick fining upwards silty-sand laminae interpreted as storm layers (Fig. 5). Upwards, the clay becomes silty and contains thick sand laminae and burrows (Unit 6). At 44 m well depth, the silty bed is sharply overlain by a thick, fine-sand bed with low-angle cross bedding at the base inferred to represent a nearshore (shoreface) environment (Unit 7). The top of the sand bed at 38 m consists of alternations of horizontally laminated fine sand with strongly bioturbated clayey fine sand. The transition from Unit 8 into Unit 9 from coarse-grained facies into lenticular silty clay with sand-filled burrows is rapid.

The various facies and the facies association point to shallowing and then deepening of the depositional environment. The offshore mudshelf is gradually more influenced by storm events and a sandy nearshore (delta front) environment. The rapid fining towards silty clay facies is interpreted as a deepening of the basin towards an offshore mudshelf (Unit 9).

In the next coarsening upwards cycle of litho Units 9-15 a similar trend is recorded. Silty, grey-green clays are transitional into bioturbated silty clay and into a fine sandy unit characterized by low-angle cross bedding (Unit 11). The latter unit is overlain by rhythmically layered wavy bedding and strongly bioturbated lenticular clay with clay clasts, interpreted as deposition in a delta-plain environment with lagoonal mudflats and sand shoals with rare wave influence. Green glauconitic fine sand with a brown clayey matrix contain low-angle parallel cross-lamination and wood fragments. The sedimentary facies is characteristic for deposition on intertidal to supratidal sand shoals influenced by waves (Jacobs et al., 1990).

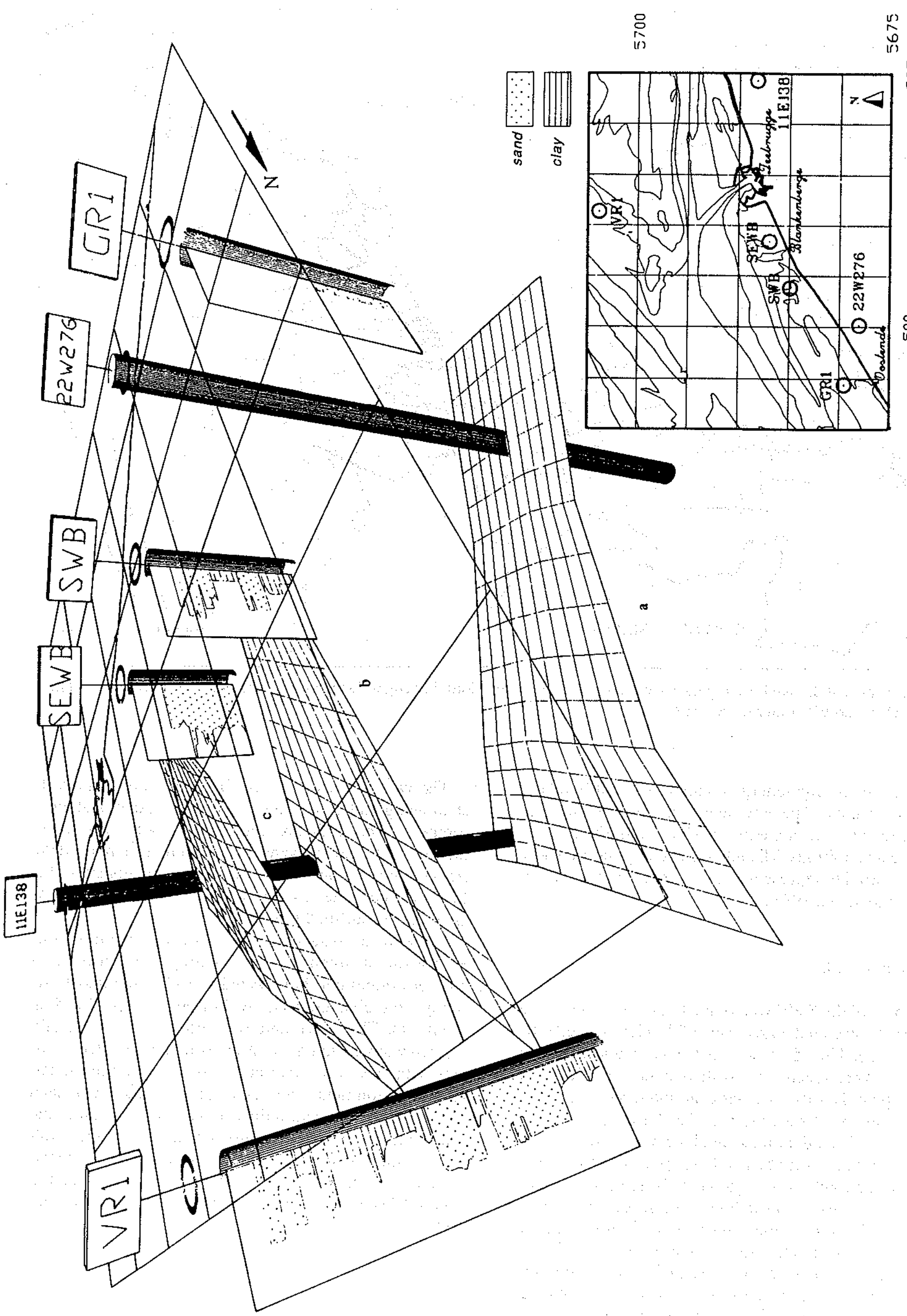

Figure 2. Lithologs of the four cored wells and of two onshore wells of the Belgian Geological Survey (11E/138 and 22W/276) with lower boundary surface of the clayey Kortrijk Formation base (a), upper boundary surface of the clayey Kortemark Member top (b) and lower boundary surface of the clayey Asse Member base (c). Insert figure shows the location of the wells.

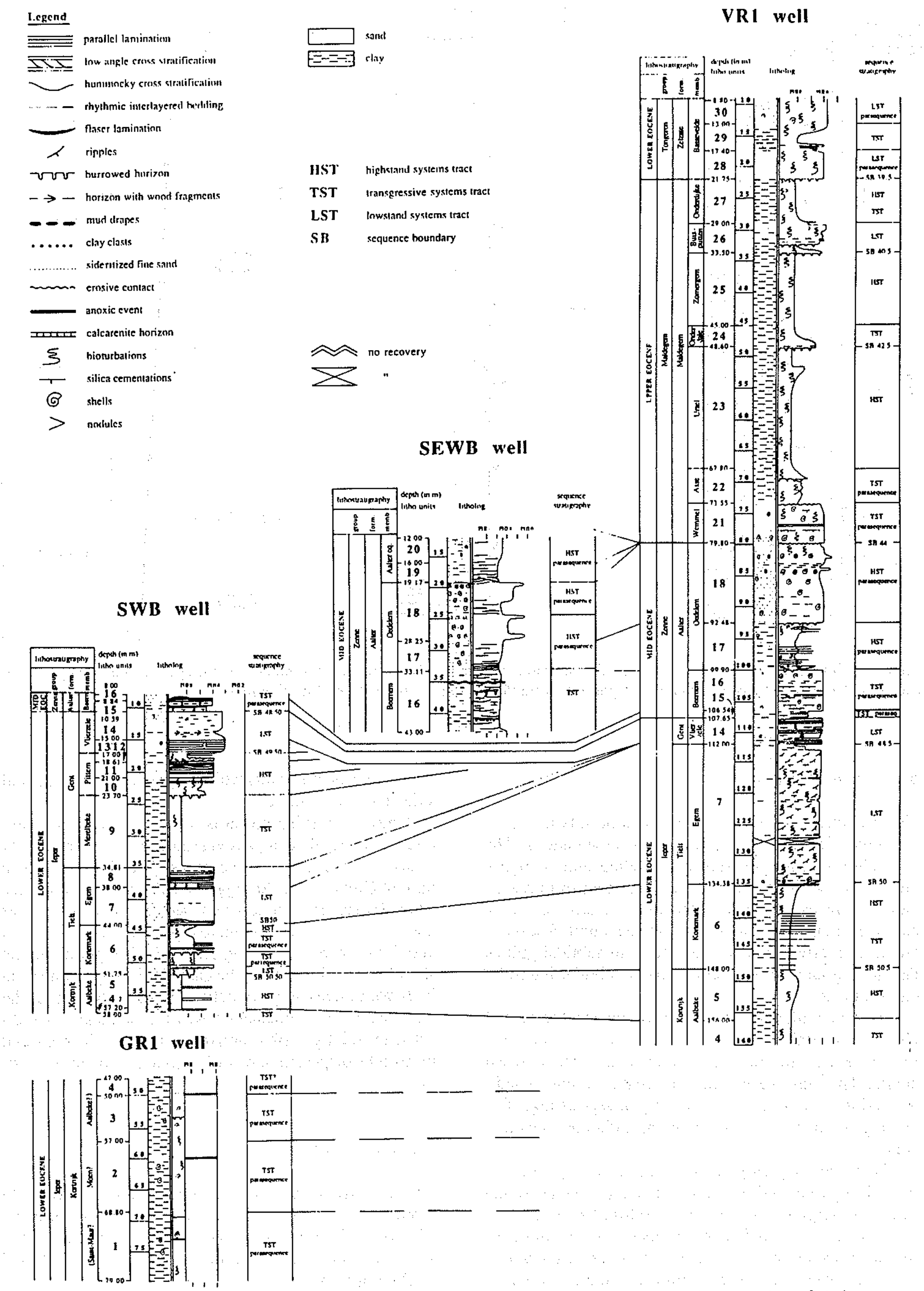

Figure 3. Composite lithologs of all 4 wells with correlation of litholog units and with the interpretation of their sequence stratigraphical character.

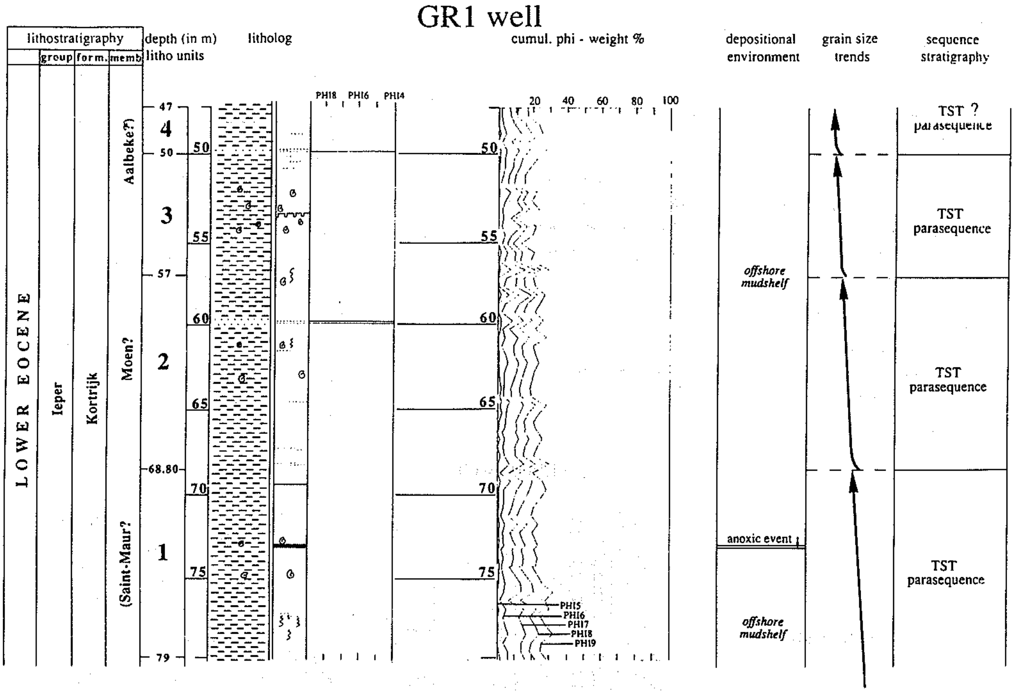

Figure 4. Lithostratigraphy of the GR1 well. The interpretations of the depositional environment and the systems tracts are given for each unit. Grain-size is given in cumulative phi-units with Phi = $-\log_2 d$. For the legend see Figure 3.

6.4 SEWB WELL

Unit 16 consists of grey-green glauconitic silty to clayey fine-sand (Fig. 6) and contains silica cementations. The sand shows coarse interlayered bedding and is highly bioturbated with vertical burrows departing from reactivation surfaces. The base of the unit contains some clay clasts. The top is gradational into the next unit. Sedimentation is inferred to have taken place in subtidal gullies developing later into a mainly mixed subtidal-intertidal environment.

Fine sand with horizontal stratification near the base of Unit 17 gradually coarsens upwards into a bioturbated fine sand with mm-thick clay laminae and coarse fossil debris. The clay flasers and bioturbation point to sedimentation in a zone where energy levels change frequently, such as may occur in the offshore transition zone.

The overlying grey-green glauconitic, highly fossiliferous clayey fine sands of Unit 18 contain several coquina beds with large specimen of the mollusc *Venericardium planicosta* and abundant gastropods like *Turritella* of middle Eocene age. The base of Unit 18 is erosional, whereas the central part contains clay laminations partly obliterated by intense bioturbation. The shell beds are interpreted as washovers which deposited at the lagoonal side of a coastal barrier.

A new coarsening upwards sequence starts with glauconitic fine sands that pass via sandy clay to very clayey sands into fossiliferous fine sands. The sharp erosional base of Units 19 and 20 suggests high-energy conditions. Mud drapes, low-angle cross bedding and clay clasts above erosion surfaces point to repeated channel incision and infill with lateral migration. Backstepping of the shoreline is inferred from the glauconitic clayey fine sand beds with intensive bioturbation. Towards the top of the unit, lagoonal sedimentation was reestablished as indicated by faintly visible horizontal burrows in mud and uniformly dispersed shells of lagoonal and marine origin.

6.5 VR1 WELL

The succession starts with early Eocene grey clays with bioturbated mm-thick silty and very fine-sandy laminae. Chondrites burrows have been filled with silt and fine-sand. In Unit 5 these laminae gradually thicken and coarsen upwards to cm-thick sand lenses, locally showing graded bedding. The facies association suggest sedi-

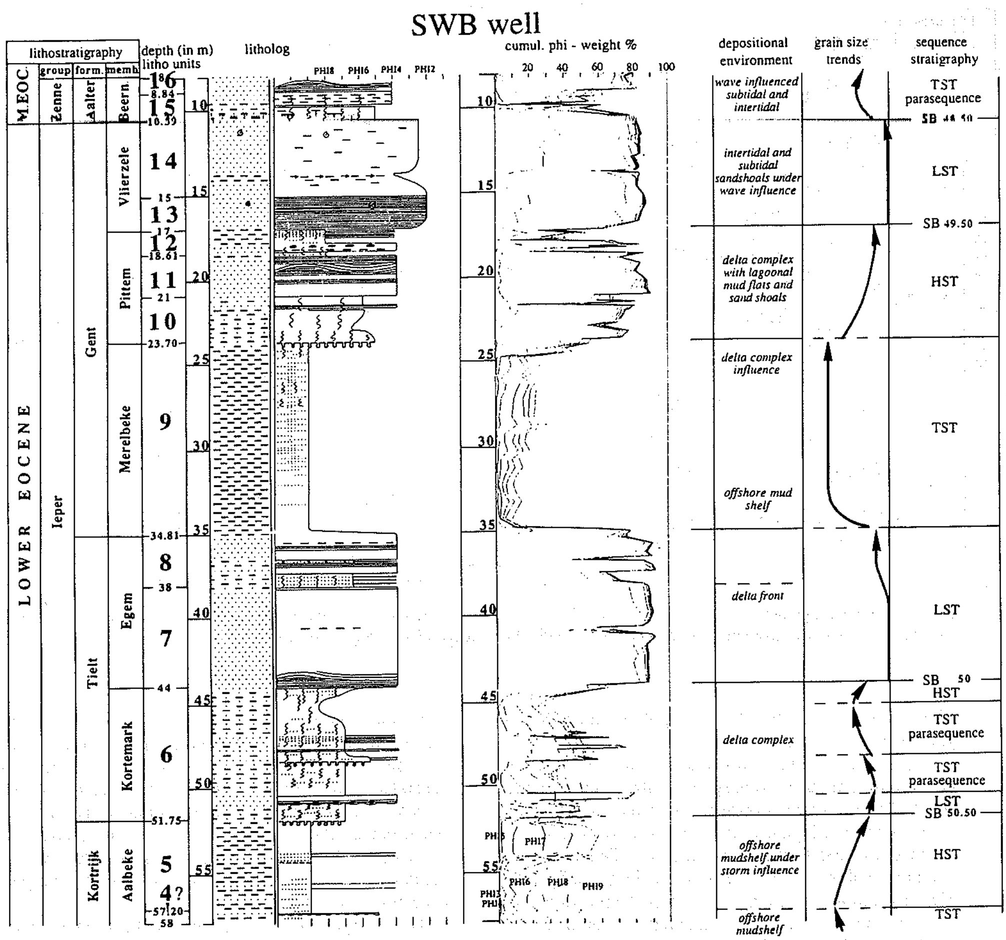

Figure 5. Lithostratigraphy of the SWB well. The interpretations of the depositional environment and the systems tracts are given for each unit. Grain-size is given in cumulative phi-units with Phi = $-\log_2 d$. For the legend see Figure 3.

mentation below storm wave base, possibly in the innershelf zone, where the graded beds originate from storm influence.

The clay of Unit 5 is overlain by a grey clay with mm-thick silt and sand laminae and with two marked yellowish clay lenses containing bothroid and phramboid siderite (Van Bavinchove, 1993). The top of Unit 6 passes gradually into strongly bioturbated, fine-sandy clay with silty and sandy patches. Sand lenses in the unit increase in number and grow in size upwards. This suggests a shallowing of the depositional environment from innershelf towards more nearshore.

Unit 7 consists of glauconitic, grey-green fine sand containing dispersed shell clasts and local silica cementations. The base of the sand bed is sharp and erosive. Sedimentary structures, such as clay drapes, ripples, flaser lamination and a decreasing degree of bioturbation point to mixed subtidal to intertidal environment passing upwards into intertidal flats.

An important erosive hiatus separates Unit 14 from the underlying Unit 7. Three thin coarsening upwards sequences, sometimes with an erosive base, are composed of grey clay gradually passing into intensively bioturbated fine sand with at the top green glauconitic fine sand with parallel lamination and local silica cementations. They are interpreted as multiple crevasse splays followed by lagoonal, tidal flat and sand shoal sedimentation. Clay clasts and large specimen of the mollusc *Venericardium*

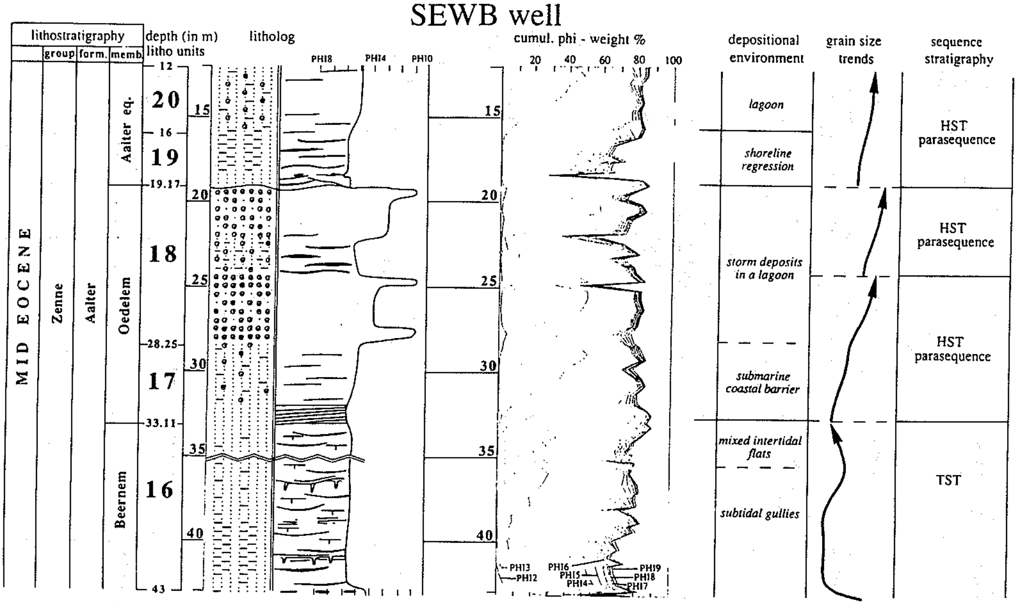

Figure 6. Lithostratigraphy of the SEWB well. The interpretations of the depositional environment and the systems tracts are given for each unit. Grain-size is given in cumulative phi-units with Phi = – $\log_2 d$. For the legend see Figure 3.

planicosta are indicative for tidal gullies filled in with glauconitic grey-green fine sand.

The middle Eocene sedimentation starts with the deposition of a bioturbated grey clay with an erosive base (Unit 15). It coarsens upwards into Unit 16 with grey-green bioturbated glauconitic fine sand with thin clay laminae and local silica cementations. The latter unit contains shell fragments at the base and large specimen of *Venericardium planicosta* at the top. Deposition took place in a mixed subtidal-intertidal flat environment.

The overlying Unit 17 consists of grey-green sandy to silty fossiliferous and bioturbated clay. The mm-laminations and the dm-thick sand lenses are disturbed and reworked by bioturbation and small-scale faulting. The lower boundary is irregular but sharp. The base of the unit contains clay clasts and burrows with sand infillings. The top of the unit is a burrowed erosional surface overlain by Unit 18. The latter unit is bioturbated and consists of grey-green glauconitic fine sands to clayey sands containing cm-thick clay laminae. A lagoonal environment with storm deposits is inferred from the flaser lamination and the abundant shells (mainly gastropods like *Turritella*, but also *Venericardia planicosta*), which are sometimes found reworked and concentrated in coquina beds. The localities with reworking may indicate the original position of the chenier.

All upper Eocene Units 21-27 show an overall fining upwards trend. The succession starts with the deposition of glauconitic slightly clayey sands to silty clays with glauconite concentrations at the base. Unit 21 contains clay-coated burrows (mostly chondrites), two calcarenite horizons and weathered shells. The base of Unit 21 is separated from the underlying unit by a sharp and burrowed lower boundary; the upper boundary is also sharp but irregular. After an important erosional phase, low-energy conditions of a shelf environment with slow sedimentation rates reestablished, as suggested by the presence of glauconite.

The overlying succession consists of 3 strongly bioturbated, fining upwards cycles each with an erosive base (Units 22-27) and abundant chondrites burrows with sand infillings. The lowermost Unit 22 is formed by highly glauconitic, clayey sands containing an alternation of thin clayey sand and sandy clay lenses. The top of Unit 22 is formed by a concentrated glauconite layer which suggest a period of reworking and non-deposition. A blue-grey clay with mm-fine burrows filled in with sand or organic-rich clay is deposited on top of the glauconite-enriched layer. The clay contains pyritized sand, small-scale faults and progressively thinning and fining upwards of sand laminae. The facies association suggest deposition in a deepening part of the shelf. Near the top of Unit 23, a transitional zone with coarsening upwards silty clay to highly sandy clay and increasing bioturbation suggests temporarily prodeltaic deposition in a more nearshore continental shelf environment.

The middle cycle (Units 24 and 25) consists of medium-fine clayey sands with coarse interlayered and

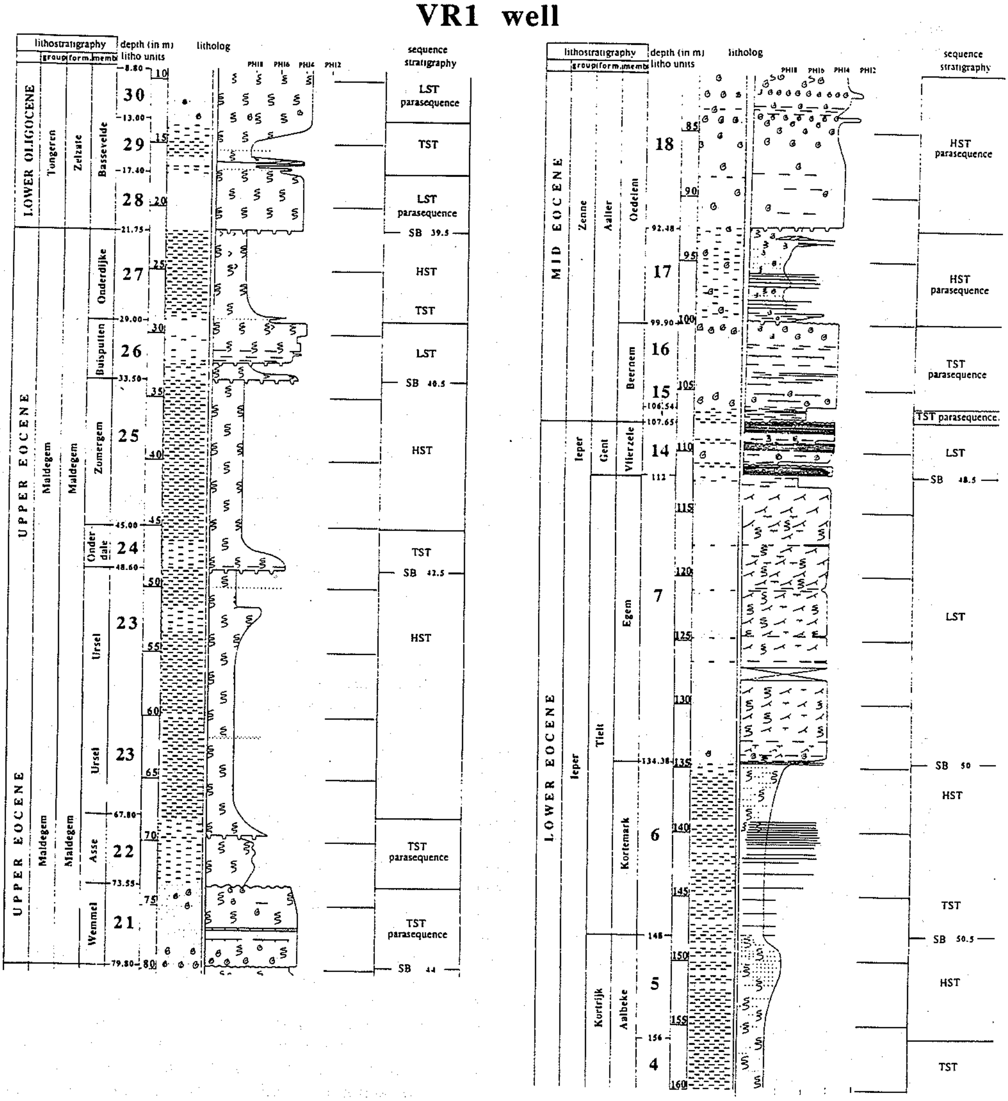

Figure 7. Lithostratigraphy of the VR1 well. The interpretations of the depositional environment and the systems tracts are given for each unit. Grain-size is given in cumulative phi-units with Phi = $-\log_2 d$. For the legend see Figure 3.

flaser bedding, fining upwards into a bioturbated blue-green clay containing rare sand lenses, organic-rich laminae and mm-burrows filled with clayey sand. After initial erosion, alternating high- and low-energy conditions controlled deposition at the base, possibly in nearshore environment. Later, energy conditions decreased pointing to deepening of the environment in Unit 25.

Unit 26 of the upper cycle is composed of strongly bioturbated clayey sands passing into silty clay bed, which is covered by grey-green glauconitic, slightly clayey sand bed with flaser lamination and burrows with clay infillings. The overlying blue-green silty clay to massive clay is strongly bioturbated (mostly chondrites), and contains large, pyritized sand spots and pyrite no-

dules. Outside the study area, thin detrital peat layers have been recorded in the top of Unit 27 (Gulinck, 1969a; Jacobs, 1975). The facies transitions are interpreted as deposition in a nearshore zone which is deepening into shelf characterized by the deposition of prodeltaic massive clays.

The latest Eocene to lower Oligocene succession starts with glauconitic fine sands which are moderately to strongly bioturbated. They have a mottled texture and contain locally carbonized plant remains. The lower boundary of this Unit 28 is burrowed. It is deposited after a major erosional phase, in an intertidal environment with rhythmic changes in energy conditions. The overlying alternation of fine-sandy clay and mottled clayey fine-sand is strongly bioturbated containing abundant chondrites burrows. The facies associations suggests wash-over deposits in the supra-tidal zone of a lagoon. The upper portion of Unit 29 is composed of blue-green silty clay coarsening upwards into glauconitic, slightly clayey fine-sand possibly representing deep lagoon. Unit 29 is covered by an incomplete Unit 30, which consists of grey-green glauconitic slightly clayey fine-sand with shell grit at the base of beds. The mottled texture and moderately to strongly bioturbated bed point to continued deposition in a mixed intertidal to supra-tidal lagoonal environment.

6.6 DELTA CHARACTERISTICS

The Eocene to lower Oligocene deltas have been formed along the southwestern coastal plains of the lowlands of northwestern Europe. The deltas were fed by the drainage networks of the rivers Rhine, Meuse and Scheldt. Their drainage area is bordered in the west by the tectonically active Weald-Artois axis (related to the opening North Atlantic, Ziegler, 1982) and in the south by the Alpine hinterland both acting as major sediment sources. On the basis of the palaeogeography, it is envisaged that the proto-Rhine, -Meuse and -Scheldt, which crossed vast coastal lowlands, formed a widely-spaced, highly stable feeder-system characterized by low bedload/total load ratio (excess of fines). If such rivers debouch in a low energy basin, the resulting delta morphology tend to be elongate (Mississippi birdfoot-type) to lobate (Niger-type) characterised by tidal shoals and cheniers, depending on the amount of reworking of the delta front and lower delta plain.

Sediment accumulation in the delta front occurred on ramp-type, gently sloping continental shelf. The ramp morphology will have caused considerably wave attenuation, but will have induced wave-generated longshore currents. The shallow water depths (in the order of some tens of meters) seaward of the river outlet will have restricted turbulent diffusion of the river's effluent jet to the horizontal. Bottom friction will have played a major role causing gently inclined delta front of less than a few degrees (shoal-water profile) (cf. Postma, 1990 and this volume).

The buildup of the deltaic systems considered here is likely favoured by the tectonic instability of the hinterland and by the changes in relative sea-level. It is noted that the close proximity of these deltas to the drainage basin makes them potentially sensative and, therefore, good recorders of the tectonic and climatic changes in the hinterland.

6.7 SEDIMENTATION MODEL

Facies analysis and sequence-stratigraphic signature allow reconstruction of the depositional palaeoenvironment (Fig. 8) of the siliciclastic sedimentary system in the SNSB Basin in relation to relative sea-level changes.

Phase 1

During earliest Eocene times, distal Kortrijk Formation sediments were deposited on an open offshore mudshelf, in a period that uplift of the Weald-Artois axis accelerated causing the separation of the Southern Bight from the North Atlantic (Ziegler, 1982). The first 4 lithologic units form stacked TST-parasequences indicating a constantly rising sea level. These series are topped by a regressive Unit 5 interpreted as HST. During deposition of the latter unit, the offshore mudshelf comes under storm influence due to sea-level fall.

Phase 2

In middle to late Early Eocene times, the sea-level fall forced deposition to occur in a more proximal position nearer the basin margin. A complete LST/TST/HST-cycle is formed by the delta complex of Unit 6. The ensuing sea-level fall of the following cycle (Units 7 and 8) must have been considerable as indicated by the characteristic 'blocky sand'-signature of the sharply based LST. The temporal reinstallation of a mud-dominated shelf (basal part of Unit 9 characterizes a TST) points to a limited amount of sea-level rise. Delta deposition with lagoonal mud flats and sand shoals is restored in the top portion of Unit 9 and in Units 10-12 (regressive facies of HST during sea-level fall). Phase 2 is generally characterized by deltas fed by the proto-Rhine-Meuse-Scheldt alluvial system. However, in the course of phase 2, another sediment source from the south is revealed by heavy-mineral provenance studies (Jacobs, in press) and probably signals the Alpine uplift. At the end of the early Eocene, after a new sea level fall, increase of wave and tide action is recorded by the wave influenced, subtidal sand shoals (LST, Units 13 and 14).

Phase 3

In the middle Eocene, the high-energy depositional zone with waves and longshore currents is further backstepping in its most proximal position (Fig. 8). In the phase 3 time slice facies characteristic for coastal barrier system with associated lagoonal/ estuarine tidal flat environment is present in all wells. Large supply of coarse sediment and a reduction in accommodation space due to a sea-level fall controlled the deposition of wave influenced subtidal and intertidal sediments (Units 15 and 16, TST).

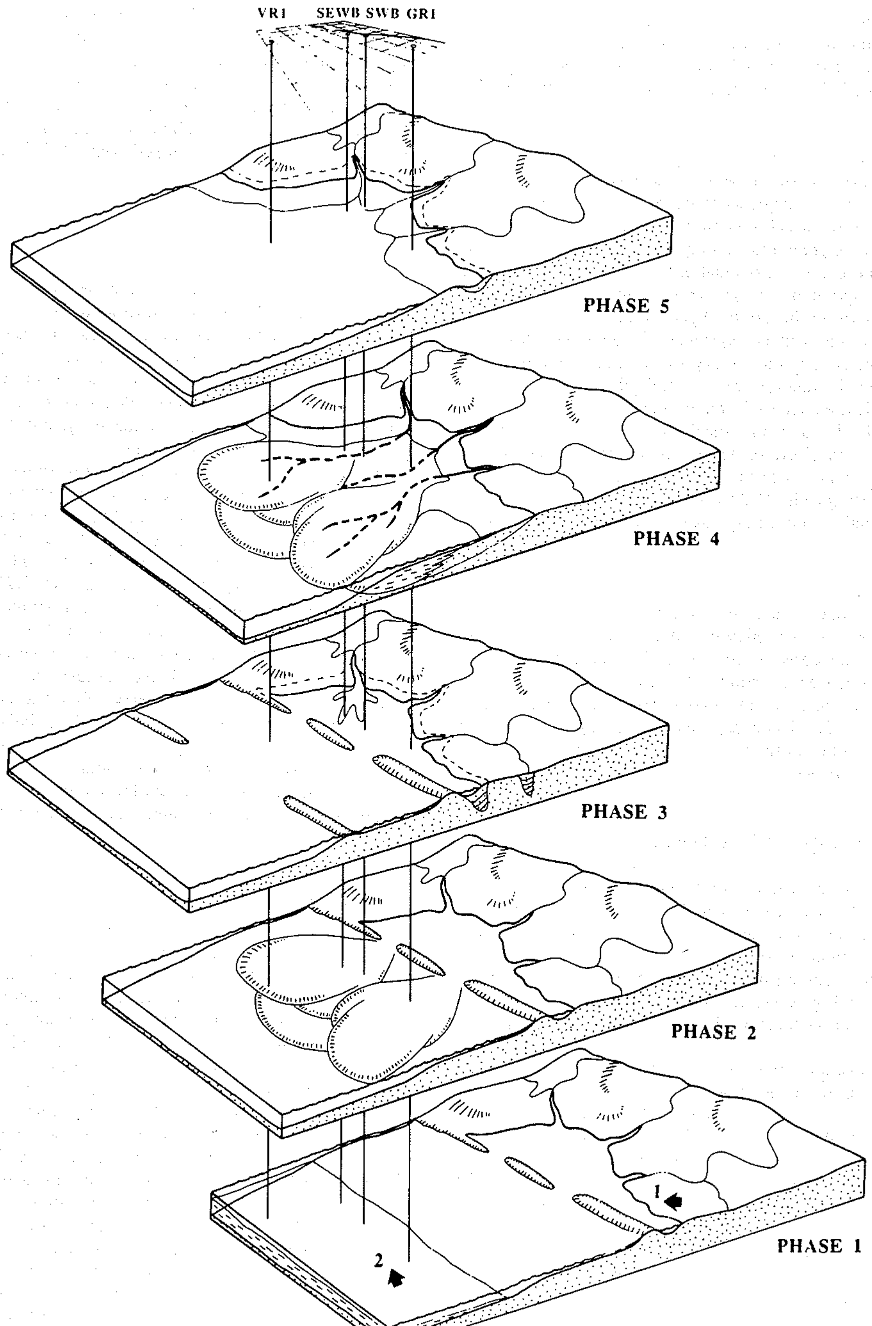

Figure 8. Evolution of the siliciclastic sedimentary system in the Southern North Sea Bight Basin during the Eocene and the early Oligocene in time and space. Arrows indicate North (1) and main longshore current direction (2).

The outbuilding of submarine coastal barriers (Unit 17) and a lagoon (Units 18 and 20) open to the sea (storm deposits) form stacked HST-parasequences, indicating continued shoreline regression and shallowing of the basin.

Phase 4

In the late Eocene, the depositional environment changes from restricted lagoonal to open marine, i.e. from tidal mud flat to coastal mud plain. The intercalation of sand beds in the predominantly muddy sediments are inferred to represent the progradational pulses of delta lobes. Sandy sediments of southern provenance are trapped close to the basin margin. Aggradation produces up to ten m-thick sedimentary sequences with a tabular geometric architecture pointing to very low intra-basinal relief.

After the relative sea-level fall which terminated the HST-parasequence of Unit 20, sea level must have risen considerably to deposit the thick mud sequences of Units 22-27. Unit 21 marks the onset of the transgression that is fully installed with the deposition of the 3 mud-cycles comprising Units 22-27, each cycle being separated by an erosional unconformity associated with a drop in sea-level.

Phase 5

After a new minor sea-level fall associated with the occurrence of detrital peat in layers and in burrows in the top of the upper Eocene Unit 27, stacked LST/TST-parasequences constitute the lower Oligocene Units 28-30. Compared with phase 4 deposition, the predominantly sandy tidal flat deposits indicate slightly shallower water depths for the late late Eocene till early Oligocene period of phase 5.

6.8 REGIONAL RELATIVE SEA-LEVEL CURVE

A schematic relative sea-level curve (cf. Jervey, 1988) for the SNSB Basin has been constructed on the basis of sedimentary facies analysis of the 4 wells with additional age information from the literature, but without further biostratigraphic studies (Fig. 9). Note, that the member names in Figure 9 refer to the members in the well studies (Figs 3-7) and that not all member names refer to one unit only.

Lithostratigraphically, in total 9 sequences each bounded by an unconformity (sensu Van Wagoner et al., 1990) can be recognized in Units 1-30. The first sequence (Units 1-4) shows an overall deepening in the GR1 well. The next four sequences (Units 5-20) are characterized by an overall fall in relative sea level with Units 19 and 20 preserved only in the SEWB well (Aalter member equivalent with Lede member). In the sequence series there is an overall coarsening upwards from clay to medium sand indicating considerable shallowing and increasing delta progradation. An important relative sea-level rise can be inferred from the onlap of the next three sequences (Units 21-27). These sequences show also an overall coarsening upwards, which is here related to shallowing of the depositional environment due to infilling of the basin. The last sequence (Units 28-30) is not fully developed in the studied cores and indicates further shallowing (infill) of the basin. The systems tracts of each sequence have been inferred for each sequence and have been indicated for each well in Figures 3-7. It is noted that only rarely a sequence is completely developed with LST, TST and HST tracts.

6.9 CLASTIC WEDGE CHARACTER

The SNSB Basin is perhaps a text-book example of a shallow-marine siliciclastic intracratonic sedimentary basin with a ramp-type margin. Such basin is characterized by low subsidence rates, rather quiet tectonic setting, low relief and absence of shelf edge. Sediment yield is rather constant (Jacobs, in press) delivered by a proto-Rhine-Meuse-Scheldt fluvial drainage system from a gradually uplifted Alpine hinterland.

The architecture if viewed in the direction of the dip of the clastic wedge consists of plurimetric systems tracts with a distinct facies signature (see Fig. 2). Most of the sequence boundaries are of type 2. The lower bounding surface of the Vlierzele Member (Units 13 and 14) is clearly erosive and a type 1-sequence boundary. LST then develop in incised valleys with fluvial and tidal infillings during late lowstand and early transgression. Many of the sequences contain TST-parasequences in response to onlap following even minor relative sea-level rises. HST tend to have low preservation potential if they are subject to offstripping during the subsequent sea-level falls.

The architecture viewed parallel to the strike of the clastic wedge shows juxtaposition of sediment series due to erosion during important sea-level falls and due to lateral shift of the feeder systems and related depocentres.

6.10 CONCLUSIONS

Four well cores taken in the Southern North Sea Bight Basin contain Eocene to early Oligocene deltaic and shelf sediments. Facies analyses and palaeo-environmental reconstructions show that infilling of the basin was controlled by an alluvial feeder system characterized by low gradient, highly stable channels feeding lobate to elongate delta systems. The delta front is characterized by shoal-water profile (prototype 8 of Postma, this volume). The sedimentary facies examined from the cores suggests, together with the geometry of the delta bodies dominance of the fluvial regime with subordinate reworking in the delta front by wave, tides and longshore currents. In certain periods (Fig. 8) this resulted in the development of coastal barriers and lagoonal systems.

The sequence-stratigraphic signature of the shallow marine sediments enabled the reconstruction of a sedimentation model, which is related to relative sea-level changes. A major (2nd order) regressive and a transgressive cycle has been identified each consisting of a number

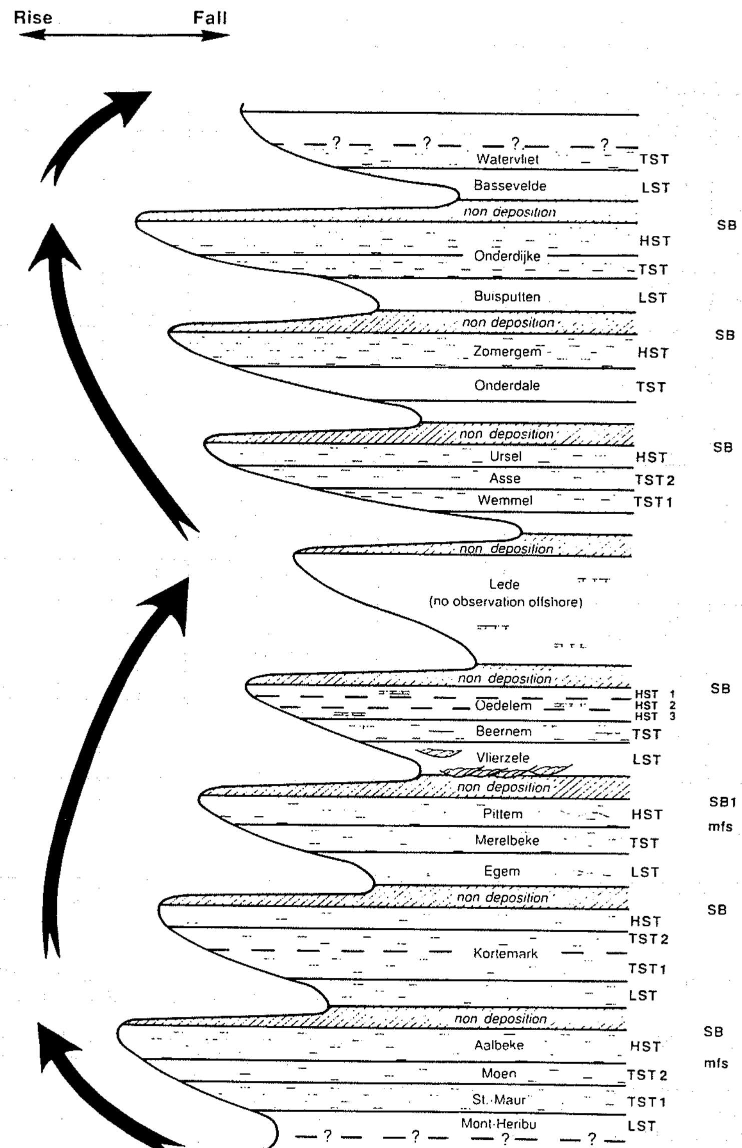

Figure 9. Regional relative sea-level curve for the Southern North Sea Bight Basin.

of 3rd order sequences (Fig. 9). The lower regressive cycle spans early to middle Eocene (see Table I). The upper transgressive succession is late Eocene to early Oligocene, with a hiatus in the late Middle Eocene. The sequences in the regressive cycle show an overall coarsening upwards trend reflecting deltas prograding onto the shelf. Sediments are characteristic for subaqueous prodelta, delta slope and delta front environments. In the transgressive cycle, also an overall coarsening is evident. Sediments in the latter cycle represent mainly lower

Table 1. Chrono-, bio- and lithostratigraphy of the onshore Belgian Eocene and early Oligocene. Biostratigraphy is mainly after Steurbaut (1990). Lithostratigraphy is according to Maréchal & Laga (1988).

CHRONO EPOCH	BIO ZONES	LITHO GROUPS	LITHO FORMATIONS	LITHO Members	Units (this paper) Number	Units (this paper) Lithology	Units (this paper) Thickness
L. OLIGOCENE	P 22		*VOORT*	Veldhoven			
M. OLIGOCENE	P 18-19	RUPEL	*EIGENBILZEN*				
			BOOM	Putte Terhagen Belsele			
			BILZEN	Kemiel Klein-Spouwen Berg			
E. OLIGOCENE	NP 22 NP 18-21	TONGEREN	*ZELZATE*	Ruisbroek Watervliet Bassevelde	28-30		> 13 m
L. EOCENE			*MALDEGEM*	Onderdijke	27		7 m
				Buisputten	26		4.5 m
				Zomergem	25		11.5 m
				Onderdale	24		3.5 m
	NP 16			Ursel	23		19 m
				Asse	22		5.5 m
	NP 15			Wemmel	21		6 m
M. EOCENE	NP 15	ZENNE	*LEDE*				
	NP 14		*BRUSSEL*	Chaumont-Gistoux/ Bois de la Houssière Neerijse/Diegem/ Archennes			
	NP 14		*AALTER*	Oedelem	17-20		20 m
				Beernem	15-16		7.5-10 m
E. EOCENE	NP 14 NP 13	IEPER	*GENT*	Vlierzele	13-14		6.5 m
				Pittem	10-12		6.5 m
				Merelbeke	9		11 m
	NP 13		*TIELT*	Egem	7-8		9-22 m
				Kortemark	6		7.5-13.5 m
	NP 11-12		*KORTRIJK*	Aalbeke	3-5		> 12 m
				Moen	2		11.5 m
				Saint-Maur	1		> 10 m
				Mont-Héribu			
L. PALAEOCENE		LANDEN	*TIENEN*	Knokke Loksbergen Erquelinnes Dormaal			
	NP 8		*HANNUT*	Grandglise Chercq Halen Lincent Waterschei			
	NP 6-7		*BERTAIMONT*				

delta-plain delta front environment.

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