GEOLOGY OF GREENLAND SURVEY BULLETIN 175 · 1998

Stratigraphy of the Neill Klinter Group; a Lower – lower Middle Jurassic tidal embayment succession, Jameson Land, East Greenland

Gregers Dam and Finn Surlyk

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
MINISTRY OF ENVIRONMENT AND ENERGY

Geology of Greenland Survey Bulletin 175

Keywords
Neill Klinter Group, Jameson Land Basin, East Greenland, Lower – lower Middle Jurassic, lithostratigraphy, sequence stratigraphy, sedimentology, tidal embayment.

Cover
Exposure of the Neill Klinter Group in the type area along Hurry Inlet in the south-eastern part of Jameson Land. Sandstones and mudstones of the Neill Klinter Group overlie the scree-covered Kap Stewart Group. Fine-grained units in the Neill Klinter Group are intruded by Tertiary sills. The view is from Astartekløft towards the north. The airport at Constable Pynt is seen on the second delta. Exposed section *c*. 200 m thick.

Gregers Dam
Geological Survey of Denmark and Greenland
Thoravej 8, DK-2400 Copenhagen NV, Denmark

Finn Surlyk
Geological Institute, University of Copenhagen
Øster Voldgade 10, DK-1350 Copenhagen K
Denmark

Chief editor of this series: Peter R. Dawes
Scientific editor: W. Stuart Watt
Editorial secretary: Esben W. Glendal
Copy editing: Peter R. Dawes and W. Stuart Watt
Critical readers: Jon Gjelberg (Norway) and Lars Henrik Nielsen (Denmark)
Drawing work: Jette Halskov and others
Photographic work: Jakob Lautrup and Anders Winter
Reproduction and graphic production: Knud Graphic Consult, Odense, Denmark
Manuscript submitted: 10th November, 1994
Final version approved: 20th March, 1998
Printed: 30th June, 1998

ISBN 87-7871-017-0
ISSN 1397-1905

Geology of Greenland Survey Bulletin
The series *Geology of Greenland Survey Bulletin* is a continuation of *Bulletin Grønlands Geologiske Undersøgelse* and incorporates *Rapport Grønlands Geologiske Undersøgelse.*

Citation of the name of this series:
It is recommended that the name of this series is cited in full, viz. *Geology of Greenland Survey Bulletin*
If abbreviation of this volume is necessary the following form is suggested: *Geol. Greenland Surv. Bull.* 175, 80 pp.

Available from:
Geological Survey of Denmark and Greenland
Thoravej 8, DK-2400 Copenhagen NV, Denmark
Phone: +45 38 14 20 00, fax: +45 38 14 20 50, e-mail: geus@geus.dk
or
Geografforlaget ApS
Fruerhøjvej 43, DK-5464 Brenderup, Denmark
Phone: +45 63 44 16 83, fax: +45 63 44 16 97, e-mail: go@geografforlaget.dk

Contents

Abstract

Dam, G. & Surlyk, F. 1997: Stratigraphy of the Neill Klinter Group; a Lower – lower Middle Jurassic tidal embayment succession, Jameson Land, East Greenland.
Geology of Greenland Survey Bulletin 175, 80 pp.

The sediments of the Neill Klinter Group of Jameson Land, East Greenland were deposited in a wide, shallow, wave, storm and tidally-influenced marine embayment situated at the western margin of the Jurassic seaway between Greenland and Norway. The group is formally defined and a new lithostratigraphic scheme is erected on the basis of recent sedimentological, biostratigraphic and sequence stratigraphic studies. The Neill Klinter Formation is changed to group rank; the Rævekløft, Gule Horn and Ostreaelv Members are revised and raised in status to formations, and the Sortehat Formation is redefined and included in the group. The Gule Horn Formation is divided into two new members and the Ostreaelv Formation into seven new members. The Neill Klinter Group is up to 450 m thick.

Sandy and muddy material was transported into the embayment from source areas to the east, west and north. A number of sub-environments are represented in the succession, including: restricted and bioturbated offshore, storm-dominated offshore transition zone, wave and storm-dominated shoreface, storm-dominated sandy shoal, subtidal sand sheet, ebb-tidal delta, tidal channel, wave and storm-dominated lagoon, and ephemeral stream delta.

The Neill Klinter Group consists of seven sequences and is characterised by a near absence of parasequences, interpreted as reflecting high influx rates of sand into the land-locked embayment. Continuous filling of accommodation space and erosion resulted in amalgamation of sedimentary packages, and poor development of facies cyclicity.

Authors' addresses:
G. D., Geological Survey of Denmark and Greenland, Thoravej 8, DK-2400 Copenhagen NV, Denmark
F. S., Geological Institute, University of Copenhagen, Øster Voldgade 10, DK-1350 Copenhagen K, Denmark

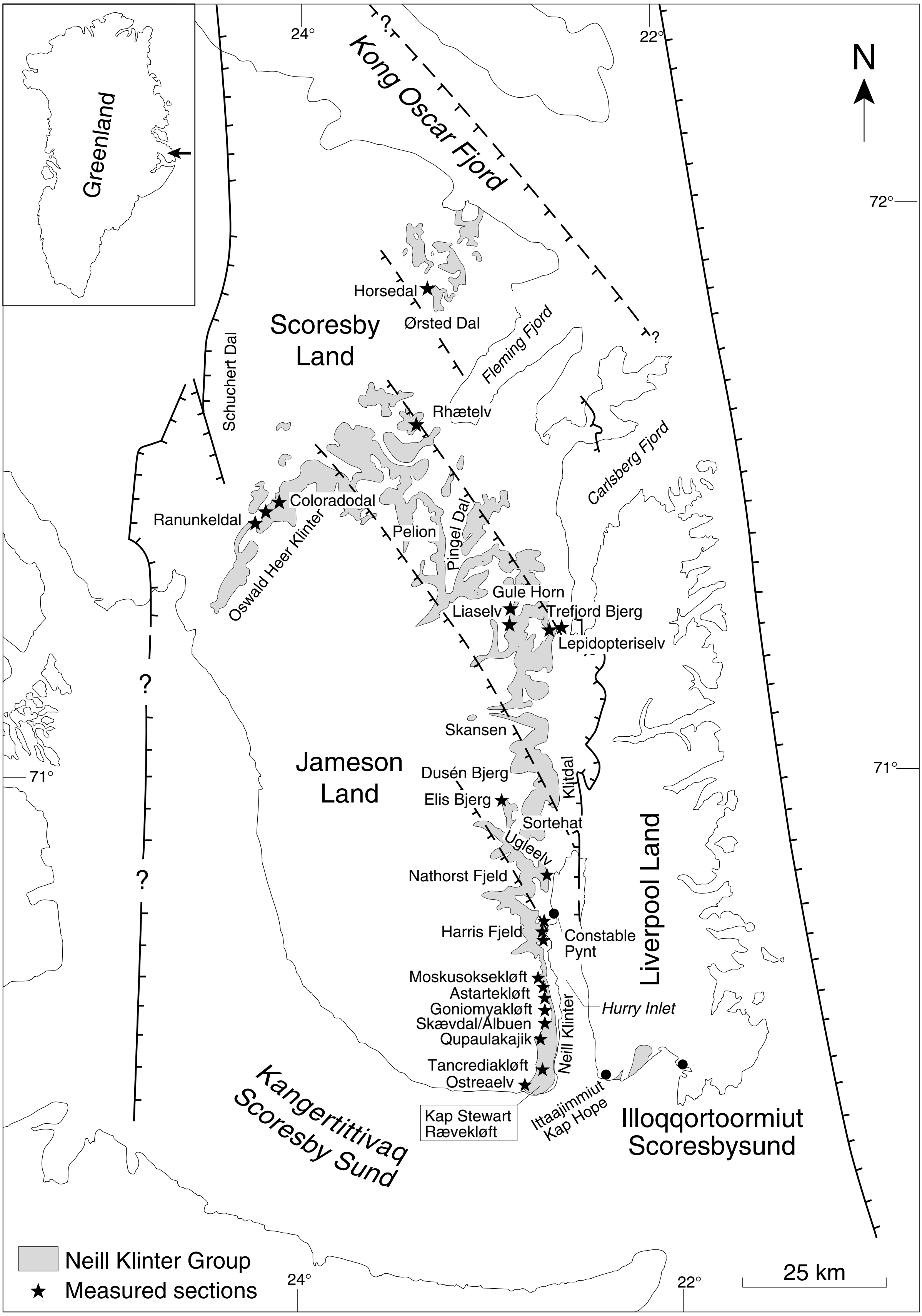

Fig. 1. Map of the Jameson Land region showing outcrops of the Neill Klinter Group and location of measured sections described in this work. Simplified after maps of the Geological Survey of Greenland. Modified from Dam & Surlyk (1995).

Previous investigations

Lower Jurassic deposits in the Scoresby Sund region were discovered in 1822 by William Scoresby Jr. at Kap Stewart, the south-easternmost point of Jameson Land (Fig. 1). Since then the Lower Jurassic of Jameson Land, especially the exposures in the cliffs of Neill Klinter along the west coast of Hurry Inlet, has been the subject of several studies. The early exploration history was documented by Rosenkrantz (1934), Koch (1939) and Donovan (1957).

Den østgrønlandske Expedition led by V. Ryder in 1891–92 reinvestigated the classical locality of W. Scoresby Jr. at Kap Stewart and along the Neill Klinter (Fig. 1) and was the first of a series of expeditions to carry out research in this area. The rich Rhaetian – Lower Jurassic floras of the Kap Stewart Formation (Hartz, 1896) were discovered during Ryder's expedition. Marine faunas of the formation overlying the plant-bearing deposits were described and figured by Lundgren (1895), who dated them to the Callovian, although the material included an ammonite fragment which was later determined as belonging to the Pliensbachian Jamesoni Zone.

A French expedition led by J. B. Charcot visited Scoresby Sund in 1925, and collected fossils from the Lower Jurassic marine strata at Kap Stewart (Fig. 1). The results were summarised by Haug (1926) who recognised the Pliensbachian age of the fauna which had previously been assigned to the Callovian by Lundgren (1895). Haug (1926) listed 27 species, but the collection was not described or figured in any detail.

Systematic geological investigations in East Greenland were initiated during the first expedition of Lauge Koch in 1926–27. T. M. Harris described the Rhaetian – Lower Jurassic floras from the coastal sections of Hurry Inlet in a series of monographs (Harris, 1926, 1931a, b, 1932a, b, 1935, 1937) and the Lower Jurassic deposits of Jameson Land were for the first time studied in detail by A. Rosenkrantz who erected the Neills Cliff Formation (Rosenkrantz, 1929) and sampled in the south-eastern part of the basin. Extensive collections were made of the invertebrate faunas, numbering more than 140 Pliensbachian species and 60 Toarcian species. The faunas were listed in subsequent stratigraphic publications together with a preliminary study of the geology of the Lower Jurassic in south-eastern Jameson Land and Liverpool Land (Rosenkrantz, 1929, 1934, 1942). Illustrations and descriptions of the crustaceans *Glyphea rosenkrantzi* Van Straelen and *Glyphea* sp., and the bivalve *Velata hartzi* Rosenkrantz were given by van Straelen (1929) and Rosenkrantz (1956). Doyle (1991) described Lower Jurassic belemnites from Jameson Land and Liverpool Land collected by Rosenkrantz, and discussed their stratigraphical and biogeographical significance. The remaining part of the fauna has never been described or figured.

The next expedition, also planned and led by Lauge Koch, was the Danish Two-Year Expedition which started in 1936. During the expedition geological mapping and stratigraphical investigations were undertaken of the coastal area of East Greenland from Scoresby Sund, at latitude 70°N, to Kuhn Ø at 75°N. No special attention was paid to the Lower Jurassic succession during this expedition, but a brief account of the geology of Jameson Land was given by Stauber (1940).

Following the expeditions of Lauge Koch no major attention was paid to the Lower Jurassic of Jameson Land until a 5-year mapping programme was initiated in 1968 by the Geological Survey of Greenland and the University of Copenhagen. Surlyk *et al.* (1973) established a lithostratigraphic scheme for the uppermost Triassic – Lower Cretaceous succession of Jameson Land and Scoresby Land. It included the Lower Jurassic Neill Klinter Formation, which was divided into the Rævekløft, Gule Horn and Ostreaelv Members. The Sortehat Member was included in the Middle Jurassic Vardekløft Formation. Upper Triassic – Jurassic trace fossils were described by Bromley & Asgaard (1972), and a palynological study of the Jurassic formations of Surlyk *et al.* (1973) in south-eastern Jameson Land was undertaken by Lund & Pedersen (1985).

The first sedimentological study of the Neill Klinter Formation in south-eastern Jameson Land was presented by Sykes (1974) who recognised a series of stacked coarsening-upward units, 8–40 m thick, which he interpreted as regressive offshore-estuarine successions. Sykes (1974) recognised shelf deposits which passed up-wards into cross-bedded sandstones representing fields of migrating dunes and mega-ripples which had accumulated in low-relief estuarine channel extensions and shoals. A WNW–ESE trending coastline was suggested, with strong bi-directional tidal currents operating normal to it. A brief lithological description of the Neill

Klinter Formation of Surlyk *et al.* (1973) in the Kap Hope area on Liverpool Land was given by Birkenmajer (1976; Fig. 1).

The palaeogeographic setting of the Lower Jurassic Neill Klinter Formation and the Sortehat Member (*sensu* Surlyk *et al.*, 1973) and their position within the sedimentary evolution of the Jameson Land Basin was described by Surlyk (1977a, 1990b) and Surlyk *et al.* (1981), and a low-resolution sequence stratigraphic interpretation was presented by Surlyk (1990a, 1991). The diverse trace fossil assemblages of the Neill Klinter Formation and their palaeoenvironmental significance were described by Dam (1990a, b), and a detailed sequence stratigraphic interpretation of the Neill Klinter Formation and a correlation with the time-equivalent Lower Jurassic succession on the mid-Norwegian shelf was undertaken by Dam & Surlyk (1995). Dam & Surlyk (1995) also included a new preliminary lithostratigraphy for the Neill Klinter Formation. However, this lithostratigraphy did not respect all the recommendations from the North American Commission on Stratigraphic Nomenclature (1983) or the International Stratigraphic Guide (Salvador, 1994), and some revisions have been made in the present paper. A micropalaeontological study of the Neill Klinter Formation has recently been completed (Koppelhus & Dam, in press; Koppelhus & Hansen, in press), and the organic geochemistry of the Sortehat Formation has been studied by Krabbe *et al.* (1994).

Since the work of Sykes (1974) no detailed sedimentological studies of the Neill Klinter Formation (*sensu* Surlyk *et al.*, 1973) have been undertaken until the results of recent field work presented in Dam (1991), Dam & Surlyk (1995) and in this study.

Geological setting

The Late Palaeozoic – Mesozoic Jameson Land Basin is located in the present-day land areas of Jameson Land and Scoresby Land, at the southern end of the East Greenland rift system (Figs 1, 2). This system is part of a larger rift complex located between Greenland and Norway before the opening of the North Atlantic Ocean (e.g. Ziegler, 1988; Fig. 2). The Jameson Land Basin is bounded to the east and west by major N–S trending faults, and to the north, by a number of reactivated Devonian NW–SE cross-faults (Surlyk, 1977a, 1978, 1990; Dam *et al.*, 1995). The southern boundary is unknown, but the basin probably extended south of Scoresby Sund (Fig. 1) where it is buried beneath Tertiary plateau basalts. The basin was initiated in the Devonian by extensional collapse of the over-thickened crust of the Caledonian mountain belt. The Devonian phase was probably associated with strike-slip or oblique-slip deformation resulting in the development of NW–SE trending transverse faults in the north-eastern part of the Jameson Land Basin (Fig. 1). This regime changed during Late Carboniferous – Early Permian times to a more orthogonal extensional stress field, resulting in development of basin margin half grabens (Surlyk *et al.*, 1984, 1986; Surlyk, 1990b; Larsen & Marcussen, 1992). The period of extensional tectonism was followed by Late Permian through Cretaceous subsidence governed by cooling and thermal contraction, interrupted by episodes of rifting and faulting in the Triassic, Middle Jurassic and Late Jurassic – Early Cretaceous (Surlyk, 1977a, b, 1990b; Clemmensen, 1980a; Surlyk *et al.*, 1981, 1986; Larsen & Marcussen, 1992).

Triassic – early Middle Jurassic sedimentation in the Jameson Land Basin was influenced by tectonic subsidence, climate, drainage pattern and eustatic sea-level changes. This time interval records a long term change from a warm arid to a more temperate humid climate. Early Triassic continental red beds with subordinate carbonates and evaporites, indicating an arid climate, were gradually succeeded during Middle to Late Triassic times by playa mudstones, lacustrine carbonates and flood plain mudstones and sandstones indicative of a more humid climate (Clemmensen 1978a, b, 1979, 1980a, b; Bromley & Asgaard, 1979). By latest Triassic time the climate had become temperate and humid as indicated by the disappearance of red beds, evaporites and carbonates, and by a change to drab and dark coloured sediments and the incoming of rootlet horizons, thin coal beds and perennial lacustrine deposits of the Kap Stewart Formation (Fig. 3; Dam, 1991; Dam & Surlyk, 1992, 1993; Surlyk *et al.,* 1993). This long term

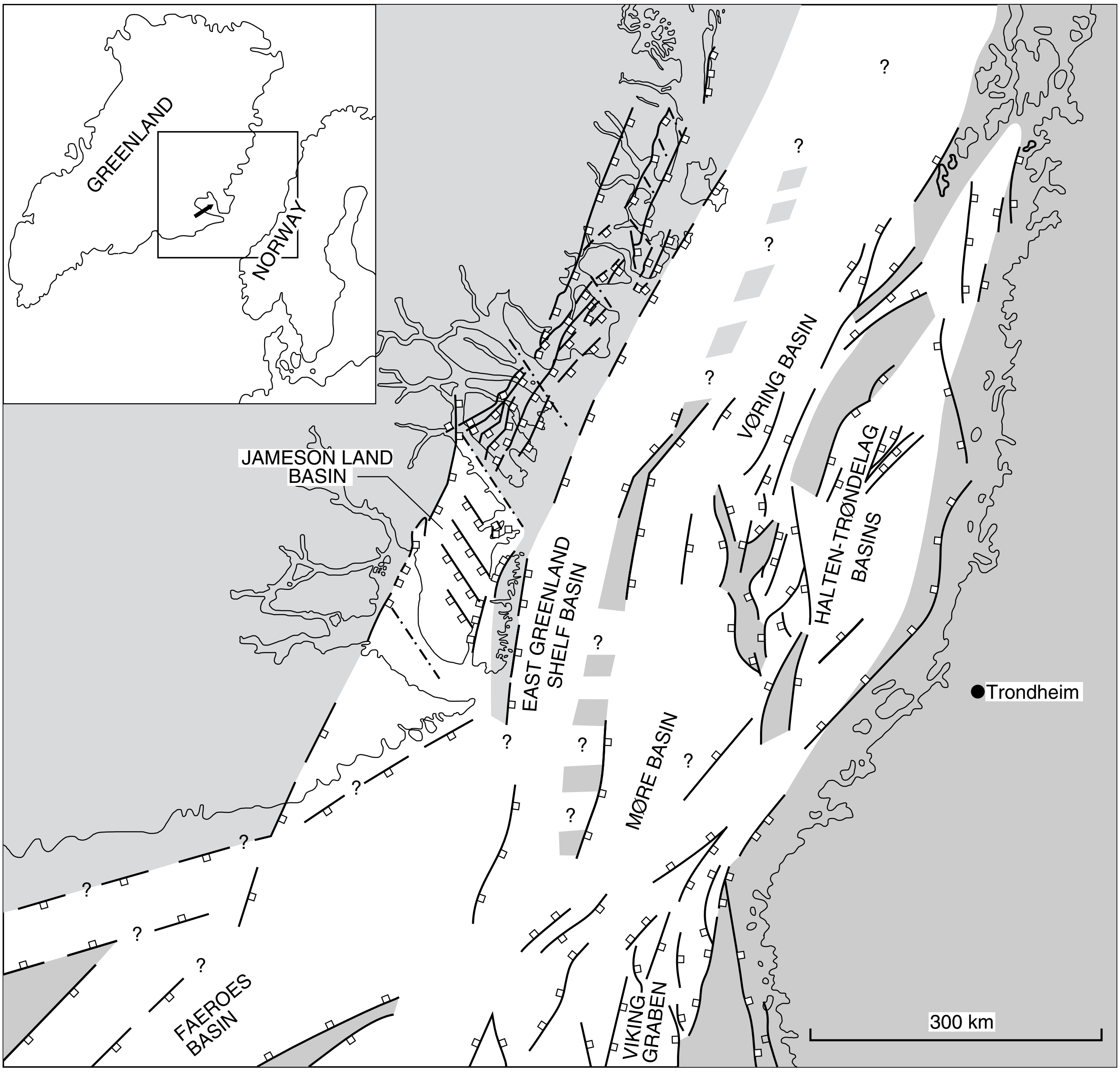

Fig. 2. Tectonic map of the North Atlantic region in Early Jurassic times showing reconstructed position of Greenland and Norway. The tone indicates position of major highs. From Dam & Surlyk (1995).

climatic change was probably caused by a gradual drift of the Triassic continent from a subtropical near-equatorial position in Middle Triassic times to a temperate position in Rhaetian – Early Jurassic times (Smith & Briden, 1977; Clemmensen, 1980a). This was accompanied by a long-term eustatic sea-level rise during the Early Jurassic and the Rhaetian – Sinemurian lacustrine complex turned into a shallow marine embayment marking the first fully marine inundation of the basin since the Late Permian – Early Triassic. The embayment was restricted to the same depositional basin as the lacustrine complex.

The shallow marine, Lower – lower Middle Jurassic Neill Klinter Group occurs in Jameson Land and Scoresby Land, and a small fault-bounded outlier is exposed in southern Liverpool Land (Fig. 1). In exposures the group varies in thickness from 300 m along the eastern basin margin to *c.* 450 m in the central part of the basin. The group and most of its formations and members show an overall sheet geometry, although the thicknesses

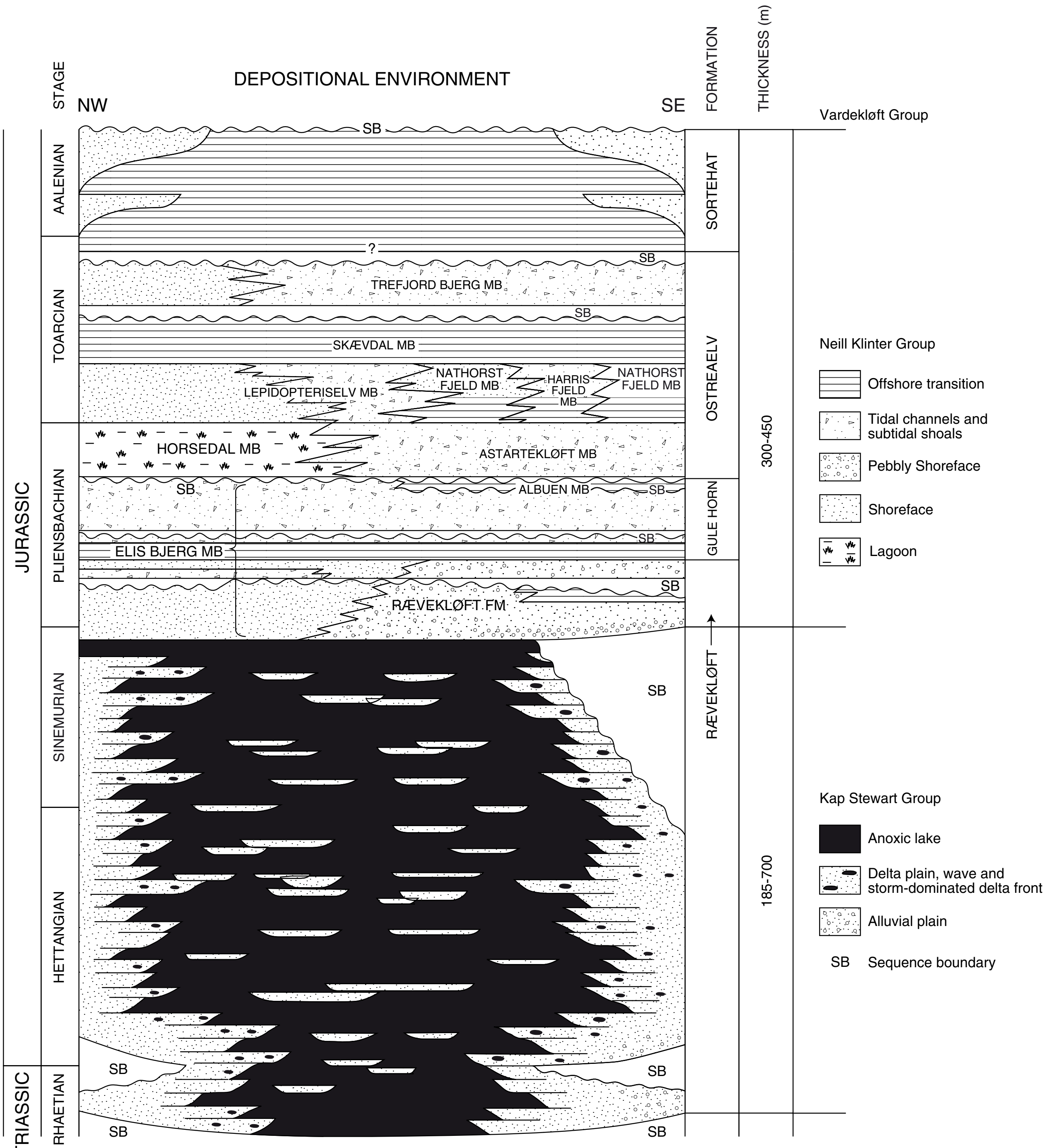

Fig. 3. Stratigraphy and depositional environments of the Upper Triassic – lower Middle Jurassic succession of the Jameson Land Basin. Modified from Dam & Surlyk (1995).

are greatest in the basin centre and decrease towards the margins. The boundary between the Kap Stewart Group (Surlyk *et al.*, in press) and Neill Klinter Group is developed as an erosional unconformity along the south-eastern basin margin, representing a major hiatus corresponding to the Sinemurian Stage (Fig. 3).The unconformity passes basinwards into a correlative conformity and the contact between the lacustrine mudstones of the Kap Stewart Group (Surlyk *et al.*, in press) and the shallow marine sandstones of the Neill Klinter Group is gradational (Fig. 4; Dam, 1991; Dam & Surlyk 1992, 1993). The Neill Klinter Group is overlain with a sharp contact by the Bajocian – Callovian Vardekløft Group (Fig. 3; Surlyk *et al.*, 1973; Surlyk 1990a, b, 1991; Engkilde & Surlyk, in press).

The sediments of the Neill Klinter Group were deposited in a shallow marine embayment during a period of relative tectonic quiescence and the facies pattern was mainly controlled by relative sea-level fluctuations, sediment influx and basinal currents, and differential subsidence along reactivated deep-seated Devonian faults.

Sykes (1974) recognised that the Gule Horn Member (Elis Bjerg Member in this paper) is made up of a series of stacked coarsening-upward successions, 8–40 m thick, in the south-eastern part of the basin. He proposed a depositional model similar to the recent Heligoland Bight of the southern North Sea and interpreted the coarsening-upward units as formed by progradation of estuaries across a shallow shelf. This simplified interpretation is not supported by the present study. Estuarine deposition takes place during transgression, and the whole succession shows very large variations.

The Jurassic – lowermost Cretaceous succession of East Greenland was interpreted within a large-scale low-resolution sequence stratigraphic framework by Surlyk (1990a, 1991). The deposits of the Lower Jurassic Neill Klinter Formation were considered as part of a transgressive systems tract passing into a thin highstand systems tract. The boundary between the two systems tracts was located within the lower, more fine-grained part of the Sortehat Formation.

A high-resolution sequence stratigraphic study of the Neill Klinter Formation and sequence stratigraphic correlation with the equivalent formations on the mid-Norwegian shelf was presented by Dam & Surlyk (1995). The Pliensbachian – Toarcian succession in both regions consists of six correlative sequences.

→

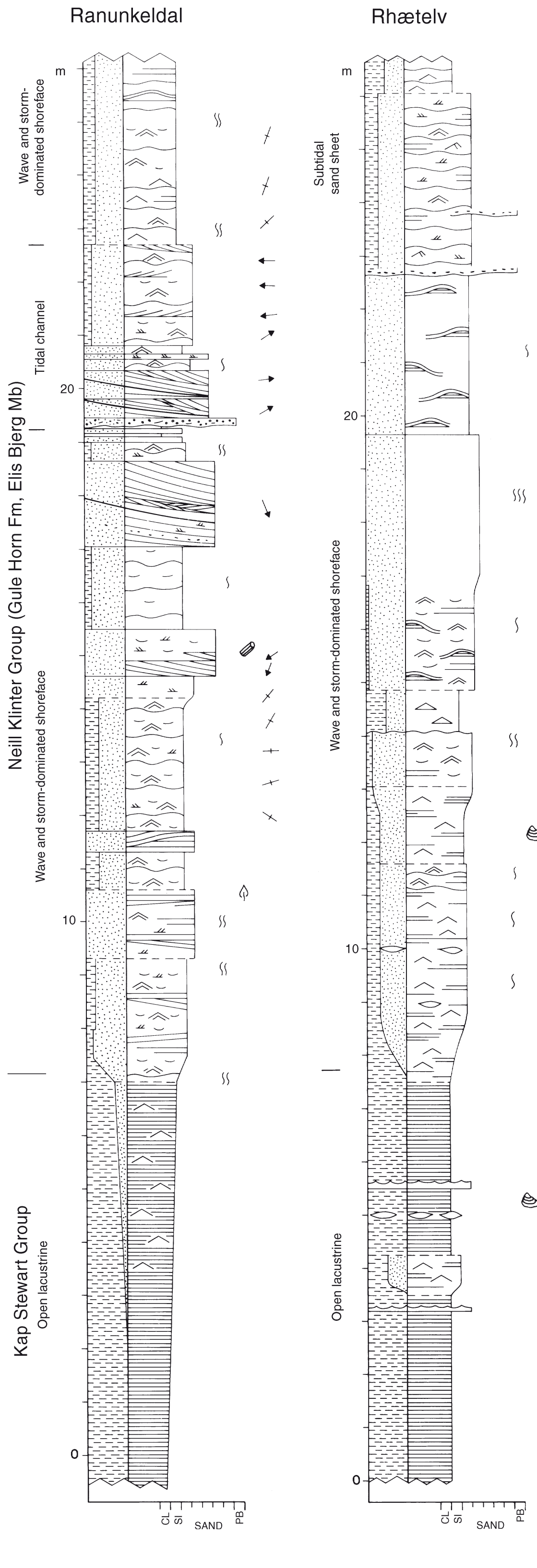

Fig. 4. Sedimentological logs from the north-western (Ranunkeldal) and northern (Rhætelv) parts of the basin showing the gradual transition from the fresh water lacustrine mudstones of the Kap Stewart Group to wave and storm-dominated upper shoreface (Facies association e) and subtidal sand sheet deposits (Facies association f) of the Elis Bjerg Member of the Gule Horn Formation. See Fig. 1 for locations and Plate 1 for legend.