Peripheral-Bulge Controlled Depositional Architecture of a Clastic Foredeep Succession: Paleocene, Spitsbergen*

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Introduction

The Paleogene Central Basin on Spitsbergen, together with the West Spitsbergen Orogenic Belt, occupy a 100 km broad, NNW-SSE striking zone in the western and central parts of the island. The deformation zone is situated along the De Geer Zone immediately west of Spitsbergen, and its development is presumably closely connected to the evolution of this major intra-plate transform fault zone (Figure 1). Compression along west Spitsbergen probably began in the Late Cretaceous to early Paleocene and culminated in the Eocene, based on fission track modelling, crosscutting relations, and comparison to the offshore record of sea-floor spreading (Braathen and Bergh, 1995; Teyssier et al., 1995; Blythe and Kleinspehn, 1998; Braathen et al., 1999). The Central Basin probably evolved as a foreland basin in front of the West Spitsbergen Orogenic Belt during the earliest phases of compression.

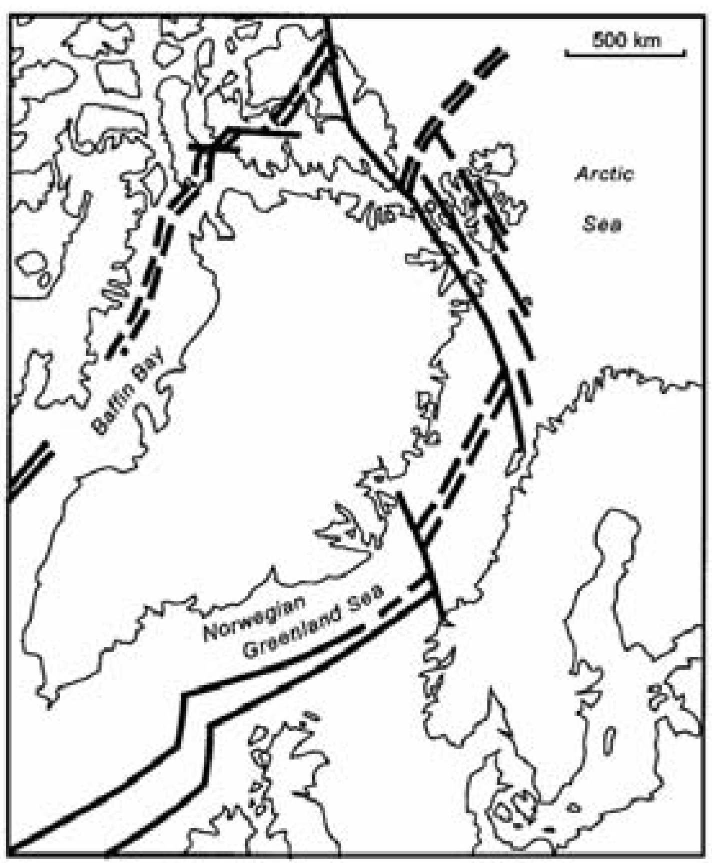

Figure 1. Paleogeographic reconstruction of the Arctic in Late Cretaceous - earliest Paleocene time showing the main spreading zones in the Arctic. The Svalbard archipelago and Spitsbergen is situated immediately offshore northeast Greenland. The De Geer Zone is the somewhat poorly constrained zone of strike-slip faults between Spitsbergen and Greenland.

Basin-Fill

The sedimentary fill in the Central Basin unconformably overlies Lower Cretaceous marine shales. The unconformity corresponds to a hiatus that spans the entire Upper Cretaceous and increases in a northward direction. It is probably a combined result of thermal doming or rift shoulder uplift of the northeast Barents Shelf, and erosion connected to passage of the initial peripheral bulge. The basin-fill, originally minimum 3600 m thick (cf., Manum and Throndsen, 1978), is overall eastwards migrating and reflects the eastward translation of the entire basin in response to lithospheric shortening in the West Spitsbergen Fold-Thrust Belt. The oldest, Paleocene, parts of the present basin fill consist of landward-stepping (eastwards) deltaic and shoreface-to-shelf deposits, 700 m thick, derived from the peripheral bulge area east of the basin and deposited along the eastern margin of the foredeep (Kellogg, 1975; Steel et al., 1981; Bruhn and Steel, *in press*). In the Early Eocene the basin-fill, 1400 m thick, was derived from the rising orogen east of the basin. Clastic wedges with impressive clinoform geometries of up to 350 m amplitude record the main progradational (eastwards) infilling of the basin from the West Spitsbergen Orogenic Belt (Steel et al., 1985; Plink-Björklund et al., 2001). A zone of deep-water shales separates the Paleocene and Eocene successions and marks the eastward passage of the foredeep.

Paleocene Cycles

The overall transgressive, Paleocene succession consists of two intermediate-scale, transgressive-regressive cycles, (a) the Firkanten Formation and (b) the Grumantbyen and Basilika Formations (Figure 2). The intermediate-scale cycles in turn consist of numerous small-scale, 10-60 m thick, coastal plain-shoreface-shelf sequences, separated by subaerially formed unconformities (Bruhn and Steel, *in press*). The sequences represent short-term coastal progradations and have average durations of 0.5-1 million years. Sequences forming the transgressive parts of the intermediate-scale cycles are relatively thin, sheet-like, and onlap the eastern basin-margin, while sequences of the regressive parts are wedge-shaped, basinward-stepping, and associated with regional unconformities along the basin-margin.

Peripheral Bulge

The transgressive-regressive cycles were probably largely controlled by peripheral-bulge dynamics with episodic uplift and erosion of the peripheral-bulge, in turn controlled by episodic thrust wedge build-up and collapse in the West Spitsbergen Orogenic Belt (Figure 3) (cf., Braathen et al., 1999).

During tectonic quiescence the basin was downwarped due to sediment loading and gradually widened. The peripheral bulge migrated eastwards, away from the thrust belt and was gradually eroded, supplying decreasing amounts of sediment to the low-gradient basin margin. The peripheral bulge margin of the foreland basin was thus gradually transgressed (cf., Flemings and Jordan, 1989, 1990). During emplacement of thrust sheets, loading of the elastic lithosphere resulted in uplift and basinward translation of the peripheral bulge toward the thrust front, and narrowing and deepening of the foreland basin. This resulted in regression of the depositional systems close to the peripheral

bulge, where the increased relief resulted in increased sediment supply to fill-in accommodation in the basin. (cf., Flemings and Jordan, 1989, 1990).
The general behaviour of the peripheral bulge is mainly predicted from published models, as the sedimentary record on the distal margin of the foreland basin is commonly dominated by hiati. Well-exposed fieldwork-based examples of a relatively complete clastic, peripheral bulge-derived foredeep succession thus provides a unique opportunity to confirm predicted responses of depositional systems on the distal foreland basin margin to adjustments in the basins flexural profile.

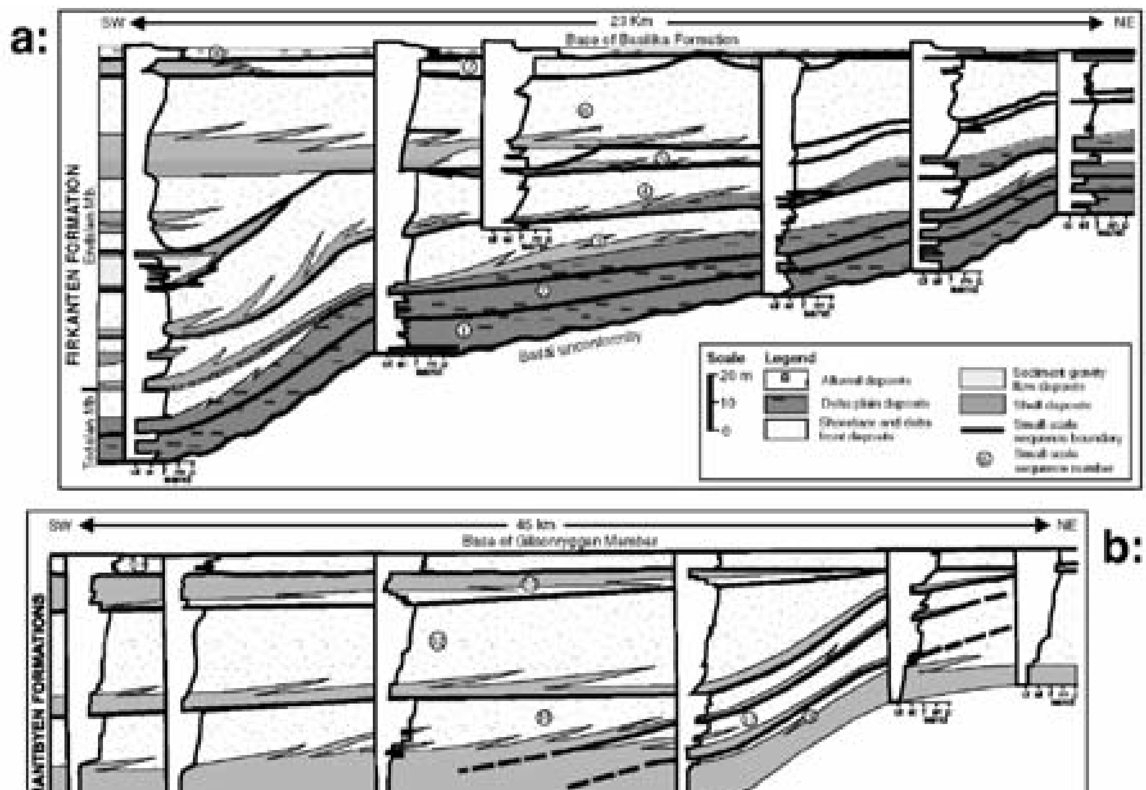

Figure 2. Dip sections across the northeast margin of the Central Basin of each of the two transgressive-regressive cycles, a: the Firkanten Formation, and b: the Grumant-Basilika Formations. The sections show the depositional architecture and stacking pattern of small-scale sequences within the intermediate-scale cycles. The small-scale sequences are numbered upward and the position of the numbers indicates the backstepping - forward-stepping stacking pattern. Note the different scales used in a and b.

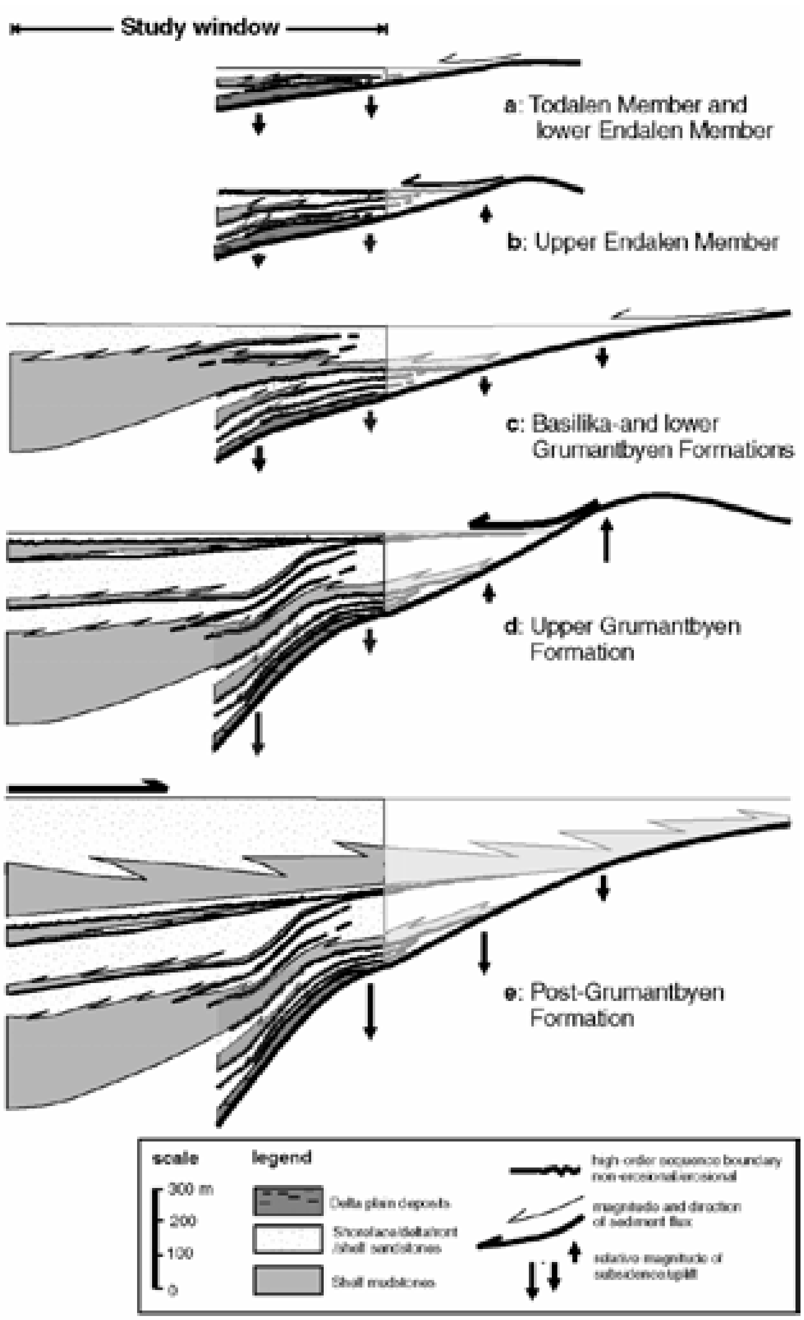

Figure 3. Development of depositional architecture and stacking patterns of small-scale sequences in the Firkanten, Basilika and Grumantbyen Formations.
a: Tabular, small-scale sequences onlap the basal unconformity on the distal basin margin in Todalen-lower Endalen Member time, after passage and relaxation of the initial peripheral bulge.
b: Deposition of basinward-stepping, wedge-shaped, small-scale sequences takes place during upper Endalen Member time in response to uplift and basinward migration of the peripheral bulge.
c-d: Basilika-Grumantbyen time: repetition of pattern A-B, with strongly basinward-stepping sand sheets in the upper part of Grumantbyen Formation.
e: Eocene: passage of the foredeep and following progradation of shelf clinoforms from the fold-thrust belt side of the basin.

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