Geomorphology, Facies Character and Stratigraphic Architecture of an Ancient Sand-prone Subaqueous Delta: Upper Jurassic Sognefjord Formation, Troll Field, Offshore Norway*

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Abstract

The integration of core, seismic stratigraphic and seismic geomorphologic observations is used to support the interpretation of a sand-prone subaqueous delta in the Upper Jurassic Sognefjord Formation, Northern Horda Platform, offshore Norway. Subaqueous deltas, characterised by compound clinoform morphology, are common in many modern tide- and wave-influenced settings, but ancient examples are rarely reported. The Sognefjord Formation data demonstrate the criteria for recognition of sand-prone subaqueous deltas in the stratigraphic record, as well as refining the depositional model of the main reservoir in the super-giant Troll oil and gas field.

Introduction

Two 10-60 m thick, wave-dominated, regressive-transgressive packages bounded by major marine flooding surfaces are identified in the lower Sognefjord Formation. Three different areas are characterized by quite dissimilar facies features. Towards the west, these packages consist mainly of coarse grained, cross-bedded sandstones (Figure 1); in the southeast, these sands are prevalently finer-grained and hummocky cross-stratified (Figure 2); in the northeast, the presence of coarser, poorly sorted sandstones is interpreted to indicate closer proximity to a fluvial sediment input point. No evidence of subaerial exposure is observed in core.

Each regressive-transgressive package corresponds to a set of seismically resolved, westerly-dipping clinoforms that are consistently identified across the study area (Figure 3). These packages thicken towards the west, with a maximum thickness at the location where the clinoform "envelope" rolls over, defining a topset-foreset-toeset geometry at the position of maximum regression. Both individual clinoforms and reflections bounding the clinoform sets are linear to curvilinear in plan-view and strike sub-parallel to the edge of the Northern Horda Platform (Figure 4). In the east of the Troll Field, individual clinoforms are thin (10-30 m) and relatively gently dipping (1°-6°) becoming thicker (15-60 m) and steeper dipping (5-14) towards the west. Topsets are consistently well developed throughout the study area, except in the westernmost area, where some seismically resolved clinoform foresets seem top-truncated.

Discussion

The consistent dip and strike of the clinoforms, the pervasiveness of sediments deposited below fair-weather wave base and absence of subaerial facies in the topsets are interpreted to represent deposition by subaqueous, wave-dominated, linear clinoforms that prograded westwards across the Horda Platform. Subaqueous clinoforms were supplied by a river outlet at the northeast and developed by the action of longshore currents running sub-parallel to the clinoform strike. These features are observed in many modern subaqueous deltas. Each clinoform set becomes coarser grained with narrower topsets and higher, steeper foresets as the subaqueous delta prograded from the inner part of the Horda Platform towards its western limit, which was directly exposed to wave and storm approach. The shoreline is inferred to have been marked by a subaerial delta clinoform, separated from the subaqueous clinoform by a subaqueous topset (Figure 5). Subaerial clinoforms were probably present beyond the eastern limit of the study area, generating a 'compound clinoform' morphology (e.g. Swenson et al., 2005). Previous interpretations of the Sognefjord Formation, based only on data from the western part of the study area include a wave-dominated shoreface (Stewart et al., 1995) and a spit-fronted tidal back-basin (Dreyer et al., 2005). These previous interpretations are based on data from the western part of the study area and are not consistent with the key observations outlined here.

Conclusions

A coarse-grained subaqueous delta model for the Sognefjord Formation may have applications to other clinoform-bearing shallow-marine sandstones in the ancient stratigraphic record. A key implication is that, without a sedimentological and/or geomorphological characterisation, the use of the clinoform rollover point as a proxy for palaeoshoreline location may lead to inaccurate predictions of relative sea level history and facies distributions.

References Cited

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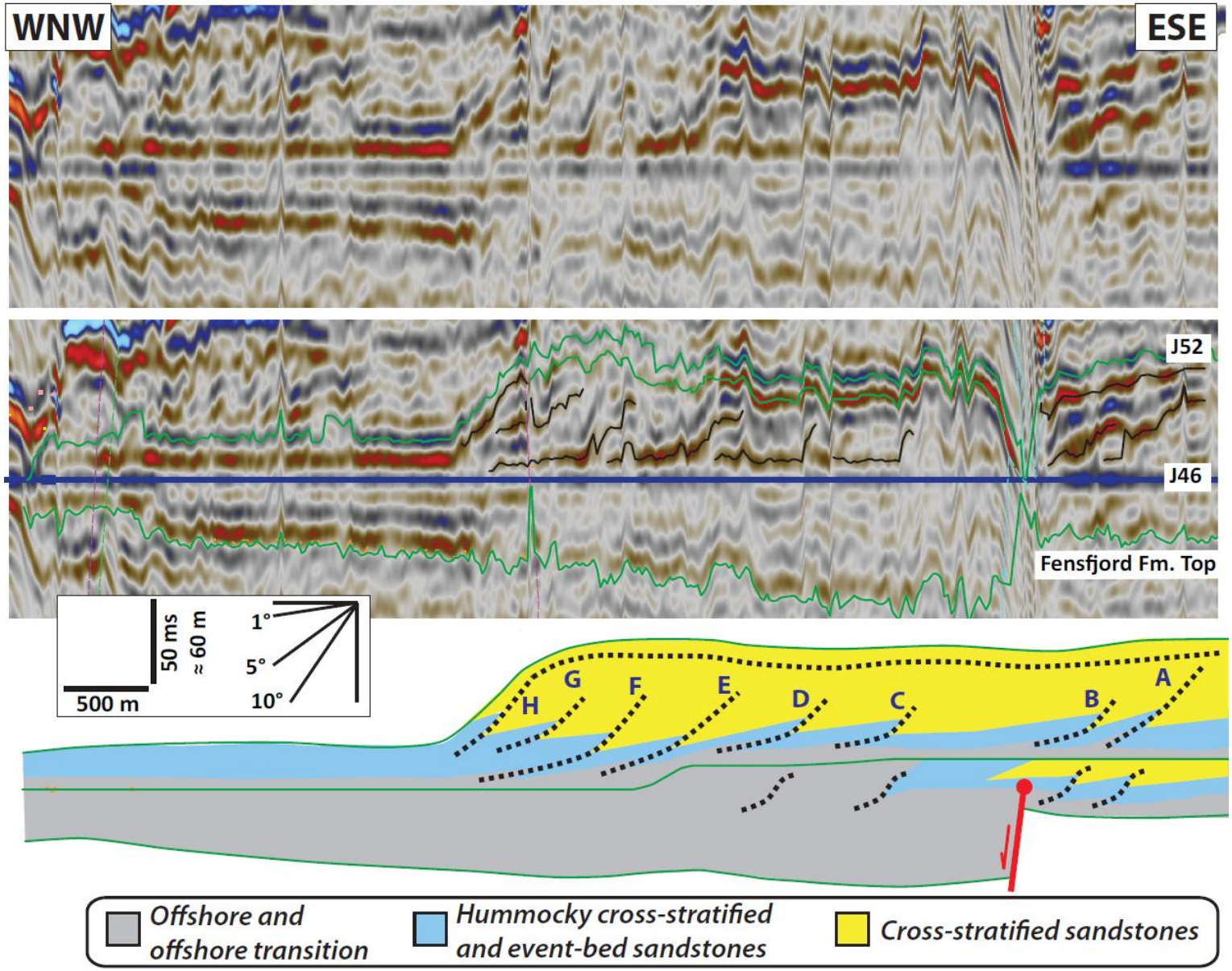

Figure 1. Uninterpreted and interpreted seismic cross-section showing clinoforms in the western part of the Troll field. The cross-section is flattened along an interpreted maximum flooding surface.

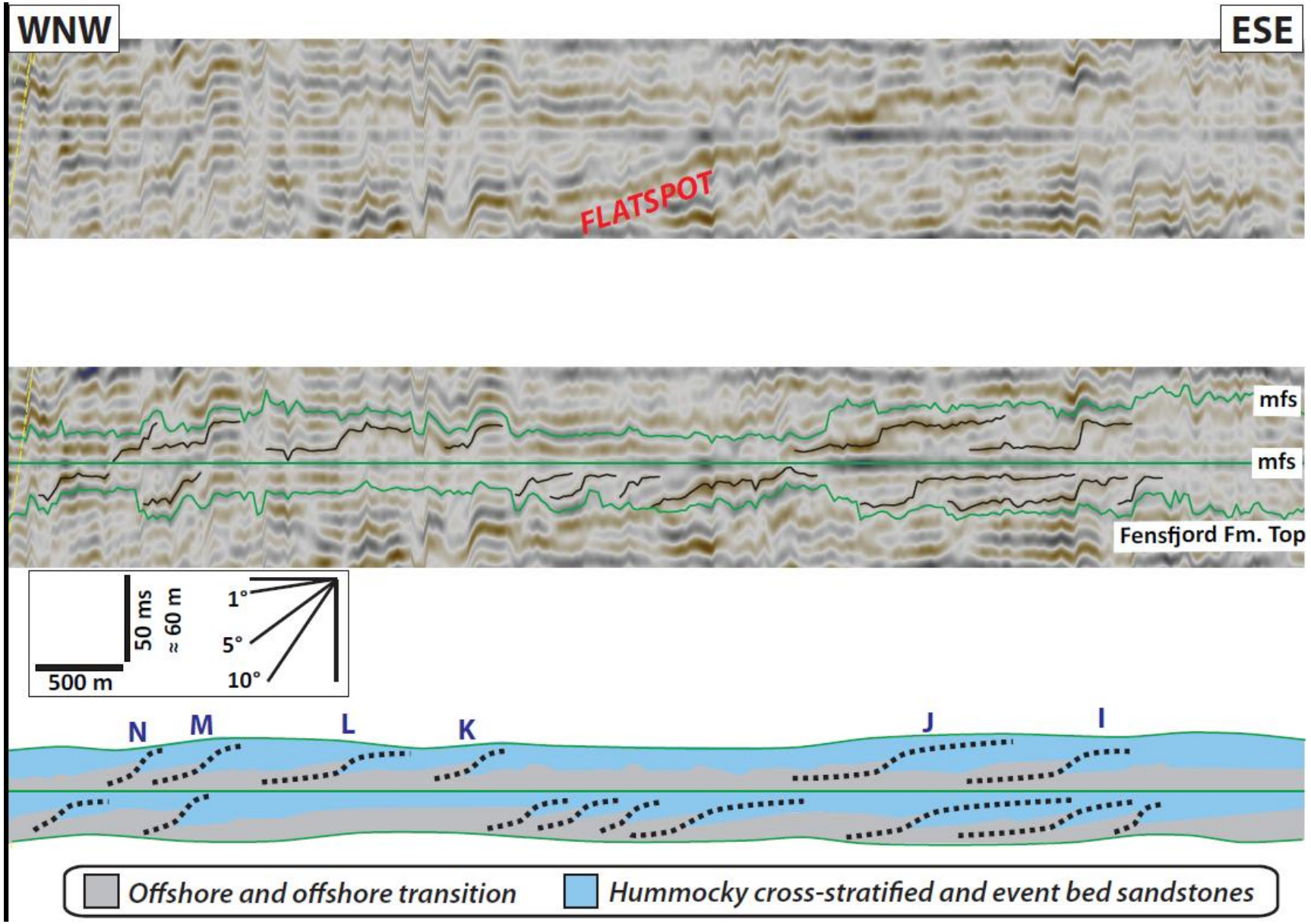

Figure 2. Uninterpreted and interpreted seismic cross-section showing clinoforms in the eastern part of the Troll field. The cross-section is flattened along an interpreted maximum flooding surface.

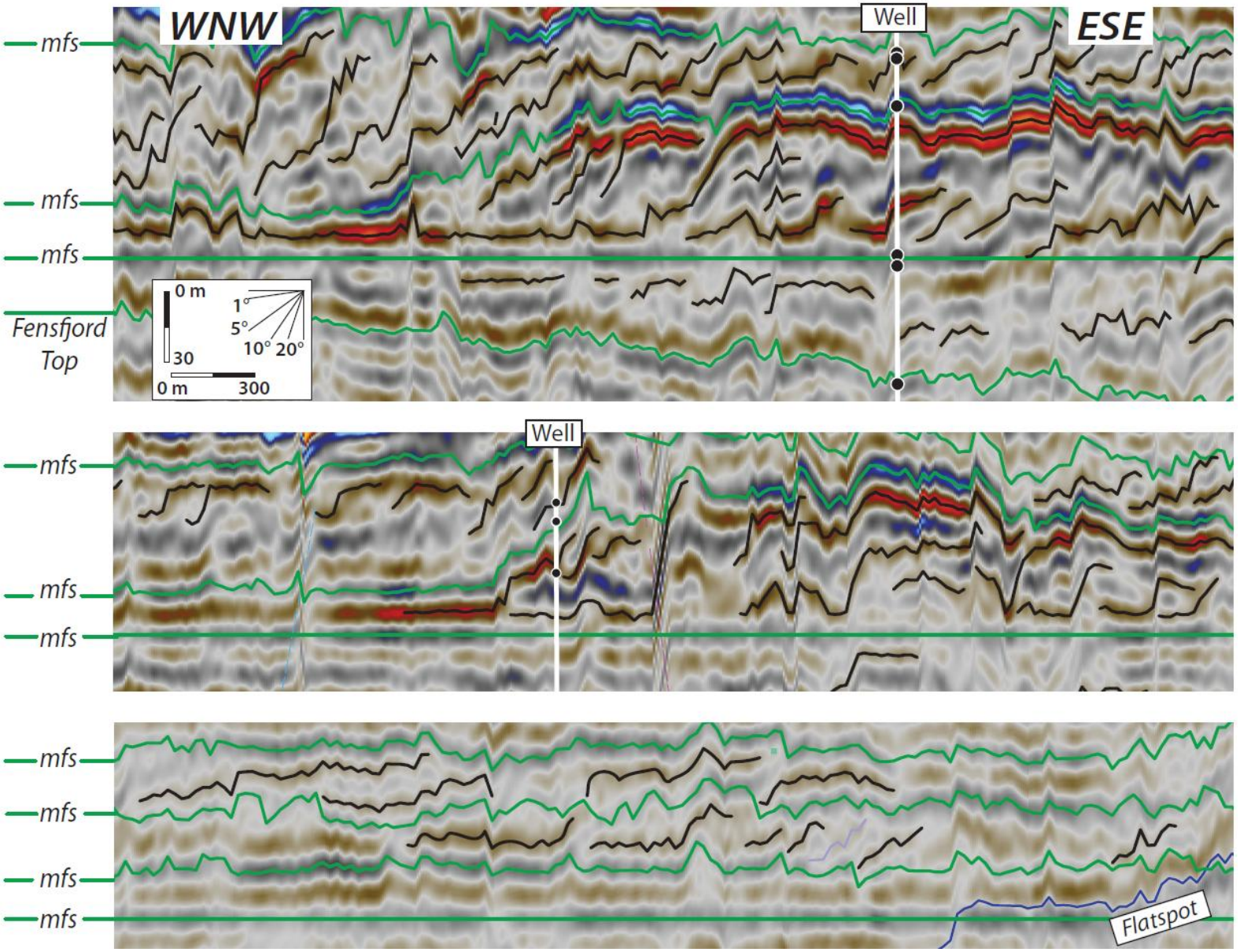

Figure 3. Seismic cross-sections oriented parallel to the depositional dip in various locations of the Troll Delta. Clinoform set features are consistent throughout the area.

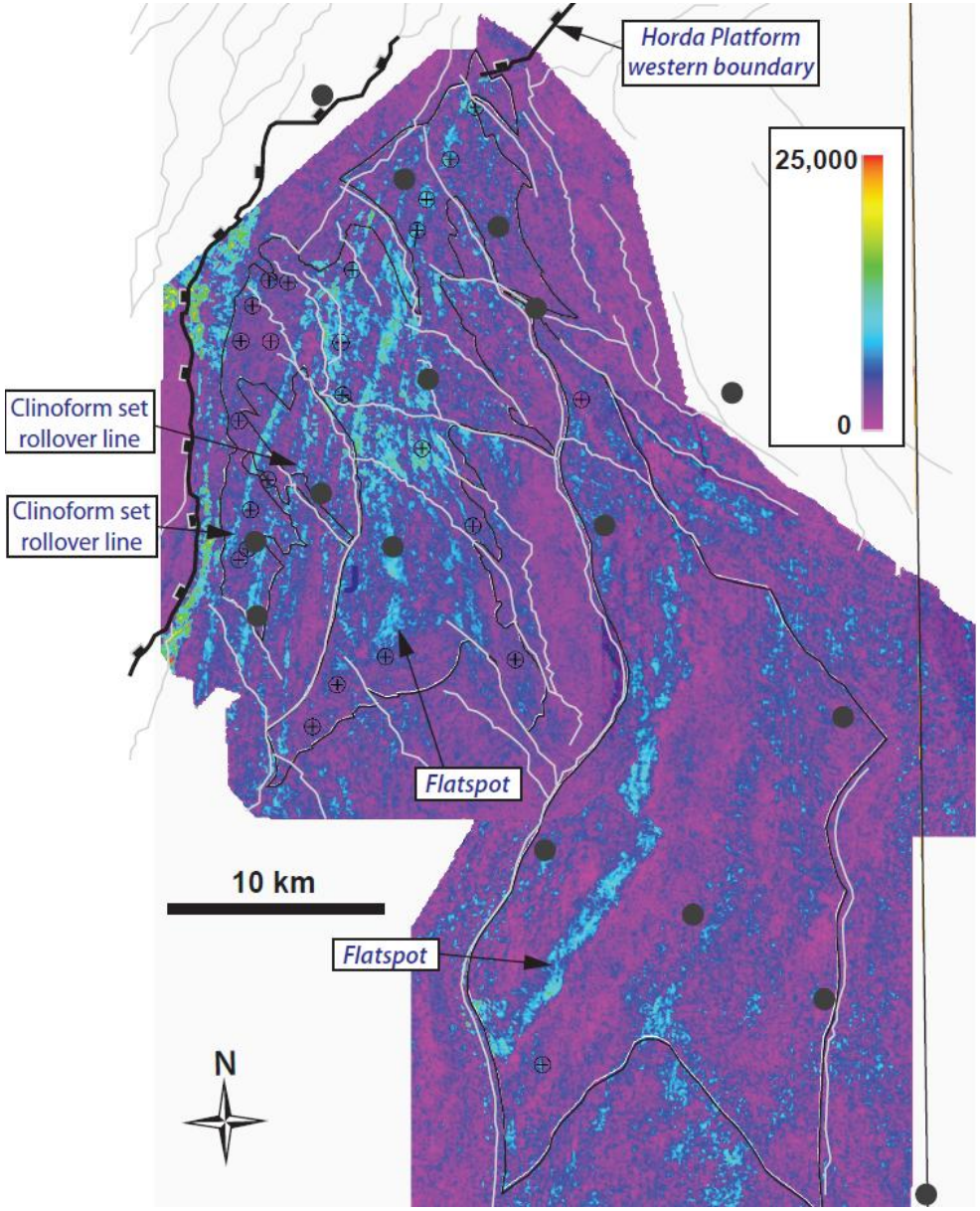

Figure 4. Maximum amplitude attribute maps extracted from a window placed 40-60 ms above the top of the Fensfjord Formation. NNE-SSW-oriented amplitude anomaly patterns represent the strike direction of clinoforms.

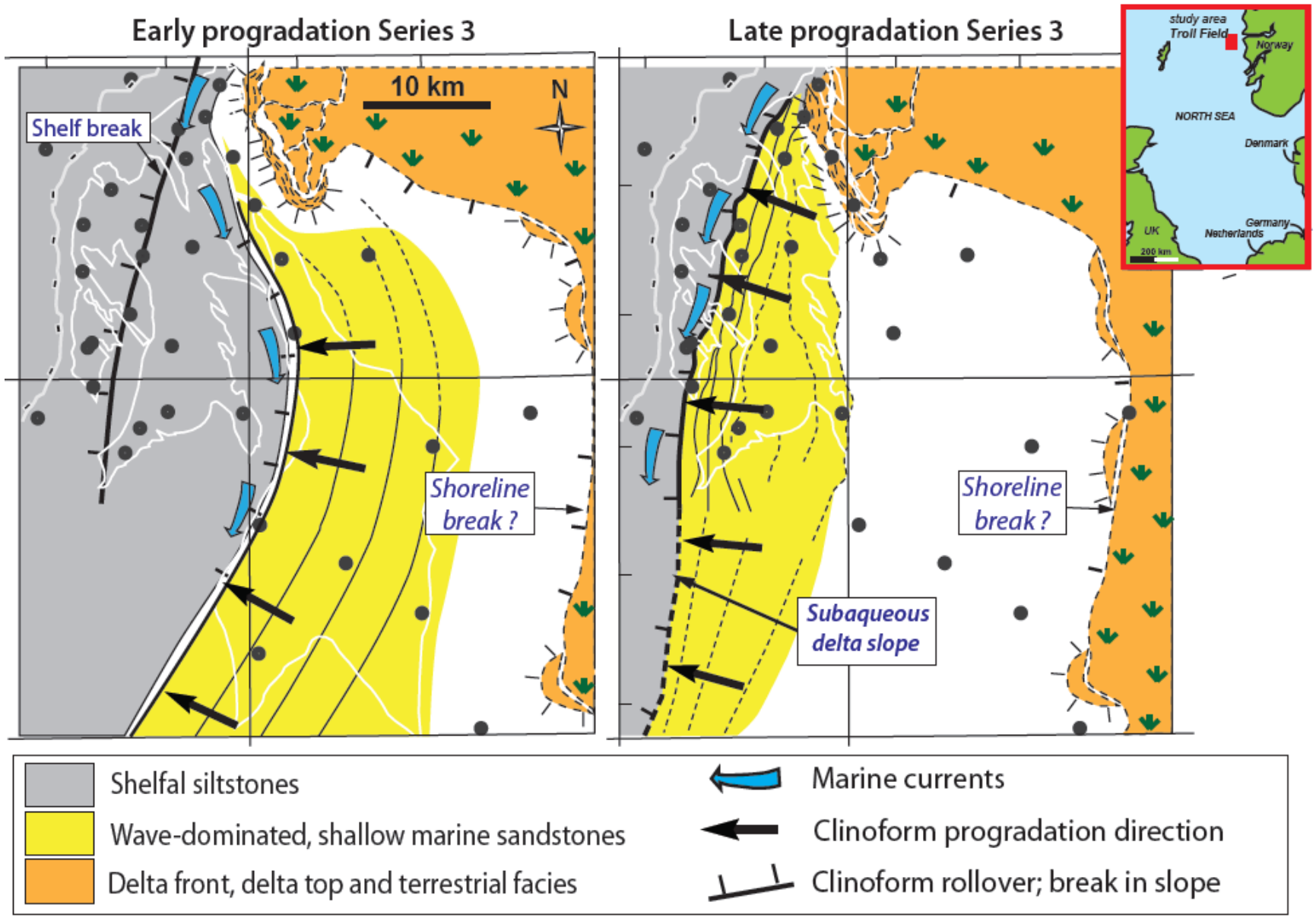

Figure 5. Interpretive palaeogeographic maps showing evolution during the progradation of a single delta-scale clinoform set.