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The northern sector of the last British Ice Sheet: Maximum extent and demise

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ABSTRACT

Strongly divided opinion has led to competing, apparently contradictory, views on the timing, extent, flow configuration and decay mechanism of the last British Ice Sheet. We review the existing literature and reconcile some of these differences using remarkable new sea-bed imagery. This bathymetric data provides unprecedented empirical evidence of confluence and subsequent separation of the last British and Fennoscandian Ice Sheets. Critically, it also allows a viable pattern of ice-sheet disintegration to be proposed for the first time. Covering the continental shelf around the northern United Kingdom, extensive echosounder data reveals striking geomorphic evidence – in the form of tunnel valleys and moraines – relating to the former British and Fennoscandian Ice Sheets. The pattern of tunnel valleys in the northern North Sea Basin and the presence of large moraines on the West Shetland Shelf, coupled with stratigraphic evidence from the Witch Ground Basin, all suggest that at its maximum extent a grounded ice sheet flowed from SE to NW across the northern North Sea Basin, terminating at the continental-shelf edge. The zone of confluence between the British and much larger Fennoscandian Ice Sheets was probably across the northern Orkney Islands, with fast-flowing ice in the Fair Isle Channel focusing sediment delivery to the Rona and Foula Wedges. This period of maximum confluent glaciation (c. 30–25 ka BP) was followed by a remarkable period of large-scale ice-sheet re-organisation. We present evidence suggesting that as sea level rose, a large marine embayment opened in the northern North Sea Basin, as far south as the Witch Ground Basin, forcing the two ice sheets to decouple rapidly along a north–south axis east of Shetland. As a result, both ice sheets rapidly adjusted to new quasi-stable margin positions forming a second distinct set of moraines (c. 24–18 ka BP). The lobate overprinted morphology of these moraines on the mid-shelf west of Orkney and Shetland indicates that the re-organisation of the British Ice Sheet was extremely dynamic — probably dominated by a series of internally forced readvances. Critically, much of the ice in the low-lying North Sea Basin may have disintegrated catastrophically as decoupling progressed in response to rising sea levels. Final-stage deglaciation was marked by near-shore ice streaming and increasing topographic control on ice-flow direction. Punctuated retreat of the British Ice Sheet continued until c. 16 ka BP when, following the North Atlantic iceberg-discharge event (Heinrich-1), ice was situated at the present-day coastline in NW Scotland.

1. Introduction

At present, views vary widely regarding the extent, thickness and geometry of the last British Ice Sheet (BIS), and its interaction with the neighbouring Fennoscandian Ice Sheet (FIS). Nowhere is this problem better highlighted than in the North Sea Basin. Whilst some authors have claimed that, at its maximum, the last BIS coalesced with the Fennoscandian Ice Sheet (FIS) in the North Sea Basin (e.g. Sejrup et al., 1994; 2005; Carr et al., 2006); others have contended that it terminated only a short distance offshore (e.g. Sutherland, 1984; Bowen et al., 2002). These differences in ice-sheet extent are contradictory and appear impossible to reconcile (cf. Bowen et al., 2002; Hall et al., 2003). Resolving this impasse has important implications, not only for underpinning past changes in the geometry and dynamics of the last BIS, but also for environmental change on a global scale. Questions regarding Northern Hemisphere ice-sheet volume, concomitant sea-level changes and the potential impact of meltwater and calving flux on the North Atlantic thermohaline circulation are central to our understanding of the coupled ocean–atmosphere system.

The glacial history of the continental shelf east of the UK, predominantly comprising the North Sea Basin, remains relatively poorly understood (Fig. 1). Previous reconstructions for the northern North Sea area (north of 57°N) depict both ice-free (e.g. Sutherland, 1984;

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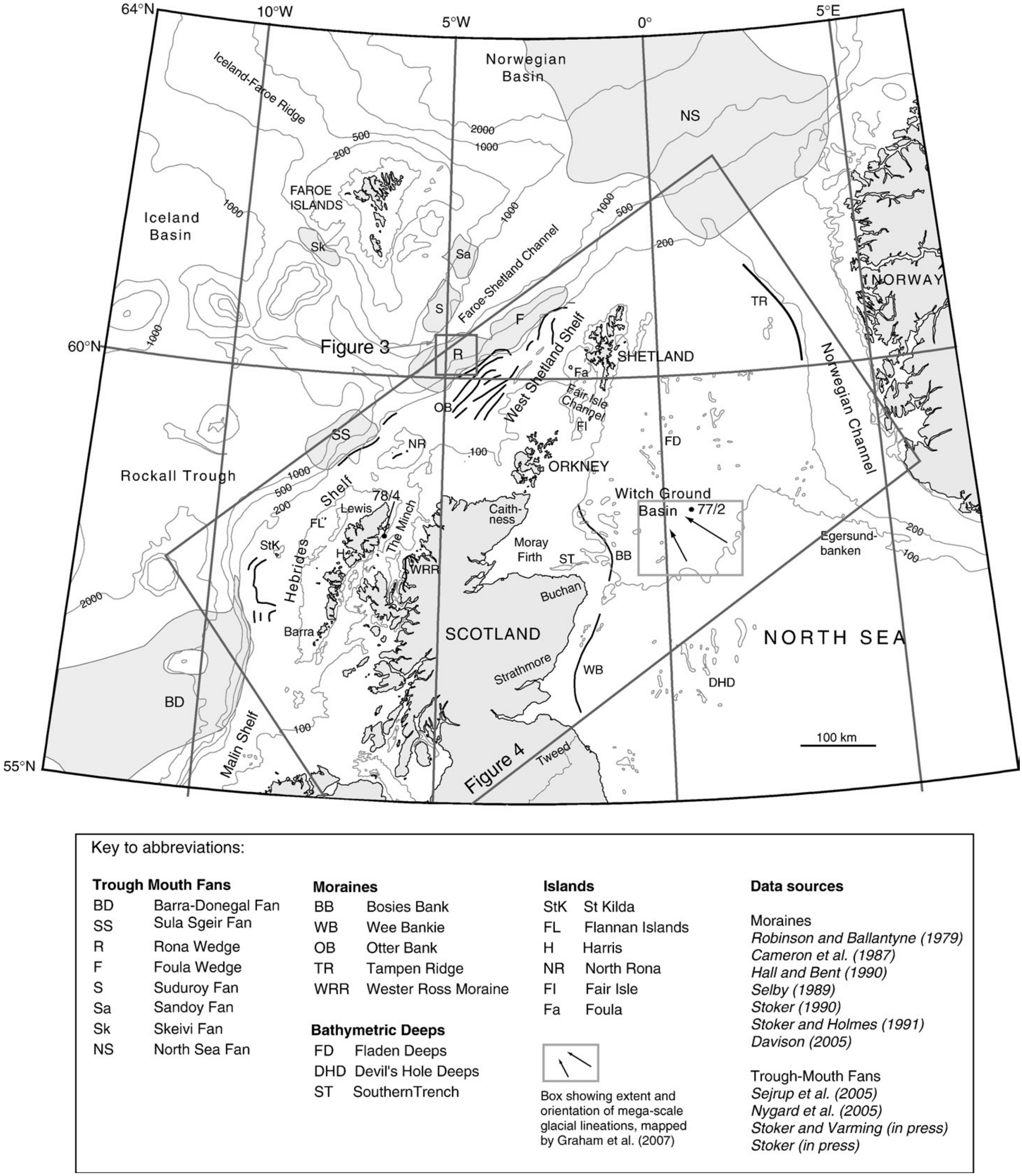

Fig. 1. Map showing the general bathymetry and main glacio-geological sea-bed landforms around the northern UK. Data sources are given in the legend. Extent of the study area (Fig. 4) and key placenames are also shown.

Boulton et al., 1985; Bowen et al., 2002) and ice-covered scenarios (e.g. Sissons, 1967; Boulton et al., 1977; Sejrup et al., 1994). Only recently has opinion begun to converge on the idea of a glaciated North Sea Basin in Late Weichselian times (Marine Isotope Stage 2) (Sejrup et al., 2005; Carr et al., 2006). This view has been strongly reinforced by the recent identification of mega-scale glacial lineations (MSGLs) in the central part of the northern North Sea (Graham et al., 2007). These sub-surface lineations, imaged on 3D seismic profiles in the Witch Ground Basin,