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Early Middle Pleistocene sediments at Sidestrand, northeast Norfolk, yield the most extensive preglacial cold stage beetle assemblage from Britain

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ABSTRACT

Fluvial sediments (Cromer Forest-bed Formation) at Sidestrand, northeast Norfolk, have yielded the most extensive preglacial early Middle Pleistocene cold (arctic) stage beetle assemblage known from Britain. The assemblage is composed of 59 taxa indicating severely cold and continental climatic conditions. Mutual Climatic Range reconstructions suggest that the mean temperature of the warmest month (July) was between 10 °C and 13 °C and the mean temperature of the coldest months (January and February) between −17 °C and −10 °C, although the actual palaeotemperatures were probably towards the lower end of these ranges. Associated pollen and macroflora remains were poorly represented but all are known from other cold stage contexts.

Excavations reveal that this freshwater arctic assemblage occurs within units between two important stratigraphic marker horizons, the Sidestrand Hall Member of the Cromer Forest-bed Formation and the first lowland glacigenic deposit (Happisburgh Till Member) in eastern England, although the ages of both remain equivocal. Recent amino-acid chronologies of molluscan faunas from the Sidestrand Hall Member indicate a MIS 13 age, with by inference a MIS 12 age for the overlying arctic units with cold beetle fauna and for the Happisburgh Till Member. However, the arctic units are separated from the two stratigraphic marker horizons by shallow marine deposits (Wroxham Crag Formation) demonstrating at least two intervening phases of marine transgression and a cold climate marine regression. The climatic significance of these marine transgressions and their chronostratigraphic implications are currently uncertain.

1. Introduction

Much of our current understanding of Quaternary climates within Britain stems principally from studies focusing upon the last 450,000 years which span the late Middle Pleistocene to the Holocene. Climate was regulated during this interval by extreme glacial- and interglacial-stage oscillations driven by the 100 ky Milankovitch (eccentricity) cycles (Imbrie et al., 1984; Lisiecki and Raymo, 2007) and smaller 'sub-Milankovitch' variations linked to ice mass-oceanic circulation feedback processes. Collectively, they resulted in high magnitude changes in climate and environment and corresponding variability in sea-levels, biomass productivity, geological processes and sediment budgets that can be observed in detail within the British Quaternary record (Candy et al., 2010).

By contrast, comparatively less is known about climates that prevailed during the preceding parts of the British Quaternary record due to the more fragmented nature of the geological evidence and limited ability of applying robust absolute and relative chronological frameworks (Rose, 2009; Candy et al., 2010). Nevertheless, understanding the climates of this interval is important to understanding the dispersal of early humans and the long-term development of cold climates and glaciation within Britain (Preece et al., 2009; Rose, 2009; Candy et al., 2010; Parfitt et al., 2010a; Lee et al., 2011; Ashton and Lewis, 2012). Currently, isotope records of ice volume, coupled with records of ice rafted debris plus onshore and offshore evidence for glaciation, portray a

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highlydynamic climatic picture within the North Atlantic region and adjacent areas, characterised by the progressive intensification of the climatic signature coupled with the step-wise up-ramping in the scale and magnitude of glaciation (Flesche Kleiven et al., 2002; Mudelsee and Raymo, 2005; Knies et al., 2009; Böse et al., 2012; Lee et al., 2012; Thierens et al., 2012). Within northern Europe the early Middle Pleistocene includes the 'Cromerian Complex' (c. 0.9–0.48 Ma) which in Britain is characterised by multiple temperate and cold climatic events depicted within the geological record by complex patterns of sea-level change, soil development, river behaviour and flora and fauna (Kemp et al., 1993; Murton et al., 1995; Preece and Parfitt, 2000, 2012; Lee et al., 2006; Rose, 2009; Candy et al., 2010). Critically, early Middle Pleistocene climates have been shown to range between warm (Mediterranean to temperate) and cold (periglacial to boreal) climate extremes (Candy et al., 2006, 2010). Whilst it is known that climates were sufficiently cold and wet to enable localised ice cap development in highland areas of Britain and Ireland throughout large parts of the early Middle Pleistocene (Lee et al., 2011, 2012; Böse et al., 2012; Thierens et al., 2012) there is generally a paucity of qualitative and quantitative climatic data during this time-interval.

Within this paper, we aim to contribute to improving the understanding of early Middle Pleistocene climates within Britain by describing the sedimentological, floral (pollen) and faunal (Coleoptera) evidence from a site in northern East Anglia, UK.

2. Site and geological context

This investigation is centered upon cliff sections and beach excavations at Sidestrand, situated approximately 4.5 km to the southeast of Cromer in northeast Norfolk, Britain (National Grid Reference: TG 262,401, Fig 1). The Quaternary geology of the locality encompasses a thick (up to 60 m) glacigenic sediment pile of early to late Middle Pleistocene age comprising several tills and intervening glaciolacustrine and outwash deposits (Hart, 1990, 1992; Lunkka, 1994; Lee, 2001; Lee et al., 2004a, 2013). These overlie up to 10 m of preglacial sands, gravels, clays and peats (West, 1980; Green and McGregor, 1990; Briant et al., 1999; Lee,

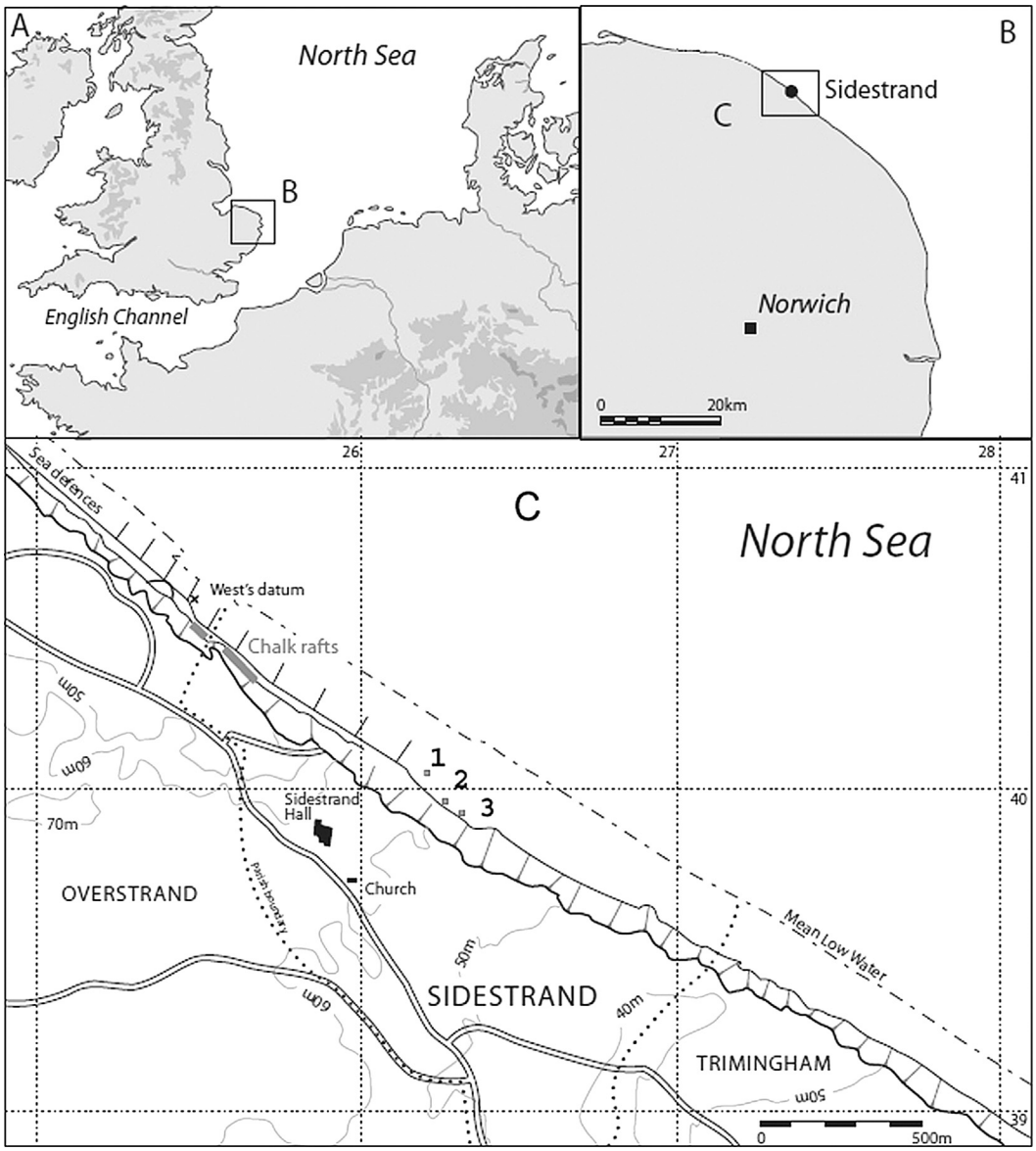

Fig. 1. Locations of sample Sites 1, 2 and 3.

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