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Lateglacial and early Holocene climates of the Atlantic margins of Europe: Stable isotope, mollusc and pollen records from Orkney, Scotland

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ABSTRACT

The margins of mainland Europe, and especially those areas coming under the influence of North Atlantic weather systems, are ideally placed to record changing palaeoclimates. Cores from an infilled lake basin at Crudale Meadow in Mainland, Orkney, revealed basal deposits of calcareous mud ('marl') beneath sedge peat. Stable isotope, palynological and molluscan analyses allowed the establishment of palaeoenvironmental changes through the Devensian Lateglacial and the early Holocene. The $\delta^{18}O_{marl}$ record exhibited the existence of possibly four climatic oscillations in the Lateglacial (one of which, within event cf. GI-1c, is not often commented upon), as well as the Preboreal Oscillation and other Holocene perturbations. The cold episodes succeeding the Preboreal Oscillation were demarcated conservatively and one of these (event C5, ~11.0 ka) may have previously been unremarked, while the putative 9.3 and 8.2 ka events seem not to produce corresponding palynologically visible floristic changes. The events at Crudale Meadow are consistent with those recorded at other sites from Britain, Ireland and elsewhere, and can be correlated with isotopic changes shown by the Greenland ice cores. The multi-proxy approach enriches the environmental reconstructions from the site, although the synchronicity of the response of the various proxies is sometimes equivocal, depending upon the time period concerned, taphonomy, and the nature of the deposits. The site may contain the most northerly Lateglacial isotope record from northwest Europe, and it has yielded one of the best archives for the demonstration of abrupt early Holocene events within Britain.

1. Introduction

Stable isotopes from lake deposits have long been used for climate reconstructions (e.g. Leng and Marshall, 2004) and their use alongside complementary proxies such as pollen, chironomids and Mollusca have strengthened insights into the processes and patterns of global palaeoclimates (e.g. Eicher and Siegenthaler, 1976; Ammann et al., 1983; Böttger et al., 1998; van Asch et al., 2012). Lateglacial successions have been a particular focus because of their sedimentological suitability and the marked oscillatory nature of the climate records they contain (O'Connell et al., 1999; von Grafenstein et al., 2000; Jones et al., 2002; Lang et al., 2010b; van Raden et al., 2013). Holocene deposits have perhaps received less attention. This is partly a function of the availability of suitable material for geochemical analysis, and partly of contemporary research foci. Instances of Holocene or combined

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Lateglacial and Holocene investigation are to be found, however, and given current concerns which emphasise a need to comprehend climate change since glacial times, they are arguably increasingly valuable (cf. Whittington et al., 1996; Ahlberg et al., 2001; Garnett et al., 2004a; Diefendorf et al., 2006; Eastwood et al., 2007; Marshall et al., 2007; Daley et al., 2011).

The margins of Continental Europe, and especially those areas coming under the influence of North Atlantic weather systems, so important in driving climate variability, are ideally placed to reflect changing palaeoclimates. In this respect, Ireland and Britain are particularly well placed to produce multi-proxy records of environmental change, as attested by the suite of sites around Lough Gur (Ahlberg et al., 1996; O'Connell et al., 1999; Diefendorf et al., 2006; van Asch et al., 2012), Gransmoor (Walker et al., 1993), Clettnadal (Whittington et al., 2003), Wester Cartmore (Edwards and Whittington, 2010), and more widely across Europe (cf. Birks et al., 2000, 2012; Brooks and Langdon, 2014). This applies equally, of course, to single proxy studies (e.g. chironomids – Lang et al., 2010a; Brooks et al., 2012; Brooks and Langdon, 2014). In spite of an abundance of publications globally, relatively few palaeoisotope studies have been carried out in Britain (e.g. Turney et al., 1997, 1998; Walker et al., 2003; Garnett et al., 2004a; Marshall et al., 2007; Daley et al., 2011; Candy et al., 2015), and Scotland, a key northerly location, has seen a single comprehensive isotope investigation (for Lundin Tower – Whittington et al., 1996) and another which produced outline details of $\delta^{13}C$ at three sites (Borrobol, Tynaspirit West, Whitrig Bog –Turney et al., 1997; Turney, 1999) (Fig. 1).

What has been lacking is a near-coastal research site in an oceanic context. Such a site might be anticipated to provide a sensitive record of environmental change, although competing site attributes and external climatic factors could always mute responses in various proxies at different times (cf. Whittington et al., 2003). A site in Orkney provides an opportunity to pursue the aims of multi-proxy climate and wider environmental enquiry for deposits of both Lateglacial and early Holocene age. This paper adds not just another comprehensive multi-proxy data set, including stable isotopes, to the few available from Britain and the rest of the Continental Atlantic margins of Europe, but it also presents evidence which reinforces environmental correlates with the Greenland ice core records and raises the issue of cold oscillations in both Lateglacial and early Holocene times which are little commented upon. Critically, as far as we are aware, the site provides the most northerly Lateglacial isotope record from northwest Europe, and one of the best instances for the demonstration of abrupt early Holocene events within Britain.

2. The site

The Orkney Islands archipelago (58°43–59°23′ N; 2°22–3°04′W) is found 16 km north of Caithness on the Scottish mainland and 78 km southwest of the Shetland Islands. The area is subject to the ameliorating effects of the North Atlantic Drift, but wind speeds and exposure are high – in many respects, its present-day weather and climatic characteristics are intermediate between those of mainland Scotland and Shetland (Berry, 2000). The site of Crudale Meadow is in the west of the island of Mainland, the largest island of the Orkney Islands (Fig. 1). It lies 1.7 km from the west coast and 6.1 km NNE of the town of Stromness in an area floored by sandstones and siltstones of the Yesnaby Sandstone Group of the Lower Old Red Sandstone (Mykura, 1976). Thin tills on the surrounding slopes derive partly from the carbonate-rich dolomitic

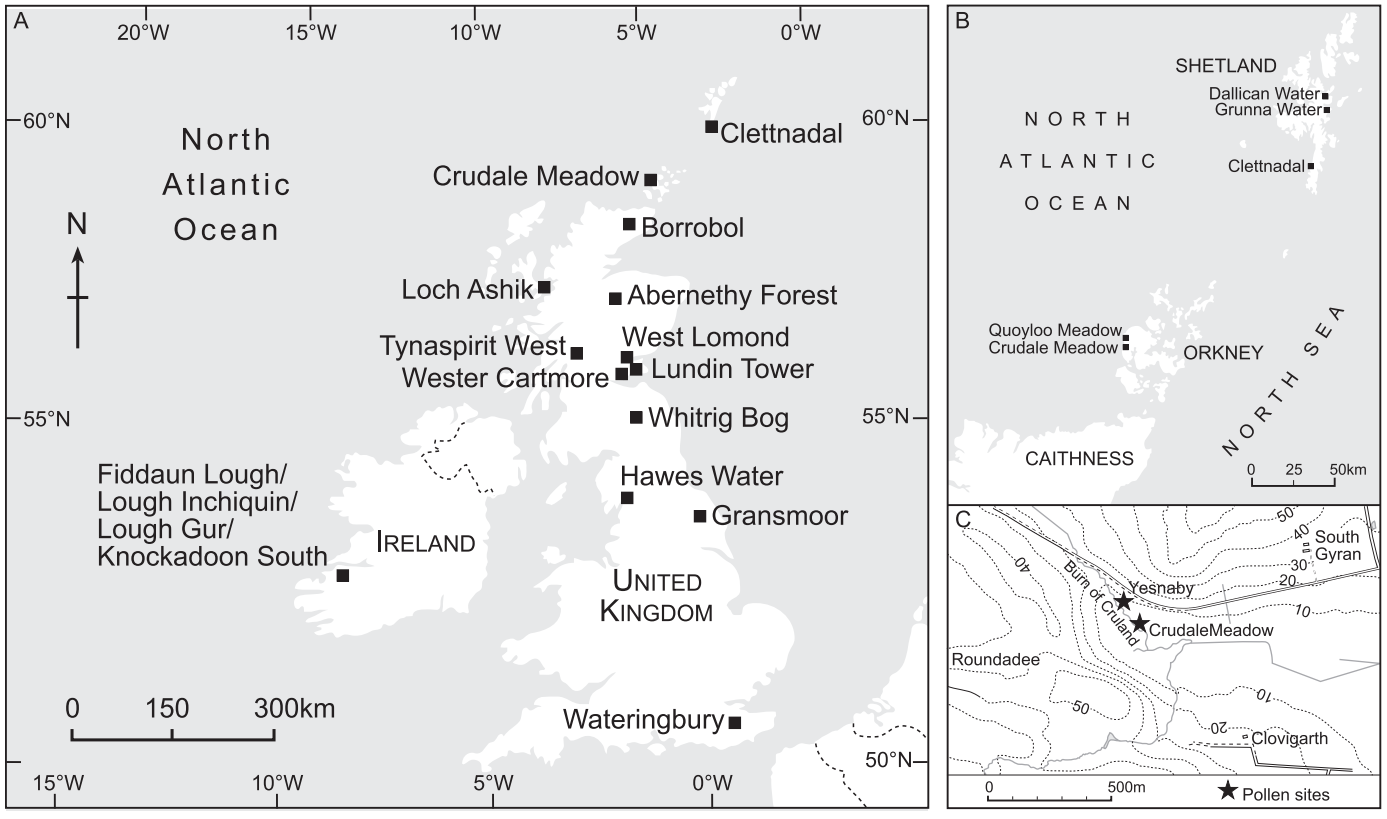

Fig. 1. A. Sites from Britain and Ireland mentioned in the text; B. The location of Orkney and Shetland in the North Atlantic Ocean and sites mentioned in the text; C. The position of Crudale Meadow on the island of Mainland.