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A 7000-year record of environmental change, including early farming impact, based on lake-sediment geochemistry and pollen data from County Sligo, western Ireland

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ABSTRACT

Detailed, chronologically tightly constrained, lake-sediment-based geochemical and pollen records have enabled local changes in soil erosion, woodland cover and composition, and prehistoric farming impact to be reconstructed in considerable detail. The profile opens shortly after 7800 BC when tall canopy trees were well-established and presumably in equilibrium with their environment. A distinct perturbation that involved an increase in pine and birch, a decrease in oak and a minor opening-up of the woodland is regarded as the local expression of the 8.2 ka climate anomaly. Lack of response in the geochemical erosional indicators is interpreted as evidence for drier conditions. A short-lived, over-compensation in climate recovery followed the 8.2 ka event. Neolithic farming impact is clearly expressed in both the pollen and geochemical data. Both datasets indicate that Neolithic impact was concentrated in the early Neolithic (3715–3440 BC). In the interval 3000–2700 BC there appears to have been a break in farming activity. The pollen data suggest substantially increased farming impact (both arable and pastoral) in the Bronze Age, with maximum farming and woodland clearances taking place in the late Bronze Age (1155–935 BC). These developments are poorly expressed in the geochemical record, possibly due to within-lake changes.

Introduction

Multi-proxy records from lake sediments are one of the main sources of evidence for long-term environmental change. While Holocene lake sediments have been widely used in Ireland for pollen investigations, a multi-proxy approach that involves investigations of the elemental chemistry of lake sediments is less common (cf. Hirons and Thompson, 1986; O'Connell, 1990; Schettler et al., 2006; Murnaghan et al., 2012; Stolze et al., 2012). In this paper we present the results of detailed pollen and geochemical analyses of lake sediments from Cooney Lough, a small lake in north Co. Sligo, western Ireland. The investigations form part of a larger research programme with focus on the Holocene and especially early farming impact and environmental change in Co. Sligo (Stolze et al., 2012; Ghilardi and O'Connell, 2013a, 2013b, 2013c; Stolze et al., 2013a, 2013b).

Cooney Lough was selected on account of its proximity to Cúil Irra, which is one of the most important regions in Ireland as regards to the Neolithic. It has the highest concentration of passage tombs (Ó Nualláin, 1989; Bergh, 1995, 2002; Egan et al., 2005). In all there are about 80 passage tombs, some 60 of which are in a cluster commonly known as the Carrowmore passage-tomb cemetery. The dominant geographical feature is Knocknarea, a large, flat-topped hill that rises in the western part of the peninsula to 327 m asl (Figs. 1B, S1). This hill has seven passage tombs, an exceptionally large cairn on its summit (*Miosgán Meadhbha*; Maeve's Tomb) that probably contains a passage tomb and there are also several other features that relate to the Neolithic (Bergh, 2002). The north-east extension of the Ox Mountains into Co. Sligo forms the southern and much of the eastern boundary of the Cúil Irra region and Cooney L. lies within the region so defined. Six cairns, ascribable to the passage tomb tradition, are recorded from these uplands (Bergh, 1995). The nearer cairns are those on the peaks Croaghaun and Doomore, 1.6 km and 4 km west of Cooney L., respectively (Fig. 1C; Doomore is ca. 3 km west of the area shown).

The passage tombs of this part of Sligo have been the subject of archaeological survey and excavation including major excavations led by Burenhult (Burenhult, 1984, 2009) and other detailed studies in more recent times (Bergh, 1995; Hensey and Bergh, 2013). There has been considerable debate regarding the chronology of the tombs (Caulfield, 1983; Cooney et al., 2011). The most recent evidence, based on AMS ^{14}C dates from antler and bone pins recovered from two tombs at Carrowmore, suggests that the start of use was in the interval ca. 3775–3520 BC and that by ca. 3000 BC, or possibly earlier, the tombs were no longer in use by Neolithic peoples (Hensey and Bergh, 2013) (BC indicates calibrated ages).

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As regards to early Neolithic activity, the recently discovered and partially excavated large enclosure at Magheraboy (Fig. 1B) has yielded ^{14}C dates indicative of Neolithic activity that may have started particularly early in the Neolithic and possibly before 4000 BC (Danaher, 2007). Some of the ^{14}C dates, however, on which this is based are so early that their validity as in indication of date of construction has been questioned (Cooney et al., 2011). Nevertheless, there is a consensus that the enclosure was particularly early in the context of the Neolithic not only in Ireland but also in Great Britain (Whittle et al., 2011).

While general proximity to the archaeology described above was one of the chief reasons for selection of Cooney L. for detailed paleoecological investigations, the lake itself had much to recommend it. It lies in a distinct depression that is sheltered from the prevailing westerlies (Figs. 1C, E, S1 and S2). This, and the lack of inflowing and outflowing streams and the overall bathymetry (see site description), suggest that the lake contains a continuous Holocene sediment sequence and there is no reason to suspect, either from a priori considerations or indeed the results obtained, that sediment focusing or slumping complicates the record.

Pollen analysis was the main method employed as it facilitated detailed reconstruction of vegetation and land-use that, in turn, can give important insights into pedogenesis, climate change and human impact. Reconstruction of climate change in the early Holocene, and especially the 8.2 ka anomaly, based on pollen data and the reconstructed vegetation dynamics at Cooney L. is described by Ghilardi and O'Connell (2013a). This, and the later part of the pollen record (the record extends to ca. 790 BC, i.e. the end of the Bronze Age), are here evaluated in the light of geochemical (elemental) data from the same sediment core. Mackereth (1966), in his pioneering investigations of lake sediments from the Lake District, north-west England, showed that sediment geochemistry reflects mainly changes in the lake catchment and especially erosion events. The geochemical record, however, may also be considerably influenced by within-lake processes, including development of meromictic conditions, changes in lake levels, and shifts in pH and redox potential at the top of the sediment

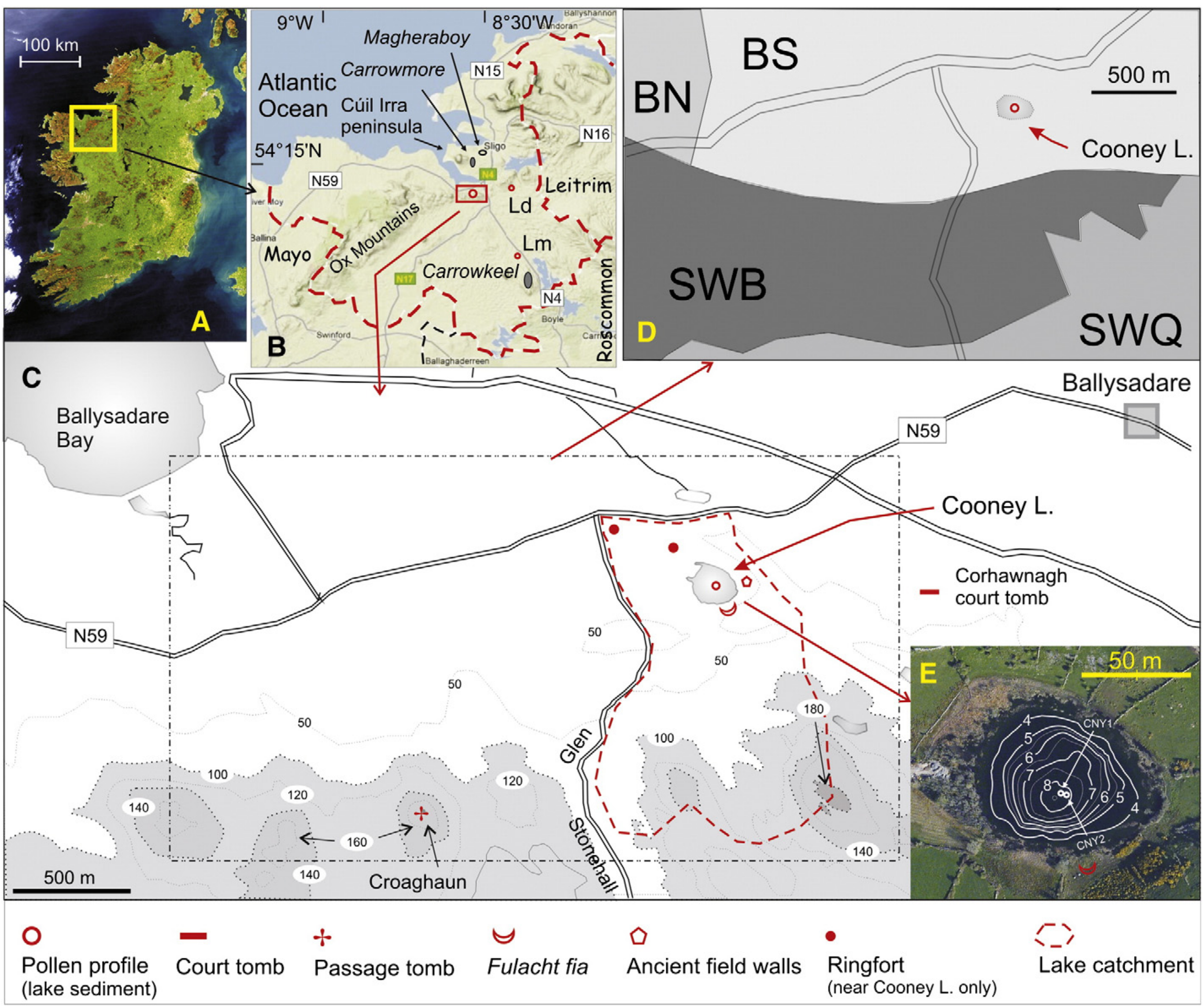

Figure 1. Maps showing the geographical location of Cooney Lough and other details relating to the study area. A. Map of Ireland showing Co. Sligo and adjacent counties; details shown in B include location of study area (enclosed by square) and selected sites of archaeological and palaeoecological interest (details in text; Carrowkeel indicates the Carrowkeel/Keshcorran area). C. Map of study area including main roads, megalithic tombs and main archaeological features beside Cooney Lough. Contours are indicated in m above sea level (asl) and the catchment of Cooney L. (approximate) is also shown. D. Bedrock geology of the area enclosed by the rectangle in C. BN, Bundoran Shale Formation and BS, Ballyshannon Limestone Formation (both Carboniferous). SWB, Slishwood Division (semi-pelitic biotite schists) and SWQ (psammitic paragneiss; both north-east Ox Mountain inlier; Dalradian or older). Geology is after MacDermot et al. (1996). E. Aerial view of Cooney L. (Bing Maps; downloaded 1/02/2013) with bathymetry (m) and coring locations CNY1 and CNY2.