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Did prehistoric and Roman mining and metallurgy have a significant impact on vegetation?

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ABSTRACT

To develop our understanding of the relationship between vegetation change and past mining and metallurgy new approaches and further studies are required to ascertain the significance of the environmental impacts of the metallurgical industry. Using new pollen and geochemical data from Cors Fochno (Borth Bog), Wales, we examine whether prehistoric and Roman mining and metallurgy had a significant impact on the development of vegetation and compare the findings with previous studies across Europe on contamination and vegetation change to develop a conceptual model. The evidence suggests that early mining and metallurgy had a minimal impact on vegetation, especially woodlands, with small-scale, non-permanent phases of woodland clearance. The impact was more severe during Roman times, normally characterised by woodland clearance followed by regeneration. Records do suggest that woodlands underwent compositional changes in tandem with increased atmospheric pollution, possibly in part as a result of demands for wood fuel for mining and metallurgy, but otherwise woodlands show a degree of resilience. The results from Cors Fochno suggest that vegetation changes that occurred during periods of mining and metallurgy, as inferred from changepoint analysis, were insignificant compared to later periods, including Roman times.

1. Introduction

The advent of mining and metallurgy in the Chalcolithic-Early Bronze Age represents one of the most significant social, technological and (potentially) environmental transformations in human history. Over the last two decades there has been an upsurge in interest in the environmental impacts of this transformation, primarily focusing on two areas: metal contamination and vegetation change. A number of studies have reconstructed the pollution history of past mining and metallurgy in Europe, particularly of metals considered to be immobile in ombrotrophic peat such as lead (Pb) and copper (Cu) (e.g. Monna et al., 2004; Kylander et al., 2005; Küttner et al., 2014), the Near East (e.g. Pyatt et al., 2000) and North America (e.g. Pompeani et al., 2013) to establish the timing, severity and longevity of metal contamination which now extends back to the Early Bronze Age in Europe (e.g. Mighall et al., 2002a; García-Alix et al., 2013; Pontevedra-Pombal et al., 2013; Martínez Cortizas et al., 2016).

Until recently the impact of mining and metallurgy on vegetation was poorly understood but investigations in regions with a long history of ferrous and non-ferrous mining and metallurgy are beginning to rectify this situation (e.g. Küster and Rehfuess, 1997; Breitenlechner et al., 2010; López-Merino et al., 2014; Mighall et al., 2010, 2012; Viehweider et al., 2015). These studies include those that are specific to a mine or furnace (e.g. Mighall and Chambers, 1993; 2002a, 2002b; Mighall et al., 2000; Myrstener et al., 2016) and those that are more regional in scope (e.g. Mighall et al., 2009; Silva-Sánchez, 2015). As mining and metallurgy does not occur in isolation and other activities, such as agriculture, occurred during periods of industrial activities, numerous studies have benefited by combining records of metals associated with pollution in tandem with pollen records to discriminate between industrial activity and other land use changes, but have also debated the impact mining and/or metallurgy had on vegetation, particularly woodlands: whether they were largely destroyed by mining and metallurgy or not. A series of studies now suggest that in prehistoric times mining/metallurgy did not have an adverse impact on woodlands (e.g. Marshall et al., 1999; Mighall et al., 2004; Jouffroy-Bapicot et al., 2007; Breitenlechner et al., 2010, 2014; Bindler et al., 2011; Viehweider et al., 2015) with Mighall and Chambers (1997) suggesting that any

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impact was influenced by some form of management, selectivity, the scale and duration of ironworking as well as other land use strategies. A further methodological advance is the use of changepoint analysis on such data which now allows us to assess the significance of environmental changes more objectively (Gallagher et al., 2011) and has been applied successfully to datasets derived from bogs (e.g. Kylander et al., 2013; Hansson et al., 2013; Martínez Cortizas et al., 2016).

In order to establish the impact of mining and/or metallurgy on woodlands more studies are needed. Therefore we present new pollen and geochemical data from Cors Fochno (Borth Bog) to exemplify whether such activities had a significant impact on the vegetation history at the site and compare the findings with previous studies across Europe to identify patterns in the data that could lead to a conceptual model of such impacts. This will be accomplished by discriminating between environmental changes caused by mining and metallurgy from other types of land use by performing principal component analysis on the geochemical data, and to identify significant vegetation changes were caused by mining and/or metallurgy using changepoint analysis.

2. Site details and context

Over 250 archaeological sites are recorded on the Dyfed Historic Environment Record in and around Cors Fochno, ranging in date from Mesolithic find spots to twentieth century military installations (Page et al., 2012). One of the most important archaeological discoveries is the evidence for early mining of metal-bearing deposits including chalcopyrite (copper iron sulphide), galena (lead sulphide) and sphalerite (zinc sulphide) (Timberlake, 1995a, 1995b, 1996, 2003a). Eight Early Bronze Age mines have been identified in mid- and north Wales, including an area of prehistoric prospection and mining around Cors Fochno (Fig. 1a–c). Bronze Age copper mining is suspected at Llancynfelin, Pwll Roman and Erglodd along the western fringe of the bog (Timberlake, 2006) but some may have been prospecting rather than actual mining (Timberlake, 2009) (Fig. 1c). Roman lead smelting also occurred at Llancynfelin, close to the Erglodd Roman fort during the first century CE (Page et al., 2012; Fig. 1b). The Blaen yr Esgair Roman road has been radiocarbon-dated to c. 80 CE. Mighall et al. (2009) presented a record of metal contamination that suggests lead mining and/or metallurgy surrounding the bog occurring in the Bronze Age, late Iron Age and Roman times.

Cors Fochno (Borth Bog) is an estuarine lowland raised bog located in northern Ceredigion, north of Aberystwyth that forms part of the Dyfed SSSI and National Nature Reserve and a UNESCO Biosphere Reserve. The bog is approximately 200 ha in extent and surrounded by a further 400 ha of degraded bog that has suffered from past peat cutting and drainage (Poucher, 2009). A full description of the bog is provided in Hughes and Schulz (2001). Cors Fochno is underlain by Silurian Aberystwyth grits group with outcrops of Ashgill beds (mudstones and siltstones to the east) (Howells, 2007).

Pollen diagrams have been published from Cors Fochno (Borth Bog) by Godwin and Newton (1938), Godwin (1943) and Moore (1968). All three studies are constrained by the absence of radiometric dating and Godwin only published tree pollen data. More recently, Page et al. (2012) published pollen data for the site but this record focusses solely on the Late Iron Age – Roman period. Other studies have focussed upon mire development (Hughes and Schulz, 2001; Hughes et al., 2007).

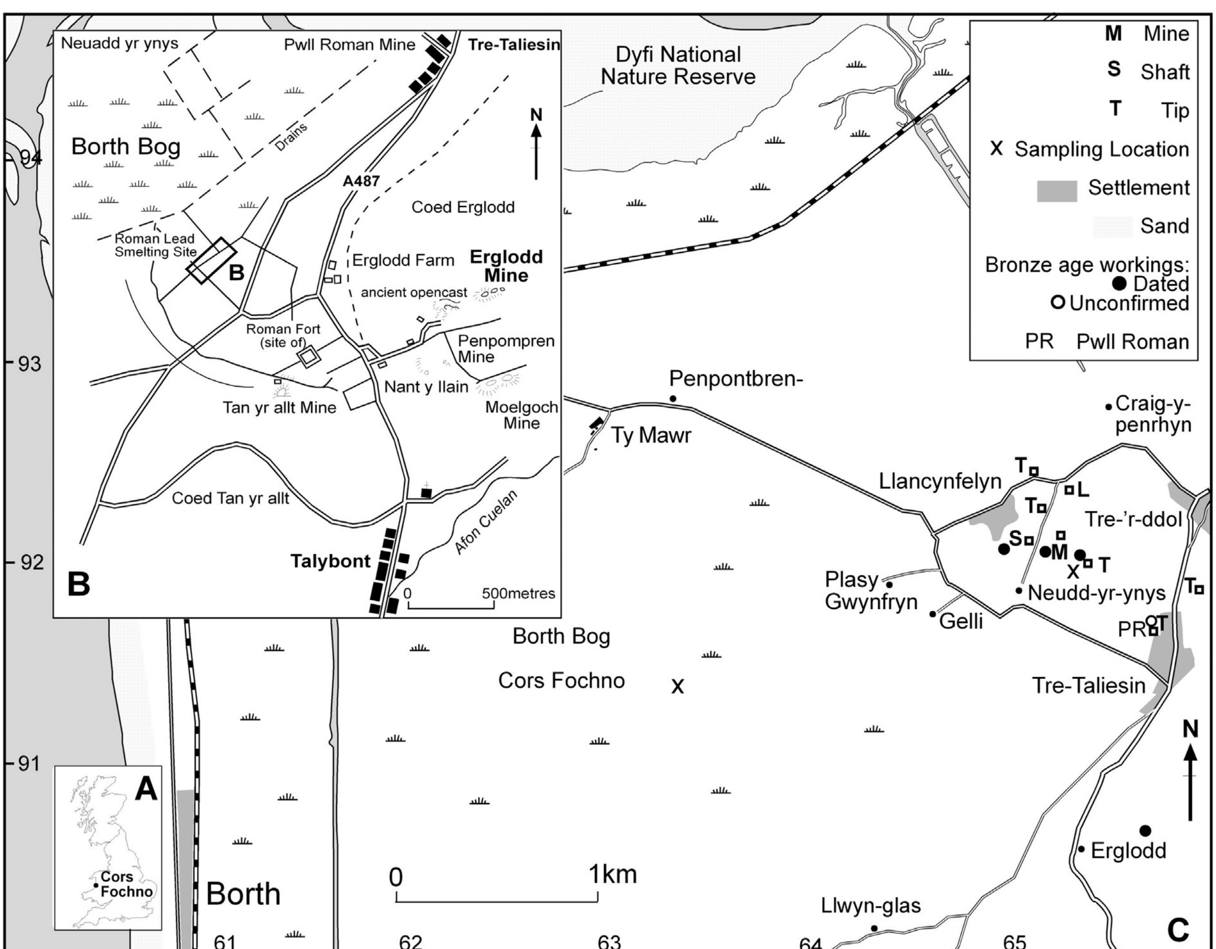

Fig. 1. Location of the study area of Cors Fochno (Borth Bog), North West Wales, showing A. Location in the UK; B. detailed map of the Erglodd mine and Roman lead smelting site; C. the location of the sampling site and mining archaeology.