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Bronze Age upland settlement decline in southwest England: testing the climate change hypothesis

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Abstract

The division of land on Dartmoor during the Bronze Age by the construction of moor-wide boundaries known as reaves represents a significant development in agricultural practice and land tenure. Previous research relating to the Dartmoor reaves suggests this way of life may have continued for no longer than 200–400 years. It has been suggested that their abandonment occurred as the result of a deteriorating climate, although there are no published palaeoclimatic reconstructions from the area. We therefore test the hypothesis that on Dartmoor, a marked climatic deterioration occurred in the late Bronze Age that can be linked to the abandonment of the reaves. A palaeoclimatic reconstruction derived from testate amoebae and peat humification analyses is presented from Tor Royal Bog, central Dartmoor, the first such record from southwest England. A major shift to a cooler and/or wetter climate is inferred from ca. 1395 to 1155 cal BC that is coincident with the period hypothesised as encompassing the abandonment. This climatic deterioration is replicated in sites in northern Britain, suggesting it was a widespread event. It is concluded that while the evidence supports a climatically forced retreat, there are a range of other socio-economic factors that must also be taken into consideration.

Keywords: Dartmoor; Palaeoclimate; Bronze Age; Reaves; Environmental determinism; Testate amoebae; Peat humification

1. Introduction

Recent research has focused on the impact of past climatic changes to prehistoric and historic societies and has argued that palaeoclimatic deteriorations have disrupted prevailing socio-economic conditions with a range of consequences (e.g. Berglund, 2003; Caseldine et al., 2005; Edwards et al., 2007; Finsinger and Tinner, 2006; Magny, 2004; Tinner et al., 2003; Turney et al., 2006; van Geel et al., 1996), including changes in subsistence patterns (Taylor et al., 2000; van Geel et al., 2004) and catastrophic collapse of society (Haug et al., 2003). Conversely, it has also been argued that the evidence for such changes, in particular the abandonment of upland settlement, is questionable and that past societies would have adapted to changes in the prevailing climate (e.g. Dark, 2006; Tipping, 2002; Young, 2000; Young and Simmonds, 1995). Recent shifts in theory have begun to reappraise the importance of past climatic conditions to past societies (Coombes and Barber, 2005; Erickson, 1999).

The division of the landscape into fields occurs early in the agricultural history of northwest Europe and is believed to indicate fundamental changes in land tenure, the intensity of agricultural production and the nature of human–environment relations. Fragments of the earliest field systems survive in western Ireland, such as the Neolithic sites at Céide Fields (Caulfield, 1978; Caulfield et al., 1998) and Belderg Beg, Co. Mayo (unpublished excavations reported in (Waddell, 1998). However, these types of sites are rare and widespread subdivision of the landscape does not appear to have taken place until the Bronze Age, with the establishment of extensive field systems across both upland and lowland environments (Brück, 2000; Fleming, 1994; Yates, 1999). Some of the most extensive

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and best preserved Bronze Age landscapes in Europe are situated on Dartmoor, an extensive region of high moorland in southwest England. The Dartmoor reaves had been correctly identified as prehistoric land boundaries as early as the 1820s (Fleming, 1984), although they were not studied in detail until the late 1970s and 1980s through the work of Andrew Fleming (1978, 1979, 1983, 1984, 1988, 1994).

The accepted model of subdivision of the Dartmoor landscape is one of enclosure through the construction of coaxial field systems, dividing the upland into a series of discrete river catchment-based territories which were subsequently abandoned after a period of about 300–400 years (Fleming, 1988). The underlying assumptions concerning the social context of the reaves and the process of subdivision of the landscape during the middle Bronze Age are currently contested (Johnston, 2005) and a critique of the chronology of Fleming's model reveals the weaknesses behind his assumptions. The chronology of the reave period was originally dependent on just three radiocarbon dates (Table 1). Calibrating these and other dates from Balaam et al. (1982), provides a probable window for reave construction of 1700–1600 cal BC (Caseldine, 1999). However, there is no direct archaeological or palaeoecological evidence for the timing of the abandonment of the reaves (Caseldine, 1999). Furthermore, Caseldine and Hatton (1994) argue that examination of the chronological evidence shows that the majority of reave evidence relates to only 200 (radiocarbon) years and any wider temporal range requires further inference and extrapolation with weak dating control. The chronology for use of the field systems is based on dating of elements within the field systems (e.g. round houses) and ideas surrounding returns on the investment of labour required to subdivide the landscape (Fleming, 1984, 1988). By inferring a potential period of use of 200–400 years onto the construction date of 1700–1600 cal BC, the above evidence suggests abandonment between 1500 and 1200 cal BC, a date supported in part by evidence from settlement sites on Holne Moor (Maguire et al., 1983). However, the dating control on the Dartmoor reaves is limited, and a possible reservoir effect in radiocarbon determinations from 1150 to 950 cal BC (Blaauw et al., 2004; Kilian et al., 1995) may further undermine the chronology of reave abandonment. Given these chronological issues, and in light of the imprecision evident in the literature regarding the climatic deterioration associated with the abandonment of the reaves (see below), precise correlation of the "synchroneity, interactions and time-lags" (Berglund, 2003) of events during the reave period is difficult to achieve.

Despite the contested nature of the chronology of the Dartmoor reaves, there has been little critical examination of the causal mechanisms for abandonment of the upland landscape. It is generally accepted that the reaves were abandoned in the late Bronze Age as the result of a deteriorating climate (Caseldine, 1999; Caseldine and Hatton, 1996; Fleming, 1988), however, this is based on broad assumptions of a climatic deterioration across Great Britain (e.g. Burgess, 1985; Simmons, 1969; Taylor, 1975). More recent palaeoclimatic studies in Great Britain have been limited to northern England and Scotland (e.g. Anderson, 1998; Barber et al., 1994; Barber et al., 1998; Barber et al., 2003; Chambers et al., 1997; Charman et al., 2006; Chiverrell, 2001; Hendon et al., 2001; Langdon et al., 2003; Langdon and Barber, 2005) and whilst these identify climatic deteriorations that may coincide with the abandonment of the reaves, their magnitude on Dartmoor is not yet understood. Fleming (1988) suggests that environmental change, in particular blanket peat formation and deterioration to a wetter climate, is the most likely factor that led to the abandonment of the reaves. Although there is little hard evidence for or against such a model (Caseldine and Hatton, 1996), climate did undoubtedly deteriorate at the onset of the sub-Atlantic period (ca. 850 BC (Godwin, 1975), i.e. the Bronze Age/Iron Age transition), although the date, nature and impact of these changes are unclear (e.g. Burgess, 1985; Lamb, 1981).

Whatever the precise time-frame of the climatic deterioration, it is likely that agrarian conditions would have been affected. Burgess (1985) states that a 2°C drop in mean annual temperatures in upland areas such as Dartmoor would have resulted in a reduction in the growing season of more than five weeks, and increased effective precipitation would have detrimentally affected soils, ground conditions and drainage, leading to over-grazing and poor crop returns (Balaam et al., 1982). Given that the onset of peat formation occurred at different times in different locations across Dartmoor, it is probable that patterns of abandonment may have been equally patchy (Burgess, 1985; Caseldine and Hatton, 1996; Staines, 1979), particularly in light of recent rethinking on the form of social control on field system development (Johnston, 2005). This is in part supported by palynological evidence for regeneration of moorland vegetation with continuation of pastoral activities in some locations (Smith et al., 1981), although the role of later transhumance in the maintenance of improved grassland is difficult to establish.

Regionally relevant palaeoclimate data are central to the debate concerning societal response to climatic change. This paper represents the first semi-quantitative palaeoclimatic reconstruction from southwest England and aims to test the hypothesis that on Dartmoor, a marked climatic deterioration occurred in the late Bronze Age which may or may not have

Table 1
^{14}C dates used to infer the dating of the Dartmoor reaves

Laboratory code	^{14}C date BC	Calibrated calendar age range (2σ)	Weighted average of 2σ calibrated calendar age range	References
BM-1609	1320 ± 50	1666–1436 BC	1551 BC	Burleigh et al., 1981; Fleming, 1983
HAR-4003	1390 ± 90	1878–1437 BC	1611 BC	Smith et al., 1981; Fleming, 1983
HAR-4005	1230 ± 80	1683–1218 BC	1471 BC	Smith et al., 1981; Fleming, 1983

been a causal mechanism associated with the abandonment of the reave systems. The ‘abandonment of the reaves’ is defined as the process whereby the extensive, moor-wide agricultural field systems and associated settlements were deserted by the populations inhabiting them.

2. Study site

Tor Royal Bog (TRB) is an ombrotrophic raised mire 1.3 km south-east of Princetown, central Dartmoor (Fig. 1). Peat-depth probing has revealed deposits in excess of 6 m providing the opportunity to investigate ca. 7000 years of stratigraphy (West et al., 1996). Previous research at the site has focused on the regional vegetation history and geochemical indicators for metalworking (West, 1997; West et al., 1996). Previously published palynological evidence from TRB (Fig. 2; West, 1997; West et al., 1996) supports the archaeological evidence for widespread intensification of land use at the time of reave construction, with the first appearance of taxa indicating human disturbance such as Poaceae, *Plantago*, *Potentilla* type and *Pteridium* at ca. 2000 cal BC (ca. 375 cm), a feature identified on uplands elsewhere within the region (Fyfe et al., 2003). This landscape-scale intensification must have impacted on vegetation across the entire upland, as TRB is distant from the formal enclosure represented by the reaves (Fig. 1). What is less clear from the TRB palynology is any indication of vegetation change suggesting later abandonment of the upland field systems. This should perhaps not be surprising for two reasons. Firstly, the remoteness of the site from the actual field systems means that it is likely to be insensitive to vegetation change on the upland margins (Davies and Tipping, 2004; Edwards, 1979; Fyfe, 2006; Fyfe et al., 2004). Secondly, settlement abandonment as represented by the archaeological evidence does not necessarily equate to landscape abandonment; it is probable that transhumance practices maintained an open pastoral landscape, an assumption supported by pollen diagrams in closer proximity to reaves (Smith et al., 1981).

TRB covers 58 hectares (Woodland et al., 1998) and has an altitude of ca. 390 m. Site vegetation is typical of an ombrotrophic mire with ericaceous shrubs, deer sedge, cotton grasses and *Sphagnum* mosses present (West, 1997; West et al.,

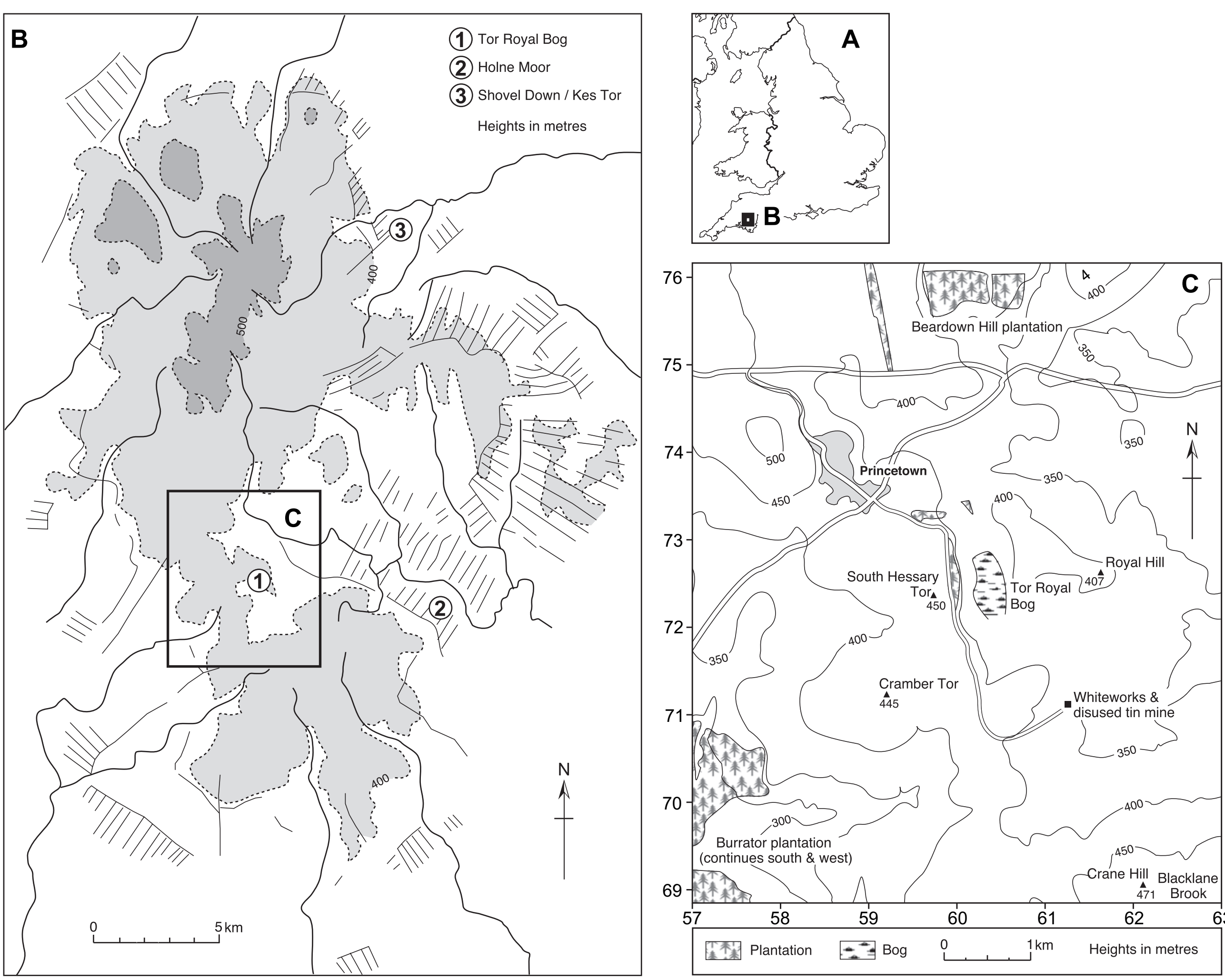

Fig. 1. Location of TRB. Map B redrawn from Fleming (1988) showing simplified pattern of reaves over Dartmoor as a whole and location of sites mentioned in text. Map C redrawn from West et al. (1996).

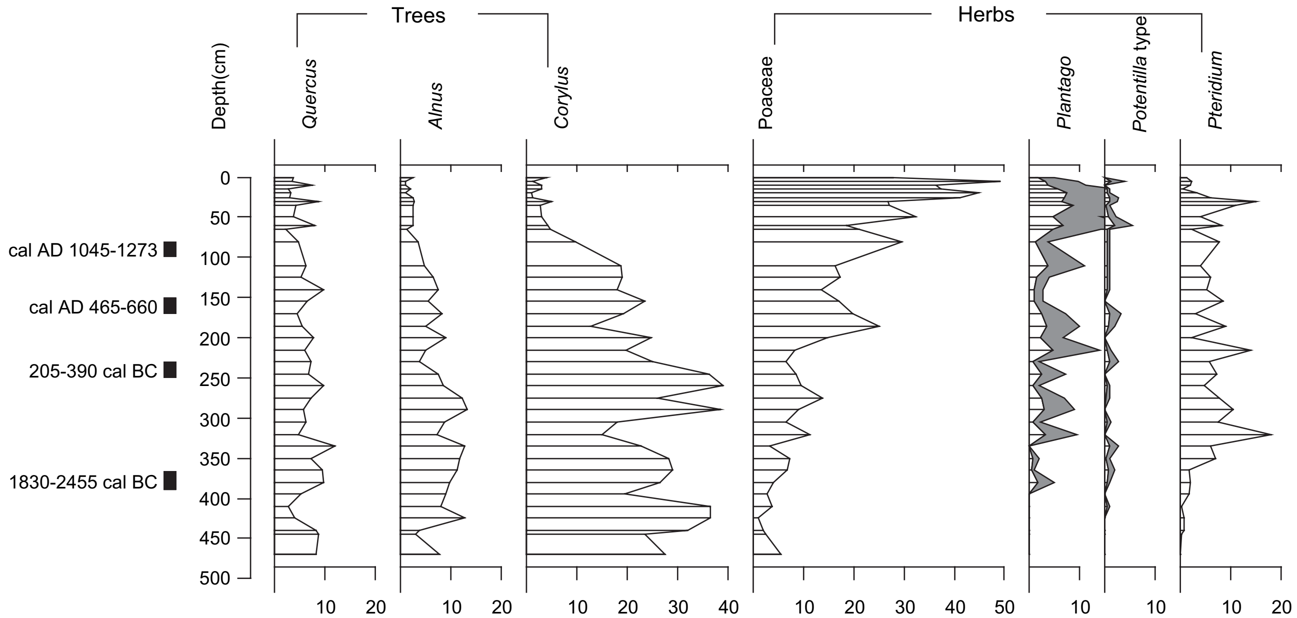

Fig. 2. Selected percentage pollen curves for main taxa recorded at TRB. 3× exaggeration factor shown for *Plantago* and *Potentilla* type. ^{14}C dates have been calibrated using the program CALIB (v. 5.0.2; Stuiver et al., 2005) and are expressed with 2σ error range. Redrawn from West (1997) and West et al. (1996).

1996). There is little evidence of significant human disturbance, although several shallow drainage channels run across the mire. It is therefore an ideal location from which to derive regionally relevant palaeoclimate data.

3. Methods

A peat core measuring 565 cm was extracted from the deepest part of the bog (50° 32.116′ N, 03° 58.267′ W) using a 50 × 5 cm diameter Russian-type corer (Barber, 1984). This location is within 20 m of the core site of West (1997) and West et al. (1996). The core was refrigerated at 4°C prior to sub-sampling. Analysis for testate amoebae and peat humification was undertaken every 16 cm from 0 to 464 cm and every 4 cm from 208 to 320 cm. The zone for high-resolution sampling was selected to encompass the late Bronze Age time period of interest based on dates inferred from West (1997) and West et al. (1996).

Preparation for testate amoebae analysis followed a slightly modified version of the technique advocated by Hendon and Charman (1997) and Charman et al. (2000). Identification and nomenclature followed Charman et al. (2000). Where possible, levels were counted to a total of 150 testate amoebae, however, concentrations of tests meant this was impractical for certain levels; these were counted to a minimum of 50 individuals (see below). Woodland et al. (1998) suggest that this count may not record all species present in the sample. However, while average species diversity was higher in those samples where 100 or more individuals were counted, this pattern was not consistent; several samples with counts of 50 individuals had higher species diversity than those with counts of 150 individuals. The testate amoebae diagram was constructed using TILIA (Grimm, 1991) and TGView (Grimm, 2004). Reconstructed annual average water-table depths were calculated using the UK transfer function of Woodland et al. (1998) and compared to the European transfer function of Charman et al. (2007). Detrended Correspondence Analysis (DCA) was applied to the testate amoebae data using CANOCO (ter Braak, 1987). Data were square-root transformed and rare species were down-weighted (ter Braak and Šmilauer, 1998).

Laboratory preparation for peat humification analysis followed a slightly modified version of the technique advocated by Blackford and Chambers (1993). Percentage light transmission was measured on a UNICAM 5625 UV/VIS spectrometer set at 540 nm and zeroed to 100% with distilled water.

4. Results

4.1. Chronology

An age-depth model has been constructed using eight bulk AMS radiocarbon determinations which focus on the period of high-resolution analysis (Table 2, Fig. 3). A further date of AD 2000 has been included for the bog surface given that West et al. (1996) identify only marginal evidence of peat cutting and physical disturbance. The time-series has been produced using a third-order polynomial trendline as this produced the best fit to the data. All dates have been calibrated to 95% confidence (2σ) using the program CALIB (v. 5.0.2; Stuiver et al., 2005), are expressed to the nearest five years and preceded by the error term ca. to represent the uncertainty inherent in the age-depth model.

4.2. Testate amoebae

The testate amoebae assemblage (Fig. 4) is dominated by *Assulina muscorum* and, to a lesser extent, *Amphitrema flavum*.

Table 2
Radiocarbon dates from TRB

Laboratory code	Depth (cm)	^{14}C date BP	Calibrated age range BP (2σ)	Calibrated calendar age range (2σ)	Weighted average of the 2σ calibrated calendar age range	Reference
OxA-15733	398–399	4105 ± 31	4814–4455	2864–2505 BC	2666 BC	This paper
OxA-15734	318–319	3179 ± 31	3458–3357	1508–1407 BC	1458 BC	This paper
OxA-15735	302–303	2941 ± 29	3212–2999	1262–1049 BC	1156 BC	This paper
OxA-15736	286–287	2792 ± 29	2962–2796	1012–846 BC	952 BC	This paper
OxA-15737	270–271	2485 ± 29	2722–2368	772–418 BC	640 BC	This paper
OxA-15738	270–271	2661 ± 29	2845–2744	895–794 BC	822 BC	This paper
OxA-15739	254–255	2438 ± 29	2701–2356	751–406 BC	500 BC	This paper
OxA-15740	238–239	2182 ± 29	2312–2120	362–170 BC	266 BC	This paper
OxA-15741	158–159	1264 ± 29	1283–1091	AD 667–859	AD 725	This paper
SRR-5715	80–100	840 ± 45	904–677	AD 1046–1273	AD 1211	West, 1997
SRR-5716	150–170	1460 ± 45	1485–1289	AD 465–661	AD 597	West, 1997
SRR-5717	230–250	2240 ± 45	2342–2153	392–203 BC	298 BC	West, 1997
Beta-93822	366–380	3700 ± 90	4303–3778	2353–1828 BC	2114 BC	West, 1997

Cyclopyxis arcelloides type, *Difflugia pristis* type and *Difflugia pulex* are also present throughout the profile. *Heleopera petricola* and *Trigonopyxis arcula* type become significant above ca. 176 cm (ca. cal AD 525). With the exception of *Nebela militaris*, species of the genera *Arcella* and *Nebela* generally occur only in very low numbers. Fluctuations between the major taxa have most influence on the reconstructed water-table (Fig. 5). Standard bootstrapped errors have been calculated for the profile with a mean of 4.05 cm (1σ) and standard deviation of 0.05 cm. The results indicate that TRB has experienced water-table depths fluctuating between 3.2 cm at ca. 3445 cal BC (448 cm) and 11.5 cm at ca. cal AD 890 (144 cm; Fig. 4). The relatively low values throughout the profile are likely to be the result of the dominance of *A. muscorum*; Charman et al. (2000) state that this species is found in greatest abundance in relatively dry conditions.

Near the base of the core, significant changes in *A. flavum* from 464 to 320 cm (ca. 3695–1455 cal BC) indicate major wet/dry shifts in water-table depth. In the high-resolution zone covering the key period of interest (320–208 cm; ca. 1455 cal BC–cal AD 130), changes are less pronounced. The early part of the record indicates a major shift to a sustained wet phase (316–300 cm; ca. 1395–1155 cal BC), inferred from a decrease in *A. muscorum* and an increase in *A. flavum* and *Amphitrema wrightianum*. These taxa are regarded as being robust hydrological indicators of relatively dry (*A. muscorum*), moist (*A. flavum*) and wet (*A. wrightianum*) mire surfaces (Charman et al., 2000). Changes in the same species drive the more rapidly fluctuating reconstructed water-table from 292 to 236 cm (ca. 1035–240 cal BC). The uppermost part of the high-resolution zone (236–224 cm; ca. 240–80 cal BC) suggests a short-lived wet phase. Above the zone of high-resolution, the extreme xerophile *T. arcula* type, with minor changes in the hydrophilous *A. wrightianum*, drive even more pronounced changes from 208 to 0 cm (ca. cal AD 130–2000).

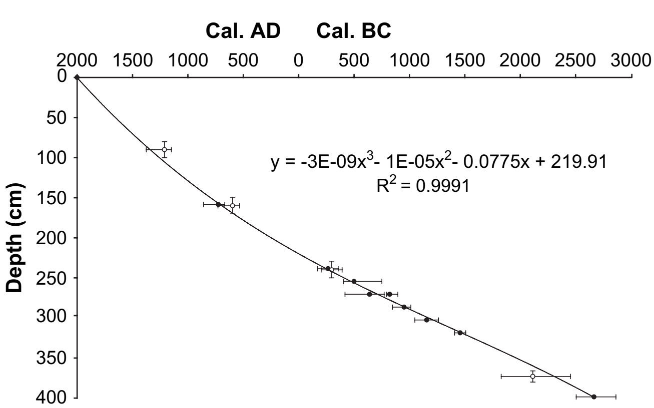

Fig. 3. Age-depth model for TRB. Closed circles represent new radiocarbon determinations. Dates of West (1997) are shown as open circles for comparison. All dates are plotted with 2σ confidence intervals. Point estimates are based on a weighted average of the probability distribution of each calibrated date (*sensu* Telford et al., 2004).

The testate amoebae data were subjected to DCA and axis one scores were plotted to examine the primary driver of changes in species composition (Fig. 4). DCA is used to identify the principal axes of variability within a dataset; each axis represents a theoretical environmental variable that may be controlling species composition (ter Braak and Šmilauer, 1998). DCA axis 1 scores correlate closely with reconstructed water-table depth, indicating that the testate amoebae assemblages have been primarily responding to this environmental variable and adding confidence in the reconstructed water-table depth profile. These results have been further tested by comparing the transfer function of Woodland et al. (1998) with that of (Charman et al. (2007); Fig. 6). The transfer function of Woodland et al. (1998) was used here as it is UK based and, moreover, includes data from TRB. However, due to a lack of modern ecological data, it does not include *D. pulex*; a species prevalent in the fossil assemblage (Fig. 4). The transfer function of Charman et al. (2007) does include *D. pulex* and therefore provides an opportunity to test whether the absence of this species in Woodland et al. (1998) may lead to differences in the palaeoclimatic reconstruction. Fig. 6 shows that while there is variation in the magnitude of change between the two profiles, these are not caused specifically by the

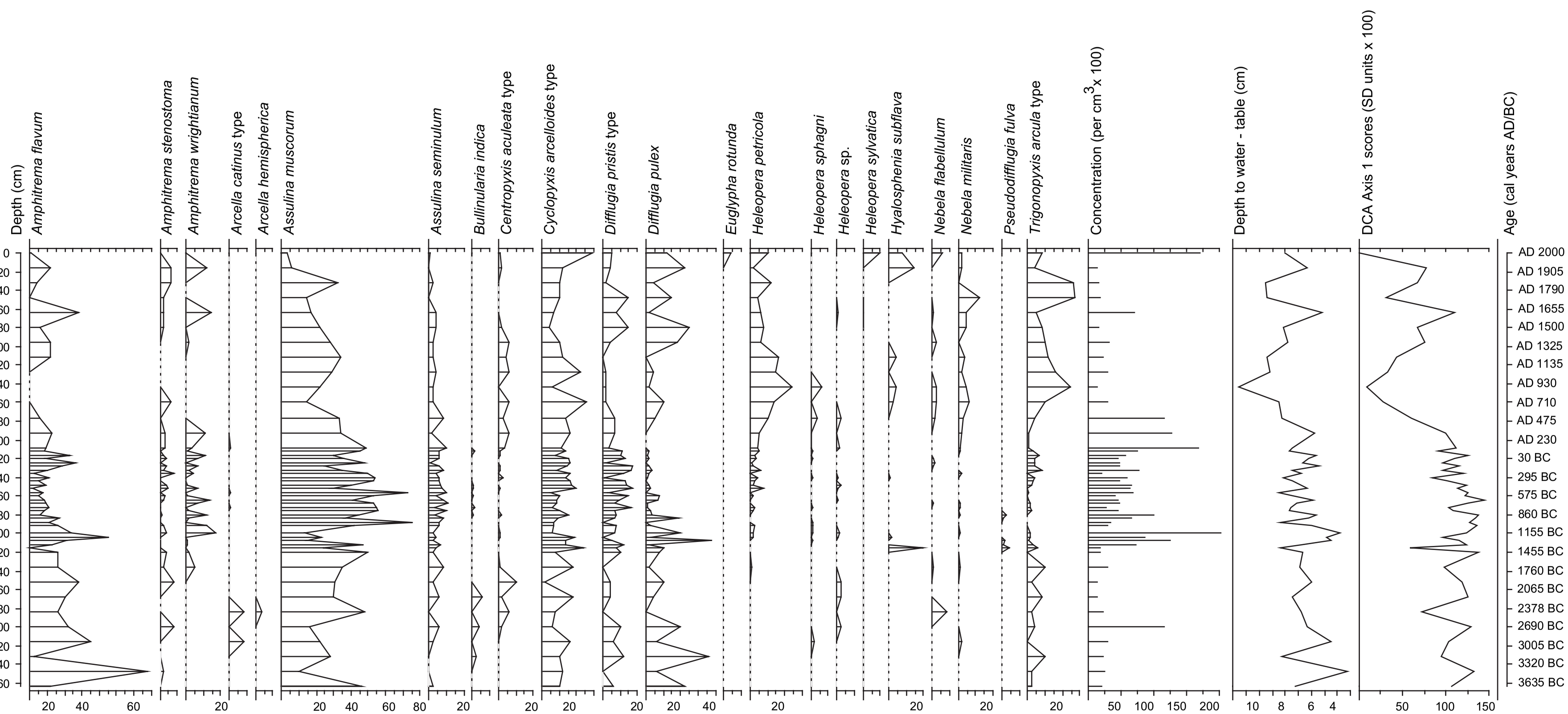

Fig. 4. Summary testate amoebae diagram from TRB showing only species that occur in >2% of any one sample. Concentration values, testate amoebae water-table reconstruction and DCA axis one scores are also illustrated. Interpolated ages based on Fig. 3 are shown and rounded to the nearest five years.

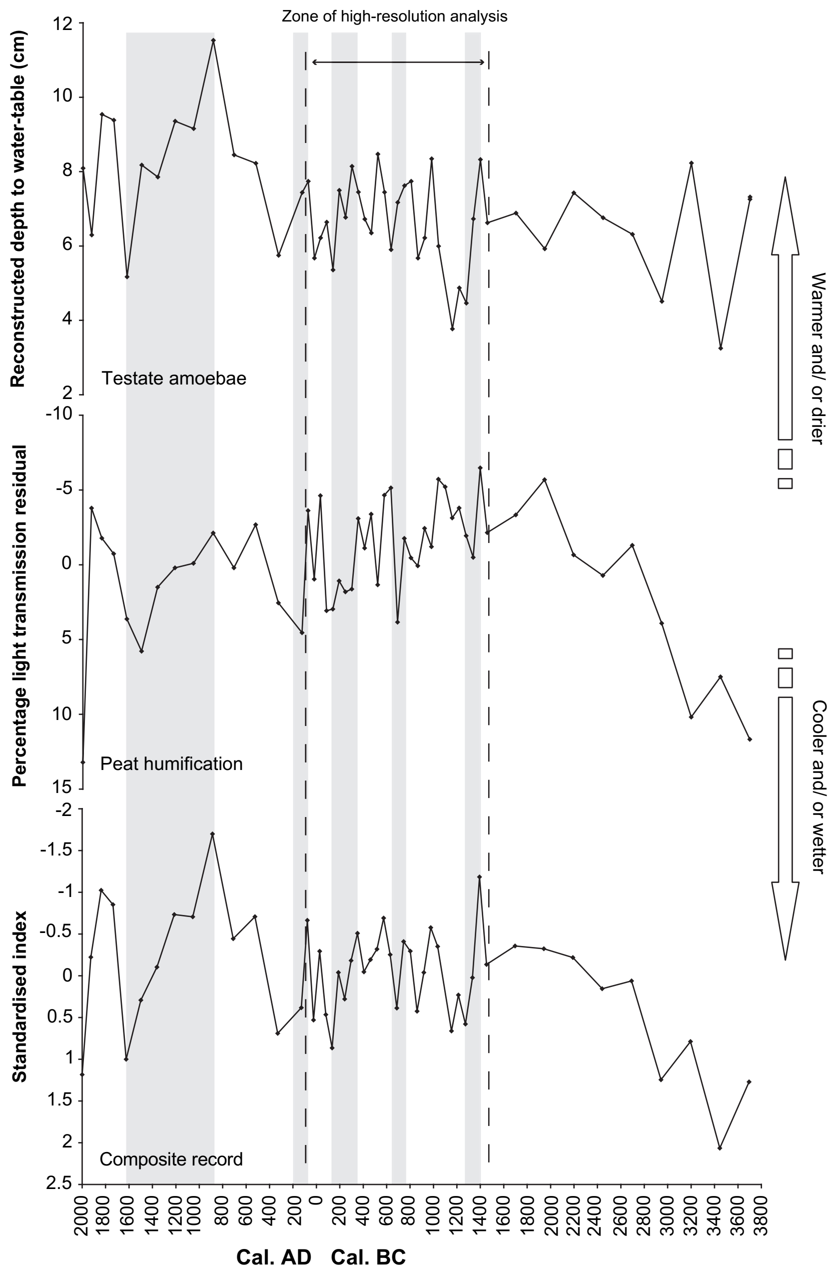

Fig. 5. Comparison of palaeoclimatic indices from TRB (upper graph – testate amoebae water-table reconstruction, middle graph – peat humification) and composite record of palaeoclimatic change (lower graph). Shaded areas illustrate wet shifts that are replicated in both proxy records.

proportion of *D. pulex* present in the assemblage and, more importantly, there are no notable differences in the timing of wet shifts, further increasing confidence in the chosen reconstructed water-table depth profile (Fig. 5).

It is unclear what may be causing the fluctuating testate amoebae concentration throughout the profile (Fig. 4). Barber and Charman (2003) state that in well-humified peat, concentrations of testate amoebae become too low to count with ease and in some cases may even be absent (e.g. Langdon and Barber, 2001). This may be relevant to those samples from 464 to 316 cm, which show a general trend towards higher humification downcore; only one of these was counted to 100 individuals. There are no apparent links between lower concentration values and the test characteristics of abundant species suggesting that differential species preservation is not an issue, although Charman (1999) states that this may occur in certain peats. Equally there is no relationship between concentration values and palaeoclimate; the latter fluctuates throughout the core whereas concentration values are generally lower at the top and bottom of the profile. In light of low counts from 16 to 48 cm (ca. cal AD 1735–1925), 80 to 160 cm (ca. cal AD 710–1500), 236 cm (ca. 240 cal BC), 316 to 320 cm (ca. 1395–1455 cal BC) and 352 to 464 cm (ca. 1940–3695 cal BC), these results should be viewed with additional caution. All critical horizons in terms of the abandonment of the Dartmoor reaves were counted to 100 or more testate amoebae.

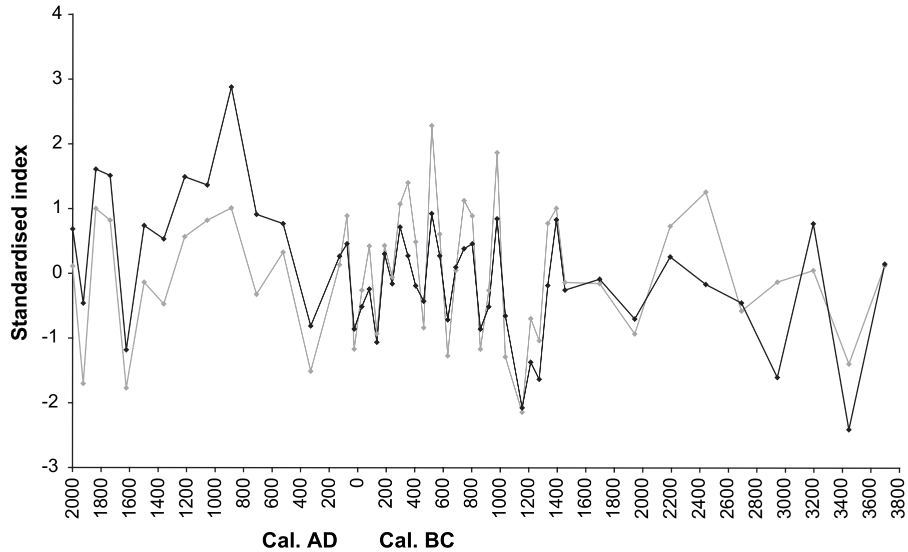

Fig. 6. Comparison of standardised reconstructed water-table depth profiles derived from the transfer functions of (Woodland et al., 1998; black line) and (Charman et al. (2007); grey line).

4.3. Peat humification

The humification data (Fig. 5) are plotted as detrended percentage light transmission residual values derived from a linear regression of the raw data and show a wide range of values from poorly humified peat at the top of the profile to very well-humified peat towards the base of the profile. There are high residual values at the base of the diagram suggesting a relatively wet bog surface at ca. 3695 cal BC. From 464 to 352 cm (ca. 3695–1940 cal BC) the humification profile shows a gradual trend towards a warmer and/or drier climate with only two shifts in the opposite direction at 432 cm (ca. 3195 cal BC) and 384 cm (ca. 2440 cal BC). The zone of high-resolution analysis, from 320 to 208 cm (ca. 1455 cal BC–cal AD 130), shows a number of small and large fluctuations superimposed on an overall trend towards decreasing humification. The sharp decrease in the degree of humification that occurs from ca. 1395 to 1330 cal BC may be relevant in the context of the abandonment of the Dartmoor reaves as it represents a deterioration in climate to cooler and/or wetter conditions. Above the zone of high-resolution analysis, the major shift represented in the reconstructed water-table depth profile to a warmer and/or drier climate is reflected by a period of well-humified peat lasting from ca. cal AD 400 to 1000. This is followed by a shift to less humified peat from ca. cal AD 1000 to 1500 and a final shift to more humified peat from ca. cal AD 1500 to 1925. The abrupt change to less humified peat above 16 cm (ca. cal AD 1925) is likely to represent the transition from the catotelm to the acrotelm; a similar change has been noted by Anderson (1998).

4.4. Composite record

Data from both proxy-climate records have been compared and show a broad degree of correlation, although this varies downcore (Fig. 5). Importantly, the shift to wetter conditions at ca. 1395 cal BC, that may be linked to the abandonment of the Dartmoor reaves, is replicated synchronously in both proxy-methods. The two records have been normalised (*sensu* Charman et al., 1999) so that values are plotted against a standard *y*-axis scale and a composite record of palaeoclimatic change has been created by averaging the two datasets (Fig. 5). Hendon et al. (2001) identify that using a composite record of change may decrease the influence of non-climatically related changes.

The composite record illustrates gradually improving conditions from the base of the core (ca. 3695 cal BC) until ca. 1455 cal BC, after which a short-lived but abrupt climatic amelioration is followed by a significant deterioration lasting from ca. 1395 to 1155 cal BC. Within the zone of high-resolution analysis the record fluctuates with climatic deteriorations that are replicated in both proxy records occurring at ca. 745 cal BC, 350 cal BC and cal AD 75. There is then a significant shift to a warmer and/or drier climate at ca. cal AD 330. This amelioration in climate continues until ca. cal AD 890 and is followed by the most significant shift to wetter and/or cooler conditions in the profile lasting until ca. cal AD 1625. There is a further climatic amelioration from ca. cal AD 1625 to 1840. The shift to wetter conditions at the top of the profile is disregarded given that there is discrepancy in the direction of change registered in the two proxy records and the acrotelm/catotelm boundary at this depth can cause distortion of the record.

5. Discussion

5.1. Regional climatic change

Recent palaeoclimatic research has taken place primarily in northern England and Scotland with no published palaeoclimatic reconstructions from southwest England. We therefore compare the composite record from TRB with previous research from these regions in order to establish the replicability of palaeoclimatic signals within Great Britain. Given the limitations of comparing single site records, Charman et al.'s (2006) northern Britain compilation of peatland water-table reconstructions, derived from testate amoebae analysis, will be focused upon, although other records will be referred to where relevant.

A review of previous research reveals correlations between the dating of wet shifts from TRB and sites in northern England and Scotland (e.g. Barber et al., 2003; Barber and Charman, 2003; Hughes et al., 2000). However, where corresponding shifts are not exactly contemporary, or a wet shift identified at one site does not occur at another, neither the method nor the results of either site are invalidated (Barber and Charman, 2003); "they may simply not be telling the whole story" (Barber et al., 1998). Where differences in the timing and direction of palaeoclimatic shifts are identified, they may be caused by methodological issues, problems with chronological control, microtopography, the influence of autogenic processes or actual climatic differences between the sites (Hendon et al., 2001). Indeed, Chiverrell (2001) believes that the variation in palaeoclimate histories across Europe emphasises the moderating effect of local environmental controls on the overall influence of climate change.

The wet shift occurring at TRB from ca. 1395 to 1155 cal BC is supported by evidence from sites in both northern England and Scotland. Taking into account both their northern Britain testate amoebae data and a period of above average mid-European lake levels identified by Magny (2004), Charman et al. (2006) identify a major wet phase lasting from 1550 to 1150 cal BC, that may correspond to this shift. Langdon and Barber (2005) record wet shifts focussing around 1400 cal BC from multi-proxy peatland records of seven sites in Scotland, including a number of upland sites (e.g. Langdon and Barber, 2001), Chambers et al. (1997) identify a contemporary shift at Talla Moss, Scotland and Barber et al. (2003) identify a prominent coincident climatic deterioration at 1250 cal BC from plant macrofossil analysis of sites in northern England and Ireland. Both Anderson (1998) and Hughes et al. (2000) state that evidence suggests this was a period of increased effective precipitation throughout Great Britain. The evidence from TRB supports this and, furthermore, extends the range over which this climatic deterioration is registered.

The differing nature by which palaeoclimatic changes are registered is highlighted when considering the marked climatic deterioration of the Bronze Age/Iron Age transition identified by van Geel et al. (1996) as occurring at ca. 700 cal BC in the Netherlands, with further evidence for a Europe-wide and possibly global extent. This widely reported event has also been identified from a number of sites in Great Britain (e.g. Barber et al., 2003; Charman et al., 2006; Langdon and Barber, 2005) and the link between this climatic deterioration and the abandonment of upland settlement in Great Britain is further discussed by Dark (2006). This event is apparent at TRB, however, only occurs as a small wet shift ca. 750 cal BC within a period of fluctuating surface wetness.

The shifts in the TRB profile to drier conditions from ca. cal AD 330 to 890 and subsequently to wetter conditions from ca. cal AD 890 to 1625 are widely discussed in the palaeoclimatic literature. These may relate to the Medieval Warm Period and the Little Ice Age, respectively, although the exact timing of these periods is poorly defined (e.g. Hendon et al., 2001). Additionally, changes in palaeoclimate from TRB above and below the zone of high-resolution analysis should be viewed with caution given the wider sampling intervals and less robust chronological control in these sections of the core.

5.2. Climatic context of the reave period

The results from the climate reconstruction clearly point to a period of climatic deterioration on Dartmoor between ca. 1395 and 1155 cal BC. Furthermore, this is preceded by a period of relatively mild and stable climate from ca. 2000 to 1455 cal BC and an abrupt climatic amelioration from ca. 1455 to 1395 cal BC. There is some agreement between the timing of this period and the supposed construction date of the field systems. The pollen evidence from TRB (Fig. 2; West, 1997; West et al., 1996) supports the idea of widespread intensification of land use at the time of reave construction (see above). A determinist approach would seek to attribute causality to this coincidence (Coombes and Barber, 2005), however, a recent reappraisal of the mechanisms and social context of enclosure by Johnston (2005) argues that the establishment of the reaves may have been accretionary and that the form of enclosure implies greater time-depth than Fleming's (1988) models assume (e.g. the juxtaposition of aggregate and coaxial enclosure on Shovel Down and Kes Tor (Brück et al., 2003)). It is possible that climatic amelioration contributed to the process of accelerated or expanded enclosure, but may only have been one of the controlling factors, alongside societal changes and formalisation of pre-existing subdivision of the upland.

Given the uncertainty over dating, some authors have linked the abandonment of the reaves to the climatic deterioration of the Bronze Age/Iron Age transition discussed above. Based on the timing and magnitude of this shift, the results from TRB suggest this is unlikely to be the case and that the earlier shift from ca. 1395 to 1155 cal BC is more likely to be relevant. Fleming's (1988) hypothesis, based on limited radiocarbon dating and evidence for change and development in the field systems, is that the reave period lasted between 300 and 400 years. A date of abandonment between 1500 and 1200 cal BC is implied. The climatic deterioration at TRB dated to ca. 1395–1155 cal BC lends support to Fleming's chronology assuming that climatic deterioration is the prime causal factor in abandonment of the upland. Although abandonment of the upland is not supported by pollen evidence from TRB (Fig. 2; West, 1997; West et al., 1996), which, as expected, suggests continued open upland grazing (see Section 2), this does not preclude settlement abandonment (as reflected in the archaeological evidence) whilst seasonal use of upland grazing continued.

A likely consequence of the climatic deterioration is edaphic change, notably the podzolisation of soils on Dartmoor and subsequent peat formation. The roles of climate and/or human influence on peat formation are still contested (Askew et al., 1985; Moore, 1993). Overexploitation of the moorland ecosystem during the middle Bronze Age may have hastened peat development that was inevitable as a result of climate change (Staines, 1979). However, this view is rejected by Cowell (1981) who argues that change in climate should be seen merely as a 'trigger mechanism' which either compounds or exacerbates problems created by other factors. Either way, Fleming (1984) argues that soil deterioration remains an important contributory factor in landscape abandonment owing to reductions in soil fertility and overall productivity.

To assume that the identification of a climatic deterioration contemporary with the abandonment of the reaves provides conclusive reasoning for the desertion of these Bronze Age field systems is environmentally deterministic and ignores the complexity of human–environment relationships. Societal decisions are made in respect to a perceived environment, not the real environment (Butzer, 1982) and whilst it is possible to reconstruct aspects of the real environment (e.g. climatic fluctuations) there are a multitude of possible perceptions of the same environment, many of which may be adaptive strategies in their own right. It should also be remembered that the prehistoric archaeology of the region remains incomplete; little is known at present about the importance of non-agrarian economic forces on social and demographic changes, in particular the role of metallurgy and extractive industries in Britain. Research over the last two decades in Ireland and Wales has led to an emerging picture of intense metallurgic activity along the western seaboard of the British Isles during the Early Bronze Age (O'Brien, 1996; Timberlake, 2003). The extent of prehistoric settlements on both Dartmoor and Bodmin Moor indicate strong links between metal extraction and population density (Gerrard, 2000) and Price (1985) has asserted that Bronze Age occupation of the moor was directly related to extraction of tin, an argument criticised by Fleming (1987). Nevertheless, the strength (or otherwise) of trade networks in complex prehistoric societies will have had direct impacts on the exploitation of tin on Dartmoor, which may in turn have had direct consequences for the expansion or contraction of settlement. However, it is difficult, and beyond the scope of this paper, to assess the relevance of these issues to the process of abandonment from the existing archaeological evidence.

6. Conclusions

The Dartmoor reaves are Bronze Age land boundaries that have been extensively recorded and discussed by Andrew Fleming and other authors. This literature focuses on the construction and use of the reaves with little discussion of their eventual abandonment, although Fleming (1988) states that a deteriorating climate was an important factor in this process. A 5700 year palaeoclimatic record based on testate amoebae and peat humification analyses has been interpreted from TRB, central Dartmoor and is the first palaeoclimatic reconstruction from southwest England. The most important feature of the profile is a climatic deterioration from ca. 1395 to 1155 cal BC. This is contemporary with the period identified from previous research as that encompassing the abandonment of the reaves. Therefore, the hypothesis that a marked climatic deterioration occurred in the late Bronze Age which can be linked to the abandonment of the reave systems is upheld. This does not imply that the abandonment of the reaves occurred as a direct result of this deterioration. However, that it has been identified contemporary to the abandonment (within the uncertainty and limitations of dating) provides compelling support that climate was a major factor in this process.

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