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Creating a research agenda for the Bronze Age in Britain

For the first volume of the Bronze Age Review, the editor invited senior scholars to draw on their experience and expertise and write on what they would like to see happening in Bronze Age research in Britain in the future. They were asked to look as broadly as they can and explore issues and areas of study that they feel are currently missing or underdeveloped. The aim is to provide a period of open consultation until 31 January 2009 with suggestions, comments and proposed new chapters to the editor who can be contacted at broberts@thebritishmuseum.ac.uk. The authors will subsequently revise their articles for inclusion in a volume published by the British Museum Press.

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The Bronze Age climate and environment of Britain

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Abstract

Over the last twenty years there have been tremendous advances in our knowledge of climate change in later British prehistory from a wide variety of proxy-climate sources. This chapter will summarise our present understanding for the period 2000-500 BC and highlight the areas in which further research is required. A secondary aim is to review how much we can infer from these proxy-climate records concerning the wider environment, including the day-to-day environment of Bronze Age peoples and the stresses imposed upon their societies. This area is far more subjective but lies at the heart of serious, i.e. non-superficial, attempts to relate aspects of change in Bronze Age society to environmental change.

Bronze Age Proxy-climate records

This period of the Holocene c. 4000-2500 BP has long been regarded as a period of decreased average temperatures following after the Holocene maximum and before the Roman-early Medieval warm periods (Lamb et. al., 1966; Godwin, 1975; Houghton et al., 1996). The most reliable, and therefore most used, terrestrial proxy-climate sources of data for the Bronze Age of Britain are derived from raised, or ombrogenous, mires. This work has its origins in the climatic stratigraphy of mires used to formulate the Blytt-Sernander climatic scheme (Sub-Boreal to Sub-Atlantic covering the Neolithic and Bronze Age) and in modern times from the overturning of the autogenic theory of bog-regeneration by Barber in 1981. Barber's work produced the first bog surface wetness (BSW) curve for the UK from Bolton Fell Moss in Cumbria and has provided the stimulace for many studies of increasingly higher temporal resolution which culminated in the recently completed ACCROTELM Project (Charman, et al., 2007) and ISOMAP-UK Project (part of the NERC Rapid Programme). The method of using macrofossils of Sphagnum spp. and peat humification has been applied in environmental transects across Europe (Barber et al., 2000) and combined with other proxies such as pollen, Testate amoebae (Hendon and Charman, 1997; Charman et al., 1999) and most recently ∂^{18}O and ∂D from plant macrofossils (Brenninkmeijer et al., 1982; Barber, 2007; Daley in prep.). Testate amoebae have proved to be very valuable as they have allowed a complimentary method of calibrating the fluctuations in the water table estimated from plant macrofossils and humification (Hendon and Charman, 2004). Temporal resolution, has been improved by both wiggle-matching and the use of in-situ tephra deposits (Mauquoy et al., 2004; Plunkett, 2006) and at the best sites a decadal resolution is claimed (Mauquoy et al., in press) which is as fine, if not finer, than the dating of most archaeological sites within the Bronze Age. One of the reasons for placing a considerable amount of faith in these climatic reconstructions is the correlation between them and a vast array of other proxies, including written records from the Post Roman period. Well known historical climatic 'events' often derived from soft-data such as the Late Medieval Climatic deterioration (or Crusader Cold Period cf. Lamb, 1977), the Medieval Warm Period and the Little Ice Age, are also clearly shown in the mire-derived data sets (Barber, 1981). For the prehistoric period BSW data has been correlated with a variety of both global and regional proxies including the European lake level record (Magny, 2004), ice drift records from the North Atlantic (Bond et al., 2001) and ocean core proxies for the North Atlantic Deep Water circulation (Chapman and Shackleton, 2000). In terms of the causal mechanism most interest has focussed around solar forcing with comparison of BSW with the ^{14}C relative production rate/solar activity including solar events such as the Homeric minimum (850-550 cal BC) which has been correlated with a major wet phase across North West Europe (van Geel et al., 1996; Mauquoy et al., 2004). Mauquoy et al. (2008) have shown that at two sites, one in northern England the other in Denmark, BSW appears to lag changes in ^{14}C production in the historical period by between 0 and 50 years. However, solar activity does not appear to explain the entire record and it is likely that the it has been moderated by other factors, particularly ocean circulation especially in the west of Britain, Scotland and Ireland. Most studies have shown a statistical periodicity to climate variability (Aaby, 1976; Langdon et al., 2003; Blundell and Barber, 2005; Swindles et al., 2007) with values of; 200 years (Chambers and Blackford, 2001; Plunkett, 2006), 265 and 373-423 years (Swindles et al., 2007), 550 years (Hughes et al., 2000), 560 years (Blundell and Barber, 2005), 580 years (Swindles et al., 2007); 600 years (Hughes et al., 2000) and 1100 years (Langdon et al., 2003). These can be compared with periodicities in other proxy data such as 210, 400, 512 and 550, 1000 and 1600 years in tree rings and ocean core-data (Chapman and Shackleton, 2000; Raspopov et al., 2001).

Taking the major studies together (Figure 1b) it can be seen that there is a large degree of agreement in relation to the major trends. Indeed the noise which appears to be fairly equally if not normally, distributed over time is typical of that which might be expected due to differences in both dating, different site sensitivity and regional variation. The trend is relatively clear. There is stability or a slight reduction in BSW from c. 2000 BC to 1800-1500 BC as reconstructed from multiple proxies in northern Scotland (Anderson et al., 1998). After which there is an increase in BSW, or rise in bog water tables, which persists for 200-300 years and ends *c.* 1200 BC when bogs go into a dry phase. This dry phase is short lived and at *c.* 800-750 BC there is an increase in BSW which is seen right across Europe and is probably the most profound climatic shift of the Holocene prior to the Little Ice Age (the so-called 2.7 Ka event; Van Geel, 1996; Yeloff et al., 2007). Most records show this phase lasting for between 200-400 years before a return to drier conditions before a wet shift again *c.* 400 BC. The Bronze Age is preceded by the so-called 4.2 Ka event which has been identified from the ocean and ice cores (Bond et al., 1997), from a severe drought event in eastern Africa and increased sand movement in coastal dune systems along the eastern Atlantic coast (Gilbertson et al., 1999; Knight and Burningham, in press). In the UK it has been identified as a cool/wet phase from BSW record in a number of sites in Northern England (Chiverrell, 2001; Charman et al., 2006 and Barber and Langdon, 2007) and Scotland (Barber and Langdon, 2005) and from combined BSW and chironomid data from Talkin Tarn (Barber and Langdon, 2007).

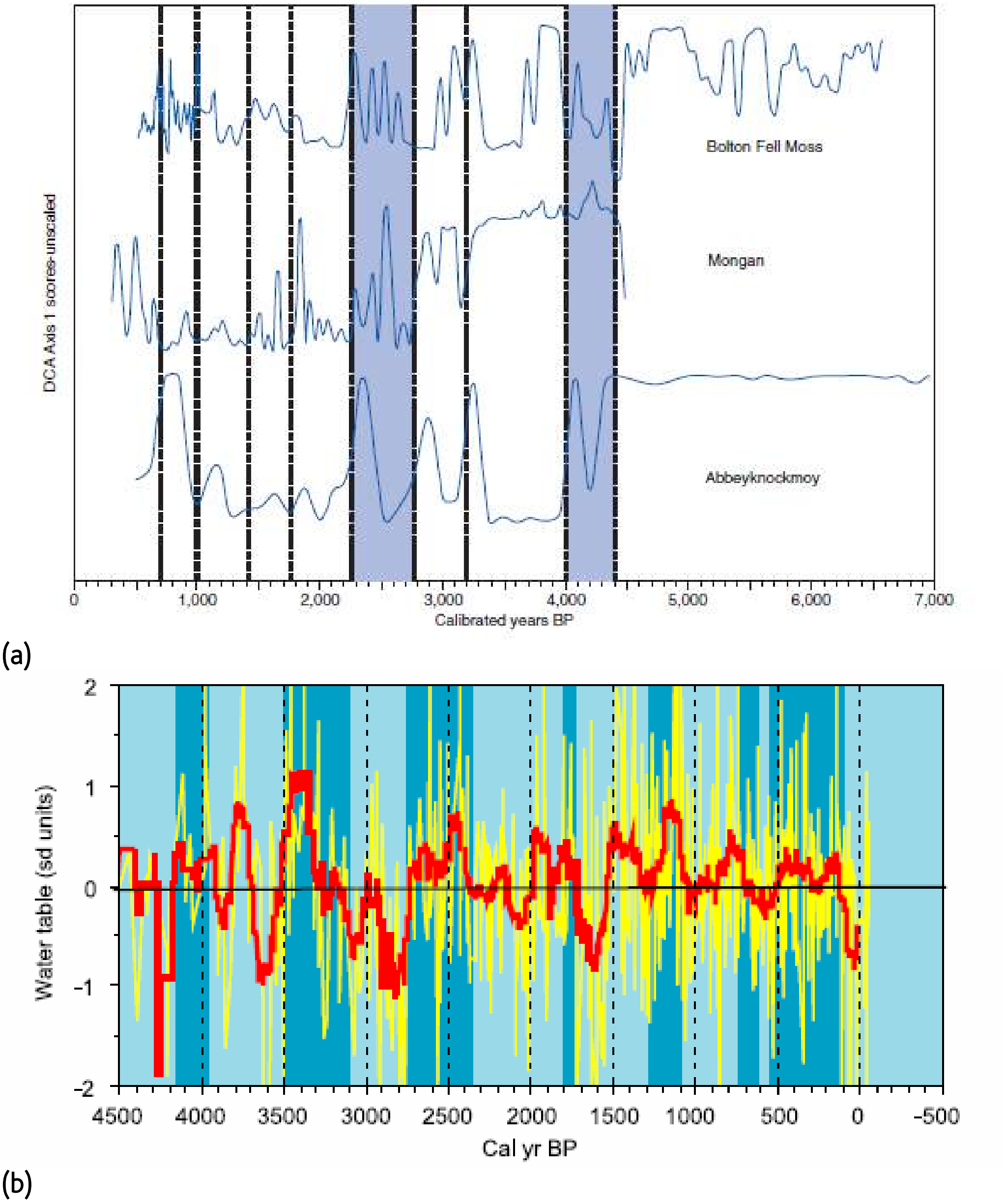

Figure. 1a-b. Climate proxy records for northern England and Ireland. (a) Climatic records derived from the Detrended Correspondence Analysis (DCA) scores of macrofossil data from cores from Bolton Fell Moss, northern England, Mongan Bog, central Ireland, and Abbeyknockmoy Bog, western Ireland, plotted against age. Peaks reflect dry conditions, troughs reflect wetter conditions. Coarse dashed lines pick out changes which are mainly at two of the sites (ca. 4400, 4000, 1750, 1400 and 1000 cal. BP); finer dashed lines pick out changes which are coincident at all three sites (ca. 3200, 2750, 2250, and 700 cal. BP). Shaded zones emphasize two major phases of change, which are apparent in many other records, around 4400–4000 and 2750–2250 cal. BP. Redrawn from Barber et al., 2003, with permission.(b) The composite record of water table variability from northern Britain (top) compared with the lake level records of Magny (2004) as dark shaded bars. The water table record shows original data points (yellow) and 100-year moving average (thick red line). Redrawn with permission from Charman et al. (2006).

This chronology will probably be further refined in the next few years with the increasing use of tephra layers but the broad pattern is unlikely to change. Far more of a problem is what these shifts mean in climatic terms and how these bog-proxies relate to other hydroclimatic variables. The water table of a raised mire is in theory simply the result of cumulative moisture deficit (precipitation-evapotranspiration) with perhaps a small marginal loss to the surrounding area due to throughflow, at least prior to extensive bog drainage. Theoretically at least either changes in precipitation or evapotranspiration could cause a bog water table to vary over the period of moisture deficit – the summer. Under present climatic conditions in the UK bog water tables during the summer are probably most sensitive to precipitation (Charman, 2007). However, it is probably not possible to entirely deconvolve the effect of temperature and precipitation from the BSW palaeo-series, although it maybe possible in contemporary hydrological studies. As Barber (2007) has emphasised - the BSW proxy is a composite measure of past climate. There are two principle reasons for this, firstly a change to a more continental climatic regime is likely to alter the relative importance of precipitation and temperature, and secondly even for the present oceanic climate of the British Isles there is a correlation between temperature and precipitation at least at the mean annual scale (Barber, 2007). Even for the site studied by Charman (2007) the driest years on record such as 1975 and 1976 were also two of the hottest. The reason is that anticyclonic conditions and high pressure cells draw in relatively dry air for Europe and Siberia, although augmented by convectional precipitation, whereas cyclonic conditions draw in warm wet air from the Atlantic. At the annual scale the linking factor is the correlation between summer precipitation and the winter NAO index (Kettlewell et al., 2003) which is also correlated strongly with changes in mean annual temperature. This climatic coupling with North Atlantic sea surface temperatures and is strong enough to be used in forecasting by the Meteorological Office (http://www.metoffice.gov.uk/research/seasonal/regional/nao/index.html; Rodwell et al., 1999 and Rodwell and Folland, 2002). This was pointed out by Barber et al., (1994) and is why there is a strong correspondence between the record of bogs like Bolton Fell Moss and both the summer wetness and winter severity indices of Lamb (1977), the NAO and on the longer term the Thermohaline Circulation (THC) as discussed by Barber (2007). The inclusion of summer temperatures as one of the drivers of BSW is confirmed by chironomid data as reported for Talkin Tarn by Barber and Langdon (2007). Given these complications it is best to regard the BSW record as principally a response to north Atlantic sea surface temperatures mediated through prevailing synoptic regimes and the resultant summer water deficit and perhaps more attention should be paid to the dry shifts which may also have significant archaeological implications as discussed later in this article.

Two other palaeoclimatic techniques which are probably more closely related to variations in precipitation and are applicable to the Bronze Age in the UK are speleothem luminescence and palaeohydrological interpretation of river valley sediments. Long-term variations in speleothem luminescence intensity can be related to climate and especially precipitation (Baker et al., 1999) although it is also sensitive to local vegetation change (Baldini et al., 2005). Using data from both mires and speleothems from Sutherland in northwest Scotland Charman et al. (2001) have shown a correlation between peat humification and speleothem luminescence emission wavelength and ice accumulation from GISP2. The use of speleothems has further potential to produce regional data in areas lacking ombrotrophic mires such as southwest England and the Mendip Hills. At present there is an examination of both the UK and Irish speleothem record to detect and measure the duration of the 2.7 Ka event as discussed above (McDermott in press). A geologically related method the use of climate proxies such as stable isotopes from travertine/tufa deposits may also have potential in southern England (Davies, et al., 2006).

The second technique is to use the proxy record of river discharge from river valley sediments. Unfortunately in the UK and Ireland hydrological conditions don't exist to allow the estimation of flood magnitude series from slack-water sediments which record individual flood events. Instead event series are inferred from river activity in alluvial reaches based on the frequency of ^{14}C dates from various sedimentary contexts as illustrated in Brown (1997, p 53) and Lewin et al., (2005). In practice this has involved the analyses of the probability density function of alluvial ^{14}C dates after calibration effects have been removed (Macklin et al., 2006). Macklin and co-workers have improved the technique and been able to sub-divide the series by UK regions (Johnstone et al., 2006). It is still not a quantitative measure of variations in precipitation, or even catchment discharge, but it is argued that it is a qualitative measure of the changing frequency of moderate and large floods. The pattern for the Bronze Age is again relatively clear with a rise in alluvial activity from *c.* 4300 to 4000 BP then a sharp fall *c.* 3500 and a period of lower alluviation until a pronounced peak around 2700-2800 BP lasting under 100 years and then a fall - but to levels higher than previously (Figure 2).

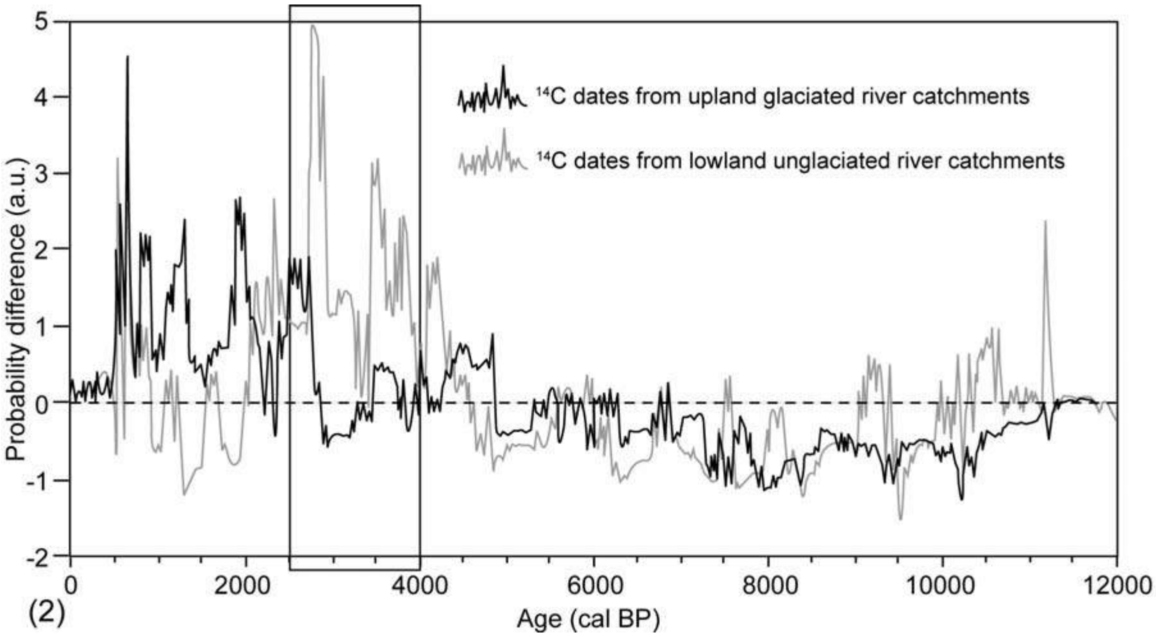

Figure. 2 The probability density function for upland and lowland river catchments in Great Britain during the Bronze Age. From Johnstone et al. (2006).

Using the aggregate data (all dated units) this peak is the highest in the entire Holocene alluvial record with the exception *c.* 600-700 BP (Lewin et al., 2006). Its co-incidence with the dramatic wet shift seen in mires at *c.* 2600-2700 BP is strong and it suggests that it is primarily the result of increased river discharges and soil erosion caused by a solar-forced climatic event under boundary conditions of a large proportion of the landscape under arable cultivation. Indeed the climatic instability of the later Bronze Age is revealed in many studies of floodplain alluviation, such as the Thames (Needham and Longley, 1980), the Trent (Brown et al., 2007; Howard et al., in press) and in tributaries of the Severn (Brown, 1988). The lack of this peak in the database record for southwest England is almost certainly due to a lack of previous studies and recent work in the Exe Basin has confirmed hydrological fluctuations in this period (Bennett et al. in press; Brown et al. in prep).

All British Rivers	**Upland rivers**	**Lowland rivers**	**Climatic deteriorations from mires (Hughes et al., 2000)**
	4030		
			4000
		3830	
	3580		
3540			
		3510	
			3500

		3150	
			2900
		2800	
2730	2730		
2550	2560		
			2600

Table 1. Episodes of major flooding in Great Britain and mire wet shifts from Macklin et al. 2005 and Hughes et al. 2000. All dates in rounded years cal BP.

From the combination of these methods it is possible to postulate climatic phases with probable synoptic conditions during the Bronze Age, which would have resulted in alternations of periods with higher frequency of wet years to periods with a higher frequency of dry years or summer droughts (Table 2).

Approximate Period BC	Bog Record (BSW)	Alluvial Record
2300-2000	cold/wet (4.2 Ka event)	high activity
2000-1800/1500	reduction in BSW	low activity
1800/1500-1200	increase in BSW	
1200-850	warm/dry phase	
850-650/550	cold/wet phase (2.6 Ka event)	sharp rise in activity
650/550-400	reduction in BSW	fall in activity but to levels higher then previous low activity periods
400-100	cold/wet phase	increase in activity

Table 2. A summary of Bronze Age (shaded) climatic trends derived from bogs and the alluvial record for Britain from sources references in the text.

Additionally taken together the mire-derived and the alluvial data suggests that there have been some major climatic events including severe storms and prolonged serious droughts. Whatever the climatic cause, the wet periods such as the late Bronze Age, must have contained large floods which would have caused localised damage and disrupted everyday life especially along floodplains. There is also evidence from both stratigraphical studies of small catchments (Shotton, 1978; Brown and Barber, 1985; Smith et al., 2005; Brown in prep.) and ^{14}C inventory studies that these storms were responsible for an acceleration of soil erosion from arable fields which could have imposed stresses via temporary reductions in agricultural productivity. What is also clear from the alluvial ^{14}C data is the regional variation in alluviation particularly between upland glaciated-catchments and lowland unglaciated-catchments (Johnstone et al., 2006, and Fig. 2). Given the lower stream powers of the lowland catchments this cannot be an autogenic effect instead it is due to greater supply of sediment to stream channels almost certainly due to arable agriculture from the late Neolithic onwards. Whilst climate supplied the 'power' it was Bronze Age agriculture that supplied the sediment.

Recent work on ombrotrophic mires has suggested that factors other than climate may have influenced their ecology during the Holocene. Studies by McClymont et al. (in press) and Hughes et al. (in press) suggest that the decline in *Sphagnum austinii* at Butterburn Flow is associated with changes in nutrient status in the bog and could be the result of pollution particularly of Ti and Si. If pollution events from agricultural, mining or metallurgical sources are associated with shifts in the balance of the ombrotrophic communtities this could have implications for the use of peat bog climate proxies at the time of major changes in land use (Hughes pers. com.).

Climate, environment and culture

Since neither the proxy-climate data nor the archaeological data are, or probably ever will be, resolvable to the event or even year, it follows that correlations between climate and cultural change will either be highly localised and an 'event effect' (e.g. abandonment or repair due to a flood event) or more commonly an approximate temporal coincidence of a climatic trend and a some change in the cultural series. If we refer to this as an 'aggregated effect' then the chances of observing it and its being meaningful are maximised in situations of marginal habitation or agriculture although it must be remembered that marginality is still fundamentally defined by particular economic and social systems (Brown et al., 1998). This approach underlies studies of farming at the margins of cultivation or in environmentally sensitive locations. It is also necessary to at least postulate the mechanisms by which a climatic change results in cultural actions. The reason for this is that it is not always clear which way climate-culture correlations should operate in temperate environments. An example is upland arable cultivation which is susceptible to both a reduction in temperatures, especially in the growing season, and to drought, a factor rarely considered but likely to be important especially on the lower and dryer of British Uplands (e.g. Dartmoor or the North York Moors). This may not have had immediate effects but been cumulative through stressing the agricultural system with lower productivity and increasing time taken to collect water for stock, domestic use and horticulture. Indeed although masked by imported food, climatic factors, such as variations in summer rainfall, still have significant effects on present day wheat production (quantity and quality) which can be linked to the North Atlantic Oscillation (Chmielewski and Potts, 1995; Kettlewell et al., 2003), Therefore a chain of causality is essential as the chances of finding correlations between climatic fluctuations of all types and cultural changes by chance is almost certainly very high and increases with the increasing number and precision of proxy climate records. For example using the BSW data already discussed for Scotland (Langdon et al., 2003) and given realistic temporal precision, even with tephras of ±25 years, the chances of having a correlation between a cultural change and a wet shift registered at one or more of the sites studied is 52%. As the number of sites studied increases this figure will rise and it could be argued that, just as there are lags in the proxy-climate record, there are also potential larger lags in the cultural record. It follows that correlation may be a necessary prerequisite but it is not sufficient to prove causality which should primarily be based upon a mechanistic explanation or theory which can be tested using independent data. In a recent study attempting to correlate proxy-climate data with "enhanced archaeological visibility" from databases of Irish ^{14}C dates by Turney et al (2006) it is far from clear how the claimed causality is supposed to operate with shifts to wetter conditions being related to an increase in crannog and settlement dates and in some, but not other wet periods, an increase in dates from forts. Since the enhanced ^{14}C duration identified in this study is approaching 50% of the Holocene, especially in later prehistory, and having regard to taphanomic factors such correlations may have little archaeological value.

Later Bronze Age climatic change

The problem of assigning climatic causality to cultural changes has been highlighted in connection with the well-known, and noted above, climatic change registered across Europe at c. 700 BC (2.7 Ka event, Barber et al., 2004) by Coombes and Barber (2005). Van Geel and co-workers have related this climatic event to a variety of archaeological changes across western Eurasia and even globally at *c.* 2650 BP although the date of this event has still to be tracked with sufficient resolution and varies considerably from study to study. Van Geel et al (2004) have also proposed that this abrupt climatic change in the form of increased humidity around 850 BC caused an expansion of population in the Altai region of Central Asia which was a stimulus for outward migration of the Scythian culture with repercussions for Europe and eastern Asia. However, this hypothesis has received archaeological criticism (Riehl and Pustovoytov, 2006), and is at odds with some data suggesting colder, and therefore drier, conditions (Andreev and Klimanov, 2000). In the British Isles this climatic event has been correlated with increases in BSW at many sites especially in northern Britain (Charman et al., 2006) and as discussed above in the alluvial record. However, what effect it had on late Bronze Age society although frequently speculated upon remains unclear, as has been emphasised by Dark's (2006) unusually comprehensive analysis of 75 pollen diagrams across Britain which on aggregate show no evidence for "wholesale" land use change at *c.* 850 BC indeed in many cases there is increased agricultural activity. Similarly Tipping et al.'s (2008) analysis of proximal upland and lowland pollen sites in north east Scotland "posits a restructuring of agricultural activities" (Tipping et al., 2008 p.2379) rather than abandonment of settlement or agriculture due to late Bronze Age climatic deterioration.

In alluvial environments it is occasionally possible to observe directly the 'event effect'. An example comes from Argosy Washolme, Aston-upon-Trent (near Shardlow), Derbyshire where a large log boat was stranded by a flood and wedged against several large oak logs on a gravel bar in an unstable reach of the River Trent (Howard et al., 1999). The stranded log-boat which was radiocarbon dated to 1440 - 1310 cal BC was carrying several large blocks of locally hewn Bromsgrove Sandstone which, given the absence of monumental construction in stone at this time in this area, were most likely destined for the construction of a causeway, wharf or landing hard. The boat was found 22m from a linear structure of oak, brushwood and stones, one of two structures interpreted as a causeway (Knight and Howard, 2004). Since then another log-boat has been found at Shardlow which is within a kilometre of Argosy Washolme and illustrate how important the Trent was for 'goods transportation'. Also at Aston 12 metal objects have been recovered dating to this period (Knight and Howard, 2004). Whilst such events can provide important evidence of Bronze Age cultural activities, which might otherwise have been archaeologically invisible, they cannot reveal climate change as a contributory factor in wide societal or cultural change.

The most commonly used aggregate effect is data concerning the abandonment or extensification of upland farming due probably as much to soil acidification as to climate change, and a corresponding re-organisation of lowland landscapes (Bradley, 1978; 2007). In the case of the well known of Dartmoor Reaves this process appear to have started earlier in the middle Bronze Age with the extension of the co-axial field system down onto lower slopes (Fleming, 1988). In the first palaeoclimatic reconstruction from Dartmoor, Amesbury et al. (2008) have shown using testate amoebae and peat humification that a major shift to cooler and/or wetter climate occurred c. 1395-1155 cal BC which is coincident with the period believed to include the abandonment of the reave system. However, as this study ably shows the problem with such a correlation is the poor dating constraint on the abandonment of the reaves rather than the proxy-climate record and the authors correctly caution that deteriorating climate may have been only a contributory factor in abandonment. What is required in this situation is better dating of the abandonment of the reave system and archaeological or palaeobotanical data revealing stress through changes in productivity, crop type or farming practices. Other aggregate effects in this period mentioned by Bradley (2007) may have been increased construction of wooden trackways in wetland such as the Somerset levels (Coles and Coles, 1986), the Fens and across parts of floodplains such as the Thames (Sidell et al. 2004) and even the construction of the first Bridges (Bradley, 2007) such as that excavated at Testwood in Hampshire (Brown, 2008). However, the chain of causality is not clear in all cases as for example with bridges, as it is arguable that societal factors such as trade, power, prestige and territoriality as well as technological changes in wood working are more likely the key drivers. Likewise the middle-late Bronze Age increase in the deposition of hoards in rivers and lakes (Bradley, 1990), the renewal of 'water cults', the use of riverine islands (Brown, 2004) or the start of crannog construction in Ireland (Fredengren, 2002) cannot be taken as direct evidence of any change in the environment. They maybe related to a changing perception of the environment or more likely or even a rise in intra-societal conflict which itself could be an aggregate effect of environmental stress although this is far from being proven. What is certain is that during this period there are major changes in the structure of society involving a concentration of power in the hands of elites, increased long-distance trade and changing ritual activity (Bradley, 2007) which may have been associated with changing belief systems – and that all these forces lead to a change in the monumentalisation of natural places. Although largely concerned with the collapse of complex societies Coombes and Barber (2005) emphasise that in order to avoid crude correlation-based determinism, environmental change must be identified as the 'critical factor' in cultural change rather than being just one of a number of factors influencing change in what are socio-economically complex systems which show many of the characteristics of self-organising systems (Dearing and Zolitscka, 1999). This applies as much to the British Bronze Age as classical civilisations and in any attempt to understand such complexity a critical parameter will always be some derivative of population density or its proxy.

Conclusions

Through the serendipitous nature of archaeological excavation there will no doubt be further remarkable sites which reveal event effects on the material record such as site destruction or the rare preservation of a catastrophy, and no doubt these will provide valuable insights into Bronze Age life. However, it is unlikely, and indeed axiomatic, that there will ever be enough of these rare events to allow the geographical delimitation of such climate-induced change on society at large. Archaeologists are therefore likely to continue, or indeed increase (due to changes in research funding) attempts to match aggregate events to the increasingly detailed and complex palaeoclimatic record – the increasing complexity of which may further in turn weaken such correlations. Several research needs are clear; firstly there is an inevitable disparity between our palaeoclimatic knowledge from northern and western Britain in comparison with southern and midland Britain. As has been pointed out many times this is unfortunate as the majority of the British population in later prehistory was located in the midlands and the south. Research into alternative sources of proxy-climate data is therefore potentially valuable. Secondly a more subtle and meteorologically meaningful description of past climate is required from the proxy-climate data which could be matched with archaeological data and particularly archaeobotanical data. Whilst reductions in temperature and increasing rainfall during critical periods of the year have been emphasised these may not have been critical and lowland England and other stresses such as drought should be considered. At the heart of most scenarios of climatic forcing there is some squeeze on resources, be it by drought or deteriorated growing conditions. This will then act on society through one or more of several mechanisms including; changes in health, the birthrate and mortality (particularly neo-natal), emigration and eventually the population density, but also resource substitution and societal change including social differentiation and conflict. What is required is regionally delimited studies in areas with high proxy-environmental potential which focus on these aspects of the archaeological record over a critical period such as the two or three centuries before the eruption of Hekla 3. Just as there has to be continued improvement in the modelling of climate forced environmental change (such as relative productivity) there also have to be improvements in the conversion of the archaeological record from site narratives, or databases of site types, to resource related parameters which can be related to changing environmental conditions rather than cultural dynamics. At the heart of aggregate effects of climate change remains demography and it is advances in this area that are most likely to clarify rather than further muddy our view of environment-human interactions in the Bronze Age.

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