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Guest Editorial

Peat stratigraphy and climate change

This volume is dedicated to the work of Keith Barber, who retired from the Palaeoecology Laboratory, School of Geography, University of Southampton (PLUS) in 2009, having made important contributions to understanding the relationships between peat stratigraphy and climate change.

Prof. Keith Barber - Director of the Palaeoecology Laboratory, University of Southampton (PLUS) until his retirement in 2009.

The question as to whether peat stratigraphy could be used as an archive of past climate change was unresolved in the 1970's (e.g. Aaby, 1976). Peats themselves were used as sedimentary archives from which pollen could be extracted and, in some cases, related to broad-scale climate change, but it was long believed that peat growth was cyclical, after the work of Osvald (1923) and his theory of cyclic regeneration. If peats were growing in a cyclic phase any changes in peat stratigraphy would be related to the ontological development of peat domes (ombrotophic bogs), and hence not related to climate change. This paradigm remained intact for the best part of 50 years until Keith Barber published his seminal work – *Peat Stratigraphy and Climate Change* (1981). Keith's paradigm shift was based upon detailed analysis of the plant macrofossils (the *Sphagnum* remains in particular) within the stratigraphy of Bolton Fell Moss, Cumbria. The site was chosen by Keith's PhD supervisors at Lancaster University, Frank Oldfield and Gordon Manle, and perhaps one of the most important considerations was that the site had been cut, revealing clear stratigraphic profiles – not often available in ombrogenous peat bogs. Immediately, Keith could see that there were clear stratigraphic changes, but that they did not appear cyclic. His detailed macrofossil work, coupled with radiocarbon dating, supported this interpretation. The cyclic regeneration spell was broken, and steadily researchers realised that peat stratigraphy could be used to develop climate proxies, independent of autogenic peat accumulation.

Over the years since Keith's founding work, a diverse range of peat-based palaeoclimate proxies have been developed. These have built upon his pioneering research that used peat stratigraphy and plant macrofossils to build records of change in bog surface wetness (BSW). This parameter is typically interpreted in term of variations in effective precipitation (precipitation minus evapotranspiration) (e.g. Charman et al., 2006, 2009; Barber et al., submitted for publication). We now have a detailed picture of climate change for much of northern Britain for the mid- to late-Holocene inferred from changes in BSW and similar records are being developed worldwide. However, one challenge for the future of peat stratigraphy and climate studies is to further quantify the relationships between peat-based proxies and climate, and determine whether more refined temperature and/or precipitation proxies can be developed. Work is currently on-going in these directions using methods such as the analysis of stable isotopes in *Sphagnum* and peat biomarkers (Daley et al., 2010). Exciting new possibilities are developing rapidly. The potential of these new proxies is considered in Chambers et al. (2012). Keith will inevitably be following these developments keenly.

Keith has also made contributions in other related areas of Quaternary Science varying from atypical Interglacial peats (Brown et al., 1987) to detailed palaeoecological studies of his beloved New Forest (Grant et al., 2009a,b). One noticeable feature has been his willingness to cross-boundaries and consider the interface between palaeoecology and both environmental conservation and archaeology. Work with his students in the latter field includes late prehistoric alluviation (Brown and Barber, 1985), Roman environmental impacts (Dumayne and Barber, 1994), and even the theoretical side of the subject (Coombes and Barber, 2005). He has also made major contributions to a number of collaborative projects including IGCP (158), NERC-RAPID and NERC-TIGGER as well as running field meetings and day trips to the New Forest for innumerable organisations from the Quaternary Research Association to the Mires Research Group.

Apart from generating key data that helped in shifting a paradigm, Keith's other great contribution to science has been his supervision of PhD students, over half of which have gone on to further develop their science in academia or related areas and have made crucial advances in science themselves. Keith has supervised 26 graduate students, an impressive number by any standard, especially considering that when he took on his first student (NERC-funded), a senior colleague remarked, "was he really sure?" as they were "a lot of work" and "would likely interfere with his teaching". How times have changed, at least in this instance for the better!

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Keith coring Walton Moss in 1995, with postgraduate students Dmitri Mauquoy (left) and Paul Hughes (right), both of whom have gone on to academic careers at Aberdeen and Southampton Universities, respectively.

This volume is dedicated to the current state of the discipline of peat stratigraphy and climate change. The papers fall into two main categories; half are focussed on methods and proxy refinement, and how they can be used to reconstruct past climate/environmental change, while the other half document/review past climate change from a range of locations. The current state-of-the-art methods for using proxy climate indicators from bogs are reviewed by Chambers et al. (2012). They discuss the use of new techniques within peats, such as biomarkers, stable isotopes and inorganic geochemistry, as well as reviewing recent developments in proxies, such as plant macrofossils, humification and testate amoebae. A key message from this review is the fact that not all proxies and techniques have universal applicability, and each must be carefully chosen depending on the mire being studied. The focus on proxy development is further considered by Hughes et al. (2012) who assess the use of humification for a palaeoclimate proxy and the issue of a species signal. They use a *k*-value (essentially an absorption value of the alkali extracts of fresh plant material) to calculate *k*-scores for peat samples based on plant macrofossil analyses. These data can then be compared with humification analyses. Hughes et al. (2012) argue that while the humification data are validated in the case study, overall a *k*-adjusted version shows that the species signal can be sufficient to change the timing and number of climate events recorded in the peats, from decadal to millennial timescales, effectively arguing that even taking this approach, humification data should be interpreted with care in terms of invoking past climate change. Daley and Barber (2012) also consider how best to interpret a peat-based palaeoclimate proxy; plant macrofossil analysis, with a focus on the best statistical methods to use. They argue that using a weighted averaging technique (Dupont Hydroclimatic Index) can work as well or better than ordination analyses such as Detrended Correspondence Analyses (DCA) or Non-metric Multidimensional Scaling (NMDS) in the sites they assess. Further assessment of these proxies is undertaken by Väliranta et al. (2012) who compare results from a transfer function from plant macrofossils with reconstructions from another proxy, testate amoebae, from the same core. The reconstructions show almost identical trends from sites in Finland and Estonia over the last 5000 years, except for one major phase of divergence. The possible reasons for this are discussed in the paper, with the conclusion that single-proxy reconstructions are subject to larger uncertainties than those based on multiple methods.

Correlating multiple peatland palaeoclimate records has become a much used approach from many researchers, but some of the approaches used may be problematic. A typical approach for attempting to get around potential chronological limitations in individual records involves tuning (to common events) and stacking of records. Swindles et al. (2012) address the uncertainties involved in this method from peat records, and note the importance of fully understanding the errors within individual records, as there is a potentially flawed assumption that events are always synchronous between sites. One impact on peatlands that is synchronous is volcanic ash (tephra) deposition. Payne (2012) discusses the impacts of tephra deposition on testate amoeba communities in Alaska, and shows that statistically different communities occurred from a range of profiles across the same tephra layer and may relate to sulphur deposition, although other aspects of the volcanic input such as chemical, physical and/or hydrological processes may drive short term changes in peatland faunal communities.

The six papers focussed on reconstructing past climate change, using bog surface wetness proxies, are based on a range of timescales. Amesbury et al. (2012) use fine-resolution sampling to compare proxy climate records with instrumental temperature and precipitation data over an 86 year period from western Sweden. Different proxies correlated with both drivers and on different timescales, leading to the suggestion that researchers should be careful when producing composite curves of proxies (notably plant macrofossils, testate amoebae and humification) and that regional variability may be greater than previously hypothesized. Charman et al. (2012) and De Vlesschouwer et al. (2012) both produce 1000 year records from peatlands, but using different proxies in each study. Charman et al. (2012) use a high resolution testate amoebae record from central Ireland to reconstruct a 1000 years summer precipitation record. The transfer function water table depths from the testate amoebae record were correlated with a 43 year instrumental precipitation record and then used to reconstruct precipitation and deficit over the last 1000 years. The slow accumulation rates hindered the calibration somewhat, but nonetheless the results showed that summer precipitation provided a better validation than annual precipitation. Results from the 1000 year long record indicated that high summer rainfall occurred between AD 1400–1850 and may have been attributed to changes in the summer North Atlantic Oscillation. The De Vlesschouwer et al. (2012) study utilised stable isotope studies on *Sphagnum* stems ($\delta^{13}C$) and leaves ($\delta^{13}C$ and $\delta^{18}O$) as well as bulk density, pollen and geochemical proxies (Si and Ti content). While the *Sphagnum* stable isotopes pick up shallow pool phases, and hence palaeoclimate, they argue that while there may be other climate indicators in other proxies such as atmospheric soil dust flux, these are difficult to decipher over the last 1000 years due to increasing human impact identified through the pollen and geochemical land-use indicators.

Three other papers assess evidence for palaeoclimate from peat stratigraphy on longer timescales. Langdon et al. (2012) assess the past 6000 years of palaeoclimate from a testate amoebae record from central Ireland. Comparisons with other regional records from the UK suggest that this region is in phase with the North of Ireland in terms of timings and durations of climate events, but there is an apparent offset with records from Northern Britain, which may be real or due to the tuning and stacking processes used (see Swindles et al. (2012) paper in this volume for further comments on this). Elliott et al. (2012) also use testate amoebae and diatoms to assess hydroseral change in a bog from Ontario, Canada. The reconstructions suggest that the fen-bog transition primarily reflects a large nutrient gradient, and secondarily a moisture gradient. Moving away from the northern hemisphere, Van der Putten et al. (2012) discuss the role of peatlands in the Subantarctic islands for reconstructing past climate change. They review and synthesise the literature, and add new data of their own from South Georgia to provide a regional overview. Ile de la Possession (Iles Crozet) appears to follow a northern hemisphere climate pattern, as it shows a clear climate event around 2800 cal. BP, whereas South Georgia shows a relatively large event between 2200 and 2000 cal. BP.

Acknowledgements

All papers present in this volume have either authors that have passed through the PLUS laboratories, under the auspices of Keith Barber, and/or authors that attended a one day meeting held on this topic in the New Forest in 2009. It is clear from the rich and varied content of the volume that Keith has inspired a generation of researchers on peat stratigraphy and climate change and we thank them all for their contributions. In addition, many thanks are due to the support of Norm Catto and all his colleagues at *Quaternary International* for encouraging us to produce this special volume.

PhD Research Students in PLUS supervised by Professor Keith Barber

Haskins, LE (1978) Vegetational history of south east Dorset. PhD thesis, University of Southampton. NERC award 1973–1976.

Waton, PV (1982) A palynological study of the impact of man on the landscape of central southern England, with special reference to the chalklands. PhD thesis, University Research Scholarship award 1978–1981.

Tilley, AR – NERC award 1979–1982: Palaeoecology of the New Forest; PhD never submitted.

Brown, AG (1983) Late Quaternary palaeohydrology, palaeoecology and floodplain development of the lower River Severn. (Jointly supervised with Professor K. J. Gregory). PhD thesis, NERC award 1979–1982.

Pyke, BJ – NERC award 1984–1986: Lake-level changes in Shropshire; withdrew January 1986.

Haslam, CJ (1987) Late Holocene peat stratigraphy and climatic change – a macrofossil investigation from the raised mires of north western Europe. PhD thesis, NERC award 1984–1987.

Clarke, MJ (1988) Past and present mire communities of the New Forest and their conservation. PhD thesis, NERC/CASE award with NCC, 1981–1984. Supervision: Dr Keith Barber (lead) and Mr Colin Tubbs.

Twigger, SN (1988) Late Holocene palaeoecology and environmental archaeology of six lowland lakes and bogs in north Shropshire. PhD thesis, NERC award 1983–1986.

Charman, DJ (1990) Origin and development of the Flow Country blanket mire, northern Scotland, with particular reference to patterned fens. PhD thesis, NERC award 1987–1990.

Hobby, RM (1990) The palaeoenvironmental significance of Holocene lake-level fluctuations in Shropshire. PhD thesis, NERC award 1987–1990.

Dumayne, L (1992) Late Holocene palaeoecology and human impact on the environment of northern Britain. PhD thesis, SERC (SBAC) award 1989–1992.

Stoneman, RS (1993) Holocene palaeoclimates from peat stratigraphy: extending and refining the model. PhD thesis, NERC award 1989–1992.

Hughes, PDM (1997) The palaeoecology of the fen/bog transition during the early to mid-Holocene in Britain. PhD thesis, University Research Scholarship award 1993–1996.

Mauquoy, D (1997) Testing the sensitivity of the palaeoclimatic record from peat stratigraphy. PhD thesis, NERC award 1994–1997.

McMullen, JA (2000) Palaeoecology and the conservation management of lowland raised bogs. PhD thesis, English Nature/University of Southampton award 1995–1998. Supervision: Dr Keith Barber (lead) and Dr Brian Johnson.

Langdon, PG (1999) Reconstructing Holocene climate change in Scotland utilising peat stratigraphy and tephrochronology. PhD thesis,NERC award 1996–1999.

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Brown, A (2006) Holocene climate change in Cumbria – a combined bog and lake approach. PhD thesis, NERC award 2002–2005. Supervision: Prof. Keith Barber (lead) and Dr Paul Hughes.

Daley, T (2007) Tracking rapid climate change from peat bog stable isotopes. NERC tied award 2003–2006. Supervision: Prof. Keith Barber (lead), Prof. F. A. Street-Perrott and Dr N. J. Loader (University of Wales Swansea).

Amesbury, M (2008) Fine resolution peat-based palaeoclimate records of the late-Holocene. NERC award 2004–2008. Supervision: Prof. Keith Barber (lead) and Dr Paul Hughes.

Forster, EE (2010) Palaeoecology of human impact in northwest England during the Early Medieval period: investigating 'cultural decline' in the Dark Ages. University of Southampton award 2005–2008. Supervision: Prof. Keith Barber (lead) and Dr Paul Hughes.
Mallon, G (in prep). Patterns of mid-Holocene climate change – evidence from the peat archive. University of Southampton award 2007–2010. Supervisors: Dr Paul Hughes and Prof Keith Barber.

Publications: Professor K.E. Barber

Keith still continues to publish articles with his many postgraduates and colleagues and the list below will continue to grow…

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Peter Langdon*, Paul Hughes, Tony Brown
Geography and Environment, University of Southampton, Southampton, Hampshire SO17 1BJ, UK

* Corresponding author.
E-mail address: p.g.langdon@soton.ac.uk (P. Langdon)

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