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Guest Editorial

Climate impact on ecosystem changes and human responses during the Last Glacial and Early Holocene: A contribution to the INTIMATE (INTegration of Ice-core, MArine and TErrestrial records) COST Action ES0907

1. Introduction

The objective of INTIMATE [http://intimate.nbi.ku.dk/] is to reconstruct past abrupt and extreme climate changes over the period 60,000–8000 years ago, by facilitating INTegration of Ice core, MArine, and TErrestrial palaeoclimate records and using the combined data in climate models to better understand the mechanisms and impact of change, thereby reducing the uncertainty of future prediction (see further Rasmussen et al., 2014a and references therein). The INTIMATE COST action [http://cost-es0907.geoenvi.org/], which formed part of the INTIMATE project was organised into four working groups.

Working Group 4 on climate impacts aimed to gain insights into the impacts of past climatic changes on animal and human populations and the ecosystems of which they are part. This included the quantification of the magnitudes and rates of population, species, and ecosystem responses in space and through time.

The Working Group 4 workshop held at November 6–7, 2012 at Ghent University, Belgium united palaeoecologists and archaeologists with the aim of investigating relationships between ecosystem and human responses to palaeoclimate change 60,000–8000 years ago. The discussions focused on the integration of palaeo-environmental and archaeological datasets and their correlation to the different palaeoclimate change events detailed in the recently extended INTIMATE event stratigraphy (Blockley et al., 2012; Rasmussen et al., 2014b). During the workshop, participants from the broad field of universities, museums and archaeological institutes across Europe (see Table 1) compared and discussed insights on ecosystem responses to palaeoclimate change 60,000–8000 years ago by integrating palaeo-environmental and archaeological data. Contributions focussed on the issue of differential chronological precision between palaeo-environmental proxies and archaeological records and the problems of response time correlation. Emphasis was placed on the ways in which different components of the ecosystem responded to these different palaeoclimate change events, and how variable responses might have differentially impacted human societies throughout Europe.

2. Bringing together palaeoecologists and archaeologists

Important part of the workshop was to exchange knowledge and ideas about the interactions of climate, environment and humans during the Last Glacial–Early Holocene. During the workshop presentations and discussions some issues arose which are outlined below and may serve as guide-lines for future studies integration archaeological and environmental records. Key issue of discussion was to what extent humans will have been influenced by (rapid) climate changes, in other words:

Can we see a human response to the events as recorded in the Greenland ice cores, what is the role of ecosystem changes, and if so do we see leads and lags in response?

An important role within INTIMATE is the dating and correlation between records, and this one of the other issues we addressed. Other issues were related to the role of different proxies to determine environmental change, and the level to which certain responses are lagging climate change.

What is the best proxy to provide environmental evidence, which parameters are of interest for the archaeological community?

One of the main questions was the issue, to what extent were climate parameters determining human behaviour? It is highly likely that the large-scale climate transitions between Stadials and Interstadial will have influenced human behaviour, but in the case of the smaller events such as the Preboreal Oscillation (Hoek and Bos, 2007), or 8.2 ka event (van der Horn et al., 2015), humans might have been able to adapt to the new conditions, or the impact of climate change was relatively small or only regionally important.

Generally, the impact of climate change on humans will be indirect through the changes of the environments such as changes in vegetation of landscape and the human resources. Furthermore, water availability is crucial for humans, but also natural resources, and this all requires knowledge on past ecosystems. This means that several proxies, which might in the first place have no direct relationship to human activity or presence, may give valuable information on environmental changes. Other issues are also important: Humans operate at the ecosystem level, are their tools appropriate for their lifestyle? Do people adapt their technology to cope with their environment? Land-use strategies influence

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Table 1
Participants in the INTIMATE WG4 Workshop Ghent, November 2012.

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Angelica Feurdean	Senckenberg BiK-F, Frankfurt am Main, Germany
Bent Odgaard	University of Aarhus, Denmark
Catherine Jessen	The National Museum of Denmark, Denmark
Christophe Cupillard	University of Franche-Comté, France
Clive Bonsall	University of Edinburgh, UK
Damien Flas	University of Liège, Belgium
Daniele Colombaroli	University of Bern, Switzerland
Danielle Schreve	Royal Holloway University of London, UK
Erick Robinson	Ghent University, Belgium
Giovanni Boschian	University of Pisa, Italy
Hanneke Bos	ADC-ArcheoProjecten, The Netherlands
Hilary Birks	University of Bergen, Norway
Kristoffer Buck Pedersen	Museerne Vordingborg, Denmark
Marie-Hélène Moncel	National Museum of Natural History, France
Martin Street	MONREPOS-Neuwied, Germany
Martin Theuerkauf	University of Greifswald, Germany
Michael Meyer	Innsbruck University, Austria
Michel Magny	University of Franche-Comté, France
Miikka Tallavaara	University of Helsinki, Finland
Mikael Manninen	University of Helsinki, Finland
Nelleke van Asch	Utrecht University, The Netherlands
Olaf Jöris	MONREPOS-Neuwied, Germany
Paul Pettitt	University of Sheffield, United Kingdom
Philippe Crombé	Ghent University, Belgium
Rob Dinnis	The British Museum, United Kingdom
Thijs van Kolfschoten	Leiden University, The Netherlands
Vanessa Gelorini	Ghent University, Belgium
Wim Hoek	Utrecht University, The Netherlands

survival during ecosystem changes. The ecosystem controls the social economy and lifestyle and the need for improvement and adaptation. Therefore, we need to reconstruct the ecosystem in which the people were living. People live in terrestrial ecosystems, which can be reconstructed most meaningfully from plant and animal (e.g. small mammal; mega-herbivore) evidence (e.g. Ponomarev et al., 2015). People live near water, so the aquatic and wetland ecosystems should also be reconstructed (Birks et al., 2015).

How can we improve the chronologies for the determination of environment vs. human activity relationships?

Correlation of archaeology and natural environment is difficult to obtain from single locations. A general rule is to follow event-stratigraphic approach, discard local chronostratigraphical terminologies and obtain accurate chronologies and perhaps use tephrostratigrapy. For palaeoclimatic data, the precision of the event stratigraphy should be taken into account. For archaeological data the detail of the chronology should be evaluated (e.g. Crombé et al., 2014).

With regard to ^{14}C dates it should be realised that not all dates give an exact answer. Some imprecision should be accepted, as well as the possible lesser reliability of especially older dates, or bulk dates. Therefore, follow ^{14}C conventions and always mention raw dates and lab codes, because calibration of dates beyond the Pleistocene–Holocene boundary will change.

The ‘wiggles’ in the oxygen isotope records from Greenland (Rasmussen et al., 2014b) and in the radiocarbon calibration curve (Reimer et al., 2013) may not be ‘significant’, and therefore should be correlated with caution, not by cherry-picking the best looking wiggle. Other dating methods, e.g. OSL, U–Th, can provide checks, especially for the period beyond 15 ka.

There are zones of uncertainty around all dating methods, even ice cores. Chronology is central for correlation. Besides statistical probabilities associated with measurement of dates, material for radiocarbon dating can also include reservoir ages caused by the origin of the carbon, and contamination during deposition and during sampling.

How can we deduct leads and lags, and to what extent is human response lagging (abrupt) climate change?

Correlations over space and time can provide the rates of geographical spread of ecosystem changes (e.g. spread of forest), which are drivers of population changes, adaptations, and movements. These could be mapped through defined time-slices, and tephra can be used as time markers (e.g. Cupillard et al., 2015).

Integrated studies, combining both archaeological and environmental changes provides usually the best indications for the existence of different response times. Therefore, evidence from different lines of research (e.g. sedimentological, botanical, palaeontological, archaeological) should be combined (e.g. Bos et al., 2012; Mortensen et al., 2014) preferably by interdisciplinary cooperation. It is important to know that also climate reconstructions have ‘error bars’, usually $\pm 1\sigma$. Furthermore, the role of scale is important: archaeological data is often linked to small-scale habitats and palaeoenvironmental reconstructions should be comparable to this scale. It further depends where people lived: if they lived in ecotonal areas, there were likely more susceptible to changes in the environment.

3. Contents of this special issue

This special issue consists of the following papers, resulting from the presentations during the workshop. Some of the papers presented were already in preparation for other journals but are closely linked to this volume (Moreno et al., 2014; Tanţău et al., 2014).

The paper on ecosystem responses to palaeoclimate change 60,000–8000 years ago: integrating palaeo-environmental and archaeological data (Birks et al., 2015) gives the outcomes of the discussions and will hopefully serve as a guide for further integrated studies.

The following paper on Holocene climate change and prehistoric settlement in the lower Danube valley (Bonsall et al., 2015), a detailed analysis of archaeological dates is presented. The frequencies of the (Early) Holocene ^{14}C dates are likely related to environmental conditions such as decreased number of dated archaeological artifacts related to flooding events, thereby implying a direct relationship between environmental change and human activity.

Moncel et al. (2015) evaluated the integrity of palaeoenvironmental and archaeological records in MIS 5 to 3 karst sequences from south-eastern France. In this study, several dating techniques as well as multiple proxies are combined to reveal the potential climate and environmental impacts on human (Neanderthal) occupation of caves and rock shelters.

In the following contribution, Cupillard et al. (2015) present an overview of ecosystem and human responses to palaeoclimate change in the Jura Mountains between 40,000 and 8000 cal BP. This comprehensive overview of available data including shows several periods of prolonged habitation, and although more research is required to fill the gaps in knowledge, there seems to be link between different cultural aspects and large-scale climate changes. However, in such a large area, there is always the need for more evidence.

Jessen et al. (2015), provide a detailed study on a smaller geographical scale focussing on an Early Maglemosian culture in the Preboreal landscape: Archaeology and vegetation from the earliest Mesolithic site in Denmark at Lundby Mose, Sjælland. In this paper, an excellent example of an integrated study is presented with sedimentological, chronological, palaeoecological evidence from a classic archeological site. Furthermore, the importance of particularly pollen-influx for vegetation reconstruction is outlined.

In the paper by Ponomarev et al. (2015) on Lateglacial desman discovered in Sed'yu-1 (Komi Republic, Russia), a site in the far northeast of Europe, the value of small mammals for the reconstruction of environmental changes is presented. Desman together with other small mammals, give additional information on the environment and are also associated to archaeological sites and appear to be related to relative warmer intervals during the Lateglacial and Early Holocene.

Markova et al. (2015) make use of the PALEOFAUNA database in order to investigate the changes in the Eurasian distribution of the musk ox and the extinct bison during the last 50 ka. For the Glacial period, the distribution patterns of these large mammals, which are characteristic species for the Mammoth Steppe, appear to be asynchronous over the Eurasian continent. The decrease of their ranges and their extinction during the Holocene (as a part of the Megafauna extinction in Eurasia) was primarily connected with changes in climate and partly the result of Anthropogenic pressure.

In the last paper, van der Horn et al. (2015) evaluate the effects of the 8.2 ka event on the natural environment of Tell Sabi Abyad, Syria with implications for ecosystem resilience studies. This paper demonstrates that the impact of a clear climate event, such as the 8.2 ka event as recorded in the North Atlantic Region, might not have had a large effect in areas also influenced by other atmospheric circulation patterns. Furthermore, the importance of other climate factors than temperature such as precipitation, which is usually more difficult to reconstruct, should not be underestimated. Finally, van der Horn et al. (2015) state that in certain cases, environmental changes might well have been caused by human activity changes, rather than the other way around. This implies that environmental and archaeological changes should be given equal weight in ecosystem resilience studies.

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