Editorial: Quaternary of the British Isles and Adjoining Seas

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1. Introduction

This volume of the Journal of Maps is one of four volumes published from an Annual Discussion Meeting (ADM) of the Quaternary Research Association (QRA), in January 2008, to examine the Quaternary of the British Isles and the adjoining seas. This volume deals with evidence for Quaternary environmental change in map-form, and the other volumes, which will be published in the journals *Quaternary Science Reviews*, *Journal of Quaternary Science* and *Proceedings of the Geologists' Association* will be concerned, respectively, with Quaternary climates and climate change, Quaternary landscapes, and Quaternary Geology.

The QRA ADM on the topic of the **Quaternary of the British Isles and the adjoining seas** was organised to review the subject upon which a vast amount of work has been done since the last meeting on the topic in 1977. The meeting also marked the 40^{th} anniversary of the founding of the QRA (although the research group was initially founded in 1964 as the Quaternary Field Study Group) and was a QRA contribution to the International Year of Planet Earth. The meeting was organised in partnership with the Royal Geographical Society and was sponsored by INQUA, the Geologists' Association, the British Society of Geomorphology, the British Geological Survey, Natural England, Elsevier and Wiley, with support from the Royal Society.

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The topics of the meeting have been the subject of a very large number of papers in important international journals such as Nature, Science, Quaternary Science Reviews, The Holocene, Journal of Quaternary Science, Boreas, Quaternary International and Proceedings of the Geologists' Association, but the QRA ADM was the first meeting to consider this topic in a comprehensive fashion since the X INQUA Congress held in Birmingham 1977. The Birmingham Meeting resulted in the publication of **British Quaternary Studies** edited by Fred Shotton, and the **X INQUA Congress Excursion Field Guides** edited by David Bowen and in many respects these publications provide a benchmark for the subject. It is the intention of the 2008 meeting to establish a new benchmark for the future - hence the attention that has been given to achieving a comprehensive array of papers in thematic volumes of international refereed journals.

2. Quaternary Environmental Change

The period of geological time that is known as the Quaternary covers the last c. 2.6 million years, including the present. It is a period in which the climate changed, in areas like the British Isles, from glaciation or permafrost (known as glacials) to cool temperate (like Britain now) or even warm temperate (like the Mediterranean) (known as interglacials), and it is a time in which climate and environmental change could be frequent and exceedingly rapid. For instance, there have been at least 10 glaciations in the last million years and the climate changed from the Last Glaciation to the present Interglacial within the duration of a normal human lifespan. The scale of these climate changes, and their proximity to the present, means that an understanding of the Quaternary is critical for understanding the consequences of present-day human-induced climate change. It also provides us with the evidence we need to test some of the predictive models developed for different climate-change scenarios.

The main cause of these climatic changes is variations in solar radiation caused by variations in the Earth's orbit around the sun, modulated or enhanced by internal interactions and feedbacks. The region of Britain is one of the areas of the Earth that shows the greatest and most rapid changes in climate - the reason being the proximity of the British Isles to the North Atlantic ocean and the fact the this ocean can transport a vast store of heat to northern latitudes by way of the North Atlantic Conveyor/

North Atlantic Drift. This means that at times like now, the British Isles are anomalously warm, but if the Conveyor is switched-off, or cannot reach the latitude of Britain then the climate of Britain reverts to a cold (tundra/ permafrost/ glacial) climate appropriate for its latitude, with a high moisture content appropriate to it's position windward of a large ocean.

The consequence of this is that the British Isles and adjoining seas have experienced the effects of Quaternary climate changes in a most dramatic way, and powerful physical processes, such as those of glaciers, permafrost, rivers and slope mass movement have made significant and long lasting changes to our landscape and geology. Likewise the temperate episodes have been times of very high bio-productivity when there was dense or productive vegetation cover and relatively high faunal populations including large mammals such as elephants, hippopotamus and humans. With these forcing controls the British landscape shows a striking imprint of Quaternary climate and environmental change. Northern and central Britain show clear evidence of glacial conditions, while southern Britain remains, in the main, a landscape inherited from permafrost processes. Likewise river systems, in periods of high discharge when spring snow-melt was an important process, or glaciers were melting from the landscape, have the power to erode the uplands and built-up the river terraces of the lowlands. In contrast, in the moist temperate periods like now (but without humans) rivers have little power and do little work. Nevertheless, floodplains and pools in river channels have the ability to hold the records of biological changes that would otherwise be destroyed on the oxygenating conditions of the surrounding landscape. Likewise the coastal zone and the offshore regions provide a record of changes of sea-level, and within the accumulating stacks of offshore sediments it is possible to extract the result of the long-term history of the processes that produced and transported the materials from the land to the adjacent seas.

3. X INQUA Congress

It is interesting to reflect upon the changes that occurred over the last 40 years since the 1977 INQUA Congress. This can be done by reference to British Quaternary Studies (Shotton, 1977) which consisted of 20 papers. Two of these, by Nick Shackleton and that by Hubert Lamb, are concerned with climatic changes through time. They have significantly changed our approaches to climate change and this is an issue that concerns much of present day Quaternary science. One paper is concerned with dating methods, and three are concerned with the stratigraphic developments within Britain: vegetation patterns, humans and shallow marine systems. Five papers provide a systematic review of a biological proxy (non-marine mollusca, marine mollusca, Coleoptera, vertebrates and humans), and six provide a systematic review of a physical proxy or process (neotectonics, rivers, shorelines, glaciers, periglaciation and wind-blown sediments). Only one of these papers gives any attention to modelling (glacial modelling by Boulton), and only one attempts numerical reconstruction of climate or process (Coope with Coleoptera). One paper (that by John Birks) adopts an ecological approach to Holocene vegetation development and the remaining two papers take a regional approach - the seismic stratigraphy of the North Sea basin and the problems of glacial-interglacial stratigraphy of midland and eastern England (something that still engages British Quaternary scientists). Although geomorphological and geological mapping had been a major element in Quaternary science prior to 1977, there are only a few maps in the volume, and no geomorphological maps; and the volume gives relatively little attention to spatial distributions.

In many ways the papers indicate subjects in early stages of development with attempts to establish proxy methods for the determination of Quaternary climates and environments and the attempts to get to grips with stratigraphic problems. There is remarkably little about Britain in the world as part of Earth systems (to which a spatial variable is fundamental) and little about the complex responses between the climate forcing processes that today dominate the subject (again the complexities of our landscape reflects the effects of these complex responses). Likewise there is remarkably little about precise timing of events and rates of change. Nevertheless others are concerned with problems that still attract our attention, although these often take the form of local or regional biographies. Much of what Nick Shackleton has to say in his very brief review of oxygen isotope stratigraphy is still steering British and global Quaternary science.

4. Spatial Distribution of Quaternary Features

This volume of Journal of Maps publishes some of the recent work examining the Quaternary history of the British Isles. These publications are important because they portray the spatial distributions of features that are caused by the earth surface processes that are driven by climate changes, and spatial distributions are critical for human occupance of the landscape. This is the land upon which we live, move and provide our subsistence and the way this landscape responds to climate change is critical to our future survival.

With the rapid rise in interest in geomorphological mapping in the 1960s it is surprising that **British Quaternary Studies** gave litte attention to spatial distributions, however it was a labour intensive, analogue technique that required considerable resources. The 1970s saw the deployment of satellites specifically targetted at acquiring imagery for environmental monitoring, yet it was not until the 1980s that they were specifically used for the geomorphological mapping of Quaternary landforms. Attention at the time was concerned more with stratigraphic sequences, biological proxies of climate and environment and techniques for dating or correlating periods of Earth history. The development of remote sensing was mirrored by advances in the digital handling of spatial data. Since the 1990s there has been a rapid increase in the use of remotely sensed data for Quaternary mapping and their storage and analysis within computer systems. Geomorphological mapping has seen a resurgence in recent years, and this volume of the Journal of Maps uses digital technology to reflect these new initiatives.

A final factor that should be highlighted here is that this issue of Journal of Maps can also be seen as a marker to the future with respect to the compilation and use of spatial information. By examination of all the papers in the volume it is clear that they are concerned with regions that have been affected by high energy or persistent surface processes such as glaciation, periglaciation, steep gradient rivers, mass failure and extensive river sedimentation. In this respect this is typical of all Quaternary mapping throughout the history of the subject. However, the use of high resolution digital imagery used in some of these papers highlights the great potential for identifying much smaller scale landforms, such as shallow landslipping, incipient deep landslipping, floodplain textural variation and small-scale glacial lineaments that may have immense significance for human activity with respect to issues like slope failure, flooding and foundation stability. With further development of these techniques, higher quality and finer resolution images will have the potential to make possible significant breakthroughs in the use of geomorphological mapping as a essential predictive tool for the evaluation and management of landscape for human activity.

5. Annual Discussion Meeting

Smith et al. (2008) present a map of historic striae observations for Ireland, principally recorded from the British Geological Survey's memoirs accompanying the First Series maps. Not only is this database extensive at over 5000 records, but ∼10% of the observations also record cross-cutting and relative ages. Such a large and extensive database is unusual in itself and will allow the authors to draw inferences about ice flow directions in areas with observations. Erosional (striae) and depositional landforms are often mutually exclusive and this work should therefore compliment that of Greenwood and Clark (2008).

Rose and Smith (2008) present original geomorphological mapping from the 1960s covering ∼750 km^2 of terrain in the Midland Valley, Scotland. This depicts both morphology and sedimentology, highlighting the benefit of field mapping in allowing the recording of shape and composition. The fieldwork was completed by Rose and this map, when compared to the maps in the other papers in this volume, clearly demonstrates the differences in style and coverage, and the ability to include verified lithological information. Because of the time and effort involved, and the availability of high quality remotely sensed imagery, it is unlikely that such mapping, in terms of consistency and extent, will be repeated again. The results of this mapping have been used to determine the behaviour of the glaciers across the region during the Last Glacial Maximum and during Younger Dryas time, and the development of the landscape in the interval between these two glaciations and during the present Holocene interglacial.

Greenwood and Clark (2008) present small scale geomorphological mapping for the entire island of Ireland using a combination of satellite imagery and digital elevation models to map topographic glacial landforms. This is a fine example of the current "status" of mapping, utilising remotely sensed data to visualise contemporary landscapes, identify and map glacial landforms and includes some remarkable images of the terrain produced by glaciers moving over deformable beds. Forthcoming results will use this evidence to reconstruct the glacial history (principally the last glaciation) of the island and this map provides a published basis from which other scientists can verify their analysis and interpretation. The authors also explicitly highlight the presence of extensive suites of "ovoid" landforms. These have been identified in the literature before (and identified by Rose and Letzer (1977) as part of the bedform continuum), but island-wide mapping has allowed a greater understanding of their distribution.

Sahlin and Glasser (2008) present an example of contemporary field mapping for Cadair Idris, the largest mountain block in mid-Wales. Of itself, the map is a beautiful cartographic product, designed to the highest standards using a NEXTMap digital elevation model of the area as a base map. It also demonstrates that field mapping remains an important technique, combined to good effect through the use of aerial photos and digital elevation models. It also extensively documents periglacial landforms on the summit plateau, but is not able to demonstrate evidence as to whether their preservation was through frozen bed conditions or as a nuntak.

Livingstone et al. (2008) again demonstrate regional scale geomorphological mapping through the use of digital elevation models for the central sector of the last British ice sheet. This is a morphologically complex region that has been studied by numerous authors dating to the early 1900s. However this remains the first mapping to be published covering the larger region and continues the work of Trotter (1929), Hollingworth (1931), Boardman (1981) and Letzer (1978). Like Greenwood and Clark (2008), the map can be used as a basis for verifying the analysis and interpretation of work to be published.

McCormack et al. (2008) present the final paper in this issue which potentially demonstrates the future of field mapping. Utilising a terrestrial laser scanner, a survey of Coire Mhic Fhearchair, NW Scotland, was completed. Whilst satellite or airborne laser scanners can provide detailed regional data on landscape morphology, terrestrial scanners typically operate on the sub-kilometre scale and are the equivalent of field mapping. The accompanying map demonstrates the utility of such data and we anticipate their increased use.

6. Conclusions

This special issue represents a landmark in the mapping of Quaternary landforms in the British Isles, demonstrating how much progress has been made since 1977 in terms of access to data, theoretical developments and implementation of new techniques and methods. It is also, uniquely, able to present maps from three epochs of mapping in the UK; geological survey mapping in the late 1800s, development of geomorphological mapping in the 1960s and the more recent resurgence in geomorphological mapping. These maps are large scale, field-based, maps, as well as regional scale maps. We hope that these serves as a firm foundation for the development of future research and an archive of the landform record of Quaternary landforms of the British Isles.

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