Quaternary of the Thames (QA-THA)

Block Description

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Introduction

The Quaternary Period is the most recent major subdivision of the geological record, spanning the late Cainozoic Era. Traditionally, it is divided into two intervals of epoch status – the Pleistocene and Holocene. The Holocene Epoch occupies only the last 10 000 years of geological time and is the warm interval or interglacial in which we now live. Consequently, it is often regarded as part of the Pleistocene rather than a separate epoch. In a strict geological sense, the base of the Pleistocene Epoch (and therefore that of the Quaternary Period) is defined in Italy at the type locality of Vrica, where it is dated to about 1.64 Ma (million years ago); it is now well established that the current warm period, the Holocene Epoch, is simply the latest interglacial in a long series of profound climatic fluctuations that have characterized the last 2.4 Ma.

The deep-sea sedimentary record shows that up to 50 'warm' and 'cold' climatic oscillations have occurred within the last 2.4 Ma. Equally, the glacial and interglacial periods cannot be characterized simply as 'cold' or 'warm', respectively; the ice ages were not unbroken in their frigidity since the exceptionally cold phases (stadials) were punctuated by warmer periods (interstadials), in some cases lasting for several thousand years. The fundamental characteristic of the Quaternary Period is therefore one of change through time and space in geomorphological processes, floras, faunas and environmental conditions, all modulated by the changing climate. The record of such changes is preserved in a variety of landforms, sediment sequences and organic remains.

The abrupt onset of the late Cenozoic ice ages is, as yet, unexplained. However, the succession of ice ages (glacials) and interglacials has occurred at known frequencies, and changes in insolation (the receipt of solar radiation at the Earth's surface and throughout its atmosphere) associated with the Earth's orbital rhythms are now established as the principal external driving forces of the Earth's climatic system.

Subdividing the Quaternary Period

The oxygen isotope chemistry of the deep-sea sediment pile now provides the main basis for subdividing the Quaternary swedimentary record, with a number of successive oxygen isotope stages recognized globally. These stages, running counter to normal geological practice, are numbered backwards in time and down through the geological column. Warm periods with correspondingly low volumes of ice are given odd numbers; the present interglacial, the Holocene, is numbered as Stage 1. Times of high ice volume (glacials) are given even numbers; the last main cold phase in Britain, the Late Devensian, being numbered as Stage 2. Stages are also divided into sub-stages, for example, Stage 5 into sub-stages 5a–5e, often reflecting stadial or interstadial events.

The position in the deep-sea sediment cores of a major reversal in the Earth's magnetic field, the Matuyama–Brunhes Reversal at 780 ka, provides a yardstick with which to calibrate the oxygen isotope record. The boundaries of the different isotope stages have also been adjusted and refined with respect to known orbital patterns

British Quaternary environments

In Britain, the area covered by ice varied considerably during different glaciations. During the last (Late Devensian) glaciation, ice extended as far south as the north Midlands, impinging on the north coast of East Anglia and covering most of South Wales. During earlier glaciations ice sheets were more extensive, but probably never reached farther south in south-central and south-east England than the present Thames Valley. In the South-West, there is a longstanding debate over whether pre-Devensian ice masses reached the northern shores of Devon and Cornwall and even the Isles of Scilly.

The major shifts of climate that characterize the Quaternary Period were accompanied by equally profound changes in environmental conditions that left a strong imprint on the landforms, fossils and sediments of Britain. During the cold or glacial stages, substantial areas were subjected to the effects of glacial erosion and deposition and a wide range of landforms and deposits was produced.

As ice sheets melted, vast quantities of meltwater were liberated, giving rise to characteristic suites of landforms and deposits.

Repeated climate change also subjected the flora and fauna of Britain to stress: fundamental changes in the distribution of plants and animals took place. Beyond the margins of the ice sheets and during the cold climatic phases of the Quaternary Period, periglacial conditions prevailed. Such environments were characterized by frost-assisted processes and by a range of frost- and ground ice-generated landforms and deposits. Mass wasting (downslope movement of soil on both large and small scales) and increased wind action were prevalent, also producing a range of characteristic features. In the fossil record, the flora and fauna of these cold periods is, not surprisingly, restricted in diversity and dominated by cold-tolerant species; large areas were dominated by tundra vegetation.

Conversely, the warmer or interglacial periods of the Quaternary are characterized by the absence of glacial, periglacial and glaciofluvial features, and there were times when chemical weathering, soil formation and the accumulation of organic sediments took place. Variations in the quantity and type of pollen grains preserved in organic deposits, such as peats and lake muds, have been used to define systems of pollen zones or pollen biozones. These zones are characterized by particular vegetational assemblages which can be used to chart sequences of vegetational, climatic and environmental change. Traditionally, these have been used as the principal basis for distinguishing between various interglacial phases in the land-based Quaternary record and for the definition of chronostratigraphic stages. Unfortunately, although several distinctive interglacial episodes in the British Pleistocene can be distinguished, very little evolution of the flora actually occurred, thus hindering biostratigraphic correlation. However, interglacial periods can be differentiated broadly on the basis of pollen assemblage zone biostratigraphy, with individual parts of interglacial cycles (sub-stages) being recognized; for example, pre-temperate, early temperate, late temperate and post-temperate sub-stages. Interglacial environments in the British Isles were generally characterized by a climax vegetation of mixed deciduous oak forest. The last time Britain experienced conditions similar to today was about 125 ka, when the interglacial (part of the Ipswichian Stage) lasted about 10 ka.

Unlike the flora, some elements of the Quaternary fauna have evolved. Therefore, certain glacial and interglacial periods can be characterized broadly by distinctive fossil assemblages, particularly those of large mammals. During the last interglacial, for example, creatures such as the hippopotamus, lion and elephant were indigenous to Britain. Likewise, fossils of both terrestrial and marine molluscs and Coleoptera (beetles) can be sensitive indicators of changing climatic conditions by analogy with their present-day environmental tolerances and geographical ranges.

The succession of glacials and interglacials and the growth and decay of ice sheets have been accompanied by equally profound changes in the coastal zone. World sea level has varied in time with the amount of water locked up in the ice sheets, and during glacial stages, world or eustatic sea levels have been lowered. The converse is true during warmer interglacial phases. The level of the land has also varied, sinking under the weight of advancing ice sheets and rising up or rebounding when they melted (isostasy). This complex interplay of changing land and sea levels has left a widespread legacy in Britain, manifested by the many beaches, shore platforms and marine sediments which now lie above the present sea level. Equally, a range of submerged shoreline features, drowned forests and valleys provide important evidence for sea levels which were relatively lower in the past.

Significant changes in the courses of rivers and their channel patterns have also occurred in the Quaternary Period. These are related to changes in discharge, sediment supply and sea level. Some rivers have reworked and built up large quantities of glacially derived sediments along their floodplains. Subsequent down-cutting has sometimes resulted in ‘staircases’ of terraces both in rock and superficial materials. In some valleys, terraces have been traced for considerable distances and been assigned specific names and ages with respect to their contained fossils and stratigraphical position; in many cases they can be ascribed with some certainty to particular interglacial or glacial phases or, more recently, to the oxygen isotope timescale.

The River Thames and its forebears

Few rivers of so modest a size have had so much attention devoted to their deposits and geological history as the Thames. The present size of the river belies its importance to British Quaternary geology, however, since Thames sediments provide a framework for the latest part of the geological record in Britain. Indeed, there is abundant evidence to show that the modern Thames is a mere shadow of its Pleistocene forebear. Not only did it once flow from the London Basin out across East Anglia to north Norfolk, but there are indications that its headwaters may once have drained a large part of the West Midlands and even North Wales. During Middle and Late Pleistocene cold episodes, when sea level was much lower and Britain was joined to the continent, the river extended for many kilometres over areas that now lie offshore; during these episodes it was a tributary of the Rhine system. Thus Thames deposits provide a potential means for correlation between the London Basin and other areas of Britain, as well as with the North Sea Basin and surrounding parts of the European continent.

The river has undergone a number of significant changes during the Pleistocene Epoch, some as a result of glaciation. It appears initially to have been a ‘consequent stream’, flowing along the approximate centre of the London syncline and receiving tributaries from the north and south. Many of the latter would have been of even greater antiquity, having originated on the then newly formed Weald and Chiltern uplands and draining into the sea that covered the London Basin during the Palaeogene. The central drainage of the western end of the London Basin is the province of the River Kennet, the Thames upstream from Reading probably having originated as an early river flowing southwards into the basin down the northern limb of the syncline. The presence of quartz pebbles in the Palaeocene deposits of Buckinghamshire suggests that a fluvial route through the Chilterns, tapping pre-Cretaceous strata beyond, was in existence by that time. The relative lowering of sea level, which brought about marine regression in the late Neogene, was responsible for the initiation of the Middle and Lower Thames as the main drainage line along the emergent sea-floor.

It appears that, by the Early Pleistocene, the Thames had acquired a much more extensive catchment, with Midlands and Welsh detrital material being brought into the London Basin via the Upper Thames system. There is still controversy as to whether the Thames once drained these areas directly, or whether glacial transport carried this ‘exotic’ material into its catchment during the Early Pleistocene. It is apparent that this supply ended by the Middle Pleistocene and that the Upper Thames was at that time confined to the south-east of the Cotswold escarpment.

Terrace formation

There has been considerable debate about the possible correlation between the formation of river terraces and climatic fluctuation during the Pleistocene. A modified climatic model for terrace formation, which may be directly related to the climatic cycles recorded in the oxygen isotope curve is reflected here:

Phase 1 Downcutting by rivers during a time of high discharge, under cold climatic conditions. The limits of this rejuvenation would be controlled by base level.

Phase 2 Aggradation of sand and gravel and the formation of floodplains at the new level; energy levels remain high, but sedimentation now exceeds erosion, leading to a vertical accumulation of sediment (final part of cold half cycle).

Phase 3 Limited deposition by less powerful rivers under temperate conditions (interglacial). This usually takes place in single thread channels covering only small areas of floodplains, although overbank deposits may be more extensive. Estuarine sediments accumulate above phase 2 deposits (often overlapping these) in the lower reaches of valleys.

Phase 4 Climatic deterioration results in increases in discharge coupled with enhanced sediment supplies, brought about by the decline of interglacial vegetation and increases in erosion and mechanical weathering. This causes the removal and/or reworking of existing floodplain deposits and the renewed aggradation of sand and gravel.

The established sequence of Thames terrace features is as follows:

9. Lower Floodplain Shepperton Gravel

8. Upper Floodplain Kempton Park Gravel

7. Taplow Taplow Gravel

6. Lynch Hill Lynch Hill Gravel

5. Boyn Hill Boyn Hill Gravel

4. Black Park Black Park Gravel

3. Winter Hill Winter Hill Gravel

2. Rassler Rassler Gravel

1. Harefield Gerrards Cross Gravel

The stratigraphical framework

The following stages are recognized for this part of the GCR in the sequence post-dating the marine crags of East Anglia (in stratigraphical order):

Flandrian (warm) = Holocene

Devensian (cold)

Ipswichian (warm)

Wolstonian (cold)

Hoxnian (warm)

Anglian (cold)

Cromerian (warm)

Beestonian (cold)

Pastonian (warm)

Baventian (cold)*

* most recent stage within the Norwich Crag, the youngest marine crag.