

Institution: Royal Holloway, University of London
Unit of Assessment: Geography, Environmental Studies and Archaeology
Title of case study:
Pleistocene River Deposits, Quaternary Science and the Aggregates Industry
<p>1. Summary of the impact</p> <p>Quaternary Science research undertaken at Royal Holloway examined the environmental archives provided by ancient rivers, now preserved in part as extensive sand and gravel deposits. In so doing, the research identified the former courses of major Pleistocene river systems in England, in particular the now-extinct Bytham river, the largest in England until its obliteration by the ice sheets of the Anglian glaciation c. 450,000 years ago. The research concerned the geographical extent and quality of these Pleistocene river deposits, as well as their palaeo-environmental context, age and archaeology. The interlinked impacts of the research have been: a) economic, via the identification of resources of economic value to the aggregates industry; and b) cultural, via enhancing heritage preservation in England's sand and gravel quarries.</p> <p>Firstly, then, the research has a direct economic benefit for the UK aggregates industry, which has used the results on Bytham river deposits to predict the location and viability of aggregates resources. This has resulted in new quarries, and in the extension of existing quarries, with a value of aggregate production circa £50m in the assessment period. These impacts were facilitated in part by the Department's close working relationships with a number of quarrying companies. A wider economic impact on the aggregates industry was also delivered through significant changes to the British Geological Survey maps that form an important basis for quarry development.</p> <p>A second impact of the research has been the enhancing of heritage preservation. The Department's relationship with the quarrying industry has had a direct effect on the archaeological and geodiversity policy that regulates its economic activity. Royal Holloway took a leading role in the English Heritage supported National Ice Age Network (NIAN) which engaged the aggregate industry, quarry workers and members of the public in the task of recognising, recording and preserving Pleistocene remains in England's sand and gravel quarries. During the assessment period, NIAN, expert advice from Royal Holloway staff and other dissemination of research has shaped ongoing heritage policy in relation to quarrying and Pleistocene and Palaeolithic remains.</p>
<p>2. Underpinning research</p> <p>The investigation of the environmental archives provided by ancient rivers has been a major research focus of the Centre for Quaternary Research (CQR) at Royal Holloway – particularly in the work of Rose (Royal Holloway Professor to 2007, Emeritus Professor 2007-present), Schreve (Royal Society Research Fellow 2000-4, Lecturer 2004-7, Reader 2007-2010, Professor 2010-present), Candy (Lecturer 2006-9, Senior Lecturer 2009-12, Reader 2012-present), Gamble (Professor 2004-11) and Matthews (Lecturer 2009-present). Collaboration and knowledge exchange with the aggregates industry has been an important part of this research.</p> <p>CQR's research has been of great value to the aggregates industry through improved understanding of Pleistocene sand and gravel deposits. Specifically, Rose's work was central to the 'discovery' of the Bytham River, identifying the river system and presenting the first mapping of its main channel's probable course (Section 3, Reference 1). Having been asked by Bullimores Sand and Gravel Ltd. to identify new sources of red building sand, Rose recognised that the red sands found at the Witham on the Hill quarry in south Lincolnshire were of the type of material found in the West Midlands. Initial analysis of structures indicated transportation to Lincolnshire by a large, eastward flowing braided river. Fieldwork was carried out at natural exposures and quarry sections across Midland and Eastern England (>25 sites), including: section logging, altitudinal levelling, clast fabric analysis, palaeocurrent analysis, Munsell Color analysis and Kubiena Tin sampling. Laboratory analyses of samples from these sites and from borehole cores (>74) was undertaken, including: particle size analysis, clast lithology, heavy mineral analysis, micromorphology, geochemistry, pollen analysis, macro-floral and macro-faunal analysis. This was used to identify and reconstruct the main channel of the Bytham, and to analyse its channel deposits (sand and gravel) and its overbank deposits (silty clay loams). Subsequent research</p>

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improved understanding of glaciations, and of the pre-existing river systems, and thus developed the mapping of the Bytham River and its sediments, and thereby increased their potential for aggregate extraction (References 2, 3, 4).

Analysis of these fluvial archives has been of enormous value in understanding Britain's changing Quaternary palaeogeography, re-dating major episodes of lowland glaciation, reconstructing past environments (including episodes of exceptional warmth) and, ultimately, leading to the recognition of one of Britain's oldest early human occupation sites at Pakefield, Suffolk, at the seaward end of the Bytham. This focus on fluvial archives has led CQR to play a key role in developing the relationship between Quaternary Science, archaeology and the aggregates industry. Commercial sand and gravel quarrying has enormous potential scientific and heritage benefit. But it is also a necessarily destructive process, so the positive impacts of aggregates quarrying for reconstructing the history of the last several million years cannot be realised unless remains are adequately recorded, recovered and interpreted. As part of its research strategy, the Department has therefore worked to ensure that the significance of these discoveries are recognised by the industry, and that the industry responds to wider public and scientific need for the responsible management of extraction.

3. References to the research

- 1) Rose, J. 1994. Major river systems of central and southern Britain during the Early and Middle Pleistocene. *Terra Nova*, 6, 435-443
- 2) Rose, J., Lee, J.A., Candy, I and Lewis, S.G. 1999. Early and Middle Pleistocene river systems in eastern England: evidence from Leet Hill, southern Norfolk. *Journal of Quaternary Science*, 14, 347-360
- 3) Rose, J., Moorlock, B.S.P. and Hamblin, R.J.O. 2001. Pre-Anglian fluvial and coastal deposits in Eastern England: lithostratigraphy and palaeoenvironments. *Quaternary International*, 79, 5-22
- 4) Rose, J. 2009. Early and Middle Pleistocene landscapes of eastern England. *Proceedings of the Geologists' Association*, 120, 3-33

4. Details of the impact*a) Economic impacts: context*

The primary impact of this research is wealth creation and the stimulation of economic activity in Central and Eastern England. Mapping of Bytham River deposits through examination of sand and gravel exposures and borehole data, combined with geochronological advances, provided not only a primary archive for Quaternary and Archaeological research but a major source of information for the aggregates industry seeking new mineral resources to extract for national priority developments in housing, business and infrastructure. The Bytham Sands and Gravels produce both un-washed (as raised) and washed products of commercial value, including: i) building sand; ii) sharp sand for screeds, rendering, and other such coatings; iii) asphalt sand; iv) mixed ballast for concrete; and v) '20 mm down' and '40 mm down' gravel mainly used for drainage. The ability to derive building sand and asphalt sand from an unwashed product makes the deposit of especially high value. The typical Bytham river aggregate is either a distinctive red sand or a very durable quartzite-rich sand and gravel; both are high-quality 'clean' products with minimal clay. The durable composition and good condition of the sands and gravels deposits is a reflection of the course of the river, eroding through the West Midlands. The purity of the aggregate is due to burial beneath glacial deposits and protection from soil-forming processes that cause the production of clay. As well as being valuable for their quality, the Bytham Sands and Gravels are also notable for their quantity. The Bytham River was very large, with an extensive catchment reaching from the West Midlands and southern Pennines through East Anglia to the North Sea. It thus provides an unparalleled potential aggregates resource in the UK. Importantly, it is located close to major urban and development areas across the Midlands and East Anglia, thus reducing transportation costs.

b) Economic impacts: new quarries (Red Barn and Brooksby)

The initial work on the identification of the Bytham River course led directly to an extension of Bullimores' quarry at Witham on the Hill, the opening of a new quarry to the north of the original site in the mid-1990s, and then a totally new quarry on the Bytham deposits at Red Barn, Castle Bytham, South Lincolnshire. Rose has served as a non-executive director for Bullimores since 1995, providing the Company with scientific advice on the location and viability of deposits. In relation to the REF2014 impact period (January 2008 to July 2013), Red Barn quarry has remained

in full production through the period and has subsequently been extended. For all quarry companies, detailed information about the productivity and profitability of individual quarries is commercially sensitive information, but broad estimates of the value of the deposits during the REF assessment period are possible. Bullimores were limited by planning control to the extraction of 90,000 tonnes a year; this figure was achieved in all years except 2012 when the workings were severely affected by both the recession in the building industry and extreme weather which increased the level of the water-table and hence running costs. Factoring this in, production over the REF2014 period (5.58 years) can be conservatively estimated at 450,000 tonnes. Prices for asphalt sand, building sand and sand and gravel in 2013 are in the order of £30 per tonne. A conservative average price of £25 per tonne 2008-13, suggests a commercial value of c. £11.25m for the Bytham Sands and Gravels production at Red Barn over the REF2014 assessment period.

In 2000, Lafarge Aggregates drew directly upon established knowledge of Bytham Sands and Gravels made available to the landowners to apply for planning permission for a major new quarry at Brooksby, Leicestershire. Their analysis drew upon earlier research in association with Rose, funded by Bullimores. Brooksby came into production in 2006 with sales starting the following year. Annual production in the REF2014 assessment period has been around 300,000 tonnes per annum, with remaining reserves of around 4m tonnes. If again we factor in a reduction in production in 2012, and use a cautious estimate of average production at 250,000 tonnes per annum, then at £25 per tonne for 5.58 years a conservative estimate of the gross value of material extracted from Brooksby in the period is c. £35m. From these two quarries, then, where Rose has provided direct scientific advice on aggregate locations, an estimate of the value of production is in excess of £45m for the REF2014 assessment period.

c) Economic impacts: quarries sustained and extended on Bytham deposits

Along the course of the 'river', knowledge of its existence has facilitated the development of the aggregates industry. The Bytham river research crucially altered the British Geological Survey maps, indicating the potential existence of extensive, high quality aggregates. BGS maps were altered as follows to show the Bytham Sands and Gravels: i) 1:50,000 Series - Map 142 Melton Mowbray, 2002; Map 155 Coalville, 2010; Map 156, Leicester, 2007; Map 174, Thetford, 2010; Map 176; Lowestoft 1996; ii) 1:200,000 series - East Anglia, Sheet 52N 00, Quaternary (n.b. on East Anglian sheets the formation related to the Bytham river is sometimes shown as the Ingham Sands and Gravels). There has also been further direct contact by Rose with aggregates companies on these deposits. Significant clusters of quarries already existed on Bytham deposits but, even where the deposits were already known and being exploited, the Bytham work indicated the likely viability of extensions to quarries. In these cases, the Bytham research and the BGS maps have been one factor in development decisions. For example, at Leet Hill / Kirby Cane Rose was directly consulted, and the extensions made delivered production at c. 50,000 tonnes p.a. for the REF period (@ £25 per tonne = c. £7m over the period). More generally, production figures for key East Anglian quarries on Bytham deposits such as Timworth (c. 500,000 tonnes per annum in the REF2014 period), Norton Subcourse (c. 100,000 tonnes per annum) and Flixton (c. 180,000 tonnes per annum) give a sense of the scale of the economic turnover that the Bytham river mapping supports (@ £25 per tonne = c. £108m in the REF period).

d) Impacts on heritage preservation

The research has had a further impact in developing the relationship between Quaternary Science, archaeology and the aggregates industry, with changes to industry practice and protocols, and to public awareness of the significance of quarries as heritage sites. The relationship between science and the aggregates industry is double-sided. The very process of mechanised aggregates extraction can destroy both sites and material unseen, but many significant sites are only uncovered through the work of the industry. In the absence of statutory protection, it is clear that the challenge of monitoring these quarries for significant finds must be achieved through partnership, between geologists, palaeontologists and archaeologists, between professionals and amateurs, but most of all partnership with the aggregates industry. This is of crucial importance within UK archaeological heritage policy, given the limited opportunities for Pleistocene archaeological mitigation in comparison to the traditional 'surface' archaeology of the Holocene.

Royal Holloway geographers have sought to effect such partnerships in a number of ways. As noted above, staff have worked directly with quarrying companies, as with Rose's non-executive

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directorship at Bullimores which has fostered good practice with regard to Palaeolithic and Pleistocene materials in their quarries. Another important strand has been the work of Rose, Schreve and Candy in the high-profile *Ancient Human Occupation of Britain* (AHOB) project, funded by the Leverhulme Trust (£3.3m) from 2001-2013, and led by Professor Christopher Stringer (Natural History Museum and Visiting Professor in the Department of Geography at Royal Holloway). Science in quarry sites has been central to the work of AHOB, which has provided high profile evidence of the earliest known sites of human occupation in Britain. Thirdly, Schreve was Primary Contact, and Royal Holloway one of four hubs, for the *National Ice Age Network* (NIAN), funded from the Aggregates Levy Sustainability Fund (2005-7) and supported by English Heritage. The other HE partners were the University of Leicester and the University of Birmingham. The fundamental aim of the NIAN project was to raise awareness of the importance of Ice Age materials uncovered during commercial aggregate extraction and to get a 'better deal', long term, for these remains. Royal Holloway's work within NIAN has had lasting impacts into the REF period through: i) site visits to every significant quarry in SE England and the Home Counties, to assess for scientific interest and raise industry awareness of good practice; ii) widespread public engagement activities to encourage local enthusiast groups to visit and to work with the aggregates industry (lectures, site visits, travelling displays, 140,000 leaflets distributed to the public on the scientific significance of quarries); iv) work with the industry body, the Quarry Products Association (now Mineral Products Association) to attempt to establish protocols for the industry in relation to Palaeolithic and Pleistocene materials. Building on this work, Royal Holloway geographers made central contributions to the development of English Heritage's national Research and Conservation Framework for the British Palaeolithic (2008), as Chair (Gamble, then at Royal Holloway) and as representatives of NIAN and AHOB (Schreve) and of the Geologists' Association (Rose). This input was particularly significant in shaping the Framework's collaborative approach to 'dealing with development' and the aggregates industry (p.16 of source 6). The Framework explicitly recognises the role played by NIAN saying it had 'done much to raise the profile of Pleistocene remains discovered during quarrying' and initiated an 'effective and systematic approach towards the recognition, reporting, recovery and recording of such materials' (pp.4-5 of source 6). English Heritage confirm that the 'industry has now formally acknowledged the need for the archaeological treatment of Palaeolithic archaeological remains within the sediment body by its adoption of practice guidance on mineral extraction and archaeology which explicitly refers to the need for appropriate monitoring and mitigation of Pleistocene remains in such contexts' (source 4, 2013).

The impact on the relationship between the industry and heritage also works through individual quarries and officials. At Brooksby, for example, the Leicestershire County Archaeologist's awareness of research on the Bytham (e.g. Rose, 1994) led directly to a requirement for there to be Palaeolithic and Pleistocene archaeological mitigation as part of the formal planning consent for extraction in 2000 (source 5). This has been enacted in the assessment period and, since 2009, CQR staff have been collaborating with the University of Leicester Archaeological Services unit for the Pleistocene mitigation at Brooksby.

5. Sources to corroborate the impact

- 1) On the role of the underpinning research for the development of Red Barn quarry and in shaping company mitigation practices: Bullimores Sand and Gravel Ltd.
- 2) On the aggregates production and mitigation at Brooksby quarry: National Mineral Development Manager, Lafarge Tarmac.
- 3) On the significance of the Bytham River research for the mapping of British Pleistocene deposits by the British Geological Survey: Quaternary Geologist, British Geological Survey.
- 4) On the role of NIAN in initiating discussion with the aggregates industry regarding protocols for recording and monitoring the Palaeolithic and Pleistocene resource in quarries: Inspector of Ancient Monuments and Senior National Minerals and Environmental Adviser, English Heritage.
- 5) On the role of the underpinning research in the mitigation strategy at Brooksby quarry: County Planning Archaeologist for Leicestershire 1990-2001.
- 6) Pettitt, P., Gamble, C. & Last, J. (eds) (2008) Research and Conservation Framework for the British Palaeolithic (English Heritage). Available at: <http://www.english-heritage.org.uk/publications/research-and-conservation-framework-for-british-palaeolithic/>