Fuelling the Early State: Understanding Energy Use, Resource Management, and Environmental Impacts in the Development of Early Urban Societies (Ref IAP2-18-148)

Durham University, Department of Archaeology

In partnership with Newcastle University and Zeiss International (CASE partner)

Supervisory Team	• **Dr Kamal Badreshany, Durham University, Department of Archaeology** • **Dr Lisa-Marie Shillito, Newcastle University, School of History, Classics and Archaeology** • **Dr Shaun Graham, Zeiss International** • **Dr Dan Lawrence, Durham University, Department of Archaeology** • **Professor Graham Philip, Durham University, Department of Archaeology** • **Professor Chris Greenwell, Durham University, Department of Earth Sciences**

Key Words	**1. Near Eastern Archaeology, Early Urbanism, Landscape Archaeology, Biofuels, Energy Resource Management**

Overview

Fuel was fundamental to the step-change in production associated with the emergence of early complex societies in the Near East. However, the role played by the deployment and management of fuel resources in this process remains poorly understood. As access to fuel sat at the nexus of a set of contemporary developments – changing transport infrastructure (donkey domestication and wheeled vehicle), extensification of agriculture, woodland management, the collection of animal dung, changes in the demand for fuel had significant implications for everyday activity, and modes of human-environment interaction

The Fertile Crescent of Middle East offers a classic example of such developments, including the earliest urban agglomerations, small scale polities and the first territorial empires. Climate and environmental fluctuations are generally considered to be a significant factor in understanding the impetus towards the development of earliest states because in pre-industrial societies they have been directly related to food production and security (Lawrence et al. 2016). Energy capture, more broadly, has been used as a proxy for complexity (Morris 2011). The archaeological record associated with early states evidences rapid population growth, new infrastructure, and increases in the type and scale of craft-industries. Underpinning these developments would have been commensurate increases in fuel consumption, with wide ranging environmental and social impacts, and yet this aspect of the energy economy has received limited attention. Improving our understanding of fuel resource management and unravelling it from agricultural and craft production enables a more nuanced understanding of the social processes which facilitated the development and decline of early urban states.

Given the critical importance of fuels, this project will employ a multidisciplinary framework to investigate the role their procurement and consumption played in the development of the earliest urban societies. Specifically, the project will focus on a key Early Bronze Age (ca. 3000-2500 BC) industry, ceramic production, in two different environments: northern coastal Lebanon (Mediterranean climate) and north-eastern Syria (semi-arid climate). The aim is to investigate the development of supply chains, energy use, and environmental impacts before, during and after this period, which is associated with a vastly greater scale of craft production.

The student will be at the nexus of a large-scale international research framework consisting of three ongoing major projects, the CRANE project (*Computational Research on the Ancient Near East* – Philip, Badreshany, and Greenwell) funded by SSHRC Canada, the ERC funded *CLaSS* project *(Climate, Settlement, and Society in the Ancient Near East* Lawrence *)*, and the Wellcome-trust funded *Biofuels and Respiratory Health* (Shillito). They will assist in the development of experiments with a potter using different types and combinations of fuels representing the full range of organic materials known to be available in the period (e.g. wood, olive by-products, dung etc) (Shillito et al. 2011, Deckers 2016). They will test their viability and efficiency for use in ceramic manufacture, which will be determined using various analytical methods detailed below. The resulting dataset will be integrated with climate, archaeological and palaeobotanical inputs from the three research projects named above to 1) determine the amount of fuels required to meet scale of ceramic production during this period 2) model what impact the collection of these resources would have on the environment of the two study areas. Expected outcomes include a greater understanding of which fuels were employed as part of wider resource management strategies, the development of archaeometric methods to quantify their use in the archaeological record and ascertaining the implications for human-environment interactions. The production of this unique dataset will allow the development of innovative explanatory frameworks, with great potential to bring about step-changes in our understanding of early urbanism.

Methodology

The student will learn a wide range of techniques used in the analysis of archaeological ceramics and biofuels. They will also work closely with experimental potters from the National Glass Centre in Sunderland and the *CRANE* Project team to build kilns and produce and fire ceramics under different conditions.

Fieldwork:

The student will assist in the design and implementation of the firing experiments, including kiln design, procurement of clay and temper materials, and the procurement of fuels. Where necessary, all samples and permissions required to conduct the proposed analytical program have been obtained by the *CRANE and CLaSS* project teams.

Laboratory Based Analyses:

1) Assessment of Fuel Resources – using calorimetry to test the heating values of various fuels (different woods, animal dung, rancid oil, animal bone etc.). Proximate and Ultimate Analysis will be used to understand the energy value of fuels in light of their composition, variables tested included, moisture, volatile compounds, fixed carbon, and burning efficiency.

2) Geochemical Analysis of Clays and Ceramic Vessels – using X-ray fluorescence (XRF), Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and X-Ray Diffraction (XRD). Aim is to characterise geochemical composition/bulk mineralogy of raw clays and the resulting fired vessels to assess any general chemical changes and those that might specifically relate to various fuel/kiln combinations. The ash samples resulting from the firing will also be tested to identify markers of fuel/kiln combinations that might preserve in the archaeological record.

3) Texture Analysis of clays and ceramics – using Polarising Light Microscopy and SEM/Zeiss Mineralogic will be used to quantify textures (rocks, minerals, and pore space) to understand the relationship between physical and geochemical characteristics and how they are impacted by firing under various fuel/kiln combinations. Zeiss Mineralogic is an SEM based platform for automated texture analyses which vastly increases the detail of textural data and the number of samples that can be analysed for this information. Durham Archaeology has one of only five units available in the UK.

3) Landscape modelling – the student will produce landcover models for fuel related flora for the two study areas. This will involve working with databases and GIS, and supported by the Durham Informatics Laboratory. The results will show how the observed changes in fuel use may have impacted the wider landscape. In conjunction with the wider CLaSS project, the work will allow for the reconstruction of both the agricultural and fuel economies through time.

Timeline

Year 1:
Oct-Dec: Research and writing of literature review. Assisting with organisation of firing experiments.

Begin training in computer-based methods. This includes auditing relevant course work as needed.

Jan-Apr: Training in the practical methods described above in the analysis of fuels for firing experiments, assisting with the planning of firing experiments. Complete training in computer-based methods. This includes auditing relevant course work as needed.

May-July: Training in the practical methods of clay and ceramic analysis described above. Assisting in the planning and scheduling of firing experiments.

Aug-Sept: Assisting with firing experiments in the field.

Year 2:
Oct-Dec: Complete review chapter
Jan-June: Carry-out laboratory analyses of clays and ceramics from firing experiments.
July-Sept: Begin building computer-models. Conduct further firing experiments if needed.

Year 3
Oct-Dec: Complete remaining analytical work or begin writing PhD. PhD can be written either as a traditional 80-100,000 word dissertation or in the form of 4 papers written and submitted to peer-reviewed journals. The student can choose either track, which will be decided early in the PhD.

Jan-Sept: Writing PhD, or the preparation and submission of one paper every 2-3 months.

Year 3.5 (6 months):
Oct-Mar:
Writing PhD, or the preparation and submission of one paper every 2-3 months.

There will be a 6-month placement with a CASE partner the timing of which to be decided early in the PhD. We aim for this to partly or fully coincide with the analytical training in clay and ceramic analyses in Year 2.

Training & Skills

The project will allow the student to develop an advanced and transferable multidisciplinary skill-set in experimental design, analytical materials analysis across a number of platforms (XRF, XRD, SEM-EDS, and ICP), and the computer based (GIS) modelling and interpretation of large-scale datasets.

Through the CASE partnership with Zeiss, the student will receive advanced training in innovative electron microscopy techniques in materials characterisation. The student will actively participate in the development of new methods for the analysis and elemental mapping of clay and ceramic samples

The student will benefit from a broad range of training opportunities provided at Durham and Newcastle Archaeology through associations with the Durham Archaeomaterials Research Centre (DARC lab; www.darclab.com) and the Newcastle Geoarchaeology group, which provide access to a comprehensive range of analytical equipment and contact with associated researchers. Involvement with the three research projects will give the student the opportunity to develop important links and networks with national and international collaborators, providing extended training possibilities and forming the basis for new research partnerships moving forward.

References & Further Reading

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Further Information

Dr Kamal Badreshany:
kamal.badreshany@durham.ac.uk