Understanding capacity in the heritage science sector

National Heritage Science Strategy

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AUTHOR **JIM WILLIAMS**	

Report written by Jim Williams,
National Heritage Science Strategy Coordinator

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Edited by the NHSS steering group (for members see appendix 1)

Additional editing, comments and text provided by Ian Brocklebank, Mike Corfield, Andrew David, Catherine Higgitt, David Saunders, Joy Russell, Joyce Townsend, Velson Horie.

Design by Robin King

Cover image
Duncan Hook, scientist in the Department of Conservation and Scientific Research at the British Museum examining the Snettisham marriage torc (Iron Age, c. 75BC gold alloy torc from Norfolk, registration no. 1991,0407.37) using X-ray Fluorescence (XRF) analysis to determine the alloy composition

Executive summary

The House of Lords Science and Technology Committee inquiry into science and heritage, held in 2006, recommended that the sector should formulate a UK wide strategy for heritage science, covering both movable and immovable heritage.

This is the last of three reports which will provide the evidence base for this strategy. It covers issues of capacity in UK heritage science for three sub-sectors: movable heritage (museums, galleries, libraries and archives); built historic environment; and archaeology. It reviews the numbers of heritage scientists working and considers what they do and where they work. Gaps in capacity, where demand exceeds current provision are explored along with arrangements for funding and training. Suggestions for improvements are identified within three general themes: *addressing practitioner capacity and capability; accessing information and infrastructure; and funding and its public benefit.*

The first theme (addressing practitioner capacity and capability) looks at mechanisms to improve capacity issues within the three heritage science sub-sectors, as well as more general recommendations which are relevant across the whole sector. These include ways to improve career structure of heritage scientists; create more long term training placements; and establish internships to improve career development; as well as ensuring that information is not lost when highly skilled practitioners retire, i.e. succession planning.

The second theme (accessing information and infrastructure) considers ways in which access to heritage science information could be improved to enhance the transfer of knowledge from research into practice. These include better coordination of the production of guidance and standards, as well as efforts to promote and provide methods of digital archiving for all heritage science disciplines. Other issues covered in this theme relate to increasing access to and proposed sharing of existing equipment and expertise.

The final theme (funding and its public benefit) reviews current funding sources for routine application (practice) and research activity and considers how existing budgets could be used more strategically. The importance of prioritising limited resources through the production of a research agenda is highlighted as is the need to build better links with industrial partners. Finally, the role of economic and social science in providing evidence of the public benefit of funding is explored.

The report does not identify how best to ensure that the issues outlined above are addressed. That is the purpose of the strategy, which will be drawn up utilising the information presented here and in NHSS reports 1 & 2.

Table of contents

1 Introduction

This report is about capacity in the heritage science sector. It provides an overview of who heritage scientists are and where they work. It gives estimate of the numbers of people undertaking heritage science, and attempts to identify areas where the sector currently lacks staffing or experience to carry out existing functions fully. Consideration of training needs in relation to current and future capacity is provided along with observations about sector organisation and the impacts this has on activity. The report also outlines present funding arrangements and reviews training routes into heritage science. A range of recommendations are made to improve practitioner and institutional capacity and to make more effective use of existing equipment and resources. Although the focus of this report is on heritage scientists, the potential to increase the use of science to answer heritage questions is also governed by the understanding of heritage science within the other parts of the heritage sector.

What is heritage science?
The term heritage science is used in this report (and throughout the development of the strategy) to encompass all technological and scientific work that can benefit the heritage sector, whether through improved management decisions, enhanced understanding of significance and cultural value or increased public engagement.

1.1 Background

In 2006, the House of Lords Science and Technology Committee held an inquiry into science and heritage. Their report concludes that the previous high regard in which the UK heritage science sector has been held is now under threat: the sector is fragmented and under-valued; conservation and sustainability of cultural heritage is not given enough importance in Government policy; there is insufficient transfer of new scientific research to heritage practitioners; and there is no strategic overview of research priorities for heritage science. One of the main recommendations of their report is the need for an all-embracing UK-wide strategy for heritage science.

This is the third report produced to underpin the development of this strategy and is concerned with *understanding capacity in the heritage science sector.* The first report explored *the role of science in the management of the UK's heritage* while the second addressed *the use of science to enhance our understanding of the past.* Recommendations from these first two reports have been used to provide a focus for assessing practitioner and institutional capacity in this current report.

1.2 Structure of report

This report is divided into three principal sections.

Chapter 2 describes where heritage scientists work and what they do in the different sub-sectors.

Chapter 3 considers current capacity and the capability in terms of the availability of heritage scientists to undertake existing work, and looks at the extent that equipment availability impacts on this current capacity. It summarises current funding arrangements for heritage science and also covers training routes into heritage science and the availability of courses

Chapter 4 looks at improving future capacity. It identifies three key themes: practitioner capacity; access to information and infrastructure; and funding of heritage science. Summary conclusions are provided in a final chapter.

1.3 Sources and methods

This report (like the other two that preceded it) has been compiled by the Strategy Coordinator, drawing on previous strategies and studies as well as discussions with individuals from the heritage and heritage science sectors and the Strategy Steering Group (see appendix 1). It should be emphasised that this is a rapidly compiled overview of sector activity, and is neither a comprehensive review of employment and occupation nor an academic literature review; in fact there are few sources of information that provide good overview of the subjects covered here.

This report currently addresses unsatisfied demand but looking forward, these requirements are likely to change. Currently the heritage sector lacks the appropriate mechanisms for measuring and predicting future need. To be able to judge what the sector **needs** to preserve most appropriately the remains of the past and increase public understanding and enjoyment, rather than merely addressing unsatisfied **demand** (what people think they need), new methodologies need to be developed.

2 Who are the heritage scientists and what do they do?

This chapter tries to give an approximate picture of the numbers of different kinds of heritage scientists working in the UK, divided into three sub-sectors:

- movable heritage
- historic built environment
- archaeology

Museums, galleries, libraries and archives have been treated together as 'movable heritage' (rather than individually as they were in NHSS report 2) because the similarity of issues that need to be addressed in terms of people and approach that make this combination more appropriate.

For each sub-sector, a summary is given of

- who the heritage scientists are and what kind of work they do,
- where they work,
- the numbers of heritage scientists engaged in particular specialisms (in approximate categories: 1-5, 5-10, 10-20, 20-30, 30-50, 50-100).
  - Numbers in each sector are based on estimates arrived at through discussion with sector representative unless data sources are given.
  - They are based on full time equivalent (FTE) estimates, not on the total number of people that sometimes engage.
  - They include university staff research time, but not teaching time; they include post-doctoral researchers, but exclude masters and PhD level research (which is treated as training in this report), although the contribution that this makes to research should be recognised.
  - They include conservation scientists but not conservators as the majority of their work is conservation and not heritage science. It is acknowledged that many conservators undertake scientific analysis as part of conservation treatment; they are a key part of the sector to influence because of the importance of science to conservation interventions and decision-making.

2.1 Movable heritage scientists

Heritage scientists working in the movable heritage sector have been grouped into those involved in

- materials and environment research – research into the degradation mechanisms of materials and the factors that influence collection environments (e.g. pollution),
- material analysis and research – identification / characterisation / authentication to learn about museums objects, works of art etc, to fill gaps in present knowledge and understanding, and to aid conservation decisions,
- scientific dating – dendrochronology of paintings and wooden objects, C14 dating, comparative dating through pigments analysis/technology, luminescence and isotopic dating,
- digitisation and laser scanning – digitisation of written and audio/visual library and archive media, scanning of objects to accurately measure and produce digital and physical recreations.

Figure 1
Catherine Higgitt has a degree and PhD in chemistry from York. After a year at the Historic Scotland Conservation Centre, she joined the Scientific Department at the National Gallery in 1999, working on natural organic materials in Old Master Paintings using spectroscopic, chromatographic and spectrometric methods. In 2007 Catherine took up the post of Head of Science at the British Museum.

Figure 2
Quanyu Wang has a PhD in archaeometallurgy from University College London. From 1990-1996 she was a lecture in archaeological science at Peking University, China. In 2004 Quanyu joined the Department of Conservation and Scientific Research at the British Museum, specialising on technology and conservation science of metals.

2.1.1 Where do movable heritage scientists work?

Heritage scientists work in museums, galleries, libraries and archives, in the private sector, and within universities or other large research facilities.

- Most material analysis (i.e. analytical work on objects / works of art) takes place within museums / galleries.
  - This is largely restricted to a small number of large, often national, museums.
- The majority of materials degradation and environment research takes place in universities and other research establishments including national heritage agencies.
  - Some are based in heritage / conservation departments, others in material science, atmospheric science, chemical or biological sciences departments.
- Scientists working on digitisation and scanning of heritage materials are largely based in a few national institutions (National Museums and Galleries Merseyside, British Library), or as freelance contractors who also work on non-heritage material.

Figure 3
Barry Knight obtained a D.Phil. in Chemistry from the University of York, and then decided to become an archaeological conservator. He worked for many years in the Ancient Monuments Laboratory (then part of the Department of the Environment, later part of English Heritage) before becoming interested in environmental management in historic buildings. In 2003 he moved to the British Library as the first Head of Conservation Research.

Figure 4
Paul Garside read chemistry at the Southampton, where he then stayed to carry out research for a PhD, developing novel methods of characterising natural polymers. Subsequently he worked at the Textile Conservation Centre as a Research Fellow in Conservation Science for seven years, before joining the British Library in 2009.

2.1.2 Numbers of movable heritage scientists

Estimated numbers of scientists working in the movable heritage sub-sector are given below for each of the categories used in section 2.1, on the basis outlined at the beginning of this chapter.

Subject	Number of UK heritage scientists (FTEs)
Materials and environment research	20-30
Material analysis	20-30
Scientific dating	1-5
Digitisation and scanning	5-10
TOTAL	46-75

As well as the scientists listed above, staff at the Institute of Conservation (ICON) estimate that there around 3-4000 conservators working in the UK. These undertake both preventive and interventive conservation work in museums (including historic house museums), galleries, libraries and archives and the private sector in conservation companies or as sole traders.

- Although their work is predominantly conservation, many conservators will undertake some heritage science in the course of their work.
  - The proportion is difficult to estimate, and harder to divide between the categories above but probably represents a further 20-30 FTE when spread across the 3-4000 conservators.

This number of heritage scientists can be placed in a broader context within the movable heritage sector by reference to a recent report by Creative and Cultural Skills (*The Creative and Cultural Industries: Impact and Footprint 2008*), which estimates that there are around 33,000 people working in the movable heritage sector, of which roughly half are involved in collections management and communication roles (rather than front of house and administrative roles). From these figures we estimate that less than 0.5% of the people involved in the movable sector are heritage scientists.

2.2 Built historic environment scientists

Heritage scientists in the built historic environment sector are involved in

- scientific dating – dendrochronology, luminescence dating of bricks, C14 of building materials,
- historic interiors research – analysis of paints and pigments,
- analysis of material – identification of materials, i.e. stone source, mortar analysis,
- identifying causes of material degradation – weathering of building materials (pollution, microbiological activity), structural integrity and building pathology, movement of salts, corrosion studies,
- analysing building performance – sustainability, climate change, energy performance, internal environmental monitoring,
- scanning and imaging – laser survey, photogrammetry, thermal / infrared or radar analysis of voids etc.

Figure 5
Maureen Young has a degree in Geology and an MSc Geochemistry. She was a research Assistant in Dundee University Geology department and then moved to the Masonry Conservation Research Group at Robert Gordon University, Aberdeen as a Research Fellow. In 2007 she joined Historic Scotland as a Conservation Scientist specialising in infrared thermography and 3D laser scanning.

2.2.1 Where do built historic environment scientists work?

Most built historic environment scientists work in private practice and the universities; a smaller number work in national heritage agencies / research centres such as the BRE (Building Research Establishment).

- A greater proportion work in the private sector, often in small / medium-sized companies than is the case for the movable heritage sub-sector.
  - This includes most people involved in dendrochronological dating, analysis of historic interiors, scanning and imaging, and some of those involved in materials analysis.
- The majority of the materials degradation and buildings performance research takes place in universities with input and sometimes project initiation coming from the national heritage agencies.
- Scientific analysis is often provided by those based in sectors other than heritage, for whom the investigation of the built historic environment is only one part of the work that they do.
  - When work is in short supply or research funding is not available, they work on projects in other fields.
  - This can mean that they are not available at short notice, and can slow the speed of research and its communication to the rest of the sector.

Figure 6
Heather Viles studied geography at Cambridge University and completed a D.Phil. at Oxford University on biological weathering of limestone, based on fieldwork in the Seychelles. She now researches weathering and landscape development in deserts and on Mars, and the deterioration and conservation of stone cultural heritage.

2.2.2 Numbers of built historic environment scientists

Estimated numbers are given below for each of the categories used in section 2.2, on the basis outlined at the beginning of this chapter.

Subject	Number of UK heritage scientists (FTEs)
Scientific dating	5-10
Historic interiors research	5-10
Analysis of materials	10-20
Identifying causes of materials degradation	5-10
Analysing building performance	5-10
Scanning and imaging	10-20
TOTAL	**40-80**

These figures can be placed in a broader context in relation to an estimated total of 1400 people working in the conservation of historic buildings who are members of Institute of Historic Building Conservation (IHBC). While this includes some people who do not currently practice, it includes most of those involved in casework and consent decisions (local government conservation officers and national heritage agencies), as well as a number of conservation architects (who are usually responsible for managing re-development / building restoration projects) and other historic building professionals such as building surveyors.

However, conservation architects and other building professionals involved with historic buildings will not necessarily be members. Research by the National Heritage Training Group estimated that around 500 are accredited through peer-reviewed schemes (i.e. conservation-accredited architects, surveyors and engineering), but there are many conservation architects and other building professionals working on historic buildings who are not accredited.

There are also conservators who work on historic buildings, both on internal (wall painting, wallpaper, paint, gilding etc.) and external (i.e. stonework, metal) surfaces and materials, and many in traditional craft skills (i.e. thatchers, stone masons, plasterers).

These very general figures for people working on historic buildings represent a small proportion of the approximately 500,000 UK building professionals working within non-manual construction occupations and related consultancy services, and a further million working within manual trades. From these figures we estimate that less than 0.01% of built environment professionals are heritage scientists.

2.3 Archaeological scientists

Archaeological scientists are involved in

- scientific dating – C14, Dendrochronology, luminescence dating etc.,
- environmental analysis – plant and animal remains, soils and sediments,
- analysis of human remains – skeletal assessments,
- biomolecular analysis – lipids, proteins, stable isotopes and DNA,
- materials analysis – study of archaeological materials (ceramics, glass and metals) and their manufacture,
- offshore and terrestrial remote sensing – magnetometry, resistivity, radar etc.,
- airborne remote sensing – lidar, multi / hyperspectral imaging,
- artefact and site preservation – assessment of degradation of materials, monitoring of sites (groundwater, compression).

Figure 7
Harriet Jacklin graduated from Leicester University with a BA in Archaeology and a MA in Post Excavation Skills in 2002 where she specialised in human osteology. She has since worked for various archaeological units including ULAS, as a human osteologist and in 2008 formed 'ULAS Osteological Services'.

2.3.1 Where do archaeological scientists work?

As highlighted in report 2 (section 3.1) the use of scientific techniques in archaeology is commonplace and is included in most projects. There are two main areas of archaeological activity in the UK.

- Developer-funded archaeology.
  - The majority of new excavation and analysis of archaeological sites in the UK is carried out in response to development proposals.
  - It is regulated by local authority archaeologists, funded by developers, and carried out by archaeological contracting units.

Figure 8
James Adcock studied Geophysics at Southampton University followed by a masters degree in Archaeological Prospection at Bradford University. Since 2002 he has worked for GSB Prospection, conducting geophysical surveys for commercial and research led archaeological projects, specialising in ground penetrating radar and the three-dimensional modelling and visualisation of datasets.

- Archaeological research.
  - This is carried out by university academics, archaeological units, archaeologists based in museums and national heritage services and local archaeological societies.
  - Much heritage science research is aimed at improving methodologies, collating existing information and enhancing data sets, including those used to support heritage management work.
  - A considerable amount of archaeological research carried out in UK universities relates to non-UK sites and material.

As with the other sectors, some heritage scientists work in universities, museums or national heritage agencies (hereafter large institutions), and others work in private practice, as consultants, or attached to archaeological units.

2.3.2 Numbers of archaeological scientists

Estimated numbers are given below for each of the categories used in section 2.3, on the basis outlined at the beginning of this chapter. Figures include those currently undertaking work as heritage scientists in UK developer-funded archaeology or undertaking heritage science research within universities or other large institutions.

Subject	Number of UK heritage scientists (FTEs)
scientific dating	10-20
environmental analysis	50-100
analysis of human remains	10-20
biomolecular analysis	1-5
materials analysis	5-10
geophysical survey	30-50
airborne remote sensing	5-10
artefact and site preservation	5-10
TOTAL	136-275

There are around 50 people involved in conservation of archaeological materials using a range of scientific techniques including x-radiography and analysis of metal composition and corrosion products within the context of the investigation, identification, stabilisation and treatment of excavated material. This probably equates to an additional 5-10 FTEs for materials analysis not counted above.

These numbers can be viewed in the wider context of the estimated total number of people working in archaeology. From these figures we estimate that between 2% and 5% of people involved in the archaeological sector are heritage scientists.

Subject	Number of archaeologists
managing archaeology	1700
archaeological unit staff	2700
university teaching and research staff	1000
Others	600
TOTAL	6000

Data from Aitchison and Edwards 2008 adjusted using recent job loss figures from Aitchison 2009

3 Assessing current capacity

This assessment of current capacity is principally about trying to identify what is not being done because there are not enough people to do the work. It is an analysis of unsatisfied demand; of a lack of qualified people to carry out the currently requested work. It is not an analysis of need, still less one of future need. What is recorded in this chapter is the result of consultation within the heritage science sector, asking questions such as

- "what is it difficult to find specialists to do?"
- "what takes too long?"
- "in what parts of the sector do you feel there are a lack of specialists, or too many?"

The extent to which equipment availability impacts on current capacity is also discussed (see section 3.2), along with current funding arrangements. A final section looks at training routes into heritage science and the availability of courses.

3.1 Where are the shortages?

3.1.1 Movable heritage – where are the shortages?

There are reported shortages of people

- who can provide science-based advice on the conservation and collection care of plastics and other modern materials,
- to carry out analysis of organic materials,
  - this may be more of a question of a lack of equipment or access to equipment so is also highlighted below in section 4.2.

Figure 9
Brenda Keneghan took a degree in Chemistry at University College Cork and her PhD in Materials Science at Queen Mary University of London. She worked for several years in academic research in polymer chemistry before joining the Conservation Department of the Victoria & Albert Museum in 1993. There she has undertaken condition surveys of the plastic objects among the museum's collections and has been involved in research on degradation mechanisms of synthetic polymers and the use of inhibitors in storage.

- to monitor gaseous pollutants and to test display cases for air tightness,
- to carry out general environmental monitoring in smaller museums including historic house museums, especially on a freelance basis,
- to undertake paint (pigment and medium) analysis.

There are few reported problems in recruiting suitable qualified specialists to fill posts such as conservation scientists or materials analysts in institutions (museums, galleries, libraries and archives); the proportion of suitable applications from outside the UK is high.

- Where difficulties exist it is often in finding someone with the right mix of analytical and experimental competence with suitable experience and knowledge of heritage issues, and who is prepared to enter a sector with no career structure and lower pay than opportunities open to them elsewhere.

3.1.2 Historic built environment – where are the shortages?

The two areas in particular where there is insufficient capacity to meet current demand are

- analysis of materials (stone, brick mortar) and material degradation,
  - The uncertain availability of people who can provide characterisation of materials.
  - The lack of people who can give advice and guidance on the causes and recommend in situ treatment of material degradation, i.e. who identify causes of building deterioration.
- building physics / environments.

There is an insufficient number of people who understand how historic buildings operate and perform and are able to give advice on how to improve their energy efficiency without causing damage to them (see also NHSS report 1, where this is identified as a large area where further knowledge is needed).

There are far fewer heritage scientists working on a full-time basis in the buildings sector than the other heritage sectors. Many have other interests and work with both historic and modern buildings, or in other sectors, such as engineering or geology. In universities these people are often based in non-heritage departments. When there is no funding for work in one area, they carry out research or do another job in a different field. This can make them difficult to track down, and sometimes availability is affected by engagement on these other projects.

3.1.3 Archaeology – where are the shortages?

Shortages highlighted below have been identified through conversations with various specialists within the archaeology sub-sector. Additional information for England alone comes from a recent informal survey by English Heritage which asked Regional Science Advisors and a sample of archaeological unit staff about capacity in different archaeological science disciplines in England.

There are reported shortages of

- archaeomagnetic dating specialists,
  - There is often a need for a quick turn around for on-site sampling.
  - It is an infrequently used service so few offer it commercially.
- people to undertake chronological modelling,
- people to carry out ceramic thin sections for pottery characterisation,
- people who offer materials analysis for ancient technology,
  - In part this is a reflection of a general lack of material culture specialists (finds specialists) working in British archaeology.
- people to undertake analysis of certain classes of environmental material such as pollen, charred plant remains, insects and snails,
  - This is sometimes due to a shortage of individuals with relevant specialist skills, such as insects and snails, and sometimes to a reluctance to use less-experienced specialists – people tend prefer to use the people they have always used and who they know do good quality work.

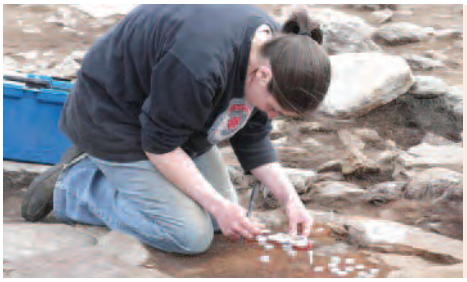


Figure 10
Zoe Outram undertaking archaeomagnetic sampling of a hearth at the site of Underhoull, Shetland, for the Viking Unst Project. Photo: S.J. Dockrill.

- people to carry out geoarchaeological analysis,
- people working on biomolecular analysis and stable isotopes,
  - There are very few specialists and users report difficulties in contacting them.
  - They are not commercial providers, and therefore have other priorities such as their own research or teaching commitments.
- people to advise on preservation in situ, the degradation of archaeological materials, monitoring, construction impacts, understanding and management burial environments.
  - This is partly caused by a lack of a well-focussed research agenda and thus of available funding.

3.1.4 Age profile and succession planning

Within all sub-sectors there are a few established scientists who are nearing retirement. As these are often well known to the profession and have significant levels of experience, their retirement can lead people to conclude that the age profile of the workforce is highly skewed. In most cases though, staff age is spread reasonably evenly within heritage science disciplines, it is just that the younger scientists are less well known.

Specific issues identified in the course of consultation for this report were

- where there is only one heritage scientist of a particular kind within an organisation, it is rare for enough thought to be given to the need for their knowledge to be passed on (e.g. by overlapping with a successor),
- within the archaeological science sub-sector a large number of currently active environmental archaeologists and materials analysts are nearing retirement age within the next decade.

3.2 To what extent does equipment availability impact on current capacity and capability?

Those working in smaller institutions and in private practice can find it difficult to access analytical equipment or funds to pay for others to carry out analysis on their behalf.

- Similar difficulties arise in relation to access to reference collections for comparative analysis, e.g. stone samples from historic buildings or archaeological plant remains.
  - Collections built up and held by individuals or SME's rather than larger institutions can also be difficult to access, and may be at risk when practitioners retire or project funding ends.
- Where formal arrangements for access or analysis exist, the emphasis on full economic costing (FEC) in universities has increased costs.

Larger museums, national agencies and universities have a wider range of equipment; however it is expensive to buy and maintain so even the largest facilities may not have access to all equipment they want or to the most up to date versions.

- This has impacts on capability as technology ages or particular new functions may not be available.
- Capacity can also be reduced by increased maintenance requirements of older machines.

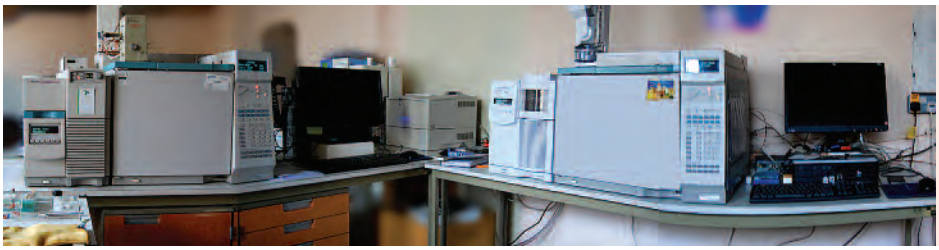


Figure 11
Some of the equipment used for organic analysis in the Department of Conservation and Scientific Research at the British Museum. Shown here are two GC-MS instruments (the instrument on the left is fitted with a pyrolyser). Other equipment includes HPLC (high-performance liquid chromatography) for dyes analysis and a FTIR (Fourier Transform Infrared) microscope for characterisation of a range of organic and inorganic materials.

Equipment sharing and formal arrangements for joint purchase amongst larger facilities are rare although this would reduce downtime (i.e. where equipment is not used) and could reduce purchase and running costs.

- Few, if any of these institutions or universities offer any commercial services for heritage scientists to send / bring objects or samples to for analysis.

Specific infrastructure capacity issues include

- a lack of facilities for organic materials analysis,
- a need to provide better access to routine provision of inorganic analysis,
- difficulties accessing facilities that are based outside heritage science such as large scale X-radiography or CT scanners (which are normally found in medical or industrial facilities).
  - However, in part, some of the "lack" of facilities is actually about people not knowing where services are or not being able to afford commercial rates.

3.3 Current funding

To look at the balance between practice (i.e. routine investigation) and research (and development), it is important to try to compare the money spent on each.

In the context of this report

- practice is taken as meaning work undertaken as part of daily functioning of the sector, for example
  - heritage science analysis and management of collections in museums, galleries, libraries and archives, to answer object-specific questions,
  - scientific analysis during the conservation and/or repair of historic buildings,
  - developer funded archaeology.
- research is taken as the investigation of a problem in order to provide findings with general application, for example
  - analysis to learn more about degradation of specific materials and their environments,
  - work to develop and enhance tools and techniques of analysis,
  - investigation of objects, buildings, sites and landscapes outside of the context of daily 'practice' (i.e. developer funded archaeology, museum cataloguing or exhibition preparation) to learn more about the past and/or to fill knowledge gaps in materials use and materials history.

3.3.1 Practice

Accurately measuring practice spend on heritage science is difficult. A rough estimate can be arrived at by considering the total spend per sector and estimating the amount spent on heritage science.

- The Institute for Archaeologists estimates that the annual amount spent by developers on archaeology is over £100 million (the spend in 2007/8 was approximately £135 million).
  - It is estimated that 5-10% per year is spent on archaeological science – i.e. £7-14 million.
- The 2007 report, "Valuing Our Heritage" highlights that nearly half of the £56billion spent by the construction sector is spent on repairs and refurbishment.
- Of this amount, the National Heritage Training Group have suggested that over £5 billion a year is spent on the conservation and restoration of pre-1919 (i.e. traditional) buildings, of which there are around 6 million in the UK.
  - The proportion of this money being spent on heritage science for building projects is probably less than 0.1% – i.e. less than £5 million.

Figure 12
Of the £800 million restoration programme for the new Eurostar Terminal at St Pancras Station, only a very small proportion was spent on the scientific analysis to research previous paint schemes. © English Heritage.

- Estimating the total heritage science practice spend for the movable sector is even more difficult to achieve. As highlighted in NHSS report 2 and in section 2.1.1 of this report, the majority of heritage science practise work takes place in only a small number of large, national institutions.
  - In evidence to the House of Lords Inquiry on science and heritage, staff from the British Museum, Tate and National Museums Scotland estimated annual conservation science spend in their establishments to be between 1% to 5% of total budgets.

These figures above reflect the approximate proportion of heritage scientists working in the three sectors, with employment within archaeology around a factor of 10 greater than within the movable or built heritage sectors.

3.3.2 Research

Currently, the director of the AHRC / EPSRC science and heritage programme is compiling a detailed analysis of the spend by research councils on heritage science over the last ten years. That analysis will be published after this report so the full results are not currently available.

Preliminary figures from that forthcoming report (*UK Research Councils' Contribution to Heritage Science*) indicate that between 1997 and 2007, the total funding for heritage science projects (excluding archaeology, archaeological science and science-based archaeology) from research councils was £4.73 million on 37 projects. This breaks down as follows

- collections, i.e. movable heritage (15 projects),
- historic buildings (10 projects),
- sites i.e. townscapes, historic gardens and landscapes as well as wall paintings (outside buildings) and monumental sculpture (6 projects),
- knowledge transfer (6 projects).

A study in 2007 by Cassar and Cockroft (*Scientific research for movable heritage in the UK*) identifies the other major source of research funding for movable heritage over the past decade as the European Commission, which provided £4.3million (for the period 2000-2009).

- This funding came predominantly from the European Commission Framework Programmes, particularly the 5th Framework.
- The budget for cultural heritage in the 6th and 7th Frameworks was much lower, and therefore fewer projects were funded.
- As the study focused only on movable heritage and the data come from questionnaire responses, the figure above is probably an underestimation of the total.
  - The report acknowledges that with only 50% of questionnaires returned it provides a "partial glance at the situation and can be considered to provide only a snap shot of trends".

Other sources of funding include funding bodies and trusts (such as Leverhulme, British Academy, British Council) and private donors, as well as museums and similar institutions who have contributed to research costs from internal funds.

The figures for UK research council spend on archaeological science from the forthcoming report by the director of the AHRC / EPSRC science and heritage programme have not yet been fully analysed and thus are not available. In their absence, data from the NERC 'Grants on the Web' page have been used to draw the following general observations.

- From 1997-2007 over 140 projects were funded by the Science Based Archaeology programme, totalling around £14.5 million.
  - Around 100 of these, with a total budget of around £12 million, relate to UK archaeology; 50, with a budget of around £2.5 million relate to archaeology overseas.
- Over a similar period (1995-2005) the Wellcome Trust Bioarchaeology programme funded 20 studentships, 25 fellowships and 5 other university grants were awarded, totalling over £6.4 million.

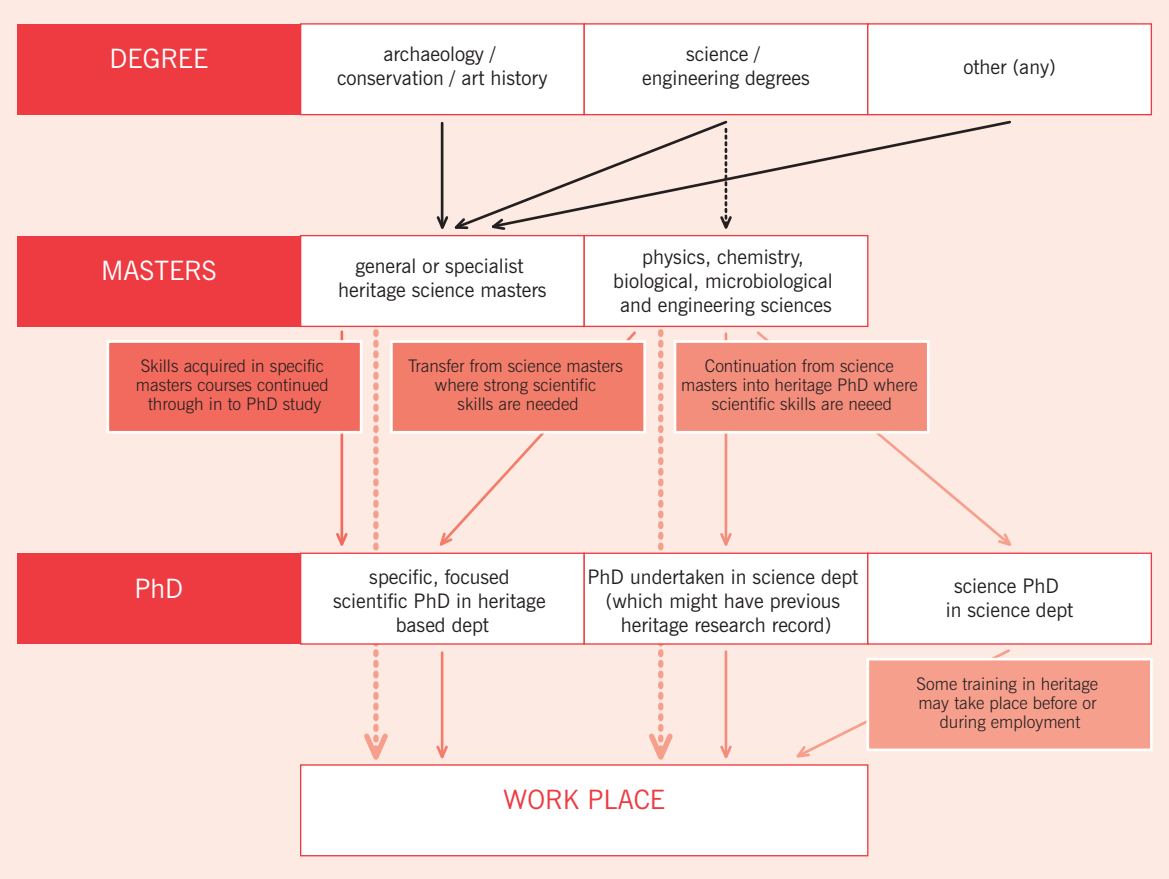
Further research funding for heritage science has also been available from national heritage agencies (i.e. English Heritage, Historic Scotland), for projects, and for specialist services such as scientific dating.

- For example, about 10% of the annual English Heritage Historic Environment Enabling Programme budget of £5 million is spent on heritage science research.
- During the period 2002-2007, a further £23.5 million of Aggregate Levy Sustainability Fund money was distributed by English Heritage, with around 20% spent on heritage science research, particularly geoarchaeology, remote sensing and scientific dating.

Figure 13
Chris Carey employing the IRIS Syscal Electrical Resistivity Ground Imaging (ERGI) system to investigate subsurface stratigraphy at Lockington, Leicestershire, as part of the English Heritage ALSF-funded Trent-Soar project (PNUM 3357). Photo: Keith Challis.

3.4 Training routes into heritage science and the availability of courses

Heritage science is a multidisciplinary subject and this is exemplified by the range of training routes by which current and prospective practitioners have, and will enter the profession. This is demonstrated visually on the flow chart.



Most specialisation takes place at the masters and PhD level, with entrants for those courses drawn from both heritage (conservation, art history, archaeology) and science (chemistry, physics, biology, engineering, forensic and earth sciences) backgrounds.

Specialisation at the masters level is common in archaeology, where there are a wide range of subject specific courses (see section 3.4.3 below). By comparison, few specific heritage science masters courses are available for subjects in the movable or built historic environment sectors.

It should also be acknowledged that a significant number of heritage science posts (in conservation and movable heritage science in particular) in the UK are filled by overseas applicants.

- These have come from a range of European countries with large heritage science training programmes (Italy Germany and France all have programmes for example).
- Recently, a number of European Countries (although not the UK) have set up a Marie Curie funded heritage science PhD programme called EPISCON – European Ph.D. in Science for Conservation.
  - Within a 3 year programme graduates with a science-based masters degree are provided with 6 months intensive training in European heritage at the University of Bologna before embarking on a specific heritage science doctoral research project chosen by the participating institutions.

3.4.1 Movable heritage

The main educational backgrounds and training routes into heritage science in the movable heritage sector are from

- earth, engineering and pure sciences (people convert to heritage science during PhDs through working on heritage science projects or on employment by museums or heritage organisations),
  - Most current heritage scientists have their first degree, at least a masters and often a PhD from a science department, perhaps one where teaching staff are also involved in heritage science research, although this is not always the case.
  - Collaborative PhDs such as those funded through the AHRC / EPSRC science and heritage programme, or NERC CASE awards continue to encourage this multidisciplinarity.
- heritage science (specific heritage or conservation science courses),
  - Currently there is only one general heritage science masters course, the MSc Forensic Conservation (Heritage Science) course at the University of Lincoln.
  - A MSc course in Analytical Chemistry at Birkbeck College, London offers students the option to take analysis for cultural heritage options. The Royal College of Arts / V&A conservation course which had a large component of heritage science was recently closed following the V&A's review of its provision of conservation training.
  - At a time before the closure of the RCA/V&A course was announced, a scoping study by another university into the potential of running a heritage science masters course concluded that there were already a number of courses and few guaranteed job opportunities for heritage science graduate.
- conservation (where people choose to specialise in analytical techniques rather than interventive activity),
  - The amount of science taught on these conservation courses (undergraduate and masters) will vary between institution and by discipline but most students will be exposed to scientific analysis of the materials that they are treating during their education (although this might be the last time that they have ready access to facilities for analysis).
  - The recent closure of the RCA/V&A course, and the Textile Conservation Centre (TCC) will therefore have a negative impact on conservation and heritage science training and research.

Figure 14
Jane Henderson advising a Cardiff University student on the use of digital x-radiography for the non-destructive investigation into the corrosion and technology of archaeological metals. Photo: David Watkinson

- archaeological science, usually archaeological material science master courses and PhDs in archaeological departments,
- specific heritage science or cultural heritage courses run outside the UK (especially in Europe, North America and Australia).

3.4.2 Built historic environment

There are no specific masters courses or other training programmes for heritage scientists working in the built historic environment sector, underlining earlier statements that most of those providing science come from outside the sector. Heritage science issues are included within building conservation courses, but these courses do not produce trained heritage scientists, but provide training for conservation officers, or qualified architects wishing to specialise in conservation architecture, not heritage science.

- Those involved in scientific dating tend to have come from archaeology departments.
- Historic interiors researchers tend to have conservation backgrounds, and have then worked as interns with other historic interiors researchers.
- Those involved in analysing materials (stones, mortars) are usually geologists or have come from an engineering background.
- People carrying out and/or researching material degradation and building performance often come from science and engineering backgrounds.
- Scanning and imaging specialists tend to have a survey rather than heritage background.

Figure 15
Alison Arnold studied Archaeology at Nottingham, graduating in 1997. Between 1997 and 2000 she worked at Trent and Peak Archaeology as a field archaeologist, combined with an English Heritage funded traineeship in dendrochronology. She has worked exclusively in dendrochronology since 2000 and forms one half of the Nottingham Tree-Ring Dating Laboratory.

3.4.3 Archaeology

As with other heritage science subjects, undergraduate and masters backgrounds vary considerably.

- Where very specific scientific skills are required graduates are more likely to have a science rather than an archaeological background.

The great difference between archaeology and the other sub-sectors is the much greater range and number of heritage science masters courses.

There are over 35 UK archaeology departments offering over 400 single and joint honours undergraduate courses in archaeology. These universities offer over 150 archaeology masters courses, of which 62 can be described as archaeological science. Scientific masters courses include

- archaeological science (general),
- archaeological material science,
- archaeozoology,
- environmental archaeology / palaeoecology,
- geophysics / archaeological prospection,
- GIS / archaeological information systems,
- geoarchaeology,
- human remains / forensic archaeology / forensic pathology.

Having completed one of these taught masters courses graduates may enter the employment market (often in private practice) or continue to undertake further training through PhD study.

3.4.4 Using heritage science in school education

There is significant potential for heritage science to engage the public with science, through sectors (museums, archaeology etc) which traditionally have a more 'arts-based' public interface. This is beginning to be recognised and addressed (see section 4.3.3).

One currently under-exploited area is the use of heritage science within science education.

- More could be done to get heritage science examples into the school science curriculum, through classroom and laboratory work, as well as on-site learning, for example, visits to heritage sites and museums with a strong scientific focus.
  - This would raise the profile of heritage science as a subject, and help to interest and engage the future crop of heritage science recruits.

4 Improving future capacity

This final section of the report considers issues of heritage science sector capacity under three themes (continuing the numbering used in the first two NHSS reports)

- Theme 7 – Addressing practitioner capacity and capability
- Theme 8 – Accessing information and infrastructure
- Theme 9 – Funding and its public benefit

4.1 Theme 7 – Addressing practitioner capacity and capability

This first theme explores

- training and career structure,
- shortages in existing capacity for practice and research,
- ways to improve capability of new and existing heritage scientists.

4.1.1 Topic 7a – the right people for the right jobs

From training to careers

Shortages in particular areas (see below for sub-sector specific details) could be addressed by additional training, such as targeted post-graduate research or training level posts.

- However, without appropriate mechanisms to help people move from training into employment, existing capacity issues will still not be addressed.
  - The Science & Heritage programme will deliver a significant number of new researchers at post doc level by the end of its 5-year funding: there is not yet an equivalent increase in the number of long-term career posts.
- One of the most significant capacity factors affecting all heritage science sub-sectors is the lack of clear career structure for both recently trained and existing scientists.
  - Currently there are few stages between entry level jobs and management positions.

Aside from jobs in academic or in large institutions (such as museums or national heritage agencies), many heritage scientists are self-employed or work for SMEs (small and medium sized enterprises).

- It is often difficult for emerging trainees to enter self employment.
  - They have little access to equipment and information.
  - They lack mentorship to develop their skills and provide them with advice.
- SME's may be less willing than larger institutions to take recent graduates without prior work experience as they tend to have less time to spend training staff.

Some of these issues could be tackled by

- creating more opportunities (i.e. through tapered funding) for newly qualified specialists to work with established self employed heritage scientists or SME's for lengthy periods (i.e. longer than current, often one year, training bursaries).
  - This could help to build up bigger 'companies' providing heritage science services.
  - Placements with experienced specialists would aid the transfer of long built up knowledge and experience to a younger generation.

Subject specific capacity issues – movable heritage

The most critical shortages within the movable heritage sector are

- conservation and collection care of plastics / modern materials,
- analysis of organic materials and pollutants.
  - Currently there are insufficient numbers of organic and polymer chemists (rather than inorganic chemists) entering conservation and conservation science roles.

To enhance future capacity

- these issues need to be viewed as priorities for growth, through funding for collaborative PhDs and post-docs and encouragement of undergraduate dissertations in heritage science topics.
  - An alternative approach would be workplace training of organic scientists within heritage, e.g. museum environments, although there are currently no mechanisms or funding streams for this.

Subject specific capacity issues – built historic environment

Current shortages in the provision of heritage science in the built historic environment include

- building material analysts / specialists in materials deterioration,
  - There is a patchy supply of people, most of whom are based in geology, geography and engineering and do not work full-time on heritage projects.
- building physicists / environmental monitoring.
  - There is a need for well qualified building physicists to cope with research issues (identified in report 1) and on-site specialists to give advice on energy efficiency of historic buildings in relation to building regulations and government sustainable development policy.

Future capacity could be improved by

- long term (i.e. several years) placements and job shadowing of those involved in heritage work by existing building physicists. This would increase the number of those building physicists and engineers who understand and can work on historic buildings.
  - There is also a need for people to provide technical, scientific support and guidance which could be addressed through the creation of advisory roles within professional bodies or government agencies in the short term.

Subject specific capacity issues – archaeology

There are shortages of archaeological scientists in

- certain areas of environmental archaeology,
- materials science,
- chronological modelling,
- biomolecular studies.

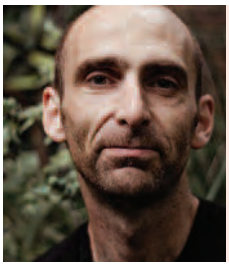


Figure 16
Peter Marshall studied archaeology and geography at the University of Sheffield undertaking palaeoenvironmental research in Austria. From 1997-2005 he worked for the RCHME and English Heritage Scientific Dating Team. Following two years in developer funded archaeology he set up a consultancy (Chronologies) to provide scientific dating advice for archaeologists.
Photo: teddave.org

Future capacity could be improved by improving the flow of trained graduates into jobs through

- addressing career structure issues,
  - i.e. providing mechanisms and funding for newly trained staff to work with established, often self employed specialists.
- re-focusing future training provision more on UK sites or regional material which would give people a better knowledge of UK archaeology and the UK employment market.
  - Archaeological units and museums could help by working with academic departments and prospective students to identify UK research projects to aid in this training.

For biomolecular analysis, the capacity issue relates more to the lack of commercially available services for those wishing to have work carried out.

- Funding for the provision of one or two 'commercial service' posts (and consumables) within universities with existing strengths in these areas would certainly cover this shortage.

4.1.2 Topic 7b – Research capacity

NHSS themes 1 & 2 cover areas where further research is recommended to enhance our existing understanding of the behaviour of heritage materials and of the environments in which heritage assets are stored, displayed or are situated (see appendix 2).

There are no shortages of potential research students and supervisors at universities to undertake this work. There are also well placed specialists in large public institutions (museums, national heritage agencies) and the private sector that could advise on or carry out this work.

For the most part this research could be undertaken within post-graduate research posts (post-doctoral) and PhDs.

- Collaborative PhDs funded through AHRC/EPSRC are one way this could be achieved.
  - Combining scientific input from host departments with heritage input from collaborating institutions helps to keep the outputs of the work focused on sector priorities.
  - However PhDs necessarily have to focus on the award of the PhD as well as the project goals. Although this provides training for future heritage scientists, it is not always the most cost-effective way of undertaking research.
- Currently there are too few programmes to maintain talented researchers in research posts.
  - People end up on temporary contracts (e.g. 1 year) usually dependent on other academic staff to submit further research bids to keep funding in place.
- Consideration should also be given to how funding can be used to maintain research posts within museums and other heritage institutions (rather than just universities).
  - This could entail existing workers undertaking science projects in collaboration with academic departments to address specific problems, particularly in understanding degradation or improved conservation methods.
  - Such projects would improve individual knowledge and capability as well as building stronger networks between academic and practitioner sectors.

Figure 17
Modelling the corrosion of iron infested with chloride salts within a climatic chamber at Cardiff University. This study to improve the understanding of the behaviour of heritage materials underpinned the conservation plan for the ss Great Britain.
Photo: David Watkinson

The other area where additional research is suggested is in relation to NHSS theme 4 where recommendations are given for the need to enhance existing techniques and develop new tools and techniques.

With regard to practitioner capacity, the developments of many existing tools are already underway.

- These improvements are often incremental, and being actively led by current researchers.
- New tools may require collaboration with industry as well as research time to test and validate.
  - As with theme 1 and 2 research, there is potential capacity within universities and large institutions to carry out this work.
  - Input from the sector is needed to help bring forward the most appropriate tools, and to refine the capabilities that are needed.
- Additionally, tool development should be prioritised as part of the research strategy to ensure that limited development funds are directed towards the areas of greatest need.

4.1.3 Topic 7c – Improving capability

Training routes into heritage science are diverse, as outlined in section 3.4. Practitioners are highly inter-disciplinary, often with graduate and post-graduate training in both science and heritage, or specific heritage science masters courses.

Regardless of the training route, many consulted during the development of this report have highlighted issues of post-qualification capability of new entrants, who often lack practical skills or adequate experience. Conversely, more established staff may be less aware of recent technical developments and methods

- These are both issues which can be addressed by additional training and mentoring in the workplace, which in some cases is not provided for in the current way the sector is organised.
  - Recent initiatives, such as HLF funded workplace training bursaries have developed mechanisms for new entrants to gain additional experience.
  - However, these are mainly targeted at people beginning their careers, and only available for limited numbers each year.
- Within more structured approaches to quality assurance, such as accreditation, certain standards of knowledge are expected and there is an emphasis on continuing professional development (CPD).
  - This type of scheme does help to raise and maintain standards, but if accreditation is not mandatory, it cannot tackle performance in those who do not wish to become accredited.
- Employers also need to accept that university education will not necessary provide people with exactly the skills that they are seeking.
  - There should be a be a greater recognition of workplace learning, greater knowledge transfer between established and entrant professionals, with continuous professional development viewed as core rather than an add-on.

4.2 Theme 8 – Accessing information and infrastructure

This theme looks at issues of how access to heritage science information and infrastructure (equipment and reference collections for example) can be improved. It identifies current barriers to the flow of information, and suggests ways in which access could be enhanced, particularly for those who currently work outside of the institutions where such infrastructure is located.

4.2.1 Topic 8a – Transfer of knowledge into practice

One of the issues identified in NHSS report 2 was the inaccessibility of many academically published research papers to those outside the academic community.

- Part of the problem is that, particularly for the movable and built historic environment sub-sectors, that there are very few peer-reviewed journals for subjects like conservation science or buildings conservation that carry sufficient academic weight to score highly within the University Research Assessment Exercise (RAE).
  - This results in researchers publishing within more specialised technically focused publications with higher RAE scores rather than subject specific journals such as 'Studies in Conservation'.
  - Although it is now easier to find academic articles through the internet, access to online journals is expensive unless you are part of an academic institution.
  - This inaccessibility – both practical and intellectual – significantly cuts down knowledge transfer of research information outside of the academic community, leads to re-inventing of the wheel and potential duplication of effort.
  - It also reduces the impact and benefit of research.
- One solution might be the development of a heritage science journal of interest to scientists and the wider heritage community that would attain higher RAE scores.
  - This would also provide an ideal location for the publication of review papers that could increase opportunities for knowledge exchange within the sector.

Guidance, standards and advice

Short, authoritative guidance and clear standards are essential for the transfer of research results into practice; something that is quick to read, based on current best practice and where appropriate, provides links to further, more detailed information and sources of professional advice.

- This is particularly the case for those members of the heritage sector who have the potential to influence the use of heritage science but are not heritage scientists themselves, such as
  - local authority planning archaeologists and archaeological unit staff,
  - conservation officers and conservation architects,
  - museum / gallery / heritage site and historic building conservators, curators and managers,
  - librarians / archivists.

Figure 18
A number of recently produced English Heritage scientific guidance documents.
© English Heritage.

However, for some sub-sectors it is not entirely clear who has a responsibility for producing guidance and standards.

- Because heritage is devolved to each UK nation, there is overlap and repetition of effort with guidance produced by separate organisations.
  - There are currently few mechanisms for heritage science guidance to be developed at a UK level.
  - Equally, due to a lack of general coordination of heritage science activity, the UK has been slow to engage fully with recent European standardisation work (e.g. *The conservation of cultural property (CEN/TC 346)* for which much of the work is being done on an almost voluntary basis).

In addition to written guidance, free impartial heritage science advice helps with knowledge dissemination. The opportunity to have someone on hand to answer questions is highly valued.

- The English Heritage Regional Science Advisors (RSAs) provide this for archaeological science; there is a shortage of similar provision elsewhere in the sector.
- This does not mean that those heritage scientists working in museums, universities and private sector are not able to provide this advice – its just not formally acknowledged as part of their role, and so when information is wanted, it might not be convenient, appropriate or possible for those people to provide it within their workload and responsibility.

Figure 19
To help with the dissemination of its scientific guidance English Heritage organises free training sessions, such as the one shown here on industrial residues where Justine Bayley is describing different types of metal working debris. © English Heritage.

Information sharing and archiving

There is great potential to increase information availability through the use of the internet. In many cases, issues highlighted below are being addressed and there are many existing examples of good practice. What is currently lacking is coordination across the heritage science sub-sectors.

- Outside the archaeology sub-sector, archiving of grey literature / internal analytical reports is not yet commonplace for heritage science reports and online resources do not commonly provide for the long-term curation of data.
- The development of new tools and software does not tend to be carried out with a view to the long-term curation of digital data.

In addition to the storage and digital availability of unpublished reports and data, greater effort is needed to increase their accessibility.

4.2.3 Topic 8b – Infrastructure

Current investigative capacity could be enhanced by better access to facilities for analysis and structured sharing to make more use of existing equipment, expertise and budgets.

In large institutions capacity could be improved through, for example

- the creation of more formal partnerships with similar institutions to share equipment,
- identification of ways in which spare capacity on machines could be used by external partners (who have the expertise to use equipment and interpret results),
- consideration of the joint purchase of new equipment to reduce individual costs, including mobile equipment.

Figure 20
Phil Parkes using a scanning electron microscope with energy dispersive x-ray analysis at Cardiff University to determine the elemental composition of heritage materials undergoing treatment by BSc Conservation students. The SEM was purchased by the University with part funding from the National Museum of Wales under the Joint Research Equipment Initiative (JREI). Its use is shared between these two organisations.
Photo: David Watkinson

Support for those working outside large organisations could be provided through

- identifying ways in which they can access reference collections and analytical equipment within universities (and other facilities) in ways that benefit both parties.
  - Current arrangements are often very ad hoc, based around personal relationships and usually only available to *alumni*, which can reduce geographical mobility for specialists.

For heritage organisations without trained heritage scientists or in-house analytical equipment, capacity for scientific investigation could be increased by

- raising awareness of the types of simple scientific analysis could be used to improve the management and interpretation of sites, buildings or collections – i.e. through guidance / case studies on what could be achieved,
  - There is a need to do more to demonstrate how analysis would increase public value and maximise relevance of and engagement with collections.
  - It is recognised that funding is also a substantial barrier (see section 4.3.1).
  - Any plans to increase demand in this way have to be matched to available funding and increased capacity to meet this demand.
- the development of mobile facilities and operators to carry out analysis perhaps based around national or large regional museums.

Figure 21
The English Heritage vertebrate skeleton reference collection at Fort Cumberland.
Photo: Polydora Baker.

International comparison

During the House of Lords inquiry on Science and Heritage different modes of infrastructure provision in other countries were highlighted by those giving evidence. These varied from centralised to distributed models.

- For example, several countries including Canada and The Netherlands resource movable heritage science through national institutes funded by government.
  - The main focus of these institutes is conservation practice, but this is underpinned with a significant number of heritage scientists working in well-equipped laboratories who undertake conservation science research as well as routine analytical work.
- Many countries have distributed facilities more similar to the situation in the UK, with well-resourced laboratories in state funded museums, including France, Germany, Australia, India.
- Other countries rely more on private funding through foundations such as the Getty Conservation Institute in the United States.

4.3 Theme 9 – Funding and its public benefit

This final theme addresses issues associated with the current funding of heritage science. Specific topics highlight the importance of prioritising research funding (so that the limited funds are spent on high priority research subjects) and quantifying the public benefit that this funding and heritage science in general, provides.

4.3.1 Topic 9a – Sources of funding

Funding practice

There are considerable disparities in funding heritage science practice (rather than research) across the 3 sub-sectors discussed in this report.

- Archaeological science is an accepted element of site investigation and analysis in developer funded archaeology and thus more likely to be funded where it is shown to be appropriate.
- The acceptance of scientific analysis is less developed in the historic built environment sector, away from repair and conservation work on the most significant buildings (e.g. grade I listed buildings).
  - This reflects past differences in the ways PPG16 and PPG15 (planning guidance for archaeological and buildings respectively) have been interpreted and applied.
  - It is hoped that this will change after the introduction of a unified planning policy statement for the historic environment (PPS15) later this year.
- Funding for routine scientific analysis within the movable heritage sub-sector is uncommon away from the major national and large institutions.
  - Outside their core budgets, there are very few sources of funding that museums, galleries, libraries and archives can apply to in order to carry out applied research that is essential to understanding collections and their contexts.
  - Unlike the archaeology and historic built environment sector where funding may be available from national heritage agencies, there are no equivalent organisations for the movable heritage sector.
  - Research council funding it is not intended for routine analytical work, or the application of existing techniques to large sets of objects.
  - Conservators can also find it hard to get scientific analysis recognised as an integral part of the conservation process by clients or museum managers.

Funding research

Differences also exist in the past distribution of research funding across the sub-sectors. In part this reflects the greater size of the archaeological research sector, and the focus provided in the past by the NERC Science Based Archaeology programme.

The increased emphasis on funding heritage science through the AHRC / EPSRC science and heritage programme has now given the sector new direction.

- However, the size of the available award, the wide scope of the project and five year duration of the programme is still small in relation to the demands of the sector.
  - As can be seen in the following table, the demand for funding has so far outstripped the available budget.

Programme Call	Applications	Awards	Short listed
Collaborative Research Studentships	25	10	
Research Clusters	49	13	
Large Interdisciplinary Grants	171		24

It should also be emphasised that research council funding is principally aimed at funding academic research.

- Large public bodies can apply to become Independent Research Organisations (IRO's) in order to compete for research council funding.
  - The British Library, British Museum and National Museum Wales for example are all currently recognised by the AHRC as IROs.
  - However, similar opportunities do not exist for the private sector to take on lead roles in research council funded projects.
- Research funding provided by private foundations tends also to go to the universities.

Partnership with industry

Where research projects are needed to improve existing tools and techniques and take methodologies forward, traditional funding sources have included the research councils or national heritage agencies.

- The technical development of new tools can be costly and the process time-consuming.
  - Partnerships with business and other sources of funding such as government initiatives for innovation or business development grants may provide sources of funding outside of heritage sector.
- Currently, there are few mechanisms in place to bring together heritage scientists and instrument developers and limited incentives for innovation in this area, i.e. specific funding aimed at technical / instrumental developments for the heritage sector.
  - Whilst it is possible to work with instrument manufactures to identify what modifications could be made to existing tools to make them more suitable for heritage application, it can be hard to make these changes commercially justifiable if they are only relevant to a small end-user group.
  - Equally, as the heritage sector is fairly small it is sometimes hard to present a suitable business case to interest developers in the first place or the necessary funding to take tools from prototypes to market, even to an international market.

4.3.2 Topic 9b – Prioritisation of research

The prioritisation of research is essential to ensure that limited research funds are directed to the most critical areas. One of the most significant capacity issues in the past for the sector in general, and for the movable sector in particular has been the lack of coordination of NHSS theme 1 & 2 research activity – i.e. the behaviour of heritage materials and environments.

- There is still a considerable lack of contact between the various sub-sectors and failure to recognise the degree of overlap.
- This is beginning to change through the work undertaken by the AHRC/EPSRC programme, as outlined in their research programme specification, and in particular the research themes 'nature of transformation' and 'resilience and adaptation'.

The lack of an agreed and prioritised agenda for research can potentially lead to

- duplication of effort and missed opportunities for partnership / collaboration,
- lack of staged small scale work building on previous small scale work – incremental improvements in knowledge,
- lack of prioritisation of limited research funds to address the most critical questions.

Coordinating the agenda

A further key element of agenda setting is also knowing when issues have been resolved, with the research having addressed the questions posed. Again there is no formal structure within the sector, and the movable sub-sector in particular to collate knowledge, and no system or structure to update research agenda.

Initiatives such as *Future Life of Collections* which identified and prioritised research for the libraries and archives sector are important developments, and have yielded useful results that have tackled some of the most critical issues. Similar programmes are needed for other sub-sectors. AHRC / EPSRC research clusters (such as EGOR) have provided settings in which to direct research agenda in the absence of more formulated structures.

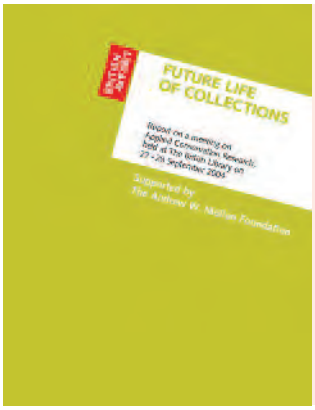


Figure 22
Cover image of the Future Life of Collections, a summary of a meeting funded by the Andrew W Mellon Foundation to discuss the development of a strategy for applied conservation research into paper-based library and archive materials.

4.3.3 Topic 9c – Public engagement and benefit

Heritage science has extensive, and largely untapped potential both to engage a much wider public in issues of general social interest, and to demonstrate the wider public benefit of its work.

- Both are essential for the future health of the sector: unless it is able to demonstrate how it benefits the wider public it will lack the capacity to advocate convincingly for future support.

NHSS report 2 has already outlined some of the areas in which heritage science addresses issues of wider public interest, from answering key questions about the human past, to providing fascinating insights into investigative techniques such as forensic analysis.

- The sector could get better at communicating effectively the contribution it can make to such issues and interests, demonstrating the value of the funding invested in both practice and research.

Figure 23
Cover image of Valuing our heritage – The case for future investment in the historic environment, which looks at the public benefits of heritage. The report was produced by Heritage Link, English Heritage, the National Trust, the Historic Houses Association and the Heritage Lottery Fund. © English Heritage.

Measuring value and benefit

To help achieve this, heritage science needs to make greater use of economic and social science approaches to demonstrate the value of the work the sector undertakes in terms of wider public benefit.

Techniques such as social surveys, Contingent Valuation Analysis, and participant observation can provide frameworks for the evaluation both of the public impact of heritage science work and help to understand how the public respond to heritage assets, and therefore how best to present and manage them for maximum public benefit. For example

- understanding how visitors respond to direct interaction with museum collections and sites will have implications for their conservation and management.
  - During the Leverhulme-funded 'dust research' project social scientists examined visitors' ability to judge soiling and how it affects their experience of historic interiors and collections.

However, up till now, such studies have not been recognised as being part of heritage science, and therefore their importance and value in helping heritage science demonstrate its public benefit, have been underplayed. Given the increasing need for all publicly funded activities to show wider public relevance, it is now time for this kind of work to be seen as a legitimate aspect of heritage science.

5.0 Conclusions

Many of the sources of funding for heritage science described in this report, such as government funding and activity resulting from development (i.e. work on archaeological sites and historic buildings) have, and are likely to in the future, come under increased pressure as a result of the recent economic crisis. Any reference to improvements of current practitioner and institutional capacity made within this report need to be considered in this context. Increases in resource to address current shortages are unlikely to materialise in the short term and in order to deliver change, the sector will have to consider how it re-focuses existing budgets to meet these additional recommendations.

Furthermore, if we are to demonstrate the public value of the current investment in heritage science, we need to become much more effective about recording how current funding, in both research and practice, is spent, and measuring the benefits that it has provided, than we have been to date.

5.1 Next steps – seeking your views

The purpose of this report is to provide a snapshot of the capacity issues within heritage science. It describes who heritage scientists are and where they work, training routes into the profession and current funding. It highlights areas (both specific and general) where there are opportunities to improve capacity in the future.

The recommendations it contains cover three strategic areas in relation capacity in the heritage science sector. These are:

- Addressing practitioner capacity and capability
- Accessing information and infrastructure
- Funding and its public benefit

We believe that these themes are where greater sector coordination is needed and where improvements to career progression and training provision, greater resource sharing, and further prioritisation of research funding will help to tackle many of the individual sub-sector issues that we have also identified in this report.

We would like to hear your views on these strategic issues and whether you think these three themes cover the main priorities for improving capacity in the heritage science sector.

A response form for you to send us your views on will be available through the NHSS website www.heritagesciencestrategy.org.uk along with this report. Please respond by the 23rd October 2009.

6.0 References

Strategies, reports, articles and books

Aitchison, K., 2009, Job Losses in Archaeology – April 2009 Report for the Institute for Archaeologists and the Federation of Archaeological Managers and Employers. Available from http://www.archaeologists.net/modules/icontent/index.php?page=219

Aitchison, K., and Edwards, R., 2008, Archaeology Labour Market Intelligence: Profiling the Profession 2007/8. Reading: Institute of Field Archaeologists.

British Library, 2004, Future Life of Collections – Report on a meeting on Applied Conservation Research, held at The British Library on 27-28 September 2004

British Library, 2008, Stewardship Research Strategy for the British Library 2008 – 2011.

Cassar, M, forthcoming report, UK Research Councils' Contribution to Heritage Science, 1997-2007.

Cassar, M. and Cockroft, N., 2007 Report on Scientific Research for Movable Heritage in the UK. Unpublished report by Centre for Sustainable Heritage. Available at http://www.heritagescience.ac.uk/index.php?section=41

Creative & Cultural Skills, (2008). The cultural heritage blueprint: A workforce development plan for cultural heritage in the UK. Creative & Cultural Skills. Available from www.ccskills.org.uk

Creative & Cultural Skills, (2008). The Creative and Cultural Industries: Impact and Footprint 2008. Creative & Cultural Skills. Available from www.ccskills.org.uk

English Heritage – Guidance documents such as Luminescence Dating; Geophysical Survey; Environmental archaeology; Science and historic industries. All available from www.helm.org.uk

English Heritage, 2008, Heritage Counts 2008 England. London: English Heritage. Available from http://www.english-heritage.org.uk/hc/

EPSRC/AHRC Science and Heritage programme, 2009, Research programme specification 2009. Available from http://www.heritagescience.ac.uk

EPSRC/AHRC Science and Heritage programme, 2008, Identifying research gaps in science and heritage. Available from http://www.heritagescience.ac.uk

Heads of Conservation and Scientific Laboratories in UK National Museums, Galleries and Libraries, 2008, A UK Strategy for Heritage Science. Unpublished document, available in the document library section of the NHSS website www.heritagesciencestrategy.org.uk

Heritage Link, English Heritage, the National Trust, the Historic Houses Association and the Heritage Lottery Fund, 2007, Valuing our heritage. The case for future investment in the historic environment. Available from http://www.english-heritage.org.uk/server/show/nav.00100200500200c

House of Lords Science and Technology Select Committee, 2006, Enquiry report on Science and Heritage. HL 256, London: The Stationery Office Limited.

ICON, unpublished, Skills demand desk study 2005, unpublished internal report.

ICON science group, 2007, Development of a UK strategy for Heritage Science. Unpublished document, available in the document library section of the NHSS website www.heritagesciencestrategy.org.uk

Leigh, D. Forthcoming, Securing conservation education in the United Kingdom, report Commissioned by the Textile Conservation Centre, University of Southampton

NHTG, 2008, UK Built Heritage Sector Professionals 2008: Current Skills, Future Training. National Heritage Training Group Available from http://www.nhtg.org.uk/nhtginitiatives/publications/research/buildingpros2008.aspx#0

The National Trust, 2008, Draft Collections Conservation Science Research Strategy. Unpublished report.

Williams, J., 2009a, The role of science in the management of the UK's heritage. NHSS report 1. Available from www.heritagesciencestrategy.org.uk

Williams, J., 2009b, The use of science to enhance our understanding of the past. NHSS report 2. Available from www.heritagesciencestrategy.org.uk

Discussions and correspondence with heritage practitioners (in addition to steering group)

Andrew David
Annie Sanderson
AnnMarie Newbigin
Ashok Roy
Barney Sloane
Barry Knight
Carol Brown
Caroline Peach
Catherine Atkinson
Catherine Hardman
Catherine Higgitt
Cathy Tyers
Chris Wood
David Leigh
David Saunders
Gill Campbell
Graham Martin
Harriet White
Hedley Swain
Helen Hughes
Ian Brocklebank
Ian Panter
Jane Henderson
Jacqui Watson
Joy Russell
Joyce Townsend
Kate Lowry
Ken Uprichard
Kostas Ntanos
Linda Ramsey
Loraine Gibson
Martin Cooper
Maurice Davies
May Cassar
Mike Corfield
Nicholas Eastaugh
Norman Tennent
Peter Marshall
Sean O'Reilly
Siobhan Stevenson
Siobhan Watts

Web-based resources

http://gotw.nerc.ac.uk/list_short.asp?pge=class_secclass_list&classtype=Secondary+Classification& classification=Science+Based+Archaeology&atype=All+Types (NERC Grants on the Web)
http://www.ahrc.ac.uk/FundingOpportunities/Pages/IndependentResearchOrganisations.aspx
http://www.collectionslink.org.uk
http://www.collectionstrust.org.uk/int-arch
http://www.episcon.scienze.unibo.it/episcon/
http://www.helm.org.uk

Appendix 1

List of steering group members

Sarah Staniforth – Chair (National Trust)
Professor Peter Brimblecombe (University of East Anglia)
Dr Craig Kennedy (Historic Scotland)
Katy Lithgow (National Trust)
Dr Nick Merriman (Manchester Museum)
Dr Sebastian Payne (English Heritage)
Professor Mark Pollard (Oxford University)
Helen Shenton (The British Library)
Dr Jim Tate (National Museums Scotland)
Professor Heather Viles (Oxford University)
David Watkinson (Cardiff University)

Appendix 2

Themes from reports 1 & 2

In the previous two reports, recommendations to *improve the use of science in the management of the UK's heritage* and about the *use of science to understand the past* are split into six themes containing 13 topics. These are:

Theme 1 – Understanding material behaviour
Understanding decay mechanisms and rates of decay – Topic 1a
Modern materials – Topic 1b
Theme 2 – Understanding environments
Creating appropriate environments – Topic 2a
Adapting to a changing climate – Topic 2b
Theme 3 – Improving practice
Assessment and monitoring of state – Topic 3a
Past, present and future conservation treatments – Topic 3b
Increased access to tools and knowledge – Topic 3c
Theme 4 – Development of tools and access to equipment
New and improved tools – Topic 4a
Accessing fixed equipment – Topic 4b
Theme 5 – Raising awareness of existing techniques and their application
Guidance and advice – Topic 5a
Theme 6 – Data use and management
Reports – Topic 6a
Digital data storage and sharing – Topic 6b
Widening access – Topic 6c