Editorial

We are delighted to welcome you to the new NatSCA Journal, the *Journal of Natural Science Collections*. The Journal focuses on useful and informative papers written by you; people working with, or researching, natural history collections. All articles are peer reviewed to ensure that they have reached a certain level of quality as judged by external reviewers chosen for their specialist knowledge of the particular subject covered.

This first issue of the Journal covers a variety of current topics which are important to natural science curators and conservators. The first article for the new Journal applies to all of us working with natural history collections: highlighting the importance of them and what we need to do to let people know! Doncaster Museum present the results of their large collection review project with details of their methodology and how it worked for them. A paper detailing the safe management of radioactive geological specimens gives more background information on this often misunderstood area. The National Museum Wales, Cardiff discuss a treatment for ammonites with pyrite decay and a new technique for preparing moulds of the specimens. A delightful article about how young children use natural history galleries may make us think a little differently when developing our own galleries. We also discover how the Natural History Museum, London are developing large volunteer curation projects with novel public interactions. Finally, we see how infrared thermal imaging can be used as an innovative technique for assessing our storerooms.

With the Journal including peer reviewed articles, the NatSCA Blog will cater for the more informal pieces and topical news and views. This will include seminar, workshop and conference write ups, as well as shorter pieces. There are several Blog posts already including 'Celebrating all our collections' to 'Natural science and the National Curriculum' and members are encouraged to contribute more items.

The Journal will be available online on the NatSCA website one year after publication for free access. All authors will receive a full colour PDF of their article. If you would like a digital copy of an article in this volume, please contact the author directly.

Natural science collections and the specialist staff that work with them provide an important resource for addressing globally important issues, and in this period of financial depression it is for us to be advocates by communicating the exciting projects we are working on. The *Journal of Natural Science Collections* and NatSCA Blog are just two ways of promoting the fascinating stories from our unique collections.

Jan Freedman (Editor)
David Notton (Assistant Editor)
November 2013

Submitting an article

The *Journal of Natural Science Collections* will be published once a year in December. We encourage our members working with natural history collections to submit articles for the Journal. The articles can vary from conservation to specific collection projects.

We would like the articles to be beneficial to all our members to assist with their day to day work. The Journal may also be an outlet for users of the collections, and researchers to publish findings they have discovered whilst working on natural history collections.

Full guidelines for authors can be found on the NatSCA website:

http://www.natsca.org/

For submitting posts for the NatSCA Blog, please email them to: blog@natsca.org

If you are interested in submitting an article, and may be unsure if it is suitable for the Journal or the Blog, please contact the Editor or the Assistant Editor:

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View From The Chair

I have been in post as chair of NatSCA for nearly three years now and have been on the NatSCA committee for over ten. I know that this is nothing in comparison to some of the rest of the committee but I am sure that they would join me in remarking on how far NatSCA has come since those first days as the newly-merged NSCG and BCG. They might also comment on how much has changed in the last couple of years: there has been a massive upturn in the pace, scale and number of projects we are taking on. This has been down to several dedicated and hard-working committee members (who give their time and energy for free) and we have also benefited from two rounds of ACE funding. My thanks goes to ACE for recognising that Subject Specialist Networks are worthy of significant funding and have an important role to play in modern museum life.

It is a privilege to be able to write this piece to be included in the first issue of the *Journal of Natural Science Collections*. For a long time we have been discussing the admirable quality of many of the articles submitted to the old '*NatSCA News'* and how appropriate it would be for them to appear in a peer-reviewed journal. We can now realise this and happily - through the medium of the internet - retain the rich and informative pickings of the other information, notices and articles that made up *NatSCA News* on our blog. I would encourage the membership to think of posting on the NatSCA blog, we are hoping that it will become a go-to source of information and resources for all walks of natural science collection life. The blog is already populated with useful articles: from barrier cream for handling herbarium to the role of natural history museums and collections in biological recording. There is even something on natural history museum bingo. It was great to see a report of the results of the Bill Pettit Memorial Award 2013 posted on the NatSCA blog earlier this year; the Margaret Gatty algal herbarium at St. Andrews University have made good use of the money.

We are using our ACE funding for two projects. For the first, NatSCA has commissioned a survey of visitors to museums with a mixed discipline of galleries. We wanted to look dispassionately at the popularity of natural science galleries with the visiting public. At present, the results of this are being processed but I hope they prove to be interesting reading for any museum manager or policy decision maker. The second project intends to solidify NatSCA into a coherent, well thought-out and sustainable organisation that is capable of fully supporting its members and the natural science collections of the UK. To this end, we have recently employed two NatSCA project co-ordinators who are now bent on streamlining NatSCA and making us better. The immediate results of this will be available to look at on the internet imminently: our new website will be launching soon. We aim to keep the content fresh and relevant to our members.

Other NatSCA initiatives this year include: the publication of three ICON leaflets on the conservation of zoological, botanical and geological material, work with the Home Office on the licensing of drugs within museum collections, progress with a ‘Memorandum of Understanding’ between NatSCA and SPNHC, a closer working relationship with GCG and watch this space for news on the developments of UK-wide initiatives to map natural science holdings in this country. I am particularly looking forward to next year's joint NatSCA-SPNHC conference in Cardiff. It replaces our usual February NatSCA conference with an opportunity for a complete week of immersion in natural science collection land. Cardiff are working hard to keep costs down and so I hope that as many of the membership as possible will be able to join us there in June.

Lastly I am very pleased to announce that Prof. Alice Roberts of Birmingham University and Prof. Iain Stewart of Plymouth University have both agreed to become patrons of NatSCA. I would like to wish them a very warm welcome and hope that we have plenty of opportunities to work together in the future.

Clare Brown
November 2013

Patrons of NatSCA

The committee is delighted to introduce two highly respected scientists who have agreed to be patrons for NatSCA. Both are skilled communicators and strong advocates for the importance and incredible value of natural science collections.

Professor Alice Roberts

"Sometimes I think objects in museum collections are thought of as being only of historical interest. But natural science collections are not only valuable for their history, they also represent a vast source of new information for contemporary researchers. Not only that, but the objects in these collections hold the potential to inspire a new generation of natural scientists. I'm delighted to be a patron of NatSCA."

Alice Roberts is the Professor of Public Engagement in Science at the University of Birmingham. Alice has written four popular science books about anatomy and human evolution. She has presented several science documentaries on the BBC, including Horizon episodes, *The Incredible Human Journey*, and *Ice Age Giants.*

Professor Iain Stewart

"Museums are more than mere time capsules - the displays, the specialists, even the buildings, are windows that throw light on how we see and make sense of the world around us. The collections are the keys to unlocking that. Through them we come close to places – and to times – that are otherwise exotic and distant. Dry labelled specimens spill out narratives and tales about scientific discovery that are too easily lost in the formal classroom. Through them, you can genuinely revel in the wonder of Nature and Science."

Iain Stewart is the Professor of Geosciences Communication at Plymouth University. Iain's main interests lie with geological natural hazards, in particular communicating the effects of these to people who may be affected. He has presented several science documentaries on the BBC, including Horizon episodes, *How the Earth Made Us*, and *Rise of the Continents.*

A survival strategy for natural science collections: The role of advocacy

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Abstract

Natural science collections and the specialist staff that work with them provide an important resource for addressing globally important issues, but that message is poorly communicated. In this period of financial depression there is a growing need for advocacy as the sector faces the budget and staffing cuts that can lead to neglect and the loss of collections. At a strategic level collections are best protected through demonstrable use, overt demand, and useful resulting outputs. The contribution of natural science collections to key science policy issues should be used to influence policy makers who affect support for collections. To achieve this, the importance of collections needs to be raised at local, regional and national levels and it falls to natural science collections professionals to make that happen.

Keywords: Advocacy; Policy; Management; Strategy; Funding; Governance

Introduction

Natural science collections often regard themselves as the Cinderella of the museum world – hard working, beautiful and intrinsically good, but oppressed by unsympathetic forces and unable to fulfil their potential. The role of oppressor may fall to an unsympathetic museum management or local authority representative with little appreciation for the relevance of natural science collections, and sadly Fairy Godmothers are not particularly forthcoming in real life. The harsh reality is that natural science collections often rely on ephemeral external advocates, missing the fact that collections are best advocated by the people that use them.

This Cinderella complex has been well established for decades, but has become more problematic since the onset of the global financial crisis in 2007. The organisations charged with supporting, regulating and advocating for the museum sector have faced year-on-year cuts in funding, with all the restructuring, reorganisation and outsourcing of staff and services associated with reduced income. For instance, the Museums Libraries and Archives Council (MLA) was disbanded and its museums role handed to Arts Council England (ACE) in May 2012. This saw the effective dissolution of the MLA Regional Hub Network, which had provided a useful advocacy structure, and the introduction of a more focussed major grant programme for regional museums, with Subject Specialist Networks (SSNs) like the Natural Science Collections Association (NatSCA) encouraged by ACE to take on more of an advocacy role.

The open application grants from ACE provide a less even distribution of support to regions than the MLA Hub system, but they allow for more effective use of the ever decreasing government funding made available to ACE where they are awarded. In light of the cuts that local authorities and central government have made over the last half-decade this equates to a patchy national landscape of dearth and relative plenty, where 'plenty' means a focus on project working, but with reduced ongoing infrastructure support. Unsurprisingly this funding situation has had a significant impact on individual museums in the UK, often forcing hard decisions about organisational structure, staffing and service provision (Evans, 2012) and ultimately the ability to remain open (Steel, 2012).

Viscardi, P. 2013. A survival strategy for natural science collections: The role of advocacy. *Journal of Natural Science Collections*. **1.** pp. 4-7.

Natural science collections are seen as particularly at risk when organisations face restructuring and staff cuts – partly because they are highly vulnerable to pest attack or environmental deterioration and require regular monitoring by trained staff – but also because they tend to contain large numbers of specimens, covering a wide spectrum of different specialist areas, requiring specialist knowledge to effectively use. This creates a knowledge gap that can lead to problems for the effective use of the collections, which may have an impact when the next round of cuts call for further hard decisions.

Role of advocacy

When hard decisions are being considered, the value of advocacy becomes apparent. Buy-in from the decision makers, or their reticence to fly in the face of a concerted vocal professional and public opposition, provides the incentive to seek alternative, more imaginative or compromise solutions to problems. Collections without strong advocates are soft targets, lacking the defence of vocal allies and making them particularly vulnerable when hard decisions are made.

Where cuts are rolling year-on-year, restructuring and changes in service provision lay the groundwork for the focus of future cuts, by weakening existing internal and external advocacy structures and shifting the terms upon which alliances have been built. Often this will be an unforeseen and unfortunate consequence, but in some instances there may be an element of 'divide and conquer' at play. A conscious awareness of the importance of advocacy is of particular relevance in such instances, in order to challenge the threat of *fait accompli* decisions being presented for collections.

In theory, natural science collections should be in a strong position in terms of advocates and allies. Natural history as a subject is hugely popular in the UK - for example when the first episode of the BBC wildlife documentary Planet Earth aired in the UK it was watched by 9.41 million people (BARB, 2013), around 15% of the country's entire population. This interest seems to also hold for museum audiences, with natural history as the highest rated topic of interest in a comprehensive survey of the London museums market (London Museums Hub, 2008), and anecdotal evidence compiled from mixed collection museums suggesting that natural history displays are among the most popular galleries with the public (Ashby *pers. comm.*, 2012). At time of writing audience research is being undertaken on behalf of NatSCA, with support from ACE, in order to further understand the public appeal of natural history in relation to other subjects in mixed museum exhibition galleries. Aside from popular public support, one might expect natural science collections to be vocally supported by the wide variety of professionals who use collections for research and reference, from population geneticists and taxonomists to archaeologists and artists.

However, despite the wide appeal and research value of natural science collections, they receive little recognition from the wider cultural sector and, perhaps more surprisingly, there is little acknowledgement of their contribution in academic and media circles. We need to identify why this is the case, and consider what we can do about it, since acknowledgement of worth by stakeholders underpins advocacy.

Solutions waiting to happen

One issue with the cultural sector is that few of the decision makers are from a natural sciences background, or when they are, they often bring their management experience from non-museum institutions and don't have a collections background. This means that influential advocates for natural science collections are scarce at higher levels within the cultural sector. Challenging this requires short and long term solutions.

In the long term we need to look to ourselves as professionals and recognise that our attitude towards, and decisions about, career progression shape our professional environment. Many of us have the skills and ability to take on management roles, but lack the inclination, especially if they take us away from our collections. This needs to change, although how that change might be brought about is beyond the scope of this article and will require a body of work on careers in the museum sector and the motivation and skills of natural science collections professionals.

In the short term we need to ensure that we communicate far more effectively with decision makers in the cultural sector about what natural science collections can do. This might be achieved in a variety of ways – sharing activities online or in the museum literature, collaborating with artists to produce high-profile exhibitions, or by overtly linking collections-based research to policy issues (Suarez & Tsutsui, 2004). Examples such as the egg-shell work that led to the banning of DDT or heavy metal contamination of bird feathers that led to a ban on alkyl-mercury fungicides (US EPA, 1975; Rocque & Winkler, 2005) provide excellent high-profile demonstrations of the potential contribution of natural science collections to top-level policy issues. Similarly, current population genetic work by species conservationists (e.g. Wandeler *et al.*, 2007; Russello *et al.*, 2010; Edwards *et al.*, 2013) and discoveries of new species (Helgen *et al.*, 2013) offer demonstrations of actual and potential uses of collections, while research that links collections to buzz-topics like climate change (Parmesan *et al.*, 1999; Peterson, *et al.*, 2002; Reutter, *et al.*, 2003; Lister *et al.*, 2011; Robbirt *et al.*, 2011) help wed collections into the concepts of Ecosystem Services (Millennium Ecosystem Assessment, 2005) and Natural Capital, which are gaining political credibility, as shown by the establishment of the Natural Capital Committee in response to the Government's Natural Environment White Paper (NCC, 2012).

Such examples may prove easier to demonstrate if the academic press and the wider media more actively acknowledged the role of natural science collections in art and science. It seems that collections are often simply taken for granted; a resource that can be used for inspiration, research or reference, but a resource that has always been there and (the assumption follows) always will be. However, the real issue may simply come down to reporting about use of collections. It is not uncommon for academic research to yield important results using specimens from a variety of collections (including specimens from small organisations), only for the people managing the collections involved to not be informed about the publication of those results. Moreover, press releases and subsequent media reporting will often focus on outcomes and their implications, but miss the pivotal role that collections have played in research. Finally, collections professionals can sometimes underplay the importance of the contribution of their specimens because multiple other sources have also been used, or the bulk of data was collected in a larger institution. This modesty is inappropriate, since all contributions to a body of work add value and earn the right to be associated with the work.

Once more, the onus falls on us as professionals to ensure that we establish a good dialogue with artists and researchers in order to make it clear that we need to know about publications, to ask that collections are mentioned in publicity where possible and to follow up on research that is conducted with our collections. Similarly we need to nurture relationships with media professionals, so that they turn to us when reporting on issues that relate to our collections (directly or indirectly). Both researchers and representatives of the media can be surprisingly willing to engage with collections advocacy if they know it is necessary - and their engagement is key to communicating our message to high-level decision makers.

NatSCA's role

As the SSN for natural science collections, NatSCA is stepping up the advocacy side of our remit in response to a need within the sector. As natural sciences collection professionals we know what natural science collections are used for and how effectively they engage our audiences, but we also recognise that this information is often poorly communicated and we are aware that our stock is relatively low in the eyes of many decision makers.

Since NatSCA is a membership organisation run by volunteers, we have little political power and are limited in what we are able to do directly. Our strategy has been one of seeking partnership with other organisations who have links with collections and the natural sciences such as the Linnean Society, the National Forum for Biological Recording (NFBR), the Natural History Museum (NHM) and ACE, who can lend their support, knowledge and influence. Of course, every effective partnership requires an element of *quid pro quo*, and in this case we bring the strength that lies in our membership, an extensive network of natural science professionals with links to the collections in museums all around the UK and beyond.

NatSCA provides a voice for non-national UK collections at the Linnean Society Taxonomy and Systematics Committee, which feeds back to the Natural Environment Research Council (Godfray *et al.,* 2011). With support from this committee we are in the process of planning a project to map natural science collections and their staffing levels in the UK, which will provide a basis for understanding our overarching national collection and the threats facing it. Elements of this work will be addressed by two recently appointed project staff, Dr Justine Aw and Russell Dornan, who will support the NatSCA Committee in advancing a variety of projects, thanks to £15k of SSN funding from ACE.

As mentioned earlier, NatSCA has been awarded an ACE grant of £10k to conduct research into audiences in mixed museums; the results of which we hope will contribute to our wider advocacy work and will allow NatSCA to establish better links with other SSNs in the sector. We are also involved in a session at the 2013 Museums Association conference in Liverpool, to further raise the profile of natural science collections in the wider museum sector. Finally, we have the help of some high profile natural science collections users to advocate for collections, with Professor Alice Roberts and Professor Iain Stewart very kindly agreeing to act as patrons of NatSCA.

More opportunities for advocacy will arise as we continue to develop partnerships, but we have no intention of letting these activities interfere with our delivery of practical workshops and sharing of information about advancements in collections practice and careers. In fact, with the launch of the peer-reviewed Journal of Natural Science Collections (JoNSC), development of our social media and redevelopment of the NatSCA website, we intend to improve the support for our members as well as improving advocacy for collections.

Since NatSCA is a network that is supported and run by members, our advocacy work should not be seen as an intervention. We all need to positively communicate the value of natural science collections to the public and decision makers if we want our voice to be heard. The future survival of natural science collections in the UK rests on all of our shoulders.

Acknowledgements

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Useful links:

NatSCA website: http://natsca.info/

GCG website: http://www.geocurator.org/

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Taking Stock, Effective Collections, Esmée Fairbairn and the natural science collections at Doncaster Museum

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Abstract

This paper will present a summary of Doncaster Museum Service's holistic collections review and rationalisation process named *Taking Stock*. A brief background to the museum service and history of the development of the collections will be given to provide context. The internally developed review methodology will be discussed before concentrating on the externally resourced and integrated reviews which took place as part of an Effective Collections project and an Esmée Fairbairn Museum and Heritage strand scheme. A more in depth synopsis of the CIRCA (Catalogued, Interpreted, Researched, Conserved, Accessible) project methodology will be provided, in order to demonstrate the review strategy used for the appraisal of the palaeontology collection. It will also demonstrate how, due to the wider aims of CIRCA project, the methodological approach developed to include a specimen level review in contrast to the Effective Collections reviews which were at collection level only. Furthermore it will serve to demonstrate the route and results of a methodology developed by an externally contracted specialist within the robust strategic framework of a full and over arching collections review process. De-accessioning and disposals are discussed throughout the paper.

Keywords: Doncaster Museum Service; Disposal; De-accession; Collections Review; Effective Collections; Esmée Fairbairn

Background

Doncaster Museum opened in 1900 in a small room in the old Guildhall. Nine years later the Museum moved to the ground floor of Beechfield House with its 'stock' of 1006 museum objects. From 1955 the Museum ran a small zoo in the grounds of Beechfield and some of the occupants, suitably mounted, form a part of the current natural sciences collections. In 1962 the Beechfield premises closed and two years later the Doncaster Museum & Art Gallery (DONMG) was opened on Chequer Road by the Borough Council – one of the first purpose built, post World War Two museum buildings to be entirely funded by a local authority.

The development of the collection through to the 1950s was steady, comprising largely of material directly relating to the local area. From the mid-1950s until mid-1980s there were several intensive periods of collecting which saw the Natural Science, Social History and Archaeology collections grow considerably. The majority of Natural Science collection acquisitions during this time came from other museums in the UK who were rationalising their collections. DONMG currently houses a range of collections, including Natural Sciences, Archaeology, Industrial Social History, World Cultures, Decorative and Fine Arts.

Robinson, P. & Bowden, A. 2013. Taking Stock, Effective Collections, Esmée Fairbairn and the natural science collections at Doncaster Museum. *Journal of Natural Science Collections.* **1.** pp.8-26.

Doncaster Museum Service is responsible for DONMG and a Grade I listed Country House and social history museum three miles from the centre of Doncaster: Cusworth Hall Museum & Park. The Service cares for over 479,250 individual items (based on recent database records). At the time of writing, DONMG has subject specialist staff in Social History (including costume and photographs), Archaeology (including Antiquities), World Cultures, and Fine and Decorative Arts.

A review across the Service

In 2009 Doncaster Museum Service began a very large collections review project called '*Taking Stock'*. The project aimed to review the entire collections across the Service, whilst evaluating the current collecting strategy. The primary aim was to protect Doncaster's specific, unique heritage and collections. The project also wanted to find solutions to gaps in in-house specialist expertise, pressures on storage space, poor curation and storage, and to support the collections and service against further predicted cuts in local authority budgets.

The stakeholders include Doncaster Metropolitan Borough Council and the elected Mayor and Council, Doncaster residents, general service users (including academic researchers, educational institutions and special interest groups). Regional Museum Development Officers were also consulted to ensure that *Taking Stock* was developed and completed in line with the Museum Association (MA) Code of Ethics and Accreditation requirements.

For such a large scale project reviewing the entire collections, there could have been the potential for the project to be misunderstood, potentially resulting in bad publicity. A short statement outlining the objective of *Taking Stock* was developed so all stakeholders were completely aware of the processes;

> "The objective of '*Taking Stock*' is to review the museums' collections at a landmark stage (after 100 years of collecting) and ensure that past, current and future collecting precisely matches the criteria of the Museum Service's Acquisition and Disposal Policy. This will guarantee the collection best serves the borough, by reflecting the heritage, culture and educational needs of its communities and representing the best use of public money."
>
> (DMS, 2010)

DONMG curatorial staff undertook consultation with stakeholders to discover how they viewed the review project. The feedback was very positive, including some quite detailed responses which demonstrated a good understanding of what collections reviews are. Through consultation the following benefits were established;

- A more focused and relevant collection which the museum service is capable of caring for and which meets best practice.
- Improved access to collections.
- Enhanced information about the current strengths and weaknesses of the collection which will lead to a more informed and responsible collecting strategy.
- Empowerment to achieve continued and improved collections care.

Recent Collection Reviews

Before developing the review methodology, it was useful to examine the core objectives of DONMG (Appendix 1) to ensure that the reviews addressed current and future priorities as outlined in the Museum's Collection Development Policy (DMS, 2013a; 2013b). It was also very useful to examine other collections reviews that had been undertaken in museums across the world to see how they had worked. This was necessary for the development of a robust bespoke review strategy that would incorporate externally developed review methodologies for collections with no in-house expertise.

The process and procedures for disposal are clearly set out in the Disposal Toolkit: Guidelines for Museums (MA, 2008a). The word 'disposal' often has negative connotations because it is often misunderstood. Disposal can be defined as "the full de-accessioning of an object through transfer, return to original donor, sale or physical destruction" (Freedman, 2012). Doncaster Museum Service follows the ethics of the Disposal Toolkit (MA, 2008a), and Code of Ethics (MA, 2008b), which promotes the transfer and sharing of collections as a means of improving care, access and value.

Until forty years ago collections appear to have been relatively dynamic. During the early 19^{th} century formation of museums in Yorkshire, there were "no scruples about selling the poorer duplicates, and indeed all societies saw this as a legitimate way of raising income" (Knell, 2007: 271). Even as late the 1950s to 1970s, "disposal by sale was not an infrequent occurrence" (Merriman, 2008: 4). Indeed Doncaster Museum Service acquired a large amount of objects in the late 1960s through transfer from other museums.

During the 1960s and 1970s, there was a growing concern over the sale of objects and an emergence of a shared notion of 'trusteeship' where collections were held in trust on behalf of the public. In 1977, the MA Code of Ethics first used the phrase that "there must be a strong presumption against the disposal of any items in the collection of a museum" (Davies, 2005: *quoted in* Merriman 2008: 4). This perspective has been maintained in later versions of the MA Code of Ethics and became a central principle of the Registration and Accreditation schemes for museums. Following this, the term 'disposal' became a taboo subject and relatively few disposals were made from museum collections in the 1980s and 1990s. There were a small number of infamous examples of disposals during this period (Robertson, 1990), for example Buxton Museum & Art Gallery were expelled from the MA for selling art work in 1991.

However museums continued to collect; collections are, after all, "the museum's 'soul' and *reason d'être"* (Alberch, 1993). A 1989 report for the Museums and Galleries Commission showed "that, on average, over 60% of museums' resources were being devoted to the direct and indirect costs of managing their collections" (Merriman, 2008: 5). The National Museum Directors' Conference Report (2003) argued that "careful review and rationalisation of collections, leading in some cases to disposal, transfer or long-term loan, can make an important contribution to ensuring that these collections are enjoyed and used".

This set the scene of the MA inquiry which led to the *Collections for the Future* report (Wilkinson, 2005). The report accepted that "too many collections are underused – not displayed, published, used for research or even understood by the institutions that care for them" and concluded that "museums must reassert the place of their collections at the heart of the public realm, and find new ways to ensure that they really are for everyone" (Wilkinson, 2005: 4).

Collections for the Future focuses on the concept of 'The Dynamic Collection'. This tackles the problem that "museums are no longer developing their collections with the vibrancy and rigour needed to ensure that they serve the needs of current and future audiences" (Wilkinson, 2005: 5). It goes on to propose that "museums also need to face up to disposal – intelligent stewardship does not mean clinging on to everything unthinkingly... Museums need to make an intelligent appraisal of their own assets and resources and do more with what they have" (Wilkinson, 2005: 9).

The MA website has a dedicated area outlining Collection Reviews (MA, 2013). Within this is a summary of a number of established review methodologies, all of which are collection level review methodologies.

There are two well established and widely used schemes:

- The Australian Significance 2.0 method works by looking at the values and meanings that items and collections have for people and communities (Russell & Winkworth, 2009). Significance helps unlock the potential of collections, creating opportunities for communities to access and enjoy collections, and to understand history, culture and environments. This appears to be a highly regarded methodology and has been used in the UK.

- In terms of reviewing utility and current condition and collection care, the exemplar methodology is that of University College London (UCL) Collections Review Toolkit (Dunn & Das, 2011). This contains two rubrics, one for assessing utility and the other for collections care.

A third approach was adopted is the Renaissance East Midlands methodology called Reviewing Significance 2.0 (Reed, 2012). This method was created by merging and adapting both the Significance 2.0 and the UCL schemes. (For details on these and other collections reviews, see Freedman, 2012.)

A specimen level assessment is the approach to reviewing individual specimens, rather than entire collections. These reviews select specimens for the future core collection; they provide the decision making process for deciding which specimens to de-accession. The emphasis at this level is on refinement of the collection; for a collection to be of a higher overall quality. It may in future grow to fill gaps, but the focus of the review process at the level of the specimen is to increase the quality by reducing the size, removing any specimen that is not adding value.

The approach taken by the Imperial War Museum (IWM) is an example of a more absolute approach where specimens are assessed in isolation (Emily Dodd, *pers. comm.*). In this case the number of specimens involved is large and the review is limited to within one organisation, so little or no external peer review takes place. The IWM approach to their specimen level review assesses six criteria and gives a weighted score for each: Significance, meaning-making, visual impact (max. score 25); Interpretive Potential (including use in exhibitions, research and learning) (max. score 25); Rarity/ Uniqueness (max. score 15); Completeness/ Authenticity (max. score 15); Relevance: does the object fit with the Museum's Purpose? (max. score 10); Condition (max. score 10). Each specimen ends up with a score out of 100. Those above 50% are retained, those with scores beneath 50% are considered for de-accessioning.

A more relative approach, where specimens are assessed in relation to similar specimens, has been taken by the Rural Museums Network (RMN) and the UK Maritime Collections Strategy (UKMCS). There are a number of organisations and experts involved and the number of objects in any one review is limited, for example: The RMN review of tractors (Viner & Wilson, 2004a: 26-7) across the UK involved 186 objects in 23 museums; The RMN review of combine harvesters (Viner & Wilson, 2004b) across the UK involved 32 objects in 10 museums; The UKMCS (2006) review of marine engineering collections involved 51 objects.

Development of *Taking Stock*

Taking Stock evaluated the entire museum collections across Doncaster Museum Service. The review priorities were based on a number of factors, including; the expected reduction in storage facilities (in particular the loss of one multi-collection off site store); collections without a designated specialist curator; collections in serious risk due to inadequate storage conditions; insufficient documentation; and pest infestation.

DONMG's mission statement and the objectives highlighted key areas in the collection which were important to retain and safeguard (Appendix 1). The founding collections were important to retain within DONMG, as these objects defined and shaped the museum from the very beginning and have continued to do so to the present. These 1006 objects are a fundamental part of the history of the area, preserving a time capsule at a key stage in Doncaster's engagement with its heritage. It also was essential to preserve objects, or collections, with strong Doncaster connections including provenance, owner and collector, or unique to Doncaster. Additionally, locally relevant research collections were also seen as a crucial component to preserve.

A special 'X-Factor' category was used to ensure that objects or collections which fell outside of the Doncaster related focus could be retained where they could fulfil a key role as defined by the museum's objectives. For example, an 'X-Factor' object would be one where it helped promote or elevate the status of the broader collections, aid interpretation or display, assist in marketing and revenue generation to the benefit of the collections as a whole.

The revised Service objectives and the *Taking Stock* mission statement provided the basis for the development of the internal collections review methodology (Appendix 2). A set of key statements were drawn up. Each statement is proceeded by a tick box and a space for noting the reason for selecting that criteria. The criteria for disposal are then backed up with notes to assist the user in determining whether an object or collection matches the statement. It is important to note at this stage that this internal review methodology was developed to assess collections where inhouse expertise existed. The first phase of review and disposal only concentrated on collections or individual objects which clearly fell outside of the Service objectives. Decisions were subject to assessment both by the Service's Acquisition and Disposal Panel and by a Focus Group consisting of a mix of stakeholders, such as members of the general public, special interest groups and external museum professionals. The internal methodology is being reviewed as a result of the lessons learnt in the external reviews described below. This will assist in developing the methodology for the next phase of internal collection reviews.

Putting *Taking Stock* into Practice

Reviewing the entire collections across the Service was a big challenge. To make it more manageable, collections were split into two groups; those which could be reviewed internally and those collections which would require external resources (funding and specialist advice). A traffic light system was informally implemented as a way of prioritising collections: red and amber indicated collections in primary and secondary need of attention respectively; green light collections were collections or objects which could be looked at once all others had been addressed. Collections were discussed at curatorial team meetings and each collection was prioritised.

Due to lack of onsite subject specialist staff, the natural science collections were identified as a priority for review and requiring external specialists. The priority to look at this collection in particular was due to their vulnerability to pest infestation, their lack of detailed and structured curation, their physical size, and inadequate method of storage. This required external funding for specialist advice.

Whilst all of the collections held by Doncaster Museum Service have to some extent been reviewed or will be reviewed as part of *Taking Stock*, this paper focuses on the reviews undertaken on three main parts of the natural history collections; the Conchology, Entomology and Palaeontology collections. Two external grants were applied for to manage these reviews; one to review the Conchology and Entomology Collections and a second to review the larger Palaeontology Collections.

Seeking Grants

The MA developed the *Effective Collections Programme* in 2009. The aim was to provide museums with funding and support to assist with developing collection reviews, identify underused objects and explore ways of improving access, care and curation through the development of partnerships, loans, transfer or alternative forms of disposal (Cross, 2009). Resulting from the success of this grant, in 2011, the MA worked together with the Esmée Fairbairn Foundation to set up the *Esmée Fairbairn Collections Fund*. Museums were able to apply for a much larger grant to focus on research into collections, conservation, collections reviews, and development of collections. The aim of this grant was for museums to understand more about what they have.

DONMG were successful in applying to both grants bodies to assist with reviewing the natural history collections;

- The *Taking Stock* project applied for £10,000 from the *Effective Collections* Main Fund to undertake a full review of two parts of the natural science collections; entomology and conchology.

- A separate funding application to the *Esmée Fairbairn Collections Fund* was prepared for the unique DONMG CIRCA **(**Catalogued, Interpreted, Researched, Conserved, Accessible**)** project to review and revitalise the palaeontological collections (£82,785).

Although the criteria for all three reviews differed slightly and were outlined in separate briefs they had broadly the same objectives which were aligned to the main *Taking Stock* project.The collections reviews were required to cover the following:

1. Specialist & Curatorial Review - provides an overview specialist curatorial opinion on the collections. It will include an indication of the significance and quality of each collection from a local, regional, national or international perspective and for research, display, learning etc, and looking at any potential legal or ethical issues.

2. Use - looks at how the collections could be best used in the future, and whether each collection is best placed with Doncaster Museum Service or with another museum or institution.

3. Collections care - looks at how well the objects are cared for, with suggestions for improving collections care standards on a limited budget. This should include an assessment of collection care needs.

The following objectives were established for the CIRCA project to meet the needs of *Taking Stock* and satisfy the criteria for funding, required of Esmée Fairbairn:

1. The assessment/collections review will generate a flexible but robust methodology. This will develop the collection to ensure that it matches the criteria of the Museums Service *Acquisition and Disposal Policy 2006-2011* (since superseded by the *Collections Development Policy 2013-2016*) and that it incorporates the desired outcomes of the Museum's collection review *Taking Stock*. This will ultimately creating a platform for achieving the remaining objectives:

2. To identify candidates for transfer to alternative institutions, or which are suitable for disposal to ensure that the collection meets the current and future needs of the Museum.

3. To have all specimens documented on Modes. This will allow curatorial staff to know exactly what is in the collection, where gaps exist for future collecting or loans and what is available for loan, exhibition or facilitating educational outputs. This will also provide full documentation of the specimens should any specimens be de-accessioned.

4. To safely store the most important and vulnerable to ensure its long term care. To ensure that the collection is in a state that allows the museum to effectively care for it according to available resources.

5. To create a well ordered and logically organised collection which is packaged/stored in a way that affords the specimens maximum protection; facilitates ease of access (reducing the need for over handling) and is stored to improve access by non specialist staff. To maximise the use of available space and to ensure the best method of storage is employed and the most suitable environment for the collection is created.

6. To achieve publication of the most important/ interesting specimens in regional or national journals, to establish good relations with other institutions (with linked collections) and to raise the profile of the collection (and its research potential) within the academic community and the general public. To generate interest in the collection by museum visitors/service users and therefore increase the use of the collection.

7. To capture and record information which will allow the collection to be effectively curated by non-specialist staff (i.e. staff without a geological or palaeontological expertise), enabling them to generate displays and facilitate research requests and public collections enquiries. The strengths of the collection, local and regional connections and star objects will be clearly identified and recorded. This will be done by adding the information to the database and ensuring all the information associated with that specimen is recorded clearly on the labels.

A standard brief was constructed for all three reviews in order that the externally contracted specialists were equipped to undertake the reviews in line with the established specifications of *Taking Stock*. The briefs all contained three key elements designed to inform the reviewers:

1. A brief history and background to the Museum Service and a synopsis of the collection to be reviewed (as far as it was known).

2. A summary of *Taking Stock* with details of the service objectives and criteria for review.

3. Details of the specific requirements to be addressed by the review (this differed between each collection due to the different nature and circumstances of each collection).

The reviewers had to submit a written report which needed to include;

1. A summary of the history and development of the collection and insights into its curation.

2. A significance assessment, outlining importance and potential (both in relation to the museum service objectives and irrespective of them).

3. Details of the key issues – considerations which have a significant bearing on the decision making process.

4. Recommendations based on the objectives with advice on how each option can be executed and the related implications.

Taking Stock of the Conchology and Entomology collections

The conchology collection was reviewed by two external reviewers; one subject specialist to review the collections and one specialist to review the educational use. The subject specialist reviewer accessed the collections to research the associated documentation and archives to develop a report with recommendations. The report included acquisition history, listing the major collections and their provenance, the general condition of the collection in terms storage, and a key to interpreting and using the card index for the entire collection, created by the former Curator of Natural Science at DONMG (Martin Limbert). The report concludes with suggested approaches and solutions to future management, divided to deal with conservation and reorganisation (including advice on resources) linked to the objectives of the Service.

To complement the curatorial review, a separate specialist assessed the education potential of the conchology collection. The reviewer interviewed education staff, sat in on school and family sessions relating to natural science activities and looked at the collection. The report compiled by the curatorial review was also examined. They evaluated the current use of the general natural history collections along with existing and potential partnerships with schools, specialist interest groups and professional organisations.

A written report was submitted with recommendations outlining how the collection could be developed for learning. There were innovative ways of developing education and access to include the conchology collection with other natural history collections, and even link in with other collections such as World Cultures. The report provided invaluable advice relating to the use of the collection and the necessary requirements for making it accessible and usable for education, learning and general outreach.

The educational recommendations from the conchology collections were broad enough to also fit the entomology collections. The specialist who undertook the entomology collection review had a wide range of skills and they were able to adapt the educational recommendations, providing comments, information and advice specific to this collection.

The entomology collection review was undertaken by one reviewer who completed the review in a few weeks. The reviewer spent time at the Natural History Museum, London, researching key links with Elphinstone Forrest Gilmour (director of the museum from 1953-1967). The majority of the time was spent working directly on the entomological specimens and associated archives at DONMG.

The reviewer designed a new type of methodology based on scoring identifiable discreet collection element. Based on the taxonomy (e.g. British Isles Lepidoptera, World Lepidoptera, etc.) the reviewer used a scoring system from 1-9 to rate relevance and importance to several defined user groups. Each user group was explained along with the necessary collection/specimen attributes required by each user group.

The specialist developed a report with recommendations, which was invaluable in locating discreet collections and finding out how the collection has been organised in the past. These reports for both the entomological collections and the conchology collections have added an enormous amount of information for the current staff to manage the collections more efficiently. The main aim of any review is to discover more about what we have in the collections.

Taking Stock **of the Palaeontology Collections: a detailed account of the review and redefining the purpose of the collection**

The palaeontology collection had been flagged as a collection without internal expertise and in need of specialist curation. It had been given an amber rating under the traffic light classification, as a collection not immediately requiring attention. However, in 2009 the museum took on a volunteer who had significant knowledge of palaeontology and had expressed an interest in researching and creating an exhibition from a mixture of the museum's collection and his own extensive private collection. The exhibition, named *Fabulous Fossils*, was incredibly popular with the museum visitors. Researching for the exhibition, the volunteer made significant discoveries within the collection. An application to the *Esmée Fairbairn's Collections Fund* (Museums and Heritage strand) was applied for to research the collection further. It is important to highlight that this collection was not an immediate priority for *Taking Stock*. However, someone working directly on the collections and who was willing to give up their time and expertise provided the ideal opportunity to develop and submit a detailed grant application.

The successful grant enabled a new and innovate project to begin to review the palaeontology collections. It was named CIRCA (Catalogued, Interpreted, Researched, Conserved, Accessible); the acronym signalling the main objectives of the project. This project is the most complete and collaborative collections management scheme to be carried out under the umbrella of *Taking Stock*. It built on the collection reviews from the Effective Collections project, developing a set of criteria and methodology for rationalisation, curation and redefining the purpose of the collection.

The history of geological collecting at DONMG

Before looking at the review methodology, it is important to understand the context of the collection. This section gives a brief summary of the history of geological collecting nationally and then provides a history of collecting at Doncaster Museum Service.

The history of geology collecting and the development of provisional museums across England is intrinsically linked. But it hasn't been a story of consistent growth. For two hundred years, the rise and fall in the popularity of collecting minerals, fossils and rocks, has been the driving factor in the formation and early success (or not) of many museums. Five key periods in this so called roller-coaster of museum geology (Knell, 1996) have been defined (Fig. 1): two periods of growth in interest, two falls of popularity and most recently a period which history may judge to be a resurgence or just a period of false optimism.

Around 1850, geology as a subject was the height of fashion, and this marked the 'Heroic Age'. During this period of discovery, "for the provincial gentlemen, works on regional geology John Phillips, Gideon Mantell and others, provided models for imitation and a framework for local studies" (Knell, 2007: 261). This period saw the formation of philosophical societies and in Yorkshire this resulted in a suite of these new social and intellectual organisations – Leeds (1818), Bradford (1822), Hull (1822), Sheffield (1822), York (1822), Whitby (1822), Wakefield (1826), and Scarborough (1827). Not only was geology collecting at the forefront of the development of museums, but local museum collecting was at the forefront of the development of the science. Each was led by a charismatic single scientist, for example William Smith was the curator at Scarborough (Osborne, 1999: 312-20), John Phillips was keeper at York (Pyrah, 1998: 37-45) and George Young at Whitby (Osborne, 1999: 44-49). Each of these men published works which were critical to the science of the day.

Between 1860 and 1870 there was a fall in popularity in museums, which marked the second phase of collecting. It was summarised at this time as: "the Provincial Philosophical Societies of England have completed their career they are the debris of an age that has passed away" (Hudson 1851: *quoted in* Alberti, 2003: 342). It was in part due to the fact that "the real science of geology was becoming more rigorous and systematic, and its publications less approachable and more specialized" (Knell 1996: 34-5). There was also the loss of the 'great men' who were critical to geology collecting, the development of the science and the fortunes of the local museum. Written after the event, this quotation summarises this reliance: "It is ... a dangerous thing for a public museum to depend thus upon the support or interest of a single individual, or even on a few amateurs ... and it has indeed often happened that when the leading scientific spirit of a locality has been removed, the museum has degenerated, and lapsed into a state of neglect" (Ruddler, 1877: *quoted in* Knell, 1996: 39).

From 1860-1870 until the 1920s there was a 'boom' related to the rise in natural history societies and field clubs, marking the third phase (Alberti, 2001). This latter 19th century rise in popularity was distinctly different. Natural history more generally had blossomed and was a common pastime at a local level: "there is scarcely a town in the kingdom, and in the North of England scarcely a village, in which some such society, either 'Botanical' or 'Entomological, or 'Naturalist' does not exist" (The Naturalist 1, 1864-1865: 1: *quoted in* Alberti, 2001: 119). In addition the natural history was becoming a profession, with civic colleges (later universities) beginning to be established from the 1870s onwards and academic positions in the natural sciences being founded. During the 1890s, in the early years of the MA the "natural sciences dominated proceedings" and "at its annual meetings geology was a popular subject for focused discussion and for the illustration of more general principles" (Knell, 1996: 44).

The critical debate during this time was the purpose of museums and their collections. The pre-existing focus on scientific research, adopted from the early 19th century philosophical society museums, resulted in collections which were focused locally. Some saw this as a strength, for example museums should "devote themselves to the thorough and complete working out of the productions of

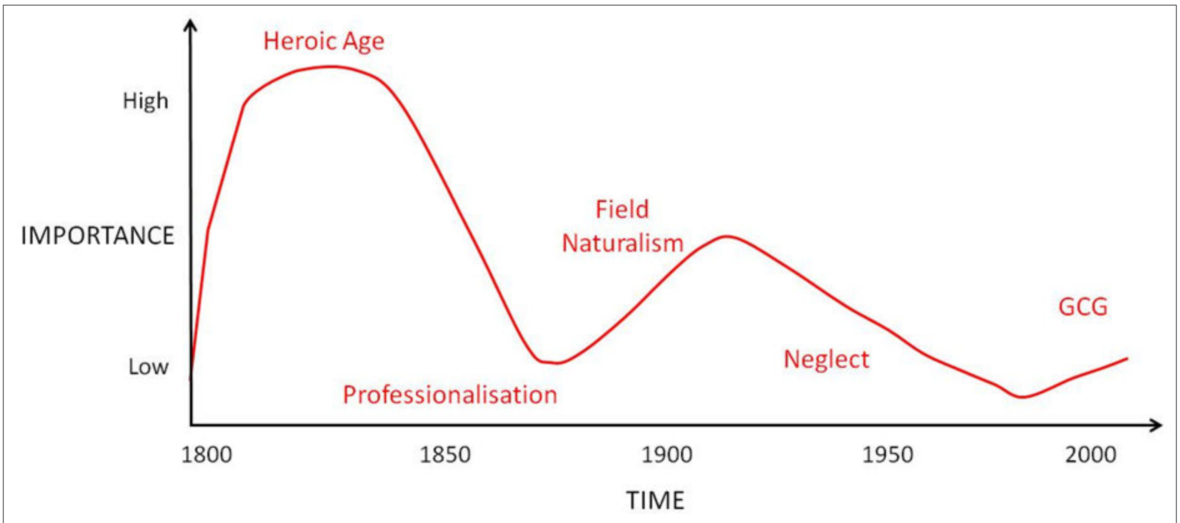

Fig. 1. The five periods of Museum Geology Collecting.

their own districts" (Knell, 1996: 42) or "the great value of your museum is and ought to be in its departments which illustrate your own land and sea" (Knell, 1996: 42). However others saw collections to be biased by the cabinets of local collectors (Alberti, 2001: 130). The alternative view to the higher scientific objectives of collections and museums, developed as a consequence of the Reform Act of 1867 and the Education Act of 1870 – "the buzzword for museums for the next 70 years became education" (Knell, 1996: 42). The local museum became the educational museum; its aim was to supply broad knowledge, not local knowledge.

The fourth period of the relationship between geology collecting and museums is a slow decline from the early part of the 20th century. "The reorganization of the Science and Art Department prior to the Great War was widely blamed for thrusting the science once more into a period of general decline.... The loss of material from the 1920s onwards, much of it dating back to the earliest days of local geological exploration, was remarkable... Neglect and loss through sale, dumping, burial and theft was regrettably commonplace" (Knell, 1996: 47-48).

The fifth and final period of the relationship between geology and museums is the current era, which began with the formation of the Geological Curators Group (GCG) in the 1970s. More critical however was a nationwide review of geology collections carried out by the GCG and its damning conclusions published by Doughty (1981). In this period, museums were more professional, better funded, better staffed and more conservation aware than ever before and this report had repercussions well beyond the subject of geology. "Curators were already aware of disarray in their own museum ... but no one had the overview [which the GCG report laid bare].... But 'the profession', as it is now known, is a very recent invention and was predated by more than a hundred and fifty years of poorly resourced amateur (i.e. without training, method or standard) involvement. ... While individual collections may have found order for a few years, [the GCG report highlighted that] most have probably spent much of their time in total or partial chaos, or simply in an unmaintained state" (Knell, 1996: 50-51). A second major change during this current period is the recent MA inquiry into museum collections, published in 2005 as *Collections for the Future* (Wilkinson, 2005).

The Doncaster Museum Service Geology Collection

The first and most important step was to map the history of the development, curation and use of the collection. This was essential for developing a review methodology but also for judging the worth of each specimen or group of specimens against the criteria established under *Taking Stock*.

The history of the geology collections at DONMG from the beginning to present day are outlined in Fig 2. The founding collection of DONMG held 1006 objects, which contains 267 geology accessions (180 of which were palaeontology). These include a significant collection of fossils from the collections of Herbert Henry Corbett and Henry Culpin; both senior members of Doncaster Microscopic and Scientific Society and key players in the establishment of Doncaster Museum. These were collected, and perhaps also purchased or swapped, during the latest part of the 19th century and earliest part of the 20th century. This was during the second boom period where naturalist and field clubs were the dominant force (rather than literary and philosophical societies). The main difference that these collections are from those put together in the early 19th century is that it was education not science that pre-occupied the collectors. Unlike the Literary & Philosophical Society founders of York or Whitby Museums who collected locally and methodically and then published their results, the founders of Doncaster Museum Service were concerned with educating the people of Doncaster. This helps us to understand the lack of local emphasis and the comprehensive nature of the collection.

A second result of this relatively late foundation is the predominance of biology over geology, as part of the field naturalist revolution. This collection was also built around several local scientists for the appreciation of all, as opposed to being built up by one man for the privileged few. Following the formation of the DONMG collections, the geology collections appear to originate from local residents through a trickle of donations; less than 50 accessions in each decade from 1910 to 1960. Little is known about the use made of these collections during this period for display or learning. However it is clear from interviews with previous curators that a permanent display was established from the opening of the new Chequer Road Museum in 1964, focussing particularly on the geology and fossils of the Doncaster area, but covering most geological periods. A stratagraphic collection seems to have been formed from a core of the early well provenanced material and additional collected specimens, which remained distinct from a more general display collection.

The rapid expansion of the geology collections came initially in the late 1960s, with the development of the new museum building and larger stores. This was linked to Elphinstone Forrest Gilmour's aspiration to place Doncaster Museum on the national stage "through sheer weight of collections" (quote from an anonymous retired member of staff). This initial expansion in the mid-late 1960s appears to have been linked to a number of collections accepted from other museum institutions (e.g. Dick Institute, Wood End Museum, Brighouse Museum, Worksop Museum, Bridlington Museum, Lincoln Museum, Wakefield Museum). It is unknown to what extent these other museums simply donated spare or unwanted material, or to what extent Gilmour was swapping or buying material (or indeed if he was selling unwanted material from the DONMG collections).

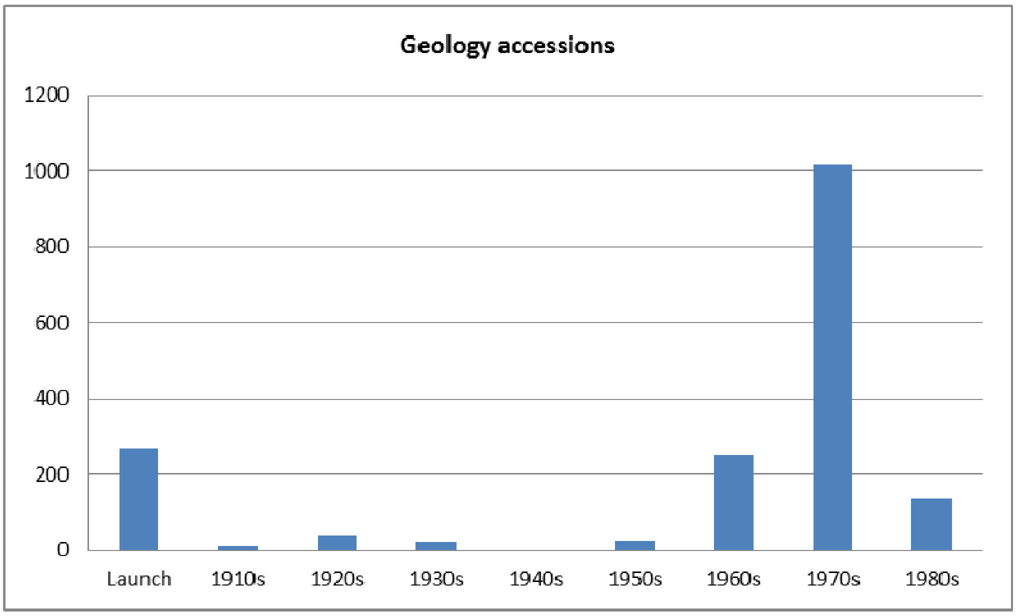

Fig. 2. Number of geology (fossils, minerals and rocks) accessions during each decade. (Note: an accession may be one specimen or hundreds).

The succeeding phase of expansion in the 1970s, which amount to over half the total geology accessions, was related to the appointment of Anne Pennington George and the efforts of an enthusiastic volunteer Don Bramley. Together they are thought to have amassed the large number of accessions that entered the museum by donation (e.g. the Gregory Collection, in late 1974 or early 1975), by personal collecting (e.g. Paul Buckland and Don Bramley), but also by purchase in the 1980s (e.g. Anne Pennington George's collection of precious and semi-precious gem stones, the dinosaur egg and the ichthyosaur). Since then the number of geology accessions has declined, perhaps due to refocusing of expertise (Anne Pennington George became the Education Officer), loss of volunteers, acquisition budget cuts, and lack of space.

Collection Priorities

It was important to assess the value of the palaeontology collections for Doncaster Museum Service for the future. If a specimen is judged by this review approach to be of low value, it means it is of low value for Doncaster Museum Service in future, but may be of value for another museum through transfer.

The CIRCA review, like all collections reviews which have assessed museum collections, is reviewing the 'value' of the fossils for DONMG and will take into account the following key factors (the previously mentioned 'X-Factor' objects would fall under factors 1-3.);

1. Audiences (who are the collections for?)

The audience for Doncaster Museum Service is primarily local (almost 70% within 15 minutes travel time and almost 85% within 30 minutes travel time). The Museum has a clear geographic focus and this can aid strategies; from the core purpose and business plan to collecting, exhibitions and events. Doncaster Museum Service is funded by the taxpayers of Doncaster. This is also a very clear driver for the strategy of the museum and one which must exert a strong influence on the make-up of the collections and future collecting. It doesn't necessarily mean that the people of Doncaster are the only audience, nor that they're only interested in Doncaster, but it does provide a strong focus for audience and usage (e.g. exhibition/ event content). However, though there is a clear local focus, there are current audiences from further afield and attracting people into Doncaster is a Council priority. The collections are primarily for the people of Doncaster, but they also used be people from further afield and they are a potential tool to attract people to visit the Borough.

2. Utility (what are the collections for?)

The palaeontology collections appear to have been built up with education broadly in mind. Their main use to date has been in an exhibition and as the basis of the school handling collection. There is no evidence that the collection has been used by anyone, with the one exception that the Institute of Geological Sciences (now British Geological Survey) visited in the 1970s. With lack of expert staff, it is unlikely these collections will be used to their full potential. It is far more likely that expertise will be brought in for time limited projects (for example, new exhibitions).

3. Exhibitions

There are two broad future uses for displays: as a basis for a relatively comprehensive, permanent type of exhibition; and as a basis for highlight, temporary exhibitions. The future palaeontology collections needs to maintain a comprehensive coverage (see below).

4. Education

The core audience for DONMG's education outreach is primary schools. This implies that only a basic education handling collection is required for day-to-day use, one which is relatively small, but high quality with specimens which are clear examples of their type totalling perhaps 50 specimens of mainly fossils with some rocks, minerals. For secondary school and higher education, the main collection would be used. It is likely that as part of the CIRCA project a non-accessioned handling collection would be formed.

5. Comprehensiveness

If exhibition use is the main priority for the future palaeontology collections and the desire is for a versatile collection which will hold specimens that can be used in a variety of permanent and temporary exhibitions, then there are implications on the future comprehensiveness of the collection. The taxonomic coverage needs to include all common and easily displayable high-level taxonomic groups (nominally phyla, class or subclass), to illustrate the diversity of life on Earth. There will be four levels of geographic focus: the greatest concentration will be local (Doncaster Metropolitan Borough Council area); then the regional collecting hotspots of the Derbyshire, South and West Yorkshire Pennines and North Yorkshire coast; then the rest of the UK; finally international. All stratigraphic periods need to be covered, so that the historic development of life on Earth can be illustrated. There needs to be a much greater emphasis on quality, rather than on quantity.

6. Founding Collection, social history of the collections and important collectors

The initial specimens that were part of the museum on the first day it opened (the Founding Collection) holds a special place in the overall collections and the social history of a museum. There are 267 geological donations (fossils, rocks and minerals) noted in the original Stock Book; 215 individual fossil specimens in the palaeontology database. The Founding Collection is considered to be so important that all specimens will be kept. Related to the Founding Collections is the ongoing development and evolution of the collection. What was added, by whom, when and why? Also, what was removed, by whom, when and why? This gives a narrative to the relative importance of different scientific and social priorities.

7. Doncaster specific and unique

The key focus of *Taking stock* is to create a focused and manageable collection where Doncaster's specific and unique natural and cultural heritage is protected, preserved and made accessible. Therefore a crucial objective of any review is the retention of specimens which originate from Doncaster or which have a strong connection with Doncaster (for example through a collector). This does not however mean that as with the founding collection, all local specimens will be kept.

Non-priorities for the collections (excluding specimens or groups of specimens with a Doncaster provenance)

Whilst it is important to consider the future collection priorities to set a strategic context within which a review can take place, it is perhaps equally important to reflect on what is not a priority. Listed below are the most important non-priorities. In the context of the CIRCA review all of these were important factors in assessing the consequences of disposal/dispersal and in effectively managing disposal.

1. Scientific (current) value

This is material which is known to be of significant scientific value, which means those specimens which are type, figured, cited and, to a lesser extent, contributory material. Without the specialist expertise to be able to care for and give access to this kind of material it will not be a priority to keep or store known scientifically valuable material which does not have a Doncaster provenance or strong Doncaster connection.

2. Scientific (future) value

This is the potential value that a collection may have as a source of scientific research. It is not a priority for DONMG to hold a reference collection which scientists would normally be expected to consult when doing research.

3. Low level taxonomic comprehensiveness

The future collection will be taxonomically comprehensive for DONMG, with greatest coverage of taxa from the local and regional hinterland and essential coverage of all higher level taxonomic groups (nominally at phylum and class level).

4. Intraspecific variation

For scientists interested in particular species, every example contains useful information on diversity, and large groups give a quantitative view on the detailed variety, balance and disparity. It is not a priority for DONMG to hold collections with multiple specimens of the same species. The focus on the palaeontology collection is for display purposes, so rarely more than one specimen may be retained for this reason.

5. **Higher level educational teaching and handling collection**

   Historically, there has been very little demand for use of the palaeontology collections to support higher education learning. There is very little scope for increasing this demand presently, resulting in little need in retaining a collection with the specific purpose of teaching comprehensive course in palaeontology. However it ought to be noted that the priority to keep a stratigraphically, taxonomically and geographically representative collection means that this future collection can be used, should it be needed.

Review Methodologies

The issues facing the palaeontology collections at DONMG are neither unique nor new. The big question is how does a museum even begin to rationalise a collection; How to make sure the process is rigorous and transparent? How to ensure value is assessed in a meaningful way and how to avoid unintended consequences? How to ensure our peers of today and successor curators of tomorrow are happy with this approach? It is important for the public to understand why these decisions were made.

Summarised above (page 9) were several examples of different collections reviews which have been successfully carried out in museums across the world. The Significance 2.0 methodology was piloted on the palaeontology collections at Doncaster, with mixed results. It was very time consuming, and reviewed an entire collection and generated overarching conclusions. This method did not assist to examine the strengths and weaknesses at the specimen level. Where collection level reviews are probably more useful is where there are many discrete and coherent collections, for example in a very large collection containing discrete and readily definable collections from different donors. However the Doncaster collections are integrated and except in a small number of cases, they are not made up of discrete individual collections. The collection level review approach was therefore not adopted for the DONMG palaeontology collections.

The review undertaken at DONMG has been developed from examining and extrapolating the main objectives of the Museum Service, and looks at the purpose of the individual specimen. For Doncaster Museums Service, there is a very clear purpose, stated in the Collection Priorities outlined above. This gives the Founding Collections and specimens, or groups, with a local provenance primary significance and secondary importance to display quality specimens which are the best of their group. There are not many competing priorities. There is one given (all specimens from the Foundation Collection should be kept) and two binary choices (is this specimen local and is it of display quality?), followed by a relative decision (which is the best of a group). So the methodology for specimen level assessment at Doncaster is distinctly different.

In addition the collection size is just about manageable using a relative approach (where like specimens are compared and the best kept). In fact it will not be possible to view all similar specimens at the same time (the collection is too large for this ideal solution), so the Stratigraphic Collection, which is comprehensive and relatively well documented, will be used to form a baseline against which other collections are judged.

CIRCA Review Methodology

The review process is made up of three stages. The first stage assesses specimens individually, focusing on the two key areas of the Collection Priorities (questions 1 and 2). The second stage is a comparative process, assessing the best fossils from a group of similar fossils (questions 3 and 4). The final stage is a check (question 5). The process is described below and summarised in the flow chart (Fig. 3). A template Excel spread-sheet has been produced to record the review process (Table. 1).

At Question 2 and Question 4 there is the option to de-accession if the flow chart is followed. Here, a specimen is so visually poor it cannot be displayed so it will go through the disposal process.

Question 3 of the review notes what additional features each specimen has that might be of interpretation potential. For each of the following categories, the specimens can be marked from 0 – 4 (0 = No Value, 4 = Great Value). Some examples of the variety of features which may be of interest include;

- Palaeontology (Good example of a particular/ distinctive body plan for the particular group; published record - type, figured, cited, contributory material; zone fossil)
- Palaeoecology (additional evidence of how it lived, including shape, growth, movement, relationship to other organisms (e.g. parasites, encruster), trace fossils, diet (e.g. gut contents), predation, palaeopathology)
- Taphonomy (additional evidence of what happened after it died, including, decay processes, transport, fossils concentrations, rapid burial, flattening (e.g. different orientations of eurypterids, showing different features), diagenesis, different modes of preservation)
- Provenance (Collection or donation associated with interesting person, collected from interesting location, general depth and richness of the documentation associated with a specimen)

The kinds of features and variety within a group that would be of interest cannot be easily defined, but can be illustrated through a number of examples (this is not an exhaustive list, but an illustration of the sorts of features that will be of interest in producing an exhibition):

- Within the Cambrian and Ordovician trilobites, a comprehensive collection worthy of display would contain: Well preserved examples of common and typical forms; Unusual forms like Trinucleus or Agnostus; A slab with the different parts of a trilobite broken up, either showing initial decay of an animal before burial, or a caste exoskeleton made during a growth stage and moult; Examples of different trilobite eyes; Trace fossils.

- In the Jurassic ammonites, a comprehensive collection would contain at least: Variety of species found on the North Yorkshire (Dinosaur) Coast; Different forms of preservation; Worn shell showing septa; Damaged by predation.

The aim of question 4 is to ensure the collection is comprehensive, i.e. which are the best specimens in each group of fossils that we want to be represented to maintain a comprehensive collection? Taking into account the specimens that have already been kept due to being part of the Founding Collection (Q1) or their great exhibition quality (Q2), of the remaining possible display quality specimens with some taxonomy, palaeoecology, taphonomy and provenance value (Q3), which specimens are worthy of keeping from the group and which should be de-accessioned? Question 4 provides the opportunity to fill in missing gaps; specimens marked "Relatively good" are kept due to the added value palaeontology, palaeoecology, taphonomy or provenance value they have for interpretation in an exhibition. Those specimens marked "Relatively poor" specimens are ones which are not as good quality as similar examples, and these are marked for de-accessioning.

The final question looks to see that all periods of collecting and important collectors are represented. This ensures that the social history behind who collected what, when and perhaps even why, can be illustrated should that be of interest as part of an exhibition. At the end of the questions, the specimen will either be retained or marked for de-accessioning.

Disposal process

Following the review of collections and their assessment by specialist curatorial staff (or contracted staff), specimens identified for de-accessioning through the *Taking Stock* process follow the process:

1. A proposed list of de-accessions is presented to the museum's Acquisition and Disposal Panel (consisting of the relevant museum manager, Conservation and Collections Care officer, Registrar and Curatorial team) for consideration/amendment/approval. The list includes recommendations relating to the outcome of de-accessioned items and/or collections exploring each successively, only using the final options as a very last resort:

    a. Exchange of items between museums
    b. Free gift or transfer to another accredited museum
    c. Free gift or transfer to another institution/organisation within the public domain
    d. Return to donor
    e. Sale of item to an accredited museum
    f. Transfer outside the public domain
    g. Sale outside the public domain
    h. Recycling of item
    i. Destruction of item

2. Examples of particularly contentious or difficult cases are taken to a focus group (consisting of ex-staff, external specialists/experts, museum users and other interested parties or stakeholder groups such as Specialist Subject Networks and local societies) for feedback/consultation.

	Individual assessment		Group assessment					Decision		
Acc No	1. Foundation Collection (Yes/No)	2. Exhibition Quality (Yes/Maybe/No)	3a. P'ontology	3b. P'ecology	3c. Taph.	3d. Prov.	4. Comparison	Keep	De-acc.	Notes
25X	Yes							1		Foundation Collection, therefore keep
1977.34.1	No	Yes						1		Great quality specimen - masses of X-factor - got 'exhibit me' written all over it!
1977.34.2	No	No							1	Broken, poor specimen with no possibility of being displayed
1980.54.1	No	Maybe	1 Little	1 Little	1 Little	3 Great	Relatively good	1		Collected from famous site (now SSSI)
1980.54.2	No	Maybe	0 None	3 Great	2 Some	0 None	Relatively good	1		Coral showing irregular (?seasonal) growth
1980.54.3	No	Maybe	0 None	0 None	3 Great	1 Little	Relatively good	1		Ammonite in septarian nodule - potential to describe early formation of concreation around ammonite before dewatering that then shattered the nodule
1981.23.1	No	Maybe	0 None	2 Some	0 None	0 None	Relatively good	1		Reasonable display quality and the best example of predation of a bivalve by a carnivourous gastropod
1981.23.2	No	Maybe	0 None	0 None	0 None	2 Some	Relatively poor		1	Interesting locality - Durdle Door - but we have better specimens from there
1981.23.3	No	Maybe	2 Some	0 None	0 None	0 None	Relatively poor		1	Trinucleus has intersting body plan - very wide and flat (like a snow shoe) - which is something which can be described in exhibition interpretation, but there are better examples
1982.46.2	No	Maybe	0 None	0 None	1 Little	0 None	Relatively poor		1	Shows flattening, but it's a common feature and this is not a great example
							TOTAL	6	4	
							%	60	40	

Table 1. A template Excel spread-sheet to record the review process.

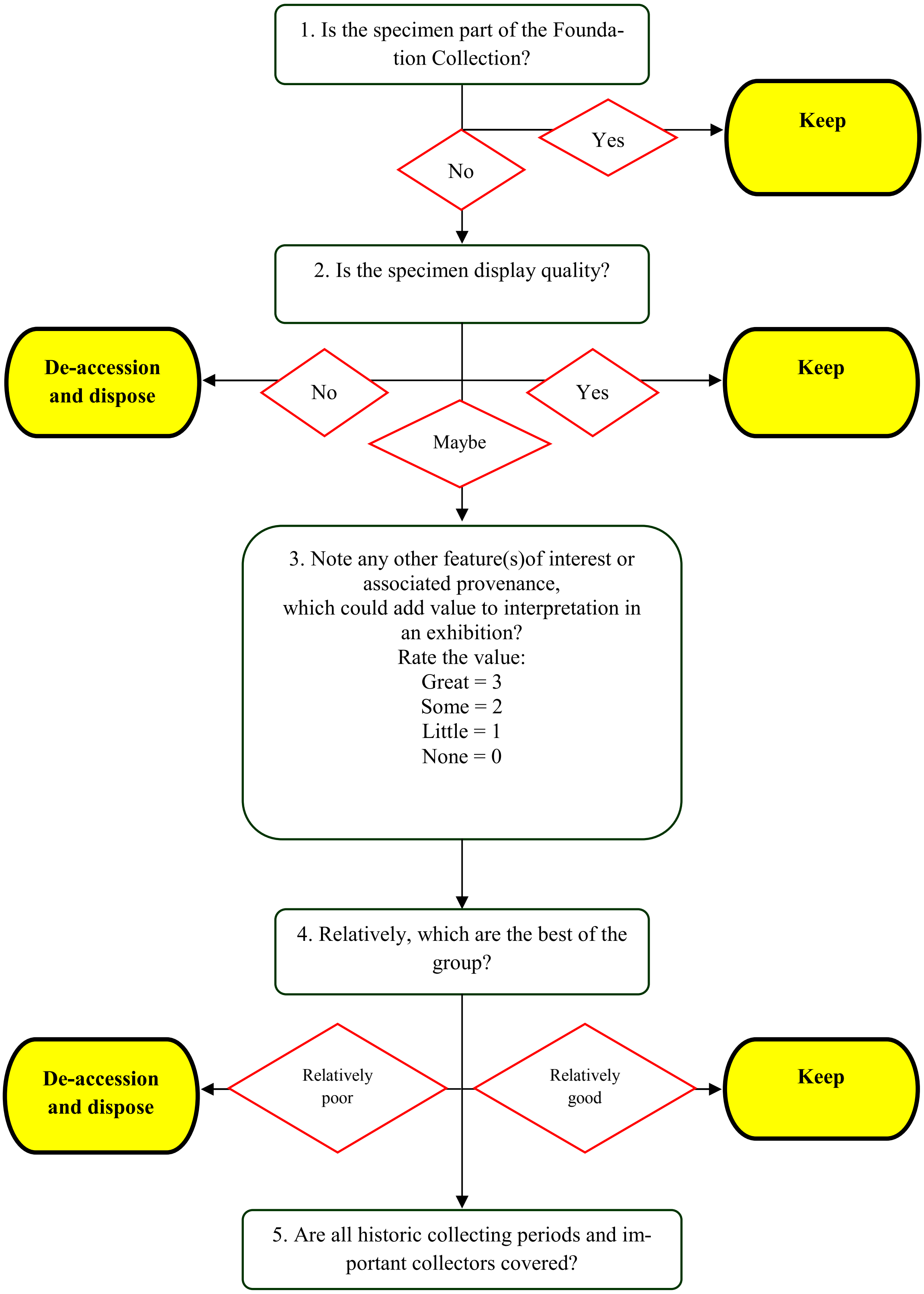

Fig. 3. Flow chart illustrating the CIRCA collections review process. Following the model allowed a clear process to be followed for the entire palaeontological collections.

3. Consultation is considered by the Acquisition and Disposal panel and decisions amended accordingly if required.

4. The final proposed de-accessions are taken to the Museum's governing body (in this case the Mayor and Cabinet of DMBC) for approval.

5. Recommendations for the outcome of de-accessioned items/collections are implemented.

The CIRCA project will follow the same de-accessioning process as *Taking Stock*. There are a number of specific issues which DONMG focused on:

- The priority will be to exchange individual objects or entire collections with other material which can enhance the palaeontology collections in line with the Collection Priorities and fill any gaps that emerge as part of the Review.

- The priority will be to find appropriate museums to exchange or transfer material to. This is most likely to be geologically appropriate (for example, if there is a set of Lower Carboniferous crinoid calyces from Clitheroe that is de-accessioned, then possible homes in the North West (e.g. Clitheroe Museum/Lancashire Museum Service or The Manchester Museum) where these specimens will be particularly relevant will be sought). Alternatively, if there is a mixed set of specimens collected by one person, who has affiliations to particular locations (perhaps they were born, worked, researched or otherwise associated with particular locations). If no particular institution is found, then the next step will be to advertise through GCG. Thirdly and finally, if that produces no interested museums, then material will be advertised on the MA channels.

- If other public institutions are considered, then schools, sixth form colleges, further education colleges and universities will be approached using the Earth Science Teachers Association as a channel.

- The sale of material to accredited museums will only be approached as first step where an item was purchased for the collection at some cost and where it is felt that it is appropriate to recoupe this expense.

- If there are contentious or difficult cases, then it is proposed to invite a member of the GCG committee to be involved in the discussions.

Reviewing the *Taking Stock* reviews

It would be naive to propose that the methodology developed for *Taking Stock* is faultless. The framework developed was as robust as possible within the limitations of time and resources available. The methodology was designed to create a coherent approach, whilst also flexible enough to cater for the different natures and circumstances of each collection being reviewed. The reviews undertaken as part of the Effective Collections and Esmée Fairbairn Museum and Heritage initiatives also had to meet the specific requirements of those funding strands. Both funds emphasise the re-vitalisation, accessibility and improved curation of collections they did not conflict with the objectives set by *Taking Stock*, they complimented them. The key to ensuring a coherent and consistent approach to the internal and external reviews rested on having a strong mission statement, with clear objectives and a well-defined set of criteria against which review methodologies can be developed and implemented.

Adaptability has been a significant contributor to the success of *Taking Stock*. Whilst the methodologies have been developed in reference to seminal strategies such as the Collections Council of Australia's Significance 2.0 (Russell & Winkworth, 2009) and the University College London's Collections Review Toolkit (Dunn & Das, 2011), they are bespoke reviews tailored to meet the particular requirements and circumstances of *Taking Stock*. A flexible, bespoke approach to undertaking reviews, which is based on best practice and open to continuous evaluation, is the most robust model and has the best chance of producing the required results from which sound decisions can be made about rationalisation, de-accessioning, transfer, etc.

An important part of the entire process was stakeholder consultation throughout the entire project. Stakeholders fed into the development of the museum objectives and the evaluation of recommendations coming out of the various reviews. This was a valuable way of checking the relevance of potential decisions in regards to the re-shaping of collections. Visitor/user feedback was analysed to ensure that the aims of the project met with consumer needs, and this had to also be balanced with what the museum deems should be protected and maintained for public benefit. The recommendations from the reviews have been examined by external professionals, such as the Regional Museum Development Officer and other museum professionals. These recommendations have also been discussed at a focus group including the Mayor and a cross section of museum users.

The involvement of external specialists has been incredibly valuable to the process of the project. It has ensured that the methods developed have been developed by a range of experience across the wider museum sector. This has allowed us to check, evaluate and adapt our approach to incorporate a broader sector overview to reviewing collections. It has also allowed DONMG to have a more accurate and up to date knowledge of the wide ranging impact of decisions that emerge from implementing the review recommendations. This ensured that the museum is fully aware of the implications and likely outcomes of decisions it makes, both for the Service and for the wider museum and academic communities. Importantly it bolsters confidence in the staff that the decisions made relating to collections which have relevance or importance beyond Doncaster Museum Service and its users are fully considered. Engagement with other museum professionals and institutions has also ensured that the best options for the disposal/ dispersal of collections are outlined.

The Museum Service's Collections Development Policy (DMS, 2013), to which all *Taking Stock* reviews refer, prioritises objects and collections with a Doncaster provenance or strong Doncaster connection. This has led to a conflict in respect of the position taken regarding research collections. Where a research collection or collection of primary scientific value has a Doncaster provenance or strong local connection, the decision to retain or dispose, preferably through dispersal to an appropriately resourced Museum, has not been straight forward. It has led to decisions made on a case by case basis, with factors such as the requirements for care and access being the key components in making a decision. It has highlighted the fact that even with a robust well-reasoned review methodology, where the objectives and priorities for collecting are clear, there are no purely black and white cases. This has in turn emphasised the need to document and record the reasons and decision making process for aspects of a review, beyond the simple execution of a formulaic review process.

The development of the 'X-Factor' objects came about through a necessity to satisfy an objective of the Museum Service which fell outside the local emphasis. This highlighted the diverse use of a museum collection with a need for flexibility and compromise when developing a review methodology.

Lessons Learned

For DONMG, the *Taking Stock* project has demonstrated that there is no best or definitive model for reviewing collections. Provided that review methodologies are developed against a single framework of objectives and criteria for assessment then each collection is best reviewed using a bespoke methodology which meets best practice and conforms to current professional guidelines. Whether a collection is reviewed internally or by external specialists the effectiveness and accuracy of the reviews will ensure that there is less chance of important factors being overlooked. Establishing and maintaining an open and honest dialogue with external specialists is vital to facilitating effective recommendations and decisions.

Without in house specialist curatorial expertise beyond a period of review the long term development of the collection is compromised and accessibility is considerably limited, unless another system for providing specialist curation can be identified. As the CIRCA project moves towards completion it will begin to address such questions and test to what extent it is possible to find alternative solutions to in house subject specialist curation.

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Appendix 1: The core objectives of DONMG

On 23rd March 1910, Doncaster Museum opened, with the founding objectives;

> *Object of the Museum*
> *I take it that one main objective of the Doncaster Museum should be to illustrate archaeology, history, geology and natural history of the district in which it is situated. There are already in the committee's possession many valuable specimens bearing upon these branches, which would form an admirable nucleus; and there is no doubt that when the public can have better access to the collections than is now possible, further gifts will be made.*
>
> *In addition to these collections, however, which are most valuable in their way, it will be necessary, if the museum is to meet with that success which characterises so many provincial institutions, that there should be an exhibition of objects illustrating various branches of Applied Art. In this way the Museum will become additionally valuable from an educational point of view, and will also be able to reap many advantages, financially and otherwise, in a way presently to be described.*
>
> (Sheppard, 1908)

It is interesting to note that the current Museum Service Mission Statement, although shortened, match the original 1910 'Mission statement' remarkably well, hinting that the service has come full circle and has returned to its original core purpose. The revised objectives would be instrumental in feeding into the revised Forward Plan (2013-2018):

> The Museum Service primarily serves those living in the Doncaster Metropolitan Borough area and those connected to the King's Own Yorkshire Light Infantry and believes that its purpose can be summed up in four words:
>
> Engage, Preserve, Inspire, Communicate

The core objectives from the Doncaster Museum Service Forward Plan 2013-18

Our core business is:
- To run Doncaster Museum & Art Gallery, Cusworth Hall Museum, Cusworth Park and the King's Own Yorkshire Light Infantry (KOYLI) Museum.
- To care for the 600,000 objects and specimens in the Museum and KOYLI collections and the Grade One listed Cusworth Hall and Grade 2 listed Site of Scientific Interest (SSI) Cusworth Park.
- To run a Museum Education Service
- To provide public access to the collections, largely through exhibitions and other displays, events, enquiries, digital access, talks and other appropriate methods; such as facilitating research.
- The definition of a museum accepted by the Museums Association is that 'Museums enable people to explore collections for inspiration, learning and enjoyment. They are institutions that collect, safeguard and make accessible artefacts and specimens, which they hold in trust for society.'

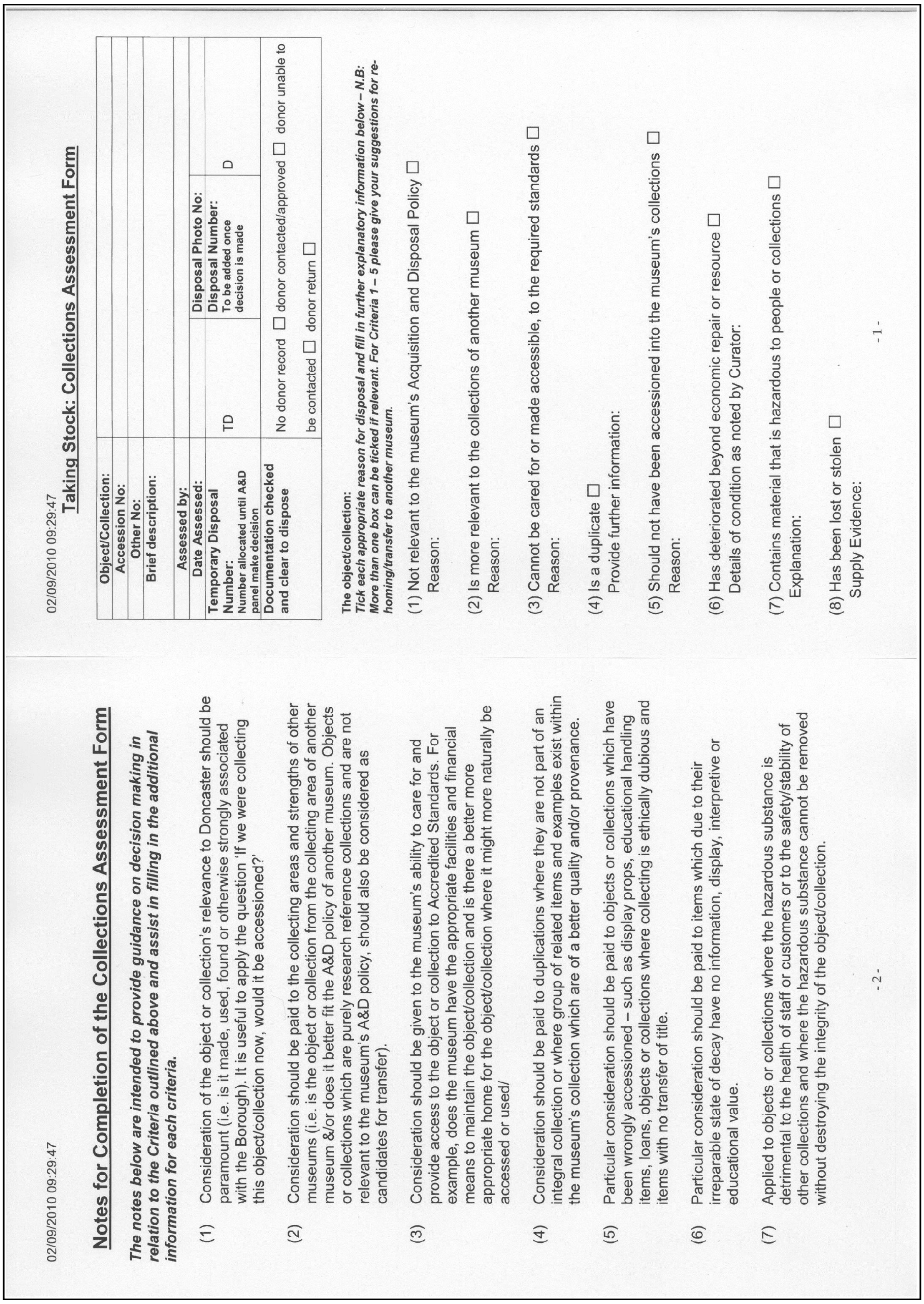
The key aims of the Service are:
- **1** To enthuse people about the heritage of Doncaster, the King's Own Yorkshire Light Infantry and the world around them through our museums.
- **2** To engage people in the preservation and appreciation of the wonderful collections that we care for, Cusworth Hall and its Park.
- **3** To give people great days out
- **4** To make Doncaster proud of its Museum Service

Objectives:
- **1** Raise the profile of the Museum Service and Doncaster's heritage
- **2** Developing new audiences (including schools)
- **3** Improving our financial sustainability
- **4** To ensure that we have collections that we can care for and that are accessible
- **5** To improve our Museum buildings and Cusworth Park, making improvements to our environmental sustainability.

Objective 1 contributes principally to key aims 2 and 4.
Objective 2 contributes to key aims 1 and 2.
Objectives 3, 4 and 5 contribute to all of the key aims.

Appendix 2: Original collection assessment form for disposals and accompanying guidance notes.

The collection assessment forms were trialled but quickly replaced with the creation of a spread sheet for recording multiple decisions, to make the process more efficient and to take advantage of the features of Windows Excel for analysing and reviewing recorded information and decisions (shown on page 26).



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Notes for Completion of the Collections Assessment Form

The notes below are intended to provide guidance on decision making in relation to the Criteria outlined above and assist in filling in the additional information for each criteria.

(1) Consideration of the object or collection's relevance to Doncaster should be paramount (i.e. is it made, used, found or otherwise strongly associated with the Borough). It is useful to apply the question 'If we were collecting this object/collection now, would it be accessioned?'

(2) Consideration should be paid to the collecting areas and strengths of other museums (i.e. is the object or collection from the collecting area of another museum &/or does it better fit the A&D policy of another museum. Objects or collections which are purely research reference collections and are not relevant to the museum's A&D policy, should also be considered as candidates for transfer).

(3) Consideration should be given to the museum's ability to care for and provide access to the object or collection to Accredited Standards. For example, does the museum have the appropriate facilities and financial means to maintain the object/collection and is there a better more appropriate home for the object/collection where it might more naturally be accessed or used/

(4) Consideration should be paid to duplications where they are not part of an integral collection or where group of related items and examples exist within the museum's collection which are of a better quality and/or provenance.

(5) Particular consideration should be paid to objects or collections which have been wrongly accessioned – such as display props, educational handling items, loans, objects or collections where collecting is ethically dubious and items with no transfer of title.

(6) Particular consideration should be paid to items which due to their irreparable state of decay have no information, display, interpretive or educational value.

(7) Applied to objects or collections where the hazardous substance is detrimental to the health of staff or customers or to the safety/stability of other collections and where the hazardous substance cannot be removed without destroying the integrity of the object/collection.

- 2 -

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Taking Stock: Collections Assessment Form

Object/Collection:			
Accession No:			
Other No:			
Brief description:			
Assessed by:			
Date Assessed:		**Disposal Photo No:**	
Temporary Disposal Number: Number allocated until A&D panel make decision	TD	**Disposal Number:** To be added once decision is made	D
Documentation checked and clear to dispose	No donor record ☐ donor contacted/approved ☐ donor unable to be contacted ☐ donor return ☐		

The object/collection:
Tick each appropriate reason for disposal and fill in further explanatory information below – N.B: More than one box can be ticked if relevant. For Criteria 1 – 5 please give your suggestions for re-homing/transfer to another museum.

(1) Not relevant to the museum's Acquisition and Disposal Policy ☐
Reason:

(2) Is more relevant to the collections of another museum ☐
Reason:

(3) Cannot be cared for or made accessible, to the required standards ☐
Reason:

(4) Is a duplicate ☐
Provide further information:

(5) Should not have been accessioned into the museum's collections ☐
Reason:

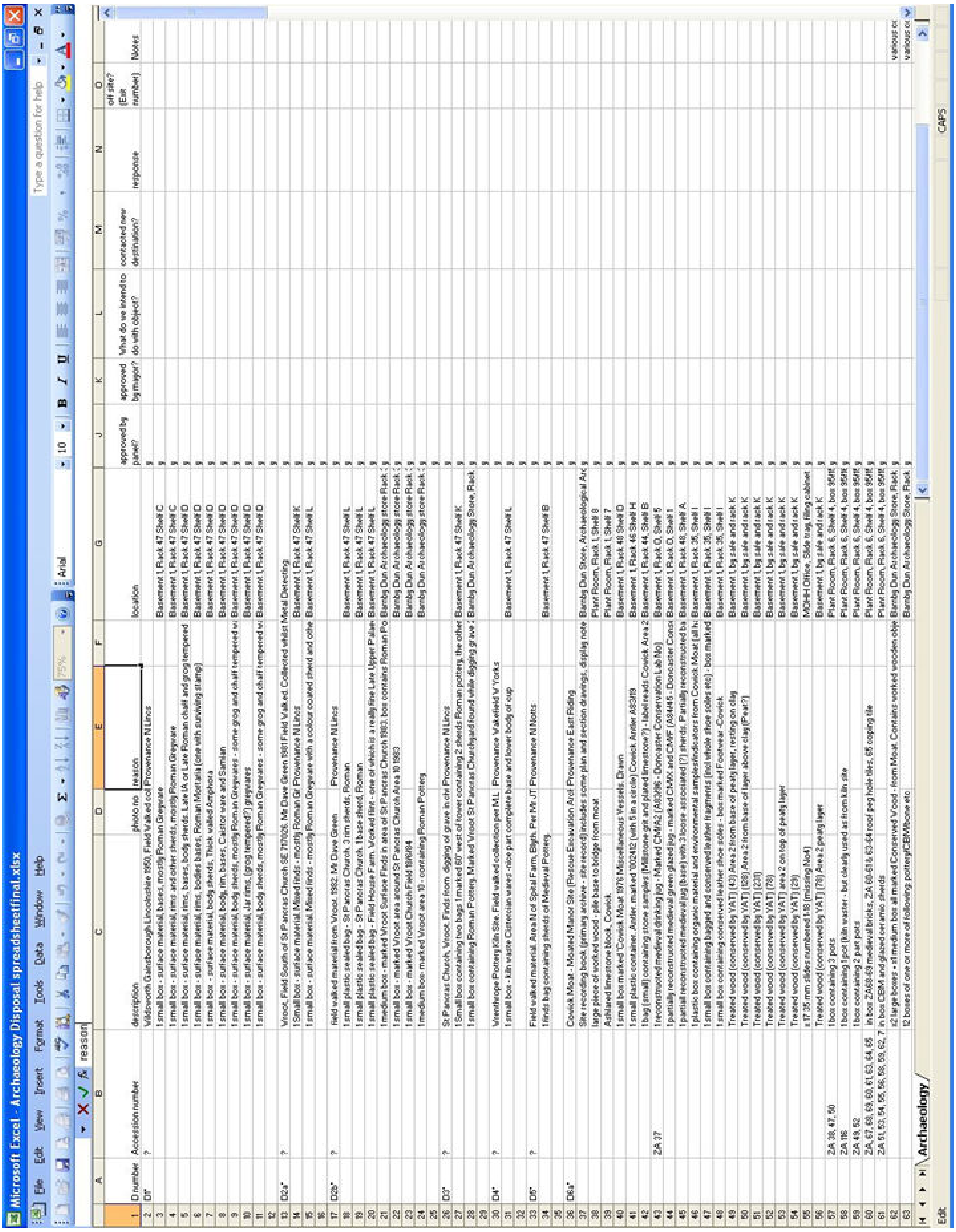
(6) Has deteriorated beyond economic repair or resource ☐
Details of condition as noted by Curator:

(7) Contains material that is hazardous to people or collections ☐
Explanation:

(8) Has been lost or stolen ☐
Supply Evidence:

- 1 -

Screen shot of the Excel collections assessment spreadsheet. This is the replacement for the collections assessment form on page 25. Transferring the form on to an Excel spreadsheet has made the information in the review process much easier to manage in terms of making checks, conducting searches and grouping items under such categories as reason for disposal, location and suggested recipient.



Identifying and managing radioactive geological specimens

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Abstract

Certain minerals, particularly those containing uranium [U] and thorium [Th], emit natural ionising radiation that presents a hazard to humans. Not all are easily identified, and the problem is compounded when radioactive elements substitute into minerals that are not normally radioactive, or form an unrecognised constituent of a specimen, whether mineral, rock or fossil The extent of radioactive holdings in a collection can only be established by measuring ionising radiation emissions for all the geological specimens using appropriate detectors. Radioactivity is subject to a variety of legislation. The Ionising Radiation Regulations (1999) detail the requirements for the protection of persons exposed as a result of work with radioactive materials. However, geological specimens fall completely out of scope of the 2010 Environment Permitting (England and Wales) Regulations and the Radioactive Substances Act 1993 in Scotland and Northern Ireland. The Euratom Safeguards Treaty has placed additional responsibilities on some institutions. This paper summarises how to identify radioactive specimens, establish who is at risk, and set up local rules that keep risk as low as is reasonably practicable. It includes examples of different approaches taken in the authors' institutions.

Keywords: Radioactive; Ionising Radiation; IRR99; Radioactive Substances Act 1993; Environmental Permitting 2010; Health and Safety

Introduction

Radioactive specimens are present in most museum geological collections, and are a potential health hazard. There is no definitive guide to their identification and management, although Lambert (1994) and Freedman (2011, 2012) give useful case studies of approaches taken in the National Museum of Wales and Plymouth City Museum and Art Gallery, respectively. The authors of this paper identify radioactive specimens and evaluate the risk they pose in broadly the same ways, but each of their institutions has independently established different rules and procedures that provide good practice and suit local circumstances. These case studies demonstrate that there is no single best method for the storage of radioactive specimens, it will depend on the size and nature of the collection, and the resources available.

Any institution which has radioactive specimens will need to obtain professional advice on radiation protection and radioactive substances legislation. Specifically, where advice is sought on the actions necessary to comply with the Ionising Radiations Regulations 1999, this advice must be obtained from a suitable (and certificated) radiation protection adviser. Details of certificated radiation protection advisers can be obtained from the Society for Radiological Protection (www.srp-uk.org/contact). Institutions may choose to seek advice directly from the relevant regulator; in this case the Health and Safety Executive.

Price, M., Horak, J., & Faithfull, P. 2013. Identifying and managing radioactive geological specimens. *Journal of Natural Science Collections.* **1.** pp.27-33.

Our paper presented at the NatSCA conference on Policy and Practice in 2013 gives just a brief overview of the subject and a more detailed study is in preparation.

Radioactivity in geological specimens

Radioactivity is a natural phenomenon, and cannot be completely avoided. Almost all Earth and planetary materials contain radioactive elements, as do all living things; for example, the element potassium, essential to every living cell, is itself weakly radioactive. Minerals are the building blocks of the inorganic natural world. They are naturally formed chemical elements and compounds, the composition of which will vary only between narrow limits. With the exception of native mercury, they are all solids, and most are crystalline materials. However radiation can break down the ordered arrangement of atoms, resulting in a disordered 'metamict' state, a feature of some radioactive minerals.

All rocks are made up of one or more minerals, and both minerals and rocks can be cut and polished to form gemstones. The fossilised remains of living organisms are also made of minerals. Consequently, radioactive specimens are found in mineral, rock, fossil, and gemstone collections.

Uranium and thorium are the most common radioactive elements in geological specimens. Their radioactive decay generates a range of radioactive daughter elements, including radon, and a radon isotope known as thoron, which being gases, can escape from mineral grains and be breathed in. Radioactive geological specimens emit:

- **alpha radiation** – positively charged particles that have a range of a very few centimetres at most in air. They are not an external health hazard, but internal exposure can be very hazardous.

- **beta radiation** – negatively charged particles that range tens of centimetres. They are particularly hazardous to the eyes and skin.

- **gamma radiation** – electromagnetic radiation. The most penetrating kind of radiation, it is hazardous to all organs of the body.

All three kinds of radiation are hazardous if radioactive materials are ingested or inhaled.

Legal issues

In the UK, the Ionising Radiation Regulations (1999), concerned with the protection of human health, are enforced by the Health and Safety Executive, and must be complied with. The regulations aim to ensure exposures are as low as reasonably practicable 'ALARP' (i.e. as low as can be reasonably achieved, allowing for work related factors to be taken into account). These regulations lay down maximum levels of exposure for different classes of person and for different parts of the body, and they set maximum annual dose limits which must not be exceeded under any circumstances. Children and unborn infants are at particular risk, and so the maximum dose is set at a substantially lower level for under 18s and pregnant women.

It is a requirement of the Ionising Radiation Regulations 1999 that guidance on the application of the Regulations should be obtained from a suitable radiation protection adviser. This may be an individual; a member of a corporate institution; or in some cases, an institution's own in-house radiation protection officer may be a certificated radiation protection adviser. A suitable radiation protection adviser should be able to advise on all aspects of the Ionising Radiations Regulations 1999 that apply to work with geological specimens.

In Northern Ireland and Scotland, the law relating to the use and disposal of radioactive materials is the Radioactive Substances Act 1993, while in England and Wales, this Act has been replaced by the Environment Permitting (England and Wales) Regulations 2010. Importantly, in all parts of the UK, naturally-occurring radioactive materials (referred to as NORMs) in the form of geological specimens are out of scope of both the 1993 and 2010 statutes under most circumstances. Details are given in a 2011 document *Exemption Guidance - Radioactivity in museums* published online by the Environment Agency and by the Scottish Environment Protection Agency.

Some collections also need to comply with the Euratom Safeguards Treaty which has placed additional responsibilities for audit and management on institutions with inventories including uranium- and thorium-bearing minerals, monitoring their physical security. This sets particularly high standards of documentation and audit.

Managers of geological collections need to first identify which specimens are radioactive, establish who may come into contact with them, think how to minimise and monitor exposure, and then develop rules and procedures to minimise that exposure and ensure legal compliance.

Identifying which specimens are radioactive

Radioactive geological specimens fall into a number of groups. Firstly, there are minerals and rocks which contain uranium and thorium as essential constituents. The most common 'primary' minerals are uraninite (UO_2) (Fig. 1), often labelled as pitchblende; thorianite (ThO_2), and thorite (Th,U) SiO_4, which may be labelled orangite. These are all non-descript, black or brown in colour, rarely form good crystals, and are very hard to recognise by eye. However their high ratio of U/Th to other elements, means that they are the 'hottest' of the radioactive minerals.

'Secondary' minerals form by weathering and alteration of the primary minerals, and include carbonates, sulphates, phosphates, arsenates, vanadates and silicates which contain uranium or

Fig.1. typical non-descript uraninite from Cornwall; only the presence of yellow and green alteration products give a visual clue to its identity.
(photo: Oxford University Museum of Natural History)

thorium and other elements. These may be much easier to identify by eye. They are often brightly coloured apple-green, yellow or orange. They typically form coatings but can develop good crystals. Examples of the more common radioactive secondary minerals include;

- torbernite ($Cu^{2+}(UO_2)_2(PO_4)_2.8\text{-}12H_2O$),;
- autunite ($Ca(UO_2)_2(PO_4)_2{\cdot}10\text{-}12H_2O$),;
- carnotite ($K_2(UO_2)_2(VO_4)_2.3H_2O$);
- uranophane $Ca(UO_2)_2[HSiO_4]_2{\cdot}5H_2O$.

Minerals containing rare earth elements (REEs) can have some of the REE substituted with thorium. This is not usually evident from the mineral's published chemical formula. Monazite ($(Ce,La)PO_4$) can form economically important beach sands, while allanite-(Y) ($CaYFe^{2+}Al_2(Si_2O_7)(SiO_4)O(OH)$) is one of a number of REE minerals that typically occurs as dark-coloured crystalline masses in certain pegmatites, coarse-grained igneous rocks.

Lambert (1994) includes lists of names and synonyms of radioactive minerals, to which a small number of more recently discovered species may be added.

Radioactive minerals can be minor or significant constituents of many rocks, especially granites and granite pegmatites, and vanadium-bearing sandstones. They can also be present in fossil specimens. Radioactive fossils are not generally common, but may be abundant at some localities. The fossil itself may be radioactive, the surrounding rock matrix, or both. Phosphatic fossils can absorb uranium from groundwaters, and over time may become significantly radioactive. Well-known examples include some Devonian fossil fish from the north of Scotland, Jurassic fossils from the Morrison Formation of the USA, and Tertiary mammal bones from the Sivalik Range in Pakistan.

It is important to remember that mineral and rock specimens usually comprise a mixture of different minerals. U//Th minerals may not be the most important, and may not be listed on labels or in catalogues. Indeed they may not even be visible if surrounded by other minerals in the specimen. Consequently, radioactive minerals can occur ANYWHERE in a geological collection and it is usually advisable that an entire collection should be surveyed for radioactive specimens.

Artificial materials and artefacts found in geological and other collections can also be radioactive. They include, for example, gemstone models made from yellow uranium glass, radioactive paint used for making fluorescent dials in instruments, and 'Trinitite', a rock fused by the 1945 Trinity atomic bomb test. As these are not naturally occurring radioactive materials, advice on their legal status should be sought from a radiation protection expert.

The detection of radioactive geological specimens is easy using a suitable radiation monitor (for example, a sufficiently sensitive contamination monitor). These instruments are available in a range of different technical specifications, and expert advice should always be sought to ensure the correct equipment is purchased. Instruments may measure counts per second (cps), the number of pulses of radiation reaching the instrument's detector; or they measure microsieverts per hour (μSvh^{-1}), a measure of the biological effect of radiation over an hourly period. This is the unit used in setting dose levels for compliance with the Ionising Radiation Regulations 1999. It is important that institutions holding radioactive specimens should have access to a dose rate meter or count rate meter to locate radioactive specimens, to make sure radiation levels are not exceeded for safe storage, and to detect contamination during routine work or in an emergency.

Identifying who is at risk

A management plan for radioactive geological specimen must cover all the people that could come into contact with them. These might include:

- Curatorial staff
- Interns and volunteers working on collections
- Cleaning and maintenance staff
- External contractors
- Research visitors
- Front of house staff
- Visiting public
- Emergency services

The number of people exposed to radioactive material should be kept to a minimum, and that might influence, for example, whether display of a radioactive specimen is *really* necessary.

Developing rules and procedures

Any institution holding radioactive geological specimens will need to establish rules and procedures to ensure it complies with the law and keeps risk as low as reasonably practicable. These 'local rules' should address:

- Who is in charge and has responsibility for compliance (the person designated Radiation Protection Supervisor).
- Where professional advice can be obtained;
- Who is permitted to handle or work with radioactive specimens, and whether they should be designated radiation workers.
- What training they should receive.
- What precautions must be taken when working with radioactive specimens.
- How incoming radioactive specimens are processed.
- How radioactive specimens are organised or segregated. It may be necessary to designate a 'Controlled area' or 'Supervised area' depending on radiation levels.
- Where radioactive specimens are kept, how they are stored and documented.
- Procedures for sampling, researching, loaning and disposing of specimens.
- How to deal with loss, theft, emergencies and other incidents.

Local rules are normally prepared by the radiation protection adviser working closely with the relevant museum staff. It is important that everyone, including management staff, should be fully aware of and comply with the institution's 'local rules'.

Local rules should lay out procedures for dealing with unexpected incoming material, for example public enquiry specimens. Other areas that will need particular consideration are the provision of suitable specimens for student or public handling; any display of radioactive specimens, and the management of radioactive specimens if they are transported and used off-site.

Minimising exposure

There are four ways to minimise exposure to ionising radiation, summarised simply as CONTAINMENT, TIME, DISTANCE, and SHIELDING.

Firstly, use of suitable **containment** to ensure that radioactive materials are segregated to ensure exposure is restricted and, in the case of crumbly or powdery specimens, that any contamination arising from specimen damage does not spread.

Secondly, by reducing the length of **time** a person is exposed to radiation. Specimen documentation, including images, can be used to help select which samples are to be used. Procedures should be planned carefully beforehand, ensuring all materials are ready to hand. Specimens should be returned to safe storage as soon as possible after use.

Thirdly, by increasing the **distance** between the person and the radioactive specimen (Fig. 2). The inverse square law applies as a very broad rule of thumb (it is accurate for a hypothetical point source), so double the distance between a person and a specimen to get just a quarter of the intensity of radiation; quadruple the distance, and the intensity reduces to just a sixteenth. In practice, this

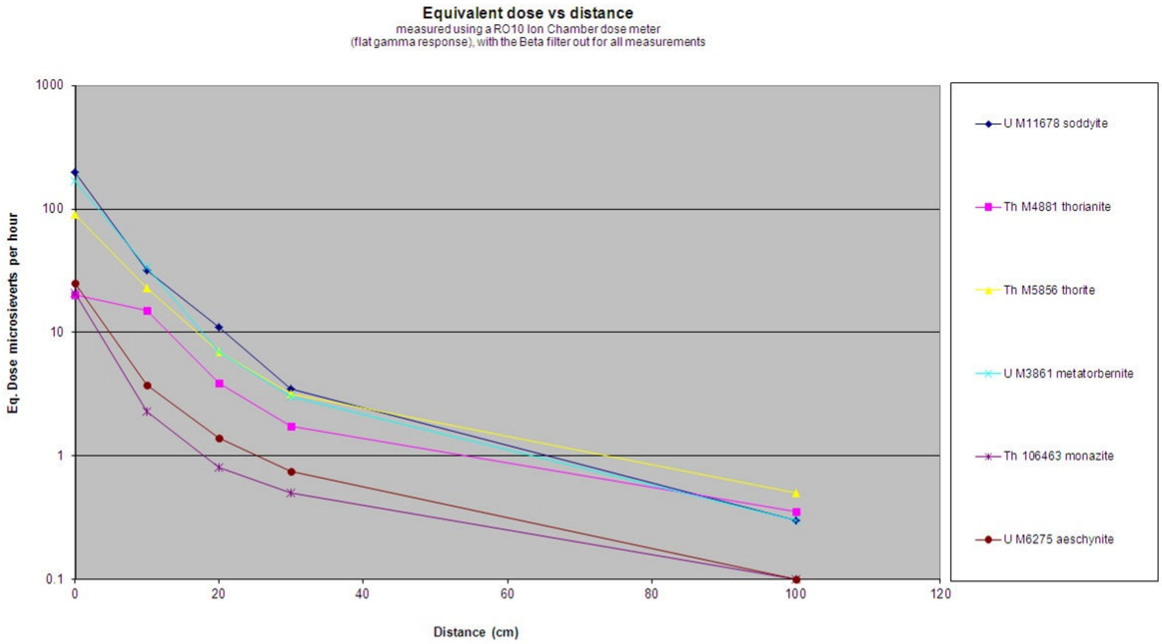

Fig.2. Measurements at the Hunterian for six different minerals show the rapid fall-off of radiation levels with distance. For example, a sample of metatorbernite, a uranium-bearing mineral that is relatively common in museum collections, gave a surface reading of 170 μSvh^{-1}. The reading dropped to a low safe level of 0.3 μSvh^{-1} just a metre away. (source: The Hunterian, Glasgow)

Fig.3. Distance can be increased by picking up a specimen's card tray rather than the specimen itself.
(photo: Simon Haycox, University of Oxford)

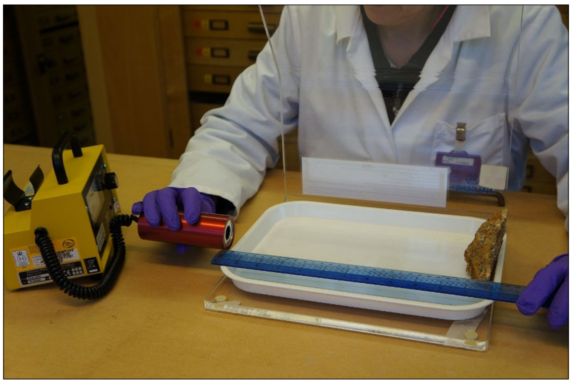

Fig.4. Measuring radiation levels at the Oxford University Museum of Natural History. Note the use of protective clothing and a beta-shield.
(photo: Simon Haycox, University of Oxford)

means that simply stepping back from a specimen will reduce exposure significantly. Other simple strategies can help; Keeping labels clearly visible will reduce the need to handle a specimen. When handling is necessary, the specimen's card tray or box can be picked up, rather than specimen itself (Fig. 3).

Finally, using **sheilding** to protect workers from radiation emissions. Laboratory coats and disposable gloves should always be worn to reduce risk of contamination to skin and clothes. A beta radiation shield, made of thick transparent acrylic, used when working on a specimen, will help protect the body from beta radiation.

Uranium and thorium bearing minerals generate gaseous decay products: radon and thoron. Collections of minerals can potentially generate significant quantities of radon gas that could present a radiation risk on inhalation. Radon gas should be fully dissipated in a well-ventilated area and therefore storage arrangements should facilitate this.

As with all handling of unknown or potentially toxic minerals or materials, users should not eat, drink, bite nails, or apply make-up while working with radioactive specimens. This will reduce the risk of ingesting radioactive material. The advice of a radiation protection specialist should always be sought before embarking on work with finely particulate specimens, or any procedure that might generate radioactive powders or dust. Such work will normally require a Scheme of Work to be prepared in advance.

Monitoring exposure

Monitoring of exposure to radiation takes two forms; firstly personal monitoring, and secondly environmental monitoring. It is important to obtain and advice and training from a professional radiation protection adviser to ensure that the correct equipment is chosen and that it is used properly.

There are a number of ways to monitor personal exposure to radiation. Personal dosimeters (known as TLDs - thermoluminescent dosimeters) are worn as badges. The dosemeter is returned to the issuing authority for assessment at regular intervals, not exceeding 3 months, and any recorded exposures above background levels are notified to the wearer. It is important that the badge is kept well away from radiation sources when it is not being worn. Similarly, finger-tip TLDs may be worn under disposable gloves where extremity exposures may be significant during specimen handling.

Both of these methods may only indicate high level of exposure some time after an incident. However, vigilant use of a dose rate meter or count rate meter of the kind used to detect radioactive specimens in a collection provides a continuous indication of an individual's potential radiation exposure. Contamination monitors allow an **immediate** check for contamination to the skin and hair, and should be used routinely to check for personal contamination during and after working with radioactive specimens.

Both radon gas and radiation levels require environmental monitoring. Radon levels are normally monitored using radon detectors hung in stores and workrooms. These devices can be obtained from Government agencies or radiation protection companies, and should be returned to them for results after a period of 3 months. If the results are higher than the recommended levels for the workplace, additional ventilation will be needed.

Radiation levels should be measured at storage surfaces to ensure that radiation levels are safe for those working in those areas. This is carried out with a dose rate meter. Again distance is important and moving specimens to the back of a storage drawer, or spacing them out more to reduce the density, may be sufficient to keep radiation levels safe for workers in front of the cabinet. Levels of radiation will increase if radioactive specimens are brought together in one place, conversely they can be reduced by dispersing radioactive specimens through the collection. Radiation levels should be checked whenever specimens are moved, to ensure compliance with local rules and the law.

Additional monitoring will be needed when working with radioactive specimens, and extra care will be needed to minimise contamination from crumbly or powdery specimens. All work should be carried out in an easily cleaned plastic tray. Contamination can be detected and measured using a count meter of the kind used for locating radioactive specimens in the collection. Surfaces and trays should be cleaned with damp wiping tissue, and then rechecked and re-cleaned as necessary until all contamination has been removed.

Managing specimens

Some local rules can be complied with by good general museum practice. Managing radioactive specimens requires up-to-date acquisition and disposal policies, good levels of specimen documentation, and high standards of security to control access to specimens and audit specimen movements. It requires preventative conservation measures, for example to protect specimens from abrasion and poor handling. It also requires attention to health and safety policies to protect people in collections areas, remembering that minerals can be toxic or asbestiform as well. Radioactivity (along with other hazards) should be specifically recorded on any Collection Impact Form and evaluation prior to acquisition of a specimen.

Details of radioactivity (radiation monitor reading, and the distance from a specimen at which it is taken) should be an integral part of the museum's specimen documentation, as should images. Specimens should be individually photographed because referring to an image can help reduce the need to spend time in close range of the specimen as well as providing a useful record for security purposes (Fig. 5).

Signage and labelling are important. Specimens can be individually tagged with a small radioactive warning sticker, but in general, clearly visible warning labels using the internationally agreed radiation warning symbol should accompany every radioactive specimen in storage. Cabinets containing radioactive specimens should also be labelled, as should any storage areas or rooms set aside for the storage of radioactive material (Fig. 6). However, special consideration should be given if the doorway leads off a public area, not only to prevent unnecessary alarm, but also to avoid compromising security (Fig. 7).

Different approaches to storage

Our experiences show that it is possible to comply with the law and manage radioactive specimens effectively, using very different procedures.

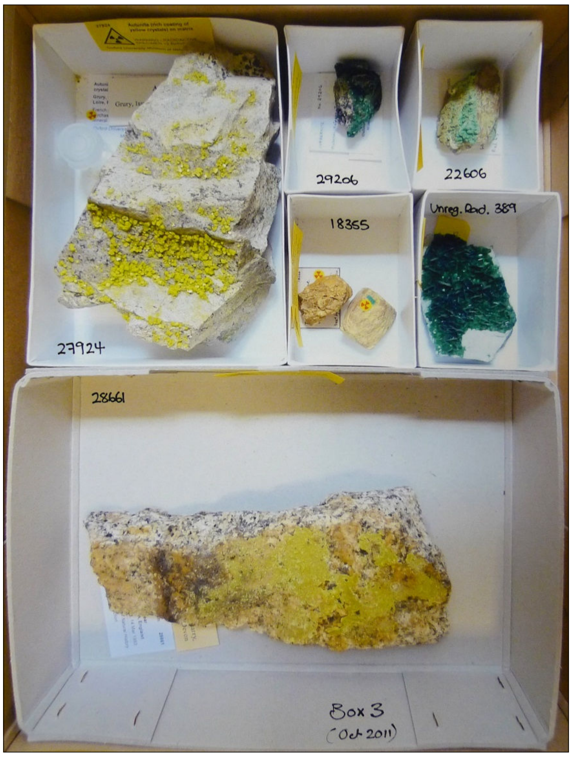

Fig.5. Use of photographic records minimises time spent in a radiation store. This annotated photograph of uranium secondary minerals is sufficient to show what each specimen looks like, and where it is located in the box. (photo: Oxford University Museum of Natural History)

Fig 6. 'Low level' radioactive minerals at Oxford, for which both drawers and individual specimens have yellow radioactive warning labels.
(photo: Oxford University Museum of Natural History)

The National Museum of Wales segregates all specimens with surface readings above background levels (14 cps). This comprises nearly 700 specimens. These specimens are stored in a locked 'controlled area' with very restricted access. All specimens are sealed in containers and dispersed around the controlled store with just a few specimens per drawer. The store has a strong air extraction system so containers can be safely opened in the store. Specimens can be used for student/public handling if the container surface dose rate is below 7.5μSvh-1.

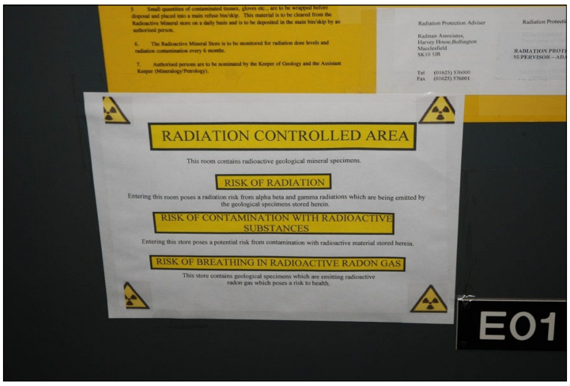

Fig.7. Radiation stores must be secure, with restricted access, and appropriate warning signs. (photo: National Museum of Wales)

Fig. 8. Radioactive specimens are stored in desiccating cabinets at the Hunterian. These must only be opened in the open air. (photo: The Hunterian, Glasgow)

The Oxford University Museum of Natural History measures radiation levels at 30cm from the specimen surface, a typical 'working distance'. It divides radioactive specimens into two groups, those above background but less than 2.5μSvh^{-1} at 30cm are designated 'low level radioactive', and those above 2.5μSvh^{-1} at 30cm are designated 'high level radioactive'. 'Low level radioactives' comprise about 750 specimens and are dispersed in the main stores so that measurements at the surface of any cabinet must never exceed 2.5μSvh^{-1}. A radioactive warning label is clearly displayed with each specimen and handling restrictions are enforced. 'High level radioactives' comprise around 150 specimens, approximately 0.5% of the mineral collection. They are stored in a secure 'controlled area' which has very good natural room ventilation to dissipate radon gas. Only designated radiation workers are permitted to handle these specimens.

The Hunterian, University of Glasgow, also has a two tier system. 'Radioactive specimens' are those which measure between 1 and 7.5μSvh^{-1} at the surface (Fig. 8). These are dispersed in the store, with similar storage and management as the Oxford collection. 'Significantly radioactive specimens' measure greater than 7.5μSvh^{-1} at the surface, and comprise just a small number of specimens, They are stored in secure 'Controlled Store', in desiccating cabinets to contain the radon, that must be opened in a fume cupboard or in the open air. Handling of these specimens is by designated radiation workers only.

Keeping the hazards in perspective

Just how hazardous is it to work with radioactive geological specimens? We can compare dose rates with those considered under the law to be safe for the adult, non-pregnant, general public. The current dose limit for the general public is 1 mSv per year. A person would have to be exposed to a specimen of 1μSvh^{-1} for greater than 1000 hours or a 7.5 μSvh^{-1} specimen for more than 133 hours, to obtain their maximum yearly dose.

During the curation and isolation of around 75 'significantly radioactive' specimens in the Hunterian, a finger-tip monitor, worn over the work period of about a week indicated no significant excess exposure. Even during this relatively intense work with radioactive specimens, actual physical handling contact was only a few seconds to tens of seconds each, and hence cumulative exposure time was very small. When not actually handling specimens, the exposure a metre or two away was negligible.

The natural radioactivity in geological specimens rarely reaches levels where specimens cannot be used for a variety of educational and research purposes provided they are handled and stored correctly and responsibly. Plenty of help and advice is available from professional radiation protection advisers and from the Health and Safety Executive.

Acknowledgements
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Conservation of pyrite damaged ammonite type specimens at the National Museum of Wales

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Abstract

A project to conserve, cast and repackage a collection of Jurassic ammonites from Dorset was undertaken at Amgueddfa Cymru - National Museum Wales. The specimens are all either cited or figured and include holotypes and paratypes. Many had been consolidated 40 years ago with the acrylic resin Bedacryl and some were embedded in plaster. The Bedacryl had become tacky with age and dust that had settled on it was difficult to remove. Pyrite is present in the rock and the fossils and many of the ammonites were affected by pyrite decay. The specimens were cleaned, treated for pyrite decay if required, re-consolidated and packaged in protective microclimates. Due to the scientific importance of the collection, casts were made of some of the ammonites to ensure a good record of the specimens, in case of further deterioration of the original specimens. Following re-consolidation, silicone moulds were taken of the specimens and from these, casts were made. It was important that the casts should be free of even microscopic bubbles, and after some experimentation it was found that the addition of the antifoaming agent Simeticone significantly reduced the number of bubbles in the casts.

Keywords: Pyrite Decay; Ammonite; Microclimate; Conservation; Casts.

Introduction

The Department of Geology at the National Museum of Wales (NMW) houses a collection of fossil ammonites from the Jurassic of Dorset. It includes approximately 160 specimens, many of the genus *Pectinatites*, collected during the 1960s and 1970s by J.C.W. Cope (Cope, 1967; 1978). The specimens are stored in the type fossil collection at the National Museum of Wales, Cardiff. The store is air conditioned and the temperature and relative humidity (RH) are within the ranges of 20-25°C and 40-60%, respectively.

Many of the specimens are naturally crushed, although the ribbing is generally well preserved. The rock is very fissile and has the mineral pyrite (Buttler 1994; Larkin 2011) finely disseminated throughout. As a result, and due to some of the pyrite oxidising, most specimens are extremely fragile (Figs. 1 and 2). The rib interspaces are often filled with hard shale, and often the entire specimen was originally encrusted with irregular pyrite aggregates (Cope, 1967). This presented considerable challenges during the original preparation of the specimens.

Many of the specimens were set in plaster at the time of collection in order to stabilise and extract them in one piece. Following original preparation in the 1960s, the specimens had been treated with ICI Bedacryl, both to consolidate the ammonites and to delay pyrite oxidation through the formation of a barrier for oxygen and water vapour (e.g. Howie, 1978).

Bedacryl is a hard, transparent, glass-like and thermoplastic polymethacrylate (PMM) resin. PMM resins were commonly used as conservation consolidants in art, archaeology and palaeontology during the 1950s by being applied directly to a specimen to prevent contact of its surface with air (eg. Costagliola, *et al*., 1997). Resin coatings have been shown more recently to be an ineffective method. Some may provide a limited barrier against gases and humidity by decreasing a specimen's natural porosity (Costagliola *et al*., 1997) but most are not impermeable to gases and humidity (Cornish & Doyle, 1984).

Baars, C. 2013. Conservation of pyrite damaged ammonite type specimens at the National Museum Wales. *Journal of Natural Science Collections.* **1.** pp.34-37.

Fig. 1. One of the specimens, an ammonite of the species *Pectinatites (Arkellites) hudlestoni* prior to treatment (NMW 77.12G.528). Damage from pyrite oxidation products shows as bright areas. The plaster jacket is just visible around the edges of the specimen.

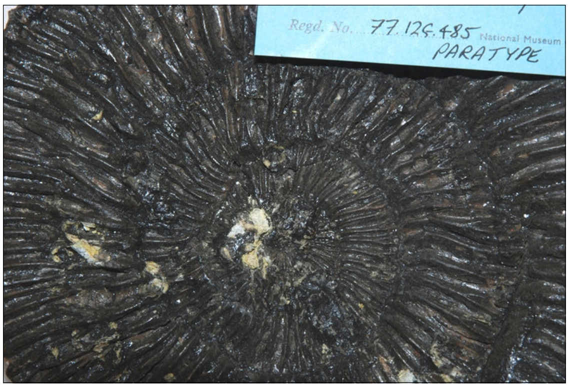

Fig. 2. Damage from pyrite decay to one of the specimens (*Pectinatites reisiformis*, NMW 77.12G.485); pyrite decay products are visible as yellow-white powdery substance.

Bedacryl fell into disuse during the 1970s when the toxicity of the solvents used with them (toluene, xylene) restricted their wider use. In addition, sealing specimens with resins inhibits analytical processes or further conservation measures and is therefore not recommended (Buttler, 1994).

Following 40 years of storage, the Bedacryl coating on the ammonites at NMW had disintegrated and become tacky. Unfortunately this meant that 40 year's worth of dust settling on the specimens was very difficult to remove. A more threatening problem was that the specimens had only been coated on one side, oxygen and water vapour had been able to pass through from the other side uninhibited. Pyrite decay now appeared to be progressing, threatening to destroy the specimens. It was therefore decided to treat the ammonites for pyrite decay, following a procedure described in detail by Waller (1987). This method attempts to delay destruction of the specimens by neutralising pyrite oxidation products through exposure to ammonia gas.

Preparation

A prerequisite for the effective treatment of pyrite decay was the removal of the consolidant to enhance penetration of the ammonia gas; this would also serve to clean the specimen surface. The specimens were therefore immersed entirely in a bath of acetone for up to several hours. Acetone did not dissolve the Bedacryl, but it softened the old consolidant and separated it from the fossils; gel-like sheets became detached and were removed gently with a soft brush. Additional gentle rinsing with acetone achieved near-complete removal of the Bedacryl. Once the old consolidant had been removed the specimens were very fragile and needed to be handled with extreme caution.

At this stage, it was possible to undertake additional preparation of the specimens to remove any adhering rock fragments that had not been removed during the original preparation, as well as remove plaster from the original stabilisation, that was obscuring the specimens. This was undertaken using a Model ST fossil preparation pen (from Ken Mannion, Barton upon Humber) and a Model AJ-1 air abrasive machine (Texas Airsonics) with sodium bicarbonate 50μm powder. This preparation had to be undertaken with extreme caution in order not to result in physical damage to the specimens.

Pyrite treatment

Pyrite can oxidise in the presence of water vapour and oxygen, forming, for example, sulphuric acid and ferrous sulphate (eg. Newman, 1998). Sulphuric acid is a strong electrolyte, which can lead to oxidation of further minerals present in the fossil; ferrous sulphate exists as any of three hydrates, with each transition being associated with a volume expansion, leading to further physical specimen damage.

The standard method for pyrite treatment subjects specimens to ammonia gas, which neutralises the products of pyrite oxidation (eg. Waller, 1987). The specimens were exposed to ammonia gas in a desiccator for several hours and up to a few days, depending on the size of the specimens. A humectant (polyethylene glycol (PEG) 400) was added to lower water vapour pressure during the neutralization reaction. This results in less water condensation in fractures within the specimen. The length of treatment was determined by a reaction indicator. The depth and speed of the neutralisation reaction is dependent on a number of factors, such as specimen size and permeability, and amount of oxidation products. An indication of the probable depth of the reaction can be gained by inclusion of a small glass tube, packed to the depth of the specimen with a reactive sulphate mixed with small glass beads. Ferric sulphate shows a clear colour contrast between non-reacted (green) and oxidised (yellow-brown) material. Following the ammonia gas treatment, the specimens were stored in sealed containers with relative humidity kept low by the addition of silica gel until re-consolidation and packaging was completed.

Consolidation
Re-consolidation was undertaken to strengthen the specimens as they were extremely fragile following removal of the previous consolidant. A consolidant should have long-term stability, short-term reversibility and ease of application. The solvent used with the consolidant in this case was selected on the basis of vapour pressure, as a high vapour pressure allows the consolidant solution to dry within a short time so that several applications could be undertaken in short succession. This is not always the case; in some applications the depth of penetration is more important, in which case a solvent with a lower vapour pressure (such as ethanol) would be used. A solution of Paraloid B72 in acetone has been used in geological specimen preparation and conservation for many years with no apparent problems. Therefore the specimens were submerged completely in a weak (5 %) solution of B72 in acetone. Then loose parts were re-attached using HMG Paraloid B72 adhesive, taking care not to over-apply the consolidant or glue and obscure any morphologically important detail. Finally, a weak solution of the consolidant was injected repeatedly into any fractures using a syringe and hypodermic needle or a plastic disposable pipette (Fig. 3).

Fig. 3. Ammonite after completed treatment (*Pectinatites reisiformis*, NMW 77.12G.410).

Casting
Following the neutralization treatment and consolidation, positive casts were made of the important type specimens. This ensured that at least replicas would be available for future study, should it not be possible to slow down the rate of pyrite oxidation sufficiently to preserve the specimens for future use and the specimens were damaged by the oxidation products. This was undertaken immediately after consolidation while the specimens were in a reasonable state of preservation, as well as newly consolidated and relatively stable, and prior to packaging in barrier film bags. Moulds were prepared using silicone rubber (Silastic 3498; Thomson Bros, Newcastle upon Tyne) which was selected to have a low viscosity for faithful replication, as the ammonites were of complex shapes and contained fine morphologically important details. The silicone rubber had to be flexible and separate easily from the fossil without tearing but also without adhering to the specimen too strongly and damaging the fossil during demoulding. Initially, white silicone rubber was used but it is advisable, should there be any need for future photography, to add a black or dark grey dye during mixing.

Jesmonite was used to make the casts. This is a gypsum-based casting medium in an acrylic resin. This product is relatively cost-effective, durable and has good long-term stability. It was prepared as suggested by the manufacturer: mixing an amount large enough to allow the stirrer (a paddle attached to a drill) to be fully immersed without dragging air into the mixture. However, on closer inspection of the casts under a microscope it was found that the casts contained a large number of small (barely visible with the naked eye) bubbles. Due to the scientific importance of the specimens this was unacceptable, and different techniques were tried to reduce the incidence of micro bubbles. Attempts included different mixing ratios of Jesmonite powder and resin, casting under vaccum conditions, and placing the moulds on top of an ultrasonic water bath immediately after pouring the Jesmonite.

Finally, it was discovered that the addition of an antifoaming agent gave much better results. The author's daughter had not long been born, and his wife observed the dispersion of washing up liquid bubbles when washing an empty bottle of Infacol ('formulated to relieve wind, infant colic and griping pain'). She therefore suggested tring the addition of a few drops of Infacol, readily available in any baby-bearing household, to the casting mix. Infacol is effective by dispersing bubbles, and it was hypothesised that it may have the same effect in the casting mix as in a baby's stomach. This worked remarkably well but greatly reduced the working time, as it accelerated the setting of Jesmonite to a few minutes. Advice from the manufacturer led to the further addition to the casting mix of a retarder, which then gave the desired results and very faithful casts. The active ingredient in Infacol is Simeticone, which can be obtained from laboratory suppliers. As Infacol also includes a number of other ingredients, it was decided to continue further experimentation with Simeticone alone to keep the number of chemicals added to the casting mix to a minimum for reasons of long-term stability. Approximately 1 drop of Simeticone was added to each 100g of Jesmonite.

The resulting casts and the moulds are now stored separately from the type specimens. The silicone rubber moulds have a shelf life and become brittle after approximately ten years (partly depending on how often they are used for casting). However, the casts can be treated as master casts from which further moulds and casts can be reproduced should this be required, for example for other museums or researchers. These master casts will be available long-term should the original specimens deteriorate further in the future.

Re-packaging

Complete sealing from the ingress of oxygen and water vapour with resins is unachievable, as even modern consolidants are permeable to some extent (Buttler, 1994; Larkin, 2011). In order for the treated specimens to be stored again in NMW's fossil store, without risking continued rapid pyrite oxidation and hence ineffectiveness of the treatment just undertaken, the treated specimens were packaged in individual microclimates. This involved sealing the specimen with an oxygen scavenger and/or a desiccant in a purpose-made bag using barrier film (Buttler, 2006). The barrier film used was Escal, a ceramic deposited barrier film with a polypropylene outer layer, a barrier layer of a vacuum-deposited ceramic on a PVA substrate and an inner (sealing) layer of polyethylene (Fig. 4). Barrier films were originally developed for the food industry, and oxygen scavengers for the electronics industry, to overcome similar problems of storing objects at certain relative humidity and oxygen levels. For the ammonites, two types of microclimate were used: the majority of specimens (those that had little or no obvious pyrite present) were stored in low RH microclimates of Escal barrier film with silica gel, and some (those with considerable pyrite-related damage) were stored in anoxic microclimates using two layers of Escal barrier film with Ageless RPA oxygen scavenger developed by Mitsubishi Gas Company. These two separate methods were chosen because the presence of little or no obvious pyrite warranted a simple protection; the former method was also more cost effective than the latter.

A note on health and safety

Ammonia gas is both toxic and flammable. Acetone is an irritant to the eyes and skin, particularly following prolonged exposure. Injecting consolidants into specimens with a syringe bears numerous hazards. All work involving the chemicals and processes mentioned in this article was undertaken, following the recommendations of COSHH and risk assessments, with appropriate personal protective equipment and in a ventilated fume cupboard.

Conclusions

The importance of the type collection of Jurassic ammonites meant that the long-term preservation of these fossils was best achieved by combining replication of the fossils with effective pyrite treatment and repackaging. Casting each specimen will eventually lead to more than doubling the size of this collection, as, in addition to the fossils, moulds and casts now also have to be stored. Space in the type collection is very much restricted, and it was decided to keep the casts in a separate store. An additional benefit of replication is to make the collection more usable, for example, in handling sessions, as the originals are too fragile to handle. The use of an antifoaming agent in conjunction with Jesmonite improves the quality of casts. In that sense, Infacol is 'suitable from birth onwards' - up to 155 million years.

Fig. 4. Storage of treated ammonites in micro-environments side by side with untreated specimens.

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Gaining young children's perspectives on natural history collections

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Abstract

Young children are an important audience for natural history museums, and there is a general belief amongst the public and museum staff alike that these museums are particularly suitable for younger visitors. However, direct research with children under the age of six years is challenging and therefore scant, and without a proper understanding of our audiences, we risk producing exhibitions that are uninteresting, irrelevant or even off-putting. Over the course of 2011, I carried out research at the Oxford University Museum of Natural History, developing a method that uses children's digital photography as a focus for interviews with participants aged four and five years old, on everyday family visits. This has proven to be an extremely effective way of accessing the viewpoints of young children, and has demonstrated that certain aspects of their museum experience are often unknown to accompanying adults. The research project has the joint aims of developing an audience research methodology, and revealing the viewpoints of this important but under-researched audience. This paper will begin with a brief description of the method, before a summary of some of the elements of the museum, collections and displays that have proven to be particularly attractive to the children and suggestions of what significance this could have for museums.

Keywords: Education; Evaluation; Digital Photography; Children.

Introduction

There seems to be a general consensus, amongst museum staff, parents and teachers, that natural history museums are ideal for young children. For example, photographer Richard Ross states that:

> Probably the first experience we all have as urban culture-seekers is the natural history museum. It is a must for kids. It's much more palatable than the art museum... The natural history museums are the starting point for many of us.
>
> (Ross, 2010)

However, in spite of their importance as an audience, the voices of young children are largely absent from visitor research (Piscitelli & Anderson, 2001; Dunn, 2012). My own PhD research seeks to redress the balance by finding ways to gain the perspectives of young children, thus helping to reveal what it is actually like for them to visit a natural history museum. I base this on the perspective that young children are experts when it comes to their own lives, and that, as visitors of today as well as (trainee) visitors of tomorrow, their views are worth listening to (Dockett, *et al.* 2011).

There are a number of reasons why young children are difficult to research within museums. One of these is that they are not yet able to read or write. Probably more significantly, research suggests that young children find it hard to recall specific events in unfamiliar contexts (Farrar & Goodman, 1990) or when questions are complex or abstract (Hatch, 1990). Thus, being questioned in the unfamiliar setting of the museum, using the unfamiliar method of being interviewed by a stranger, about abstract changes in feelings or knowledge, may be expected to pose significant challenges to younger museum research participants.

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Fig. 1. Boy photographing a badger. (Copyright E.S. Kirk)

Fig. 2. Small things: Anna's photograph of eggs, which we discussed during her interview. (Copyright E.S. Kirk)

A number of researchers have begun to try to find ways of researching children in museums (Kelly, *et al.* 2006; Graham, 2009; Dunn, 2012). Unsurprisingly, various methods exist in the world of education – my own methods draw on the Reggio Emilia approach (Rinaldi, 2005) and the Mosaic approach (Clark & Moss, 2011), but it must be remembered that the research method needs to suit the *setting* as well as the *audience*. Some educational research methods simply will not work in museums, for example when they depend on a child using the same space on a daily basis. As well as ensuring that the method suits the audience *and* the setting, more importantly it needs to suit the audience *in* the setting. In other words, it is not just a matter of logistics, but of expectations, mood, context-based social behaviour and so on. After trialing a number of methods, I found that digital photography worked particularly well for young children within museums, for reasons I will elaborate on below (Fig. 1).

My research was carried out in the Oxford University Museum of Natural History, with four- and five-year-old children, visiting with their families. I recruited families as they entered the museum, and asked the child to borrow my digital camera during their visit and to take photographs of the things they liked or found interesting. I asked them to come and find me 15 minutes before they intended to leave so that we could look together at the photographs on my laptop and talk about what they had photographed. My data therefore consists of the photographs that the children took, plus the recorded interviews with the children about their pictures. In total, I worked with 32 children, both girls and boys, who took between them just under 1,600 photographs.

In the rest of this paper I will present a snapshot of some of the research findings that I think will be of most interest to natural history museum curators and educators. I will then go on to suggest some of the implications of these findings.

Advantages of photography-based research

Often, when we carry out research or evaluations with everyday visitors who are not part of a bigger project, we might expect to find that what visitors remember are the more 'charismatic' objects in the museum – the large or superstar artifacts that the museum has chosen to highlight. When visitors use a camera, they take pictures all the way around the museum, and photograph whatever catches their attention at any one time. This gives a chance for the smaller objects to be featured in the research. These objects may not be as memorable by the end of the visit, but they have still caught the visitor's attention, they have still been significant to the visitor in some small way, and they still form part of the tapestry of the visitor's museum experience.

During my own research, the children took an average of 50 photographs each, ranging from a minimum of seven, to a maximum of over 200. Where children took more than 10 photographs, it wasn't possible to talk about every picture, so I asked the child to choose which ones they wanted to talk to me about (on average, the children talked about 8 photographs each). Many of the pictures they chose to talk about *were* of the more charismatic objects, such as the tyrannosauruses, crocodiles, or the taxidermy mammals that visitors are allowed to touch. But many other photographs, including those that were discussed in the interviews, were of less obviously memorable objects, such as small skulls, ammonites, eggs, beetles and pine cones (Fig. 2). The fact that some of this latter group of objects also makes it into the interviews suggests that photography is a useful aide memoire for understanding the meaning that visitors attach to objects of all types and sizes. We can also see the photographs themselves as an alternative, visual language that we can use to understand the children's perspectives, even where the pictures aren't actually discussed. My ongoing analysis of the data will reveal further patterns in children's choices of photographic subject matter.

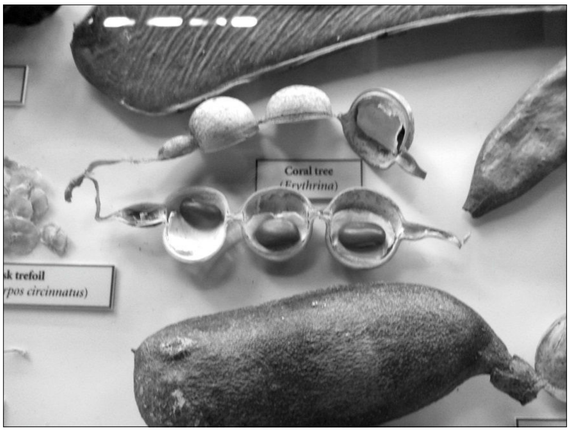

Fig. 3. Jack's photograph of a seed pod, taken without his dad's knowledge. (Copyright E.S. Kirk)

The social context

Although I did not observe the children during their visits, the photographs and interviews together also reveal some of the social aspects of the visits. In addition, I have carried out 90 observations of other family visitors in the museum. The combined data suggest that, while the children and adults do walk around the museum and talk about what they see together, this is not the whole picture. The young visitors were also very much their own people, exploring on their own, looking at things their parents hadn't seen, and understanding things from their own perspectives. For example, five-year-old Jack visited the museum with his dad. They stuck closely together and Jack's dad was important during the interview in filling in some of the gaps in the story of the visit, which Jack himself didn't think to tell me. However, one of the pictures that Jack wanted to show me was of a tiny pod, containing red beans (Fig. 3). Jack's dad was very surprised by the picture, telling me he had no idea what it was or where Jack had seen it. He seemed shocked that an element of Jack's visit was unknown to him, and that here was a photograph that he couldn't help to explain to me.

In other cases, children visited in large family groups, so that parents' attention was often with other members of the group, and the child – even if they were within sight of the adults – was essentially experiencing much of the museum on their own. For a number of groups it was also clear that siblings rather than parents had helped the young child to explore the museum. All of this calls into question research in which parents or teachers are asked to speak on behalf of their children, and shows the importance of finding ways to ask children directly about their museum visit.

Handling collections versus glass cases

Oxford University Museum of Natural History is a very traditional museum, with most of the collection in wood-framed glass display cases, interspersed with free-standing mammal skeletons, dinosaur skeleton casts and dinosaur models. What sets this museum apart is the large number of objects (taxidermy, skeletons, fossils and other geological specimens) available for visitors to touch, both at designated handling tables and at various points around the museum.

In my discussions with museum professionals I have often encountered the view that young children will be more engaged with a museum if they can interact physically with objects, rather than simply looking at them behind glass. Black (2005: 68) states that museums should treat young children 'not as passive observers but as participants, with opportunities for active engagement; direct and immediate experiencing of objects, people and events'. My research confirms that the handling objects were certainly very attractive to the children – they account for about 16% of the photographs taken, and just over 20% of the photographs they chose to discuss in interviews. (I do not have data on the percentage of the displayed collections that are available for handling, but it must surely be less than 1%.) However, this means that 84% of the photographs taken, and 80% of those discussed, were of things that weren't part of the handling collection (although these do also include photographs of family members and the building). In fact, 68% of the photographs were of objects behind glass, and these also accounted for over half of the photographs that children wanted to talk to me about in the interviews. It certainly seems that simply putting an object behind glass is not necessarily as off-putting to young children as might be assumed. And while the presence of the handling collections may help to make the museum experience more stimulating, in this museum at least, this does not seem to be at the expense of the collections that are displayed in cases.

In addition to children's attraction to handling collections, it was interesting to discover that even where children photographed handling objects, they did not necessarily touch them. A number of parents suggested to me that this may at least in part have been because of the camera, which may have either provided them with an alternative activity to handling, or which may simply have acted as a barrier, as it was hung around their necks. However, many of the children did touch things, so it was obviously not an insurmountable barrier, and my subsequent observations suggest children without cameras sometimes choose not to touch objects at the handling tables, even when they do take time to look at them. It may be that there is something else about the handling collections that is attractive to the children. For example, all objects available to be touched are also at a particularly suitable height and location to be looked at very closely, which the children seemed to favour. It may also be that the types of objects displayed for handling are particularly attractive for young children, for example familiar animals like the taxidermy fox, pony, cheetah and owl, and the sparkly pyrite and huge ammonite. On this point my research can

Fig. 4. Marie's photograph of a snake, which she discussed in terms of its patterning. (Copyright E.S. Kirk)

only reveal the patterns, about which I can speculate. But this does suggest interesting areas to be followed up by future research.

Observation skills

Museum education literature often talks about how visitors make meaning of objects depending on their prior knowledge (e.g. Falk & Dierking, 2000). This is certainly the case for the young children in this study who, for example, talked about what they knew of dinosaurs and extant animals. However, it was also clear that very often, children's knowledge of an animal was limited to its name and a general type, and sometimes not even that. This lack of knowledge did not stop children from noticing details, or from wanting to find out more. In fact, it was clear that the children were very observant, and frequently described to me the form, colour, pattern and texture of familiar and unfamiliar objects and animals.

One area in which children's observation skills were apparent was in the discussion of colour. They discussed the colours of not only bright or sparkly objects, as might be expected, but also objects with duller colours, particularly if the specimens in question were also patterned. For example Marie (5), said of a model snake that she liked its colours because 'brown and green go quite nicely together' (Fig. 4). This is consistent with Dunn's finding (2012) that children in a history museum talked about both bright and subtle colours. Children also used colour and pattern to draw comparisons between specimens. For example, Josh remembered the colours of a dinosaur from the BBC television show *Walking with Dinosaurs*, and noticed that a similar dinosaur in the museum 'didn't have any spots on it … but it did have the blue edges around the eye … it did have the stripes on the arms'.

In the above cases, children were already familiar with the animals in question. However, they also talked about form and colour in cases where they did not understand what the specimens were, or the reasons for these specimens looking the way that they did. A significant number of photographs were taken of ammonites, which were described in terms of their 'swirly' shape, although most children could not identify them. The children also very naturally attempted to put their observations into context. Seeing colour and pattern as significant aspects of the specimens, some children attempted to draw further inferences from these features. For example, Eloise (5) told me that she thought that the red colour of the salmon was blood (a conclusion that her older sister was keen to refute). It appears that colour and form are seen as important aspects of the objects, which children are using to categorise and make sense of the familiar and unfamiliar things that they encounter in the museum.

Phobias and fears

I have found it particularly interesting that the museum seems to be a space in which some children encounter things that are actually or potentially scary. In one case, four-year-old Greg was very keen to show me his photograph of rocks glowing under UV light, which he saw in a dark booth. His mother explained that, although they had been to the museum many times before, this was the first time that he had been into this booth, as he had previously been 'unhappy' about the dark. Greg agreed that this time he had been brave enough to go in, and, unsurprisingly, given the intensity of emotions associated with overcoming a phobia, this seemed to make the experience particularly meaningful, and he spent a significant amount of time discussing this picture. It also transpired that, for Greg and for Harvey (5), parental phobias added to the excitement of certain exhibits. In both of these cases the mother's arachnophobia provided a particular attraction to the live tarantula. It seemed that the museum was a safe space in which children could encounter their own and their parents' fears.

However, much more common than actual phobias was an excited, play-acting sort of fearful response to the various large predators that the children encountered in the museum. I discovered that the children referred particularly frequently to the teeth of animals such as predatory prehistoric reptiles and crocodiles. During the interviews, these sorts of teeth were talked about by 18 of the 32 participating children. Words and phrases used include 'sharp', 'spiky', 'big', 'zig zag', 'scary', and 'lots and lots of teeth'. They also talked about their semi-fearful encounters with the model *Tyrannosaurus* head, which not all of them had been brave enough to touch. Josh (5) told me, "I stuck my head in its mouth … I thought it would bite my head off!", and, when I asked if that was scary, he enthusiastically agreed that it was.

The two points of significance that I want to raise here are the types of teeth that elicit these responses, and also the nature of the responses. Firstly, from looking at the photographs that elicit children to say the words 'teeth' or 'tooth', it becomes apparent that in every case these are

Fig. 5. Amar's photograph of the model *Tyrannosaurus* teeth. (Copyright E.S. Kirk)

spiked, predatory teeth (Fig. 5). They were almost all large, and they were all either in skulls or in model or taxidermy animals which didn't have fur, and in which the teeth were clearly visible, and many of them were in animals that would be big enough to eat the child, were the animal alive. When I analysed the photographs, including those which hadn't been talked about, I found that 8% of the photographs included teeth of this kind. To put this into more real terms, this means each child took, on average, 4 photographs of predatory teeth. And only three of the 32 children didn't take any photographs of this type of teeth.

The second point of interest is the type of response that the children were displaying. They clearly knew that the owners of these teeth were 'scary' – they often used this word to describe these animals. Yet their responses were not phobic in the same way that we saw with Greg's fear of the dark or the adults' arachnophobia. They made no particular attempt to avoid the animals, and did not seem to be upset by them. Instead, the children seemed to combine fascination, fear and excitement, which often led to them laughing, bouncing in their seat, bearing their own teeth, or making the shape of snapping jaws with their hands as they told me about the scary animals they had seen.

Edward O. Wilson has written about what he calls 'biophilia': the love that humans have for various elements of nature, including landscapes and animals. This, he argues, stems from our evolutionary history within certain environments, and selection pressures from the need to find food and shelter (Wilson, 1984). He also talks about biophilia's flipside: 'biophobia', which is the natural aversion that people tend to have to things that were threatening to our ancestors – particularly dangerous animals. In the museum, I suggest that the children's behaviour can be seen as 'biophobophilia', in other words, an enjoyment of, or fascination with, certain fearful aspects of nature. Evolutionary psychologist H.C. Barratt has suggested that we would expect to see young children being both fearful of and interested in predators, as this would help to ensure that they would stay safe, whilst also learning about potentially dangerous animals (Barrett, 2005). He also suggests that this behaviour may be in response to a 'minimal set of prespecified cues to dangerousness (e.g. size, sharp teeth)' (Barrett, 2005: 217). It is interesting to see a similar pattern of behaviour being played out in the museum, although of course the relationship between such an 'instinctive' response and the cultural context in this case is not clear.

What does seem to be the case is that the museum provides a safe space in which children can encounter animals and objects which are scary and fascinating to them, that it stimulates their powers of observation, and that this is done both within a social context and on a very individual level.

Significance for museum research

Although at the time of writing this research is still in the process of being completed, it already has a number of implications for museums and museum research. Firstly, it confirms that it is both possible and worthwhile to find ways of listening to the young children who visit museums. It also shows that, at least for this age group, digital cameras are a useful research tool; providing a visual voice to those who find it harder to express themselves verbally; helping the participants to record and remember their visit; and focusing the research on both charismatic and less charismatic objects. The fact that cameras are used by all ages of visitors suggests that this methodology may be worth testing with other age groups.

In addition, it should not be immediately assumed that the research findings are only relevant to four- and five-year-old children. Future research could explore whether these patterns are also found in other visitors and also other museums. It may be that listening to young children helps raise our awareness to aspects of the experiences of older visitors. David Unwin, of the University of Leicester, suggested to me in conversation that pre-literate children are, in a way, 'ideal audiences' to help understand responses to exhibition design, as they are neither as self-conscious as older visitors about giving the 'correct' response to the researcher, nor is their response to the exhibition design affected by reading text panels. It would be fascinating to know if the impacts of colour, form, touch, ferociousness and so on were similar in adults to the patterns seen in these children.

Significance for museums

There are also some suggestions of the implications of this research for museum practice, both for working with young children and for visitors of other ages. Firstly, the children's interest in handling collections and small objects suggests that they appreciated being able to get close to things, and to look at things that are relatively low down. Museums need to remember that children are an important audience, but that, in practical terms, small children have a very different viewpoint from adults. So we need to be wary of restricting children's view in displays, either by using high table-top cases or by blocking the view with signage in the lower parts of cases.

Secondly, by taking the child's perspective, this research is also helping to reveal the types of objects that children are drawn to, and the ways in which they talk and think about and interact with these objects. A deeper understanding of children's preferences, the aspects of objects that they focus on and use to make sense of them, and their physical and social patterns of behaviour in museums, can help museum professionals to make displays more engaging for a wider range of audiences. While this paper only hints at some of these patterns, for example children's fascination with predatory teeth, the research project as a whole will add to a growing literature in this area (for example Piscitelli & Anderson, 2001; Anderson, *et al.*, 2002; Kelly, *et al.,* 2006; Dunn, 2012).

Thirdly, we should keep in mind the potential impact of photography for visitors' own meaning-making in the museum. This research suggests that photography may help visitors both to focus on elements of the exhibitions as well as providing a way of remembering and discussing the visit at a later date. The issue of the impact of photography in museums was discussed in a recent edition of the *Museums Journal* (Atkinson, 2012), suggesting that this is a timely subject for research, for example into the possible pedagogical or personal meaning-making benefits of photography.

For me, one of the most significant implications of this work is an imaginative one: it very quickly became apparent that every child I interviewed experienced the museum in a totally individual way. While, of course, there were patterns and trends in the data, the children remained steadfastly different from one another. Each experience was not only individual because of the personality differences of the children, but also because of who they happened to be visiting with on that day, what they had recently watched on TV or done at school or during the holidays, and so on. For me, this showed that, while we can go some way towards understanding our visitors, almost all of what is experienced in the museum is, and will remain, invisible to us (Kirk & Buckingham, 2013). And most importantly, that is ok. We should be proud of being places where people are emotionally and intellectually stimulated in ways that we can never know. This personal significance is clearly something that is valuable to our visitors of all ages, and therefore we must, ourselves, remember to value it too.

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Recuration of the Fulgoridae collection at the Manchester Museum

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Abstract

This article is a brief summary of a project which recatalogued the Fulgoridae collection at Manchester Museum. The collection of over 150 specimens of Fulgoridae (Lantern Bugs) were accessioned, photographed and databased. The project updated species information for several specimens as well as adding previously unknown information about the collector.

Keywords: Fulgoridae; Lantern Bug; Manchester Museum

Introduction

The Manchester Museum's Entomology department houses some two and a half million specimens and is considered the third or fourth largest in the UK (Logunov, 2012). The collection began with the Manchester Society for the Promotion of Natural History in 1821 and was first assembled by John R. Hardy (1844-1921) who was appointed as Senior Keeper and Entomology Curator in January 1908. (Logunov, 2012: 86-87).

The Manchester Museum's Entomology department contains several important collections including the C. H. Schill World Lepidoptera Collection, W. D. Hincks and J. Dibbs collection of world Coleoptera and the worldwide Dermaptera collection assembled by W. D. Hincks and Alan Brindle. Smaller, important collections of Odonata, Hemiptera and Neuroptera also exist. The British Hemiptera collection is well documented and within the Auchenorrhyncha, seven families, 134 genera and 311 species are represented in the British collection.

This paper will focus on the Manchester Museum's collection of Fulgoridae. The Fulgoridae make up a Family belonging to the suborder Auchenorrhyncha. They are known as "Lantern Bugs" because of the erroneous belief that the insect's large head process lit up when it was disturbed (Kirby and Spence, 1823: 508-509). There are about 130 Genera and over 687 species found word wide (see FLOW: Fulgoromorpha Lists on the Web).

It is estimated that less than 40% of the existing species remain to be discovered (see Poiron and Nagai, 1996: 9). Though little is known about their behaviour, Fulgoridae are important organisms, especially regarding their role as trophobionts (see Naskrecki & Nishida, 2007).

The Manchester Museum's Fulgoridae collection

The Fulgoridae collection at the Manchester Museum consists of over 150 specimens, including 28 Genera and 34 species (Table 1). Though small, the collection is important historically and represents species from all tropical ecozones of the world.

The collection is housed in 6 drawers (with an additional drawer, No. 38, housing 11 nymphs collected by Herbert Stevens). It is part of the World Auchenorrhyncha collection (accession number F3227) which is housed in two wooden cabinets containing 38 glass topped drawers. Each individual specimen has yet to be allocated with its own accession number, though this will eventually be done for all the entomology collections. As well as the pinned specimens, slide material of Fulgorid specimens also exists in the collection. The Fulgoridae collection has been photographed and databased on the electronic collections management system KE Emu (Manchester Museum, 2013).

Allnatt, G. 2013. Recuration of the Fulgoridae collection at the Manchester Museum.
Journal of Natural Science Collections. **1.** pp.44-47.

Tribe	Genera	Species	Specimens
Amyclini	0	0	0
Aphaeini	10	11	57
Diloburini	0	0	0
Enchophorini	1	3	3
Fulgorini	3	5	13
Lystrini	1	1	8
Paralystrini	0	0	0
Poiocerini	1	2	2
Zannini	1	2	2
Laternarini	11	10	70
Limoisini	0	0	0
Xosopharini	0	0	0

Table 1. Specimens in the Manchester Museum collection by Tribe.

Fig. 1. A specimen *Laternaria clavata* (Westwood, 1839) collected by Herbert Stevens.

The development of the collection

Herbert Stevens (1877-1964)

The majority of the specimens in the Fulgoridae collection come from Herbert Stevens (1877-1964), a tea planter and naturalist who lived in India. Most of the Fulgorid specimens in the Manchester Museum collection were collected between 1910-1914 at his tea plantation in Gopaldhara-Rungbong valley, Darjeeling District and other surrounding areas. In 1965 his collection of Fulgoridae which had originally been held at the Natural History Museum, Tring was bequeathed to the Manchester Museum, along with 100 store boxes of Coleoptera, including cotypes and 620 papered specimens of Sphingidae. Stevens was a Fellow of the Zoological Society of London and the Royal Geographical Society. Though primarily an ornithologist, he collected many insects on his expeditions to the Sikkim Himalayas and neighbouring regions. His book, *Through Deep defiles to Tibetan Uplands* describes his experience as a naturalist and collector on the Kelly-Roosevelt Expedition. His bird collections are currently held at The Great North Museum in Newcastle, and the Natural History Museum, Tring.

James Cosmo Melvill

James Cosmo Melvill (1845-1929) was a naturalist born in Hampstead. He was the elder son of James Cosmo Melvill, Assistant Under-Secretary of State for India and grandson of Sir James Cosmo Melvill, K.C.B ,F.R.S., Chief Secretary of the East India Company. Though Melvill's primary interests as a naturalist were Conchology and Botany, he was also interested in Entomology, and donated the oldest specimens of Fulgoridae in the collection (collected in 1886 in Ceylon-now Sri Lanka) to the Manchester Museum. His largest donation to the museum consisted of his exotic herbarium, containing 36,000 species of flowering plants, and 6000 species of non-flowering plants such as Liverworts, Mosses, Ferns and Algae. At the time of his death, he was one of the oldest members of the Linnaean Society.

Alan Brindle

Alan Brindle (1915-2001) was Keeper of Entomology at the Manchester Museum from 1961-1982. Before his role at the Manchester Museum, he was called up in 1942 to join the Lancashire Fusiliers and transferred to the intelligence section. While posted abroad in India, he collected numerous insect specimens in the 1940s including Coleoptera, Hemiptera and Hymenoptera. Brindle collected thousands of insect specimens throughout his career, and some of his most important collections are kept at the Manchester Museum, including the Hincks and Brindle Dermaptera collection, which consists of over 11,000 specimens.

Other Collectors: P. S. Nathan, R. N. Baxter and W. H. Clayton:

This collection also contains specimens collected by Peter Susai Nathan (accession number 2588 and collection date 1972) and R.N. Baxter (accession number 2870 and collection dates 1977

Fig. 2. A small fulgorid nymph collected by Herbert Stevens.

Fig. 3. An engraving by Rösel von Rosenhof circa 1760-1770 in which a Neotropical species is listed as a "Chinese Lantern Fly." Image courtesy the Victoria and Albert Museum and used with permission.

and 1978). Seventy-three envelopes of papered specimens from Nathan have yet to be incorporated into the collection.

Also of note are Fulgoridae specimens donated by W. H. Clayton. All of the Fulgoridae specimens from this source were erroneously labelled, with 4 neotropical specimens being labelled as "found in China, Tibet" etc. It is unknown why all the labels on these specimens have wrong information. A possibility is that the specimens were from an amateur collector or dealer who misidentified the species as Chinese.

The newest specimens in the collection are from the Genus *Scamandra*, collected by A. Murray and were collected in Sulawesi, Puncak, Palapo in September 2007 and December 2008.

Collection recuration and expansion

The first step during the project was to make sure all the current data was accurate. Nomenclature was updated according to current taxonomic references such as the FLOW online database (http://hemiptera-databases.org/flow). In addition, photographs of each species were taken and uploaded to the KE Emu collections management database. The next step was to make sure all the label data was accurate. The W. H. Clayton specimens in particular contained erroneous information. Species that were from neotropical regions were labelled "Chinese." It is unknown why all the labels from this donor contain incorrect information. One possibility is they were purchased from an insect dealer and the data was later added. Another possibility is that the specimens were from an amateur collector or dealer who misidentified the species as Chinese. Apparently Clayton was not the first person to make this mistake, as *Fulgora laternaria* seems to have been labelled as an Asian species by people since the 1700s (see Fig. 3). It is possible it was confused with the Asian Genus *Laternaria (*formerly *Pyrops)*. Mislabelling of museum specimens often disrupts scientific progress, as unless the specimen can positively be identified no further information such as geographical data about where it was originally collected can be gleaned from label information.

Some specimens had no labels or labels with locality and collector information but no information stating taxonomic information. Some specimens were also undetermined. Identification of undetermined specimens was carried out using guides by Porion and Nagai (*Fulgoridae 1: An Illustrated Catalogue of the American Fauna* (1994) pg 34-35 and *Fulgoridae 2: An Illustrated Catalogue of the Asiatic and Australian Fauna* (1996) pg 46-47). In addition, examination of the head processes of several lantern bug specimens established that, instead of one species in a particular Genus (*Fulgora*), there were actually several. For example, eight specimens were labelled as *Fulgora laternaria* (Linnaeus, 1758) but closer inspection of the head process determined that one of the specimens was actually *Fulgora lucifera* Germar 1821.

Through this method, the collection was found to be richer in species diversity than originally thought. Extra labels with the newly discovered information were then added to the original data. Several specimens were moved from "undetermined specimen" drawers to Genus specific drawers. Now only four specimens remain undetermined. The location data was then updated on the collections management database.

Summary

The collection contains no type specimens and, apart from some undetermined material, is probably not a strong resource with regards to taxonomic research. Instead, the collection's strengths are in specimens that detail geographical and historical data for localities where collecting is now forbidden.

During research for this article, more papered Fulgoridae were discovered in the collection in store boxes from P. S. Nathan (collection dates 1967-1972). The specimens were relaxed, set, identified and incorporated into the collection (Fig. 4). The specimens are all from India, where collecting is now strictly forbidden, even for scientific purposes.

Following recuration of the collection, Fulgoridae specimens were used in outreach sessions and exhibitions. The new permanent gallery at the Manchester Museum, *Nature's Library* features five specimens.

Fig. 4. Pinning specimens for incorporation into the collection.

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V Factor: Volunteers as a bridge between museum scientists and the public

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Abstract

V Factor is a new programme at the Natural History Museum in London. It offers volunteers the chance to work in public view alongside Museum scientists on collection-based research and curation projects, taking them from visitor to proactive volunteer. It aims to involve a volunteers project manager, scientists, curators, volunteers and the public in the museum's research. Volunteers work alongside scientists on a research project whilst benefiting from a unique, informal and fun learning experience. Visitors are able to observe the processing of samples and interact with those involved. The management of this volunteer programme is described in this paper. The pilot project was 'Throughflow'; an international study of South-east Asian fossil corals as a means to describe the high biodiversity of their ecosystem and the effects of environmental change. Volunteers have successfully assisted with the cleaning of specimens so that they may be curated. At the same time, they have been discussing with experts project-related information, collections care, and the role of museums today. The programme has been continuously evaluated and changed as felt necessary. By March 2013, 45 volunteers were involved. Outcomes have included improved volunteer talent and education management, excellent assistance with scientific work and novel means of attracting the public to the museum's work.

Keywords: Volunteers; Science; Museum Education; Natural History Museum, Darwin Centre

Introduction

Although scientific research is an important function of the Natural History Museum in London (NHM), and the museum employs over 300 scientists, most visitors have only a limited knowledge of its contributions to science. This is unfortunate, as with knowledge comes an understanding of the nature of scientific work, its impact on our daily lives and how it can best be supported. One of the purposes of the new Darwin Centre (DC2) is to showcase the science undertaken at the NHM. Within DC2 is a Specimen Preparation Area (SPA), where scientific activities can be observed through a large glass window by visitors. In 2012 a new programme 'V Factor' was established in the SPA (Figs. 1 & 2).

The project aimed to increase the use of this area as well as a way of informing the public about the scientific work carried out at the NHM. The project also aimed to provide opportunities for volunteers to engage in research projects, whilst also educating them about working in museums and assisting in essential projects for the museum science teams (the 'V Factor Programme'). In this publication we present the development, application and evaluation of this programme. The publication has been put together by members of staff and present or previous volunteers of the Natural History Museum. It is hoped that the information provided here will be a useful model for other museums.

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Fig 1. The SPA area of DC2 in the Natural History Museum with volunteers working to clean fossil corals. As seen from inside the SPA (Photo: A.T.)

Fig 2. The SPA area of DC2 in the Natural History Museum with volunteers working to clean fossil corals. A visitor's view from outside the SPA (Photo: A.T.)

Previous studies on museums and their roles in communicating science

Elliott (1929) noted that educational opportunities are available for adults in museums, but also questioned whether and how they were being used. He noted that adults seek both education and enjoyment from museums, and it should be the role of the museum to aid them in their quest. Taylor (1942: 146) wrote that:

> *'Our role is not to feed…temporary excitements or to dish up ephemeral and inconsequential exhibitions- Our responsibility is to integrate what the man in the street has learned with what he has to face in the future.'*

More recent publications such as *Museums and the Education of Adults* (Chadwick & Stannett, eds,1995), 'Nonformal and Informal Adult Learning in Museums: A Literature Review' (Dudzinska-Przesmitzki, 2008), and 'Museums as Sites of Adult Learning' (Grenier, 2010) have explored the role that adult education in museums can play in creating a learning society, using nonformal and informal approaches. Grenier (2010) explores how museums can act as 'dynamic agents of cultural dissemination', so that adults can 'experience the unknown, revisit the familiar, stimulate their curiosity, and challenge their existing beliefs'. This allows people to test, confirm or modify their ideas; their understanding can be increased, providing opportunities to share in conversations, discussions, debates, and social interactions.

A recent demonstration of the value of museums in adult education is reported by Carney *et al* (2009). Using a large sample, these researchers have demonstrated that community-based museums, partnered with academic institutions, can inform the public for example about health research. McPherson (2006) reinforces the view that in the future museums will continue to preserve and provide recreation, but also to educate.

In the UK, a government programme aimed at raising the standards of educational work in museums, the UK Education Challenge Fund project 'Seeing the museum through visitors' eyes', has been evaluated by Hooper-Greenhill & Dodd (2002). The programme included over 400 projects. Although it was assumed that most museums already had included formal, informal and lifelong learning in their remit, it was hoped that an exchange of ideas would improve their provision. The authors say:

> *'The impact of involvement with museums and galleries is potentially rich, diverse and multiple. Participation in museum projects has encouraged higher and more focused aspirations, increased feelings of confidence, self-worth and personal identity, has led to the development of skills and increased employability, and broadened knowledge and awareness of cultural institutions. While these outcomes are difficult to measure in the statistical sense, they give a clear sense of the character of the social impact that museums can achieve.'*
>
> (Hooper-Greenhill & Dodd, 2002: 22)

As a result of the programme, it was found that staff gained knowledge about the value of museums in education and how staff could develop more educational roles. Hooper-Greenhill & Dodd (2002) are hopeful that the enthusiasm associated with this project, together with realistic, focused, strategic objectives and clear evaluations, will allow museum educational capacities to improve even further in the future.

Engaging adult audiences

Questions about how and why adults attend museums and how and why they benefit from their experiences continually need to be asked. Black (2005) describes the challenge to understand the nature, motivation, and expectations of visitors and how to retain them; the issue is always how to engage the visitor. Ross (2004) describes a new museology, where museums have displays/ exhibitions acting as catalysts for learning for a wide public, involving a paradigm shift, from display towards education. Pearce (1994) stresses the need for interpretation, rather than simple collecting. According to Silverman (2010), museums and their contents elicit introspection as well as cognitive responses. Visitors can engage in meaning-making and self-exploration, while exploring, contemplating and discussing what they see. For visitors, but more especially for volunteers, there are opportunities to build competence and capabilities in communication and work. And as Golding (2009) maintains, museums are also now places where new identities are formed and individuals from many different groups can make connections. She believes that museums can tackle societal problems such as injustice and exclusion.

The role of museums in communicating science has also been discussed (Rader & Cain, 2008). The NHM contains over 70 million specimens and the number continues to grow as museum researchers collect to address old and new questions. Access to the collections is mainly through curators – and the importance of the collections cannot be overestimated. For example, Johnson *et al* (2011) have recently written about how historical and collections can be used to inform debates on the impact of anthropogenic environmental change on the biosphere. Historical collections can provide useful baseline data when modelling past and present ecosystems and adaptation to change. This follows on from the writings of Janes (2009) on the role of museums in a troubled world and the urgency of curatorial work. Rader and Cain (2008) have noted how science museums today are involved with government policy and public culture as well as science. Public participation in a museum's work can improve public involvement and engagement with science, to empower the public towards an understanding of the natural world. Science museums now aim to show real phenomena and provide real experiences in enjoyable, unstructured social settings, while providing props (their unique selling points; the collections) which are unlikely to be available elsewhere.

There then follows the question of how to involve museum visitors in scientific exploration, to make sense of what they are experiencing; they often cannot seem to make the expected links and/or are reluctant to ask for assistance. Carney *et al* (2009) compared direct versus indirect visitor interactions with medical researchers in a museum and found, surprisingly, that the public appeared to prefer a permanent, unstaffed programme, as they were somewhat reluctant to speak with experts. Whether this was due to the public themselves or to the fact that the experts did not have the skills to interact is not known. How the public can be encouraged to speak with scientists was considered to be problematic.

Another programme, involving the NHM, together with other UK and US museums, was set up to improve public engagement with science ('PEST') (Lehr *et al,* 2007). Here 'dialogue events', adult-focused, face-to-face forums for scientific experts to meet with the public were set up to discuss policy. They intended to move museums from didactic education to constructivism, where the learner is an active participant in his/her learning. These dialogue events included public participation directly in scientific and technical decision-making and the promotion of broad interactions between the public, experts, and policy-makers. One important question is how to attract less forthcoming participants to such events.

The journal '*Museum and Society'* has devoted an entire issue (July 2011) towards **'**Hot Science Global Citizens: The Agency of the Museum Sector in Climate Change Interventions'. A variety of topics were openly discussed, including examining if museums are trying too hard to have something for everyone (Dibley, 2011), what a hostile review of an exhibition does in a museum (Hodge, 2011), and whether museums can act as cultural brokers concerning climate change (Salazar, 2011) are discussed. Cameron (2011), the editor of the issue, deals with current topics such as cultural governance and deliberative democracy for example towards climate change. It is of importance for institutions such as museums to consider audiences as moral and responsible citizens, and also as actors who can influence governments.

Getting the public interested in science can be problematic. Freedman *et al* (2010) have addressed this topic in their work on creating natural history events in Plymouth that are accessible and of interest for all the family. The role of the family, and parental interest, in promoting science careers is part of a STEM research programme being carried out by UK researchers (Archer, 2013). One recent approach is to include science in traditionally non-scientific museum exhibits (Copley, 2010). Copley (2010) assessed the scientific content in UK archaeology museums, both in character and extent, and the attitudes of the curators (those preparing exhibits) towards scientific content in their displays. Scientific explanations were reported as welcome if they are in accessible, in everyday language, with little detail of techniques. Obstacles mentioned were lack of space and/or funds and/or visitor interest.

Visible scientists

Another way of approaching science in museums is to have laboratories visible to the public. Meyer (2011) has recently reviewed this subject. In these laboratories, scientists carry out research, interact with the public, provide demonstrations and present their work. In this way, museums become places where the public can encounter 'research in the making' and can also discuss the needs, risks and ethics of scientific research. DC2 at the NHM is mentioned, where the public can view labs and collection storage through glass windows. Displays thus move from providing answers to allowing questions. These are important and interesting models, because all the work that goes on behind the scenes from conservation of specimens to digitising and creating online databases is not ordinarily seen by the public.

The challenges presented in using open laboratories include the potential downside of researchers who are 'on display' having to deal with noise and disturbance to their work. There may also be problems concerning safety. Meyer (2011) states that it is not always easy to recruit researchers and other specialists to work in public view; also, the researchers need to learn how to communicate their work to a wide audience of lay people. In addition, the vast majority of a researcher's time is spent on activities that do not look especially interesting (for example reading and writing papers or emails) nor can be easily displayed (for example, field work) so thought has to be put into what can actually be done in public view. But with field work, or new donations, new collections can be cleaned, prepared, sorted, and catalogued. Meyer (2011: 267-268) recommends ecology as a:

> *'…fruitful starting point for visitors to reflect upon socio-economic and environmental problems and issues of sustainability, and therefore help them to become more engaged and critical citizens'.*

The visitor and the volunteer

There are two principal groups of adults who attend museums and can benefit from contact with museum staff: visitors and volunteers. The role of volunteers as intermediaries or bridges between scientific experts and the general public has not been clearly examined. Most museums do have significant numbers of volunteers; the NHM can have up to 400 at any one time in the year. Some work behind the scenes with the scientists, others work with the public. People volunteer for a number of reasons (Wilson, 2000), but many wish to develop confidence, capabilities and competence, so that they can move further along in their lives. Silverman (2010) writes about the desire to acquire skills, and how museums can help volunteers gain and improve many abilities by providing unique vocational experiences. Internships, volunteer and employment opportunities in museums help adults develop their competencies, knowledge and abilities. Volunteering can serve as an important step towards employment, while also offering social opportunities and satisfying altruistic desires.

The management of volunteer programmes is seen to be critical. As Wilson (2000) states, people usually do not contribute goods and services to others unless there is some reward or profit involved, for example, recognition of their efforts. They may also enjoy the socialising aspects of volunteering – with staff, other volunteers and the public. The volunteering can be a learning experience, making up for what they see as a deficiency of learning experiences in their lives, or just to give something back to society. With respect to science, and more specifically the natural world of coral reefs, Stepath (2000) discusses the need for members of the community (volunteers) to become aware of the problems being faced. But this author also emphasizes how important it is to move from awareness into participatory action, and if volunteer participation is to be useful and meaningful, it must be well managed. Jordan *et al* (2011) have described how 'citizen science' (i.e. volunteer) programmes vary in their effectiveness, largely dependent on giving consideration to how people learn and their goals, as well as the goals of the scientific endeavour.

In addition to increased knowledge of science, volunteering in a museum setting can improve other competencies. Mixing of volunteers from different backgrounds can enhance their learning. For example, Reser & Bentrupperbäumer (2000) note how useful it can be for natural scientists to work together with social scientists; thus skills relevant for both disciplines can develop. When volunteers spend time speaking and working with experts and other volunteers and explaining objects and phenomena to the general public, they are developing competencies and confidence in many spheres.

Wilson (2000) lists life satisfaction, self-esteem, self-rated health, educational and occupational achievement, and functional ability as just some of the personal positive effects of volunteering. According to Silverman (2010) museums are important for society as a whole by contributing to self identity, by fostering stability and by providing support for change. Thus volunteers in a museum with natural science collections appear to be perfectly placed to serve as intermediaries between scientific experts and the general public.

The new V Factor programme at the NHM has been developed to improve links between scientists and visitors, using proactive volunteers as the vehicle. Following discussions with the Museum staff and observations of volunteer interactions with the public at the Museum of London in March 2009, it was decided to commence on this new scheme at the NHM. Using the large bank of available volunteers together with the expertise of staff in the NHM Organisational Development Department, the volunteers project manager began to develop a learning programme for staff, volunteers and museum visitors. What follows is the process which was used in the development, results of the scheme and an evaluation of its success.

How the V Factor programme was put together
In 2009, the NHM opened the DC2, which is now home to many scientists. Opening up their work to the public is a principal aim of V Factor. Through establishing V Factor we aimed to raise awareness of museum science and the profile of the NHM as a research centre; the NHM is both a national (and international) visitor attraction and a scientific study centre. However, only a small proportion of the collections are on display to the public so the research and curatorial aspects are often not obvious to visitors.

We also intended to set up a programme for all involved. There have been, and continue to be many volunteers working successfully behind the scenes, but in the main they work intimately with scientific staff. The new programme had to instil confidence in the science staff that their work would benefit from the programme. It also had to produce benefits for the participating volunteers and for visitors to the NHM.

Another aim was to increase visitor number and diversity. The Specimen Preparation Area (SPA) within the 'Cocoon' in DC2 was designed so that visitors could see scientists at work. Unfortunately, the area was not being used to maximum effect. The aim was to make the space function for extended periods of time and to create an atmosphere where the public could observe and engage with real science. Visitors range from small children to adult groups, from the UK and abroad, but all can be helped to understand what is going on in the space and what the benefits of the scientific endeavours might be.

We intended to provide engaging, inclusive and fun volunteer opportunities. Most of the opportunities for volunteering at the Museum are very selective. The V factor programme was and is aimed to provide a more inclusive programme and increase the diversity of our volunteers. In this way many members of the public could become more knowledgeable about the Museum's work and, as a result, hopefully become supportive of it. In addition, V factor volunteers could potentially transfer to other work in the Museum.

Finally, we hoped to increase public understanding of the importance of museums, our science, the roles of curators and other employees. V Factor challenges participants to consider the role of museums today. Through the programme we hoped to inspire new people into the heritage sector and into our talent pool for jobs/opportunities.

Principal participants
In addition to the general support from NHM staff and volunteers, there was a special group of participants who focussed on the V factor programme. These included the volunteers project manager (VPM) who initiated and developed the scheme, and provides ongoing management required for the successful continuation of the programme; the scientists directing the research programmes involved in V factor: in the first instance, the 'Throughflow' project involved with fossil corals from Indonesia; researchers working with the 'Throughflow' project to acquire collections from the field and gather new scientific evidence; a member of the NHM Department of Earth Sciences collection team (a 'curator') with the role of supporting the volunteers while still carrying out curatorial duties; volunteer leaders to assist the collections specialist ('curator'), help the other volunteers and engage (inform) the visiting public; volunteers who agree to attend the Museum one day a week for 10 weeks; volunteer evaluators who monitored the project and produced documentation about how it was/is progressing; and visitors who engage with the volunteer leaders and observe the volunteers working together with the curator and volunteer leaders.

Sequence of events
The programme was initiated following consultation with many different experts across the Museum (both volunteers and staff) to make V Factor truly a cross departmental collaboration. Issues such as funding, risk assessments, pest control, recruitment, programme design needed to be resolved. Experts outside the Museum (e.g., Museum of London volunteer leaders) were also consulted and provided invaluable assistance.

The impetus for starting the scheme was the arrival from East Kalimantan (Indonesia) several tonnes of rock containing fossil corals and other marine invertebrates which resulted from large-scale field expeditions; these samples needed to be processed in a short period of time and thus provided the perfect pilot study for the programme. The principal scientist from the 'Throughflow' project asked for assistance and was referred to the volunteers project manager. In addition, there was a strong desire on the part of the NHM to improve the public's knowledge of its research and curation activities and the level of inclusivity within the volunteer programme.

The first group of individuals trained were those intending to become volunteer leaders. Topics included in the training covered a general understanding of the aims of the 'Throughflow' project, coral biology and palaeontology, curation, the history and present organisation of the NHM, integrated pest management, basic visitor operations, health and safety, as well as how best to prepare the specimens for observation. Fieldwork planning was also included as one of the topics, with the aim of providing a feel of fieldwork and highlighting the importance of planning in any field-based science project. Standard teaching methods such as ice breakers/energisers, analysis of known and unknown samples, quizzes, etc, were used in the training. The training covered in detail how to work with the rock samples and hold the specimens, so that the fossil corals could be clearly observed.

Recruitment of subsequent volunteers was through a simple sign up process, an expression of interest form available on the NHM Website or to be picked up on site. Social media and the local authority volunteer centre were also used to advertise for volunteers. Volunteers were informed that they were expected to allocate one day per week for 10 weeks to the project.

The volunteers' practical task was principally to process fossil corals each week through the unpacking, washing, sieving and labelling of Indonesian fossil corals. In addition to these practical skills the programme included activities and discussions each week based on the following topics:-

Week 1: Volunteer induction, setting up the work station, how to process fossil corals, key do's and don'ts, collection care techniques.

Week 2: What is a fossil, how are they formed and where can they be found? Why we collect natural history specimens.

Week 3: Why coral reefs are important. Why we curate collections, why collections are important.

Week 4: Ten top tips for communicating science, the importance of education in museums and informal science communication.

Week 5: A brief history of the NHM, overview of our collections, outline of various roles/sections within the NHM (visitor attraction & scientific research centre).

Week 6: Collecting and processing. The steps from the field to the lab, using 'Throughflow' as a case study. A deeper understanding of 'Throughflow'.

Week 7: Deeper understanding of underwater ecosystems and their reactions to climate change, why projects like 'Throughflow' are important. What risks there are to our collections. Defining IPM, why it is essential to museums, IPM top tips.

Week 8: Object handling and conservation. Dealing with breakages.

Week 9: Key differences between bryozoans and corals, identification key for bryozoans and corals. How to handle specimens safely, what to do in case of breakages, and what exactly is conservation. Scientific nomenclature explained; why species are named this way.

Week 10: How we can measure knowledge growth. 'Mystery' specimens as a practical application of techniques learnt over the previous ten weeks.

At times, these topics formed the basis of chats with the public, and this might encourage repeat visits to the SPA. However, it has to be said that conversations with the public varied greatly. From early in the development of the programme feedback to the volunteers project manager was encouraged and the programme modified accordingly. Being open to change has been one of the strengths of V factor. Throughout the early stages two volunteers with experience in evaluation observed the progress of the scheme and those involved, whether staff, volunteer or visitor, and they subsequently produced a report on their findings.

Pilot project evaluation

A pilot project evaluation was carried out for 10 weeks, at a time when the project was already in place. At that time, the evaluators observed and analysed the working of the programme and its participants. The participants included 5 V factor volunteers (for the purpose of their report they were referred to as VVs), 6 volunteer Leaders (VLs), the curator and 2 Evaluation Volunteers (EVs) headed up by the Volunteers Project Manager (VPM, Ali Thomas), and members of the public. The evaluators understood that the V factor involved work on the 'Throughflow' project, focussing on fossil corals from Indonesia. The aims of the evaluation were to ensure the VVs individual needs were being met; to discover prior knowledge about the role of a museum and distance travelled; to discover if the VVs developed practical skills over each session; to discover if the VVs absorbed the key messages outlined in each session; to find out how beneficial each session was for each VV personally to discover how beneficial interacting with the public has been for the VVs; and to discover any areas/ suggestions for improvement.

The methods used by the evaluators included mind mapping (Mindmapping, 2012) as a method of discovering the distance travelled by volunteers (their learning) over the 10 weeks they spent with V factor. In Week 1 participants we provided with a blank mind map sheet and asked to create their own personal mind map surrounding the question "What is the role of museums?". Each volunteer was then asked to contribute their answers to a master mind map written on a white board (Fig. 3). The responses were then analysed, trying to ascertain prior knowledge and/or preconceptions. This exercise was repeated Week 10 to assess the distance travelled.

Two questionnaires were also used in the evaluation process. A general questionnaire (Appendix 1) was completed every week by the V Factor volunteers to discover if any practical skills and knowledge was gained in that session. The questionnaires were completed online via iPads so that they could be collated easily. In each of the latter weeks a second questionnaire was completed by one of the volunteers interacting with the visiting public. This questionnaire was used to capture the number and quality of the interactions, how beneficial to the

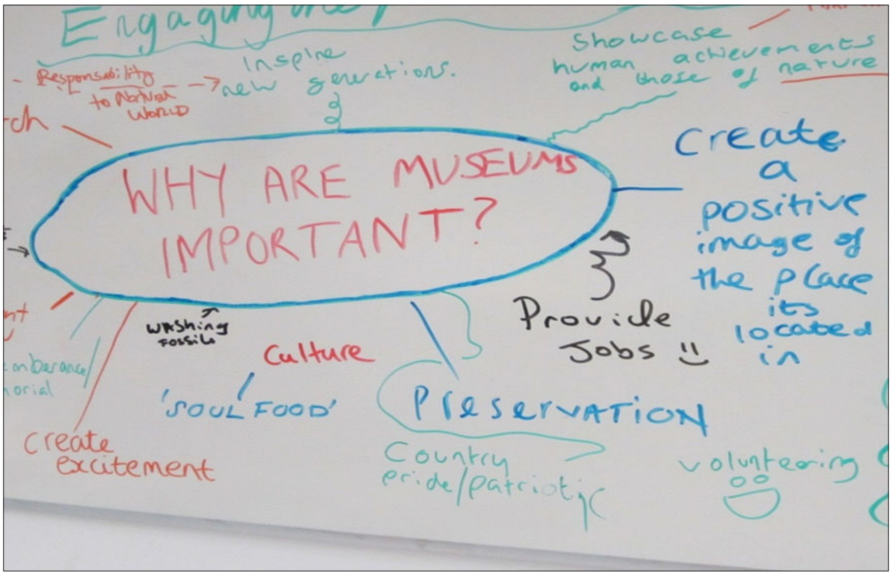


Fig 3: Mind Map completed by one group of V Factor volunteers at the end of their ten week placement. This map was compared with the one produced by the same group at the beginning of their training. The technique was used to evaluate the learning of the volunteers. (Photo: A.T.)

volunteer these interactions were and how they might improve the interactions with the public.

Observations were carried out by the evaluators over three V factor sessions; at the beginning, middle and end of the 10 week programme. The following variables for visitors directly outside the SPA space were recorded: time of observation; activity in the SPA at that time; whether or not a volunteer leader/volunteer was then present outside the SPA; the demographics of each group (gender, age of each visitor); approximate 'stop' times (length of visitor interaction with SPA activity); level of interactions between visitor and volunteer leaders/volunteers; conversations (including quotes); and total number of visitors who stopped or did not stop at the SPA during an observation period.

What has been learned

The evaluation during the pilot stage of V factor by CM and TS has produced many interesting results, which are discussed below. With supervision by the VPM the evaluators (also volunteers) were able to assess aspects of the programme for visitors and volunteers and to produce a meaningful report on their studies.

1.Mind mapping: In Week 1 when asked 'What is the role of Museums?' 26 responses were given by the volunteers. The evaluators identified 17 different responses, the most popular being: 'Preservation and Exhibit/Display'. These were both mentioned by 3 out of the 5 volunteers questioned. In Week 10 when asked the same question, 46 responses were given, including 24 different responses. The most popular responses were: 'Preservation, Exhibit/Display' and 'Allow Access', each of which was mentioned by 4 out of 5 volunteers. There were also changes in the language linked to the maps – responses became more specific by Week 10. Specific roles and tasks also became more frequently listed.

2.Volunteer questionnaires: When the volunteers were asked to agree or disagree with the following statements, there was 100% agreement that V factor had made them more aware of the scientific work of the Museum, Increased their knowledge and understanding of museums, inspired them about science, and led them to recommend V Factor to others. They rated their overall experience in terms of enjoyment as 100%. Ratings concerning the benefits of individual sessions definitely improved over time. In week 1 the highest rating was 9 (out of 10) and the lowest 3; by week 9 the highest was 10 and the lowest 7.

Some quotes from the volunteers include;

"…Taking part in V Factor has been both a fun and educational time."

"V Factor gives me the opportunity to learn new things about science, meet with intelligent young people doing research and talk with visitors from all over the world."

When the volunteers were asked about their interactions with the public, a selection of the responses were:

"I found it fun and very beneficial, I learnt much myself, as well as teaching others."

"It was good, quite fun + interesting to get response from very different kinds of people."

"Very scary at first!! But found it enjoyable after my 3rd interaction. Helped build up confidence + gain better understanding of the project."

3.Visitor observations: Over 11 V Factor sessions the evaluators observed 869 visitors passing by the SPA. Of these, 73% took some interest in V Factor, 60% stopped outside the SPA for more than 10 seconds, and 13% interacted with one of

Volunteer Leaders. As a comparison, it was observed that on a non V-Factor day, when a scientist worked in the SPA in view of the public, 57% of visitors did not stop as they walked past.

Evaluations from the first session saw 123 people stopping in 2.5h to look at the work in the SPA and/ or to ask the volunteers questions relating to 'Throughflow' and V Factor. Many interactions lasted longer than three minutes. Evaluations from the sixth session saw 215 people stopping in 1 ¾ hours, with many interactions lasting for two minutes. On average VV's interacted with 12 visitors whist outside of SPA. When volunteers were absent from outside the SPA the stopping time decreased to less than one minute.

Some pertinent quotes from the visitors included:

> *"This information is hugely important! Thank you V Factor."*
>
> *"Really interesting stuff, I had no idea that corals were in such danger from climate change."*
>
> *"Fantastic information and research that the collaboration of teams are working on.Very informative and professional and a good insight into the inner workings of a scientific project."*
>
> *"What a wonderful experience, seeing scientists and volunteers at work it's really a privilege. Thank you!"* –Visitor & Director of Education from the KwaZulu-Natal Museum in South Africa.

At the end of their paper the evaluators included some limitations, failures and recommendations associated with the evaluation process. For example, the time allotted to the evaluation process was limited; to ensure any progress through evaluation, this should be an ongoing procedure. However, overall the evaluation has informed those involved in the project and also provided support for these people when seeking to extend the V Factor programme in the Museum.

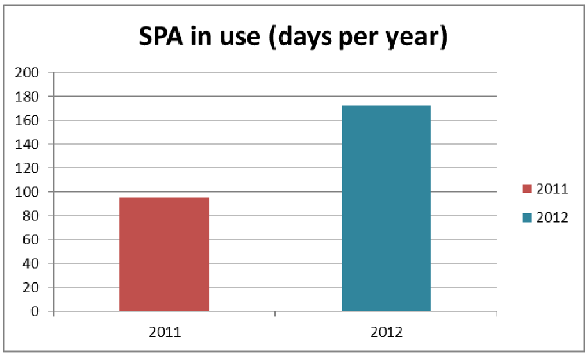
Links with other work

The UK government has great interest in how museums can be used to support lifelong learning (Hooper-Greenhill & Dodd, 2002). As the authors note, although it may be difficult to assess statistically any effects, there are real social impacts that museums can achieve, for visitors and for staff. For visitors but more especially for volunteers, there are opportunities to build competence and capabilities (Silverman, 2010). Grenier (2010) describes how museums can be the focus of conversations, discussions, debates and social interactions, all aiding lifelong learning. At the end of their report, Hooper-Greenhill & Dodd (2002) recommend the development of programmes with realistic, focused and strategic objectives and clear evaluations. It is hoped that the V factor scheme has begun to address these goals by developing clear aims and evaluating what has been accomplished.

Museums have long been exhibiting at least part of their collections to the public; one of their major goals (Rader & Cain, 2008; McPherson, 2006). However, as times have changed, so museums have to adapt to new ways of teaching and learning (Janes, 2009). Although visitor numbers in the NHM have always been high, there continues to be the question about how best to communicate the role of the Museum to the public and its supporters; which may be the case for any museum. Whilst in the past simple observation of life's wonders was considered to be acceptable, in the modern world with all its alternatives for digital observation and learning, museums have to develop new schemes for teaching and learning. With respect to science, observation of working scientists is being used in many places, including the NHM (Meyer, 2011). This allows visitors not only to be aware of what scientists know but also how they come to know. Even scientific field work can be made clearer through seeing collected field samples being processed; it bridges the gap between the known and unknown. Other techniques often being used are personal, sometimes one-to-one interactions between museum staff and visitors (Lehr *et al*, 2007; Carney *et al*, 2009; Meyer, 2011). V Factor is one way that links between museum work and visitors can be established.

Volunteers can provide much assistance in museums (Wilson, 2000). These individuals are generally well-educated and interested in learning, perhaps more so than the general visitor to a museum. Providing learning experiences for this group, whilst still benefiting from their assistance, is one of the goals of volunteer management. Meeting with professional staff, being informed about the rationale behind their work and being asked about their views, all in informal settings, are ways of improving the volunteer experience.

Volunteers can be very useful in respect to observations of scientific work and in one-to-one interactions. For example, scientists expected to work in public view and answer questions may feel they are being distracted from their primary tasks, as noted in the review by Meyer (2011) on the open laboratory at the Deutsches Museum in Munich. Volunteers may have more time and patience to do more routine tasks and to speak with the public. In addition, volunteers may be more approachable to speak with the general visitor on a one-to-one basis. After all, they are not experts in the research programme and not so embedded in academic/ scientific nomenclature. In V Factor, the 'Throughflow' project is communicated to the public via volunteers. Thus the V factor scheme at the NHM addresses both of these points – visitors observe volunteers carrying out scientific work and volunteers speak with the visitors. Through the project, the museum is able to improve its role in education.



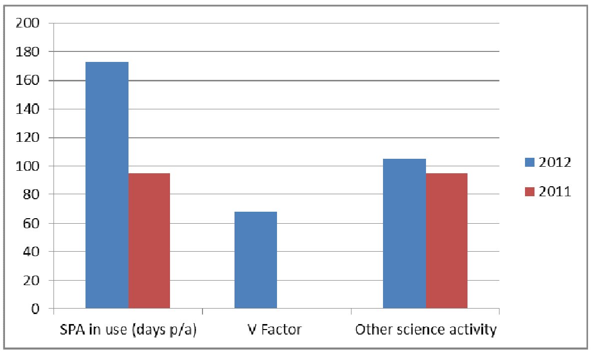


Fig. 4. Bar charts showing use of SPA space.
The top graph shows the doubling in use of the space due principally to the V factor programme.
The graph below demonstrates that other science activities also increased in the SPA area during the period when V factor was operating.

Future plans and recommendations for improvements

The programme has represented and showcased the scientific research presently being carried out by the NHM. Once the 'Throughflow' project is completed there will be another large scale project using the same formula and framework, although the primary focus will be different. The SPA may also become useful over more days each week, including the weekend when most visitors attend the Museum. The success of this pilot scheme has demonstrated the sustainability and the need for the V project, as reflected by changes in use of the space (Fig. 4).

There was a major investment of time required to set up the programme, principally by the Volunteers Project Manager and the Project Leaders. However, now that a framework is in place, it is expected that the management need not be so time-intensive. There will always need to be staff input into the V factor, as projects and teams change and as the scheme progresses. New annual projects will follow the same format but the nature of the project and work will change. Early signs are showing that there is a large pay off for invested time versus outputs as demonstrated by the evaluation above, and future ongoing evaluation will demonstrate whether or not this continues..

At each turnover of projects there will be new scientists and collections staff involved. They will always require support to ensure they have the training and confidence involved in working with the volunteers and visitors. One of the important factors is their ability to run sessions and manage volunteers. Whilst many staff have experience with public outreach, some scientists have expressed the opinion that teaching went far beyond their delivery of scientific content and can encourage their professional development.

More emphasis in the future will be put on teaching the Volunteer Leaders how to deal with the public and a variety of situations - they need to have both confidence and support in dealing with a variety of situations outside of their immediate roles. This can be anything as simple as locating the nearest toilets through to handling difficult individuals or groups.

It is hoped that the programme will continue to improve. We have been testing the volunteers, using informal quizzes, to determine how well they have retained new information. They have also been involved in evaluating and reacting to the present scheme, so that it can develop. Most importantly, all the volunteers involved in V factor remain open to suggestions.

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Appendix 1

Assessment form given to volunteers to complete following each session. This was used for the evaluation process. (Produced by CM & TS)

V FACTOR
FROM VISITOR TO VOLUNTEER

Our aim is to be leaders in science education. V Factor aims to provide you with experience of good practice and knowledge of collections care.

To help us achieve this aim, we need to know what you thought about today's session.

1. **Please tell us about all the practical skills that you developed in this session? (i.e. is there something you can do now that you couldn't do before?)**

2. **Please tell us about any new knowledge have you gained from this session? i.e. is there something that you know now that you didn't know before?)**

On a scale of 1 to 10 (1 being not at all and 10 being extremely) please rate how beneficial this session has been to you personally.

1 2 3 4 5 6 7 8 9 10

3. **Please let us know how you found the experience (e.g. what went well, what could be improved?)**

Infrared thermal imaging as a collections management tool

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Abstract

As natural history collections often contain specimens that require quite different environmental conditions from one another it makes sense to try to understand the sometimes subtle differences in conditions provided within the storage and display areas concerned so that the specimens can be arranged accordingly to better suit their particular needs. Modern digital infrared thermal imaging technology is now highly portable and provides exactly the sort of detailed data required in a way that other environmental data logging equipment cannot and presents it in a highly visual format that is generally intuitively understood and easily analysed with proprietary software. However, there are many factors influencing the accuracy and interpretation of the data so training is required. Fortunately, the cost of equipment is falling. Uptake of the technology for collections management purposes in museums is in its infancy due to a lack of awareness of how the technology can be applied.

Keywords: Infrared Thermal Imaging; Temperature; Humidity; Store Room.

The changing climate within museums

It is not just the global climate that is changing. Within the confines of museum storage and display areas, environments might soon become more varied than recently. For many years British Standard 5454 'Recommendations for the storage and exhibition of archival documents' dictated that environmental conditions for archive and museum collections should be 50% relative humidity (RH) +/- 2%, and 19ºC temperature +/- 1ºC. This very narrow target of ideal environmental conditions was withdrawn in March 2012 and replaced with the National Archives' 'Guide for the storage and exhibition of archival materials' and 'Specification for managing environmental conditions for cultural collections' (National Archives, 2012a; 2012b), published by the British Standards Institute. These two documents reflect the changes in policy called for by the National Museum Directors Conference (NMBC) in 2009 after cultural heritage institutions were asked to reduce their reliance on fossil fuels while meeting their responsibility to preserve collections. The NMDC adjusted their own environmental guidelines to a much broader range of 40-60% RH and 16-25˚C in an attempt to reduce energy consumption by museums and related institu-

The previous very narrow range of environmental parameters recommended by the MLA was a target that was increasingly costly to attempt to meet in typically old, leaky, energy-hungry museum buildings that are largely 'horribly inefficient and unsustainable' (Staniforth, 2011) and often beset with various degrees of listed status preventing useful remedial action. Therefore relaxing the target to the new recommended range of environmental conditions will in theory save both money and greenhouse gas emissions. But what about the collections? The new approach places the actual environmental needs of particular types of objects at the center, rather than setting universal ranges applicable to all. It makes sense therefore not only to understand as fully as possible the different environmental requirements of specific types of object within a collection, but also to gain as good an understanding of the storage or display area as possible, to make the best use of any subtle differences between and within the areas in question – especially if the environmental controls in the institution are going to be relaxed and a wider range of conditions are likely to be experienced.

Larkin, N. R. 2013. Infrared thermal imaging as a collections management tool.
Journal of Natural Science Collections. **1.** pp.59-65.

The different environmental requirements of natural history sub-collections
Specialist curators in larger museums will know exactly the environmental requirements of the collections within their care, and hopefully will have storage areas providing the right conditions suitable for their specific collections. However, most small to medium sized museums are likely to have a general natural history collection containing a wide variety of material, probably all located in the same store. For historical reasons the specimens may be packed in a particular order that does not necessarily best reflect the environmental needs of the objects.

Generally, areas in which natural history collections are stored should be kept as cool as practically and economically possible. A cooler environment benefits specimens not just by reducing pest activity (Carter and Walker, 1998; Pinniger and Meyer, 2001) but the lower the temperature the lower the rate of all damaging biological activity and chemical reactions generally and for this reason low temperatures can help to preserve DNA in specimens themselves. Advice varies slightly but stores containing a wide variety of natural history material should be maintained at about 13ºC to 15ºC (Carter and Walker, 1998) even though this is lower than would generally be comfortable for people working in the collections (for which 16ºC to 18ºC is recommended. Active cooling is expensive however, so the practical solution is to provide as low a temperature as the institution can afford whilst not making it impossible for workers to spend some time in the collection area. The caveat is that relative humidity should not exceed 60% nor fall below 45%. Rapid and extreme fluctuations (even within the parameters above) should be avoided as this can be more damaging to specimens than generally being near one of the limits with gentle changes (Carter and Walker, 1998).

At high humidities mould growth can occur and insect pests become more common, as with higher temperatures. Higher temperatures can also cause consolidants and adhesives to slowly weaken and fail (Fitzgerald, 1995). Natural history specimens preserved in fluid particularly benefit from cool conditions of about 13ºC to 15ºC (Carter and Walker, 1998) as it reduces evaporation and the rate at which the specimens deteriorate. It is recommended that botanical specimens be kept at between 45% and 55%RH and 18ºC to 22 ºC (ICON, 2013a), and zoological specimens between 45% and 55% and temperature levels as stable as possible but between 10ºC and 22ºC (ICON, 2013b). It is generally agreed that geological and palaeontological material should be stored with minimal daily fluctuations at around 15ºC to 25ºC but more importantly between 45% to 50% RH. RH of 55% would be the very upper limit because at 60% RH pyrite oxidation (pyrite 'decay') can be triggered in some susceptible material (Buttler, 1994; Newman, 1998; Larkin, 2011) so a much lower humidity, around 40% RH, would be better for these specimens. However, if sub-fossil material is also present in the collection, especially mammoth ivory and teeth, then RH as low as this would probably cause it to crack, along with some clays or mudstones of various ages (possibly containing fossil specimens) that may delaminate. This is an example of why it is important to understand which specimens in a collection and even in a sub-collection may require quite different conditions so their needs can be accommodated suitably.

Microclimates can be created for some specimens with lidded sealable containers employing silica gel or Artsorb but this may not be practical or economically feasible, depending on the material. Storage environments can be controlled to an extent by the intelligent use of dehumidifiers and radiators, preferably controlled by humidistats (particularly in winter) but in a large store room they may struggle to make more than a local difference especially if there is a large rate of air exchange. In smaller rooms they affect all the specimens indiscriminately.

The subtly different environments within a room
It is important not only to understand what parts of a collection require a higher or lower humidity or temperature but also to know which part of your storage area best provides the optimum conditions for the specimen or sub-collection as not only will conditions vary from store to store but even within a store. There will inevitably be some stratification, especially in higher-ceilinged rooms with no active air circulation and more dramatically so if heated in winter. The surfaces of external walls will probably be at a slightly different temperature to those of internal walls. There will be drafts around doors and window frames and unless large glass window panes are very well double or triple glazed they will conduct heat effectively to the outside, and act as a source of 'coolth' in a room. Poorly lagged or unlagged hot water pipes will create localised warm spots diurnally, and even plant running servers, lifts, heating or ventilation systems can create permanent warm spots on the walls of adjoining rooms.

If these sorts of environmental peculiarities within a room are quantified and understood, the variations can be exploited by rearranging specific parts of a collection, taking into account the needs of the material. However, whilst most museums now record the environment of at least some of their stores some of the time, even the best live telemetric environmental data logging system only produce data relating to a very small area around the sensors in what is a probably a large and varied three dimensional space. Until recently, it would have been extremely time consuming and costly to investigate and understand subtle differences, requiring multiple sets of environmental data loggers and associated number crunching and graph wrangling to produce a sketchy picture of the temperature and RH gradients across a room. Therefore it is generally underappreciated just how much environmental conditions can vary within a store room or gallery.

However, recent improvements in infrared thermal imaging technology and a consequent drop in the price of the equipment has the potential to revolutionise the way we assess and manage our museum environments.

Infrared thermal imaging: how it works and how it is normally applied

Everything with a temperature above absolute zero emits heat. Generally, the higher an object's temperature, the greater the infrared radiation it emits. However, the exact amount of infrared radiation emitted depends on two factors: the temperature of the object's surface, and the 'emissivity' of the material, relating to the material's innate ability to emit heat. The temperature of the object's surface is affected by the energy conducting through it, the exact structure of the object, the energy being radiated on to it and even the water content of the object. Therefore the pattern of heat radiating from an object will reflect variations in its internal state. For instance if part of a brick wall is damp, this will affect its emissivity and it will show up in an infrared image**.**

Fig. 1. An example of an infrared thermal imaging camera: The author's 'FLIR E40bx' in use. Image resolution 160 × 120 pixels (providing 19,200 data points); digital infrared still images and video; range minus 20°C to plus 120 ºC; thermal sensitivity <0.045 °C; built-in 'normal' digital camera (3.1 megapixels); one LED spotlight; and wireless/Bluetooth technology.

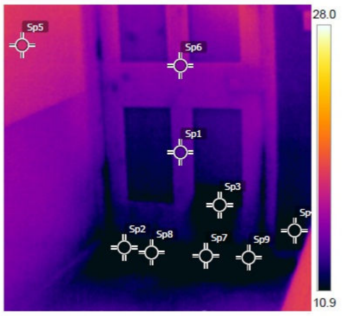
Emitted infrared radiation lies between the visible and microwave portions of the electromagnetic spectrum. A thermal imaging camera (Fig. 1) scans this part of the spectrum in the same way that a digital camera scans the visible light portion, and produces an image on the LCD screen in much the same way as a normal digital camera would (in fact most models will also take a normal digital photo at the same time as the infrared image is taken, as a record of what the infrared image is showing). The image or video is captured and stored on a card in the camera simply by pressing a button, as on a normal camera. However, the resulting radiometric image allows detailed temperature values to be analysed easily with appropriate software as every single pixel is in fact a temperature measurement. These data points can be highlighted on the resulting image (see Figs. 2 to 8). As well as individual pixels, areas of various shapes can be selected and the data within the area can be analysed automatically to give the minimum, maximum and average values. This allows for fair and accurate comparisons between portions of images. An infrared camera with a resolution of 60 x 60 pixels provides the equivalent data of 3,600 individual digital thermometers but visualised perfectly and all at the same time. An infrared camera with an image resolution of 640 x 480 pixels will give 307,200 temperature data points. Depending on the exact model used (see Fig. 1 for an example), the temperature range measureable should be between about minus 20ºC to plus 120ºC and the accuracy should be about 0.1ºC to 0.045ºC.

Heat loss by radiation can account for up to 60% of a normal building's total energy consumption (Hugo, 2001). Infrared thermal imaging usefully reveals conductive heat losses resulting from such issues as missing insulation or improperly installed insulation and excessive thermal bridging (Fig. 2a). It can also show the cold air being brought into a building by drafts (Fig. 2b). In addition to energy loss, air leakage can also cause condensation to form within and on walls, which is also visualised by infrared imaging. Other causes of hidden moisture that infrared can reveal include leaking roofs, plumbing leaks and water intrusion in basements.

Usefully, infrared images also visualise the wasted heat energy from appliances consuming electricity whilst being left on standby unnecessarily. It can also reveal any thermal stratification issues. This is the layering of differing air temperatures from the floor to ceiling (Fig. 3). This results from the natural process of heat rising in an internal space but it can be an issue in that it creates quite different microclimates of temperature and therefore RH throughout the air column. In regards to energy conservation it has been suggested that stratification is the single biggest waste of energy in buildings today. In buildings with stratification, temperature differentials of up to 10ºC can be found over a height of 10m on average. In extreme cases temperature differentials of 10ºC have been found over a height of 1m. Thermal de-stratification is the process of mixing these internal air temperatures to effectively eliminate the stratified layers and achieve temperature equalisation throughout the space, saving energy on heating because previously the heat was accumulating where it was least needed. In a de-stratified building temperature differentials can be reduced to 1ºC to 2ºC or less from floor to ceiling. In commercial or industrial buildings with warm air heaters and high ceilings, de-stratification fans can reduce energy use by 20% by blowing warm air back down to ground level where it is needed.

Measurements	°C
Sp1	5.2
Sp2	13.8
Sp3	14.4
Sp4	14.3
Sp5	3.9
Sp6	4.4
Sp7	4.2

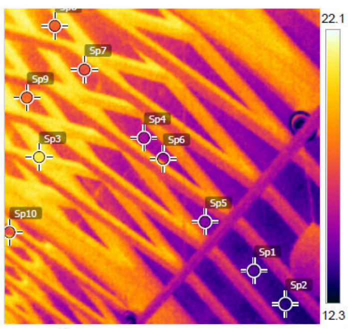
a



Measurements	°C
Sp9	6.1
Sp5	17.5
Sp7	5.7
Sp1	13.3
Sp4	10.8
Sp3	7.6
Sp2	6.4
Sp8	6.1
Sp6	14.9

b

Fig. 2. (a) This infrared image taken outside early in the morning is of museum offices and store rooms losing heat: the glowing areas of this external wall are where radiators are sited on the other side of the wall and are conducting heat through the wall to the extent that these areas on the outside of the external wall are consistently about 9ºC or 10ºC warmer than the surrounding wall. This image shows how the temperature data related to individual pixels can easily be shown in an image.
(b) The gaps through which cold drafts (between 7ºC and 10ºC cooler than the surrounding air) are blowing under this museum door are big enough to allow access to large pests including rodents.



Measurements	°C
Sp6	16.1
Sp8	17.3
Sp3	19.1
Sp7	17.2
Sp1	15.4
Sp4	16.3
Sp2	14.6
Sp5	15.8
Sp9	17.4
Sp10	17.0

Fig. 3. This high-ceilinged museum display area has stratification issues. Shown here is the top quarter of the air column, within the raftered ceiling, where there is 2.5ºC of stratification. The difference between the very bottom of the air column at ground level to the top was 7.5ºC.

Infrared thermal imaging and collections management

Obviously infrared thermal imaging can facilitate understanding how energy can be conserved in museums by highlighting insulation issues (Fig 2), discovering equipment left on standby and revealing inefficient equipment (Fig. 4), but it is also a very useful tool throughout the year for helping with collections management issues. Although infrared thermal imaging does not measure air temperature directly but the temperature being radiated from surfaces this is still very useful. Thermal imaging can locate and visualise drafts coming in from outside through cracks and holes that insects can probably exploit to gain access (Fig. 2) so a draft proofing plan based on infrared imaging would help to reduce pests getting access into a museum building. Where equipment such as servers, lifts or heating, ventilation and air conditioning systems create so much warmth in an adjoining room there can be a permanent warm spot on the other side of a connecting wall (Fig.5) which may be a museum store. This might be an ideal location for a storage cabinet of material requiring slightly lower RH.

In displays, the temperature of the lights can be quantified, useful not just for deciding how inefficient the bulbs may be but for making judgements about how appropriate they are for the material within the display case that may be exposed to undesirably high temperatures.

Conditions within in a store or gallery will probably vary the most in the winter due to some external walls being colder combined with the presence of unlagged or poorly lagged hot water heating pipes. These can be obvious but sometimes you simply will not know where the hot water pipes run as they may lie unnoticed within a wall, ceiling or floor. For example, during a recent energy conservation survey unlagged or poorly lagged hot water heating pipes were discovered running under the length of the floor of an art store including right under a large permanent area of clutter (Fig. 6). As the temperature of the carpet under this clutter was at 23˚C this was an area ripe for a pest infestation. No-one knew about the warm pipes so this area would not have been checked. A simple remedy to the situation was to move the clutter elsewhere, allowing a more even heating of the room and making the warm spot a lot less attractive to pests.

Similarly, curators were horrified to discover during a recent thermal imaging demonstration that warm pipes appeared to run behind sections of the bookshelves in their rare books and manuscripts room (Fig. 7). Parts of the wall behind the books were over 14ºC warmer than equivalent parts of the walls in stacks nearby. The spines of the books facing in to the room were over 2ºC warmer than the spines of other books nearby. Some books were removed from the warmer shelves and infrared imaged taken of their spines which faced in to the room and then of the opposite edge of the book that faced the warm wall. There was an average of 2ºC difference

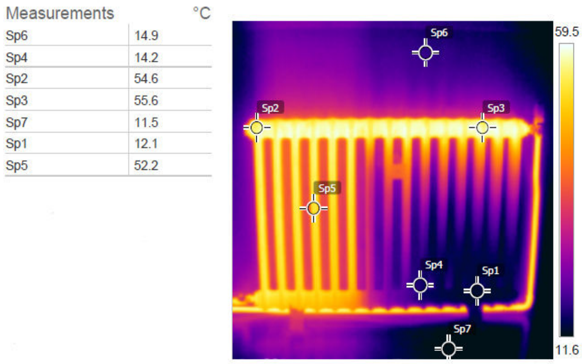


Fig. 4. This radiator located in a museum store room is clearly not functioning properly and may need bleeding.

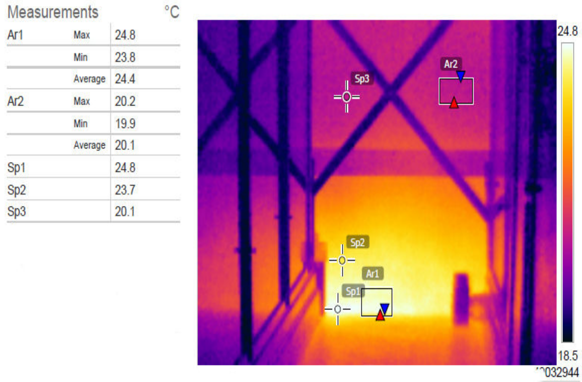


Fig. 5. This warm spot low down on a wall was found in a part of a store containing very valuable bird remains. No-one had any idea that this part of the wall was permanently warmer than the surrounding walls (by over 4ºC in this image). There is HVAC machinery in the room next door, creating this warmth. This image shows how areas can be selected (e.g. Ar1 and Ar2) and the maximum, minimum and average temperature within the area drawn is automatically calculated and easily be compared to other areas. As many of these boxes (or circles) can be drawn as needed.

Fig. 6. Unlagged or poorly lagged hot water heating pipes were discovered running under the entire length of the floor of this art store during a recent energy conservation survey. They ran right under a large permanent area of clutter where the temperature of the carpet was at 23˚C, making this area under the boxes and tables ripe for a pest infestation.

between the two edges of the books, which could result in a theoretical difference of about 20% relative humidity across the object - and the rear of these books were over four degrees warmer than the spines of the books on the cooler shelves nearby. If this had been discovered in a natural history storeroom the curator might consider storing certain parts of the collection here (such as geological material prone to pyrite decay) unless the temperatures involved were considered too high or were found to fluctuate too much. The area could be insulated to reduce the localised warming.

Where the temperature differences within a storeroom are less extreme, specimens requiring a lower RH might be best stored against an internal wall on the higher shelves where the air is generally warmer. Sub-fossil material (especially tusks, ivory and mammoth teeth etc), fluid-preserved specimens and osteological material could be stored in areas that are stable but cooler on average with a higher RH, such as on lower shelves against an external wall away from radiators and unlagged hot water pipes. Other material – the bulk of the collection - can be stored in the middle ground.

In some rooms, many different interesting things are seen to be happening. In a particular image of an art gallery stratification can be observed, very cool air is issuing through HVAC vents (even though it was winter) and there is localised warming high on the wall resulting from an inefficient spotlight (Fig. 8). There is a difference of up to 8ºC between various parts of this gallery wall and this is likely to have an effect on RH levels as well. Traditional environmental monitoring would not reveal a fraction of these subtle differences.

Infrared thermal imaging cameras are demonstrably useful for gaining a much better understanding of museum environments and they have dropped in price over the last few years. However, the cameras are still very expensive in the context of museum budgets. Also, they do have to be operated by someone trained in their use or the wrong data can be collected and the images can be misinterpreted. For instance, undertaking infrared surveys outside is best done at night long after the sun has gone down, or very first thing in the morning before dawn, as direct sunlight interferes with what is being surveyed. Materials warmed by the sun can stay warm for many hours. This can be true for south-facing walls and roofs/ceiling even inside a

Measurements		°C
Ar1	Max	22.3
	Min	20.5
	Average	20.9
Ar2	Max	19.2
	Min	17.6
	Average	18.6
Sp1		17.0
Sp2		31.2

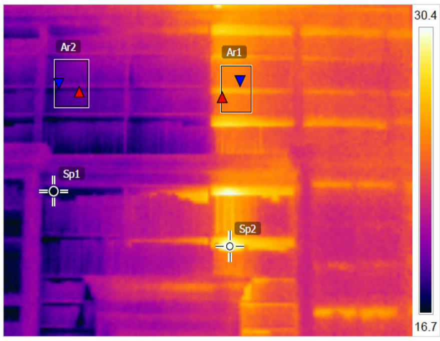


Fig.7. The rare books room where warm pipes behind one section of the wall led to some objects being exposed to environments over 14°C warmer than others, with RH also no doubt varying as much as a consequence.

Measurements		°C
Ar1	Max	19.2
	Min	18.9
	Average	19.1
Ar2	Max	19.0
	Min	15.9
	Average	17.1
Sp1		13.0
Sp2		20.9
Sp3		18.5

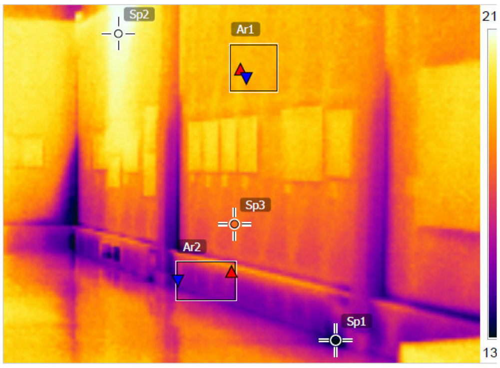


Fig.8. This art gallery was recently checked as part of a museum's energy conservation survey. 'Sp2' is a warm spot on the wall created by a nearby spotlight and it is about 2°C warmer than the average for area 'Ar1' which is part of the wall nearby that is only slightly lower in height. Cool air is issuing from the vents at the bottom of the wall, adding to the stratification and uneven temperatures and RH. Note that the very shiny hardwood floor is reflecting the infrared in the same way it reflects visible light.

building. Both the wind and the rain cool down the surfaces of materials, subsequently lowering the temperature differences between hot and cold areas. Thermal imaging is at its best when there is a good temperature gradient (at least 10˚C) between the inside of a building and the outside. In the UK this mostly occurs between November to about March or April.

At all times the camera should be set for the right emissivity of the materials being surveyed. For instance concrete has a different emissivity value from brick or wood etc. The camera needs to be as parallel as possible to the surface being assessed (which can make surveying roofs a bit difficult). The images have to be interpreted carefully. Some materials reflect infrared radiation much like a mirror or smooth metal surfaces can reflects visible light (Fig. 8); sometimes damp areas can be interpreted as cold areas and vice versa; warm spots might be 'real' situations or might be a temporary artefact of warming by sunlight; on walls, changes in the image might simply be a result of changes in materials or even just the paint; heating systems create temperature differences that can cause misleading thermal patterns; and cool air flows from ventilators or air conditioning systems can cool down the surfaces of materials while the object underneath the surface is actually warmer.

Infrared thermal imaging: the cost

As energy costs have risen steeply at a time when portable infrared technology has greatly improved, the ability of these cameras to reveal where energy is being wasted – and importantly where it can be conserved - has made them very attractive and their various applications in the building, engineering and energy industries has helped to bring down their cost.

Bottom of the range infrared cameras now start at about £1,700, but in terms of image resolution you do not get much for your money (usually about 60 x 60 pixels for this price). A decent entry-level infrared camera useful for assessing museum environments currently costs in the region of £3,600 and would provide an image resolution of 160 × 120 pixels or 19,200 data points, as used for all the images in this paper. Although the point of purchasing such equipment would be to save a museum money by reducing energy wastage and to improve collection storage conditions this is still likely to be too expensive for most small to medium museums. Although larger museums or museum services might be able to justify it, there is also the high cost of training to consider. A more affordable option would be to employ for a day or two a trained specialist with their own equipment and an understanding of museum collections who would assess the rooms or buildings in question and provide a detailed report.

Conclusions

For many years infrared thermal imaging has been used to show where energy is being wasted in buildings, enabling effective energy conservation plans to be devised and savings to be made in carbon dioxide as well as in financial terms. It is now clear that infrared thermal imaging can also be applied effectively in museums as a collections management tool to enable a much more detailed understanding of the subtle, and sometimes not so subtle, environmental differences within a storage or display area. This can help curators to ensure that sensitive specimens are placed in the most appropriate environment available.

Infrared thermal imaging has not been used in museums for collections management purposes simply due to a lack of awareness of the relevance of the technology rather than the cost, which is falling. A large budget for hardware and training is not even necessary as only a relatively small sum would be required to hire an experienced museum professional to get the best possible use out of storage and display areas for the long-term benefit of specimens.

Editor's note: Due to the heavy reliance of the colour images for this article, a free colour PDF is available on request. Please contact the Editor or author of this article for a full colour PDF.

Acknowledgements

Thanks are due to: the various curators and other museum staff who have invited me to undertake energy conservation surveys or demonstrations of thermal imaging in their institutions, from which some of the images above are taken; to an anonymous reviewer whose help improved this paper; and to my family for their support and understanding whilst I was undertaking an MSc degree in 'Architecture: Advanced Environmental and Energy Studies' at the University of East London and the Centre for Alternative Technology, when some of this research was carried out.

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NatSCA AGM Minutes
15.55 to 16.40, Thursday 28th February, 2013

Yorkshire Museum, Museum Gardens, York, YO1 7FR.

Committee members present: Clare Brown (chair), Tony Irwin, Miranda Lowe, Nicola Newton, Jan Freedman, Paolo Viscardi, Maggie Reilly, Kate Andrew, David Notton, Jack Ashby, Roberto Portela Miguez, David Gelsthorpe, Holly Morganroth, Vicky Purewal, Donna Young

1. **Apologies for absence** were received from Paul Brown, Simon Moore, Claire Mellish, Beulah Garner

2. **Minutes of AGM Horniman, London, 29th March, 2012**. These were signed as the correct record by Chair

3. **Matters arising from Horniman, London AGM minutes.** None

4. **Update on HLF 'Skills for the Future' project:** David Gelsthorpe.

5.

Another successful year was reported and everyone involved was thanked.

Heritage Lottery Fund 'Skills for the Future' Natural History, Social History & Applied Art Training Opportunities

The partnership offers a twelve month training programme commencing in May 2013 until April 2014. Applications are invited for the following opportunities:

- One Natural History traineeship based at The Manchester Museum The University of Manchester
- One Natural History traineeship based at Leeds Museum Discovery Centre
- One Applied Art traineeship based at Birmingham Museum and Art Gallery
- One Social History traineeship based at The Herbert Art Gallery & Museum, Coventry

Full information and application forms can be found within the job packs

Closing date is: **14 March 2013 at 10.00 AM** Proposed date for interviews: W/c **8 April 2013** If you have any enquiries about these traineeship opportunities, please contact Paulette Francis-Green Project Manager by email: projmangctrainee@aol.co.uk

5. Chairman's Report: Clare Brown

It has been yet another trying year for natural history collections with swingeing cuts biting deep across the country. Posts are being frozen, local authorities are thinking of removing arts funding and that infamous word, "restructure", is causing worry and resulting in cuts in more than one institution.

Obviously, NatSCA is doing what it can in this difficult time. Earlier this year several committee members, with Trevor James of the NBN, met with Director of Museums and Renaissance at ACE, Hedley Swain. They discussed ACE's approach to natural science collections and how they might fit into the 'Arts' of the 'Arts Council England'. I understand it was a very positive meeting and we are looking forward to working with ACE further. As part of this push for a higher profile for natural science collections, NatSCA issued a Natural Science Advocacy Document, please have a look at it on the web. NatSCA also ran the 'Elephant in the Room' session at last year's MA conference in Edinburgh and we have proposed a further session at this year's MA conference. NatSCA are also searching for a high-profile patron who would be able to spread our message to wider audiences. We would like to do more; if anyone in the membership would like to talk to the committee about how we can improve the lot of natural science collections in this country then we are all ears. I would, of course, encourage you all to be your collection's loudest advocates and to give your management no excuse for natural science cuts.

NatSCA's bread and butter activities continue: we ran two successful workshops this year – 'Caring for Botanical Collections' in in Liverpool and Cardiff and 'Natural Science Collections and the Law' in Manchester. We are hoping to run an entomology day in London later this year and we are considering a fieldtrip to Berlin in 2014.

NatSCA News is changing with the introduction of the 'Journal of Natural Science Collections' and the long-awaited ICON leaflets are now in production. We are also making some headway with our new website - we are hoping to use it in an engaging way and make it a much more useful resource for the membership.

NatSCA continues to fund various projects. The curatorial trainee project is moving into its third year with two new biologists due to be employed in Manchester and Leeds on year-long contracts in May. We have awarded this year's Bill Pettit Memorial Award (up to £2,000 for projects every year) to The Margaret Gatty Algal Herbarium at St. Andrews University. NatSCA also continues to support its membership through bursaries.

I would like to thank Tony Irwin for all his hard work as Treasurer for NatSCA. I think everyone is very pleased that he's agreed to remain on the committee.

Lastly, a date for your diary is the 2014 NatSCA-SPNHC conference in Cardiff. The title is 'Historic collections – a resource for the future' and it will be in June 2014. We will not hold a separate NatSCA conference that year.

6. Secretary's Report: Paul Brown

	Manchester Museum 02.07.2012	**Liverpool Museums 28.09.2012**	**NHM, London 11.01.2013**	**York 27.02.2013**
Kate Andrew	✔	✔	⊘	✔
Jack Ashby	⊘	⊘	✔	✔
Clare Brown	✔	✔	✔	✔
Paul Brown	✔	✔	✔	⊘
Jan Freedman	⊘	⊘	⊘	✔
Beulah Garner	✔		✔	⊘
David Gelsthorpe	✔	✔	⊘	⊘
Tony Irwin	⊘	⊘	⊘	✔
Miranda Lowe	✔	⊘	✔	✔
Claire Mellish	⊘	⊘	✔	⊘
Simon Moore	⊘	⊘	✔	⊘
Holly Morgenroth	⊘	⊘	✔	✔
Nicola Newton	⊘	⊘	⊘	✔
David Notton	⊘	⊘	✔	✔
Roberto Portela Miguez	⊘	⊘	✔	✔
Vicky Purewal	✔	⊘	✔	✔
Maggie Reilly	✔	✔	✔	✔
Angela Smith	⊘	⊘	✔	⊘
Paolo Viscardi	✔	✔	✔	✔
Donna Young	✔	✔	✔	✔

7. Treasurer's Report: Tony Irwin
The Treasurer's Report is in the form of the Accounts sheet and attached notes.

Attention is drawn to the increase in subscription income this year, due mainly to the efforts of our Membership Secretary chasing up late payments, etc. Although subscriptions don't cover all our operational costs, they are vital to the well-being of the Association. Fortunately most of our members recognise that the annual subscription is excellent value for money, and we do appreciate the support we get from all our members.

Meeting income was up on the previous year, not least of all because of the good attendance at the conference in London, and the botany workshops in Cardiff and Liverpool.

Meeting expenditure was down on the previous year and again, I want to express our gratitude to the speakers, organisers and host venues for being so generous with their time and resources. During the year we were not called upon to sponsor any large conferences, so that also helped.

Operational costs were up on the previous year – printing and postage being a major factor.

Overall we made a small surplus during the year, so I am able to hand over the reins to a new treasurer with no great pangs of guilt. It has been five years since I took on the post of NatSCA Treasurer, but recently other commitments have prevented me from carrying out the duties as efficiently as I should, so I am standing down this year. Many thanks to Holly Morgenroth for volunteering to take over. She has demonstrated her ability by sending out the invoices for the Law Seminar and this year's conference, so has already had to cope with the countless peculiar finance systems that operate around the country.

I do want to thank the other members of Committee who work so hard, mostly in their own time, to ensure that NatSCA serves the needs of its members and natural science collections.

Finally thank you to Steve Garland for examining and approving the accounts in a very short space of time. If we are to continue having our AGM at the end of February, I think we may have to change the accounting year accordingly.

Ladies and gentlemen, I present the NatSCA accounts for 2012/2013 for your acceptance.

NATSCA ACCOUNTS 2012-2013
(1 Feb 2012 - 31 January 2013)

	2012-13			2011-12	
10 INCOME					
Subscriptions (*note 1)					
134 Personal @ £15.00	2010			1845	
3 Incorrect rate	58.8			14.66	
10 Student @ £10	100			50	
2 pers.sub for 2011 @ £15	30			60	
41 Institutional @ £30	1230			1140	
2 inst.sub for 2011 @ £30	60				
2 pers.sub for 2013 @ £15	30			15	
3 inst.sub for 2013 @ £30	90			120	
Total of 197 subscriptions		**3608.8**			**3244.66**
Other income					
Interest (deposit account)	10.99			10.19	
Bank Error	6				
Total other income		**16.99**			**10.19**
Meeting income (*note 2)					
2011 AGM (meeting fees & conf meals)	435			270	(2010 agm)
2012 AGM (meeting fees & conf meals)	5713			4310	(2011 agm)
2012 Botany Workshop 1	210			1140	(2011 Ent)
2012 Botany Workshop 2	325			205	(2012 Bot1)
2013 AGM (meeting fees & conf meals)	810			1057	(2012 agm)
2013 Law Seminar	70				
Total meeting income		**7563**			**6982**
TOTAL INCOME			**11188.79**		**10236.85**

11 EXPENDITURE					
Subscriptions, etc.					
Information Commission (data protection)	35			35	
National Biodiversity Network	30			30	
Total Subscriptions Expenditure		**65**			**65**
Meetings					
2012 Conference (*note 3)					
Speakers expenses	515.05			403.29	(2011agm)
Room hire and catering	3500.75			3841.2	(2011agm)
Bursaries	700			628.09	(2011agm)
Miscellaneous	15			10	(2011agm)
2011Entomology Workshop					
Room hire and catering	27			847.57	
2012 Botany Workshop 1					
Speakers expenses	136.88				
2012 Botany Workshop 2					
Speakers expenses	259.49				
2011 Pest Odyssey Conference				600	
Total meeting expenditure		**5154.17**			**6330.15**
Committee expenses (* note 4)					
Insurance	860.7			835.7	
Travel to meetings	682.43			984.1	
Postage	19.68			14.65	
Printing & distribution of newsletter	2914.48			2459.61	
Misc.	1243.5			1033	
Total operational costs		**5720.79**			**5327.06**
TOTAL EXPENDITURE			**10939.96**		**11722.21**

Difference between Income and Expenditure (2012/13 surplus) (*note 5)			**248.83**		**-1485.36**
ASSETS					
HSBC Deposit account 41653636					
Opening balance, 1st Feb 2012	18356.3			19346.09	
Bank interest	10.99			10.19	
net transfer to c/a	-2000			-1000	
Total and actual balance, 31 Jan 2013	16367.3			18356.28	
HSBC Current account 91645722					
Opening balance, 1st Feb 2012	2273.33			2768.88	
Balance on 31 Jan 2013	4511.17			2273.33	
Total Assets (Cash Funds) at year end	**20878.4**			**20629.61**	
Assets at start of year	20629.6			22114.97	
2012/3 surplus	248.83			-1485.36	(loss)
Assets at start of year plus surplus	**20878.4**			**20629.61**	

* Points to note:

1. There was a welcome increase in subscription income this year, especially as both personal and institutional members are under increased budgetary pressure. Although subscriptions do not cover all of our operational expenses, we should be able to hold them at the current rates, providing meetings continue to be self-financing.

2. Good attendance at the 2012 Conference and Botany Workshops has resulted in a surplus of over £1000 just for these meetings. The meetings surplus overall is even greater because of late payments for 2011 Conference and advance payments for 2013 meetings.

3. Expenditure on the 2012 meetings was kept low by the generosity of the host venues and speakers, and by the hard work of the organisers.

4. Total operational costs rose by £400 in 2012/13, despite a £300 reduction in travel expenses for committee members. Most of the increase was due to increased printing costs, and additional miscellaneous items, including NatSCA representation at the MA Conference, and scanning of Carter and Walker's Care and conservation of natural history collections which will be made available for download on the NatSCA website.
Operational costs exceeded subscription income by over £2100, but this is offset by the surplus generated from meetings.

5. The surplus of £248 this year is a welcome reversal of trends in recent years. We continue to achieve our charitable aims of supporting the care and use of Natural History Collections, through seminars, workshops and conferences, publication of a peer-reviewed journal, and maintenance of our website. In addition, we have supported career development through the Skills for the Future programme and bursaries for individuals to attend meetings and courses.

The accounts are based on the bank transactions that took place in 2012-13.
Issued cheques that were presented, or income banked, after 31 January 2013 are not included.

Tony Irwin 11 February 2013

Examined and approved by Steve Garland (Hon. Examiner) February 2013

The accounts were proposed by Kate Andrew and seconded by Paolo Viscardi. The vote was carried with no abstentions.

8. Membership secretary's Report:
Maggie Reilly

Membership numbers fluctuate year to year but overall numbers have declined in the last couple of years from 220 – 30 to around the 200 mark.

For 2012 we have 47 institutional members, which represents a gain on last year's totals though the apparent gain was largely due to late payments from existing members, rather than brand new joiners.

There are 153 personal members – again this is an improvement on last year's dip in numbers. We welcomed 32 new or returning members in this total – this is very encouraging in the current climate.

Note that membership records and accounts entries do not always correspond due to dates of receiving subs.

Membership fees remain at the very reasonable rates of £15.00 for personal subs and £30.00 for institutional subs. An institutional membership entitles the organisation to two member rate places at conferences, workshops and other events organised by NatSCA plus one copy of the periodical. Institutional members however have no voting rights in committee matters. Furthermore, to serve as a committee member, you are required to hold a personal membership. Also remember that a reduced subs rate of £10.00 is available to unwaged members and this has full membership benefits.

We intend to include a Paypal facility on the new website which will be another convenient way to pay for all members but should especially help recruit and retain overseas members. Some protocols for identifying payments will be developed.

On behalf of NatSCA, I would like to thank Chris Norris and Jane Pickering at the Peabody Museum at Yale for help in past years in collecting subs from US members. This has been very helpful.

9. Editorial & Website Report:
Jan Freedman & Paolo Viscardi

We will be changing the name of *NatSCA News* to the Journal of Natural Science Collections. This will include peer reviewed articles. David Notton, the assistant editor and I are going through to reformat the new journal, and it will be unveiled in June/July.

Although the articles will be peer reviewed and of a consistent high quality, the NatSCA committee still want them to be accessible to everyone on the NatSCA membership. We are aiming for articles which will be interesting and useful to all natural history curators.

The deadline for sending in papers is the 31st March 2013. All the talks from this conference will be included.

As has been mentioned many times already at this conference, we need to shout about what we are doing, so submitting an article is an excellent way of sharing with others what you are doing, and also is a way of promoting the work you do to your managers.

Paolo Viscardi introduced Sam Barnett as NatSCA's new web manager. Sam has already been going through the website and changes will be seen fairly soon.

The blog will be updated more regularly and members are encouraged to use it and feedback.

10. Natural Science Conservation (& Institute of Conservation) Report:
Simon Moore

Firstly a big apology as the second day at York Conference was originally intended to be another conservation-based day, similar to that in Newcastle but with rather less topics and more in-depth detail. Somehow the earlier-than-usual date clashed directly with my holidays!

Ownership of the book *Care & Conservation of Natural History Collections* is available to view on the website. In time it will be updated by several of the authors, including Simon Moore but so far nothing has progressed. Hopefully an editable version of the relevant chapter on fluid preservation will soon be made available so that I can update it.
The ICON leaflets were completed having been re-edited/updated by Donna Young, Vicky Purewal, Kate Andrew and Simon Moore. They are now in the final stages of production and we hope to receive them via Lynette Gill (ICON) shortly.
We have also paid for a subscription to ICON (Institute for Conservation).
Conservation in natural sciences still continues to move onwards and as the discipline is becoming more recognised in other countries, the all-too valuable knowledge sharing and expertise continues to spread even wider each year. This year Spain and Portugal have shown a greater awareness and interest. The NH-COLL. Natural history problems forum has again been busy this year but the Cons. Dist. List has had rather less NH-related enquiries than before.

Each year more students and professional interns are being encouraged to qualify in Natural Sciences and numbers are slightly down since last year. To try and encourage and help conservators, collection managers and would-be/student conservators, I am also still running courses in fluid preservation, taxidermy cleaning, taxidermy case conservation and/or restoration, entomology and herbarium specimen repair. As funding seems to run lower each year in the UK, I am doing more of these with people from other European Museums, particularly Spain and Portugal.

The seminar programme:

Botany day at Cardiff, Vicky Purewal: Cardiff Botany day had 12 participants and was over-subscribed so that they plan to run the same course very soon at Liverpool with Donna Young.

'Natural Sciences & the Law', David Gelsthorpe: at Manchester Museum on 8th February 2013 for the next 'Natural Science Collections and the Law' day. Clare Brown is working on getting a programme and some speakers and will try not to restrict it to taxidermy this time. If anyone has any suggestions for topics/speakers then please let her know.

Osseous and keratinaceous workshop at the Horniman Museum in October/November 2012.

Jan Freedman would like to organise a Mineralogy seminar: Mineralogy course (venue & date TBC)

Monica Price of the Oxford course could be approached.

A possible course on Mammal Skins (London, Summer 2013) might be organised.

The fluid preservation course in December at the Horniman Museum was very successful with some of the attendees being part-funded by NatSCA.

Simon Moore is running another fluid preservation course hosted by the Horniman once again in June (full). Plus there should be another at the Horniman Museum in the winter of this year (November/ December).
Keep looking on JISC mail.

11. Election of Treasurer & ordinary members of NatSCA committee

Below are the nominees for NatSCA committee posts to serve from 2013 to 2015 **except the Treasurer, who will serve from 2013 to 2016,** which have reached the secretary.
The membership secretary has checked to see that those proposed, those proposing and those seconding are all present members of NatSCA.

1. Treasurer 2013-16
Holly Morgenroth (Exeter Museum)
Proposed: Tony Irwin seconded: Kate Andrew

2. OM 2013-2015
Jack Ashby (Grant Museum, UCL)
Proposed: Gerard McGowan seconded: David Waterhouse

3. **OM 2013-2015**
Paolo Viscardi (Horniman Museum)
Proposed: Holly Morgenroth seconded: Jack Ashby

4. OM 2013-2015
Miranda Lowe (NHM,)
Proposed: Clare Valentine seconded: Paul A Brown

5. **OM 2013-2015**
Roberto Portela Miguez (NHM, London)
Proposed: Clare Valentine seconded: Oliver Crimmen

6. OM 2013-2015
Vicky Purewal (NMGW, Cardiff)
Proposed: Jen Gallichan seconded: Wendy Atkinson

7. OM 2013-2015
David Gelsthorpe (Manchester Museum)
Proposed: Rachel Webster seconded: Andrew Lawton

8. OM 2013-2015
Tony Irwin (Norwich Museum)
Proposed: Dave Waterhouse seconded: Paul A. Brown

9. OM 2013-2015
Emma Bernard (NHM)
Proposed: Clare Brown seconded: Claire Mellish

10. OM 2013-2015
Beulah Garner (NHM)
Proposed: Clare Brown seconded: Paolo Viscardi

As there are no contested posts, no election is required. If there are no objections to the candidates, can we accept and elect the listed people en block onto committee to serve for three years for the treasurer and two years for other committee members.

This was proposed by Peter Howlett and seconded by Julian Carter and was carried with no abstentions.

Still In Post:
11. Chair 2011-2014
Clare Brown (Leeds Museum)
12. Secretary 2011-2014
Paul Brown (NHM, London)
13. Editor 2012-2014
Jan Freedman (Plymouth Museum)
14. Membership 2012-2014
Maggie Reilly (Hunterian, Glasgow)
15. Conservation 2012-2014
Simon Moore (Freelance)
16. OM 2012-2014
Kate Andrew (Freelance)
17. OM 2012-2014
Nicola Newton (Freelance)
18. OM 2012-2014
David Notton (NHM, London)
19. OM 2012-2014
Claire Mellish (NHM, London)
20. OM 2012-2014
Donna Young (National Museums Liverpool)

Angela Smith is retiring from the committee this year. Tony wishes to retire from the Treasurer post but wishes to come back onto committee as an ordinary member. We hope to continue to see Angela at NatSCA events and we extend our thanks to her and wish her all the best for the future.

12. Any Other Business. None

13. Vote of thanks: Clare Brown
I wish to formally thank the committee for their hard work this year, the conference organisers: Isla Gladstone, Donna Young and the team at York Museums Trust and all those how have contributed talks and workshops at the conference this year.

14. Close

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