GEOLOGICAL CURATOR

GCG

Volume 9 Number 10

GEOLOGICAL CURATORS' GROUP

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The Group is affiliated to the Geological Society of London. It was founded in 1974 to improve the status of geology in museums and similar institutions, and to improve the standard of geological curation in general by:

- holding meetings to promote the exchange of information
- providing information and advice on all matters relating to geology in museums
- the surveillance of collections of geological specimens and information with a view to ensuring their well being
- the maintenance of a code of practice for the curation and deployment of collections
- the advancement of the documentation and conservation of geological sites
- initiating and conducting surveys relating to the aims of the Group.

2013 COMMITTEE

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Cover: Amethyst geode in the National Museum of Scotland, Restless Earth Gallery.
See paper by Carrio and Stevenson inside.

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EDITORIAL

As I struggle to complete this volume with an index, I am confronted by past errors I have made in production. Volume 8 has an index that appears to miss out the issue 10 within which it is published. Other errors are sloppy things such as bold or italic font missing, or inconsistencies in referencing that I missed in the editing and production. These are annoying things to find, but overall, I can look at the issues and feel comfortable in a belief that the journal still has value to our community, and that I have generally maintained the high standards set by my editorial predecessors.

However, these are even more rapidly changing times, as new technologies change the way we can do things, and bureaucrats reorganise our administration and governance structures with ever greater frequency, making our curatorial lives difficult and our personal lives more uncertain. More restricted purses mean that individual memberships and institutional subscriptions to GCG are gradually falling, especially where specialist geological curators are lost in a museum or institution through cutbacks or restructuring. As a community we are under threat on all sides as usurpers across the arts and music world steal, or at least misappropriate, the term 'curator'. Geology itself is so poorly understood in society, and the value of the collections we hold in trust is totally unappreciated.

These changes require that we, as a community, look at the way we do things and what we must do to survive and prosper. The Geological Curators' Group Committee is of course looking at this but would always be glad to hear from members with ideas of how to respond to changes. As Editor of this journal, I would be glad to hear a discussion of whether the journal in its present form fulfils people's wishes and meets their needs. Other journals I am involved with are shifting gradually into a more digital world, and I think we need to consider implications for *The Geological Curator*. My suspicion is that most people are actually happy with the way things are, since we do make it available freely in a digital format (except for the last two years), including pdfs of papers to individual authors as 'offprints'. More importantly, I think I have only ever once been asked for a digital version of the journal as opposed to hard printed copy. Perhaps we have all had enough bitter experience with databases, IT and collections that we prefer to have a physical thing in our hands. If I am wrong and members are just assuming quietly that we are working on a different approach and that they are imminently expecting to receive their journal issue electronically for a tablet or kindle then we need to be told! Such a switch-over in production may be within my capacity, but is more likely to be something tackled by the next editor, from a different generation.

For the moment at least, I shall remain with my trusted printer, and say thanks to Mark Rogers of Naas Printing Ltd, who consistently deliver a quality job. I shall also thank Patrick Wyse Jackson for continued guidance and wise counsel when required, and especially for his massive help with compiling the index for the volume. Helen Kerbey has been a practical Assistant Editor for the past year and she continues to encourage authors to write up and submit papers. Most authors of papers fail to acknowledge the input of referees to the final version of their paper, whether known or unknown to them, and so I record a special thanks here to all the wide circle of people who have acted as referee for me - your assistance is critical to the whole journal.

Lastly, to this issue. I wish to thank the authors, both regular contributors and new ones. We have a steady flow of papers, but I would be happy to see more arriving without the effort of suggestion, encouragement and prompting, and finally appeal, that goes into ensuring that steady flow. A variety of formats other than papers allow notes, exhibition reviews, book reviews, fact files, lost and found topics, conservation forum and so on. Please make full use of the journal and contact me with prospective material. Finally, the Director of the National Museum of Ireland is gratefully acknowledged for his recognition of the value of work such as editing a professional network publication like this one, and also Nigel Monaghan who facilitates it within our work programme.

Matthew Parkes, December 2013.

APPLYING GLASS CONSERVATION TECHNIQUES TO A MINERAL VASE

by Lu Allington-Jones

Allington-Jones, L.2013. Applying glass conservation techniques to a mineral vase. *The Geological Curator* 9 (10): 497 - 500.

This article briefly describes the successes and failures encountered during a project to repair a mineral vase using established methods in the field of glass conservation. Plaster of Paris pre-casts and wax profiling proved to be unsuccessful. Temporary assembly using tape and casting from a silicone mould were, however, found to be very successful and are recommended for similar projects.

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Introduction

A Victorian Blue John vase (Calcium fluoride) was severely broken when it fell from its display plinth. The fragments were collected from the dark recesses behind the exhibition. Three trays were collected, according to whether the fragments were found on the floor level or on one of the steps above it. Large fragments were put into small inert foam-lined trays and small fragments were stored in zip-lock polythene bags (Figure 1). It was decided that the fragments of the vase should be re-assembled as far as possible, to promote conceptual integrity and the readability of its original form. Minimal intervention is a poorly-defined concept (Muñoz Viñas 2009, 50) but re-assembly was considered acceptable within the premises of rational restraint (Villers 2004, 8) and balanced meaning-loss (Muñoz Viñas 2009, 55-7).

Re-assembly

The vase was reconstructed following some of the ideas taken from glass conservation techniques. Firstly the larger pieces were assembled using scotch tape as a temporary attachment (Figure 2). This allowed the locations for the smaller fragments to be identified before any adhesion occurred. This prevented any "locking out" of fragments. The correct location of the majority of the smaller fragments were identified and then painstakingly adhered together using paraloid B72. This ethyl-methacrylate copolymer was chosen because it is easily reversible and has good aging properties (Koob 1986). Epotek 201 (epoxy resin) was applied by capillary action to the cracks to allow finer blemishes to disappear. This epoxy was chosen for its excellent aging properties (Down 1986) and because it traps fewer air bubbles than paraloid B72. Epoxies can be removed using a

Figure 1. One of the three trays of fragments.

methylene chloride vapour chamber. Because this process causes swelling, rather than dissolution, it should not be attempted on fragile objects or those with blind-ended cracks. The Blue John vase did not possess any blind-ended cracks and its relative hardness permitted the use of epoxies. Nevertheless, the epoxy was only applied in areas which had first been protected with a barrier layer of paraloid B72, which can easily be removed using acetone - this would cre-

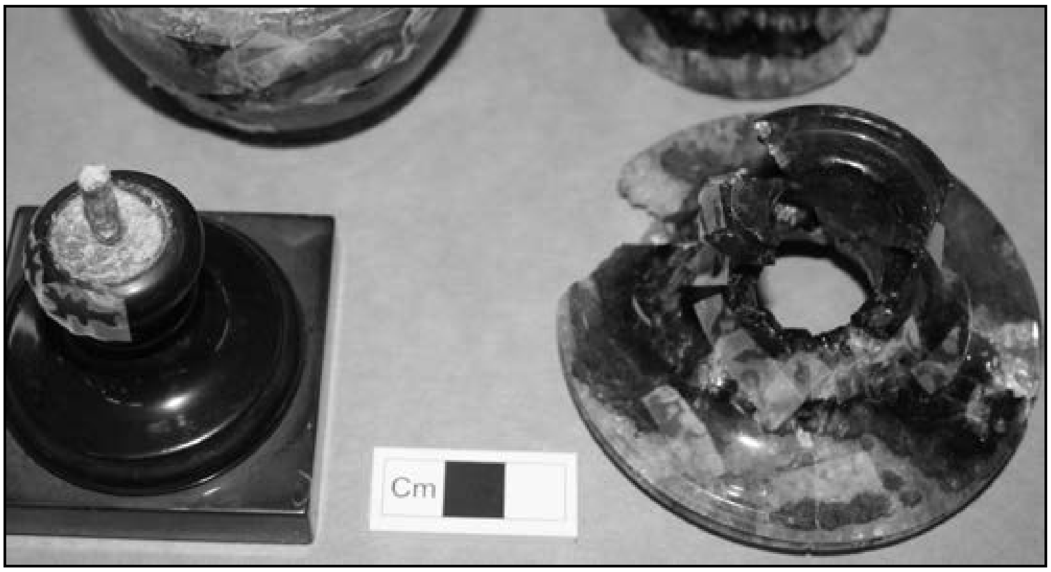


Figure 2. Large fragments were temporarily assembled using tape.

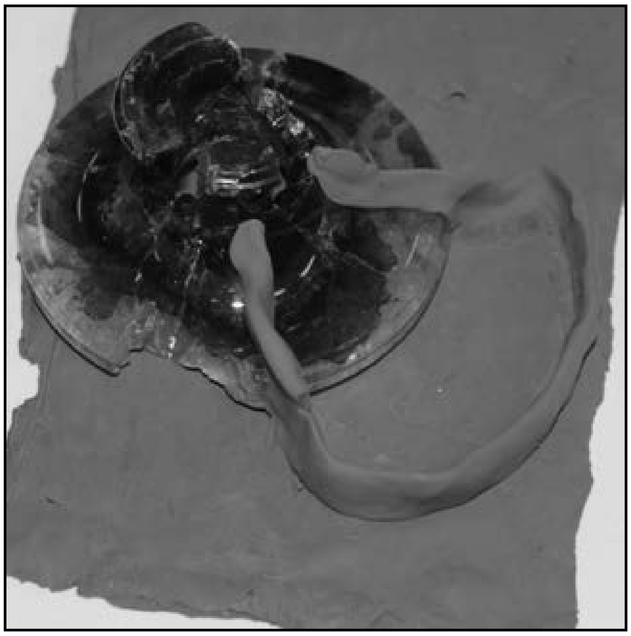
ate a region for expansion, if methylene chloride still proved necessary. Any excess epoxy was removed using acetone and a cotton swab within 4 hours of application (Figure 3).

Filling in the gaps

There were still several areas where the fragments were missing. Detachable fills using plaster of Paris to cast the voids were considered (Koob 2006, 95). The plaster was supposed to be removed once it had set and then moulded in silicone rubber. Epoxy resin casts would then be made from these moulds and adhered to the vase using a reversible polymer. Unfortunately, due to the difference in fracture form between Blue John and glass, the plaster fills would have become locked-in. This method was rejected.

Due to the curvature of the vase, and reduced potential reversibility, direct fills (Koob 2006, 77) were considered unsuitable. Although reversibility has been recognised as an unrealistic and unnecessary goal by many (Caple 2000, 64; UKIC Rules of Practice 1996, 7), it should not be altogether abandoned as an ideal. It was decided that only one fill should therefore be made, a detachable epoxy resin fill of the shoulder of the vase. This would increase stability and aid interpretation of form. To ensure that it was recognisable as a fill, and not original material, the resin was to remain uncoloured. Restoration should be discernible through cursory examination (Villers 2004:4; UKIC Rules of Practice 1996: 8). The fragments which had not been able to be re-assembled could have been crushed up into the new fill but this idea was rejected for several reasons: (1) the fill would have been less discernible to curso-

Figure 3. The re-adhered sections.



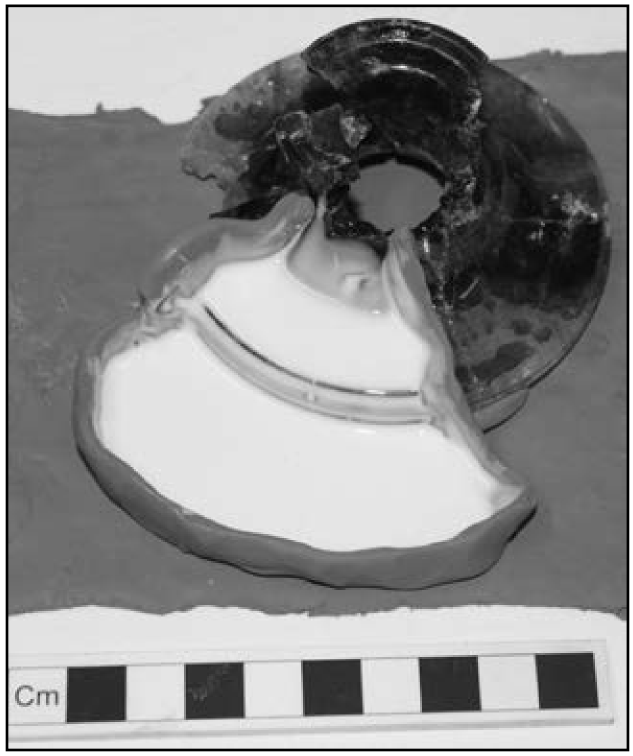


Figure 4. (a) A dam was created in modelling clay to isolate an intact section of the shoulder. (b) the first layer of silicone rubber.

ry examination; (2) the process would not represent the minimal intervention necessary to achieve the goal of recovering form; (3) powdering the fragments would be irreversible and reduces the potential for future treatment; (4) the fragments in their current separate form are available for scientific analysis without causing further damage to the main object. The fragments were therefore collected in a zip-lock bag and stored together with the vase.

The fill was created by making a mould of one of the intact surfaces using modelling clay and silicone rubber (Koob 2006, 83). The vase segment was laid on modelling clay instead of glass (as would be done with a glass repair) because the bottom edge had an undercut and was quite roughly finished. Without the lower layer of clay, the rubber would have seeped away instead of pooling. A layer of thin silicone rubber was painted on using a brush (Figure 4) and a thickened layer was applied once this had set.

The mould was then moved around the shoulder to the area of loss and adhered using a thin smear of fresh silicone rubber. The mould and vase section were turned over and levelled using sand bags. Epotek 201 was then poured into the mould cavity. When the mould was removed a few bubbles were found in the upper layer so dental wax was moulded

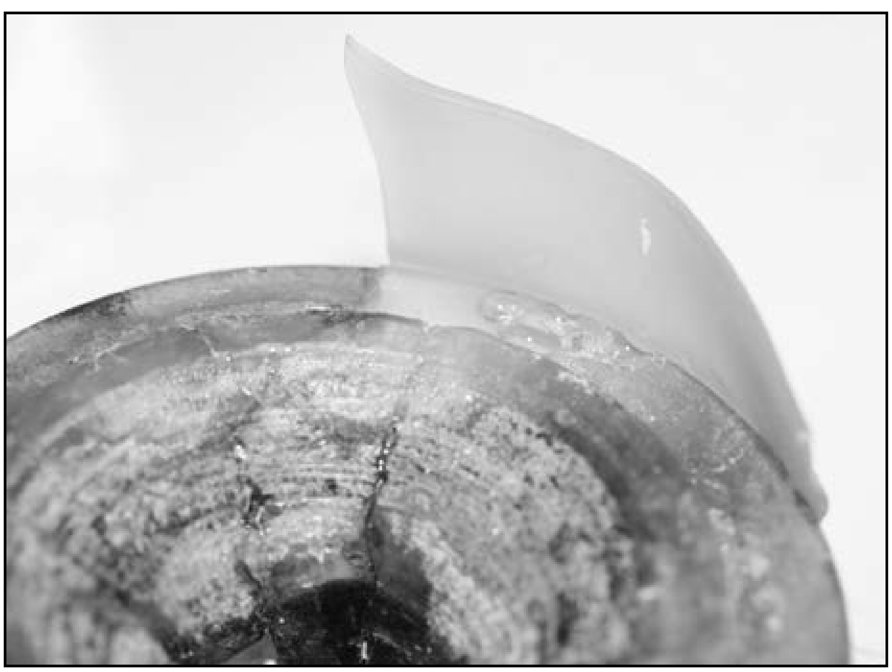


Figure 5. Dental wax backing (adhered and formed using hot air).

Figure 6. The finished fill can be seen as the clear section on the right-hand side of the shoulder.

around the edge (Koob 2006, 81) and additional epotek applied with a pipette (Figure 5). This proved to be a mistake. The wax had not created a complete seal and the extremely fluid resin slipped through. When the epotek had set and the wax removed, the beautiful surface of the cast piece was found to have been ruined by a run. A diamond burr (NSK rotary tool) and various grade sanding papers were used to restore the correct profile but these created an undesirably matt finish. A high gloss was achieved by applying a thin coat of fresh epotek (Figure 6). The finished vase was re-assembled using paraloid B72 and stored in a new acid-free cardboard box with carved foam supports (Figure 7).

Figure 7. The vase was stored in an acid-free card board box with inert foam cut-outs.

Conclusion

Glass conservation techniques have mixed applicability to the treatment of mineral vases, but borrowing ideas from another discipline has proved to be a valuable activity.

Acknowledgements

Many thanks to Peter Tandy and Chris Collins of the Natural History Museum, London, and Stephen Koob of the Corning Museum of Glass, New York.

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THE APPLICATION OF DESKTOP VIDEO MAGNIFIER TECHNOLOGY TO MUSEUMS AND ARCHIVES

by Lyall I. Anderson and Sandra J. Freshney

Anderson, L. I. and Freshney, S. J. 2013. The application of desktop video magnifier technology to Museums and Archives. *The Geological Curator* 9 (10): 501-505.

Assistive technology developed for blind and partially sighted people can find wider application in the museum workplace. Ease of operation, combined with high levels of potential magnification and object sympathetic light sources add to the utility of desktop video magnifiers. As well as assisting in day to day paper-based office tasks, the magnifier finds application in various archival tasks and collections-based work. This equipment enhances the visitor experience of looking at archival material, both for the visually impaired and the general visitor. In particular, it helps with the study of smaller documents and photographs. It also assists in the examination of old handwriting, and in particular hand written ink script which has begun to fade with time.

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Introduction

> "*A culture of good handling will significantly reduce the need for costly conservation work and ensure continued access to collections*"
>
> (Anon. 2011).

Recent developments in digital and flat screen technology have provided significant advances in assistive technology for visually impaired people. A combination of reduction in overall unit size and digital connectivity with desktop computing means that powerful video magnifiers can now be desk mounted and used as part of a day to day workstation. Such magnifiers can allow visually impaired people to enter and then remain in the workplace undertaking tasks which would otherwise be closed to them. This paper illustrates a case study relating to the use of one such magnifier in an archive and museum workplace setting. It aims to inform other museum professionals that such equipment exists and how it could be a useful addition to the array of equipment and techniques they can employ within collections work.

The Sedgwick Museum of Earth Sciences has recently embarked on an intensive programme of re-boxing, cataloguing and arranging of a sizeable and historically significant paper archive (see Anderson and Theodore 2012; Marsh and Anderson 2012). This has involved the sympathetic handling of substantial quantities of fragile and sensitive paper materials. Handling needs to be kept to a minimum for archival documents. Chemical damage such as stains may be caused by grease and oil originating from the fingers of those handling the papers. In addition to leaving unsightly marks these areas can then attract further dust and dirt to the object. Physical damage can also take place due to bad and excessive handling (Anon. 2006).

Due to sight loss in June 2010, one of us (LIA) obtained a grant from the DWP (Department of Work and Pensions) 'Access to Work' Scheme to purchase accessibility equipment in order to work in the Sedgwick Museum Archive. The grant was promptly paid to the museum and the requisite equipment purchased from the current RNIB (Royal National Institute for Blind People) products catalogue (http://www.rnib.org.uk).

Specifications

The RNIB-branded 'SmartView Synergy' was purchased in early 2011 and set up in the Archive room of the A. G. Brighton Building, a facility of the Sedgwick Museum of Earth Sciences situated on the western outskirts of Cambridge. This particular desktop magnifier model offers a range of magnification from x2.6 up to x57. The output to a 22" flat screen can be manipulated in terms of brightness, enhanced contrast, black and white negative and actual colour display. The screen itself can be raised or lowered in height for comfortable image viewing without the need for refocusing the image, or moving the viewed object. It also possesses a degree of lateral movement either left or right. This allows the screen to be angled towards the operator whilst working alongside it with a laptop computer. It became rapidly apparent to us that the major advantage of this equipment over many other magnification devices was that the horizontally movable document table minimised the need for excessive handling of archival documents during examination. A book pillow and weighted book beads were routinely used to position and maintain the document in the field of view of the video camera. Any subsequent movement could be accommodated for, by moving the document table. Additionally, this allowed high levels of magnification without the need for hand held magnifying devices - a hand lens necessitates the user's face (and breath) to be in close proximity to the original paper document, potentially causing damage through increased moisture levels. The additional feature of a controllable 'brake' lever on the document table allows either free movement of the table whilst searching through a document, or a fixed table when an area of interest is identified and needs to be kept in position for further examination.

The SmartView Synergy uses a bank of LED light sources to illuminate the document table. Prior to first use with archival documents, UV (Ultra-violet) and visible light (Lux) levels were measured by positioning an environmental monitor on the document table directly below the light sources. These light sources produce no measurable UV emissions. At normal operating conditions, visible light levels were measured at 1300 *lux*. This is significantly higher than the recommended level of 50 *lux*. Anon. (2012) sets out information on acceptable light levels for archival documents (p. 12). Section 6.3 deals with the upper limits for illumination, but does note that a higher level (above 50 *lux*) is needed for scholarly study and also conservation work. All light damage is cumulative and irreversible. UV light is the most damaging and causes yellowing and weakening of the paper structure. However, individual items were only exposed for a short duration, and in overall terms, the collection benefited from being catalogued for the first time. The fact that these light sources do not emit any UV light is excellent and worthy of note.

Applications

Accessibility

Obviously, the principal application of this form of technology is accessibility; the enabling of a visually impaired person to examine and read a variety of both day to day office papers and archival materials. These ranged from single sheets of paper, to multi-page letters, to sizeable notebooks and photograph albums. However, this usage is not exclusive to the employee. The equipment also finds application in making archival collections accessible to visiting researchers either with or without visual impairment. Although desk mountable, the video magnifier is heavy enough to ensure that it is not easily moved around in the Archive. This means that a defined work area can be set up and visiting researchers supervised in its use in a specified locale.

The large flat screen display allows multiple users to view the same document or object simultaneously. During Open Day and specialist group visits, we discovered that a small group of people can comfortably view and discuss the image whilst reducing the overall amount of handling an individual document gets whilst it is being appraised.

Examining Documents

Single sheet paper documents are laid directly onto the movable document table. This is particularly useful for unfolded letters and single photographs, free of album mounting. For objects with some three-dimensionality, deployment of a book pillow is useful (Figure 1). There is sufficient clearance height (150 mm) between the document table and the camera to allow quite large books to be placed opened in the viewing area. However, it is best to pull the document table fully out towards the reader prior to turning pages to avoid unintentional damage. Weighted book strings, also commonly referred to as 'snake weights', placed over open pages of books keep them flat and allow the camera to focus sharply on the contents. Once the document has been set up, the movable document table can be used to move the whole document without further need to touch and adjust it. This cuts down on the amount of physical contact with the object being viewed.

The high level of magnification afforded by the equipment means that it may find future application in the study of paper fibres and watermarks. Close examination of paper fibre may be useful in conservation and cleaning work on archival documents.

Figure 1: The Synergy SmartView in operation. Examining one of Edward B. Tawney's geological notebooks) TWNY 1 /6, p.87). A black ink sketch of the strata exposed in Stoly Quarry, Rillage Point, Devon.

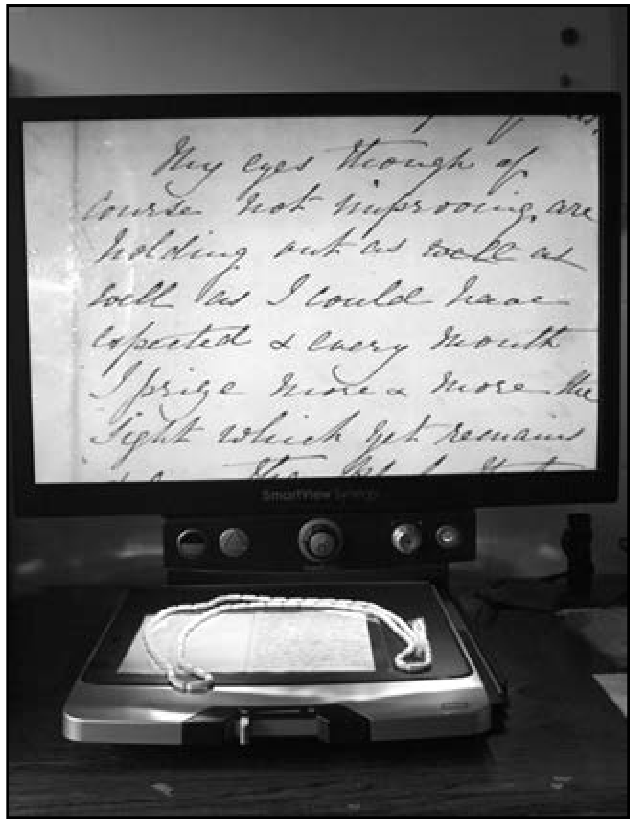

Figure 2: Examining letters: A letter from Sir Charles Lyell to Prof. Thomas McKenny Hughes dated 14 August 1874. The text reads "My eyes though of course not improving are holding out as well as I could have expected & every month I prize more and more the sight which yet remains...".

Deciphering labels

The CCTV camera on the SmartView Synergy allows continuous smooth magnification. Obtaining an image is achieved either through the camera autofocus, or manually using the control on the front of the console. Old museum labels, particularly on geological specimens can become faded over time. This makes them difficult to read and retrieve collections information from. Often this is due to former periods of extended light exposure whilst geological material was on museum display. Although the geological object is often unharmed the accompanying paper record often suffers. Magnifying the label and altering contrast and brightness settings or indeed producing a negative image of the original can sometimes aid in the reading of faded labels.

Palaeography

Palaeography, the study or reading, deciphering and dating of historic manuscripts, is also a useful application of the desktop video magnifier. The magnification function allows single words to be massively increased in size on the viewing screen (Figure 2 and particularly Figure 3). Again, this facilitates more

Figure 3. An example of Sir Charles Lyell's signature at the end of a letter. In the case of some of his letters, his signature is the only authentication where someone else wrote the letter under his dictation.

Figure 4: Magnification of fossil objects: **Euproops rotundatus** ***(Prestwich, 1840) from the Upper Carboniferous of Westhoughton, Lancashire (LY052, LIA's personal collection). The magnification was set at x8 for the observed image. The horseshoe crab carapace is 40mm across.***

than one person to examine the same archival document simultaneously and discuss alternative possibilities as to the identity of an otherwise intractable word. High magnification allows close scrutiny of an individual's handwriting, and consequently a suite of distinctive 'tells' or person-specific ways of writing characters, could be assembled for Alfred Harker (1859 - 1939), John E. Marr (1857 - 1933) and Edward B. Tawney (1840 - 1882). This allowed otherwise loose and stray items in the archive to be reassigned to their rightful author and stored together.

In the case of the Sedgwick Museum Archive, particular success was achieved in the transcription of a series of letters from Sir Charles Lyell (1797 - 1875) to the then Woodwardian Professor, Thomas McKenny Hughes (1832 - 1917). These are stored in box HGHS 721. Lyell was one of the people who had supported Mckenny Hughes' election to that post, and the two men continued their correspondence after1873 (O'Connor 2005).

Whilst transcribing these particular archival letters, an interesting feature was sometimes encountered and identified. Most of the letters were written in Lyell's distinctive hand. However others were begun by him, only to be continued and completed in one of two other distinctive handwriting styles. Comparison with other letters in the Archive revealed that the identity of these other scribes were initially his wife Mary (d.1873), then subsequently his sister Marianne. These letters with mixed handwriting were always signed by Charles Lyell providing essential provenance (Figure 3). Lyell's eyesight had troubled him since his late twenties, and had forced him to give up the practice of Law in favour of his geological investigations (Wilson 1973). These letters chart his later reliance on others to read and take dictation of his replies to correspondence.

Photographs

The desktop magnifier has both a colour and black and white display function. Again magnification and display on the flat screen reduces the need for close proximity of documents to the examiners face and allows simultaneous examination of the same object by multiple viewers. The level of magnification is sufficient in some photographs in order to be able to read small and otherwise missed detail such as the time on clock faces of buildings or words on signs.

Geological objects

The SmartView video camera has a remarkably good depth of field, so much so that in domestic application, ingredient lists printed on the labels of curved tins and bottles can be comfortably read without continuous refocusing. This depth of field also makes it suitable for the magnified viewing of moderately three-dimensional geological objects (Figure 4). The utility of this application ranges from personal investigation of objects for morphological details and conservation checking to illustrating features to open day groups and students. Again, there is sufficient height clearance between table and camera to enable relatively large specimens to be placed underneath it for viewing.

Conclusions

We have listed here some preliminary findings relating to the use of a particular model of desktop video magnifier in a museums environment. Primarily the combination of decent levels of magnification along with a large display screen provides a powerful investigative tool. No doubt as this technology becomes more widely available and falls in price further, other uses in the museum environment may be identified.

Acknowledgements

We thank Sarah M. Finney for helping to facilitate this work at the Brighton Building. 'The Friends of the Sedgwick Museum' provided funding which allowed LIA to continue the description and cataloguing of the papers of Alfred Harker. Dr Peter Friend provided encouragement and useful discussions on the contents of the archive as they were discovered. The Cambridge based charity Cam Sight (Registered charity no. 201640) and Gail Blackwell in particular, provided advice and help in the selection and purchase of this equipment.

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PERMANENCY OF LABELLING INKS: A 25-YEAR EXPERIMENT

by Patrick N. Wyse Jackson

Wyse Jackson, P.N. 2013. Permanency of labelling inks: a 25-year experiment. *The Geological Curator* 9 (10): 507 - 508.

Subjecting eight inks to sunlight over a 25-year period has demonstrated that 'permanent' and 'indelible' dye- and spirit-based inks fade more readily than do pigment-based inks such as Indian Ink.

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Introduction

Museum curators need to be concerned about the permanency of specimen labels and tray labels, and other documentation relating to the specimens in their care. All too often fading by light has obliterated writing on specimens and labels, some of which are illegible except under ultra-violet light. Can one be certain that labels and accession numbers will stand the test of time, and be legible and therefore instructive to the scientific and museum community in years to come?

Aims and experimental scheme

Shortly after my appointment in 1988 as Curator of the Geological Museum in Trinity College, Dublin, I set up a simple experiment that aimed to test the long-term readability of various inks then on the market. The aim was to determine which of the inks would fade least, and thus suggest which would be best used to provide documentation as permanent as possible.

The procedure involved writing or typing the name "TRINITY COLLEGE" onto an Index Card using eight different inks (Figure 1). Seven of these were black while one was blue, and a range of types were utilized: Fountain pen ink (1), Permanent/indelible ink (2), Waterproof ink (1), ballpoint pen ink (2), Indian Ink (used in a Rotring Pen) (1), and manual typewriter ink (1).

The card was then placed face upwards on a top shelf in my office, ten feet above the floor level. The office has a glazed roof and so the card was in normal lighting conditions for most of the day and in direct sunlight for a portion of it. Every six months or so the card was taken down, its surface dusted, and placed back on the shelf.

Results

Indian Ink did not show any fading at all. Black and blue ballpoint ink from a Parker Pen performed well, showing little fading, as did a 'waterproof' black ink in an Edding narrow tipped pen. The ink used in the

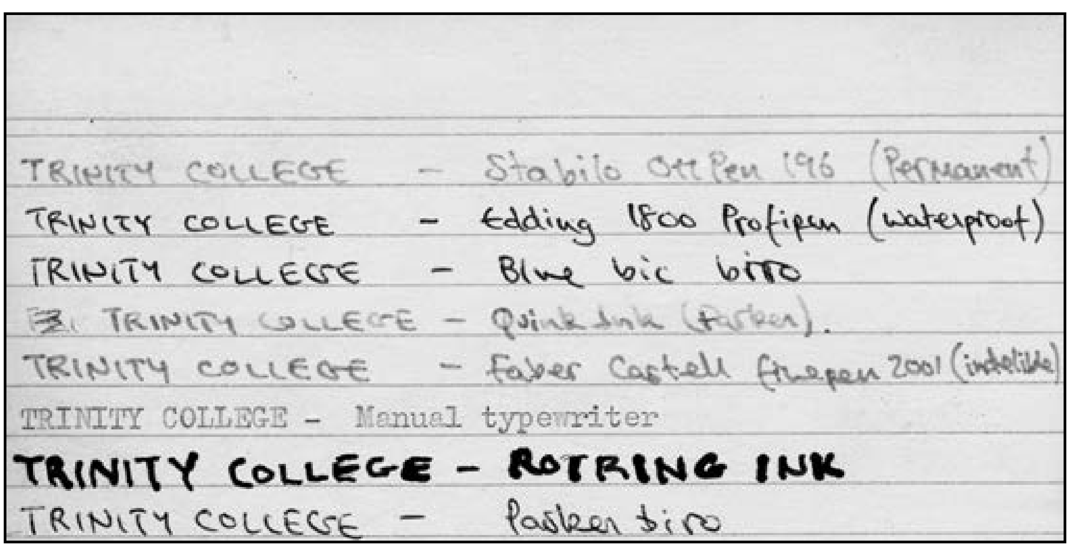

Figure 1. Index Card marked with eight different inks and subjected to light over a period of 25 years.

manual typewriter also showed little fading. 'Quink Ink ' (produced by the Parker Pen Company and used in a fountain pen, and two indelible inks did not perform well, and faded to a brown, red or green colour respectively.

As this experiment was set up before the general availability of desktop laser printers, inks from such have not been subjected to this sunlight test. For a discussion of the viability of laser-printed labels in wet collections see Zala *et al*. (2005) and for a method of applying accession numbers using printed labels see Braun (2007). Equally, manual typewriters are virtually redundant, and unlikely to be used by latter-day curators.

Discussion

Carter (1996) conducted two tests on three inks used on labels placed in fluid storage jars for the storage of biological specimens. While used in a different context to the labeling of many geological specimens, this study did reveal some interesting results and some parallels with how the inks behaved can be drawn with my 25-year experiment. Carter subjected two computer printer inks and Indian Ink (as the control) to a boiling test and a storage test in various fluids over three weeks. The 'indelible' or 'permanent' ink largely disappeared or became very blotchy over a short period, whereas the second printer in, a 'PermaDry' variety performed well although was moderately easy to scrape off or abraid under some conditions. However, in comparison with the Indian Ink used as a control the two printer inks did not perform as well. This is in keeping with the current study where there was no fading of Indian Ink over the time-span of the experiment. Zala *et al*. (2006) following a 14-year testing regime found that laser-printed labels appeared durable when placed in 70% ethanol or 10% formalin, but they did not definitively recommend their use until further testing determined the longevity of the toner-paper bonding.

Conclusion and recommendations

This small long-term experiment demonstrates that labels written in pigment-based Indian Ink will have the greatest permanency, and that 'indelible' spirit-based inks will not. The bulk of the 'permanent' and 'indelible' markers currently on the market are dye-based and the ink will fade rapidly (Davidson *et al*. 2006). Alten (1998) also warns that some "Indian Ink" may contain dyes and these are less-resistant to fading than those that are pigment-based, and that the composition of the inks should be ascertained before its adoption. Ideally black carbon-based pigment inks should be used for labeling (Hawks and Williams 2005).

The draw back to this 25-year experiment is that it only documented hand-written labeling and not computer-generated labels. However, it has been clearly demonstrated in this small experiment, that pigment-based inks are more lasting and fade-resistant than dye-based inks. Given this, curators might wish handwrite specimen accession numbers and basic tray label information in pigment-based carbon inks, in preference to other, perhaps faster, labeling methods, and to keep additional more extensive specimen documentation in printed form elsewhere.

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THE IMPORTANCE OF LABELS TO SPECIMENS: AN EXAMPLE FROM THE SEDGWICK MUSEUM

by Stephen K. Donovan and Matthew Riley

Donovan, S.K. and Riley, M. 2013. The importance of labels to specimens: an example from the Sedgwick Museum. *The Geological Curator* 9 (10): 509 - 514.

The value of a fossil specimen is enhanced by the contribution provided by adequate supporting information commonly preserved on its label(s) and our interpretation of these data. As an example, a specimen in the Whidborne Collection of the Sedgwick Museum, University of Cambridge, is supported by the data on two labels. The apparently minimal information that these contain has been extrapolated to determine details of the locality, horizon and collectors. The specimen itself, although not described by Whidborne, is nevertheless worthy of identification, description and interpretation. Both the specimen and the labels were essential to give a complete view; the data on the labels was additional to, and could not be determined from, the specimen.

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Introduction

Documentation is as important to palaeontology and mineralogy as is collecting (Wood and Donovan 1996; Donovan 2004), but receives less enthusiastic attention. Finding a specimen is in some way significant, but, if in the future its provenance is forgotten, then its scientific value is seriously reduced. Tray labels, as well as drawer labels, original field sheets, notebooks, manuscript catalogues and even original packaging (Wyse Jackson 1999, p. 425), provide relevant information that cannot be determined from the specimen. Any curator of a geological museum will be able to relate horror stories of indecipherable handwritten labels, lost labels, spoilt labels ruined by damp or eaten by cockroaches, and specimens without any label at all. Information on labels needs to be complete, otherwise it may lead to guesswork in interpretation; what would you make of a label such as "Silurian? of Scotland?" (Donovan 2009).

These comments apply to a private collection as much as to that of any public museum. If tomorrow a private collector had to provide written documentation for the origin of all their specimens - locality, horizon and so on - could they do so? Why not? And is it on paper and associated with the relevant specimens or is it only in their head? As the person who collected the material, they should know more about provenance than anyone else, but is it recorded? Doubtless, Benjamin Walworth Arnold (1865-1932; Groft and MacKay 1998, p. 134) knew where he had bought and collected the fossil echinoids described in Arnold and Clark (1934, p. 39), but he died before he had informed his co-author. Similarly, there are a number of drawers of specimens in the Sedgwick Museum stores (donated in the 1990s, before the current documentation procedures were implemented) and labelled "do not unpack without speaking to Barrie Rickards". Unfortunately, Professor Rickards passed away several years ago, so curating the collection has now become rather difficult. In contrast, Dr Colin Forbes, ex-curator the Sedgwick Museum, returned to the Museum as Curator Emeritus in 2012, at age 90, to curate a cabinet of his own material that he'd left unfinished when he retired in 1986.

Herein, we look at the data provided by a specimen in the collections of the Sedgwick Museum (CAMSM) in Cambridge, CAMSM H3776, and see how that supplements our interpretation of the specimen itself. This paper could have been written about any one of a myriad of specimens in a multitude of museums or private collections, but we started to write this note while S.K.D. was on a research visit to Cambridge and when this specimen first caught our imagination. The specimen label simply states "Crinoid. Mid Devonian. Lummaton, Torquay, Devon. Whidborne ex Champernowne Coll." (Figure 1); additional data was not available in the accession catalogue. How much information does this label actually provide, how much new data can we squeeze from an apparently nondescript specimen (Figure 2) and how much overlap is there between the two?

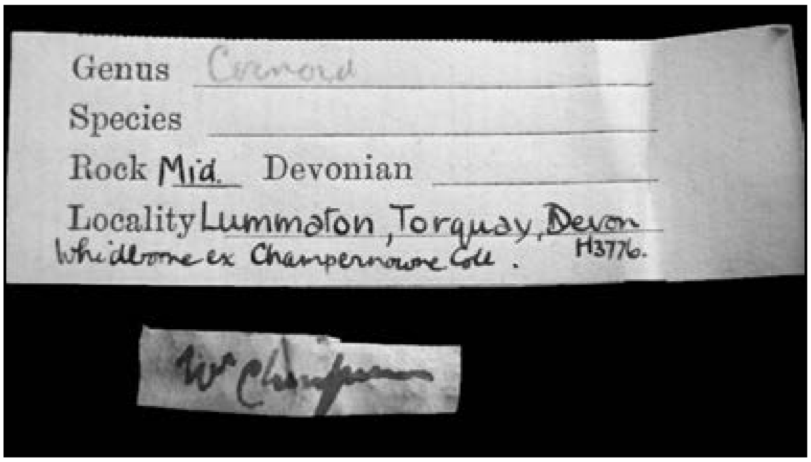

Figure 1. Specimen labels associated with CAMSM H3776. The upper label is the CAMSM label, containing the minimal, yet informative data discussed herein. The lower label was weakly stuck to the specimen and fell off. The ink has bled into the paper, but it presumed to be a 19th Century label indicating the collector, "Mr.[?] Champernowne", and was presumably written by the Reverend Whidborne; the handwriting agrees with other labels thought to have been written by him. The first word is problematic, but is unlikely to be Champernowne's initials, A.M.

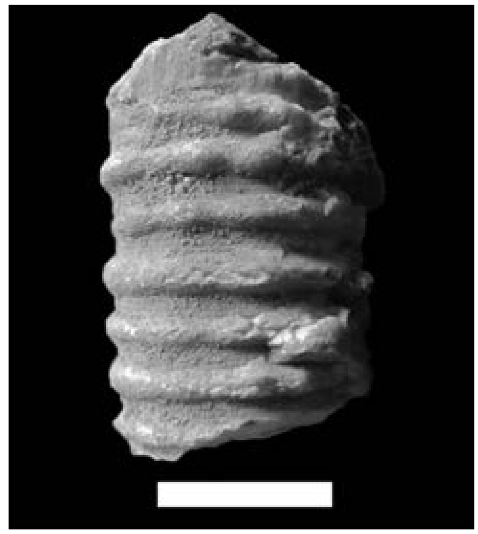

Figure 2. The specimen, CAMSM H3776, a crinoid pluricolumnal in lateral view showing the intercalation of groups of three low priminternodals with planar latera between larger nodals with convex latera. This specimen is referred to **Hexacrinites** *sp. Scale bar represents 10 mm.*

Current good practice at the Sedgwick Museum

SPECTRUM, the UK Museum Collections Management Standard (published by Collections Trust; previously the Museum Documentation Association) is a set of guidelines designed to help museums care for their collections. Museums are encouraged to have written policies and procedures for all aspects of collections care, including documentation and labelling.

For new acquisitions, museums should follow the process of Pre-Entry, defined by SPECTRUM as "the management and documentation of the assessment of potential acquisitions before they arrive at the organisation" (SPECTRUM 4.0, 2011 Collections Trust). This is a way of accumulating the detailed information about potential new acquisitions, so that the museum trustees can make an informed decision about whether to acquire the material. Current Sedgwick Museum Collections Manager Dan Pemberton has designed a pre-entry form for just this purpose. Potential donors are asked to fill in a table describing each object. There are columns for field number, identification, stratigraphy, locality and type or figured status. Only after the Museum has received a completed, signed pre-entry form will the curators assess the material for acquisition and then assign permanent numbers to the specimens. This information can then be transcribed or mail merged into a label, to be stored in the box or bag with the individual object. Catalogue numbers are glued directly to the objects (using archive paper, archive ink and paraloid/acryloid) and can be cross-referenced with the information label, the pre-entry form and a computerised database.

This process, of course, works well for recent objects collected and studied by the donor, as they can easily provide this information. It doesn't work as well when dealing with bequests deposited by a spouse or colleague who knows nothing about the collection. In this case you would hope the collection comes with a catalogue and that each object is clearly labelled. The specimen discussed below, CAMSM H3776, is one such specimen amongst many.

Locality and horizon

The label provides a minimum of data on locality and horizon, but it is enough to direct us to more detailed sources in the relevant publications. A useful starting point to locate old British fossil localities is often Arkell *et al.* (1954).

The Lummaton Hill quarries are on the northern outskirts of Torquay, Devon [NGR SX 9130 6645] and a Geological Conservation Review site (Leveridge *et al.* 2003, p. 9; Leveridge 2011, pp. 682-684, fig. 44), exposing part of the Torquay Limestone Formation. These quarries were particularly important fossil sites in the 19th Century (listed by Arkell *et al.* 1954, p. 17, as "Barton, N. Torquay"). The Lummaton Shell

Beds Member is the basal unit of the Middle Devonian (high lower to middle Givetian; Leveridge 2011, p. 684) Barton Limestone (terebratum Biozone; Scrutton, 1968, fig. 2, 1978, pp. 39-40). "In the N end of the working quarry lenses of shell bed can usually be found … packed with shells, mainly brachiopods but also including bivalves, gastropods, trilobites, crinoids, bryozoans, ostracods, conodonts and algae" (Scrutton 1978, p. 39). The crinoid fauna of these and coeval limestones in south Devon is dominated by *Hexacrinites* spp. (Whidborne, 1895 in 1889-1907; Donovan and Fearnhead in review).

The collectors

Again, the label makes a minimum comment concerning the identities of the collectors - "Whidborne ex Champernowne Coll." - but this is sufficient to indicate the association of the specimen with two notable 19th Century amateur collectors. We recommend Cleevely (1983) as an excellent first resource in tracing collectors who donated to museums, supplemented by Sherborn (1940) and Doughty (1981).

Arthur M. Champernowne (1839-1887), MA, JP, FGS, appears to have been the original collector. He belonged to an old established Devonshire family (Woodward 1887; Cleevely 1983, p. 80). Champernowne studied at Eton College and Trinity College, Oxford, where he attended lectures by Professor John Phillips. His geological pursuits included mapping, microscopic mineralogy, and the palaeontology of Devonian corals and stromatoporoids. He corresponded with many of the leading 19th Century experts on the geology of south-west England, including William Pengelly, John Lee and W.A.E. Ussher. Champernowne was a council member of both the Geological Society and Palaeontographical Society.

It was his passion for fieldwork that led to Champernowne's death. "It was after attending the Council Meeting of the Geological Society on May 11th, that he hurried down to Dartington intent on setting to work at once upon a revision of his maps, and having gone abroad in unfavourable weather, and suffering from a severe cold, he caught a chill which developed into inflammation of the lungs, under which he gradually sunk" (Woodward 1887, p. 384).

Champernowne gave the specimen described below to the Reverend George Ferris Whidborne (1846-1910), MA, FGS. Whidborne was author of the notable *Monograph of the Devonian fauna of the south of England* in three volumes and thirteen parts (Whidborne 1889-1907). He was "a man of considerable wealth" (Newton 1911, p. 89), and a generous benefactor to church institutions and scientific societies. Whidborne lived in Torquay for much of his life (Cleevely 1983, p. 307). His principal palaeontological interests were in the Devonian and Jurassic, particularly the molluscs. He was a member of the Malacological Society, and served on the councils of the Palaeontographical Society and Geological Society. He donated most of his private collection to the Sedgwick Museum.

Description

This specimen thus has notable historical associations, was collected from an important locality, but has not hitherto been documented in the scientific literature. This is presumably because it is a crinoid pluricolumnal, not the most popular of specimens amongst collectors or for scientific research (Donovan 1991). Yet CAMSM H3776 shows a number of features that are worthy of description and interpretation.

The specimen is a robust pluricolumnal of circular section (Figure 2); nodals are about 16 mm in diameter. The ends are broken, but faintly on one end and between internodals in lateral view it is apparent that articulation was symplectial, that is, by interlocking radiating ridges; these appear to have been short. The lumen was small and central, presumably surrounded by a circular, planar areola which would have supported ligaments attaching columnals. The pluricolumnal is heteromorphic, formed of two sorts of columnals and arranged N111. This means that each nodal columnal (N) is succeeded by three internodal columnals (more correctly, priminternodals). The nodals are moderately high, with convex, slightly nodose latera and are unsculptured. Internodals are all the same height, but are low, with planar, unsculptured latera.

Discussion

This rather battered crinoid pluricolumnal has now been accurately located stratigraphically, its historic associations determined and its morphology described. That it was not highly regarded is indicated by the lack of description in Whidborne (1889-1907). Is that all? No, the specimen itself poses certain questions and permits informed speculation. For example, the pattern of growth of this part of the stem can be determined. Growth of the crinoid stem proceeds by a series of identical columnals being generated immediately beneath the cup (=nodals). More distally, lower and more numerous columnals

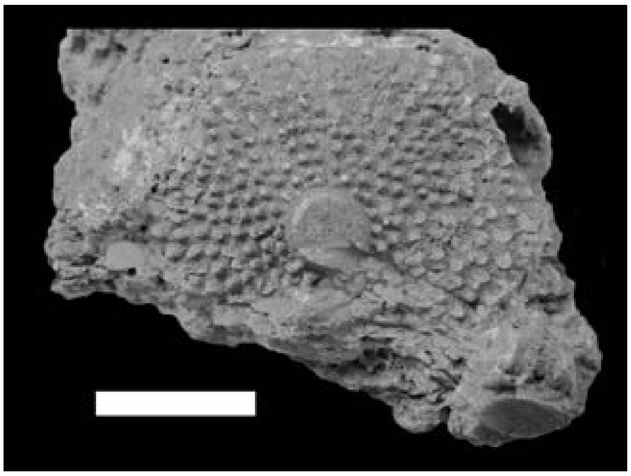

Figure 3. CAM SM H3390, **Hexacrinites interscapularis (Phillips),** ***from the Middle Devonian of Ogwell, near Newton Abbott, Devon. This incomplete basal circlet shows the narrow articular facet for the stem at the base of the cup, about 4 mm in diameter in this example, that is, only about 25% of the diameter of CAMSM H3776. Scale bar represents 10 mm.***

are commonly grown by insertion between the nodals; these are the internodals. These are differentiated on the basis of size; priminternodals (1) are highest, secundinternodals (2) are second highest and so on (Donovan 1984). In CAMSM H3776, nodals are separated from each other by groups of three internodals of equal size, that is, by three priminternodals. This arrangement is stable throughout the specimen, indicating that it represents part of the stem below the growing region, but N111 is an unusual arrangement; N212 is far commoner. The internodals increased the length of the stem and increased its flexibility.

The classification of the pluricolumnal presents few problems, at least to the generic level. The pluricolumnal is quite large and is thus derived from one of the two groups that include larger species, either a cladid (with a vase-shaped cup) or a camerate, with a theca commonly resembling a golf-ball. The observed features (and inferences) of the articular facet indicate that CAMSM H3776 probably belongs to the camerate *Hexacrinites* Austin and Austin. Eight nominal species of *Hexacrinites* are known from the Middle Devonian limestones of south Devon, based on features of the thecae. However, the stem facet at the base of a *Hexacrinites* cup is smaller than our pluricolumnal (Figure 3). This is because a specimen like CAMSM H3776 is derived from a more distal part of the stem where it had increased in diameter. *Hexacrinites* columnals typically have a narrow marginal symplectial articulation, a small central lumen and a diameter of about 15-20 mm (Donovan 2012). Such columnals are widespread in the Devonian of south-west England, but the stem of *Hexacrinites* from Lummaton remains neglected.

If this pluricolumnal represents part of the more distal stem of *Hexacrinites,* then its main function was

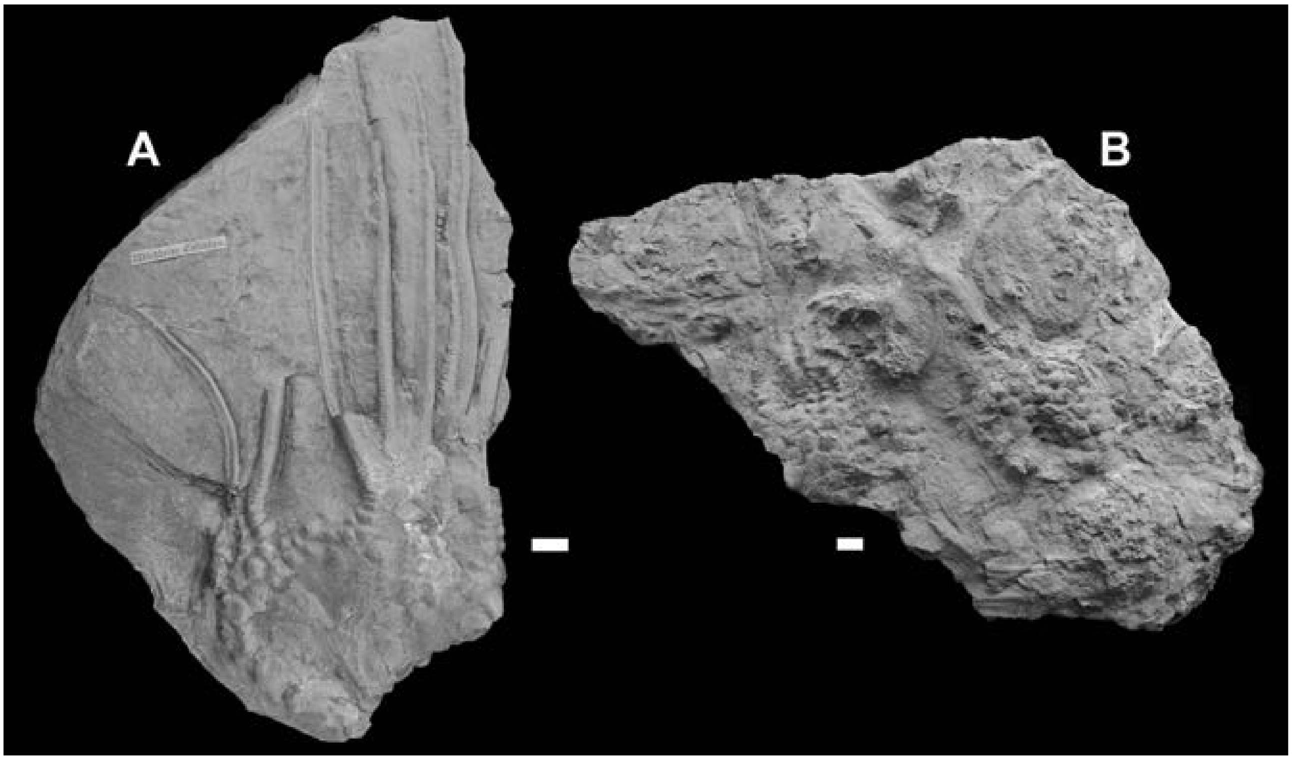

Figure 4. Camerate sp. A of Donovan and Fearnhead (in review, pl. 4, figs 9, 10), locality and horizon unknown. (A) CAMSM TN2508/1, part of a large, but incomplete crown. (B) CAMSM TN2508/3, two incomplete crowns with a third theca. Scale bars represent 10 mm. Specimens not coated for photography.

elevation; the symplectial articulation would have provided moderate flexibility through 360º. It was probably not part of the attachment structure, which most probably anchored to the substrate using root-like radices which are not seen in CAMSM H3776.

As a contrast, consider CAMSM drawer P1.13.2.1. The whole drawer is simply labelled "Palaeozoic. Miscellaneous. Whidborne Collection", and contains an assortment of trilobites, brachiopods, bivalves and crinoids. One rock chip rests on a torn piece of yellowing newspaper on which is written "Lummaton. Acidaspis?" The lithology of this chip is typical of the Lummaton Shell Beds Member, but the other samples in the drawer represent a mixture of lithologies. The label of the drawer tells us little, and the contents give the impression that this was Whidborne's 'junk box' of unloved and unwanted material. This is unfortunate, because the crinoids, if Devonian, are new to science (Donovan and Fearnhead in review, camerate sp. A; Figure 4 herein).

In conclusion, a fossil specimen must be supplemented by adequate supporting information - locality, horizon, collector, etc. - to enhance its value as a scientific object. These data are commonly provided by an associated label. CAMSM H3776 (Figure 2) is supported by two labels (Figure 1) which provide an apparent minimum of information, but the data thereon has enabled us to determine details of the locality, horizon and collectors. The specimen itself has provided morphological information that has supported informed speculation regarding function. Both the specimen and the labels were essential to give a complete view of the specimen. And, most importantly, the data on the labels could not be determined from the specimen. At best, recognising the pluricolumnal as Devonian would have followed from our identification of *Hexacrinites*, but similar fragments of crinoid stem are known from the Lower, Middle and Upper Devonian of south-west England. The preservation would suggest Middle Devonian, but such a determination would have needed stronger evidence.

A donor may not be intending to donate their collection to your museum immediately - by all means they should continue collecting and researching in the pursuit of scientific knowledge - but please make sure that they catalogue or label everything with clarity and detail now, not tomorrow, for you never know what's around the next corner.

Acknowledgements

We thank our reviewer, Dr. Patrick N. Wyse Jackson (Trinity College, Dublin), for his positive and perspicacious comments.

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DAVID FORBES F.R.S. (1828-1876): A CHEMIST AND MINERALOGIST WHO ADVOCATED FOR THIN SECTION MICROSCOPY

by Helen C Kerbey

Kerbey, H.C. 2013. David Forbes F.R.S. (1828-1876): a chemist and mineralogist who advocated for thin section microscopy. *The Geological Curator* 9 (10): 515 - 527.

David Forbes was a chemist and mineralogist who supported H. C. Sorby in the development of thin section microscopy. Employed initially by a mining firm he travelled extensively in Norway and Southern America. He advocated for a chemical understanding of geology, and argued profusely with field geologists about terminology and the importance of examining rocks using the microscope. His controversial letter writing combined with an early death perhaps prevented him from becoming well known today. He left an interesting collection of minerals at the Manchester Museum, though his thin sections are missing and it is hoped that publication of this paper will raise awareness of their importance, and help to locate them.

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Introduction

David Forbes was born on the 6th September, 1828 in Douglas, Isle of Man to a large family. One of his elder brothers was the eminent naturalist and geologist Edward Forbes (1815-1854). He was not directly related to the glaciologist James David Forbes (1809-1868).

David Forbes appears to have been fairly precocious - writing to his sister when 11 that he had finished a short history of the chemist W.H. Wollaston and was now working on Sir Humphry Davy (Anon 1877). He was at the University of Edinburgh by the age of 16 and such were his talents that he was immediately appointed to be Assistant Chemist. In 1846 he spent a year studying metallurgy with Dr John Percy (1817-1889) at Birmingham University then in 1847 began his career as an assistant to the nickel company Evans & Askin of Birmingham. Evans & Askin owned nickel mines in Norway and in 1848 Forbes joined Brooke Evans on a tour of them; shortly afterwards becoming their Norway manager. Over the next ten years he studied the mineralogy of that country, collected specimens, and produced papers including: 'On the chemical composition of some Norwegian minerals' (Forbes 1855a, 1857a) and 'On the Borders of the fossiliferous and so-called Primitive Formation and on the so-called Primitive Formation of the South Coast of Norway' (Forbes 1858). Field (1876) writes of Forbes' adventurous

Figure 1. Image of David Forbes. Image of a painting labeled on the back as by "Grace Baldry?". Grace Baldry's dates are 1866-1931 so she is unlikely to have painted David Forbes in the flesh. Either she copied another painting or the painting is actually by her father George Baldry. It closely matches George Baldry's style of portraiture work. The location of the original painting is unknown and attempts to trace it have been unsuccessful. The Royal Society #IM00/1488. A further image of a younger Forbes is known at the Museum of the History of Science, Oxford #46725.

nature, and his insensibility to fear. In Norway this manifested itself when he decided to organise an army of 400 miners in Espedal, north of Bergen, to aid the government against revolution. For this he was personally thanked by the Norwegian King.

In 1856 he became a partner in the nickel firm and started travelling and exploring further afield, particularly in South America. Then began a series of adventures from which he never really recovered. He became mixed up in a revolution in Santiago, was taken 'sort of prisoner' in Bolivia and escaped at night on a coal barge, allegedly using shirts for sails. He reached Copiapó in Chile and had to join the legion formed to protect the town. During this period he suffered many privations: "..*thirty-three nights in command, and never was in a bed or had my clothes off*" (Anon 1877) but afterwards managed to set out again to the Pitcairns and then to Brazil and Argentina where he arrived in Mendoza just after a large earthquake. Later, writing from Bolivia, he complains of being wounded by a bayonet during another revolution.

Around 1871 he returned to the UK and became Foreign Secretary to the Iron and Steel Institute, writing 6 monthly reports on the state of the industry abroad. He was elected Fellow of the Royal Society in 1856 and served as Secretary to the Geological Society between 1871 and 1876 (Herries Davies 2007).

Sorby's 'henchman' and supporting petrology

There are numerous obituaries of Forbes, most of whom are kind: Duncan (1877) writes of "*A great linguist, a most genial companion and loving friend, and a man possessed of great energy, he was wounded in spirit by the loss of his wife*." Anon (1877) states "*Being an old traveller, Mr. Forbes was a most entertaining and sociable companion, and his genial manner made him many friends wherever he went. His Home was the resort of men of science from all parts of the worlds, and a place where they were always certain of a kind and hospitable welcome.*" However J.M. (1877) hints at some controversy declaring "*his loss is keenly felt by those friends who really knew his genial and social character*".

One reason for some of the slightly circumspect comments was Forbes support for the new science of petrology. In 1851 Henry Clifton Sorby (1826-1908) published a paper (Sorby 1851) describing a new technique for examining very thin rock slices using polarising light microscopy. Many of the big names in geology at the time ridiculed the idea and famously claimed Sorby would learn nothing about mountains by looking down microscopes (Sorby 1897). Forbes appears to have seen the potential for this new technology and writes (Forbes 1867d) that he studied microscope slides sections prepared by the German Adolph Friedrich Oschatz (1812-1857) in 1852 and then received further training from Sorby on how to make them. The techniques and equipment required to be able to study specimens using polarising light microscopy were only just becoming widely available. Producing polarised light (where the light waves only vibrate in one direction) is the first hurdle, and then cutting a hard rock and grinding it until almost transparent is the next. Sorby and Oschatz were probably two of only a handful of people who persevered with this practice, and they seem to be the only people who demonstrated their results in literature (Sorby 1851, Oschatz 1852). When polarised light travels through a very thin rock slice it is diffracted and produces a characteristic optical pattern dependent on the crystal structure of the mineral it passes through. Thus it provides a very useful identification tool.

Forbes became very keen on microscopy and an advocate for Sorby and his work. Judd (1908) when writing about Sorby describes Forbes as "*a trusty henchman and doughty champion who ..... was always ready to take up the cudgels in Sorby's defence when, as was frequently the case, the new method was assailed or ridiculed*". One of the results of Forbes interest in Microscopy was a long article for *The Popular Science Review* in 1867 (Forbes 1867d). Entitled 'The Microscope in Geology' he wrote that: "*with the exception of Sorby's invaluable memoirs on some special points of enquiry, literally nothing has yet been made public which could even serve as an introductory guide to the geologist who might wish to commence the study of the subject. It is therefore with great hesitation, and only after much solicitation, that the author of these remarks has now ventured into print, with the hope that by once breaking the ice, others more capable than himself may be induced to communicate the results of their researches on the same subject.*" The article contains two plates with colour diagrams of microscope images of minerals in thin section, some of which are reproduced in Figure 2.

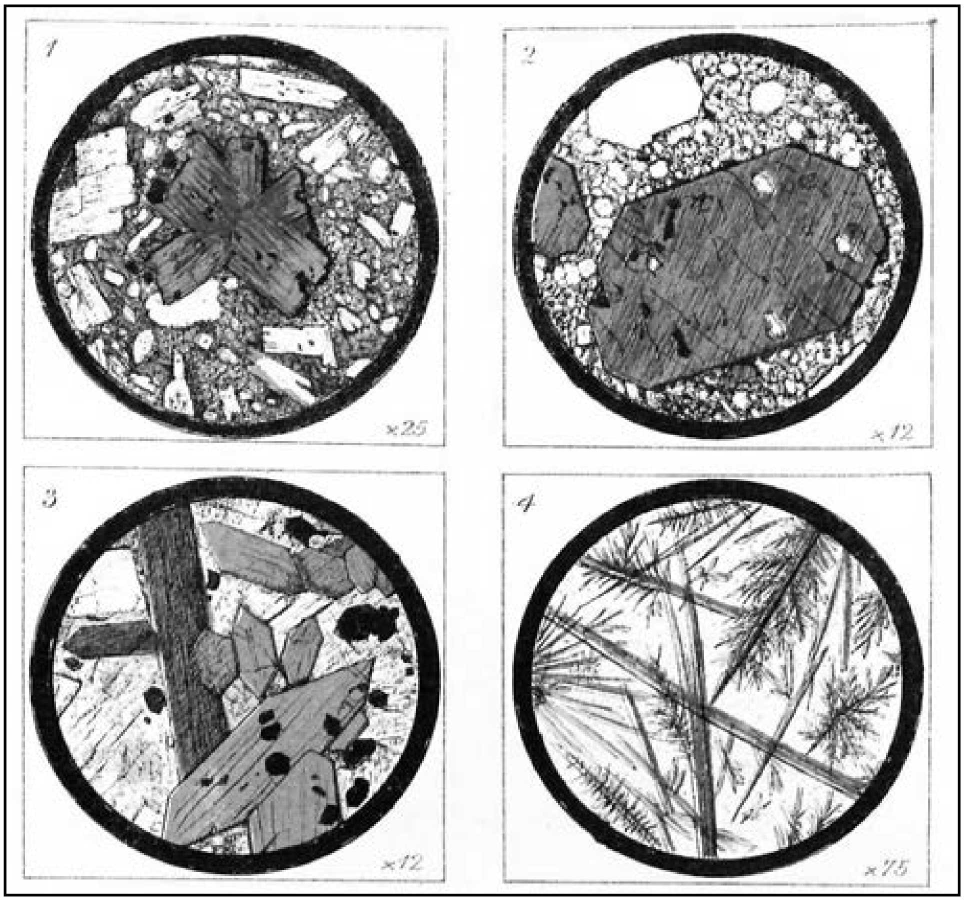

Figure 2. A colour plate from Forbes (1867d). Key: 1) Augite in lava from Etna lifted from the molten rock by Forbes using a pole on 21st May 1865. 2) Augite in lava from the Vesuvius eruption of AD79. 3) Pyroxene in a volcanic rock from Tahiti. 4) Green crystals in pitchstone from Arran.

James Geikie, granite and more arguments

The second likely explanation for the underlying tension lies in a series of correspondences in 1867 in the *Geological Magazine* and the *Chemical Journal* between Forbes, James Geikie (1839-1915) (the younger brother of Archibald Geikie, and then an Assistant at the British Geological Survey); and Dr Thomas Sterry Hunt FRS (1826-1892) (an American, and chemist to the Geological Survey of Canada).

Forbes' first letter (1867a) complains about two recent Geikie publications: Geikie (1866a) is a long paper describing some Silurian rocks in Ayrshire and hypothesising that they may have a hydrothermal origin; Geikie (1866b) on the other hand is a shorter work, much more narrative in style, and makes some comments that would suggest that there was some discussion between the men before this paper was produced (though Forbes (Forbes 1867a, p.58) claims not to have met Geikie). This paper concerns itself with a possible metamorphic origin for granites and other igneous rocks - an idea we know today to be incorrect. For example Geikie (1866b) writes: "*No disrespect for the work of the laboratory is implied in the belief that the question of the origin of granite and other allied rocks will ultimately be solved by the field observer. The labours of the chemist have been invaluable but experience is ever showing us that the chemical or mineralogical composition of a crystalline rock can not always be taken as a test by which to discover its geological nature*."

Forbes (1867a) writes bluntly about the "*rather startling statements embodied in these papers*", wondering if "*the papers here under consideration come up to the mark [since the] substance of the papers themselves does not prove the author to be much at home either in chemistry, mineralogy, petrology, or physics*". As for the origin of granite being solved by the field observer alone "*The progress of science demands that the geologist, also, shall no longer put his whole reliance in a pair of good legs, and plenty of field practice*". Forbes points out that Geikie's rather unlikely hypothesis would suggest that "*any stratified bed, like greywacke can by the wondrous activity of hydrothermal action be converted in situ into granite, minette, diorite, serpentine, porphyrite, etc., etc.,* "

Working on the geology of Scotland was a very difficult task, and the style of the article is one of Geikie just reporting on what he could see, and suggesting a possible reason for it, but he did make some errors that probably should not have got to publication. Forbes complains of Geikie's use of greenness to suggest the presence of magnesia: "*the chemist could have informed him it was due to iron*" and on writing about finding lime in rocks "*native lime is never found in the mineral kingdom*".

Of interest to curators of igneous rocks Forbes complains bitterly of Geikie's use of nomenclature: "*surely the petrologist will throw up his hands in despair when he finds Mr James Geikie defining minette as a quartzless granite; just as soon as he would expect to see limestone defined as a clayless marlstone or as a calcareous sandstone without the sand*" On the use of the term 'porphyry' he complains "*when used as an adjective, to imply a definite structure is understandable, as a porphyritic greenstone; but the terms felstone porphyry, felspar porphyry or felspathic porphyry sound rather tautalogical*." Further "*in investigations where exactitude is essential, trap is an extremely vague name to designate rocks by*" and "*such names are used as syenitic granite for hornblendic granite, augitic greenstone for dolerite, greenstone porphyry for porphyritic greenstone [...] rocks coloured as greenstones on the map of the Survey frequently turn out to be dolerites, felstones, altered clay slates etc. [...] whilst at the same time no explanations have been furnished by the Survey, whether mineralogical or chemical, for the use, or rather misuse of such names*." A glossary of some of the terms used are in Table 1.

Since many geologists at this time did not understand the origin of igneous rocks it had been the practice to name them in relation to their age as it was assumed that rock type was age dependent. For example this meant that basalts were called melaphyre if in older rocks and basalt if younger. Slowly, and especially with the aid of microscopic petrology, this idea began to lose hold. Forbes contributed to its decline by publishing an important work on the igneous rocks of Staffordshire (Forbes, 1866). He examined fifteen rocks and found many of them were identically composed of ilmenite, plagioclase and augite (therefore a dolerite) despite being been named: white rock trap, basalt, greenstone, trap, felspathic rock, green rock, white horse, and Rowley Rag. Forbes continually wrote about the lack of systematic nomenclature in naming these rocks and how a good understanding of chemistry and thin-section petrography could help explain so much. It took about ten more years of argument, petrography and chemistry before most geologists accepted that igneous rocks were formed by magma with varying degrees of heat and pressure producing different varieties.

Meanwhile Geikie replied (Geikie 1867a) in a more humble manner than Forbes' outburst: "*I have looked over my paper [...] and must own that I have been careless and unguarded in the use of chemical phraseology*." He complains that Forbes has stretched his meaning several times and that he never claimed that any stratified bed could be converted into granite. As for all the rock names, Geikie points out all the other geologists who use them with no problems in understanding what was meant. As a final shot he states how unnecessary it was for Forbes to list all the countries he had visited, languages he spoke, rocks he had seen, to prove that he knew what he was talking about. Forbes cannot resist replying again (Forbes 1867b) arguing that even though other geologists use the varied rock names it was his view that this is not good enough and there should be a standard nomenclature. Geikie (1867b) replies one last time suggesting that if Forbes isn't happy with nomenclature then he should "*render [his invaluable store of knowledge] available for the edification of the geological world.*"

By this time Forbes has moved on to the American geologist and chemist Dr Sterry Hunt and his publications. In Forbes (1867b) he writes "*the arrival of Dr Sterry Hunt in this country has procured me the pleasure of his personal acquaintance [...] showed me how many similar*

Trap	Used imprecisely for volcanic and medium grained rocks of basaltic composition.
Felstone	Used originally for a microcrystalline variety of felspar. Then for microcrystalline ground mass of porphyries, now for microcrystalline rocks of granitic composition.
Porphyry	Various uses in different forms: porphyrite, porphyrin, but became a general term for any igneous rock that contains phenocrysts in a finer grained ground mass. Note: this does not tell you the composition of the rock only its texture.
Greenstone	Used for a green rock in many different settings. Most commonly used to describe metamorphosed basalts.
Minette	Originally oolitic iron stones. Now a variety of lamprophyre with biotite, hornblende and orthoclase. An officially recognised standard term.

Table 1. Glossary of some igneous rock terms complained about by Forbes, from LeMaitre (2002).

conclusions we had respectively come to". After reading Hunt's work though he seems to have changed his mind: Hunt authored a badly edited paper in the Geological Magazine (Hunt 1867) due to it being transcribed from a talk he gave, but alongside these printing errors his theories on quartz and granite kept Forbes going for several years, with more correspondence in the Chemical News. (Hunt believed that quartz was a low temperature mineral requiring water, implying all granites were sedimentary). Brock (1978) describes these arguments as being about whether it was more important to be a geological chemist (as Hunt advocated) or, as Forbes believed, a chemical geologist. The letters between the two men were more personal than those with Geikie including for example Hunt (1868): "*those who make many pilgrimages rarely become saints*" being returned by Forbes (1868) with "*Curses like chickens come home to roost*".

These arguments made it into other parts of the press. The Day Star- "A monthly magazine devoted to the revival of religion" - describes the argument between Forbes and Geikie about metamorphic and igneous rocks (J.K. 1867) and concludes "*let all young readers have patience. Geology, like all other 'ologies' must pass through the fire of controversy seven times or more yet, and then we shall see how much is left of the thing*".

In 1872-3 he had a similar correspondence with Robert Mallet in *Nature* (Forbes 1873a, 1873b; Mallet 1873a, 1873b) about Volcanoes. Firstly Forbes provided a critical book review of Mallet's translation of "The Eruption of Vesuvius in 1872" (Mallet 1873). The original Italian pamphlet was an important report by Professor Palmieri who "s*o courageously stuck to his post in the Observatory [...] when that building actually stood between two torrents of liquid fire*" (Forbes 1873a, p. 259), however Mallet chose to preface his edition with an introductory sketch containing his theories on 'vulcanicity'. Forbes review (Forbes 1873a), like others of the book (e.g. Anon 1873) states that he does not like the style of Mallet's introduction as it does not list the works of others on volcanoes, and it makes the pamphlet too long and unaffordable. Mallet's reply and the subsequent letters between the two gentlemen go into a little detail about the source of volcanoes but spend most of their time arguing over whether Mallet's work is published, whether anyone will agree with him, and whether he should mention other theories and not just his own.

One mistake Forbes appears to make is to state that "*volcanic products [...] are all identical in chemical or mineralogical constitution*" (Forbes 1873a, p. 261) Mallet spends several paragraphs (Mallet 1873a, p. 383) explaining that this is not correct. Forbes does not acknowledge any error in reply but instead makes statements that are broader: "*as regards the mineralogical and chemical constitution of unaltered volcanic rocks [...] they are essentially made up of a very limited number of mineral species*." and then "*are the ancient basalts identical with each other in different localities? [...] they are identical in mineralogical and chemical constitution, and often even approximate closely in percentage composition.*" (Forbes 1873b, p. 363.) Other papers by Forbes do not contain mistakes of this nature so it is interesting to see that he does not acknowledge the error, even though Mallet repeatedly comes back to the statement, instead he re-writes his views to apply to ancient basalts alone. It is unlikely Forbes believed that **all** volcanic rocks were the same having examined many of them. However, since his work (e.g. Forbes 1866) had shown that many older rocks believed to be different were in fact mineralogically similar, it is more likely that he did not explain his first statement very clearly and meant to apply it to basalts alone.

In 1861, David Forbes, having returned from South America, was hoping to be appointed as Her Majesty's Representative in Bolivia. On 20th October 1860 he wrote to Lord John Russell, Her Majesty's Secretary of State for Foreign Affairs (Forbes 1861b) to explain the trade situation in Bolivia and to ask for an official appointment (not explicitly for himself) to be made. In the published pamphlet he provided a memorandum on the mineral wealth of Bolivia along with a summary of the present state of Bolivian affairs. According to Forbes there was no representative of HM Government in Bolivia, and even the various appointees to the consulate had not officially presented themselves since 1853. There was a real possibility of the trade starting to move towards the USA. The reply came from Lord Wodehouse in November 1860 "*Lord John Russell is not of the opinion that it is not necessary to revive that appointment*" (Forbes notes the double negative is probably a mistake). Despite Forbes asking again if Lord Russell could personally attend to the matter, especially since one of the last embassy incumbents was so "*strange as to confirm the suspicion of mental derangement*" the appointment was not made.

Forbes corresponded with a number of other geologists about publications, and viewpoints. Those known about to date are listed in Appendix A. Charles Darwin asked him a few questions relating to the wildlife of Chile and Forbes asked Darwin about aspects of his anthropology paper (Forbes 1870b) however none are as combative as those with Geikie, Hunt and Mallet.

Minerals discovered by Forbes

While working on Norwegian minerals Forbes described and named a new mineral: tyrite after Tyr the Norwegian god of war, since the discovery was about the same time as "the commencement of the present war" (Forbes 1855a). Blow pipe analysis showed it to be a "hydrous columbate of yttria" which would be described as hydrous yttrium niobate using today's nomenclature. Unfortunately, after some discussion about the water content (e.g. Forbes 1857b), it was shown to be the same as the mineral fergusonite (Y), or $YNbO_4$.

In 1863 Forbes described a new Chilian [sic] mineral with a possible formula of $(NiO+CoO)^2(AsO_5)$ +8HO (Note this is his formula based on knowledge of chemistry at the time; it should have been written $(NiO+CoO)^2(As_2O_5)+8H_2O$ which becomes the more compact $(Ni,Co)^2(AsO_4)_2.H_2O$). He does not name the mineral in this paper (Forbes 1863) - it was subsequently termed forbesite by Kenngott (1868), however later research (Braithwaite, 1982) found the original type specimen in the collections at Manchester Museum labelled "Chanaralite (new species Forbes), a Hydrous Bibasic Arseniate of Nickel and Cobalt, near Chanaral, Desert of Atacama, Chile, South America" (Figure 3). Braithwaite (1982) showed the specimen to be a cobaltoan annabergite i.e. between annabergite $Ni_3(AsO_4)_2.H_2O$ and erythrite $Co_3(AsO_4)_2.H_2O$ and proved that it was not, unfortunately, a new mineral species.

Forbes named another mineral evansite after Brook Evans, the owner of the nickel firm that he worked for (Forbes 1864) since Mr Evans gave him the specimen from Hungary. Forbes reported the results of his analysis as a hydrated aluminium hydroxy phosphate $3Al_2O_3.PO_5+18HO$. Evansite is amorphous so determination of it's exact formula is difficult, however it is recognised by the International Mineralogical Association with the formula: $Al_3PO_4(OH)_6.8H_2O$.

Another specimen given to Forbes for analysis was a copper arsenide from Copiapo, Chile. This he analysed and determined to be a new mineral that he named darwinite in honour of a man "*whose admirable geological examination of this part of South America is so well known as to require no comment*" Forbes (1860). Forbes' original sample has yet to be re-examined (it is not in the catalogue at Manchester Museum as darwinite, but may be databased under a different name), but it is generally thought that darwinite is a synonym of whitneyite (Cu_3As) that was described two years earlier (Brush 1861).

Other notable publications:

Forbes authored more than fifty scientific papers for geological and chemical journals before his untimely death. Some of his more notable chemical papers not already discussed that show his interests and abilities include 'On the determination of Copper and Nickel in Quantitative Analysis' (Forbes 1853), and on the 'Effects of Chlorine in Colouring the Flame of Burning Bodies' (Forbes 1856) and an important series on blowpipe analysis of minerals (Forbes 1867c).

As well as publishing findings from his travels (e.g. On the Geology of Bolivia and Southern Peru (Forbes 1861a)) he became keen on igneous and

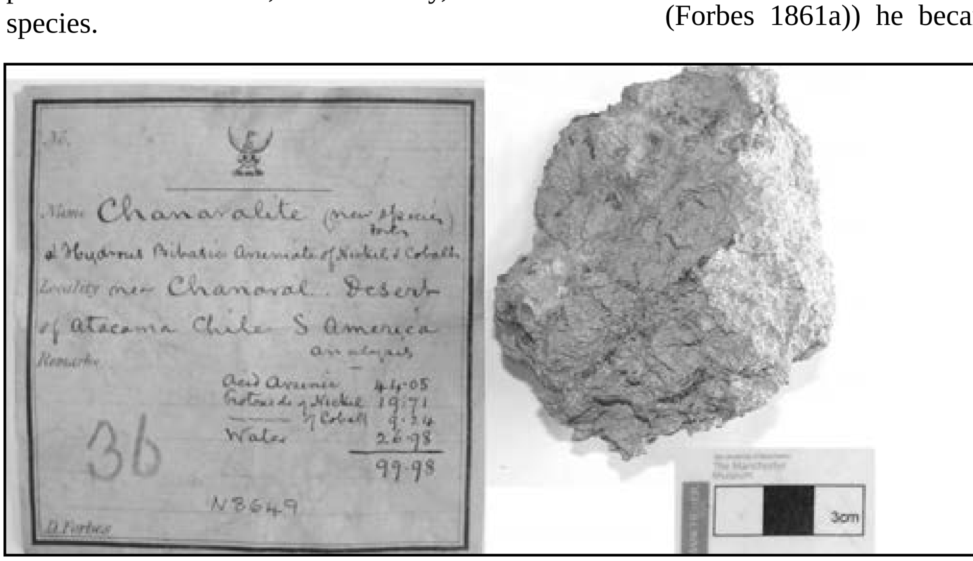

Figure 3. Chanaralite, the mineral analysed by Forbes but later discovered to be cobaltoan anabergite. Photo: David Gelsthorpe, Manchester Museum. Specimen No. MANCH:N8649.

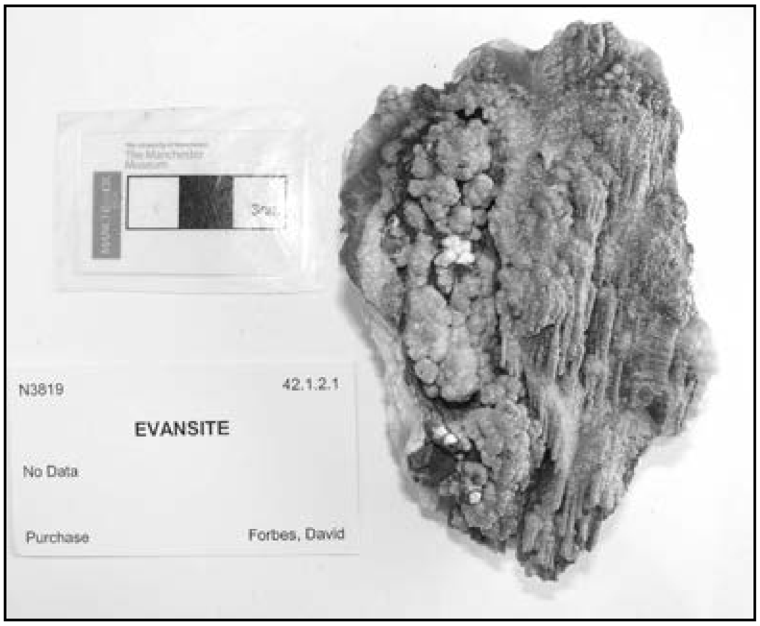

Figure 4. A specimen of evansite in the Forbes collection (MANCH:N3819). Photo: David Gelsthorpe, Manchester Museum.

metamorphic phenomena and conducted his own experiments using high temperatures and pressures such as in Forbes (1855b) and Forbes (1870a).

During his last few years he became Foreign Secretary of the newly formed Iron and Steel Institute (1871-1876) and prepared copious notes on the iron and steel industries in developing countries. Along side his mineralogical interests he was also interested in ethnography. He was a very a good linguist and found it easy to secure the confidence of the native peoples he met. Like many scientists of his time he corresponded with Charles Darwin, particularly asking for comments on his paper on the Aymara Indians of Bolivia and Peru (Forbes 1870b). (See appendix A for more details.) He also appears to have applied for some early patents as his name appears in some of the *London Gazette* in 1870 as a Consultant Mining and Metallurgical Engineer registering an invention of 'improvements in the manufacture of artificial manures'. No further details of this invention has yet been found.

His health, character, and early death

Field (1876) gives a great detail on the adventurous nature of Forbes in his obituary. Forbes would make up his mind in an instant and head off to remote parts of the world, his 'iron frame' seemingly helping him survive deserts, many nights of sleeping on the ground, the hardships of travelling on horseback in the hot sun, and being swept out to sea in a small boat. The cause of his death is given with varying degrees of detail but it seems that he went rapidly into decline. His last years were described as "*[Forbes] took but little physical exercise, and it is probably that his too sedentary habits, together with a sad domestic loss he had recently suffered depressed his spirits and broke up a constitution already to some extent enfeebled by intermittent fever caught in South America*" (Anon 1876). Sorby (1877) explains 'the death of his wife in the early part of the year was to him a sad blow to which he never recovered." Harrison (1889) notes: "during his later years Forbes was so entirely absorbed in his literary and scientific pursuits that he neglected to take sufficient exercise; the death of his wife, to whom he was profoundly attached, caused him to suffer severe mental trouble". Julia Elizabeth Camilla Forbes died on 28th March 1876, and he survived her for less than ten months, dying at home on 5th December 1876, of recurrent Malarial Fever (Anon 1876) that he had originally contracted in Peru (Brock 2004). He was buried at Kensal Green Cemetery, London with his wife and four of their children.

His Collection

He was an expert blowpipe-operator and his house in London (11 York Place, Portman Square) contained a laboratory, along with an extensive library. By all accounts he had a great deal yet to publish and had numerous notebooks. J.M. (1877) wrote that "*his cabinets are replete with abundant and carefully selected rocks and minerals, all intended to illustrate the association, paragenesis and mode of occurrence of minerals in connexion with the origin and formation of the rock-massess or mineral veins in which they are found imbedded*." Forbes hand specimens went to Owens College and are now housed by Manchester Museum, and of those that I have seen, none of them stand out in any aesthetic way, and have clearly been collected for content and studies of paragenesis. There are a total of 1521 specimens on the database in the David Forbes collection. Appendix B gives some more details about the minerals represented and the locations they are from.

Figures 5 and 6 shows some further specimens and labels in the Manchester Museum collection. The labels often contain the results of chemical analysis, and also record the collector/donor. Forbes' own are marked with a D. The M Attwood marked on some of the gold specimens is most likely Melville

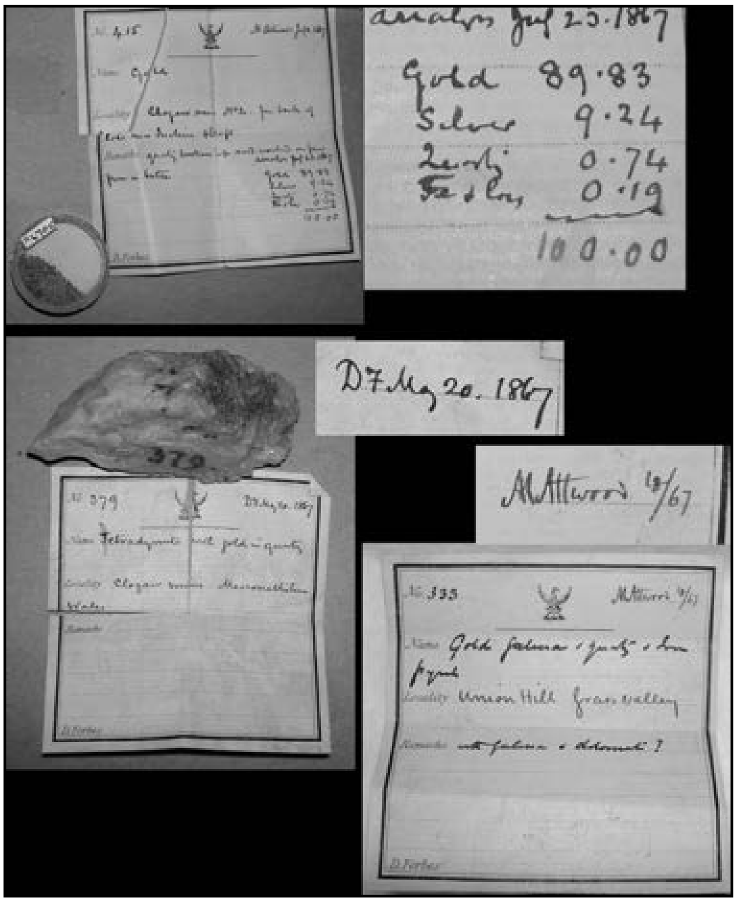

Figure 5. A collection of Forbes specimens and labels from Manchester University. Clockwise from top left: Specimen of Clogau Gold (MANCH:N6700) from M. Attwood with Forbes' label detailing chemical analysis. Another Forbes label documenting a specimen of gold from Union Hill, Grass Valley, also donated by M. Attwood (MANCH:N6242). Tetradymite with gold in quartz from Clogau Mine, Merionethsire, Wales (MANCH:N6673) with a D label.

Figure 6. Phosporite from Mina San Jose, Cerra do los Romanos, Extramadura, Spain (Specimen No. MANCH:N8668). An example of the 'massive' rather than crystalline mineral specimens preferred by Forbes. Photo: David Gelsthorpe, Manchester Museum.

Attwood (1812-1898). Attwood set up one of the first gold mills in California at Grass Valley (Attwood 1898) and won a medal from the State of California. He was born in Worcestershire but moved to California in order to improve the health of his wife Jane Alice Forbes - the sister of David Forbes.

Forbes' collection of thin sections "above 900 sections of crystalline and metamorphic rocks from about 480 localities" (Forbes 1867a, p. 50) appears to have been lost. Judd (1908, p. 201) writes that Forbes sections were preserved in the Manchester University, though unfortunately attempts to locate them have been largely unsuccessful so far. A single section has been found taken from one of his specimens and is shown in Figure 6. It is not known for certain whether this is an original Forbes but is seems unlikely. The writing is dissimilar to that in Forbes' letters and the label style was commonly used in the 1960's. The section is a standard shape and size while in comparison, Sorby's early hand made sections are on square glass slides (they are all housed at Sheffield University).

Forbes is described as a "careful collector, a most painstaking note-taker, and an admirable analyst" (Duncan 1877) but his early death meant he left a great deal of work unfinished. Manchester University library has books from his collection but on enquiry only one manuscript item has yet been found: A chemical analysis notebook from 1849-1850 recording experiments on nickel oxide using porcelain and platinum crucibles. (pers. comm. Manchester University Library reference: 1165931).

A catalogue of specimens in the Dr John Percy (1817-1879) collection (Blake 1892) implies that Forbes also provided numerous samples of slag from Norway to the metallurgist. The exact phrase used is 'communicated by David Forbes' but it is unlikely that his means anything other than 'given by' in this context. Dr Percy's collection is now at the Science Museum and those relating to Forbes are detailed in Appendix B. Enquiries have revealed no other paperwork relating to this collection and David Forbes.

The Natural History Museum, London has two minerals collected by Forbes: Tourmaline

Figure 7. A thin section of a Sanidine trachyte in Manchester Museum (Specimen No. MANCH:M7785) cut from a hand specimen (right) collected by Forbes from Monte Vetta, Ischia, Italy. The handwriting does not match that of Forbes and the label style suggests it was manufactured much later and is not an original Forbes section. Photos: David Green Ex. Manchester Museum.

var. taltalite from Taltal, Atacama, Chile (BM1985, M1632) and Bismuth from Sorata, La Paz, Bolivia (BM1985, M1788). Also present is a fossil conulariid called *Conularia forbesi* (PG 4461). The catalogue (Sendino and Darrell 2008) labels the donor as: Geological Society of London (David Forbes Collection), 1911. Despite enquiries to both institutions no more information can be found about this collection. A second David Forbes was a member of the Geological Society from 1901-1909 but since the conulariid comes from Bolivia this strongly implies that it was from David Forbes F.R.S.

Searches of census records show that Forbes' wife was from Poland and that they had at least eight children before she died. After Forbes' death the surviving children lived with two widowed women, one of whom was Forbes' sister-in-law, the other his sister. Four of these children died young apparently leaving only Edmund Forbes as the male heir, and it would appear from the records that his only heir David Kenneth Forbes died in 1909. Though boxes of collections and note books are sometimes found in notable houses it is very unlikely that anything not obtained by the scientific world at the time of David Forbes death will now ever be found.

Conclusion

David Forbes had an eventful life, published many papers, and was into controversial letter writing. His chemical approach to geology helped the science of petrology to become mainstream, though it is a shame so many of his new minerals have turned out to be already defined. His early death meant his promised great work on petrology was never written and probably precluded him from becoming a "Geological Name" known to many of us. It is hoped that this publication may reveal more of Forbes specimens and archives in other institutions.

Acknowledgments

I am grateful to all the people who have helped me access Forbes material. In particular David Green and David Gelsthorpe at Manchester Museum where many of Forbes' specimens are stored.

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Appendix A. Letters in various collections.

A1. Letters relating to Forbes in the Darwin Collection

2621 Forbes to Darwin 11 Dec 1860 About Chile, horses, sheep and glaciation in the Andes

3019F Darwin to Forbes 11 Dec 1860 Various discussions for new edition of Origin of Species

6002 Darwin to Forbes 20 Mar 1868 Ideas of human beauty by natives who have little association with Europeans.

6054 Forbes to Darwin 26 Mar 1868 Blushing in South American Indians, hairlessness of Aymaras and Quechuas

6584 Forbes to Darwin 30 Jan 1869 Thanks for Jenzsch's book. It is "consummate rubbish"

6606 Darwin to Forbes 7 Feb 1869 Re: Jenzsch "I dare say the man is mad."

7228 Forbes to Darwin 13 June 1870 Completed work on the Aymara Indians of Bolivia. Has data for CD's work on Man

7291 Forbes to Darwin 30 July 1870 Would much like CD to contribute a note for insertion after his paper on Aymara Indians.

7292 Darwin to Forbes 31 July 1870 Thanks for proofs of paper on Aymara Indians.

7487 Forbes to Darwin 18 Feb 1871 Thanks for copy of Descent.

8075 Darwin to Forbes 18 Nov [1871] Turf coverings and disintegration of rock

8081 Forbes to Darwin 22 Nov [1871]Turf coverings and the weathering of rocks

8233 Forbes to Darwin 1 Mar 1872 Information on composition of chalk at Shoreham and Folkestone.

A2. Miscellaneous letters

Forbes to Geikie. Correspondence over his late brother - Edward Forbes - Memoir. Source: University of Edinburgh http://www.nahste.ac.uk/cgi-bin/view_isad.pl?id=GB-0237-Sir-Archibald-Geikie-Gen-524-3-11&view=basic.

Forbes to Sorby. 24th March 1855. Hasn't yet met Sorby but fully agrees with him. Thanks for Sorby's paper and will send own foliation paper soon. Source: Thackray (2003) To See the Fellow Fight. BSHS Monographs 12 (Item No. 203a)

Forbes to ? 30 July 1870. Note of thanks for a sample of chalkosiderite. Addressed to Dear Sir. Source: The Waller Manuscript Collection. Uppsala Universitet http://waller.ub.uu.se/19690.html

Appendix B. Specimens relating to David Forbes

B1. The Percy Collection at the Science Museum in London

Specimen No.	Description
1889-164/2403	Alloy of aluminium and copper. Communicated by D. Forbes, 1857
1889-164/2472	Nickeliferous pyrites from Espedal, Norway. Communicated by D. Forbes
1889-164/2476	Crystallised nickel speiss, from Espedal, Norway, communicated by D. Forbes
1889-164/2477	Crystallised matt and speiss of nickel, from Espedal, Norway, communicated by D. Forbes
1889-164/2487	Blast furnace slags, from Espedal, Norway, communicated by D. Forbes
1889-164/2488	Crystallised slag, from the smelting of nickel ores in a reverberatory furnace, communicated by D. Forbes
1889-164/2489	Crystallised slag, from melting nickeliferous iron pyrites in a blast furnace with coke, from Espedal Works, Norway, communicated by D. Forbes
1889-164/2496	Crystallised nickel regulus from a furnace bottom. Espedal Nickel Works. Communicated by D. Forbes
1889-164/2497	Crystallised basic sulphates from a furnace bottom. Espedal Nickel Works, Norway. Communicated by D. Forbes
1889-164/2500	The rock from the bottom of a nickel furnace at Espedal, communicated by D. Forbes
1889-164/2501	Rock from the bottom of a nickel furnace, Espedal, communicated by D. Forbes
1889-164/2502	Mass of sulphide of iron, showing crystalline cleavage surfaces. Communicated by D. Forbes, from the nickel furnaces of Espedal, Norway
1889-164/2503	Miscellaneous specimens from the Nickel Works of Espedal, Norway, communicated by D. Forbes
1889-164/2504	Sulphur obtained from the roasting heaps at the Nickel Works of Espedal, communicated by D. Forbes
1889-164/3021	Blast-furnace slag from smelting ores containing titanium at Espedal, Norway, communicated by D. Forbes
1889-164/3043	Intermediate slag from the hot-blast-furnaces of L'Esperance, Seraing, Belgium, communicated by S.H. Blackwell, analysed by D. Forbes
1889-164/3037*	Basic slag, Russell Hall’s Iron Works, Dudley, S. Staffordshire
1889-164/3039*	Cold blast furnace slag from Philip Willim’ Iron Works, Wednesbury Oak, Tipton, Staffordshire
1889-164/3060	Blast furnace slag from the Oldsberger furnaces on the Rhine, obtained from M. Krantz, analysis by D. Forbes
1889-164/3070	Blast-furnace slag from Espedal, Norway, communicated by D. Forbes
1889-164/3072	Old slag from a blast-furnace at Julsrudalen, Norway, communicated by D. Forbes
1889-164/3073	Slag from old Norwegian bloomeries, communicated by D. Forbes
1889-164/3321	Iron finery slag from Cujo, showing a crystalline surface, communicated by D. Forbes

Table B.1 Samples relating to the David Forbes in the John Percy collection at the Science Museum, London. Presumably 'communicated by' means the same as donated. See No. 3043 and 3060 for two samples analysed by Forbes. *Two samples in the Science Museum collections that are listed in the Catalogue as having been analysed by David Forbes, but do not have this detail added to the Science Museum database. The catalogue was published as BLAKE, J.F. 1892.* Catalogue of the collection of metallurgical specimens formed by the late John Percy Esq MD FRS now in the South Kensington Museum*. Department of Science and Art of the Committee of Council on Education. Eyre and Spottiswoode, London. pp. 458.

Mineral	Count	Mineral	Count	Mineral	Count
Aegirine	11	Copper	17	Ore sample (gold)	14
Amphibole	34	Covellite	11	Ore sample (silver)	17
Apatite	44	Cuprite	12	Orthoclase	38
Arsenopyrite	12	Diopside	10	Pentlandite	16
Atacamite	11	Domeykite	10	Pyrargyrite	10
Augite	15	Feldspar (group)	24	Pyrite	14
Bismuth	14	Galena	26	Pyrrhotite	13
Bismuthinite	10	Garnet (group)	17	Quartz	13
Bornite	19	Goethite	23	Scapolite	47
Cassiterite	14	Gold	40	Silver	36
Chalcocite	23	Hematite	59	Skutterudite	13
Chalcopyrite	40	Magnetite	36	Sphalerite	11
Chlorargyrite	17	Meteorite	10	Tetrahedrite	17
Chrysocolla	27	Mica (group)	11	Vesuvianite	10
Cinnabar	10	Oligoclase	15	Zircon	34

Table B.2. The top occurring mineral types in the collection of 1521 specimens. Specimens are listed where they occur ten times or more in the collection, in alphabetical order. Note: some of these are generic names such as ore sample, and ten specimens are meteorites.

Location	Count
Norway	395
Europe total	860
Bolivia	79
Chile	302
South America total	401

Table B.3 Collection locations of interest from a total of 1521 specimens:

ACC No. MANCH:	Mineral	Location	Status of mineral.
N08594	Ammiolite	Andacollo Coquimbo, Chile	A doubtful mineral - probably a mixture of cinnabar and a copper antimonate. Occurs as an alteration product of mercurian tetrahedrite.
N06572	Chilenite	Mina Discubridoria de San Antonio, Copiapo, Atacama, Chile	Mixture of cuprite and silver
N08039	Chrome-ochre	Siberia	An aluminosilicate of Cr - doubtful
N03996, N03998	Erdmannite	Stokoen, Langesundfjord, Telemark, Norway	Two different erdmannites documented from Norway. An inadequately described mineral
N04000		Finderstat, Klokkerholm, Langesundfjord, Telemark, Norway	probably related to melanocerite-(Ce) OR an inadequately described borosilicate.
N04110, N04116	Gillingite	Gillinge Iron Mine, Sweden	An ill-defined silicate of ferric iron.
N03786	Hjelmite	Sweden	Inadequately described/studied. A doubtful species possibly related to tapiolite or samarskite.
N11328, N18724	Polyhydrite	Breitenbrunn, Saxony, Germany	An amorphous(?) aluminosilicate of Fe and minor Mn. Questionable/doubtful.

Table B.4 List of some specimens with mineral identifications that require further analysis. The relatively large number of these obscure specimens in the collection shows the interest Forbes had in chemistry and mineralogy. Mineral status descriptions are taken from Mindat.org

B5. Specimens in the Natural History Museum of London:

Tourmaline var. taltalite from Taltal, Atacama, Chile (BM1985, M1632) donated in December 1864
Bismuth from Sorata, La Paz, Bolivia (BM1985, M1788) donated in June 1865

QUANTITATIVE ASSESSMENT OF PERCEIVED VALUE OF GEOLOGICAL COLLECTIONS BY 'EXPERTS' FOR IMPROVED COLLECTIONS MANAGEMENT

by Jane Robb, Catherine Dillon, Mike Rumsey, Matija Strlic

Jane Robb, Catherine Dillon, Mike Rumsey, Matija Strlic 2013. Quantitative Assessment of Perceived Value of Geological Collections by 'Experts' for Improved Collections Management. *The Geological Curator* 9 (10): 529 - 543.

Through application of an attitude questionnaire this research explored expert stakeholders' values associated with geological collections. Six values were identified using exploratory factor analysis:

- Personal/Inspirational
- Uniqueness
- Originality/Historic
- Educational/Future
- Aesthetic/Commercial
- Information

All values except Aesthetic/Commercial heavily rely on 'contextual information' associated with a specimen, but not directly contained within the specimen (such as where the specimen was collected, by whom and when, storage objects, notes and labels), indicating the object is formed of the specimen and its contextual information.

An analysis of trends of agreement with these values showed that museum/heritage and academic professionals tended to strongly focus on contextual information in comparison to those working in a geological industry or company.

The findings were applied to a case study using the Russell Collection at the Natural History Museum (London), where a randomised collection survey was carried out. The research indicates that along with the specimens themselves, it is just as important to ensure that associated contextual information contributing to Personal/Inspirational, Originality/Historical and Uniqueness Values are preserved as part of the collection.

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Introduction - The Theoretical Construct of Value in the Field of Heritage

Values attributed to heritage depend on the use and type of heritage (Avrami *et al.* 2000; Baars 2011), which may be defined by material, form, location, spatial configuration, use, cultural association and meaning (Kerr 2007). Material is not preserved for its own sake, but to maintain the values it embodies, and identification of these values helps to inform us of how to best preserve them in the form of the physical object (Avrami *et al.* 2000).

The concept of value is highly subjective, and is defined by how stakeholders use specimens and remember the past and present, in the act of valuing (appreciation of value already attributed) and valorising (attributing new value to an object; Avrami *et al.* 2000). The fact that valorisation is possible means that values are constantly changing and evolving (Kerr 2007). The Natural History Museum's (2003) acquisitions policy is a good example of the transient nature of values, as the museum looks to acquire specimens that reflect current research and might be 'valued' more than certain older specimens.

Lowenthal (1994) explains how what is perceived as 'damage' to an object can become part of its value. To date, there has been substantial work (Waller 1984, 1992; Nassau 1992; Howie 1992; King 1986) dealing with physical degradation in specimens, but little on how this affects value. Baars (2011) has also touched on how human intervention such as (destructive) sampling can affect the value of specimens. However, the question of whether degradation or absence of labels and other associated historical and scientific data commonly stored alongside the physical geological specimens can affect value, remains poorly analysed.

Understanding and Measurement of Value in Heritage

Methods have been developed for measuring value and significance of collections, where significance can be defined as the derivative assessment for decision making (Carter and Bramley 2002). Valuation surveys undertaken on natural history collections (Baars 2011; REM 2010; Krikken 1995) are commonly created with a set of standard 'pre-defined' values against which the collections are holistically measured. Torre *et al.* (2002) and Mason (2002) discuss the most common methods for assessing heritage value including ethnographic surveys, interviews, gathering of oral histories and other participatory approaches; or economically revealed preference and stated preference methods. The use of economic methods is disputed as it is recognised that monetary value cannot effectively reflect the range of values associated with heritage, such as spiritual or personal. The ethnographic approaches rely on qualitative approaches, which, although they produce good 'thick' descriptions of embedded cultural values and practices (Holliday 2007), they do not allow for reaction to (predicted) material or economic change which may affect the way in which objects are valued. However, value is not a concept to which the quantitative approach could be easily applied (Mason 2002).

The Need for Quantitative Examination of Value in Geological Heritage

Heritage stakeholders can broadly be split into 'experts' and 'non-experts' (Swensen 2012). At the core of this may be the idea that local, public or 'insider' knowledge is intangible and embedded in local knowledge, practices, expressions and skills, while tangible knowledge is held by 'experts' who understand the material object and make the decisions on what to preserve (Swensen 2012). Even within the realm of 'experts' there may be differences in values and these are expressed in their mission statements and research policies (NHM 2010; London National Gallery 2010). Scientists, artists and scholars may use the same collections but may have different needs. Kerr (2007) also notes that a more developed understanding of one facet of value in heritage, such as that defined by 'experts', can lead to hegemony. It is therefore important to understand the full range of values that may be attributable to heritage before assigning importance to a certain individual, stakeholder group or set of values.

Underpinning the need for a greater understanding of value associated with geological collections is the fact that value is used to assess how and whether to acquire and conserve geological collections (Geological Society 1984; Museums and Galleries Commission 1993). In *Guidelines for the Curation of Geological Materials* (Geological Society 1984) scientific evaluation for acquisition is undertaken by assessing value either related to the research function of the specimen (i.e. research potential) or by its association (if from a suite of similar specimens). Some geological specimens may have very little (current) scientific value, but it has been known for a large number of geological sub-collections to have cultural, historical, artistic, spiritual and educational values associated with them (Timberlake 1995). In these cases, associated aspects such as documentation and labelling are an intrinsic part of the specimen and may need to be assessed simultaneously and with equal weight. Timberlake (1995) further argues that we need to ensure that the range of stakeholder values is accounted for as collection survival depends upon us arguing the case for their proper value and evaluation. Clercq (2003) has noted that the shift from the field to the laboratory in geological research and education led to loss of collections in the Netherlands, an issue that is also becoming apparent in the UK (Fothergill 2005). It is increasingly apparent that the value of geological specimens needs to be assessed. This is particularly important in a time of austerity where museums feel the need to de-accession material that may appear to have little or no value.

This research quantitatively examines stakeholder values associated with geological collection objects (where stakeholders are anyone who has worked with, personally owned or cared for geological collections in museums, universities, other heritage institutions or geological companies). In relation to degradation, the importance of physical change to a specimen was also of interest and explored in the questionnaire. The obtained value set was then applied in a small-scale survey of the Russell Collection held by the Natural History Museum in London. The collection is one of the best known

British topographical mineralogical collections with extraordinary historical importance relating to Sir Arthur Russell the collector, the localities from which he collected a vast majority of the collection, and the many individuals and institutions from whom he obtained specimens (King 1986).

Materials and Methods

Qualitative Exploratory Interviews

In this work, exploratory interviewing of stakeholders of geological collections was used to gain insight into value through the personal narratives of the interviewees. Since interviews are important in developing and uncovering a research problem (Oppenheim 1992), they are ideal for identifying the components of stakeholder values.

To be representative of the range of values that could be associated with geological collections by expert stakeholders, the interview participants represented the different types of users of the Russell Collection case study: two curators of mineralogical collections, an academic mineral physics researcher, a volunteer geochemist, a cartographer and paleontological conservator, an archivist/geoinformation specialist, a mineral specimen dealer, a geological specimen shop manager, and two non-professional gemmologists.

A loose structure was used for each interview, but the narratives of the interviewees were the determining factor in the direction of the interview and the overall structure was allowed to evolve. Base questions included (i) What do you do/describe yourself as doing in your work? (ii) Why do you use geological collections? (iii) Do you know of the Russell Collection/why do you think a collection such as Russell's be considered important? (iv) What do you look for in a specimen (in relation to your work and personal perspectives)? In each of the questions the interviewer was careful not to mention the words value or degradation as these could be seen to be leading the discussion towards statements regarding value and loss that they may not naturally consider.

Attitude statements for the questionnaire were formed and agreed upon through collaborative textual analysis of the transcribed interviews. Statements were re-worded in order to minimise ambiguity in comprehension of the questions (Lietz 2008) and to ensure validity of the results and alertness when answering questions (Lietz 2008; Campanelli 2008).

Quantitative Questionnaire Development

The interviews were followed by a quantitative attitude questionnaire in conjunction with exploratory factor analysis, commonly used in epidemiological and psychological studies (Watson *et al.* 1995). So far, this has only been used once in heritage values research, in a study by Dillon *et al.* (2012) on library and archival heritage. A questionnaire is a measurement tool, and should derive from issues identified and investigated through research into the project design (Oppenheim 1992). It is often necessary to include a prior scoping exercise to clarify the research question, in this case the exploratory interviews (Boynton and Greenhalgh 2004). Value statements were extracted from the interviews and literature and used to make a series of rated attitude statements on the questionnaire.

Section 1 of the questionnaire involved attitude statements, derived from the stakeholder interviews, randomly ordered to ensure that statements that described the same theme were not adjacent in the questionnaire to ensure no bias (Lietz 2008). Participants were asked to rate their level of agreement with each statement. A seven point Likert scale was used (Lietz 2008; Oppenheim 1992) with a middle point of 'neither agree nor disagree'. A 'don't know' option was also included. Section 2 of the questionnaire utilised questions from the Dillon *et al.* (2012) questionnaire regarding the future life of collections and included a question on what the term 'information' means to the respondent. Section 3 gathered demographic data, including information on the expertise and experience of participants. The questionnaire was piloted using 6 stakeholders of geological collections. The questionnaire (Appendix 1) was disseminated electronically, and 236 responses were returned at the end of a 2-week dissemination period.

Exploratory factor analysis using principal axis factoring was conducted using IBM SPSS Statistics software v.19. Exploratory factor analysis was chosen to explore underlying relationships between the measured variables (components) in the questionnaire by discovering emerging factor structures to describe values that are common throughout the participant responses (Norris and Lecavalier 2009). Principal axis factoring allows consideration of the common variance between variables and discovers the least number of factors needed to account for the variance (Finch 1997). Further analysis by computing factor scores (Klovan and Imbrie 1992) and using textual analysis, linear regression and one-way ANOVA (Field 2005) in

Rotated Factor Matrixa	Factor					
	1	2	3	4	5	6
I value photographs and research notes associated with a specimen/collection	.657					
Collections have inspired me to learn about science	.644					
Collections should be used to inspire others to learn	.599				.332	
The personality of a collector is reflected in their collection	.570	.303				
Collections represent the evolution of a science	.566					
Collections represent the cultural history of a locality	.547					
The more information a specimen comes with, the more I value it	.357	.664				
I value a specimen if a story is associated with it		.564				
Specimens from a now inaccessible location are of more value		.477				
Unique collections are more valuable		.435				
I visit collections because specimens are pretty			.637			
I prefer to visit collections of high commercial value			.634			
Beautiful specimens are more valuable			.567			
Original storage cabinets and specimen boxes are integral parts of the collection				.706		
I value original scientific instruments used by the collector	.358			.515		
Specimen labels are valuable because of the information they contain				.455		
I value a collection that has survived through time 'against the odds'		.310		.392		
I value specimens that are easily identifiable for educational purposes					.565	
Specimens are more valuable because of their information content			-.304		.547	
I value the educational potential of specimens	.440				.529	
Damaged specimens have no value						-.630
If a specimen has no label it has no value						-.370
Degraded specimens yield new knowledge						.304

Figure 1. 6 factor varimax solution showing relationships as numerical values between the components (statements) within the questionnaire. Higher numerical values indicate higher correlations between statements.

conjunction with agreed factor solutions can then provide further in depth predictive analysis of the value factors. The obtained factors were then conceptually interpreted using a focus group to determine the values they are associated with.

The Russell Collection Survey

A survey of the Russell Collection was carried out as a case study using the value factors obtained from the questionnaire analysis. Out of 12,185 collection items, a random selection of 201 ensured an acceptable 5% margin of error with an 85% confidence level. The collection survey was designed to enable an assessment of whether collection management (documentation, use and conservation) of geological collections effectively supports the values stakeholders associate with them.

Results and Discussion

Questionnaire Analysis

After factor analysis, the 6-factor varimax solution (Figure 1) was found to be the most conceptually and statistically sound, accounting for the largest common variance. Below is a summary of the conceptual interpretations and discussion of the value components of each factor.

Factor One: Personal/Inspirational

Factor one is thought to be about collections as a whole, possibly representing the subject of geology. Associated with this was a personal aspect, an emotional engagement with collections and with science. Key words picked out of the statements were: inspiration, personality and cultural history. It is possible that there is also an aspect of longevity in the sense that a person can be carried on through their subject and that the subject can continue to be relevant for research through inspirational questions raised by new generations. The word 'science' was not found in any other factors, indicating a close personal relationship with science and learning. In this factor the personal and emotional engagement with the collections was not solely attributed to the specimens, but to the contextual associations of the collection, such as: cultural history, evolution of the science, photographs and research notes, and information.

Factor Two: Uniqueness

Factor two is thought to represent uniqueness. The key words are: story, inaccessibility of the location where the specimen was originally collected, information and uniqueness. All the statements but one focused on individual specimens. The uniqueness was reflected in individuality of a specimen or collection through a specific story associated with it, association with a 'lost' locality, or an increase in the amount of information associated with the specimen.

Factor Three: Aesthetic/Commercial

Factor three was interpreted to be about aesthetics and financial/commercial value. The key words were: pretty, beautiful, visit and commercial value.

Factor Four: Originality/Historic

Factor four is about originality and historical value of the contextual components of an object. Similarly to factor one, the specimens are not the focus of value but rather the context of the specimen/collection. In this factor the physical embodiments of contextual information are valued, with key words being: original, storage cabinets, storage boxes, scientific instruments, labels and information. Originality is separate from the uniqueness value in factor two, in that originality is associated more strongly with the historical contextual components of the objects/collection, such as labels.

Factor Five: Educational/Future

Factor five is thought to represent the educational potential of specimens and the only one to deal exclusively with the future of specimens. This factor and factor six are the only two factors that only discuss specimens/objects and not collections as a whole. The key words are: educational, information and educational potential.

Factor Six: Information

Factor six is thought to relate to information content of specimens. The negative correlation with the two statements that contain the phrase 'no value' and positive correlation with the statement indicating that specimens retain information with degradation, even contributing to new knowledge, indicated that this factor is dealing with the notion of preservation and information. This factor also deals with contextual components such as labels, but associated with a specimen and not a collection. The key words are: damaged, direct association of a label with value, degraded and 'new knowledge'.

Based on the results, geological collections appear to share similar values with other types of cultural heritage as outlined in UNESCO's convention of 1977: those of aesthetic, uniqueness and historical value. Baars (2011) discusses in detail several values that can be associated with geological specimens and collections, including scientific, historic, future, preparation and sampling and research, with findings similar to this research and UNESCO, but unlike those of English Nature (2006), who identified four main values associated with geodiversity: appreciation, knowledge, products and ecosystem/natural functions. This is likely due to the fact that English Nature's study focused more on the use of geological heritage, and less on the individual aspects of a geological landscape such as a specimen.

Context and Contextual Information

Two common themes emerged from the interpreted factors: context and information. Context came in two forms: tangible, such as boxes, cabinets, instruments, labels, photographs or research notes, and intangible such as stories, culture, 'lost' or inaccessible localities and the potential for new information to be extracted. With the exception of factor three (Aesthetic/Commercial Value), which deals exclusively with the physical attributes of a specimen alone, the context is highly important throughout the factor structure.

Physical change to the specimen itself may lead to loss of Aesthetic/Commercial Value, but what appears more important are the contextual aspects of specimens (labels, knowledge) as loss of these may have a larger impact on value than physical change to a specimen.

Information is mentioned exclusively in factors two, five and six. The statement regarding information in factor two was the most unstable in the factor structure, while four statements with 'information' have been removed from the dataset (Appendix 2): (i) I think the paper labels can be lost if the information is retained, (ii) Information to be gained from a specimen is more valuable than the specimen itself, (iii) Information contained in specimens contributes to new research, (iv) I value the information content of a whole collection.

From subsequent analysis of the open box question 'What does the term information mean to you when applied to a geological specimen/collection?' in Section 2 of the questionnaire it became clear that 'information' has a wide variety of meanings when it comes to geological collections. Frequency analysis describes the frequency of occurrence of individual words (Fig. 2). Terms such as 'specimen', 'collection', and 'information' were disregarded, as these did not provide an insight into what the meaning of information could be. The analysis was run on the answers of 198 respondents who answered the question out of the 229 used for factor analysis.

This analysis indicates that the person/collector and the locality are most important, but it is also clear that date, name, composition, history, context,

Figure 2. Word frequency analysis of the question 'What does the term information mean to you when applied to a geological specimen/collection?' A larger font indicates a higher frequency of occurrence.

chemical, data and notes, are all highly important in defining what information is. In the interviews, statements containing the word information occurred frequently, indicating its importance to the users of geological collections. However, when used in the questionnaire, it was clear that due to the level of subjectivity associated with the word, attitude statements containing the term represented difficulties in data analysis.

However, it is important to note that the primary associations of the word 'information' can be associated with the values and contextual information interpreted from the factor structure. In relation to Personal/Inspirational Value, it is clear that the identity of the collector is highly important. Locality is important to Uniqueness Value. In Originality/Historic Value, and Educational/Future Value, labels are mentioned, where the bulk of this information is contained, relating the material specimen to its context. Educational/Future Value and Information Value focus on the potential for new information to be extracted from specimens, which again relates the intangible context to information.

Scientific Content of Collections

In the Personality/Inspirational, Originality/Historic, Educational Potential and Information values, statements refer to either 'science', 'scientific', 'educational potential', 'knowledge' or 'information'. However, in none of the factors is 'scientific content' of a specimen or collection specifically referred to and yet 'science' and references to knowledge, learning, and information are incredibly popular. This indicates that according to experts, scientific content of specimens or collections is not an individualistic concept but an aspect of collections that is heavily embedded within many of the key values associated with them.

The Figure 2 word frequency analysis (above) describes this as words such as data, chemical, composition, age, geological, analysis and scientific are referred to with relative frequency in the analysis. This highlights the relevance of 'scientific content' of collections as embedded within one of the key themes of 'information' brought out of the values identified.

Further Analysis

Having shown that there is a set of stakeholder values applicable to geological collections using quantitative methods, further analysis was used to look at the backgrounds of respondents and how these relate to each factor.

One-way ANOVA (analysis of variance) was run to correlate current professional activity with factor scores. The analysis examines the significant differences between three or more groups on each factor (Field 2005). Multiple comparisons reveal that many differences are not statistically significant. Descriptive analysis was then used to graphically correlate current professional activity data with the values (Figure 3).

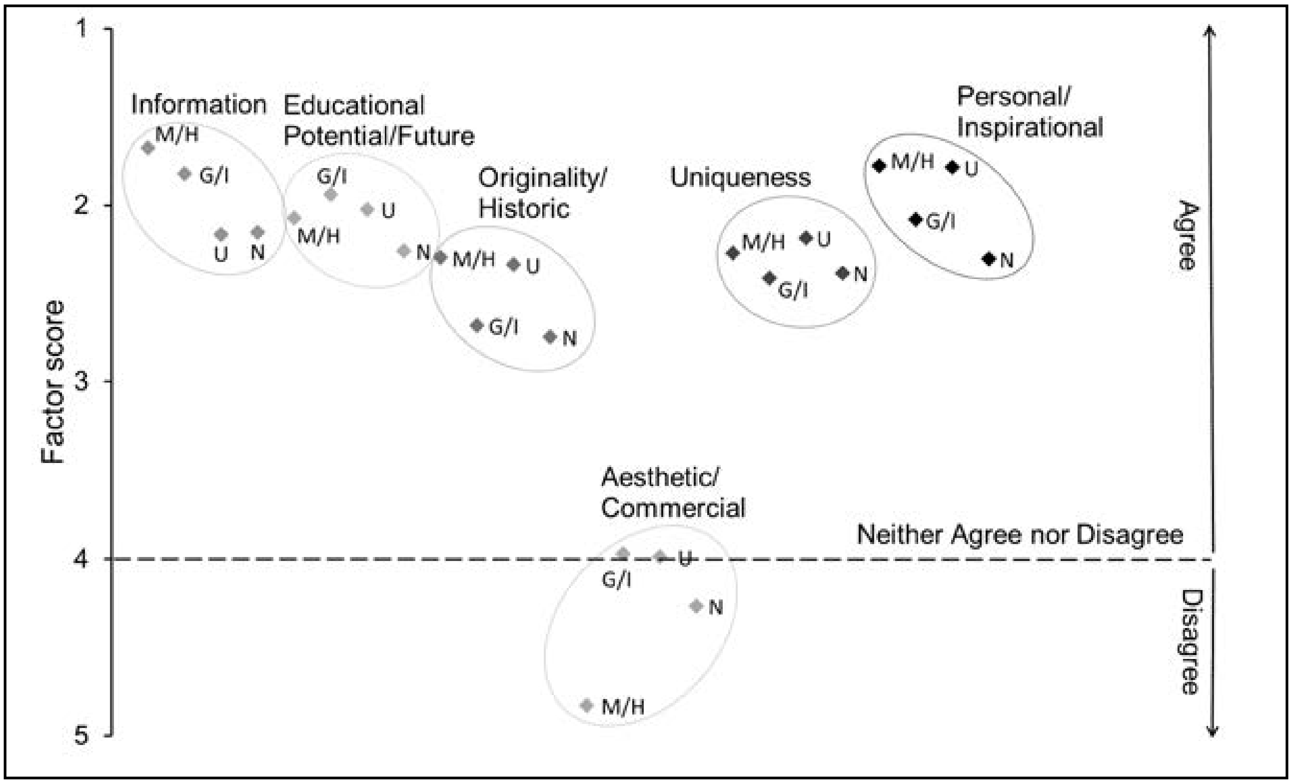

Figure 3. Correlations between current professional background (M/H = Museum/Heritage Institution, G/I = Geological Industry/Company, U = University, N = None of these) and mean factor scores per factor. The mean factor scores represent the Likert scale used in the questionnaire where 1 = Strongly Agree and 7 = Strongly Disagree, with 4 = Neither Agree nor Disagree.

The results indicate that museum/heritage and university professionals tend to agree more strongly with Personal/Inspirational, Uniqueness, Educational Potential/Future, Information and Originality/Historic Values in comparison with the other respondents. The opposite is true for the Aesthetic/Commercial Value.

Overall, there is less agreement with the Aesthetic/Commercial Value of geological collections by expert stakeholders. The distribution also indicates that those who disagree most strongly with the Aesthetic/Commercial Value also agree most strongly with the values relating to contextual aspects of specimens/collections, and helps to reinforce the idea that loss of contextual aspects of a specimen is more important than physical change of a specimen when it comes to loss of value. This is most pronounced with museum/heritage and academic professionals.

Results of The Russell Collection Survey

The survey's aim was to provide a case study of how the stakeholder attitudes to geological collections are reflected in collection management (documentation, use and conservation).

As discussed above, contextual information belonging to the specimens has been found to be extremely important. However, since information has so many different meanings, for the purpose of the survey, each specimen's contextual information was split into individual measurable components: (i) whether there was Russell's own label and the label of the benefactor he acquired the specimen from (unless collected by Russell himself), (ii) whether the original benefactor could be identified by name, (iii) whether there was locality data and a date (year only) of collection associated with the specimen. Each of these components, when combined together with the physical mineral specimen, would produce an object with as much contextual information as possible. By recording the presence or absence of each of these individual components either alongside the specimen or documented in the catalogue, in conjunction with measurement of the physical degradation to the specimen, it was possible to produce figures relating to how much of the collection had been conserved.

This was based on three realistic premises: (i) that each object should possess all of these components, (ii) that all components of an object are equally weighted, and (iii) that all objects in a collection are equally weighted. It would have been impossible to determine whether each specimen had originally possessed all components, although the assumption

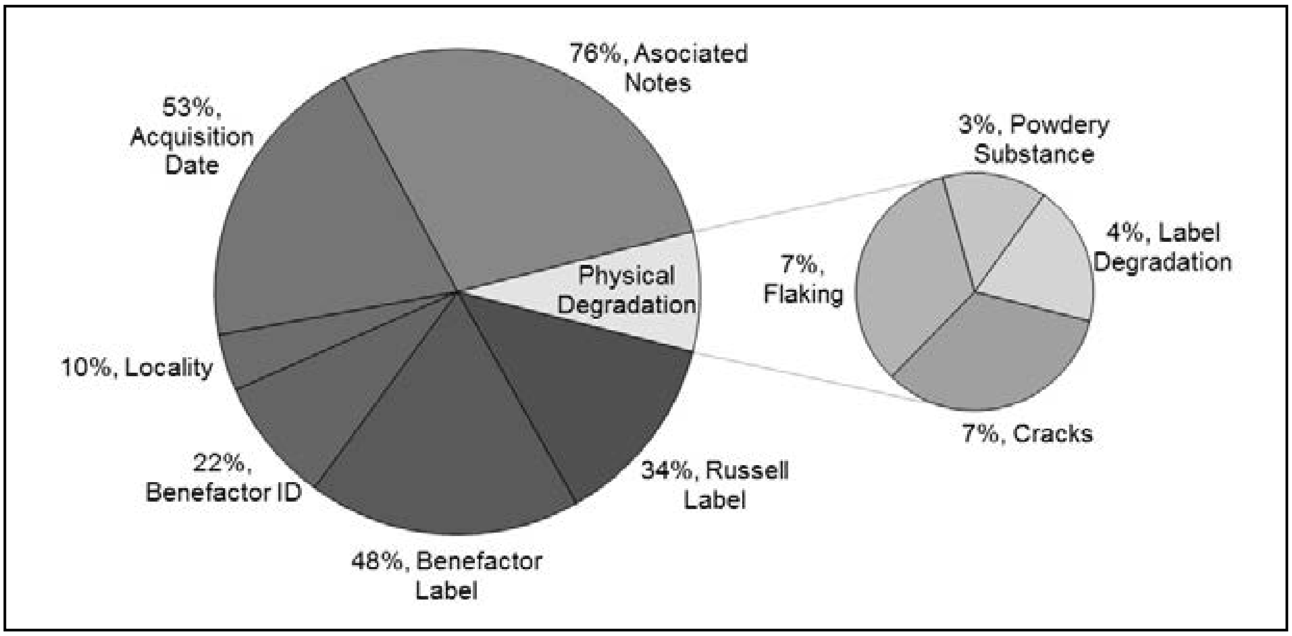

Figure 4. Relative percentages of observed physical degradation and missing contextual information in the 201 objects surveyed in the Russell Collection. An object can exhibit one of more signs of degradation/loss. 75% of the objects were missing contextual information items and 15% showed signs of physical degradation.

is in line with Russell's collecting and documentation practice. Premise (ii) was based on questionnaire analysis showing that contextual information is of significant value in comparison with the specimen itself. Premise (iii) is in line with the usual collection survey practice.

In addition, signs of physical degradation were noted as an indicator of the physical material state and potentially as an indicator of conservation condition. Physical degradation (cracking, flaking, powdering, and label deterioration) was assessed visually, and was based on the collection's curator's knowledge of the objects. Physical degradation was of interest with respect to the loss of Information Value and Aesthetic/Commercial Value, while labels and identification, date of acquisition and associated notes, are all components of Personal/Inspirational, Uniqueness, Originality/Historic and Educational/Future Values.

The survey (Figure 4) showed that 34% of the collection was missing Russell's original labels, and 48% of the collection was missing original benefactor labels (not including those collected by Russell himself), 22% of the collection did not have the name of an original benefactor associated with the specimen and 76% did not have any associated notes (separate to the label and register/catalogue). 53% of specimens did not contain any reference to the date of when it was acquired. Although many specimens may never have had notes associated with them, labels and the ability to trace a specimen through its origins including previous owners and locality is very important to stakeholders, as indicated by the questionnaire and reflected in the Personal/Inspirational, Originality/Historic and Uniqueness Values.

Only 15% of the surveyed objects exhibited some form of physical degradation to the specimen or any of the labels. This indicates that the majority of specimens are in a good material state. It is also interesting to note that only 10% of the objects did not contain any locality data. In geology, locality data is extremely important to the information in an object (Figure 2) and is of high scientific importance (Fothergill 2005; Baars 2011; Guidelines for the Curation of Geological Material 1984).

In the NHM's *Curatorial Policies and Collections Management Procedures* (2003) it is stated that "the vast majority of objects in the science collections serve research and reference functions" and that "the Museum recognises the primary importance of the employment of best practice in collections conservation to prevent the physical deterioration of the collections to preserve their scientific and cultural worth". NHM's policy relies (NHM 2003) on the Museums and Galleries Commission publication on the *Standards in the Museum Care of Geological Collections* (1993), in which the focus is again put heavily on the scientific and educational potential of geological collections: "only by keeping these collections in good and accessible order can scientists today or in the future study the specimens collected or described in the past". It is evident from this case study that the primary objective to conserve specimens' physical integrity and scientific information has been pursued effectively. However, this research also indicates that it is just as important to ensure that the associated contextual information contributing to Information, Personal/Inspirational, Originality/Historical and Uniqueness Values is preserved as part of the collection.

Conclusion

Through an attitude questionnaire the research set out to explore and define the expert stakeholder values associated with geological collections:

- Personal/Inspirational
- Uniqueness
- Originality/Historic
- Educational/Future
- Aesthetic/Commercial
- Information

Contextual aspects such as where a specimen was collected, by whom and when, were found to be particularly important to stakeholders. In geological collections, when 'information' is referred to, it is not just dependent on what is contained in, or is part of, the specimen itself, but is also dependent on a number of these contextual elements, collectively forming the object. Importantly, all but Aesthetic/Commercial Values are heavily influenced by contextual information.

When assessing loss of value, the study indicated that loss of contextual information may be more detrimental than physical degradation of the specimen. When the research was applied to a case study, the Russell collection at the Natural History Museum in London, only 15% of the surveyed collection showed signs of physical damage and 10% missed locality data. However, the survey indicated that 75% of the collection lacked other elements of contextual information.

Objective quantitative assessment of the values associated with geological collections is a further tool that can enable curators, conservators and researchers to make better informed decisions regarding the conservation of their collections: should conservation be limited to that of just the specimen or should there be a larger initiative to ensure the longevity of the associated contextual information? From a wider perspective, this research opens up avenues of discussion, looking at what information is and the role it plays in different types of natural and cultural heritage collections.

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APPENDIX 1

Stakeholder Attitudes to Geological Collections

Thank you for taking five minutes to complete this questionnaire on what you think is important about geological collections.

The exercise is part of an MRes Heritage Science research project at University College London. The project is looking to utilise social science techniques to define 'condition' through an understanding of how geological collections are valued by stakeholders. The exercise is being performed in association with the Natural History Museum utilising where necessary collections within the Mineralogical department.

The questionnaire is part one of two, with the second section to be based on the results gained from this section. If you take the time to complete this questionnaire, please do kindly respond to section two, which will be made available in due time.

There is no need for you to enter personal details as all questionnaire answers will be treated confidentially. No personally identifiable data will be stored or used. By returning this questionnaire you are consenting for me to use your questionnaire data in my MRes project. Please email your responses to: jane.robb.11@ucl.ac.uk

The results from the questionnaire will form a part of my MRes Dissertation and may be published, but will also be available on request. For any extra information or to provide further comments please contact:

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Section 1.1: Please rate how you feel about these statements regarding geological collections (Please rate your initial reactions)

	Strongly Agree			Neither Agree nor Disagree			Strongly Disagree	Don't Know
A degraded specimen should be replaced by a new one from the same locality	1	2	3	4	5	6	7	8
Aesthetic attributes of a specimen contribute to its scientific importance	1	2	3	4	5	6	7	8
Degraded specimens yield new knowledge	1	2	3	4	5	6	7	8
Geological collections are important to my business	1	2	3	4	5	6	7	8
I think the paper label can be lost if the information is retained	1	2	3	4	5	6	7	8
Repaired specimens look beautiful	1	2	3	4	5	6	7	8
Specimens should be sub-sampled to learn more about them	1	2	3	4	5	6	7	8
Specimens are valuable because of their information content	1	2	3	4	5	6	7	8
Information contained in specimens contributes to new research	1	2	3	4	5	6	7	8
If a specimen has no label it has no value	1	2	3	4	5	6	7	8
Collections are valuable because of the potential for future additions	1	2	3	4	5	6	7	8
Degradation increases the value of a specimen	1	2	3	4	5	6	7	8
Specimens from a now inaccessible location are more valuable	1	2	3	4	5	6	7	8
Information to be gained from a specimen is more important than the specimen itself	1	2	3	4	5	6	7	8
I value specimens that are easily identifiable for educational purposes	1	2	3	4	5	6	7	8
A collection is more than the sum of its specimens	1	2	3	4	5	6	7	8
Specimens need to be traceable	1	2	3	4	5	6	7	8
Damaged specimens have no value	1	2	3	4	5	6	7	8
I value the information content of a whole collection	1	2	3	4	5	6	7	8
Original Storage cabinets and specimen boxes are integral parts of a collection	1	2	3	4	5	6	7	8
Specimen labels are valuable because of the information they contain	1	2	3	4	5	6	7	8
Synthetic specimens are equally valuable to natural specimens	1	2	3	4	5	6	7	8
Collections have inspired me to learn about science	1	2	3	4	5	6	7	8
I value photographs and research notes associated with a specimen/collection	1	2	3	4	5	6	7	8
Unique collections are more valuable	1	2	3	4	5	6	7	8
The financial value of a specimen is of no importance to me	1	2	3	4	5	6	7	8
Collections should be used to inspire others to learn	1	2	3	4	5	6	7	8
Beautiful specimens are more valuable	1	2	3	4	5	6	7	8
I value original scientific instruments used by the collector	1	2	3	4	5	6	7	8
Newly collected specimens are more important	1	2	3	4	5	6	7	8
Collections represent the evolution of a science	1	2	3	4	5	6	7	8
I value repaired specimens	1	2	3	4	5	6	7	8
I value a collection that has survived through time 'against the odds'	1	2	3	4	5	6	7	8
I value the knowledge that may be obtained from a specimen in the future	1	2	3	4	5	6	7	8
I visit collections because specimens are pretty	1	2	3	4	5	6	7	8
Specimens that have not been conserved (passive or intravenous) are more valuable	1	2	3	4	5	6	7	8
Collections represent the cultural history of a locality	1	2	3	4	5	6	7	8
I prefer to visit collections of high commercial value	1	2	3	4	5	6	7	8
The personality of a collector is reflected in their collection	1	2	3	4	5	6	7	8
The more information a specimen comes with, the more I value it	1	2	3	4	5	6	7	8
I value a specimen if a story is associated with it	1	2	3	4	5	6	7	8
I value the educational potential of specimens	1	2	3	4	5	6	7	8

Section 1.2: Accessibility in the future

Specimens degrade over time. For how many years would you like the original specimens to last in a state that enables information to be extracted and used?

- ☐ 0-50
- ☐ 50-100
- ☐ 100-1000
- ☐ >1000

If 1 is extremely important and 7 is not at all:

How important do you think it is that...							
...the specimen can be accessed and used?	1	2	3	4	5	6	7
...the specimen is preserved in good condition?	1	2	3	4	5	6	7

How important do you think it is that the following groups of people can access and use the original specimen (and not its digital representation, or a surrogate specimen):

Visitors/users in the present day?	1	2	3	4	5	6	7
Future generations of visitors/users?	1	2	3	4	5	6	7

When you think about future generations of visitors/users, how many years into the future are you thinking?

- ☐ 0-50
- ☐ 50-100
- ☐ 100-1000
- ☐ >1000

At what point in a collection would you consider a specimen to be old (i.e. not in geological terms)?

- ☐ 0-50
- ☐ 50-100
- ☐ 100-1000
- ☐ >1000

What does the term 'information' mean to you when applied to a geological specimen/collection?

Continue over the page...

Section 1.3: Demographics

Age:__________yrs

Gender: ☐ Male
☐ Female

Nationality:____________

Highest qualification:

1. Higher degree or equivalent
2. Degree or equivalent
3. Below degree level
4. None
5. Other:_____________

How often do you visit a geological collection? (Giving the number of times and circle either week, month or year):
_____times per week/month/year

In the past year, approximately how many physical specimens from a museum/institutional collection have you worked with?
_____ specimens

Are you an employee/volunteer in any of the following?

1. Museum
2. Heritage organisation
3. Geological Industry/Company
4. University
5. None of these

Rate your knowledge of the geological sciences:

1. None
2. Basic
3. Intermediate
4. Expert

And finally...

What is your primary area of Interest (please choose ONE):

1. Geology (Structural/Petroleum or general)
2. Mineralogy
3. Petrology
4. Palaeontology
5. Gemmology
6. Curation
7. Conservation
8. Art
9. Photography
10. Archives/Library
11. History
12. Education
13. Museums
14. Management
15. Sales/Dealing
16. Archaeology
17. Heritage science
18. Other:__________

Thank you for taking time to complete this questionnaire. Please email your responses to: jane.robb.11@ucl.ac.uk

APPENDIX 2

The questionnaire returned 236 responses in total at the end of a 2 week dissemination period. Out of the 236 responses 7 participants with >20% missing data from Section 1.1 were excluded. The missing data analysis was completed using pairwise and listwise deletion to understand the impact of the participants with missing data on the dataset. The total number of responses after exclusion was 229. This still allowed for statistically valid factor analysis as the ratio of questions to respondents needed is 1:5. For 41 questions only 205 respondents are needed.

5 attitude statements from Section 1.1 were omitted due to the high amount of missing data or highly skewed data. This left the questionnaire with 36 statements for factor analysis with 229 respondents. Not all of the statements were normally distributed, but this is not a requirement for exploratory factor analysis. Descriptive statistics show the distribution of the responses for each statement. Most show a range of responses across the scale but some indicated extreme skewing towards one point on the scale. For exploratory factor analysis a spread across the scale is needed to understand the variance.

The correlation matrix for the initial factor analysis produced a moderate to low number of significant correlations (R >.3). The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was .762 and Bartlett's test of sphericity was less than .001 indicating the data's suitability for factor analysis. Communalities for each factor solution expressed a moderate number of communalities (~30%) below .4. This means that although the dataset is suitable for exploratory factor analysis, the overall 'factorability' of the dataset may be quite low.

Through several re-iterations of reliability testing 17 attitude statements were removed from the original varimax solution and 19 statements from the direct oblimin as they were found to be unreliable, leaving final datasets of 24 and 22 statements respectively.

Initial factor analysis produced solutions that indicated two attitude statements that did not load onto any of the 3 to 7 factors in the solutions. The statements were then deleted and exploratory factor analysis re-run for solutions 3-7. The comparison of solutions 3 to 7 indicated that solutions 5, 6 and 7 were most viable. The Kaiser-Meyer-Olkin measure was .771 and Bartlett's test was significant to below .001. The 5 factor solution explained 33% of total common variance, the 6 factor solution explained 36% and 7 factors accounted for 38.8%.

Conceptual sense also needed to be made of the factor solutions as some small factors may be present due to an insufficient number of attitude statements about other factors rather than lack of a simple factor structure. A brief look at the feasibility of the factors was undertaken at this point collaboratively. The 7 factor solution was rejected at this point because there were two factors of six questions that did not make conceptual sense and so were deemed unstable. The addition of the factors in this solution did not offer any deeper understanding of smaller factors that may be subsumed in other solutions. The 5 factor solution was overall conceptually sound, but the first factor was difficult to interpret with too many diverse variables. The 6 factor solution looked the most viable conceptually, possibly bringing out smaller factors that were subsumed by the 5 factor solution.
To confirm the overall structure of the factor solution the data set was split into two random sub-samples in SPSS and exploratory factor analysis re-run for factor solutions 5 and 6.

As the dataset is 229 participants to 34 questions, the split test will lower the participant to question ratio to less than the required 5:1 for exploratory factor analysis, meaning the results of the split test must be treated with caution.

The 5 and 6 factor solutions indicated that there were nearing 50% of statements that switched affiliation for factors. Statements which grouped together in a factor also changed which factor they were attributed to, usually progressing to a higher factor number i.e. from factor 2 to factor 3. This indicated that these solutions may not be stable.

Alpha reliability tests on each factor for solutions 5 and 6 were calculated to assess the internal consistency of the attitude statements within each factor. Only factor 1 for both solutions provided a Cronbach's alpha of >.8 indicating good internal consistency. The other factors in both solutions had values of around .6. The statements that would raise Cronbach's alpha for each factor were also noted and compared with those identified from the split test. Two of the statements were also noted as unstable in the split test and the third question raised Cronbach's alpha if deleted in both factor solutions. 5 statements were deleted.

The total common variance explained increased when exploratory factor analysis was performed on the 29 statements and 229 respondents for the varimax rotations. To check whether the factors were correlated with each other, exploratory factor analysis was also run with direct oblimin (oblique) rotation with Delta set at 0. The overall variance accounted for is still low <50%. This could be due to high distinctiveness between the statements, and therefore low relatedness between the variables in the factors.

In each of the above factor solutions two statements cross loaded significantly onto 3 factors and so deemed unstable and deleted. Analysis with the deleted statements was not re-run using oblique rotation, because cross-loading onto more than two factors might be important in correlating between factors.

In an attempt to further streamline the factor solutions and determine the underlying basic structure, statements were deleted that were only just significant at between .3 and .32. Cross-loading questions that were only just reaching significance, between .3 and .32 were also deleted. 5 statements were deleted from the direct oblimin rotation solutions leaving 24 statements. Varimax rotation deleted 2 statements leaving 25 statements.

The factor correlation matrix for 5 and 6 factor solutions for varimax and direct oblimin rotations indicated that there were not any highly significant correlations >.3. This could be due to the fact that there are not enough statements in the factors 4, 5 and 6 for each solution to provide meaningful correlations.

Alpha tests were also run on each factor for each solution. Two statements raised Cronbach's alpha in the direct oblimin rotations. With deletion of the two statements (leaving 22), the pattern matrix failed to converge within 50 iterations for the 6 factor solution but was successful with the 5 factor solution. The 5 factor solution produced moderate significance correlation between factors of .369 for factors 3 and 1 and .338 for 5 and 1. One statement raised Cronbach's alpha if deleted from the varimax solution.

Three factor solutions were finally chosen. Each of the three final solutions is similar indicating that the structure is likely to be reliable. The 5 factor direct oblimin solution accounted for 38% common variance, with factors 3 and 1 and 5 and 1 correlating with a significance level of >.3. The KMO and Bartlett's test were .781 and .000 indicating better suitability and significance for the analysis than the original dataset. The 5 and 6 factor varimax solutions accounted for 36% and 40% common variance respectively. The KMO and Bartlett's test were .783 and .000. The 6 factor varimax solution had the most strong marker variables and no non-loading variables while both the 5 factor varimax and direct oblimin solutions had 3 and 4 non-loading variables respectively.

The 6 factor varimax solution was the most conceptually and statistically sound solution that accounted for the largest amount of common variance and was subsequently deemed most useful for further analysis.

OUT OF CHINA: DINOSAUR EGGS AND THE LAW ON 'KONG LONG DAN'

by Jeff Liston

Liston, J. 2013. Out of China: Dinosaur eggs and the Law on 'Kong Long Dan'. *The Geological Curator* 9 (10): 545 - 555.

Chinese legislation since 1982 relating to the export of vertebrate fossils from China is reviewed, with particular reference to dinosaur eggs, where a surprising legal loophole was identified. Problems of economic incentives and corruption are briefly considered in connection with the illegal export market, along with a pragmatic assessment of the threat from Chinese sources of future repatriation of this material where it lies abroad.

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Introduction

Since I started work at the Hunterian Museum in the University of Glasgow in November 1993, I have been aware of the question marks hanging over Chinese fossil material that has entered western museum collections. Now based at a university in China, I have a somewhat broader perspective, working on the other side of the Great Wall. In particular, I have renewed my former interest in 'Kong Long Dan' - dinosaur eggs. Dinosaur eggs have been known from a variety of the twenty two provinces of China for over 50 years. In the late 1980s, as large numbers were being unearthed by farmers, Chinese examples began to enter collections regularly throughout Europe, through the aegis of international fossil dealers. As small and discrete objects, they were appealing to museums, and presented a compelling object that swiftly captured the imagination of a public audience. From a research perspective, they were suddenly a new and accessible resource - the application of emergent scanning technologies to these objects (albeit with widely varying results, Liston & McJury 2003) allowed the possibility of exploring the contents of unhatched eggs, in search of possible dinosaur embryos, and many research institutions acquired them with this in mind.

Although I had done some work in Romania on dinosaur eggs as an undergraduate, and so was familiar from the literature with the huge quantities of dinosaur eggs being discovered in China, it was at the Hunterian that I first literally came to grips with the phenomenon. The Hunterian had just acquired some eggs as an unprepared block of red mudstone through a public appeal and sponsorship (through The Time Capsule, Coatbridge, leisure centre) just prior to my arrival, the resident curator having prepared the block to reveal six eggs (Figure 1, only two were originally visible), with traces of others. Press releases were regularly prepared and distributed by the University of Glasgow's press office whenever we tried a new analysis protocol (CT, MRI, see McJury *et al.* 1994) or found something that could be construed as interesting from the 'nest', and palpable spikes in visitor figures showed up for 2-3 weeks after each one.

Figure 1. The Hunterian Museum's clutch of dinosaur eggs (GLAHM V8318), acquired in summer 1993. Photograph by Trevor Graham, © Hunterian Museum and Art Gallery, University of Glasgow.

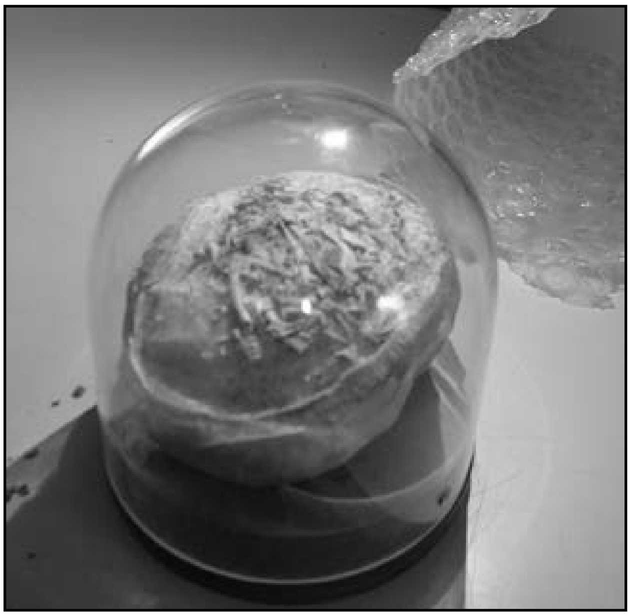

Figure 2. The most impressive of the specimens produced by Terry Manning's preparation techniques, prior to 1994.

But over the years, there was growing unease in the department, that perhaps the material had not been taken from China legally. The same dealer that had sold us the dinosaur 'nest' block had a whole range of eggs on which he had perfected preparation techniques, producing beautiful details of dinosaur embryos. I recall being given some of the early pictures of the remains, and asked to identify which dinosaur they might be (Figure 2). Going through the 'dinosaur bible' (or Weishampel *et al.* 1992 as it was otherwise known), I thought the unhatched remains most resembled a troodontid (which shows how much I knew about dinosaurs - they were therizinosaurs. I wish I could claim that my knowledge had improved.) Then we started hearing the sums of money being discussed for a possible sale of this material to a museum…and the reluctance of some museums to discuss acquiring them, not just because of the cost to their budget (6 or 7 figure sums were regularly being bandied around the museum community, in part due to the years of work and investment to develop the preparation techniques, but that could have simply been speculation brought on by the beauty of the objects to those that saw them), but also because of unresolved provenance issues. I spent some time working on these specimens, as the group steering Terry Manning's egg project were promoting their work through a touring exhibition, 'The Dinosaur Egg & Embryo Project', and I was asked to put together a proposal for the Hunterian to host this exhibition (Cohen *et al.* 1995). (Eventually we went with a perfume exhibition - what can I say?) The material was quite remarkable, both for its preservation, and also for the revolutionary preparation techniques devised by Terry Manning, yielding exquisite results. But this fantastic research resource was in academic limbo - the palaeontological equivalent of film projects lost in Hollywood's 'development hell': everybody knew they were there, but nobody could publish on them, as they could not get a museum to take them and thereby issue collection numbers (Knell 2002).

Smoke, mirrors and paranoia

At the Hunterian, we wondered if problems would arise with the eggs that we had acquired, and if we might have to return them; some members of staff even suggested taking them off display temporarily 'until the heat died down', perhaps. A fundamental question was, could this actually happen - was there any real serious possibility of forced repatriation of this material? We sometimes heard rumours of representatives of the Chinese Government visiting museums across the UK, and issues of repatriation being raised - also that China had enacted a retrospective law, which meant that it did not matter if it had been legal to remove the material at a particular time, as this later law could be backdated to cover material removed in the past, but details or certifiable facts were rarer (as the late Arthur Cruickshank used to say) than hen's teeth.

I find myself now working in a vertebrate research group in Yunnan University (one of China's oldest universities, at a mere 90 years), and much of my role has had a certain 'gamekeeper' quality to it, often to do with dinosaur eggs and embryonic remains (Figure 3), which has required me to get more heavily involved with the legislation for collecting and exporting Chinese fossil material. Given my past experience, and the unclarity of the position at the time that I was in Glasgow, I decided to take advantage of the opportunity, and dive into the historical dimension of previous legislation. Had the Hunterian's eggs come out of China illegally? Had substantive moves ever really been made by the Chinese Government to repatriate such material? If so, this would clearly present some threats to museums and other institutions that either already hold such material, or are looking to acquire examples - in terms of political sensitivity, the palaeontological equivalent of Australasian aboriginal remains. Can one legally acquire such material? What are the lessons in terms of acquiring material for either research work or museum collections? Perhaps more importantly, what are the potential dangers of repatriation of such objects ever becoming a priority?

Figure 3. Searching for eggs and embryonic remains in Lufeng County at DaWaShan.

I should make clear at this stage that this paper will not concern itself with the issues of the material coming into a specific territory whether in the UK, EU or elsewhere. There are many practical reasons to exclude this from the scope of this current work, as it involves many pieces of legislation such as UNESCO's 1970 Convention on Illicit Traffic (which the UK Government refused to become even a partial signatory to until October 2002), and the UNIDROIT Convention on stolen and illegally exported cultural objects 1994 (still not adopted by the UK), and the actual implementation of these varies widely across different territories. Besterman (2001) provides a good overview from a UK perspective, into which interested readers might wish to look, in advance of a forthcoming paper (see below), but the intention of this current work is to focus on the perspective of material leaving China - what Schmidt (2000) referred to as the 'source nation' dimension **-** in order to assess what criteria would have needed to be met for the material to leave the People's Republic of China legally, irrespective of what happened once the material had crossed that state's national boundaries. This is the legislation of exit, not arrival: fully recognising (and setting clearly aside) all the issues surrounding appropriate documentation for import and export, this is simply focussed on the issue of whether it was **possible** that such fossil material could have legally left the People's Republic of China.

An initial assessment of the national legislation in China seems, at first sight, pretty clear-cut: there was no fossil protection law enacted in China until 2011. However, vertebrate fossils **were** explicitly protected for a long period prior to this: article two section 3 of the 1982 Cultural Relics Protection Law explicitly states that "Fossils of ancient vertebrate animals and ancient anthropoids having scientific value receive the same state protection as cultural relics", and this sentence appeared on every subsequent piece of Cultural Relics Protection legislation (it was revised in 1991, 2002 and 2007, but retained this key statement each time) until fossils finally received their own customised legal protection in 2011. (For a more detailed account of the current legislative requirements, see Liston *et al.* in review, and to see how this legislation has evolved over time, with implications for both collecting and export, see a forthcoming paper from the Jehol Biota meeting in Southampton, UK, Liston in prep). Although to some other geological specialists, this separation out of these two categories might seem arbitrary or even unfair, there is some logic in this segregation, beyond China's main palaeontological organisation, the Institute of Vertebrate Palaeontology and Palaeoanthropology (founded in 1953, Sullivan *et al.* 2012), reflecting those same categories in its title. In comparison to other fossils, vertebrate specimens tend to be rarer, larger, more easily recognised by the non-specialists that form the bulk of the open market (Nudds 2001), and so command larger prices: this makes them most in demand in terms of any attempt to sell geological material outside China, and so it makes sense that these two categories were identified as priorities within this legislation.

The 1982 Cultural Relics Protection Law neatly brought all 'valuable' fossils under state ownership including "all cultural relics remaining underground" (Schmidt 2000, p.202). Although this is somewhat simpler and different from the law in other parts of the world (e.g. in Scotland, fossils are treated as minerals and can be owned by the Crown, the private, public or voluntary sector, while the land itself might be owned and managed separately by other individuals, McFadyen 2008), it is consistent with pre-revolutionary China's 1930 Law on the Preservation of Ancient Objects, which similarly asserted state control of unexcavated relics (as well as excavation to be undertaken by Chinese institutions instead of foreign scientists) in both cases making all unauthorized digging for fossils an act of theft (Schmidt 2000).

So what of the legal export restrictions on vertebrate fossil material from China? Again, the Cultural Relics Protection Law enacted on 19th November 1982 is very clear: in article 28 it notes that transport of all material abroad must be reported to the Customs Office, and requires a permit to be issued (after investigation) by the Ministry of Archaeology. It can only then proceed through the Customs Office of a designated port. If the investigation decides against issuing a permit, then the material is seized by the State. It also notes that material of 'high scientific significance' cannot go abroad without special permission from the Ministry of Archaeology.

In the 2007 revision of the Cultural Relics Protection Law, this is strengthened significantly: article 64 notes that precious material, whether State or privately-owned cannot go abroad, only under exceptional circumstances would the Ministry of Archaeology issue a permit as before. It also explicitly notes the following as criminal acts: excavation without permission; intent to destroy material or a site; sale of State material without authorisation, or transfer to a private individual; the export of material to foreigners (or otherwise smuggling) is strictly forbidden, as is stealing or otherwise illegally obtaining material. Interestingly, comparing it with the situation of a fossil coming from Scotland, customs is a reserved area for Westminster rather than the Scottish Government, yet there is no actual control over the export of fossils unless they are either going outwith the European Union, or are a collection valued at £30,400 or more (correct as of McFadyen 2008).

However, the Cultural Relics Protection Law is far from an effective law, in terms of resolving the problem. As Nudds notes: "Peasant farmers in China are becoming experts in collecting fossils and know what sells well. They can make far more from quarrying their land than they can from farming it, but it risks prison sentences, or worse, if caught." (Nudds 2001, p.194) Schmidt observes that there is "very little economic incentive to [hand] in a fossil" (Schmidt 2000, p.206), as only a fraction of the black market value would come to the farmer from the government as a result of such an act. The economic incentives in an impoverished environment are a lure significant enough to risk execution (Martill 2001), despite government efforts to educate the people that those who deal in illegally excavated fossils will be dealt with according to the law.

But of course the blame for this cannot lie solely with the farmers, who would not do this - at considerable risk to themselves and their families - without there being a market to receive them, and a means of reaching that market. As with excavation, the Cultural Relics Protection Law was similarly ineffective in stemming the flow of objects out of the country. As Kevin Padian noted of China, when discussing the case of *Archaeoraptor*, "there's a huge international market in the sale of vertebrate fossils...any so-called export papers, even if signed by local authorities, are regarded as invalid (fossil dealers tell me that they are easy to arrange)" (quoted in Besterman 2001, p.201). Indeed these sentiments were echoed in July 1998 by China's own Premier, Zhu Rongji, who stated that the root causes for both smuggling and poor protection of cultural relics were the same: "corruption and weak law enforcement." (Zhu 1998, quoted in Schmidt 2000, p.217). In this context, dinosaur-related material has been illegally taken out of the People's Republic of China through Hong Kong, Japan, Macao (Schmidt 2000) and Taiwan (Huang 2013), in some cases quite openly: one Japanese dealer noted that he had never been asked by Chinese customs officials for any documents authorizing his transport of fossils that he brought to Japan (Stone *et al.* 1998), despite having made more than a dozen trips with such material. It is also not impossible for such illegally removed material to lead to high profile publications (Huang 2013, Reisz *et al.* 2013).

At this point, you might be forgiven for thinking that the 'jig' was well and truly up for dinosaur eggs. Any that were acquired outside China after the 1982 Cultural Relics Protection Law was enacted, clearly left the country illegally - or did they? Again, things are not what they might at first seem.

It is worth noting, at this point, that many relics also appear to enter the marketplace through government outlets. Schmidt (2000) notes museum shop managers and museum officials (with relatively low salaries) as particular categories, with the poor storage and a general lack of registers of catalogued objects meaning that it is hard to keep track of specimens. Museum shops in Jinzhou City Museum

Figure 4. a) (top) The Jinzhou City Museum shop with Liaoning fish and **Sinohydrasaurus** ***on sale, 2004. (© JR Nudds, used with permission).***
b) (below left) The Jinzhou airport shop selling Liaoning fish and crustaceans, 2004. (© JR Nudds, used with permission).
c) (below right) Detail of counter display.

and Shanghai Natural History Museum have also been observed openly selling vertebrate fossils (Figure 4, Figure 5). In Beipiao, the Fossil Administration Office of Liaoning (formerly part of the provincial, now part of the regional government) has also been noted as keeping a large store of specimens together with supplies of velvet and silk presentation boxes, of the kind in which Liaoning fossils often reach trade shows such as the Tucson Fair, as well as making gifts of such specimens (e.g. at the opening of the Feathered Dinosaurs Exhibition in San Diego in February 2004, Figure 6).

Schmidt (2000), in drawing attention to failures of the then legal system in China to "effectively protect fossilized objects" (p.220) highlighted a case that "dramatically demonstrates the flaws in China's present legal framework" (p.187). It concerned a group of individuals apprehended for acquiring 156 dinosaur eggs in Xixia County, Henan Province in November 1993. During the case, the defendants noted that three times successively the State had failed to record dinosaur eggs as cultural relics, and the State Cultural Bureau had only recommended that dinosaur eggs should fall within the jurisdiction of the Cultural Relics Protection Law in December 1993, after the actions of the defendants had occurred. In other words, as Schmidt noted, the Cultural Relics Protection Law definition of palaeontological material treated as cultural relics "includes only the fossils of humans and vertebrate animals, a category that does not include fossilized eggs." (p.214). In legal terms, an egg (fossilised or otherwise) is not a 'fossil vertebrate' - as much as it might be a fossil *from* a vertebrate.

Sound ridiculous? Perhaps not - it is easy to forget that elsewhere in the world's scientific literature, dinosaur eggs were traditionally dealt with as trace fossils, and exclusively covered only in trace fossil books (e.g. Gillette & Lockley 1991), so this was far from a purely Chinese idiosyncrasy. It is hard to

Figure 5. Shanghai Natural History Museum Shop selling Liaoning fish (left) with detail view (right), 2004. (© JR Nudds, used with permission)

imagine these days with the wealth of dinosaur embryo research that has subsequently been produced (e.g. Kundrát *et al.* 2008, Reisz *et al.* 2013) that eggs could ever have been regarded as anything but 'vertebrate fossils', but it was not always the case: they were generally regarded as barren, therefore of little interest or use in research terms - merely a sign that something more intrinsically interesting had passed by. The publications that mainly changed that perception in the 1990s (despite Horner's work from 1979 onwards) were Carpenter *et al.* (1994), Mikhailov (1997) and Carpenter (1999). It is worth remembering that the Cultural Relics Protection Law was put together primarily (if not exclusively) by those from an antiquities rather than a palaeontological background, and it is extremely doubtful whether they would have perceived dinosaur eggs (or, indeed, anything that did not clearly and simply fall under the description of 'dinosaur skeletal remains') as 'vertebrate fossils',

Figure 6. a) (left) Liaoning Fossil Administration Office storeroom, containing stacks of Liaoning vertebrate fossils juxtaposed with presentation boxes of the sort seen at Tucson, 2001. It seems unlikely that they have undergone the required inventory of article 19 of the 2001 'Fossil Protection and Administration Rules of Liaoning Province'. (© JR Nudds, used with permission)

b) (right) At the February 2004 opening of the Feathered Dinosaurs Exhibition at the San Diego Museum, the Director was given a present of a framed **Sinohydrasaurus** ***by officials of the Liaoning Fossil Administration Office. The specimen is on the table in front of the Director (right). This directly contravenes article 31 of the 2001 'Fossil Protection and Administration Rules of Liaoning Province' which prohibits staff of fossil administration offices giving fossils as gifts to individuals or organisations. (© JR Nudds, used with permission).***

particularly as the bulk of the global trade in Chinese dinosaur eggs developed subsequent to the law being enacted. It is also evident from China's recently enacted dedicated fossil protection laws (both 2011 and the revised version in 2013, see Liston *et al.* in review) that they make a very clear distinction between 'vertebrate' and 'trace' fossils in their articles, perhaps reflecting a historical difference in perspective similar to that in the English-speaking literature, as well as a desire to close a particular loophole.

In the Xixia County case, Schmidt (2000) noted that the court then had to indulge in a somewhat convoluted argument to try and justify the inclusion of fossil eggs in the Cultural Relics Protection Law, in order to convict the three defendants. Indeed, it is noteworthy that the court avoided simply declaring dinosaur eggs as 'vertebrate fossils': after reiterating article 2 section 3 of the Cultural Relics Protection Law, the court goes on to argue "Dinosaurs are a huge branch of ancient vertebrate animals, thus it can be **inferred** that fossilised dinosaur eggs **ought** to be categorised as cultural relics which are protected by the law." (Schmidt 2000, p.226, my emphasis in bold). Similarly, it is worth noting that Liaoning Province felt it necessary to pass a separate law on 1st March 2001, preventing the removal of feathered dinosaurs and other fossil birds (indeed, expanding the range of included palaeontological material to include rare or valuable invertebrate and plant fossils). Presumably, again, because the Liaoning People's Congress felt that the existing national legislation as embodied by the Cultural Relics Protection Law was not explicit enough to indicate that these specimens were included (although far more clearly representing 'vertebrate fossils' than dinosaur eggs arguably were under the legislation) (Nudds 2001). In Henan Province, legislation was also enacted in December 1993, in the wake of the State Cultural Bureau's recommendation, to state that "illegal excavation, or selling fossilized dinosaur eggs are included in the scope of criminal behaviour" (Schmidt 2000, p.225), and it has been argued that the requirement to pass this legislation indicates that prior to that date, the eggs could be removed legally, as they were not recognised as 'cultural relics'. It has to be noted that the fact that the relevant Province in both cases needed to enact further legislation to make the point that the objects were included, does at least imply that they were not beforehand, at least not in a way that the province prosecutors felt could solidly guarantee convictions. The exception to this interpretation for the Liaoning material, is perhaps indicated by the representative of the State Administration for Cultural Relics in 1998 stating that his body had never approved the export of any specimen of *Confuciusornis*, nor had it ever received any requests to do so, therefore its presence outside of China was simply "robbery" (Stone *et al.* 1998, p.315).

In 2000, Schmidt noted that the Cultural Relics Protection Law did not give protection to palaeontological sites in the way that it did to archaeological sites, which made them vulnerable to damage, with the emphasis being on a crime only having been committed once the contextual information had already been separated from the specimen. As such, she noted individual initiatives at preventative measures, such as Hubei Province protecting its dinosaur egg beds with a 15 square kilometre sealed protection zone, and Liaoning Province establishing a 46 square kilometre Fossil Birds Preservation Zone south of Beipiao. However, things have moved on since then.

Attendees at the 5th International Dinosaur Eggs and Babies Symposium (DEBS 5) hosted by the Zhejiang Natural History Museum in Hangzhou in September 2012, witnessed a peculiar exhibition run in parallel (Figure 7). 'Dinosaur Babies Came Home' was an interesting exhibition on dinosaur eggs and nest remains, but the 'prize' exhibit was a Jiangxi Province nest of twenty two *Oviraptor* eggs, nineteen of which had embryos, that had been repatriated from the United States of America earlier that year (Figure 8). To some acclaim, with stirring patriotic overtones, delegates were frequently reminded throughout the conference's (somewhat protracted) opening session about this great national triumph at having recovered this part of their heritage (pers. obs.), whose new home is the China National Geological Museum. Indeed, the event was strongly resonant with the reports of the smuggled cultural relics displayed when returned from Britain to Beijing in 1994, "exhibition had a patriotic undertone….a demonstration of China's legal success locally and internationally." (Schmidt 2000, p.219). Although Schmidt noted that as of 1994 there had not been a single case of China asserting ownership in the legal system of another state (2000, p.202), things are changing - the return of the Jiangxi nest marks the first time that China has secured the return of dinosaur eggs through legal means abroad. Repatriation is becoming a more and more important thing for China: initiated in 2005, the China Fossil Preservation Foundation (Figure 9) was established in 2008, and is supported by the IVPP. It has worked for the voluntary repatriation of a few high profile

Figure 7. Promotional sign for the 'Dinosaur Babies Came Home' exhibition, outside the Zhejiang Natural History Museum, Hangzhou, for the start of the 5th international Dinosaur Eggs and Babies Symposium, September 2012.

specimens, similar to the infamous Czerkas' *Archaeoraptor* from Blanding Dinosaur Museum in Utah (Besterman 2001, Martill 2001).

So (assuming the legal interpretation of Schmidt (2000) stands), the following question arises: if (unlike the Hunterian) your dinosaur egg specimen was acquired (or left China) after December 28th 1993, how likely is it that your institution might have an enquiry from Chinese Government representatives, interested in the return of the material? Well, there is some good news: the sheer scale of egg exports means that it is apparent that the CFPF can only really afford to make a priority of dinosaur eggs that are truly exceptional, in terms of research or display value. If you have a bog-standard clutch or specimen that does not look anything special and has not been important in research terms, then it is highly unlikely to attract their attention. On the down side, this also means that you are unlikely

Figure 8. Inside the 'Dinosaur Babies Came Home' exhibition, (with inset detail of the visitors crammed around the repatriated* Oviraptor *nest specimen on opening day.

Figure 9. China Fossil Preservation Foundation members. Coming to a museum near you? (© JR Nudds, used with permission)

to be offered a cash sum to help you to repatriate the material voluntarily.

But there is one final development, in this year's implementation legislation for the new fossil protection law, that adds yet another twist to this story. Enacted in March 2013, it has a slightly ominous addition to what has been noted in previous implementation legislation: article 47, headed 'Suspected Chinese Material Abroad', outlines the procedure for reporting material that might have been taken out of the country illegally. Once a report is made, and investigated, the police, customs, and diplomatic corps are all involved. So a procedure has now been formalised, this year, involving responsible parties in the Chinese Government being mobilised to investigate and retrieve specimens abroad. Although it is far more likely that this legislation would be applied to material that has more recently been taken illegally from China (in terms of requiring a report to initiate the process), it looks very much as though this is the shape of things to come.

Therizinosaur postscript

Finally, some of you might be asking whatever happened to those spectacular therizinosaur eggs (which incidentally had been exported from China in December 1992). After years of dogged work by my dear late friend Arthur Cruickshank, and his colleague Ken Joysey (who were both - in my opinion - grossly unfairly vilified by some members of the 'museum establishment' for their role in trying to progress work on the eggs and finding them a home), the logjam was eventually broken with a publication in Acta Zoologica, in which the specimens were given Chinese Academy of Geological Sciences temporary accession numbers "pending their permanent repository in a museum in China" (Kundrát *et al.* 2008, p.232). Those eggs look to be going back to China, probably to the sort of welcome that the Jiangxi nest received (they certainly look more impressive), but if the new legislation is anything to go by, they will not be the last.

Conclusions

1 - Dinosaur and other vertebrate fossils 'of significant value' were illegal to export (without an official permit from the Ministry of Archaeology) since November 1982.

2 - Dinosaur eggs do not appear to have been formally regarded or treated as vertebrates (= non trace fossils) until December 1993.

3 - If you have export documentation from before that date, it probably indicates that your eggs were exported within Chinese law.

4 - You are unlikely to be requested to return your material, unless it is exceptional amongst the many thousands of dinosaur eggs that were taken out of China.

5 - Nothing is certain.

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(Adopted at the 25th Meeting of the Standing Committee of the Fifth National People's Congress on 19th November, 1982; revised in accordance with the "Decision of the Standing Committee of the National People's Congress Regarding the Revision of Article 30 and Article 31 of the Law of the People's Republic of China on Protection of Cultural Relics" at the 20th Meeting of the Standing Committee of the Seventh National People's Congress on June 29, 1991; and revised again at the 30th Meeting of the Standing Committee of the Ninth National People's Congress on October 28, 2002)

2007:
Order No.84 of the President of the People's Republic of China-Decision of the Standing Committee of the National People's Congress on Amending the Law of the People's Republic of China on the Protection of Culture Relics
(Adopted at the 31st Meeting of the Standing Committee of the Tenth National People's Congress on December 29, 2007)

2010:
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2010:
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(Adopted at the Fourth Ministerial Meeting of the Ministry of Land and Resources of the People's Republic of China on December 11, 2012, effective March 1, 2013)

ODYSSEY OF AN AMETHYST GEODE

by V. Carrió and S. Stevenson

Carrió, V. and Stevenson, S. Odyssey of an amethyst geode. *The Geological Curator* 9 (10): 557 - 562.

The National Museum of Scotland in Edinburgh, Scotland (UK) (formerly known as The Royal Museum), reopened in July 2011 after undergoing a massive renovation programme which resulted in the completion of 16 new exhibitions - among them several Natural Science galleries.

A huge amethyst geode weighing 2300 kg was chosen as the iconic centrepiece for the gallery entitled Restless Earth. The amethyst was formed in Brazil, was mined and cut there to reveal its stunningly attractively crystals, and then crated and shipped in two parts to the National Museum of Scotland. Before installation it had numerous moves within the museum, was unpacked and required re-crating. Did the geode suffer any damage in transit? Were there problems caused by changing the orientation of the crates during lengthy storage periods? What challenges were faced in handling, storing and installing such a large, heavy, brittle object?

Follow the Odyssey of the Amethyst Geode from its formation in the volcanic lavas of Brazil on its 10,000 km journey to the National Museum of Scotland.

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Introduction

In 2007 National Museums Scotland (NMS) purchased a fantastic complete amethyst geode from Rio Grande do Sul, Brazil.

A specialist dealer gave an assurance of authenticity, a choice of several pieces/ dimensions (accompanied by photographs) and prices. The pieces chosen have aesthetically pleasing shapes and the crystals show top quality deep purple colour. Their shapes are significantly different to the normal oval or cathedral arch-like amethyst geodes. This large, stunningly attractive amethyst geode, in two parts (1100 Kg and 1200kg) was purchased to be displayed in one of the new science galleries. Indeed these giant (over 1.88m tall), multiple lobed geodes are unlike anything seen in other UK museums and have an immediate impact on visitors, leaving a lasting memory. The proposed new geology exhibit entitled Restless Earth created the perfect location to display this iconic item.

The gallery portrays our habitable planet as a dynamic system. A large globe displays earth changing events - earthquakes, volcanic eruptions, tsunamis and landslides. An array of rocks, fossils and minerals are also displayed - evidence of the Earth's structure and processes.

The Geology of Geodes

The name geode is derived from the Greek word "Geoides" which means Earth like, referring to the shape of the Earth, since many geodes are spherical. A geode is a hollow cavity lined with crystals that can form in any void within a rock. When a cavity is completely filled (e.g. an agate) it is called a nodule.

The most common method by which geodes are formed is when a bubble is trapped in cooling volcanic lava. This can sometimes merge into single large bubbles or lobed aggregates. Over time permeating mineralised fluids fill the cavities and crystals grow. Each geode has a unique size, shape and crystal formation. Although some may be similar in composition and origin, no two are exactly alike. The rough exterior of the geode gives no indication of the secrets held within. This is only discovered when the geode is cracked open or cut with a rock saw.

For many years geologists have tried to explain how geodes form and several theories have been explored. Both Kantor (2003) and Macpherson (1989) have different explanations as to how crystallisation from mineralised solutions can generally occur within a cavity. Regardless of which theory is correct the outcome is the same: a spherical or distorted gas cavity lined with microcrystalline material and/or crystals.

The mineralised fluids permeating in the Rio Grande do Sul lavas can give rise to a number of precipitates. Most common are varieties of quartz, but calcite, barite, gypsum and goethite amongst others are also found.

The quartz crystals can be of many colours: smoky, brown, grey, violet and colourless. Amethyst is the purple variety of quartz and is often considered the most spectacular. Amethyst crystals get their colour from trace amounts of ferric iron within the crystal lattice and exposure to natural radiation within the rock.

Giant amethyst geodes occur in few places in the world. Those which occur in the Brazilian state of Rio Grande do Sul are abundant and are of the highest quality. Amethyst geode 'caves' and 'cathedrals' have been found in this locality. The geodes are found within a huge basalt formation known as the Parana basalts, which formed 130 million years ago.

Most mining is done by driving tunnels (up to 150m) into the richest basalt flows allowing large geodes to be located. A small hole is drilled, and then a light inserted to check the size and quality of the amethysts. Decisions are made on the method of extraction depending on the assessed quality of the geode. If it is identified as being of good quality it will be removed very carefully (although breakages can occur). Those of poorer quality will be broken and sold in small pieces (Balser 2008). Each year two to three thousand tons of agate and amethyst are exported from this region to all parts of the world. (Currier 1997).

Transport and storage

Before packing, vulnerable micro-fractured areas between crystals were consolidated with epoxy resin and the outer surfaces reinforced with toning plaster (Currier 1997).

The supplier then packed each part of the geode into wooden, locally made crates, which had reinforced bases designed to allow vertical storage and transportation. The packing materials comprised plastic film wrap, bubble wrap and lots of sawdust.

When the crates arrived at NMS (Figures 1-2) and were opened in May 2007, the packing material covering the geode's surface was removed (Figures 3-4). After thorough visual inspection, no damage was detected. Some small areas were recorded as vulnerable and images were taken for the record.

Figure 1. Crated geode (two parts), in vertical position, arriving at NMS.

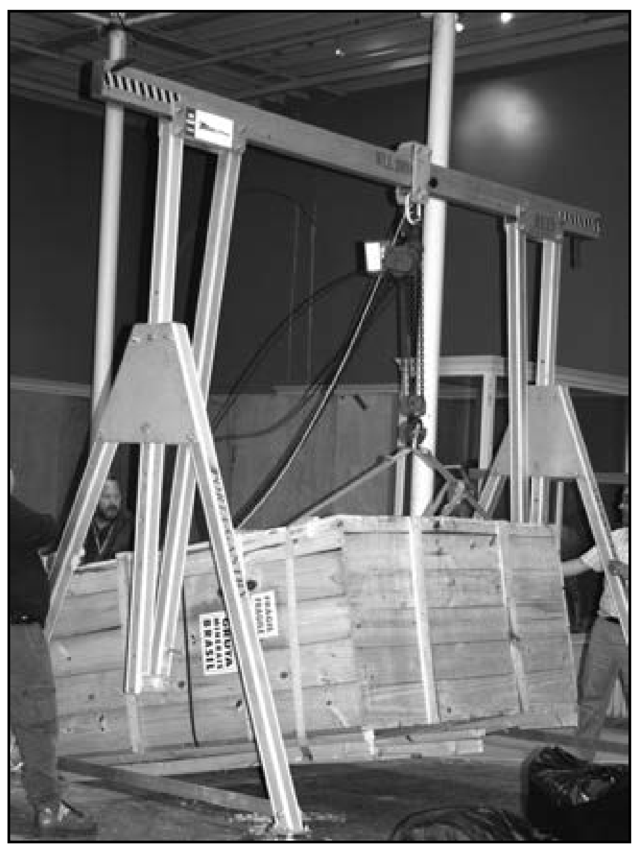

Figure 2. NMS staff constructed a metal A- frame to allow the crate to be turned to a horizontal position to check the contents.

Figure 3. Removing top layers of sawdust and clear film packing to allow inspection.

Figure 4. Inside view of one amethyst geode inside the crate.

The closed crates containing the geodes were stored in a temporary area in a horizontal position for easier handling and to allow access by exhibition designers and planners.

During the next two years the crates were moved on numerous occasions with lifting pallets to allow construction work on the building to be carried out.

Re-crating the geode

By summer 2009 overloading of the crate by storing in a horizontal position had caused structural failure. Both crates were broken (Figure 5). A condition report was commissioned to established how best to move the crates without causing damage to the geodes. The report concluded that new crates should be constructed with reinforced bases, to allow the geodes to be safely stored horizontally. The geodes were transferred by an external contractor supervised by an NMS conservator.

The external contractors built a metal A-frame (similar to that shown in Figure 2) to support the weight of the geode. This was reinforced with extra padding in vulnerable areas. Lifting slings were inserted under the geode and then attached to metal bars fixed to tensioned cables (Figures 6-8). These cables allowed good control when lifting. The slow motion allowed listening carefully for cracking sounds therefore avoiding damage to the geode. The sawdust packing was re-used in the new crate to support the geode until the crates were transported to the final destination on the floor above.

The geodes were safely stored in the new crates until the permanent display space was completed.

Final Destination

The new challenge at the beginning of July 2011 was to move the geodes to an upper level for display in the Restless Earth Gallery, their final destination. A spider crane (Figure 9) was hired to carry out this complex and specialist job. Because the spider crane required the full floor space, the two parts of the

Figure 5. Damage to original crate.

Figure 6. Crate removed showing compressed sawdust supporting the geode.

Figure 7. Channels excavated through the compressed sawdust allowing lifting slings to be fitted.

geode were the first specimens installed in the gallery.

The geodes were unpacked, checked for conservation requirements, and prepared for display. The official date for the NMS opening was 29th July 2011, four years after the geodes arrived.

A metal frame (Figure 10) was constructed to support the geodes which were to be displayed back to back. After an engineer checked that all the metal frame supports were safe, a wooden skirting structure was constructed around both part of the geode. All dust, sawdust packing and building debris around the structure and between crystals were removed with a vacuum cleaner and air dusters before the visible parts of the frame were painted to blend in with the matrix.

Figure 8. Lowering suspended geode into new crate.

Figure 10 Back to back metal support structure.

Figure 9. Spider crane lifting crated geode from Level 1 to Level 3.

Conclusion

This experience has facilitated a better understanding of the importance of "this way up" instructions during transport and storage, especially when dealing with extremely heavy brittle objects. Many of the complexities associated with moving this type of object particularly in small, restricted areas surrounded by glass display cases, have also been learned.

There is a high potential for damage to heavy/vulnerable objects during lifting and it is essential to have even distribution of weight with no pressure on any particular point during handling. When handling objects that have been prepared elsewhere and little information has been provided, it is important to think the worst. The geode may have had areas vulnerable to fracture which were camouflaged by the plaster reinforcement.

Figure 11. The amethyst geode display in the Restless Earth Gallery.

Throughout the long journey from Brazil to Edinburgh (10,000 km) and during the many transfers within the Museum, these spectacular geodes were not damaged and so vital conservation work was not required.

This fantastic amethyst geode display now has pride of place in the recently completed Restless Earth Gallery (Figure 11). Since the reopening of NMS in summer 2011, around 3 million people have visited the museum.

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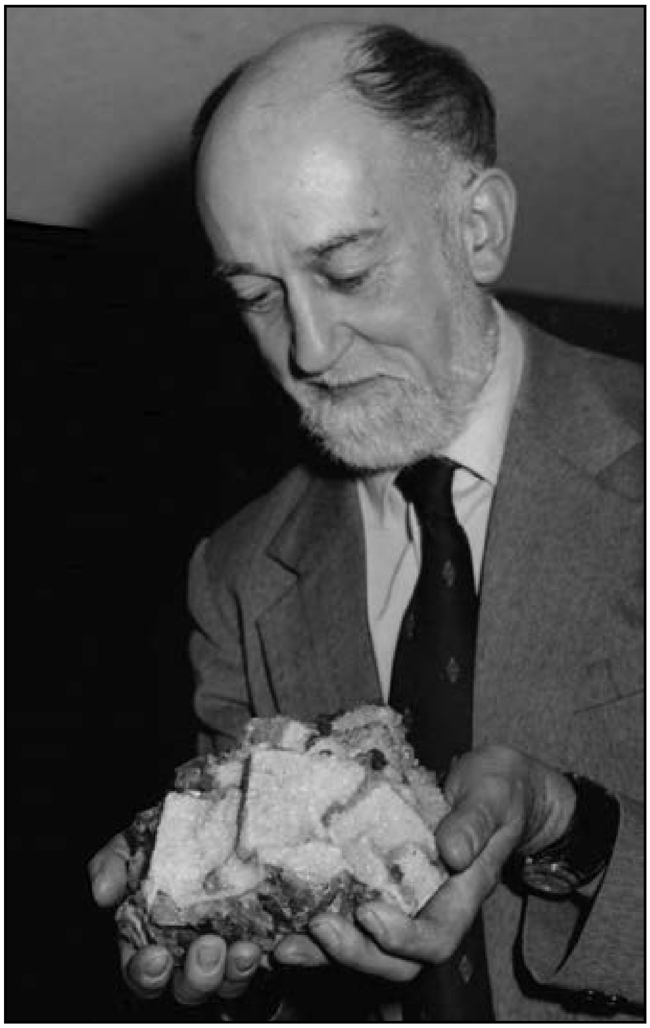
ROBERT (BOB) JOSEPH KING - (1923-2013)



Bob King at the British Mineral and Gemshow in Leicester - March 1981, reproduced by permission of the *Leicester Mercury*.

Bob King will be known to almost all current and past members of the Russell Society, as its founder, and greatest advocate. He was a major figure in the fields of British mineralogy and mineral collecting, with a network of friends and colleagues that spanned the globe.

Robert Joseph King was born on the 18th March 1923 in Leicester, England. He attended the City Boys School, Leicester, and obtained a post as a student at Leicester (New Walk) Museum, until interrupted by World War II. Bob served in North Africa and Italy, returning with a large suite of minerals from Monte Somma (Mt. Vesuvius). After being demobbed from the armed forces in 1946, he worked for eight years on a farm in Newton Harcourt, Leicestershire. He became friends with the late John Harry McDonald (Mac) Whitaker who would send people bringing mineral specimens into the Leicester New Walk Museum to "go and speak with Mr. King at Newton Harcourt".

Mac regularly visited Bob to discuss identifications and localities in Leicestershire, forming a friendship which later led to him recruiting Bob to a post as technician in the Geography Department of the University of Leicester in 1954, (along with Trevor Ford and Tony Evans). Mac formed the Geology with Geography Department in 1952 and by 1954 Geology had become an independent department that flourished under Mac's team (and later with Peter Sylvester-Bradley). It became one of the UK's leading teaching and research departments, of which Mac was a key member until his retirement in 1985. Bob progressed to become Chief Technician and Curator, a role which suited his interests and skill set admirably. He studied for an external degree from Imperial College, London, gaining an MSc in geology in 1972, and went on to read for a PhD on "The Mineralogy of Leicestershire", in the Geology Department at Leicester, a subject which remained an abiding passion for much of his life.

Bob's interest in minerals started when he was about 8 years old, encouraged by his father Robert William King who was a strong believer in getting out to look at the natural world, and also bought Bob his first mineral book. Being based in Leicester, he focused initially on collecting in the East Midlands, but from the late 1930s he diversified, going further afield (using public transport and a bicycle) in search of fine mineral specimens. The Cumbrian iron mines, the North Pennines, and the Caldbeck Fells in the northern Lake District were some of his most popular collecting areas.

Bob was a protégé of the late Sir Arthur Edward Ian Montagu Russell, 6th Baronet, MBE, FRS (30 November 1878 - 24 February 1964) perhaps the most famous British mineralogist of the 20th century. He corresponded and exchanged specimens with Sir Arthur, visiting him at his home in Swallowfield Park, near Reading.

Bob was married to his first wife, Iris in 1949, who sadly died, and with whom he had two children, Barry and Josephine. Later, in 1977, he married his present wife Sally, with whom he also had two children, Amy and Daniel, and enjoyed many happy years.

In his professional life Bob was member of numerous organisations including the Mineralogical Society of Great Britain (since 1948; Elected Fellow in January 1998); Fellow of the Institute of Quarrying since December 1981; Fellow of the Institute of Science and Technology since March 1996; and Founder member of Geological Curators' Group in 1974 (and winner of its A.G.Brighton Medal in 1995 - see the citation in *The Geological Curator* 6(7), 287-289 [1997]).

Bob's local geological and mining interests lead to him participating in the activities of the Peak District Mines Historical Society (with his great friend and colleague Trevor Ford); the Leicester Literary and Philosophical Society (where he became Life President of Section C: geology); and in his later years, following a move to rural Gloucestershire he became keenly involved with the Cotteswold Naturalists Field Club.

The Russell Society was born, out of an evening class, on the 27th October 1972 when approximately thirty people, all from the area in and around Leicester, met to inaugurate a mineralogical society. Bob sought the blessing of Lady Russell to adopt her late husband's name, and the rest, as they say, is history. Bob provided early leadership and direction, and served as President from 1973 - 1975.

The early days of the Society saw many exciting initiatives, including the sinking of a shaft to gain access to a small lead deposit (Tickow Lane mine), and extensive investigations and a feasibility study on reopening the famous Earl Ferrers' Lead mine at Staunton Harold.

Ten years after the founding of the Society, Bob proposed that a new publication be launched - The Journal of the Russell Society, the aim being to provide a vehicle for the publication and recording of papers relating to British Topographical Mineralogy. The Journal continues today as a respected peer-reviewed publication, regularly reporting significant new finds and research projects, both by members and third party researchers and mineralogists.

Bob's very fine personal mineral collection was purchased in 1983 by The National Museum of Wales, Cardiff, where it now forms an important part of the collections. As part of this arrangement Bob took up an honorary post at the Museum, where he planned to conduct research on his collection and the many associated field notes and documents. He and Sally moved from Leicester to St. Athan, near Cardiff, and enjoyed five years living in South Wales, seeing through the establishment of the Russell Society's Wales and West Branch, in which they both played an active role.

Things did not work out quite as Bob had hoped on the mineralogical front, and he and Sally decided to move to Tewkesbury 1988 where Bob took up the post of Curator at the John Moore Countryside Museum, providing an opportunity for him to rekindle his fondness for the countryside, agriculture and the broader field of natural history. They later moved out of town to a plot near Longdon, where they built a house with a large garden and beautiful rural views.

In 1980 Bob had suffered a stroke whilst working at Leicester University, but from which he made an excellent recovery. Sadly, he suffered another stroke in 2008, from which he never fully recovered, and his health deteriorated steadily over a number of years. He was however invariably pleased to see me when I called-in every couple of months or so on my way home from work, eager to hear the latest mineralogical news and gossip, and wanting to know what everyone was up to in the mineral world.

With Bob's declining health it was decided to move to Bishops Cleeve, just outside Cheltenham, to be nearer to their daughter Amy and also to shops and services. During this period Bob undertook extensive research on the minerals of Gloucestershire, a programme of work which led to a series of papers in the Proceedings of the Cotteswold Naturalists' Field Club from 2007-2012.

Bob's published works are predominantly in the fields of specimen and topographic mineralogy, but he also compiled a comprehensive series of articles under the title "The Care of Minerals" intended to be of use to both collectors and mineralogical curators. His article on "The Boltsburn mine, Weardale, County Durham, England" won the award for "best article of the year" in the Mineralogical Record for 1982. Even in retirement, Bob's written output was impressive, and he was engaged to write a regular column for the journal Geology Today, taking a different mineral or mineral group in each issue, and providing an introductory review aimed at the non-specialist reader. The series began in 1985 with "Minerals Explained 1: Fluorite" and concluded with "Minerals Explained 50: "Olivine Group" in 2009, comprising a total of fifty articles and a true tour de force of educational specimen mineralogy writing. Being a strong believer in the value of handling and studying specimens, Bob sought to acquire representative examples of the minerals he was to describe in each issue, and this gradually built up to become what was known as the "New King Collection", and which was eventually sold by auction to Society members and friends on 26th June 2011.

The Russell Society celebrated its 20th Anniversary in 1992 by establishing a new international award, the Russell Medal, to recognise "… *outstanding contributions which lead to the education and promotion of topographical and specimen mineralogical studies, specimen and site documentation, preservation and conservation*." There was unanimous agreement amongst the Society Council that the first recipient should be Dr R.J. King, and Bob was duly presented with the medal at the Society's Annual General Meeting in Leicester in May 1992.

Bob's contributions to earth science have been formally recognised, firstly in 2000 by the naming of *Offacolus kingi* a chelicerate arthropod which he discovered in the concretions of the Silurian-aged Wenlock Formation in Herefordshire (Orr *et al*., 2000); and in 2002 the new mineral bobkingite ($Cu^{2+}5Cl_2(OH)_8(H_2O)_2$) was named for him. The mineral is a hydrous cupric chlorohydroxide that occurs as a secondary mineral with malachite and azurite on massive cuprite at the type locality, New Cliffe Hill quarry, Stanton-under-Bardon, Leicestershire, first described from a specimen collected by Society member Neil Hubbard. (Hawthorne *et al*., 2002)

A man of many interests, Bob greatly enjoyed gardening, was an accomplished chorister (singing firstly in the choir at Leicester Cathedral, and following their move to Tewkesbury, in the abbey there), and had a formidable knowledge of natural history.

Bob is survived by his wife Sally, daughter Amy and son Daniel; son Barry and daughter Josephine from his earlier marriage, and grandchildren Michael, Lily and Emily, of whom he was extremely proud. Always interested and enthusiastic about anything to do with geology and mineralogy, Bob was keen to encourage newcomers and youngsters, and always took time to explain things to those less knowledgeable about the subject. He will be greatly missed, but also remembered for the many contributions which he made and for the lives he touched.

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Roy Starkey

[Reproduced, with slight amendment from the Journal of the Russell Society]

LOST & FOUND

Enquiries and information, please to Matthew Parkes, (National Museum of Ireland - Natural History, Merrion Street, Dublin 2, Ireland; e-mail: mparkes@museum.ie). Include full personal and institutional names and addressess, full biographical details of publications mentioned, and credits for any illustrations submitted.

The index to 'Lost & Found' Volumes 1-4 was published in *The Geological Curator* 5(2), 79-85. The index for Volume 5 was published in *The Geological Curator* 6(4), 175-177.

Abbreviations:

CLEEVELY - Cleevely, R.J. 1983. *World Palaeontological Collections*. British Museum (Natural History() and Mansell Publishing Company, London.
GCG - *Newsletter of the Geological Curators' Group*, continued as *The Geological Curator*.
LF - 'Lost & Found' reference number in GCG.

270. The fossil collection of John Innes (c.1853-1923)

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Amongst the many centenaries of 2014 is that of the death of the Welsh artist James Dickson Innes (1887-1914). With Augustus John, Innes made repeated visits between 1910 and 1912 to Snowdonia, painting the mountains of Arenig Fawr and Arenig Fach near Bala, in what is a classic area of British Lower Palaeozoic geology. It was here, from the western flanks of Arenig Fawr to Bala and the upper part of the Hirnant valley southeast of Bala Lake, that Adam Sedgwick defined the Arenig and Bala Groups in 1835. This is also where Charles Lapworth in 1879 defined the Ordovician System and Period, and included Sedgwick's Arenig rocks as the Arenig Series at the base of the Ordovician (Bassett *et al.* 1966).

In attempting to assess what influence some geological knowledge may have had on Innes' portrayal of these mountains, I would like to locate the whereabouts of his father's fossil collection.

His father, John Innes (c.1853-1923), was an accountant for the copperworks of Nevill Druce & Co in Llanelli in Carmarthenshire in South Wales. He had broad antiquarian interests and was involved in the Mechanics' Institute which later became Llanelli Public Library. His lectures on local history there were later the basis for a book, *Old Llanelly*, (Innes 1902), to which he also contributed a short chapter on the local geology. In July 1913, a few years after retiring and suffering from ill health, Innes moved to Devon, settling in Whitchurch just south of Tavistock until his death, aged 69 or 70, on 7 May 1923. (Emannuel 1940, Hughes 1984, 1985).

His contribution to local history in Llanelli warranted his inclusion in the *Welsh Dictionary of Biography* where it is said that "Innes was also interested in photography and geology and possessed a fine collection of fossils obtained from local mines and quarries".

The collection probably comprised Coal Measures plants and Carboniferous Limestone fossils, but seems too to have had some significant trilobites, possibly from the Ordovician or Silurian of Carmarthenshire. An artist and friend of James Dickson Innes recorded a visit to the house in Tavistock, and describes John Innes as "quiet but studious, an authority on Trilobites, many of which he had collected, and some new specimens in South Wales" (Frank Slade, 'Memories of Dick Innes', typescript dated 28.8.58, Tate Gallery Archives, TGA 937.1). Although not mentioned outright, this suggests that when John Innes moved to Devon he took his collection with him.

Innes' collection is not recorded by Cleevely, and enquiries so far to museums in Tavistock, Exeter, Plymouth, Cardiff, Carmarthen and Llanelli have failed to bring any success. Any information on the present location of the collection, if it survives, would be most welcome.

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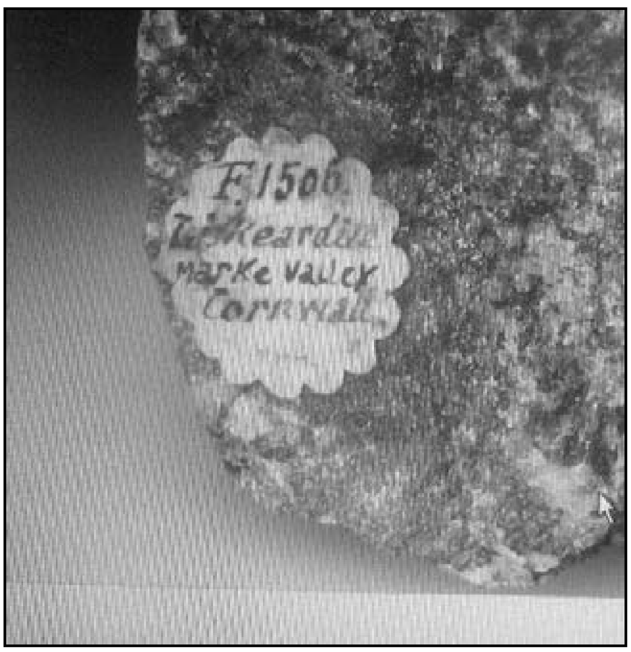
INNES, J.,1902. *Old Llanelly*. Cardiff: The Western Mail, xii + 175pp.

271. Unusual flower style label

Martin Vincent.
Email: martinvincent1@blackberry.orange.co.uk

If anyone has any information on the unusual flowery style label, particularly provenance or any collectors who used them, please contact Martin Vincent.



The Geological Curator

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THE GEOLOGICAL CURATOR

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