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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 wellbeing
- 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.

2016 COMMITTEE

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Cover: Giant Irish Deer skeleton after conservation. See paper by Aughey *et al.* inside.

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A GAME OF TWO HALVES? SPLIT SPECIMENS IN DIFFERENT COLLECTIONS

by Stephen K. Donovan and Deborah I.E. Schoor

Donovan, S. K. and Schoor, D. I. E. 2016. A game of two halves? Split specimens in different collections. *The Geological Curator* 10 (5): 195 - 199.

Museum specimens consisting of more than one component, a part and counterpart(s), may be split up by our actions, intentionally or otherwise, and the knowledge that they have been divided either forgotten or lost. We present two contrasting examples. A syntype of an Upper Devonian crinoid from Devon, south-west England, *Eumorphocrinus*(?) *porteri* (Whidborne), is now divided between the Geological Survey Museum, Keyworth, and the Natural History Museum, London. One of the specimens has gained a label bearing erroneous locality data. In contrast, the 'other half' of a pluricolumnal recently described from Noil Simaam, Timor, and identified as *Barycrinus*? sp., is recorded. It was missed hitherto because of the division of accessions in the Naturalis Biodiversity Center, Leiden, into smaller, bagged aliquots. We recommend that curators and researchers remain vigilant of possible separations when dealing with their own collections and with those of other museums.

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Introduction

We present this brief discussion of two pairs of specimens as an indication of some rare, perhaps unexpected and certainly unintentional distributions of specimens in museum collections. The examples discussed are Palaeozoic crinoids, but analogous examples may be envisaged for any and all groups of fossils or, indeed, rock specimens. Certainly, both of the examples discussed below are the result of human error, rather than any influence of the taphonomy of the crinoids.

Both examples were discovered recently by the authors during their respective research programmes investigating the crinoids from the Devonian of south-west England and the Permian of Timor, south-east Asia. The two examples show dissimilar modes of preservation and their spatial distribution in collections is an artefact of human endeavour. The two examples are united in that the specimens either consist of two parts that are presumed to have been knowingly separated or are two parts from one site, yet divided between different aliquots of the sample by the original collector(s). The specimens discussed herein are deposited in the British Geological Survey, Geological Survey Museum, Keyworth, UK (BGS GSM), the Natural History Museum, London, UK (BMNH) and the Naturalis Biodiversity Center, Leiden, the Netherlands (RGM).

An errant British Devonian crinoid

In a short paper, Whidborne (1896, p. 377) erected several new species of Upper Devonian crinoids without illustration and with minimal information. A syntype of one of these species, *Eumorphocrinus*(?) *porteri* (Whidborne), is of interest in the present study; it was originally named *Actinocrinus Porteri*. Whidborne's (1898) monograph included ample illustrations of this species, together with a more detailed description and discussion. Two of Whidborne's figures are of interest (Figures 1B, F, 2). Whidborne's plate 32, figure 1 (Figure 2 herein; compare with Figure 1B) (= BGS GSM7141), was published with the following original caption: "Specimen, containing the opposite side of the dorsal cup figured on Pl. XXXI, fig. 5, together with the stems of several other individuals. Braunton. Museum of Practical Geology." The second specimen mentioned in this caption and figured by Whidborne (1898, pl. 31, figure 5) is BGS GSM7140

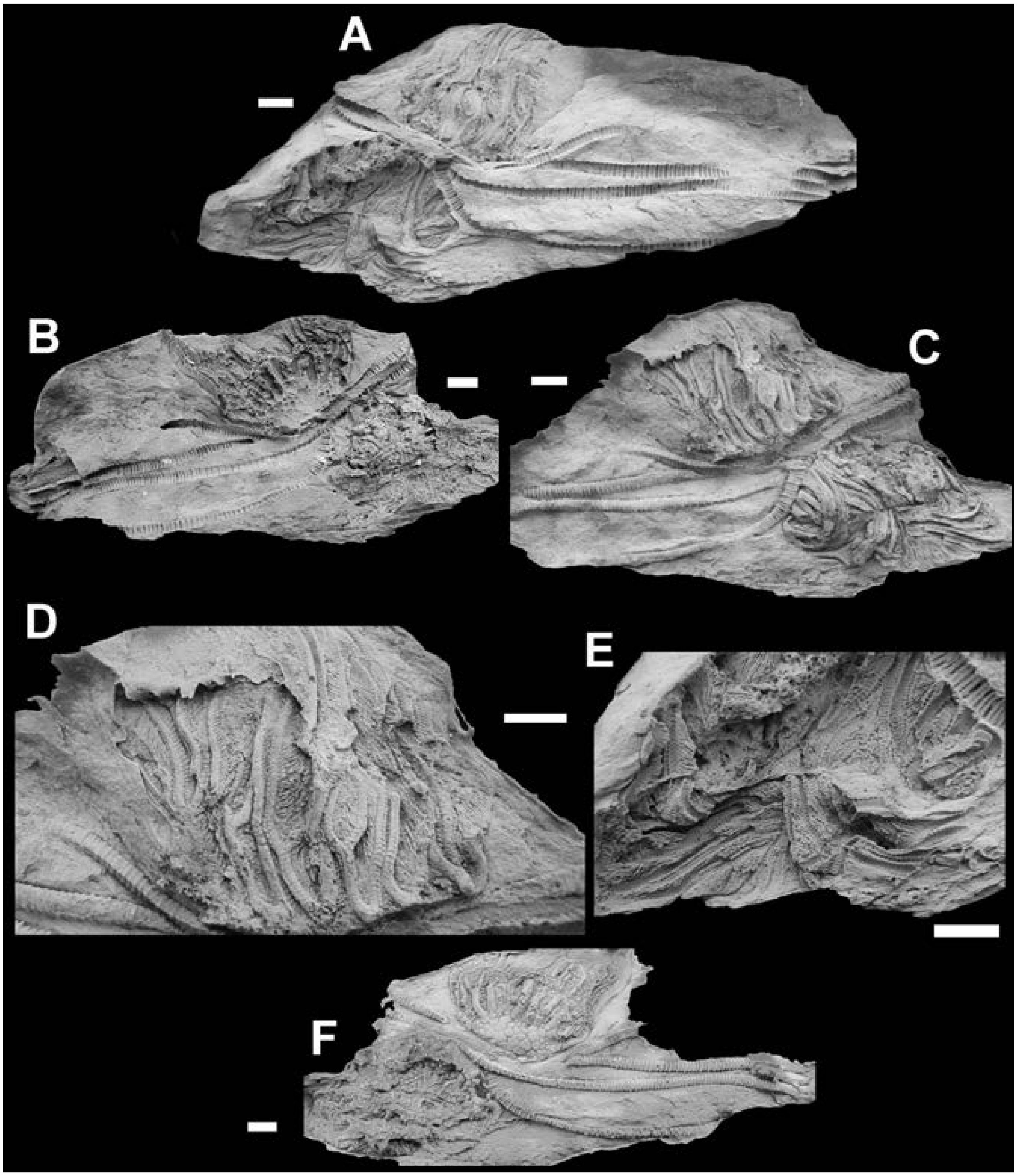

Figure 1. **Eumorphocrinus***(?)* **porteri** *(Whidborne, 1896) from the Upper Devonian of north Devon. (A, C-E) BMNH E1374ii, syntype, natural external moulds (A, E) and latex casts (C, D) (counterparts of BGS GSM7141; after Donovan and Fearnhead 2014, pl. 8, figs 1, 4, 7 and 5, respectively). (A) Complete slab. (C) Cast of left side of slab. (D) Cast of arms in upper left of slab. (E) Mould of arms in lower left of slab. (B, F) BGS GSM7141, syntype (counterpart of BMNH E1374ii; after Donovan and Fearnhead 2014, pl. 9, figs 9 and 10, respectively). (B) External mould, complete slab (compare with Figure 2). (F) Latex cast of same. Specimens whitened with ammonium chloride. Scale bars represent 10 mm.*

(Donovan and Fearnhead 2014, text-figure 11C, pl. 9, fig. 6), which is not a counterpart of 7141. The actual counterpart is BMNH E1374ii (Figure 1A, C-E). Of this part and counterpart, only BGS GSM7141 was recognized as a syntype by Lane *et al.* (2001, p. 1058).

How these specimens became separated is unknown, one being in the collection of the BGS GSM and the other in the BMNH, a strange division for what was a single specimen. Even more peculiar are the specimen labels. "The type locality is the Upper Devonian at Barnstaple … Although obviously the

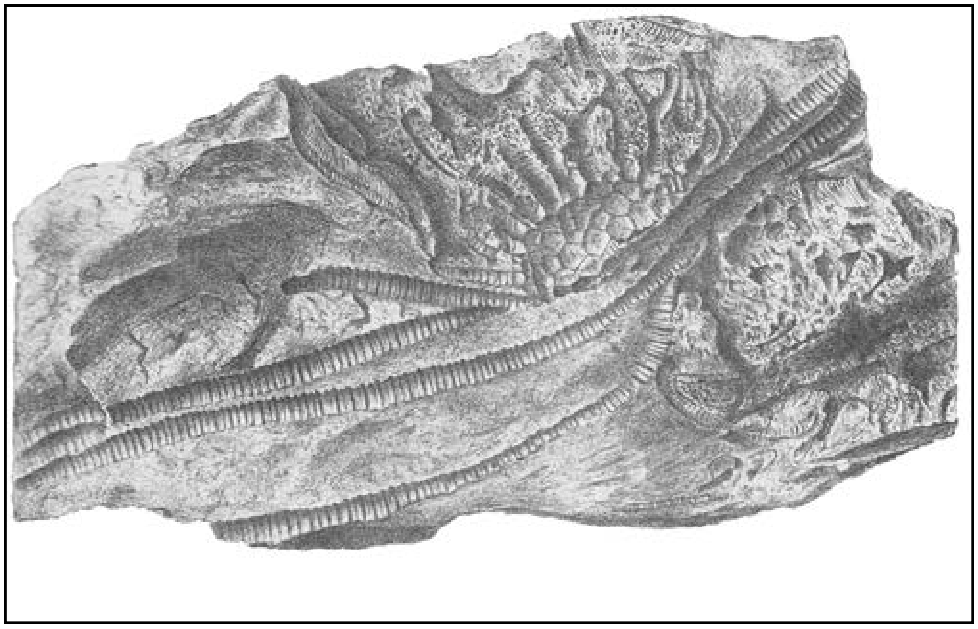

Figure 2.* Eumorphocrinus*(?)* porteri *(Whidborne, 1896) from the Upper Devonian of north Devon, BGS GSM7141 (after Whidborne 1898, pl. 32, fig. 1; compare with Figure 1B).

counterpart of BGS GSM7141, from Braunton [see Whidborne 1898], the label of BMNH 1374ii, labelled *Rhodocrinites*, states "Ur. Devonian - Marwood Beds. Marwood"" (Donovan and Fearnhead 2014, p. 26).

Why the counterpart of the BGS GSM specimen should have found its way into a different museum is unknown. After Whidborne, the first serious research on this species was more than a century later by Lane *et al.* (2001), who did not recognize the separation and it thus remained unidentified until recently (Donovan and Fearnhead 2014). Both the BGS GSM and the Sedgwick Museum, Cambridge, have several specimens of *E.*(?) *porteri* in their collections whereas only BMNH 1374ii is to be found in the BMNH, yet this cannot have been any reason to obtain the counterpart as it was misidentified as *Rhodocrinites* on the label. There is no indication on the labels of either BGS GSM7141 or BMNH E1374ii that a counterpart exists elsewhere, and it only came to light when S.K.D. examined the Devonian crinoid collections of both museums in detail, presumably for the first time since Whidborne.

Dr. Michael J. Simms (written comm. to S.K.D., February 2016) has made a comment which we consider so relevant as to quote at length: "Several possibilities exist that might account for this separation. Firstly, the [former] close proximity of the [BGS GSM] and [BMNH] might be a factor, although I don't think it is. What seems more likely is that the specimen was purchased … from a local collector … Certainly there is anecdotal evidence from Northern Ireland that fossil sellers at the Giant's Causeway in the 19th Century would sell two halves of a broken ammonite separately, and I can certainly imagine that they would do the same with part/counterpart. … Maybe the BMNH specimen was acquired or found by a third party who didn't know the exact history/locality from which it was recovered. In an analogous situation, we have an ichthyosaur skull on display [in the National Museums Northern Ireland], found on the Antrim coast, that was found as four separate pieces by two individuals, and a dissociated ichthyosaur skeleton of which pieces were found (around 2002) by at least half a dozen different individuals (including me!) over a period of several months. Many palaeontologists in the 19th Century were describing material that they had acquired from quarrymen or local collectors, so this seems a plausible explanation to me."

A Permian crinoid from Timor

A recent contribution described the first specimen of the cladid crinoid *Barycrinus*? Wachsmuth, a large, distinctive and pentameric pluricolumnal, from Noil Simaam, which is probably in the western part of East Timor (Donovan and Webster 2016). This specimen, in the collections of the Naturalis Biodiversity Center, Leiden, was given a new registration number RGM 792 283. Formerly it had been part of a bulk sample, RGM 878 276, spread over a number of bagged lots.

Subsequent to the original communication, D.I.E.S. commenced a M.Sc. project on selected aspects of the systematics and palaeoecology of the fossil crinoid columnals and pluricolumnals of the Permian of Timor. The Permian succession of Timor has yielded the richest fauna of marine invertebrates

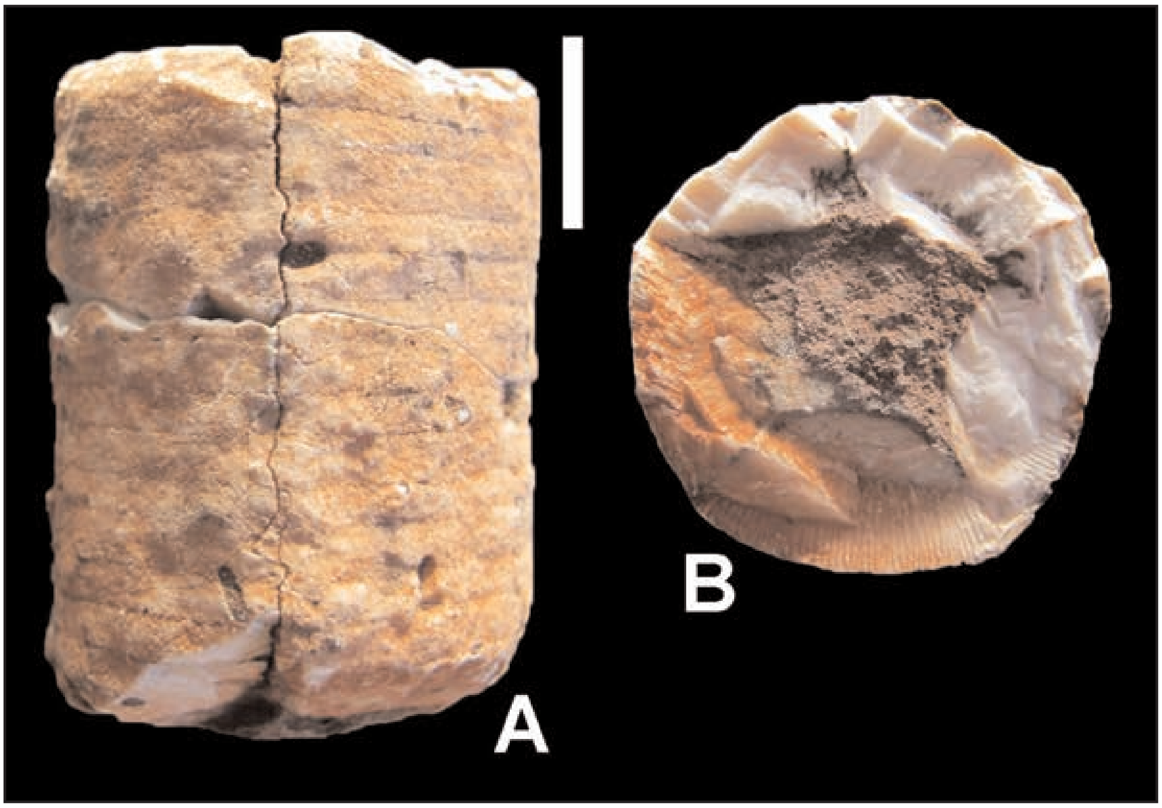

Figure 3. **Barycrinus***? sp. nov., RGM 792 283, from the Permian of Timor. (A) Pluricolumnal, RGM 792 283a (upper; compare with Donovan and Webster 2016, fig. 1B, taken from a different angle and inverted) and b (lower) in close association . (B) Articular facet, RGM 792 283b. This would have articulated with the facet illustrated by Donovan and Webster (2016, fig. 1A). Specimens uncoated. Scale bar = 10 mm.*

from anywhere in the world (Charlton *et al.* 2002), including about 300 species and subspecies of crinoid. The largest collection of Permian stalked echinoderms from Timor is that of the Naturalis Biodiversity Center, Leiden (Meijer *et al.* 2009). New taxa continue to be described from these collections, but systematic studies based on columnals and pluricolumnals are almost non-existent. These fragments form a significant part of the Naturalis collection and they are being surveyed by D.I.E.S. as part of her ongoing study.

Shortly after the proofs of Donovan and Webster (2016) were corrected, D.I.E.S. found the specimen documented herein (Figure 3), also in a bag from Noil Simaam, but numbered RGM 878 277. Although it adds little to the morphology of *Barycrinus*? sp., it is considered worthy of record if only to illustrate the complete pluricolumnal with both specimens restored to their relative positions (Figure 3A). The subtly-heteromorphic pluricolumnal consists of eighteen complete or partial columnals of similar, but slightly different heights.

The question posed by this pluricolumnal is how big was this crinoid, particularly the crown? Donovan and Veltkamp (1990, p. 988) had this to say about *Barycrinus* in the Mississippian of north-west England: "Comparison of *Barycrinus* sp. pluricolumnals [locally abundant at Salthill Quarry, Clitheroe, Lancashire] with the base of the dorsal cup of *B. ribblesdalensis* (Wright) [from broadly the same area of Lancashire] shows them to be similar … However, it is improbable that they are conspecific because the base of the cup in *B. ribblesdalensis* is generally much broader (usually at least three times) than the Salthill columnals." The Timor pluricolumnal is about twice the diameter of the stem facet at the base of the cup of *B. ribblesdalensis* (Wright 1950, figs 4, 8); large cups of the latter species are about 110 mm wide and 32 mm tall. Thus, if the Timor pluricolumnal is indicative of the size of the crown (that is, it is derived from the proxistele or proximal mesistele), then the cup would have been particularly large and it remains unknown either due to some taphonomic filtering process or collection failure; the latter is considered improbable. Alternately, and perhaps more likely, such a pluricolumnal may be large as part of an anchoring dististele (compare with Donovan 2013), although proximal to the distal-most part of the stem which was probably modified for attachment by root-like radices. Whichever is correct, RGM 792 283 poses questions that will only be answered by more and better preserved material.

Discussion

These examples are very different and yet show similarities. Both examples are preserved as two separate specimens for there was no indication on their labels that they were a part or counterpart of a pair. The Devonian crinoid is the more confusing, with part and counterpart each residing in a different museum (BGS GSM and BMNH), and the BMNH specimen even gaining an erroneous suite of locality information.

The Permian crinoid is easier to explain. The two halves of the specimen were collected from the same locality, but in different bulk samples that have been stored for many years in separate plastic bags, precluding easy access and comparison. It is entirely coincidental that S.K.D. first recognized one part of the specimen (Donovan and Webster 2016) only shortly before D.I.E.S. commenced her M.Sc. research and found the counterpart.

The lesson of this story is that we need to be vigilant both in our own collections and those of other museums. There may be parts of some specimens masquerading as separate entities and this separation may be further compounded by erroneous data on labels. Specimens in bulk samples need particular vigilance. Such separations may be old or recent.

Acknowledgements

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THE MINERAL COLLECTION OF WILLIAM 'BILL' TERRILL, FCS, MIMM (1845-1901)

by Tom. F. Cotterell

Cotterell, T.F. 2016. The mineral collection of William 'Bill' Terrill, FCS, MIMM (1845-1901). *The Geological Curator* 10 (5): 201 - 220.

William 'Bill' Terrill is little-known of as a collector of minerals but his well-curated collection of British and Worldwide minerals preserved at Amgueddfa Cymru - National Museum Wales is an excellent example of why it is important to properly label and catalogue specimens. It is also a testament to his widow and youngest daughter that his collection is preserved and so too his brother, Bertie, who kept meticulous diaries of family events which would otherwise have been long forgotten. Remarkably there are very few examples of mineral collections assembled within Wales and this represents a fine example of late Victorian collecting. Research into the history behind William Terrill and his collection has revealed a fascinating set of stories including his role in the establishment of a geological society in Swansea and his work as curator of the mineral collection at the Royal Institution of South Wales.

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Introduction

In 1937 the mineral collection of the late Wm. Terrill, FCS, MIMM (1845-1901) (Figure 1), was donated to the National Museum of Wales by his widow, Mrs M.E. Terrill. Mrs Terrill was by then quite elderly and all correspondence was through their daughter Miss Val Terrill.

Val wrote to the director, Sir Cyril Fox on 21 February, 1937, explaining, "*My father, the late Wm. Terrill, F.C.S., M.I.M.M., during his lifetime made a comprehensive collection of minerals including some very fine fossils. He also made a collection of shells - British and Foreign. For some time it has been felt that such a valuable collection should be used and not hidden in a private home*."

Val recorded that she had spoken to a Mr Grant Murray about the collection and that he had recommended approaching the museum as a suitable repository. Val's letter continued, "*If you consider the collection suitable for the National Museum of Wales, my mother, sister and I will be proud to make it a gift unconditionally*."

Dr F.J. North, Keeper of Geology, was informed and he arranged to visit the Terrill's at 42, St George's Terrace, Swansea on Wednesday 10 March, 1937, in order to assess the collections. This he did and on 12

Figure 1. W. Terrill photograph courtesy of the Royal Society of Chemistry.

March he wrote that "*I have given very careful consideration to the collections which I saw, and having spoken to my colleague in the Department of Zoology about the shells. He definitely confirms the opinion which I expressed to you, namely, that the Museum would not be able to accept the shell collection owing, partly to its exotic character, but principally because of the absence of locality information with the specimens.*

With regard to the geological material, a good many of the minerals are such that we should be able to incorporate them either into the exhibition series, or into our study series. There is, however, a large number of specimens which are either too small for either of these purposes, or in respect of which the information recorded is insufficient. Some of this material would be of use in the collections which we prepare for school purposes, and the residue, is, I fear, of no present value either here or in any other institution.

I trust that you will not think that in making these frank statements, I am, in any way, belittling the efforts of the collector of the material, but I am speaking of it from the standpoint of modern scientific usage.

We shall be very glad indeed, to accept your kind offer to present the mineral and fossil specimens if you are able to give us a free hand to use them in whatever way seems best, according to the potential utility of each individual specimen. In the circumstances, realising that you would naturally wish, if possible, to keep the collection together it might be worth while considering offering the collection to the Royal Institution in Swansea, or even the Museum in Merthyr Tydfil, where it would still remain within the confines of the county."

Despite North's somewhat uncomplimentary assessment, the Terrill family, in a letter dated 14 March, thanked Dr North for his frank assessment and advice and advised him that they had decided to give the museum "*a free hand with the collection and will afterwards take steps to find a suitable home for the collection of shells*." Mr Hall (the museum attendant) was duly sent to package the geological specimens ready for transport to the museum in April. Further correspondence from Val Terrill on 27 April highlighted that a few fossils had been overlooked, but that she would send them within the next few days. Their arrival is not recorded.

Although the collection was presented to the National Museum of Wales in 1937, it was not critically examined until 1951 (Howarth, 1954) when, it would appear, North's recommendations had been forgotten. This is somewhat fortuitous as a total of 752 mineral specimens were registered (under accession number NMW 37.239). It is not known exactly how many specimens actually entered the museum, but an estimate can be made by consulting William Terrill's small handwritten catalogue which records 995 mineral specimens. An undated handwritten (possibly in Howarth's handwriting) list documents the specimens which could be matched to entries within the catalogue. 324 are recorded indicating that by the early 1950s approximately 2/3 of those listed within the catalogue had lost their numbers. Eight of the numbered specimens were noted as 'not registered' indicating that they were considered to be of poor quality.

The collection was valued by the museum (for insurance purposes), in 1937, at a rather paltry £5.0.0 (approximately £276.80 in 2014 using the 'real price' method of calculation at https://www.measuringworth.com/ukcompare/relativevalue.php). Clearly the assessor had not consulted the catalogue or else they would have spotted that William kept a record of the prices he paid (although this only extended to the first 192 minerals). The total value expended by William on these 192 specimens was £16.5.1 (or £1,571 at 2014 'real price' values, based on an assumption that the price he paid was in 1900) and his most expensive specimen cost £3.0.0, or 60 shillings, on its own! The large fossil collection is entirely (bar a solitary trilobite mislabelled as the mineral franklinite) absent despite the original correspondence implying that it came to the museum.

Family

William 'Bill' Terrill was born on 24 November, 1845 the eldest of ten children (six sons and four daughters) of William Terrill (1809-1872) a shopkeeper and Marianne Terrill, née Tucker (1819-1908) of Upper Rose Row, Redruth, Cornwall. Only six of his siblings survived to adulthood. His youngest brother, Robert Philip King Terrill (born c. 1858) - known as 'Bertie', survived the longest and kept detailed diaries of family events which are now preserved at Swansea University as the 'Terrill Collection' (Reference code: GB 0217 LAC/141). Bertie worked with William in Swansea working for a time as technical manager at Morfa Copper Works, Landore. His diaries have been crucial in piecing together William's career and family history. Bertie's work diaries record events up to 1905 and his notebooks continue to record sporadic events up to at least 1933, but it is not known when he died.

In Cornwall, William worked in his father's shop, running the business during his father's illness in 1867. However, he was far more suited to the pursuit of knowledge and, at the age of 21, had gone to London to study under Professor Huxley (Anon. 1901b). He moved to Swansea on 17 September, 1869 to take up a position as chemist at The Morfa Silver Works. His salary was £80 per annum (approximately £43,360 in 2014 calculated using the equivalent 'labour value' which is always considerably more than the 'real price' used to calculate the value of specimens - https://www.measuringworth.com/ukcompare/relativevalue.php). In 1872 William was listed as Chief Chemist and Bertie was also on the staff (Bertie's diaries). William was living at 4 Westbury Street in Swansea when their father died in November 1872. William had travelled all night and arrived just in time to see him alive (Bertie's diaries).

William married Maria E. Eveleigh (born in Bedminster, Somerset on 31 May, 1854) in Bristol on Saturday 16 August, 1873 and during the same year informed Bertie that the whole family were to move to Swansea.

By the time of the 1881 census, William's house at 3 Hanover Street, Swansea housed his mother, brother Robert (Bertie), sister Olympia Dale, as well as his growing family: including his wife, eldest son William who was six years old, and another son Augustus S. (Stanley) who was just a few months old. The house was almost certainly very crowded and, in 1883, Bertie moved to 76 Westbury Street with his mother and sister.

In 1888 William moved from 3 Hanover Street to 42 St Georges Terrace. In the 1891 census William, Maria and their children lived at 42 St Georges Terrace and in the 1901 census William's mother was head of the house at 21 Bryn-y-mor Crescent with her children Ellen (44), Bertie (42) and Olive (Olympia) (37).

In all, William and Maria had seven children, but only five survived beyond childhood. Their first child, William Hubert Archibald Terrill was born on 10 May, 1874. He died aged 49 on 10 September, 1933. Their second son, W. Stanley Terrill, was born on 9 June, 1876, but died when only a few months old in August of that year. Augustus Stanley Terrill was born on 23 February, 1881 and died at sea sometime between 31 December, 1905 and 1 January, 1906 aged 24. Their first daughter, Claudia (Gladys) Eveleigh Terrill, was born on 11 May, 1883 and lived to the age of 41. She was followed by another girl, Rhonddalina Terrill, born on 26 September, 1886 (Bertie diary) who lived until at least 1948. Finally twin girls, Gwenmore and Valvire, were born on 3 September, 1890. Tragically, Gwenmore died at the age of just two on 21 January, 1893. Valvire, or Val as she was better known, lived until at least 1963 (Swansea phone book, 1963).

In early January 1895 William had his first illness - a haemorrhage of the stomach - as reported by Bertie in his diary. This affected him badly, so much so that he reduced the size of his teaching classes in 1896. In spring 1897 he gave up his teaching altogether.

He battled on, and on 7 August, 1900 he started a new job as copper works manager at Lamberts (Charles Lambert & Co., Port Tennant Copper and Arsenic Works). However his illness continued and (as reported in Bertie Terrill's diary) William died on 25 July, 1901 after a long very painful illness. William's death was reported in the South Wales Daily Post - as "*died on July 24* [sic], *aged 55, at 43 St George Terrace. Burial at Cockett*".

Bertie reported in his diary on 25 July, 1901, "*after a long very painful illness poor brother Bill has bowed his head to the common lot and passed over to that unknown bourne from which no traveller returns. His career may be said to begin when Mr. Wicket recommended him to John Michael Williams as a promising young man and he was sent to Swansea to take a situation at the Morfa Silver Works as a chemist in the end of 1869. His salary was of the £80 per annum. He stayed at first at 56 Mousel Terrace with Mrs Binden and very soon made himself known and formed a circle of acquaintance among whom were Harry Rees*…."

Maria outlived her husband by more than 36 years and, indeed, outlived most of her children too. When William's collection was donated to the National Museum of Wales, in 1937, their youngest daughter Val, who was 47 years of age and unmarried, conducted negotiations with the museum. Her sister Rhonddalina was also still alive, but also unmarried. Perhaps realising that they were the end of the family line they decided to convince their mother to donate William's collection to the museum, otherwise risk it ending up being forgotten and disposed of.

William was well-educated (according to Bertie's diaries he achieved a 1st Class pass in Chemistry examinations in May 1866) and had a very successful career. He encouraged his children to pursue education and the results can been seen by their involvement in local learned societies: "*Miss R.*

Terrill, Swansea", was a member of the Gower Society in 1948 and "*Miss Rhonddalina Terrill*" of 42 St Georges Terrace Swansea was a member of the Roman Society in 1933. Val Terrill is known to have attended a suffragette rally in Swansea in 1910.

Career

According to Bertie's diary (in a form of an obituary written the day after William's death) William's career "*may be said to begin when Mr Wicket recommended him to John Michael Williams as a promising young man and he was sent to Swansea to take a situation at the Morfa Silver Works as a chemist in the end of 1869*."

William's career blossomed in Swansea. By 1872 he was Chief Chemist at Morfa Silver Works and, following the sacking of Mr Grenfell in 1875, he was made manager at Old Morfa Copper Works. In 1886 he was manager at Laby assaying silver ores a job which he appears to have held for many years. Following his illness, he started a new job as copper works manager at Lamberts (Charles Lambert & Co., Port Tennant Copper and Arsenic Works) on 7 August, 1900. This was to be his last job.

Not long after he had relocated his family to Swansea, William joined the Royal Institution of South Wales (1874-75), which had formed in 1835 as the Swansea Philosophical and Literary Society. From 1874 he regularly taught chemistry, metallurgy and organic chemistry classes at the Royal Institution. His classes were held in a small committee room on Saturday afternoons and his pupils included his brother, Bertie. His lectures to the Royal Institution included "*A lesson in Chemistry*" on 13 November, 1876 and "*Coal Measures*" on 7 July, 1882.

William was instrumental in the establishment of a geological club in Swansea. He was a founding member, and President, of the Swansea Geological Society in 1877 (Anon. 1878). He led field excursions to Bacon Hole (21 July, 1877) and St David's (19-22 April, 1878) and gave presentations including "*What is Coal*?" (12 June, 1877), "*Uses of a collection of rock specimens*" and "*Glacial drift*" (both during 1878-79) as well as "*Granite*" (October 1879) (Austin 2010).

Membership of the Swansea Geological Society reached 41 during 1879-80, but the following year it was decided that the society would change its name to the Swansea Scientific Society to encourage more general science (Austin 2010). The process with which the renaming took place is confused by the absence of annual reports covering the period 1881 to 1885 (Austin 2010). However, Anon. (1901a) implied that the Swansea Geological Society continued until 1883 with William Terrill as secretary, at which point it became defunct, but was resuscitated under the name of the Swansea Scientific Society in 1885.

Geological lectures continued during the period of transition with William contributing a lecture on Cornish mines in November 1883 (Austin 2010). During the last few years of his life William continued to provide lectures and served once more as society secretary (Anon. 1901b). He also acted as curator of the mineral collection of the Royal Institution from the 1890s up until his death. Following his death concern was raised by I. H. Clatton (Anon. 1902) about the care of the collection. This appears to have been wholly justified as the Royal Institution's geological collections are now sadly untraceable.

Despite all of his lectures, teaching classes and field excursions William published very little himself - a couple of short papers on slag and smelting products (Terrill 1881, 1882) are the only records - but he did contribute analytical data to others (Semmons 1881) and communicated various improvements in refining methods through the Institution of Mining and Metallurgy. William was also involved in applying for patents, notably "*improvements in the manufacture of White Arsenic*" (British Patent no. 9076 from 30 April, 1896).

William was also a Fellow of the Chemical Society, elected in 1876-77, and was a keen artist and photographer. In 1877, he took an active part in establishing the Swansea Sketching Society, later known as the Swansea Art Society (Anon. 1901b) and, in 1895, he was Vice President of the Swansea Amateur Photographic Association.

The collection

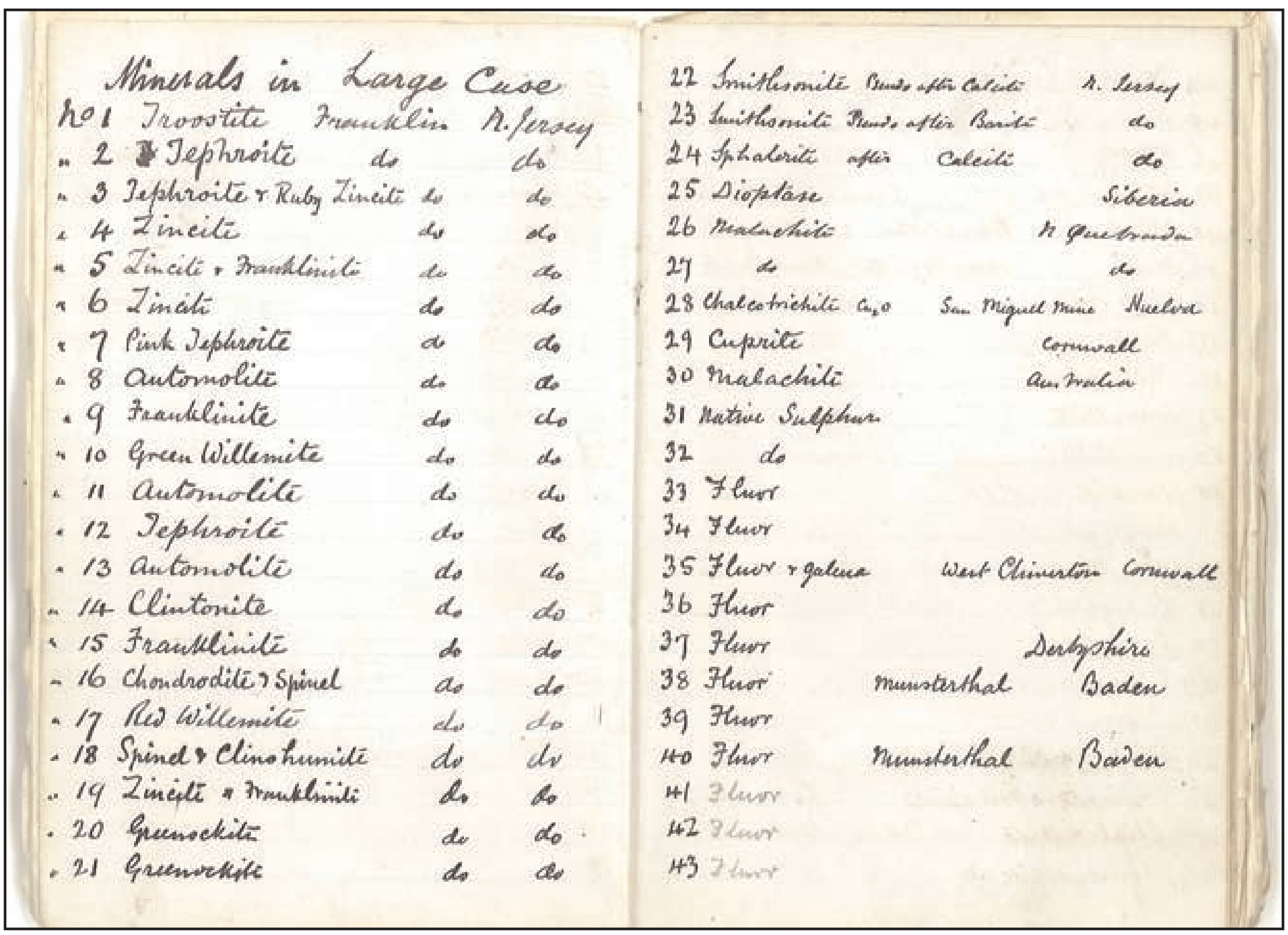
According to William's small handwritten catalogue (Figures 2 and 3) his geological collection comprised nearly 1,900 mineralogical, metallurgical and palaeontological specimens.

His mineralogical collection which formed the largest part of the catalogue (995 specimens) is extant, although not all of the catalogued specimens have been identified. Additionally, another 250 or so specimens are registered that do not appear to match, or have not yet been matched to, entries within the catalogue. A total of 752 'objects' are recorded as having been part of this accession (number NMW

Figure 2. William Terrill's handwritten collection catalogue. 172 x 110 mm.

37.239) described as "*a collection of minerals and fossils from various localities*." We know that more specimens entered the museum - Terrill specimens have been discovered within education and outreach collections and in other, later, accessions - but no specific details are recorded for the number that arrived in the museum.

The whereabouts of the palaeontological material (870 specimens are listed in the Terrill catalogue) is not known. Its listing within the catalogue is less concise when compared to the minerals and the contents appear more random, than systematic, but the specimens still appear to have been numbered. Only one fossil, labelled "*Coleoptera indet*" - a Jurassic insect, is registered in the Palaeontology collections at AC-NMW as NMW 37.239.G1. Tantalisingly one other fossil specimen - Terrill no. 5., "*Olenus from St. Davids*" was found registered in the mineral collection at AC-NMW (as NMW 37.239.GR.646) erroneously labelled as "*Zincite and franklinite from Franklin, New Jersey*" based on the same Terrill no. (5) in the mineral section of his catalogue (Figure 3). The whereabouts of the other fossils remain a mystery.



Minerals in Large Case

No 1	Troostite	Franklin	N. Jersey
" 2	Tephroite	do	do
" 3	Tephroite & Ruby Zincite	do	do
" 4	Zincite	do	do
" 5	Zincite & Franklinite	do	do
" 6	Zincite	do	do
" 7	Pink Tephroite	do	do
" 8	Automolite	do	do
" 9	Franklinite	do	do
" 10	Green Willemite	do	do
" 11	Automolite	do	do
" 12	Tephroite	do	do
" 13	Automolite	do	do
" 14	Clintonite	do	do
" 15	Franklinite	do	do
" 16	Chondrodite & Spinel	do	do
" 17	Red Willemite	do	do
" 18	Spinel & Clinohumite	do	do
" 19	Zincite & Franklinite	do	do
" 20	Greenockite	do	do
" 21	Greenockite	do	do
22	Smithsonite Pseudo after Calcite		N. Jersey
23	Smithsonite Pseudo after Barite		do
24	Sphalerite after Calcite		do
25	Dioptase		Siberia
26	Malachite		N Quebrada
27	do		do
28	Chalcotrichite Cu_2O	San Miguel Mine	Huelva
29	Cuprite		Cornwall
30	Malachite		Australia
31	Native Sulphur		
32	do		
33	Fluor		
34	Fluor		
35	Fluor & galena	West Chiverton	Cornwall
36	Fluor		
37	Fluor		Derbyshire
38	Fluor	Munsterthal	Baden
39	Fluor		
40	Fluor	Munsterthal	Baden
41	Fluor		
42	Fluor		
43	Fluor		

Figure 3. An example of the content of William Terrill's handwritten catalogue.

William's small collection (23 specimens) of metallurgical specimens had also appeared to be lost, but much of this collection was accessioned in 1995 as from an "*unknown source*". Thankfully his similar numbering system and descriptions of the specimens has aided re-identification. These 'artificial and refined' specimens form part of accession number NMW 95.14G. The fact that the metallurgical specimens were not recorded in the original documentation (for the NMW 37.239 accession) supports Howarth's (1954) assertion that there was a long delay in critically examining the collection.

There are also two meteorite specimens registered in the Terrill collection: NMW 37.239.GR.41, a 29.33 gm. ataxite from a fall in 1875 at Santa Catharina, Brazil and; NMW 37.239.GR.40, labelled by William Terrill as "*Meteorite fragment*" was identified by A.W.R. Bevan at the BM(NH), in April 1983, as a nickel-rich ataxite also from the 1875 find at Santa Catharina. Neither of these specimens are recorded in the Terrill catalogue.

William probably also had a rock collection: a specimen bearing a handwritten label similar in style to his handwriting recording, "*Olivine basalt. Dunapis Loch, Edinburgh*" is in the education collection at AC-NMW (no. GER 863). The museum tray label accompanying this specimen has affixed to it a small circular label similar in style to those used by William Terrill and bearing the number 115.

Mineral collection

William's mineral collection is divided into several 'groups' within his catalogue:

Minerals in Large Case: 1-389;
Minerals in Large Case: 390-667;
Pseudomorphs: 668-700;
Minerals in Case A Drawer III Laurium Series: 701-730;
Case A Drawer I: 731-773;
Case A Drawer II: 774-818;
Case A Drawer IV: 819-863;
Case A Drawer 5: 864-946;
Collection of small crystals: 1-49.

The cases/cabinets were left behind when William's collection was transported to the museum in 1937 and there is no record of what they looked like.

William used a straightforward ascending numbering sequence for his minerals. Circular number labels (Figure 4) were affixed to his mineralogical specimens which relate to numbers within the catalogue. His "*collection of small crystals*" are, somewhat confusingly, also numbered 1 to 49 within his catalogue, but none of the specimens appear to have numbers affixed to them. Instead, the minerals that appear to relate to this sub-collection are generally accompanied by small, handwritten, card labels (Figure 5). These labels are generally almost square, but are variable in dimensions. Their size is very much dependent on the amount of text, which typically includes the mineral name and brief locality information. The handwriting is neat and unjoined. Strangely there appear to be many more specimens of small crystals than are listed within the catalogue, suggesting that perhaps they were some of the latest specimens that he acquired. This style of label is also present alongside some of the main collection specimens (Figure 6).

Figure 4. William Terrill's characteristic circular number labels (697) affixed to specimens along with his pseudomorph collection labels (Ps 30, Ps 32 and Ps 33) and museum number labels 37.239.GR.546.1, 2 and 3. The circular labels are 9.5 mm in diameter. Specimens described in the Terrill catalogue as "after Felspar Cornwall".

Figure 5. An example of a small handwritten card label accompanying a specimen from the "collection of small crystals". Small crystal number 30. (NMW 37.239.GR.67). Label dimensions 21 x 18.5 mm.

Figure 6 Typical small, irregularly-sized, handwritten card labels present with some of William Terrill's specimens. On the left is Terrill collection no. 336 (NMW 37.239.GR.124) and on the right Terrill collection no. 628 (NMW 37.239.GR.340). The larger label measures 38 x 22 mm and the smaller one 21.5 x 21.5 mm.

Despite being very basic, the circular number labels attached to his main collection specimens are actually very distinctive when compared to other collections. This system has helped enormously in identifying Terrill specimens, not just within his catalogue, but in locating specimens which have over the years been misplaced. Additionally many of the mineral specimens are also accompanied by labels in various forms. In some cases a simple species name label written in similar handwriting to the small card labels is affixed to the specimen (Figure 7).

A suite of "*pseudomorphs*", numbered from 668-700 in the Terrill catalogue, have small rectangular '*Ps*' number labels affixed to them (Figure 4) in addition to the characteristic circular number label. A small number of specimens bear small chemistry-based labels (Figure 8). These are usually hidden beneath the circular labels, perhaps relating to one of his earlier teaching classes.

Figure 7. A typical 'species name' label, in William Terrill's handwriting, affixed to one of his specimens accompanied by an unidentified number label (166) and a later museum number label (37.239.GR.123). Terrill label measures 24 x 5 mm.

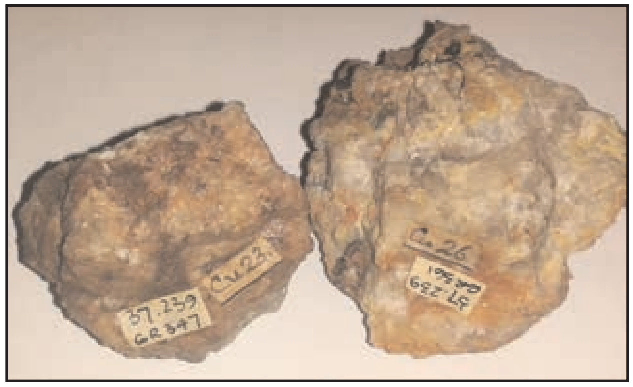


Figure 8. Small (10 x 5 mm) chemistry-related labels affixed to two of William Terrill's Cornish olivenite specimens (NMW 37.239.GR.347 and 361).

Despite the collection catalogue being donated with his collection and numbered labels being attached to the specimens some of the minerals were originally accessioned as "*locality unrecorded*". This suggests that the catalogue was not thoroughly consulted when the specimens were registered at the museum. This is supported by Howarth's (1954) comment that "*although the collection was presented to the National Museum of Wales in 1937, it was not critically examined until 1951*." Some of the unprovenanced specimens have now been identified within the catalogue and the locality information updated on the museum database. Unfortunately during the 1970s the National Museum of Wales exchanged some of these unprovenanced specimens with the famous Cornish mineral dealer Richard Barstow (Starkey and Cooper, 2010). These included a William Terrill specimen - a tetrahedrite registered as NMW 37.239.GR.307 and now believed to be Terrill no. 279: "*Fahlerz*", locality unrecorded. Barstow was presumably well aware of the true provenance of this piece - almost certainly being classic Cornish material from Herodsfoot Mine, near Liskeard. Sadly the museum staff were not quite so well informed.

Many specimens have lost their original Terrill collection number labels, but nearly one third (325) of his original mineral specimens still bear their original number labels. A further 150, or so, specimens have been matched with numbers using catalogue entries. A small number of Terrill specimens have been found within education and outreach collections - their original identity forgotten. The importance of William Terrill's collection as a complete entity has dictated that when unregistered specimens are re-discovered they are assimilated with the main collection under accession number NMW 37.239. This way it is possible to keep track of the total number of his original 995 mineral specimens that are extant. A few examples of re-discovered specimens are listed in Appendix 1.

Analytical research has also been undertaken on parts of the collection. A glass tube containing numerous small well-formed grey metallic crystals labelled as cobaltite [CoAsS] was registered as NMW 37.239.GR.98. One of the crystals was analysed by SEM-EDS and identified as glaucodot [(Co,Fe)AsS]. Meanwhile a small handwritten card label found with specimen no. NMW 37.239.GR.104 stated, "*Glaucodote, Hokansbo, Sweden*", but that specimen has now been re-identified as native silver. It would therefore appear that the original Terrill label had been wrongly assigned to the silver specimen and has now been placed back with the glaucodot specimen. Interestingly the silver specimen bears a small number label (18.) in a style atypical of the rest of the Terrill collection. The significance of this has yet to be ascertained.

It has also been discovered that a small number of Terrill specimens had been broken and accessioned as different numbers. In one example - NMW 37.239.GR.216 and NMW 37.239.GR.231 relating to Terrill collection number 12 (Figure 9) - remains of Terrill's circular number label can still be seen attached to both specimens and the latter specimen is accompanied by a William Raimond Baird label marked as no. 12. Quite why the specimens would have been split prior to accession is unknown. One can only surmise that they were damaged in transit, or prior to registration in the museum, and that when they were accessioned it was not realised that some of the specimens joined together.

The total number of specimens identified within William Terrill's catalogue stands at 484, or 49% of the original collection. However, a significant number of other Terrill specimens are accompanied by handwritten card labels or have mineral name labels affixed to them that do not relate to entries within the catalogue, so perhaps his collection was much larger than his records show.

Overall the collection is notable for the care and effort made in the cataloguing and labelling of specimens. It is known that William served as curator for the Royal Institute of South Wales and this attention to detail has helped to preserve his own collection. It is highly likely that William used his own specimens to aid his teaching classes at the Royal Institute.

The influence that mineralogy had on William was far-reaching and this is no-more apparent than when one looks at the name of his second daughter born on 26 September, 1886: Rhonddalina (Bertie's diary). Without knowing William's mineralogical

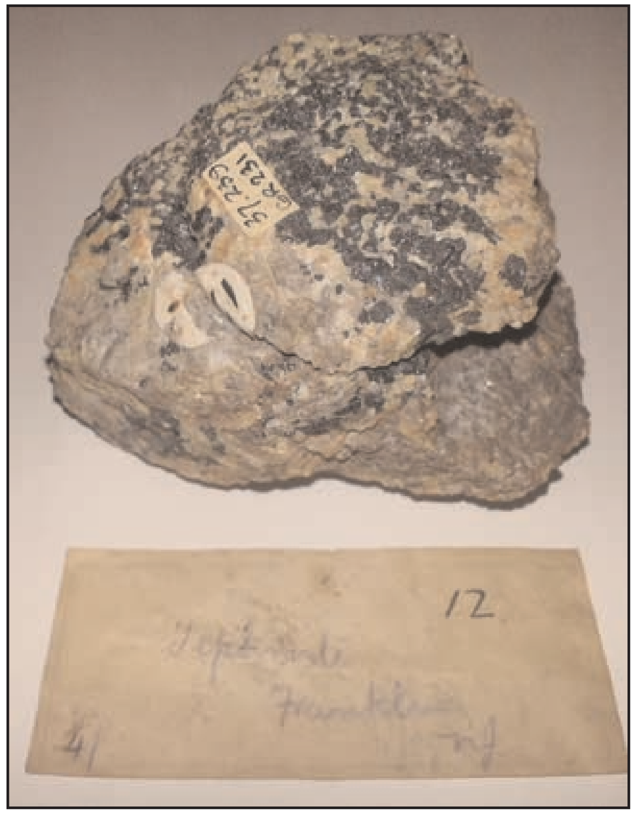


Figure 9. Terrill collection no. 12. An example of a Terrill collection specimen split into two pieces and registered as separate specimens (NMW 37.239.GR.216 and 231). A William Raimond Baird label accompanies the smaller (upper) part of this specimen and records the price as 4 shillings.

background this name might seem unusual, but perhaps not significant. However when one considers that in 1880 the French mineralogist Des Cloizeaux described (Des Cloizeaux 1880) the rare cobalt sulphide mineral linnaeite [$Co^{2+}Co^{3+}{}_2S_4$] on a specimen from "*Rhonda Valley, Glamorganshire*" belonging to "*Mr. Terrill of Swansea*" one can begin to see the naming process taking shape! This specimen can be traced as NMW 37.239.GR.1, but was much later (Bevins and Horák 1985) re-identified as the nickel-dominant species siegenite [$(Ni,Co)_3S_4$].

William's catalogue rarely records who he obtained specimens from, but a wide range of other labels preserved with his specimens provides a useful insight into when, and who, he acquired specimens from. What is apparent is that he collected very few of his own specimens and only a handful of specimens are from Welsh localities.

It was noted in his private obituary written in Bertie's diary that William's career began when Mr Wicket recommended him to John Michael Williams to work in his silver works in Swansea. John Michael Williams (1813-1880) lived at Caerhays Castle in

Cornwall and was one of the most powerful businessmen in Cornwall. His family had made their fortune through copper mining several generations earlier and, coincidentally, possessed one of the finest collections of British minerals ever assembled - a collection started by his grandfather John Williams (1753-1841) and developed by successive generations of the Williams family (Smale 2011). With Terrill's link to Redruth and the culture of mineral collecting associated with the local mines it is tempting to believe that Mr Wicket was James Wickett (1841-1921), a highly successful mineral collector and dealer based in Redruth between 1860 and 1897 and whose collection was acquired by the Royal Institution of Cornwall in 1922 (http://www.cornwall-calling.co.uk/museums/royal-cornwall-museum.htm).

Another link to the Williams family is William Semmons (1841-1915), himself an important collector and dealer in Cornish minerals (Bancroft and Weller 1993). Semmons had many different jobs during his lifetime, but in the 1860s he worked as a clerk for the Williams family at their Burncoose office and apparently assisted John Michael Williams in adding to the family mineral collection (Embrey and Symes 1987). Semmons transferred to the Williams' office in Liverpool, becoming manager, and finally became a self-employed metal broker in London (Embrey and Symes 1987). For a short time (in 1885) he worked as an apprentice to William Terrill at Morfa Works (Bertie Terrill diaries), but based on analytical data from Terrill in Semmons (1881, p. 262) they must have been well acquainted before this.

Semmons was well established as a mineral dealer from the 1890s until 1905 selling fine Cornish mineral specimens to European dealers and to the BM(NH) (Cooper 2006). He amassed a large collection from which he later sold many of the best specimens (Embrey and Symes 1987). William Terrill's catalogue records that he purchased a small number of specimens from 'Mr. W. Semmons' including, no. 60 (NMW 37.239.GR.648) - "*Lievrite*" and no. 61 (NMW 37.239.GR.445) - "*Dufrenite*" as well as no. 203 (NMW 37.239.GR.378) - "*Vanadinite*" from "*U.S.*" which is accompanied by a handwritten label noting that it is from "*Mr Semmons*" (Figure 10). It is highly likely that Semmons was dealing in minerals earlier than has previously been documented by Cooper (2006) and almost certainly the number of specimens William obtained from Semmons is greater than those directly recorded in his catalogue.

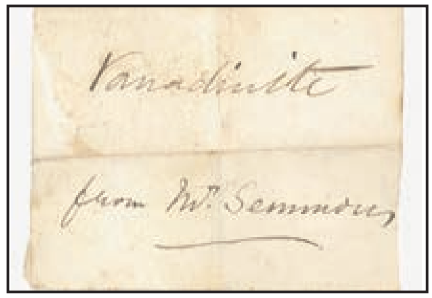


Figure 10. Label (81.5 x 63.5 mm) recording a specimen of "Vanadinite from Mr. Semmons". Terrill collection number 203. NMW 37.239.GR.378. Specimen from USA.

Trawling through William Terrill's catalogue it is obvious that he had a keen interest in Cornish minerals, reflecting his family roots back to his county of birth. Many of the important mineralogical discoveries made in Cornwall during the late nineteenth century are represented showing that he kept pace with mineralogical developments. Notable among these is a small suite of specimens from "*Marke Valley, Liskeard*", obtained from the Penzance-based mineral dealer Andrew Ketcham Barnett. These include the mineral liskeardite (Terrill no. 641 - NMW 37.239.GR.301) (Figure 11): Marke Valley is the Type Locality for liskeardite discovered in about 1878 (Maskelyne 1878). Chalcophyllite is recorded in his catalogue (Terrill no. 287 - NMW 37.239.GR.367) under the old name "*tamarite (copper mica)*" and as "*tamarite*" (Terrill no. 624): this particular occurrence is very obscure - having been omitted by Greg and Lettson (1858), Collins (1892) and Golley and Williams (1995), but Rust (1982) mentions connellite associated with cuprite, malachite and chalcophyllite from this mine.

He also acquired from Andrew Ketcham Barnett a rich specimen (82 mm long) of "*Chalkosiderite*" from "*West Phoenix Liskeard*" (Terrill no. 638 - NMW 37.239.GR.306) (Figure 12): Chalcosiderite was first described from this locality by Maskelyne (1875).

Small examples of ludlamite from Wheal Jane are represented in William Terrill's collection as numbers 72 and 73. Ludlamite was described as a new species from Wheal Jane by Field (1877). Terrill also possessed a number of other iron phosphate minerals (vivianite and cronstedtite) from Wheal Jane in his collection and perhaps he obtained them all from Frederick Field (1826-1885) who was himself a chemist. The most expensive of these was Terrill no. 72 - "*Ludlamite Wh Jane Nr Truro*" - which cost 4 shillings (the equivalent of about £11.50 in 2005). A large, and interesting, suite of minerals attributed to Frederick Field is preserved at the Bath Royal Literary and Scientific Institution.

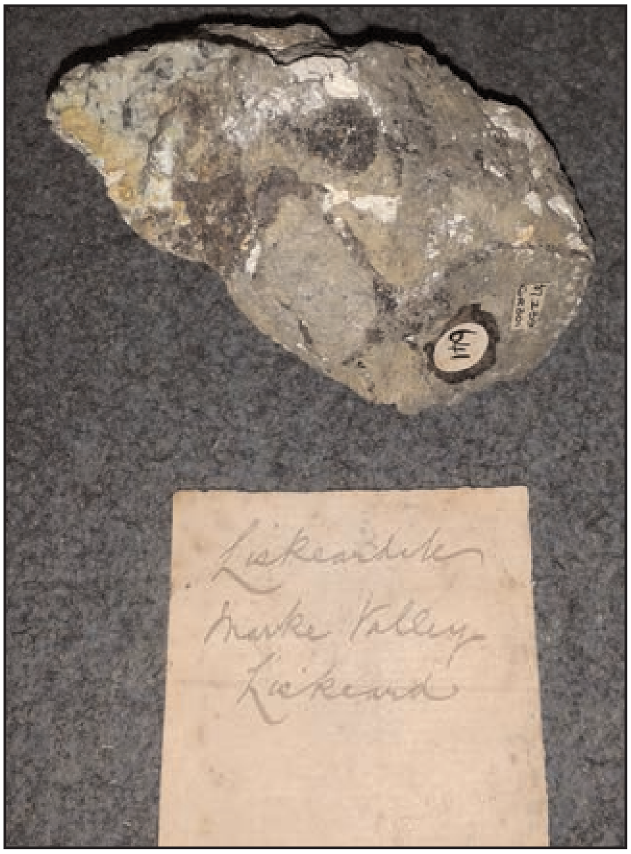


Figure 11. Terrill collection no. 641 (NMW 37.239.GR.301). "Liskeardite" from the Type Locality at "Marke Valley, Liskeard". The accompanying handwritten label (dimensions 56.5 x 56.5 mm) is from Andrew Ketcham Barnett (1852-1914) - a mineral dealer based in Penzance, Cornwall. Specimen 87 mm in length.

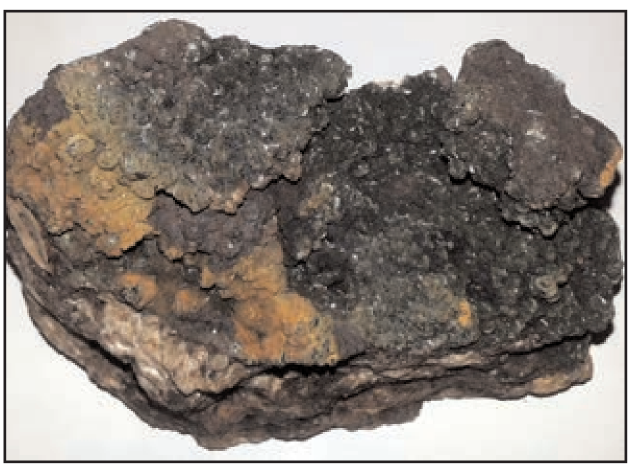


Figure 12. Terrill collection no. 638 (NMW 37.239.GR.306). "Chalkosiderite" from "West Phoenix, Liskeard". Specimen 82 mm in length.

Some examples of William Terrill's other fine Cornish minerals include: Terrill no. 266 (NMW 37.239.GR.400) - a small (40 mm across), but attractive, blister copper (chalcopyrite) from Cornwall (Figure 13); NMW 37.239.GR.423 - coarse (to 18 mm on edge) tarnished tetragonal chalcopyrite crystals on quartz from Cornwall (Figure 14). The exact Terrill collection number is missing, but this is almost certainly either 265, 615 or 625; Terrill no. 269 (NMW 37.239.GR.402) - unusual long prismatic crystal aggregates (to 24 mm in length) of "*Bornite*" from "*Cornwall*" (Figure 15). This form of bornite is identical to a specimen donated by Henry Keyes Jordan to AC-NMW in 1910 (NMW 10.34.GR.3) which is labelled as from "*South Wheal Francis Mine, near Redruth, Cornwall. 1861*."; Terrill no. 630 (NMW 37.239.GR.685) - chalcocite from St. Ives Consols; Terrill no. 628 (NMW 37.239.GR.340) - finely crystallized tennantite from Wheal Gorland; Terrill no. 393 (NMW 37.239.GR.131) - a pyramidal, prismatic, aragonite from St. Just, Cornwall (Figure 16); Terrill no. 80 (NMW 37.239.GR.587) - "*Chalybite*" (siderite) from "*East Pool*" (Cornwall) (Figure 17); Terrill no. 286 (NMW 37.239.GR.345) - massive aggregate (63 mm across) of intense blue "*liroconite*" from "Cornwall" noted in a later label (circa 1970s) appearing to have been written by Richard Barstow as "*Wheal Gorland, St. Day (Gwennap Parish)*"; Terrill no. 694 and pseudomorph collection no. Ps 27 (NMW 37.239.GR.543) - "*Quartz after ? Dolcoath*" an unusual quartz pseudomorph after and unidentified bladed mineral (Figure 18).

Terrill collection numbers 769, 770 and 771 (NMW 37.239.GR.193, 624 and 625 respectively) are recorded as "*autunite*" from "*Wh*^{l}*. Bassett*", These are likely to be the much rarer hydrated iron uranium phosphate mineral, bassetite, described by Hallimond (1915) on material from Wheal Bassett, Cornwall.

Excellent examples of cassiterite pseudomorphs after orthoclase crystals, to 40 mm in length, from Cornwall are represented as NMW 37.239.GR.90.1-4 but are not mentioned within William Terrill's catalogue. These are almost certainly derived from the classic locality at Wheal Coates first found in 1828 (Embrey and Symes 1987).

Specimens from elsewhere in Britain are also represented. William Terrill possessed several fine display specimens of barite and dolomite from the West Cumbrian iron mines. Terrill no. 371 (NMW 37.239.GR.642) is a 115 mm tall crystal of blue barite with dolomite (Figure 19) listed as from "*Cumberland*", but this is undoubtedly from the West Cumbrian iron mining district. Although this specimen is not included in his list of the prices he paid it can be assumed that this was one of his more expensive pieces. Terrill no. 370 (NMW 37.239.GR.342) is another fine barite on dolomite from Cumberland some 170 mm across and Terrill no. 403 (NMW 37.239.GR.183) is a large cabinet

Figure 13. Terrill collection no. 266 (NMW 37.239.GR.400). "Blister Copper Ore" (chalcopyrite) from "Cornwall". Specimen 40 mm across.

Figure 14. Terrill collection no. 265, 615 or 625 (NMW 37.239.GR.423). An aggregate of coarse (to 18 mm on edge) tarnished tetragonal chalcopyrite crystals on quartz from Cornwall.

specimen encrusted with colourless prismatic calcite crystals typical of the iron mines. It is highly likely that these specimens came through the hands of the famous Cumbrian mineral dealer John Graves (1842-1928) (see Cooper 2006 for more details about Graves).

There are several specimens (see for example NMW 37.239.GR.551) bearing old handwritten labels stating "*Sulphate of Strontium*" (celestine) from "*Aust Passage*" (Figure 20). Despite not bearing

Figure 15. Terrill collection no. 269 (NMW 37.239.GR.402). Prismatic aggregates (to 24 mm in length) of "Bornite" from "Cornwall".

Figure 16. Terrill collection no. 393 (NMW 37.239.GR.131). "Aragonite" from "St. Just" (Cornwall). Specimen 56 mm across.

Figure 17. Terrill collection no. 80 (NMW 37.239.GR.587). "Chalybite" (siderite) from "East Pool" (Cornwall). Specimen 57 mm in length.

Figure 18. An unusual quartz pseudomorph after and unidentified bladed mineral from Dolcoath. Recorded in the Terrill catalogue as "Quartz after ? Dolcoath". Note the characteristic circular number label (694) affixed to a specimen along with a pseudomorph collection label (Ps 27.), a species label possibly in William Terrill's handwriting, and a museum label (37.239.GR.543). The circular label is 9.5 mm in diameter.

original Terrill number labels there are five specimens of "*Celestine*" from "*Aust Cliff*" listed within the Terrill catalogue as numbers 462, 464, 465, 466 and 470. A further celestine specimen (NMW 37.239.GR.182) displaying very large pale blue-grey tabular crystals upon red marl does not appear to be listed within the Terrill catalogue.

Figure 19. Terrill collection no. 371 (NMW 37.239.GR.642). "Barite" from "Cumberland". The main crystal is 115 mm tall, with dolomite.

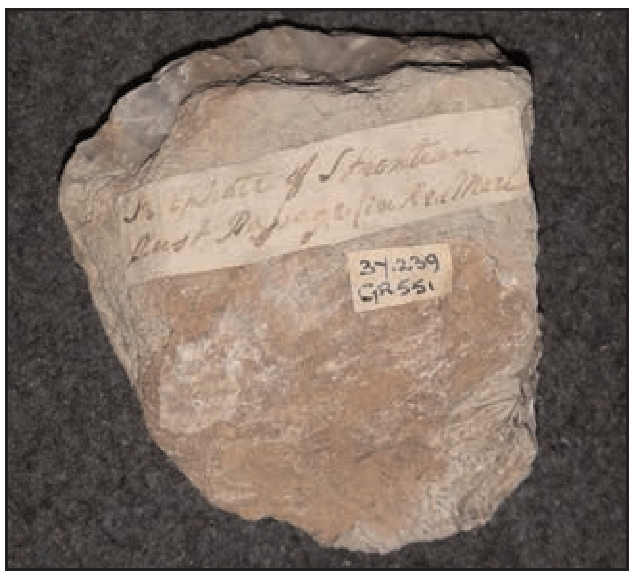


Figure 20. Terrill collection no. 462, 464, 465, 466 or 470? Specimen no. NMW 37.239.GR.551 bearing an old handwritten label not in William Terrill's handwriting. Label dimensions 47 x 10 mm.

Registered as "*baryte, locality unrecorded*" X-ray powder diffraction (PXRD no. NMW X-3271) has confirmed the identification as celestine. This is likely to be from the huge celestine deposits discovered near Chipping Sodbury in the 1870s and which became the world's largest producer of celestine from 1875 to about 1968 (Nickless *et al*. 1976).

Highlights from William Terrill's worldwide minerals include: a large (125 mm tall) crystallized native copper from Calumet & Hecla mine, Lake Superior (Terrill no. 337 - NMW 37.239.GR.358) (Figure 21); an unusual 'cog-wheel' hemimorphite from Genoa (Terrill no. 611 - NMW 37.239.GR.687); a large (123 mm tall) turquoise and grey banded smithsonite stalactite (Figure 22) from Laurium, Greece (Terrill no. 345 - NMW 37.239.GR.264); an aggregate (56 mm long) of coarse tabular orange wulfenite crystals from Eureka Consolidated, Eureka, Nevada, USA (Figure 23).

Several very fine coarsely crystallized azurite specimens are also present (NMW 37.239.GR.32 and 170) (Figure 24). Although they do not bear Terrill number labels these are interpreted as being from the classic mid-19th century locality at Chessy in France. At least one of these is probably Terrill no. 297 listed in the catalogue as "*Chessylite*" - a synonym of azurite introduced by Brooke and Miller (1852) - from "*Chessy*". Chessy was the foremost locality of crystallized azurite prior to the discovery of the enormous supergene copper deposit at Tsumeb, Namibia in the early 20th century.
Also prominent within William's catalogue is a suite of specimens from Laurium. The "*Laurium Series*", as it is recorded in his catalogue (Figure 25), is described as in "*Case A, Drawer III*". It consists of a fairly comprehensive suite of secondary minerals from the Laurium mines at Attiki, Greece. There are multiple good examples of adamine (adamite), calamine (smithsonite), serpierite, chessylite (azurite) and arseniate of copper with a little zinc (zincolivenite). Unfortunately there are no additional labels with the Laurium material and no indication of how or who Terrill acquired the specimens from.

Some of William Terrill's other specimens are accompanied by a variety of dealer labels. In consultation with Cooper (2006) these labels appear to relate to the 1870s which fits with when William was most actively involved with the Royal Institute. Examples of these labels include those from:

Samuel Henson, 277, Strand, London (Figure 26); James R. Gregory, 88, Charlotte St, Fitzroy Sq., London (Gregory was based at that address between 1874-1895) (Figure 27); Bryce M. Wright Snr., 90 Great Russell St, London (at that address from 1866-1874) (Figure 28); Bryce M. Wright Jnr, 38, Southampton Row, London (at that address from 1875-1876) (Figure 28); E. Deyrolle, Naturaliste. Paris, 23, Rue de la Monnaie (at that address pre-1881) (Figure 29); Thomas J. Downing (*fl*. 1859-1884) - a trimmed label (Figure 30) matched by

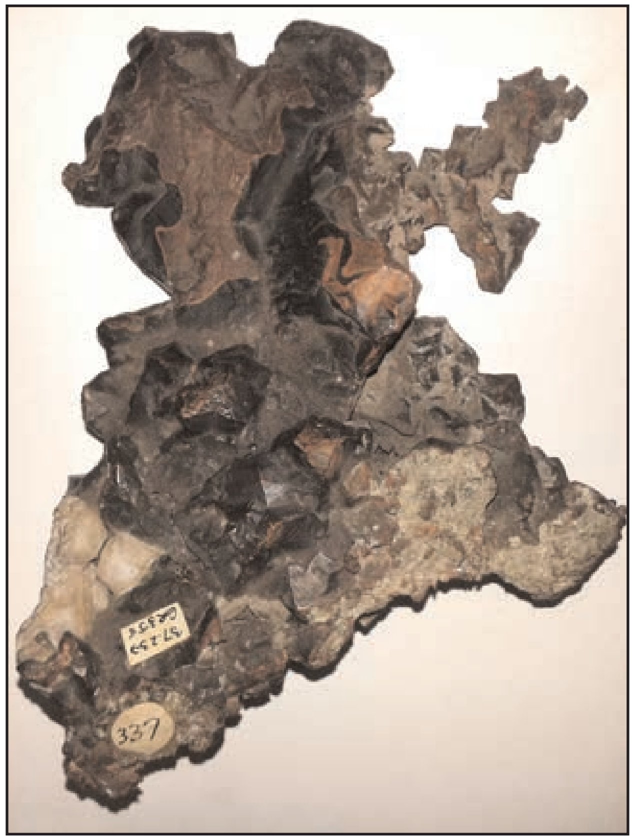


Figure 21. Terrill collection no. 337 (NMW 37.239.GR.358). A large (125 mm tall) crystallized native copper from Calumet & Hecla mine, Lake Superior.

Figure 22. Terrill collection no. 345 (NMW 37.239.GR.264). "Calamine" (smithsonite) stalactite from "Laurium" (Greece). Specimen 123 mm in height.

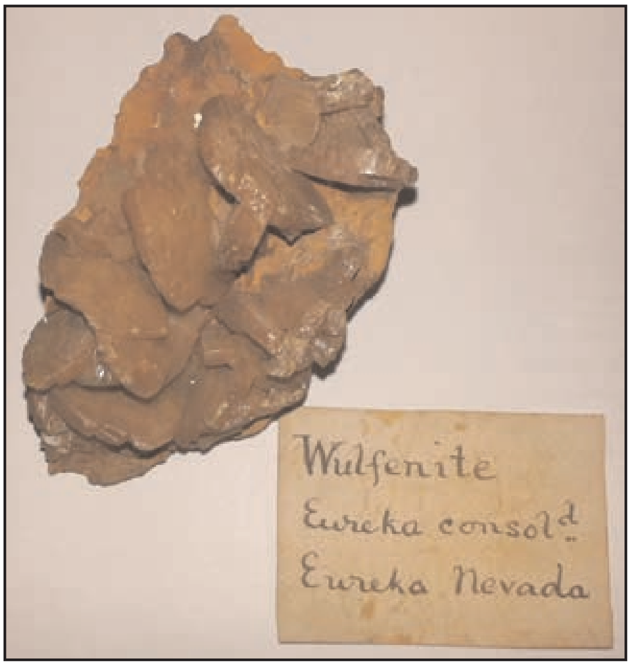


Figure 23. Terrill collection no. 205 (NMW 37.239.GR.380). An aggregate of coarse tabular wulfenite crystals, to 15.5 mm on edge, accompanied by William Terrill's handwritten card label (39 x 27 mm).

Figure 24. Specimen no. NMW 37.239.GR.170. Terrill collection no. unrecorded, but probably number 297 listed in the catalogue as "Chessylite" - a synonym of azurite introduced by Brooke and Miller (1852) - from "Chessy". Specimen 40 mm tall.

comparison with one illustrated in Cooper (2006, pg. 123); Andrew Ketcham Barnett (1852-1914) Cornish mineral dealer based in Penzance from at least 1876 (Cooper 2006) - a small number of specimens in the Terrill collection have labels which match the handwriting of Andrew Ketcham Barnett (Figure 31) although they do not display the typical printed background of the example figured by Cooper (2006). These specimens are predominantly from localities around Liskeard, including Marke Valley and West Phoenix.

Of particular interest are a large number of specimens from North American localities accompanied by handwritten labels written on the back of rectangular (64 mm x 28 mm) pieces of paper printed with (Figure 32):

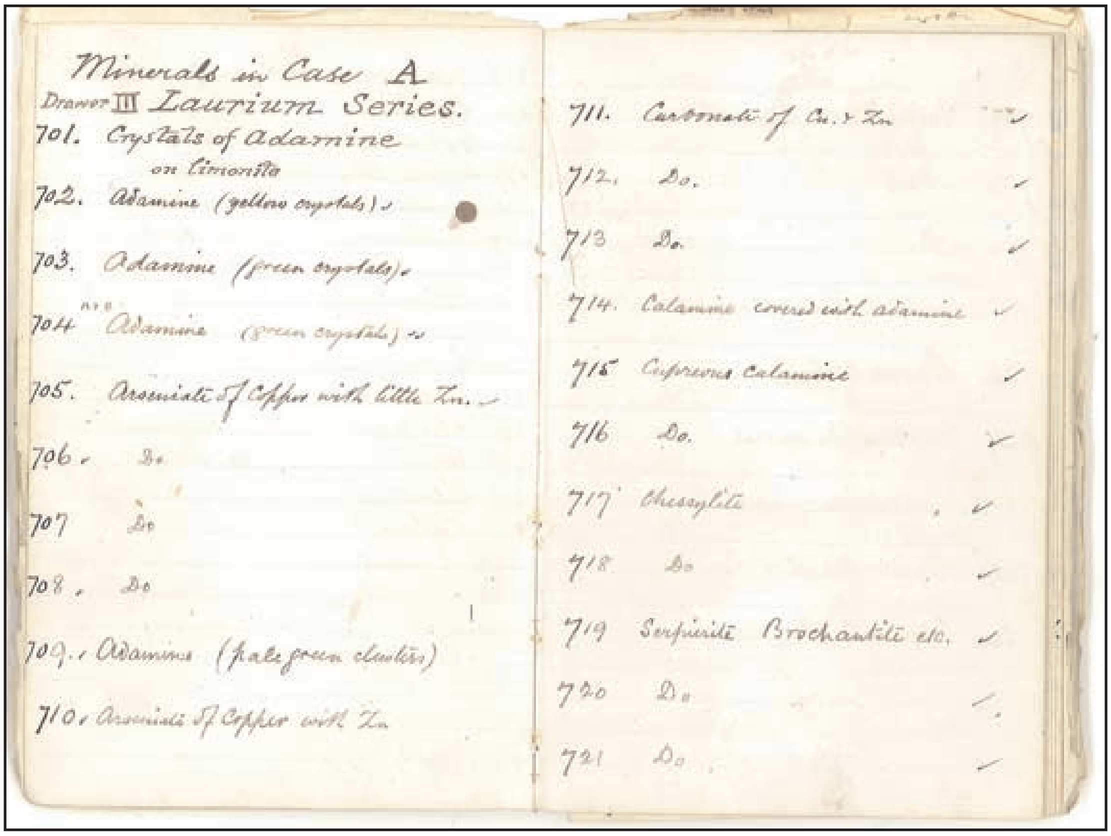
"*Wm. Raimond Baird, '78*
STEVENS' INSTITUTE,
HOBOKEN, N.J."

Stevens' Institute was founded in 1867 and by 1873 the Department of Chemistry had already established a sizable cabinet of minerals numbering some 5,500 specimens (pg. 39 in Announcement of the Stevens Institute of Technology, 1873). In 1875 the annual report highlighted that "*During the past year very extensive collections have been made in that district of New Jersey in which the Institute is located, and duplicates sent to many of the colleges in this country and in Europe*."

William Raimond Baird (1858-1917) is not widely known as a mineral collector, but he was recorded as a member of "*La Societie Mineralogique de France*" (Hill 1919). Baird is much better known for his influence in American society described in Hill (1919). At Stevens' Institute he studied mechanical engineering graduating in 1878 (Hill 1919). How William came to acquire these specimens is unknown, but they possibly came in contact through the chemical industry - Baird was a member of the Society of Chemical Industry, and the American Chemical Society (Hill 1919). William appears to have bought the specimens from Baird because each label records a price in the bottom left corner (Figure 32) and the prices paid are recorded in the Terrill catalogue.

Based on the specimens in William's collection Baird clearly had access to a wide range of mineralogical material from the USA. The largest suite of specimens are from Franklin, New Jersey which fits in with the Institute's acquisition policy to obtain material from the local district. Whether or not Baird collected the specimens himself is not known, but he certainly had access to most of the classic mineral species including: troostite, tephroite, zincite, franklinite, automalite, willemite, clintonite, chondrodite, spinel, clinohumite, greenockite, vauxenite, calcite, chalcozincite, keatingite, chalcophanite and hetaerolite (Figures 33 to 35).

William also acquired specimens from collectors and academic researchers. A small number of specimens

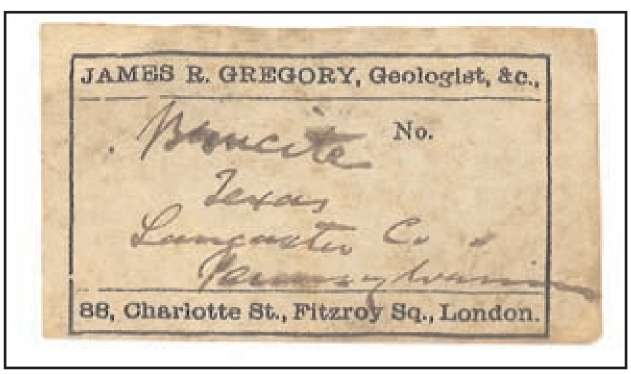


Minerals in Case A
Drawer III Laurium Series.
701. Crystals of adamine on limonite
702. Adamine (yellow crystals)
703. Adamine (green crystals)
704. Adamine (green crystals)
705. Arseniate of Copper with little Zn.
706. Do
707 Do
708. Do
709. Adamine (pale green clusters)
710. Arseniate of Copper with Zn
711. Carbonate of Cu. & Zn
712. Do.
713 Do.
714. Calamine covered with adamine
715 Cupreous Calamine
716 Do.
717 Chessylite
718 Do
719 Serpierite Brochantite etc.
720 Do
721 Do

Figure 25. Catalogue entry for the "Laurium Series".

S. HENSON, 277, Strand, London.
No.
Vanadinite Crystd
Wanlockhead.
Scotland
MINERALOGIST, &c.
6/-

Figure 26. Samuel Henson label. Accompanies Terrill collection no. 202 (NMW 37.239.GR. 377). Label dimensions 70 x 43.5 mm.



JAMES R. GREGORY, Geologist, &c.,
No.
Brucite
Texas
Lancaster Co
Pennsylvania
88, Charlotte St., Fitzroy Sq., London.

Figure 27. James R. Gregory label. Accompanies Terrill collection no. 491 (NMW 37.239.GR.137). Label dimensions 61.5 x 34.5 mm.

No.
NAME Natrolite
LOCALITY Aussig Bohemia
FROM
BRYCE M. WRIGHT, 90 Great Russell St., London.

No.
NAME Mesotype,
LOCALITY Salesel Bohemia
4/-
FROM
BRYCE M. WRIGHT, 38, Southampton Row, London, W.C.

Figure 28. Bryce M. Wright Snr. & Jnr. dealer labels (upper and lower labels respectively). The upper label accompanies Terrill collection no. 536 (NMW 37.239.GR.248 and 249). Label dimensions 65.5 x 36 mm. The lower label accompanies Terrill collection no. 535 (NMW 37.239.GR.130). Label dimensions 67.5 x 36.5 mm.

Figure 29. E. Deyrolle dealer label. Accompanies Terrill collection no. 658 (NMW 37.239.GR.552). Label dimensions 44 x 30 mm.

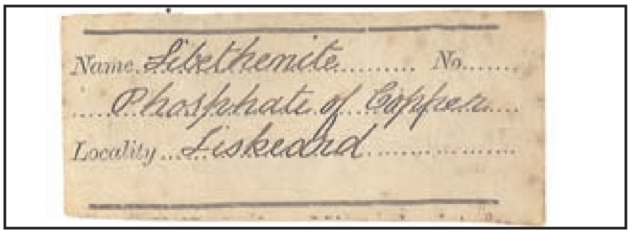
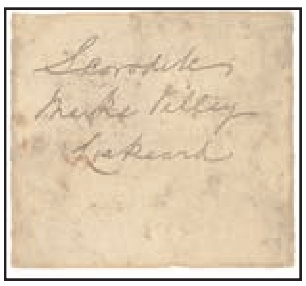


Figure 30. Thomas Downing (trimmed) label. Accompanies Terrill collection no. 295 (NMW 37.239.GR.348). Label dimensions 64 x 28 mm.



Left: Figure 31. Andrew Ketcham Barnett (1852-1914) handwritten label. Accompanies Terrill collection no. 640 (NMW 37.239.GR.303). Label dimensions 62 x 56 mm.

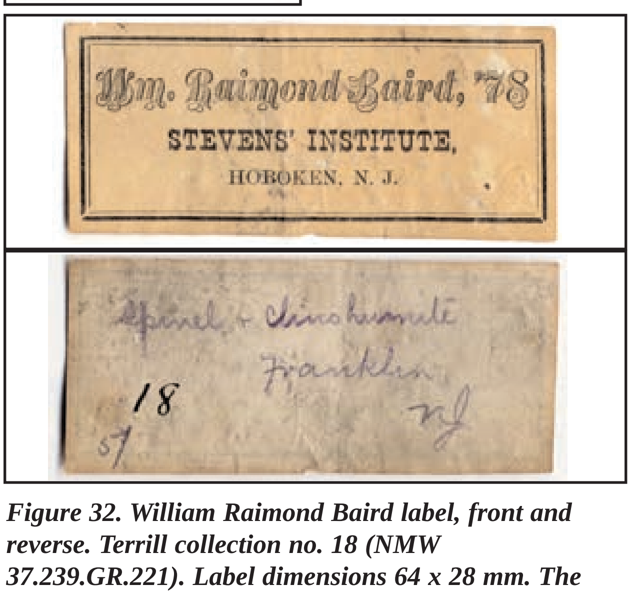


Figure 32. William Raimond Baird label, front and reverse. Terrill collection no. 18 (NMW 37.239.GR.221). Label dimensions 64 x 28 mm. The price is marked as 5 shillings.

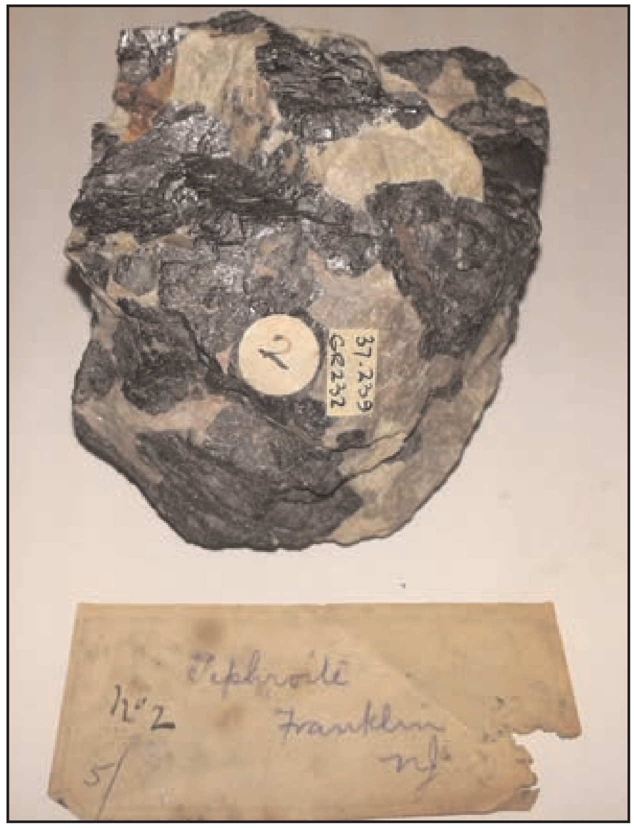


Figure 33. Terrill collection no. 2 (NMW 37.239.GR.232). "Tephroite" from "Franklin, N. J." associated with franklinite (black), willemite (green) and zincite (red). Specimen 67 mm tall.

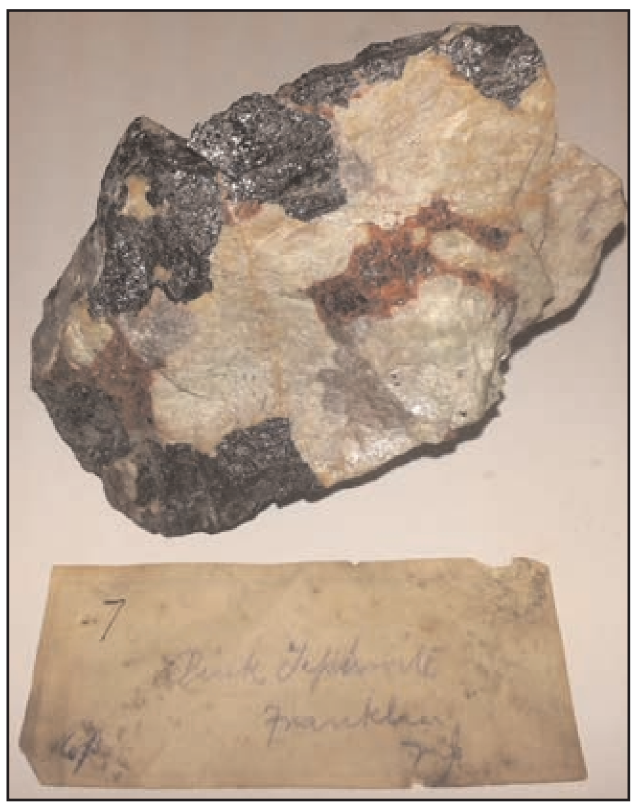


Figure 34. Terrill collection no. 7 (NMW 37.239.GR.226). "Pink Tephroite" from "Franklin, N. J." associated with franklinite (black), willemite (green) and zincite (red). Label 64 mm in length.

are recorded as having come from Prof. Bonney. Canon Thomas George Bonney (1833-1923) was Professor of Geology at University College London. Two of these are "*Olivine Enstatite Rock*" from "*Levant*" (see for example NMW 37.239.GR.434 and 435).

Two labels (NMW 37.239.GR.107 and 255) are reminiscent of Arthur Russell (Figure 36), but the year in which William Terrill died Russell would have been only 23 years old. Given that Russell began collecting minerals when he was just seven years old it is not impossible that he corresponded with William Terrill, but as yet little is really known of Russell's early label styles.

A small set of zeolite specimens from the Faeroe Islands are registered within the Terrill collection at AC-NMW (see for example NMW 37.239.GR.87, 112, 406, 407, 432, 437, 486, 522). They all bear similar handwritten labels which are attributed to Caroline Birley (1851-1907) (Figure 37). A further specimen, NMW 37.239.GR.199, bears a label with handwriting very similar in style to Birley's recording "*Heulandite. Iceland (East Coast)*". William's catalogue does not mention any material from the Faroe Islands and none of these specimens are accompanied by circular Terrill collection number labels. This has naturally led to some confusion over whether they actually formed part of his collection.

Caroline Birley lived in Manchester but she donated zeolites to many institutions including the British Museum (Natural History), Manchester University and Cardiff Museum. The Cardiff Museum collections were transferred to the new National Museum of Wales in the early 20th century. Four zeolite specimens donated by Caroline Birley to Cardiff Museum can still be identified (NMW 91.73; 91.74; 91.78; 91.75). The original correspondence between Caroline Birley and the curator, Mr Storrie, is dated 14 October, 1891, and is preserved at AC-NMW. It reveals that she only donated four specimens. It therefore appears most likely that those in the Terrill collection came to him from Caroline Birley when he was curator of the geological collections at the Royal Institute in Swansea. With his health deteriorating during the 1890s it is likely that he did not catalogue the Birley specimens.

Other specimens are absent from his catalogue and these too are likely to have been his later additions. Amongst these is a small suite of minerals (NMW 37.239.GR.413; 425; 431) from Paphos, Cyprus, which bear labels in his handwriting and specimen NMW 37.239.GR.168 which shows grains of native gold within baryte crystals and is accompanied by an old handwritten label stating, "*auriferous Barytes Antofagasta from W.G. Andrews*."

Part of the doubt over these uncatalogued specimens has been brought about by a small number of other specimens registered by museum staff as part of the Terrill collection, but which clearly relate to earlier museum accessions. Specimen NMW 37.239.GR.241 is one such example: The three small dark brown fragmentary vesuvianite crystals bear old collection labels (Figure 38) unrelated to William Terrill - two match those typical of Robert Henry Fernando Rippon's (c. 1836-1917) collection donated by Lord Rhondda in 1918 and attributed to the extensive collection of Colonel John Wilson Rimington (1832-1909) and the other is similar to a style of number label used by J. F. Jackson in the 1920s.

Indeed it appears that mislabelling of specimens during the inter-war years was not uncommon. A specimen of gypsum labelled as NMW 18.95.GR.111 (Rippon collection) has been found to be a part broken from Terrill collection no. 376 (NMW 37.239.GR.262). The true specimen NMW 18.95.GR.111 was later found, still numbered, in the teaching collection.

Inside the back of William's catalogue is listed the prices he paid for the mineral specimens. His list is far from complete - only providing information up to specimen number 192 - but emphasises that he purchased, rather than self-collected, most of the mineral specimens. This view is supported by the wide variety of old mineral dealer labels which accompany his specimens.

It is interesting to examine the prices he paid and thus discover what were once considered the most valuable, or prized, minerals. By far his most expensive acquisition was number 25 (NMW 37.239.GR.106), "*Dioptase*" from "*Siberia*", which cost him 60 shillings (a "real price" value of approximately £289.90 in 2014 - https://www.measuringworth.com/ukcompare/relativevalue.php). This is more staggering when one considers that the value placed on the collection by the museum in 1937 was £5.0.0 which, due to the effects of negative inflation during the 1920s, equates to just £276.80 today (2014 figures)! Furthermore when one looks at the quality, or lack of, of the specimen (Figure 39) it is apparent how mineral prices fluctuate as localities become more accessible. His next most expensive specimen was

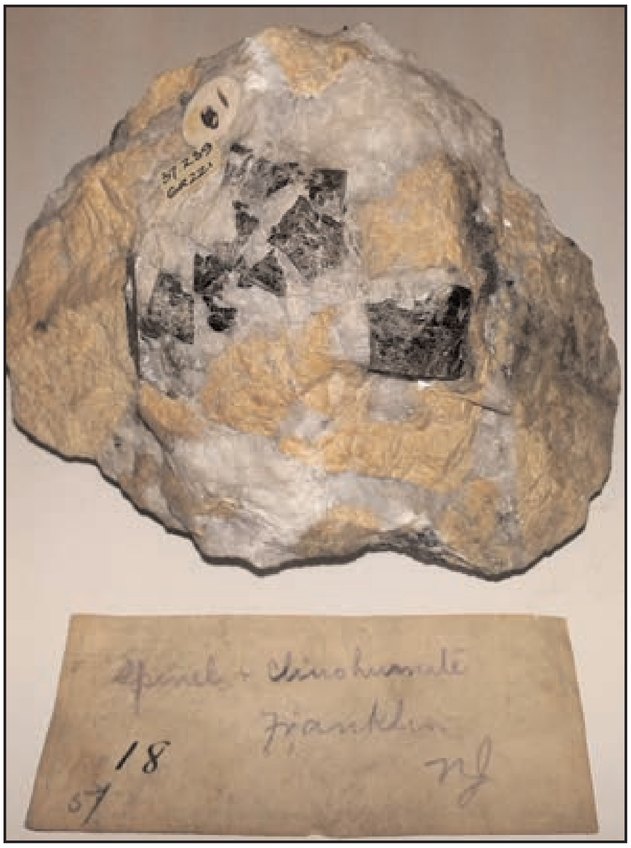


Figure 35. Terrill collection no. 18 (NMW 37.239.GR.221). "Spinel and Clinohumite" from "Franklin, N. J.". Specimen 85 mm across.

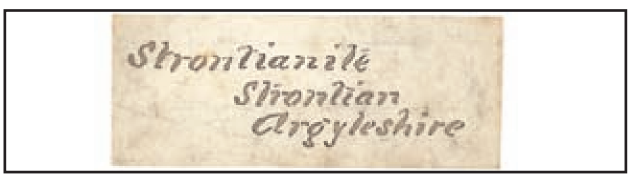


Figure 36. An unidentified label associated with Terrill collection no. 457 (NMW 37.239.GR.255). The handwriting and label style bears similarities to Arthur Russell. Label dimensions 51.5 x 20 mm.

number 162, "*Precious Opal*" from "*Queensland*", which cost 10 shillings. The vast majority of specimens cost less than 2 shillings each which would still equate to roughly £9.66 at current rates.

William's specimens were not the very best that money could buy, but his job allowed him to be able to obtain good representative examples of what was available from mineral dealers operating during the late nineteenth century.

Discussion

The Terrill collection at AC-NMW is a fine example of a late Victorian mineral collection and one of just a few know to have been assembled within Wales. The completeness of the collection is testament to both the curatorial care taken by William Terrill in labelling and cataloguing his collection, but also to

Figure 37. Caroline Birley handwritten labels affixed to specimen numbers NMW 37.239.GR.112 and NMW 37.239.GR.432 (No Terrill collection numbers assigned). The Birley label in the foreground measures 32 x 7 mm.

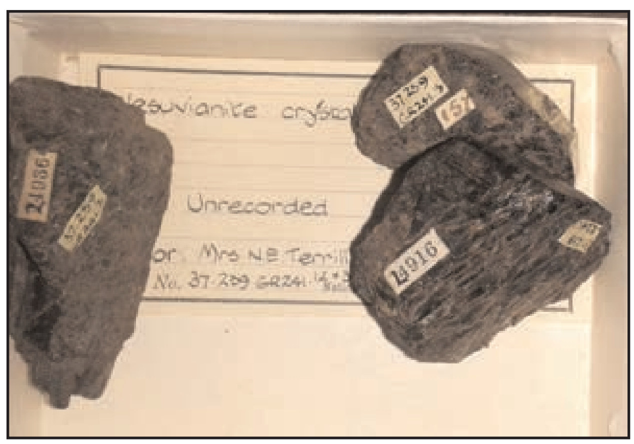


Figure 38. Alleged Terrill collection specimens registered as NMW 37.239.GR.241.1, 2 & 3, but bearing number labels typical of earlier accessions at AC-NMW. Three small, dark brown, fragmentary vesuvianite crystals. The two five-digit labels (10.5 x 4.5 mm) are attributed to Colonel John Wilson Rimington (1832-1909) part of whose collection was acquired by Robert Henry Fernando Rippon's (c. 1836-1917) whose collection was purchased and, immediately, donated to AC-NMW by Lord Rhondda in 1918 (registered as accession 18.95.GR.). The three-digit handwritten label is typical of J. F. Jackson accessions dating to the 1920s.

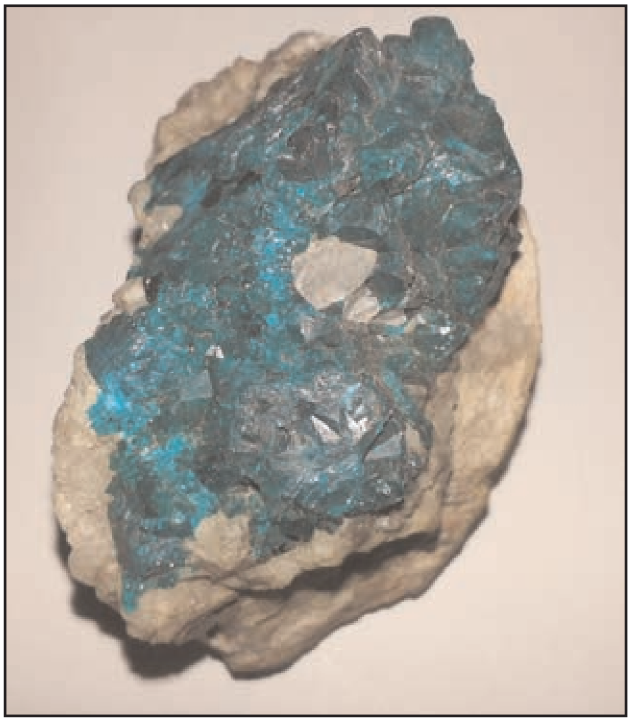


Figure 39. Terrill collection no. 25 (NMW 37.239.GR.106), "Dioptase" from "Siberia". Specimen 55 mm in length.

his widow and youngest daughter for looking after and keeping the collection intact for the 36 years after his death to when it was donated to the National Museum of Wales.

The fact that the museum's intention (as agreed with the Terrill family) was to split the collection up into several usable groups of minerals appears, fortunately, to have been forgotten due to the long delay between the collection arriving at the museum and when it was critically examined.

William was well respected within his family as the one who 'provided' for them all - relocating them from Cornwall to south Wales and leading his children to an educated life. After his death his brother Tom (Thomas Tucker Terrill) wrote a poem in his memory in December 1902 (Bertie's diary):

"His wealth and knowledge prematurely lost,
Ambition forced him to a life of toil,
He worked uncessantly beneath the soil,
Of Tropic continents and artic frost.

He did not breathe a college air in Youth,
Which make the gradient easier to climb,
But fortified by gifts that were sublime,
He tore the mountain sides to get at truth.

He swayed the sceptre where so ?s' s-l he ?woo,
In angular problems, logarithims, stars,
The Chemistry of matter, Crystals, Leyden Jars,
He mastered shew with all their ?coyout laws.

In art, in science penetrating deep,
Defeat was stranger to his inviolate will,
He saw sweet pictures in the rugged Hill,
The landscape lulled him with rest and sleep.

T.Terrill."

It is hoped that his mineral collection will now also serve as a memorial to his scientific endeavours.

Acknowledgements

The author gratefully acknowledges the help of Dr Stephen Plant in bringing to his attention the photograph of William Terrill at the Royal Society of Chemistry. The Royal Society of Chemistry are thanked for allowing reproduction of their photograph of William Terrill.

David Von Bargen is thanked for assisting in tracing information about William Raimond Baird and Howard Heitner is thanked for his views on 19th century American mineral collectors.

The staff at Swansea Archives are thanked for providing access to the diaries of Bertie Terrill and Robert Protheroe-Jones of Amgueddfa Cymru - National Museum Wales is thanked for discussions relating to the copper processing industries in Swansea.

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Appendix 1.

Re-discovered William Terrill specimens:

Terrill no. 893 - berthierite from Corsica - discovered unregistered and unaccessioned in the teaching/education collection (as no. GEM 2160) in June 2010, but identified by Terrill's characteristic circular number label affixed to the specimen. It is now registered as NMW 37.239.GR.753;

Terrill no. 214 - galena from Wheal Alfred - also discovered in the teaching/education collection (as no. GEM 129) and again identified by the presence of a circular Terrill label in February 2012. Now registered as NMW 37.239.GR.754;

Terrill no. 367 - aragonite, var. Flos Ferri, from Carthagenia - discovered during an assessment of education collections stored at the National Collection Centre at Nantgarw on June 25, 2015 in an 'Outreach Collection' box previously used to demonstrate 'Carbonates' It is now registered as NMW 37.239.GR.755;

Terrill no. 56 - wavellite, locality unrecorded - previously registered as NMW 37.239.GR.440, a small wavellite specimen found in the main education collection housed at the National Museum, Cardiff (specimen no. GEM 1771) found bearing a blank (faded?) circular label similar to those in the Terrill collection attaches to this specimen and has now been registered as 37.239.GR.440b. Another, sizable, part of the original specimen appears to have been removed at some point, but has not been located;

Terrill no. 420 - hydro-dolomite - registered as NMW 78.20G.R.5367 in 1978 as part of a bulk accession of unregistered material also bears a handwritten Terrill label (Hydro-dolomite).

Terrill no. 752 - cassiterite from Pednandrea - a rather battered specimen bearing two distinctive Terrill labels discovered in education material on March 4, 2016. One of the labels is a somewhat worn "Cassiterite" and the other a damaged circular number label appearing to read "152", but in consultation with the Terrill catalogue it is clear that this is specimen 752 "Cassiterite Pednandrea". This specimen is now registered as NMW 37.239.GR.756.

THE CONSERVATION OF A 19TH CENTURY GIANT DEER DISPLAY SKELETON FOR PUBLIC EXHIBITION

by Kate Aughey[1], Ruth F. Carden[2] and Sven Habermann[1]

Aughey, K., Carden, R.F. and Habermann, S. 2016. The conservation of a 19th Century giant deer display skeleton for public exhibition. *The Geological Curator* 10 (5): 221 - 232.

Following a mishap, a 19th Century mounted giant deer was subjected to a detailed osteological assessment and conservation treatment which required both structural repair and the extensive modeling of broken and missing skeletal components. The historic mounting system and plinth were largely intact and structurally safe for the skeleton and so these could be retained along with any historic restorations deemed sound and non-damaging. The original skull suffered irreparable damage and both antlers were detached from the specimen. A replacement skull was acquired but it was necessary to attach the original antlers to the new skull in a manner both structurally sound and aesthetically accurate enough for the deer to be placed back on open display. After testing commonly used conservation-grade filler materials suitable for fabricating missing skeletal components, losses to the vertebra and the ribcage were re-built using epoxy resin bulked to putty consistency with phenolic microballoons and applied over barrier layers of Paraloid B72 and Japanese tissue. All losses were in-painted with earth pigments in Paraloid B72 before re-articulation. The unique role of this specimen determined the conservation approaches adopted and included a balanced consideration of conservation ethical concerns, client expectations, future structural stability, aesthetic impact and the limitations of the future display location.

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Introduction

The extinct giant deer (*Megaloceros giganteus* Blumenbach, 1803) is classified as an Old World deer within the Family Cervidae and is genetically and morphologically the most similar to the extant European fallow deer (*Dama dama dama*) (Lister *et al.* 2005; Hughes *et al.* 2006). The giant deer had a geological history spanning from the Middle/Upper Pleistocene to Early Holocene periods and its subfossils have been found in hundreds of deposits across Europe, Russia, northern Africa and southwestern Asia (Gould 1974, 1977; Lister 1994; Geist 1999). Giant deer were locally extirpated in Ireland towards the end of the Younger Dryas (Woodman *et al.* 1997).

The first remains of giant deer subfossils in Ireland were discovered in County Meath in 1588 (Mitchell and Parkes 1949). The Late Glacial lakebeds of Ireland and Britain have yielded a preponderance of giant deer remains since the 17th century to recent times, while some remains date back to before the last Ice Age (Woodman *et al.* 1997). The distinctive characteristic palmate antlers, borne only by the males and spanning up to 4m tip to tip, are rarely found fully intact. From the mid-late 1800s, giant deer skeletal remains were prepared as full skeletal mounted specimens for exhibition displays, usually with unnatural straight necks to enhance the overall large 'body' size, within numerous museums worldwide including: the National Museum of Ireland, The Field Museum (Chicago), Ulster Museum (Northern Ireland) and the Natural History Museum (London). However, many of these mounted exhibited skeletal specimens are composite skeletons, i.e. bones from many individuals were utilised to produce a single mounted skeleton. Both male and female bones have been identified within the same exhibited skeleton in several museum/other collections, along with absences of some individual bones (e.g. the full complement of the ribs and smaller leg bones) (Carden 2006).

In the 19th Century, preparators of fully mounted skeletal display specimens of large mammals were typically articulated around a wrought iron frame with holes drilled through the long bones and the vertebrae enabling them to be threaded onto iron bars, which could then be bolted together to form a rigid frame. Lighter skeletal elements such as the ribs and the metatarsals were then wired onto the mounted skeleton. It was necessary to forge the structural iron rods into a more life-like approximation of legs and spinal column before articulation; therefore the holes drilled into bones had to be large enough to accommodate any such kinks and curves in the iron bars. Such preparations frequently meant that large amounts of bone material were lost during the articulation process thereby further weakening the already compromised bone structure.

The term sub-fossil bone refers to osseous material that has been exposed to the elements for a period of time before burial whereupon a proportion of the organic and inorganic content of the bone becomes degraded (Andrew 1996). Through the partial loss of the collagen framework (vital for flexibility and strength) and lack of any secondary mineralisation, sub-fossil bone has a propensity for mechanical weakness (Shelton and Johnson 1995).

The mounted giant deer skeletal specimen

This particular giant deer specimen was mounted in the mid-19th Century and acquired around this period by the original owners. In 1971, the deer was donated to a university collection where it was exhibited on open display in a public location for a number of years until a mishap occurred in the late 2000s. The insufficient support of the antlers had allowed them to come crashing down during the aforementioned incident, shattering the original skull into three main sections and hundreds of fragments. Upon impact with the ground a number of antler tines had also become damaged or detached. The client had sourced a replacement skull, however the antlers of that skull had been sawn off and thus any treatment would necessitate the marrying of the original antlers to the new skull.

The incident provided an opportunity to conserve the skeleton as a whole and address wider issues such as the failing previous repairs and the broken or detached skeletal elements. Extensive conservation works were required to re-assemble the specimen and identify and monitor any environmental conditions which may have contributed to its deteriorating condition.

Conservation objectives

The unique role of this object determined the conservation approach adopted. This individual is the only fully articulated specimen in a private collection in Ireland and would be returned to open display within a university library. This meant that it must be structurally sound, so as not to present a hazard to any library visitors, be anatomically correct as befits an object in a centre for learning, and also be of a high aesthetic standard to justify its prominent display position within a newly developed building whilst still retaining much of its original features as a historical skeletal exhibition-style mounted specimen.

Pre-conservation state

Initial condition assessments of the whole specimen revealed that extensive restoration had occurred in the past as well as a number of *ad-hoc* repairs. The plaster-based fillers used for both gap-filling and the larger areas of re-modelling were crumbling and a very dark brown paint-layer on the bone surfaces further emphasised this state of disrepair (Figure 1). Other fillers and stabilising materials included wood, various metal rods and nails, cable ties and even a plastic syringe cap used to dowel two sections of rib together (Figure 2).

Figure 1. The pre-conservation condition of the giant deer specimen ribcage whilst still in situ. The light brown painted surface of the old repair works is clearly visible against the real bone.

Figure 2. A selection of materials applied during previous restoration treatments found and removed from the specimen.

The specimen was entirely coated in a shellac-like substance soluble in both alcohol and acetone. As mentioned previously the skull was in an extremely fragmented state and was therefore detached from the mounted specimen, as were the antlers, after falling approximately 1.5m onto the ground.

In order to limit the movement of the bones once they were mounted, cavities around the iron rods were routinely filled with plaster or linseed putty and packed with soft materials such as newspaper (Buttler 1994; Andrew 2009). In the case of this specimen, a fracture to the left distal femoral condyle region revealed the plaster-fill along with a tantalising scrap of newspaper containing articles which could be dated to 1864, giving an approximate date for the original mounting (Figure 3).

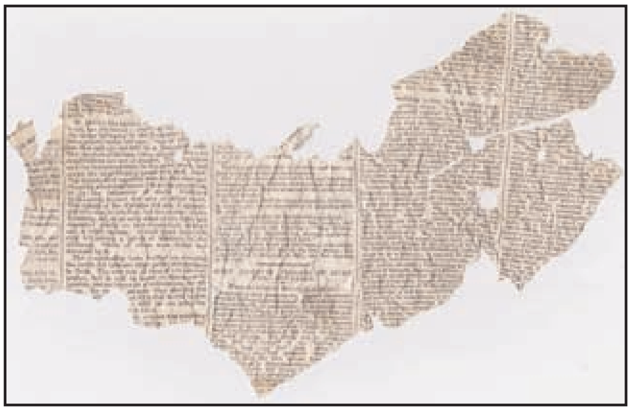

Figure 3. Newspaper fragment found within the left femur dated to 1864.

Pre-conservation assessment of the skeleton

The majority of the skeleton was disarticulated to allow a thorough series of anatomical and conditional assessments. The long bones comprising the fore- and hind limbs however, they were well anchored to their mounting rods and were relatively structurally sound. For this reason, the limbs were unbolted from the spinal rod and left assembled as four distinct articulated units. It had always been the intention to retain as much of the historic mount as possible and so unnecessary articulation was avoided to minimise any further damage to the specimen.

A detailed anatomical assessment was performed on the various disarticulated and articulated parts of the specimen. All of the bones were examined in detail to ascertain (i) their anatomical and taxonomical identifications, (ii) to provide the correct sequence of the elements (e.g. order of left/right ribs), (iii) to determine what, if any, skeletal elements were absent and (iv) to record the overall preservation state of each element. All of the examined bones were identified as adult giant deer. There were numerous duplicate ribs, not necessarily from the same individual adult (all epiphyseal sutures were fully fused) giant deer (composite skeleton). Of the eight left ribs, two 4^{th} ribs were present and originated from different individual adult giant deer. There were a number of missing skeletal elements which included the hyoid apparatus, some teeth, 12 ribs and all of the false ribs, all of the caudal (tail) vertebra and some of the smaller cuboid leg bones. Many fractures and evidence of breakages were immediately visible in numerous parts of the skeletal remains, along with historical repair works (for further specific details see Carden 2015).

It was decided not to attempt to remove the shellac-like coating from the surface of the specimen as it appeared stable and possessed a sufficiently high enough glass transition temperature not to become tacky and adhering dirt in the future. Any surface dirt present was removed with a soft brush and vacuum. The areas of visible plaster and dark brown paint on external surfaces were removed with acetone on cotton swabs while dental tools and tweezers were used to carefully extract fragments of plaster from the interstices of fractured areas. Any areas of plaster that were stable and not visually disruptive were left in situ as it was deemed too damaging to attempt to remove it all. In the case of the articulated limbs, the plaster was providing an anchor between bone and iron rod and so it was particularly important to leave this intact as both a structural element and evidence of this historic mounting method.

One concern when assessing the condition and potential stability of the specimen in the future, were the large splits running longitudinally though the centre of each of the long bones within the four legs. Without disarticulating the legs and risking significant damage, it was not possible to see whether one iron rod passed through the long bones continuously or if shorter sections of iron secured the joints leaving the bones themselves to bear the weight of the rest of the specimen. The latter scenario had obvious structural limitations and would need to be addressed. The least invasive way to investigate whether there was a single continuous iron rod or not, was by radiological (X-ray) imagery of one of each of the fore- and hind limbs.

The X-rays revealed that the iron rods did indeed run continuously through each leg (Figure 4) and that rather than being stress fractures caused by compression, the longitudinal splits were likely the result of the expansion and contraction of the bones during environmental fluctuation.

Ethical Considerations

A balanced consideration of conservation ethical concerns, client expectations, future structural stability and the limitations of the future display location was necessary before treatment and was re-assessed as work progressed. The main conservation principles of reversibility/re-treatability must be adhered to, which embodies that any treatments

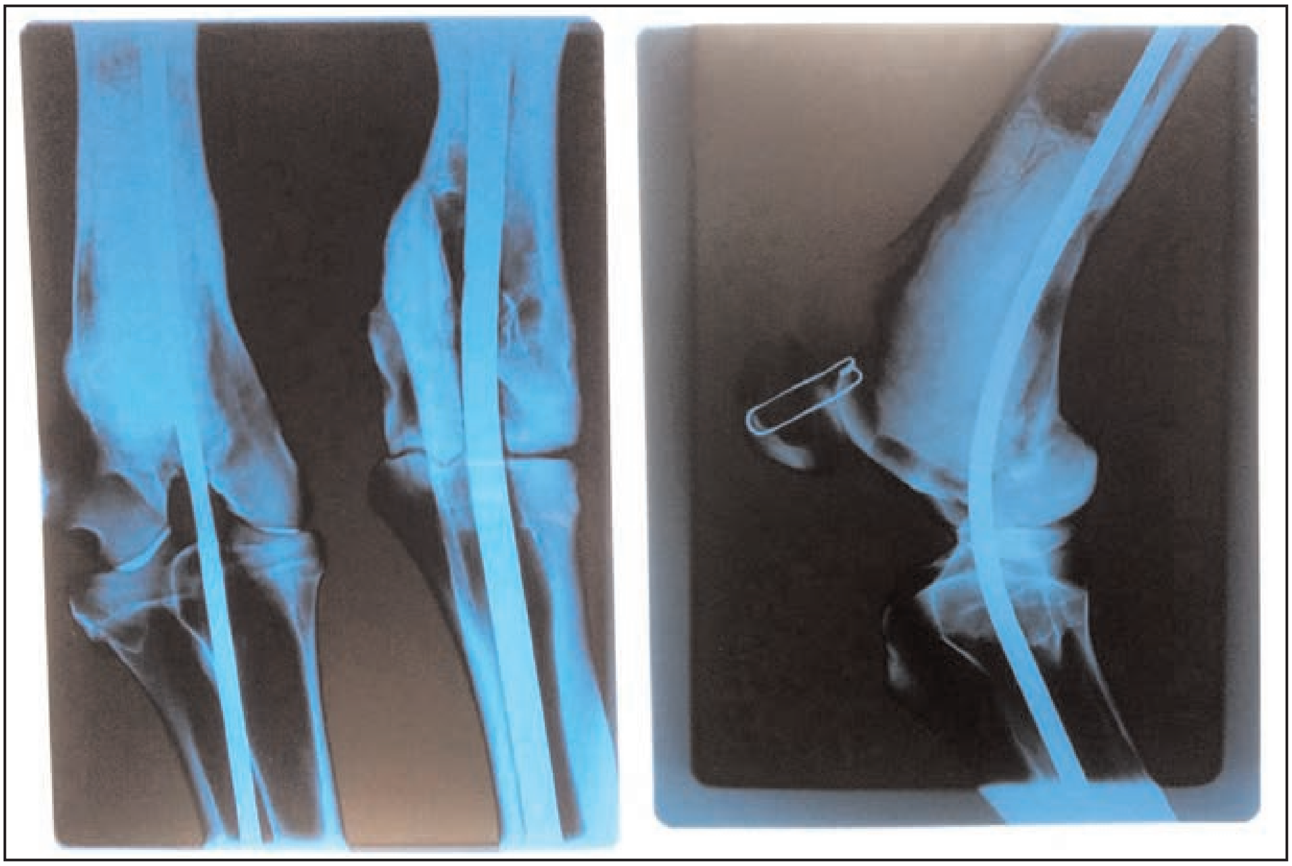

Figure 4. Radiological (X-ray) imagery of the (A) right femur-tibia junction anterior, (B) right humerus-radius/ulna junction posterior aspect and (C) right humerus-radius/ulna junction, medial aspect. X-ray images courtesy of Jens Werner MRCVS of Western Veterinary Surgery, Clifden, Co. Galway, Ireland.

applied to the object should be able to be reversed in so far as is practicably possible. The materials introduced in the course of those treatments should also meet conservation standards for long-term stability. It was also important to consider that any adhesives or consolidants penetrating the specimen could severely compromise the retrieval of genetic material in the future. The historic mounting system and plinth were largely intact and structurally safe for the skeleton and so these could be retained along with any historic restorations deemed sound and non-damaging.

Materials

When considering which materials may be suitable for reinstating missing skeletal components and re-modelling missing sections a number of fillers, commonly used in conservation, were tested. A range of proprietary fillers and bulked adhesives were assessed for their handling properties, level of adhesion and the ease with which they could be shaped. The introduction of compressively weak fillers such as microballoon spheres have been found to lower the compression modulus of a polymer based adhesive whilst heavy levels of bulking reduce adhesion through a lowering of contact surface area (Barclay and Mathias 1989). For these reasons, microballoons became the primary bulking agents tested. The phenolic microballoons chosen had a particle size ranging between 0.005-0.127 mm. Paraloid B72, a solvent evaporation adhesive widely used in a variety of conservation applications, offers desirable properties such as long-term stability and ease of removal (Horie 2003). However, when subjected to a high degree of bulking and applied in large quantities solvent retention can occur resulting in a fill that fails to cure fully (Larkin and Makridou 1999).

Building up multiple layers of bulked Paraloid B72 filler over a period of time was impractical for reinstating the large areas of bone related loss in this specimen but could have provided effective lightweight fills for the smaller areas of bone loss. Utilising a single material for both gap filling and structural remodelling limited the number of different substances introduced to the specimen and enabled treatment to be identified as a single phase of conservation in the future. Grattan and Barclay's (1988) research has demonstrated that an epoxy resin and phenolic microballoon mixture performed well in compression tests, resisting fluctuations in relative humidity, without damaging weakened surrounding timber.

Epoxy resin, when bulked with phenolic microballoons, could be easily carved and was capable of holding crisp detail, which is an essential property in accurately modelling large areas of bone (Barclay and Matthias 1989). A low viscosity two-part epoxy resin was chosen (UKH-137 Resin, UKH-136 Hardener: Material safety datasheet outlining chemical composition available upon request at online at www.epoxy-resins.co.uk). As a commercial product, it is possible that impurities may contribute to slow oxidation causing yellowing over time (Horie 2003; Down 1984). Given that the epoxy filler would be heavily bulked with brown phenolic microballoons and in-painted, potential yellowing was not considered problematic. The cohesive strength of the bulked epoxy filler also meant that it required very limited internal support and in many cases could be built up in just one application. Concern has been expressed over the heat generated by the exothermic reaction, which occurs during the curing of epoxy, and this should be taken into account in the application of fills deeper than 20mm (Barclay and Mathias 1989). In the course of this treatment however, the gaps filled were not sufficiently deep to create any perceptible heat build-up. When applied in large quantities, the epoxy fill material was exposed to the air on all sides, with the exception of the interface between bone and fill, and so heat could quickly dissipate.

In order to address issues of reversibility around the use of epoxy resin, the epoxy / microballoon filler was applied over a barrier layer of Japanese tissue adhered with 40 % solution Paraloid B72 in acetone (w/w). The high viscosity of this Paraloid B72 solution was selected in order to maintain a reasonably homogenous layer at the joint between bone and fill, without excessive absorption into deeper levels (Ellis and Heginbotham 2004). The bond between Paraloid B72 and a bulked epoxy fill applied to wood is reversible, if required, through exposure to a solvent vapour with acetone exposure which requires nine hours to fully reverse bonding (Podany *et al.* 2001). In the planning of the treatment of the giant deer specimen, the experiment conducted by Podany *et al.* (2001) was replicated using samples of new and weathered bone and the results were found to be comparable. A layer of 12gsm Japanese tissue was included in the barrier layer system to limit the mechanical adhesion of the fill material by minimising any interstices in the uneven bone surfaces. As with any solvents or epoxy-based adhesives, care was taken to ensure appropriate extraction and personal protection was utilised at all times.

Conservation methods

Fractured bone surfaces

Prior to the application of the bulked epoxy filler, all the fractured surfaces were consolidated with a viscous layer of Paraloid B72. This was applied with a No.10 synthetic hair brush and whilst tacky, a single layer of Japanese tissue was applied to the Paraloid B72 with care taken to ensure that the tissue conformed to the uneven surfaces. A second layer of the Paraloid B72 solution was then applied on top of the Japanese tissue. The barrier layer was left to cure for twenty-eight hours to allow full solvent evaporation before the epoxy / microballoon mixture was applied (Ellis and Heginbotham 2004). The majority of bone surfaces were relatively stable with very few friable or flaking areas so deeper penetration of a consolidant was not required.

Remodelling of the bone

Larger areas, for example the scapula, required re-modelling and 1.5mm copper plated mild steel welding rods were used to provide an internal armature (Figure 5). The welding rods were chosen as they offered a high degree of stiffness and malleability allowing small gauge rods to be used. Since they would be entirely enclosed within the filler the likelihood of oxidation of the copper plating was limited. A stainless steel wire could also have been used as an alternative but would likely have required a higher gauge size for comparable stiffness. Where possible, the holes left by previous doweling attempts were reused but where there were no existing holes, the wire was pushed approximately 20mm into the cancellous bone interior and secured with a highly viscous solution of B72. The bulked epoxy filler could then be applied and left to cure for twenty-four hours before shaping.

Consultation Process

After the skeleton had been fully disarticulated and anatomically assessed a consultation process between the conservators and the anatomist commenced. The condition of the various skeletal elements was discussed and decisions were made about the extent to which missing or damaged components should be remodelled. The anatomical features of the skeletal elements of the exhibited giant deer skeletal mounts, fallow deer and red deer skeletal material held within the Zoological Collections of the National Museum of Ireland - Natural History Division were examined and detailed observations were recorded in terms of anatomy and articulation. Other published material on deer skeletal morphology proved useful (for example, Post 2014).

In order for the viewer to fully understand the overall scale and shape of the specimen, it was decided that certain anatomically correct areas of a proportion of the skeletal elements should be reinstated namely, the distinctive vertically protruding dorsal processes of the thoracic vertebra and the posterior ribs within the ribcage. The caudal (or tail) vertebrae were not included within the restoration since these bones have been rarely found with giant deer subfossil remains, either due to lack of preservation or poor retrieval excavation techniques. The number of caudal vertebrae found within deer species can vary in total number and we do not know the full number of these bones found within giant deer tails.

Repair and re-modelling of skeletal elements

Skeletal components that required remodelling in their entirety were created in a similar way to the

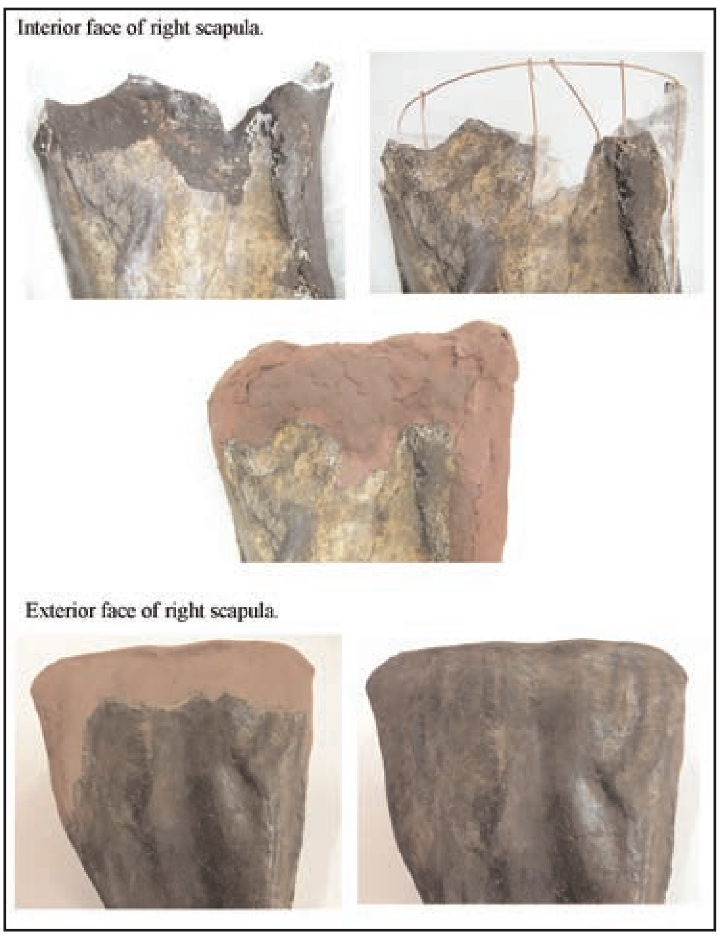

Figure 5. Stages in the modelling of damaged skeletal components (see text for stage explanations).

aforementioned missing localised larger areas. In the case of the ribcage, the vertebrae and ribs were anatomically arranged to establish where the new ribs should be located and to ensure they followed the contour of those already present. Reference photographs and an average set of dimensions were recorded from three similarly mounted specimens within the National Museum of Ireland - Natural History Museum and these measurements were used as a guideline for approximating the anatomically correct rib lengths and shapes. A series of 1.5mm copper plated steel welding rods and existing ribs were temporarily secured to a flexible external armature made from 5mm diameter fiberglass rods with low tack masking tape. The bulked epoxy filler could then be shaped around the welding rod supports and refined once cured (Figure 6). All modelled components were constructed in this way using photographs of mounted giant deer specimens for reference in-conjunction with anatomical diagrams of morphologically similar deer species.

Colouring

Once shaped with riflers, files and wood carving chisels, the fills and modelled sections were in-painted with earth pigments in a 10% solution of Paraloid B72 in 50:50 IMS and acetone. The earth

Figure 6. (Top) The ribcage of the giant deer specimen during construction. (Middle) The remodelling and fabricated ribs are those areas that display a lighter brown relative to the remaining darker brown coloured real bone. (Bottom) The fabricated ribs post 24-hour curing and shaping, and subsequently in-painted with earth pigmentation.

Figure 7. The giant deer (right) humerus bone before and after colouring with earth pigmentation.

Figure 8. Giant deer lumbar vertebrae with newly remodelled bone infilled areas clearly visible in ultraviolet light (bluish colour), after in-painting with earth pigments.

pigments had the advantage of closely matching the brown earth tones of the specimen, providing a convincing aesthetic match and could be easily and quickly removed if swabbed with acetone. The reddish brown hue of the phenolic microballoons was also advantageous in achieving a close match (Figure 7). As a binding agent, the Paraloid B72 added a slight sheen that accurately represented the sheen of the shellac-covered bones. An additional benefit to this system is that the in-painted areas can be quickly identified as matt dark areas in contrast to the shellac coated bone surfaces when exposed to ultraviolet light (Figure 8).

Treatment of skull and antlers

By far the most challenging aspect of remounting the giant deer, was establishing a viable way to integrate the newly obtained skull with the antlers belonging to the specimen. Aesthetically, introducing external brackets was undesirable and while the antlers could be partially supported from above, attaching load bearing supports from the ceiling in the proposed display location was not possible. This meant that however the antlers were attached they would need to be largely self-supporting. The left antler had suffered two serious breaks across the main beam in the past and been repaired with several heavy duty brackets. The large number of holes in this area and the presence of weak historic fillers made finding a location to securely attach a new external bracket problematic. For these reasons, the difficult decision was taken to permanently attach the antlers to the new skull without the reversibility measures usually associated with the use of epoxy resin adhesives. An un-bulked structural two-part epoxy (UKH-136 and UKH-137) offered high levels of adhesive strength and the high glass transition temperature necessary in a very warm display location. It has been suggested that on a porous substrate, the bond strength of epoxy based adhesives applied over a barrier layer of Paraloid B72 is comparable to the bonds yielded by epoxy alone (Ellis and Heginbotham 2004; Podany *et al.* 2001).

The post-treatment internal access to either the skull or antlers however, was deemed too limited to allow such a barrier layer to be reversed in any practical way and so this was ruled out. An alternative to this somewhat drastic measure could have been to cast replica antlers in a light-weight, conservation grade material and instead mount these on the new skull and store the original antlers. The time and materials required to cast high quality replicas was outside of the budgetary constraints and so the decision was made to use 15mm high tension CFRP carbon fibre rods to effectively dowel the antlers onto the replacement skull. This was done by drilling two diagonal holes down through the pedicles at such an angle that the carbon fibre dowels passed through the thickest structures within the skull with the crossed ends meeting at the nasal cavity. Corresponding holes were drilled into the cancellous interior of the antlers and adhered with several applications of the liquid epoxy. Milliput® modeling epoxy was then used to extend the lower edges of the antler coronets to hide the join and in-painted to match. Upon reinstallation, heavy duty fishing line was looped around both antler beams and secured to ceiling trusses for additional support.

The broken antler tines were adhered with a lightly bulked solution of epoxy resin and phenolic microballoons applied over the Paraloid B72 and Japanese tissue barrier system. Any missing tines were recreated in soft lightweight pine, shaped using a rasp and coated with a thin skin of the epoxy and microballoon filler before in-painting. Although aesthetically effective, this method was greatly improved upon in the treatment of another antler set through the use of an expanded metal mesh armature coated in the same epoxy based filler.

Skull and anterior spinal rod and the vertebra

Within the original mounted specimen, the anterior portion of the spinal iron rod had been inserted into the skull through the foramen magnum with a bar that passed through a hole in the rod creating a T-shaped support. Both ends of the T-bar exited through the orbits and were secured simply by bending the bar ends around the edge of each orbits. As an aesthetic improvement to this system, the new skull was secured to the spinal rod with two heavy duty stainless steel nuts and bolts from the ventral aspect.

A layer of 2mm Plastazote® was adhered to the spinal rod to minimise unwanted movement of the vertebrae which were subsequently threaded onto the rod in the same original manner. The addition of Plastazote® discs between each vertebra provided further cushioning that similarly mimicked the functions of the *pre-mortem* intervertebral discs or fibrocartilage in these locations. The ribcage was attached by reusing the previous mounting holes; however, these were first consolidated with several applications of Paraloid B72 to impart greater strength. Soft copper wire was utilised for its malleability and in-painted with acrylic paints.

Historical use of metal fixtures

As well as the intrinsic structural mounting rods, a number of metal brackets, nails and metal bars had been used externally to secure weakened components. One such example was the pelvis, which bore a high degree of structural stress and strain as the only point of contact between the rods protruding from the proximal areas of the hind limbs, and the rod supporting the spinal column. A large internal section had been historically incised from the sacrum to allow it to be threaded onto the end of the spinal column and this was then adhered to the pelvis with an animal glue and cotton filler. Subsequently, the pelvis was attached to the femoral articular heads with M6 mild steel threaded bars, screwed into a tapped hole in the top of the leg rod, which protruded through holes drilled in the both of the femoral articular heads and passed on through the centre of the acetabular fossa of the pelvis (acetabular-femoral articular head joints) where they were secured with nuts and washers. The holes in the articular heads of each femur had become enlarged through wear and allowed the threaded rods to be upgraded to heavier duty M8 stainless steel replacements. It was clear that the stress placed on the pelvis in this way must be transferred to a supportive bracket and so a new stainless steel bracket was designed and cold forged in 1.2mm stainless steel sheet to run in a continuous loop, conforming to the interior facets of the pelvis and sacrum with 2mm Plastazote® providing a cushion between bone and bracket (Figure 9). The original holes securing the leg rods to the pelvis were then re-used with new stainless steel rods, nuts and Plastazote® washers.

Figure 9. The pelvic bracket in situ after the completion of the treatment.

Future care and recommendations

In fluctuating environments, damage to sub-fossil bone typically takes the form of surface de-lamination, longitudinal splits or cracks along lines of weakness such as growth plate/epiphyseal sutural boundaries (Doyle 1986). The longitudinal splits and localised fractures observed in this specimen required ongoing observation and thus a monitoring programme was instigated which involved visual inspections by staff of Conservation | Letterfrack of the mounted specimen every few months to examine the bone surfaces in detail for any signs of new cracks or the widening of those already treated. An Easy Log USB data logger was also tucked inside the eye socket (orbit) to gain an overall picture of the day-to-day conditions experienced by the specimen. In long-term storage, ideal conditions for sub-fossil bone range between 50-60% relative humidity whereas on display, around 40-50% is recommended with fluctuation of 10% or more per day likely to cause damage (Andrew 1996).

The proposed display location for the completed specimen was always likely to be problematic as the position, directly in front of a large expanse of windows, was subject to high levels of temperature and relative humidity fluctuation. As well as diurnal temperature fluctuation caused by central heating and the greenhouse effect of largely glass surroundings, varying occupancy within the room influenced less predictable relative humidity levels. The opening and closing of doors and windows inside the space further compounds this issue.

The readings obtained from the data logger (Figure 10), taking hourly readings across a four-month period, recorded a minimum temperature of 12.5°C with the highest temperatures reaching 34°C. The average relative humidity recorded across this span was 37.7% but alarmingly, on particularly unstable days the specimen was subject to diurnal relative humidity fluctuations of around 20%. These values fall well outside of recommended levels and so a maximum exhibition period of six months was advised for this specific location with regular monitoring in place to flag up potential issues before they became damaging to the conserved skeleton. Presently, the specimen has been removed to a climatically stable storage location while research is underway to source a suitable display case with incorporated climate control.

Conclusions

From our examination of this historically prepared full skeletal mounted giant deer specimen, we outlined procedures, in line with best practice conservation guidelines, with regards to use of fillers and adhesives that will ensure an accurate reconstruction and aesthetically pleasing remodelling while still retaining historical features of the original mount. The highly interventive and largely irreversible adhesion of the original specimen antlers to the newly obtained skull was decided upon after an exhaustive exploration of reversible options. The conservation treatment imparted structural strength to an otherwise unsteady display specimen

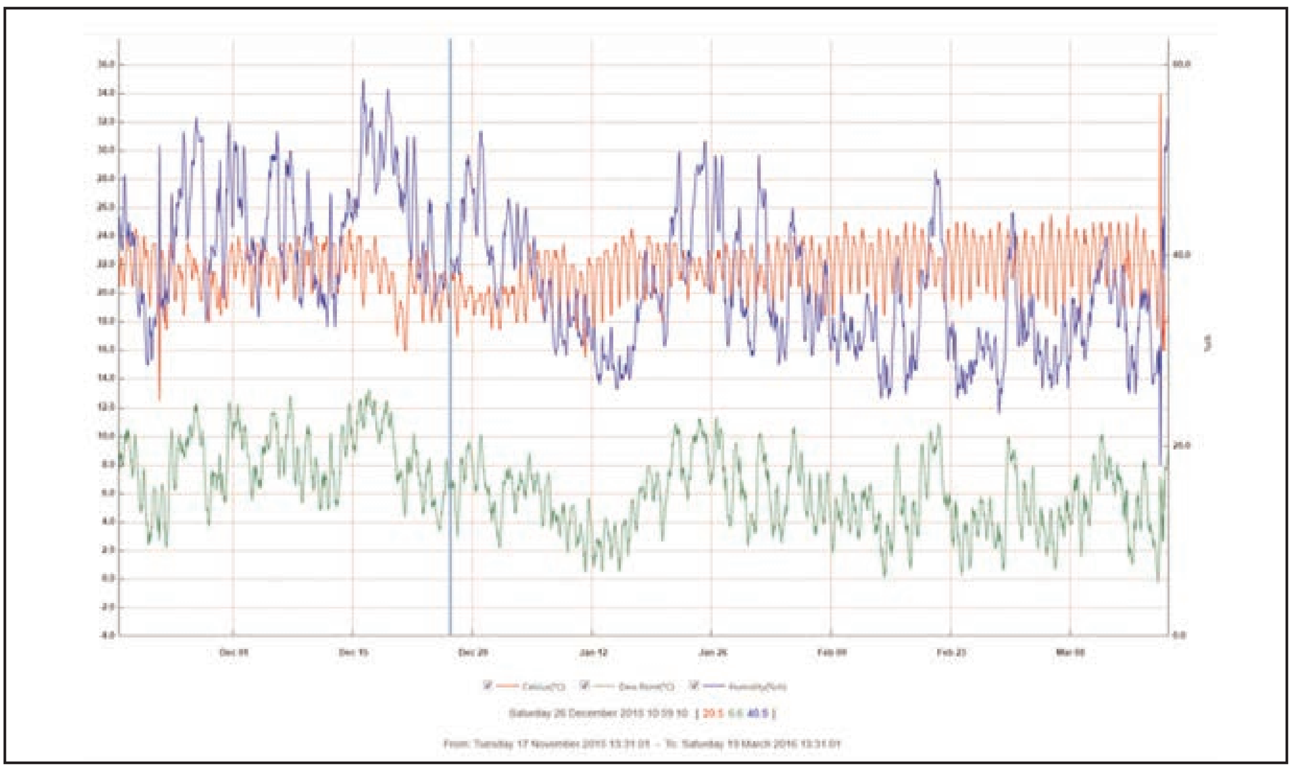

Figure 10. Data logger hourly readings across a four-month period, illustrating fluctuations in recorded minimum temperatures (red), average relative humidity (blue) and the dew point (green).

and aimed to improve the viewers understanding of the scale and shape of the specimen by reinstating missing or broken skeletal components. The use of an epoxy resin bulked with phenolic microballons for modeling purposes was largely informed by the sucessful use of such materials in the conservation of degraded wood. A comparison of the compressive and tensile strengths of this material with subfossil bone is an area for future research. Due to fluctuating environmental factors occurring within the display area, a maximum exhibition period of six months was recommended with an ongoing monitoring programme in place to safeguard the future of the specimen. A climate controlled display case and alternative future display location are currently being investigated (Figure 11).

Acknowledgements

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ADDENDUM TO: A TALE OF TWO HOLOTYPES: REDISCOVERY OF THE TYPE SPECIMEN OF *EDESTUS MINOR*

by Wayne M. Itano

Itano, Wayne, M. 2016. Addendum to: A tale of two holotypes: Rediscovery of the type specimen of *Edestus minor*. *The Geological Curator* 10 (5): 233 - 234.

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Itano (2014) reproduced several of the nineteenth century depictions of the two specimens that have been regarded as holotypes of *Edestus minor*. Recent photographs of the real holotype, AMNH FF477, were shown. As was pointed out by a reviewer, recent photographs of the other specimen, ACM 85, would be of interest. However, such photographs could not be obtained in time to be included in that article. In June 2016, an opportunity presented itself for the author to travel to the Beneski Museum in Amherst, Massachusetts, to photograph ACM 85. As can be seen in Figure 1, that specimen appears to be in very much the same condition as in the early depictions. In contrast, AMNH FF477 is now missing the apical portion of the crown. To the best of the author's knowledge, the most recent

Figure 1. ***Two lateral views of ACM 85. (A) Anterior to the left. (B) Anterior to the right. Scale bars = 5 cm.***

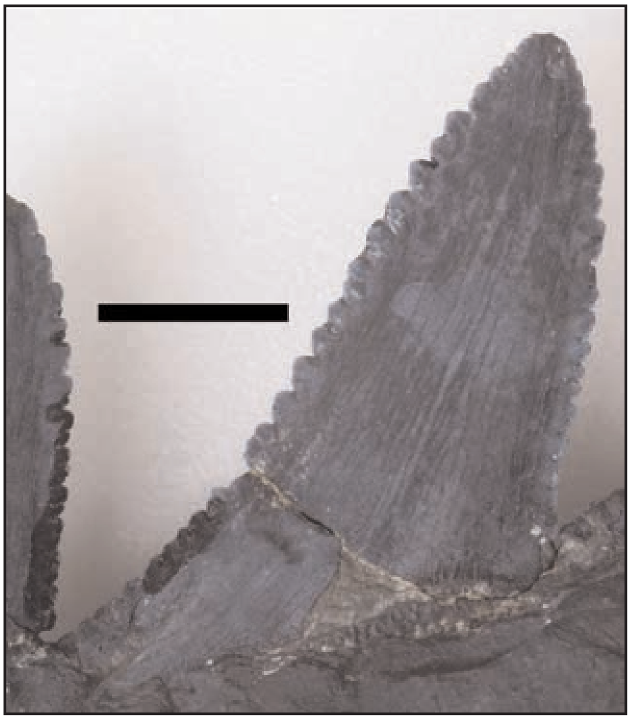

Figure 2. Lateral view of sixth crown from the anterior end of ACM 85. Scale bar = 1 cm.

photographs of ACM 85 published previously are those of Eastman (1903). Since the time that those photographs were taken, the specimen number has been painted on one side (Figure 1B). The specimen appears to have had very little reconstruction. Part of the base appears to have been coated with a preservative and painted. Most of the crown surfaces preserve the original hypermineralized layer. Depending on the lighting, this may give them a shiny appearance (Figure 1A) or not (Figs. 1B, 2). It was found that the second crown from the anterior end is not reconstructed, but is made up of the original material. Because most of that crown was missing in the earliest depiction (Hitchcock 1856; Itano 2014, figure 3), it had been surmised that that crown had been reconstructed so as to improve the appearance (Itano 2014, p. 19). Apparently the detached portion of that crown was preserved and was later reattached.

Acknowledgements

I thank K. Wellspring, T. Harms, and P. Crowley of the Beneski Museum of Natural History, Amherst College, Amherst, Massachusetts, USA, for allowing me to examine specimen ACM85 and for providing the facilities for photography of that specimen. The photographs are published courtesy of the Trustees of Amherst College, Beneski Museum of Natural History, Amherst College.

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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.

272. The two birthdays (and baptisms) of Charles W. Peach (1800-1886)

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We recently noted that family information gave a different date of birth for Charles W. Peach (1800-1886), 30 September 1800, from genealogical sources such as FreeREG, which has Peach's birth on 12 October and baptism on 6 November (Taylor and Anderson 2015, p. 160). This raised the possibility that we were conflating two separate individuals of the same name, but we had to leave the matter open as we were unable to trace any surviving volume covering 1800 in the parish church records for his native village of Wansford in Cambridgeshire (but at that time Northamptonshire).

It has since emerged that in 1800 the parish register for nearby Thornhaugh was being used for at least some Wansford events, including the baptism at 'Wandsford' of one Charles William, son of Charles William and Elizabeth Peach, twice in 1800 - once, 'privately', on 12 October, and again, 'publickly', on 6 November (image of original register page on www.ancestry.co.uk, whose online database has those baptisms occurring at 'Thornhaugh', accessed 9 February 2016). The 12 October 'birthday' must therefore be a transcription error and can be ignored.

The public baptism would have been by a clergyman at a regular church service, much as is conventional today. The private baptism would have been by a lay person, probably a parent or nurse, and later confirmed by a public baptism. Studies in adjacent counties show several reasons for a delay in public baptism, and in turn an earlier private baptism, presumably to ensure that the child did not die unbaptised, and be buried outside consecrated ground (Mills 1973; Ambler 1974). Private baptism could be an emergency practice, especially if the child was seriously ill. However, it could be for practicality and convenience. A delay would allow the mother to recover from the birth and the parents to prepare for a family get-together at the formal public baptism. Or perhaps no clergyman was available in the parish and it was undesirable to take the new mother and child to the next parish, for instance because of bad weather, so they waited till the next service at Wansford. This last seems likely in Peach's case, for David Stuart-Mogg (pers. comm. 2016) kindly points out that Wansford parish church was operated as a so-called chapel of ease, i.e. a satellite chapel, of Thornhaugh parish church just over a mile to the north, under the Rector of Thornhaugh. (The chancel at Wansford had fallen down sometime in the 1400s and was not replaced till 1902.) A final possibility, potentially significant given Peach's Unitarianism and its connections with his geological interests, is that the family were Dissenters. They might then baptise their child outwith the State Church of England, thereby getting in before the priest, so to speak, even if they were later forced to take the child for a public baptism. This must however be discounted in the absence of any other evidence for Nonconformism in Peach's natal family (Taylor and Anderson 2015).

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BOOK REVIEWS

The Abyss of Time: A study in geological time and Earth history. **Paul Lyle. Published by Dunedin Academic Press Ltd. £25. hardback, 204 pp. ISBN 978-1-78046-039-0.**

Paul Lyle is a retired lecturer in geology at the University of Ulster. His book is an introduction to geological or 'deep time' aimed at general readers but with an unusual focus on "environmentalists and policy-makers" and on "the importance of understanding geological time in economic and political decision-making", as it says on the blurb. The book shifts between being a cultural history of time, a history of geology, a modern geological text book and a popular science book.

The book starts with some interesting and varied chapters. ‘In Good Time’ considers the nature of time, moving from its everyday to geological meaning. It introduces the recurring theme of how a landscape can reveal the passage of time, using the classic example from the Moine Thrust of the north-west highlands of Scotland. The second chapter, ‘Tempus fugit - time flies’, covers the measurement of time and the relationship that different societies have had with time throughout human history, for example how the industrial revolution moved society from a natural to a mechanical understanding of time. The third chapter, ‘The importance of understanding time’, outlines the economic, political and cultural implications of deep time, such as its role in understanding evolution and non-renewable resources.

The book then shifts to the development of geology. Chapter four, ‘The early chronologers’, relates how the age of the earth was estimated up until the time of Hutton. Next, ‘Time's arrow and time's cycle’, explains how time has been seen as either cyclical or linear, linking this to some key developments in the history of geology, such as the uniformitarianism versus catastrophism controversy and plate tectonics and the Wilson cycle. The Grand Canyon and meteorite impacts are introduced to show how evidence of both uniformitarianism and catastrophism are now recognised in the rock record.

Chapter six, ‘The determination of relative time - beds in order’, covers relative aging of rocks, including Steno's principles of stratigraphy, the law of faunal succession and the history of how the stratigraphic column took shape through the work of key geological figures such as William Smith, Sedgewick, Lyell, Lapworth and Agassiz. The next chapter, ‘Measurement of absolute time - the age of the Earth’, continues with how the age of the universe was calculated and then how the stratigraphic column was radiometrically dated. The penultimate chapter, ‘Archaeological time’, covers archaeological dating methods. The final chapter, ‘Time Future’, introduces the concept of the Anthropocene, climate change and the future of the continents and the human species.

I enjoyed this book. The interesting subject matter is enlivened with well-chosen geological examples and historical debates and characters. It is glossy and well-illustrated with colour photographs and diagrams. My main criticism is that it could have been clearer. The book skips between different points in time, for example moving from the Precambrian abruptly back to archaeological time. A chronological structure following either the age of the Earth or the discovery of geological time could have given it a simple and compelling narrative (following "time's arrow" to use the terminology of the book). I also felt that introductions and conclusions, both for the book as a whole and for individual chapters, could have aided understanding by more explicitly introducing the content at the beginning and then pulling it together and consolidating it afterwards.

Given the stated aim of informing economic and political decision-making, this could have been a more prominent theme throughout the book but it is concentrated in chapter three. Policy-makers are often short of time and patience so a glossary and chapter summaries would also have been worth considering.

In summary though, I would definitely recommend this book as a great starting point to a friend who wanted to get to grips with the concept of geological time. I also agree that if policy-makers could be made to read and reflect on it, then the world would be a better place.

Luanne Meehitiya, Natural Science Curator - Birmingham Museums. July 2016

Introducing Natural Resources. **Graham Park. Published by Dunedin Academic Press, 2015. £14.99, paperback, x + 116pp. ISBN 978-1-78046-048-2.**

Whilst I have observed before the potential confusion of having an 'Introducing' series in two different size formats, with a somewhat different level of information, this book contributes further, being the larger format, but with an accessible text that should be easily understood and followed by any reader. Graham Park has been a mainstay author for this Dunedin series since its inception, and he continues his quality work with this title.

Natural Resources are considered in a fairly conventional geological way in relation to ore deposits, metallic minerals, non-metallic elements and rocks as economic resources. There is a chapter on non-renewable energy resources (oil, gas, nuclear) as might be expected, but the coverage of fracking is disappointingly brief, for a topic that raises much ill-informed public concern. However, this book takes a fairly modern perspective of natural resources with a chapter on renewable energy resources and another on the atmosphere, oceans and biosphere. A concluding chapter is entitled 'Protecting the Planet' and provides a concise summary of the threats the planet faces from humans and the threats that human society faces from the utilisation of natural resources, and their depletion. The script is succinctly factual and unemotional in baldly stating positions with predictions of future trends and stark figures where required.

The second chapter on the 'Origin and early history of the Earth' is an excellent summary of our place in space and the background to natural resources as elements in the Periodic Table. The redistribution and concentration of mineral resources is dealt with in the third chapter and the vast variety and complexity of geology is admirably simplified and summarised in relation to natural resources.

Subsequent chapters look at ore deposits and metallic minerals. In general each metallic element is considered with a history of use, occurrence and origin and resources described as subheadings. As well as good illustrations of the minerals, tables of production from the main producing countries give a straightforward picture of the kilotonnes or millions of tonnes mined each year. The minerals covered include many rare minerals for which global production might be only in tonnes or even kilogrammes. Non-metallic elements are addressed in a broadly similar chapter including all the radioactive elements, noble gases, halogens, carbon group and so on. Rocks as economic resources get a chapter, but with less detail than the minerals, although considering the global reach of the text, information is packed into the chapter. There is a glossary and a brief list of selected further reading.

Overall, this is a good overview of the topic and I would recommend it alongside other titles in the Dunedin series. For someone with no previous knowledge of geology it would an excellent starting point for any interested adult to learn about natural resources and their essential geology. As the publisher's information points out it is also intended as a course text for 'minor' courses and as inspiration for aspiring scientists thinking about their degree options. Since these are all museum audiences too, it is a book I could recommend having for sale in a museum shop if you had space, as a reliable source book. It is also available as an eBook.

Matthew Parkes, Natural History Museum, Merrion St., Dublin 2, Ireland.

***Matthew Forster Heddle. Mineralogist and Mountaineer*. Hamish Johnston. Published by National Museums Scotland, 2015. £14.99, paperback, viii + 270 pages. ISBN 978 1 905267 98 9.**

Matthew Forster Heddle (1828 - 1897) was one of Scotland's foremost mineralogists, but he had an interesting and varied career, training as a doctor in Edinburgh before becoming Professor of Chemistry at St Andrews. He suffered financial pressures for most of his life, but these didn't stop him from spending much of his time on Scottish mineralogy. He was an avid collector, collaborating with numerous friends, including those with sufficient means to charter yachts when collecting from the Scottish Isles. He was also a supporter of several learned societies, making use of these for networking and publications.

The book is written by Hamish Johnston, Heddle's great-great-grandson, and as such is more of a detailed and general biography than a scientific appraisal and monograph, although there is a full bibliography of Heddle's publications. It represents several years of detailed research. I thoroughly enjoyed the read, picking a wealth of information on such varied subjects as the abolition of slavery and the global backdrop to the life of many of the British during the late eighteenth and nineteenth centuries.
The biography opens with an account of Heddle's ancestry. He was descended from two Orkney families, the Heddles of South Ronaldsay and the Moodies of Hoy. Their lives were affected by the events and values of the day, ranging from the Napoleonic wars to the earlier abolition of slavery by Britain than by France. Many middle class Britons were making (or loosing) a fortune abroad before returning to Britain (sometimes complete with a second, illegitimate family). Others profited from overseas trading companies and investment companies.

The second chapter covers Heddle's childhood and schooling and the third, the complexities of studying medicine in Edinburgh in the 1840s. Heddle had been interested in collecting from his school days, when he assembled a herbarium. Apparently a friend destroyed this by dropping it in a stream, so Heddle decided to collect more durable items - rocks and minerals. During the early nineteenth century, Edinburgh was a key centre of geological theorising, with James Hutton having challenged the biblical notion of a recent earth with his ideas of uniformitarianism: no vestige of a beginning, - no prospect of an end. Hutton's views were in turn being challenged by Werner, who believed all rocks had been deposited in a large primeval ocean - Neptunism. Jameson, the Professor of Natural History at Edinburgh, was a strong supporter of Werner, but around 1845 he realised that Arthur's Seat, the hill near Edinburgh, was formed of a volcanic rock that could not be explained by Neptunism. Heddle learnt much from Jameson, and his MD thesis (1851) explored the medicinal properties of minerals.

By the mid 1850s, Heddle had decided that medicine was not for him, and he began applying for various mineralogical and geological posts. The majority of the book (Chapters 5 - 8) chronicles his time at St Andrews, being formally appointed Professor of Chemistry in 1862. He appears to have walked a financial tight-rope, receiving a low professorial salary and having to spend some of this covering his teaching expenses. When not teaching he appears to have been on field work with friends collecting minerals from all round Scotland. He published papers on these in the journals of several learned societies, and played a significant part in the governance of several of these.

In his retirement he worked for a gold mining company in South Africa, but the company collapsed and he was involved in lengthy court proceedings to recover his contractual payments. He was also involved in prolonged negotiations to find a suitable home for his mineral collection, the organisation now known as National Museums Scotland eventually agreeing terms. He died in 1897 and was buried in the grounds of St Andrews Cathedral.

I enjoyed reading the book and found it a mass of information about Heddle, and the mineralogists, geologists, geological societies, journals and museums of the day. At times there was almost too much information and it could be difficult to pick out the underlying themes from the detail provided. I remain unsure of Heddle's place in the evolution of mineralogy, other than as an amasser and documenter of a large and exemplary collection of Scottish minerals. His networking abilities were significant, and he corresponded with many of the leading geologists of the day, so the book also provided useful information on topics such as the "Highlands Controversy" and characters including the Geikie brothers, and Peach and Horne.

I recommend the book, but expect a mass of organised facts closely related to the social history of the times, together with some excellent quality plates, rather than a systematic account of the development of mineralogy during the nineteenth century.

Dr Mike Howe, Chief Curator, Head of the National Geological Repository, British Geological Survey, Keyworth,Notts, NG12 5GG, UK.

***The Making of Europe. A geological history*. Graham Park. Published by Dunedin Academic Press. 2014. £24.99, paperback, Xii + 164 pages. ISBN 978-1-78046-043-7, £50, hardback, ISBN 978-1-78046-043-7.**

As a fan of the Dunedin Academic Press geology books generally, I was interested to read this offering. It provides a comprehensive look at the geological history of Europe, trying to answer the question of why are there such distinct regions and landscapes, ranging from the wide plains of Northern Europe to the mountains of the South? Graham Park achieves this aspiration and his text is readable and very well illustrated with a good balance of photographs and explanatory diagrams, all in colour.

However, this is no introductory text and some previous knowledge of geology is assumed and probably required, although a newcomer could make sense of it all with the introductory chapter on geological concepts and the dense glossary. To me though, it is not a book to read from page 1 to the last page, but something to dip into for general interest in a particular period (for me the Caledonian Orogeny chapter) or relating to a region of interest (perhaps in advance of a holiday). The last chapter on the Neogene and Quaternary, although very brief on the latter, provides a perspective on the whole of Europe that is refreshing, when compared to most texts that tackle the confines of one country only.

It would make a good undergraduate course text for a geology student in a range of courses. However, other than in the largest natural history or geology museums, it would be difficult to argue that it would be a relevant title to stock in a museum shop, compared to the 'Introducing' series of titles from Dunedin Academic Press. For a curator trying to prepare an exhibition covering any aspect of the wide reach of this book, it could make a very useful resource and I would recommend having it in the library or on a personal bookshelf.

Matthew Parkes, Natural History Museum, Merrions St., Dublin 2, Ireland.

***Earth System Science: A Very Short Introduction*. Tim Lenton. Published by Oxford University Press, Oxford, 2016. UK£7-99, paperback, xiv+153 pages. ISBN 978-0-19-871887-1.**

I snapped up *Earth System Science* when I found it in a bookstore. I know the 'Very Short Introduction' books to be first rate - I have bought only one of this series that I failed to finish. Moreover, the title was a hook to this greying geologist, concerning a concept in the Earth sciences that was not even named when I was an undergraduate.

Earth System Science is well produced and highly readable. The chapter headings give a simple indication of the scope of the book - Home, Recycling, Regulation, Revolutions, Anthropocene, Projection, Sustainability and Generalization. The excellent diagrams are a significant feature, absolutely essential for explaining concepts such as biogeochemical cycles. However, several figures unnecessarily take up a full page (e.g., fig. 22); reducing them to half this size would not impair clarity.

The most unexpected information provided by 'Home' is that the core and mantle are not considered part of the Earth System apart from some mantle-related volcanism. Rather, the Earth System is comprised of the crust, atmosphere, hydrosphere and biosphere.

'Recycling' considers the essential biogeochemical cycles of the Earth's surface - the rock, oxygen, carbon, phosphorus and nitrogen cycles. This chapter would form the basis of an excellent undergraduate lecture and, indeed, I could phrase various potential exam questions around the diagrams. More than any other volume that I have read in the 'Very Short Introduction' series, *Earth System Science* would be an affordable, yet comprehensive text for a course for undergraduates.

'Anthropocene' is packed with data relevant to all of us, but stumbles over the ambiguous title. The anthropocene is discussed as if it is a geological unit that succeeds the Holocene, yet it is more a concept for the social than the Earth scientist - where is the base, where is the type section (Finney and Edwards 2016)? It is defined by 'gut feelings' rather than measured sections. Until adequate scientific rigour can be injected into the concept, I recommend that anthropocene receives a lower case 'aye' to indicate its indefinite existence.

'Projection' looks at future changes in the anthropocene. No scenario is good, but some are less bad than others. Lenton explains that projection is not the same as prediction (pp. 94-95), although this is one elucidation lacking in clarity - I had to read it three times before I felt comfortable with the concept.

'Sustainability' is a chapter of hope. The model of a sustainable anthroposphere (fig. 26) is absorbing, yet arrows are unlabelled and extrapolating from associated diagrams is ambiguous. Sustainable energy and material recycling are key elements of a sustainable future, preferably with the human population stabilizing, even declining. Figure 27, 'Planetary boundaries …', is important, and cries out for colour and a more informative caption, not shades of grey.

I most enjoyed the final chapter, 'Generalization', which extrapolates and expands the previous discussion into a general science of habitable worlds. A key concept that is new to me is that the Earth's biosphere is entering its old age; after 4 billion years of life on our planet, at most there is only about 1 billion years to go before Solar overheating becomes intolerable. Lenton extends these discussions to extra-Solar planets which are Earth-like. We cannot possibly go there, so what can we determine about their Exo-Earth System Science? A lot, it seems.

Reference

FINNEY, S.C. and EDWARDS, L.E. 2016. The "Anthropocene" epoch: Scientific decision or political statement? *GSA Today* **26**(3-4), 4-10.

Stephen K. Donovan, Naturalis Biodiversity Center, Leiden, the Netherlands.

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