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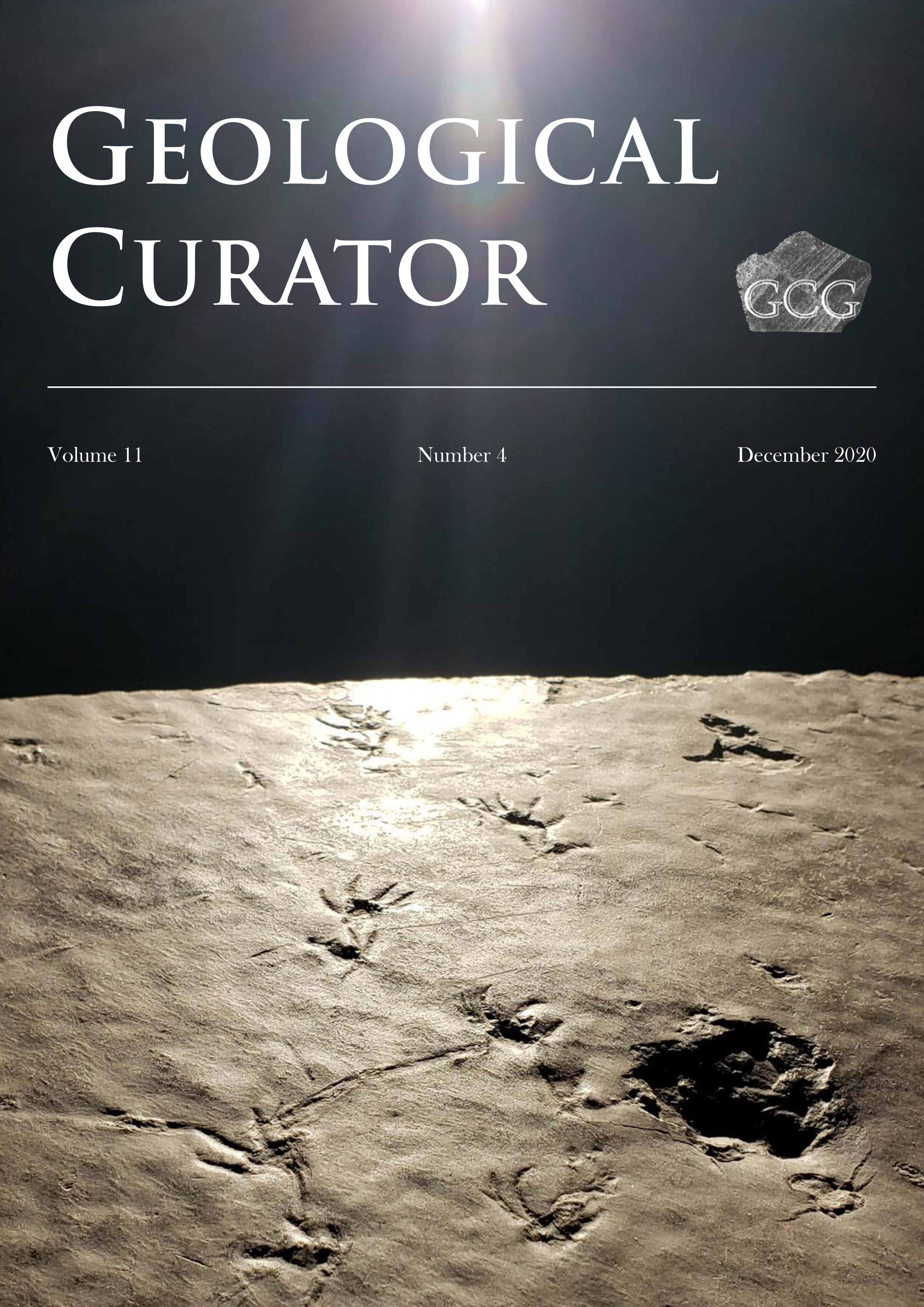

GEOLOGICAL CURATORS' GROUP

Geological collections thriving for science and society

The Geological Curators' Group (GCG) is a membership organisation founded in 1974, and a charity registered in England and Wales (no. 296050). We are affiliated to the Geological Society of London (the oldest national geological society in the world) and recognised by Arts Council England as a Subject Specialist Network (SSN). Further information can be found at www.geocurator.org.

Geological collections (rocks, minerals and fossils) are vital Earth heritage that help us understand the natural world. The Geological Curators' Group strives to connect every geological collection with appropriate resources, knowledge and skills to thrive and positively impact science and society.

We do this by:
- Supporting everyone working with and caring for geological collections of all types
- Advocating the value of expertise in the care and use of geological collections, and their importance for scientific research and education
- Connecting people, skills, information, and collections

GCG has always been a community, run by members elected from its membership. We take pride in our goals and enjoy working hard to reach them. Geological collections enrich lives and stimulate cutting edge science.

2020 COMMITTEE

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Cover image: see Mehling and Buta inside

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Contents

Editorial

Welcome to issue 11 (4).

I made the decision relatively early on that I would not write an accompanying editorial for each issue unless there was something urgent and topical which needed to be said. However, whilst compiling this issue I noticed an important and recurring theme running through the articles which is worth commenting on. That theme is the importance of the contextual information associated with specimens and collections. After all, a specimen is only as important as the information associated with it.

We all understand the importance of labels and definitively associating those labels with specimens (usually via a unique number added directly to the specimens). However, contextual information can take many forms. As Harvey (page 255) points out, associated packaging and ephemera (such as newspaper and cotton wool) have the potential to illuminate the history of the specimens. Di Giacomo et al. (page 263) demonstrate the power of images and notes written by people associated with the collections and archival sources are used extensively by Graham (page 275), Newell (page 281), Hadland (page 295) and Mehling and Buta (page 307) to reflect on the history of the specimens and provide important contextual information.

Metadata associated with specimens can greatly increase the scientific importance of those specimens (see Mehling and Buta; page 307). Whilst descriptions and taxonomic analyses are the bedrock (no pun intended) of Earth Sciences, modern investigations seek to build upon this to tackle broader and far reaching issues such as relating changes in communities through time to global environmental change, using the past to predict the future or understanding the impacts of and sustainability of mineral extraction. For historical collections, this metadata can often be inferred based on evidence such as knowing the dates the specimens were collected or by whom. It is worth noting that it is equally as important to be able to firmly link this associated metadata to the specimens and make the information easily retrievable in posterity. This means assigning and accurately citing specimen numbers and institutional prefixes, as well as archival sources in publications, and having a means to be able to relate these sources of information in a publicly accessible way. This will allow us to harvest that data and aggregate it to help answer fundamental questions about the Earth; its past, present and future.

In addition, to the scientific importance of specimens, associated metadata can provide information on the social and historical context of specimens. Working with Earth Sciences collections we sometimes forget that the specimens under our care are equally as relevant to our social history. I echo the experiences of Harvey (page 255); during conversations with a wide range of people, it is the context around the specimens which helps provide the hook and the initial engagement. The history, ideas, people, mysteries, hardships and successes associated with specimens are what make them special (see Newell for examples of how to achieve this; page 281). This context can also help secure their future preservation and relevance. Note the immense pride of the residents of the town of Sauce in Uruguay (Di Giacomo; page 263) regarding the Arroyo del Vizcaíno collection. This cannot fail to generate a deeper appreciation of Earth Sciences collections in that region and an understanding of their relevance and their need for preservation.

It is also important to celebrate the people associated with these collections, those people who are all too easily forgotten (see the article by Graham as an example; page 275). These are the people who collected, worked on and fought for these specimens and ensured they have a place in our future. Matthew Parkes was one of those people (Monaghan; page 323). Quiet and unassuming, but without his efforts many specimens, a lot of contextual knowledge, and this journal would probably not exist. This issue is dedicated to his memory.

Pip Brewer
Editor

Treasures in tins: historical packaging in natural history collections

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Historical packaging that utilises unusual or readily available items rather than modern conservation grade materials to store specimens is commonplace in many museum collections. It can be an additional, and fascinating, source of information about specimens and can expand on the time, place and historical context in which they were collected. Whilst now recognised as unsuitable storage media, such packaging does offer data relevant to scientific research as well as the culture and history of specimen collection. Information about the packaging itself should therefore be preserved in association with the specimens. This article documents some discoveries of historical packaging at the Natural History Museum (London, UK) and makes recommendations for an approach to documenting historical packaging as an integral part of re-storage projects. It also touches upon some of the conservation issues associated with historical packaging and highlights its potential use as a novel outreach tool which can develop a greater understanding of the history of museum collections.

Harvey, L. 2020. Treasures in tins: historical packaging in natural history collections. *Geological Curator* **11** (4): 255-262

Introduction

Many museums were created through the amalgamation of disparate collections and the accumulation of often eccentric acquisitions, specimens and packaging alike. This means that specimens can be stored in potentially inappropriate receptacles until there is a need for their storage conditions to be updated due to the degradation of the container, or research interest in the specimen necessitates it. An understanding of the long-term preservation of collections and the management of associated issues such as off-gassing—in which materials used for storage can emit destructive volatile compounds—are relatively recent endeavours (Thickett and Lee 2004). As such, larger historical collections contain many examples of historical packaging that are generally in the process of being replaced. Although it is more likely now for collections to arrive at an institution stored appropriately in archival quality boxes, the problem of historic packaging is still an issue to consider when dealing with new donations from private collections or the movement of a legacy collection into the museum.

In institutions across the UK and internationally, specimens can be found in a wide variety of boxes and tins, often those they were placed into when collected in the field or sorted into at the museum. I am personally aware of palaeontological and other natural history specimens stored in nineteenth- and twentieth-century containers of the types listed in Table 1—none of which were necessarily destined to contain museum specimens. It is likely all curators dealing with historic collections will have similar examples spring to mind, some more unusual and some more commonplace.

Specimens can also be packaged in additional material, including cotton wool, tissue and newspapers

- *Biscuit tins*
- *Tobacco tins and cigarette boxes*
- *Chocolate and confectionary boxes*
- *Cocoa tins*
- *Pill boxes*
- *Photographic film canisters and plate boxes*
- *Match boxes*
- *Correspondence card boxes*
- *Ammunition cases*

Table 1. Historic packaging observed in museum collections

Figure 1. Evening Standard newspaper sheets used as specimen packing material, dated 1940.

Figure 2. A 1920's 'Thorne's Extra Super Crème Toffee' tin containing specimens from Derbyshire cave excavations by A. L. Armstrong.

or other kinds of printed material, often associated with protection during travel to or from the museum. For example, in expectation of air raids and potential bomb damage to specimens in the Second World War, many collections in the Natural History Museum were packaged up for removal to "country houses that had been pressed into service" (Schindler 2010). Eighty years later, boxes of material are occasionally opened and found to contain specimens wrapped in newspapers dated to the late 1930s and early 1940s (Figure 1), quite likely a legacy of this apposite war-time planning.

This article is intended to present a brief overview of the kinds of historical packaging encountered in historic geological and palaeontological collections, describe the treatments of this material and make some suggestions towards what could be the best course of action for such items found within collections.

What kinds of historical packaging?

In the Fossil Mammal collections of the Natural History Museum, London, there are numerous instances of specimens in historical packaging. A typical example is shown in Figure 2 which forms part of an amalgamation of material excavated from Derbyshire cave sites by "gifted amateur" archaeologist Albert Leslie Armstrong (Burkitt 1963: p. xiii). The 'Thorne's Extra Special Super Crème' toffee tin is contemporaneous with the date of the dig—mid 1920s—a testament to reuse and recycling before they became modern-day catchphrases. Alongside this confectionary tin there are also matchboxes and tobacco tins. Although there is nothing to suggest Armstrong's brand loyalty in this selection, curators in other institutions have noted that whole collections were sometimes donated in hundreds of identical tobacco tins (H. Ketchum pers. comm. 2020). Whilst such quantities could reflect individual preference, it may also suggest wider connections between collectors, curators and local suppliers. Tobacconists tended to have a surplus of large advertising boxes from which tobacco was dispensed. Similarly, smaller containers were clearly obtained through the generosity of tobacconists or through friends and associates of collectors (D. Russell pers. comm. 2020).

Another typical example is shown in Figure 3, a wooden 'Weinberg's special' cigarette box containing a small mammal mandible from excavations at Manifold Valley, Staffordshire/Derbyshire. Advertising pasted into the interior of the box takes the form of an article in The Lancet, in which the brand of tobacco is favourably reviewed (somewhat incredibly by modern standards!). The article is apparently genuine (Anonymous 1927: p. 976) and dated 1927, indicating that perhaps the contents were excavated sometime after this—and indeed, records indicate that a great deal of material in this assemblage was purchased in 1932. Of course, the contents of boxes move and can be historically re-boxed and moved any number of times, but clearly it is occasionally possible to infer a *terminus post quem* for the collection and storage of items. This may in turn aid identification if other records have been affected by

Figure 3. Wooden cigarette box dated 1927 containing a specimen from Manifold Valley, Staffordshire/Derbyshire.

'horror story' scenarios of "lost labels, spoilt labels ruined by damp or eaten by cockroaches, and specimens with-out any label at all" (Donovan and Riley 2013: p. 509). Certainly, the container would be of extra value if other labels were lost, as the age or type of box could potentially link it with a particular collection.

A geological specimen from Durlston Bay, Dorset is shown in Figure 4 along with its original 'Lyons Individual Pie' box, which has been retained in the Mesozoic mammaliaform collection for its adhering contextual annotation. Whilst there is no indication on the label of when this sample was taken "for comparison", it can be narrowed down by information on the packaging. The history of the Lyons' individual fruit pie is well known (Bird 2002). The pies went into production in the 1930s, costing around 2d (two pence) per pie in 1937 and rising to 5d in the late 1940s. Costing 4d, but retaining a similar design to 1930s examples, this box was likely produced in the early to mid-1940s. This may coincide with one of the many endeavours to retrieve further specimens from this coastal section after its "legendary excavation" in 1857 (Kielan-Jaworowska and Ensom 1992: p. 95).

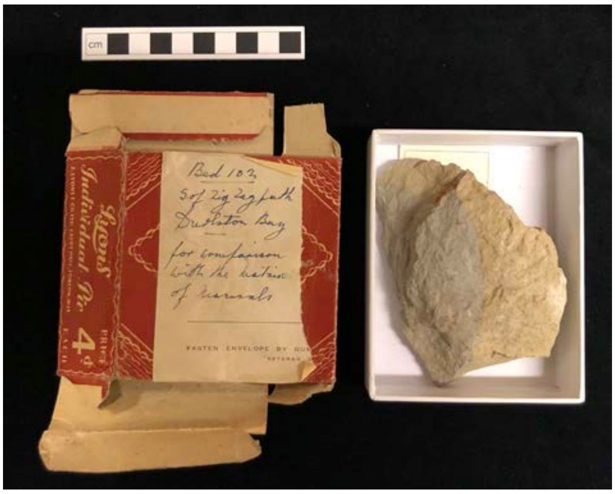

Figure 4. A 'Lyons Individual Pie' box, the original receptacle for a geological specimen from Durlston Bay, Dorset, which has been retained—but now kept separate—from the specimen.

Historic containers can become exhibits in their own right. A travelling trunk which had originally been the vessel for a donation of dresses to the Victoria & Albert Museum in the 1960s is now featured in an upcoming exhibition about bags, despite having sat undocumented on a shelf in the museum collections for half a century (Kennedy 2020). The Louis Vuitton case once part of socialite Emilie Grigsby's travelling wardrobe is now key to understanding the travels and adventures of its owner, as much an exhibit as the couture garments it once contained (Windross 2020).

Whilst a designer travelling case may not seem immediately relevant to geological or palaeontological collections, there are also precedents for less salubrious storage items becoming exhibits. Geological samples from Darwin's voyage on HMS Beagle were sent back to England packed in glass sauce bottles, in which they remain (Anderson 2009: p. 69), forming part of the collections at the Sedgwick Museum, Cambridge. The packaging is now integral to the story of the specimens themselves and are perhaps unlikely to be repackaged or ever separated from their contents. Historical packaging can therefore become relevant, at least by association.

During the preparation of a *Hylaeosaurus* specimen at the Natural History Museum, 171 years after its original collection by Gideon Mantell, a pair of deliberately concealed coins were noted, placed on their rims, in a gap between two blocks. It is possible that these coins, dated 1806 and 1827, were chosen deliberately by Mantell to commemorate important life events including the birth of his son (Gray *et al.* 2005). Although this numismatic time capsule is only associated with packing material in the broadest sense, it is worth keeping in mind that some decisions made by those who originally collected material and packaged it up were deliberate and could tell a story that is worth recording.

Approaches to historical packaging

Approaches to historical packaging in museums vary by collection but are usually assessed on an individual basis. There are no particular standards covering treatment of historical packaging. A curator will generally understand the nature of the collection and be aware of specific issues regarding provenance or condition, and will respond to the packaging with that in mind. Of course, any visible primary information such as numbers, names or locations written on the box are recorded, with notes made of the handwriting (if it is a well-known hand) or a digital photograph taken. Everyday materials like newspaper can become labels if annotated. For example, Geospiza finch nests, collected in the Galapagos by explorer and ornithologist Rollo Beck, were wrapped in newspaper faintly annotated with a corresponding number that referred to the associated eggs. This paper has been kept as a label would, mindful of the conservation challenges that poses (D. Russell pers. comm. 2020). If multiple sides of a box have notes or information on them, photographs are sometimes taken of all sides. This information can then be attached to the collections management system record of the item.

In some cases, sections of the writing are physically removed from the box and kept with the specimen in new boxes. There is an example of this in Figure 5, in which part of an annotated German cigarette or tobacco box has been retained alongside small mammal specimens from Grotta Del Margine, Corsica. Packaging is then usually discarded if it is unwanted by the curator or if the condition is notably poor e.g. brittle, crumbling cardboard. Sometimes items are retained in an informal way away from the collections. There is very often nowhere else to put the item after releasing it from the collection. Larger institutions may have a social history department or an archive that could take the item, although this would be an exception rather than a rule. It is unusual for a curator to request retention of original packaging during conservation or re-boxing (L. Allington-Jones pers. comm. 2020). In many cases this will be because it has been assessed as unnecessary to keep as not relevant to the specimen or collection—although it is also possible that the consideration to retain information about the box itself is not something on the typical geological or palaeontological curator's radar.

Thinking outside the box

Contextual information is essential to understanding fossils and specimens of any kind. Whilst location, site or stratigraphic data are perhaps of the greatest use to researchers, there is a whole gamut of information, from the "original attached specimen labels, tray labels, original field sheets and notebooks, manuscript catalogues and *even original packing materials*…" (Wyse Jackson 1999: p. 425, my emphasis) that can be important. The original packaging should therefore not be discounted as a potential source of information, however ordinary it may initially seem. Even the type and colour of cotton wool used to pack specimens historically may have some degree of informational use, with certain colours of cotton wool more typical of some periods than others (Z. Hughes pers. comm. 2020).

Figure 5. Part of a German tobacco or cigarette box retained with collections from Grotta del Margine, Corsica with handwritten labels and evidence of historic re-use, being originally used to store material from Grotta di Funtanedu. August Sperr in Stuttgart was awarded the use of the 'Hoflieferant' (purveyors to the court) in 1902, so the box dates sometime after this.

Newspaper when used as a packaging material devoid of other information is rarely kept, although a date may occasionally be recorded. However, when newspaper is used as packing material within, rather than around, an item, its importance is clear. When a blue whale skeleton was dismantled and removed from the Mammals gallery in the Natural History Museum (the whale was subsequently named Hope on its spectacular reinstallation in what is now Hintze Hall) it was discovered that a range of materials, including newspapers, had been used as 'fillers and bulking agents' in its original reconstruction (Cornish and Bernucci 2016). These pieces of scrunched-up newspaper dated to the early 1930s, associated with the whale being installed in 1934. Some of these fragments were on display alongside conservation work in action at the museum, and this material became part of the whale archive. Similarly, during the conservation of a stuffed sunfish at the museum, a scrap of newspaper from The Sydney Morning Herald, dated January 1883 was found in the body cavity, along with wheat straw and a broken chair seat (Allington-Jones and McKibben 2017). The sunfish had been displayed in 1883 by Edward Ramsey, representing New South Wales, at the Great International Fisheries Exhibition (*ibid.*). Clearly, this fragment of newspaper is reflective of the sunfish's origin and now rightly forms part of the archive for this important holotype.

Could—or should—some storage materials be treated as objects with their own research and archive potential? Brands, packaging and ephemera are rich sources for understanding society and cultural developments in history (Museum of Brands 2020). The reuse of tins and cartons considered to be 'throwaway history' (Heller and Kelly 2014), could therefore be of interest in some capacity greater than what these boxes now contain. Is it important to consider what people ate, smoked or otherwise utilised in the collection of specimens? It may not be geological or palaeontological research per se, but if we accept that the non-specimen-related history of collections, donors and past curators is important, then this data should also be captured. It is worth keeping in mind that the Victoria and Albert Museum has a wide selection of biscuit tins in their collections (over 800 tinplate biscuit boxes come up in an online search of the metalwork collections) and such items are certainly present in other institutions and considered as artefacts. It is possible that the antique tins and hastily annotated cigarette boxes dotted across different kinds of natural history collections could present an untapped resource for the culture and history of collecting.

Conservation issues

Of course, the conservation issues presented by historical packaging are not negligible. Modern standards of storage necessarily focus on the use of inert materials to safely contain specimens (Caple 2012), including acid- and lignin-free cardboard boxes and polyethylene foams such as Plastazote™ to cushion specimens. The deterioration of metals such as those found in biscuit or tobacco tins (thin steel with tin plate) can have detrimental effects on the specimens or labels, including staining and erosion. Cardboard boxes are liable to become brittle and acidic over time which affects both their capacity to safely hold items and threatens the integrity of items in close proximity. These effects must be negated for the long-term preservation of any collection. Since most re-boxing efforts also seek to use space efficiently—an absolute priority with the problem of ever-growing collections in finite areas—it would be unreasonable to suggest each specimen be kept with its contemporaneous packaging. As such, this article should not be taken as a call to keep unsuitable materials within collections spaces or to archive every scrap of paper, but rather as a step towards developing an appropriate and flexible response to encountering historic packaging.

If the retention of certain items is desired, it is possible to test historical or antique packaging for its suitability as a storage media using accelerated aging tests as outlined by Thickett and Lee (2004). It is also worth considering that off-gassing by packing materials may have already reached a natural conclusion after many years within a collection (L. Cornish pers. comm. 2020). Furthermore, some older items may actually be less prone to degradation. Although dealing primarily with food cans in museum collections, Brambilla *et al.* (2016) noticed that cans produced from the 1970s were degrading faster than older ones due to thinner tin plating of the steel in later examples. As long as a specimen is not in very close contact with a non-conservation grade material, it may be possible for a physical association to continue. I believe it would be beneficial to have these kinds of conversations with conservators as part of any re-storage projects to ensure that information is not lost, whilst ensuring that the needs of each collection are met with regard to its specimens.

To initiate this conversation, I have created Chart 1 as a practical three-tier approach in dealing with historical packaging. The 'Essential' information to record is the specimen information written on or otherwise attached to the historic packaging. This is already being captured by curators and conservators as boxes are replaced. Retaining this information physically is suggested wherever feasible. The 'Desirable' information—details about the receptacle itself and packing materials—is currently less likely to be captured but could provide additional social and historic information about the specimen or collection or aid in dating specimen movement, e.g., when it was excavated or moved from site to museum. We could include here probable dates of manufacture or dates in which companies or brands existed. The last

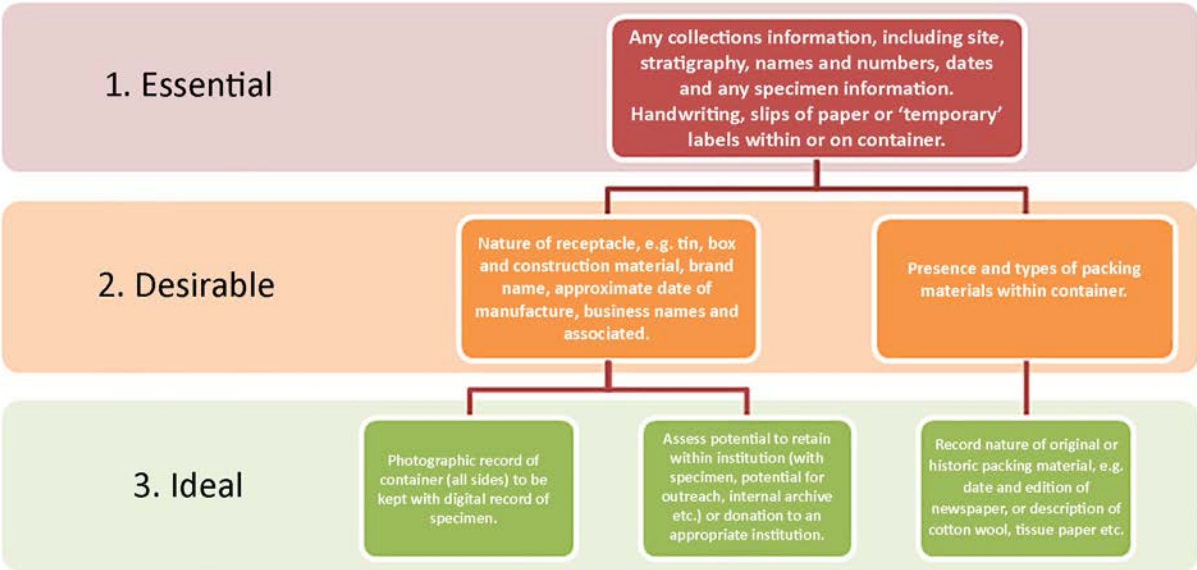

Chart 1. Approaches to historical packaging in museum collections—what is Essential, Desirable, and Ideal to record?

tier suggests what should be recorded in an 'Ideal' situation, including creating a full digital record of the container and further details about the packing material. It is important here to consciously assess whether the item has further potential as an artefact in and of itself before discard and whether it could be used in the museum or even deposited elsewhere.

Finally, if this original packaging is deemed worth of retention, it may well be necessary to think of space within departments or institutions in which these items can be kept in an environment suitable for their own long-term conservation, along with their own contextual information—what they had stored, when they had entered the museum and so on.

Observations during an outreach session

In 2018 I presented a new talk as a 'Nature Live' event at the Natural History Museum that focussed on some of the lesser-known specimens and associated characters encountered whilst conducting audits of material in the Fossil Mammals and Anthropology sections. The items that captured the public imagination most of all were not specimens at all, but a selection of old boxes, tins and newspapers that had been previously discarded during re-boxing efforts. The amount of interest these created—and the variety of questions received at each presentation—convinced me that the informal way items are discarded could be beneficially reassessed. People in the audience asked where these tins would be deposited, in the assumption of their value as an important historic object. This was a novel perspective for me, as before I had not considered them to be artefacts, which of course they are in other settings. The old newspapers fascinated the audience and provided an opportunity to segue into conversations about the museum in wartime, the storage of items in museums, the number of specimens held 'behind the scenes' and the role of curators and conservation in a modern day museum. Historical packaging clearly has an outreach value that could be utilised on occasions where using specimens is not practical.

Discussion

A wide range of historical packaging is present in natural history collections. At the very least the details of packaging are potentially useful in constructing specimen or donor histories. The examples given here illustrate that it is possible to date boxes by examining the packaging, and this could be useful when other information is sparse. The transient nature of packaging (Elsner and Cardinal 1994: p. 25) and the rapid changes in the form and structure of such things means that within each museum collection there are likely examples of tins and boxes otherwise lost to time. Checking the historic value of the box or tin with a knowledgeable source prior to discard and recording full details about the box itself—rather than just specimen-specific information—should become a standard response to these items. It is worth considering that the specimens and artefacts that we often consider to be the 'treasures' in the tins may, in fact, be eclipsed by the tins and boxes themselves, albeit in a different kind of institution or for a different audience.

Conclusions

It is common to find historical packaging in museum collections spaces as receptacles for specimens and samples. Some containers may be physically unsuitable for protecting these items or may have the longer-term potential to damage them. Inappropriate packaging and packing materials should generally be replaced, but the information they convey must not be lost during this transition. The information gleaned from packaging can help identify a collector or date of collection when other labels are lost or damaged. It can additionally provide social and cultural contextualisation for some items, telling a story somewhat removed from the specimen itself. Historic packaging can also contribute to outreach opportunities, creating tangible and emotive links between specimens and social history. Whilst retention of packaging is not always appropriate for the preservation of collections, or is made impossible by space restrictions, the value of thinking 'outside the box' is clear. Data must be recorded, not just as label transcriptions, but as descriptions of the physical receptacle and other packaging materials and as digital photographs. These data must be stored within the collections management system to allow permanent association with the specimens.

Acknowledgements

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Images of historic packaging from Fossil Mammal collections at the NHM

Keeping old giants at the service of a local community: The Arroyo del Vizcaíno collection (Sauce, Uruguay)

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The Arroyo del Vizcaíno collection began informally in 1997, when a group of high school students, teachers and other members of the community extracted around 300 bones from the Vizcaíno stream. Efforts were made by the students to prepare, catalogue and identify the remains, as well as to try to keep the remains in their hometown. The collection was housed at the local high school for many years until we obtained the permits to excavate the site and reunited the fossils collected in 1997 with those extracted in subsequent years. Since then the collection has grown substantially, with more than 1,800 fossils collected to date. The collection was moved several times, but in 2018 a new collaboration with the local high school meant the fossils could return there, but to new spaces, specially designed and built for them. These new spaces allow for better care of the remains and for the development of outreach activities with the community. The team of palaeontologists, students and designers involved in the project has developed didactic and educational resources both in physical and digital form, which have expanded the mission of the team to other localities within Uruguay. Today, the collection has been formally recognized as part of the Universidad de la República, a milestone that will translate into further collaborations with other institutions and members of the community. These past 10 years, the team has improved the conservation of the remains, generated academic publications and established relationships with local residents, hoping to help regain the sense of belonging and enthusiasm for fossils that the community felt in 1997.

Di Giacomo, M., Batallés, M., Varela, L., Tambusso, P. S., Clavijo, L. and Fariña, R. A. 2020. Keeping old giants at the service of a local community: The Arroyo del Vizcaíno collection (Sauce, Uruguay). *Geological Curator* **11** (4): 263-274.

Introduction

The Vizcaíno stream ("arroyo" in Spanish) runs near the Uruguayan town of Sauce (ˈsau̯.se), not far from the country's capital, Montevideo. There, heavy winter rains cause flooding, but the stream flow usually comes to a standstill in the summer, leaving a string of little lagoons, similar to a beaded necklace, that local farmers use to irrigate their crops. One of these pools nearly completely dried during the severe 1997 summer drought. As a result of that, a wondrous surprise appeared on its bed: numerous remains of giant mammals such as ground sloths, toxodonts, glyptodonts and other members of the megafauna, which had been waiting to be discovered for about 30 millennia. Local *liceo* (high school) students, teachers and neighbours extracted more than 300 fossils before the rains returned and filled the bed again, covering the bones (Figure 1). The students took care of the remains until professional palaeontologists confirmed their importance as the most plentiful Pleistocene mammal site in the whole country (Fariña *et al*. 2014).

The initial collection work, care and use of the fossils by the Sauce community was the beginning of the Arroyo del Vizcaíno collection, which is now a centre of palaeontological research, education and outreach. In this work, we tell the story of the collection, how it began, how it evolved and what its future may be, but most importantly, how the community shaped its course and was kept involved throughout its history.

Figure 1. First excavation made by local residents, teachers and students, 1997 (author unknown).

The surroundings

The town of Sauce ("willow tree" in Spanish) has a population of around 13,000 people and is located 35 km from downtown Montevideo. Surrounded by farms and vineyards, Sauce is rich in its history. Uruguay's national hero, José Artigas, was supposedly born there, and many battles during the Independence War and civil wars of the 19th century were fought in the area. The fossil bone bed described in this paper outcrops about 4 km northeast from Sauce.

The Vizcaíno stream is a minor course whose headwaters are close to the palaeontological site. Despite intense human modification and impact due to agricultural activities, the area remains biodiverse. Because the site is covered by water, during the fieldwork season the stream needs to be dammed and diverted into a bypass, and the remaining water must be pumped out. The site is never fully dry due to continuous contribution of water from the aquifer below, so the pumping must be done more than once a day. No ecological analyses have been performed to assess the impact of our activities, but we have been striving to reduce our impact during our short field seasons, which last around two weeks.

In the neighbouring area, the soil lies on top of Cretaceous silicified sandstones of the Mercedes Formation. Quaternary sediments tend to deposit in lower areas, such as those in which the fossils are preserved.

History of the collection

The 1997 archives

Some records remain about the events that occurred in the summer of 1997 (Figures 1 and 2). These include a VHS tape with footage of the initial collection of the remains and the consequent cleaning, identifying and cataloguing over the following months; an assortment of photographic prints, newspaper clippings, and other documents. Among them is a remarkable notebook (both a catalogue and a fieldwork book) kept by Reinaldo Castilla, one of the students that extracted the first fossils from the site (Figure 3). The first part of the notebook is a catalogue of the bones extracted that summer with a first attempt at anatomical and taxonomic identification. On the first pages, it is mentioned that some bones appear to belong to glyptodonts or the giant ground sloth *Lestodon*. The second part of the notebook is a diary that covers the period January–September 1997. The excavation days, participants and extracted bones are noted there, as well as the preparation and identification activities, the teachers that advised and the visits of the public, academics, politicians and the press. In addition, the diary contains meetings, organisation plans and museum projects, donations received, appearances in radio shows, promises from the authorities and even the arrival of a fossil dealer who offered money to take the pieces to the United States.

This notebook is a key document to understand the origins of the collection, the expectations that

Figure 2. Frames from a home VHS recording of the first excavation (A and B), the process of fossil preparation and cleaning (C and D), made by local residents, teachers and students, 1997 (author[s] unknown).

this finding generated in the town, the roles of the government, academia and civil society and the decisive role that the community had in protecting this heritage. We summarize short passages of the notebook below (names have been removed as sensitive information):

Friday 1/31/97
Afternoon: (EXTRACTION) we removed the water with a pump and made dams in the slopes, then we extracted bones. CLEANING OF THE BONES: ONLY WITH TOOTHBRUSHES AND WATER (NOT WITH A JET LIKE FROM THE TAP)

Wednesday 2/19/97
A person came to extract bones with us, he left phone number and name (…) he had palaeontological tools, he appears to be a private collector.
Wednesday night we found out that [the collector] offered thousands of dollars (…) to take the bones to the USA, and, before that, take them out himself.

Tuesday 2/25/97
[Authorities] come. One of them talks about leaving 3 or 4 bones and taking the rest.
MEETING: 19:00hs
The Commercial Centre of Sauce gives us a store location for us to use and donates U$500, they gave us the idea to form a PRO-MUSEUM OF SAUCE commission.
AFTERNOON: councilman [of Canelones] came and said he wants the museum to remain in Sauce (the bones) …
NIGHT: after the meeting until 4:30 am [we] glued bones, cleaned [bones] and put joints together.

Tuesday 3/4/97
The governor's wife came and said that they (the bones) are staying in Sauce…
AFTERNOON: [we] received the public, glued bones and went to see a [railroad] warehouse to place the museum.

Monday 3/10/97
At school the teachers made each student write a letter so that the bones could remain in Sauce (a letter to the intendente [i.e., the governor of the administrative unit or departamento of Canelones])

Tuesday 4/8/97
FARIÑA and VIZCAÍNO (the palaeontologists that gave the talk) are going to teach a course of introduction to palaeontology, POSTERS WERE MADE (…), the course is from 4/14 to 4/18." (note from the authors: the diary states that the course had to be moved from its original location on April 15th because 75 people signed up and there was no room)

Monday 8/18/97
We are told that together with R. Fariña will come a Canadian palaeontologist (he speaks English), Fariña translates, and they will give a talk on 8/21 in the Commercial Centre.

THURSDAY 8/21/97
At 16:30 came Fariña, with the Canadian palaeontologist Jerry D. IULIIS and his wife, at 20:00 the talk begins (70 people more or less) and it was awesome, then Jerry was shown the lines on the bones - "we think that this was make for humans" - "I don't know, it probably" he answered*
Then we had a meeting to start the pro-museum commission. We wrote up the minutes, and all (or almost all) the institutions of the city were represented, it was decided that the teenagers would call people to be part of the group, and that those people vote the members of the pro-museum commission, and that all the institutions of the city would support them morally and effectively
TAKE THAT!

Transcribed notebook. *Note they mean Dr. Gerry De Iuliis. The dialogue was transcribed literally, as the teenager wrote it in English on the notebook.

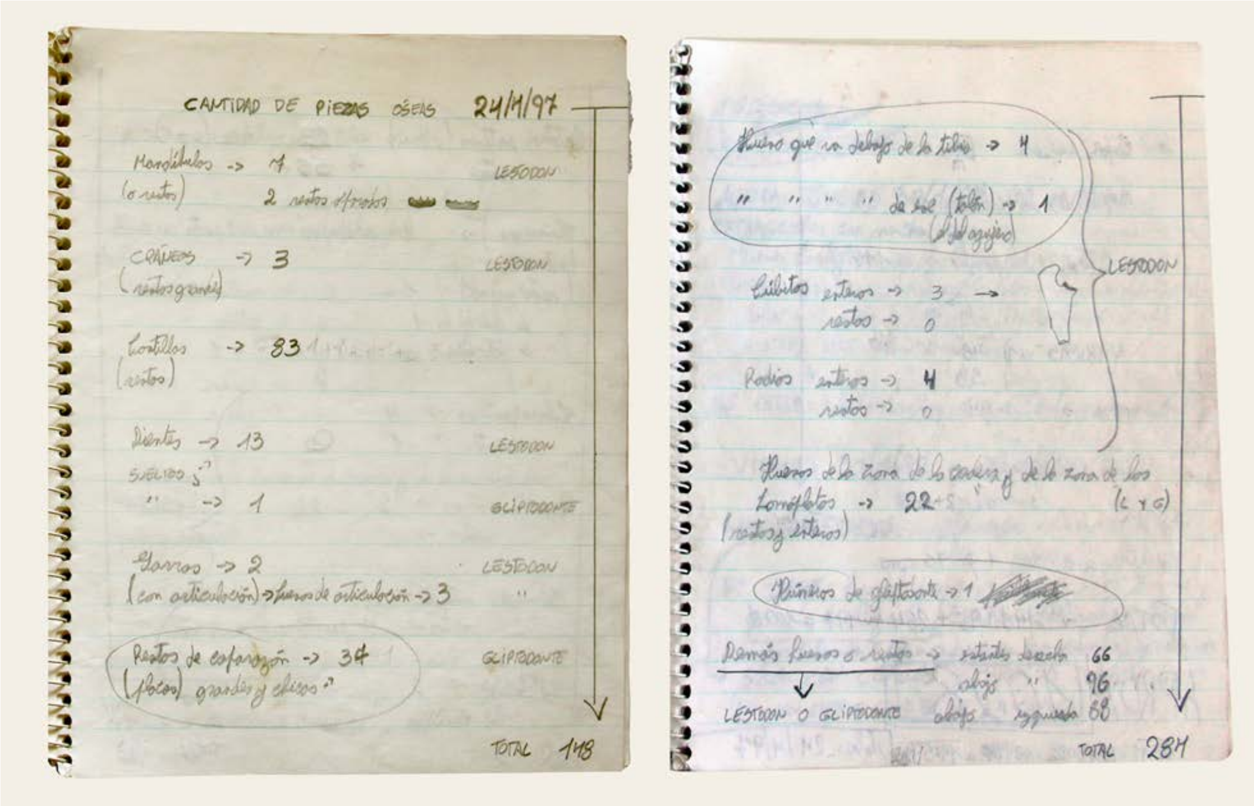

Figure 3. Pages from the first catalogue and field diary, made by students of the local high school.

Testimonials

Aside from the physical archives, oral testimonies from those involved in the finding and first excavation of the remains are key to interpreting the meaning of the collection for the community, the context in which the findings were made, and even to understand the state of preservation of some of the remains we work with. To this day, the authors and rest of the team involved continue to hear stories from that time that bring new perspectives and slowly complete the jigsaw puzzle of the history of this site and collection. Here we present a few of those testimonials from neighbours and teachers, taken from the book *Historia reciente del poblamiento remoto* ("Recent History of the Distant Past," Courtoisie and Fariña 2015; approximate translation that falls short of the local vernacular).

> "The bone thing was in a drought in 1997. We saw the lagoon come down. One day I tell Marta [his wife] that we are going to take the fish out of the lagoon. The water into the lagoon was cut off. There were very few fish, but those bones appeared. I called the neighbour. Look what fish we have here. We were amazed at all that. Night fell. We left everything as it was." (p. 30)

"He was the one who found them. In the afternoon. He said to me: I found some bones. They were huge. Then the children came. All muddy. It was nice to see those children, they looked like ovenbirds." (p. 31)

"The truth is that the first to find a bone and remove it was me. But I pulled it out thinking it was an ox that had died in the stream. We had an ox die there and I thought that maybe the water brought him back. I had just asked the neighbour to come so I washed the carrots. I was in the water and I found that bone I was stepping on and threw it away. I kept passing the bins. I found that bone but the one who realised it was the other [neighbour, Alberto Valetto]. After a while he told me that with that bone the animal should be this tall. He realised that it was not an ox. I did not pay any attention because at first I thought it was the house ox. I think he took the bone home and that's when everything started to wake up." (p. 36)

"What I will always ask myself is what happened. Why so many animals there. It is a strange thing, so many different animals. All together there! And there must be much more. Under a wicker the other day it seems that more bones had been hooked." (p. 37)

"… Someone asked for permission to dig. A guy said to me 'I can assure you that you can ask for a lot of money'. Here some Brazilian guys came 8 or 10 years ago. They were after this meteorite thing. They heard about the bones and they dived here. 'If we take out X piece, we pay you X amount.' I told them that that was of no use to me. That can't be touched down there." (p. 31)

"Bones were removed in two instances. Naldo Castilla's grandmother who had a shop in front of a shoe shop was the first destination of the bones. A group of young people gathered there to work on preservation tasks. Then the bones went to the Liceo de Sauce [the local high school]. Talks were given, the motivation was very great." (p. 32)

The birth of the collection

The finding generated excitement in the community. In addition to the excavation, conservation and preparation, some students and teachers began to organise themselves to publicise the discovery and find a permanent place to house the new collection. Professionals from the public university were contacted, meetings were generated with local and provincial authorities and the press was convened. Public talks on palaeontology were held with national and international academics who visited Sauce to learn about the findings and analyse the fossils. It was evident that this was an important discovery, and the expectations of creating a palaeontological museum in the town grew significantly, as can be attested in newspaper articles from 1997 (Anonymous 1997a-c).

For different reasons, typical of the ups and downs of the public administration and the academic world (see Courtoisie and Fariña 2016, chapters 5 and 6, and "Haunted Bones" 1997), not all of these expectations were met, in particular the creation of the museum. As a consequence, the fossils were finally stored (and almost forgotten) in the Sauce high school awaiting a destination more suited to their importance, and excavations could not be resumed until many years later.

After the hiatus: 2010–2020

Excavations and research

Fourteen years after the original discovery, and after overcoming several difficulties (Courtoisie & Fariña 2016, chapters 5 and 6) and obtaining the necessary permits, it was possible to begin with the systematic extraction of the material. In March 2011, the weather conditions were favourable. The small team of the *Laboratorio de Paleobiología, Facultad de Ciencias, Universidad de la República* [Palaeobiology Laboratory, Faculty of Sciences, University of the Republic] (referred to from now on as 'the team') finally undertook the first excavation campaign (Fariña and Di Giacomo 2014). The stream was dammed with dirt bags and the water was pumped out. The sight of the fossil-lined stream floor was the reward for so much waiting (Figure 4). Since that year, every summer (weather permitting) excavation campaigns have been carried out in which palaeontologists, geologists, archaeologists, photographers, students and volunteers participate, both from Uruguay and

Figure 4. View of the fossils in situ *(with field grid for reference) and of the collaborative nature of the excavations, 2016 (left) and 2012 (right). Photos by Martín Batallés, left, and Gabriela Costoya, right.*

abroad. Numerous new fossils have emerged from these excavations, which added to those extracted in 1997 to form the current Arroyo del Vizcaíno collection.

The collection, which still remains in the town of Sauce, houses more than 1,800 pieces and contains representatives of many of the great mammals of the South American Pleistocene. Although some species of sloths, glyptodonts and other mammals were found, over 90 percent of the fossils belong to the same species of ground sloth: *Lestodon armatus*. Together with the absence of small organisms and adding the massive accumulation of bones in that specific place, many questions have arisen about the formation of the site and the ecological relationships between these species.

A distinctive feature of the site is the high density of bones. With approximately 20 m^2 excavated, at about 100 elements per m^2, the majority of the fossils were found in very good condition. Most of them do not show signs of major transport or erosion and, although many are fragmentary, others are complete or with minimal weathering. Preservation, in many cases, is remarkable. Several fossils contain relatively high amounts of proteins, like collagen, that allow to conduct several studies, including ^{14}C dating, ^{13}C and ^{15}N isotopes analyses, and phylogenetic studies based on proteomics (Buckley *et al.* 2015). This exceptional preservation is also exemplified in relation to the presence of microfossils like pollen grains, silicophytoliths and diatoms, which, in conjunction with the macrofossils, provide a unique opportunity to study a large part of an ecosystem in a crucial moment of the Earth's history during the onset of the Last Glacial Maximum. The study of the site and the collection has enabled studies covering diverse lines of research, including morphology and biomechanics (Tambusso and Fariña 2019), ecology (Czerwonogora *et al.* 2011) and biogeography (Varela and Fariña 2016).

Many of the fossils collected show marks that could be explained due to the trampling of other animals while the fossils were near or on the surface before being buried. However, we observe other marks that, due to their characteristics, could be attributed to human-made tools. When the remains found in the site in 1997 were still in the local high school, the Spanish palaeontologist Alfonso Arribas observed that a *Lestodon* clavicle showed marks that could be interpreted as being made by human tools (Arribas *et al.* 2001). The morphological features of these marks, their association with muscle insertion areas and their orientation were analysed. However, Alfonso's trained eye had not been the first to find such interesting evidence; as early as 1997, the enthusiastic teenager collectors had identified some of those surprising marks.

After these initial findings, a rib with marks belonging to the ground sloth *Lestodon* from this deposit and the marked clavicle itself were dated using radiocarbon. The ages were much older than expected: between 28,000 and 29,000 years before present. To address the contradiction with the received knowledge that humans arrived in the Americas not before half that age, the research continued. The marks were studied in greater detail using 3D reconstructions from photomicrographs to define whether they were due to trampling or if they were the consequence of human agency. Five other dates obtained from fossils from the site, four of them on bone and one on wood, corroborate the dates previously obtained and transform the Arroyo del Vizcaíno into a site with interesting evidence of ancient human presence on the continent (Fariña *et al.* 2014). The publication of these investigations generated a debate in the local and international academic community (Courtoisie and Fariña 2016, chapter 7).

Management and preservation of the remains

The fossil remains were first stored in a room of Reinaldo Castilla's grandmother's house (Figure 5). After that they were moved to the local high school where they had several homes, from cabinets and shelves in storage rooms to filing cabinets in an

Figure 5. First collection storage room, at one of the student's grandmother's house, 1997 (author unknown).

Figure 6. Preparation (A), labelling (B) and storage (C and D) of the fossils in the second location at the Casa de la Cultura, 2012. Photos by Martín Batallés.

outbuilding. The bones were assessed a few times in those spaces by some of the palaeontologists to begin a formal catalogue, and numbers were painted on them. A few of the bones were housed in a glass vitrine in a central location of the high school, where students and teachers could see them on a daily basis.

Not long before the excavations began in 2011, the bones were moved by the team to a small room at the Casa de la Cultura, a cultural centre in the town of Sauce. This small room could fit only two palaeontologists working together on identification and cataloguing at a time, which made the initial assessment of the collection rather slow. Since this room was so small, after the first excavation the recently excavated bones were stored in the mayor's office building, until a new, larger room in the Casa de la Cultura was allocated a few months later (Figure 6). After that, the new room housed both the 1997 collection and those extracted in the subsequent excavations. This new location marked a new chapter in the collection, as the space served as laboratory, where preparation, cataloguing, digitalization and storage could be performed simultaneously by several members of the team.

In 2016, the collection was moved once again to a rented location in Sauce due to the Casa de la Cultura moving to a different building and the local authorities not being able to provide an alternative, multipurpose location as was needed for normal activities to continue. This new space had separation between the collection and laboratory spaces, making the work easier. During this time, conversations began to build a new lab and collection space in the high school lot, bringing back the collaborations between secondary and tertiary education institutions.

In 2018, the collection was moved one last time to the high school lot, to its specially built spaces (Figure 7). The new collection space has room for the collection to grow, while the lab space has the capability to serve as outreach, education and exhibit space. Increased separation between the lab and collection allows for better preservation of the remains, as dust from preparation activities does not get into the collection area, maintaining a better environment where the fossils are stored. In addition, the fossils are kept in a more stable environ-

Figure 7. Views of the new collection space, during installation of specimens, 2018. Photos by Martín Batallés (top) and Luciano Varela (bottom).

ment and the team has been working on rehousing and digitising the remains.

From the beginning, it was important for the fossils to remain in Sauce and to be part of the public sphere. The Arroyo del Vizcaíno collection has not only achieved this, but has also gone full circle, returning to the high school where it lived in its beginnings.

Outreach and community engagement

The new space as a vector for outreach

Aiming at keeping the collection's original spirit, the work currently being done maintains a strong vocation for the dissemination, communication and social appropriation of knowledge. In this sense, since the resumption of excavations and conservation work, the collection space has also attempted to be a space open to the community. Even in its most precarious locations, the collection has been (and still is) the site of talks, workshops, guided tours and periodic visits to high schools and other schools in the area and in other regions of the country (Figures 8A, C and D). In the new lab/exhibit space we sometimes work, weather and activities permitting, with the door open, allowing occasional visitors to pass by and ask questions or even sit and colour pictures of animals from the megafauna. This spirit of community involvement brings people of all ages to the space, some curious about the fossils, others fascinated by the colourful prints of reconstructions of these animals.

The Arroyo del Vizcaíno collection is conceived as a flexible and itinerant environment. Flexible, because, in addition to its being a research and conservation centre (and despite its small dimensions), it has managed to become a classroom, a conference auditorium, a projection room, a space for games and art activities and an exhibition room. Itinerant, because its pieces have travelled to be part of temporary exhibitions in other museums and at science fairs, and also because the team moves frequently to give talks and workshops in colloquia, schools, high schools, teacher training centres and palaeontological collections from different parts of the country.

One example of outreach outside our walls happened in 2017 when, together with the *Centro de Fotografía de Montevideo* (CDF, Photographic Centre of Montevideo), we set up an extensive photo exhibition about the history of the findings of the Arroyo del Vizcaíno. This project encompassed images from the archive of the discovery in 1997 to recent photographs of the excavations, conservation and preparation work (Figure 8B). In addition, the exhibit included palaeoartistic reconstructions of the animals and specially-designed infographics about evolution, human settlement in the Americas and the different stages of our scientific research (Figure 9). The exhibit, which was free and open to all, was held for several weeks in an outdoor photo gallery space in Montevideo and later displayed in Sauce's high school lot, where it remained for several months.

The team and collaborators have found other means to tell stories about the findings and work done: books have been published (Courtoisie and Fariña 2016), short films have been broadcast, articles have been published in magazines, blogs and popular portals and some television specials have been filmed. The summer excavations have also been an open space to receive visits from residents of the area, students, journalists and curious people in general. Our physical spaces have been the roots that allowed these and many other projects to grow, which in turn allow us to achieve our main goals: research, education and outreach.

Digital Outreach Initiatives

Aside from the workshops, talks and other in-person activities, much of the collection's outreach happens on the internet. The www.arroyodelvizcaino.org site

Figure 8: Outreach activities: A) School visit to the collection, 2016 (Photo by Martín Batallés); B) Photo exhibition of excavations and lab work, Montevideo, 2017 (Photo by Gabriela Costoya); C) School students and teachers gathered at the school to hear a talk by the team, 2017 (Photo by Martín Batallés); D) Children's activity based on augmented reality, Sauce, 2018 (Photo by Martín Batallés).

houses images and videos of the excavations and fossils, shows the history of the findings and research and offers general information on South American megafauna (Figure 10). Information on the progress of the research and excavations is kept up to date on its associated social media platforms, where outreach activities are announced and exchanges with followers are generated. These tools make it possible to give the collection great visibility, maintain active contact with the community and reach audiences beyond the immediate geographical area.

Our audiences not only interact with us by liking or commenting on our posts, they engage more actively with us via our direct messages by showing us their own findings and alerting us of possible new palaeontological sites. The Arroyo del Vizcaíno collection is slowly becoming a repository of fossils from other Uruguayan sites, some of which were found by our followers. This has shown us the power of community science as a tool for the accumulation of knowledge and appreciation of our palaeontological heritage.

What began as an idea to digitise the Arroyo del Vizcaíno collection became a new standalone project as we added fossils from other collections in Uruguay. The Megafauna 3D project was created and has since gone far beyond its initial conception, becoming an autonomous platform for outreach and education. It is a project that seeks to gather fossils from different collections to disseminate and bring value to the palaeontological heritage of Uruguay and South America through new digitisation and 3D-printing technologies. Apart from an initiative to digitise fossils of the South American megafauna of the Pleistocene, it is also an online educational platform, a repository of 3D models, a series of educational resources and didactic and interactive activities on palaeontology, a physical didactic suitcase and a tour of talks and workshops visiting schools and museums in different locations of Uruguay (Figure 11). Megafauna 3D lives mainly on its website (www.megafauna3d.org) and social media platforms (Figure 10), but also expands to in-person activities that not only engage audiences differently, but act as a first step for the public to interact with the physical didactic resourc-

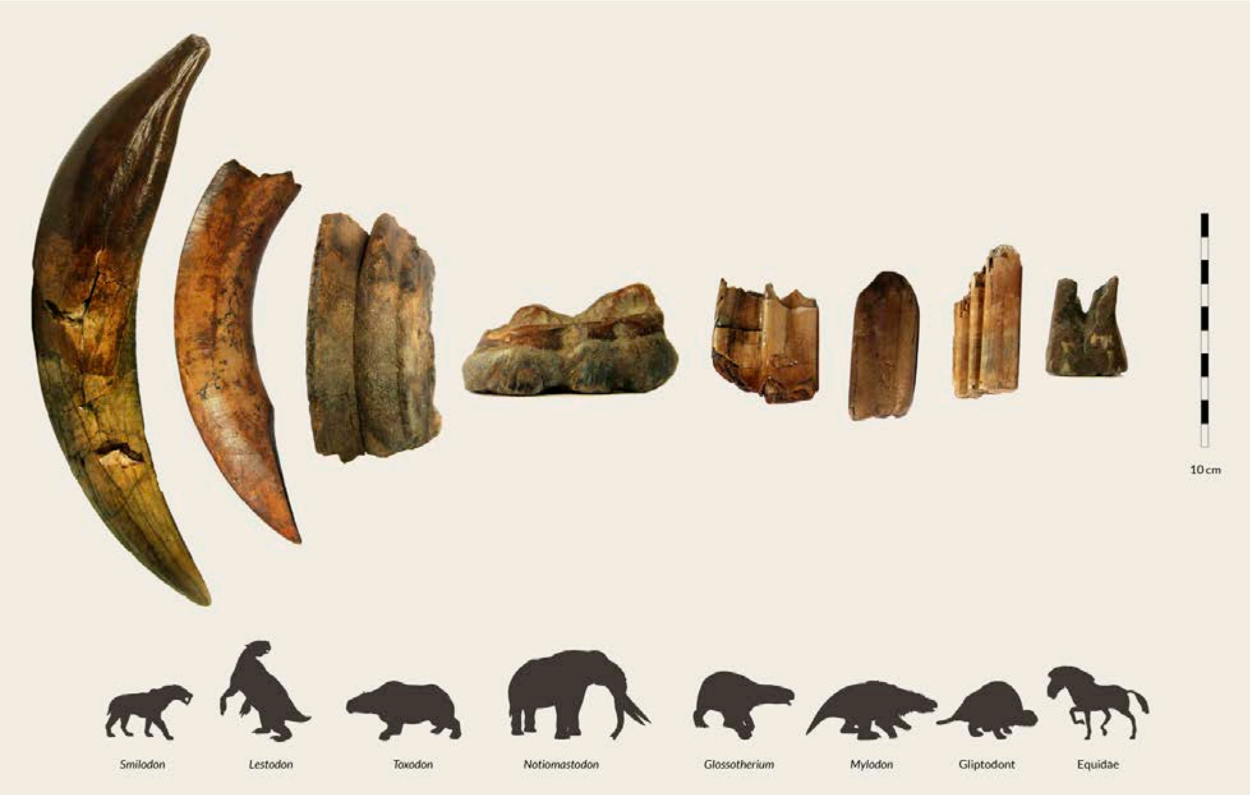

Figure 9: Educational graphic showing teeth from the collection and which animals they belonged to. Photo by Martín Batallés and Gabriela Costoya.

es and then continue on their own with the digital ones.

The main goal of the project is to preserve the richness of the palaeontological heritage of the region, with an emphasis on the giant mammals of the Pleistocene, making it accessible to the general public. It also seeks to promote the communication of scientific knowledge by the community, on issues such as biodiversity and extinction processes, using new technologies to generate exchanges between different social actors.

Figure 10: Screenshots and images from www.megafauna3d.org *and* www.arroyodelvizcaino.org *websites.*

The future of the collection

The Arroyo del Vizcaíno collection began as a quick recovery of fossils from a stream bed after a drought. High school students were involved not only in the recovery but also in identifying the remains and requesting they stay in their town. Two decades later, the fossil remains are once again tied to the high school, both due to their physical location and the collaborations that have occurred since the team of palaeontologists and collaborators became involved. Our goal is to continue to strengthen these ties and to expand them even further.

Since 2019, the collection is officially affiliated with the Universidad de la República, after the creation of SAUCE-P (*Servicio Académico Universitario y Centro de Estudios Paleontológicos*, University Academic Service and Palaeontological Studies Centre), a formal institution that serves as education and research facility for palaeontological studies. With the support of the university, we hope to continue to educate undergraduate and graduate students and to incorporate high school students and teachers in our

Figure 11: Megafauna 3D educational suitcase, containing plastic fossil replicas, 3D glasses, a teacher's guide and other didactic resources.

education efforts. Teachers have already shown interest in incorporating palaeontology into their curricula as part of both science and humanities classes. When we began our work, we paid attention to the requests of the high school students and other members of the community to keep the remains in Sauce; we hope that with the creation of SAUCE-P and the collaborations we established with the authorities in charge of public education, we will be able to fulfil the community's wish.

The work done in the collection is a continuation of what the community started. The archives from 1997 and testimonials tell the story of the collection and beginnings of the research on the material. This shows the importance of keeping this information as part of the collection, as it is informative about the collection's state at different points throughout its history. The archives and other documentation we have kept throughout the years allow us to understand issues with cataloguing, the coloration of the fossils and the history of the fossils' preparation. This is information we have been keeping and will continue to keep in the coming years as it will inform future researchers about where it all began and how things evolved.

Finally, outreach activities will continue to be developed and new projects will be created. Our experience working with our audience has taught us the interest in this collection goes beyond the limits of Sauce. For this reason, we will continue to expand our digital platforms, think of new ways to create educational and didactic content and collaborate with other institutions. Our doors will continue to be open (both literally and figuratively) for anyone wanting to learn.

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Statement

All authors declare no competing interests.

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An overlooked contributor to palaeontology—the preparator Richard Hall (b. 1839) and his work on an armoured dinosaur and a giant sea dragon

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The work of Richard Hall, a fossil preparator at the British Museum (Natural History) in the late 19th century, has been largely unrecorded. It included the excavation, preparation and restoration of two important specimens: the dinosaur *Polacanthus foxii* and the ichthyosaur *Temnodontosaurus platyodon*. The painstaking reconstruction of the dorsal shield of *Polacanthus* took seven years to complete and enabled a supplemental note redescribing the specimen to be published in 1887. The significance of the discovery in 1898 of the *Temnodontosaurus* to the town of Stockton in Warwickshire was such that it featured in an article in Nature. It has entered the local folklore and remains celebrated on the town's road signage and features as the logo of Stockton Primary School.

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Introduction

During the late nineteenth and early twentieth centuries a significant number of fossil vertebrate specimens were acquired for the national collections at the British Museum (Natural History) (BM(NH); now the Natural History Museum London), from both UK localities and overseas. Whereas the provenance of such material was recorded in the museum records and, in the case of published specimens, the scientific literature, all too often scant or no detail was recorded as to whom had undertaken the excavation, preparation and mounting of specimens. Where such information exists at all, it is often to be found in museum archives, although not necessarily associated with the specimen records. Accounts of discoveries and excavations of more spectacular specimens were sometimes covered in the local press, but these reports are seldom picked up and held together by museums, and so, over time, the contributions of the people whose work facilitated scientific study and research are lost and forgotten.

One such individual was Richard Hall. Born in 1839 in Raglan, Monmouthshire, Wales, he was working at the BM(NH) as an Assistant Mason in 1885 and became a Mason (fossil preparator) in 1889. Except for one of his work diaries from 1885, some correspondence relating to the excavation and recovery of an ichthyosaur in 1889 and a single Geological Department junior staff group photograph from 1900 (DF PAL/106/13 in the Natural History Museum, London, archives), there is nothing in the museum archives relating to his work. He received a passing mention in a scientific publication of 1887 relating to several years' work he performed on reconstructing the dermal shield of the armoured dinosaur *Polacanthus foxii* (Anonymous 1865a, attributed to Owen). Remarkably (yet not unusually in those times), he was never publicly associated with the difficult excavation, recovery and mounting of a large articulated specimen of the ichthyosaur *Temnodontosaurus platyodon* (Conybeare 1822) from Stockton in Warwickshire, UK. The find and its excavation were photographed and covered in articles in the local newspaper and the journal Nature, but while "the Stockton ichthyosaur", as it came to be known, entered the local folklore and was placed on public display at the BM(NH), Richard Hall's part in the story was unrecorded until now.

Background

During the course of research into the history of fossil collecting and preparation at the British Museum of Natural History (BM(NH); Graham 2019),

Figure 1. BM(NH) Geological Department Junior Staff photograph, 19 November 1900, including Richard Hall (back row, centre). Credit: NHMUK Archives PH/2/5/1/8, Staff Portraits and Group Photographs 19th–21st Century).

a short reference to "Mr Hall, assistant mason in the Department of Geology" was found in relation to the preparation and restoration of the armoured dinosaur, *Polacanthus foxii* Anonymous, 1865, collected from Lower Cretaceous deposits on the Isle of Wight, UK (Hulke 1887).

The NHM's archives contain little material associated with Mr. Hall but there exists his hand-written work diary from 1885 and a Geological Department junior staff photograph from 1900 that shows him standing in the middle of the back row (Figure 1). Nothing connected with his long and patient work between 1881 and 1887 on *Polacanthus* is recorded except for Hulke's passing reference:

> "The great dorsal shield [(Figure 2)]… was represented by several hundred disconnected pieces, many of these being of less size than one cubic inch [16 cm^3]. It was also evident that many had been lost. In this mutilated condition the reconstruction of the shield appeared hopeless, but at length, under the guidance of the heads of the Palaeontological Department, this has been accomplished by Mr. Hall and Mr. Barlow ("Masons"), who brought to the task a painstaking perseverance and skill worthy of the highest praise" (Hulke 1887: p.169).

Caleb Barlow (1840–1908) is also shown in Figure 1, second from the right in the front row and was the mason (preparator) appointed by Sir Richard Owen. He worked at the Museum from 1874 to 1908 and

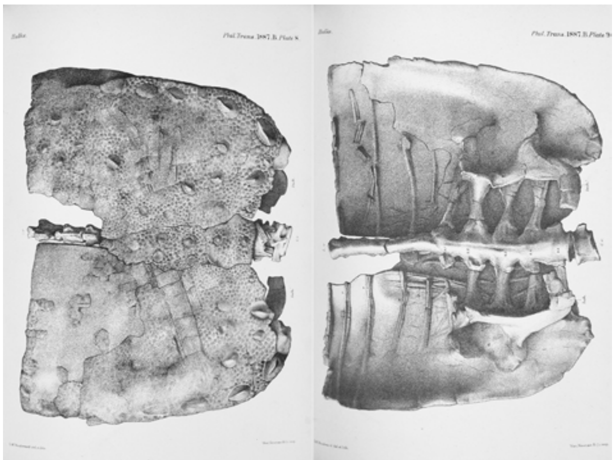

Figure 2. Reconstructed dorsal shield of the dinosaur **Polacanthus foxii** *Anonymous, 1865. Figured in Hulke 1887. Part of the Holotype NHMUK PV R 175. Photo credit: Mark Graham.*

is the first recorded person to have been engaged in professional fossil preparation at the Museum (Graham 2019).

However, in the museum archives for 1898 there is correspondence between Hall and Dr. Henry Woodward, the Keeper of Geology at the museum, which concerns the inspection and recovery in August and September of that year of a large ichthyosaur from Lower Jurassic rocks at Stockton in Warwickshire, UK. The specimen was a largely complete and articulated example of the ichthyosaur *Temnodontosaurus platyodon* (Conybeare 1822), referred to at the time as an example of the genus *Ichthyosaurus*. Its discovery created much interest among the local community and press, and an account of the find was published that year in the journal Nature (Anonymous 1898a). What is missing from the accounts of the excavation is any recognition of the significant role played by Richard Hall, who was sent by the museum to excavate, secure and recover the fossil for the BM(NH). As with his earlier work on *Polacanthus,* this contribution in bringing the Stockton ichthyosaur, as it came to be known, to public display was also destined to slide into obscurity in terms of the official record.

Historical setting

In the latter part of the nineteenth century the village of Stockton was well known for its quarries, dug in the Early Jurassic Blue Lias Formation as raw material for the cement industry (Old et al. 1987; Ambrose 2001). According to the Nature article of 1898, there were three manufacturing cement firms working at that time. Good fossil specimens were regularly found, including isolated vertebrate material as well as invertebrates. The village's "late rector" [likely the Reverend William Tuckwell, who was appointed in 1878 and known as the Radical Parson (Littlebeams undated)] had educated the quarrymen through lectures and conversation about the fossils they unearthed (Anonymous 1898a).

The rector had predicted to the quarrymen that a "perfect monster" would someday be unearthed and urged that, should they ever come across a head or row of vertebrae, they would cease digging and call in experts to direct the excavations. The prediction came true when one of the pickaxe-wielding workers announced that he was "grapplin' along a lot of backbones", stopped work and called in the foreman. The quarry owner, Sir Maurice Lakin of Leamington, recognised it as an important find and chose to donate the specimen to the national collections (Anonymous 1898a), and so Richard Hall was duly despatched from the Geology Department to Stockton to complete the excavation and secure the fossil.

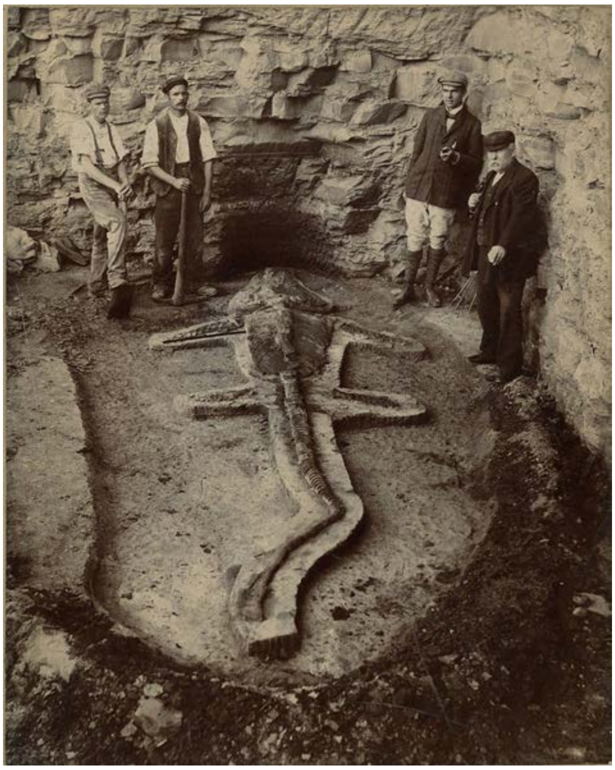

Figure 3. Excavation in 1898 of **Temnodontosaurus platyodon** *(Conybeare, 1822), the Stockton ichthyosaur, supervised by Richard Hall (right). Photo credit: The Lapworth Museum of Geology, University of Birmingham.*

Inspection, excavation and recovery

Upon arrival, Hall based himself at the nearby Blue Lias Inn hotel from where he wrote to Charles W. Andrews, the palaeontologist and marine reptile specialist at the BM(NH), noting that the excavation was "a formidable job" and that he "had it rough for a few days". He described the numerous visitors to the quarry as being "plentiful as bees which hinders me" and requested additional sacks of plaster in order to encase the underside of the block containing the fossil in readiness for transportation to London (Hall 1898a).

During the course of excavation, photographs were taken of Hall and others working on the specimen and copies have been retained at and published online by the Lapworth Museum of Geology, University of Birmingham (Figure 3). Although no names seem to have been recorded with the images, it was possible, by reference to the BM(NH) Geological Department photograph of 1900, for (MRG) to identify Richard Hall by his distinctive face and moustache.

On 2 September 1898, Hall also wrote to Dr. Woodward at the museum, explaining that he had been afraid to write earlier as he could not say what success he was likely to have "lifting the animal from his bed" (Hall 1898b). He had removed two sections of the tail which had to be sawn off the bedrock and encased it all round in plaster of Paris strengthened with longitudinal and transverse irons and bonded with wire. "I have not lost sight of the animal many hours since I have been here" he wrote. Three days later, in an update to Woodward, he reported "satisfactory but slow progress in the sawing - the whole of the tail, the 4 paddles sawn off and cased in plaster ready for packing and the pelvis, body and head to do which is much harder and will take a lot of sawing". Hall referenced the intense heat in which he had been toiling and hoped that, "all things favourable", he would be able to put the specimen "on rail about Thursday night" (Hall 1898c).

The following week, on 8 September, Hall reported that he could begin to see the end of the job, having nine sections cased with plaster and partly packed although the head and body he noted "takes a great deal of cutting and is extremely difficult to get out in casing" (Hall 1898d). By now he had used 8 cwt (406 kg) of plaster and a quantity of iron to strengthen the jackets. Turning his attention to the transport logistics, Hall discussed with the quarry owner how to get the weighty objects back to the museum and was advised to have it lifted and loaded into one of the covered trucks in their quarry sidings for despatch to London Euston railway terminus. The final tally recorded for transportation on 15 September 1898 was for "5 CWT fossils, 8 CWT plaster, 11 pieces, 19 feet" [5.8 m] (Hall 1898e).

An account of the area's geology and fossil discoveries was printed by a local cement company (CEMEX 2016), noting that the Stockton ichthyosaur find had been reported at the time of its discovery in the Leamington Spa Courier of 13 August 1898 (Anonymous 1898b: p. 7). The local newspaper article was headed "A Testimony of The Rocks", from which Cemex quoted the following extract:

> "The lime quarries are situated about 2 miles from Southam on the road to Dunchurch and are entered by a gate on the left hand where the road to Long I[t]chington to Stockton and Napton crosses.
>
> When first entering the field there is little to show that anything unusual is taking place, but a walk 200 yards brings us to the edge of the quarry, where a crane is busily at work removing the lias to the surface. Trestlework bridges intersect the intervening spaces, which have been dug out to enable the quarrymen to convey, by means of barrows, the lias from the opposite side and also to deposit the debris.
>
> It was on one of the platforms, 20 feet from the surface and reached by ladder, that the fish lizard was discovered lying with its head due north. The tip of its tail was first brought to light and the quarrymen noticing that this was in good preservation took unusual precautions in unbedding the remainder". (CEMEX 2016: p. 2).

Figure 4. The fossil marine reptile gallery at the NHMUK. Shown are (top) NHMUK PV OR 2918 from Stockton, (middle) NHMUK PV OR 2003 and (bottom) NHMUK PV OR 1158, both from Lyme Regis. The display cabinet measures 6.6 m in length. Photo credit: Trustees of the NHM, London.

In a short article published in Nature (Anonymous 1898a) under the heading "A Dragon of the Prime" and which featured a full-length image of the ichthyosaur, the following descriptive account of its discovery and excavation was written:

> "Slowly with due precaution a noble Ichthyosaurus was uncovered. He lies 45 feet below the surface; 20 feet in length, the head 2 feet across and 3 feet 10 inches long. The paddles are unusually distinct, the front pair 2 feet 6 inches, the hind pair 1 foot 8 inches in length. The tail is abruptly curved, and some of the lumbar vertebrae are slightly displaced. The pelvic ring is missing, removed, perhaps, before the nature of the find was guessed, and still to be recovered. Crowds from all parts of the county throng to see it; and not a little vigilance is necessary to protect it from dishonest visitors, attempting to purloin teeth or fragments". (Anonymous 1898: p. 418–419).

Legacy

The magnificent specimen of *Temnodontosaurus platyodon* recovered and prepared by Hall has for many years been on public display in a glass case high up in the Fossil Marine Reptiles Gallery at the Natural History Museum London (Figure 4). It is recorded as specimen number NHMUK PV OR 2918 (Figure 5).

Displayed directly beneath it (Figure 4) are two other more widely recognised examples of *T. platyodon* which were discovered by the Annings at Lyme Regis, Dorset, UK many years before the Stockton specimen. NHMUK PV OR 1158, on the bottom of

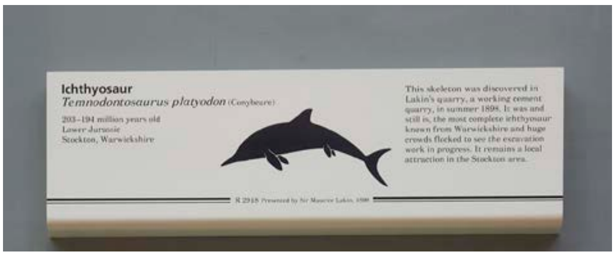

Figure 5. Display case label for NHMUK PV OR 2918. Photo credit: Trustees of the NHM, London.

the case, is the famous skull and fragmentary skeleton, comprising vertebrae and some pectoral elements, of the first ichthyosaur ever to be formally recognised by science. The skull was found in 1811 by Mary Anning's brother Joseph and the remainder was discovered a year later by Mary herself (Torrens 1995). The large articulated specimen, NHMUK PV OR 2003, designated as the neotype by McGowan (1974) and displayed in dorsal view like the Stockton example, was found by Mary, sold to the geologist Thomas Hawkins (1810–1889) and subsequently purchased by the museum for £210 in 1834.

An image of an ichthyosaur skeleton became featured on road signage welcoming visitors to the village of Stockton some 25–30 years ago (Figure 6) after Warwickshire County Council's highways department asked John Crossling, then geology curator at the Warwickshire Museum, for a suitable image to incorporate (J. Radley pers. comm.). Reference was made to Thomas Hawkins' Book of the great sea dragons (Hawkins 1840), and the image selected was that from plate 17 (Figure 7). The specimen, NHMUK PV OR 2013*, was collected from one of the famous quarries in Street, Somerset, UK. This is a different species, *Ichthyosaurus somersetensis* (Lomax and Massare 2016), but effectively captures the spirit of the 1898 skeleton, its discovery and what it means to the village of Stockton. The Street skeleton too is on public display at the NHMUK (Figure 8B). Interestingly the artwork for the Stockton signage was adapted so that the distinctive kink in the tail of the specimen became gently curved, presumably for aesthetic reasons (Figure 8A). A caption on the road sign reads "Stockton quarrymen found this fossilised skeleton of an *Ichthyosaurus* in the summer of 1898". Today a colourful and stylised version of the image also serves as the logo of the Stockton Primary School and can be seen on their website (Stockton Primary School 2020). Picking up on the area's geological history, the nearby Blue Lias Inn, where Richard Hall stayed in the summer of 1889, has a sauropod dinosaur as a logo and on its pub sign (The Blue Lias Inn 2020), although no sauropod material has ever been recorded from the Lias of the UK.

Figure 6. Road signage in Stockton, Warwickshire. Photo credit: Jon Radley.

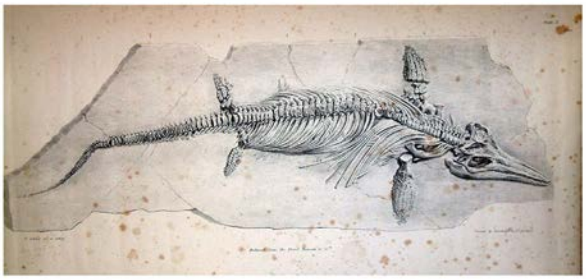

*Figure 7. NHMUK PV OR 2013** **Ichthyosaurus somersetensis** *(Lomax and Massare, 2016) which was collected from Street, Somerset, UK and upon which the Stockton road sign logo was later based. Figured in Hawkins 1840. Photo credit: Dean Lomax.*

Conclusion

While the discovery of the Stockton ichthyosaur and association with the village remains celebrated locally, Richard Hall's part in the story has remained unrecorded. Regrettably, his work on both *Polacanthus* and later, the Stockton ichthyosaur was scarcely recorded, virtually unattributed to him and has been largely forgotten. Who can say what other specimens he may have prepared and conserved during what was a golden age for collecting in the UK, and to what extent his skills contributed to the study and publication of vertebrate fossils? Perhaps this short account of some of his work will serve as a lasting record of two major contributions.

Figure 8. The tail of NHMUK PV OR 2013 on the Stockton road sign image A) was adapted to remove the kink in the real specimen B). The tail had been accurately represented in Hawkins' 1840 plate that had been provided to Warwickshire County Highways department for reference. The display cabinet measures 2.8 m in length. Photo credit: Dean Lomax.*

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Historical collections in museums: the legacy of William Buckland's 'Geological Museum' collection at Oxford and its potential as a teaching resource today

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The exhibits on display in natural science museums today often have parallels within the historical collections carefully preserved behind the scenes. One such is the collection of William Buckland (1784–1856) in Oxford University's Museum of Natural History, amassed during the first half of the nineteenth century. As the first to hold the post of Reader (Professor) of Geology at Oxford, Buckland worked hard to develop his geological knowledge and quickly established a central place for himself in the Geological Society through his bold new theories and fieldwork. Thanks to his own collecting and numerous exchanges and gifts from individuals in his networks, he built up a diverse collection for use in his research and teaching. Through five case studies in this article I consider how Buckland's, and by extension other such collections, could be used again in teaching today, particularly with university students. This would contribute to the reinforcement of Science, Technology, Engineering and Mathematics (STEM) subjects urged by the UK government, as well as aligning with the interest in material culture current in academia (Department fo Education 2015). Historical collections abound with objects that embody multidisciplinary narratives, and as such they can play an important role in deepening students' interest in science. I also discuss additional ways that some educators are using objects in undergraduate teaching today. These are designed to transcend disciplinary approaches and promote a range of soft skills, such as confidence, inclusivity, imagination and empathy. Considered afresh, historical science collections could have increased value for museum curators and educators of all kinds.

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Introduction

William Buckland (1784–1856; Figure 1) is an early example of a British university teacher who created a collection of objects he termed his 'Geological Museum' specifically for the purpose of teaching. I use the term 'objects' here to refer to all the items of material culture, including casts, models and illustrations (maps, diagrams, drawings and prints) in Buckland's collection sited at Oxford University Museum of Natural History (OUMNH) today. Under this term I also include his specimens, for by virtue of having been selected, extracted, labelled and inserted into a museum collection these have been rendered cultural artefacts. Of course, many specialists work in museums and use objects in teaching people of all ages as this is part of the remit of most museum curators and educators. For example, at OUMNH, the Public Engagement team has, in addition to the main displays, an object handling collection at their disposal that includes zoological, mineralogical and palaeontological specimens (Oxford University Museum of Natural History undated). This collection is used to teach school students in practical sessions related to the national curriculum across a range of subjects, including palaeontology, evolution, osteology, anatomy, bioanthropology and entomology.

At OUMNH, Collections Managers and Research staff teach students in tertiary education using the main museum collections, as well as specimens often acquired specially for the purposes of scientific research. Objects in historical collections such as Buckland's are not generally used in this context, although they are often shown to special interest groups of adults. Their potential will be explored here as a resource for different kinds of university teaching within a science museum setting, including

Figure 1. Thomas Sopwith (1803–79), Costume of the Glaciers, [William Buckland], lithograph, undated [c. 1840]. OUMNH Library and Archives, Buckland Collection.

and beyond the disciplinary boundaries of science education. In terms of the drive in recent years to attract diverse students to STEM subjects, historical collections abound with positive stories that tie in with contemporary narratives around women in science, citizen science and national and international collaborations. They also offer examples of an alternative methodology for doing science that interrogates the dominance of the experimental sciences (physics and chemistry), and notions of a universal scientific method (Dodick *et al.* 2009). More broadly they can be used to relate to multiple histories including histories of science, collecting and colonialism, as well as gender studies, museum studies and the histories of print culture, art and illustration. There is also potential to situate items from these collections within the specific framework of object-based teaching that embraces all of the above without buying into particular subject areas. This type of teaching has received attention from scholars as the evidence of the positive effects of experiential learning has been analysed and published in recent years (Chatterjee *et al.* 2015). Sensory engagement with objects has been proven to elicit a wide range of responses from students that support course work; the benefits range from inclusivity, increased curiosity, imagination, validation of students' experiences relating to their individual cultural background and team building, to inspiring and memorable experiences that engender creative thinking (Falk and Dierking 2013).

Interdisciplinary teaching approaches seem particularly appropriate with regards to Buckland's collection, as in the early nineteenth century scientific geology developed from many existing areas of study (e.g. mineralogy and mining, chemistry, geography, surveying and medicine) and was thus fundamentally heterogeneous (Rudwick 1976). As was typical for many university teachers at the time, Buckland was trained in the classics and ordained in the Anglican Church; he embodied an Aristotelian desire for knowledge with a sense of wonder at the complexity and appropriateness of God's designs in nature (Rupke 1983). He had received guidance in geology from a few key individuals but he honed his skills through observation and direct engagement with specimens, often collected personally by him in the field. Why and how Buckland formed his collections, and their central role in his teaching and the making of the new scientific geology as a university discipline, is the focus of my current doctoral research project. Identified, extracted, selected, labelled, commissioned or made by him, objects of all kinds were an indispensable part of his teaching.

William Buckland, a 'celebrity' man of science: his teaching career and collecting

Buckland taught at Oxford from c. 1813–49, a period that coincided with major advances in geological science. His own contributions to the history of geology can be traced across many areas and include the early scientific study of Quaternary cave remains of extinct animals in Britain, global correlation of strata and the palaeoecology of extinct animals in relation to trace fossils. He also had an important role in publicising developments in geology more broadly through his lavishly illustrated treatise, *Mineralogy and Geology Considered with Reference to Natural Theology* (Buckland 1836). Written in an accessible and engaging style, this became a 'must read' work for the educated elite in the early Victorian period (Topham in press).

Buckland achieved a degree of fame not normally associated with university teachers at the time. A number of factors were at play in addition to his publications; in an age when the majority of people in Britain believed in the creation of the Earth according to the letter of the biblical account in Genesis, the geological discoveries and theories he discussed in his works were controversial. Buckland's lectures became famous as he was charismatic, funny and given to theatrical flourishes. Those who attended his Oxford courses, as well as audience members at his public lectures, often discussed him in their letters, journals and diaries, satirized him in poems and prints, and included anecdotes about him in their memoirs, many of which eventually found their way into print, for example: Charles Lyell (Lyell and Lyell 1881), Gideon Mantell (Mantell and Curwen 1940), Roderick Murchison (Geikie 1875) and Elizabeth Gordon, Buckland's daughter (Gordon 1894). For these reasons, Buckland's significance has been explored by various scholars in relation to the histories of nineteenth-century culture and science more broadly; indeed, his name soon crops up even in popular accounts of the history of geology today (O'Connor 2008).

Buckland's university career started out modestly enough, with few indications of his later successes. He arrived in Oxford in 1801, aged seventeen, as a scholarship boy from Devon, the son of a genteel clergyman of limited means (Foster 1887–88). After graduating in December 1804, he remained at the University and eked out a modest living tutoring students in Latin and the classical texts that constituted the core of the curriculum at the time. His financial position improved when he gained a fellowship at his college (Corpus Christi) in 1808 and from then on he was able to develop his interests by attending lectures in science, termed Natural and Experimental Philosophy at the time (Edmonds 1979, 1991). By 1813, at the age of almost thirty, Buckland had transformed himself from a classics scholar into an eligible candidate for the post of Reader in Mineralogy. His Oxford connections to the young Geological Society (GS), founded in 1807, seem to have played a major role here. John Kidd, D. M. (1785–1851), held the Mineralogy Readership before Buckland. He was appointed an Honorary Member of the GS on its foundation and published a popular mineralogy handbook two years later (Kidd 1809). Two other Oxford dons were welcomed into the Society at the same time: Christopher Pegge (1765–1822), Regius Professor of Medicine, and the Rev. J. J. Conybeare (1779–1824), Professor of Poetry. All three men had private geological collections of their own, and Pegge had also acquired a number of important palaeontological and zoological specimens for the anatomy collection at Christ Church College (MacGregor *et al.* 2000).

The influence of the early GS through these important Oxford contacts can also be inferred from the fact that Buckland undertook his first geological field excursion in 1808, the year when the Society issued its pamphlet, Geological Inquiries (Anonymous 1808; Gordon 1894). This was a call for members to submit their observations on the geology of their own regions with a view to producing a geological map of England and Wales. Buckland certainly appears to have caught the geology bug, for surviving correspondence reveals that by 1811 he was attending Kidd's lectures on mineralogy and Pegge's on comparative anatomy, and the large volume of geological specimens in his collection made it increasingly difficult to manoeuvre in his college rooms (Buckland 1811; Gordon 1894). In 1813, Buckland joined the GS himself and was appointed to the Readership of Mineralogy formerly held by Kidd in the same year.

Buckland's personal collection was fundamental to his teaching from the start for, although some items of geological interest were in the collections of the University's Ashmolean Museum, there were few of relevance to the new scientific geology (MacGregor and Headon 2000). By tradition, lectures on different aspects of natural philosophy were delivered in the Ashmolean (the building now occupied by the university's History of Science Museum), and this is where Buckland can be seen in the well-known lithographic print of 1823 that shows him teaching before an audience (MacGregor 1983; Figure 2). This print represents a rich source for my project that focuses on Buckland's collections and the role they played in his teaching. An astonishing range of geological specimens, maps and illustrations dominate the picture (Edmonds and Douglas 1976). The print provides certainty that barely ten years after his arrival in post, Buckland's collections were being used by him for teaching purposes in the Ashmolean. We know from the surviving notes taken by his students that specimens were passed round during lectures, and students were encouraged to engage with them in different ways to learn how to identify them and their potential utility (Boylan 1984). For example: in addition to paying close attention to the appearance of a rock or mineral, Buckland was interested in

Figure 2. Nathaniel Whittock, A Geological Lecture, [Buckland teaching in the Old Ashmolean], lithograph, undated [c. 1823]. OUMNH Library and Archives, Buckland Collection.

other qualities such as weight, temperature, texture, smell or taste and, in certain cases, even the sound of specimens when struck.

As we can be sure Buckland commissioned the lecture room print personally, we can also interpret it as advertising his presentation of his collections to the University in that year, and that as a mark of honour he was in turn awarded a space specially appointed for his collections on the raised ground floor of the prestigious, ancient Museum building (Hall 1823). Buckland continued adding to his collection up to the late 1840s, when he was forced to suspend his lecturing work due to illness. On his death in 1856, his will revealed that he had made a second gift to the University of all the additional material accumulated by him in Oxford since 1823 (Gordon 1894).

An overview of Buckland's collections and how he acquired them

In terms of the related histories of science, museums, collecting and material culture more generally, Buckland's collection would provide an interesting case study in the same way that the collections of Sir Hans Sloane (1660–1753) at the Natural History Museum, British Library and British Museum or the ceramics of Henry De la Beche (1796–1855) at the Museum of Practical Geology have been analysed (Newell 2017; Ortolja-Baird and Wickendan 2019). Identification of Buckland's collection is a necessary first step at OUMNH: over approximately the last fifty years curators have been recording associations with Buckland against catalogue records, however, this exercise poses difficulties as his collection has, for the most part, long been integrated into the Museum's broader holdings. We are fortunate that Mary Morland (1797–1857) took on the important task of the curation of Buckland's collection following her marriage to him on 31 December 1825. Her inscriptions, written in a characteristically neat hand, are a fool-proof way of linking many specimens to Buckland (Buckland 1858; Gordon 1894; Figure 3). He had been collecting for around fifteen years prior to his marriage, so it is not surprising that his own notoriously erratic handwriting can be found on some specimens, either inked directly onto their surface or on applied paper labels (Figure 4). However, as is often the case with historical items, original inscriptions and paper labels have sometimes degraded or become lost over time, and we can assume that not all of Buckland's specimens have been identified.

Buckland collected hundreds of geological specimens in the field himself and he certainly also bought items from quarrymen, miners, fossilists and dealers working in the numerous localities he visited. A number of his important palaeontological items have received attention in recent years, such as the *Megalosaurus* specimens that were the subject of his first important paper on fossils to the GS (Howlett *et al.* 2017). Some distinct groups have been documented, such as the items he collected on his first European tour in 1816–17 (Torrens 1998). Buckland also acquired contemporary examples of fauna and flora for the purposes of comparison with extinct species. In fact, a benefit of my own research is that

Figure 3. Tooth of **Nothosaurus giganteus** *Münster, specimen inscribed by Mary Buckland 'Muschel Kalk' with the location where it was found, 'Lunéville'. OUMNH GZ.139.*

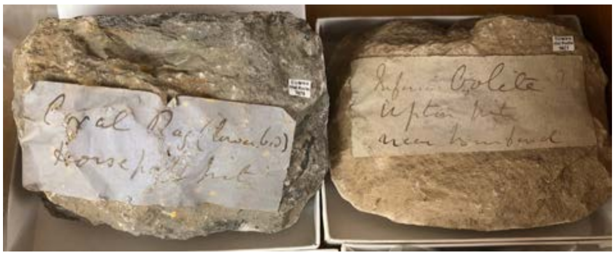

Figure 4. Rock specimens with labels inscribed by William Buckland, 'Coral Rag (lower bed) Horsepath pit' and 'Inferior Oolite Upton pit near Burford'. OUMNH Hist. Rocks 1670 and 1671.

connections to Buckland are now being re-discovered, including some regarding specimens that have always been in the Zoology and Botany collections of the Museum. In addition to comparisons with living species, analogies with objects of various other kinds were also important for Buckland, and he actively sought out items that could illuminate the basis for his theories. For this reason, a number of antiquarian objects were originally part of his collection (Buckland 1860). These were bought in curiosity shops, presented by friends or were even tourist souvenirs collected on his travels.

As Buckland's fame grew, many people, sometimes completely unknown to him, wrote to tell him about interesting geological features or finds in their local areas. As well as asking for his help in identifying them, they often sent him fossil specimens for the Museum. This diverse group included men and women who were often avid collectors with an in-depth knowledge of their particular regions (Figure 5). Buckland's students were helpful too in expanding his collection on occasion by providing specimens, prints or casts of items in their own collections. There can be no doubt that it was Buckland and his teaching that inspired many of them to collect, and among this group were aristocrats with deep pockets, such as William Cole (1807–86; Viscount Cole, later 3rd Earl of Enniskillen), Philip de Malpas Grey Egerton (1806–81), and Walter Calverley Trevelyan (1797–1879; Figure 6), as well as young men of more modest means such as Andrew Bloxham (1801–78), the son of a schoolmaster at Rugby (Buckland 1822). The notion of social capital accrued from collecting and gifting has been explored by post-Marxist scholars, but at the time these donors often expressed a wish to oblige Buckland and appear to be motivated by a sense of wanting to assist in the furtherance of his research and teaching (Smart 1993).

Another category of acquisition in Buckland's collection can be defined by links to learned men in his extensive network of acquaintances. Buckland was typical of his time in being keenly aware of his own status and that of others involved in developing new knowledge. These men engaged in a reciprocal exchange of publications, specimens, or casts of specimens that were too valuable for them to part with (Thackray 1985; Rudwick 2000; Taquet 2003). Some donors were active in the GS like him, and of these a small number were themselves teaching, such as the Woodwardian Professor of Geology at Cambridge, Adam Sedgwick (1785–1873). Others were based overseas and included the universally admired naturalists Alexander von Humboldt (1769–1859), and Georges Cuvier (1769–1832), Director of the Muséum d'Histoire Naturelle in Paris (Figures 7A, 7B). Buckland counted all these learned men at the centre of scientific research among his 'geological friends' (Buckland 1840).

A different network that contributed to Buckland's supply of specimens can be found in his links to official bodies. Through the support of Lord Bathurst (Secretary of State, 1812–27), John Barrow (Second Secretary to the Admiralty, 1804–45) and the eminent natural scientist Sir Joseph Banks (1743–1820), Buckland acquired specimens from global locations associated with Britain's programme of colonial expansion. The principal collections from naval expeditions went to the British Museum, but Buckland was sometimes allowed to keep duplicates for teaching purposes. At Bathurst's request he drew up instructions for collecting and these were sent out to all colonial outposts in 1819 (Buckland 1819, 1820). These soon had an effect as crates of speci-

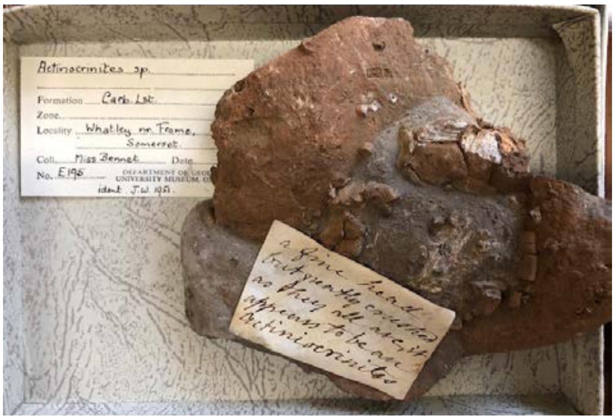

Figure 5. **Actinocrinites** ***sp., a specimen from Whatley near Frome, Somerset, donated and labelled by Etheldred Bennet. Bennet was a collector who became a specialist and published author on the fossils of her region. OUMNH E195.***

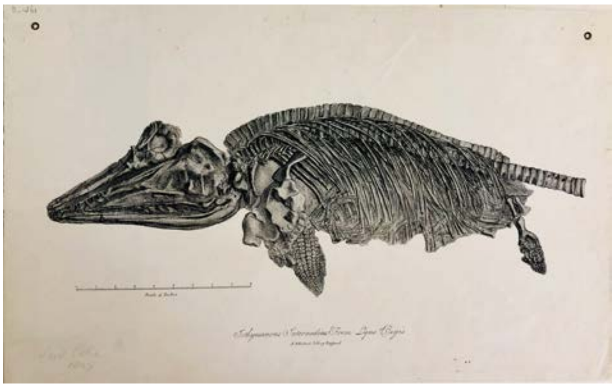

Figure 6. N. Whittock, [undated, c. 1827]. **Ichthyosaurus intermedius**, *from Lyme Regis. Lithograph presented by Buckland's student, Viscount Cole, inscribed in Buckland's hand, 'Lord Cole 1827' (This specimen is now in the Natural History Museum, London, NHMUK PV R 1072). OUMNH Library and Archives, Buckland Collection.*

mens from different regions of the globe eventually arrived in Oxford. For these reasons, while the main strengths are British, geological specimens from Europe, North America, Russia and Australia are also included in Buckland's collections.

Examples of the teaching potential of objects from Buckland's collection

The following examples have been drawn from across Buckland's collection and comprise a palaeontological specimen, illustrations commissioned as teaching diagrams, a cast and a 'found object', in this case a fragment of iron pipe. In addition to characterising Buckland's collection, they will serve to demonstrate how historical collection items could be used to illuminate a range of themes in practical teaching sessions. None of them has featured in the literature to date.

My first example comprises a group of mammoth bones given to Buckland by Captain Frederick Beechey (1796–1856) in 1829 (Figure 8). In 1825, Beechey had set off in command of the Blossom on a voyage to the Bering Strait. This trip was one of a series of exploratory voyages undertaken by the British navy as part of the country's programme of imperialist expansion following the end of hostilities in Europe after the Napoleonic Wars. Beechey published an account of his travels, with an appendix by Buckland on his geological findings in the Kotzebue Sound region of North-West America, now Alaska (Beechey 1831). He wrote, "I found Mr. Collie [Alexander Collie, the expedition's surgeon] had been successful in his search among the cliffs and had discovered several bones and grinders of elephants and other animals in a fossil state, I bestowed the name of Elephant upon the Point, to mark its vicinity to the place where the fossils were found....", (Beechey 1831). The bones turned out to be mammoth rather than elephant, and as was the norm with official expeditions, these and other finds went to the British Museum. In acknowledgement of his work on identifying the bones, Buckland was allowed to keep a small group for his teaching collection in Oxford.

The remains of Pleistocene mammals are regularly found in Alaska today (University of Alaska Museum of the North undated). However, two hundred years ago such discoveries were considered rarities in Europe, and these bones could be used to make a powerful statement about the consequences of accelerated climate change today. Prints in Buckland's collection commemorating the discovery of mammoth bones (including complete skeletons in the USA) would serve to re-capture the wonderment experienced by the public following scientific discoveries that are relatively commonplace now. For example, in the early nineteenth century, enterprising showmen toured mammoth skeletons around major cities, presenting them to the paying public as scientific curiosities (Altick 1978; O'Connor 2008). The bones would also serve to illustrate the historical interest in polar exploration and its relationship to imperialism and cultural appropriation. Other items

Figure 7. **Paleotherium** *skull, painted cast sent by Georges Cuvier, c. 1821–2. OUMNH LZ11/p. 7A (top). oblique view. 7B (bottom), underside of cast, inscribed 'Rev. W. Buckland Oxford' 'Buckland' and 'genior pinxit 1821'*

Figure 8. Two mammoth femur bones, inscribed 'Captn Beechey Escholtz Bay 1827'. OUMNH Earth Inventory 01749.

in the collection, particularly mammoth teeth found in various locations in Britain, could reinforce the broader point about the changing climate and extinction of certain animal species following the end of the Ice Age in Northern Europe.

A teaching illustration showing a hippopotamus by Mary Morland is my second example (Figure 9). It seems likely that Morland could have met Buckland through Professor Pegge, his lecturer in comparative anatomy, as she was partly raised in Oxford as a member of Pegge's family. However, she developed her interest in science from a young age and had her own natural history collection including fossils and minerals (Kölbl-Ebert 1997). She was respected in her own right as a natural history artist before she is known to have worked for Buckland, and had even supplied detailed lithographic drawings of specimens for inclusion in Cuvier's magnum opus of early comparative anatomy, *Ossemens fossiles* (Cuvier 1821-1824; Gordon 1894; Howlett *et al.* 2017).

The drawing shows another side of Morland's abilities as, presumably at Buckland's request, she made this teaching illustration of a hippo. The animal's benign appearance can be accounted for by the fact it has been copied from the encyclopaedia of natural history published by the Comte de Buffon (1707–88) (Buffon 1749–88). This contained thousands of representations of animals that were widely used as a source for educational manuals throughout the nineteenth century (Cambefort 2001). Mary has copied, enlarged and coloured Buffon's small original engraved vignette to create an illustration on high quality paper specifically for use in the lecture room. We know this was the purpose of the drawing as it has been fitted with brass eyelets at the corners to allow it to be pinned up without damaging the paper.

Before 1850, when Obaysh, a male hippopotamus, arrived in London Zoo causing a sensation, it is unlikely any of Buckland's students would have seen a live hippo, so knowledge of the species was mediated by Buffon's publication, interpreted in turn by Morland (Herrmann 2020). The bones of extinct species of hippo had been identified by Buckland in the Yorkshire cave at Kirkdale in 1823, and among the specimens sent from Myanmar (then Burma) by the diplomat John Crawfurd in 1828 (Buckland 1823, 1828). In order to teach effectively with these, as a follower of Cuvier's method of comparative anatomy, Buckland would have needed an illustration of the living animal to display alongside the bone specimens of the extinct related species.

In the same way as the print of Buckland teaching shows him combining specimens and visual representations, this illustration (Figure 9) could be used in various ways as a 'museum object', alongside relevant palaeontological specimens in teaching. Although hippos are obviously a familiar animal from wildlife documentaries and zoos now, the point about the former range of such species still needs to be made. The presence of these and other African animals in Asia and Britain must have seemed farfetched before plate tectonics theory was accepted in the twentieth century, and this fact still elicits a good deal of wonder from children learning such facts today. The fossil evidence that was discovered in Buckland's time provided early pieces of the jigsaw of evidence that over the course of nearly two centuries led

Figure 9. Mary Morland, (1797–1857). Teaching illustration of a hippopotamus, signed 'MM' for Mary Morland, undated [c. 1822–5]. Watercolour with annotations in Buckland's hand (illegible), 48 x 35 cm. OUMNH Library and Archives, Buckland Collection.

to this major advance in geological knowledge. The illustration (and relevant specimens) would make it possible to historicise these discoveries appropriately. It would also help in recovering the often invisible contribution made by many women in the construction of scientific knowledge, even when, as here, their role was subservient to their husbands'. The materiality of the drawing adds another dimension to its interest, from the expense of fine hand-made paper that constitutes its support and the watercolour paints probably sourced in an Oxford stationers, to the fashion for drawing and, more especially, natural history illustration that was seen as an acceptable occupation for genteel women at the time.

This next example is another teaching illustration depicting '*Ichthyosaurus Tenuirostris*' (Figure 10). Dr Michael Taylor has linked this to Plate 9 of Buckland's Mineralogy and Geology (Buckland 1836; M. Taylor pers. comm. 2019). The specimen depicted belonged to the Rev. David Williams of Bleadon near Glastonbury in Somerset, now lost (Taylor 2016). Close examination of the canvas reveals the outline was drawn in pencil, suggesting it was probably drawn around fragments and individual fossil bones carefully laid out on the canvas like an enormous jigsaw. Although unsigned, by virtue of the quality of the work it is unsurprising to find archival evidence corroborating that George Johann Scharf (1788–1860) was the artist (Scharf 1833). Scharf was a talented Bavarian artist and illustrator who worked in London from 1816. The drawing is an eloquent stand-in for a magnificent specimen which, even if it had been available for purchase, would have been beyond Buckland's reach by virtue of its size and value. The archival evidence confirms that he arranged for the specimen to be packed up and sent to him for examination in Oxford in 1833 before sending it to Scharf in London.

This massive detailed drawing and the archives that add to its story have added value today as the original specimen cannot now be traced. As an illustration, it cannot fail to impress by a combination of its extraordinary size and detail and the artist's skilful rendering of light and shade, imbuing the specimen with a glowing presence. The effect of this drawing would have been doubly striking in a lecture, as the size could be asserted as the animal's natural size. The quality and scale of this life-size illustration would be equally impactful for students today. The choices Buckland made around this commission il-

Figure 10. George Johann Scharf (1788–1860). **'Ichthyosaurus Tenuirostris'**, *teaching illustration. Gouache on fine canvas, 95 x approx. 350 cm. OUMNH Library and Archives, Buckland Collection.*

luminate the traits of his personality that combined to make him so famous as a teacher in the nineteenth century. He spared no expense or effort in procuring teaching materials, he was meticulous, insisting Scharf corrected the drawing (the overpainting is clearly visible) and he loved spectacle—we can imagine Buckland getting his students to help unfurl the long canvas and pin it up, setting the scene for a spell-binding lesson on the gigantic extinct marine reptile. It also demonstrates the limits of reconstruction, an area that continues to exercise the ingenuity and skills of scientists today (Symposium of Palaeontological Preservation and Conservation 2020).

This teaching diagram would link to the theme of women in science, as Mary Anning was responsible for finding the first complete ichthyosaur specimen in 1819, thereby making a significant contribution to knowledge about the species (Conybeare and De la Beche 1822; Conybeare 1824). Anning, as an example of an individual disadvantaged by her class and gender, yet making important contributions to new scientific knowledge, has been explored in a variety of contexts for teaching children, although not usually with objects (Clary and Wandersee 2015). The role of the artist is also worthy of consideration, for in his illustration Scharf has managed to combine the anatomical accuracy demanded by Buckland with capturing the inherent drama of a giant extinct animal. In any practical session using the illustration it would be relevant not only to show palaeontological specimens from Buckland's collection, but also the well-known lithograph by Henry De la Beche that imagined the habitat of these and other extinct marine reptiles, Duria Antiquor (Ancient Dorset). This reconstruction, drawn in a light-hearted vein and produced cheaply to raise money for Anning, was one of the earliest contributions to the field now called palaeoecology (Rudwick 1992).

A section of a cast iron water pipe containing a flowstone is an example of Buckland's pragmatic approach to teaching with objects (Figure 11). The surviving notes from his Mineralogy Lectures allow us to identify this section as part of a length of pipe, partially blocked by calcareous deposits (Buckland undated). He refers to it as having come from 'Carfax', the central Oxford street next to St Martin's Church, Carfax, when a replacement had to be installed. Given Buckland's interest in civic improvements relating to water supply and his propensity to seize every opportunity to acquire teaching items, it is likely he salvaged the pipe himself from the workings (Buckland 1858).

Figure 11. Flowstone, calcium carbonate deposits in a section of a cast iron water pipe. OUMNH Misc. Rocks 0262.

This item might initially pose a conundrum to students today as it is a hybrid object, part industrial archaeology, part natural material (calcium carbonate). However, observation and handling would allow many to identify this 'mystery object', as residents of Oxfordshire as well as many other areas of Britain, tend to be familiar with the concept of hard water. Without the context of teaching mineralogy, they might have more trouble in understanding why someone would take a slice from the pipe and preserve it. Notes taken by one of Buckland's Oxford students, John Henry Newman (1801–90), confirm that is exactly what Buckland did. He used sections of the pipe as a handling object in his own lectures to illustrate the process of 'petrifaction' (Newman 1821 in Boylan 1984, Appendix 1). Buckland drew an analogy between the formation of stalactites and stalagmites and the calcareous deposits found in kettles, and until recently this object was on display at OUMNH in this context, although without reference to Buckland.

In terms of the history of museums and collecting, this flowstone is an example of the rejection of customary hierarchies of value in relation to objects. Provided they served to illustrate a point in teaching, Buckland was just as likely to use a section of discarded old pipe as other more expensive objects in his collection, such as the finely crafted stone tablets illustrating the still recent geological knowledge regarding the importance of stratigraphical sections. Buckland bought several of these from White Watson (1760–1835) the Derbyshire mineralogist, surveyor and dealer who generally supplied these cabinet objects to wealthy collectors, including the Duchess of Devonshire (Ford 1960). These could be introduced into a handling session together with other calcified everyday objects (a bird's nest, a bunch of grapes and a crayfish) that Buckland bought during his honeymoon tour of the continent with Mary in 1826. The flowstone can be interpreted as an example of 'the transformation of objects' described in Michael Thompson's 'Rubbish Theory'. This theory can provide a useful framework in the history of collecting as it asserts that objects have no intrinsic value other than those awarded to them by societal mechanisms (Thompson 1979).

My final example is a sandstone slab containing trace fossils of a Permian tetrapod from Scotland (Figure 12). This is a historic object on many levels as it is part of a group of specimens and casts that mark the beginning of the scientific study of trace fossils. In a letter of 11 June 1827, the Rev. Dr Henry Duncan of Ruthwell, Dumfries and Galloway, wrote to Buckland (known to him only 'by fame'), and gave a preliminary account of impressions discovered by workers in a quarry near his home. Duncan had noted their resemblance to animal footprints and he proposed sending Buckland a cast to get his opinion on the matter (Duncan 1827). By September this slab was among those Duncan had arranged to have extracted from the quarry to send to Oxford, and Buckland, who had reserved judgement until then, endorsed Duncan's speculation and set about making his own experiments to determine the type of extinct species responsible for the footprints. His wife, Mary, was enrolled in these endeavours, as were various family pets, including his son's tortoise, and a quantity of dough (Gordon 1894). The result was that Buckland pronounced the tracks to have been made by an extinct type of tortoise, and thus made the first ever identification of a trace fossil (Pemberton *et al.* 2007).

Today, museums choose to interpret trace fossils in various ways, among which are painted reconstructions that often include models and even holograms to evoke, as realistically as possible, the extinct animals responsible for the footprints and their environment. Duncan's recognition of the impressions as animal prints was of paramount importance in the historical narrative of this type of fossil, which continues as an important area of research today. Buckland's collection provides an opportunity to highlight the value of Duncan's and his own his contribution in creating a new branch of palaeontological knowledge and research (Boylan 1997). In effect, through his analogical experiments with living animals, Buckland founded the ichnological approach to understanding trace fossils that includes considering the shape, size, weight and stride length of related living animals to construct knowledge about extinct species. The specimens Duncan sent to Buckland in 1827 (the slab illustrated here, another similar and the original cast) all survive and are therefore key objects.

Figure 12. Chelichnus duncani, trace fossil of Permian tetrapod (tortoise), original sandstone slab, Corncockle Muir Quarry, Dumfriesshire. OUMNH F188.

Related items in Buckland's archive of teaching illustrations include diagrams of the footsteps of many different animals and birds that were developed from these early researches, as well as fine prints made to publicise subsequent discoveries. The specimens could also provide a starting point for discussing knowledge networks in science that relied on collaboration, discussion and the exchange of specimens and casts; the intertwined role of his research and teaching using specimens and diagrams; the importance of casts in the nineteenth century and their underappreciated role in the history of palaeontology; the role of the quarry workers in finding, extracting and transporting building stones and their contribution to palaeontological discoveries (Tresise 2003); and again, women in science, as Mary worked with Buckland to develop those initial experiments. Beyond geology and the history of science, these related objects provide other potential opportunities: for example, in 2019 the inherently comic aspects of Buckland's research were exploited by undergraduates studying Illustration and Design at Plymouth University to produce reconstructions for use with members of the public (particularly children) in the Museum.

The advantages of object-based teaching with historical collections in tertiary education

In the limited range of examples above I have provided a number of possible areas where Buckland's specimens could be mobilised, either in the context of adding to the teaching of geology proper or in many different socio-historical fields. There is a wealth of stories waiting to be exploited in historical museum collections that could go far in engaging undergraduates embarking on unfamiliar areas of study. While additional planning may be involved in the procurement of specimens and preparation for such teaching sessions, as mentioned in my introduction, interaction with objects can yield additional benefits that take students' interest to another level.

Studies about the way we investigate objects through the senses have a particular resonance with Buckland's own biography for, in the course of his own fieldwork and teaching (as mentioned above), he is known to have used and encouraged his students to use, touch, smell, hearing and taste, as well as close observation to investigate specimens. Obviously, engagement with museum objects today cannot extend to this degree due to conservation, health and safety concerns, but much can still be gleaned from the close visual and haptic examination of objects. While Buckland was careful to explain the scientific rationale for his sensory exploration of specimens, accounts of these incidents generally focussed on their absurd or comic aspects, resulting in charges of eccentricity against him in the literature (Sommer 2004; O'Connor 2008).

Researchers today in the fields of education and psychology refer to multi-sensory engagement with objects as a feature of 'kinaesthetic' or 'somatic' learning, i.e. through the body, and have demonstrated that it has benefits on various levels, irrespective of the students' particular courses of study (Sharp *et al.* 2015). Aided by a teacher trained in non-didactic methods to present the objects and prompt the students, these can include 'physical, emotional and cognitive engagement' that can tap into different types of non-verbal intelligence and stimulate learning and memory. Object-based teaching can also provide students from very different backgrounds the opportunity to open up and express themselves in ways that can break down barriers and contribute to a sense of shared experience and community.

A recent survey investigating the effects of attending object learning sessions on Oxford University students bears out these positive conclusions (Notaras *et al.* 2020). The sessions were conducted by Dr Jim Harris, Andrew W. Mellon Teaching Curator, in the Ashmolean Museum of Art and Archaeology. Teaching in this way is reputed to work best when students have no prior background knowledge of the objects because it is then that they operate on a level playing field and can use the objects to reflect and draw on their own experiences. In the survey, English Literature students were asked about their sessions with Dr Harris that used archaeological objects. The students were prompted to engage with the objects by articulating their sensations, attitudes and values, and their survey responses revealed that they found the interactions stimulating and enjoyable, as well as challenging to their assumptions. This approach is the opposite of the passive reception of knowledge that may have characterised the learning experience of many students. Impressions, feelings and memories are shared and validated in a supportive learning environment where knowledge is built up collectively, often benefitting from multi-cultural references.

In addition to enhancing and enlarging the tertiary curriculum, early secondary and lifelong learning students can also utilise museum collections. Children and adults of all abilities and ages can benefit from object-based learning within the museum setting as such learning requires no prior knowledge, depending rather on close observation and questioning. Low literacy and confidence levels, in particular, pose no barrier to the potential value of such sessions.

Conclusion

More than two hundred years have passed since Buckland started assembling his Geological Museum collection of specimens, illustrations and models. He viewed objects as evidential proof of new geological facts, thereby embodying epistemic content, and, as such, the practice of handling and showing them underpinned his teaching. I have demonstrated that in a contemporary setting, historical objects could illuminate multiple themes current in education today. Object-based teaching that includes object handling has additional potential, and at a later stage of my project I intend to put all of this to the test in sessions with a mixed group of undergraduates from different disciplines. I will then be able to follow this essentially speculative proposition about the potential of historical collections in teaching, with reports of how students actually responded to teaching sessions using such different types of objects. Reflecting on Buckland's example, making use of his collections in the university context now would have a pleasing symmetry from the history of science viewpoint, but, first and foremost, I believe the use of his or similar collections in hands-on sessions would enrich the learning experiences of students today. Historical collections provide a rich seam of material for public engagement at various levels, and their reassessment could even potentially attract project funding to develop their use with different audiences and safeguard their future.

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The history, state and reinterpretation of the palaeontological collection at Folkestone Museum

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The Folkestone Museum was moved to a new home in the Folkestone Town Hall in 2017 as part of a UK Heritage Lottery Fund project. The collection includes around 1,000 geological specimens, many of which were acquired in the 19th Century. During the project, examination of the palaeontological collection in particular revealed new insights into its history. Information gathered from diverse sources, including online collections, blogs and published literature, have helped to reveal some of these previously unknown aspects. For example, the museum holds fossil material from important names in the history of palaeontology including Etheldred Benett and Gideon and Mary Mantell. They also provide tangible evidence of a rich culture of exchanging fossil material going back to the early 1800s. The work also shows the potential for using old labels, associated documents and online resources to improve understanding of the history of geological collections. This also demonstrates the importance of caring for old labels and associated documentation and the importance of specialist knowledge. The curatorial state and use of the collection are not to the highest potential and recommendations to address this are given. This paper also describes aspects of the new interpretation at the museum, including using 3D-printing to create handling exhibits.

Hadland, P. 2020. The history, state and reinterpretation of the palaeontological collection at Folkestone Museum. *Geological Curator* **11** (4): 295-306.

Introduction

The founding collection of the Folkestone Museum (Folkestone, Kent, UK) was the palaeontological collection of Samuel Joseph Mackie. On 18 February 1857, following insolvency, his fossil collection was sold at auction to local tradesmen for £33. This was reported in the Folkestone Chronicle as follows:

> "Sale of Fossils. - The very large and splendid collection of Fossil remains and geological specimens, collected by Mr. S. J. Mackie, and which we have before alluded to, were bought to the hammer on Wednesday last, and after some spirited biddings, were ultimately sold for only £33. They were purchased by several of the tradesmen, who united together for the purpose if possible of preserving them in the town, and we believe they are still open to the town of the committee of the Harveian Institution, at a very moderate advance on the cost, so that we hope to see one of the other of these parties at once endeavour to secure them, as the foundation of a museum, the utility of which as a public institution, both to visitors and the inhabitants generally must be apparent." (Anonymous 1857a: p. 8)

The collection was later repurchased by J. G. Breach, the proprietor of the Pavilion Hotel who then presented it to the town. This was reported in the South Eastern Gazette as follows:

> "Mr. Mackie's Collection of Fossils, &c. – We have much pleasure in announcing that the splendid collection of fossils, &c., lately sold by auction, have been re-purchased by J. G. Breach, Esq., and will be presented to the town. We trust this corporation will, in making their improvements at the Town-hall, apportion one large room for a museum." (Anonymous 1857a: p. 5)

The Town Council then hired a room from Mr. Dunk in Tontine Street for one year to be used as a temporary museum (Anonymous 1857b). The museum stayed at Dunk's until about 1862.

By 1868, the collection was kept at Sessions Hall, a Borough Council premises on the High Street. Soon after this point, the Folkestone Natural History Society, which had its first meeting on 4 April 1868 (Folkestone Natural History Society 1868) became involved. Noting that the collection was "in sad disorder" the society wrote to the mayor, aldermen and councillors of the borough of Folkestone. In return for use of the space for meetings, lectures and to display their own collections, they would take on the task of curating the existing collection and make it available for public viewing. Initially there was no agreement due to various punitive conditions laid out by the borough council (Folkestone Natural History Society 1869). However, an agreement was later reached and the museum opened under the charge of the society on 4 October 1870 and the Council paid for a curator named John Ashtell (Folkestone Natural History Society 1871).

In 1888, the Natural History Society fulfilled its aim of establishing a permanent home for the collections within a purpose-built Museum and Library on Grace Hill. This was all part of the Grace Hill development promoted by the Town Council. Their first meeting there was held on 15 May 1888 (Folkestone Natural History Society 1888). John Ashtell continued as curator.

The museum flourished in its early days and up to World War 2 with donations of large geological collections and other natural history material from the Hon L. Walter Rothschild MP, Tring (Cross *et al.* 2016). There were over 2,000 accessions between 1887 and 1944 and very little (fewer than 100 accessions) was added to the collection between the end of World War 2 up to 2016 (Cross *et al.* 2016). Into the late 20th Century and early 21st Century, as with many local-authority-run institutions, the museum and its collections suffered during periods of recession, upheavals and changes in staffing.

There was a lack of consistent collections management and input by subject specialist collections staff between the 1980s and 2010s. Recommendations for peripatetic collections care based on survey work (Knell 1986; Timberlake 1995a, b) were unfulfilled. This lack of investment in the collections has resulted in a lack of institutional understanding, a patchy quality of cataloguing and limited use of the collection for engagement and research. There have also been governance changes over the years, such as the formation and later break up of a County Wide Museum Service in Kent, which have had a mixed impact. In the early 2000s the museum ceased to operate and collect, and the displays were replaced by open storage at Grace Hill, which was occasionally open to the public and supervised by volunteers. In 2015, funding from the Heritage Lottery Fund was awarded to create a new museum in the Town Hall.

From July 2016 and into early 2017, work proceeded to prepare and move the collections to the new museum within the Town Hall on Guildhall Street. Since then, new material has been added to the collection and UK Museum Accreditation regained. New acquisitions include important donations of recently discovered dinosaur footprints (Hadland 2012, 2018) and other fossils from the local Lower Greensand and Gault Formations which are Cretaceous Albian in age (Hadland 2018). The new museum opened in May 2017. Time, although limited, enabled some documentation work on the geological collection, but this remains unfinished, and the collection is not yet fully catalogued to the SPECTRUM standard (Gosling and McKenna 2017). It should be noted that the museum also holds a number of mineralogical and petrological specimens.

Summary of the makeup and state of the fossil collections

The palaeontological collection is mostly comprised of Cretaceous marine fossils collected from Folkestone's coastal outcrops and Pleistocene mammal bones from inland temporary exposures in the town. This local material comes from the Cretaceous Lower Greensand (Albian stage), Gault Formation (Albian stage), Chalk (Cenomanian – Turonian stage) and some Ipswichian to Devensian age Pleistocene deposits. From elsewhere in England, there are Lower Cretaceous dinosaur bones from Kingsnorth in Ashford (Kent) and Brook Chine on the Isle of Wight, Chalk fossils from the East Sussex area and Jurassic fossils from West Dorset, Wiltshire and Leicestershire. Jurassic material of note includes cut and polished ichthyosaur jawbones from Barrow upon Soar (Leicesteshire) that were donated by one-time curator A. M. Browne Anderson (Timberlake 1995b; Cross *et al.* 2016). The small amount of Palaeozoic material present includes fossil fish from the Devonian Old Red Sandstone of Scotland, which were donated by a J. W Webster (Timberlake 1995b).

Several well-known local collectors are represented in the collection, including John Griffiths and Samuel Mackie. Reports on the collection (Knell 1986; Timberlake 1995a, b) identify a number of these. Other notable collectors mentioned as having material in the Folkestone Museum collection include Etheldred Benett (Cleevely 1983; Knell 1986; Timberlake 1995b).

There have been various disposal events, including in the 1950s (Knell 1986), for which records are seemingly absent, but some material relating to this is apparently at the British Geological Survey (Knell 1986). There have also been losses due to pyrite decay (Knell 1986; Timberlake 1995b). Some of these specimens have been conserved in the past but a number await conservation.

Most of the fossil collection can be linked to stratigraphic units and localities. However, the cataloguing of the collections is not as good as it should be. Many superficially similar, yet quite separate and often very different specimens share the same number. This has led to difficulties in maintaining SPECTRUM standard location controls and poor accuracy of identification. Some parts of the collection, especially the Gault Formation fish and Pleistocene mammal material, need better identification and are also worthy of further study by specialists.

Work on the Fossil Collections

As Heritage Support Officer – Collections, employed by Folkestone Town Council, my main tasks were to prepare the entire collection (including the social history, archaeology, fine art and biological collections) for the move to new storage at the town hall, put in place collections care systems and also to develop interpretation and interactives for the new displays. This work was generously supported by several volunteers. There was little time for in-depth research, but the packing of the objects for display and transport enabled some inspection of much of the fossil material and some insight into the history of the collection. The new findings come from combining observations made from previous visits to assess the collection (Knell 1986; Timberlake 1995a, b) with:

- Conversations with other people who had knowledge of the collection.
- Observations in related publications on the history of collection.
- An internal catalogue of old registration receipts compiled by volunteers.
- Online collections content provided by museums with related collections.
- Visual inspection of the collection.

Collectors

The following is a summary of some of the associations identified of which some have either not previously been confirmed or published.

John Griffiths (c. 1829–30 July 1911)

John Griffiths was a skilled preparator and often preserved fossils he found on distinctive clay blocks of the local Gault Formation (Figure 1A–C). Personal observation has revealed his prepared Gault fossils were so popular that they can be found among several museum collections in the UK. These include specimens in the Brassey Fossil Collection at Bexhill Museum, the Starkie Gardner Collection at Bolton Museum, the Natural History Museum in London and Oxford University Museum of Natural History (Figure 1A). One Gault specimen of a fossil crab fitting the same preparation style is observed overseas at the Museum of New Zealand Te Papa Tongarewa and is part of the Mantell collection (Figure 1C). Other Gault material in the same preparation style can be seen at the Naturhistorisches Museum in Basel.

Griffiths' notable finds included the armoured dinosaur *Acanthopholis horrida* Huxley, 1867. The Folkestone Museum material from Griffiths includes fine specimens of Gault ammonites complete with rostra, rare articulated Gault crustaceans and probably the finest collection of Gault fish outside of the Natural History Museum, London.

Another of Griffiths' income streams seems to have been the sale of what have come to be known as 'Fossil Puddings' (R. Anderson pers. comm. 2008). These are shaped rounds or ovals of artificial matrix around 15 to 20 cm across with inserted fossils. It is thought these would have been sold to tourists in Folkestone. During a two-day session of volunteering in the old collection store in 2012 one of these 'fossil puddings', F2702, was located (Figure 1D). Fragments of another are in the collections of the Canterbury Museums Service (R. Anderson pers. comm 2008). As part of the new interpretation scheme, a small tribute to him in the form of a handling exhibit using a 3D print of one of the bones of *Acanthopholis horrida* was created (see later).

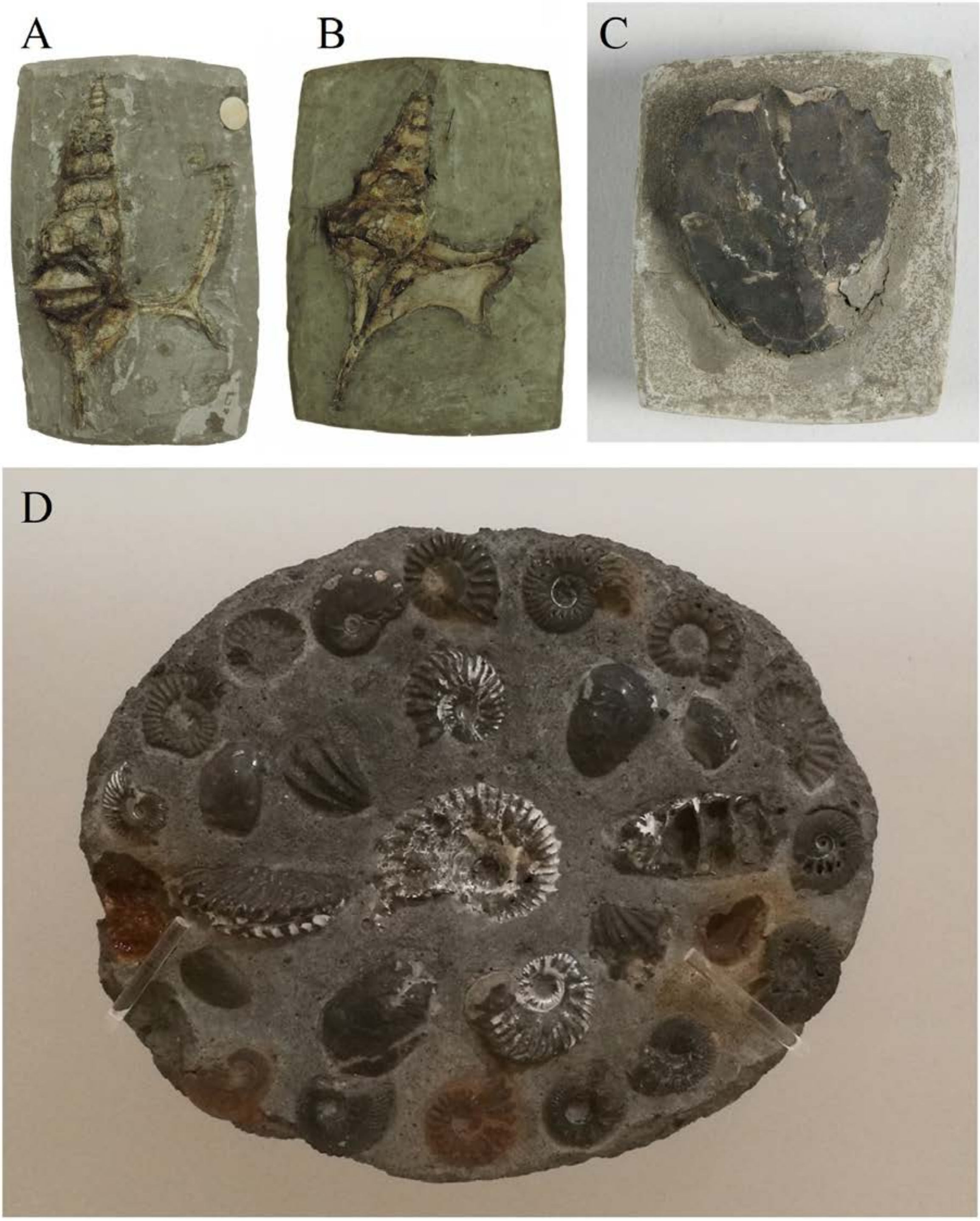

Figure 1. Top: Gault formation gastropod fossils and one crab fossil showing the distinct preparation style used by John Griffiths. A) Specimen in Oxford University Museum of Natural History (OUMNH K.37726). B) Specimen in Folkestone Museum (FOLMU F2933). C: Fossil crab from the Gault formation in the Te Papa Museum (46 x 29 x 42 mm; NMNZ GH23023). D) A Griffiths' "fossil pudding" at Folkestone Museum (width: 18 cm; F2702).

Etheldred Benett (22 July 1776–11 January 1845)

Cleevely (1983), indicates that there was material relating to Etheldred Benett in the collection, but neither of the visits by Simon Knell (1986) and Simon Timberlake (Timberlake 1995a, b) found any evidence. Examination of the collection during the collections packing phase of the museum project in 2016 confirms that there is material relating to Benett present. Labels in a printed form can be found on specimens she once owned (Spamer *et al.* 1989; Torrens *et al.* 2000). This insight also led to the discovery of 'lost' type specimens at the Academy of Natural Sciences of Philadelphia (Torrens *et al.* 2000). These are evidence of the value of geological collections for historians of geology (Wyse-Jackson 1999) and also the value of historians of geology for geological collections.

Etheldred Benett is known to have used small rectangular pre-printed labels (Torrens *et al.* 2000). Therefore, looking for similar labels was a good strategy to locate them. FOLMU F2431 (Figure 2A-B) is a specimen with a label fitting this description. It is a limestone cobble with an eroded reptilian vertebra with the characteristic printed label stating 'Lyme, Dorsetshire'. The label is consistent with other Benett labels shown in Torrens *et al.* (2000), including the use of an apostrophe and a full stop. Intriguingly there is second handwritten label (Figure 2B) which is tentatively attributed to Gideon and Mary Mantell.

Benett is known to have been in regular correspondence with the Mantels (Spamer *et al.* 1989; Torrens *et al.* 2000). It is also known from Gideon Mantell's journal (Cooper 2010) that specimens were exchanged between them a number of times. For example, entries state that on 16 September 1819 Gideon Mantell "Packed up fossils for Miss Benett" and on 26 March 1821 "'A parcel of fossils arrived from Miss Benett'" Other fossil specimens in the Folkestone collection were found with similar handwritten labels on blue paper, with horizontal lines above and below the text (FOLMU F2456, Figure 2F) so it is thought these could be others that were sent to Benett. The reverse is true to known Mantell collections in other museums, such as at the Museum of New Zealand Te Papa Tongarewa, where there are Mantell collection specimens with Benett-style printed labels such as an echinoid fossil (GH022863) from Wiltshire, UK (Figure 2C). This label is also consistent with other Benett labels shown in Torrens *et al.* 2000, with the use of an apostrophe and a full stop.

Another (non-fossil) item relating to Benett is also present in Folkestone. At Folkestone Library, where the museum collection formerly resided, is an 1820 geological map by George Bellas Greenough (1778–1855), which is annotated with her name (Grenough 1819). It is thought that this map would have been in the same donation as the fossils.

After Benett died, the majority of her collection was purchased by English expatriate and physician Thomas Bellerby Wilson (1807–1865) of Newark, Delaware, U.S.A., who donated it to the Academy of Natural Sciences of Philadelphia (ANSP; Torrens *et al.* 2000). It is possible that some of the various fine specimens of fossil sponges and other good specimens from Wiltshire in the Folkestone Museum collection may have been part of the original Benett material.

Gideon Mantell (3 February 1790–10 November 1852) and Mary Mantell (née Woodhouse; April 9 1795–October 20 1869)

The specimens thought to originate from the Mantells are identifiable via handwritten labels. The labels at Folkestone Museum are characterised by rectangular blue paper strips with inked lines across the top and bottom (Figure 2B and 2F). Another fitting this description and found on a specimen attributed to the Mantells is found in the Natural History Museum in London (NHMUK PV OR 4286; Figure 2D). It shows a label in the same style as 2B and 2F. Similar labels are also seen at the Museum of New Zealand Te Papa Tongarewa (Figure 2E, G) and may have been written originally on blue paper that has later faded. The handwriting on 2B, 2E and 2F are also very similar. However, further research is needed to verify the attribution of these labels to the Mantells.

It is thought that the specimens were acquired by Etheldred Benett through the exchanges listed in Gideon Mantell's diary (Cooper 2010), though it cannot currently be ruled out that some could have found their way to the Folkestone museum collection by other means. The different styles of handwriting may be the different hands of Mary Mantell (1795–1869) and Gideon (1790–1852), although differences in handwriting may also be due to changes in health or personal taste. Further assessment of other Mantell collection labels, associated handwriting and documentation could add further insight into who exactly wrote them and possibly even when.

There is also another specimen, without a label, that is related to the Mantells. This is a plaster cast of an '*Iguanodon*' tooth numbered FOLMU F2919 (Figure 2H). The cast, albeit not of the highest quality, is of one of the original Tilgate specimens now known to have been acquired by Mrs. Mantell (Simpson 2020). It is thought that this may have been sent along with

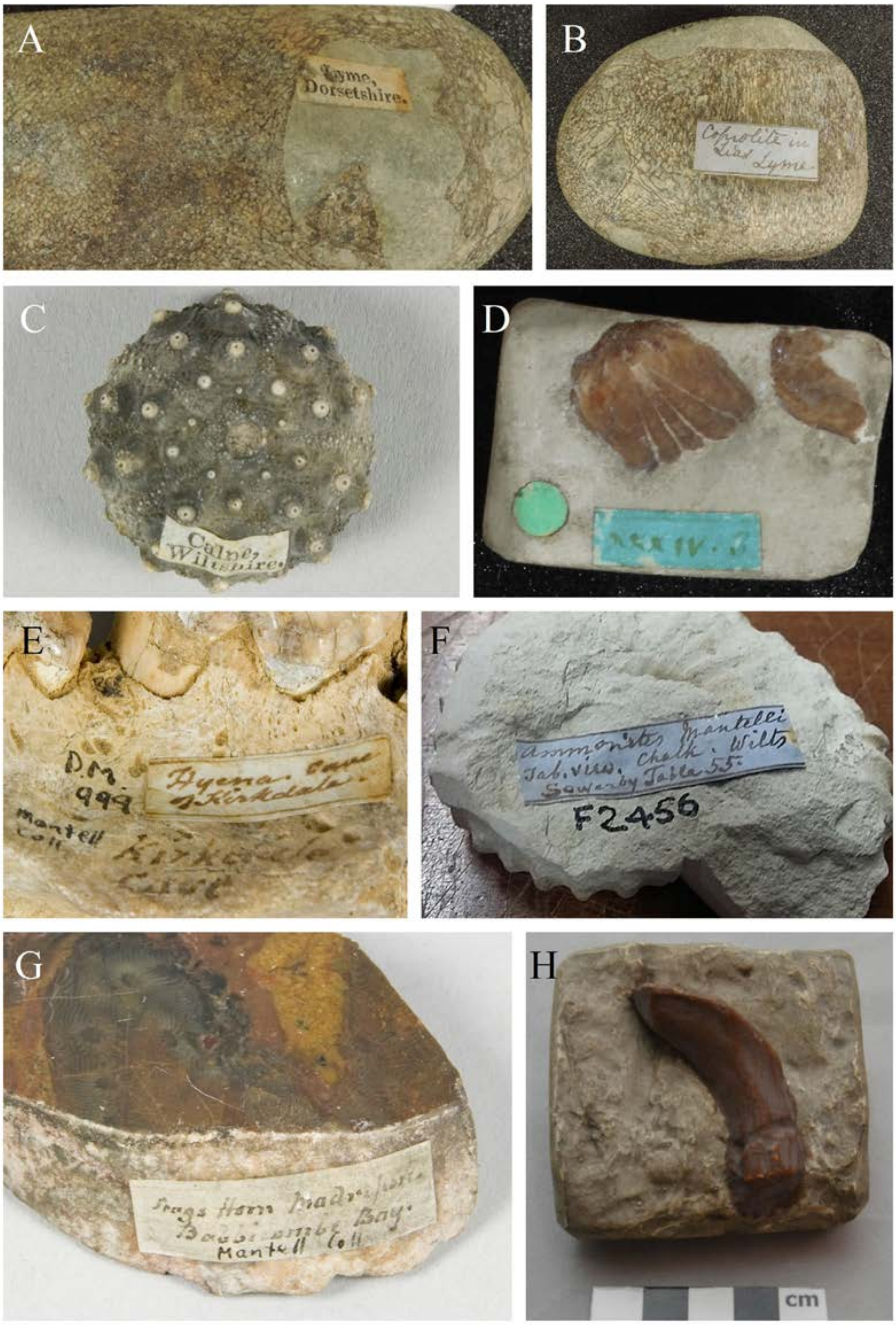

Figure 2. Various specimens with labels relating to E. Benett and the Mantells. Museums and registration number prefixes in brackets: Folkestone Museum (FOLMU), The Museum of New Zealand (GH) and the Natural History Museum, London, UK (NHMUK). A–B) Two views of a rolled limestone pebble (FOLMU F2431) containing a reptile vertebra from Lyme Regis, UK. On the left is the Etheldred Benett label. On the right is the Mantell label. C) Echinoid from Wiltshire, UK in the Te Papa Museum (NMNZ GH22863) with a Benett label (25 x 26 x 23 mm). D) **Osmeroides lewesiensis** *(Mantell, 1822) fish scale specimen from Lewes, UK from the Mantell collection with a similar style of blue label to those at Folkestone (NHMUK PV OR 4286). E) Specimen of a hyena tooth from the Kirkdale Cave, UK (NMNZ GH23077). F) Chalk ammonite from Wiltshire, UK (FOLMU F2456). G) Frogs Horn Madripore (fossilised coral) from Babbacombe Bay, UK (41 x 19 x 61 mm; NMNZ GH22959). H) Plaster cast of an* **Iguanodon** *tooth (FOLMU F2919). Figure 2C, 2E, 2G: © Te Papa. Museum of New Zealand - CC BY-NC-ND 4.0. Figure 2D: © The Trustees of the Natural History Museum, London - CC BY 4.0.*

other fossils referred to in Gideon's diary. Similar casts have turned up in other museums (Freedman 2014).

Henry Bean Mackeson FGS (11 December 1812–29 February 1894)

Henry Bean Mackeson was the proprietor of the family Brewery in Hythe (Kent, just west of Folkestone). Mackeson was a keen amateur geologist and became a Fellow of the Geological Society. He was also a committee member of the Folkestone Natural History Society. In 1840, when in his late 20s, he discovered part of the skeleton of a gigantic saurian in one of the Hythe Greensand quarries (Petrie 2017). This is now in the Natural History Museum in London and currently bears the name *Dinodocus mackesoni* (Owen 1844).

Registration records (Cross *et al.* 2016) suggest the remainder of his collection (six cases of fossils and minerals and books and maps) was donated by his wife to Folkestone Museum in 1896 when he died. It should be said of course that Mrs. Mackeson may also have been actively involved in the collecting of this collection. The question of what became of the bulk of this collection, as with other large donations to the museum, is uncertain, but it is probable that, given the description of the quantity, a significant proportion of the current geological collection at Folkestone Museum comes from this particular donation.

Mary Sophia Johnston FGS (1875–1955)

Mary Johnston, who was born in Folkestone, is known to have donated a number of flints and flint implements to Folkestone Museum (Cross *et al.* 2016). She was an active member and Fellow of many societies including the Geological Society of London and the Geologist's Association, and much of her palaeontological material was donated to the British Museum (Natural History), now the Natural History Museum, London (Burek 2009).

A passionate field geologist, collector, keen amateur photographer, illustrator and dedicated archivist, she became one of the first 13 female Fellows elected to the Geological Society on 21 May 1919 (O'Donnell 2019). Specific material collected by Johnston has, at the time of writing, not been identified in the collection.

Raymond Casey DSc, PhD, FRS, FGS, FRPSL (10 October 1917–26 April 2016)

Raymond Casey became interested in fossils as a boy after finding *mammilatum* bed nodules from the Lower Greensand containing numerous fossils ammonites in his back garden (Cuddeford undated). He went on to become a volunteer at Folkestone Museum (aged just 12) under the mentorship of the then curator John Walton (Cuddeford) and was involved with the museum over several decades, donating various local specimens from the Gault and Greensand (Cross *et al.* 2016).

Casey was later employed by the Geological Survey, going on to record fossil ammonite faunas from around the World. He described many type specimens now held in national collections, including those at the British Geological Survey, and was elected as a fellow of the Royal Society in 1970 (Rawson *et al.* 2020). As part of the new interpretation scheme, a small tribute to him in the form of a handling exhibit using a 3D print of one of the ammonite types he described (*Otohoplites waltoni* Casey, 1965) was created (Figure 6).

Samuel Joseph Mackie FGS, FSA (21 January 1823–31 May 1902).

Mackie's collection was the founding part of the museum's collection in 1868 (Knell 1986). He was also one of the founders of the Geologists' Association, playing an important part in its formation during 1858 (Freeman 1996).

The most obvious part of his collection at the museum is a selection bones of Pleistocene mammals. These come from an Ipswichian-aged bone bed at the Bayle and the Battery in Folkestone. These included bones of hippo, elephant, red deer and aurochs. He published a report on the findings (Mackie 1851). Some of these specimens retain O.C numbers meaning 'Old Collection' (Figure 3).

Pleistocene hippos

In the 1800s various mammal bones including those of *Hippopotamus amphibius* Linnaeus, 1758 were discovered during building works including the digging of a Victorian sewer at the Bayle in Folkestone (Mackie 1851). The bones were acquired by Samuel Joseph Mackie and found their way into Folkestone Museum as part of the founding collection. Mackie's

1851 report on the findings includes a map of the extent of the 'bone bed' that the bones were found in.

When working on the collection in 2017, it was observed that many of the bones might be from a single hippo. One bone (F2680, a hippo tibia; Figure 3A) had been erroneously catalogued as an ox tibia and was identified as hippo through comparison with figures in British Pleistocene Mammalia Vol. III, part. I, *Hippopotamus* (Reynolds 1922). This tibia seems to correspond with another tibia (F2684, F2674; Figure 3B), broken into multiple pieces and with multiple registration numbers. So, there was a left tibia and right tibia, possibly from the same animal. There is some difference in patina between the two but this may be due to variations in the original substrate of the finds, or the way each bone was treated subsequently after being dug up. Other hippo material in the collection includes a femur, skull fragments, teeth, potentially phalanges and possibly vertebrae.

Some other hippo remains were found in Folkestone more recently and present an intriguing possibility. In the late 1980s, a partial skeleton of a hippo was excavated at the Bayle in Folkestone (Keller 1991). The skeleton had been cut through the middle by a Victorian age sewer trench. At the time of writing, these bones are not part of the Folkestone Museum collection but may be seen on display at the Roman Painted House in Dover (Kent) when it is open.

Bearing in mind the location of the more recent find of hippo remains and that the missing bones from this specimen (left and right tibia, femurs, skull and jaw parts) correspond with those identified in the museum collection so far (left and right tibia, a femur, jaw fragments), it is not impossible that they are from the same animal. It is also possible that some of the missing bones from the Dover-based specimen may have found their way into other institutions. Further investigation could confirm if the bones at Dover are from the same hippo. This work might provide the basis of an interesting research, digitisation and public engagement project.

*Figure 3. A pair of hippo tibia (***Hippopotamus amphibius** *Linnaeus, 1758) from the Mackie collection of Pleistocene mammalia found at the Bayle/Battery in Folkestone. Left: FOLMU F2680, right: FOLMU F2684, F2674 x 2.*

Recent conservation work

Local geologist Steve Friedrich carried out conservation work on some fossils from the collection. One of the objects worked on is an ichthyosaur jaw (F2782) referred to *Pervushovisaurus campylodon* Carter, 1846 (Fischer 2016) from the Chalk. This included further preparation and the addition of separately numbered fragments (F2030) that were found to fit onto it (Figure 4). It was reported in the past that an associated piece is figured in *The Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex* (Dixon 1850; Timberlake 1995a, b).

New acquisitions including dinosaur footprints

Having amassed an impressive collection of fossils from the Lower Greensand and Gault Formations of Folkestone, specimens were donated by P. Hadland to fill gaps and enhance the coverage of the new displays. This donation included a dinosaur footprint from the Albian-aged Lower Greensand (FM:2017.8.1), a new discovery for Folkestone.

The presence of dinosaur tracks in the Lower Greensand beds to the East of Copt Point and in East Wear Bay was initially widely dismissed based on accounts that the Lower Greensand was formed in a marine environment (Hadland 2012; 2018). Later finds, including a fine example of a theropod track (FM:2018.23) made by fellow Folkestone collector Steve Friedrich, helped confirm the discovery and was donated to the museum (Figure 5).

New displays

To some extent the order of the new fossil display is unconventional with specimens grouped according to taxonomy first rather than stratigraphy. The benefit of this is being able to easily compare simi-

Figure 4. The jaw of an ichthyosaur (FOLMU F2782 + F2030) of the species **Pervushovisaurus campylodon** *(Carter, 1846). before and after conservation. Length: 450 mm. Preparation and photography by Steve Friedrich.*

lar kinds of animal from different time periods. This might not have been the preference of all curators if starting from scratch.

Hands-on interactive interpretation (Figure 6) includes touchable 3D prints of type specimens. The ones chosen are specimens from Folkestone. The first is an ammonite described by Raymond Casey, called *Otohoplites waltoni* Casey, 1965, and named after his mentor and former curator of Folkestone Museum John Walton. The second is an *Acanthopholis horridus* Huxley, 1867 bone found by John Griffiths. These are both in the British Geological Survey collection and were made using digital models available from the online resource 3d-fossils.ac.uk. The other geological hands-on activity is the 'dig interactive' which replicates the layers in the local geology with a mixture of real and replica fossils embedded in each.

Conclusions

Small local-authority-owned museum collections often have complex histories. They are also sometimes poorly understood and not well used as a resource. The level of knowledge and understanding applied to such collections has a substantial impact on how these collections are used in interpretation schemes and for research.

Treating historic labels as an important part of the documentation of objects is important and may be used to help reconstruct the all-too-often-hidden stories of who collected them, and how collections as a whole were formed. Publications and online resources relating to the history of geology and digitisation are also a growing resource and can be useful in aiding the reconstruction and confirmation of hidden collections histories and in enhancing interpretation.

Finally, the application of subject specialist knowledge and employment of specialist curators, even temporarily or on a peripatetic basis, is essential to unlocking the potential of similar collections and to ensure informed decision making.

Recommendations

The following are recommendations for further work that needs to be done to realise the full potential of Folkestone Museum's palaeontological collection:

- Work to catalogue the geological collection should be completed with each specimen having a unique number allocated.
- The collection should be photographed with specific attention paid to attached and associated labels.
- Further work to link up more unattributed specimens with specific donors and collectors using similar methods to those described

Figure 5. A theropod dinosaur track in a block of greensand now in the museum (FM:2018.23). Hammer head for scale is 172 mm.

Figure 6. New interpretation. Top: the new display of fossils. Bottom left: Touchable 3D prints made using the 3D Fossils online resource. Bottom right: A hands-on dig interactive replicating the layers in the local geology with both real and replica fossils embedded in each.

above.

- Identification of the Gault formation fish collection.
- Further investigation into the history of, and more rigorous identification of, the Pleistocene mammal collection.
- Increased use of the collection to engage with the public and history of geology research groups.
- Publication of updated accession and catalogue records including photographs online.

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The long walk from the Carboniferous: mysterious fossil tracks are rediscovered after 87 years

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An unmarked crate stored for many years in the American Museum of Natural History's Division of Paleontology was opened in 2005 and found to contain large slabs of small (one- to a few-centimetre-sized) fossil tetrapod footprints that were clearly geologically very old. The lack of data on or in the crate left the contained specimens orphaned and mysterious and nothing was definitively gleaned about their age, provenance or history for over a dozen years. But when a new book on an extraordinary assemblage of Carboniferous trackways in Alabama was published in 2016, it was found to contain a few sentences that gave clues to the origin of the specimens and soon illuminated the hidden story. Not only had the tracks been amassed by George Gaylord Simpson, one of the foremost vertebrate paleontologists of the 20th Century, many are exquisitely preserved and quite important scientifically. The story of their rediscovery and ongoing interpretation is an intriguing mix of luck, revelations and probing of both the geologic and paper records.

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A mystery crate

In late 2004, a project was initiated at the American Museum of Natural History (AMNH) to open any remaining original crates from the historic 1934 AMNH-Sinclair Dinosaur Expedition to Howe Quarry in Wyoming (Tschopp *et al.* 2020). The expedition was run by the AMNH's Barnum Brown (1873–1963), often considered the greatest dinosaur collector of all time. Because of a lack of funds due to the Great Depression and World War II, and because of Brown's 1941 retirement and the concomitant change in curatorial focus, the material collected from this expedition languished in the collections for decades, much of it still in the original crates. It was, at last, time to finish the uncrating.

On 7 April 2005, a large, flat crate was reached for unpacking that differed in size, shape and construction from the Howe Quarry crates. This odd crate lacked any external marks, whereas Howe crates were labelled on the exterior with 'American Museum of Natural History', a box number and '1934', which clearly linked them with the only AMNH paleontological dig of that year. This crate also lacked any direct documentation within that would illuminate its contents, which turned out to be distinctly different from the contents of the Howe Quarry crates. Genuine Howe Quarry crates contained plaster jacketed, Jurassic dinosaur bones, with numbers painted on or scratched into the plaster. The atypical crate held slabs of fine, grey shale, some of them directly numbered, with well-preserved tetrapod trackways (Figure 1). Also included was a single flattened *Calamites* pith cast (AMNH FP 608; a common fossil taxon related to modern horsetails) where the tree-sized hollow centre of the trunk is infilled with sediment and buried under pressure, leaving a compressed cast of the central pith (Figure 2). The numbers that were painted on the slabs (AMNH 1, AMNH 2, etc.), although mimicking AMNH catalog numbers, clearly did not correspond with catalog entries for those numbers and thus represented field numbers. The morphology of the tracks, the rock type and especially the Calamites all strongly suggested a Pennsylvanian time frame for the material. Aside from the fossils, there was some tattered burlap, offering negligible cushioning, a few bits of newspaper and five mummified rats that attested to the crate's long interment in the bowels of the museum.

Institutional abbreviations: ALMNH, Alabama Museum of Natural History; AMNH, American Museum of Natural History.

Figure 1. The mystery crate, immediately after it was opened on 7 April 2005. Note that the largest slab (AMNH FARB 33680) spans the crate between the points marked A and B.

With no precise information about the material's provenance or history, great caution was taken while unpacking to preserve anything of potential value inside. Unfortunately, the contents were not well-packed: little, if any, padding was included, and the often heavy and brittle specimens were sometimes touching the crate walls and each other (Figure 1). This, plus the crate's obvious age, suggesting it had been moved around the museum, left much of the material badly damaged, especially the thinner slabs. Any fragments were removed along with other fragments that appeared to be associated and were kept together. The fragments were carefully examined for ichnofossils and, because of storage space limitations, any lacking such marks were discarded, such as part of the original slab containing AMNH FARB 33674 (Figure 3). Fortunately, a significant fraction of the specimens had sustained little or no damage (Figures 4–10).

The Fossil Amphibian, Reptile and Bird collections at the AMNH contain comparatively few early tetrapod trackways, thus attracting only a handful of researchers from a field which, worldwide, has only a small pool of researchers to begin with, compared to those interested in body fossils. Nevertheless, any vertebrate ichnology researchers visiting the AMNH collections in the years following the unpacking of the crate were asked if they had any thoughts about the mysterious trackways; none was able to offer any useful suggestions.

The sealed door cracks open

In mid-September 2017, CMM acquired a book, *Footprints in Stone: Fossil Traces of Coal-Age Tetrapods* (Buta and Kopaska-Merkel 2016) that unexpectedly offered the first real clues to the story of the contents of the mystery crate. *Footprints in Stone* outlines the history and significance of the 320 million-year-old trace fossils of Alabama's Pennsylvanian Pottsville Formation coal deposits in Walker County, which is comparable in age with the earliest terrestrial tetrapod fauna from the Baskirian, Lowermost Pennsylvanian of Joggins, Nova Scotia (Falcon-Lang 2006). The Joggins fauna includes amphibians, synapsids and the earliest reptile, *Hylonomus lyelli* Dawson 1860. In the foreword, CMM found the statement: "American Museum of Natural History paleontologist George Gaylord Simpson even worked to secure specimens for his institution back in New York City." The preface adds that Simpson visited Alabama in January of 1930 for the purpose of collecting Carboniferous trackways. Simpson (1902–1984) was an AMNH curator, a palaeomammalogist, and is considered by many to be one of the most influential palaeontologists and evolutionary biologists of the 20th Century. He made crucial contributions to evolutionary theory and played a vital role in developing the understanding of intercontinental migrations of extinct mammals, as described in his classic book *Tempo and Mode in Evolution* (Simpson 1944).

The trackways illustrated in Buta and Kopaska-Merkel's book were immediately recognized as similar to those in the mystery crate as was the rock type in which they were preserved. These seemingly meager bits of new data—a person, a place and a time—when combined, were exactly what was needed to finally elucidate the history of this material.

Figure 2. Both sides of a fragile, but intact, flattened **Calamites** ***pith cast (AMNH FP 608) salvaged from the mystery crate.***

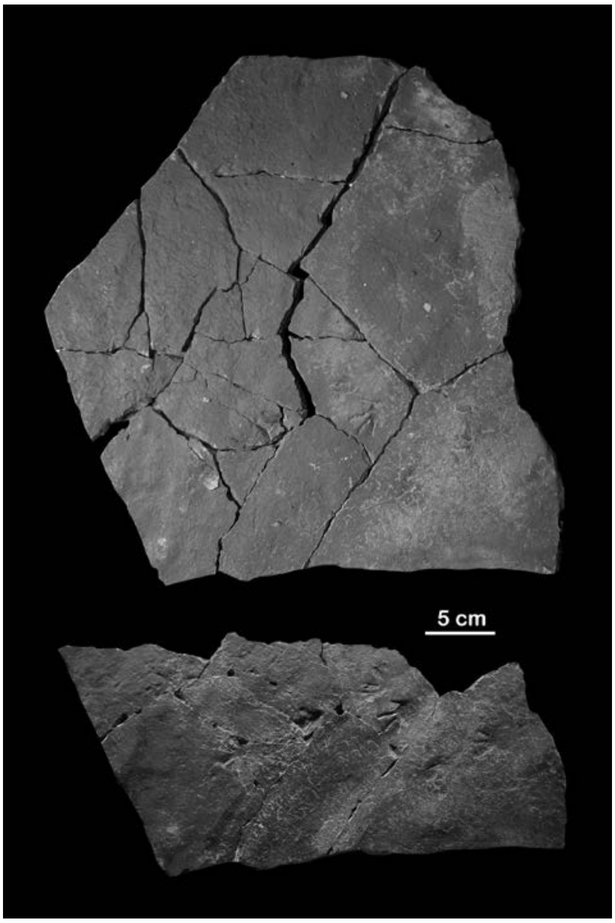

Figure 3. The fragments of this thin slab (AMNH FARB 33674) with a few faint* Cincosaurus cobbi *undertracks were removed from the crate and reassembled. Since about half of the fragments (upper half in top image) contained no ichnofossils they were discarded and the remaining pieces adhered and conserved (bottom).

The original rescued newspaper bits were dutifully kept with the specimens and one turned out to be from The Boston Evening Transcript of 6 December 1930. Another scrap from the Commercial Appeal, a daily for Memphis and the surrounding metropolitan area, preserved only the year: 1931. Although these dates and places weren't in perfect agreement with Simpson's January 1930 Alabama visit, it was certainly better than finding dates before 1930.

The only reference found in Simpson's writings to the 1930 Alabama trip and its fossils is a note in his handwriting: "A day spent weirdly and unsupported by the solace of tobacco in the depths of a coalmine, looking for the footprints of animals dead since 250,000,000 B.C.," plus the same text as part of a letter interpreted as being from "early 1930?". This note was part of a collection of letters from Simpson to his family members (Laporte 1988; Figure 11).

On 10 October 2017, Susan Bell, Archivist in the AMNH Division of Paleontology, unearthed substantial clues relating to G. G. Simpson's 1930 trip to Alabama to collect fossil trackways. Her initial searches produced a few things bolstering the idea that the mystery crate contained Simpson's Alabama Carboniferous trackways: a telegram from Brown to Simpson on 6 January 1930 asking him to wire W. F. Cobb, General Manager of the Galloway Coal Company in Carbon Hill, Alabama, about his upcoming visit (Brown 1930a); a letter from Brown to Simpson on 8 January 1930 advising that Simpson get "fine slabs up to six feet in length showing as many and varied labyrinthodont tracks as possible" (Brown 1930b); and an itinerary of Simpson's peripatetic trip through the South that has him in Carbon Hill, Alabama, to see Pennsylvanian footprints on 17–18 January 1930 (Anonymous 1930).

Bell then found the most informative archives jackpot: a folder labeled CARBON HILL Ala. Fossil Tracks (Various Authors 1929–1931). It included a significant correspondence thread from 5 December 1929–13 May 1931 about the tracks from Mine #11 of the Galloway Coal Company and their acquisition, plus photographs and drawings of trackways. It also included an extremely important list of specimens that were selected by Simpson for the AMNH with clear descriptions of each slab (Appendix 1). This confirmed that Specimens 2, 3, 4, 7, 9, 10, 11B (which doesn't appear to show any ichnofossils on the salvaged parts), 12, and possibly 13A–C and 14 were salvaged. There are other slabs that show ichnofossils but have no number to compare to the list and don't appear to match any of the descriptions on Simpson's list. Missing from the crate but on the list are Specimens 1A–B, 5, 6, 8 and 11A, which is less than half of the listed slabs. Specimen 8 was described as "Pieces of bark, probably *sigillaria*. Slab about 14 inches by 6 inches by four inches." The only plant material found in the crate was the *Calamites* cast, which was not mentioned on the list.

Specimen 1-A is especially curious, as it is described in Simpson's notes as a "Slab about 7 ft. long." The largest slab found in the crate was Specimen 3 (AMNH FARB 33680), which was very thick and survived entirely intact. It was described as "about 4 ft. long" but is actually closer to 5 ft. A photograph of the crate immediately after its lid was removed shows this specimen spanning the length of the crate and touching both ends (Figure 1). This information, and the fact that nothing was found labe-

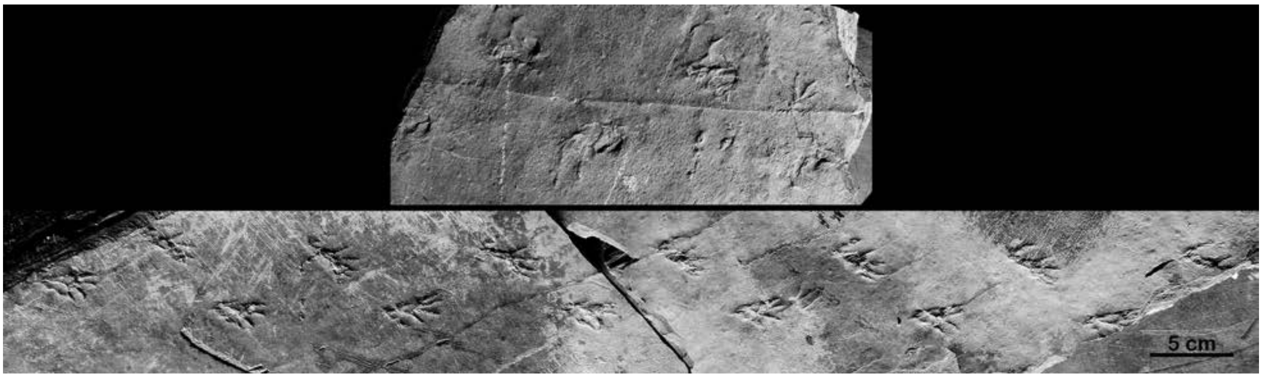

Figure 4. Details of the AMNH FARB 33675 slab show two tetrapod trackways. The upper photo shows a probable surface trackway of an indeterminate ichnotaxon and on the right side, two extraneous* C. cobbi *tracks are seen. The lower photo shows probable* C. cobbi *undertracks.

led as "1-A", emphasizes that not all of what was on Simpson's list was in the crate. Unfortunately, due to the extensive damage to and loss of some of the crate's contents, it is probably impossible to determine exactly which of the 14 specimens on the list were included in the crate and even a definitive list of which were received. All of the crates in the AMNH Fossil Amphibian, Reptile, and Bird collections have recently been inventoried, and there is no evidence for any other crates associated with this material. A slab as large as Specimen 1-A could only have been collected in situ, and thus would be of considerable scientific value. We can only hope that its reappearance is one of our future surprises.

Most of what can be restored of the history of the crate and its contents comes from what was found in the AMNH Division of Paleontology's Archives. The preserved, partial correspondence thread records the sometimes tense and protracted negotiations over the material to be exchanged for the Alabama fossils. The speed at which the initial arrangements occurred—all within a month in letters and phone calls mentioned in some of the letters—attests to the excitement about this discovery at the time. For example, on 18 December 1929, Raymond Deck, Director of James L. Clark Studios, Inc., a group of New York sculptor-taxidermists, wrote to Dr. Chester A. Reeds of the AMNH's Geology and Fossil Invertebrates Department about the discovery, encouraging the AMNH to secure slabs as had been done by the Alabama Museum of Natural History (now ALMNH) and suggesting that the AMNH scoop the publication of these important specimens. Deck also proposed that, in exchange for footprint slabs, the AMNH might consider trading some of their "undisplayed exhibition material" to "the newly-born and struggling Memphis institution". This institution was the Memphis Museum of Natural History, whose Chairman of the Board was F. N. Fisher, who also happened to be the President of the coalmine in which the trackways were discovered. Simpson was already on a reconnaissance trip through the southeast states and the Alabama leg was added as a side trip on his return to New York. Brown was very interested in fossil footprints and hoped that Simpson could acquire specimens suitable for exhibition. This add-on proved to be the most exciting part of Simpson's tour.

On 19 March 1930, Cobb informed Simpson that the AMNH slabs had been shipped from the mine to the Memphis Museum on 1 March from where they would eventually head to New York. The last preserved letter, to the AMNH from the Memphis Park Commission, shows that three specimens of African mammals, mounted by Clark Studios, were received in exchange for the track slabs. Also, the Commission sought reimbursement of the $16 it cost to crate and haul the specimens, which had been sent to the AMNH on 26 March 1931. This late shipping date explains the incongruous dates of the newspaper scraps found inside the crate, and the Memphis origin of the 1931 scrap now makes perfect sense, but the Boston origin of one of the scraps remains unexplained.

Second chances

What happened after the crate finally arrived in New York is likely the same story as that of the Howe Quarry crates with which it was stored: lack of funds and curatorial redirection left it orphaned. *Footprints in Stone* tells the story of how in 1999 the richness of Alabama's Coal-Age ichnofossils was rediscovered by knowledgeable amateurs associated

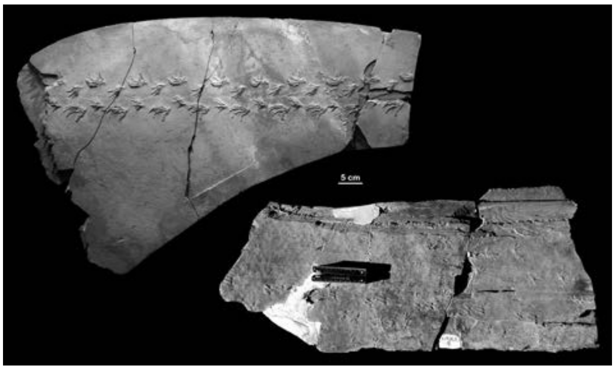

Figure 5. AMNH FARB 33676 (top) shows a well-preserved **C. cobbi** *trackway. AMNH FARB 33677 (bottom) shows three small trackways. Two are likely preservational variants of* **C. cobbi***, one traveling right to left parallel to the lower edge and one walking through the middle of the slab traveling from lower left to upper right, while the third, on the far right traveling from the top edge to the lower right, is a possible tetrapod trackway.*

with the Birmingham (and later the Alabama) Paleontological Society. The site where the fossils were found, the Union Chapel Mine, was located 23 miles east-southeast of the location of the Galloway No. 11 mine, whose operations were ended in 1934. A concerted effort by these amateurs led to state protection of the Union Chapel site in 2005 and its renaming as the Steven C. Minkin Paleozoic Footprint Site. Also, a new track site, the Crescent Valley Mine, was discovered within a half-mile north of the former entrance to the Galloway No. 11 Mine (Buta *et al.* 2013). It is this resurgence of interest in the Alabama tracks that allowed these lost specimens of the mystery crate to be recognized and now properly studied. And most importantly, the AMNH specimens were collected *in situ* from described areas of the underground mine (see Appendix 1) whereas most of what has been recently collected in Alabama is from strip mine spoil.

Trace fossils collected *in situ* are scientifically very valuable because they offer the potential of determining their stratigraphic context; in fact, it was known for years prior to the discovery announcement that the tracks found in the Galloway No. 11 mine came from rock layers within a meter of the top of the Jagger coal seam, the lowest of the four main seams that make up the Mary Lee coal zone. For spoil pile collecting, stratigraphic context is lost but nevertheless stratigraphic analysis of the mine highwall can narrow down the range of rock layers where the tracks originate (Pashin 2005). Additionally, some of the AMNH slabs are much larger than what might be found in the spoils, and more of a trackway simply offers more data on behavior and morphology plus a better chance for associated trackways of contemporaneous animals to appear on the same rock horizons.

In the process of researching *Footprints in Stone*, RJB learned about Simpson's visit and the material acquired by the AMNH. He contacted Ruth O'Leary, Director of Collections, Archives, and Preparation in the AMNH's Division of Paleontology, in October 2012, hoping to find out more about what Simpson collected, what publications these specimens might have generated and the fate of the proposed exhibit of the fossils. At that time, the specimens could not be located, either in the collections or on display, and no papers seem to have been published about the material. One of us (CMM) was aware of this request at the time and wondered if this might pertain to the mystery crate, but attention was refocused and this earlier opportunity to illuminate the back story of the crate was lost. Luckily, a second chance was

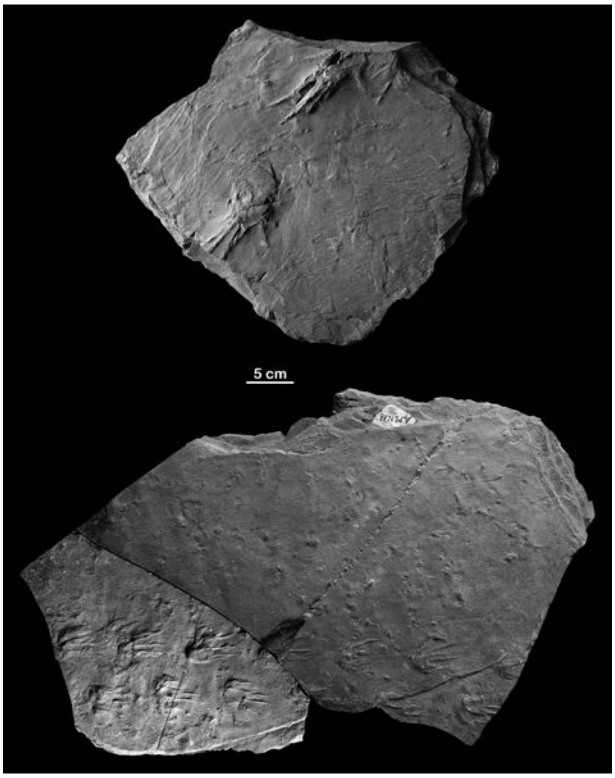

Figure 6. AMNH FARB 33678 (top) shows only two prints resembling **Attenosaursus subulensis** *traveling from top center to lower left. (Bottom) Composite image of a smaller left-hand slab and a larger right-hand one that make up AMNH FARB 33679. It shows a small trackway (cf.* **C. cobbi**) *travelling left to right.*

offered by the publication of *Footprints in Stone*.

Description of mystery crate specimens

The contents of the crate turned out to be not only of great historical value but also include specimens that are very important scientifically. A brief introduction to this ichnofossil assemblage precedes the more in-depth description of the material.

Most episurficial trace fossils in sediments are preserved as pairs—the impression, where tracks appear depressed into the rock (referred to as concave epirelief), and the counter-impression, where the tracks appear elevated from the rock's surface because they are composed of the sediment that infilled those depressions (convex hyporelief). Also, most of the tracks collected in Alabama, whether from spoil piles or *in situ*, are undertracks, meaning they are distortions in the sediment layers caused by the weight of the animal that are recorded below the surface on which the animal walked. Undertracks have a much higher preservation probability than do surface tracks because they are already buried and more protected from erosion than are surface tracks. Undertracks also often show what is known as undertrack deficiency, or loss of detail (usually digits) with increasing depth (Seilacher 2007), but others, like horseshoe crab undertracks, can show finer detail than the actual surface trackway.

Cincosaurus cobbi Aldrich 1930 is the most common vertebrate ichnotaxon from the Carbon Hill area, named for the pentadactyl manus and pes; it is generally regarded as having been made by an early amniote, possibly a synapsid (Haubold *et al.* 2005). As noted by Aldrich and Jones (1930), the *C. cobbi* tracemaker was "undoubtedly the most abundant of all the reptiles living at that time. These tracks were found throughout the [No. 11] mine. This little animal had five toes with a thumb directed laterally". In the examination of the mystery crate slabs, *C. cobbi* tracks are found either as directly defined by Aldrich and Jones, or in various preservational or undertrack variants. In fact, Haubold *et al.* (2005) concluded that seven of the eight small vertebrate ichnotaxa named by Aldrich are probably synonyms of *C. cobbi*.

AMNH FARB 33674 (Figure 3) might be Specimen 14 on Simpson's list, because a loose fragment that did not appear to fit any of these fragments bears the number and, in all details, closely resembles the rock of the fragmented slab, and no details disagree with the description of Specimen 14 on the list. This thin slab preserves a few faint *C. cobbi* undertracks in concave epirelief.

Details of two separate tetrapod trackways on AMNH FARB 33675 (Specimen 2), preserved as convex hyporeliefs, are highlighted in Figure 4. One is a likely a surface trackway, as opposed to an undertrack, as evidenced by the tail drag mark along the trackway's midline, and exhibits probably significant manus/pes overlap. The trackway doesn't resemble any previously recognized ichnotypes from Walker County and may represent a new ichnotaxon. The slab also exhibits a fairly typical small trackway with strong manus/pes overlap. These are probable *C. cobbi* undertracks where the manus preserves only 4 digits and the pes mostly has only 2 digits. To show such widely separated, overlapping tracks implies a longer stride length, suggesting the animal was moving more rapidly. Two extraneous *C. cobbi* tracks are also seen on the slab.

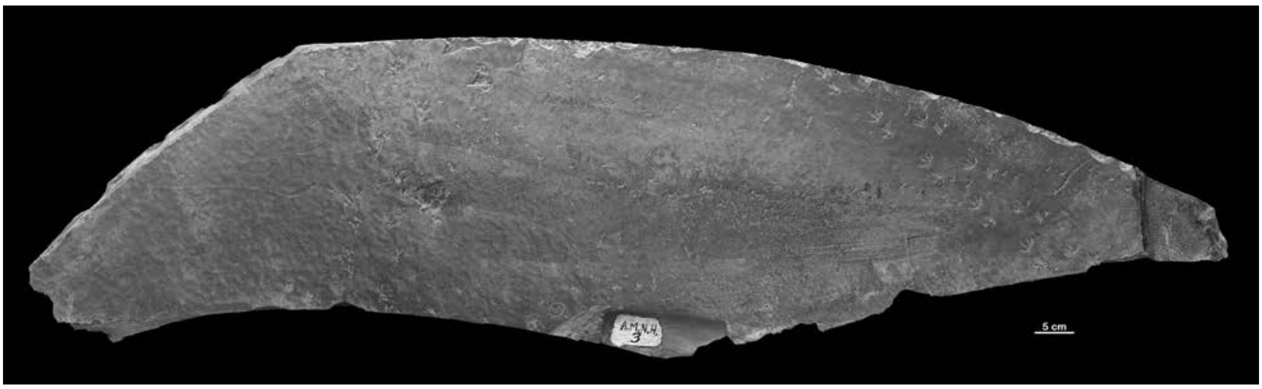

Figure 7. The main slab of AMNH FARB 33680. Two obvious tetrapod trackways (likely both* C. cobbi*) and a long* K. aspodon *trackway appear on this large slab. Several, small, less-obvious invertebrate traces are also preserved. Photograph by Mick Ellison.

One slab from the crate not only beautifully preserves a strong trackway but is very important in an additional respect. AMNH FARB 33676 (Specimen 10; Figure 5, top) preserves a single *C. cobbi* trackway in convex hyporelief. Because of its identical preservation and time and place of collection, this slab may actually be part of the lectotype trackway of *C. cobbi* (ALMNH PV 1985.0001.0027; Aldrich and Jones 1930; Ehret 2016) and thus would have been extracted directly from the ceiling of one of the mine tunnels. We suspect that the AMNH FARB 33676 trackway is the one that led Alabama palaeontologist Walter Jones to write that, when local geologist Arthur J. Blair and I. W. Miller, of the Land Department of the Tennessee Coal, Iron, and Railway Company, went into the underground mine, "They were somewhat startled to behold the trail of the animal leading for some forty feet along the roof of the slope, until it disappeared into solid rock" (Aldrich and Jones 1930: p. 7). The specimen would therefore be the most historically valuable Alabama trackway slab in the AMNH collection as it was the specimen that sparked scientific interest in these fossils.

Many of the manus and pes tracks of AMNH FARB 33676 show the full complement of five digits. In spite of this, the tracks in this case could still be undertracks, because there is no trace of a tail or body mark. The tracks nevertheless cannot have been preserved too far below the actual surface. It is remarkable that although thousands of specimens of vertebrate trackways have been found in Alabama coal mines, no well-defined and clear-cut surface tracks linked to *C. cobbi* undertracks have yet been found. Note that the AMNH FARB 33676 animal was walking differently from the one that left the AMNH FARB 33675 tracks (Figure 4, bottom). The AMNH FARB 33676 animal may have been walking more slowly; there is no manus/pes overlap in this case.

Figure 5 (bottom) shows AMNH FARB 33677 (Specimen 9), which has three small trackways. One trackway shows paired (but not overlapping) manus/pes prints, both showing only two digits each. A second trackway is from an animal of similar size with mostly three digits in the manus and an uncertain number of pes digits. Both of these trackways are likely preservational variants (and deeper undertracks than AMNH FARB 33676) of *C. cobbi*. A third trackway with broader width than the others appears to be a tetrapod but is poorly preserved, and an invertebrate source cannot be ruled out. The slab also exhibits some smaller invertebrate trails. All these ichnofossils are in convex hyporelief. Note that although all of these trackways are on the same rock horizon, this does not mean that the animals walked on exactly the same surface. Different levels of undertracks can appear on the same rock horizon.

AMNH FARB 33678 (Specimen 12; Figure 6, top) shows two prints (each 10–12 cm long) in convex epirelief with possible manus/pes overlap from a large animal. These resemble the largest vertebrate ichnotaxon found in Walker County, Alabama, *Attenosaurus subulensis*, thought to have been made by a reptile-like amphibian (an anthracosaur). AMNH FARB 33679 (Figure 6, bottom) shows a small trackway (cf. *C. cobbi*) in convex hyporelief with over-

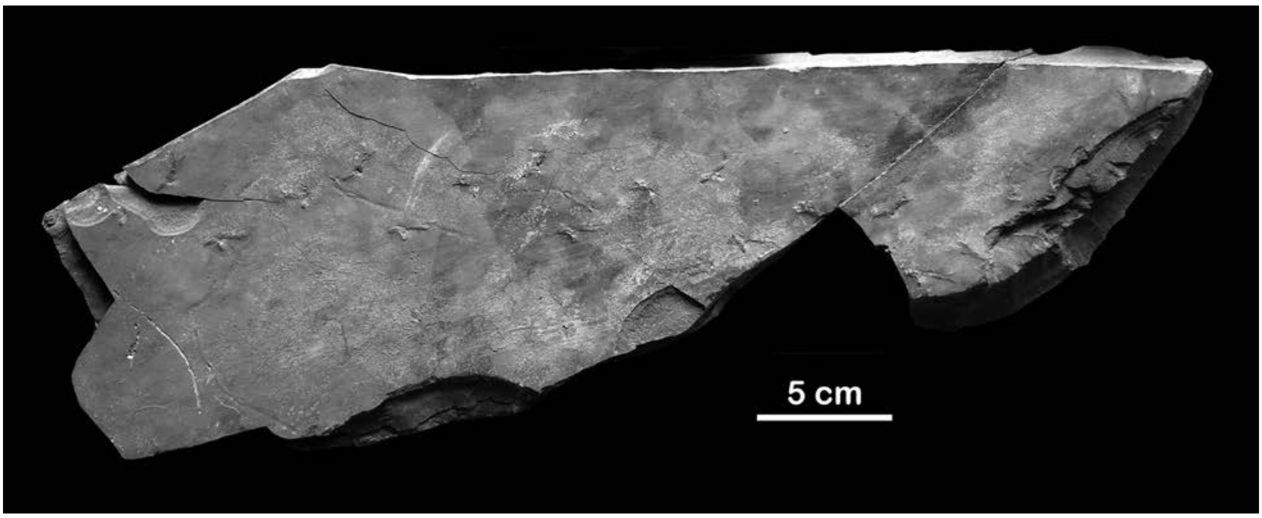

Figure 8. Originally unnumbered slab (part of AMNH FARB 33680) with one side of a* K. aspodon *trackway and an indet. invertebrate trace.

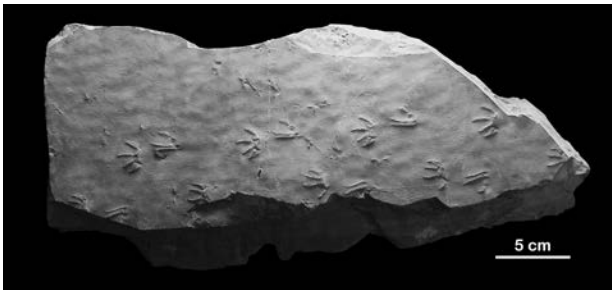

Figure 9. Specimen 4 (part of AMNH FARB 33680) showing a **C. cobbi** *trackway traveling right to left and a* **K. aspodon** *trackway traveling from the lower edge to the upper left.*

lapping manus/pes pairs where each print shows at most three digits. The left-hand slab in the composite image has curatorial marks that appear to read "13C." Simpson's list has a Specimen 12 followed by a Specimen 12-A-B-C followed by Specimen 14. It is being assumed that 12-A-B-C is a typo for 13-A-B-C.

The right-hand slab in Figure 6 (bottom) was retrieved from the crate with "AMNH" written on it in two places, but in at least one the number following the AMNH was scratched off. In preparing the manuscript for this paper it was noticed that the left-hand and right-hand slabs were parts of the same larger slab. The original description for Specimen 13 is an approximately 30-inch-long slab broken into three pieces. It was not recorded at the time of unpacking whether the left-hand piece was found as two pieces, but if the visible crack on the left-hand slab represents one of the original breaks, this could be all of 13-A-B-C, which as restored is about 24 inches long. The composite slab shows what is likely to be a *C. cobbi* trackway in convex hyporelief with considerable manus/pes overlap. In this case, the manus and pes are deeper undertracks than AMNH FARB 33676 and overlap with approximately three digits each. The pes appears larger than the manus.

The most spectacular slab from the mystery crate is the 5-foot-long AMNH FARB 33680 (Specimen 3; Figure 7). The obvious features first noted on the slab were two well-preserved tetrapod trackways. One is a fairly well-defined *C. cobbi* trackway showing mostly 4–5 manus digits and only three pes digits, including in many cases the outwardly directed 'thumb-like' digit (actually a 5th digit or 'pinky toe'). The tracks are mildly paired and non-overlapping. In contrast, the second trackway, likely also *C. cobbi*, shows similar-sized but more ill-defined tetrapod tracks. Some of these appear paired with the manus at most showing about three digits.

Closer inspection also shows that the AMNH FARB 33680 slab is covered with a surprising diversity of invertebrate ichnofossils. In addition to mentioning the two tetrapod trails on Specimen 3, the original description in Simpson's list added "Specimen also carries two trails (lengthwise), showing one to two claw marks of some small animal". These turned out to be a single, very well-preserved underprint trackway of a horseshoe crab (Figure 12). In 1930, these trackways, now called *Kouphichnium* Nopcsa 1923, were not recognized as having been made by horseshoe crabs. They were described instead as having been made by birds as far back as 1862 (Oppel 1862), and later as pterosaurs, non-avian dinosaurs, amphibians and mammals (Thulborn 1990), usually walking in the opposite direction to what we now understand the direction of movement of the invertebrate trackmaker to have been. In the first paper on the Alabama tracks (Aldrich and Jones 1930), a new ichnotaxon was introduced, *Bipedes aspodon*, and described erroneously as an amphibian with two toes. Aldrich and Jones' ichnotaxon is now known as *K. aspodon*.

It is interesting to note that Simpson came quite close to understanding the origins of these strange marks. He states that some of the tracks he saw in Alabama "were made by other types of creatures [than tetrapods], perhaps distantly related to the present day crabs, worms, etc. These may consist of broad irregular trails with no definitive foot marks or of trails with a series of small pits or scratches from crab-like claws" (Simpson in Various Authors 1929–1931). Caster (1938) was the first to recognize that tracks of *Kouphichnium*-type were likely made by horseshoe crabs.

Due to the complexity, clarity and obvious scientific

Figure 10. Specimen 7 (part of AMNH FARB 33680) shows a **C. cobbi** *trackway traveling from the lower edge of the slab to the upper edge.*

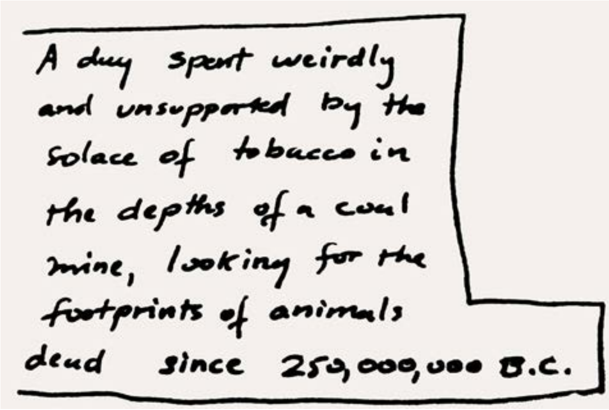

Figure 11. Simpson's sparse words on his time in the Alabama coal mine.

value of the AMNH FARB 33680 slab, a detailed map of the ichnofossils on its surface was created. While zoomed in very close to an extremely large, high resolution tiff image of the slab, all the tracks and trails on the surface were outlined using Photoshop. To avoid being misled by variations in the colours of the slab's surface and only record topographical variations representing trace fossils, the slab was kept close and frequently cross-checked with low-angle light to confirm marks recorded in the digital map. Close scrutiny of these marks allowed marks on a small, unnumbered slab from the Simpson crate to be recognized as one side of a *K. aspodon* trackway (Figure 8). The perfect match of all the marks on this small slab with marks on Specimen 3 proved this was actually part of AMNH FARB 33680's counterslab.

Specimen 4 (Figure 9), which preserves a *C. cobbi* trackway in convex hyporelief and a *K. aspodon* trackway, turned out to be a second piece of the counterslab of AMNH FARB 33680. Since this one was numbered, the locations for Specimens 3 and 4 noted on Simpson's list were compared and found to match, reinforcing the connection. In fact, part of the description of Specimen 4 in Simpson's list is "also shows claw marks crossing same similar to those on specimen 3." Similar, indeed. The Simpson list was then checked to see if any of the other recovered slabs also shared this mine location and remarkably, a third piece of the counterslab (Specimen 7; Figure 10) was found this way.

Most remarkably, an invertebrate trace preserved with the holotype of *K. aspodon* from Mine #11, ALMNH 6 (King *et al.* 2019) was found to be very similar to one on the surface of AMNH FARB 33680. At least four of the holotype's bifid tracks can clearly be seen along one edge of the ALMNH 6 slab with a meandering trace of an unidentified invertebrate crossing the track near the middle of the slab (Figure 13). Further scrutiny revealed that the marks on the holotype slab, including a small portion of a *C. cobbi* trackway, mirrored perfectly the marks on AMNH FARB 33680. This demonstrates that not only is the holotype slab for *K. aspodon* yet another part of the counterslab of AMNH FARB 33680, but the *K. aspodon* trackway on AMNH FARB 33680 is more of that made by the same individual animal that made the holotype trackway. The number '3' is scratched into the surface of ALMNH 6 in three places and might have some connection to 'Specimen 3', but this can't be demonstrated at this point. The only possible discrepancy between the AMNH and ALMNH specimens is the specific locality data describing where they were found within Mine #11: the AMNH data is "Manway between 7th and 8th Right headings off of Main South heading" and the ALMNH data is "4th left off of 7th right."

Somehow, the association of these five separate slabs was lost after they were collected, and, without the main slab of AMNH FARB 33680 acting as the jigsaw puzzle box top, these four small puzzle pieces would not likely ever have been understood as part of the same surface. Figure 14 brings all the puzzle pieces together. Represented are the two separate *C. cobbi* trackways, the *K. aspodon* trackway and six different indeterminate invertebrate traces, all preserved as concave epireliefs on the main slab. Also shown are

Figure 12. Drawing of **K. aspodon** ***trackway from AMNH FARB 33680 probably traveling from right to left.***

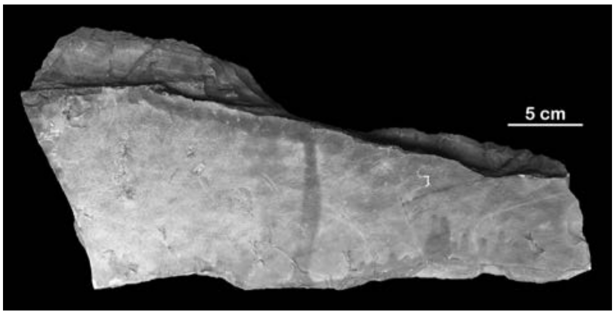

Figure 13. Slab containing the holotype of **Bipedes aspodon** *(=***K. aspodon***), ALMNH 6. In the upper left are parts of two tracks from a* **C. cobbi** *trackway. Photograph by Adiel Klompmaker.*

the placements of the four recovered fragments of the counterslab. The three AMNH counterslab fragments are all now considered part of AMNH FARB 33680.

All this has restored the available data to the unnumbered slab and greatly increased the morphological information for *K. aspodon*. There are other specimens on Simpson's list from the same area of the mine that have tantalizing descriptions that could relate them to AMNH FARB 33680, but the specimens haven't been identified in the rescued elements of the crate.

Unexpected connections

All of this also emphasises that there are really two parts to a scientific specimen: the object and its data. If one of the pair is missing, the value of the specimen is drastically reduced to near uselessness. Keeping the connection between these parts robust and available to researchers is a primary focus of any museum's collections staff. Therefore, the reunion of the contents of Simpson's crate with its data was very rewarding and important. In that initial investigation, two other surprises came about that helped restore the usefulness of other related specimens.

Dr. Mark Norell, AMNH Division of Paleontology Chair, recalled that a couple of similar track slabs of unknown origins were under the sink in his old office, which he vacated 20 years previously. The two trackway slabs found there agreed in every detail to the other slabs from Mine #11 of Galloway Coal Company but lacked curatorial marks of any kind. They immediately became known as the Under-the-Sinkosaurus specimens which alluded to the site's commonest ichnogenus, *Cincosaurus*.

One Under-the-Sinkosaurus slab (AMNH FARB 33111) shows two footprints of uncertain ichnotype in concave epirelief (Figure 15). The other slab (Figure 16) contains two trackways of different ichnotaxa in concave epirelief: *Quadropedia prima* (AMNH FARB 33110) and *Trisaurus secundus* (AMNH FARB 33116). Both of these ichnotaxa are now thought to be preservational variants of *C. cobbi* (Haubold *et al.* 2005).

While trying to understand the story of these unnumbered, unlabelled slabs, the idea was briefly entertained that a trackway on one of them might actually be the holotype of *Trisaurus secundus* (ALMNH P 985.1.14; Aldrich and Jones 1930) because of its uncanny similarity to the published holotype image (plate 17 of Aldrich and Jones 1930). While it turned out that they differed in minute detail, they are still

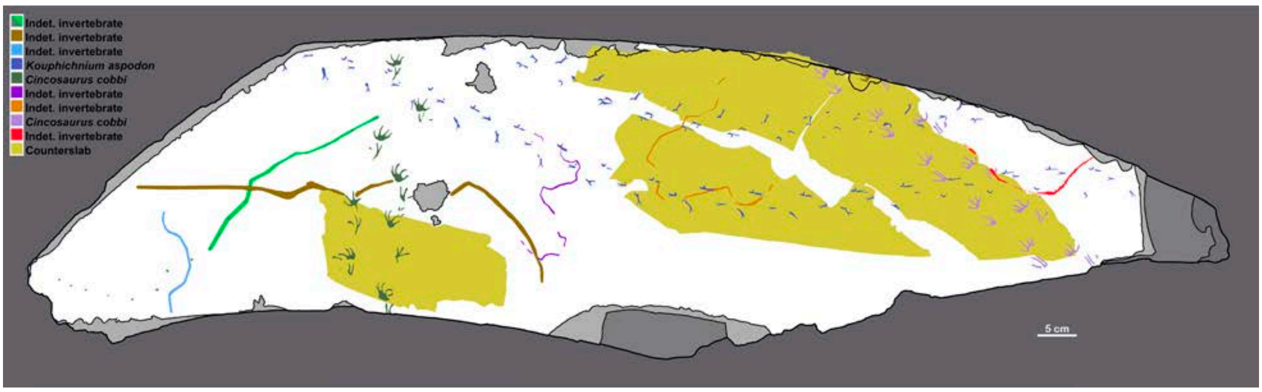

Figure 14. Map of all ichnofossils found on the face of the main slab of AMNH FARB 33680 (Specimen 3; Figure 7). Also shown are the placements of the four recovered fragments of the counterslab (outlines flipped): Specimen 7 (Figure 10) on the left, the unnumbered slab in the middle (Fig 8), with ALMNH 6 (the **K. aspodon** *holotype slab; Figure 13) just above it, and Specimen 4 (Figure 9) adjoining it to the right. The three AMNH counterslab fragments are now considered part of AMNH FARB 33680.*

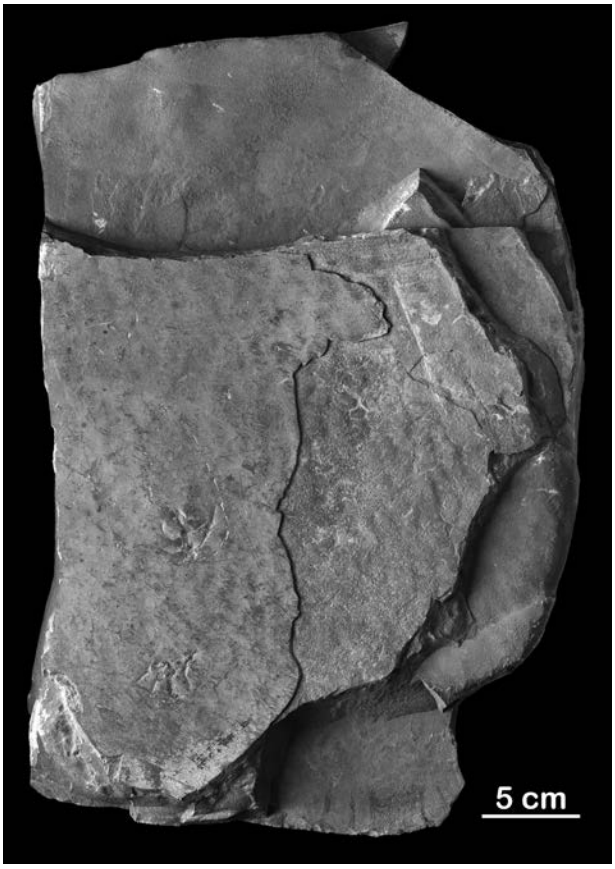

Figure 15. The Under-the-Sinkosaurus specimen now catalogued as AMNH FARB 33111 showing two footprints of uncertain ichnotype. Photograph by Mick Ellison.

so similar that the two specimens could easily belong to the same trackway. It was hoped that broken edges on the two slabs might match, but the published images of the holotype are close-ups that omit the edges of the slab. Additionally, the slab was found to have been damaged since 1930 and has lost any edges it had when it was originally photographed.

One item was found in the Archives that might pertain to these slabs: an Accession Record dated 8 April 1931, after the 26 March 1931 shipment of the Simpson crate. It describes the acquisition of "2 – slabs of fossil tracks" from "No. 11 Mine, Carbon Hill, Alabama" received from "W. F. Cobb, Gen. Mgr. of Galloway Coal Co. Carbon Hill, Alabama" and that "Exchange material [was] sent from the Department of Mammalogy, by Dr. H. E. Anthony." This exchange further separates this accessioned material from the Simpson crate in that mammal mounts traded for it came from AMNH rather than from Clark Studios as in the Simpson exchange.

It is certainly tempting to link this Accession Record to the Under-the-Sinkosaurus specimens, but the ambiguity of the specimen description on the form and complete lack of data found with the specimens themselves leaves this open. However, they don't appear to match any of the descriptions in Simpson's list, so they didn't likely have anything to do with the original 14 specimens chosen for the AMNH.

Another surprise came after RJB first contacted the AMNH and, based on what he was told by the AMNH in 2012, became convinced that the Simpson material never made it to New York, except for maybe the two slabs mentioned in the Accession Record, but which hadn't yet been found under the sink at that point. That suggested that the fossils might still be at the Memphis Museum of Natural History (now called the Pink Palace Museum), where they were sent on 1 March 1930. RJB was informed that two uncatalogued slabs were located there, one of which clearly had a trackway. According to Tamara Braithwaite, Registrar of collections at the Pink Palace, "This slab is probably the one that was on display… as it has numerous places where people scratched their names or initials into it" (T. Braithwaite pers. comm.). At least one of the slabs was displayed, unprotected, outside of the mansion doors of the museum building. The slabs were likely acquired from the Alabama Museum of Natural History in 1932 as part of a trade and they were put into dead basement storage sometime after 1969, after they were vandalized.

During a trip to see the Pink Palace slabs around

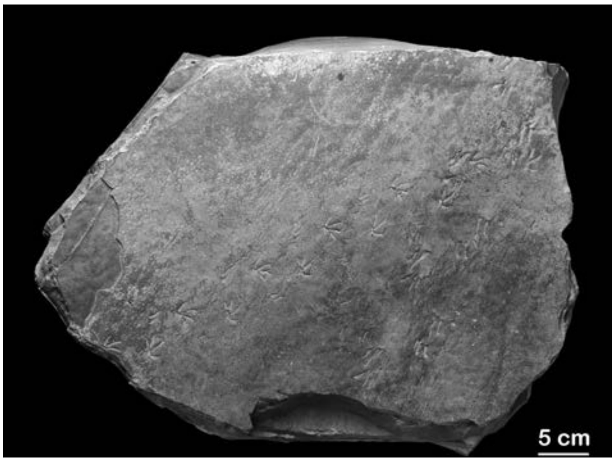

Figure 16. The other Under-the-Sinkosaurus slab, which shows two trackways of different taxa in concave epirelief: **Quadropedia prima** *(AMNH FARB 33110), traveling from the lower left to the upper right and* **Trisaurus secundus** *(AMNH FARB 33116), traveling from the upper right to the bottom edge. Photograph by Mick Ellison.*

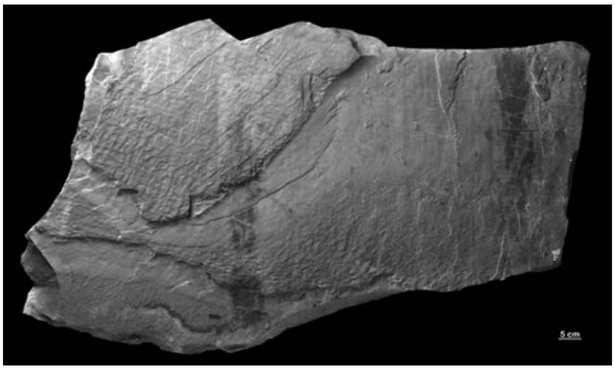

Figure 17. The Pink Palace slab AMNH FARB 33171 shows at least one **C. cobbi** *trackway traveling to the right. Photograph by Mick Ellison and Nicole Wong.*

2013, RJB was told by Braithwaite and their former Collections Manager Ron Brister that he could take the slabs home if he would like. This was certainly startling news as museums don't often give away their specimens. RJB nevertheless could not take them up on their offer because he was traveling with his family at the time and had no room for such large slabs in his van. It was later suggested by Kopaska-Merkel (pers. comm. 2017) that the AMNH might be able to acquire the specimens if the Pink Palace Museum was still willing to part with them. The donation was still on offer, so the AMNH arranged for shipment and both slabs arrived in New York on 28 June 2018. They are now AMNH FARB 33171 (Figure 17) and 33172 (Figure 18); both have preserved trackways in concave epirelief and are covered in various scratched names, marks and symbols—future human trace fossils—from their unsheltered time in Memphis. AMNH FARB 33171 shows fairly deep undertracks of *C. cobbi*, and AMNH FARB 33172 exhibits two trackways: a probable *K. aspodon* trackway and one, probably from a tetrapod, that was made in very wet mud, rendering it too obscure to identify. Although all of the slabs herein described probably came from Mine #11 in the 1930s, because of the damage and loss to the slabs from the crate and the ambiguity of the history of the Under-the-Sinkosaurus and Pink Palace specimens, any relationship of these three sets of fossils cannot be determined at this time.

Epilogue

Simpson noted in a letter to Cobb on 24 January 1930 that the Carbon Hill sediments record the time when "the first reptiles were arising" and that if some of the tracks are shown to be from these animals "it will be of extreme importance as one of the oldest known traces of reptilian life" (Simpson 1930). But he ends, ever the pragmatist (or downplaying it to increase his shot at publication priority—although this was not to be, as the first paper was written by Alabama paleontologists [Aldrich and Jones 1930] well before the crate arrived in New York): "The discovery is not sensational, but it is of great scientific importance and popular interest and is worthy of careful study and of preservation" (Simpson 1930). Clearly work was planned on studying, publishing and even displaying these wonderful specimens, but none of this ever happened until now.

The purpose of natural history collections is to preserve specimens with the understanding that at any time they can become useful. We disagree with the discovery not being sensational. As it turned out, trackways of among the very oldest known reptiles are, indeed, preserved in the material from Alabama. With the restoration of the data of the rescued specimens of the Simpson crate, the AMNH now has one of the finest collections of well-preserved Paleozoic trackways in the world, and it is hoped that what was intended for these fossils can pick up from where the trail ran cold in 1931.

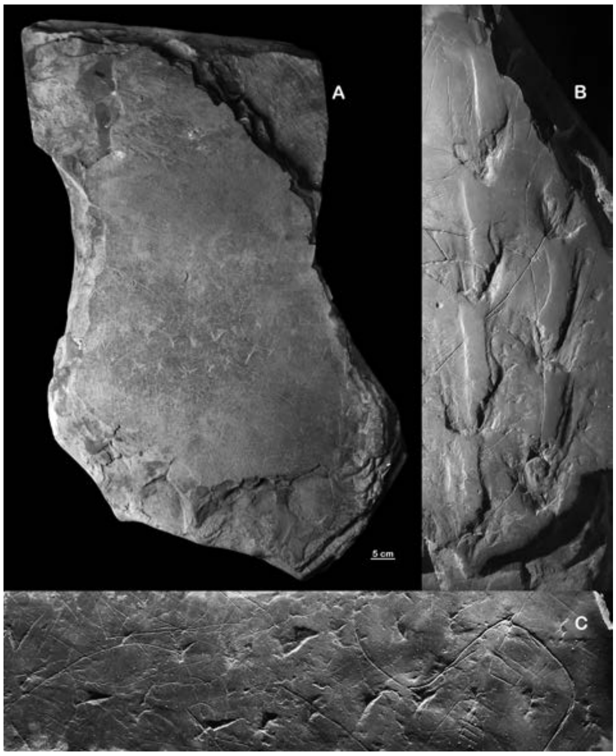

Figure 18. The Pink Palace slab AMNH FARB 33172 (A) shows two trackways and a network of vandalism scratches. A probably-tetrapod trackway (B) is on the extreme lower right of the slab travelling up or down, and a probable **K. aspodon** *trackway (C) is just below center on the slab traveling either left or right. Photograph by Mick Ellison and Nicole Wong.*

Acknowledgements

The authors would like to recognize and thank Prescott Atkinson, Susan Bell, Fiona Brady, Tamara Braithwaite, Mick Ellison, Adiel Klompmaker, David Kopaska-Merkel, Mark Norell, Ruth O'Leary and Nicole Wong for their help and enthusiasm in bringing together the story of the wayward track slabs. Angela Milner and two anonymous reviewers are thanked for their excellent and thorough comments. We are also grateful to the late Barnum Brown, Jack Conrad and George Simpson for the roles they played in this story. Figures by CMM unless otherwise noted.

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Appendix 1. ***In these notes, locale information is given; these can be interpreted using Figure 7.2 of Buta and Kopaska-Merkel 2016, which shows the layout of the Galloway No. 11 mine.***

Transcription of Simpson's list (some formatting altered for clarity; spellings are original)

Memo re: Specimens for American Museum of Natural History, New York City.

Selected by: Dr. G. G. Simpson, Associate Curator of Vertebrate and Paleontology, American Museum of Natural History, 77th St. and Central Park, W., New York City.

Specimen 1-A: Tracks. Slab about 7 ft. long; has one trail full length of specimen showing three claw marks. Also has three trails crossing. These are little curved toed tracks showing entire footprints.
Location in Mine: Manway between 7th and 8th Right headings off of Main South heading, Mine #11.

Specimen 1-B: This adjoins specimen 1-A and carries trail of small curved toed animal with tail marks.
Location in Mine: Same location as specimen 1-A.

Specimen 2: Mold of tracks. Slab about 4 ft. long with small trail crossing diagonally. Small four toed hind foot, straight toes. Track of hind foot over-laps track of front foot, also shows on end of specimen tracks of small curved toed animal with tail tracks.
Location in Mine: Same location as Specimen 1-A

Specimen 3: Tracks. Slab about 4 ft. long; carries two small trails crossing. One curved toed animal with four of five toes; one straight toed animal with four or five toes. Specimen also carries two trails (lengthwise), showing one to two claw marks of some small animal.
Location in Mine: Same location as specimen No. 1.

Specimen 4: Mold of tracks. Small slab about 1 ft. long. Specimen carries trail lengthwise of small four toed animal with short curved toes, also shows claw marks crossing same similar to those on specimen 3.
Location in Mine: Same as specimen No. 1.

Specimen 5: Mold of tracks. Slab about 1 ft. in length; has very small prints. About the same as on Specimen 3.
Location in Mine: Same as specimen No. 1.

Specimen 6: Tracks. Slab about 14 inches in length carrying tracks of small three toed animal. These are not very distinct; principally claw marks.
Location in Mine: Same as Specimen No. 1.

Specimen 7: Mold of tracks. Small slab about 1 ft. long carrying trails crossing of small four toed, straight toed front foot and four toed curved hind foot.
Location in Mine: Same as Specimen No. 1.

Specimen 8: Pieces of bark, probably sigillaria. Slab about 14 inches by 6 inches by four inches. Definite location in mine *not known. Picked up from refuse pile.*

Specimen 9: Mold of tracks. Slab about 30 inches by fifteen inches. Specimen carries tracks of three toed animal lengthwise - crossed diagonally by tracks of two species (curved and straight toed) of four toed animals.
Location in Mine: Same as Specimen No. 1.

Specimen 10: Mold of tracks. Slab about 30 inches in length, which carries a trail lengthwise of small curved toed animal with footprints about one and a half inches across. This specimen bears 37 tracks and is apparently good specimen for study.
Note: Adjoining specimens No. 10-A and 10-B - save for Memphis Museum.
Location in Mine: Manway at Motor Generator Sub-Station.

Specimens 11A-B: Tracks. Slab about 2 ft. by 2 ft. Specimen carries 7 tracks of large curved toed hind feet - four distinct toes about 5 inches across. Front foot shows four short straight toes. Good specimen for study.
Note: Similar specimens should be secured for Memphis Museum, if possible.
Location in Mine: Mainway at 1st Left Heading off Main South Slope.

Specimen 12: Mold of tracks. Slab about 12 inches in diameter carrying two tracks of five toed animal; toes about four inches in length and straight.
Location in Mine: Between 4th and 5th Right Headings off of 7th Right straight heading.
Note: This is probably the same track as shown on specimen marked No. 20, and it is desired to secure a better specimen for the American Museum, if possible.

Specimens 12A-B-C-: Tracks(?) Slab about 30 inches long, broken into three pieces. This specimen carries tracks lengthwise of five toed animal with straight toes about 2 inches long. Toe marks are longer but apparently animal was slipping. Probably the same type of track as track crossing No. 20.
Location in Mine: About 100 ft. in by 5th Right Heading off the 7th Right Straight.

Specimen 14: Tracks. Slab about 28 inches by 14 inches (thin slab). Specimen carries small trail lengthwise. Small four toed animal with straight toes about 1 inch long.
Location in Mine: No. 6 room off of 8th Left Heading off of Southwest Slope Heading.

Dr. Simpson wants, if possible specimens similar to No. 20 and 21; also invertebrate tracks associated with specimens No. 21 found on Main Side Track near 1st Left Switch. If possible specimens should be secured showing where the two trails cross.

Dr. Simpson also wants specimen similar to one appearing at loaded track knuckle on 7th Right Side Track.

Dr. Simpson recommends securing the specimen of lepidodendron in the 1st North Heading and calamites found nearby, where specimen No. 1 was taken and at some other points in the mine. Also good specimens of "pots", or other stumps or ferns from the mine or Stripping Operation. Dr. Simpson states that specimen of lepidodendron, referred to above, is one of the prettiest that he has seen and by all means should be secured for the Memphis Museum.

Dr. Simpson states that so far as known there has been found in the United States only one track in formation older than at Mine #11. This track was found in Pennsylvania - a single track and not very perfect. This is on exhibition at Yale University.

Comments of Dr. Simpson:

"This find of fossil tracks is one of extreme scientific importance. It gives light on the animal life of the period which was hitherto very little known – making it one of the most interesting fossil discoveries of recent years.
It is urged that as many of the well preserved [sic] tracks be saved as possible."

Carbon Hill, Ala.,
January 18, 1930.

WFC-wc

[Pencil sketches of trackways and descriptions of sequences]

Matthew Alastair Parkes PhD, MA, BSc, EuGeol, PGeo
1962–2020

by Nigel T. Monaghan[1]

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Matthew Parkes passed away suddenly on Friday, 23 October 2020, a former Chair of the Geological Curators' Group (GCG), but more importantly a man who was kind, capable, a great colleague, and welcoming. New members of the GCG committee have remarked on how quickly they were made to feel at home, something the volunteers at the National Museum of Ireland (NMI) all knew well, as did the budding geologists who came in with their first fossils for identification.

The first time I met Matthew, he was a student working on his PhD in Galway and he needed to see the fossils in our museum collections that date back to the 1830s and the first geological map of Ireland. As I climbed up the set of steps in the store to find what Matthew (at six feet, seven and a half inches) was looking for in the top drawers, I realised he was still standing on the floor and just opening them and peering in. Our height was one of the few things we differed on, he used to say that the only disadvantage of being tall was people going on about it. He stood out in a crowd for physical reasons but didn't seek to be noticed, other things were more important to him. Our long car journeys were more likely to be spent talking about the geology of the landscape we were passing through, rather than details of his family life. I am reminded of him every time I admire the walls of bedrock visible in Irish road cuttings nowadays, as he pushed the agency responsible for the new EU funded motorways to leave bedrock exposed, as a reminder of geology. They are also a much cheaper and environmentally sound alternative to grading the edges into grassy verges covered with imported trees or shrubs. He didn't go on about these achievements, to him they just seemed sensible things to do, but these asides always impressed me as insights into his quietly persistent nature.

The geology student

Matthew was a geologist to his bones and joined the staff of the National Museum of Ireland in November 2005, where he worked for the last fifteen years. He grew up in Hertfordshire, where he focused on sciences at school ending up with A levels in Geology and Geography in 1981, the year I started in NMI. He worked at the Soil Survey of England and Wales, then went to Sheffield University to study geology and obtained his BSc in 1985.

Working for his PhD at NUI Galway is what brought him to Ireland, where he studied small areas of rocks of Ordovician and Silurian age on the south-eastern margin of the Iapetus Ocean, from Meath to Waterford. These island relics with their endemic brachiopod faunas are poorly exposed and it takes determination to get decent fossils out of the scrappy outcrops. The fossils on each side of the ocean, while now only an hour's drive apart, were then animals that lived on coastlines 1,000 km apart. His good friend in NUIG Eamon Doyle, now geologist for the Burren Geopark in Co. Clare, studied the other side of that ocean but from the same office. Even before he completed his PhD in 1990, Matthew was working as an Assistant Lecturer and looking after overseas students on summer programmes. I remember we were discussing the subtle differences that separate us from our American cousins and the guilty pleasure he had of leaving the students to work out how to fit an Irish lightbulb with its bayonet fitting.

Galway is also where he met his life partner Michelle, and while they were together for thirty-one years it was only five years ago when they got married. Typically, he made no fuss at work and waited to see how long it would be before colleagues would notice the ring on his finger. His time at Galway also allowed him to indulge his love of caves and karst landscapes, something he maintained for the rest of his life.

The geological curator

I got to know Matthew better on his next posting to Trinity College Dublin in 1991 as a Research Fellow for two years, followed by short term contract work curating fossils in Geological Survey Ireland. In 1992 National Museum Wales was embarking on major geology galleries and he spent a year and a half in Cardiff, standing in for curators to free them up for that project. Matthew's use of geological collections in his research and the time in Cardiff drew him into the world of museums and the value of old specimens was always clear to him, as was the need to care for neglected collections. In 1994 Geological Survey Ireland applied for a Heritage Council grant to get their fossil collections into shape. Never having employed a curator, there was plenty for Matthew to do in the two years of that project (Sleeman 1992). The project was published in Geological Curator (Parkes *et al.* 1994) and followed by a catalogue of type and figured specimens (Parkes and Sleeman 1997).

While that contract on the fossil collections was finite, he cared deeply about the collections and their future, and never took his eye off them, even through all the years at NMI where he remained the go to person for anything to do with GSI fossils. In May 1996, he moved within GSI to work in the bedrock mapping section, and also spent time working in his own company Geoscapes. From 1998, his work in GSI was focused on their Heritage Programme, setting up a scheme for the assessment and protection of Sites of Special Scientific Interest. This involved establishing a protocol for selection, panels of advisors, overseeing surveys and site reports, and raising public awareness.

Before Matthew came to work at NMI, we had a series of discussions on his freedom to carry on with his work at Geoscapes, maintaining his involvement in heritage assessments and sitting on a variety of geological committees. Continuing these while working at our museum was essential in his eyes and I was very happy to sign up to these, as he made such

a contribution to Irish geology. It was a pleasure to see such commitment and passion, while having the energy to dive into the museum work on the day shift. Geologists will appreciate the quality and diversity of his contributions to our science. His list of well over a hundred publications runs to six pages, many as collaborations with experts in Ordovician rocks in other countries. From the Geological Society's correlation of Ordovician (Fortey *et al.* 2000), to books on Irish geology county by county.

National Museum of Ireland

We were very lucky that Matthew took up the post of curator for the geological collections in the Natural History Division of NMI in 2005. It took a bit of persuasion as he was in the process of being made permanent in the Geological Survey after many years on multiple contracts, but he was able to transfer across with no loss of salary or status. On leaving GSI, Matthew stated that he was leaving behind a job he really enjoyed for one that he wanted even more. At that time, NMI was planning major geological galleries at Collins Barracks and the intention was to move there to set up office. Instead, with the shrinking economy and delay of those plans, he ended up with an office in the Natural History Division research building, able to see his old GSI office out his new window and even watch the work there pile up while they slowly recruited a replacement.

He worked hard on the curation of the extensive national geological collections, capably filling a post that used to be staffed by three people in the 1980s, and having held that post before him I knew how much he was taking on and how well he did it. He built up a reputation in NMI as someone who would help with anything and who would go out of his way in particular when a young budding geologist would arrive with an enquiry. One colleague remembers an occasion when a family won a television wish to meet a palaeontologist and follow the dream of a young boy. Matthew picked the family up from the train, drove to the museum, and both of our offsite collections buildings for a day of fossil delights, and sent the boy home with a pack of booklets, many of which Matthew had been involved in producing.

Matthew never considered his education finished and he was always keen to develop his skills and learn more about his craft. He earned an MA degree in Museum Studies at the University of Leicester in 2001 through distance learning, followed by a Diploma in Gemmology. The Institute of Geologists Ireland endorsed his status as a professional geologist in 1998, and he achieved the equivalent accreditation of the European Federation of Geologists (EuGeol) in 1999. Matthew was a key player in setting standards of geological curation in museums across Ireland and in the UK, where he sat on the British Geological Survey's National Geological Repository Advisory Committee, and was a long time Editor and later Chair of the Geological Curators' Group. He visited small museums in various Irish counties, producing a survey that showed there were small collections in several places that needed attention (Parkes and Wyse Jackson 1998). Off his own bat, he helped those small museums over the years and would improve the labels and information with tact, adding representative rocks of the neighbourhood and trying to spread his enthusiasm for the subject.

Among Matthew's many passions was the heritage associated with Ireland's mines, and in 1996 he helped to set up the Mining History Society of Ireland, holding office continually as Secretary, Journal Editor and finally Chair of what became the Mining Heritage Trust of Ireland (MHTI) charitable company in 2000. As the last four people actively involved, it fell to Matthew, myself and two others to wind up the organisation. Matthew put a great deal of effort in 2019 into bringing the 21 years of work by the MHTI into a legacy website (www.mhti.org), so that despite the winding up of the organisation, there is

a significant body of knowledge preserved for posterity. He was a Director of Copper Coast Geopark clg, promoting the mining heritage and tourism potential of what is now recognised by UNESCO as an important Geopark on the County Waterford coast.

Matthew was keen to see things published and made publicly accessible. When working on the technical reports relating to geological heritage, he pushed to ensure that these also came out in books and leaflets that were at an accessible level for the average member of the public. Having completed 22 county audits of geological heritage he had many more publications planned and his friends and colleagues are following these through to publication. He acted as Editor for journals of the Geological Curators' Group, Speleological Union of Ireland and the prestigious *Irish Journal of Earth Science* of the Royal Irish Academy, as well as contributing regularly to the popular magazine *Earth Science Ireland*. A mutual friend rang the other day to quote to me from Matthew's description of the rocks of County Clare as the best geology mind picture he had read, and which he shared with his daughter at the outcrop, which captured their familiar landscape but explained it in new ways.

The karst landscapes of Ireland, where limestone bedrock is full of fissures and caves, was an area of research interest and enjoyment through caving. Matthew looked after the library of the Speleological Union of Ireland and was an active member of their cave rescue organisation. He loved the music and the pint (Beamish stout preferably) as much as anyone, and caving is thirsty work. Clare and Galway are great places to have a few pints, a mandatory bowl of chowder, and to fill your ears. The well-known Irish traditional folk musician Andy Irvine remembers meeting Matthew at many gigs and while he may initially have looked like a stalker, they often chatted afterwards. Matthew organised a special private concert for the annual meeting of the MHTI, and Andy even took a mining theme for several compositions and worked with Matthew on the historical accuracy of his lyrics. His musical tastes were broad, from Rachmaninov to Television, Buzzcocks, and many points in between.

His work at NMI saw a major project to care for the mineral collections of University College Dublin (UCD), which were no longer used in teaching, and banished to unsuitable stores. With the help of a long term friend, Patrick Roycroft, Matthew pushed for Heritage Council funding that saw the 10,000 minerals plus many rocks and fossils transferred to NMI, rehoused, and documented by volunteers. The museum employed an Inventory Project team that completed their work in 2017 through the main NMI geology collections under Matthew's guidance and resulted in a database that is now a valuable tool for daily collections management and information. Every member of that team remembers 'prosecco Thursdays' where Matthew would occasionally decide that the week was getting too long and we all needed a special afternoon tea break.

Exhibitions at NMI included Fossils (2006), Our Place in Space (2009), Dead Zoo at Large (2009-10), the Natural History Museum redevelopment (2010), Leske Minerals (Munich Mineral Show, 2016), Devonian Plant Fossils – a window into the past (Botanic Gardens, 2018) and Jurassic Skies (2018). NMI has been working on a long term strategy towards an Earth Science Museum and Matthew was central to developing and pitching that proposal to potential funders and partners. A step on that road will be *Down to Earth – Exploring Ireland's Geology*, an exhibition in the Riding School at Collins Barracks that marks 175 years of GSI and is scheduled to open early in 2021.

Matthew was not a fan of rules, regulation, red tape, but he worked hard and full days, starting the day early at home with a mug of weak Earl Grey tea, stroking his beloved cat Athos, while he worked on some text for a publication or exhibition, and then heading to the day job at the museum, where his dress code might well include the occasional shorts and sandals, T-shirts on a theme of badger protection, Buzzcocks, or "N^2 – Nerd to the power of amazing". He was a nerd and very proud of the fact; he loved the intricacies of a scientific puzzle,

including the science behind the best way to look after museum collections. Unlike many nerds he also shared that immense knowledge freely and wore his expertise lightly. He chanced him arm asking once if it was OK to bring pets to work, against museum rules on pest management, the answer had to be no. You just have to smile as a manager when someone explains they need to go home at lunchtime to see to a sick animal, administer drugs, or visit the vets. My favourite explanation for a later start was that he had to visit a neighbour and extract a cat from inside her sofa, a cat he had nursed to health and offered as a pet to keep the elderly lady company. It took a good hour to extract the cat, calm the pet and its owner.

The NMI staff and GCG members over many years know what a great colleague we had in Matthew: it is evident from the shock, sadness, and many tributes that came in from all quarters. He would want us to be kind and look after each other – that was the trait that nearly everyone mentions in their emails or messages.

That was how his museum colleagues remember 'our Matthew' and we were all the better for knowing him.

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