PITFALLS AND SUCCESSES: THE EVOLUTION OF THE NATIONAL MUSEUM OF NATURAL HISTORY (SMITHSONIAN INSTITUTION) PALEOBIOLOGY COLLECTIONS VOLUNTEER CATALOGING PROGRAM

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As 60-70% of the workforce, the volunteers at the Smithsonian National Museum of Natural History Department of Paleobiology have an enormous impact. Historically, volunteers worked with department research staff to assist with their projects, but with a renewed focus on creating accessible, high quality digital collections records to support research we determined that integration of a larger volunteer program was necessary. Establishing this program came with many challenges and lessons learned that ultimately led to a successful volunteer effort for collections digitization.

An early brachiopod cataloging project proceeded slowly due to numerous organizational problems with the collection and highly complex data that required constant supervisorial input to resolve transcription and data quality issues. These challenges resulted in an average of 6,000 new records per year. To help curb these issues, we created a four-hour volunteer evaluation which included an hour of training, a packet of relevant information, a detailed workflow, and a cataloging exam covering a suite of specimens that ranged in difficulty entering data. Prospective volunteers that used the workflow, asked questions, could work independently, and were detail driven became catalogers.

In addition to improving volunteer vetting, we revaluated the projects given to volunteers. The volunteers began a new project cataloging a subcollection of Wasatchian mammals. Since the data was more uniform and less complex, we could streamline data entry workflows and reduce the amount of data the volunteers collected. With the revisions, the volunteers recorded data for 17,000 mammals within the first six months of the project.

Since 2016, volunteers have created over 28,000 new digital records. Though collections staff manage most of the data processing, the focused efforts and number of volunteers results in a far greater rate of data creation than our staff could achieve. Volunteers can be an asset to any cataloging project if they are trained and vetted properly, and if projects are chosen carefully. Ultimately, this increases data accessibility to the benefit of the paleontological community.

PREPARATION OF WET VERTEBRATE FOSSILS: DEVISING STRATEGIES TO MITIGATE DAMAGE

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The Field Museum of Natural History has worked in the Chronister Dinosaur Site in southeastern Missouri, U.S.A. for the past three seasons and collected over 80 specimens in 12 plaster field jackets. The quarry is a wet, clay-rich matrix. Preparation of materials from the site has been challenging. The wet specimens are unsafe to prepare due to no separation between clay and fossil. Three different field jackets were opened at different times in order to compare the desiccation process and to determine the best approach to prepare the fossils.

The first field jacket containing a skull and cervical vertebrae was opened immediately after returning from the site to gradually dry the contents under a controlled environment. Matrix and fossil material were still wet. A weekly consolidation with an aqueous glue, 10% Acrysol WS24, was applied; and a large perforated plastic tarp was placed over the jacket over two months. Toilet paper infused with polyethylene glycol (PEG) was used to fill desiccation cracks for stability. After the clay dried completely, the mechanical preparation began; and the fossil was consolidated with 10% Paraloid B72. The second field jacket containing forelimb elements had a rounded and smooth edge. It was left untouched for about a year, so the contents were allowed to completely dry before opening it. The shrinkage of the clay was apparent with a gap of ¾" away from the jacket walls, but the contents uniformly shrank with only a few cracks. The forelimb elements showed very little distortion, but porous fossils were fragile; so frequent B72 application was required. The third field jacket of about 6 feet in length and a foot in width and depth contained semi-articulated caudal vertebrae. When the jacket was opened after four months, the contents were still moist and unsafe to prepare; so it was left to dry for an additional month. Several large cracks had formed, as the clay was constrained by the shape of the field jacket. The large fissures were filled with PEG, and B72 was used for consolidation of exposed fossil material.

The preparation of three field jackets showed that a gradual drying method with frequent WS24 application was the most effective method. Cracks and fissures could be filled with toilet paper and impregnated with PEG for stabilization. B72 could be used after specimens had totally dried. The rounded edge of the field jacket was advantageous for uniform shrinkage of the wet clay within the jacket, therefore minimizing the formation of desiccation cracks.

DIGITAL AND MECHANICAL PREPARATION OF DELICATE SKELETAL REMAINS FROM AN UPPER CRETACEOUS BONEBED IN MADAGASCAR

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We demonstrate an integrated methodology for using CT in both mechanical and digital preparation of field jackets collected from locality MAD 05-42 in Upper Cretaceous deposits of the Maevarano Formation, Mahajanga Basin, Madagascar. Following in-quarry surface mapping, field jackets were documented in a medical CT scanner before mechanical preparation to provide preliminary identifications and spatial relationships of encased fossils. The initial scanning assisted in both prioritizing and in performing mechanical preparation. Specimens were prepared exclusively under magnification, using insect pins and carbide needles held in pin vices. Paraloid B-72 was used for consolidation of specimens and adhesion of fragments. Cyclododecane served to stabilize elements during disassociation. Specimens too fragile to prepare entirely, or presumed to have delicate materials preserved below exposed and prepared materials, were micro-CT scanned. These data were then digitally prepared (segmented), providing highresolution information on the spatial arrangements and anatomical details of materials too

delicate to be exposed or removed from matrix. The workflow for this effort was coordinated between Ohio University and the Denver Museum of Nature and Science using two software platforms (Avizo and Dragonfly); it involved substantial processing by students and volunteers for initial segmentation, followed by quality control and data organization prior to study. As a result of preparation, associations of elements from individuals were demonstrable taphonomically (e.g., by connecting fragments of sternum prepared digitally and prototyped for confirmation of fits along predepositional breaks) and anatomically (by close physical association of nonoverlapping elements, many of which were not visible on the mechanically prepared surface). We created high-resolution taphonomic digital reconstructions of materials across largely unprepared blocks of matrix. The two preparation approaches resulted in the defensible organization of discrete, dispersed anatomical elements into the context of individuals whose anatomy, functional morphology, and phylogenetic relationships can be studied. We also produced prototype outputs of morphology that could not be replicated through molding and casting, resulting in 3D models for primary research and comparative work, as well as for dissemination and exhibition activities.

Grant Information: National Science Foundation (EAR_1525915)

COMPACTED FIBERGLASS ARMATURE FOR SUPPORTING SMALL FOSSIL SPECIMENS

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Armatures to support fossil specimens are commonly constructed with metals such as steel or brass. Metallic armatures can present risks for small and delicate fossil specimens, as repeated fit tests, abrasion, and metal corrosion can damage the fossil. An alternate armature material is here presented, made using stacked layers of fiberglass cloth which are saturated with Butvar B-76 adhesive liquefied in acetone, and compressed between sheets of Tyvek polyethylene cloth until set. The result is a stiff sheet of archival material which can be cut to size, adjusted in shape with the use of a liquid solvent, and adhered directly to the specimen if desired. The reversible properties of the adhesive used ensure that the armature can be removed in the future. This method is an adaptation of preexisting related techniques: using string temporarily adhered to segments of easily-fractured fossil, and using paper or fiberglass adhered to thin specimens as a supporting backing material. A drawback of this technique is the reduced function of the fiberglass support when spanning large weights or across large surface areas. This method can be used not only in exhibit environments, but also in creating storage supports which can be CT scanned along with the specimen, and for the reinforcement of select fragile specimen features.

A case study is presented using this method and materials to alter a historical display mount of the small mammal *Leptomeryx evansi* (USNM V16754) to provide support for fragile freestanding articulated limbs. The use of this method reduced time needed in working with the specimen, avoided the use of equipment and hazards associated with welding or brazing, and avoided risk to the specimen associated with altering the original mount structure to properly anchor metal armature. Results of work include the greatly reduced likelihood of fracture and loss of limb elements, preserving the integrity of the specimen as both a display and research object.

TECHNIQUES FOR SUCCESSFUL COLLECTION OF PLEISTOCENE MEGAFAUNA MATERIAL FROM LAKE CALLABONNA FOSSIL RESERVE, SOUTH AUSTRALIA.

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The Pleistocene megafauna fossil deposits of Lake Callabonna have been known for over a century. The many challenges that arise from working in this inhospitable terrain continue to test paleontologists. Fossils usually consist of articulated skeletons entombed in damp, hypersaline clays with localised concretions. There is a history of rapid deterioration of specimens after collection and aborted attempts to reach the fossil sites. The abundance and quality of fossil material at Lake Callabonna make it an enticing prospect for researchers. The integration of logistic, collection and preparation techniques have enabled Flinders University researchers to recover exceptional fossil material from this site.

Logistics- Lake Callabonna is extremely remote, desolate and difficult to traverse. The use of quad bikes and small ATVs to navigate the landscape is essential as standard four-wheel drive vehicles cannot access the lake surface without becoming bogged. These extra vehicles restrict the number of people and amount of supplies/equipment that can be transported to the site. The remote, desolate nature of the lake prevents supplementation of resources. Field workers require experience or training in all aspects of remote area hazards.

Collection- Standard plaster jacketing techniques are supplemented by a layer of plastic pallet wrap within the jacket to prevent desiccation. Sediments surrounding bones can harbour integument impressions. Multiple sites are worked simultaneously as shifting sand can make excavation impossible in some areas. Regular prospecting ensures that new skeletons are noted as they become exposed by erosional winds.

Preparation- Lake Callabonna fossils do not store well. Desiccating specimens results in shrinking and cracking of the dense clay matrix, destroying bone in the process. Best results are obtained while the clays are still wet. Standard mechanical removal of clay matrix followed by cleaning and consolidation with acetone and Paraloid B72 as the bones slowly dry will halt the extrusion of halite crystals from the exposed surfaces and prevent the specimen from becoming brittle. Microjacks are employed to remove localised concretions. Funding and space resources for the prompt preparation of Lake Callabonna fossil material must be considered before the expedition can proceed.

Grant Information: ARC Discovery Project DP180101913

MOVING AND UPDATING THE MOUNTED *TYRANNOSAURUS REX*, "SUE"

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FMNH PR2081, or "SUE" is undoubtedly the most well-known *Tyrannosaurus rex* skeleton in the world. After being "temporarily" mounted in Field Museum's large main hall for 18 years, the museum wanted to finally finish the SUE project by moving it into its own exhibit hall as part of the array of halls that make up the Evolving Planet Exhibition on the second floor. As the most complete example of *T. rex*, SUE is both an important scientific specimen, but has also become an icon for both Field Museum and Chicago. The decision to move the specimen presented an opportunity to update the mount and include elements not mounted previously.

Moving any large real fossil skeleton is a challenge but moving one of great intrinsic, academic and monetary value made the project challenging. The job included dismantling the existing mount, executing a condition report on all the bones, and carefully packaging everything for the move upstairs to the new exhibit hall which served as the workshop for the re-assembly. Some changes were made to the mount, and armatures for new elements were added. The museum requested that this whole process be done in public view, further increasing the complexity of the project.

The majority of the mount was reused, but some portions were altered to create a more life-like pose. The cervical ribs were mounted more parallel to the vertebral column, the dorsal ribs were swept back a bit, making the skeleton less barrel-chested, and the right knee was extended giving the animal a less crouched pose. The real, but pathologic, furcula replaced the previous reconstructed element which represented an educated guess at the time the specimen was first mounted. The scapulacoracoids were brought closer to the midline to articulate with the real furcula, which resulted in the pectoral girdle and forelimbs being moved anteriorly and ventrally to fit the ribcage. Finally, a new armature was created for the gastralia adding the largely complete gastral basket to the mount for the first time.

Changing the pose of a skeleton is like pulling a thread. One modification has a ripple effect invariably affecting other areas of the skeleton. The movement of such a large, real skeleton required careful coordination between the mounting crew, exhibit registrar and collections management to preserve this unique specimen. The alterations to the mount of "Sue" were done under the direction of the exhibit curators led by Peter Makovicky, and has resulted one of the most scientifically accurate *Tyrannosaurus rex* skeletons on display today.

MOVING MAMMOTHS AND MOR: HOW TO SURVIVE YOUR COLLECTIONS MOVE

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No matter the size of a museum, moving a collection can be a stressful, time consuming, and expensive endeavor. The Museum of the Rockies (MOR) recently moved thousands of fossil specimens, molds, and casts from offsite storage to newly available collections space within the museum. Intensive paleontology field collecting begun by MOR in 1982 had produced a collection that by 1992 had outgrown the existing collections facility and required the use of offsite storage. Stored material included over 400 plaster jackets, 500 boxes of unprepared specimens, and hundreds of molds and casts. By 2016 this collection filled a 6000 sq ft offsite facility several miles from MOR. In 2017 the historical and cultural collections of MOR were moved into a new addition to the museum. Space previously occupied by the historical and cultural collections was made available for the paleontology department. From January through early June 2018, MOR planned and executed a twofold project: refit the fossil preparation lab to

allow for more utilitarian applications followed by moving all offsite storage material to the newly available collections space at MOR. The move needed to be accomplished with a limited budget. Part one began in January 2018 with a strategy retreat for MOR paleontology staff. Meetings were then held with paleontology volunteers to clarify logistics for the move. Over six weeks the fossil lab was thoroughly cleaned, organized and developed into a more open, centralized space for a variety of projects. Simultaneously, new shelving, reinforced pallets, and battery-operated pallet lifters were obtained and used to prepare the new space for paleontology collections. Following the completion of part one, MOR staff and volunteers started moving all material from the offsite storage facility back to MOR. Hundreds of old boxes containing specimens were rehoused for transport. Plaster jackets, molds and casts were palletized for easier transport. To track the material, boxes and pallets were assigned numbers and jackets were painted colors denoting geologic formations. The palletized specimens and newly boxed material was moved to MOR using field trailers and trucks. The project was completed two days ahead of schedule and has facilitated access to fossils at MOR. This project offers tested solutions for a successful collections move with limited time and a limited budget. From tracking objects to overcoming obstacles and maintaining a move timeline, this model illustrates strategies, techniques, and solutions for other institutions' collections moves.

Grant Information: Funding for shelving, pallets, and cabinets provided in part by the U.S. Department of the Interior.

PREPARATION OF INDURATED CAVE DEPOSITS FROM BARROW ISLAND, WESTERN AUSTRALIA

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In 1995, E. L. Lundelius, A. Baynes, and K. Aplin traveled to Barrow Island, Western Australia, to prospect the abundant Plio-Pleistocene fissure-fill deposits in the Miocene Trealla Limestone for vertebrate fossils. One fissurefill, labeled Y1, is a breccia consisting of limestone clasts within a calcitecemented red siltstone. Abundant disarticulated microvertebrate remains were present in the siltstone and visible on the surface of the fill. During excavation, this deposit was broken into cobble- to boulder-sized blocks and shipped to The University of Texas at Austin for preparation. Initial mechanical and chemical preparation proved to be time-consuming and challenging. Difficulties included poor separation between soft bone and hard matrix, high density of overlapping bone fragments, and calcite infilling of bones that reacted strongly with acid. As a result, the project was temporarily postponed. The project was revisited after advances in high-resolution X-ray CT scanning (HRXCT) allowed for the assessment of individual blocks of matrix for mechanical preparation. Two scans were performed on a block of matrix: a lower resolution data set of the entire block (voxel size = 0.1061 mm), and a higher-resolution scan (voxel size = 0.0219 mm) focusing on two toothbearing elements observed in the lower resolution data. The calcite-cemented matrix of the block has similar X-ray attenuation to preserved enamel on teeth, but is considerably more dense than bone. Nevertheless, the scans reveal abundant bone throughout the sample, except within large clasts presumed to be derived from the cave walls. The higher resolution data reveal two mandibles representing a marsupial and a rodent, as well as isolated teeth and other skeletal elements.

Digital segmentation of the mandibles shows extensively fractured bone, suggesting additional physical preparation of the bone may not be advisable. However, due to the difficulty of digital separation of the enamel from the matrix, mechanical preparation of the teeth is necessary for identification. Experiments with chemical preparation were yet inconclusive, therefore finedetailed micropreparation was completed with a sharp carbide needle in a pin vice under high magnification using HRXCT as a roadmap. These results underscore the utility of CT data for both identifying candidates for mechanical preparation and for documenting the distribution and abundance of fossils in samples that are otherwise extremely difficult to physically prepare.

DISTINGUISHING REGURGITALITES AND COPROLITES: A CASE STUDY USING A TRIASSIC BROMALITE CONTAINING SOFT TISSUE FROM *REVUELTOSAURUS*

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There is currently no consensus procedure for distinguishing fossilized fecal and gastric pellets. Herein, we devise a method for distinguishing coprolites from regurgitalites, using a large bone mass of postcranial material and soft tissue fibers (YPM VP.061134) from the Owl Rock Member of the Upper Triassic Chinle Formation. Synapomorphies in the teeth and dermal scutes suggest that these remains belong to the pseudosuchian archosaur *Revueltosaurus*. The bones in this specimen were compacted together and aligned in subparallel, semi-articulated clusters, indicating that this specimen represented a digestive residue (or "bromalite") and not a sedimentary accumulation. However, it remained unclear whether this bromalite preserved ejecta or fecal matter. To determine whether this bone mass constitutes a regurgitalite or a coprolite, we subjected the specimen to chemical and microstructural analysis. A dearth of gastric etching, the absence of a scat-associated phosphate residue, and the presence of proteinaceous soft tissue suggest that this specimen represents a regurgitalite, and not a coprolite. From this approach, we offer a three-pronged method for distinguishing between different types of digestive remains on the basis of (i) phosphate concentration, (ii) degree of bone corrosion, and (iii) soft tissue preservation. We also comment on the nature of our pseudosuchian soft tissue fibers, and argue that they represent phosphatized skeletal myocytes, which retain individual myofibrils and Z lines.

GEOCHEMICAL TRACE ELEMENT ANALYSES ON FOSSIL BONE: A PROVENANCE TOOL FOR EXISTING FOSSIL COLLECTIONS WITH POORLY DOCUMENTED LOCALITIES.

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Interpreting paleobiology and paleoecology requires knowledge of depositional and fossilization environments. However, specimens from older collections commonly lack detailed provenance documentation. Such is the case with many existing collections worldwide, and is especially true of the Darling Downs region of eastern Australia. This is a major PliocenePleistocene vertebrate-bearing fossil region where numerous specimens have been recovered over the past 150 years,

but most lack detailed stratigraphic information. Here we applied a series of geochemical (trace element) analyses on fossil collections from two major Darling Downs locations to test if trace element signatures can provide a useful provenance tool. The first locality is a Pleistocene fluvial deposit in Kings Creek, southern Darling Downs, which was systematically excavated and yields three stratigraphic horizons. The second location includes three Pliocene fluvial sites at Chinchilla, northern Darling Downs, where the fossils lack detailed stratigraphic context. Kings Creek fossil trace element signatures are mostly consistent, regardless of stratigraphic position or taphonomy, suggesting a similar diagenetic setting during deposition and fossilization. However, despite the consistent signature, variation was observed in some specimens from the uppermost horizon suggesting that some reworking may have occurred. Chinchilla fossil trace element signatures are more variable compared to Kings Creek, suggesting more complex site depositional processes and fossilization settings. The three Chinchilla sites share similar trace element signature variability, however, site-specific signatures also occur. There is a notable difference in geochemical signatures between the Chinchilla and Kings Creek datasets. The variability between the two localities demonstrates that trace element analyses can be effectively used to provenance Darling Downs specimens of varying ages from the existing historic fossil collections. This geochemical approach could also easily be adopted across the planet for other collections where fossils remain poorly provenanced.

Grant Information: Linnean Society Betty Mayne Scientific Research Fund; ARC grants (DP120101752, DE120101533, LE0989067); and the Ian Potter Foundation.