

2011 Preparator's Session

NEW APPLICATIONS FOR MEDIUM AND SMALL SCALE 3D PHOTOGRAMMETRY IN VERTEBRATE PALEONTOLOGY

---ESKER, Donald, The Mammoth Site of Hot Springs, South Dakota, Hot Springs, SD, USA

Photogrammetry is the science of taking measurements from photographs. In the past this was done strictly on the largest scales for the purpose of producing topographic maps. The process required precisely calibrated equipment and took time-consuming, painstaking manual labor; thus photogrammetry on the scale of a single paleontological site was impractical. Fortunately, recent advances in computer processing power and new software has brought photogrammetry into the digital age and made it a practical tool for bonebed cartography. Simply by loading multiple images into the appropriate program, would-be photogrammetricians can produce a precise and accurate three dimensional representation of nearly any surface, at nearly any scale. The significance of these advances was not lost on paleontologists. Digital photogrammetry has been used for years to document and monitor large ichnosites with great success. The technology need not be limited to the study of trackways; with appropriate vantage points, entire paleontological sites can be mapped. On the other end of the scale, it is possible to combine macrophotography with photogrammetry to produce accurate three-dimensional computer models of even the tiniest specimens.

At The Mammoth Site of Hot Springs South Dakota, progress is being made on both fronts. Much of the western half of the sinkhole has been mapped with digital photogrammetry, with results that compare well to the site's state-of-the-art geographic information system map. Researchers who are unable to travel to South Dakota can now study the bonebed almost as if they were there in person. Macrophotogrammetry has proven invaluable for studying the microfaunal material from the site. Most of this material has consisted of invertebrate shells, scattered fish bones, and miniscule rodent teeth. By producing digital models of these specimens, it is possible to examine them closely without risk of damage. With the advent of rapid-prototyping, it is even possible to 'print out' a greatly enlarged copy of the specimen under consideration. Photogrammetry promises to revolutionize paleontological cartography at every scale.

PHOTOGRAMMETRIC ICHNOLOGY: STATE-OF-THE-ART DIGITAL DATA ANALYSIS OF PALEONTOLOGICAL RESOURCES IN NORTH AMERICA, EUROPE, ASIA, AND AFRICA

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Vertebrate trace fossils reflect the complex interrelationship between an animal and the substrate. Digital data collection provides an excellent tool for capturing an incredible wealth of information provided by ichnofossils. Close-range photogrammetry is one of the easiest and most cost-effective digital data collection techniques and forms the basis for photogrammetric ichnology. Three-dimensional image datasets created from digital photography can provide a permanent digital record of fossil tracks (including the creation of digital type specimens) and tracksites and is a non-invasive method to obtain 3D data for assessment. Photogrammetry is an objective recording and analysis method, which provides a visual, quantifiable baseline to evaluate track-bearing surfaces. It has been especially useful in remote locations of Korea,

Tanzania, and the United States. Not only do these datasets support accurate visualization of the fossils, they can also be used to make accurate measurements, as well as highly accurate solid, three-dimensional models of the surface. As 3D terrain surfaces or point clouds created from photogrammetric documentation may contain thousands of very accurate x, y, and z coordinates, researchers can measure various track and trackway dimensions at a submillimeter level. In addition to traditional ichnological measurements, higherlevel mathematical analyses may be conducted on the 3-D data. These calculations can automatically quantify areas of surface curvature, roughness, slope and other morphometric characteristics. Because these calculations are conducted by algorithms within the software, human bias is greatly removed if not eliminated. Utilizing this type of data analysis, unbiased morphological correlations of various ichnofaunas (e.g., Jurassic tracks from Wyoming, Utah, Scotland, and England) can be made and footprint data normalized (e.g., converting convex hyporelief forms to concave epirelief) for comparison purposes. Digital datasets are stored easily, provide a permanent record, are readily shared, and are currently helping to unravel numerous ichnological complexities in Permian-Pliocene sites throughout the world.

CLOSE-RANGE PHOTOGRAMMETRY OF PARTIAL RE-EXCAVATION OF THE LAETOLI HOMININ FOOTPRINTS, IN NORTHERN TANZANIA

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In 1978 members of Mary Leakey's team working near Olduvai Gorge, Tanzania, discovered fossil hominin footprints preserved in a 3.6 million year old volcanic tuff layer. These footprints provide the earliest known evidence of an upright stance in our human ancestors marking a significant milestone in the vertebrate fossil record. At the time of the discovery, a trail containing approximately 40 steps was excavated and documented by Leakey's team, who reburied the excavation to protect the footprints. In 1995, prompted by concerns of vegetation overgrowing the site, members of the Getty Conservation group removed the vegetation, re-exposed, conserved, and documented the previously excavated surface, and re-buried it using a multilayer strategy. In February of 2011, an international team of scientists under the request of the Ministry of Natural Resources and Tourism in Tanzania re-excavated a 3.5 meter long section of the trackway to evaluate and document the condition of the footprints. This provided an opportunity to conduct new, close-range photogrammetric documentation of the footprints, as well as a first generation cast residing in the National Museum of Tanzania and House of Culture in Dar es Salaam. Stereoscopic imaging was conducted using a remotely triggered digital SLR camera mounted on a monopod to obtain overhead images of the re-excavation stages culminating with the footprint tuff. Imagery acquisition averaged approximately 25 minutes per layer and was of minimal impact to the excavation process. Multi-stage imagery was placed in a common coordinate space and used to generate 3D point clouds, surfaces, and associated "aerial" orthophotographs. These data sets allow for a virtual re-excavation, as over 13 layers of materials can be digitally removed to expose the final footprint surface. Close-

range photogrammetry provided an excellent method for documenting field subjects in remote regions of East Africa, as well as museum specimens in display situations. Rapidly developing innovations and reduction in costs of software make this technique available to a much larger spectrum of users and vital to proper documentation and conservation efforts.

COLLECTION AND PREPARATION OF VERTEBRATE FOSSILS FROM THE EARLY PERMIAN BROMACKER QUARRY LOCALITY, CENTRAL GERMANY

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The Carnegie Museum of Natural History, Pittsburgh, has been working for the past 20 years in collaboration with the Museum der Natur, Gotha, Germany, California State University, San Bernardino, and other institutions to collect, prepare, and study tetrapod fossils from the Early Permian Bromacker Quarry Locality, central Germany. The fossils occur in the Tambach Sandstone of the Tambach Formation, typically within one of two sheet flood units consisting of massive siltstone to very-fine-grained-sandstone separated by an intervening unit of laminated to massive siltstone. Preservation of the fossils is excellent, with most of the skeletons being complete to nearly complete and fully or loosely articulated. The fossiliferous section is carefully quarried for fossils using hand tools such as hammers, chisels, and pry bars, and a rock saw and jack hammer are used when needed. Once a specimen is discovered, its dimensions are determined, exposing as little of the skeleton as possible to prevent loss or damage to the specimen. The fossil is then removed in one or more blocks encased in a burlap and plaster jacket. The fine-grained, indurated matrix lends itself well to mechanical preparation. After the block is opened in the lab, removal of overburden rock is achieved with a small hammer and chisel and/or pneumatic scribe, followed by detailed exposure of the bone with a pneumatic scribe and/or small hand tools. Several problems commonly encountered during preparation of these fossils and their solutions are as follows: 1) numerous cracks run through the blocks, including the fossil bone. This is remedied by filling the cracks with polyethylene glycol. 2) Postdepositional chemical weathering of some of the bone has left it with a spongy texture that lacks surface detail and good separation from the surrounding rock. Polyvinyl butyral, cyanoacrylates, and polyethylene glycol have been used in attempts to consolidate the spongy bone, but none of them has proved to be entirely satisfactory and/or time efficient. 3) Occasionally bone is lost during the process of discovering and collecting a fossil. Casting epoxies have been applied to remaining natural molds in the rock with some success.

COLLECTION, PREPARATION, AND MOUNTING OF TWO LARGE, ORIGINAL GRYPOSAUR SKELETONS FROM THE KAIPAROWITS FORMATION OF GRAND STAIRCASE ESCALANTE NATIONAL MONUMENT, FOR THE NEW UTAH MUSEUM OF NATURAL HISTORY, SALT LAKE CITY

---GETTY, Mike, Utah Museum of Natural History, Salt Lake City, UT, USA; LUND, Eric, Utah Museum of Natural History, Salt Lake City, UT, USA

In November 2011, the Utah Museum of Natural History (UMNH) will reopen to the public in a brand new home at the Rio Tinto Center on the University of Utah's campus in Salt Lake City. This facility will exhibit a number of new paleontology exhibits, including one featuring

vertebrate specimens collected from the Upper Campanian Kaiparowits Formation of Grand Staircase Escalante National Monument (GSENM) over the past twelve years. This exhibit will display mounted original skeletons of two of the most complete gryposaur specimens collected in the Kaiparowits thus far. These specimens, discovered in 2001 and 2007, each took three seasons to excavate in more than one hundred large field jackets, several weighing in excess of 1000 lbs. Preparation of this material has taken a team of more than 80 volunteer preparators 10,000 man hours to complete over nearly a decade. In both specimens, preparation was complicated by exceedingly hard matrix, and skin impressions which needed to be preserved. One specimen (UMNH VP12665) had skin impressions covering nearly all of its articulated tail and was prepared and mounted in a manner to exhibit the association of skin and bone. This specimen is mounted into the floor in an "in situ" style, recreating how the skeleton was preserved in the field. The second specimen (UMNH VP 20121) is the most complete large hadrosaur ever collected in Utah, and was prepared out entirely from its matrix and by UMNH volunteers and ultimately mounted in a life position by a paid contractor. This mounted specimen is nearly 40 feet long, 12 feet high, and consists of more than 80% original skeletal material. The collection and preparation of the specimens for these two mounts highlights the extremely effective collaboration between the UMNH and the BLM administered GSENM, as well as the significance of a highly motivated and dedicated team of volunteers in the field and lab.

THE MAMMOTH SITE OF HOT SPRINGS, SD: CURATION AND PREPARATION OF AN ACTIVE IN-SITU DIG SITE

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The Mammoth Site in Hot Springs, South Dakota represents a highly fossiliferous Late Quaternary deposit formed from the collapse of bedrock forming sinkhole approximately 26,000 years ago. The sinkhole was a thermal pond fed by artesian spring water which was slowly in-filled over the course of about 350-700 years. Over 80 different Pleistocene taxa are represented here. and behaviorally favored adolescent male mammoths, with minimum number of 59 individuals. Since 1976, the Mammoth Site has been maintained as an active in-situ dig site and functions as an immersive exhibit for visitors. Curation and preparation are necessary tasks for this collection in order to maintain its scientific and public value. Currently over 5,000 specimens have been discovered, with over 1,500 remaining in-situ. While the bonebed acts as a natural archival storage facility for unexposed specimens, protecting and repairing the exposed specimens is the responsibility of Mammoth Site curatorial staff. Specific threats to the collection include: fluctuating environmental conditions (such as air temperature, relative humidity and light), consolidant degradation, accidental anthropogenic modification and natural disasters. Bonebed procedures at the Mammoth Site have been constantly modified In light of new advances in fossil conservation strategies to address these threats. Temperature, relative humidity and light have been controlled through the use of mass air humidifiers, inhibiting agents of deterioration. Consolidants have been changed following industry standards, going from the initial consolidant, Glyptal, to the current standards, Butvar and Acryloid. Solvents for removing thick or peeling consolidants are addressed, specifically for the use of ethanol on the Glyptal consolidant. Additionally the tools used for excavation and repair have been expanded from simple hand tools to include plastic and pneumatic instruments. Cataloguing and

cartography are addressed through the use of a robotic total station and ArcGIS.

BEST PRACTICES IN CLEANING, DRYING, AND STABILIZATION WET PLEISTOCENE MEGAFUNA MATERIAL FROM SNOWMASS, COLORADO

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In 2010, the Denver Museum of Nature and Science collected ca. 600 Pleistocene bones from Ziegler Reservoir in Snowmass Village, Colorado. The first fossils were discovered by construction workers enlarging the reservoir. Working with a combination of heavy equipment and basic manual excavation techniques, museum staff and volunteers recovered the remains of multiple Columbian mammoths, American mastodons, giant bison, deer, and a Jefferson's ground sloth. Bones, teeth, and tusks were extremely well preserved with much of the original organic material intact and no permineralization. Freshly excavated bones were sediment-covered and saturated with water, presenting conservators and preparators with challenges in cleaning, drying and stabilizing specimens. Minimally invasive techniques (e.g., only water or ethanol as cleaning agents) were used to permit subsequent sampling for testing of DNA, histology, isotopes, and other aspects of composition. Different protocols were developed for bones, teeth, and tusks, but most involved retardation of drying by enclosing specimens in plastic bags, plastic containers, or plastic tents. With careful monitoring, specimens dried slowly enough to reduce warping and cracking but had enough air circulation to prevent mold growth. Minimizing moisture gradients was critical for maintaining integrity as specimens equilibrated to Denver's low ambient humidity. To minimize differential drying of bones in plaster field jackets, small holes were cut in the bottom of the jackets. Stabilizing the tusk material is vital to preserving the record of the lives of proboscideans. Age, sex, and season of death can be determined by studying the growth layers and composition of tusks. Zip ties were used to help prevent warping and expansion of cracks during the drying process, and in some cases, to close cracks. Once specimens were dry, methyl methacrylate was used as a consolidant and adhesive. For heavier items, epoxy was the preferred adhesive. Ultimately, almost every specimen required unique consideration to determine the best practices for its care and conservation.

LESSONS LEARNED FROM "DEAD SHEEP 148", OR THE FINE ART OF DEALING WITH BIG PLASTER JACKETS

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Because of their size and weight, collecting large dinosaur specimens can be a logistical challenge. From 2005-2007, crews from the Tate Geological Museum at Casper College collected a hadrosaur known as "Dead Sheep 148" from the Lance Formation in eastern Wyoming. The pelvic region of this animal was well articulated and collected as one jacket eight feet long, three feet wide and two feet thick. Over the next few years the jacket was opened in the museum's prep lab and the specimen were prepared by museum volunteers. Since the bones were well articulated, including many ossified tendons, they were left in situ in the jacket. The jacket contains a series of 22 articulated vertebrae, much of the pelvis and one femur.

After opening the jacket, three cracks developed in the specimen. It is uncertain if the cracking was due to structural issues in the jacket, or to drying out, or to other factors. The cracks were stabilized using glues and epoxy putty. We had planned to move the specimen using a tripod, chain hoist, and two-inch wide nylon webbing, but the cracks were almost exactly above where the nylon straps would be suspending the jacket, raising fears that in moving it, the cracks would re-activate and the specimen would fall apart. We came up with a technique to move the specimen into the museum galleries while minimizing the chances of its breaking. The jacket was lifted using the same tripod set-up plus a scissor jack under each end of the jacket to prevent the jacket from buckling. A custom fit piece of plywood was slid in underneath the jacket, and then the jacket was lowered onto the plywood. While the jacket was still suspended, two-part foam was injected into the space between the jacket and the plywood, making a rigid support for the jacket. This rigid support makes the specimen easily movable in the future should we need to move it again. Many lessons were learned in dealing with a big jacket and unforeseen problems, and will influence how we will deal with future large jackets.

THE PREPARATION OF YPM 57103, A CASE STUDY

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In 2005, a Yale Peabody Museum team working in the Triassic Chinle Formation of Utah's Grand Staircase - Escalante National Monument excavated the complete, articulated skeleton of an as yet undescribed 1.5 meter long crocodylomorph. This case study will describe the preparation of this specimen; the materials and methods used in its preparation and its molding and casting, and why these were chosen. It will also describe the challenges presented by abundant calcium-carbonate concretions, the need to work the matrix block from two sides, and repairs necessitated by damage from a water leak while in the preparation lab. Because the specimen is both fragile and complex, it was impossible to remove it from its matrix block; however, it was necessary to reduce the block dramatically to optimize the specimen for CT scanning. Before molding, cracks were filled with a polyethylene glycol 1000/3350 mixture. The specimen was molded with silicone rubber. Support jackets of specialized high strength plaster and fiberglass cloth were made to support the smaller block while allowing preparation and research on both sides. Since water damage was confined to the matrix, repairs were made using a paste of ground matrix and methyl methacrylate, over a layer of fiberglass cloth adhered with methyl methacrylate, to reinforce thin areas. CT scanning required beam adjustment to maximize grayscale values in the range of the bone because of challenging aspects of matrix composition, in particular the abundance of concretions in close proximity to the bone. Size limits necessitated the use of both micron CT and medical CT. Even after scanning parameters were optimized, scans showed considerably less morphology than was visible by examining the fossil itself because of excellent color separation between bone and matrix. Thus, in this case, scans proved to be no substitute for good manual preparation, which ultimately provided the primary data for analyzing the specimen's morphology. This specimen experienced many usual and unusual aspects of the complete preparation process from excavation to research.

HIGH-RESOLUTION X-RAY COMPUTED TOMOGRAPHIC SCANNING FOR PREPARATION: LOGISTICS AND LIMITATIONS

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Paleontological application of high-resolution X-Ray computed tomography (HRXCT) has exploded in the last decade. Literally hundreds of papers and abstracts have implemented HRXCT technology. Data from HRXCT scans may be used to create three-dimensional models of specimens with magnification allowing easy viewing of specimens without the risks of repeated, manual manipulations. Internal anatomy of enclosed structures (e.g., the inner ears of fossil rodents) may be documented for the first time. This might lead one to ask the question: Is this the end of physical specimen preparation? The answer is: No. Like any other medium which puts steps between observers and the observed, HRXCT introduces potential for data loss and error. Importantly, digital scans are not photographs of objects, but reconstructed images produced from overlapping tomogram slices. Some of the finest structures (e.g., pterygoid teeth of the tiny gekkonomorph AMNH FR 21444) may be lost in these reconstructions, and soft-tissue impressions may be completely invisible. Instead, HRXCT is a powerful complementary tool for use in conjunction with traditional tools and procedures for specimen observation (preparation, microscopy, photography, etc.). I will discuss specimens offering the biggest challenges to HRXCT, such as those in highly lithified sediments and those with low fossil/matrix density differentials and offer several case studies. Among these are a new chinchillid rodent from the Chilean Andes, two notoungulate basicrania encased in volcanic ash, and a Jurassic lizard from China. Each case offers specific applications for HRXCT and distinct limitations of such approaches based on mechanical capacities, software, and logistics of even the best HRXCT scanners. Materials, settings, raw and reconstructed data, and fully prepared specimens will be compared. Further application of lower-cost, quicker scans may allow a quick 'triage' of backlogged specimens, allowing researchers and preparators to prioritize specimens for processing. Finally, although technology offers spectacular ways to further study specimens, there is still no replacement for an in-hand original specimen.

USING NEUTRON RADIOGRAPHY TO QUANTIFY CONSOLIDANT PENETRATION IN FOSSIL BONE

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When applying solvent-based consolidant systems in vertebrate paleontological conservation, it is important to understand the factors determining the distribution of the consolidant in the fossil. Of particular interest is the question under which conditions the consolidant may be dragged back to the bone surface by the evaporating solvent. This may result in the unwanted buildup of a thick layer of consolidant on the surface of the fossil, while generally a deep and isotropic penetration is preferred instead. Physical sectioning of a fossil provides a quick, affordable and destructive assessment of the penetration characteristics of a solvent-based consolidant system. Neutron imaging instead, apart from being non-destructive, has the advantage of providing a much more quantitative, spatial impression of the actual distribution of the consolidant. Because of its non-destructive nature, it could potentially also provide better insight into the effect of multiple applications of consolidant. Therefore, as a proof-of-concept, bone material from the type Maastrichtian (SE Netherlands) was partially consolidated and

imaged using the High Flux Reactor facility (HFR) in Petten. As neutrons are particularly well absorbed by hydrogen bonds, many consolidants become clearly visible in otherwise neutron-radiolucent materials such as the fossils considered here. The fossil material was stored in a climate-controlled museum collection at 50-60% RH prior to making the radiographs. Air RH at the HFR facility was controlled at 55%. Neutron radiographs were made using sub-thermal neutrons, flux $7.88 \cdot 10^9 \text{m}^{-2}\text{s}^{-1}$ with a reactor power of 45MW; exposure time 50 minutes, using a gadolinium backscreen. Field of view was 230 mm. Neutron imaging of an acetone/methylmethacrylate system applied on type Maastrichtian mosasaur material showed that in this case, the consolidant distribution was rather even, and that the penetration of the consolidant, poorly visible and hard to assess on a physical section, turned out to be effective.

IMPROVING THE SCIENCE OF PALEONTOLOGY THROUGH EFFECTIVE COMMUNICATION IN THE LABORATORY

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The ability to conduct research on fossil vertebrates is typically predicated on exposure of morphology. This exposure often takes place in preparation laboratories, and is conducted by laboratory staff that usually do not have as extensive an understanding of specific morphological features or their relevance as the primary researchers requesting the work. Likewise, laboratory and collections staff may have concerns about long-term effects of treatments that conflict with the goals of short-term research projects. Misunderstandings can have dire consequences due to loss of information through damage to specimens, increased labor costs, and potential risk to specimens. These risks can be mitigated by improving communication between members of the research team. Expectations and concerns must be clearly stated throughout the project, and can be communicated consistently using common technology, e.g., email, digital photos, CT scans, and digital maps, as well as through the use of tools like dual-head teaching microscopes and computer monitors. This information should be maintained, along with detailed records of materials and techniques applied, within the collections database or laboratory archives and included in the methods section of resulting publications.

DEFORMATION IN SILICONE MOLDS AND ITS EFFECT ON THE ACCURACY OF CASTS

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Fossils are molded and cast to produce near-perfect copies of specimens for research, display, trade, or sale. There are two basic types of multi-part silicone molds: block molds and glove molds. Block molds have thick silicone walls and are self-supporting. Glove molds are thin walled molds that are supported by a rigid mother mold. The two halves of a mother mold can either be in contact along the seam line, or they can be separated by an extension of the silicone mold, forming a gasket. A phytosaur tooth was cast in a one-part mold and re-molded using all three kinds of the multi-part mold. A grid pattern was carved into the surface of the tooth cast to provide points for measuring the amount and type of distortion. The resulting block mold and glove molds were tested to determine how the molds deform during the process of casting. The molds and casts were produced with a platinum-cured silicone rubber and polyurethane plastic. During the casting process, two-part molds were bound together using a variety of techniques: rubber bands, plywood with c-clamps, and shrink-wrap. All three types of molds can consistently produce accurate casts when used properly. If block molds or gasket-

type mother molds are bound together too tightly, the casts will compress along the seam line. Contact mother molds initially produce high quality copies of fossils, but later casts are often distorted after plastic leaks between the silicone mold and mother mold. This problem can be solved by separating the mother mold from the silicone mold with a single layer of plastic wrap and changing the wrap between pours. Molds should be bound tight enough to prevent leaks but not enough to deform the silicone surface. The greatest amount of deformation typically occurs where a thin layer of silicone surrounds a large void within the mold. To avoid this problem, a silicone mold can be opened, filled with plastic resin, and allowed to cure before combining the two halves.

SEISMIC MITIGATION FOR PALEONTOLOGICAL DISPLAY SPECIMENS

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Potential damage caused by seismic activity and rough handling of exhibits by museum visitors is a threat faced by all museum displays. Traveling exhibits are particularly at risk as they may move from localities with low probability of seismic activity to areas that are more prone to earthquakes. An American Museum of Natural History traveling exhibition, "Dinosaurs: Ancient Fossils, New Discoveries" was scheduled to travel to venues in seismically active areas in southern California and central Italy. Seismic mitigation was not integrated into the exhibit design during the original fabrication in 2005. After consultation with museum conservators, changes were made to twenty six specimen mounts or mounting techniques in an attempt to better secure specimens and minimize damages in the event of an earthquake. The modifications occurred during the 1-2 week periods between exhibition venues when specimens were accessible by museum staff. Due to time constraints, any modifications had to be simple, practical and inexpensive. The aim of these modifications was to decrease the potential for lateral and vertical movement due to seismic forces. Tie downs, anti-walkers, and removable clips were added to mounts that previously relied mainly upon gravity to secure paleontological specimens. Microcrystalline wax was used in some cases to secure casts, and it was avoided if possible with fossil material. Specimen mounts with removable clips have the added advantage of reducing damage caused by abrasion between the specimen and its mount while installing the object. Several of the earliest modifications were unintentionally tested by the April 4, 2010 Mexicali Earthquake which shook San Diego with a Modified Mercalli Intensity scale of V-VI, with the result that no damage occurred.

VIRTUAL AND REAL: USING 3-D SCANNING, MODELING, AND PRINTING IN RECONSTRUCTING A JUVENILE APATOSAURUS SKELETON

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Using Apatosaurus bones from the Morrison Formation of the Oklahoma panhandle collected between 1933-1941, the Oklahoma Museum of Natural History determined to build a full skeletal mount of the smallest individual represented, an animal only around 84 centimeters (33 inches) high at the hip and 4 meters (13 feet) long. In the 1990s a 28 meter (92 feet) long display mount had been created from bones representing a huge adult individual from the same

quarry. A minimum of four juveniles, shown by duplicate right tibiae all within 10% of each other in size, contributed to bones in the smallest size grouping. Early on 3-D imaging and printing was chosen to produce mirror images of selected bones and models versus hand sculpting. Use of 3-D computer modeling expanded to where nearly 57% of the bone reconstructions by count (skull and jaws counting as only three pieces) were generated on the computer. Besides mirror images, methods included shrinking scans of bones from larger individuals to fit, blending between models or real bones to fill gaps in a series, and using formulas to generate other series by distortion of models. Some crushing, distortion, and damage was removed or repaired on scans of real bones. All regularly reconstructed bones or sculpted clay models were also 3-D scanned and a virtual skeleton made. Care was taken to retain juvenile characters that could be identified in the real bones and add the best guesstimates for missing bones. The virtual skeleton allowed evaluation of reconstruction choices and correction of those choices, if needed, as work progressed. The virtual skeleton remains as a resource to evaluate possible changes to the reconstruction in the future.

A TUTORIAL ON TIME-LAPSE PHOTOGRAPHY FOR ONLINE DISSEMINATION OF PALEONTOLOGICAL SCIENCE: FOSSIL PREPARATION, SKELETAL MOUNTING, AND FLESH MODEL RESTORATION AS EXAMPLES

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The use of photography to create time-lapse movies has the potential to vividly capture important sequential activities in paleontology, such as fossil preparation, skeletal mounting, and flesh model reconstruction. These common activities, which are often depicted much less effectively in still photos, can be brought to life in movie for lecture, exhibit, film, or online dissemination. The expenses involved are minimal and the benefits are long-term.

We created a time-lapse tutorial which will be posted online to outline best practices in the creation of time-lapse movies. This tutorial covers image framing, stage and lighting, camera settings (shutter speed, aperture, etc.) and incorporation of static graphics, computed-tomographic animation, and sound. We also discuss strategies during preparation, modeling and mounting that will result in the most effective time-lapse movies. The time has come to bring fellow scholars and the public common sequential activities in paleontological laboratory work via effective cost-efficient media productions.