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New Mexico Museum of Natural History and Science paleontological database

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Abstract

The entire catalogued paleontological collection of the New Mexico Museum of Natural History and Science (NMMNH), including 35,902+ fossils from New Mexico, is now online and searchable by the general public, avocational paleontologist, researcher, and geoscience educator. The Web site does not include sensitive geographic localities, but all aspects of the taxonomy, stratigraphy, and chronology of the specimens are viewable at <http://164.64.119.14/nmmnh/web/default.html>. The NMMNH's collection encompasses fossils from 5,630+ localities (5,115+ in New Mexico) ranging in age from Cambrian to Holocene and representing almost every county in New Mexico. The online database is searchable by taxonomic, stratigraphic, chronologic, and geographic criteria, using a "drill-down" approach that takes advantage of the hierarchical nature of these data to search for specimens or localities at several discrete levels. Taxonomic categories are principally Linnean ranks (class, order, family, genus). Stratigraphic criteria include group, formation, and member. Chronologic criteria are era, period, epoch, stage, and land vertebrate biochron (= land mammal "age"). Geographic criteria are country, state, county, and 7.5-min topographic quadrangle. Complex (Boolean) searches are not presently a feature of the online database. However, chronologic, stratigraphic, and geographic searches will yield complete faunal lists by locality. Additionally, more than 1,400 of the specimens in the database are illustrated digitally, and a digital image (.jpg) of the fossil will appear if it is selected. We envision a wide range of research and outreach opportunities based on this database. For example, geologic mappers can readily learn the number and age of all NMMNH fossil localities on a 7.5-min topographic quadrangle. Similarly, educators and their students can compile questions about fossil faunas from particular areas, times, or stratigraphic units from New Mexico or elsewhere.

Introduction

As a result of a collaborative effort with the U.S. Bureau of Land Management (BLM), the entire catalogued paleontological collection of the New Mexico Museum of Natural History and Science (NMMNH) is now accessible online. We do not provide sensitive geographic localities or some other details, but all taxonomic, stratigraphic, and chronologic data recorded for catalogued specimens is viewable at <http://164.64.119.14/nmmnh/web/>

default.html. This page can also be accessed through the NMMNH's homepage (www.nmnaturalhistory.org), then clicking on "Science, Research, Collections" and then "Dinosaur and Science News." A forthcoming redesign of the Web page will keep the database at the same .html address, but render it accessible from pull-down menus on the NMMNH home page.

Presently the NMMNH is home to more than half a million fossils. The catalogued paleontology collection consists of 42,750+ specimens that probably include approximately 400,000 fossils. Many of these fossils come from public lands, including federal lands administered by the BLM, the National Forest Service, the National Park Service, and the Bureau of Reclamation. Fossils also come from a variety of other entities, including from lands owned by the state of New Mexico and by private landowners. Because the NMMNH is a public institution whose mission explicitly states that it will "foster an understanding and appreciation of the diverse and evolving natural history of New Mexico and the Southwest" we have made a conscious effort to facilitate access to our collections well beyond the few hundred specimens and casts presently on display.

The online database uses a "drill-down" approach, taking advantage of the hierarchical nature of taxonomic, stratigraphic, chronologic, and geographic data to allow interested parties to look for specimens or localities at several discrete levels (see inset). It is not possible at this time to do Boolean searches (e.g., combine searches for "Paleocene" and "Alligatoridae"), but we think that for many applications the available information will be more than sufficient. The format of the database will continue to evolve over the

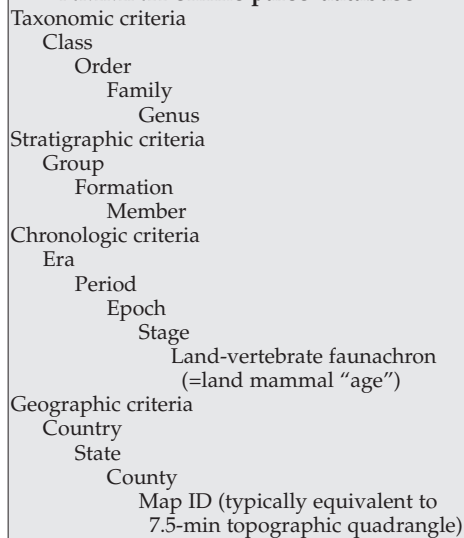
next few months, and of course the database itself will grow as we catalog additional specimens. Updates will be incremental, probably occurring several times a year, and will eventually be automated.

NMMNH paleontology collection

The paleontology collection at the NMMNH reflects the diverse efforts of museum personnel, their collaborators, and volunteers for the past 20 yrs. The 42,750+ catalogued specimens include body fossils of vertebrates and invertebrates, as well as fossil plants and an enormous collection of trace fossils ranging from invertebrate trails to vertebrate trackways and coprolites. The collection currently holds almost 400 type specimens, including more than 85 published holotypes, 121 paratypes, and 169 topotypes, as well as thousands of illustrated specimens, principally from New Mexico but including fossils from across the United States and some international holdings. Fossils from almost every county in New Mexico are included in the collections—Curry County is the sole exception.

Fossils in the collections represent every period of the Phanerozoic, with heaviest emphasis in the late Paleozoic, Mesozoic, and early Cenozoic. Particularly important Paleozoic collections include invertebrates, fish, and tetrapods from the Upper Pennsylvanian Kinney Brick Quarry (e.g., Zidek and Lucas 1992), Lower Permian vertebrate and invertebrate tracks from across New Mexico (e.g., Lucas and Heckert 1995; Lucas et al. 1998; Braddy and Briggs 2002), and the Permian–Pennsylvanian plants and invertebrates from Carrizo Arroyo (Lucas and Zeigler 2004). Mesozoic collections are principally those of vertebrates and include extensive holdings of Upper

Hierarchy of searchable criteria for the NMMNH online paleo-database



Triassic tetrapods from across the American Southwest (e.g., Lucas and Morales 1993; Heckert and Lucas 2002; Zeigler et al. 2003) and Upper Cretaceous vertebrates from the San Juan Basin (e.g., Lucas et al. 1981; Hunt and Lucas 1993; Lucas et al. 2000), as well as representative Cretaceous interior seaway invertebrates. Important Cenozoic collections include Paleogene tetrapods from the San Juan Basin (Lucas et al. 1981; Williamson and Lucas 1993; Lucas and Williamson 1993) and a growing collection of Neogene vertebrates, principally mammals, from across the state (e.g., Morgan and Lucas 2000, 2003).

The NMMNH has been the primary repository for all paleontological collections resulting from paleontology thesis projects at the University of New Mexico (UNM) since 1980. They include many master's theses (Williamson 1989; Goodspeed 1996; Heckert 1997; Zeigler 2002), several doctoral dissertations (Williamson 1993; Hunt 1994; Ma 1997; Heckert 2001), and many related publications (e.g., Williamson and Lucas 1992; Williamson 1996; Hunt 2001; Zeigler et al. 2003; Heckert 2004). Additionally, every New Mexico Geological Society guidebook since 1989 (and several before that) includes at least one article, and usually several, featuring fossils from the NMMNH collections. Thus a huge volume of paleontological research is vouchered in the collections. The online database does not explicitly refer to the publications for specimens, but researchers and the interested public can use the database to verify and even update published information by cross-referencing by geographic, stratigraphic, or temporal data.

We have not, as yet, incorporated the collections of Rousseau Flower, formerly of the New Mexico Bureau of Mines and Mineral Resources (NMBMMR) into the catalogued collections (e.g., Rowland and Neville 2000). We are striving, however, to make the type specimens from those collections at least more accessible and are cataloguing holo-, para-, and topotype specimens into the NMMNH collections as we re-curate the collections.

Methodology

The catalogued paleontological collection at the New Mexico Museum of Natural History and Science thus consists of 42,750+ specimens from 5,630+ localities. The database documenting this collection is a Microsoft Access 2000 file that presently occupies 22 MB of disk space. A subset of this relational database, lacking detailed locality information and other fields we deemed superfluous to the Web version, was created as an entirely separate file, in part for security purposes, for the Web-based version. This subset of the database, or Relational Database Management System (RDBMS) has two principal tables, the Specimen table and the Locality table. For

Web purposes these were augmented with derivative tables that contained unique values for each data element (Class table, Order table, Family table, Genera table, etc) used in the drill-down process to locate detailed specimen records through either the Locality or Specimen tables. This process was constantly monitored by the NMMNH's geosciences collection manager (ABH) to ensure that we were retrieving the appropriate record set in response to each particular browser data call. The Web-based paleo-database module is written in ASP (Active Server Pages) 3.0, which connects to Internet Information Server (IIS) through Internet Server Application Programming Interface (ISAPI) to provide dynamic Web content and which uses VBScript (Visual Basic Scripting Edition—a language for programming documents displayed by World Wide Web browsers) to establish an OLE DB connection to the RDBMS. Through the drill-down process information retrieved from the RDBMS is progressively refined through the use of session variables that increasingly narrow the scope of the specimen search. The four searchable criteria (taxonomic, stratigraphic, chronologic, and geographic) used to retrieve information can be accessed from any point in their hierarchical delineation (i.e., search by era, search by period, search by epoch, search by age, etc.).

The system is currently running on Microsoft Internet Information Server (IIS) version 6.0, and the files have been placed in a virtual directory for security. We are also running the Microsoft SQL Desktop Engine (MSDE; available as a free download from Microsoft). This allows the RDBMS to interact with the Web server without having Microsoft Access installed on the server. Because MSDE automatically installs the Microsoft Access ODBC driver, no settings changes have to be made. However, installing MSDE requires careful reading of the installation instructions, including important information on setting up a user name and password.

The database could, theoretically, be set up to run on other Web servers (Apache, Sun One, IBM, etc.) that use a different set of protocols. We have not attempted to do this, so the exact procedures required to convert the database to MySQL or PostgreSQL are unknown to us at this time.

Additionally, in excess of 1,400 of the 42,750+ specimens are digitally illustrated in the Web-based database, and an image of the fossil will pop up when the specimen record is selected. The Web-based database is thus linked to more than 1,400 digital image files showing actual photographs or scanning electron micrographs (SEM images) of specimens. Digital photographs were acquired using a digital camera (Nikon Coolpix 995) or by scanning original photographic plates (illustrations) with a Microtek 6300 scanner. The digital images were then further manipulated and

reduced to small (<100 kb size) .jpg files with Adobe Photoshop 6.0 or Adobe Photoshop Elements 2.0. SEM images were collected using the Link ISIS software (revision 3.3) on a JEOL-JSM5800 scanning electron microscope (SEM) housed at the Institute of Meteoritics at the Department of Earth and Planetary Sciences at the University of New Mexico. This software created high-resolution (768 x 1024 pixel) TIFF (.tif) images. The digital photographs and SEM micrographs were then batch processed using IrfanView, some other graphic work was accomplished using ThumbsPlus 6. This facilitated rapid conversion of large numbers of .tif and high-quality .jpg files to smaller (<100 kb) .jpg files. We will continually add more images as time allows.

This project was made possible through the ongoing interagency cooperation of the NMMNH with the BLM. The BLM administers lands from which many of the fossils in the NMMNH collection were collected, including almost all of the vertebrates from the San Juan Basin. Indeed, in 1993 the BLM and the NMMNH entered into a partnership agreement "whereby each agreed to share expertise in developing a common database, establishing the museum as the central repository for all data and information of the paleontological resources of New Mexico" (O'Neill 2000, p. 7). We obtained support for this effort through BLM's Challenge Cost Share, Science Initiative, and Cultural Resource programs. Challenge Cost Share funding, established by Congress in 1985, is matched by BLM partners with private funding or in kind services. The BLM has only recently been able to compete for Science Initiative funding. Because one focus of the Science Initiative funding is making scientific information more readily available to the public, development of the database hosted on a Web site fit perfectly into this program. Paleontological resources on BLM lands are managed under the Cultural Resource Program, and some funds were available through that source as well. The BLM and NMMNH will continue to ask for funding to maintain and expand the database. Future steps will include addition of more digital images and ultimately a link to a geographic information system (GIS) that can be used by the BLM and qualified researchers as a planning tool. The BLM, NMMNH, and the public will all benefit from this effort through better availability of information and more effective management of the resource.

Acknowledgments

There are two separate credits pages on the Web-based database, but we would be remiss if we did not thank the artists who donated the use of their work for this non-profit, educational endeavor (Mineo Shi-

raishi, Christopher Srnka, and Joe Tucciarone). Each is credited on the site, with links to their Web sites. We also thank the funding agencies described above as well as many individuals, within the NMMNH and beyond, who improved the database with their suggestions. Student intern Caleb Lewis, funded by the NSF INRAM project, compiled most of the digital images used in the database.

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