NATIONAL PARK SERVICE PALEONTOLOGICAL RESEARCH

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INTRODUCTION

The National Park Service represents a land managing agency of the federal government that is committed towards preservation and responsible management of natural and cultural resources. During the 1980s and early 1990s the National Park Service has taken the lead in developing comprehensive paleontological resource management strategies. Through the efforts of park paleontologists Ted Fremd (John Day Fossil Beds National Monument) and Dan Chure (Dinosaur National Monument), a set of guidelines and policies have been established for the management of fossils in national parks.

Fossil Resource Conferences hosted by the National Park Service at Dinosaur National Monument, in 1986, and Petrified Forest National Park, in 1988, have provided a forum for communication between education of NPS personnel working in fossil parks. The publication, "Park Paleontology", first released in 1991, has further provided a means of communication between professional paleontologists and fossil park managers and staff. The communication network that has been established provides a more organized and credible voice for Paleontological Resource issues.

The significance of fossils and the special needs related to the management of fossil resources has gained greater recognition in the NPS over the last few years. Over 100 national parks and monuments have been identified that manage, interpret and curate fossils. During 1991, Fossil Butte National Monument and Petrified Forest National Park, hired permanent staff paleontologists. In 1992, newly established Hagerman Fossil Beds National Monument has also hired a permanent staff paleontologist and Florissant Fossil Beds National Monument has created a seasonal paleontologist position.

The NPS paleontologists have worked closely with paleontologists and land managers from other agencies in their attempts to develop paleontological resource management policies and guidelines. Additionally, three park paleontologists are members of the Society of Vertebrate Paleontology's Government Liaison Committee. NPS paleontologists were also represented at the North American Paleontological Convention Roundtable Discussion entitled, "Paleontology on Public Lands", along with representatives of the U.S. Forest Service and the Bureau of Land Management.

The direction in the management of fossils in national parks has been one of intensive field monitoring, inventory and salvage. Further, scientific research by paleontologists has not only been permitted, but promoted in the national parks. The NPS philosophy, applied towards the management of fossils, provides the potential for areas where scientists can study fossil deposits that have not been pillaged by illegal fossil collection.

This Third Fossil Resource Conference could not convene at a better time. With the new NPS paleontologists coming on board, the constant turnover of park staff in the fossil parks, and the recent introduction of important paleontological resource protection legislation, it is time again to convene and to continue the evolution of the paleontological resource management program of the NPS. The participation of many representatives from other land managing agencies and

professional paleontologists will permit discussion directed to the broader needs of, perhaps, a Federal Paleontology Program.

The staff at Fossil Butte National Monument, Dave McGinnis and Rachel Benton are to be congratulated for taking the initiative in organizing this important conference. An additional thanks to all of the researchers who have helped us to further understand the paleontological resources in our parks and this volume is dedicated to them.

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AMISTAD NATIONAL RECREATION AREA: STRATIGRAPHY AND PALEONTOLOGY

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Abstract- Amistad National Recreation Area is located northwest of Del Rio, Texas in Val Verde County. Most of the area is occupied by Amistad Reservoir and except for some isolated acreage, only the shore area up to the high pool level is within the recreation area. The lake was formed by the damming of the Rio Grande River, therefore, the boundary between the United States and Mexico is under water along the former valley of the Rio Grande River. Upper reaches of the lake are over 50 miles from the dam.

All marine fossil bearing rocks in Amistad NRA are Cretaceous in age. Two Lower Cretaceous formations are present and are known as the Devils Ridge and Salmon Peak. Lithology of both units is principally limestone. The Devils River Formation is Albian in age and the Salmon Peak Formation is a middle and late Albian facies. The Devils River was deposited as a basin margin reef around the rim of the Maverick Basin and the Salmon Peak was deposited as reef margin and basin facies. Amistad has both facies present. An open ocean connection to the basin provided the path for many genera of ammonites to move into the area and these fossils are good time indicators. In addition, many varieties of bivalves are present. Of particular interest are the various genera of rudistids that provide information concerning the depositional environment. Gastropods, echinoderms and an occasional scleractinian constitute the major marine fossils. Foraminifera are abundant, probably the most notable is the milliolid variety. Ostracods and various types of algae constitute the other known micro-organisms in the strata.

Lower Cretaceous rocks in the NRA are unconformable with Upper Cretaceous rocks. Upper Cretaceous rocks are composed of the Del Rio Clay, Buda Limestone and the Boquillas Formation. Del Rio and Buda are Cenomanian and the Boquillas is Upper Cenomanian through Turonian. The depositional setting of the Del Rio Formation was a shallow nearshore muddy siliciclastic basal transgressive unit. It is easily recognized by the very abundant bivalve, *Ilymatogyra arietina*, formerly *Exogyra arietina*. In addition, numerous other clams and a few gastropods are present. Foraminifera and ostracods are very abundant. Iron stained surfaces with borings and worm tubes mark several beds. Three genera of algae have been reported. The Buda limestone is unconformable with the underlying Del Rio and the Boquillas is unconformable with the underlying Buda. Both the Buda and Boquillas contain ammonites, various bivalves, ophiuroid and echinoid fragments, an abundance of foraminifera and some ostracods, burrows and borings. Several genera of algae are present. Although corals and bryozoans are seldom reported, they probably occur within the formations.

SYNOPSIS OF DINOSAUR MEGATRACKSITE IN ARCHES NATIONAL PARK

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Abstract- Arches National Park contains many sedimentary formations rich in fossil resources from the Late Paleozoic Era through the Mesozoic Era to the Quaternary Period. Of recent growing interest are its dinosaur tracksites. Tracksites are known within the Arches and Canyonlands region in the Chinle, Kayenta, Entrada and Morrison Formations. The majority of tracksites occur between the Entrada-Morrison contact.

Some of the sites have been known by local residents since 1940. An early ichnologist, Roland T. Bird surveyed a few of the sites after that time for possible inclusion into eastern museums. Research in the 1990s has been undertaken by Martin Lockley, Associate Professor of Geology at the University of Colorado and Director of the Dinosaur Trackers Research Group.

Originally, these tracks were believed to be part of the Moab Tongue member of the Entrada Sandstone. Evidence today suggest the tracks occur in the lowest member of the Morrison Formation of Late Jurassic age. The sediments represent a vast basin where the water table was at or near the surface (Lockley, 1991). The majority of tracks are of one type, a theropod that walked upright on two feet and left a three-toed impression. The track size ranges from several inches to over two feet. Claw marks are occasionally preserved.

The frequency of tracks ranges from one to several per square meter. Discoveries in the past six years have extended the tracksite boundaries to cover possibly hundreds of square kilometers. There may be from several million to over a billion tracks in the area occurring both within Arches National Park and outside the park on the surrounding Bureau of Land Management Lands (Lockley, 1991). Because of its extensive nature, it is referred to as a Megatracksite and is one of the few known in the country.

The full extent and significance of the Megatracksite is not known as many sections have not been completely inventoried, and additional sections have not been completely inventoried, and additional sections are discovered yearly. Currently, there is no special designation for the site and it is the present policy of the Bureau of Land Management and the National Park Service not to disclose the site to the general public.

HOLOCENE BISON FROM ARCHES NATIONAL PARK, SE UTAH

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Abstract- An artifact constructed from a bison (*Bison bison*) hornsheath was recovered from the surface of a sandstone shelter also containing skeletal remains of bison and bighorn (*Ovis canadensis*). Radiocarbon dating of bison, bighorn, and the artifact indicate that all co-occurred on the central Colorado Plateau, southeastern Utah, either between A.D. 1405 and A.D. 1420, or between A.D. 1535 and A.D. 1605. Skeletal remains of the bison imply that the animal was of the local faunal community during the transition between Protohistoric and Historic time.

Great Basin Naturalist 51 (4), p.336-342, 1991.

FOSSIL FISH FROM WHITE RIVER FORMATIONS OF THE BIG BADLANDS OF SOUTH DAKOTA

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Abstract- Three unidentified fossil fish were found in the paleontological reference collection of Badlands National Park. All collecting data was absent, including information regarding the discoverer and the locality of the find. The fossils have since been identified and a likely source area has been found.

The three fossils represent two families of the Suborder Actinopterygii, Amiidae and Centrarchidae. The first fossil, *Amia*, is missing the head and so measures 21 cm from gill to tip-of-tail. The remaining two fossils represent the family Centrarchidae (Order Perchiformes). They are basically sunfish and measure 3.5 cm each. Although the occurrence of sunfish is not unexpected, to my knowledge they do represent the only known occurrence of sunfish in White River deposits.

A probable source locality for the fossils has been found in sedimentary lake deposits at an unconformity between the Chadron and Brule formations. The lake deposits have not been positively correlated with either of the formations yet. Petrologic thin sections from both the fish matrix and the lake deposits should indicate the likelihood of their similar origin. It is recognized, however, that until actual fish fossils are found in the probable source area, the correlation of the fish to the lake cannot be claimed with any certainty. This will be the emphasis of future field work.

MICROVERTEBRATE FOSSIL RECOVERY FROM THE BRULE FORMATION OF BADLANDS NATIONAL PARK

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Abstract- Microvertebrate fossil remains can potentially unlock many mysteries regarding past faunal diversity and relationships. Unfortunately microfossils will easily erode, transport and redeposit into younger sediments. For this reason, extreme care must be taken to record exact location, stratigraphy, and topography of all microvertebrate finds.

Microvertebrate fossils have been collected from harvester ant mounds across specific basins within Badlands National Park. The nature of the collections from mid-basin areas have then been compared to collections from close proximity to specific buttes and walls. All of the ant mound collections are then compared to collections taken directly from specific source areas on buttes and walls.

Collections from mid-basin are expected to possess the most diverse fauna and include the most recently transported and reworked matter. In fact, some collections are extremely rich in grossular garnets, which have been transported great distances from the Black Hills. The actual results are mixed at this time but will become clearer with more collecting and much more sorting of material.

A COMPARATIVE STUDY OF FEEDING MECHANISMS IN THE OLIGOCENE RHINOCEROTIDS, *HYRACODON* AND *SUBHYRACODON*

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Abstract- *Hyracodon* and *Subhyracodon* are two rhinocerotoids found in the Oligocene deposits of Badlands National Park. Traditionally *Hyracodon* is reconstructed as a sub-cursorial runner. However, recently completed work by Hickerson and Wall on *Hyracodon* locomotor mechanics showed that this animal was not highly specialized for running. These results indicate that competition between *Hyracodon* and *Subhyracodon* was not significantly reduced by differences in locomotor abilities. *Hyracodon* is smaller than *Subhyracodon* but this distinction alone seems insufficient to account for their coexistence. Our field studies show that these two taxa differ in relative abundance over time. *Subhyracodon* is more common in the Orellan while *Hyracodon* is more common in the overlying Whitneyan age rocks. This implies that changes in vegetation due to increasing aridity had a different impact on these two herbivores. We plan to conduct a detailed comparison of feeding mechanics in these two taxa to determine if differences in food habits minimized competition between these rhinocerotoids. Our analysis will center on jaw muscle mechanics, dental wear facets, and incisor and diastema specializations in *Subhyracodon*.

BIOSTRATIGRAPHY AND MAGNETOSTRATIGRAPHY OF THE LATE OLIGOCENE SEDIMENTS, CEDAR PASS AREA, BADLANDS NATIONAL PARK

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Abstract- The fossil record of vertebrates from the lower portion of the Sharps Formation in South Dakota does not exhibit the taxonomic diversity as do the records from superadjacent middle and upper portions of the Sharps and the subadjacent Poleslide Member of the Brule Formation. Channel sandstone deposits in the Cedar Pass area of Badlands National Park, which downcut into the Brule Formation, represent a Lower Sharps age. These channels are rich in fossil mammals and provide new stratigraphic and taxonomic information about the Lower Sharps fauna.

The lack of a lithostratigraphic landmark, coincident with the Whitneyan/Arikareean Land Mammal Age boundary, has created consternation in regards to the placement of this boundary. Review of the Oligocene mammal biostratigraphy indicates that the concurrent ranges of

Whitneyan taxa making their last appearance and Arikareean taxa making their first appearance would best serve as the boundary horizon. The fauna of the lower portion of the Sharps Formation best represents this transitional fauna and is suggested as the boundary in South Dakota.

Paleomagnetic measurements at Cedar Pass indicate a polarity transition from normal in the Poleslide Member of the Brule Formation to reversed within the overlying Lower Sharps Formation. The transition occurs within the basal Rockyford Ash Member of the Sharps. This polarity shift can serve as a boundary marker, for the Whitneyan/Arikareean Land Mammal transition, given the lack of a lithostratigraphic landmark. Further, the paleomagnetic samples from channel sediments downcutting into the Brule (reversed polarity) support a Lower Sharps age (normal polarity) for the channel and the associated fossils.

DENTAL MORPHOMETRY OF THE LATE OLIGOCENE BEAVER *PALAEOCASTOR*

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Abstract- The genus *Palaeocastor* is one of the most commonly collected fossil vertebrates from the Late Oligocene channel sandstone deposits at Cedar Pass in Badlands National Park. *Palaeocastor* has previously been considered a good index fossil for the Arikareean Land Mammal Age. Collections from the Poleslide Member of the Brule Formation in Badlands National Park and other Whitneyan localities indicate that the range of this genus is extended into the Whitneyan and should not be considered a definitive Arikareean indicator.

The numerous Oligocene beaver specimens within the Frick Collection at the American Museum of Natural History were examined. All specimens incorporated into the database included detailed stratigraphic information. The study involved a morphometric evaluation of a few dental characters that are typically considered in the identification and description of new beaver taxa. The following measurements were obtained in 57 White River Oligocene beavers: (1) anterio-posterior length of P4-M2; (2) anterio-posterior length of P4; (3) width of P4; (4) anterio-posterior length of M1; (5) width of M1; (6) anterio-posterior length of M2; (7) width of M2; (8) anterio-posterior length of M3; (9) width of M3.

In addition, the ratio between the anterio-posterior length and the width of each tooth was used to establish an index to assess the dental morphology. Indices greater than one (>1.0) indicate a tooth with an anterio-posterior length greater than the width. Indices less than one (<1.0) indicate a tooth with a width greater than the anterio-posterior length. An index of one (1.0) indicates a tooth with an anterio-posterior length equal to the width (a rounded or squared tooth).

The dental morphometry data of *Palaeocastor* indicates that the age of an individual beaver, with an increasing wear pattern with greater age, is the most significant determinant of dental morphology. Any observable stratigraphic variations in dental morphology are masked by the extent of wear on the teeth.

A more comprehensive study of dental morphology could be accomplished by considering a series of five age classes: (1) specimens that possess a deciduous P4; (2) specimens that lost deciduous P4, but permanent P4 not yet fully erupted; (3) specimens with a fully erupted P4 exhibiting the earliest stages of wear; (4) specimens with an intermediate stage of wear on P4; and (5) specimens with an advanced stage of wear on P4. The general pattern observed indicates that heavier wear yields a more squared tooth (index closer to 1.0).

A systematic revision of the castorids has not been accomplished since Stirton's work in 1935. Dental morphology should be implemented in this study.

A SYSTEMATIC ANALYSIS OF ORELLAN AND WHITNEYAN MICROVERTEBRATES IN BADLANDS NATIONAL PARK

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Abstract- Preliminary work on microvertebrates collected by Georgia College field crews in Badlands National Park yields the following information. Three mammalian taxa, *Paleolagus,* a rabbit, *Ischyromys,* a primitive rodent, and *Eumys* an early mouse, are common throughout Orellan age rocks. Exposures of the Scenic Member of the Brule at Cottonwood Pass in the Southern Unit of the park contain the highest concentration of microvertebrates we have found. Four complete skulls and jaws of the burrowing lizard *Rhineura hatcheri* are probably the most important finds from this locality. Peltosaur lizards are also more frequently found here. Significant mammalian finds in this region are: a complete skull and jaws of the marsupial *Peratherium,* numerous skulls of the insectivore-like *Leptictis,* jaws and a partial skull of the earliest beaver *Agnotocastor,* and several partial skulls of *Protosciurus* an early relative of squirrels. Our only other significant Orellan microvertebrate locality is in the southern end of Big Corral Draw. Major finds at this locality include a skull and jaws of the insectivore *Centetodon* and partial skulls of two eomyid rodents, *Adjidaumo* and *Pseudoadjidaumo*. Our fieldwork in Whitneyan exposures in the Palmer Creek area of the park has not yielded comparable diversity or abundance. Jaws of the beaver *Palaeocastor* are most common but more interesting are two jaws of an as yet undescribed rodent.

PALEONTOLOGICAL RESEARCH AT BERING LAND BRIDGE NATIONAL PRESERVE

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Abstract- The fossil resources of Bering Land Bridge National Preserve are largely unknown. Coalified wood, isolated bones of Pleistocene mammals, leaves and insects have been observed during baseline survey work in the region. Thaw lakes and volcanic maars have been studied for plant microfossils and fossil pollen deposits. Most reports of fossil material from the preserve consist of isolated finds along rivers or beaches. Indications from other sites in the region are that of the fossil record protected in the preserve should be significant. Concentrations of mammal bones have been found nearby on private land. The northern Seward Peninsula, where the preserve lies, has not been glaciated for at least 100,000 years and the potential for preserved materials is high.

A series of volcanic eruptions have taken place over several million years and have left thick deposits of tephra to cover much of the preserve. The few areas where rivers, lakes or the ocean have eroded banks to expose potential fossil deposits remain largely unexplored. Limited work has been done with fossil pollens, but other reports of fossils are largely footnotes to other types of research.

As we complete baseline work on biological resources over the next few years, we will begin a specific survey to locate and document the paleontological resources of the preserve. The challenge is enormous. Of the 2.69 million acres of federal lands inside our boundaries, approximately 70% has potential for fossil resources. We have no roads for access and very few locations where a fixed-wing aircraft can land. Our initial efforts will be focussed on river courses and selected lakes and it will be decades before we have an adequate data base and appreciation for what we have.

PLANT AND DINOSAUR INTERACTIONS

NINA BAGHAI

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Abstract- Land plants formed the trophic foundation for large populations of dinosaurs throughout the Mesozoic. Two Upper Cretaceous formations, the Aguja and Javelina, possess a rich dinosaur fauna. This reptilian fauna has been intensely studied at Big Bend National Park. Different and unique species of hadrosaurs, ceratopsians, ankylosaurs and large sauropods are common to the Aguja Formation; many of the dinosaur associations found here do not occur anywhere else in North America. Additionally, associated plant remains are encountered in carbonaceous shales, lignites and sandstones of equivalent age throughout the park. The current study will focus on the microflora and megaflora of both formations and will highlight how past herbivores exerted different selective pressures on plants. Research objectives for 1991 include finding a prolific leaf locality associated with the dinosaur fauna and processing and analyzing a stratigraphic sequence of 80 pollen samples.

CHASMOSAURUS MARISCALENSIS SKULL FROM BIG BEND NATIONAL PARK

CATHERINE FORSTER AND PAUL SERENO

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Abstract- The recent discovery of a nearly complete ceratopsid skull in the Aguja Formation of southwest Texas supports previous conclusions that the Aguja ceratopsid represents a distinct species, *Chasmosaurus mariscalensis*. The diagnostic features of *C. mariscalensis* include an extensive anteromedial projection of the nasal between the premaxillae, erect supraorbital horns, and laterally rounded squamosal. Nine cranial features that vary among *Chasmosaurus* species, *Pentaceratops sternbergii*, and other chasmosaurines are analyzed. *Chasmosaurus mariscalensis* appears to be most closely related to northern species of *Chasmosaurus* (*C. belli*, *C. russelli*), which also exhibit a transversely flattened nasal horn and modifications of the anterior margin of the external naris. The genus *Chasmosaurus*, in turn, appears to be most closely related to the other southern chasmosaurine, *Pentaceratops sternbergii*. The biogeographic history inferred from these relationships suggest that the biogeographic exchange between northern and southern chasmosaurines that must have occurred cannot be explained by a single dispersal event to the south.

DISTRIBUTION OF FOSSIL MATERIAL IN THE MCKINNEY SPRINGS TONGUE OF THE PEN FORMATION (LATE CRETACEOUS) BIG BEND NATIONAL PARK, TEXAS

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Abstract- The McKinney Springs tongue of the Pen Formation is the highest Upper Cretaceous marine unit in the Big Bend region and consists of four lithologic facies. These intergrading lithofacies are, in ascending order, the calcareous shale facies, interbedded sandstone and shale facies, the phosphate nodule facies, and the silty shale facies. This series of lithofacies records deposition in a muddy shelf or prodeltaic setting during a marine transgression, high water still stand, and subsequent deltaic progradation. The fauna in this unit is not abundant and exhibits a low species diversity.

The calcareous shale facies contains two different types of trace fossils. These are horizontal, randomly-directed, feeding burrows (fodichnia) and vertically-oriented, spiral burrows (*Gyrolithes*). Macrofauna consists of large oysters (*Exogyra ponderosa*) and other bivalves including *Inoceramus vanuxemi* and *Durania* sp. Many of the bivalves have been bored and encrusted with oysters (*Pseudoperna* sp.). Also present are fragments of freshwater turtle and dinosaur bone.

The interbedded sandstone and shale facies contains alternating thin beds of sandstone and shale. The sandstone beds contain poorly preserved specimens of *Inoceramus* sp. The shale beds contain *Exogyra ponderosa* that are 15 to 20 centimeters in diameter, oriented in life position, and contain clionid sponge and lithophagid bivalve borings in the shell material.

The phosphate nodule facies is a lag deposit which contains rounded and abraded skeletal material. Shark teeth from three species are common - *Scapanorhynchus texanus, Squalicorax kaupi*, and *Cretolamna* sp. Also present are phosphatized small inoceramid bivalves, other small mactrid bivalves, small gastropods, and occasional crabs.

Within the silty shale facies, there are several thin sandstone beds which contain well developed trace fossils (fodichnia). Macrofauna consists of occasional shark teeth and fish vertebrae. Two types of ammonites, *Placenticeras* sp. and *Baculites* sp., are present in the upper portion of this facies. Bivalves in this facies are restricted to small clusters of *Inoceramus biconstrictus*.

STRATIGRAPHY AND VERTEBRATE PALEONTOLOGY OF THE LATE TERTIARY SEDIMENTS, LOWER TORNILLO CREEK-ESTUFA CANYON AREAS. BIG BEND NP

MARGARET STEVENS

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Abstract- The project is nearing conclusion with most of the mapping complete. The deposits being studied are of a geologic age unique to North America. From this study an important gap of information will be filled by increasing our understanding of the progressive change in faunal succession. During our 1990 field season two very important specimens were recovered when we prospected a virgin region never before studied. One was the partial skull of the horse *Hipparion forcei*, and the other was the lower jaw bone and some rib and vertebral scrap of a long-jawed mastodon.

FOSSIL DICOTYLEDONOUS WOODS OF BIG BEND NATIONAL PARK, TEXAS

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Abstract- Big Bend National Park has abundant remains of fossil dicotyledonous woods of Cretaceous and Paleocene age. These woods are significant because worldwide there are fewer than 100 records of Cretaceous dicot woods, and fewer than 40 records of Paleocene dicot woods. In collaboration with Tom Lehman of Texas Tech, work is underway to document the diversity of fossil dicot woods of Big Bend. The Aguja Formation (Campanian, Late Cretaceous) has yielded woods of the platnoid (sycamore-like) and phyllanthoid types, wood types that occur at other Cretaceous localities in the northern hemisphere. In addition, there are at least five other wood types, and these represent new species. All five have characteristics of tropical trees, and, as a group, are relatively unspecialized anatomically. In the Javelina Formation (Maestrichtian, Late Cretaceous), a large log (>1m diameter) has specialized features and resembles tropical members of the Malvales.

Over 30 logs in the Paleocene Black Peaks Formation are of a single type, and have been described as a new species, *Paraphyllanthoxylon abbotti*. The species name recognizes the late Maxine Abbott who collected this material. These woods and a platanoid type are the only Paleocene dicot woods described from the United States. The Cretaceous and Paleocene dicot woods of Big Bend cannot be assigned with confidence to a single extant plant family.

INVESTIGATION OF PETRIFIED WOOD SAMPLES FROM BIG BEND NATIONAL PARK

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Abstract- Several samples of silicified and carbonized woods from the Cretaceous non-marine Gulfian Series of geological formations (Javelina or Aguja formations) are under investigation. Representative specimens were examined by R.V. Gentry of Earth Science Associates to determine if any radiohalos were present in the materials. No radiohalos were detected in the petrographic thin sections. Gentry concluded that there had been no uranium infiltration of the Big Bend fossil woods he examined as was the case in the carbonized woods he studied from the Colorado Plateau and from Chattanooga Shale.

A sample of carbonized wood was found to contain 59.2% carbon and was subjected to a radiocarbon age determination. No C-14 was detected and the radiocarbon age was found to be greater than 42,000 years B.P. Other C-14 age determinations will be done. Several silicified wood samples were analyzed for SiO2 to determine the degree of petrification. The results are as follows:

SAMPLE DESIGNATION	(% SiO2)
A	85-96.4
B	94-97.2
C	93-95.3
D	4.5-5.2
E	4.3-5.3

From the analyses, it appears that all samples except D and E are well-petrified. Also energy dispersive x-ray analyses were conducted on all samples. Further chemical tests are planned. Attempts will be made to identify all wood samples from scanning electron micrographs and petrographic thin sections.

PLANT MEGAFOSSILS OF THE UPPER TRIASSIC CHINLE FORMATION, CANYON DE CHELLY NATIONAL MONUMENT, ARIZONA

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Abstract- Although Canyon de Chelly National Monument is most famous for the Indian cliff dwellings found within its boundaries, it also includes several localities that contain plant megafossils. These fossils are found in the Chinle Formation of Late Triassic age. Interestingly, the first Triassic plant fossils to be collected from Arizona were found in the Monument in 1849. The work which has been accomplished thus far shows that plant megafossils occur at several horizons in the lower part of the formation in the Shinarump and Monitor Butte Members. The flora is comparatively small and include representatives of only the lycopods, cycadophytes, conifers, and several taxa of uncertain classification. The most interesting form in the flora is *Dechellyia*, a fossil which combines features that usually occur in separate groups. The Chinle plant fossils are preserved as compressions, impressions, and petrifications. In general, the flora correlates with the classic Chinle flora of Petrified Forest National Park and northwestern New Mexico. Several of the fossils that occur in the Monument have either been described or mentioned in the literature but no complete study of the flora has yet been published. At this time the following plant megafossils have been recognized in the Chinle Formation in Canyon de Chelly National Monument:

Lycopods

Seleginella anasazia

Conifers

Masculostrobus clathratus
Araucarioxylon arizonicum
Pelourdea sp.
Dechellyia gormanii
Dinophyton spinosus

PALEONTOLOGIC, SEDIMENTOLOGIC, AND PALEOECOLOGIC EXAMINATION OF THE CANYONLANDS NATIONAL PARK VICINITY, UTAH

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Abstract- Four field seasons of study has shown that the Upper Triassic Chinle Formation in the area of Canyonlands National Park contains important and diverse vertebrate, invertebrate, plant and trace fossils. These occurrences in and around the park help to reconstruct the paleoecologic setting and interpret paleoclimate.

Vertebrate fossils include phytosaurs, aetosaurs, metaposaurids, and several types of semionotid and turseodid fishes. The assemblage shows that there must have been ample water to sustain these aquatic and amphibian vertebrates.

Invertebrate fossils include gastropods, clams, conchostrachans, and crayfish. The crayfish are associated with burrows and are the earliest known fossils of freshwater burrowing crayfish. The invertebrates show that ample water existed, but with periods of drier conditions (i.e., seasonality).

Trace fossils include crayfish burrows and crawling traces, oligochaete feeding burrows, insect burrows, and the resting trace of a horseshoe crab. Many of these traces are newly described and important assets to the park area.

These fossils occur in continentally deposited fluvial, paludal, and deltaic-lacustrine systems fed by tropical monsoonal weather patterns that produced seasonality in precipitation.

PLANT MEGAFOSSILS OF THE UPPER TRIASSIC CHINLE FORMATION, CAPITOL REEF NATIONAL PARK, UTAH

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Abstract- Plant megafossils occur at many localities in the Chinle Formation of Late Triassic age in Capitol Reef National Park. These localities, which occur at several horizons in the formation ranging from the Shinarump Member at the base to the Owl Rock Member equivalent at the top, contain representatives of most major groups of vascular plants including horsetails, ferns, cycadophytes, conifers, and several taxa of uncertain classification, including *Sanmigueia*, a fossil that some authors believe is an angiosperm. The Chinle plant fossils are preserved as compressions, impressions, petrifications and pith casts. The flora correlates in general with the classic Chinle flora of northern Arizona and New Mexico. When study of these fossils is completed science will have a better understanding of the plant life and paleoecology of the area during Late Triassic.

Some of the fossils that occur in the park have either been described or mentioned in the literature but no complete study of the flora has yet been published. At this time the following plant megafossils have been recognized in the Chinle Formation in Capitol Reef National Park:

Horsetails

Equsetites sp.

Conifers

Pagiophyllum sp.

Brachyphyllum sp.

Araucarioxylon arizonicum

Ferns

Phlebopteris smithii

Cynepteris lasiophora

Cladophlebis sp.

Cycadophytes

Eoginkgoites davidsonii

Zamites powellii

Zamites n. sp.

Classification uncertain

Sanmiguelia lewisi

THE PRESETTLEMENT VEGETATION OF CAPITOL REEF NP RECONSTRUCTED WITH FOSSIL PACKRAT MIDDENS

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Abstract- Plant macrofossils and pollen from twenty five packrat middens were analyzed in order to reconstruct the past vegetation and to analyze vegetation changes occurring since settlement at Capitol Reef National Park. The middens ranged in age from modern to greater than 39,000 years. Eight middens collected from Hartnet Draw in northern Capitol Reef allowed the reconstruction of vegetation over the last 5400 years. Presettlement middens consistently contained fossils of plants now heavily browsed by cattle such as winterfat (*Ceratoides lanata*), pinyon pine (*Pinus edulis*), sagebrush (*Artemisia tridentata*) and rice grass (*Oryzopsis hymenoides*), none of which are present in a modern packrat midden although some of these plants are present in varying amounts in the modern community. In contrast, the modern sample is the only midden containing specimens of plants typical of overgrazed range such as whitebark rabbitbrush (*Chrysothamnus visidiflorus*), and greasewood (*Sarcobatus vermiculatus*), and one of two middens containing snakeweed (*Gutterezia sarothrae*). The recent grazing impacts precipitated by far the most severe vegetation changes of the last 5000 years.

HOLOCENE PALEOECOLOGY OF AN ESTUARY ON SANTA ROSA ISLAND, CHANNEL ISLANDS NATIONAL PARK

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Abstract- A 5 meter sediment core was taken from a small estuary at the eastern end of Santa Rosa Island, within Channel Islands National Park, California. The core produced a stratigraphic and pollen record spanning the last 5200 years. Three major zones, distinguished through pollen analysis and sediment chemistry, are visible in the core. The lowermost zone (5200 to 3436 yr B.P.) represents a time of arid environments with predominantly marine sediment input and high Cheno-AM and *Ambrosia* pollen values. The next zone (3319 yr B.P. to 1800 A.D.) is characterized by greater fresh water input with high values for Compositae, Cyperaceae, and charcoal particles. The uppermost zone (1800 A.D. to present) documents the vegetation disturbances and high sedimentation rates which resulted from the introduction of large exotic herbivores and exotic plants to the island during the settlement period. The identification of pollen grains from a nearby stand of Torrey Pine (*P. torreyana*), one of only two natural stands, document its persistence on the island throughout the late Holocene.

LOWER DEVONIAN VERTEBRATES FROM THE LIPPINCOTT MEMBER OF THE LOST BURRO FORMATION IN DEATH VALLEY NATIONAL MONUMENT

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Abstract- Lower Devonian vertebrate faunas in the western USA are currently known from a small number of localities in Wyoming (Beartooth Butte Formation) and Utah (Water Canyon Formation), and most recently from the Sevy Dolomite of Nevada and Utah. These faunas are most commonly found in sediments filling channels cut into the underlying Lower Paleozoic strata, and appear to record a major transgressive event in which the early Devonian sea advanced to the east.

The new Lower Devonian fauna in Death Valley extends the record of this event to the south and west. It occurs in a large channel at least 150 m deep and 600-800 m wide, located near Trail Canyon on the eastern flank of the Panamint Range. The fauna contains gnathostomes (jawed vertebrates) represented by one placoderm and several acanthodians; and agnathans (jawless vertebrates) represented by one cephalaspid, six cyathaspidids, and six pteraspidids. The agnathan fauna adds considerably to our knowledge of the diversity of these organisms during the Lower Devonian as only one cyathaspidid and ten pteraspidids had been described previously from Utah and Wyoming.

Sufficient genera are found in common between the Death Valley fauna and those previously described to allow them to be correlated. In addition there is sufficient invertebrate dating of the Lippincott member of the Lost Burro Formation to show that the fauna must be late Emsian in age.

Work is continuing to collect a more complete fauna, and to complete studies on the sediments in the channel-fill and their environment of deposition.

GRAPTOLITE BIOSTRATIGRAPHY OF THE ORDOVICIAN MARTINSBURG FORMATION IN THE DELAWARE WATER GAP REGION

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Abstract- Within the Delaware Water Gap National Recreation Area (New Jersey & Pennsylvania) are many fossil localities that are significant in the biostratigraphy of the Silurian and Devonian Systems. Shelly invertebrate fossils are abundant in the formations of Silurian and Devonian age and have been studied for more than a century.

The fossils of the Ordovician System are less well known, and the rocks are structurally complicated. Biostratigraphy of such formations generally is based on graptolites rather than shelly fossils. Graptolites were floating colonial marine invertebrates with which widely recognized mappable zones have been established.

As an outgrowth of paleontological resource surveys in the Delaware Water Gap National Recreation Area (funded by the Eastern Parks and Monuments Association), the Ordovician Martinsburg Formation can now be studied with reference to a biostratigraphic framework (New Jersey Geological Survey Report 28, 1992). Historically important to the slate industry, it is one of the most important geologic resources of the region.

The collections, including many new graptolite discoveries from northern New Jersey, eastern Pennsylvania, and southeastern New York, confirm that the Ordovician Martinsburg Formation consists of three members: in ascending order the Bushkill, Ramseyburg and Pen Argyl Members. The Bushkill and Pen Argyl Members are not equivalent in age as previously suggested by some authors. The Bushkill Member correlates with the *Climacograptus bicornis* to *Corynoides americanus* Zones. The Ramseyburg Member correlates with the interval represented by the *Orthograptus ruedemanni* Zone and the lowest part of the *Climacograptus spiniferus* Zone. The Pen Argyl Member correlates with the upper part of the *Climacograptus spiniferus* Zone.

PLANT MEGAFOSSILS OF THE UPPER JURASSIC MORRISON FORMATION, DINOSAUR NATIONAL MONUMENT, UTAH

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Abstract- Although Dinosaur National Monument is most famous for the dinosaur bones that are found within its boundaries, it also contains several localities that contain plant megafossils. These fossils are found in the Morrison Formation of late Jurassic age and for the most part have not yet been studied. The Morrison plant fossils are preserved as compressions, impressions, and petrifications. Unfortunately, the leaf compressions are, for the most part, highly fragmented and unidentifiable. Some, however, are large enough to identify at least to the generic level and show that ferns, conifers, and other groups are present. A manuscript has been submitted for publication that records the presence of the unusual leaf *Czekanowskia* at one of these localities in the monument. This discovery is significant because the fossil is considered to be indicative of a humid climate and its occurrence in the monument suggests that the Morrison was deposited under similar climatic conditions.

STRATIGRAPHY AND SEDIMENTARY PETROLOGY OF THE UPPER JURASSIC - LOWER CRETACEOUS ROCKS AT THE CLEVELAND-LLOYD DINOSAUR QUARRY WITH A COMPARISON TO THE DINOSAUR NATIONAL MONUMENT

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Abstract- Two Jurassic dinosaur quarries occur in the state of Utah -- the Cleveland-Lloyd Dinosaur Quarry, a National Landmark, and Dinosaur National Monument. The dinosaur fossils in both quarries occur in the Brushy Basin Member of the Morrison Formation, well below the boundary with the Lower Cretaceous Cedar Mountain Formation. Due to similarities in the dinosaur faunas and in the rocks of the enclosing formations, the fossiliferous strata in the quarries generally are considered nearly contemporaneous. Analyses of biotites from volcaniclastic, montmorillonitic claystone collected in proximity to the quarries reveal disparate dates, 146.8 +1 Ma for a claystone 1.5 m above the fossiliferous interval at the Cleveland-Lloyd Dinosaur Quarry, and 135.2 +5.5 Ma for a claystone 11 m above the main fossiliferous interval at Dinosaur National Monument. Therefore the quarry at Dinosaur National Monument is substantially younger than the one at the Cleveland-Lloyd Dinosaur Quarry and much of the uppermost Brushy Basin at Dinosaur NM is Early Cretaceous rather than Late Jurassic.

Petrologic analyses of the Middle Jurassic through Lower Cretaceous rocks at the Cleveland-Lloyd Dinosaur Quarry reveal a regressive sequence from the intertidal beds of the Summerville, through the supratidal deposits of the Tidwell Member of the Morrison, into the continental deposits of the rest of the Morrison and Cedar Mountain formations. At Dinosaur National Monument the transition from the marine Sundance Formation to the fluvial Morrison Formation

was rapid. Source areas for the two localities were similar, although pulses of cherty conglomerate from the west occur more frequently and earlier at Dinosaur NM. The clay mineral suites are similar, revealing syngenetic neoformations indicative of the paleoclimates. Particularly at the Cleveland-Lloyd Dinosaur Quarry there appears to be a progression from arid to monsoonal to humid conditions, which coincidentally helps define the formation and member boundaries. The paraconformity the encompasses much of the Berriasian at the Cleveland-Lloyd and the caliche, magadiite-type chert, and dolomite in the uppermost Brushy Basin at Dinosaur NM attest to an arid environment, coinciding with uplift to the west during the early pulses of the Sevier orogeny.

NEW DATA ON THE THEROPOD *MARSHOSAURUS* FROM THE MORRISON FORMATION (UPPER JURASSIC: KIMMERIDGIAN-TITHONIAN) OF DINOSAUR NM

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Abstract- Two new specimens of the rare carnivorous dinosaur *Marshosaurus* have been collected from in and near Dinosaur National Monument, including the first cranial material of this species. The skull of *Marshosaurus* is primitive in having an unconstricted lateral temporal fenestra but derived in possessing a system of pneumatic fenestra in the braincase similar to the pattern seen in tyrannosaurids. Preliminary phylogenetic analysis indicates that *Marshosaurus* is a carnosaurian tetanuran. The articulated vertebral columns will allow for identification of isolated *Marshosaurus* bones from the type locality, the Cleveland-Lloyd Quarry.

The new specimens extend the geographic distribution of this taxon into NE Utah and NW Colorado. They also extend the range from high in the Brushy Basin Member (early Tithonian) to far down into the Salt Wash Member (late Kimmeridgian). The associated fauna includes crocodilians, turtles, and *Stegosaurus* and indicates that typical Brushy Basin fauna probably arose during Salt Wash times.

A NEW CARNOSAURIAN DINOSAUR (SAURISCHIA: TETANURAE) FROM THE SALT WASH MEMBER OF THE MORRISON FORMATION (JURASSIC: KIMMERIDGIAN) OF DINOSAUR NATIONAL MONUMENT

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Abstract- An isolated, articulated skeleton of a large (20-25 ft. long) carnivorous dinosaur is currently being excavated in Dinosaur National Monument. The specimen was discovered in 1989 during a paleontological survey of the Morrison Formation. The part exposed to date includes all of the skeleton from the should blades back to the tip of the tail. The front part of the specimen continues into the hill side and excavations are continuing. It is highly likely that all of the skeleton (including the skull) is present.

Although preparation has only been done in the field at present, the specimen shows a suite of morphological features quite at variance with any other known Morrison theropod dinosaur and indicates that it is at least a new species and probably a new genus. Pelvic structure shows similarities with mid-Jurassic theropods (*Piatnitzskyosaurus*) from Argentina and late-Cretaceous tyrannosaurids. Overall morphology strongly suggests carnosaurian tetanuran affinities.

This specimen is one of the best carnivorous dinosaur skeletons ever found anywhere in the Morrison Formation and the only good theropod skeleton from the Salt Wash Member of the Morrison.

A LIZARD SKULL (SQUATMATA: PARAMCELLODIDAE) FROM THE BRUSHY BASIN MEMBER (EARLY TITHONIAN) OF THE MORRISON FORMATION, DINOSAUR NATIONAL MONUMENT

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Abstract- An isolated, small (1.5 cm long) skull has been collected from the early Tithonian upper part of the Brushy Basin Member of the Morrison Formation. The shape and size of the teeth and the morphology of the maxilla identify the specimen as belonging to the extinct lizard family Paramacellodidae. The morphology of the back of the skull confirms earlier speculations that this family may be closely related to the living cordylid lizards.

The new specimen is only the second skull known for the family and the first skull from the western hemisphere. Because the only other known skull is obscured by preserved skin, the morphology of this family and will prove useful in identifying isolated skull bones from this taxon in Upper Jurassic deposits of North America and western Europe.

AN EMBRYO OF *CAMPTOSAURUS* FROM THE BRUSHY BASIN MEMBER OF THE MORRISON FORMATION IN DINOSAUR NATIONAL MONUMENT

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Abstract- A small partial skeleton of an ornithopod dinosaur was collected from bentonitic mudstone in the upper part (Tithonian) of the Brushy Basin Member of the Morrison Formation. The specimen consists of two posterior cervical and six anterior dorsal vertebrae, five anterior caudal vertebrae, scapula, coracoid, humerus, tibia, fibula, and dorsal ribs. On the basis of distinctively shaped coracoid the specimen is referred to *Camptosaurus*, a common Morrison ornithopod which reached lengths of 8 meters. Bone texture, extreme small size, and some morphological features indicates that the specimen is the remains of an advanced embryo, even though there is no associated eggshell. The unossified epiphyses of the long bones suggests that *Camptosaurus* hatchlings were altricial. Estimated total length is 240 mm.

Beds at or near the fossil horizon are characterized by smectitic overbank and lacustrine mudstones with scattered isolated fluvial channel sandstones. The locality is 10 m stratigraphically above the level of the famous Carnegie Dinosaur Quarry. Both the Dinosaur specimen and embryonic and hatchling *Dryosaurus* specimens from western Colorado are located in alluvial plain sediments of the Morrison Formation some 200-300 km downstream from inferred highland sediment source areas to the west.

(in press) "Dinosaur eggs & babies", Cambridge University Press

DEPOSITIONAL ARCHITECTURE, PROVENANCE, AND SEQUENCE STRATIGRAPHY OF THE NONMARINE JURASSIC-CRETACEOUS CORDILLERAN FORELAND BASIN, NORTHEASTERN UTAH, NORTHWESTERN COLORADO

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Abstract- This proposal seeks permission to conduct a detailed study of Jurassic-Cretaceous nonmarine sedimentary rocks within the boundaries of Dinosaur National Monument. These rocks, known as the Morrison, Cedar Mountain, and Dakota Formations, record the initial development of the Cordilleran foreland basin during the late Jurassic and early Cretaceous time. However, due to variable facies relationships and internal stratigraphic complexity, correlation between depositional systems and foreland basin development is enigmatic. In order to better understand basin evolution, the primary goals of this study are to: 1) reconstruct basin architecture and depositional systems of the Morrison, Cedar Mountain and Dakota Formations; 2) determine sediment provenance; 3) define a chrono-stratigraphic framework for nonmarine deposition; and 4) develop a sequence stratigraphic approach to interpreting nonmarine facies evolution within the Cordilleran foreland basin. The detailed stratigraphic resolution generated

by this study will facilitate the identification of important surfaces of discontinuity and define regional depositional packages. The sedimentologic nature of these packages, as well as their three-dimensional distribution, will offer insight into the tectonic, eustatic, and climatic factors affecting early Cordilleran foreland basin evolution.

A MAMMALIAN FAUNA FROM THE JURASSIC MORRISON FM. OF DINOSAUR NATIONAL MONUMENT

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Abstract- A microvertebrate locality in the Rainbow Park area of Dinosaur National Monument has yielded a diverse fauna of small vertebrates, including mammals. Specimens have been recovered from two quarries by hand quarrying and screenwashing of quarried matrix. Both quarries are within the Brushy Basin Member of the Morrison Formation and are stratigraphically and geographically close to each other. Both occur in mudstones but probably represent somewhat different overbank facies. The mammalian element of the fauna is represented primarily by more than 100 isolated teeth and includes: a triconodont, at least two species of multituberculates, a symmetrodont at least two species of dryolestids, and a paurodontid. No docodonts have been identified yet. One specimen is a partial skull of a multituberculate that preserves a complete palate with upper dentition.
49th SVP Meeting, Austin, Texas, 1989.

FOOT PROPORTIONS OF BIPEDAL DINOSAURS AND THE IDENTIFICATION OF TRIDACTYL DINOSAUR FOOTPRINTS

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Abstract- One of the most vexing problems facing dinosaur ichnology is making an accurate identification of a trackmaker. Using dinosaur footprints to make ichnological censuses for comparison with skeletal faunas, to investigate the extent to which ichnofacies correspond to lithological facies, or to make interpretations of the behavior of trackmakers, depends in large degree on whether tracks can be correctly ascribed to their makers. For tridactyl footprints of bipedal dinosaurs, such assignments have hitherto been based largely on the gross appearance of tracks, their "gestalt". Attempts have been made to use multivariate statistical techniques to discriminate theropod tracks from ornithopod prints, but in the absence of independent criteria for assigning footprints to zoological taxa in the first place, such approaches seem to be little more than extended exercises in circular reasoning.

I have sought criteria by which footprint taxa might better be correlated with skeletal taxa of dinosaurs. My approach is to examine the foot skeletons of described dinosaur taxa for features that might be expected to be preserved in tracks made by these animals, and then to see if different groups of potential makers of tridactyl tracks differ in any of these features. A critical assumption here, of course, is that the fleshy features of a bipedal dinosaur's foot closely matched its underlying bony structure. This assumption will probably not always be warranted. However, my observations on the feet of ground-living birds lead me to believe that the assumption is more nearly valid than not.

During the next year I will use the criteria developed in this report to make tentative identifications of the kinds of dinosaurs responsible for footprint taxa (*Eubrontes*, *Gigandipus*, *Anchisauripus*, *Grallator*, *Anomoepus*, etc.) of the classic Connecticut ichnofauna. Preliminary comparisons suggest that the traditional identifications of *Anchisauripus* and *Eubrontes* tracks as those of tetrapods are correct.

THE FIRST ARTICULATED FROGS FROM THE UPPER JURASSIC OF NORTH AMERICA

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Abstract- A small slab from the Brushy Basin Member of the Morrison Formation in Dinosaur National Monument contains the first articulated frogs from the Upper Jurassic of North America. The remains of nearly a dozen individuals are preserved. The specimens are small, measuring less than 1 inch in total length. The degree of ossification, the lack of well formed ends to the humerus and femur, and the unfused neural arches in the vertebral column indicate that these frogs were metamorphosing when they died. Identification of these individuals has not yet been completed but they may represent a previously unknown species of frog. Other frog species from the site include *Comobatrachus* and *Eobatrachus*, frogs previously reported only from a locality in the Morrison of Wyoming.

PATTERNS OF SILICIFICATION OF THE BONE BED AT THE DINOSAUR NM: IMPLICATIONS FOR THE TAPHONOMY AND PALEOCLIMATE OF THE BRUSHY BASIN MEMBER OF THE MORRISON FORMATION

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Abstract- Evidently special circumstances were necessary to silicify and thus preserve the dinosaur and other reptile bones at Dinosaur National Monument (DNM). Not only are the bones silicified, but the enclosing sandstone is also cemented by silica. The other sandstones at DNM

and elsewhere in the Brushy Basin Member seem to be largely cemented by calcite and generally lack reptile bones.

I propose to cut thin sections of selected dinosaur bones, particularly those with canals, in order to observe the patterns of silicification. Perhaps some 20 samples of bone will be needed to obtain a representative selection of the three bone horizons and different types of dinosaurs. Also, as needed, scanning electron microscope images will be made of bones, using fingernail size pieces of bone. Thin sections will also be cut from several samples of sandstone matrix of each bone horizon to see if the diagenetic mineral sequence in the sandstone horizons matches or contrasts with that of the bones.

It may be possible to determine if the bones were silicified in one stage or whether there was more than one stage, for example an early burial stage where silt was incorporated within the earliest cement layer in the canals, followed by silt-free cement layers. Furthermore, if some of the bones have contrasting cement stratigraphies, for example calcite-, silica-, or hematite-dominated, then perhaps it would be possible to determine if some of the bones had been hardened elsewhere before being transported to their final resting place, as has proved possible with dinosaur bones of Late Cretaceous age in southern Alberta.

TAPHONOMY OF AN *ALLOSAURUS* QUARRY IN THE DEPOSITS OF A LATE JURASSIC BRAIDED RIVER WITH GRAVEL-SAND BEDLOAD, SALT WASH MEMBER OF THE MORRISON FM., DINOSAUR NM

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Abstract- During Late Jurassic time, a shallow braided river with a gravel-sand bedload deposited the fluvial strata of the Salt Wash Member of the Morrison Formation in Dinosaur National Monument. An articulated *Allosaurus* skeleton is being excavated at the Monument from the upper portion of a 60 cm layer of conglomerate at the bottom of a paleochannel 1.4 m deep. A high-energy flood cut the channel into a coset of planar crossbed sets built by coalescing transverse bars, probably of linguoid shape. The flood waters transported and deposited the gravel and the *Allosaurus* carcass. As the flood stage fell, the carcass was rapidly buried, mostly by down channel migration of trains of three-dimensional dunes of the lower flow regime that deposited a coset of trough crossbedded sands. Simultaneously, the carcass was partly covered by plane-bedded sand deposited in the upper flow regime, the lateral transition from dunes being caused by slightly higher velocities in that part of the channel. The skeleton was preserved due to its location in a topographic low and rapid burial, which protected it from scavengers and exhumation by subsequent floods.

Utah Geological Survey, Miscellaneous Publication 92-3, 1992.

LATE TRIASSIC VERTEBRATE TRACKS IN THE DINOSAUR NATIONAL MONUMENT AREA

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Abstract- Recent studies indicate that the older Mesozoic sedimentary rocks of the Dinosaur National Monument area are rich in vertebrate tracksites. A total of 21 tracksites have been discovered in the Late Triassic Popo Agie/Chinle Formation in the last few years. Three tracksites have also been discovered in the lower part of the Glen Canyon Group. The Popo Agie/Chinle sites are particularly significant because they yield the trackways of most of the major groups of reptiles known from this epoch (dinosaurs, mammal-like reptiles, phytosaurs, aetosaurs, lepidosaurs, ?trilophosaurs and tanystropheids). In fact the diversity of tracks rival the diversity of Late Triassic body fossils known from many sites in the well-known Chinle Formation, for example at the Petrified Forest National Park, and in the fossiliferous Dockum Group.

The discovery of aetosaur tracks (*Brachychirotherium*) in the lower part of Glen Canyon Group provides strong evidence for a Late Triassic age for the track-bearing bed. This is a significant contribution to unresolved questions about the age of the Glen Canyon Group in this area.

Utah Geological Survey, Miscellaneous Publications 92-3, 1992.

ON THE ASSOCIATED REMAINS OF SEVERAL JUVENILE *DIPLODOCUS* FROM DINOSAUR NATIONAL MONUMENT, WITH OBSERVATIONS ON JUVENILE SAUROPODS FROM THE MORRISON FORMATION

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Abstract- Although the Morrison Formation is well known for its abundance of large sauropod dinosaurs, juveniles from this formation are rare, and associated remains of juveniles are extremely rare. Although a few associated remains of juveniles have been described, additional undescribed specimens exist in the collections of Dinosaur National Monument.

This paper will 1) describe the morphology of juvenile specimens of *Diplodocus* from DNM, 2) compare the morphology of juvenile and adult *Diplodocus*, 3) test the constancy of the robustness ratio for long bones and constancy of the relative lengths of long bones in *Diplodocus* specimens of widely different ages, and 4) test the hypothesis that the robustness ratio and relative length of long bones are unique and ontogenetically constant for the common genera of

Morrison sauropods. Confirmation of 3 and 4 would allow for the generic identification of isolated sauropod limb bones in the Morrison Formation.

NEW SALAMANDERS FROM THE UPPER JURASSIC MORRISON FM. OF DINOSAUR NATIONAL MONUMENT

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Abstract- The early Mesozoic records of salamanders is very poor and fragmentary. Pond deposits in the Brushy Basin Member of Dinosaur National Monument provide important evidence on the early evolution and diversification of these amphibians. Analysis of the material is currently underway, but at least two new species and one new genus have been recognized. An isolated atlantes shows features diagnostic for the family Karauruidae and would constitute the first occurrence of this salamander family in the western hemisphere. This study will examine the diversity and biogeography of Upper Jurassic salamanders.

A REVIEW OF F. MARTIN BROWN'S RESEARCH ON THE FLORISSANT FM., FLORISSANT FOSSIL BEDS NATIONAL MONUMENT, FLORISSANT, COLORADO

BOB CUSHMAN

Florissant Fossil Beds National Monument

Abstract- Dr. Brown first came to the Florissant area in 1933. His work on the paleoentomology of the Florissant Formation continued until the late 1980's. During his career, he was a research associate with the University of Colorado Museum, The American Museum of Natural History, and others. Brown's primary contribution to the paleontology of the Florissant area consisted of locating, assembling, and cataloging the original descriptions and plates of over 1200 species of fossil insects from the Florissant Formation. From 1976 to 1986, Brown published six papers of his own on the fossil insects. In 1986, Brown published a review and taxonomic key to the fossil tsetse flies that occur in the Florissant Formation. The tsetse flies of the Florissant Formation represent the only reported occurrence of tsetse flies in the fossil record. The tsetse flies are also significant because they are climatically restricted. According to Brown, modern tsetse flies are only able to maintain breeding populations when temperatures range from 64 to 86 degrees F (18 to 30 degrees C). Therefore, the occurrence of tsetse flies in the Florissant Formation can help us in our reconstruction of the late Eocene paleoclimate. Today, Dr. Brown is no longer actively doing research, he still maintains his interest in the geology and paleontology of the Florissant area.

STRATIGRAPHIC RESEARCH ON THE FLORISSANT "LAKE BEDS" AT FLORISSANT FOSSIL BEDS NATIONAL MONUMENT, COLORADO

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Abstract- The University of Colorado Museum has a long history of paleontologic research on the Florissant "Lake Beds", starting with the work of T.D.A. Cockerell around the turn of the century. In the summer of 1992, a field crew sponsored by the Museum studied the stratigraphy, sedimentology, and vertebrate paleontology of Florissant Fossil Beds National Monument. As a result of this work, ten detailed stratigraphic sections, a surficial geologic map of the Monument, and a detailed map of the "Petrified Forest" area was compiled. Two previously unknown fossil mammal localities were discovered, which help constrain the biostratigraphic relations of the formation with the contemporaneous White River Group of Badlands National Park.
The Florissant "Lake Beds" include a combination of fluvial, lacustrine, and proximal volcanigenic deposits. The lowest exposed rocks in the Monument are tuffaceous mudstones and rare arkosic sandstones and conglomerates that were deposited in an ancient valley cut into Precambrian granite. The fossil redwood stumps occur in these lower rocks, as do the bones of titanotheres, rhinoceros, oreodonts, horses and small artiodactyls. The mammal fauna indicates a latest Eocene age (Chadronian Land Mammal Age). These fluvial rocks are covered by a tuffaceous sandy mudstone representing a volcanic mudflow which buried the stumps. The first

widespread lacustrine shales occur above this mudflow deposit, and are the shales that include the historic insect and leaf quarries. Other invertebrates, such as mollusks and ostracodes, are rare in these lower shales. These shales are capped by a thick, poorly bedded, mud-rich, volcaniclastic conglomerate that represents a volcanic debris flow that entered the lake. The conglomerate is thickest in the axis of the paleovalley, and is overlain on the west and north sides of the Monument by lacustrine shales. These upper lacustrine shales contain leaves and insects as well as locally abundant ostracodes and sphaeriid clams. The abundance of invertebrates suggest a change in lake chemistry after the deposition of the volcaniclastic gravels. The lake was gradually filled by pumiceous detritus, with stream-deposited, crossbedded pumice conglomerates capping the formation. The region was tilted to the west-northwest after deposition, and minor folding occurred locally. The modern exposures of the formation strongly reflects the original form of the dendritic paleovalley, with little post-depositional modification by faulting or intense folding.

TECTONIC SIGNIFICANCE OF PALEOBOTANICALLY ESTIMATED CLIMATE AND ALTITUDE OF THE LATE EOCENE SURFACE, COLORADO

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Abstract- Erosion beveled the Laramide Front Range uplift in Colorado to a surface of low relief by the end of the Eocene. This study uses J. S. Wolfe's new multivariate climate analysis techniques to determine the paleoelevation of this regional surface by examining the overlying 35 Ma Florissant flora. A multiple regression model explaining 93.3% of the variance in mean annual temperature was developed using Wolfe's dataset of 31 leaf physiognomic character states for 86 modern vegetation sites. These character states were scored on 29 species collected from one facies of the Florissant Lake Beds. The paleotemperature estimate of mean annual temperature (10.7 $\pm$ 1.5 degrees C) derived from these data, when combined with sea-level temperature and terrestrial lapse rate, implies a late Eocene paleoelevation of 2.4-2.7 km. Pliocene uplift is thus not required to explain the present elevation of 2.5 km. It is unclear when and why the southern Rocky Mountains achieved this elevation. Magmatic crustal thickening can explain the late Eocene high elevation of the southern Rockies, but neither this mechanism nor compressive thickening explains why the Great Plains, which are tied to the Florissant elevation by the Wall Mountain Tuff, were also high. This paleoelevation estimate indicates that regional surfaces of planation could be formed at high elevation in the Eocene, probably because of peculiarities of the Eocene climate.

FOURTEEN YEARS OF RESEARCH AT FOSSIL BUTTE NATIONAL MONUMENT: DETAILED LOOKS INTO AN EOCENE LAKE

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Abstract- The investigator has spent fourteen years studying the sedimentology, stratigraphy, and paleontology of Eocene Fossil Lake in the Fossil Basin within which Fossil Butte National Monument is located. The research has largely depended on high resolution paleogeographic analysis of correlated sedimentary units. Over one hundred stratigraphic sections have been measured and sampled. About six of these sections have been sampled on a decimeter to centimeter resolution. The collected samples have been subjected to X-ray diffraction, isotope, total organic carbon, petrographic, and paleontologic analysis.

The results have been rewarding. The paleoenvironments of Eocene Fossil Lake are now better understood. Facies maps showing the distribution of facies as well as the size and shape of Fossil Lake have been constructed. The location of river inlets, volcanic vents, and the shores of the lake have been delineated.

The fossil fishes, which are central to the purpose of the park, have received taphonomic and paleoecologic study. As a result, we now know details about their distribution and preservation.

The origin of the finely laminated sediments are now better understood. This aspect is receiving more intense study at this time. Other studies have focused on the unusual ichno facies, lake-margin and fluvial interactions, and paleobotany.

The above studies have discovered new scientific problems that will provide many productive future studies for years to come. Studies proposed for the near future include the origin of possible turbidite beds, soft sediment deformation structures, and laminae cycles.

PALEONTOLOGIC RESOURCE MAP OF THE GARDEN PARK DINOSAUR AREA: A TOOL FOR LAND MANAGEMENT

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Abstract- In 1985, BLM land managers in the Royal Gorge Resource Area requested a paleontologic evaluation of the Garden Park Dinosaur area north of Canon City, Colorado. Some of the oldest dinosaur quarries in the U.S. occur in the Morrison Formation in this area, which include the type localities of such well-known genera as *Stegosaurus, Allosaurus*, *Diplodocus*, and *Camarasaurus*. The area has been used for recreation and grazing, and has limited potential for mining. One of the most pressing concerns was an understanding of the distribution of the fossil bearing outcrops and the location of historic quarries in the area. Because of this need, a paleontologic resources map was compiled which has proven to be a valuable tool for land management decisions.

The first task was to make a detailed surficial geologic map on a large-scale topographic map base (scale 1:12,000). Most of the mapping was from low-altitude aerial photographs provided by the BLM, with field checking of important areas. The mapping included plotting bedrock outcrops of all lithostratigraphic units (Fountain, Ralston Creek, Morrison and Dakota formations), and morphostratigraphic units (landslide, interlandslide valley fill, terrace, alluvial, and colluvial deposits) that cover the bedrock. The locations of mines, wells, and quarries were also plotted on the map. From the surficial map, a paleontologic resources map was compiled that classifies the various fossiliferous exposures by their degree of paleontologic importance. Class 1 exposures are outcrops of any size with known dinosaur quarries or fossil type localities, and are the areas of highest paleontologic interest. Class 2 exposures are large outcrops of potentially fossiliferous rocks but with no developed quarries or type localities. These exposures have high research potential. Class 3 exposures are scattered, small outcrops of potentially fossiliferous rocks, which have moderate to low paleontologic research potential. Class 4 exposures include outcrops of unfossiliferous rocks or areas covered by extensive Quaternary deposits and have very little to no paleontologic research interest.

Class 1 and 2 exposures were recommended for Research Natural Area designation. In addition, the extensive landslides in the area were recommended as Areas of Critical Environmental Concern due to their value to research and education. The 2 maps have been used extensively in the planning of a visitor's center and interpretive trails, have helped researchers locate new fossil sites, and have helped land managers control disturbances from gravel quarrying, road building, and mining. The map has also been used to negotiate land transfers and purchases of private lands to include additional Class 1 outcrops.

THE PLEISTOCENE DUNG BLANKET OF BECHAN CAVE, UTAH

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Abstract- Boluses of dung rich in graminoid stems dropped by a large herbivore and comparable in size and content to African elephant (Loxodonta) dung were discovered recently in Bechan Cave, southeastern Utah. Two boluses were radiocarbon dated at 11,670 and 12,900 yr B.P., respectively. They are embedded in a 225 cubic meter dung blanket along with fecal remains and hair of ground sloths, artiodactyls, and small mammals. While no diagnostic bones of mammoth were recovered, the deposit yielded long coarse hair attributed to mammoth.
The unusual discovery supports the previous report by Hansen (in Jennings, 1980) of mammoth dung at Cowboy Cave, Utah. Both deposits constitute major finds for paleoecologists and are the most impressive discovery of their kind since the discovery in the 1930's of dry caves yielding ground sloth dung in Nevada, Arizona, New Mexico, and west Texas. The Bechan Cave deposit accumulated during an interval of vegetation change when blue spruce and water birch declined, oak became more abundant, and the regional vegetation was sagebrush steppe. Blue spruce and water birch currently occupy higher elevations in southern, Utah. Megaherbivore occupation of Bechan Cave evidently ended hundreds of years before mammoth and ground sloth (Nothrotheriops) extinction in the region, ca. 11,000 yr B.P.

LATE PLEISTOCENE VERTEBRATES FROM BECHAN CAVE, UTAH

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Abstract- Typically the vertebrate paleoecologist is left with only skeletal remains to provide a reconstruction of the various animals, their diet, and their associated biotic community. The hyperarid climate of the Colorado Plateau provides an unusual preservational environment where little organic decay has occurred since deposition during the Wisconsin Glacial. The Pleistocene organic layer in Bechan Cave contains +300 cubic meters of predominantly plant remains and herbivore dung. This is a unique deposit in that it contains a great quantity of dry-preserved animal remains. Megaherbivore species identified from dung include: Mammathus sp., Euceratherium collinum, Nothrotheriops shastensis, Bison sp., and cf. Oreamnos harringtoni. Only two skeletal remains of a large species have been recovered from the excavations (Euceratherium: LM/2, fragment of a metapodial). Microfaunal studies of Pleistocene deposits are rare on the Colorado Plateau outside of the Grand Canyon. Fine sieving of the excavated deposits has permitted the recovery of an associated microfauna. Identified species from Bechan

Cave include: Scaphiopus intermontanus, S. cf. bombifrons, Pituophis melanoleucus, Crotalus cf. viridis, a grouse-sized bird, Brachylagus idahoensis, Marmota flaviventris, Spermophilus sp., Thomomys sp., Lagurus curtatus, Microtus sp., and Neotoma cinerea.

LATE QUATERNARY VEGETATION OF THE GRAND CANYON RECONSTRUCTED FROM FOSSIL PACKRAT MIDDENS

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Abstract- The late Quaternary vegetation of Grand Canyon National Park was reconstructed using plant macrofossils extracted from radiocarbon dated fossil packrat (Neotoma sp.) middens. During the Wisconsin period, the Grand Canyon supported coniferous woodlands and forests, ranging from an association of juniper, shadscale, and sagebrush below 1400 m, to a mixed coniferous forest of Douglas fir, limber pine, and spruce at higher elevations. During the early Holocene (11,000 to 8500 yr B.P.), these species were replaced by associations of juniper and single leaf ash at low elevations, and by Douglas fir, ponderosa pine, and shrub live oak at high elevations. The modern plant communities developed sometime after 8500 yr B.P.
In general, plant species are now distributed 700 to 900 m higher in elevation and 400 to 700 km further up-river than they were during the late Wisconsin. However, many Wisconsin-age plant assemblages were unique, with their modern analogs either unknown or having a restricted distribution. Similarly, some modern communities either had no analog in the Wisconsin, or they were too restricted in distribution to produce a fossil record.

COMPUTERIZED DATABASE ON GRAND CANYON PALEONTOLOGY

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Abstract- Well over a thousand species of fossil animals and plants have been reported from Grand Canyon National Park and vicinity. Fossil and sub-fossil remains occur in nearly every rock stratum and in cave deposits, ranging in age from Middle Proterozoic (~1.4 billion years) virtually to the present (but excluding most of the Mesozoic era since these strata have been eroded away from the Grand Canyon). Records of these fossils are scattered through hundreds of papers and monographs, the first having been published in 1861. A database, GCPALEO, has been prepared that provides a page-by-page index to every fossil cited throughout the entire library of Grand Canyon Geology. As well as bibliographical coverage, it includes cross-indexes that encompass all published information on biological systematic groupings, stratigraphic and geographic distributions, and individual specimens held in research collections. GCPALEO now contains more than 17,500 records. It occupies 11.5 MB of uncondensed disk space, but it can be converted to a delimited ASCII-format file of 3.1 MB. Data entry, done directly from books and journal papers that had already been located, took about a year. A bibliography and 39 subject-related indexes to the Grand Canyon paleontological record have been extracted from the database. To obtain the information, the database was queried, and the answer tables were transported into word processing software where they were manipulated to produce a typeset, camera-ready document more than 1,000 pages long. After peer review, it is now in press (Geological Society of America Microform Pub. 24). The database can also provide data on the

history of paleontological research in the Grand Canyon region. Comparable productions in other NPS areas with significant paleontological resources would be limited only by the degree of knowledgeable access to the geologic literature, and by pragmatic constraints of staffing and time.

GEOLOGIC STUDIES IN CARLSBAD CAVERNS AND GUADALUPE MOUNTAINS NATIONAL PARKS, NEW MEXICO AND TEXAS

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Abstract- Geologic studies in the Carlsbad Caverns and Guadalupe Mountains National Parks (New Mexico and Texas) areas during the last 15 years have focused on understanding the sedimentological origin of the Upper Permian (Guadalupian) Capitan reef and equivalent platform depositional systems (Yates and Tansill formations) through time, the paleoecology of platform environments as determined from paleontological studies of microfauna, and marine diagenesis of carbonate sediments. These studies have been done by integrated field mapping and compilation of regional lithostratigraphic data, and laboratory analyses of samples utilizing normal-light and cathodoluminescence petrography and stable oxygen-carbon isotope data. Studies indicate that shelf deposition systems in the Yates and Tansill formations, specifically those on the outer-shelf proximal to the Capitan reef, were influenced to a great extent by sea level fluctuations through time. Platform carbonate facies deposited during sea level highstands are characterized by mosaics of shallow-marine sands, sponge-algal patch reefs, and low-lying islands. These deposits, as well as those of the adjoining Capitan reef, were pervasively cemented at these times by marine aragonite cements. In contrast, platforms were exposed subaerially during periods of sea level lowstand, at which time siliciclastic sediments (sands and silts) were deposited as thin but regionally extensive "sheets" across the platforms. Platform bypassing resulted in the deposition of some of the sands and silts into the adjoining Delaware Basin. Diagenetic processes operative during lowstands include lithification by meteoric calcite cements, and extensive karsting of exposed carbonate platforms. Alternating periods of sea level highstand and lowstand resulted in a complex facies stratigraphy of interbedded carbonate and siliciclastic sediments.

ASSEMBLAGES OF FOSSIL VERTEBRATES IN PRE-IGNIMBRITE DEPOSITS OF THE TURTLE COVE MEMBER, JOHN DAY FORMATION, FROM OUTCROPS WITHIN THE SHEEP ROCK UNIT, JOHN DAY FOSSIL BEDS NATIONAL MONUMENT, OREGON

TED FREMD

National Park Service, 420 West Main Street, John Day, Oregon 98745

Abstract- The diagenetic history of lower John Day vertebrates is enigmatic. For the past several years, field workers have been involved in cyclic prospecting and recovery of skeletal material preserved in zeolitized tuffaceous paleosols within the southern portion of Turtle Cove. Grant County, Oregon, and documenting the precise location of in situ specimens on aerial photographs. These and newly-discovered sites are recorded on high resolution color stereo air photographs, and the coordinates, taphonomic data, and stratigraphic information have been compiled using dBase III+ programs. The samples are dominated by hypertraguiids, merycoidodontids, rhinocerotids, canids, felids, and equids, as well as numerous species belonging to 18 other families.
Many of the disarticulated specimens found within certain layers are weathered and abraded, broken, and possess rodent chew marks. Samples from other units suggest burial in varied environments, re-exposure, possible transportation, and reburial in subsequent volcaniclastic episodes.

48th SVP Meeting, Drumheller, Alberta, October 1988.

EARLY MIOCENE MAMMALIAN POPULATIONS FROM TURTLE COVE, OREGON

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Abstract- Interpreting the taphonomic biases in the biostratigraphic record of the lower John Day Formation (early Arikareean) has been facilitated with the use of detailed prospecting and site recording techniques. Over thirty localities within "The Cove" are narrowly separated both temporally and spatially. Comparisons of taxonomic, skeletal element, and other properties of these assemblages demonstrates a surprisingly diverse array of preservational histories.

51st SVP Meeting, San Diego, California, October 1991.

COOPERATIVE MANAGEMENT OF PALEONTOLOGICAL RESOURCES IN THE JOHN DAY BASIN, CENTRAL OREGON

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Abstract- Numerous scientifically significant vertebrate fossils, threatened by erosion and unauthorized collectors, occur on lands administered by the Prineville District of the Bureau of Land Management (PD). These are important localities that add to our knowledge of paleoclimates, mammalian evolution, and global change. The strata are adjacent to boundaries of John Day Fossil Beds National Monument (JODA), which is equipped with the mandate, staff, and equipment to provide research and curatorial services. The NPS has surveyed BLM resource areas for paleontological values, provided identifications and curation of over 500 specimens into the National Catalog System, and provided input into management and planning documents. The BLM helped defray the cost of an NPS museum technician, and has purchased museum cabinetry. Participants jointly funded high-resolution color stereo aerial photography. Other NPS and BLM areas may wish to use this coop agreement as model for partnerships in paleontological stewardship.

The George Wright Society, Jacksonville, Florida, November 1992

CUT-AND-FILL EPISODES IN THE JOHN DAY FORMATION IN THE PAINTED HILLS AREA OF CENTRAL OREGON

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Abstract- Recent lithostratigraphic mapping in the Painted Hills Unit of the John Day Fossil Beds National Monument in central Oregon has identified mappable subdivisions of the lower John Day Formation as well as refined the local boundary between the John Day and Clarno formations. The boundary between the two formations is placed at the base of a distinctive welded tuff recognized as member A, mapped in the western facies of the John Day Formation. A sequence of basalt flows, exposed directly south of the park, were previously mapped as Clarno but are stratigraphically above member A and are thus part of the John Day Formation. Several large (200 ft. of relief) intra-formational erosional surfaces are recognized in the lower part of the John Day Formation and separate otherwise conformable units. The sequences between erosional surfaces could be considered members and contain distinctive paleosols which aid in their identification and mapping. Each contains a variety of paleosol types, based on texture, fabric, color, and clay and pebble content. The relief on these erosional surfaces appears to decrease up-section from member A to the Picture Gorge Ignimbrite.
These erosional surfaces and their overlying beds represent cut-and-fill cycles which may

correlate to world-wide changes in sea level and paleoclimate. During the late Eocene and early to mid Oligocene, these climatic-eustatic fluctuations spanned 2 to 4 my apiece and were of large magnitude.

Geological Society of American Annual Meeting, 1992.

RECOVERY AND ANALYSIS OF THE VIRGIN MAMMOTH, LAKE MEAD NATIONAL RECREATION AREA, NEVADA

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Abstract- Exposure of a partial mammoth skeleton in an arroyo bank above the high water level of Lake Mead prompted initial field visitation. A 1987 visit resulted in a recovery of limb elements in the arroyo wall, and a maxillary tooth below the existing lake level. Continued monitoring of the site, by NPS personnel, revealed tusk, rib and long bone fragments in sediments below the high water level. A NPS request led to field visitation and salvage excavation during the fall of 1991. The specimen was originally preserved in alluvial deposits grading from the Muddy Mountains to the Virgin River arm of the reservoir. Examination of the deposits led to the conclusion the faunal material below lake level was the result of arroyo wall collapse and reworking of the material by high lake level. This specimen represents the first reported *Mammuthus columbi* remains from this portion of Clark County, Nevada.

AAAS 68th Annual Meeting, Tucson, AZ, 1992.

EXTINCT MOUNTAIN GOAT (*OREAMNOS HARRINGTONI*) IN SOUTHEASTERN UTAH

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Abstract- The extinct Harrington's mountain goat (*Oreamnos harringtoni*) is predominantly known from dry cave localities in the Grand Canyon, Arizona, in addition to two sites in the Great Basin, Nevada, and from San Josecito Cave, Nuevo Leon, Mexico. A dry shelter in Natural Bridges National Monument, on the central Colorado Plateau, southeastern Utah, preserves numerous remains of the extinct mountain goat in addition to pack rat middens. Remains from a 100-cm stratigraphic profile indicate that *O. harringtoni* lived on the plateau >39,800 yr B.P., the oldest directly dated find of extinct mountain goat. Plant microfossils indicate that Engelmann's spruce (*Picea engelmannii*), limber pine (*Pinus flexilis*), rose (*Rosa* cf. *woodsii*), and Douglas fir (*Pseudotsuga menziesii*) grew during the late Pleistocene where a riparian and a pinyon-juniper (*Pinus edulis - Juniperus osteosperma*) community now predominates; Douglas fir are found only in mesic, protected, north-facing areas. Limber pine, Douglas fir, bark, and grasses were the major dietary components in the dung. A springtime diet of birch (*Betula*) is determined from pollen clumps in dung pellets.

Quaternary Research, vol.27,p.323-331,(1987).

PLEISTOCENE VERTEBRATE FOSSILS FORM THE CONTINENTAL SHELF, NW GULF OF MEXICO

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Abstract- Pleistocene vertebrate fossils have recently been collected on a sedimentary rock outcrop located in the nearshore waters of the continental shelf in the northwestern Gulf of Mexico. Whitemore (1967) has reported over 40 fossils occurring in three concentrations on the continental shelf off the eastern United States and has also mentioned the need for reporting other vertebrate fossils from the continental shelf. The University of Texas vertebrate paleontology collection houses one mammoth tooth collected from the continental shelf off Port Isabel, Texas. This specimen was taken in approximately 180 feet of water by a commercial shrimp trawler. Hayes (1967) reported the discovery of a single mammoth tooth on Padre Island. The tooth was a component of a hurricane beach sample taken after Hurricane Carla. Under the direction of E. Sellards over 2,000 specimens of Pleistocene vertebrate bones were collected by the University of Texas Bureau of Economic Geology in Tedford Quarry, Ingleside, Texas.

PLANT BIOSTRATIGRAPHY OF THE CHINLE FORMATION IN THE PETRIFIED FOREST AND VICINITY

SIDNEY R. ASH

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Abstract- The principle objective of this project is to determine the stratigraphic distribution of plant mega and microfossils in the Chinle Formation in the park and to integrate the results obtained from other areas in the Southwest. Although this concerns mainly plant fossils that have been collected in the past, data on new finds will be incorporated in it as time allows. In this project I have been cooperating with R.J.Litwin (USGS) and we have published one paper which helps relate the biostratigraphy of both the plant megafossils and the palynomorphs. Others are in preparation.

Petrified Forest National Park, Research Abstract Volume 1, 1991.

PALEOCLIMATIC STUDIES OF THE CHINLE FORMATION IN THE PETRIFIED FOREST AND VICINITY

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Abstract- These studies which are being carried on in collaboration with Dr. G. Creber of the University of London began in the summer of 1984 when Dr. Jane Francis helped me excavate Walker's Stump. The object of the project is to determine if annual growth rings occur in the petrified trees in the park. If they do indicate that seasons were well developed in the park during the Late Triassic; if not they would confirm that they lived in a season-less climate such as you get in the tropics. Several dozen specimens have been published. Laboratory examination of these and other specimens seem to indicate that annual growth rings are not present. I gave a paper in early 1990 in which I discussed our findings. More recently we finished a draft of a full-blown treatment of our results. Hopefully this manuscript will be published during the coming year.

Petrified Forest National Park, Research Abstract Volume 1, 1991.

SYSTEMATIC STUDIES OF THE PLANT MEGAFOSSILS AND RELATED FOSSILS IN THE PETRIFIED FOREST

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Abstract- The objective of this project is to gain a better understanding of the plant life of the Chinle Formation in the park and adjacent areas. This is an on-going project in which previously unknown fossils are described as they are found in the park and previously known fossils are redescribed on the basis of new material or on re-evaluation of old material. During the past year I described a new cycad leaf from the park, and Ron Litwin and I described the first known occurrence of Triassic amber from the Petrified Forest. Earlier, Geoff Creber and I described evidence for frugal infection of the wood in the park.

Petrified Forest National Park, Research Abstract Volume 1, 1991.

STRATIGRAPHY OF THE CHINLE FORMATION IN THE PETRIFIED FOREST

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I now have a manuscript on the Black Forest Bed in press and expect that it will appear soon. I gave a talk on the source of the volcanic debris in the Black Forest Bed at the Museum of Northern Arizona in 1989. I am cooperating with Nancy Riggs in further studies on the radiometric age of the Black Forest Bed. Also, I have almost completed a draft of a paper on the stratigraphy of the Chinle Formation throughout the park. Every effort will be made to see that this paper will be completed early in 1992 and published as soon as possible thereafter.

Petrified Forest National Park, Research Abstract Volume 1, 1991.

TAPHONOMIC ANALYSIS OF CREVASSE SPLAY BIVALVE DEATH ASSEMBLAGES, UPPER TRIASSIC CHINLE FORMATION PETRIFIED FOREST NATIONAL PARK

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Abstract- Freshwater unionid bivalves occur in highly concentrated, localized distributions interpreted as death assemblages deposited in crevasse splay systems. These coarse-grained beds

occur within fine-grained overbank deposits. Vertical stacking of crevasse splay deposits indicate reactivation of the crevasse system during multiple flooding events. The disarticulated valves of dead bivalves accumulated on the channel bed and were entrained during high energy flood events and deposited in proximal crevasse splay environments where flow velocity rapidly dissipated.

The bivalve-bearing portions of crevasse beds are less than 10m wide, 30m in length, and 20cm thick. Transects were made perpendicular and parallel to flow and the variation studied at one meter intervals for two locations. The bedding surfaces were photographed and uniform volume samples collected. Taphonomic features common to all samples are (1) >95% disarticulated valves consistently in current stable orientations and frequently imbricated, (2) valves fragmented and surfaces abraded, and (3) wide and continuous range of size from juveniles to adults. The perpendicular to flow transect samples near the center of the bed contain a higher density of valves, larger and heavier individual shells at the high end of the size distribution, and clay and granule matrix. Samples from the margins of the bed feature increased articulation, lower density of valves, and coarser matrix composed of limestone pebbles. With increasing distance from the source channel along the parallel to flow transect, sample feature a decrease in the density of valves, and decrease in the size of the high end of the size continuum.

Petrified Forest National Park, Research Abstract Volume 1, 1991.

TRACE FOSSILS OF THE PETRIFIED FOREST MEMBER, PETRIFIED FOREST NATIONAL PARK, ARIZONA

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Abstract- Preliminary field work at the Petrified Forest National Park revealed that diverse and important trace fossil assemblages occur in the Petrified Forest Member and possibly in the Owl Rock Member of the Upper Triassic Chinle Formation. Many of these traces are the earliest known of their kind and are important assets of the park.

Invertebrate traces include horseshoe crab tracks and trails, millipede trails, adult and juvenile insect burrows and nests, beetle borings and gallery nests in wood, annelid burrows, and Scoyenia (an insect larvae burrow). Crayfish burrows may exist in the park, with some found in crevasse splays and loose in the washes near Tiponi Point.

Plant traces include individual and intertwined root systems and pith casts of the horsetail Neocalamites. Stages of calcium carbonate root concretions may exist in the paleosols throughout the park.

Trace fossil assemblages in continentally deposited units, such as the Petrified Forest and Owl Rock Members of the Upper Triassic Chinle Formation are very important because they are rarely described, often go unnoticed, and hold a wealth of information waiting to be tapped.

TAXONOMY AND BIOSTRATIGRAPHY OF METOPOSAURID AMPHIBIANS FROM PETRIFIED FOREST NATIONAL PARK

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Abstract- Metoposaurid amphibians have been recovered from the Blue Mesa and Painted Desert Members of the Petrified Forest Formation (Upper Triassic) in Petrified Forest National Park (PFNP). No amphibian specimens have been collected from the Owl Rock Formation. Two taxa of metoposaurids are present in PFNP. One taxon is a large-skulled species with relatively short intercentra. The oldest valid name for this taxon is Buettneria perfecta. B. perfecta is most common at localities in the Blue Mesa Member including Devil's Playground, the Teepees Blue Mesa, King's Throne, Lot's Wife, Jasper Forest and Giant Logs. This taxon is rarely present at a few localities in the Painted Desert Member including the Flattops and near Lacey Point. Specimens include several skulls and much postcrania. The second taxon is a small metoposaurid with elongate intercentra which represents a new genus. This taxon has a distribution which contrasts strikingly with the distribution of B. perfecta at PFNP. Thus, it is rare in the Blue Mesa Member (e.g., The Teepees and Blue Mesa) and relatively common in the Painted Desert Member (e.g., Lacey Point and Flattops). The only skull of this taxon is from Lacey Point. Most other occurrences are of the characteristic intercentra. This pattern of metoposaurid distribution is also characteristic of other areas of the Chinle Group. The only Chinle Group metoposaurid which is not present in PFNP is Metoposaurus bakeri which is characteristic of early Tuvalian strata older than those exposed at PFNP.

Petrified Forest National Park, Research Abstract Volume 1, 1991.

TRIASSIC AMBER AND POLLEN AT PETRIFIED FOREST NP

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Abstract- This past field season Sidney Ash and I collected at several of our established Triassic amber sites in order to do spectroscopic analyses of samples from these sites this winter with Vicki Comer (USGS, Coal Branch). We prospected and discovered several additional amber producing sites as well, and collected samples for the paleoecological pollen analyses I am beginning on the lacustrine deposits in the park (I hope to begin multivariate pollen analyses of them before spring). Additionally, I collected rock samples for biostratigraphic analyses from the western sections of the park, but need to return to the Flattops area for additional collecting so that I can augment my current data on the pollen assemblage transition across the Carnian-

Norian stage boundary.

Petrified Forest National Park, Research Abstract Volume 1, 1991.

UPPER TRIASSIC (CARNIAN AND NORIAN) AMPHIBIANS AND REPTILES FROM PETRIFIED FOREST NATIONAL PARK

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Abstract- The Chinle Formation of Petrified Forest National Park, Arizona, has yielded numerous Carnian and Norian age vertebrate fossils. Metoposaurus fraasi is a large metoposaurid amphibian that is very common in Carnian age sediments below the Sonsela Sandstone. A smaller new metoposaur taxon is found primarily in strata of Norian age. A unique archosauromorph whose long, slender skull was covered with large osteoderms has been recovered from the Carnian age Crocodile Hill locality. Another unique archosauromorph is based largely on postcranial material recovered from Carnian age deposits in the park. Its body is covered with three armored morphotypes, the vertebrae are long and low, and the pelvic and appendicular elements are of proterosuchian grade. Postosuchus kirkpatricki is a 4-5 m long, heavily built, large skulled, short necked quadrupedal rauisuchid. The pelvis exhibits a short, anteriorly directed iliac blade, two sacral rib attachments, a moderate sized pubic foot and rod like weakly fused ischia. Postosuchus has been recovered from both Carnian and Norian age sediments within Petrified Forest NP. A new two to three meter long gracile rauisuchian has been recovered from the Upper Petrified Forest Member within the park. It is known from Carnian and Norian age deposits and from the Owl Rock Member elsewhere. The cervical centra of this taxon are much more elongate than in other rauisuchians, the humerus and lower hind limb elements are long and slender, the pelvis has a large anteriorly directed iliac blade, a huge pubic foot, and flattened, strongly fused ischia. Calyptosuchus wellesi is a common three to four meter long Carnian age aetosaur. It may be differentiated from the Carnian and Norian aged Desmatosuchus haploceras in its relatively delicate build with long and slender limbs. The Norian age Typothorax coccinarum may be differentiated from Calyptosuchus and Desmatosuchus in its extremely wide and flat body, shortened cervical vertebrae, ilia and high, dorsolaterally directed supracetabular blades and relatively small appendicular elements as compared to overall body size. Paratypothorax andressi is only known on the basis of its distinctive dermal armor from the Carnian and Norian. A moderately large (3-4 m) new staurikosaurid saurischian was recovered from three localities in the Upper Petrified Forest Member in Petrified Forest NP. The dorsal centra are short and wide, the femur is relatively long, the ilium has a relatively long posteriorly directed blade and the astragalus is similar to that seen in sauropodomorphs.

REVISED UPPER TRIASSIC STRATIGRAPHY PETRIFIED FOREST NATIONAL PARK

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Abstract- Approximately 575 m of Upper Triassic nonmarine strata are exposed in the Petrified Forest National Park (PFNP). These strata have long been assigned to the Chinle Formation, divided (in ascending order) into the lower Petrified Forest Member, Sonsela Sandstone Bed, upper Petrified Forest Member and Owl Rock Member. Informal stratigraphic terminology also exists for persistent sandstone beds in the lower and upper Petrified Forest Members. A revised stratigraphic nomenclature of the Upper Triassic strata in the PFNP is consistent with that of other Upper Triassic nonmarine strata in the western United States, assigns the PFNP strata to the Chinle Group divided (in ascending order) in to the Blue Mesa, Sonsela and Painted Desert Members of the Petrified Forest Formation overlain by the Owl Rock Formation. The Blue Mesa and Painted Desert Members of the Petrified Forest Formation take their names from features in the PFNP where their type sections are located. Late Carnian (Tuvalian) fossils from the upper part of the Blue Mesa Member and early Norian fossils from the lower part of the Painted Desert Member provide significant standards for the correlation of Chinle Group fossils throughout the western United States.

Petrified Forest National Park, Research Abstract Volume 1, 1991.

LATE TRIASSIC CALCAREOUS MICROFOSSILS FROM THE PETRIFIED FOREST NATIONAL PARK

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Abstract- We processed more than 500 rock samples to recover calcareous microfossils (charophytes and ostracods) from Upper Triassic strata in the Petrified Forest National Park (PFNP). The samples were collected from distinctive lithologic units throughout the entire 575 m of Chinle Group strata exposed in PFNP and from selected strata that produce unionid bivalves. However, only rock samples from the upper part of the Painted Desert Member of the Petrified Forest Formation produced calcareous microfossils.

These microfossils pertain to one taxon of charophyte (Stellatochara sp.) and two taxa of darwinolid ostracods (Darwinula aff. D. liulungchuanensis and Gerdalia sp.). They most resemble microfossils from the lower Norian Bull Canyon Formation of east-central New Mexico and thus support tetrapod-based correlation of the Bull Canyon Formation and the Painted Desert Member. The Painted Desert Member microfossils also indicate the presence of

highly mineralized, permanent limnic environments with water depths of 6-8 m or less. The absence of calcareous microfossils throughout most of the Chinle Group section in the PFNP probably reflects the rarity of such environments.

Petrified Forest National Park, Research Abstract Volume 1, 1991.

THE STRATIGRAPHY AND VERTEBRATE MICROFAUNAS OF THE UPPER TRIASSIC CHINLE FM., PETRIFIED FOREST NP

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Abstract- The Petrified Forest Member of the Triassic Chinle Formation in Petrified Forest National Park, Arizona, may be divided into a lower and upper unit by means of the Sonsela Sandstone Bed. Analysis of fossil vertebrates indicates that the Sonsela Sandstone Bed and Upper Petrified Forest Member are characterized by a fauna distinct from that within the lower portion of the Petrified Forest Member. These faunas are believed to be of Norian and Carnian age respectively. Utilizing fossil vertebrates and certain lithostratigraphic units, especially the Sonsela Sandstone Bed and Black Forest Tuff, exposures have been correlated within and between the Rainbow Forest, Blue Mesa and Painted Desert areas of Petrified Forest National Park.

An upper Carnian age fauna may be indicated by localities below the Sonsela Sandstone. At these localities numerous teeth of the freshwater shark Xenacanthus were found (the most abundant element in the lower unit faunas) and rare elements of the polyacrodont Lissodus. Lungfish typically represent rare components in these faunas. Redfieldiid and colobodontid fish elements are common. Rare identifiable reptile elements include Trilophosaurus teeth and jaw fragments of neodiapsids or lepidosauromorphs. Numerous teeth of small archosauromorphs are found, including abundant, distinctive, laterally compressed teeth bearing compound serrae.

The dipnoan and hybodont faunas of the Sonsela Sandstone and Upper Petrified Forest Member are quite different than those within the lower member. No xenacanth or Lissodus specimens have yet been recovered. A new species of shark has been described from the Sonsela Sandstone, Upper Petrified and Owl Rock Members. The new shark is characterized by low crowned teeth that typically bear a reticulate tooth sculpture. Colobodontid fish toothplates of distinctive morphology are also present. Large numbers of lungfish toothplates have been obtained from the Upper Petrified Forest Member. Toothplate morphologies are very similar to those of Arganodos from the Upper Triassic of the Atlas Mountains, Morocco. A small distinctive metoposaurid amphibian has been recovered from the upper member, along with asphenodontid and distinctive isolated teeth of dinosaurs and numerous other carnivorous archosauromorphs.

Petrified Forest National Park, Research Abstract Volume 1, 1991.

SUMMARY OF PALEONTOLOGICAL RESEARCH IN PETRIFIED FOREST NP

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Abstract- My most recent research in Petrified Forest has involved characterizing the important fossil localities in a variety of ways and relating their biological content and mode of preservation to the geological nature of the localities. In particular, the degree of the development as fossil soils and the positions of localities relative to ancient bodies of water, specifically fossil channels and ponds. This work has been accomplished in part with Russell Dubiel of the USGS and Steve Good of the University of Colorado. I have worked with J.T.Parrish, of the University of Arizona, on the arrangement of fossil logs in the Long Logs area as a method of determining the position of the channel and direction of flow during the deposition of the logs. I have also been interested in Chinle climates and a survey of the climates of the Triassic in Arizona has just been published.

I have also been working on a number of the large archosaurs from the park, specifically an articulated phytosaur skeleton that was collected south of Lacey Point, and a large crocodylomorph from the same area. More extended work on the classification of the archosaurs is utilizing material from the park and from the Chinle and Dockum formations in other areas of the southwest.

Petrified Forest National Park, Research Abstract Volume 1, 1991.

ENERGY DISPERSIVE X-RAY ANALYSIS OF PETRIFIED WOOD SAMPLES FROM PETRIFIED FOREST NATIONAL PARK, ARIZONA

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Abstract- Petrified Forest National Park preserves outstanding exposures of fossilized wood from the Triassic. To date, three genera of trees have been recognized from the park (Araucarioxylon, Schilderia, and Woodworthia). The different morphologic and histologic characters have been identified for each genus. These characters can influence the preservational and taphonomic history of the wood. A series of very fundamental questions related to the actual fossilization of the wood are not fully understood. Some of these questions include:

(1) how does the mineral composition of each type of fossil wood vary both in content and percent composition?
(2) do the variances reflect different processes of fossilization in each type of fossil wood?
(3) how does the mineral composition in each fossil wood vary with respect to internal morphology of the plant and the depositional setting in which preserved?

A pilot study was initiated in order to gain some understanding of the elemental and mineral composition of each type of fossil wood and the percentage composition of each component. Energy Dispersal X-Ray (EDX) analysis was performed on each of the three genera of fossil wood found in the park. The technique involved the utilization of a small piece (2-3" hand sample) of fossil wood. In this procedure a non-destructive electron beam is emitted onto each sample. Secondary electrons are released by the sample and recorded by both X-ray and EDX detectors. A multi-channel analyzer determines both the elemental content and percent composition of each element.
Analyses revealed that all samples were primarily rich in oxygen (O) and silicon (Si), suggesting silicates. Smaller amounts of iron (Fe), aluminum (Al), calcium (Ca) and potassium (K). Woodworthia specimens were the only genus to contain manganese (Mn). A significantly higher percent composition of aluminum and calcium were measured in Schilderia. Sulfer and titanium occurred in both Woodworthia and Schilderia, but was absent in Araucarioxylon.

STRATIGRAPHIC CORRELATION OF THE MIO-PLIOCENE BIDAHOCHI FORMATION IN PETRIFIED FOREST NATIONAL PARK AND LOCALITIES IN NE ARIZONA

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Abstract- The Upper Tertiary Bidahochi Formation is well exposed in northeastern Arizona and western New Mexico. Extensive outcrops of this fossiliferous formation can be found both at Petrified Forest National Park and on the Navajo Reservation. Within the Bidahochi is an important Late Miocene and Early Pliocene fossil mammal zone. This mammalian fauna is referred to as the "White Cone" fauna and represents the earliest Late Hemphillian fossil remains known.
The type locality for the Bidahochi Formation and the fossil producing localities will be paleomagnetically sampled in order to facilitate local correlation. The establishment of a paleomagnetic polarity profile for the Bidahochi formation will additionally permit correlation to

the world wide polarity time scale.

SOURCE STUDY BY NEUTRON ACTIVATION ANALYSIS OF PETRIFIED WOODS FROM THE PETRIFIED FOREST NATIONAL PARK, ARIZONA

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Abstract- The purpose of this study is twofold: 1) to characterize the trace element composition(s) of petrified wood from different localities within the forests in order to supply the geological community with the full range of chemical compositional and trace elements from those that are now available. In this sense, the study is a major amplification of Sigleo's trace element study; 2) to try to establish "provenience postulate(s)" for various outcrops of petrified woods. Briefly, provenience postulates are the unique trace element structures, or fingerprints, that compounds show in their chemistry that mark their source areas to the exclusion of all others. We do not yet know whether provenience postulates can be established for petrified woods. That will be the goal of the first stage of this study

Petrified Forest National Park, Research Abstract Volume 1, 1991.

PORT KENNEDY LOCAL FAUNA AND FLORA (MID-PLEISTOCENE), VALLEY FORGE NATIONAL HISTORIC PARK, UPPER MERION TOWNSHIP, MONTGOMERY COUNTY, PENNSYLVANIA

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Abstract- The fossil fauna and flora recovered from the Port Kennedy deposit offers a rare glimpse of the biota living in southeastern Pennsylvania during the Irvingtonian Land Mammal Age (Mid-Pleistocene). Kurten and Anderson (1980) refer this assemblage to the Aftonian Interglacial or Kansan Glacial Stage. Extensive collections from this site were made in the late 19th century when limestone quarrying exposed a fossiliferous infilled fissure. The significant papers on the site were published by Charles Wheatley in 1871, Henry C. Mercer in 1895 and 1899, and Edward Drinker Cope in 1871, 1895, and 1899. What remained of the Port Kennedy deposit was filled after the quarry was abandoned.

About 1500 to 2000 specimens from this early work are housed in the collections of the Academy of Natural Sciences of Philadelphia. A project has been undertaken to curate and organize the Port Kennedy material. A paper reviewing the history of the site, depositional conditions, updating the taxonomy, and presenting new data on the fauna and flora, is currently in press (Daeschler, E., E. Spamer and D. Parris, The Mosasaur, v.5). The new faunal list includes 5 reptiles, 1 bird and 34 mammals. Noteworthy aspects of the fauna include a unique skunk, fisher, water rat and muskrat; early records of wolverine, black bear, river otter, and Blanding's turtle; and large population samples of Wheatley's ground sloth, lesser short-faced bear, long-nosed peccary and Hay's tapir.

FOSSIL TURTLES OF PORT KENNEDY CAVE (PLEISTOCENE); VALLEY FORGE NATIONAL HISTORICAL PARK, PENNSYLVANIA

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Abstract- One of the most significant paleontological sites now within a National Park Service tract was the Port Kennedy Cave site in Montgomery County, Pennsylvania. Its famed interglacial fauna was collected and described by nineteenth century authorities with remarkable precision. During 1992 the Academy of Natural Sciences of Philadelphia (repository of most of the specimens) initiated review of the collections with the cooperation of the National Park Service. Important new information on the fossil turtles has already resulted.

Of the four species of turtles from Port Kennedy the wood turtle, *Clemmys insculpta*, is present in the modern regional fauna, although uncommon. The Eastern Box Turtle, *Terrapene carolina*, specimens from Port Kennedy are among the earliest known of the species (Pleistocene -

Yarmouthian) and several other named species should be synonymized with it. The species presumably diverged in earlier (?Pliocene?) times, developed in eastern North America, and later expanded its range westward. Blanding's Turtle, *Emydoidea blandingii*, has no modern distribution in Delaware Valley region. A specimen of *Emydoidea blandingii* from Port Kennedy, coupled with two specimens from New Jersey, demonstrates the existence of a Quaternary population. The type specimen of a true tortoise, *Geochelone* (*Hesperotestudo*) *percrassa*, is from Port Kennedy. It is perhaps the most northerly record of a tortoise in eastern North America.

Although the Port Kennedy fauna was not part of the basis for establishment of Valley Forge National Historical Park, the specimens have both historic and scientific significance to that unit of the National Park Service.

EARLY AND MIDDLE ARCHAIC SECTIONS OF THE BEAVER CREEK SHELTER, WIND CAVE NATIONAL PARK, SOUTH DAKOTA

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Abstract- This study is based on a 1 m thick section encompassing the Early and Middle Archaic time periods within the Beaver Creek Shelter, Wind Cave National Park. Radiocarbon dates indicate that the studied units range in age from 4010 + 100 BP, which closely correlates with the Altithermal climatic period. Artifacts found within the 4 younger stratigraphic layers provide evidence for human habitation of the site.

The sedimentary deposits from the site document the existence of overbank deposits probably due to occasional flooding. These depositional events are very similar to those occurring in the Beaver Creek Valley today, and Beaver Creek may have flowed very close to the shelter at one time.

Although, vertebrate, plant and gastropod remains were found throughout the studied units, this study is based solely on the vertebrate materials. All of the vertebrate remains were disarticulated and many of the elements were broken. Specimens were brought into the site by human inhabitants, carnivores and by fluvial processes. Animals who were in search of food and cover were also attracted to the site. Based on a tabulation of minimum number of individuals, within 10 cm thick increments, Levels 11 and 12 indicate a rise in abundance of specimens without a corresponding increase in matrix. A small percentage of burned elements, comprising mostly mammals were primarily concentrated within Levels 6-10. The majority of specimens within the studied section were from mature adults with few juveniles or older individuals signifying a rapid faunal accumulation.

Overall, the vertebrates correlate closely with the extant fauna found in the Black Hills. As an ecological community, the taxa are most commonly associated with a meadow, woodland and grassland interface which presently occurs along Beaver Creek. Even though this change has not been shown to be statistically significant, it is important to note that a slight increase in taxa with a dry habitat preference occurs within the lower levels of the studied section.

Because of the higher elevation of the site in relation to the surrounding plains and its close proximity to flowing water, the Beaver Creek Shelter could comply with the refuge hypothesis proposed by many earlier researchers. A noticeable addition of taxa preferring a drier habitat, and the site's elevation provide evidence for a slight drying trend and the existence of a possible refuge for both humans and animals under climatic pressure.

FOSSIL VERTEBRATES FROM THE OLIGOCENE WHITE RIVER DEPOSITS OF WIND CAVE NATIONAL PARK, BLACK HILLS, SOUTH DAKOTA

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Abstract- Oligocene deposits in the Big Badlands of western South Dakota are internationally famous for their fossil vertebrates. However, vertebrates of this age are rare in deposits occurring at higher elevations in the Black Hills to the west. The Klukas localities (named for their discoverer, Richard Klukas) in northeastern Wind Cave National Park have produced the largest diversity of Oligocene invertebrates and vertebrates from the Black Hills proper. The invertebrates are represented by gastropod species; the vertebrate assemblage includes turtles, lizards, insectivores, rodents, lagomorphs, carnivores, perissodactyls, and artiodactyls. All genera have been previously found in the Big Badlands and indicate that the sedimentary succession in Wind Cave National Park was deposited during the Orellan Land Mammal Age.

THE BEAVER CREEK SHELTER (39CU779): A HOLOCENE SUCCESSION IN THE BLACK HILLS OF SOUTH DAKOTA

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Abstract- The Beaver Creek Shelter contains the most complete Holocene section in the Black Hills and evidence for the cultural transition regionally between the Early and Middle Archaic periods from approximately 6,720 years to 3,800 years ago. Test excavations were limited to 22 stratigraphic units through 4.77 m of section, ranging from 9,380 to 1,750 years ago. Mollusk, plant, and vertebrate remains occur throughout the section and provide documentation for Holocene environmental change in the southern Black Hills. Shelter occupation was during warm seasons by peoples engaged in hunting and food processing activities who utilized locally available raw materials. The McKean cultural complex in this locality represents a continuation of the lifestyles represented in the later portion of the Early Archaic period. A change in artifact styles, lithic composition, and reduction of the numbers of modified flakes and debitage, however, suggest changes in site utilization may have occurred by the Middle Archaic period.

FOSSIL DICOTYLEDONOUS WOODS OF YELLOWSTONE NATIONAL PARK, WYOMING

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Abstract- The dicot woods of the middle Eocene Yellowstone fossil forests of Specimen Ridge and Amethyst Mountain are some of the most exquisitely preserved fossil woods known. Some of the Yellowstone woods are referable to extant genera (e.g., *Alnus*, alder), while others do not conform exactly to a single extant genus (e.g., *Zelkovoxylon*, similar to *Zelkova*, chinese elm). Over twenty woods have been described in print, there are ten additional types, including members of the Leguminosae and Sterculiaceae. These wood expand considerably our knowledge of trees that grew during one of the warmest portions of the Tertiary.