M·A·P·S Digest

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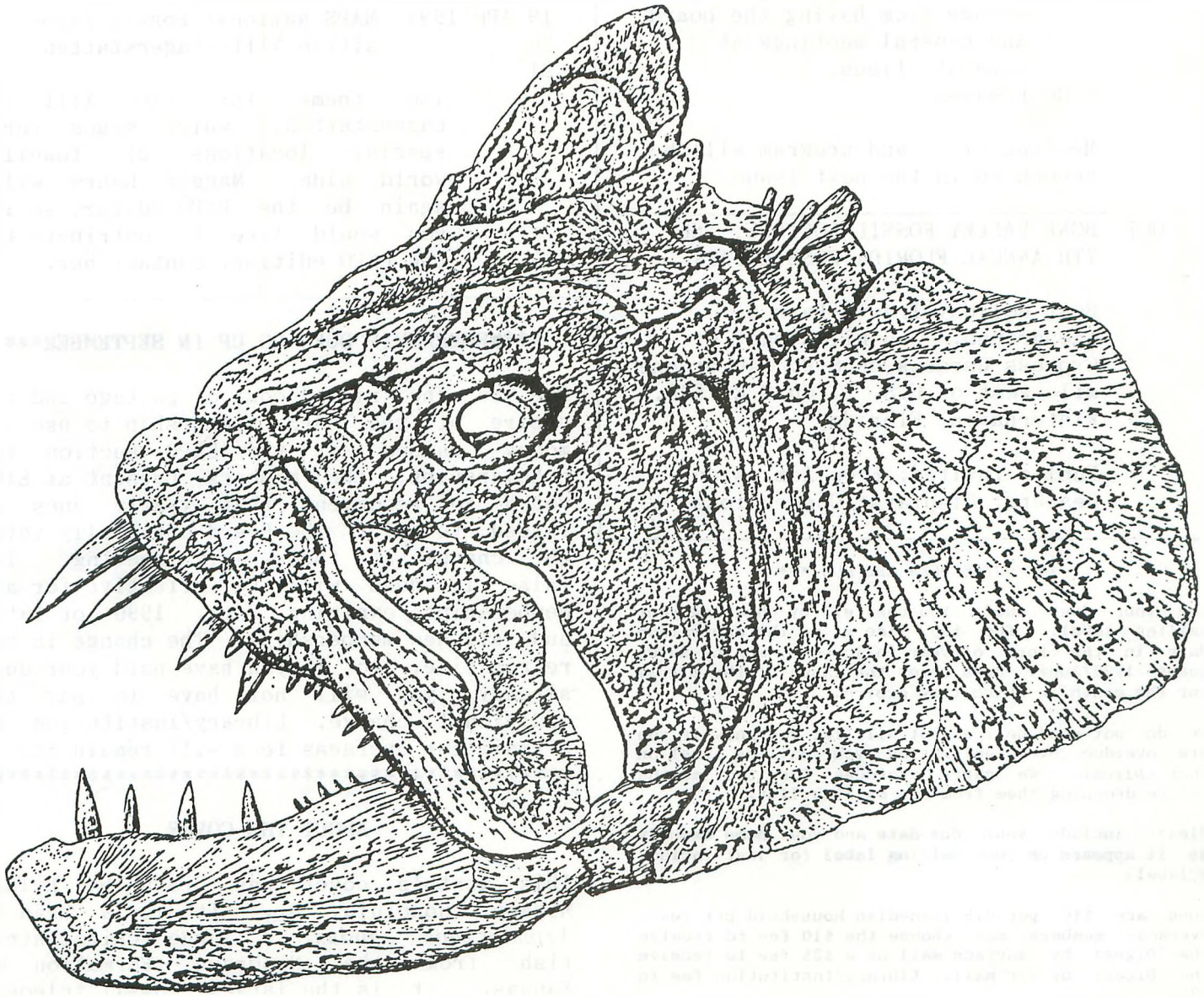

XIPHACTINUS AUDAX

A LOVE OF FOSSILS BRINGS US TOGETHER

MARK YOUR CALENDARS

6 OCT
7

MAPS FIELD TRIPS

Plans are being made for the fall field trip, which may be one or two days on the weekend of October 6-7. Details will follow in the October *Digest* or by postcard.

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10 NOV

MAPS MEETING. ***NOTE CHANGE OF WEEKEND***

1:00 Board & General Meeting combined. NOTE this is a change from having the board and general meetings at separate times.
2:00 Program

Meeting place and program will be announced in the next issue.

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5 OCT
6
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BONE VALLEY FOSSIL SOCIETY, INC.
7TH ANNUAL FLORIDA FOSSIL FAIR

Best Holiday Trav-L-Park & Campground. 2.6 miles east of Cypress Gardens on S.R. 540 or one mile west of U.S. 27 on S.R. 540, Winterhaven, Florida.

Public Invited; Free Admission; Dealers; Displays; Concessions.

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2 NOV
3
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FOSSILMANIA VIII
AUSTIN PALEO & DALLAS PALEO SOC.
Oakdale Park, Highway 144 South, Glen Rose, TX.

Joan Crane, show chairman.
1603 Twilight Ridge, Austin, TX 78746. (512) 327-4005

RV hookups, Cabins, Campsites, Fellowship, Swapping, Selling, Bar-B-Q Dinner, Baked Potato Bust

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19 APR 1991
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21

MAPS National Fossil Exposition XIII--Lagerstatten

The theme for EXPO XIII is Lagerstatten, which means very special locations of fossils world wide. Maggie Kahrs will again be the EXPO editor, so if you would like to contribute to the EXPO edition, contact her.

*** 90/06 DUES ARE DUE ***

Are your dues due? You can tell by checking your mailing label. The top line gives the expiration date in the form of year followed by month--90/06 means 1990/June. Dues cover the issue of the *Digest* for the month in which they expire.

We do not send notices but will let you know if you are overdue by highlighting your mailing label on your *Digest*. We carry overdues for two months before dropping them from our mailing list.

Please include your **due date** and your **name exactly as it appears on your mailing label** (or just include a label).

Dues are $10 per U.S./Canadian household per year. Overseas members may choose the $10 fee to receive the *Digest* by surface mail or a $25 fee to receive the *Digest* by air mail. Library/Institution fee is $25.

Make checks payable to MAPS and mail to:

Sharon Sonnleitner, Treas.
4800 Sunset Dr. SW
Cedar Rapids, IA 52404

*****MEMBERSHIP DUES GO UP IN SEPTEMBER*****

Due to the rising cost of postage and the desire of the MAPS membership to use the money raised at the EXPO auction for scholarships, the members present at EXPO voted to recommend that yearly dues be raised to $15. The Board officially voted the change at their July meeting. The raise in dues will be effective for all memberships expiring Sept. 1990 or later and all new memberships. The change is not retroactive, so if you have paid your dues already, you will not have to pay the additional charge. Library/institution and airmail for overseas fees will remain $25.

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ABOUT THE COVER

This month's cover was drawn by Leland Miyamo, Honolulu, HI. It is a head of *Xiphactinus audax*, a large chirocentrid fish from the Niobrara Formation of Kansas. It is the largest fossil teleost; a specimen in the Sternberg Museum on the campus of Fort Hays State University is 14 feet long with a six foot *Gillicus* fish preserved in its abdomen. The drawing was adapted from a reference by Stewart, and additional information was derived from Bardacks' Account of Chirocentrid Fishes.

EDITOR/TREASURER ADDRESS

Due to an oversight I failed to correct my address in the 1990 Directory. The Post Office decided to change our address to Cedar Rapids about a year ago, and our former post office is getting tired of forwarding our mail and is now returning it, so please make the following change in your Directory in case you have a need to contact me:

Sharon Sonnleitner
4800 Sunset Dr., **S.W.**
Cedar Rapids, IA 52404

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GRAY TOTE LEFT AT EXPO

LOST--left by freight elevator at EXPO, gray canvas tote, marked "Le Bag," containing clear plastic raincoat, white nylon jacket, etc. Call collect or write:

Mary Boland
N2047 Valley Road
La Crosse, WI 54601
608-788-6994 (collect)

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CANADIAN FOSSIL STAMPS DUE IN JULY

Leslie Harris, Ontario, Canada, sent a brochure with the following information about a new issue of four stamps featuring prehistoric life in Canada:

Canada Post Corporation is issuing the first four stamps in a four-year series on Prehistoric Life in Canada. The series, which will cover a time period of 1900 million to 10,000 years ago, will feature organisms found fossilized in different parts of Canada. This issue depicts: *columnar stromatolite*, uncovered in western Quebec, which was formed 2900 million years ago by photosynthetic bacteria; a soft-bodied *marine invertebrate*, an example of Cambrian Period sea life from 530 million years ago, which was discovered in the Burgess Shale of British Columbia; a 530 million year old *trilobite*, found in Newfoundland's Cambrian rocks, ... and a *sea scorpion*, from the Silurian Period 420 million years ago, which was found fossilized in the shale and limestone of southern Ontario.

For more information, write to the National Philatelic Centre, Canada Post Corporation, Antigonish, Nova Scotia, Canada B2G 2R8.

ONSBY HAMMONS PASSES AWAY

Our deep sympathy is sent to Ernest Hammons and family in their loss of Onsby in early June. As many of you know, Ernest and Onsby were awarded the Strimple Award this past spring for their many contributions to the field of paleontology. Both have given much of their time and knowledge to help many members of MAPS. They were also regulars at EXPO, and Onsby will be missed by all of us.

MAPS sent flowers in honor of Onsby, and Ernest sent the following note in return:

Dear MAPS members,

Thank you for the beautiful basket of flowers you sent. The family appreciates your thoughtfulness. Onsby cherished the friendships she had made with the MAPS members. Your acts of kindness and sympathy will always be remembered.

Love,
Ernest and family

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SPLIT THE MATRIX RIGHT

Gerry Norris sent the following tip for getting matrix to split the right way:

When sharpening the chissel, bevel the ends slightly shorter than the center,
so any striking gives a long plane.

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CORRECTION: OKLAHOMA LAW REPORT IN ERROR

Tony Raines, Oklahoma, sent the following note regarding the report in the May *Digest* concerning an Oklahoma fossil regulation law:

... it appears that I misinterpreted the article. I am happy to report the House bill was defeated in the Okla. Senate. There is no law. A couple of MAPS members, Robert Carroll of Ann Arbor, Michigan, and John Alf of Bartlesville, OK, contacted me and set me straight. I apologize for promulgating this bit of misinformation.

Several MAPS members contacted me to say they had helped to defeat the bill in 1988. See next page for more.

AMATEURS HELPED TO DEFEAT OKLAHOMA FOSSIL LAW WHICH PASSED HOUSE IN 1988

As noted on page 2, several MAPS members contacted me regarding the incorrect reporting of a very restrictive fossil regulation law in Oklahoma in the May Digest. I appreciate their help in supplying the correct information that although the bill passed the Oklahoma House in 1988, it never made it to the Senate because of the efforts of amateurs.

*The following is by **John T. Alf, Chairman, Rocky Mountain Federation of Mineralogical Soc., Inc., Public Lands Advisory Comm.***

In the MAPS DIGEST, May issue, there appeared an article which contained some incorrect information, and I would like to take this opportunity to offer the correct information. This appeared on Page 3 under the heading "Oklahoma Has Fossil Regulation Law, Too". The fact is that such a bill passed the Oklahoma House of Representatives in early 1988 but never made it to the Senate, and is **not** law today. Tony Raines, of Oklahoma City, sent you the clipping from the Daily Oklahoman which you excerpted, but he was unaware that the bill had not become law. I have had a long discussion with him, filling him in on all the details of our successful fight to stop the bill.

The bill sailed through the House on a 95-4 vote because the preamble sounded good to the non-fossil oriented House members and because no one in the amateur or commercial community knew it was being considered. Upon publication of the article Tony sent you, almost the entire population of the gem and mineral clubs in Oklahoma went into action to contact their Senators. I don't believe there was a single Senator who in a couple weeks hadn't heard of the bill and become aware that there was significant opposition to it. It died on the last day for committee consideration because the committee to which it was assigned couldn't get a quorum (an antiseptic way of voting "no" on something controversial).

The bill claimed to deal with vertebrate fossils, but according to the definition in the bill, invertebrates, plants and trace fossils would all have been considered to be "vertebrate fossils." Sale of any Oklahoma fossil, whether it came from public or private land, would have been a felony. Collection or trading would have been a misdemeanor. We are, indeed, fortunate that the amateurs of Oklahoma responded to our call for action in the way they did. In addition, this success was due in no small part to the efforts of one of Oklahoma's largest commercial dealers.

*The following is from **Glen F. Rockers, MAPS member since 1979 and President of the American Association of Paleontological Suppliers:***

... I was happy to discover that the Oklahoma fossil collecting bill was not a reality... Also, I think it is important that you know that two members of MAPS AND AAPS (American Association of Paleontological Suppliers) were responsible for defeating the Oklahoma fossil bill in 1988. Both Allen Graffham, owner of Geological Enterprises, and Pete Larson, President of Black Hills Institute of Geological Research, lobbied intensely against that proposed legislation...

As President of AAPS, I wish to inform you that our organization has been very instrumental in fighting proposed legislation that not only would hinder commercial collecting but <u>all</u> types of fossil collecting. There is a misconception that lawmakers and members of the scientific community are only out to regulate commercial collecting. This is absolutely not true; when the laws are written, absolutely no distinction is shown for the different types of fossil collectors. Usually commercial, amateur and recreational collecting activities are grouped under one definition. Example: the proposed Oklahoma law that was defeated in 1988 had a section which stated that it shall be a felony to traffic in, for profit, vertebrate fossils collected in the State of Oklahoma. (i.e., the sale of a shark's tooth, by an adolescent, for 25¢, would have been a felonious act.) In my own state of Kansas, a commercial fossil collector is defined as <u>anyone</u> who collects with intent to sell fossils for a value. (i.e., this means that anyone who has ever sold a fossil at the EXPOS, or at any other time, is considered a commercial fossil collector and is regulated by the new law in Kansas.)

It is becoming apparent to businessmen in the fossil industry that there is an organized effort in this nation to prohibit all individuals, except the scientific elite, from collecting fossils. This has happened in Canada and other countries and the MAPS membership must be made aware that all fossil collectors cannot let this happen in the United States.

Anyone who would like more information about AAPS continuing effort to protect our rights to collect, prepare, own and sell fossils, I urge you to write our membership chairperson, Mrs. Linda Ross, 913 S. Clarion, Gillette, WY 82716. AAPS has a membership category for all interested parties. You do not have to be a commercial collector to be a member of our organization and help us fight this battle to protect our rights!! Please write for a free brochure which explains the American Association of Paleontological Suppliers' role as businessmen promoting science. This brochure also includes a list of our members and the Code Of Ethics which we adhere to as commercial fossil collectors.

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KANSAS FOSSIL REGULATION LAW
by Glenn F. Rockers, Hays, KS

Kansas has a new law regulating commercial fossil collecting. This law is effective July 1, 1990. MAPS members, Glenn and Barbara Rockers, spent a lot of time, energy, and money trying to defeat the bill but nevertheless it was passed. They were successful in changing and/or deleting the wording of several crucial sentences that would have made it impossible for the commercial collector to function in the State of Kansas. This law pertains only to private land (98% of Kansas is private land). Highway roadcuts, state parks and recreational areas are exempt.

Basically, the law, as passed, says that the commercial collector must identify himself as such and obtain written permission from the landowner to search for fossils and then get specific written permission to collect the fossil. This law pertains to both vertebrate and invertebrate fossils. There are substantial fines for non-compliance.

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FOSSIL COLLECTING ON PUBLIC LANDS
by John Boland, MAPS member

Meetings have been held in December 1989 and May 1990 by representatives of federal and state agencies, museums, and amateur and commercial collectors to discuss and reach a consensus for fossil collecting rights on federal lands. Conditions for amateur (not-for-sale) collecting have been described in earlier articles and, briefly stated, surface collecting can be done without a permit, but surface disturbances, where allowed, must be less that 18 sq. ft. using only hand tools. Collecting beyond these limits requires a permit. All vertebrate fossil finds should be reported, and scientifically important fossils should be given to museums or research institutions.

Collecting by commercial fossil collectors requires a permit. The participants in the meeting agreed to a number of conditions for commercial collecting:

- -no surface collecting
- -quarry collecting requires a permit with an application and competitive bidding
- -ongoing monitoring by a three-person professional oversight group with all expenses borne by the commercial collector
- -With certain exceptions, fossil vertebrates are considered rare, invertebrates, plants, and trace fossils are considered common. Commercial collection will be considered for common vertebrates, invertebrates, plants, and trace fossils.
- -Scientifically valuable fossils shall go to museums or research institutions (public or private) within United States.
- -Compenstation to commercial finder of scientific specimens equivalent to normal collection costs as determined by BLM/FS.
- -Access to fossils by scientific researchers and educators over time (fossils stay in United States to maintain access to fossils and database)

The BLM and Forest Service will review the proposed rules and formulate regulations which will be reviewed by the Secretary of the Interior, OMB, and many other federal land managers. The final review is by YOU, the public, when it appears in the Federal Register probably in October. At that time, you have 60 days to comment.

COLLECTION, RESTORATION, AND PRESERVATION OF LARGE VERTEBRATES, INCLUDING DINOSARUS

by Tony B. Raines, Oklahoma City, OK

Few members of the lay public, when viewing the giant dinosaurs in major museums, have any concept of the tremendous amount of time and effort involved in the collection, preparation, and restoration of those impressive remains. Many of them probably assume the bones were just pulled out of the ground and the skeletons assembled as is. This is not too surprising since most popular books on dinosaurs written for the layman direct little attention to those preliminary details, but primarily dwell on their classification, morphology, and life-styles, sometimes embellished by the inclusion of fanciful life restorations (chicken-legged tyrannosaurids take a lot of getting used to). Scientific papers and journals principally concerned with the osteology, phylogeny, or systematics of new genera and species give even less attention to the preparatory work necessary to enable study of the finished product. Hence there is little public awareness of the contributions of the unsung and unassuming workers of the fossil world, the collectors and preparators. They are individuals who apply a good working knowledge of geology, paleontology, and osteology along with a certain artistic and hands-on mechanical ability. This is not meant to imply that professional paleontologists do not accomplish their own collecting and preparation; many of them do.

* * * * * * * * * * * *

Before getting into the details of collecting, a general outline on the geologic and physiographic background of the dinosaur horizons in the United States is presented. In Middle and Late Jurassic time, and again in Late Cretaceous time a shallow, epicontinental sea bisected the U.S. approximately through the middle in a generally north and south direction. At both times a large community of dinosaurs flourished in a belt of coastal swamps, deltas, flood plains, and uplands on the western side of the inland sea in what is now the states of Colorado, New Mexico, Utah, Wyoming, and Montana, and extending northward into Alberta, Canada.

After numerous transgressive and regressive cycles of the sea coast, the beginning of the Laramide Revoltution with the initial uplifting of the Rocky Mountains at Late Cretaceous time started the final regression of the inland seaway and consequent draining of the bordering coastal environments. Left behind was a vast multitude of dinosaur and other reptilian fauna buried in sediments which were later elevated in Mid to Late Tertiary time. Subsequent to that age, the dissection of the Colorado Plateau province and areas to the north by wind and winter erosion has resulted in what we see today in those Western states, a rugged, mountainous, canyon-cut land.

The continental fluvial sediments of the Upper Jurassic Morrison Formation in the Colorado Plateau province mainly consist of two members, although four members are assigned to some areas. The two principal members are considered here. The lower member, the Salt Wash is chiefly composed of gray and buff sandstone with intermittent lenses of shale and conglomerate. The upper member of the Morrison, the Brushy Basin, is predominantly vari-colored bentonitic clay and mudstone, with upper and lower beds of brightly colored pebble conglomerate in some areas. Deposited in latest Jurassic time (Tithonian), the Brushy Basin contains one of the most prolific dinosaur horizons in the world and some of the largest dinosaurs that ever lived. Hardly any species of the large sauropods survived into the Cretaceous, and along with the stegosaurids their extinction at the end of the Jurassic has not been satisfactorily explained.

Typical of Upper Morrison excavations are the Brigham Young University's Jim Jensen site in Mesa County, Colorado, and the Cleveland-Lloyd quarry in Utah. The methods of excavation and collection of vertebrate fossils briefly outlined here are based on those representative kinds of digs. This outline is not intended to attempt to cover all aspects of fossil collecting. More specifics can be found in some of the available literature. Primarily directed toward the amateur, the

methods should acquaint the serious collector with the basic requirements for accomplishing a satisfactory job with a minimal outlay of supplies and equipment.

The logistics involved in the collection of large vertebrates, i.e. dinosaurs, can be intimidating. The remains are almost always discovered in remote, rugged terrain filled with badlands and canyons, and accessible only by foot or horseback, or at best by four-wheel drive. Along with the problems of transport of supplies, tools, water, and camping equipment, potential physical hazards including blistering heat and dehydration sometimes must be contended with. In some regions the determined collector is victimized by a little-noted, but none-the-less insufferable animal hazard quite disproportionate to its size. In the summer months in southwestern U.S., especially in the states of Colorado, Utah, and New Mexico, swarms of a particularly vicious gnat descend on unsuspecting man and beast. Popularly known as punkies or "no-see-ums," this midge which is not much larger than the dot above the vertical bar in the "i" of *Culicoides gutapennis*, cna penetrate mosquito netting with ease. Hardly any repellants are effective except those that contain about 100% "DEET." This is a persistent gnat whose bite causes swelling and painful suppurating sores. This all may sound like hyperbole but the problem is intimidating enough that some residents restrict their activities in the wilderness areas during the summer months.

COLLECTION

The methods used in extracting fossil bones are dependent to some degree on their physical condition, which in turn is determined by the age and nature of the sediments, their mineral composition, burial environment, and the depth at which they are found. Fossil bones may be permineralized, silicified, carbonized, or a combination of all of these, with varying degrees of porosity, brittleness, and density.

The lithology of the typical Brushy Basin locality is predominantly tan-grey, bentonitic clay and mudstone with scattered lenses of bluish-grey and greenish-grey clay. Commonly included with the vertebrate remains are carbonaceous seed and sporangial casts and compressions, stems, branches, and leaves randomly intermingled throughout the mudstone, including the matrix surrounding the bones. Plant specimens include *Carpolithus*, a common genus in the Morrison, *Behunninia*, ferns, small coniferous cones, and large coniferous logs. A helpful clue in the location of dinosaur remains in the Morrison is the presence of mudstone seams and plant "trash" beds. The sauropods *Apatosaurus* and *Diplodocus* are represented as well as the ornithiscian *Stegosaurus*, and a large carnosaur, *Allosaurus*. The haphazard jumble of various skeletal parts of different species and different-sized parts of the same species, together with the close association of hashed-up plant material indicates the remains were buried in a low or medium energy depositional environment. A sort of backwater boneyard. Rather than the result of some short term catastrophic fluvial attrition from a large dinosaur community, a stable and comformable deposition of lacustrine and palustine sediments over a fairly long period of time.

Almost all of the bones are black and carbonized on the surface and throughout the lamellar outer layers. The bones are permineralized with a complex mixture of calcite, collophanite (hydrous calcium phosphate), sometimes colored siliceous minerals in the form of chalcedony filling the central pores and Haversian canals, and kerogenous hydrocarbons. After a year or two of exposure to weathering the black color changes to grey on the surface.

Treatment of crushed samples of the black bone with 30% hydrochloric acid produces the characteristic petroliferous odor associated with crude oil or oil shale when heated. The acid attacks the calcite and collophanite releasing the trapped biochemicals. A small amount of a brownish, oily liquid is produced. After removal of insoluble minerals and excess acid, a black, tarry kerogenous residue is obtained. Living bone tissue composed of about 65% hydroxyapatite, the organic

homologue of collophanite, like other organic tissue also contains the elements carbon, nitrogen, oxygen, and sulphur. Burial in mud under anoxic conditions can be contributive to the formation of kerogen, a complex hydrocargon polymer in fossil bone in much the same manner kerogen is produced from the burial of microbiota. Black, kerogenous fossil bone is found only where the right combination of burial and fossilization processes occured. If this seems farfetched, kerogen and amino compounds have been found in much older Paleozoic fossils.

An example of the diverse effects of different burial environments on fossilization can be found in Triassic sediments in the same region. In contrast to the Morrison sediments, most of the Late Triassic deposits in the states of Colorado and Utah are composed of brick-red shale, clay and mudstone. Oddly, the fossils from those sediments, including teeth, are white, creamy white, and bluish-white. There is some superficial red staining, but other than some slight silicification, there is little change from the original state.

The bones in a typical Brushy Basin deposit have usually been subjected to thermal, mechanical, and chemical stresses over a long period of time--cyclical freezing and thawing, wetting and drying (especially those close to the surface), ground shifting and gravity slump, and widening of incipient cracks by the expansionary forces of growing plant roots. Hence most of the bones are already broken *in situ* before uncovering. This is characteristic of fossils lying relatively close to the surface in clay and mudstone matrix. Acids and other organic chemicals from plant roots growing in and around the cracks in the bones cause a type of rotting, a deterioration and softening, especially in the thinner parts. In addition, some degradation of bones is caused by chemical alteration in some of the soluble minerals. All of these effects can cause a loss of rigidity and density, leaving a crumbly, punky mass that is likely to fall apart when disturbed. While these drawbacks are somewhat offset by the greater ease of excavation and extraction from clay and mudstone sediments, it may be noted that the generally better preservation and structural integrity of bones in more stable sandstone matrix is offset by greater difficulty in their removal.

It has been observed that a change in the physical properties of the punky bone occurs after removing from the matrix and allowing to air dry or "cure" for a day or two. This also applies to the outer layers of some solid bones with porous areas. An overall hardening of the bone with an increase in rigidity and resistance to damage is evident. The hardening probably involves a chemical alteration. The principal cementing minerals in the clay and mudstone sediments are carbonates and silicates. Calcium carbonate constitutes an appreciable part in the permineralization of fossil bones. Where ground water permeates the matrix surrounding the fossils, it holds some calcite in solution, possibly some in colloidal suspension. As long as the water containing the dissolved minerals infuses the porous bones, they are slightly softened. When the bones are removed from the wet and anoxic environment and dried out, the calcite mineral comes out of solution or suspension and crystallizes in the minute pore spaces, or "sets" in a manner similar to that of concrete. The lithology and mineralogy of a fossil dig may at first seem irrelevant to the task of romoving a bone from the gound, but some knowledge of its physical characteristics and origin may assist the collector in its extraction with the least amount of damage and wasted effort.

When a fossil site is located by one of the following methods: by tracing out weathered fragments, by lucky accident, or by word of mouth, its extent is carefully determined by judicious probing and digging. Assuming the collector has no bulldozer or backhoe available, the overburden must be removed by the old standbys, pick and shovel. For large vertebrate fossils the overburden can be removed down to within three to four inches above the bones. If the site is located on a slope, which is usually the case, loose rocks and other debris should be removed for a distance above the dig to prevent injury to

personnel or damage to the fossils. In loose, unconsolidated sands or shales, a plank fence may be required around the excavation to prevent falling rubble or cave-ins.

After overburden removal, the next step involves the careful removal of matrix from the bones so that the tops and sides are fully exposed while leaving them in place. The matrix is excavated around the bones to a depth of several inches below their undersides, and undercut to form a sort of pedestal for support. This is to facilitate encapsulation with a plaster jacket with a bottom curvature that will prevent the specimen from falling out when lifted or overturned. When digging around broken jumbled masses of bones that represent a disintegrated skull or other fragile part, an effort should be made to retain as much matrix as practicable for support of the imbedded bones. Jacketed matrix and all is then taken out.

The importance of careful, deliberate work cannot be over-emphasized. Partially exposed or loose bones should never be pulled out of the matrix. This usually results in breakage or disturbance from their proper position relative to other parts with which they may be associated. Any chiseling or prying on the matrix surrounding a bone should be done in such a manner that impact vibrations or prying stress will be directed away from the specimen. Bones are very brittle and fracture easily, even with the application of slight force. Usually a matrix composed of clay and mudstone, such as the Brushy Basin, will be jointed profusely, with separated cracks running parallel. In some cases when a large bone is lying perpendicular to the direction of the cracks and across several of them, it may require jacketing sections of the bone separately. Hard, calcite-cemented mudstone balls or shells encapsulating bones wholly or partially, especially on the rough sculptured ends of saurian limb bones, are a common problem. Chiseling or prying on such usually breaks the bone instead of the hard matrix. Hard matrix sheaths and ferrous mineral encrustations should be romoved in the workshop with silicon carbide saws and grinders.

Some collectors may have at their disposal air or gasoline-powered rock drills or chisels, and powered rock saws, especially when working with sandstone matrix, but the following list of readily available tools is sufficient for most jobs of matrix excavation and removal. Required are various small picks and shovels, including the short, folding-handle military type for working in close quarters, pry bars, hammers, small chisels, hand-held masonry drills, and possibly silicon carbide hack saw blades. For final close work on the specimens, homemade modifications of ordinary hardware items work very well, such as the following: a hand weeding tool with the V-fork sharpened, a 3-tined hand cultivator with the two outer tines removed and the central point sharpened, an ice pick or scratch awl heated to redness and bent into a 90 degree curve about two inches from the point, and a common screwdriver with sharpened blade. Also required are a stiff whisk broom and several soft bristle brushes.

When all of the fossils are well exposed and outlined, a compass oriented drawing or photograph of the site should be made. Strike and dip of the bone layers should be ascertained and noted. If the site is large, it can be divided into measured and numbered sections. The sketch or photo will be helpful in reconstructing the specimens in the event some of the parts are inadvertently mixed up, mislabeled, or not labeled at all. Before jacketing or removal, each major part can be identified with a number or code designating the site. On a partial or complete skeleton, the parts should be numbered sequentially, especially vertebrae, for later reconstruction. This can be applied by painting on the number using a permanent marker pen such as the Sanford Ink Co. SHARPIE, or affixing a piece of duct tape and writing on the tape. Any area where duct tape is applied should first be cleaned and sprayed with a clear plastic coating.

A perfect, complete fossil bone or skeleton is a rarity. Most are found fractured, splintered, flaking, or with crumbly rotten areas, especially those with large length-to-diameter ratios, or those with thin cross sections relative to their masses, such as scapulae, pelvic members, cora-

coids, and skulls. Before plaster jacketing, a quick-drying liquid consolidant to harden and preserve the affected areas should be sprayed, poured, or brushed on the specimen. Before any application of consolidants, all affected areas should be carefully cleaned of extraneous dirt or rubble.

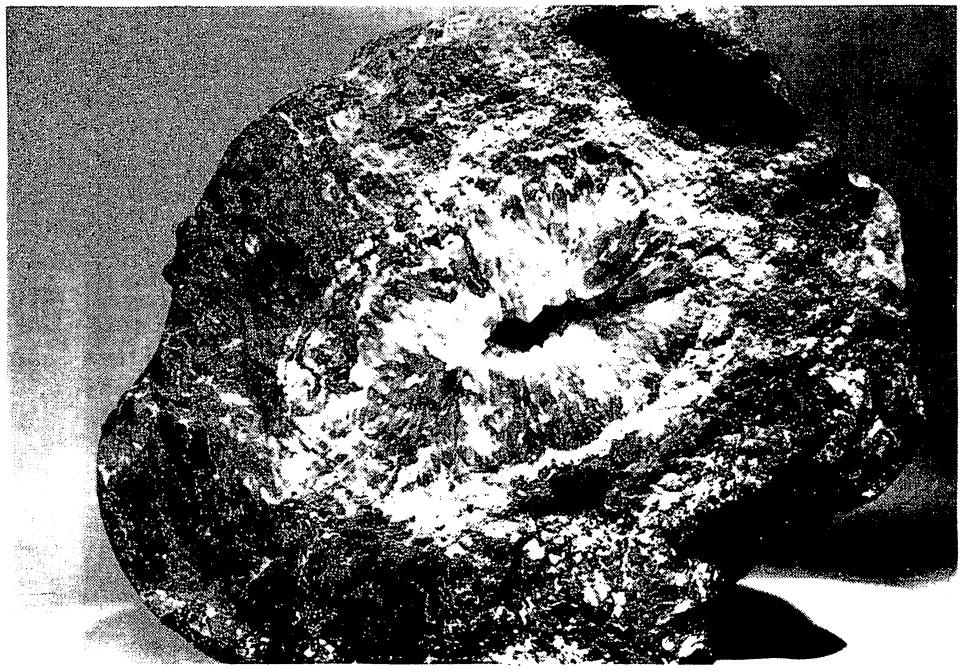

Figure 1. Broken portion of large sauropod limb bone. Core filled with crystalline quartz.

There are several fillers and preservatives that can be used satisfactorily as consolidants. Clear lacquer thinned to watery consistency with acetone or lacquer thinner can be poured over the specimen, or brushed on. Here a pure bristle brush is required; some of the synthetic plastic types soften and dissolve in the solvents. Clear acrylic plastic sprays such as KRYLON work well on the crumbly areas, at least for preliminary hardening in the field, since the force of brushing can dislodge and scatter fragments from those areas. Other consolidants include soluble alkyd resins like the polyurethane-based clear plastic varnishes thinned with lacquer thinner or toluol, and polyvinyl acetate, a water miscible bonding agent (a 2:1 parts ratio of polyvinyl acetate to water is preferable) sold under the trade name ELMER'S GLUE-ALL. The adhesive can be used straight from the bottle for small repair jobs in the field, although the time required for drying is longer than other cementing agents. A faster drying cement for small repair work is a thinned mixture of rubber-based contact cement thinned with methanol or lacquer thinner. DUCO cement thinned with acetone makes a good but rather expensive consolidnat, poured or brushed on. Straight from the squeeze tube it provides a quick drying cement for replacing small pieces. It should be pointed out that the use of contact cement and DUCO cement for small repair jobs in the field is usually a temporary fix for collection of the specimens. At later repair and final reconstruction the adhesives should be removed if possible, and replaced with stronger and more durable bonding agents, preferably epoxies. There is one area where the clarity and quick drying characteristics of DUCO cement makes it a good cementing medium, the repair and restoration of loose, fragmented teeth.

One more colsolidant/preservative agent for field or lab use should be mentioned. A common household item, ladies' hair spray, is an excellent medium for consolidating and fixing small, delicate impression and compression fossils such as fish, insects,

and carbonaceous plant stems, leaves, and seed casts. Most of these fossils tend to be thin and powdery, flaking away easily upon exposure to air, or damaged by brushing. The hair spray, is applied sparingly, makes an invisible, non-glossy fixative that will prevent disintegration of the specimens until they can be stored properly.

A good quality industrial grade duct tape is one of the most indispensable items to have around a dig site. Besides its labeling and packaging uses, in some cases it can be used to lift out small broken bones intact, providing the specimen is only a few inches long and has a diameter less than the width of the tape. The matrix is carefully removed from all sides of the specimen with fine-pointed curved picks and soft brushes, leaving it in place but not bound or restricted by the matrix. After cleaning, the surface is sprayed lightly with plastic spray. When dried the plastic consolidates any small flakes or splinters and prevents them from coming loose and adhering to the duct tape. The broken pieces are numbered sequentially with a permanent marker pen for later repair. A length of duct tape slightly longer than the specimen is applied axially so that it overlaps and encloses a good part of the sides and ends. Good adherence is essential. The bone is lifted out of the matrix *in toto* with the tape. After removal, the same procedure is applied to the other side of the specimen. Identification can be marked on the tape.

Even after a centruy of dinosaur fossil collecting, the old-fashioned but tried-and-true method using plaster of Paris, burlap, and rice paper jacketing is still essentially the best method available for retrieving and transporting large bones. However, a better and much cheaper replacement for plaster of Paris is available in the form of No. 1 MOULDING PLASTER, a product manufactured by the United States Gypsum Co. and obtainable from cement and building products distributors. With about the same setting time as plaster of Paris, it is harder and has a greater tensile strength, therefore it requires a lesser thickness of jacket to provide an equal protection factor. As for the rice paper, several easily available substitutes work as well or better. Newspaper, heavy wrapping paper, or plastic sheeting are preferable for large bones. Toilet tissue or paper towels have been used, but their inadequacy for large vertebrates is readily apparent. The purpose of these materials is to provide a barrier between the plaster and the bones to prevent plaster adherence. Large garbage or tradsh bags, or plastic sheeting with at least a 1 to 2 mil thickness can provide the plastic barrier material.

In preparing a bone for jacketing, the surrounding matrix is removed from the top and all sides of the speciemn to a depth well below the bottom. The matrix is then undercut just below the bone in order to leave it resting on a pedestal. Plastic sheeting is cut to a size large enough so that it will completely cover and overlap the widest dimension of the specimen sufficiently to curve back under to where the matrix has been undercut. It is essential that all the contours of the specimen are followed closely in order to prevent looseness and empty spaces between the plaster jacket and the specimen. If newspaper is used instead of plastic, three to four single sheet thicknesses are wetted and applied, closely following the contours of the fossil. Plaster-soaked burlap strips should be applied immediately before the paper dries.

For best results on large bones, 2 to 3-inch strips of burlap (gunny sack) are crisscrossed in various directions like a bandage, but the lengths should be such that the ends always go under the curvature of the specimen the same distance as the barrier material. The strips are saturated with a thick soupy mixture of plaster and water before application. The primary purpose of the burlap bandages is to hold the barrier material in close contact with the specimen.

After the plaster-soaked burlap strips are set, the main plaster jacket is applied. Granted the plastered burlap strips could be used to build up a suitable jacket, but the cost in time and materials would not be feasible for large fossils. The mixture of plaster and water should be of a

consistency that allows working in by hand, but only enough should be mixed at any one time that can be handled in a time period of 15 minutes or less; otherwise the plaster sets up and becomes unworkable. The required average thickness of the jacket for satisfactory containment depends on various factors: size and mass of the speciemn, structural condition, and method of transport, but for very large bones one to two inches average thickness should be sufficient, two inches at the most when using splints. If necessary, some weak areas can be built up with a thicker application of plaster. It is advisable that all specimens with a very large mass and/or large length-to-diameter ratios be splinted with wood if available at the site, or by lumber brought in. The splints are plastered thoroughly onto the main jacket for added rigidity. A large sauropod femur such as that of *Apatosaurus* with an intrinsic weight of its own of 500 pounds or more, and with two "2-by-4" splints plastered in, requires a considerable amount of plaster and water and totals out a fairly hefty package. This kind of weight requires a wooden skid if it is to be winched over the ground surface.

When jacketing is accomplished, each specimen should be identified and labeled. Label information should include site designation, location, date, and geologic formation. Additional information in the form of field notes should be recorded covering the geology, lithology, and stratigraphic position of the site. Location of the site should be pinpointed by section, township and range, provided geologic or topographic maps are available. In addition, its geographic location can be signified by association with the name of the nearest town, ranch, river, creek, wash, hill, mountain, canyon, or any other pertinent geographic feature that has been named or mapped.

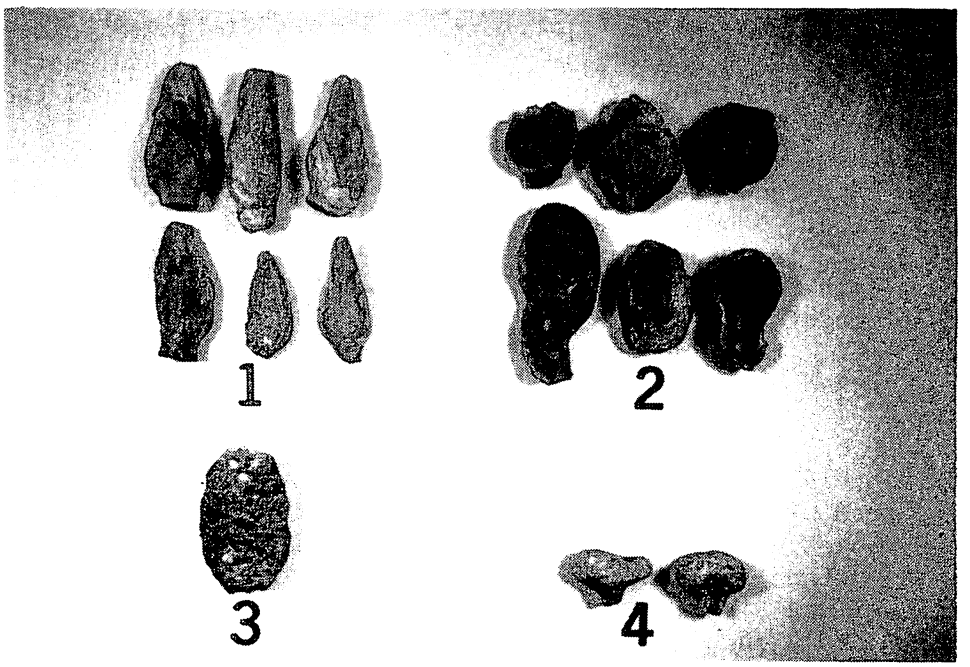

Figure 2. Carbonaceous seed-like casts from the Upper Morrison Formation, Colorado.
(1) *Carpolithus* sp.
(2) *Behunninia* sp.
(3) Coniferous cone similar to *Sequoiadendron.*
(4) *Carnolithus radiatus.*

Essential to the complete recovery of valuable paleontological information from a dig site is the collection of any associated fossils. Plant seeds, leaves, stems, sporangia, etc., provide useful information pertaining to the food chain and paleoenvironment. Matrix sediment samples should be collected and bagged for later examination for plant nannofossils--spores and pollen. Pertinent geologic characteristics of the site should be noted and recorded, such as lithic compostion of the host sediments, mode of deposition, stratigraphic and facies relationships. All this is helpful in establishing the taphonomy and paleoenvironment of the buried animals.

Large vertebrate fossils, especially dinosaur bones present a particular problem in retrieving and loading for transport. As a rule, owing to the rugged terrain, the dig sites are not directly accessible to motorized vehicles other than bulldozers. Some of the methods for manually accomplishing these operations involve winching, and the use of slings, slides, or skids. It is suggested that any jacketed fossil weighing more than 100 pounds should be mounted on a skid if it is to be dragged up or down hill by winching or rope hauling. Skids for the very large specimens such as sauropod limb bones or pelvic girdles should be constructed of sturdy lumber--"2-by-12's" or "3-by-12's." They should be securely lashed to the skid with rope or chains. Bumps against rocks or other impediments could crack the plaster if it is dragged directly on the ground. Provided it can be positioned close enough to the dig, a truck-mounted winch with long cable or nylon rope can be utilized. Otherwise winching can be accomplished manually with a hand operated power-pull or "come-along" of not less than a two-ton capacity.

Some specimens can be hand-carried by the sling method. The fossil is secured in nylon rope or webbing, or a strong tarp, and slung on a sturdy pole or pipe for safari-style transport. This method is somewhat limited by the size of the fossil and available manpower. Another option involves securing the specimen in a strong tarp, one that will withstand considerable abrasion, and hauling with a rope. The use of this method is restricted by specimen size and weight and smoothness of the ground. Naturally this works better going down hill. All of the procedures outlined above are somewhat dictated by circumstances, and improvisations are expected.

PRESERVATION

The removal of matrix and other unwanted material from fossil vertebrate bones is one of the most tedious and time consuming operations involved in their preparation. The first step, removing the plaster jacket, is not accomplished by indiscriminately cracking the plaster off the specimen, but by sawing or chiseling it off a little at a time. Here again caution is observed in preventing impact vibrations from affecting the fossil bone. Mechanized electric powered hand tools such as sabre saws or reciprocating saws mounted with 4 to 6-inch rough cut sabre saw blades work rapidly. High speed, silicon carbide masonry cutting discs chucked in a electric drill also work well, but more slowly. Hand tools available include the keyhole saw, plaster board saw, and compass saw. With pointed blades and large teeth, they work effectively on the relatively soft plaster. Plaster removal is a dusty, messy job and as with all work of this nature, normal precautions to prevent dust inhalation and eye injury should be observed.

The top of the jacket is removed first. The cutting operation should be stopped when it reaches the burlap bandage layer close to the bone. The cutout layer is lifted off and the burlap bandage and barrier material carefully removed. The surface of the exposed speciemn should be carefully cleaned and brushed, and observed for cracked or broken areas. Any repairs that can be made at this point without disturbing the fossil should be accomplished, and consolidant applied if necessary. For the next step a narrow section of plaster is cut away from the sides all around the circumference of the specimen, exposing more matrix. Again the barrier material is removed and the bone carefully cleaned of dirt and matrix and

repairs made. These precedures are repeated until the plaster is almost completely removed. It is best to leave the bottom portion of the plaster jacket as a form fitting, supporting shell or mold which helps precision placement and cementing of the parts. The whole point of the repetitive precedures of gradual plaster removal is to contain the specimen in a fixed position while cleaning and repair is accomplished. This is especially important for badly broken specimens (skulls usually are) where the loose bones are out of position and intermingled with the mtrix. The collapse without the supporting plaster would result in a mass of broken and unrelated parts requiring a great amount of time and effort to reassemble.

of its parts. Broken surfaces of bones are rough and provide a trap for limey and ferrous mineral encrustations and dirt. All this must be cleaned before cementing can be done. The edges around the breaks in brittle bones are ragged and chipped, and tend to become more so with handling. It is important for consolidant and hardening material to be applied to prevent this, but not in a manner that would contaminate the broken surfaces to be joined and cemented.

Besides matrix, limey deposits in the form of scum or crusts, and ferrous mineral deposits, mostly limonite, are the more common unwanted materials that require removal from fossil bones. Some calcium carbonate deposits can be removed chem-

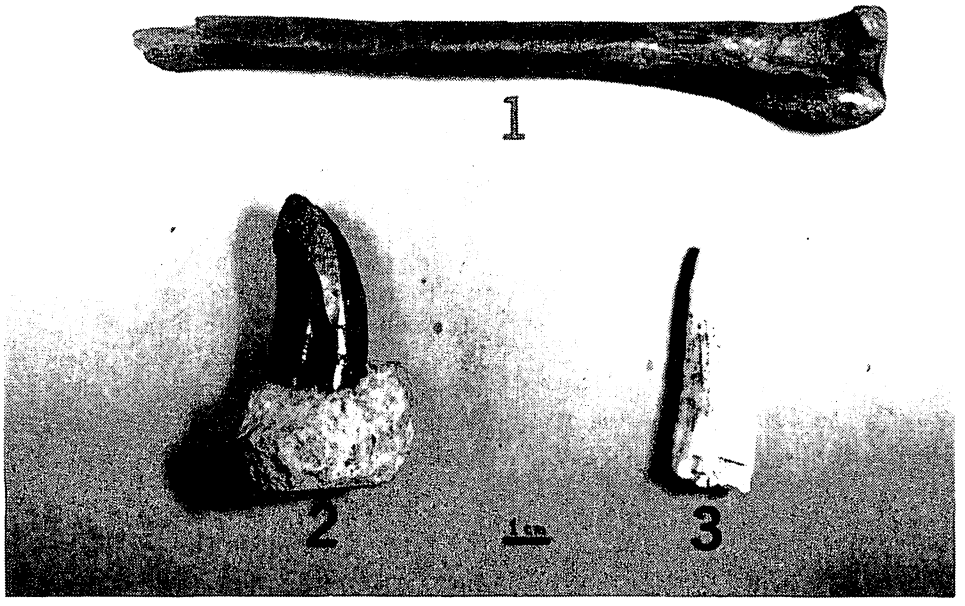

Figure 3. Contrasts in color and size.
(1) Tibia of small coelurid theropod, Upper Morrison, Colorado
(2) Well-worn Allosaurus tooth, Upper Morrison, CO
(3) Phytosaur tooth, Chinle Formation, Triassic, CO

Not all broken bones can be repaired and reassembled without first removing matrix or other extraneous material, but it would generally be advantageous in the long run if this could be done. Matrix removal after reassembly is usually better; there is more strength in the whole than in any

ically with dilute hydrochloric or acetic acids. Since these acids, particularly HCl, attack collophanite and calcite, the principal constituents of permineralized bones, extreme care must be used. Bones should not be immersed in even dilute HCl. A recommended method is to swipe the limey

area with a brush or cloth saturated with about a 10% solution of HCl and immediately rinse with water, repeating the process several times if necessary. If the lime deposit is too thick, or has not softened enough for removal, it can be cracked off by careful use of an impact engraving tool with tungsten carbide tip such as a DREMEL, or use of a sharp pointed scribe-like pick hit with a hammer. A high-grade machinist's bastard file with the end ground down on one side to a sharp chisel edge makes a worth-while tool for scraping and planing off thin deposits.

Limonite deposits are much harder than calcium deposits and impervious to most acids. These must be chipped off with the mechanical methods listed above, or ground off with silicon carbide grinders. Rusty iron discolorations can be removed, or at least diminished by use of one or more of the following household materials: chlorine bleach, chlorited cleansing powder such as AJAX, oxalic acid, the principal cleaning ingredient in the cleanser sold as ZUD, and TSP (trisodium phosphate). Vigorous brushing with a brass brush or hard toothbrush may be required. Most of these materials are used in conjunction with water, and immediately after the job is finished the affected areas should be cleaned and dried thoroughly. Any bones subjected to acids or water during cleaning should be thoroughly dried out before application of any type of preservative or consolidant. Just lying around for a few days will ordinarily do the job, or if less time is desired, a few hours in an oven at about 140 degrees F. should be sufficient. The potential for causing expansion cracks must be considered. Obviously very large bones could not be treated in this fashion.

Very sturdy work tables, including a sand table are a must when working with large vertebrate fossils, especially with dinosaurs. A chain hoist or other means of lifting and handling large weights is essential. Several bags filled with sand provide a means of propping up and positioning pieces for joining. Several tools and methods are available for matrix removal and preparation, but their effective use in the end is dependent on the individual's abilty, which comes about with practice and experience.

For the heavy work on hard thick matrix, the pneumatic impact driver fitted with various-sized chisels or an electric hammer/drill fitted with tungsten carbide masonry bits can be utilized. The hammer/drill rotates in the same fashion as an ordinary electric drill, but delivers rapid reciprocating impact blows at the same time. When using impact tools, including hand held hammers and chisels, the operator must always be aware of the potential for damage to brittle bone from impact vibrations and adjust his methods accordingly. Another good tool is a small diameter silicon carbide masonry cutting disc chucked in a high speed electric drill. Lastly, a hacksaw fitted with a silicon carbide blade is useful for some jobs where the other tools cannot be used advantageously.

A lot of the matrix adhering to bones removed from clay, shale, or mudstone beds is relatively easy to remove by scraping, brushing, or washing. Loosely consolidated shale or clay matrix responds to soaking or washing with a solution of TSP. Mineral spirits, a type of paint thinner, is sometimes effective in loosening the cohesive bond between soft mudstone or shales and bones, but it has an undesirable affinity for soaking into porous areas. In many instances, hard, dense, calcite-cemented caps or sheaths have a propensity for forming on the rugose surfaces of the ends of limb bones where cartilage and muscles were attached, and on the concave ends of some vertebral centra. Sometimes the adherence of the boundary layer joining the matrix to the bone is more resistant than the bone, and cannot be separated in one piece without lifting part of the bone.

One method of removing hard, thick matrix plugs, such as those that cap the ends of vertebral centra, or fill the spaces between the distal condyles of large limb bones is outlined here. Several holes about one-half inch apart are drilled in the matrix with masonry bits to a depth just short of contacting bone. The holes are drilled parallel in both coordinates to cover the whole matrix. If circumstances warrant, instead a silicon carbide masonry disc can be used to cut a crisscross waffle pattern to the same spacing as the drill

holes. The purpose is to weaken the whole structure for chiseling and grinding. Then each section of the plug is removed one at a time; here a hand chisel is preferred over powered impact tools, the blows can be better controlled. After the bulk of the matrix is removed, a thin layer remains which can be removed with a small flexible shaft rotary grinder of the hobbyist type, a vibratory scribe engraver, hand picks and chisels, or a combination of all. Rotary cutter bits chucked in an electric drill can be effective on fairly soft clay and mudstone. For cleaning out grooves, rough areas, blood vessel and nerve openings, air-brasive type machines serve well, along with small hand picks, dental tools, and brushes.

One of the more challenging jobs is the removal of the ever present plug or cast of the spinal cord opening from the neural arches of vertebrae. Consideration must be given to the fragility of the surrounding pedicels and neural arches. The plug cannot be knocked or chiseled out. It must be drilled clear through axially as many times as space allows with a rock drill and the remaining surround carefully ground out, or picked out with small hand-hammered picks and chisels.

There is a great variety of cements and bonding agents available for repair and reconstruction of fossil bones. Several brands of epoxy cements are available on the market. In general they consist of a resin and a hardener which are mixed before use. Setting time varies from a few minutes to several hours. A general purpose epoxy cement, Duro brand E-POX-E, or MASTERMEND, distributed by Loctite Corporation is found to be satisfactory in repairing small to medium sized bones. Cost, working time, and other factors would prohibit use on very large bones. When working with large vertebrates like dinosaurs, "small" bones would include tail chevrons, tarsal and carpal elements, and distal caudal vertebra. Considered as large elements are the femur, humerus, tibia, pelvis, and cervical, sacral and proximal caudal vertebra. The Duro epoxy is dark grey in color when mixed and can be colored with the addition of very finely ground mortar coloring powders obtainable from building products distributors. Amounts of coloring powder to be added to the epoxy should be restricted to proportions that would not degrade the effectiveness of its adhesive properties, not more than 8 to 10% by volume. Common colors of the tinting powders are brown, black, and red. The epoxy has a setting time of approximately four hours but should not be considered safe until about twenty-four hours have elapsed. During the four-hour period, after it has become somewhat firm and nontacky, the epoxy can be cut, shaped, or filed.

Many of the epoxies vended for use in auto repairs may be used. The fiberglass-based products can be utilized to provide filler for voids where bone is missing. There are too many brands for listing; the potential user must make a selective appraisal of their suitable characteristics for bone repair.

One of the best and most resistant bonding cements, even for very large specimens is Durham brand ROCK HARD, a plastic based water putty. Relatively inexpensive, it is mixed with water and may have a non-glossy, *latex-based* paint or stain added for coloring, preferably not more than 10% by volume. it must be worked rapidly as it is fairly quick setting. Before it is completely set and while in a firm but slightly soft condition, it can be carved and reshaped. The principal drawback to the material is that once completely set it is nonporous and cannot be colored effectively. Sanding and filing on it has negligible effect; it is really "rock hard."

Another type of material that can be used for bonding or filling gaps on the larger bones is anchoring cement. Primarily sold in hardware and building products stores for anchoring metal bolts in concrete, the product brand-name POUR-STONE is stronger than concrete, finely powdered and non-gritty. Mixed with water, this cement has a limited working time of about 15 minutes. Powdered mortar colors can be added in proportions up to 1 part in 12 without appreciably affecting bonding strength. Reworking, scraping, and carving can be accomplished before the cement

completely hardens. It is an excellent medium for filling cracks and gaps, and for reshaping and rebuilding missing portions of bones.

The same material used to jacket specimens, No. 1 MOUNDING PLASTER can be used to fill large gaps or build up missing portions of bones. Powdered mortar colors can be added to the plaster before mixing with water. Working time is short, but it can be carved and shaped easily before completely hardening.

Coloring agents in the materials used to cement or build up broken or missing parts of bones are perhaps a matter of personal choice. Some purists prefer all added repair material to be a contrasting color, commonly white, especially on those remains prepared for scientific study or museums. The man-made additions are sharply defined relative to the natural bone. Others, for esthetic reasons, may prefer repairs be made to duplicate the original color of the specimens. It might be pointed out that obtaining the right color mix to match the original bone color for any of the previously listed cements requires some experimentation.

Consolidants are used as fillers to harden and strengthen soft, crumbly parts, to fill pore spaces, and to provide an overall nonporous preservative coating to add strength and prevent moisture and chemical deterioration. Most should be quick drying, and a non-glossy appearance is desirable. Clear lacquer thinned with acetone or lacquer thinner can be brushed or sprayed on. Clear acrylic plastic spray may be used on small, less demanding jobs. The best consolidant agents are the soluble resins and polyvinyl compounds, except for

Figure 4. Badly weathered *Stagosaurus* neck plate requiring extensive treatment with consolidant/preservative.

the water miscible variety of polyvinyl acetate which may not be desirable for long-term strength and preservation attributes. Those preservation agents are preferred that are soluble in quick drying solvents such as acetone, lacquer thinner, and methyl ethyl ketone. Vapors from all of these highly evaporative chemicals are harmful to some degree, and their application should be done only with adequate ventilation and protection.

Preparation and restoration of fossil remains requires involvement in several disciplines, including anatomy and osteology. Possibly the most demanding of preparatory skills is the repair and restoration of vertebrate skulls. Seldom is a complete undamaged skull recovered, even those of large dinosaurs. The skulls of large sauropods are inordinately small in comparison with their body size. Exceptions are the large saurischian carnivores and the ceratopsians. Skull bones are comparatively thin and fragile; most are found crushed, distorted in some fashion, or broken up into many pieces intermixed with matrix. If containment of the remains in the plaster jacket is satisfactory, restoration consists of methodical separation of broken parts from the matrix, cleaning and cementing one piece at a time while removing the plaster surround in stages, starting at the top. The generous application of strengthening consolidants is required. Modeling clay or plumbers putty can be used to hold small parts in place for cementing.

Sometimes a vertebrate skull is fossilized under a fortunate combination of circumstances where mud or sandstone has filled the skull cavity completely, holding the bones in place while the matrix has hardened into an internal cast. The bones are held in practically their original position. Matrix is removed only from the outer surfaces of the bones, leaving them in place. Eye sockets, nasal openings and other foramina should be cleaned back to a depth well defining those features while leaving them plugged. Matrix should be removed from around the teeth, leaving them well exposed with serrations visible. Final preparation on skulls should be done with the smallest of powered precision rotary or vibratory tools, and finished with hand picks and dental tools. Airbrasive machines may be applicable in certain areas where cleaning out nerve and blood vessel openings is required. The final product of this type of skull preparation makes a good display specimen, but in order to study the dentition and internal morphology of the jaws and skull cavity, the matrix plug will have to be removed from the inside. This type of restored skull also can serve as a model from which excellent molds can be constructed for casting exact replicas.

An aspect of fossil preparation that should not be overlooked is the examination of the specimens for pathological conditions. items to look for are healed bone fractures, arthritic growths on joints and vertebrae, fused vertebrae other than sacral, and teeth scarring on bones.

Mounting of articulated vertebrate skeletons or partial skeletons can be accomplished by one of the following methods or a combination of them. (a) Cementing all of the parts together in natural articulated position and placing vertical weight-bearing supports at strategic positions; (b) cementing all the parts in position and adding externally attached metal stiffeners and supports (the iron work on some of the early day dinosaurs would have done credit to any foundry); or (c) drilling holes through the individual bones and utilizing internal welded metal supports and rods as a core or framework to support the skeleton. The latter method of concealment of the support system while esthetically desirable, unavoidably causes some damage and waste to the bones. In recent times this method has been used extensively in mounting the light weight fiberglass and resin replicas of the giant dinosaurs, especially in view of the now popular belief in some circles that dinosaurs walked, ran, or ambled around all of the time with their tails standing straight out behind them, and even curled up somewhat. It is difficult to envision *Apatosaurus* with 80 or more tail vertebrae, walking or standing for any length of time with its tail extended horizontally.

The distal terminal vertebrae of sauropods

like *Apatosaurus* have 5 to 6-inch long, thin, finger-like centra with convex knobs on the ends. There are no stiffening rods or other similar processes present on the centra, no neural arches or spines for muscle and ligament attachment. Starting with the third vertebra up from the tip-end member, axially aligned, vestigial bumps situated approximately midway on the centra become slightly higher and longer and more rugose on each succeeding centrum as they progress proximally. These rudimentary apophyses, together with the highly rugose areas on the necks just back of the peripheries of the dumbbell-shaped ends apparently functioned as muscle and ligament attachment points. With the last 18 to 20 tail vertebrae lacking the muscular articulation provided by vertebrae with neural spines, most likely the last 6 to 8 feet of the sauropod's tail was a relatively limp whiplash termination that was just carried along with manipulation of the main part of the tail.

When reconstructing and mounting a fossil skeleton, a photo or drawing, or an already existing mount of the same genus is a helpful, if not an indispensable model to work with. If no previous model is available, then the osteological and anatomical characteristics of a similar form could be referred to as a basis for reconstruction. In any case the mount should be articulated in a natural pose. Before starting, a fairly accurate estimation of the overall size and attitude of the finished specimen should be made. Smaller specimens can be reassembled on a work table. Large fossils usually require a strong wooden or metal framework or scaffolding to be constructed higher than the finished mount which will be assembled under it. The scaffolding will allow working at various heights around the mount as well as suspension of strong cords or wires which are tied to separate parts of the skeleton as mounting progresses. Hoists for very heavy parts may have to be used. The suspension system allows the individual parts to be manipulated for proper articulated positioning when being joined.

Starting with the pelvic girdle, the primary weight bearing part of the mount, as a pivot point, the post-cranial skeleton is assembled working both ways from the pelvis. Whatever type of support system is selected for the mount, it has to be installed as the reconstruction progresses. The pelvis is assembled starting with the illia and attached sacral vertebrae, then the ischia and pubes are joined to form the socket (acetabulum) for insertion of the femurs. Working in the proximal direction, dorsal vertebrae are joined until the posterior cervical is reached at least. Joining the caudal vertebrae in the opposite direction should be continued until an appreciable part of the tail is assembled. All of this sets up the preliminary axial alignment and contours of the skeleton. After mounting of the femurs for articulation with the acetabulum, the epipodials are installed, tibia and fibula, tarsus and pes, in that order.

Assembly of the shoulder girdle and forelimbs is somewhat more complicated. Since the scapula is attached in life on the front of the rib cage, and not by bone articulation, the anterior dorsal ribs will have to be mounted on the anterior dorsal vertebrae first. The scapula is then positioned and fastened to the rib cage. The coracoid is assembled to the scapula. The clavicles, if present, require being assembled after both forelimbs have been installed. The above procedures require a sophisticated support system since it will have to withstand a considerable weight without putting a strain on the fragile ribs when the forelimbs are attached. The humerus, radius and ulna, carpus and manus are mounted in the order named.

Possibly by this time the height, contours, and pose of the final body mount will have been established without the necessity of rework. There remains the cervical vertebrae, atlas-axis, skull, and various smaller skeletal parts--ribs, chevrons, and gastralia if present. After the cervical vertebrae and atlas-axis, the skull should be assembled last. Again a very strong support is mandatory for suspension of the neck and attached skull. When assembly of the mount is completed, touchup and any necessary repair is done and a final non-glossy coat of preservative is applied.

Figure 5. Prepared, incomplete vertebrate skull. *Merycoidodon culbertsoni*, a mammal ruminant. Oligocene Epoch, Brule Formation, South Dakota.

The many options available to collectors for storing and cataloguing their fossil collections may resolve into a matter of personal choice. Whatever system of classification and record keeping is selected, to be of scientific value it must reference all pertinent information of each fossil. A system based on phylogenetic categorization using a card file indexed by order could be chosen. A typed or hand written file card containing the name, order, family and subfamily, genus and species of each specimen, along with designation of the period, formation, member, exact geographic location, name of collector, and date would be required. The card should be cross-referenced to the individual specimen label, and also to the main catalogue by a code or catalogue number.

Because of the many thousands of specimens under their control required to be catalogued and stored, universities and museums usually paint a small white area on each specimen and affix their own identifying catalogue number in black ink. This may be accompanied by a regular specimen label. Some individual collectors might prefer to use this numbering system, but others, for reasons of appearance may not choose to have anything written or painted on their fossils. Anyway, a fossil should have an individual specimen label attached or nearby, whether stored or on display.

Maintaining a ready access specimen catalogue containing more detailed data than that of the index cards and specimen labeds is desirable. Specific information of the collection site obtained from field notes, such as the geology, lithology, stratigraphic and facies relationships, and geographic location would be included. Also information as to how and by whom the specimen was obtained, whether by actual field collection, trade or purchase. A catalogue system can be set up by establishing some kind of a code consisting

of abbreviated symbols for the collection source and date of acquisition, coupled with a sequential numerical designation for each specimen. The numerical sequence can be arbitrarily started at any number, one or one hundred, assigning the first number to the oldest fossil (in order of acquisition), providing historical records have been kept. The numbering sequence should be kept up with the addition of each new specimen to the collection.

A final word concerning the little-publicized but worthwhile contributions many amateurs have made to the field of paleontology. Motivated by an unflagging interest in things extinct, they usually have the time and opportunity to hunt and collect extensively, especially in their own areas of interest, as compared to the more structured and less frequent collecting activities fielded by professional organizations. The valuable contributions of amateurs should be taken into consideration by those organizations, government and otherwise, which are presently engaged in the process of defining regulations governing fossil collecting.

There are many others too numerous to mention, but two of the major dinosaur fossil sites of interest today were initially discovered by amateurs. The well-known Jim Jensen dig at Dry Mesa in Colorado, cited elsewhere in this article, produced specimens of the two largest brachiosaurids known, "Supersaurus" and "Ultrasaurus," as well as the largest theropod from the Jurassic, *Torvosaurus*, due to the intitial collecting activities of an amateur collector from Delta, Colorado. John Horner's famous hadrosaur from the Upper Cretaceous Two Medicine Formation was discovered by local collectors. The hadrosaur skull along with the extraordinary hadrosaurine and hypsilophodont nesting sites were found on the Peebles ranch near Bynum, Montana.

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NOTE: *I want to emphasize that this is not meant to be the last word on collection and preparation. Due to the scope of the subject it can only be a general outline. It is one man's experience with methods and materials that have proven effective for the job. I am well aware that there are alternative techniques and materials that also work effectively. Possibly there are some readers who will disagree with my methods in some areas covered.*

Tony

ADVERTISING SECTION

SEDIMENTARY NOTES

***Tom Walsh**, Coal Valley, IL, worked at a New Mexico fossil site for a week this summer. He writes:*

I went out (West) to work on a site in New Mexico with a graduate student from Indiana University. I got the idea from Gary Lane's "Presidential Address" which you published in the last summer issue, (Vol. 12, Number 6, 1989). I talked to Gary about it at EXPO, and he had the graduate student (Mark Schult) contact me... I told him I would come out and help for a week. I let him know which week I would be there and I did it.

I really enjoyed it. I took notes on what we did each day and may try to write something for the *Digest* about it...

The site was near Las Cruces, NM, and is tracks of reptiles, amphibians and invertebrates which walked along the shoreline of this sea or body of water and left their tracks in the mud... I took pictures of the site (SLIDES) and of the person (Jerry MacDonald) who has found about 12 places in the mountains near Las Cruces where there are tracks... (Jerry) has worked for three years on the one site excavating and carrying out trackways. He has given some to the Smithsonian Institute, the Carnegie Museum of Natural History, and other museums.

It was fun! I had a great time and Jerry let me keep some of the tracks I found and gave me some examples before I left. I was never too excited about trace fossils, but they can be exciting and tell you a whole story that the fossil body does not tell.

Please ADD the Following NEW OR REJOINING MEMBERS to Your Directory:

Ed Armentrout
Village Rock Shop
346 S. Chicago
Hot Springs, SD 57747
605-745-5446

Dealer. No trades. Retail only. OLIGOCENE vertebrate skulls, bones, teeth. Mostly unprepared oreodonts, rhinos, turtles. Occasional pig, camel, dog, etc. Local CRETACEOUS ammonites/scaphites. Indeterminate N.D. fossil leaves. Interest in buying vertebrate material, sharks' teeth, trilobites, etc. May - Sept. & by appointment.

Michael Curto
55 Rt 35 #34
Neptune, NJ 07753
201-988-5815

Water Polution Control. Will trade. Major interest fossil shark teeth, whale bones, ice age mammal fossils, also dinosaur bones. Has for trade fossil whale bones, shark teeth, fern fossils. Member DVPS. Wants to enlarge his collection.

James P. Durkin
80 Toby Drive
Succasunna, NJ 07876

Steven H. Gittelman, Ph.D.
60 Brookhill Lane
Huntington, NY 11743
516-368-8476

Steven R. Green
4425 Lela Ave., Apt. 6
Roanoke, VA 24019

Bill Heim
7309B Gammon St.
Ft. Meade, MD 20755
309-672-2864

Air Force. Collecting since 1986. Will trade. Major interest marine vertebrates (particularly sharks). Has for trade East Coast shark teeth, can obtain shells if need be for trade. Wants to trade.

John M. Kelley
P.O. Box 23705
Milwaukee, WI 53223

Deborah Koss-Warner
S.E.2441 Binns Swiger Loop
Shelton, WA 98584

FC1 Phillip A. Mucha
USS Chandler DDG-996, CF Div.
FPO San Francisco, CA 96662

E-6/US Navy. Will trade. Major interest fish fossils--worldwide ichthyological taxonomy. Has for trade diverse collections. Goes on cross county fossil hunts & wants to expand his knowledge of the occurences in other states.

Mr. William Speer, Jr.
American Bank of Commerce
P.O. Box 6888
Boise, ID 83707

Didier Lelubre
42, Rue de la Bourse
7060 Bracquegnies
BELGIUM

Laboratory's technician. Will trade. Major interest complete trilobites (crinoids and shark teeth). Has for trade Calcedonious Cretaceous molluscs, spirifers, Carboniferous trilobites from Belgium and Germany... Wants to correspond with members of the Society who collect trilobites.

Please Note the Following CHANGES OF ADDRESS and CORRECTIONS.

Gary D. Chilson
8406 SW 26th Pl.
Davie, FL 33328-1220

David DeBell
1117 Buddy Holly Place
Clear Lake, IA 50428

John Fagan
c/o All Hallows Institute
111 E. 164th St.
Bronx, NY 10452
212-293-4545

Dr. Merrill W. Foster
Department of Geol. Sciences
Bradley University
Peoria, IL 61625

Professor of Geology specializing in Paleontology and Marine Biology Chairman. Collecting since 1950. Will trade. Interested in all fossils particularly those that have educational value and/or are spectacular.

Charles B. Moldenhauer
4013 N. Brookdale Pl., A8
Peoria, IL 61614

Brad & Linda Ross
913 S. Clarion
Gillette, WY 82716

Mike Triebold
535 Central Avenue North
Valley City, ND 58072

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SEDIMENTARY NOTES

***Leland Miyano,** Honolulu, HI, writes about Hawaii's active volcano, Kilauea:*

Kilauea has largely destroyed Kalapana Town. Over one hundred homes are gone. Some are 50' beneath the lava.

Nature is awesome. Hawaii has so few fossils but no shortage of lava. I saw leaf impressions in lava once (on exhibit) but have never found any myself. I buy all my fossils out of necessity and I envy all those collectors who can drive out and dig their own.

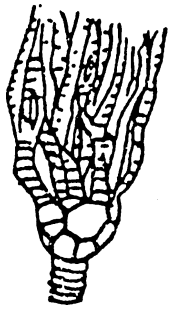
The Mid-America Paleontology Society (MAPS) was formed to promote popular interest in the subject of paleontology; to encourage the proper collecting, study, preparation, and display of fossil material; and to assist other individuals, groups, and institutions interested in the various aspects of paleontology. It is a non-profit society incorporated under the laws of the State of Iowa.

Membership in MAPS is open to anyone, anywhere who is sincerely interested in fossils and the aims of the Society.

Membership fee: One year from month of payment is $10.00 per household. Institution or Library fee is $25.00. Overseas fee is $10.00 with Surface Mailing of DIGESTS OR $25.00 with Air Mailing of DIGESTS.

MAPS meetings are held on the 1st Saturday of each month (2nd Saturday if inclement weather). October & May meetings are scheduled field trips. The June meeting is in conjunction with the Bloomington, IN, Gem, Mineral, Fossil Show & Swap. A picnic is held the fourth weekend in July. November through April meetings are scheduled for 2 p.m. in the Science Building, Augustana College, Rock Island, Illinois. One annual International Fossil Exposition is held in the Spring.

MAPS official publication, MAPS DIGEST, is published 9 months of the year--October through June.



CYATHOCRINITES

FIRST CLASS MAIL

MID-AMERICA PALEONTOLOGY SOCIETY

Mrs. Sharon Sonnleitner
MAPS DIGEST Editor
4800 Sunset Dr. SW
Cedar Rapids, IA 52404

Dated Material - Meeting Notice