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1:50 p.m.

A LOVE OF FOSSILS BRING US TOGETHER

MAGIC STONES

Jan Terry, Artist
Blue Window Studio
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Cedar Crest, NM 87008

Set there in curve of red flat stone, shining in the firelight are a belemnite and a clam.

When the hearth was laid out I put those pieces there.

I have carried, treasured, and remembered—

Sunny days in the summer of 1964 when my two oldest sons—ages 10 and 12—interrupted my busy day. I was in the headlong pursuit of the almighty dollar. These children were in the pursuit of each other in play.

"Boys, what is it?"

"Look, Mom, what we found!"

They were dusted with gravel. I had seen them out there in the eight-acre parking lot—running up and playing "King of the Mountain" on truckloads of gravel that had been dumped to surface a field that we hoped would accommodate tourist parking.

Now the third son shyly holds out his sunburned hand. The perfect imprint of a fern leaf caught forever in a stone lay in the hollow of that small hand.

"Timmy, where did you find that?"

"Out there." He waves to the open door. "That's what we were trying to tell you, Mom."

COVER STORY:
ISOTELUS PREPARATION IN PROCESS

The clock times recorded under each photo represent the actual time it took MAPS member Dan Cooper to complete each stage of restoring the trilobite. One hopes he took a few breaks during the process:

Back Cover

Top photo shows the trilobite before any preparation.
Center photo was taken after the major center of the head had been added along with the left side and front of the tail. This took about 1 ½ hours.
Bottom photo shows that the remaining parts of the tail have been added—about 20 minutes work.

Front Cover

Lower photo taken after the main piece of matrix with the left side of the specimen has been added using Super glue (1 hour) and the majority of matrix removed from the left side (2 hours).
Large photo shows the completed (another ½ hour) *Isotelus maximus* about life size (5 inches).

This *Isotelus maximus* is from Mount Orab, Ohio, and according to Dan, the specimen was found upside down, as are most of the Isotelus. It was found in the same layer as the smaller Flexicalymene trilobites have been found. Since 1982, Dan has found over 1,500 Isotelus and 15,000 Flexicalymene from this layer. Since Isotelus have such a large surface, they almost always peel when collected. The pieces that come off have to be replaced in a manner similar to piecing together a jigsaw puzzle.

PALEOTECHNIQUES

Discover! Develop! Display!

M.A.P.S. DIGEST

EXPO XXVI EDITION

MID-AMERICA PALEONTOLOGY SOCIETY

A LOVE OF FOSSILS BRINGS US TOGETHER

Western Illinois University
Western Hall
Macomb, Illinois
March 26, 27, 28, 2004

ACKNOWLEDGMENT

Last March as we were observing the 25th MAPS EXPO, it seemed appropriate that after a quarter of a century we should find a way to celebrate the expertise of our members. And so the plan for Paleotechniques: Discover! Develop! Display, a MAPS EXPO Digest in which people could share their fossil-related practices, came about.

I am grateful that so many found the time to contribute to this issue. You may notice as you look through the Table of Contents that nearly all the authors are MAPS members. As I communicated with you authors through email and on the phone, I heard story after story of illness and even death. These family crises caused distress to you and delay, but yet, somehow, you came through with your articles. We are all richer because of your effort.

Each article is unique. There are several that touch on the art and science of fossil preparation, but you will find as you read them that each writer brings a different angle to the subject.

This is my first issue as editor, and I stand in awe of the work of the editors who have gone before me—Madelynne Lillybeck, Margaret Kahrs, Charles Oldham, and also, Sharon Sonnleitner, our long-time editor of the monthly MAPS Digest. I am particularly grateful to both Margaret and Sharon, with whom I was in constant consultation and without whom I never would have managed to produce the issue. I say, "stand in awe," because with this project I inaugurated my new standup desk. It was built for my height and allows me to work at the computer with my forearms fully supported. Because spending several hours standing at the desk also required that I have good support for my feet, I hit upon the idea of working in my fossil-collecting boots. Am I thus allowed to claim that editing text and inserting photos are paleotechniques?

Kathleen Morner

DEDICATION

Tom McNamara, our long-time printer from Davenport, IA, died of a heart attack shortly before he was to begin printing the MAPS 2004 EXPO Digest. We would like to dedicate this issue to his memory. He was an old-time craftsman, although only in his mid-fifties when he died, and we probably will not see his like again. He was also the kind of person who would call an editor at 10 o'clock at night to say that he had discovered a missing page, and then, yet that night, drive halfway to Cedar Rapids to meet her and pick up the page.

We will miss you, Tom.

The **Mid-American Paleontology Society** 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.

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MAPS DIGEST EXPO XXVI EDITION
PALEOTECHNIQUES: DISCOVER! DEVELOP! DISPLAY!

* MAPS Members

Experiences of a Fossil Collector

Margaret Kahrs
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In the forty years I have collected fossils, I have had some strange and wonderful experiences. The first fossil I ever found was a Dalmanites tail, and, of course, I didn't have the slightest idea what it was. All I knew was that if someone else wanted it, it must be something worth keeping, and a man in the group wanted it. I still have it in my collection.

Collecting at Tunnel Mill

The site where I found the Dalmanites tail is not far from where I live, and I have visited it quite often. The first complete trilobite I ever found was also from there.

If I do say so myself, I have a good memory (even yet). Whenever I found a fossil that was worth keeping, I remembered the exact spot where it came from, and when I went collecting there again, I always returned to look in that same spot. You would be surprised at what can be found by doing that.

I have had a number of interesting experiences at this, "my favorite," site. Once I found an Ampheristocrinus typus. I had never seen one. I was thrilled, to say the least, although I didn't have a clue as to what it was. When I got home and looked in my book on the Waldron shale (James Hall), I found it.

Two weeks later, I went back to the site and decided I might as well look in that same spot again and was really shocked to find another crinoid of the same species about a foot from where I found the first one.

There might be others who have found one of these, but I have never seen or heard of anyone finding one. There must have been at least one because the crinoid is listed by James Hall.

At this site the fossils are in the walls of a man-made tunnel, which was dug in 1821 to bring water from the river on the other side of the hill to run a grist mill. The site is known as Tunnel Mill. Because it is a tunnel, it is pretty gloomy in there. I often collect with a light attached to my shoulder. With my light, I can collect even after the sun goes down. One time Tom Walsh and his son came to collect with me, and they didn't arrive until evening. But that didn't stop us. We went right over there and collected with the artificial illumination.

I have had run-ins with a few up-to-date animals, such as snakes and bats, and both of these scare me. Then there are cave swallows, which have tried to light on my head. But nothing has deterred me from collecting there, except some teenagers playing hooky from school.

Once I found some people who had camped over night and were in the tunnel with their sleeping bags. You should have seen them scurrying around when I started digging. They probably wouldn't have stayed there if they had known what I know: There are copperheads among the fallen stones of the tunnel.

A beautiful sight to see is when there is a heavy rain or flash flood. The water comes through the tunnel with such force from the river on the other side that it shoots up in the air 25 to 50 feet. The best thing about that is a lot of fossils wash out. This happens maybe two or three times a year.

Many beautiful specimens have been destroyed by amateur collectors because they don't want to carry so much rock or shale home. So they pound the edges around the fossil to make it smaller and easier to carry. Then, when they get their fossil home, parts of it have been beaten away, and sometimes it is the most significant part, so they have nothing. It would have been better to leave the fossil than to destroy it. Leave it and come back with the proper tools to get it.

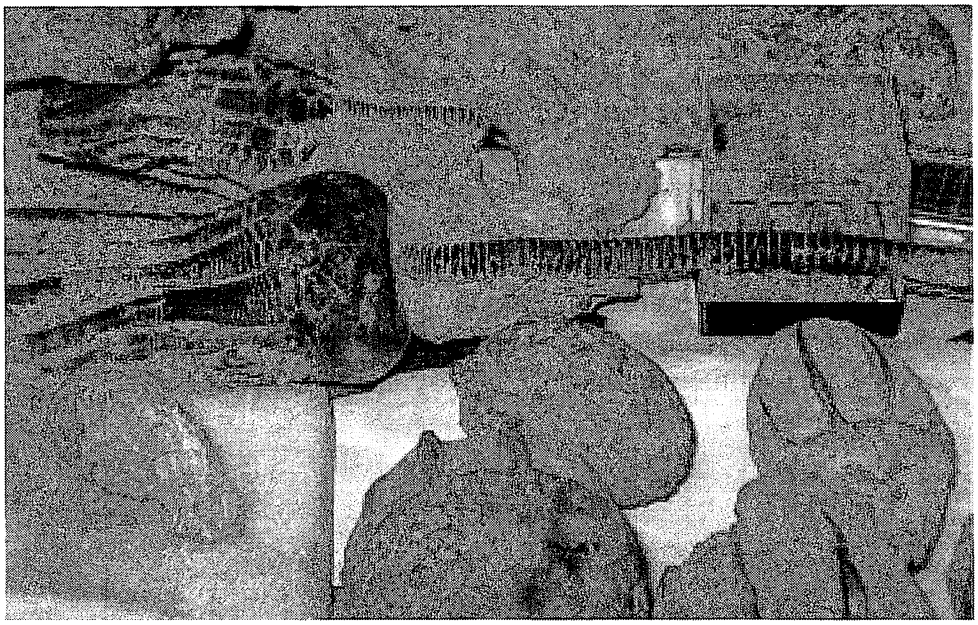
In all the collecting I have done, I have found many fossils that I didn't need in my collection because they were duplicates. I still brought them home, sometimes in large chunks of matrix. After deciding which ones I wanted to keep, I dumped the rest out in my "Rock-Fossil Garden." My friends collect there and find some really good keepers for their collections and to sell at their shows and swaps. Kids get a big kick out of collecting there. I've found that when the chunks are left for a few seasons in the rock garden, fossils weather out that I didn't see when I first brought them home.

The formation is in the Waldron shale—Silurian Age. The Waldron shale is soft shale and right next to that will be hard shale. Some of the hard shale must be dealt with right away because the longer it lies around the harder it gets.

Margaret Kahrs holding a Waldron crinoid

When checking the shale, also check for pyrite. If you find specimens that are pyritized, check to see if the pyrite is stable (pure cubed, square hard crystals) or mixed with marcasite, which is made up of small blades. You can tell by looking at it through a microscope or a 10 power loupe. If it has blades instead of cubes, it is marcasite. If you store it away and don't look at it for a while, when you do look at it, you will find a bluish ash and no fossil. It will have oxidized (eaten itself up). There is a remedy for this. First, don't store it away without testing it, and if you find it is unstable with a mix of marcasite, pay a visit to a beauty shop and see if they will sell you a bottle of permanent wave neutralizer. Brush it on your specimen or douse the specimen in the neutralizer. Check it now and then to see if you need to treat it again. If I knew chemistry, I could probably have used other words to describe what happens when your fossil oxidizes or is "eaten up," but I'm not a chemist. All I know is that the neutralizer does work.

Another way to destroy your fossil is by not testing the shale to find out if it dissolves quickly in water. Some shale goes to mud in a short time, and there goes your fossil with it. (I can just hear you saying, "Oh, I know about that.")



A selection of Waldron Formation crinoids collected by Margaret Kahrs

Collecting Geodized Fossils

If your club goes collecting geodized fossils in Indiana creeks, be sure to tell the newcomers how you go about collecting them. When you go up the creek, don't try to carry all the rocks you want to take. Instead, pile them up and remember to stop and get them on the way back to the car. If you don't let people know that this is what you're doing, you can lose your fossils. I had such an experience once. There was a young teenager who had come along for the first time, and he kept bragging about the nice geodes he had found, so I asked to see them, and he opened his bag to show us. Of course, I (with my memory) recognized them as the ones I had piled up. He said, "They were all just lying in a pile." I said, "Yes, I laid them there." I told him he could keep them, but if he did it again, he would be in trouble.

Identifying Fossils

For several years I have assumed the duties of fossil identification at the "Falls of the Ohio" Fossil Festival. The Falls of the Ohio Museum is located across the Ohio River from Louisville, Kentucky, at Clarksville, Indiana.

Each year during the festival, the Indiana Society of Paleontology exhibits fossils and identifies what people bring to show them what they have and also to find out what people have collected.

One experience I had I shall never forget. Some people brought a rock up to me and asked me to tell them what kind of egg it was.

They said, "See, this in the center is the yolk, and around that is the 'white.'"

I said, "Yes, but it is not an egg."

They got so mad, I was afraid I was going to get hit with the rock.

I said, "It is a concretion."

That made them madder than ever. They went on down the line to where Professor James Conkin and his wife Barbara were. They told them that the "woman over there that is supposed to be identifying fossils is crazy. She said this is not an egg, and anyone can see that it is."

Barbara looked at the rock and said, "Well, she is right. It's not an egg; it's a concretion."

For those of you who are not familiar with a concretion, it's a rock that weathers out of rocky soil and takes on a lot of different shapes and colors. Most of them are a "poor" grade of chert.

Barbara came down to my table afterward, and she was laughing so hard she could hardly tell me what happened about the "egg."

This happened in September. In October the Indiana State Museum held its Fossil Festival. I identify fossils there, also. And would you believe! The egg people were there. The curator of the museum came over to my table. He had gone through the same experience that I had. He finally told the people to call it whatever they wanted to, but that it was a concretion.

Margaret Kahrs with some of her many fossils

Map Use in Paleontology

Rick Poropat
Kirkwood, Missouri

It seemed like we had been walking for days.

"I know those ribs are around here somewhere," Joe said. "I remember them being on the side of the hill facing the east. There were four or five of them laid out in a row. Triceratops, I think."

We had been wandering around the Hell Creek formation in central Montana for several hours looking for the dino site Joe had found the summer before. All the formations looked the same in this hot, empty country. "I can walk right to them," Joe had boasted when we were planning the trip. Easier said than done.

Some things are best not left to memory. We never did find Joe's ribs and we covered a lot of territory during that long week. Too bad Joe hadn't drawn a map to his fossil site. Planning like that would have saved us a lot of work and heartache.

Maps have been used as tools for centuries. The earliest maps were created on cloth or paper-like material by explorers, the Church, and by the military. The military is still a big user of maps today; however, map production has changed a great deal over the past thirty years. When I first began drawing maps for the government back in the late 1970s, we created map overlays on mylar using colored pencils. The details were then transferred to a printable format by engraving them on negatives using fine instruments. These negatives were used to produce paper maps. In the 1980s, machines were developed to replace negative engraving and hand drawn mapping. Since then, mapping has evolved to such an extent that maps are produced almost exclusively by computer systems today. Paper maps have given way to digital databases, which can be queried for useful information. Mapping has become easier, faster and more accurate.

The U.S. government has traditionally been the largest producer and user of maps in the world, 'but times they are a changin.' In the last few years, the government has been getting out of the map-making business. Most standard format products are now contracted out and mapping has become a big, commercial enterprise. There are a large variety of map products available to the consumer, including both printed maps and digital map databases for use in GPS systems and home computers. They can be found in many stores as well as on line. There is even a map department at Wal-Mart. The basic components of map products haven't changed much, however, and remain a valuable tool for the paleontologist.

The value of a map is determined by its intended use; however, some map characteristics are more useful than others. The most important feature of a map is its scale because it is the scale that determines the size of the area of coverage and the amount of information to be included. Scale is usually shown as a ratio between a unit of measure on paper compared to the equivalent distance on the Earth's surface. For example, 1:25,000 scale means one inch on the map is equal to 25,000 inches on the ground. Most maps also have a bar scale to show a given distance in miles, kilometers, meters and feet: the unit of measure depending on the size of the covered area. Generally, the larger the map scale, the greater the area of coverage and the smaller the amount of detail.

Depending on the map scale, there are literally thousands of different types of features that can be portrayed on a map. The amount of this detail depends on the map scale. Highway maps are considered to be large scale because they cover a large area, usually an entire state or group of states. It is not practical to overload a map such as this with every town, road, or drainage feature that exists. Information on a large-scale map is generalized to include only the largest, most important features. It is useful for planning a trip to the general area of a collecting site but doesn't contain enough detailed information to determine the exact location of the site. Distance on a large-scale map is measured in terms of miles, kilometers and driving time.

An example of a small-scale map is the USGS quad. It covers a small area of interest, usually a few square miles, but is loaded with useful information. Think of a quad as the enlargement of a small portion of a highway map to which greater feature detail has been added. It contains small towns, individual buildings, roads, cart tracks, trails, railroad lines and small creeks. The quad also uses contour interval lines of elevation to portray hills, valleys, gullies, stream banks and other terrain details useful in identifying a fossil locality. Distance measurement on this type of map is in miles, kilometers, meters and feet. Driving time is measured in minutes instead of hours.

The USGS quad is useful for determining the more precise location of a fossil site, but it does not portray all of the useful information about the site. For the purpose of providing information, a map drawn by the user may be the most important resource to the fossil collector. A custom made map can be used to provide minute details that are not found on a conventional map; however, it must be indexed to a larger scale map in order to be effective. A custom map usually covers a small area, and the units of measurement are in meters and centimeters instead of miles. Site map detail is very intense, yet it is limited to only those features necessary to accurately describe the locality. A custom map is useful for conveying information to others or as a time saver on return trips to the site, but the real value is in the data it can provide to other collectors and to the scientific community. In the field of Stratigraphic Paleontology a custom map can be used to visually describe the local geology of a particular site by identifying and correlating fossiliferous strata. Important chronofauna locations—geographically restricted natural assemblages of interacting fauna that maintain their basic structures over time—can be identified and studied. In addition, important individual specimens can be keyed to specific locations to add scientific value to a collection.

Most maps available to the fossil collector are called Horizontal Surface Maps. They represent the Earth's surface in two dimensions: north-south and east-west; but there is a limit to their usefulness. It has been my experience that most fossils aren't found on the ground at one's feet. They are more often located at some elevation off the ground, usually just out of arm's reach. Information about the vertical position of fossils at a given locality is as important as the location of the collecting site itself. Most surface maps don't do a good job of portraying this data.

Mapping the vertical characteristics of a chronozone—to repeat, a time-stratigraphic unit or group of strata representing rocks formed during a minor interval of geologic time—can be quite a challenge; however, geology has created an important tool to make the job easier. This tool is the Chronostratigraphic Unit: a geologic time indicator that visually illustrates a given sequence of rocks in descending order of magnitude. It is actually a form of vertical map because it illustrates the vertical relationship between rock units at scale at a given site on Earth. The Geologic Time Scale is a commonly recognized general form of this tool. As with other types of maps, its feature content becomes more detailed as the area of interest decreases. In this case, the "features" are individual rock layers within a chronozone and the unit of measurement is in meters, centimeters and millimeters. For maximum scientific value, it should be used in correlation with a site surface map for it is important that the data be tied to a specific place on Earth.

To a fossil collector, the most important use of a map is to determine the location of a fossil locality. There are many types of maps available for this task but no single map will be adequate for the job. Several maps must be used in a logical sequence and everyone will develop a method for doing this. Using a well-known locality as an example, I will explain my own method to the madness.

Everyone has heard of the famous Eocene leaf and insect locality known as Bonanza, Utah. The locality is actually a region containing numerous collecting sites. Some are better producers than others and some contain different fauna. While the specimens collected from this region are attractive, there isn't much scientific value to them unless they can be correlated with a specific chronozone. There are three challenges to be met in our search for the best collecting area. First, we must plot a route and travel to the general vicinity of the collecting locality. Second, we must pinpoint specific sites within the locality. Finally, we must identify specific chronozones at each site, collect specimens and correlate them to specific layers within each zone, if possible.

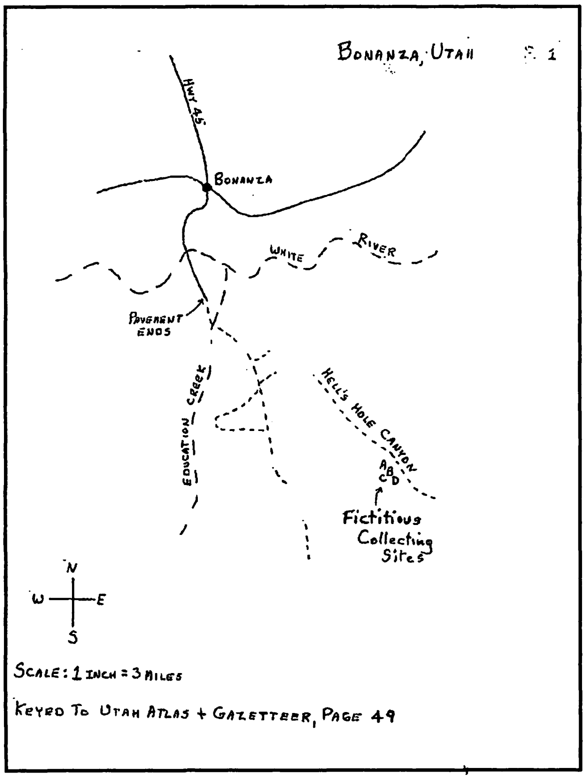
The best choice for planning our travel route to Utah is a large-scale highway map of the United States. It will contain the general information about highways and populated places we need to find the best route. It can also be used to determine driving time and convenient stopping points along the way. We will also use this source to find a convenient town close to the collecting area that can be our base of operations. Those who are familiar with Bonanza, Utah, know that there is nothing there except some mining buildings. There are no services available to the traveler, and there is no water. If you had never been to the "town," you would not know this and would have a major change of plans when you arrived. This is why it pays to do research for your trip in addition to planning the travel route.

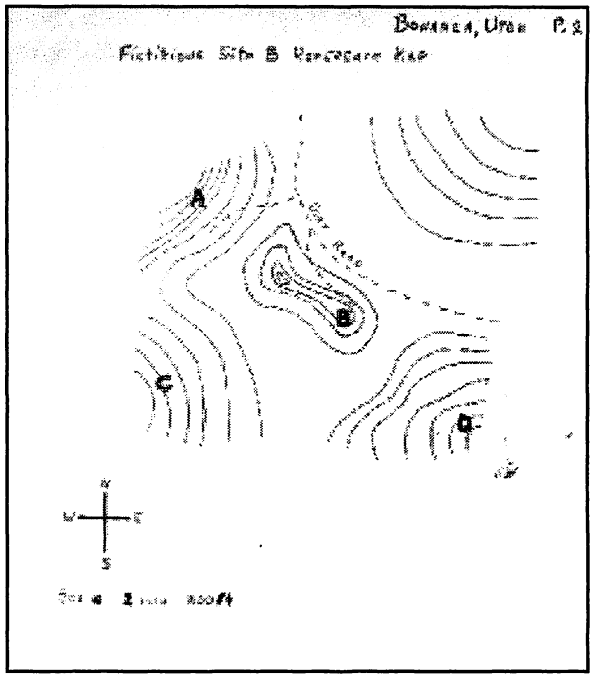
The closest major town to the Bonanza collecting area is Vernal, about 35 miles to the north. It has plenty of services, including campgrounds and motels and is the logical choice for a base of operations, unless you prefer to do primitive camping in the Bonanza area. The first challenge, then, is to plot a good route from our starting point in St. Louis, Missouri to Vernal, our base of operations. Having done this, we begin our trip and arrive in Vernal.

Our second challenge in our fossil quest is to determine the best route to the Bonanza collecting area. My choice of map for travel within the state of Utah is the Utah Atlas and Gazetteer published by DeLorme. This is a great source for road trips because it contains several useful types of maps and a huge amount of information about the state, all under the same cover. DeLorme has a publication for just about every state and I use them for all of my collecting trips.

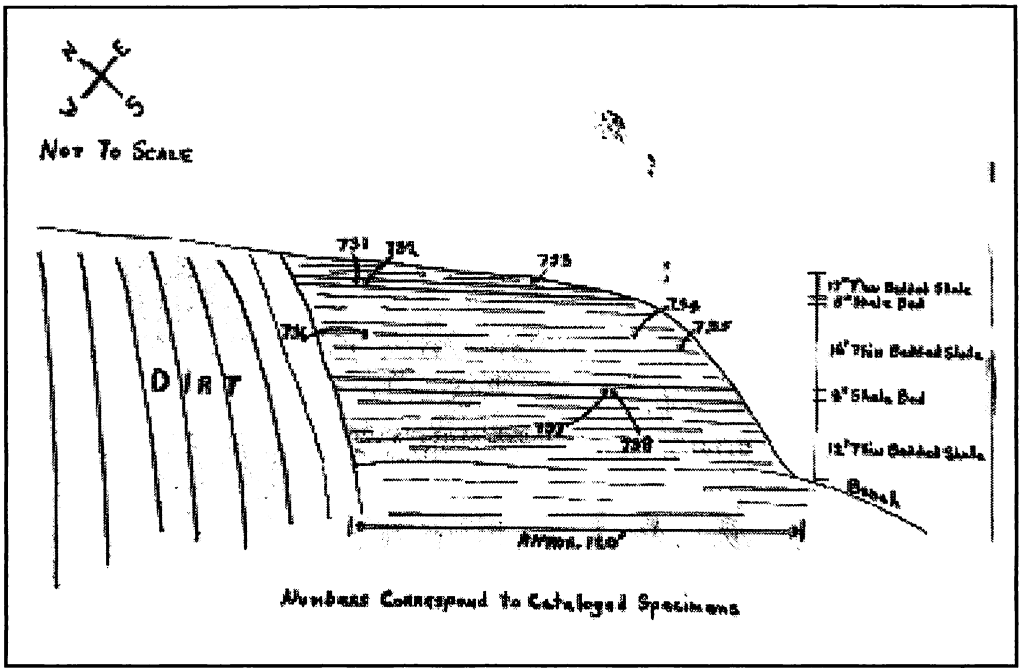
For determining the best route from Vernal to Bonanza we will use the state map on page one of the DeLorme book. It is a smaller scale map than our U.S. highway map, but it contains useful information about travel within the state. The map is overlain with a pattern of numbered boxes that refer to detailed, small-scale maps that compose the bulk of the publication. Each one of these maps covers two pages and is extremely detailed. We will use them in the next phase of our collecting trip.

Having traveled from Vernal to Bonanza, we arrive in the general region of the Bonanza locality. Our next task is to locate specific collecting sites within the locality. For this we will use the small-scale topographic maps referred to in the state map grid. On the state map we see that Bonanza lies within box number 49 so we must turn to topo map number 49 on pages 48-49. This map in 1:250,000 scale and one inch on the map is equal to about four miles on the ground. Distance is misleading, however, because the scale doesn't consider every change in grade or curve in the road. The map is called a topographic map because it contains both surface features and contour lines representing terrain. The combination of these map elements identifies small streams, dry washes, canyons, hills, dirt roads, trails and individual ranch sites. The map also has symbols to identify BLM, state and privately owned land within the area. These are the details we need to identify specific collecting sites within the locality.





If we had never visited the locality before, the next step in our search would be to travel all of the dirt roads in the local area, stopping to investigate every rock outcrop on state and BLM land. We will not have to do this, however, as I have been to the Bonanza locality before. On my first trip I had the advantage of traveling with someone who was familiar with the locale and knew the best sites. In preparation for a return trip, I wrote detailed directions to the outcrops we visited, crossreferencing each site on the topo map with a letter of the alphabet. I also created my own custom-made maps of the specific sites, using surface details to identify the more productive outcrops. Each custom mapcarried the same index letter. For each site, a vertical map was also created in order toidentify specific horizons or chronozones where specific specimens were found. Entries for these specimens in my collection catalog carry the same collecting site information. Thus, the final challenge of identifying specific productive collecting sites and zones within these sites has already been accomplished. They will prove invaluable on our return trip.



Everyone will, over time, develop their own system for using maps to plan, locate and describe collecting sites. I hope this article has given everyone an idea of where to start. Mapping fossil collecting sites presents what may seem like an enormous series of challenges to the fossil collector. The job can be made easier by becoming familiar with and developing a system for using the large number of mapping resources available. You can save a lot of time and trouble (remember Joe's ribs?) if you do appropriate research before a trip begins. Detail and organization will make the difference between a successful collecting trip and a total waste of time and your collection will have scientific value instead of being just a bunch of pretty rocks.

Finding It Again: The Use of the GPS Receiver

John V. Brown
Albuquerque, New Mexico

Although I have collected fossils, my major interest is photographing wildflowers and unique plants and presenting photography workshops. I don't know how many times I have walked into a wilderness area hoping to return to that special location the next year only to get there and not recognize the surroundings.

Nature makes changes and so does man. The vegetation that marked that special spot that was so prevalent the previous year has changed. A new cut in a road makes things look different. And with a few senior moments added on, disorientation becomes the name of the game.

To help solve this problem, I take out my handy GPS (Global Positioning System) receiver, and in a few seconds, I will know that I have returned to the same location, providing, of course, that I have written down the latitude and longitude from the previous visit in a small notebook.

Handheld GPS receivers are getting smaller as the technology improves, and certainly now a GPS should be an added accessory for anyone who hikes in the back country.

Most of the GPS receivers you can purchase today have more bells and whistles than you can imagine. Not only do they give you latitude and longitude—the most important reason to have a GPS—they also have programmed in maps; and some even have built-in walky-talkies or games to play when you are bored.

Frankly speaking, I use very few of the bells and whistles on my GPS. Basically, all I want to know is my latitude and longitude down to degrees and minutes and decimal points thereof. Of course, maps are also very handy to have on a GPS unit. They can save you from walking extra miles, plus they give you a sense of the topography and direction.

Let me explain a little about latitude and longitude in case it's been a long time since your seventh grade geography course.

Our planet is marked off with imaginary lines that form a crisscross grid pattern over the surface of the planet.

The imaginary lines that run east and west are called latitude lines, and the imaginary lines that run north and south converging at the north and south poles are called longitude lines. Thus, anywhere on this planet, an imaginary latitude and longitude line will cross each other. Where these two lines cross determines the latitude/longitude of that spot on earth. No other place on the planet will have the same latitude and longitude. This can be most helpful when you are trying to find that special location you discovered several years ago.

These latitude and longitude lines are marked off in degrees, minutes and decimal points of minutes. Keep in mind: these minutes have nothing to do with the minutes on a clock. If you don't like degrees and minutes, you can further divide the fractions of a minute into seconds. Keep in mind there are sixty minutes in one degree and sixty seconds in one minute. Just about any GPS unit will allow you to set your longitude/ latitude numbers to either minutes and decimal points thereof or to minutes and seconds.

Most maps are flat and we often think of the surface of the earth as being flat. We know the earth is not flat, but we usually only see such a small part of the earth, we assume that this small part is flat. However, if we are to understand latitude and longitude, we will have to think about these latitude and longitude lines on the surface of a sphere, the earth. One of the best ways to visualize these lines, as they go around the earth, is to purchase a small globe of the earth that has these lines well marked.

With a globe in hand, find London, England. The zero degree longitude line happens to be just outside of London, at a place called Greenwich.

Now, with your finger on the zero degree longitude line, head north from Greenwich toward the North Pole. This line runs through the North Pole and then south from the North Pole past the equator toward the South Pole. Once your finger has gone over the South Pole, it will again head north past the equator, on the opposite side of the earth and again finally ending up back at Greenwich, England. You will note this line divides the earth into two hemispheres, an east and west. In fact, any longitude line will cut the earth into two hemispheres.

Now let's examine the zero degree latitude line. The zero degree latitude line is at the equator and goes around the earth in an east west direction dividing the earth into a northern and southern hemisphere. Please note, it's only the zero degree latitude line, the equator, that cuts the earth into a two equal hemispheres, the northern and southern hemispheres. All the other latitude lines simply slice off parts of the earth. Unlike the longitude lines that cross each other at the poles, latitude lines remain parallel to each other no matter where they are on the surface of the planet.

Here are more interesting facts about these longitude and latitude lines. We have heard that parallel lines do not cross. At the equator all longitude lines are parallel; however, they do cross each other at the poles. So you can say that parallel lines on a sphere do cross.

The latitude lines are parallel to each other and yet they do not cross and of course these latitude lines, except for the zero degree latitude line at the equator, do not cut the earth into two equal hemispheres.

Keep this in mind: since the zero degree longitude line that starts at Greenwich divides the earth into two hemispheres, you can only go 180 degrees west or east of Greenwich. If you went 180 degrees east of Greenwich, you would end up on the opposite side of the earth from Greenwich. And if you went 180 degrees west of Greenwich, you would end up again on the opposite side of the planet from Greenwich. In fact, 180 degrees east or west from Greenwich, providing that you never changed your latitude, would put you actually at the same spot on the earth. Therefore, 180 degrees is the maximum for describing longitude. Thus longitude is written as east or west of Greenwich and by no more than 180 degrees.

On the other hand, latitude is represented by being either north or south of the equator and only by ninety degrees north or south.

Before we go any further let's remind ourselves how to read latitude and longitude numbers:

Here is an example:
31° 52.394' N, 109° 14.119' W

To read the above aloud, you would say, "Thirty one degrees fifty two point three nine four minutes North and one hundred nine degrees fourteen point one one nine minutes West.

Can you determine the location on the planet Earth for the above latitude/longitude numbers?

Now let's look at some actual latitude and longitude positions on earth.

I live in Albuquerque, New Mexico, and there are two Interstate Highways that cross each other in the city. They are Interstate-25 and Interstate-40. If I stand at the intersection of these two highways and look at my GPS it displays 35° 6.31' N.

This latitude reading tells me that I am north of the equator by slightly more than 35 degrees. Again, looking at my GPS unit, I would notice that I am 106° 37.82' W of Greenwich, England. This longitude reading tells me that I am a great distance west from Greenwich, England. Actually, I am more than one fourth of the way west around the planet from Greenwich.

Also, from the above latitude and longitude information, I know that Albuquerque, NM, is west of Greenwich and also south of Greenwich. These latitude/ longitude numbers also tell me that Albuquerque is north of the equator but not as far north as Greenwich, England. As you can see, you can get a lot of information from the latitude and longitude numbers.

Now let's expand out a bit and get away from Albuquerque, NM.

We'll try another GPS reading:
25° 45' N, 80° 9' W

Just by looking at the numbers we know this place on earth is south of Albuquerque and east of Albuquerque. In fact, if we were to fly to this latitude/longitude location, we would be in the city of Miami. Florida.

Here's another one: We are 0 degrees North latitude and 0 degrees West longitude. If we were actually at this location, we had better know how to swim. We would be in the Atlantic Ocean off the east coast of Africa. Actually, 0 degrees East longitude is the same as 0 degrees West longitude, and of course the same is true for the zero north and zero south latitudes. Zero degrees north or south latitude is actually on the equator.

Let's try another one:
25°, 0' S and 130°, 0' W

Just by looking at the numbers, we know we are south of the equator and certainly no where near Greenwich. In fact, by simply being West 130 degrees of Greenwich, we know that we must be nearly on the other side of the Earth from Greenwich. If we were to fly to this location, we would be in a very unpopulated part of Australia.

Here is the last one. We are 0 degrees North latitude and 180 degrees West longitude.

0°, 0', North and 180° 0' West

Where are we? The answer will show up later in this text.

In the above examples, I have shown latitude and longitude in degrees and minutes with decimal points thereafter. Some GPS units will allow you to change from degrees/ minutes to degrees/minutes/seconds. I strongly suggest that you read the manual that came with your GPS unit and practice using the unit.

Here is an exercise you can do with your GPS.

Purchase a map of your area that is marked with latitude/longitude lines. Find a location on the map that you can drive to. Then take out your ruler and pencil and try to determine on the map the latitude/longitude with a pencil and straight edge. Now try to find that location with your GPS by going there. This can be a lot of fun.

The care and feeding of your GPS:

GPS units do use up batteries. Always carry a spare set of batteries. For example, my GPS unit uses two AA size batteries, and so do my small radio and my flashlight. Having devices that use the same size batteries can be a convenience when traveling. Make sure your GPS unit is easy to read in all sorts of light. Make sure you write down, in a small notebook, your latitude/longitude for all the places you visit and wish to find again. Protect the GPS unit from excessive sunlight and heat, extreme cold, and rough abuse. Finally, make sure you turn off your GPS when it's not in use. Learn how to use your GPS and study the manual thoroughly. Such knowledge may save your life someday.

Now for that unanswered question from above. We are at (0°, 0' N and 180°, 0' West). Do we need to know how to swim? Should we have a boat? Are there nearby islands? And if we were to change our location to 0° 0' South; 180° 0' East) would this help?

The answer to the above paragraph is this. Yes, we should know how to swim and it would be much better to have a boat with a good motor. We would be in the south Pacific near a bunch of small islands, and if we did change the latitude and longitude to the last mentioned latitude/longitude location above, we would still be in the same place.

In other words, 180 degrees West of Greenwich is the same as 180 degrees East of Greenwich and 180 degrees east or west of Greenwich is on the opposite side of the planet from Greenwich.

As an afterthought, it strikes me that there is some other helpful information found on most GPS receivers. Your GPS should have a screen display that will tell you the times for sunrise and sunset at your particular latitude. This information can be most useful as it can help you to determine what time you should start to walk out of a remote location. Nothing can be more disorientating than to be caught at a remote location in the dark.

Most GPS units will also give you the correct time. This can be useful if you don't happen to have a watch. Just make sure you have set the GPS to your local time zone.

Also, most GPS receivers have a compass display on one of the screens. What is interesting about this compass display is that you must be moving to make the compass work correctly. If you stop, the compass only remembers your last heading.

Finally, your GPS can tell you how fast you are going at the moment and how far you have traveled. The best way to see this function is to have the GPS on while driving with the receiver placed on the dash by the windshield or have an outside antenna attached to the receiver. You want your GPS to have a clear view of the sky. The metal of the car can interfere with your GPS receiver. Just keep in mind, the GPS receiver will work best outdoors where there are no overhead obstructions such as roofs or dense foliage. I cannot repeat enough times, to best understand all the functions on the GPS, study the manual that came with your model of GPS. As they say, if all else fails, read the manual.

You might want to go to the Internet to learn more about latitude and longitude. There is a wealth of information there and more is being added each day.

And you may enjoy exploring the large number of maps made for computer use that can be found on CDs or on the Internet. Many of these maps are very detailed. I have a CD map of the American Southwest, and by simply moving my mouse over the map, I can see the latitude and longitude for any location on the map.

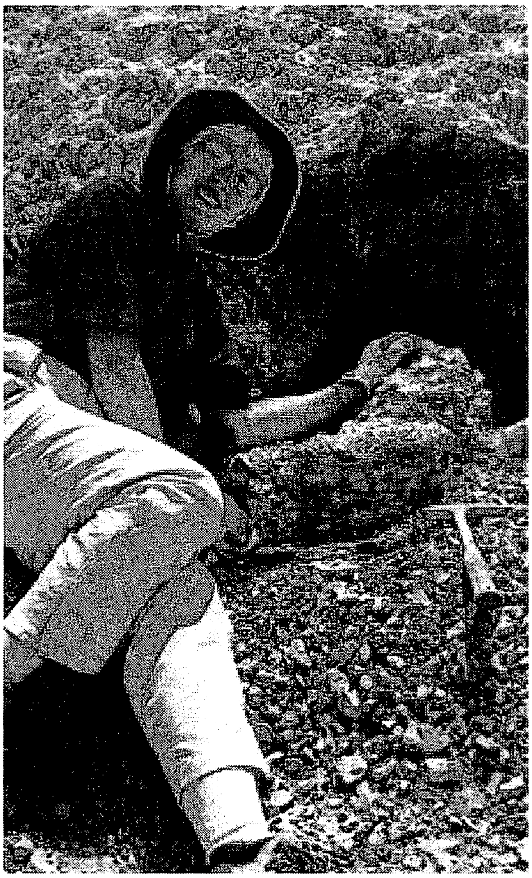
Just remember that even if you are lost, with a GPS receiver you know, at least, exactly where you are.

If you have questions about your GPS unit, you are welcome to write to me. You will find my email address at my website www.bioflora.net.

The Little Pig Dig

Nancy Mathura
Waterford, Michigan

Memorial Day, 2003, it was 72 F, partly sunny with 10 mph west winds in the White River badlands of Sioux County, Nebraska. Since 8 a.m. I had been walking looking for the unusual—something that didn't belong—examining every bone bit. By 4 p.m. my "lucky pants" hadn't helped me much and I was working my way back to the



van. Five hundred yards from it I saw a 6 inch smooth, flat circle with bone splinters in it about 4 feet up a butte. I probed horizontal to the circle with my hunting knife. On the second jab I pulled it out with a 1 inch square chocolate colored upper molar of a giant pig impaled on the tip. Oh Boy!

Archaeotherim are not common, and assuredly I had a skull.

Digging carefully, I found 2 more teeth in a row parallel to the butte. I butvared everything to hold it in place, then decided how far I dared go on each end in making a trench without damaging bone. Trenching around the front and both sides to make a pedestal for the skull was easy. The trench for the back border was in really solid matrix so it took twice as long, plus I was looking for postcranial bones. Two hours after the first tooth I was surprised to see 5 lower incisors grinning out at me from the back wall of the hole. The jaw was perpendicular to the skull. From the size of the teeth I knew it was a juvenile pig and probably already weaned. No mother would want those teeth near her nipples!

Time to eat—6 p.m.—so I butvared everything and left. Thankfully, no rain was predicted.

The next morning I knew I would have a lot of overburden to move before I could uncover the jaw, so I took a throw rug and heavy shirt to cover the exposed fossil and protect it from falling rock. Terry Sellari, MAPS member, wandered by and chivalrously offered to move the overburden for me. I declined and only 4 hours later I had everything butvared on a pedestal and covered with crumpled heavy duty foil to protect the fossil from plaster adhering. I used 5 inch wide plaster bandages, and when those dried I flipped the jacket. Nothing was showing so I butvared and then plastered the bottom. Two of the guys carried it to the van for me.

You experienced fossil hunters are probably getting a funny feeling about this and are mumbling, "Field prep? Field prep?"

The 38-pound box was sent back to Michigan by UPS Priority Mail. When it arrived, my son Ravi—MAPS member—couldn't wait to see the pig so he opened the skull end of the jacket from the underside and started removing matrix.

The thing about removing matrix is this: whatever works. Often, White River matrix can be picked away with the fingers. Dental picks, pin vises, scalpels or side cutters work, too, as do small chisels and hammers. A drop of water put on the matrix with a small brush, then quickly scraping the "mud" away with a dental pick sometimes works, but it can weaken the fossil. Acetone applied the same way won't weaken the fossil, but it is flammable and must be used in good ventilation. Look over each piece removed and save the sediment in a pail in case you toss a bit of bone or tooth away accidentally. Beautiful work can be done with hand tools; it just takes longer.

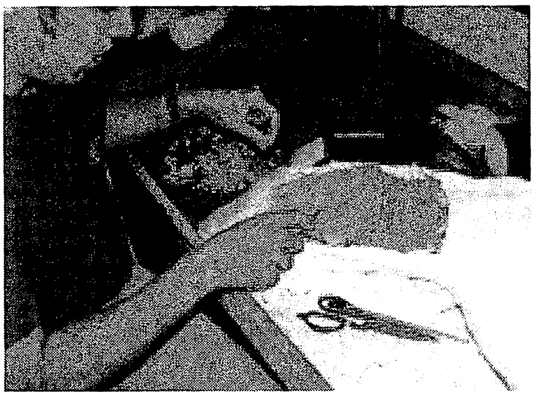
As for mechanical prep, the pneumatic tools from PaleoTools, owned by MAPS members—the Murrays—are trouble free. I can't praise them enough and the Murray's technical support, too. You do need an air compressor (noisy) and must work in a dust collecting cabinet, but they are my first choice. I don't use micro sand blasters for big fossils. They are more trouble than they are worth, always clogging. Often I use a $28.00 vibrating engraver from Sears. The Dremel I use to open jackets and grind off "oops" of reconstruction.

In removing matrix with mechanical tools, make valleys, then cross cut them and pieces will drop away. Let the tool dance across the surface. Don't push or pry. Use safety glasses, a mask and sometimes ear plugs when prepping with machines. The fossil sat there for how long? It will wait for you to put on protective gear.

Your work area should be uncluttered and well lighted. A white cloth over everything will catch loose pieces of fossil you weren't aware you lost. It also makes clean up after each session easier. Pick up the cloth and shake it out the back door. Work with the fossil on a sandbag, cushion or in your hand if it's a small fossil. This cuts down on vibration damage. A point will come when the fossil looks great in the matrix. Then the meltdown starts. Keep your fingers near the area you're cleaning so if something starts to break you will feel it and can glue it. This is only true if it's a fresh break with no matrix involved. Always look for and glue hairline fractures along the way. Parts start to fall off due to sediment in old cracks. This is a good thing even though it looks awful and your heart just sinks out at the sight.

If you think you'll forget how it goes together, take a soft lead pencil and draw a line across the crack. Clean the contacts on both pieces, line up pencil marks and glue. Paleobond makes glues of various viscosities to meet different needs. I used pB40 with disposable capillary tips to lace a tiny drop in hairlines. For larger pieces I used pB100. Paleobond also makes an accelerator spray which dries the glue in seconds. However, on the White River stuff it causes a green cast on the bone. I keep a small pot filled with cat litter to hold a freshly glued piece upright while it air dries.

Ravi was down to the original teeth and there was NO SKULL! If I had sent it to a preparator and she had informed me there was no skull, I would not have believe it. Remember the bone splinters that caused me to look in the first place?



It had mostly eroded away. At least, I had the mandible although I was somewhat worried even in the field since I thought it should be longer. Finding a fossil in solid matrix is no guarantee that the fossil is complete. Over the years, the matrix may have become more plastic, allowing the fossils to bobble around knocking off pieces and making breaks. It may have even come to the surface and been eroded in the past. Sure enough, both condyles and one ascending ramus were gone, and the angles of both sides were in pieces.

When the jaw was free of matrix on the bottom and turned over, several teeth were loose in their sockets, in pieces, cracked, missing pieces, or all of the above. They were my first priority. To prevent further damage, everything was glued with pB40 using a capillary tube. Some of the reassembled teeth had missing areas filled with Paleobond's Paleosculp. The teeth of the skull were also repaired and set aside, including the molar whose enamel shattered when removed from my knife. (Everything that happens in the field returns to haunt the preparator.)

Paleosculp I is a two-part epoxy with equal parts from both containers mixed in your palm until it is all one color: a greenish gray. I don't use gloves for this, but anyone allergic to epoxy would need to. This is then applied, small amounts at a time, with a metal tool like a dental pick or clay sculpting tool until the area is filled and looks right in all dimensions. To duplicate the smooth surface of tooth enamel, dip a finger in water and go over the epoxy. It will harden in 3 hours and cure in 24. Set it aside and go clean off your tools or you will be sanding the epoxy off them before their next use.

The remainder of the matrix was then removed from the jaw and suddenly it was in 3 large pieces. I cleaned each contact and began to work on the proximal ends, one at a time. Working with these 4 inch pieces was easier than gluing the jaw together and working with the whole thing. I marked the lateral aspect of the jaw and its corresponding lateral small pieces with a small bit of tape in addition to the pencil line on obvious contacts. Cleaning can then take place without worrying which side goes to the outside. It will keep your fossil from looking like something out of Stephen King's Pet Cemetery if it should come back to life.

After all pieces were glued, it was time for reconstruction. I was fortunate to have a pig jaw of Ravi's to consult. I took a piece of plastic wrap and a magic marker, laid it on the area missing from my pig jaw and traced the shape. Using that as a template, I rolled out a flat piece of Paleosculp, cut it to size and fit it onto the jaw, where it stuck, and shaped it into lifelike curves. To give it bone-like texture I used a dry 1 inch square cellulose sponge, dabbing it over the fresh surface. Two-sided dish sponges and the bristles on a toothbrush work well, too. Experiment! You will be surprised and pleased at how natural it looks. The condyles were formed free hand and everything was set aside to dry. The next day, the condyles were joined to the jaw with small bits of Paleosculp.

Painting is done with acrylic water soluble paint. For the teeth I used raw umber with a dot of black mixed together with a brush in a white dish and painted only on the Paleosculp with a No. 5/0 brush. Reconstruction on the jaw was painted with raw umber, gray, black, unbleached titanium, and soft white beige mixing "a little of this, a little of that" with a slightly larger flat brush. This gives a more realistic look because no fossil is the same color overall. Don't be afraid to mix colors or add a little water if the paint seems too thick. You don't want to obliterate the texturing. Clean your brushes with soap and water after every use. Keep notes on the colors and mixes you use so you don't reinvent the wheel each time you paint.

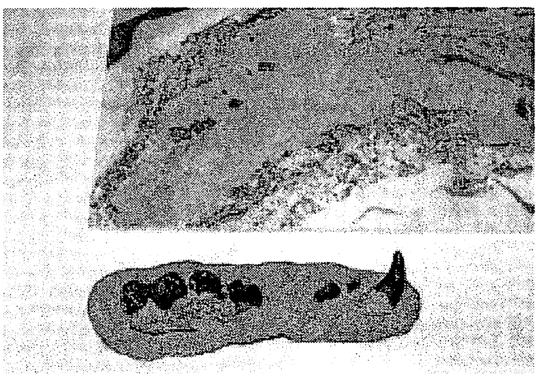
The most important thing to remember about painting is DO IT IN NATURAL LIGIHT. If you paint using a light bulb as your light source when you see your fossil in daylight you'll wonder what you were thinking! Paint only the Paleosculp. Don't cover the entire fossil or it will look like you bought it at the Dollar Store.

What to do about the few teeth from the skull? I wanted a matrix-like look and to show them arrayed as in life without reconstructing bone. There were two problems here: One, the matrix and two, the placement of the teeth. I had found 4 more teeth, including a badly broken canine and a smaller canine, 1 premolar and 1 first molar. Fortunately, I have a copy of the plates from Scott, Jepsen and Wood 1936-1941 *The Mammalian Fauna of the White River Oligocene*, which has on Plate xxxviii: Archaeotherim skull "plate of young animal with milk teeth." Perfect! I now knew I had an erupting canine and how to space the teeth, but into what?

The Black Hills Institute and my Florida friends use Durham's Rock Hard Water Putty, a powder you mix with water. I couldn't get it to a consistency I could control, hated the color—too yellow, and the weight didn't feel right. I never got as far as setting the teeth in. I just pitched it. At the art supply store, I told the salesperson about my dilemma. She showed me 4 different kinds of self-hardening clays. I picked Marblex because it is gray, very like the matrix. With a wire I cut a chunk out of the 5 pound brick and molded it into an elongated shape slightly longer and wider than the fossil teeth placement. Then I pressed in the teeth and some fossil hackberry seeds from the matrix and set it aside to dry. Apparently you can't hurry clay. When I asked how long it takes to dry, the salesperson said, "If it's clay, give it a day" (past the point where it feels cool to the touch). Four days later it felt right, but one of the molars was loose. Maybe I didn't press it in deep enough or the clay shrank. Anyway I glued it down and it is fine. As an afterthought I wish I had inserted 1 or 2 wires the length of the clay, but it seems stable without it.

The next step is pure genius. It's a tip from my friend, Barbara Farrell, a member of Tampa Bay Fossil Club. She makes a "soup" out of matrix and water, adds Elmer's glue, beats it with a mixer and brushes it to a depth of 1/4 inch over the dry clay around the fossils. When this dries it crackles, and the fossils look like they are in original matrix. I made the "soup" without the glue and brushed it thinly over the clay. When it was dry and crazed, I masked off the fossils with individual plastic wraps and sprayed it with matte acrylic to keep it from flaking.

A geologist from Cranbrook Institute of Science who has hunted the badlands said, "That was a good idea leaving it in the matrix." He thought it was real! Of course the clay could have been just textured and painted.



When everything is finished, I like to coat the fossil with PVA to seal it. If it had been a friable fossil, I would have used it on all contacts to penetrate into the bone, strengthening it, and on all surfaces as they emerge from the matrix. One teaspoon of PVA beads dissolved into 4 ounces of acetone gives the watery solution needed. This can be brushed on or applied with a dropper. PVA can be used in the field since it sinks not only into the fossil but also into the matrix, hardening and supporting the specimen.

Matrix removal must be done with mechanical means or the "brush on acetone—scrape off mud" trick. On this dig I was using Butvar. This sits on the surface and has the disadvantage of having to be peeled off like sunburned skin. Bone fragments may be displaced in the process. Butvar is prepared like PVA and therefore is acetone soluble. Paleobond makes a penetrant/stabilizer, but it is essentially a glue and can't be easily removed.

The prep time on this fossil was about 12 hours—the same time it takes to read this far. I was pleased with how well the fossil turned out. Every fossil presents different problems. What you decide to do for your fossil depends on whatever you are comfortable with and whatever works for you. To broaden your options, get a 3-ring binder and start your own reference list of articles and communications. Take pictures as the development of your fossil progresses. Be alert for useful material at hardware and art stores, flea markets and garage sales. It beats paying someone else to have all this fun.

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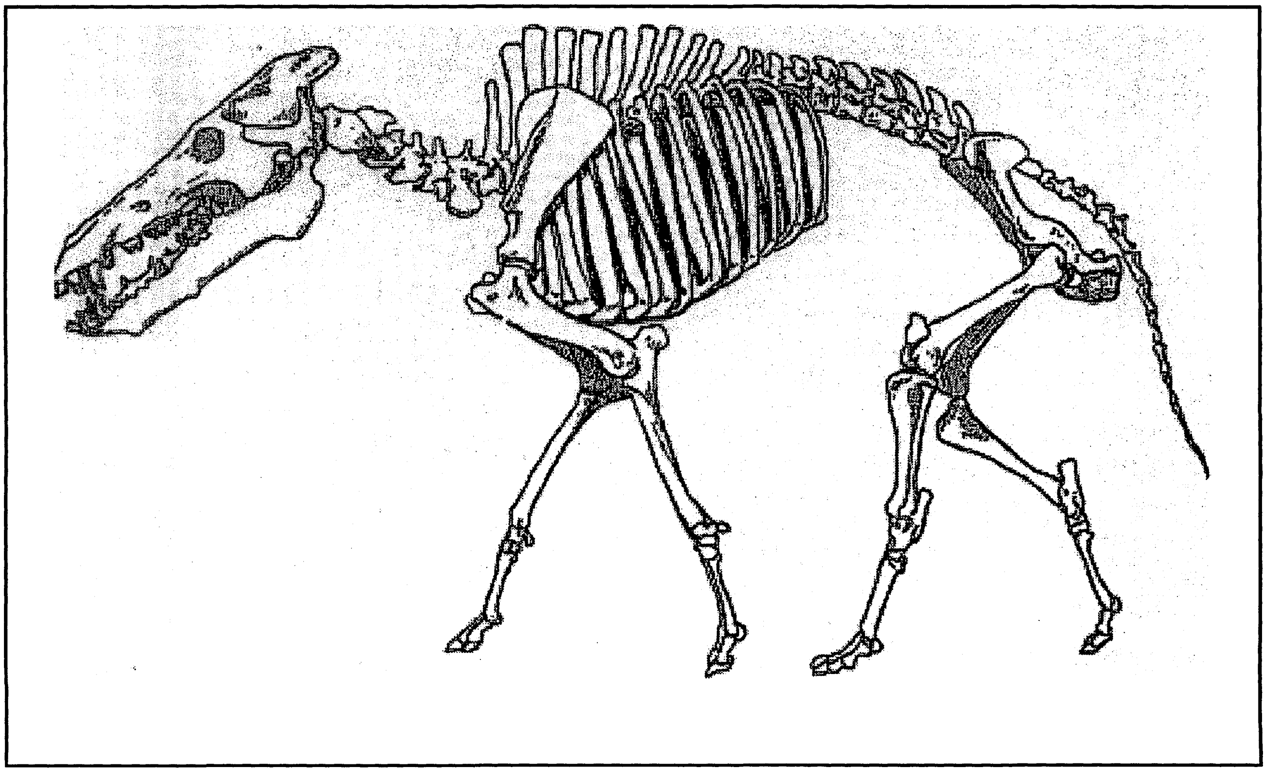
3. O'Harra, Cleophas C. The White River Badlands. South Dakota School of Mines, Bulletin No. 13, Department of Geology, Rapid City, S.D., Nov. 1920.
4. Scott, W.B., Jepsen, G.L. and Wood, A.E. Philadelphia: Transactions of the American Philosophical Society. N.S. 28 (1-5), 1036-1941.

Sources of Materials and Tools

1. Butvar (Polyvinyl/Butyral, B-76)—Florida Museum of Natural History, see No.1 above.
2. Cyanoacrilate glues and epoxy—Paleobond 1-800-323-4545, Website—www.uncommonconglomerates.com
3. "Lucky pants"—Sierra Trading Post Catalog (no guarantees) 1-800-713-4534, Website—SierraTradingPost.como
4. Marblex by Amaco—art supply store. 5# for $9.49.
5. Paints—art supply store.
   Golden Acrylics—Bone Black 1010-2, Neutral Gray 1445-2, Liquitex Acrylic Artist Color—Raw Umber 331, Soft White Beige 9904, Taupe 831, Unbleached Titanium 434.
6. Paleotools—Bill and Jane Murray, 1-800-93-8130, Pneumatic tools—
   Paleoscribe email bill@paleotools.com
7. PVA (Polyvinyl acetate, B-15, Vinac)—Black Hills Institute 1-605-574-4289,
   Web site—www.bhigr.com



Archeotherium mortoni. Adult. Scott, Jepsen, Wood. This appears in the bottom right corner of the butte picture.

Searching for Chinchilla Pliocene Past

C. & D. Wilkinson
9 Birkett St.
Chinchilla, Queensland, Australia

May we introduce ourselves—our names are Cec and Doris Wilkinson. When we retired, we sold our home in Victoria and bought our new home in Chinchilla, a nice country town in Queensland. We became very involved in the Early – Mid Pliocene fossil deposit not far from town.

Chinchilla is located on the Western Darling Downs, 300ks from Brisbane on the Warrego Highway. Industries include grazing, agriculture, anthracite coal mining, and natural gas. Oil comes from wells at Roma to the west and Moonie to the south. Geologically, the surrounds are known as the Surat Basin. The main water course is the Condamine River, which is fed by many creeks in the wet season. The Condamine rises above the town of Warwick. Pleistocene fauna deposits exist near Clifton and Dalby, and fossil material is often found eroded out along creek beds and in the Condamine.

Our deposit occurs within "Chinchilla Sands," a geological feature with varying depths of overburden. We are fortunate here as the area we work in has remained a "pedestal" formation, escaping the worst of past erosional events. This area is one of very few that have escaped the plow and tree-felling and contains 3 different bands of ecology progressing toward the present river bank. We belong to our local Field Naturalists' Club. This club received a state government grant to aid the leasees in fencing off the entire area and we are grateful to our fellow members. They cover a wide range of talents and include Grace Lithgow, our illustrator and a naturalist artist of some note.

In need of guidance, we visited the Brisbane Museum, where we met Dr. Ralf Molnar, the then head of the Palaeontology Department. We showed him some of our early finds, including a supra-orbital bone from a Megalania (Komodo dragon-like reptile). He assured us that this was a rare and important find, so we donated it to the museum. Dr. Molnar was instrumental in our becoming Honorary Technical Assistants with the museum. This has been a happy and successful relationship over the last 15 years.

We have over 5,600 cataloged specimens from this locality. The Chinchilla component of our collection has been willed to "our" institution. In Queensland, it is illegal to collect vertebrate fossils unless one is attached to "an institute of learning," except when the "finder" owns the land the material was recovered on, or has given written permission to work on his land. On our location we have been fortunate to have the cooperation of the land leasees and they are supportive of our work here. The entire area is now fenced. There is an active black market trade in fossils that is world-wide, and securing our dig site and the surrounding fossiliferous land has been an ongoing problem.

While we have personal liability insurance cover and the land leasees do as well, our cover does not include taking others in to see where we work. However, we welcome visitors to our Rock Room and make no admission charge. The Rock Room also contains fossil material from other Australian locations and includes examples of fossil woods from Chinchilla and the surrounding area. Jurassic in age and consisting of conifers, tree ferns, palms, grevillias and the pentoxcylins, the local fossil woods are better known than our much-later-in-time fossil fauna. We also display our gemstones, rocks and minerals in our Rock Room. Most of these we have mined ourselves on four-month-long annual trips around Australia. We welcome visits by classes from local schools and really enjoy these.

The age of our local deposit is generally regarded as Early – Mid-Pliocene. It is located a short distance from the Condamine River and contains "lense" deposits as well as isolated specimens.

Experts feel the area was a lacustrine one—we believe that it was subjected to periodic flooding as well. Ends of long bones and protuberances often seem worn down by high energy water and the deposition has been described as a fossil bearing unit within our quarry that lies unconformably on top of an indurated layer of fine sand. The sediments are primarily fluvatile in nature and represent a number of depositional events. Most specimens recovered are isolated—e.g., Macropod tibia fragments, turtle-shell fragments, single crocodile teeth, etc.

We have hand-worked our quarry for fifteen years and are still learning about the local fossil fauna. We have been able to extend the faunal list with four discoveries previously unknown to science, as well as others not known in this time-frame or new to Queensland, and we feel there is more to be revealed with continued work here.

With trial and error we have found a system that works for us. In the field our tools are those you would all be familiar with—from miners' picks and geo-hammers to brushes and plaster. At home Cec used dental tools and brushes and Acquadhere in solution plus Super Glues. Add a large amount of patience as well!!! Any sand/clay removed from "wash' surrounding larger specimens is saved and wet sieved through gem sieves and finally through fly-wire. We also sieve buckets of wash recovered from those layers experience tells us may yield very small specimens—e.g., mice molars and incisors (both marsupial and placental), fish teeth and fish vertebrae, reptile teeth and fragments of reptile dentaries, upright gastropods, crustacean calcium deposits, snake teeth, and, rarely, bat teeth.

Cec begins sorting out these small specimens using a 10x jeweler's loupe in natural light. Anything of interest is given closer scrutiny under our microscope, a setting 20 being just right; any greater magnification tends to blur out detail. These small specimens are stored in capsules.

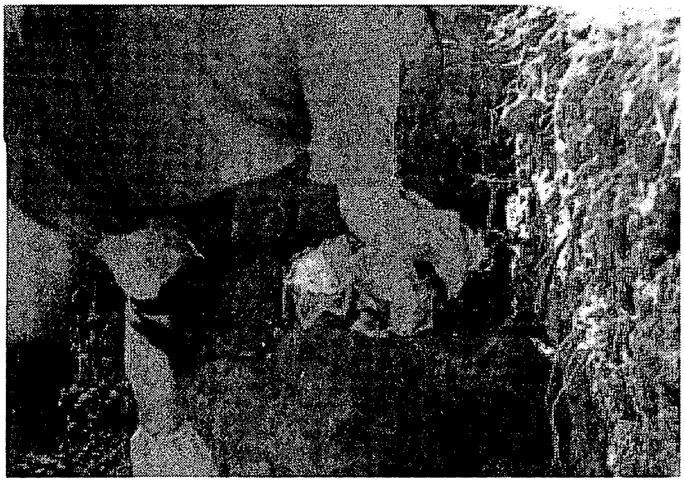
I keep a "Dig Diary." It contains a sketch of the part of our quarry face we have worked on that day. Each entry is dated, deposition layers are sketched in and cataloged numbers are entered where they were found. I note how many buckets of wash were recovered for wet sieving and note any specimens eroded out from the vicinity of our quarry.

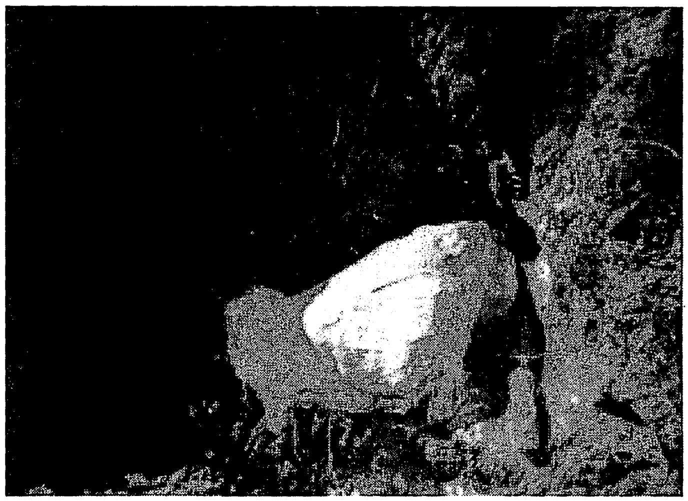
We do not use a grid system because resident extant macropods (wallabies) use our quarry as a resting place in the heat of the day. We have small mobs of wallabies and kangaroos as our neighbors in the bush around our quarry.

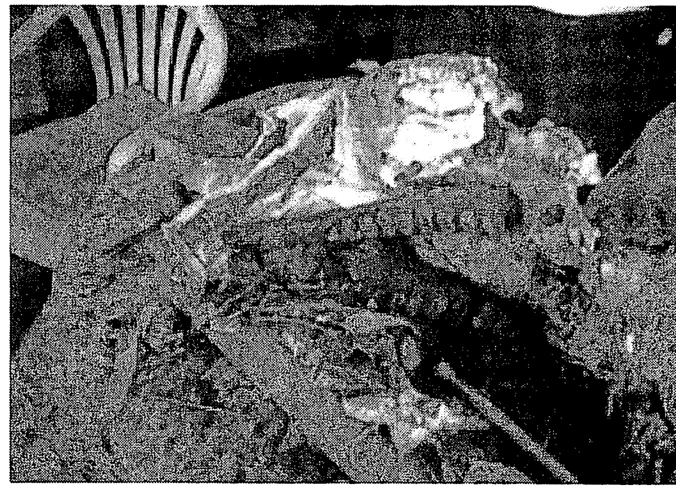
The photos show in sequence—excavation, plastering, removal and repair of Specimen No. 5601, fragments of left and right diprotodontid dentaries that were recovered in September 2003. This was an unusual formation—a large macropod humerus, a large turtle bone, 2 crocodile teeth, and some small turtle-shell fragments were all bundled together. Plaster and recovery represented one day's work. Subsequently, wet sieving of the surrounding material did not produce any small specimens.

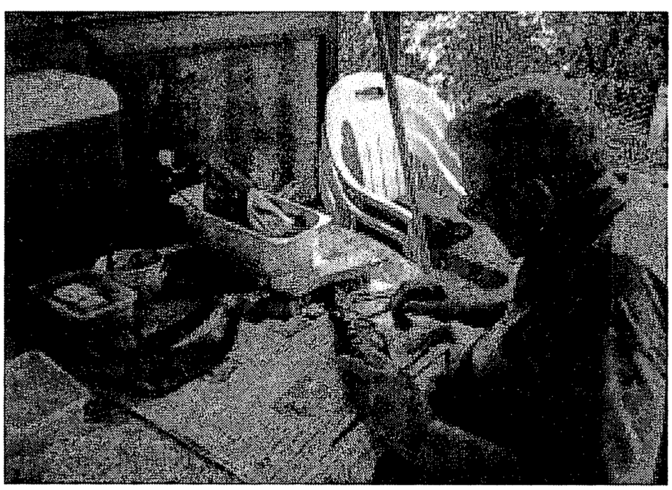
Within the next week we will walk 2.5ks into our quarry. We had four inches of very welcome rain and do not wish to tear up our access track by driving in. We will check our drainage at the quarry—it is designed to check the flow of run-off and prevent erosion. We will also check for any material that may have eroded out in the land surrounding our quarry.

This really is an amazing place, and our excitement level rises high every time we enter it—we really do not know what will turn up in our next "shovel full."





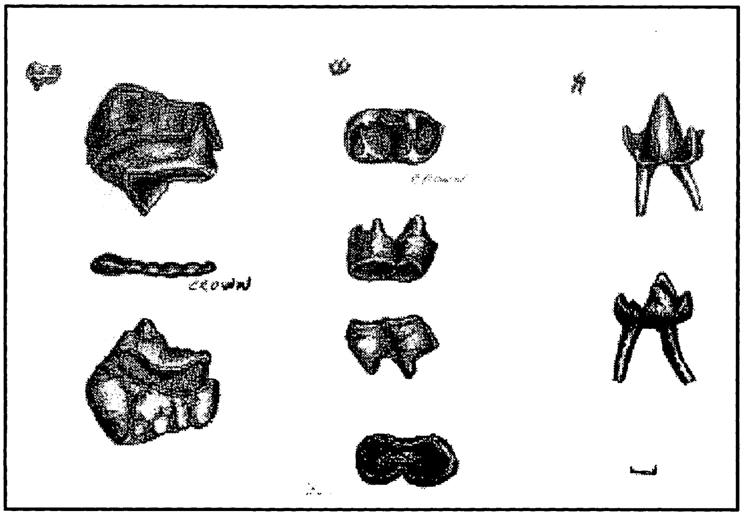




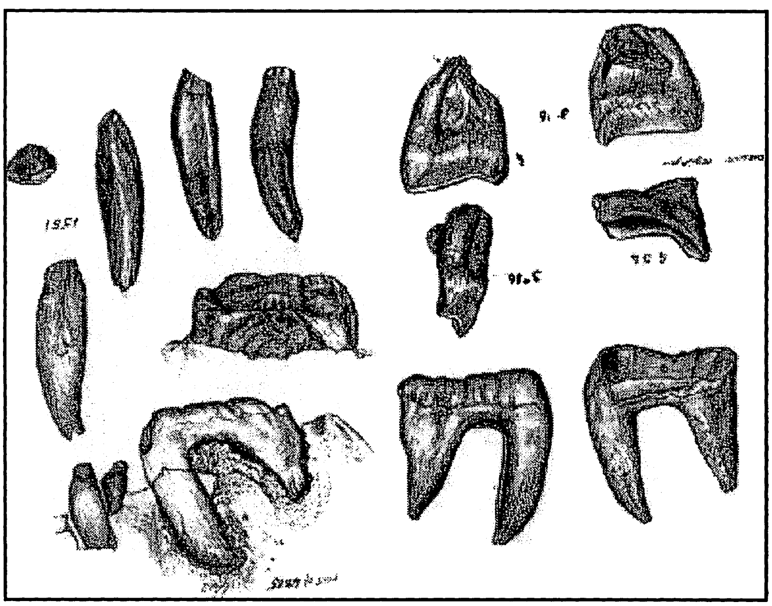
Chinchilla Local Faunal List (Incomplete)

Molluscs	A bivalve.
Crustaceans	Unknown Species.
Chelidae	Rheodytes.
Molossidae	Normopterus (micronomus).
Varanidae	Megolania.
Gekkonidae	
Agamidae	
Scincidae	Tiliqua Wilkinsonorum. New-to-science.
Snake	Boid.
Aves	Cape Baron Goose. Bird material is hard to classify due to feeding habits of carnivores. (They chew the ends off.)
Thylacine	"Tasmanian Tiger." Wolf-like marsupial carnivore.
Crocodilian	Palimnarchus Pollens.(Plio-Pleistocene).
Macropodae	Bohra Wilkinsoni. A new-to-science tree kangaroo. Silvaroo Bila. A new-to-science Wallaby.
Diprotodontid	Euryzygoma Dunese.
Diprotodontid	Euowenia Grata.
Palorchestes	Palorchestes Ayeal. (Rare) Presumed to have a short trunk.
Fish	Meta Cerotodus (Dipnoid) Family Ceratodonotidae). Plotosidae. (Catfish)

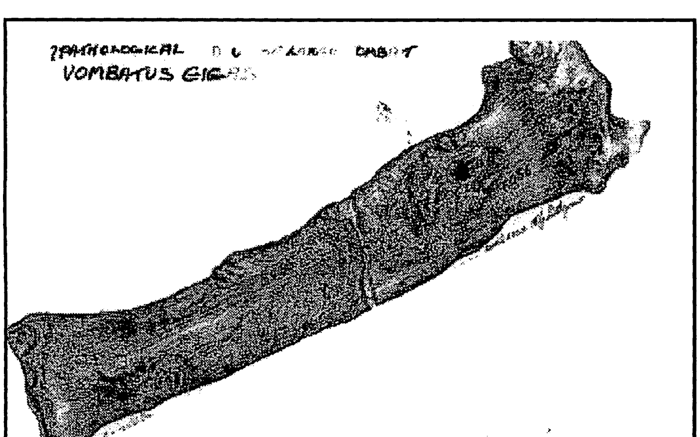
Different views of three microfossils



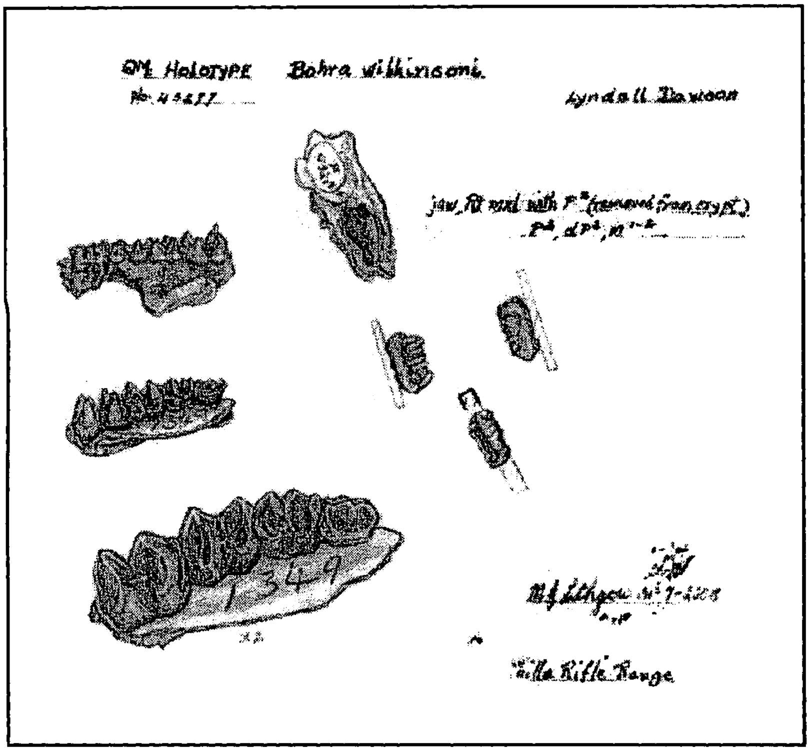
Isolated molars and incisors of Thylacaleo Crassidentatus (so-called Marsupial Lion)



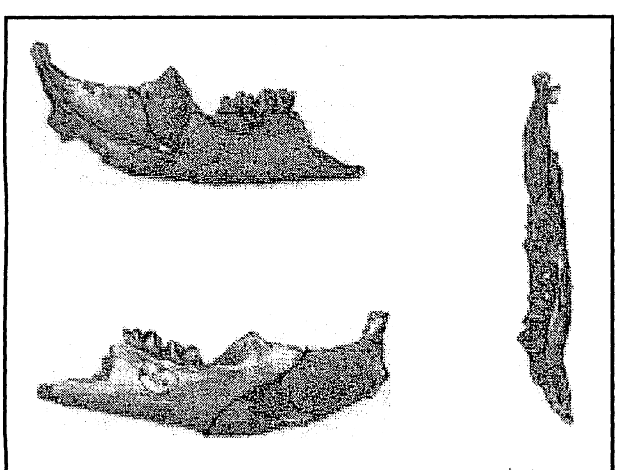
Pathological specimens of a Wombat radius (?) Injuries from attack by carnivore.



Dentary fragment of Bohra Wilkinsoni (Holotype)



Dentary fragment of Silveroo Bila (Holotype)



All illustrations by Grace Lithgow

Acknowledgments:
We would like to give grateful thanks to Dr. Ralf Molnar, Joanne Wilkinson, Dr. Alex Cook, and Dr. Scott Hucknell, and many other Brisbane Museum Palaeontology staff members during the past fifteen years. Their help and guidance continues to be invaluable. To Dr. L. Daws, for his expertise and patience, along with ongoing plans for our macropods. We are very grateful to Dr. M. Archer and Dr. Sue Hand from Sydney; also to Dr. Mark Hutchinson of South Australian Museum for his vast knowledge of Australian reptiles; Dr. John Lang from Perth, Western Australia, for including the mollosoid bat paper in "Records of the West Aust. Museum," Supplement N. 57, and Brian Mackness, not least for his quick feedback.

Sharing Paleontology with Children

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Introduction

My earliest memory of mixing paleontology and young children is an incident which took place over 30 years ago. I was standing in front of a dinosaur display at the Smithsonian with several small first-graders in front of me, and I was checking to see if they had clearly understood the concept of extinction. "So," I asked, "if your dog dies, ...does that mean that dogs are extinct?" One little girl piped up confidently, "Well, one is!"

The next year I moved on to my present job of English teacher at the French International School in Washington, D.C. It wasn't until the early eighties that I began my avid pursuit of fossils. Several times in those years I accompanied the third grade classes on their week at camp in Annapolis, Maryland. I worked up a series of introductory fossil lessons, then led collecting trips on the beach. These were always successful and a lot of fun.

In 1998, some fifth grade parents requested an extra-curricular activity that would challenge their children's English skills. I decided to offer an after-school club to share my love of fossil life with some of my students and named it Young Paleontologists.

The Club is Created

The first club ran for the spring trimester. Nine boys and girls from my advanced fifth-grade English class, about evenly mixed by gender, signed up for the club. We met once a week, for an hour and a half after school, in a small office room. We started with the meaning of the word "paleontology" and how Greek and Latin roots are used for scientific language. We talked about what fossils are and how they are preserved, and I shared extensive examples from my collection. We learned the names of each era on the geologic time scale and debated extinction and evolution. (They all learned to say "Ontogeny recapitulates phylogeny," to amaze their parents.) We raised Triops. We watched pill bugs roll up and studied their relatives, the trilobites. We made plaster casts of trilobites and painted them garish colors. We watched magazines and newspapers for the latest paleontological discoveries and started a bulletin board for articles the kids found. I brought in stacks of books—children's dinosaur books, fossil picture books, identification guides and field guides, and fiction and non-fiction by real, actual paleontologists. Soon several of the students were seen in the halls with copies of Bob Bakker's *Raptor Red* under their arms.

From the beginning I decided that our club activities would include actual fossil hunting trips, and that these, for reasons of time and liability, would occur on weekends. We planned a field trip into the mountains of West Virginia and learned how to equip a fossil hunter's backpack. (e.g., Toilet paper has three uses: 1. the obvious use, 2. to blow your nose and 3. to wrap delicate fossils.) One or two parents volunteered to deliver the kids to a McDonald's near my home in Virginia.

Spring 1998 My very first paleontology group on our very first field trip

We had breakfast, then drove out to the sites. The kids went wild! They loved it! So did my husband and I, but we quickly learned the three canons of fossil hunting with children. They are invariable. I state them here clearly, so you remember them:

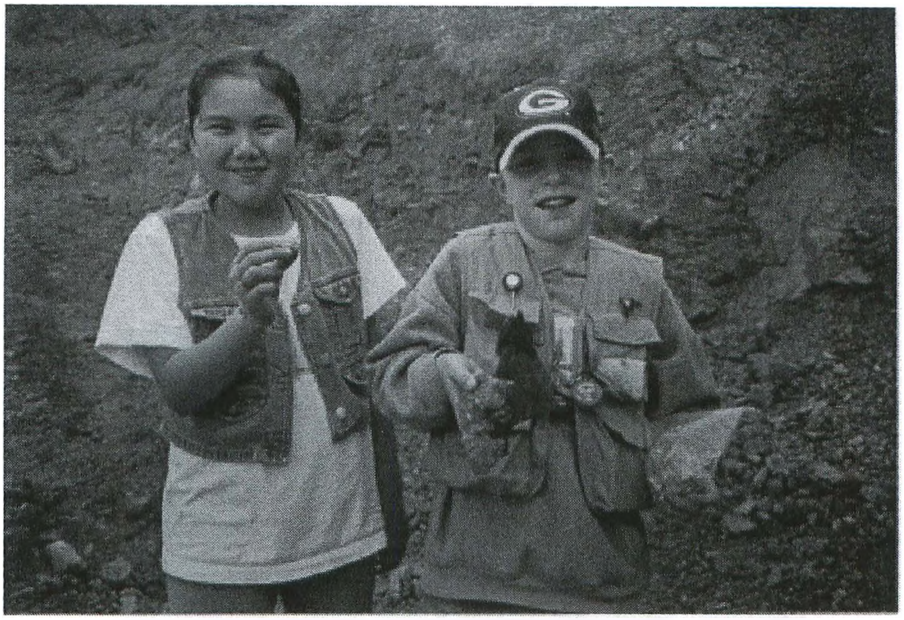
A child will find the perfect specimen—the one you have hunted forever.

A child will not realize how amazing the find really is.

A child will, in many cases, break or lose it before you have even left the site.

At the first stop, my husband gathered the group around him to explain how to hunt the site. One boy bent over and picked up, at my husband's feet, a complete *Phacops rana* on a block of matrix. Then everyone bent over to look and picked up other complete specimens, several of which were soon lost—dropped in the excitement. I had, to this point, never found even one complete one! I was devastated!

Back in the classroom the next week we learned how to label our finds and the importance of doing so. There was that perfect specimen again. I couldn't help myself. I offered to buy it. Martin said, "Sure, I have several others!" I gave him $25. (Turned out he would have thought $5 was a lot!) This beautiful *Phacops* is still in my collection, along with Martin Roux's carefully hand-printed label, and I show it to each new batch of club members.



Holding the trilobites they found. Martin Roux on right with trilobite I later bought.

The Club Evolves

Looking back, that first group of YPs was special. In their approach, they were the most intellectual group I have worked with. They are now juniors in high school, and while some have moved to distant points on the planet, others are still at the French School and we keep in touch.

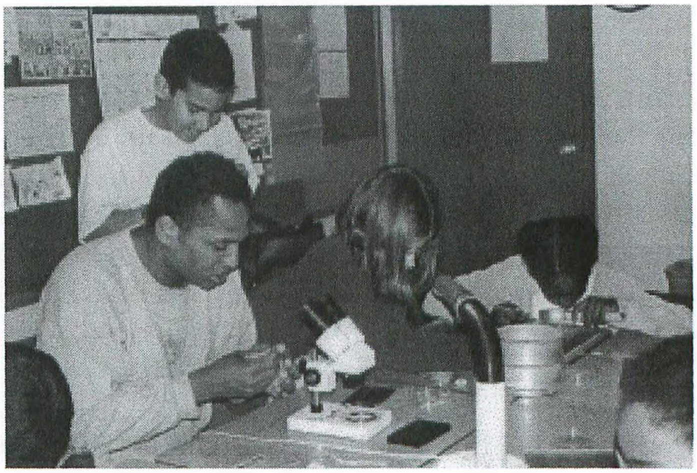
I thought of that spring as a one-time adventure, but the following fall I decided to offer the club again for the first trimester. I easily signed up a group of fourth and fifth graders and followed most of the same activities as the previous spring. It was while we were out on our first field trip that everything changed. Several students asked me what activities were planned for the second trimester and I suddenly realized that as far as these kids were concerned, they had signed on for the YEAR! If I agreed to this concept, I would have to come up with a lot of new lessons and activities, especially for the winter months.

It didn't take me long to decide that I rather liked the idea of having the time to delve deeper into the subject with kids, and I agreed to continue the club through the next spring. At the end of the school year, the fourth graders declared that they wanted to sign up for a second year! This became the pattern that continues to this day: fourth and fifth graders are accepted, a few stay only one trimester, but those fourth graders who are passionate about the club are there for two years!

The Club Thrives

Luckily, the next two years of the club were a time of excitement in the world of paleontology: Newspapers were full of new discoveries and museums vied for the showiest displays and speakers. From the fall of 1998 to the spring of 2000 the club was dominated by a group of giggly girls, who, if not passionate about the science of paleontology, were definitely passionate about each other, the club, and all of our activities. We visited the National Geographic Society to see "Dinosaurs of the Sahara," "Fossils and Feathers," and "Giant Dinosaurs." This last featured Paul Sereno as the speaker, and the girls mobbed him. We were led on a behind-the scenes tours of the paleontology lab at the Smithsonian (by Dave Bohaska) and the holding facility of the US Botanical Garden (by Wally Reed). Two of my fossil-hunting friends, Chuck Ball and Mike Filmer, hosted the group at a restricted Eocene site, Muddy Ceek, where we all got down in the water and screened the muddy matrix.

Spring 2000 Screening Eocene material at Muddy Creek with Chuck Ball



Spring 2000 Searching for foraminifera in samples brought by Eric Woody

Chuck later came into class to show slides of his dinosaur hunting in Montana. Another friend, Eric Woody, came to talk about foraminifera and demonstrate how to prepare them on microscope slides. We searched for tiny pieces of amber in a bucket of material I had brought back from a site in New Jersey. This group also answered dinosaur questions sent by a class of first graders from a school in California. At the end of the year we hosted a Paleo Expo in the school hallway, at which we displayed our projects for the year and answered questions about the club and about paleontology.

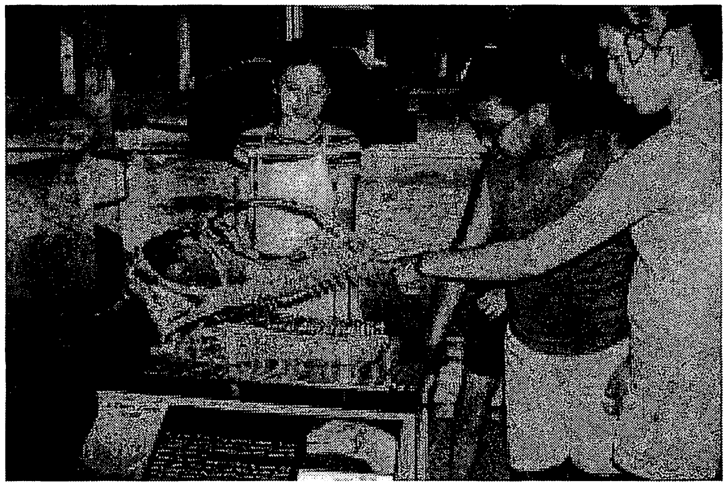
Spring 1999 Our first Paleo Expo—explaining collecting to audience.

The following year, 2000-2001, saw a complete turnover in the membership, and a new era of participation by the parents. Whereas before we had carpooled rather heavily on our field trips, now most of the parents wanted to join in. The caravans became eight to ten cars long, and parents were always stopping me in school to ask, “When are we going out again?” By now, I had the occasional brother or sister of someone who had previously been in the club, and “alums” were often present on field trips. Besides the standard West Virginia trilobite hunts, we took our first trip to the Miocene deposits of the Eastern Shore and visited the Calvert Marine Museum, where a life-size model of the *Carcharodon megalodon* is on display.

Spring 2001 Hunting Miocene fossils at Scientists' Cliffs

Most of the group carried on to the next year, 2001-2002, and it was another big year. We studied foraminifera again, but now we went to the beach to collect them ourselves and prepared them back in the classroom. On another trip to the Calvert Marine Museum we heard a speech by Dr. Uhen of The Cranbrook Institute of Science on evolution of the whale, and the kids talked to him at the pizza reception later. Here they also met Stephen Godfrey, who had helped with the model skeleton of Super Croc. This was the huge Cretaceous crocodile, presented at National Geographic by Brady

Barr, who had worked with Paul Sereno. The kids met Barr and gawked at the huge reconstructed skeleton in the atrium of the building. Along with us were some alums



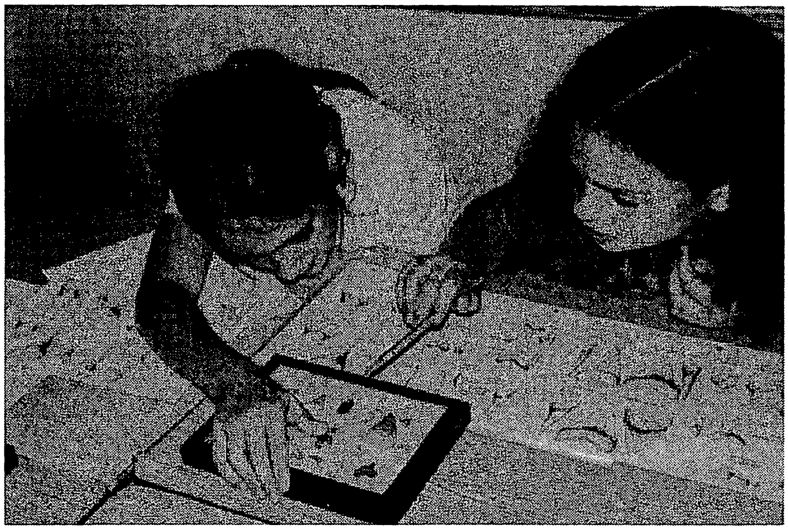
Spring 2000 Juvenile human meets juvenile *Jobaria* at Paul Sereno's speech at the National Geographic.

who had met Sereno himself twoyears before! One of my girls turned the experience into an essay, which was submitted to a writing contest, and she was the winner in the fifth-grade category!

Other highlights for this group were the trips to Muddy Creek and the US Botanic Garden, and a visit from a paleontologist, Dr. Ralph Eshelman, who taught the kids how to identify Miocene shark teeth with a scientific key. These kids, even more than those before, begged for some way for them to continue the club the following year at their new campus. It just doesn't work, but they are always invited to major functions.

Fall 2003 The newest crop of kids with trilobite cookies they decorated.

My current group of "paleo-pals" is about half holdovers from last year, and half new kids. With the restricted size of the group, many kids were turned away this year, which was hard on them as well as on me. We began last year with another speech at National Geographic, "The Making of Super Croc," by the Gary Staab, the artist who designed the "skin" for the full-sized, fleshed out model of the beast. (This was attended by more alums than "newbies.") Chuck Ball came back to give his talk on Montana, and donated Hadrosaur bone fragments to the kids. Once again, many alums—and a few parents—attended. We put together Paleo Expo III in spring of 2003.



Spring 1999 Identifying shark teeth

On this year's first trilobite hunt, one of the boys found that picture-perfect roll-up that we all hope for, proving once again that first canon of hunting with children. He does, however, realize the value of what he found, and he has not, so far, lost it!! Another child on this trip exclaimed, "This is better than television!" And we all agreed.

Spring 1999 Searching for amber on the classroom floor

In the Classroom

With a trimester system for the club, I loosely (very loosely) divide the year into Paleozoic, Mesozoic and Cenozoic. Following is a sample of lessons we might cover:

First Trimester
What is a fossil; how are they formed; what is their importance
Geologic time; change in life forms through the eras and periods
Plate tectonics, volcano
Scientific method
Bibliography of most interesting and kid-friendly books and field guides
Paleozoic creatures, especially trilobites
Collecting, cleaning and labeling specimens

Second Trimester
Classification systems
What is a dinosaur; how are they classified
Dinosaur names
Methods of studying dinosaurs; e.g., trackways, teeth, skeletons
Famous paleontologists, past and present
"Living fossils"; plants
Trace fossils

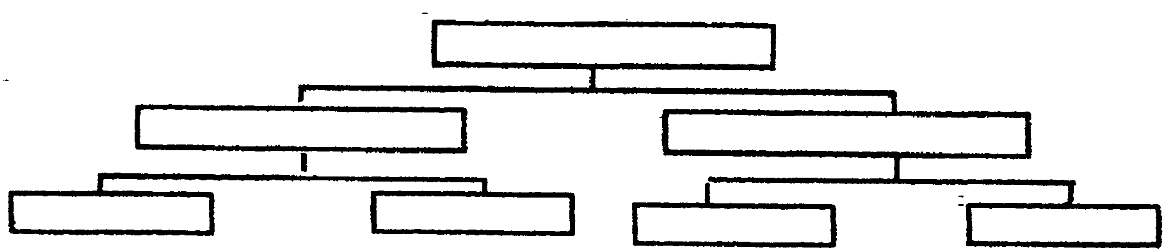
Third Trimester
Evolution, including discussion of humans' past and possible future
Miocene creatures, especially sharks and their teeth
Mammoths; cloning
Amber
Everything else we didn't finish in the first two trimesters

Sample Lesson Plan
Constructing a Binary Classification System for Common Objects adapted from the Dinosaur Classification teacher's guide

1. Divide the children into groups of three to four.
2. Give each group an identical set of objects

A suggested set—a yellow wooden pencil, a red ball-point pen and an identical black ball-point pen, a wooden ruler, a plastic ruler, a brass paper fastener, a large clamp clip and a small paper clip.

3. Give each group a chart on which to record their decisions. The kids will have to add to the chart in pencil to reflect their own decisions.



4. Ask the children to divide their sets into two smaller sets, based on a particular characteristic. Here is where the fun begins. Of course, there is no one right answer, and getting the kids between groups (even less within groups) to agree leads to some great discussion. Many want to go wood versus plastic, but quickly see that the metal objects won't fit. Most end up with some version of "writes" versus "doesn't write."

5. When each group has come to its own decision, ask them to subdivide each of their two sets into two more sets, again on the strength of a particular characteristic. The writing instruments are now easily divided into wood versus plastic, if not lead versus ink, but the other set is now hotly debated.

6. Continue in this vein until each item is alone in its set. (The pens have obviously now been subdivided into red and black.) Under the last box for each object, write the name of the actual object it represents.

7. Draw the empty chart on the blackboard, and have each group present its classification for the objects. Discuss.

8. Pick up any one of the objects and ask each group to "key it out." If their systems are reasonably well written, they should have no trouble finding only one path which leads them to the correct object.

9. At this point, introduce some new objects into the mix, and ask each group how its classification system would handle each one. Start with something simple, such as a wooden pencil of another color. Then try things such as plastic coated paper clips, metal rulers, and blue ink pens. Most of their classification systems should be able to handle these objects with only slight modifications, but some might not. Discuss the problems.

10. Finally, introduce something like a piece of paper, a glue stick or stapler, or a pair of scissors. Watch the chaos. Whose system best accommodates most of these objects?

This lesson is instructive in so many ways. The children understand what a classification system is, and they are in absolute awe when you ask them to imagine writing one to include all the living plants and animals on Earth. They are now better equipped to understand the kingdom to species system we use and why it is so complex. They can see the arbitrary nature of any classification system and how it depends on the point of view of the person inventing it and the information available at the time.

This leads to an understanding of why paleontologists disagree so much over the classification of a particular group or individual. They understand why, when a new species is discovered, it may be difficult to impossible to fit it into the existing system. They understand how to use a scientific key to identify a specimen. (See the last book in the list below.)

Below is a partial list of sources on which I have relied for lesson plans. I always emphasize that anything we read or hear in the area of science is true only so far as our best information at the time.

Resource Books

1. The Amazing Earth Model Book, Scholastic Professional Books, 1997. This is subtitled Easy-to-Make, Hands-on Models That Teach. This cool book includes models and lessons plans for learning about volcanoes, the rock cycle, weathering, earthquakes and plate tectonics. (There are a few errors to watch for: When we constructed the "Fossil Timeline," my students immediately yelled when they saw the incorrect spelling of "Hallucigeni ," and dissolved into uncontrollable giggles at the "Horny" coral.)

2. Dinosaur Classification / Teacher's Guide, Delta Education, Inc., 1997. This is part of a Delta Science Module in Life Science, aimed at emphasizing basic science concepts and content with hands-on activities. All the materials needed for each activity are also available from Delta, but can be gathered on your own. Activities include study of dinosaur classification and stride and height predictions from trackways.

3. Investigating Science with Dinosaurs, Craig A. Munsart, Teacher Ideas Press, 1993. This book is a much heavier version of what book #2 above is trying to do. (I generally use parts of each to develop lessons with a difficulty level somewhere in between the two.) It begins with an explanation of how science works and goes on to investigate dinosaur size, naming, skeletons, feeding habits, trackways, and much more. Part three investigates subjects such as fossil assemblages, relative dating, and plate tectonics.

4. The Big Beast Book: Dinosaurs and How They Got that Way, Jerry Booth, Little, Brown and Company, 1988. This book has a more whimsical approach to investigation, with some novel approaches. For example, kids are introduced to the concept of the older geological layers being lower in the earth by exploring their laundry hampers at home!

5. Dinosaurs and Dinosaur National Monument, Linda West, Dinosaur nature Association, 1988. I bought this book when I was at the Dinosaur Quarry in Jensen, Utah, about ten years ago. This is "a resource packet for students and teachers," and concentrates on the dinosaurs of the Utah site. Most of the activities are for very young children, but there are a few great charts and maps. The best thing is a large reproducible skeleton of Apatosaurus which is great fun for a small group to put together on the floor.

6. DinoSauring, Simmons, Thomas and Beckman, Channels to Children, 1989. This book has great activities for very young children, and includes small posters of the Triassic, Jurassic and Cretaceous. It does contain some great charts, including a "Comparative Size Chart with Classification and Time Periods" and an "Elephant Equivalent Unit Chart" and a "Comparative Egg Chart."

7. Master Tree Finder, May Theilgaard Watts, Nature Study Guild, 1963. This is a very child-friendly key for identification of trees by their leaves. The kids understand the "keying-out" process better after doing the lesson on classification. I demonstrate its use with the ginkgo leaves from trees that grow near our school...which also leads to a discussion of living fossils.

Resources for the Computer

1. The Theory of Plate Tectonics / Interactive Educational Software, Edward J. Tarbuck, TASA Graphic Arts, Inc, 1994. (I believe there is now a newer version.) This is a multimedia CD-ROM for Macintosh & Windows containing a grades 7-12 and a college edition. In the product's own words: "Concise content combined with superb graphics and animated sequences...The user is truly involved, plotting charts, answering questions, labeling diagrams..." This is a super program for introducing and visualizing continental drift. Those kids who really find the subject fascinating can take it further.

2. Message in a Fossil, Brighter Child, Adventure Series. This is another CD-ROM for Mac & Windows. Players become "virtual paleontologists," viewing real-life paleontologists at work at a real 1930s dig site, uncovering fossils at their own dig site, identifying specimens with the help of the museum collection, constructing complete skeletons, and creating their own fossil dioramas for the museum. This is a program the kids really love!

3. http://www.enchantedlearning.com This is a fantastic site for kids, and it is just huge. You could spend all day here and not see anything twice. You can find a paleo dictionary, bios on all the famous paleontologists (past and present), dinosaur jokes, skeleton printouts of favorite dinosaurs, ... If it isn't here, you didn't care about it anyway.

4. http://www.ucmp.berkeley.edu This is another great resource site. Click on "Discover the History of Life" and start exploring. "Geologic Time" 4 "Tectonics" will give you the chance to watch in slow motion the continental drift from Pre Cambrian to the present. "Education" 4 "K - 12" takes you to a host of teaching ideas. Try "Learning From the Fossil Record" and "Explorations Through Time."

5. http://www.nmnh.si.edu/paleo This is the Smithsonian's paleobiology site. There is a shark tooth identification key and some beautiful information on the Burgess Shale. Unfortunately, the promised geology and dinosaur material has yet to appear.

Videos

1. Walking With Dinosaurs, BBC Video, 1999. The best for giving a sense of reality to the past. We always watch these segments with popcorn.

2. Allosaurus, BBC Video, 2000. Interesting to use a year when most of the group has already seen number one above,

3. Dinosaur Giants Found, National Geographic, 2000. Three short segments: "Africa's Dinosaur Giants" with Paul Sereno, "Dinosaur Egg Hunt", and "Sue the T-rex." Good for showing a variety of paleontologists and their work.

4. Dinosaur Hunters, National Geographic, 1997. Documents an expedition to the Gobi Desert and the finding of Oviraptor.

5. Super Croc, National Geographic, 2001. Paul Sereno again, and the finding and reconstruction of the giant Cretaceous crocodile. Terrific information and activities to accompany this are at http://www.nationalgeographic.com/supercroc and http://www.supercroc.com

6. Mysteries in the Dust, GPN, 1800 North 33rd Street, PO Box 80669, Lincoln, Nebraska, 68501. I bought this when I visited Ashfall Fossil Beds in Nebraska. This is a fascinating Miocene tale of death by falling ash from a far-away volcanic eruption, and present day discovery and interpretation. It shows the work not only of paleontologists, but of paleontological artists who must bring extinct creatures to life for the public.

7. Raising the Mammoth, Discovery Channel / Family Home Entertainment, 2000. The unearthing of a complete mammoth inside the Arctic Circle, and discussion of the possibility of cloning it.

Winter 2000 At the U.S. Botanical Garden Holding Facility looking at a cycad cone with Wally Reed.

The Right Tools for the Job

Val and Glade Gunther
Brigham City, UT
www.geo-tools.com

Have you ever tried to work on your own car or truck? Replace an alternator, change your sparkplugs, or even the oil. I suspect most of you have, and I guarantee that some of you did it much faster and easier than others. The difference wasn't how strong you were, not even how many times you have done it. It was the tools that you had. In almost every occupation or hobby that anyone may have, it is the tools and the ability to use them properly that make the difference between success and failure. There is no question that this is, in fact, the case when it comes to collecting fossils as well.

One might think that with all the advances in technology that fossil collecting might have been enhanced by the discovery of some magical tool. As nice as this might be, in fact the techniques and tools have changed very little over time. One paleontologist noted that the greatest improvement in field equipment was the introduction of the felt-tipped pen. When it comes to collecting fossils, all other things being equal, "He who moves the most rock finds the most fossils." The secret then, is to find the tools that help move the rock. Hopefully, after reading this article you will be better able to find those tools.

The Gunther family has been collecting fossils for three generations and more than seventy years. We have done extensive collecting in Utah and all of the surrounding states. Our specialty has been Middle Cambrian trilobites, but we collect fossils of almost every kind. For us, finding the right tools has been a never-ending challenge. There are no hardware stores that sell tools directed specifically for fossil collecting. Even with the help of the Internet, it has been difficult to find the right tools. We have engaged in lengthy searches and, in many cases, have had either to modify a standard tool or make our own. Trial and error and plenty of time has smoothed and shaped our collection of tools, equipment, and, just as important, techniques. What it has boiled down to is a selection of tools and techniques that have been used and abused and have withstood the test of time. The following is a list and description of some of the tools in our inventory.

Lloyd, Val, and Glade Gunther at MAPS EXPO

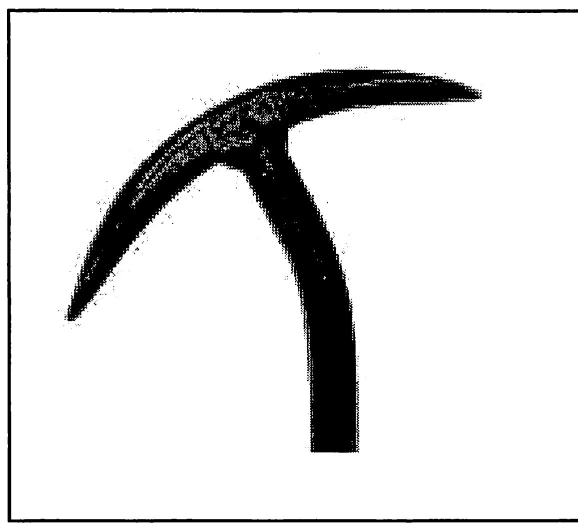
In many of the places that fossils are collected, as much time is spent moving overburden as it is splitting productive rock. Because of this, the shovel has become a very important implement. We use two types of shovels. The first is a standard, long handled garden shovel. It is used primarily for moving and discarding dirt and small, loose rocks. The long handle makes it easier on the back by requiring less bending than a short handled shovel. Once the rocks get large and you start working against solid rock, the choice of shovels changes. The second shovel is a short handled spade. The blade of the shovel is very flat with no corrugations or turned up edges. It has a long steel shank for prying strength. Wooden handles work fine,

Lloyd Gunther; Val Gunther with shovel

but fiberglass handles will take more abuse and last longer. The shorter handle allows the user to move larger rocks because the weight isn't so far away from you when shoveling. It also "cleans" the surface of the rock better than the standard shovel because of the flat square point. This design is used primarily to quarry shales. If the rock is cooperative, it can be pushed into the bedrock and used to pry open large sheets. Because it presents a large surface area, it can generally lift large sheets without breakage. The short handle allows the worker to sit and work at close quarters. When working large flat sheets of shale, we find this tool extremely useful.

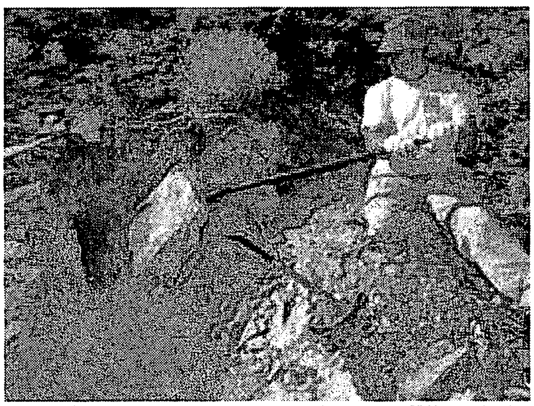
We occasionally use a miner's pick to break up consolidated overburden and to initiate fractures in the layers of rock. There is nothing special or unusual about the design. We recently invested in the Estwing version of the Paleo-Pick. Though lighter in weight than a traditional pick, it has the added advantage of being able to move material with the blade end. Though it can be a useful tool in the right conditions, it is not one of those tools that travel with us everywhere we go. We prefer to use one of several bars for most of our efforts. A pry bar can be an indispensable tool in the field, especially when you are dealing with hard and heavy rock quarrying. We have a number of large pinch bars, ranging in size from four to five feet long and weighing eight to sixteen pounds. They are straight bars with a heavy wedge that can break, pry and lift hundreds of pounds. We refer to this type of bar as "The Persuader."

The most utilized bars in our collection are a series of smaller pry bars. This pry bar is somewhat similar to the common crowbar but has a double crow on the end.



We have found that this "Wizard" bar is the best and most versatile pry bar. Because of its unique shaped rocker head it can be used in many ways. This unusual design allows numerous orientations, giving the operator a great
great advantage over the rock and works very easily. These bars are made in lengths from 24" to 48," weigh from four to ten pounds, and are nearly indestructible. The flat chisel tipped end is convenient for driving into and prying loose the rock layers. The rocker head end can be used to lift or shift very heavy rocks. This is the part that truly sets this

bar apart from all others. It can let the user lift or slide the rock up to six or seven inches at a time. It also allows the user to get into places that a normal



Glade Gunther moving rock with the "Wizard" bar

pry bar would not. We feel that these bars pay for themselves every time we use them. Among other things they are also useful as walking "sticks." They come in four sizes and are handily used in either the standing or sitting position. They are capable of freeing, lifting, and moving slabs that are hundreds of pounds. The 48" bar can move some of the heaviest blocks you dare handle.

We have found similar bars by other manufacturers, but every one of them has broken. We have never broken a true wizard bar. If you do, they have a limited lifetime guarantee from the manufacturer.

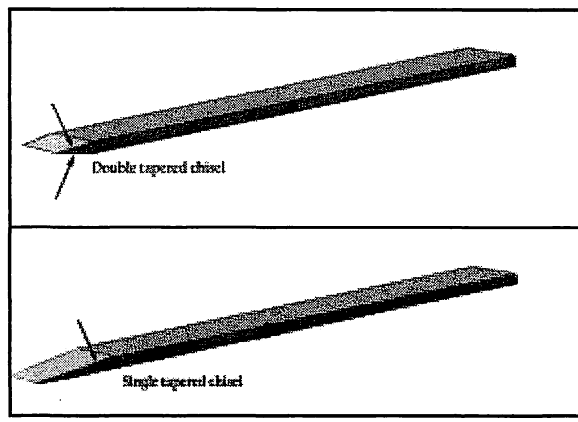
The hammer is the basic tool for the fossil collector. Though they may seem somewhat universal, having the right hammer makes a big difference. The combination of head shape, proper weight, and handle design is essential. There are a number of different hammers in our inventory of many dozens. Only a few are used now. Most have been retired as we have found better-suited hammers for making the job of splitting rock an easier task. The hammer of choice is a brick, or mason's, hammer. It has a chisel blade and hammer end. With a chisel pointed hammer, it is much easier to split sedimentary rock than with a standard rock pick.

Many years ago it seemed that the Estwing brand of rock and fossil picks was the only true fossil collecting hammer available. In fact, there are a dozen or more manufacturers of brick hammers. We have tried many brands and found a few features that we like or dislike. The bottom line is that we did not find one hammer that has proved to be everything we wanted. The head design and shape of the Stanley brick hammers is one of our favorites, but we have broken the handle on every one that we own; they are also one of the most expensive. We have also owned plenty of Estwings. The best thing about them is the single piece anti-vibration construction of the handle and head; it is nearly impossible to break the handle, but we don't particularly care for the design or hardness of the head. We prefer a little less curve to the head, and the hammers seem to wear down quicker than we would like. After years of searching, we have settled on the line of Plumb brick hammers for a number of reasons. We feel that this hammer has the combination of features that we prefer. The shape and hardness of the head is similar to the Stanley brand and is preferred over the Estwing. It also has a handle that is very similar to the design of the Estwing: a single piece construction anti-vibration handle that makes it very durable. The only remaining problem was the sharpness of the chisel end. On both the Estwing and Plumb line of hammers the chisel edge was too blunt to effectively split rock. So we developed a technique to cold grind the chisel end with an improved taper and sharper cutting bit, which is preferable when splitting thinly bedded sedimentary rocks. All of the grinding is done on the underside of the chisel edge so that the head geometry is not changed. They must be cold ground so as not to affect the hardness or temper of the metal. An additional feature of the hammers is an orange anti-vibration grip, which gives the hammer high visibility. This is especially handy for those of us who have ever laid a hammer down and then couldn't find it.

When a heavier hammer is needed, we prefer a cross-peen hammer. The cross peen hammer offers additional capabilities that can't be achieved with the smaller hammers. They have greater head weight for more power delivery to the striking surface, and a chisel can be driven in with fewer strokes. These hammers are just the ticket for breaking limestone and other hard sedimentary rocks. The chisel end is blunt but can still split rock. They come in various weights, but tend to have a longer handle than we prefer. So, we found a three-pound cross-peen hammerhead and mounted a short fiberglass handle to it.

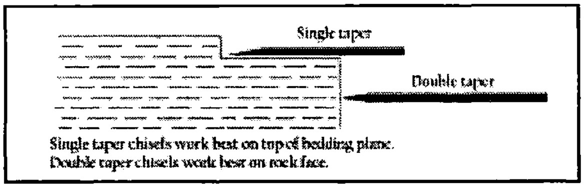
Nothing has been more difficult than finding good chisels. No hardware store chisel is designed to do the job of splitting sedimentary rock. The typical chisel has an abrupt taper and thick shaft that will often result in undesirable breakout of the rock before the bedding plane can be separated. We tried everything from putty knives to leaf springs, but nothing quite did the job. A strong slim chisel that would easily slip between the layers of rock without creating undesirable secondary cracks was just not available.

Finally, we began making our own. Trial and error taught us how to make good chisels. It was necessary to make a long smooth taper with a sharp and durable leading edge. The challenge was how to keep the edge sharp on a thin piece of metal while hammering it into rock. A small secondary bevel just at the cutting edge of the chisel helps them to be both durable and retain the edge. In the beginning we made chisels with a double bevel, which worked for most applications, but we decided that in some circumstances the double bevel is too aggressive. A single bevel with half the angle of approach works very well with softer shales as it penetrates smooth and straight into the more delicate soft shales.



These thin rock-splitting chisels have a number of benefits. They are easier to drive between layers of sedimentary rock. A thin, flat and wide chisel slips in between the bedding plane and gently separates the layers allowing you to split larger more repeatable layers. When selecting a chisel, you should consider two other factors. The width of the chisel is important. In general, the softer the rock, the wider the chisel should be. The point of use also plays a factor in the chisel bevel that should be used. When breaking into the rock face, a double tapered chisel will work better.

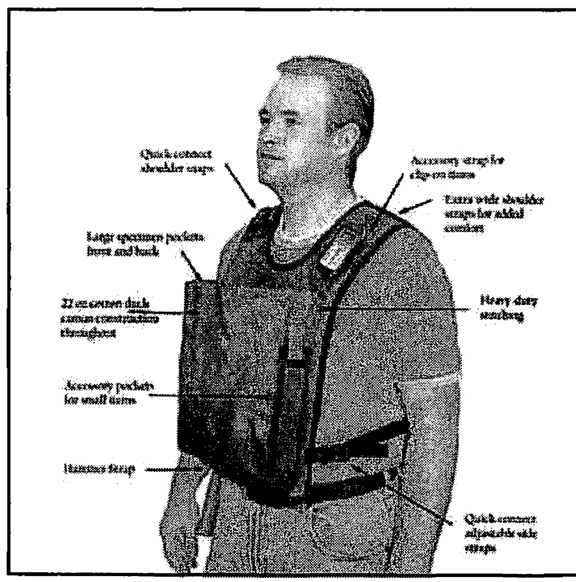
When working on a bedding surface, the single tapered chisel will often give better results. Also in general the double taper chisel is better for splitting harder rocks. The single bevel is most effective when used on softer rocks.



We make our chisels in three different sizes, 8"x1", 10"x1¼, and 12"x1½. All chisels are 1/8" thick and are manufactured from quality steel made for shock resistance and maximum wear. They're hard enough to hold a good edge but not brittle.

For years we have collected specimens in the field and transported them up and down mountains. Sometimes we carry a hundred pounds or more. Back in the 1950s Lloyd Gunther bought a bunch of WWII surplus ammunition packs. These packs were made of heavy-duty canvas cotton duck. They had one large pocket in back and one in front. The pack slipped over your head like a poncho and could carry equal amounts of weight front and back. This keeps your center of gravity right where nature intended it and makes it easier to carry your day's work back with you. Extra wide shoulders straps made them very comfortable. Well, maybe comfortable isn't the right word. When you're carrying eighty pounds of rock, it may be more accurate to call it tolerable. Everywhere we went, people would ask us where they could get a pack like that.

Because the ammunition packs are no longer available at the army surplus stores, we decided to make our own packs. We bought 24 oz. canvas duck (4 oz. heavier than the military packs), hired a seamstress, and together we redesigned the pack with a number of improvements. Double side release buckles on shoulder make it easier to get your pack on and off, especially when it is loaded with rocks. An accessory strap was added for carrying your phone, two-way radios, GPS, glasses, and many other items. Two additional accessory pockets on each side of the front pouch are perfect for carrying chisels, markers, and many other items. You never have to worry about digging these items out of the bottom of your pack. They are always accessible when you need them. Wide and deep pockets in front and back make it easy to carry your day's work back with you. A hammer loop on the belt makes sure that your hammer is always available for use. These packs are made to fit on the young as well as "well fed" adults.



Gradually, we have learned that it is generally a bad idea to try to "field prep" any specimen. It is best to leave it covered or in the natural matrix until you get home. Unfortunately, specimens often get broken in the field. When this happens we recommend repairing them on the spot with a quick drying glue. We typically use cyanoacrylate (super glue) type adhesives in various viscosities. *This* will usually prevent additional damage and loss of fragments from abrasion and handling.

It is also important to carefully wrap specimens to protect them during transport. For many years, newspaper has been used but for some of the more valuable or delicate specimens, this did not always present the best protection. If you have ever wrapped your specimens in newspaper, you know the challenge of keeping your specimens adequately protected. By the time you unload the specimens, half of them have come unwrapped. You just have to make sure that you have enough newspaper to provide plenty of padding.

Our solution to this problem has been to use aluminum foil. It works exceptionally well at containing and providing protection for your fossils. It can be used in conjunction with other padding or by itself, depending on how fragile the specimens are. There are a couple of specific benefits that should be noted. It is much more compact. One roll of aluminum foil will outdo a number of complete newspapers. It is form fitting and easy to size specifically to the dimensions of the specimen. The aluminum foil can also provide superior protection to your fossils as well. We use rolls and pre-cut sheets of aluminum foil, depending on the size of the rocks. Small rocks/fossils wrap up really well in pre-cut sheets. Larger or irregular shaped specimens usually require rolls. You can also label the outside of the foil with a marker. Something you wouldn't dare do with newspaper. For a dollar or two you can wrap lots of specimens and do a much better job of it.

One final piece of equipment that we have found to be of great importance is a good quality 10X hand lens. Our greatest satisfaction in collecting fossils has come from the discovery and donation of new and unusual fossil specimens. In many cases this would not have been possible without the aid of magnification. There are literally hundreds of loupes available, but a quality triplet at a reasonable price can be hard to come by. We recommend the Belomo 10X Triplet. They are made in Belarus, the former Soviet state. These loupes are of exceptional quality, are inexpensive, and larger than most. They are protected by a metal case and are great for fieldwork. The only flaw that was found in this loupe was the fact that there was no place to hook it to a lanyard for hanging around your neck. To accommodate this problem, we just made our own lanyards. The lanyard is custom designed to fit on the Belomo triplet, and to make using it even easier, a quick release buckle was added to allow the user to remove the loupe without having to take the lanyard off of your neck.

For many years, we have collected with hundreds of other people who have observed that our tools gave us an advantage. We seemed to be just a little luckier than many who have collected with us. Much of the credit has to be given to the tools we use, which enabled us to split and move rock more efficiently and faster. After many years of finding and making tools for ourselves, we decided to offer them to anyone interested in fossil collecting. We started a business called Geological Tools and Outfitter, LLC. On our website www.geo-tools.com, we offer many of these tools and other things. We include other interesting things such as collecting tips, photographs of our recent trips and a photo gallery of some of our better specimens. We offer help to novices and the seasoned collectors. If you need help finding something, let us know.

Hiring a Fossil Preparator

Marc Behrendt

The trip is over and the memories are now carefully stored in the photo albums. It is time to prepare the fossils. There are 3 avenues one may take at this point. First, the fossils may be good enough as they are and ready to display. Second, to save oneself a great deal of time and effort, the fossils may be sent to a fossil preparator to be spiffed up. Last, you have the equipment to prepare your own material. This article will deal with sending your specimen to a preparator.

Fossil preparators come in several breeds. Some work for museums and universities, some prepare fossils professionally for a living out of their homes or businesses, and some prepare fossils as a hobby and will clean a friend's material for fun. Fossil preparators also come in two flavors, vertebrate and invertebrate. Most preparators will work on both sorts of fossils; however the majority of one's work - thus skill - favors either verts or inverts. Some preparators will repair or restore the fossil and matrix by manufacturing the missing parts while others simply expose the fossil, making no reparations.

Most Yellow Pages do not carry "Fossil Preparation" as a listing category. So how do you find a fossil preparator? There are several ways. Check out fossil and rock club classified ads. Very often one or more preparators are listed. Attend a Rock and Fossil show and ask anybody who has fossils displayed; you can be confident there are folks present who can lead you right to a preparator's doorstep. Check Internet search engines, many preparators have their own websites. Check the link pages on fossil related websites. Last, commercial fossil dealers are apt to know some good fossil preparators.

Be sure to ask questions to make sure a preparator can and will do what you desire. First, make certain that preparator works on your kind of fossil. Ask about pricing, and to see some of the preparator's work, and ask approximately how long it may be before your fossil would be completed and returned to you. Prices range from \$10 to \$30 or more an hour. Turn-around time (the time it takes to get your specimen back) may take a week or 3 years. Some preparators are so good, people will wait that long to get their special pieces prepped out.

If you choose to send your specimen to a preparator, be sure to pack it properly. Find a box that will allow space on all sides of the fossil. Firmly surround the specimen by using Styrofoam popcorn, newspaper, old clothes or towels, etc, so it will not move around. If it's exceptionally fragile, you may need to be a bit creative in your packing, or better yet, forego the mail and hand deliver the specimen. Be sure to include your name, address, and phone number inside the package. Also include explicit instructions of what you would like done to your specimen. Seal the box with a large amount of plastic packing tape or strapping tape (it has the fibers running its length for added strength). You do not want the box to spring open during transit!

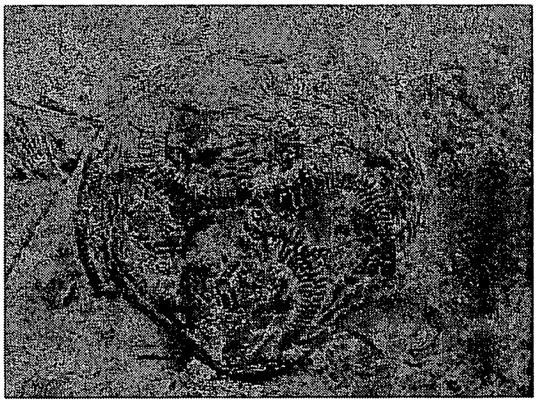
I am often asked who should deliver the packages. The following is my experience. The United States Postal System is by far the gentlest, least expensive and fastest delivery company that I utilize. In a decade of daily deliveries, only one properly packed domestic specimen has ever been broken (knock on wood!) I recommend all my clients to use USPS. United Parcel Service (UPS) does a satisfactory job, but they do tend to bash the boxes up occasionally. Federal Express may be good with letters, but my experience has taught me to avoid FedEx at all cost. If the specimen is rare or fragile, I also recommend parcel insurance and a tracking number. In the last year, 2 packages with no tracking number never arrived to my lab, and sadly, the specimens have never been recovered.

The few specimens I have received that were banged up or destroyed were poorly packed, having bounced around within the package during their journey. I get frustrated, my clients become angry, and the prep work, if possible, is less than satisfactory to all of us. No matter who delivers your specimens, <u>pack them well</u>!

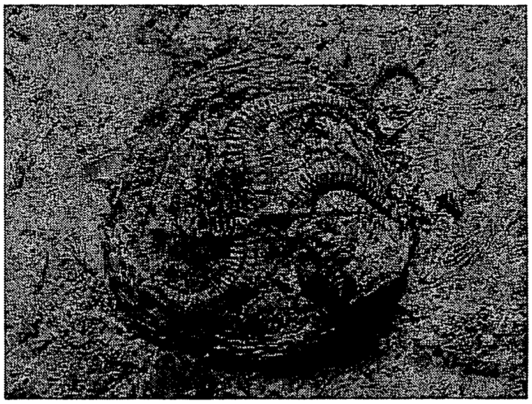
Occasionally, a specimen is in a matrix of incredible hardness; it may be soft and fragile but covered with hard lime deposits, or possess other unexpected attributes. The preparator may contact you to determine whether you would prefer not to risk damaging the fossil or to make an effort to remove the problem matrix with the chance of damage. Personally, I prefer the credo "do no harm" and clean what I can and leave the matrix or deposit.

In the end, you should receive your specimen looking better than it did when you sent it away. The time you save in contrast to prepping the specimen yourself is the dividend. The day arrives when the package is delivered to your home. You open the box in eager anticipation and see the fossil for the first time as it really looks with no matrix. What a great feeling!

Fossil Preparation: Before and After



Edrioasteroid, unidentified, before preparation
Collected from the Ordovician, Ontario, Canada
by Bryan Ritchie



Edrioasteroid, unidentified, after preparation
Prepared by Marc Behrendt
From collection of Bryan Ritchie

Fossil Preparation: A Chemist's Viewpoint

Larry Osterberger
Ringold, Georgia

Fossils are found anywhere that sedimentary rocks are found. In the United States fossils can be found almost anywhere, though the quality, quantity, and ease of extraction varies dramatically. Occasionally, fossils can also be found in lightly metamorphosed rock and very rarely in igneous rocks.

Field Work

To properly prepare fossils it is best to begin in the field though it may not always be possible. When you are surface collecting, it is always best to try to collect all pieces of a fossil and keep the pieces together. If you are digging for fossils, try to define the fossiliferous layers by digging a trench down the face of the outcrop or by visual inspection. Excavate from the top or by creating a bench in the outcrop by driving chisels or picks into the face above the fossil layers and forming a bench.

It is always better to stabilize the matrix before extracting the fossils if it is necessary. If there are any cracks in the matrix, prying the fossils out can break fragile fossils. There are numerous polymers and monomers that can be used in the field to stabilize the matrix. Super Glue or alpha methyl cyanoacrylate is the fastest setting penetrant and adhesive. It is a very fast crosslinking monomer in which the catalyst is usually water though there are some other catalysts which can be sprayed onto the adhesive if the air is very dry or something in the rock interferes with the crosslinking. I prefer the very thin, very fast setting versions. The higher viscosity versions are meant for void filling, but they tend to set much slower without an additional catalyst. The catalyst for Super Glues is water. For this reason Super Glues do not work well on wet matrix even with an external catalyst. In very dry climates an external catalyst must be used. These external catalysts are available in spray bottles and cause the catalyst to crosslink so rapidly that inadvertent contact with the glue on skin can cause a heat burn. Use of a catalyst can occasionally create a greenish tinge which can be removed with bleach or 30% Hydrogen Peroxide.

Because of the ease of use and speed of set, Super Glue is the adhesive stabilizer best to use, but is difficult to remove after setting because Super Glues crosslink and are no longer soluble.

A new stabilizer that I developed will work on matrix that is either dry or wet. It is supplied as a solid prill and must be dissolved in acetone, which is quite flammable, but in other ways is relatively safe. It must be kept away from any source of ignition. Acetone is a very fast evaporating solvent and can generate pressure in a container if stored in the sun or in a hot vehicle. The product is called *Rockstabe,* and to use it on wet matrix, a small amount of household ammonia (approximately 1 oz. per gallon) must be added to the acetone solution to allow acceptance of the water (other solution polymers [Vinac, Butvar, and Glyptal] turn white and do not adhere to the rock when wet).

Vinac is a polyvinyl acetate solution polymer related to the polymer in Elmer's glue but has a much lower molecular weight. Vinac can be dissolved in a variety of solvents to control the drying rate. It is soluble in acetone and many other solvents and can be easily removed with solvent since it is a thermoplastic and does not crosslink. It cannot be used on wet matrix because water will precipitate and turn white.

Butvar is a polyvinyl butyral thermoplastic which is extremely strong. It also needs to be dissolved in solvent like a mixture of Toluene and Ethanol. Polyvinyl butyral solutions dry slowly and cannot be used on wet matrix because of precipitation. Removal is with the same solvents that initially dissolve it. Because it is relatively slow drying, it is better used in preparation rather than in the field. In an emergency, any of these can be used.

Glyptal and Duco cement are both nitrocellulose solution polymers. Nitracellulose is the oldest of the polymer solution resins. It was developed to replace ivory on piano keys. It was also used for making films for cameras and for movie films. They eventually used it to make lacquers and adhesives. Nitrocellusose solution polymers make good adhesives for rock because they are again very tough. Aging with nitrocellulose is not as good as with other polymer solutions because they require an external plasticizer, which can migrate from the adhesive and emorittle the adhesive. The solvent system can be very fast evaporating, but too fast a solvent system causes extreme blushing and whitening due to water. Nitrocellulose has the least tolerance for water.

Elmer's glue or other white glues can be used in a pinch to stabilize fossils. The water present in matrix makes white glues dry slowly. White glues do not dry by evaporation alone. When they lose a little water, the emulsion breaks and the glue precipitates and sets. Unfortunately, there is little or no penetration with white glues unless they are diluted with water. Dilution causes them to set even slower. Elmer's and other all-purpose glues are also softened with an external plasticizer. Wood glues usually have little or no plasticizer and consequently are the hardest of the polyvinyl acetates.

Epoxies can be used to stabilize matrix. They are tough and can be made to set very quickly with the right formula. There are several potential drawbacks to epoxies. They are very difficult to remove. The reaction is exothermic and the extra heat cause the reaction to proceed faster, generating more heat, i.e., you can't mix too much because the reaction will go so fast that the container can catch on fire! Epoxies need to be mixed in the correct ratio or they won't cure correctly, and inadequate mixing or cold temperature can cause difficulties in curing. Epoxies have excellent adhesion, so that isn't a problem.

Polyesters can also be used, but the adhesion is sometimes not very good. The catalyst systems can also be interfered with, leaving uncured resin between the fossil and the stabilizer.

Most of the solution systems also tend to darken the matrix when they stabilize it. I have developed a stabilizer called *Aquastabe*, which can be used to stabilize matrix while preparing, but is a little bit slow for using in the field. It can be used on wet matrix and on most matrix is invisible upon drying. It is applied as a thin water solution and penetrates very well. It is also one of the easiest stabilizers to prepare.

It is often necessary to cushion specimens to remove them from the outcrop. Methods include plaster jackets where strips of cheese cloth are wrapped around the fossil and saturated with plaster; foam in place insulation, foil; and white glue.

To extract specimens, saws, prybars, hammers and chisels, picks, and butter knives all have their place. Before transporting specimens, it is necessary to pack the specimens carefully to prevent breakage and drying out. Methods besides the previously mentioned ones include plastic wrap, egg cartons, pill bottles, ziplock bags, cloth bags, and newspapers, and boxes and coke flats.

Reducing the size of the matrix

After getting the fossils home, you can use various tools to reduce the size of the matrix. There are carbide coated hacksaw blades, which can be used to trim rock. Circular saws can be used with a masonry blade to cut rock. Some band saws can be fitted with a diamond blade and tile saws usually have diamond blades. Additionally, there are many rock saws for slabbing rock and even some radial saws have movable carriages and watercooling.

Some of the most useful tools are the impact type, which can chip off rock. These impacting tools work because there is usually an air gap between the fossil and the matrix. There are various sizes from jackhammers to large pneumatic hammers like those used to remove mufflers on cars. They are available in electric and air types in sizes all the way down to air pencils and even micro styluses for very small work. Another inexpensive type of impacting tool is the electric engraver, which is available for only a few dollars.

Other useful tools for removing excess rock are hydraulic, mechanical, or pneumatic presses with either chisel points or conical points.

Tile nippers used for ceramic tile also work well on thin pieces of matrix.

Dental picks help to remove matrix and ultrasonic cleaners—both tank type and probe, or wand type, have utility in cleaning fossils although tank type must be used judiciously.

There are also some excellent gouges and grinders. Rotary type grinders like Dremel tools, Pfingst, and Foredon flexible shaft tools are all used for cleaning fossils. There are also many pneumatic grinders, such as die grinders, high-speed grinders, and ultra high-speed grinders.

The tips used with these grinders are not simply aluminum oxide, silicon carbide or other stone types. Most of the time, I use carbide or diamond type tips with on very rough surfaces. I also use diamond impregnating sculpting tools, which can cut through matrix rapidly.

One of the MAPS members often has some carbide rotary rasp tips, which work extremely well.

Besides dental picks, other picks and awls are useful. I have found the picks and gouges supplied by MAPS member Bernhard Sadowski are excellent and I recommend them for field use and for finishing work, but I recommend putting some bright paint on them to prevent losing them. One should use an acrylic paint and not an enamel because the copper may cause the paint to fail.

Sanders are of use in removing matrix and in polishing cross sections as well as shaping and removing rock quickly. Most types of power sanders can be used, including detail sanders, belt and rotary sanders.

The Air Abrasive Unit

The most useful tool for preparation is the air abrasive unit. There are now many manufacturers of air abrasive units. Many new suppliers have started making units for dental use. S.S. White made the first units in the 1950s, and Crystalmark *and* Comco are the current main suppliers. The newer units are less complicated and less prone to problems.

Air abrasive units mix air with abrasive like a sand blaster. Good units can change the amount of abrasive and the air pressure. The other variables are the size and the hardness of the abrasives. It is also possible to mix the types of abrasive, taking care not to use too hard an abrasive. It is important to remember that even water can cut through rock. The softest abrasives available are starch followed by sodium bicarbonate, dolomite, aluminum oxide and silicon carbide. There are many silicates available, but they are quite dangerous in a finely divided form and can cause silicosis. Any abrasive in finely divided form can cause problem so a good dust removal system is necessary and a good canister type dust mask is also necessary. I use the air abrasive unit for nearly the final step in preparation—preferring to use impacters and mini grinders to get close because if the air abrasive is used too much it can cause too much erosion of the surface.

Chemical Cleaners

Water is the most universally used chemical cleaner and most matrix and fossils are not affected by it, but any cleaner should be tested on pieces that don't matter too much first.

Soaps and quaternary ammonium compounds (which are also soaps) are extremely useful. Especially the quaternary ammonium compounds like Quaternary O and my *Rockquat* work very well. These are used by diluting the compound 10 % and soaking fossils in the liquid for one to several days. The Quaternary O works best when heated, but repeated heating can erode some of the fossils.

Trisodium phosphate and sodium carbonate are used to break down shales and thin limestones with little damage to the fossils. Both these chemicals are very alkaline and care should be taken when using them. Phosphates in large amounts cause problems because they promote algae and other plant growth, which can clog waterways. Both are heated with the rock in the water and boiled to break down the rock.

Kerosene is used to break up some shales by soaking the shale and then soaking it in hot water. I have not had too much luck using this method, but it is well known and published.

Unleaded gasoline and purer petroleum distillates like toluene and naptha can remove asphalt seepage and some other deposits but do not affect most other materials in the rock. Some of the solvents can dissolve adhesives or cause the bonds to break if the matrix or fossil has been previously glued or stabilized. The biggest problem with organic solvents is their flammability. For that reason, solvents should only be used outside the house or in areas away from flame and heat sources. Evaporation of solvents can completely evaporate and fill a room, which can then explode or burst into flames.

For bone material and some other silicified fossils, acid is used to clean the fossils. Bone material usually uses acetic acid at 10% concentration or formic acid. While silicified fossils can use stronger mineral acids like hydrochloric (muriatic is the same thin), phosphoric acid, or even very strong acids like nitric and sulfuric, but these are extremely strong and I wouldn't recommend their use. I normally use nothing stronger than phosphoric.

Chelating agents like the derivatives of ethylene diamine tetra acetic acid also help to soften matrix.

Actual Preparation

The steps in preparation vary depending on the fossil and the matrix.

The following list is my procedure. Many preparators use different methods. Some use air abrasive units almost exclusively and others don't even have an air abrasive. The biggest advantage of having a lot of different equipment is that preparation can be done more quickly with less damage.

One of the most important tools in fossil preparation is magnifying equipment. A lower power binocular microscope from 5-30 power is ideal for most work. I have two microscopes: One is a preparation scope with two magnifications 10x and 30x. To get a better working distance I have a .5 diopter that I attach to the microscope. This gives me an effective magnification of 5x and 15x at double the focal length. I also use ring lights with magnifying lenses and optivisors of 5, 7, and 10x.

I will usually test the matrix to see how easy it will be to remove, then I will soak it in the appropriate cleaning agent.

My next step is usually to determine the extent of the fossil and the number of fossils on the matrix. I have seen X rays of fossils, and they work very well, but very few people have access to an X-ray machine. Other methods of finding fossils in the matrix include soaking the fossil matrix in water and using Exacto knives to probe by hand, or using an impacting tool or air abrasive unit to probe. I don't like rotary tools for probing because you can't see where the fossils are because the rotary tool can go right through the fossil. Chemical means can often expose the fossils to some degree and the fossil can then be exposed using impacting tools, grinding tools, and dental picks, gouges or awls. After the fossils are exposed, I will use grinders to remove as much material as quickly as possible. Sometimes I will stabilize the matrix before grinding and occasionally I will even coat the fossil before doing a lot of work—to prevent loose chips or cracks from being blown off with the air abrasive. I normally clean completely around fossils, giving them high relief.

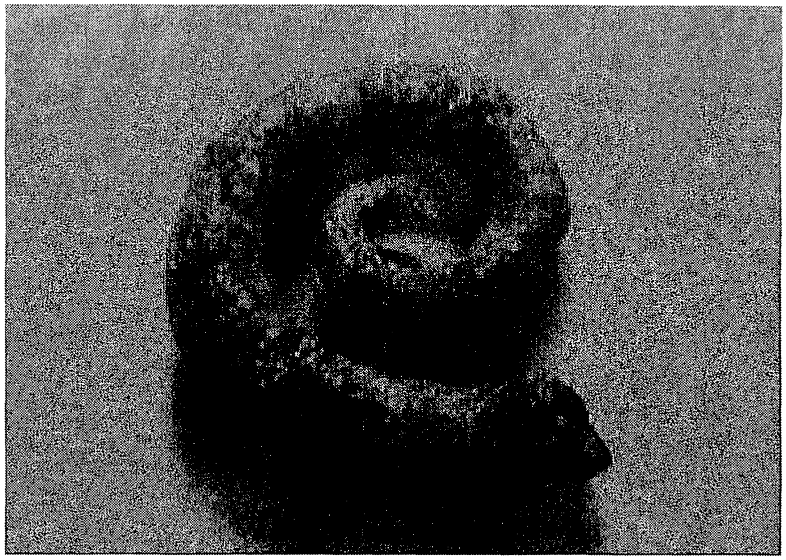
I then use the air abrasive to clean the fossils and may then use the ultrasonic (probe type) to finish the preparation.

After cleaning the fossils, I may find it necessary to fill in cracks in the matrix or even in the fossil. (If repairs are made to the fossil I tell the customer if there is any restoration.) I don't normally care if there are repairs of cracks in the matrix or even if a piece has been glued back in position, but if there has been restoration of part of the fossil, that information should always be told as well as the extent of the restoration.

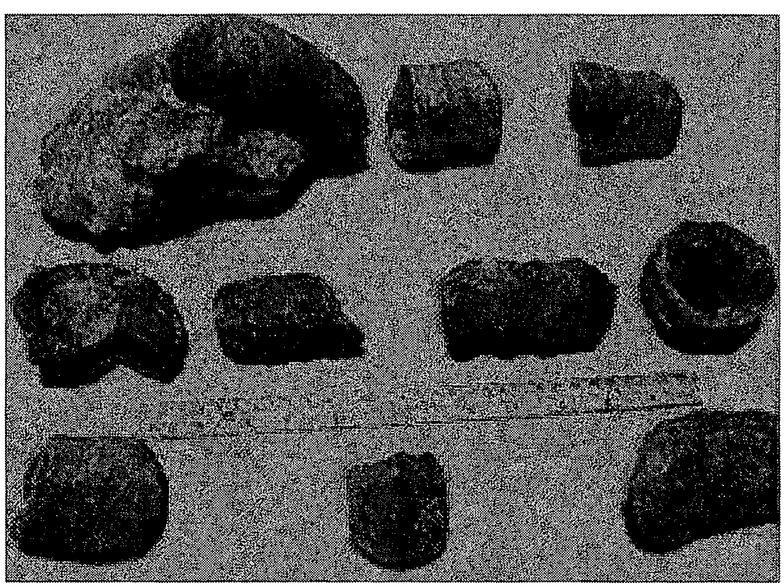
Matrix repair is often necessary. I usually use epoxy because it is very strong and adheres well to the rock. I usually fill the epoxy with ground rock to mach the color, density and hardness of the original. Ground up rock is the easiest way to color match matrix, though a lot of adhesive materials darken the ground rock so it is important to use as much filler as possible with as little binder as possible.

This technique can be used with most stabilizers and adhesives, though almost all of the polymers should be diluted with solvent. And in the case of Elmer's glue, and the like, they need to be diluted quite a bit because the filler will remove some of the water causing the emulsion to break and the adhesive to stop sticking. My *Aquastabe* is one of the easiest stabilizers to use because it is tough and water soluble and doesn't darken the matrix. When the filler is added, the repair will be pretty much invisible.

Fossil Preparation: Before and After



Reconstructed Nautiloid *Goldringia* sp. From Cedar Valley Limestone, Middle Devonian. Prepared by Gil Norris from pieces shown below. Gil used Elmer's heavy grip cement, as none of it would show, and then filled the cracks with Rock Hard wood filler.



Nautiloid pieces as collected from the Conklin Quarry, Iowa City, IA, by Gil Norris. *Goldringia* sp., Cedar Valley Limestone, Middle Devonian.

Pyrite Disease - Is There a Cure ?

By Wolfgang F. Vogel
Toronto, Ontario, Canada

Pyritization is one of the most spectacular modes of fossil preservation. The shell of many fossil groups, such as ammonites, but also entire dinosaur bones can be partly or completely replaced by pyrite. The metallic shine of pyrite, which is also called fool's gold, is sometimes enhanced by a "sugar-coating" with fine crystals covering the entire fossil. Also, certain fossils are commonly enclosed in a pyrite concretion. For example, prime localities for such specimens are the Devonian Shale at the Alden Creek in Upstate New York or the Ordovician Whitby Shale in Ontario. Other well-known pyritized fossils come from the Jurassic badlands in southern France.

While most of these fossils need little initial prep work, the joy of displaying them can be short-lived: Within a few weeks, **pyrite disease** may turn the most beautiful specimen into a little heap of rubble (Figure 1). The first signs of pyrite disease are yellowish crusts or white needles on the surface of the fossil, leading to cracks throughout the specimen and finally to complete decomposition. Onset and progression of pyrite disease can be either rapid or very slow, sometimes after decades of apparent "healthy life" within a collection. Here, I want to give an update on more recent techniques that aim to cure or prevent pyrite disease.

Figure 1 : A Jurassic ammonite, destroyed by pyrite disease.

Pyrite/marcasite: beautiful and vain

Most of the pyritized fossils in danger of decaying are actually not made out of pyrite, but out of marcasite: a close relative of pyrite. Chemically, pyrite and marcasite are identical; both are iron sulfide (FeS_2). While pyrite prefers to form cubic (isometric) crystals, marcasite crystals are orthorhombic. For a pyritized fossil, however, it will be difficult to define which mineral is actually present without using complex physical or chemical technology. For pyrite (or marcasite) to decay, it needs water and oxygen present in the air. During the process of breakdown, several reaction products can form, including iron sulfate, sulfur, and **sulfuric acid** (H_2SO_4). My apologies to anyone, who does not want to be reminded of chemistry class in high school. So, I will only give one out of many possible chemical reactions:

$$2\ FeS_2 + 7\ O_2 + 2\ H_2O \rightarrow 2\ FeSO_4 + 2\ H_2SO_4$$

The smell of sulfur in a collection can be the first indication of the onset of pyrite disease. Sulfuric acid is rather aggressive and will not only destroy the fossil itself, but also labels attached to the fossil or wooden drawers and storage cabinets. Due to the acidic fumes, pyrite disease will easily spread to so far unaffected pyritized fossils nearby.

Initially, museum custodians have used a variety of coating substances to treat or prevent pyrite decomposition. However, because coating alone never results in a complete sealing of fossils from oxygen or humidity, these treatments were largely unsuccessful. Later, sulfuric acid was successfully neutralized by concentrated ammonia vapor. However this process is too hazardous to be used outside of a chemical laboratory.

Rescue of decomposing specimens with ethanolamine thioglycollate

In 1984, Lorraine Cornish and Adrian Doyle from the British Museum of Natural History in London introduced **ethanolamine thioglycollate**, or short "ET", as novel treatment against pyrite decay. ET is normally used to perm hair, but can do wonders in rescuing affected fossils. The pale pink ET liquid smells rather unpleasant and is moderately toxic. Therefore, it should be only used outside with proper ventilation and safety gear such as PVC gloves and eye goggles. A 5% solution of ET in industrial spirit (95% alcohol) is used to treat oxidizing fossils. The fossils are soaked in the solution for about 1-2 hours. During this time, the color will change from clear to purple, indicating neutralization of the specimen and the formation of various organic iron-complexes (hence the purple color). The treatment should be repeated until the color reaction no longer appears. A final wash with spirit will remove remaining ET (and the smell of it). Before re-introducing the fossil into the collection, the storage container should be replaced and the label laminated, if it was in contact with the fossil. I have successfully used this method; however, a few specimens required a second round of treatment.

Preventative treatments

Probably, the most effective way of preventing pyrite disease is keeping the **humidity** in the collection area low. Optimal humidity is 30-45%, the "danger zone" is around 45-60%, and anything above 60% can be actively inducing pyrite breakdown. While large museums can afford climate control systems, private collectors will have to adjust their storage area. To this end, I managed to rescue a nice collection of Jurassic ammonites by simply moving them from the (rather damp) basement into a room on the second floor. To monitor humidity, I found a digital hygrometer in the science store. One of my friends used a more radical method to permanently seal-off oxygen and vapor: he found pyritized fossil plants, which he neatly sealed by polymerizing epoxy resin around it. To some extent, the little translucent blocks still allow him to study his fossils.

Additionally, I successfully tested a treatment with **linseed oil** to further reduce the chances of an outbreak of pyrite disease. Linseed oil is a natural product, which has a slightly basic pH, therefore eliminating any traces of acid on the fossil's surface. To treat a specimen, I first dried it in an oven at around 120°C for several hours. Next, I prepared a 25% solution of linseed oil in ethyl acetate, a non-toxic, however flammable, organic solvent. The fossils were immersed in the solution for at least 30 minutes. To allow better penetration of the substance deep into cavities within the fossil, I placed the beaker (with the fossils soaked in the linseed oil mix) into a desiccator and applied vacuum. A desiccator is a large glass container often used in chemistry labs, which can be closed-off and connected to a vacuum line. Optimal vacuum is reached, when the solvent (ethyl acetate) starts to bubble. After taking the specimens out of the solution, excess linseed oil is removed by placing them on a thick layer of kitchen role. The fossils will appear slightly darker than before, but most of the pyrite shine remains (Figure 2).

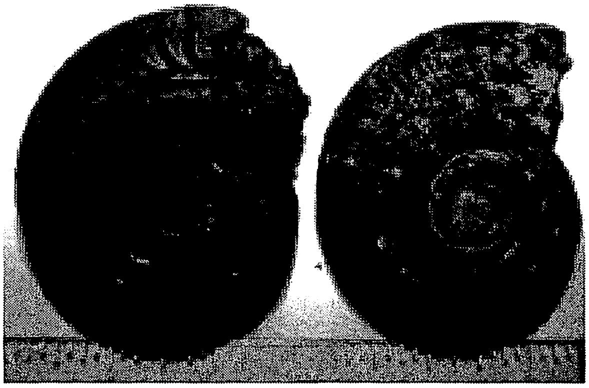


Figure 2 : Harpocears ammonites, before (right) and after (left) treatment with linseed oil.

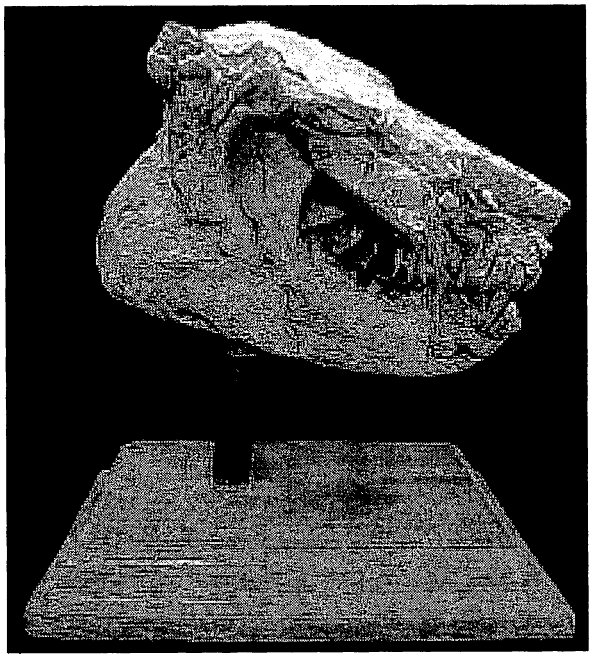
Some scientists studying pyrite disease have suggested that **microbes** are involved in driving the breakdown. Certain bacteria, such as *Thiobacillus ferrooxidans* thrive on iron sulfide and have been used to extract gold and silver from iron sulfide ores, a process called bio-leaching. So, potentially, pyrite decay is not just a chemical reaction, but actually an infectious disease. Maybe, future fossil collectors can cure the infection by just giving the right antibiotic to their fossils.

References:

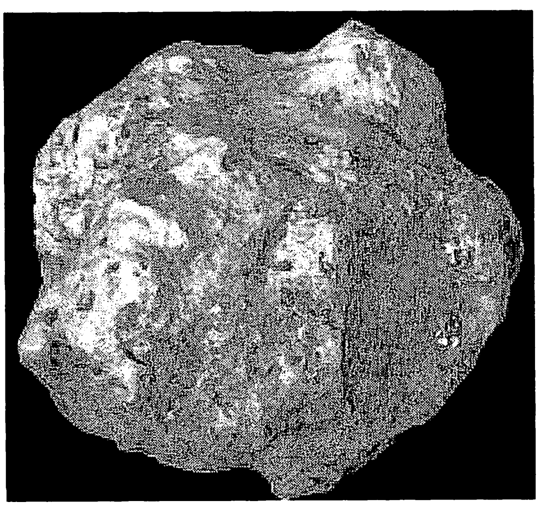
1. Cornish L and Doyle A (1984) Use of ethanolamine thioglycollate in the conservation of pyriterized fossils. Palaeontology, vol.27, Part 2, pp.421-424.

2. Wolberg DL (1989) Stabilizing pyritic material. Paleotechniques, Special Publication (Paleontological Society), vol.4, pp.249-259.

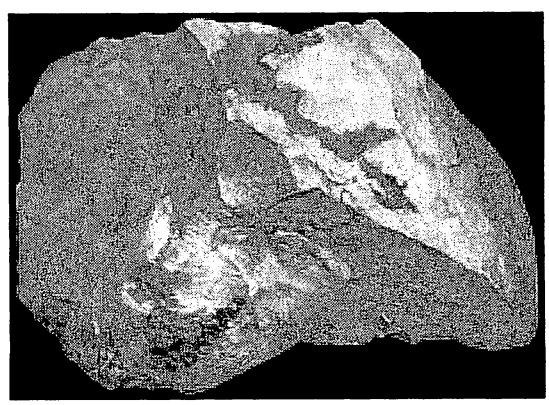
Fossil Preparation: Before and After



Oreodont head after preparation by Marc Behrendt



Unprepared Oreodont head, collected from the White River Formation in Nebraska.



Oreodont preparation by Marc Behrendt in process.

The Dinosaur Egg and Embryo Project

Terry Manning
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(*Terry Manning, a professional fossil technician, has been working on the Dinosaur Egg and Embryo Project for several years and has had to develop new techniques to identify those fossil eggs that are most likely to contain embryonic remains. Some of these rare fossils show extraordinary detail of the embryonic soft tissues. They provide a mass of new information for scientists, and as Dr. Dale Russell, the Canadian dinosaur expert, has said "They are the most wonderful dinosaur remains that I have had the privilege of viewing during my professional life." The fossil eggs, which come from the Upper Cretaceous, or Nanchao, Formation of the Nanyang Valley, Henan Provice of the People's Republic of China, show stages of dinosaur embryos from the period when only soft tissues (such as cartilage) are present, to the almost macabre evidence that insects have gained access to unhatched eggs to eat the contents.* –Florence Magovern, Boulder, Co. The Stone Company)*

The extinct reptiles commonly known as dinosaurs appeared about 225 million years ago and became extinct about 65 million years ago. Although some dinosaurs were gigantic, others were relatively small, about the size of a chicken. It is believed that birds evolved from one of these species of small dinosaur.

Dinosaurs and Eggs

Dinosaurs laid eggs rather like those of living lizards, crocodiles and turtles. Some reptile eggs are soft and leathery whereas others have a hard shell, like that of birds' eggs. The eggshells of large birds (such as the ostrich) and large dinosaurs are quite robust, consisting of several layers of mineral material, which lends itself to fossilization.

Dinosaur egg remains are not particularly rare; they are known from over 220 localities worldwide. Dinosaur eggs have been found in North America, France, Mongolia and China. It seems likely that some species of dinosaur, like some living reptiles, buried their eggs in the ground; this would make them more likely to become fossilized. The 'Dinosaur Egg and Embryo Project' is centered upon four different kinds of egg from the Nanchao Formation (Upper Cretaceous; about 75-85 million years ago) of the Nanyang Valley, Henan Province, PRC.

Embryonic bones within dinosaur eggs

This is not the first time that bones of developing dinosaurs have been found within fossil eggs. Previous finds are summarized in a book entitled *Dinosaur Eggs and*

Babies, published by Cambridge University Press in 1994. This book includes a description of a remarkably good embryonic skull of Hypacrosaurus from Canada. Others have subsequently described a partial embryonic skull of an oviraptorid dinosaur from Mongolia. All four kinds of egg studied in the present project have yielded embryonic bones and two kinds have also yielded complete skulls.

Extraction of the embryos

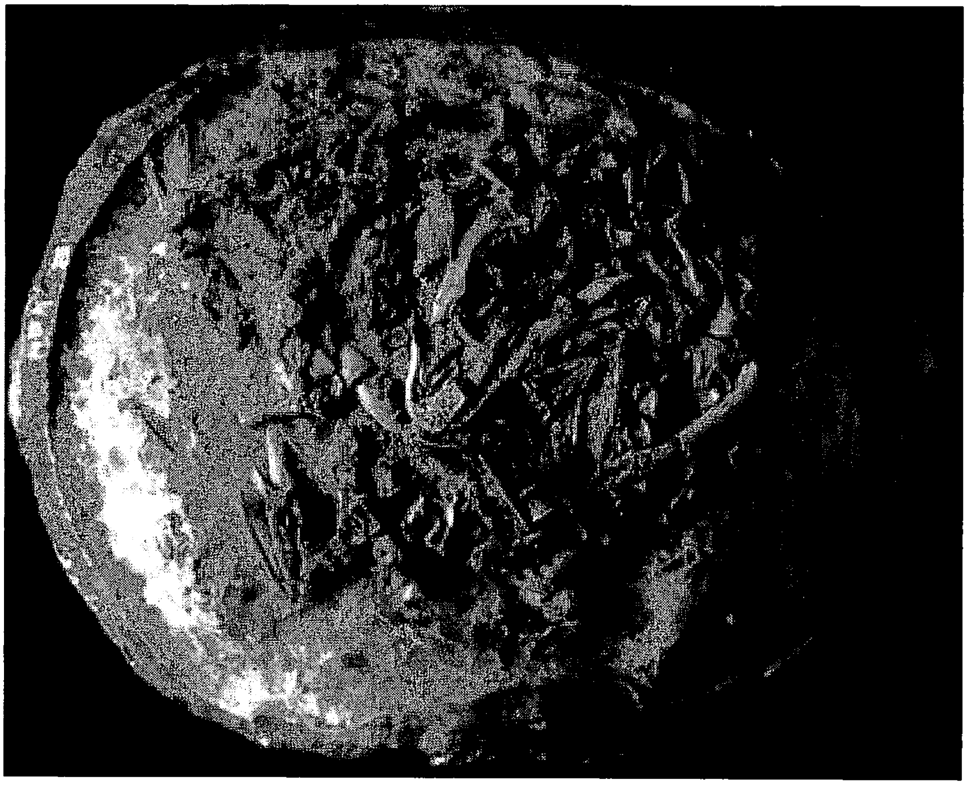
Some of the eggs are infilled by silt (which could not have happened unless they were cracked), some are infilled by calcite crystals (calcium carbonate) and barites (barium sulphate) deposited by percolating ground waters, and others by a mixture of silt and calcite. Bones are composed partly of calcium phosphate. After tiny holes are drilled in the eggs, the eggs, each in its own plastic bowl, are immersed in very dilute acetic acid, which breaks down the calcareous matrix of the silt and dissolves the calcite, but it does not attack the bones as readily. At intervals the specimen is washed thoroughly to remove salts and acid, dried in an oven, and any exposed bone is impregnated with a plastic to prevent damage by further immersion in acid. If the bone were only covered with the plastic, gasses trapped in tiny teeth and bones could build up under the coating and explode. Next the specimen is put back in the acid bath. Because the acetic acid dissolves only 1/2000 of an inch of matrix a day, the process is repeated again and again, over many weeks, as much as a year.

Mode of preservation of the embryos

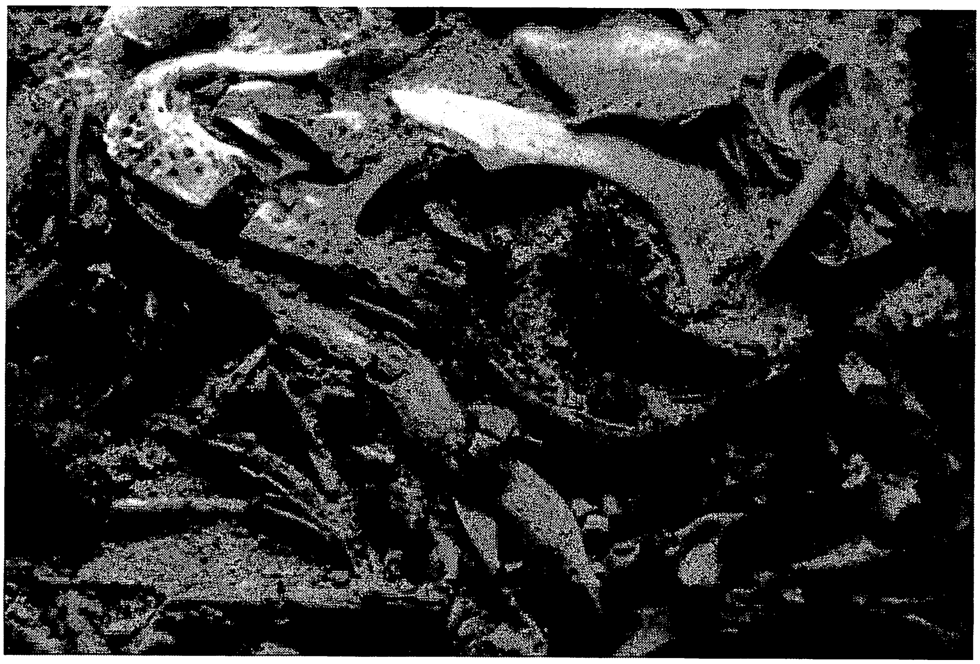
If an embryo died very young, then its bones are less well ossified than in an embryo that died at full-term. The position of the bones within the egg also varies according to the stage of development at which the embryo died. It seems that earlier embryos are usually preserved around the center of the egg, perhaps suspended on the dried surface of the yolk. Mid-stage embryos are often stuck to the roof of the egg, perhaps having been buoyed up by gas produced during decomposition, and subsequently sealed in that position when the egg dried up. By contrast, the more dense bones of late-stage embryos are usually spread over the floor of the egg. Drying of the egg also seems to be an important component in the preservation of unossified tissue such as cartilage.

Therizinosaur eggs

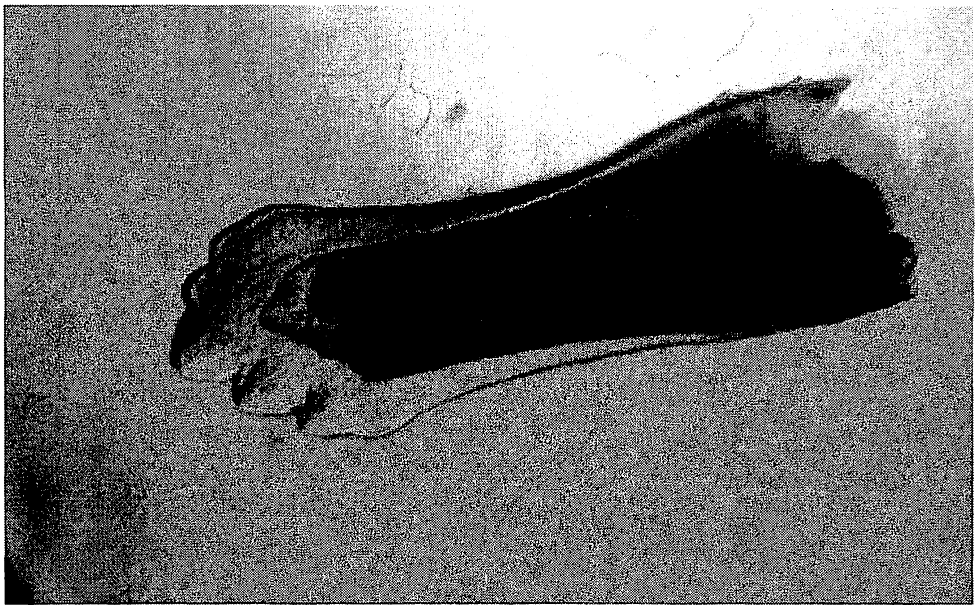
The only sure way of identifying a dinosaur egg is to identify an embryo within it. On this basis, one of the four kinds of eggs available to us has been identified as a therizinosaur: these are an enigmatic group of dinosaurs of uncertain affinity, perhaps sauropodomorphs (big four-footed forms), perhaps herbivorous theropods (normally meat-eaters), or perhaps they are a group in their own right? Therizinosaurs stood about 3 meters high and were maybe 4 meters long. These eggs are oval in shape and about 90 mm long.



Embryo revealed as calcite filling egg cavity has gradually been etched away. Skeleton is joined together with skull, claws, teeth and jawbone intact. Photo by Terry Manning



Closeup of embryo skull Photo by Terry Manning



Closeup of Therizinosaur embryo teeth—1/25 inch long each Photo by Terry Manning

What sort of animals were therizinosaurs?

Therizinosaurs are bipedal dinosaurs which have been discovered in the Middle and Late Cretaceous rocks of China (PRC) and Mongolia. They were medium-sized forms, reaching lengths up to 4 meters. Their skulls are rather unusual, possessing a well-developed toothless beak at the front end of the jaws, and many small, leaf-shaped, serrated teeth further back. The hands and feet seem to have been equipped with very large and sharp claws. We do not fully understand what therizinosaurs ate or how they lived, although most other fossil and recent reptiles with similar teeth are plant-eaters.

The three other kinds of eggs that we are working with are different from the Therizinosaur eggs in shape and size:

The embryos in cylindrical eggs about 200 mm long seem to be Ankylosaur, a quadrupedal, short-necked, armoured herbivore that stood 2.5 meters high and was up to 10 meters long when adult.

Eggs that are cylindrical and at least half a meter long contain an as yet unidentified dinosaur.

One type of egg—spherical and 40 mm in diameter turned out to contain a fossil tortoise. Previously the earliest fossil tortoise of this modern type was about 40 million years old. This find pushes their history back at least another 35 million years.

All four kinds of egg studied in this project have yielded embryonic bones and two kinds have yielded complete skulls.

What is so outstanding about this particular find?

There are four special features:

1. The exceptional completeness of the embryonic skull; it appears to be less damaged than any described previously.

2. The exquisite preservation of fine detail, such as the claws, revealed by chemical preparation techniques.

3. The discovery of preserved soft-tissues, such as cartilage and perhaps muscle and skin, in the therizinosaur eggs.

4. The recognition of various agencies that have contributed to the partial preservation and to the partial destruction of the embryos.

Preservation of soft tissues

Soft tissues may be preserved in fossils by several different processes. Sometimes the actual tissue may be preserved intact because it is embedded within mineralized tissue: for example, collagens are relatively stable and have been extracted from fossil bones. By contrast, other soft tissues may be preserved by mineral replacement of the tissue, on a molecule by molecule basis, producing replicas of muscle tissue such as those known in some fossil fishes from the Santana Formation of Brazil. It seems that both of these processes may have occurred within the therizinosaur eggs, and produced some rather complicated results. For example, some material which is not attacked by the acetic acid has the characteristic appearance of cartilage, but chemical analysis is essential to determine whether it is actually cartilage or a mineral replica. Some thin layers appear to be composed of mineral replicas of flattened (epithelial ?) cells; one sheet of non-bony material is reminiscent of skin. Skin preservation is already known from adult dinosaurs, especially where the skin has been mummified by drying. This aspect of the therizinosaur eggs is in urgent need of further research.

Pond-tortoise embryos

As indicated above, four different kinds of eggs were available for study from the Upper Cretaceous of China. All of these were originally thought to be dinosaurian. But one of the small, nearly spherical eggs has now been shown to contain the complete, largely articulated skeleton of an embryonic pond-tortoise (emyid). The black preservation of the bones is somewhat different from that of the therizinosaur. Although this egg lacks the glamour of the dinosaurs, it is probably the most perfectly preserved Upper Cretaceous embryo known. It is up to 40 million years older than the previous earliest record of this group of reptiles. In another disarticulated skeleton one of the smallest bones of the body, the stapes, which conducts vibrations from the ear-drum to the inner ear, is exquisitely preserved.

Scavengers

The majority of the embryonic remains found within dinosaur eggs are not preserved as complete skeletons. Some eggs clearly decomposed before they dried out, thereby scrambling the arrangement of the bones. In other eggs the bones are actually broken up and appear to be gnawed, and in several eggs the bones are reduced to bone chips. There are clues regarding the identity of one of the culprits. Several eggs contain large numbers of small ovoid structures, rounded at one end and slightly pointed at the other. They closely match the frass (faecal pellets of larvae) of dermestid beetles, which scavenge dried carcasses. Differences in the size of the fossil frass would indicate several different larval stages. The frass does not dissolve in acetic acid, suggesting that it contains a high proportion of powdered bone.

Moldy eggs?

A rotten egg might be expected to be suitable for the growth of molds. When the egg was subsequently infilled and mineralized any molds present might be preserved as mineral replicas by the same processes that were responsible for the preservation of embryonic tissues. We suggest that this may account for some structures resembling a tiny fungus, but this interpretation needs to be investigated by further research.

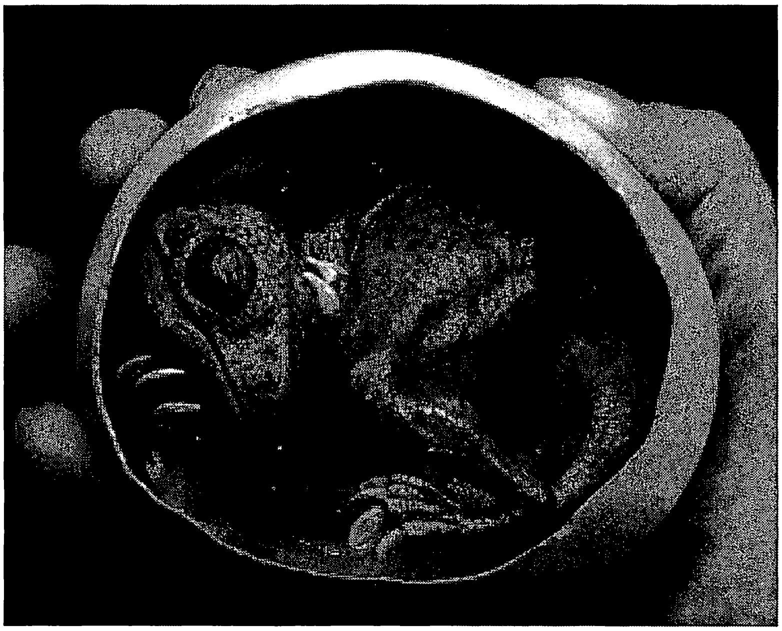
Cretaceous Park

It is well known that attempts are being made world-wide to amplify traces of dinosaur DNA, so far without success. We drilled a core from an egg known to contain both cartilage and well-preserved bone. The core was subjected to the usual cleaning techniques to reduce the possibility of contamination with DNA from a modern source. It was then ground to powder and subjected to the same techniques that have been used successfully to extract residual DNA from less ancient fossil bones. We have so far failed to detect any trace of DNA. Perhaps we should be relieved, bearing in mind that we might have amplified the DNA of Upper Cretaceous bacteria, fungi and dermestid beetles!

Dinosaur classification

When paleontologists hear that a dinosaur egg has a baby inside, the first thing they want to know is 'What kind of dinosaur is it?' As you will have seen, at least some of these Chinese eggs contain a dinosaur which has been identified as a 'therizinosaur' - but what is a therizinosaur? Dinosaurs are divided into two main groups. The Ornithischia (or 'birdhipped dinosaurs) include many well-known forms such as the armored stegosaurs and the horned ceratopsians, as well as Iguanodon. The second group is called the Saurischia (or 'lizard-hipped' dinosaurs). This group contains the sauropodomorphs and the theropods. The first includes some very early dinosaur forms, known as prosauropods, and gigantic sauropods (such as Diplodocus which were particularly abundant towards the end of the Jurassic period (about 140 million years ago). The theropods were carnivorous forms and included Tyrannosaurus and Velociraptor. Theropods are of particular interest because they are thought to be the group that gave rise to birds. It is very unclear where therizinosaurs fit into the classification of the dinosaurs. Some paleontologists believe that therizinosaurs are sauropodomorphs. More recently several researchers have found evidence that suggests that they were unusual theropods.

The issue is still controversial, but it may be that our baby therizinosaur will help settle this argument.



Model of Terry Manning's egg by Brian Cooley

**Florence and Charlie Magovern provide natural history services such as traveling exhibits, appraisals, fossil acquisition and preparation, from their on-line family business in Boulder, Co, StoneCompany.com, Inc. Their exhibit of dinosaur eggs called "Hatching the Past" has appeared in a number of museums and special expositions around the country and is available to museums. Using mechanical preparation, Charlie Magovern revealed a dinosaur embryo in one of the Chinese eggs he had acquired. The embryo resembles Manning's therezinosaur and is named Baby Louie. Magovern is planning next to use CT scanning to view the interior of fossil eggs. Magovern and Terry Manning were featured in a* National Geographic *article called Dinosaur Eggs in 1996. To read the article and find out more about dinosaur eggs, go online to* www.stonecompany.com

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How to 'Print Out' a Lizard Head

Kristina Bartlett

Timothy Rowe has been carrying the head of a rare lizard around in his pocket for months now.

Well, it's not a real head of *Lanthanotus borneensis*, but a bronze replica. Rowe, a geology professor at the University of Texas at Austin, "printed it out" using a ThermoJet solid object printer that rendered a digital version of the lizard head into a wax model, which he cast in bronze. The digital version came from a high-resolution CT (computer tomography) scanner run by the university's department of geology and used by researchers all over the world. The scanner is a high-resolution version of a medical CAT scanner. But, because its specimens are not alive, it can blast fossils, rocks, even pickled lizard heads with higher energy X-rays for longer stretches. Differing densities within the specimen either absorb or transmit the X-rays. This pattern of absorption vs. transmission creates a digital image of the object in 2-D slices ranging from as thick as 5 millimeters to as thin as 5 microns. Medical scanners generally create layers 1 to 2 millimeters thick. Because it maps density differences, the CT scan is a high-resolution look inside any specimen.

"You can see inside the head without having to chop it open," Rowe says. To render the digital scan solid, the ThermoJet solid object printer accesses an STL, or stereo lithography file, created from the CT scan. It sets down wax layers until it builds the lizard head. Like the scanner, the printer borrows existing technology: rapid prototyping, a key tool in the manufacturing industry for creating solid models from computer-aided design files.

The result is a 3-D replica of the lizard's head that is three times the size of the original. Or, Rowe could have printed a replica of the lizard's brain, or a cross section of its sinus cavity.

"There's no substitute for the real deal," Rowe says. But the lizard is rare and the real thing is hard to find and study, he adds. "Now I know the anatomy of the head of *Lanthanotus* in far more detail than I know the anatomy of the heads of the gecko lizards living in my backyard."

The scanner is handy for seeing inside rock samples, too. Lab director Richard Ketcham remembers scanning a diamoniferous eclogite. "It's one of the only examples of diamonds in their host rock," Ketcham says. "You can't study it through thin sections because the diamonds stop the saw."

The lab has everything from meteorites, salamander heads and tiny fossils in the queue for scanning. According to Ketcham, the department gained funding for the scanner from the work of Rowe, a paleontologist, along with anthropologist John Kappelman and metamorphic petrologist Bill Carlson.

From the lab's Web site, digimorph.org, anyone can access digital files and look inside a purple urchin, or the head of the dinosaur *Herrerasaurus ischigualastensis*. And those who own a rapid prototyping machine can, for some specimens, download an STL file and create as many replicas of, say, the Texas horned lizard, as they like.

Visit the website:
www.digimorph.org

The Waldron Shale: Notes on Collecting and Preparation

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Introduction: The Waldron Shale in Brief Context

A simple back-of-the-envelope calculation reveals that only approximately two percent of all marine animal species that have ever lived are currently known from the fossil record. If animals that lack hard parts, such as worms and jellyfish, are included in the calculation, then this number shrinks considerably. Although new fossil species are discovered and described every year, by any estimate, the fossil record offers an incomplete view of the history of animal life. At first blush, this might seem to be a discouraging fact, and indeed, for paleontologists concerned with recon-structing the history of biodiversity and measuring rates of taxonomic evolution, the incompleteness and imperfection of the fossil record is a source of considerable frustration.

Nevertheless, for all the imperfection of the geological record on a global scale, there are very many local triumphs. As a general rule, where those few surviving and exposed remnants of ancient sediments crop-out at the surface of the earth, a rather complete record of local biodiversity is preserved. It is the destruction of these rocks by erosion or the forces of plate tectonics that contribute most severely to the imperfection of the global fossil record. Of course, to be taxonomically complete, the fossil record simply needs to yield identifiable fragments of all of the species that were present. Other factors limit the degree of preservation within those sediments that survive the ages.

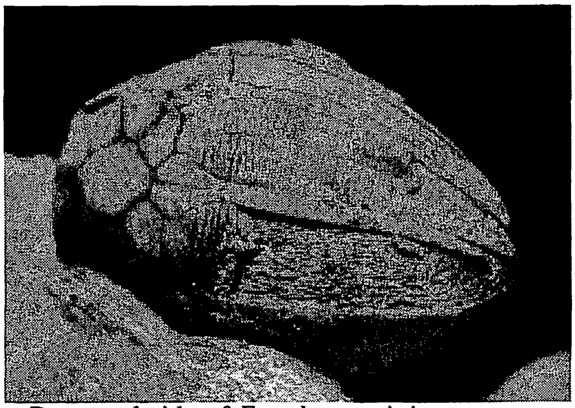
Many of the environments that are preserved in the geological record were not very conducive to animal life, and so, unless some hapless creatures were carried into relatively inhospitable bottom sediments (the spectacular Burgess Shale fauna is an example of this relatively rare phenomenon), the rock will be barren if for no other reason than nobody was home.

Uninhabitable environments are commonly preserved because in order to survive for long periods of time, sediments must be deposited in epeiric seas (seas that overlie continents), where water circulation is often limited. However, where bottom conditions are favorable, sediment supplies can be limited and bottom waters energetic, resulting in a record that is biased towards the more robust parts of disarticulated and broken skeletons. Increasing sediment supplies and/or decreasing the degree of persistent wave energy push the assemblage towards greater degrees of completeness.

It is no accident, then, that in epeiric seas, one of the most common environments yielding well-preserved marine animal communities are those that occupy water depths in the vicinity of storm wave base. These settings are shallow enough to offer favorable living conditions to a wide variety of animals and often close enough to sedi-ment sources to experience relatively fre-quent sedimentation events during storms. It is in these settings that some of the most well known fossil assemblages were formed. The Waldron Shale is one of our favorite examples of such an assemblage.

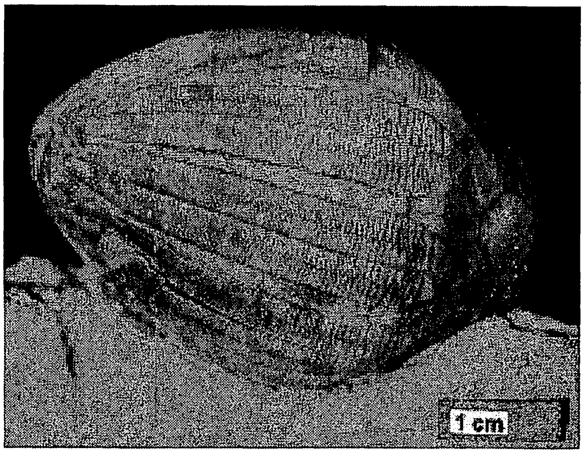
The Waldron Shale was deposited during a small-scale rise in sea level that served both to increase circulation on the carbonate platform (represented by the underlying Laurel Limestone Member of the Salamonie Dolomite) and to open the platform to a limited supply of fine-grained siliciclastic sediment and, presumably, nutrients. The latter helped support a diverse assemblage and the former was important in providing some of the sediment necessary to entomb the biota.

During deposition of much of the Waldron Shale, which must have occurred over the course of several hundred thousand years at most, the sea floor was near or just below storm wave base. The role that storms played in fossil preservation cannot be overestimated in this case. Virtually every single fossil collected in much of the Waldron was, to some extent, directly influenced by storm activity. Ironically, storms were both agents of preservation and agents of exhumation and destruction of would-be fossils. This is often beautifully illustrated in single specimens. For example, articulated crowns of *Eucalyptocrinites crassus* Hall are often found with one side missing the rather delicate feeding arms and one side preserving them. The preservation of one side (the side facing downward on the



Damaged side of *Eucalyptocrinites crassus*

ocean floor) owes itself to rapid toppling and burial of a living individual during a storm, the destruction of the other (the side facing the water column) owes itself to subsequent re-working by yet another storm or to incomplete burial by the first.



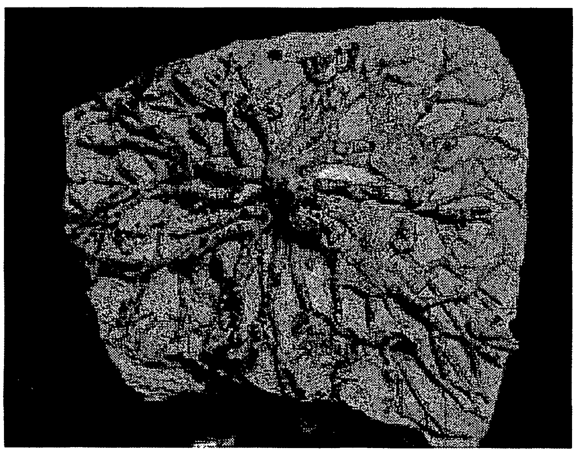
Undamaged side of same *Eucalyptocrinites crassus*

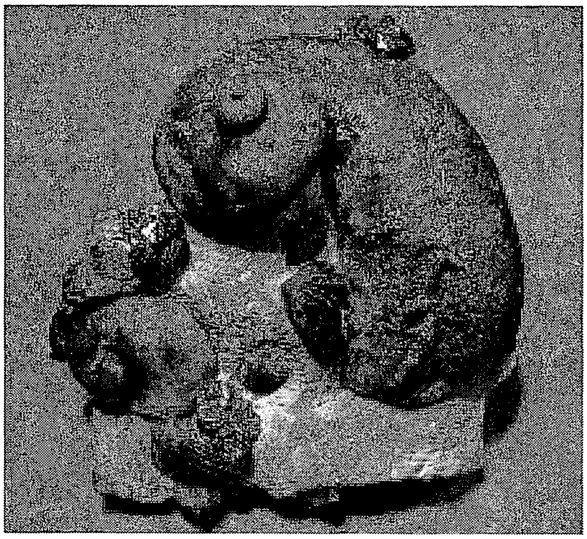
Lithologically, the Waldron Shale is not really a shale at all in many places, although relative to the surrounding rocks, it is most certainly soft and subject to recessive weathering. Instead, the Waldron Shale is composed predominately of fine carbonate mud and terrigenous muds and silts. The carbonate mud is typically at least partly dolomitic and often forms thin argillaceous lime mudstones interbedded with thin mud/silt drapes that were deposited during waning storm flows. Where lime mudstone beds are not so well defined in the Waldron (in the southern part of Indiana, for example), carbonate mud is more thoroughly mixed with terrigenous material, yielding a calcareous, silty shale to argillaceous lime mudstone. Because dolomite is present in the Waldron (and in all of the Silurian of the region), preparation of Waldron fossils can be particularly challenging due to the lack of separation that occurs between the matrix and exoskeleton of specimens, which will be discussed below.

Several different lithofacies and paleocommunity types occur in the Waldron Shale. We are most familiar with the deeper portion of the local Waldron depositional basin, which occurs in the northern reaches of the unit's outcrop area in Indiana (further north still, the Waldron has temporal equivalents in shallower-water carbonates).

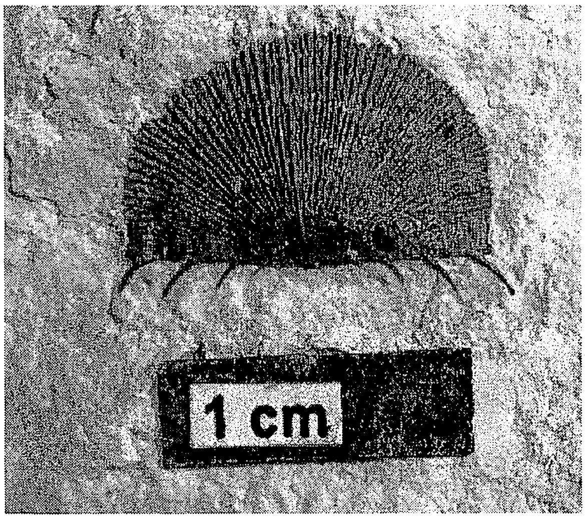
Here, three rather distinct paleocommunities occur. These were summarized by Peters and Bork (1999). Because the bottom sediments in the Waldron were rather soft, many sessile epibenthic organisms, like non-strophomenid brachiopods, were not viable on the sea floor itself. They required a firm attachment surface. For this reason (among others), the most diverse community in the northern Waldron occurs in the lower reaches of the Waldron Shale, where firm, algal-constructed mounds formed small, meter-scale reef-like structures. These positive topographic features served as attachment surfaces for a wide range of organisms and were centers of biodiversity not unlike patch-reefs in today's back-reef environments. Because skeletons can be densely packed around these structures, bedding is not well defined and the shale does not split readily. This facies is presumably similar to that found in southern Indiana, where water depth may have been slightly less than in the northern reaches of the Waldron.

Over much of the northern area, microbioherms disappeared rather abruptly, presumable due to increasing water depth that placed the bottom out of the viable light zone for the algae. Certain sedimentary structures support this hypothesis as well, including regular, persistent bedding surfaces that split readily. After the disappearance of the microbioherms, the bottom environment could no longer support as many benthic organisms. Were it not for the fact that *Eucalyptocrinites* had a root-like holdfast that was well suited for life in soft substrates, attachment surfaces for organisms like brachiopods would have been very limited indeed. It is common to find little hoards of fossils around crinoid holdfasts in this facies. In fact, some specimens have been recovered that show living crinoids serving as attachment surfaces for brachiopods, corals, other crinoids, bryozoans and other organisms (Peters and Bork, 1998). Gastropods, being mobile and tolerant of soft substrates, are also very common in this facies. We have also found specimens indicating that gastropods were the "decorator crabs" of the Waldron. They carried with them an amazingly abundant collection of shelled invertebrates, including brachiopods, crinoids, and cornulitids. Trilobites are also common in this facies, but they did not appear to carry epizoans, presumably because they molt too frequently to be of service.


Crinoid holdfast with little hoards of fossils


"Decorator" gastropods

The upper reaches of the Waldron Shale in the northern region consist of blocky mudstone and are the least fossiliferous of all. *Eucalyptocrinites* appears to be virtually absent in this facies, possibly suggesting either increased turbidity or decreased oxygen content in the water column. Nevertheless, some fossils are present. The delicate, spine-bearing strophomenid brachiopod *Strophochonetes novascotica* is abundant in places. Other strophomenids also occur occasionally. Strophomenids were capable of living on a muddy surface without an attachment surface and so they may not have missed the attachment surfaces afforded by *Eucalyptocrinites* in the underlying facies.

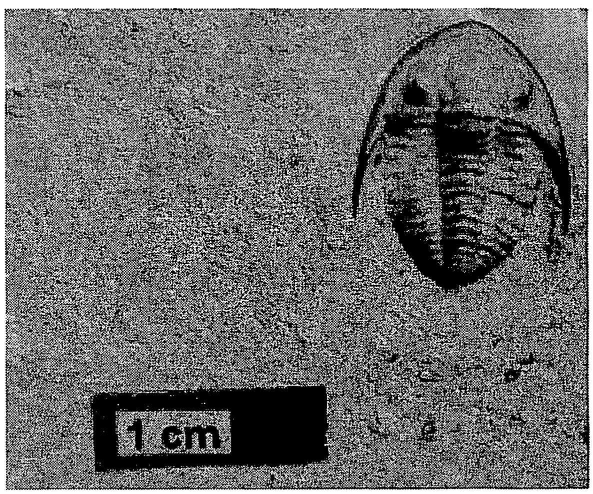


Strophochonetes novascotica

Preparing Waldron Specimens

Much has been written regarding fossil preparation. One excellent manual is the *Fossil Preparation Manual*, by Tom Whiteley and Gerry Kloc. This 78 page illustrated manual is a must for anyone who collects and/or prepares fossils or is contemplating setting up a prep lab of any kind. There is a superb section on selection and use of adhesives. If you don't have this manual, get one! It will serve as a good starting point in cleaning the challenging Waldron fauna. To help you even further should you pick up some favorite specimens from the Waldron, we will offer a few tips and suggestions that may help turn a decent preparation job into a fantastic one.

The first steps towards successful preparation begin in the field. Although today's advances in preparation can often restore a specimen that was needlessly damaged during collection, a little time and attention in the field one can usually avoid such problems. Specimens from the Waldron can be easily damaged or even completely overlooked and thereby destroyed during the collecting process. As mentioned above, there is very little separation between the matrix and exoskeleton of the invertebrate fauna in freshly exposed shale. This causes many specimens, particularly smaller ones, to be incompletely exposed on many bedding surfaces. Over time, the weathering process does break down the matrix to expose reclusive specimens, but many collectors eagerly seek the "freshest" material, thinking it will yield the most well-preserved specimens. However, in relatively fresh material, many fine specimens are all but invisible and many species are exceedingly unlikely to be collected without careful examination of bedding surfaces. For example, the beautiful and diminutive trilobite *Maurotarion chrysti* (Hall) will almost certainly be missed if one hastens through Waldron material.



Maurotarion chrysti

Because of the poor separation between matrix and exoskeleton and rather hard nature of most of the Waldron Shale, hand trimming specimens in the field should always be avoided unless absolutely necessary. If trimming is absolutely necessary, or if a concrete saw is available for field trimming, then one should keep in mind that it is very likely that the specimen you think you are collecting is not alone!

We can site dozens of fine specimens in our collection that we were not even aware were present when the specimen was collected. They were instead discovered during the laboratory preparation process or during detailed examination under the microscope.

One particularly striking example of this was experienced by Marc Behrendt. A fine collector, Marc found one of the most interesting Waldron *Maurotarion* and *Homocrinus* specimens we have ever seen in his driveway scrap material! The specimen had been collected because it happened to be near another, more prominent specimen.

This is a lesson to all of us to take our time in the field and examine every potential specimen for additional goodies. In the Waldron, this lesson is particularly relevant because of the unique nature of the biota. Crinoids, trilobites, blastoids, brachiopods, bryozoans, gastropods, bivalves, cornulitids, and corals are all likely to occur side-by-side on the same bedding surface. Few formations can boast such a richly intermixed and associated fauna.

After relating some of the finer points of how specimens in the Waldron are manifested on outcrop, it is worth noting a few essential tools. Just as air abrasive technology has revolutionized laboratory preparation of fossil specimens, use of cyanoacrylates, or Super Glue, has impacted field collecting like nothing else! No serious fossil collector should venture out in the field without it. Everyone has their own particular arsenal of field collecting equipment of various hammers, sledges, chisels, pry bars, etc. much of this is personal preference. Not with Super Glue, you either have it or you don't! It is not a replacement for careless collecting techniques, and should only be used on dry specimens, but countless fine specimens have been stabilized, repaired, and outright saved by its careful and prudent use. Super Glue works extremely well on Waldron Shale fossils.

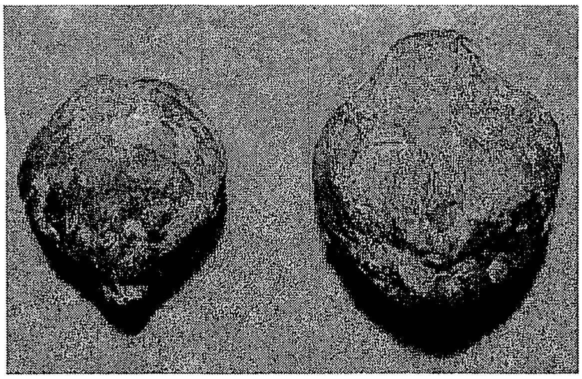
However, people often apply an accelerant to speed up the curing time of the Super Glue and discover that on Waldron Shale, the accelerant turns the matrix a most unpleasant green color. Avoid using accelerant on the Waldron Shale!

Once Waldron specimens are collected, stabilized, labeled, and properly packaged in the field, it is time to return to the laboratory for the real preparation process.

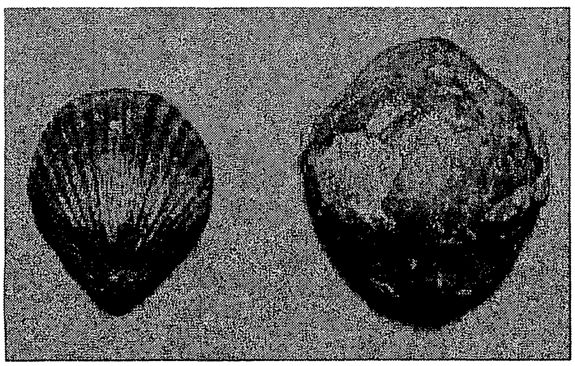
Although it would be wonderful to be able to use a magic chemical to weaken the hard Waldron matrix, chemical preparation should be avoided on all Waldron material. In fact, the only chemical preparation we would recommend is the detergent-based surfactant Quaternary-O or another similar product.

Even then, we recommend that this be used sparingly and only on freely weathered, durable specimens such as corals and brachiopods. Although the surfactant preferentially affects the matrix, it will also affect the surface detail of specimens. Even with the availability of such easy to use and relatively effective chemicals, we still prepare virtually all Waldron material with an air abrasive machine under *high magnification* unless the specimens are retained for study and reference purposes.

Compared side-by-side the difference between a specimen prepared in "Quaternary-O" and one carefully prepared with the air abrasive machine is quite obvious:



Left specimen, *Whitfieldella nitada* (Hall) and right specimen *Meristina maria* (Hall) were both cleaned by boiling in Q-O. Note the incomplete removal of matrix in and around pedicle areas and on shell.



Left specimen, *Homoeospira evax* (Hall) and right specimen *Meristina maria* (Hall) were both prepared with air abrasive with #30 dolomite. Note the fine detail and complete removal of all matrix with retention of the bryozoan epifauna on the *Meristina*.

With respect to abrasives for Waldron Shale fossils anything can be used as long as it's dolomite! In fact, we prepare virtually all invertebrate fossils with pure dolomite powder. The dolomite we use, and highly recommend, is #30 dolomite from Crystal Mark Inc. It's more expensive than agricultural dolomite but the quality is excellent and it can basically be used directly from the container, though sieving is recommended. The use of more aggressive powders such as aluminum oxide should not be used on Waldron Shale fossils.

Once the abrasive has been selected and loaded into our abrasive machine (an SS White model A), we set the pressure to around 35-40 psi for rough cleaning the specimen. Our standard nozzle size is .011 inches and the SS White Model A works splendidly with this nozzle diameter. Many preparators use a larger diameter tip, but we've found that the smaller nozzle concentrates the abrasive stream and cleans better, quicker, and with less collateral damage to the specimen. In rough cleaning, matrix is removed from the slab of the specimen and the specimen itself is cleaned down almost to the shell. The shale actually becomes almost transparent and the color of the underlying specimen can be seen when a specimen is properly "roughed."

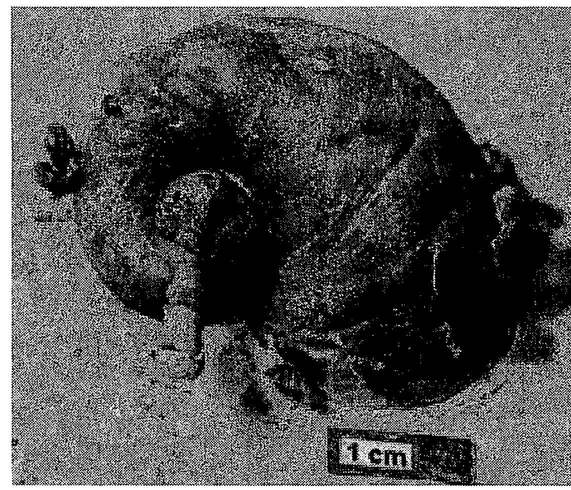
During the rough cleaning process, frequent alternation between the Aro pneumatic scribe and air abrasive is required. The Aro scribe is excellent for fine work and matrix removal can be accomplished right down to just above the specimen, with proper care and a steady hand. Once the specimen is roughed, the pressure is backed down to approximately 10-15 psi. Again, we use the .011 inches tip and dolomite.

Throughout the preparation process, magnification and adequate lighting cannot be underestimated. A proper scope with adequate working distance is absolutely essential to achieve proper detail and results, particularly with Waldron specimens because of the poor separation between matrix and exoskeleton. This is especially true during the final preparation of an already "roughed" specimen. This must be done under very high magnification. During this stage, and every other stage of the preparation process, extreme care must be taken with Waldron fossils as the air abrasive can "burn" specimens very easily. Improperly prepared Waldron specimens can be distinguished by a very shiny, wet look and obvious loss of detail and microstructure.

It is unfortunately all too common to see Waldron fossils prepared using improper pressures or powders. Waldron specimens suffer this fate so commonly because the matrix is dolomitic and very hard, with little separation. The temptation to which all too many preparators succumb is to increase pressure or use a more aggressive powder to overcome the durability of the matrix. In so doing, the specimen invariably suffers because no amount of skill can deter improper pressure or powder.

Another common fate, even when low pressures and proper powder is used, is to over clean Waldron fossils. Again, the durability and poor separation of the matrix contribute to this tendency. Waldron specimens of every variety, mundane to extraordinary, will be transformed into amazing pieces of natural history with the proper preparation techniques. Be patient! After all, they've waited 425 million years to be prepared. What are a few more minutes?

Another particularly interesting feature of the Waldron fauna is that it is commonly associated with pyrite that forms during early diagenesis. Pyrite commonly forms in marine sediments that are oxygen-deprived and organic rich. Although the Waldron is not particularly organic rich, euhedral pyrite crystals are commonly attached directly to many specimens. Although some forms of pyrite are easily oxidized and can actually contribute to the destruction of fossil material, the cubic pyrite in the Waldron is rather stable. When properly prepared the pyrite adds to the beauty of finished specimens and should be carefully cleaned and retained in most cases. Like shell material, pyrite crystals can be pitted and burnt by air abrasive. To avoid this, one can coat prominent crystals that are likely to be damaged during the coarse of preparation with a thin layer of white glue. The glue is sufficient to protect the crystal and can be easily removed during final preparation. The pyrite itself should also be cleaned lightly with air abrasive

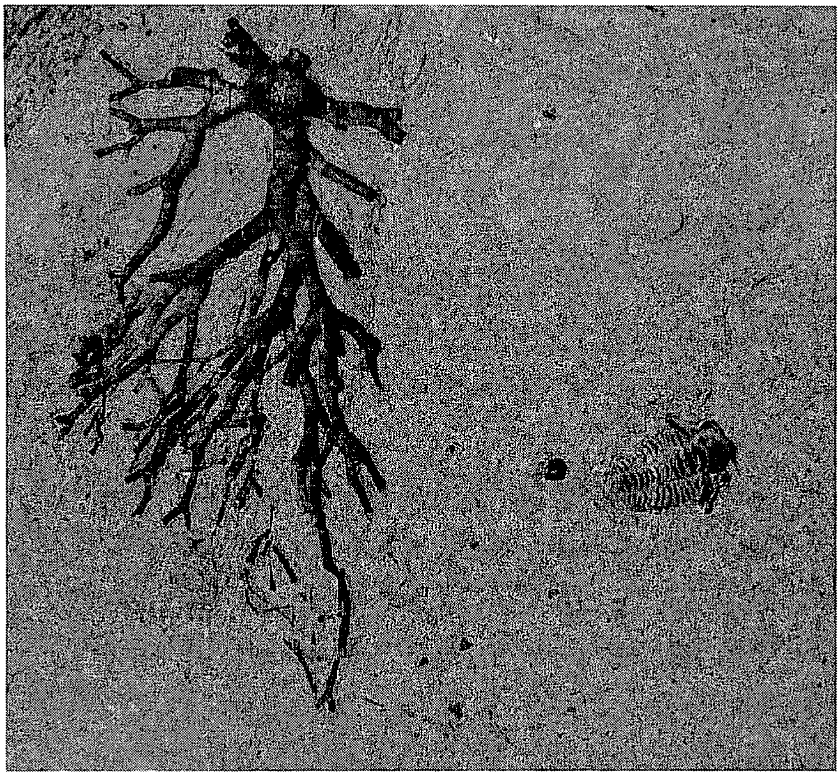


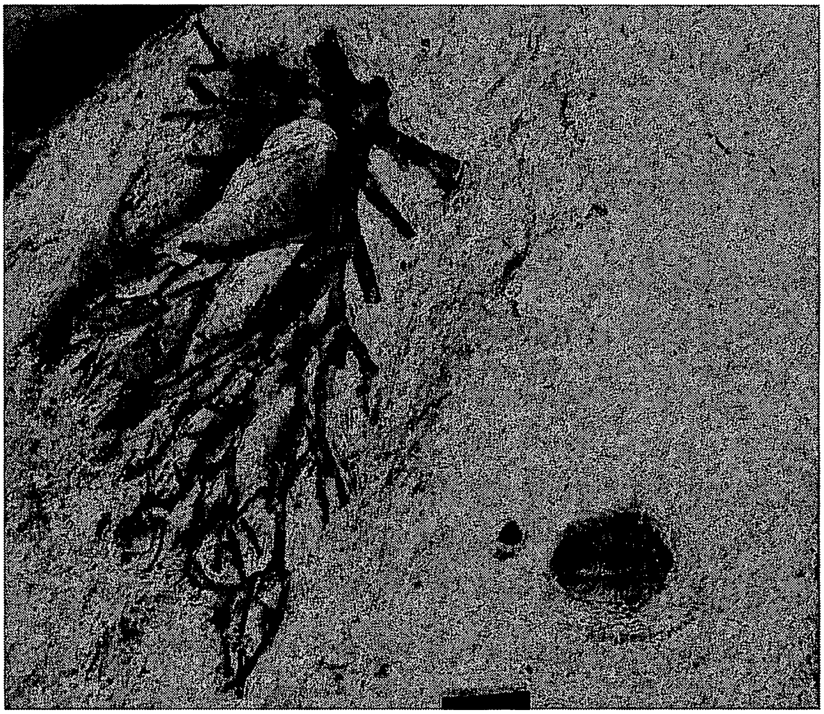
Gastropod with Cornulites and other epizoans

as this gives the mineral surface a brilliant sheen by removing any oxidized rind that may exist. (For an interesting discussion of the role that microbes may play during the pyritization process, see Borkow and Babcock, The Sedimentary Record vol. 1 no. 3.)

Another aspect of the Waldron fauna that demands special attention during preparation is the very high prevalence of epizoans on all taxa. For example, an extraordinarily high percentage of the gastropods in the Waldron carry one or more *Cornulites proprius* Hall, in addition to bryozoans, spirorbids, crinozoan holdfasts, and, rarely, the small rhynchonellid brahciopod *Stegerhynchus*. Such epizoan-host relation-ships often reveal fascinating paleo-ecological interactions and should be preserved. (For more discussion on the taphonomy and stratigraphy of the Waldron, see Feldman, Palaios vol. 4, pp. 144-156.)

Of course, because the epizoans are typically small and not usually the focus of the preparation process, they are very easy to destroy. However, if proper care is taken to preserve epizoans, the overall





quality and scientific value of the specimen is often enhanced considerably.

The incompleteness of the global fossil record is easy to forget when collecting and preparing the well-preserved fauna of the Waldron Shale, yet in so remembering, appreciation and respect for every single specimen, spectacular to ordinary, becomes unavoidable. We contend that this respect breeds success in both the collecting and preparation process, particularly in units that not only represent a unique paleocommunity preserved in exquisite detail but also pose interesting collecting and preparation challenges.

REMOVING SILICIFIED FOSSILS FROM LIMESTONE
BY ACID ETCHING

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Acid-etching of silicified fossils from a limestone matrix provides a rapid, inexpensive, and efficient method of processing large or small rock specimens. Grant (1989) provided an excellent review of the process, and the purpose of this summary is to illustrate some of the steps involved. The process has been especially valuable in processing bulk samples involving hundreds or thousands of pounds of rock. Cooper and Grant, in their classic multi-volume "Permian Brachiopods of West Texas" published by the Smithsonian Institution in the 1970s, illustrated some of the most spectacularly preserved fossils in the world. Cooper and Grant (1972) dissolved over 7000 pounds of rock to produce their large collection from Texas. The paleontologist's purpose in making large collections is to try to find the "perfect specimen," but also to find the rare species seldom documented in small collections.

The main requirement, of course, is that the original minerals in the fossil (commonly calcite) have been replaced by silica; otherwise, the fossils and limestone will both be dissolved. Figure 1 shows specimens of the spine-bearing Permian brachiopod *Yakovlevia* from the Glass Mountains of Texas. In Figure 1a the brachiopod is exposed on the rock surface through natural weathering. Because the shell is replaced by silica, it stands out in relief. It would be very difficult and time-consuming to try to break the specimen from the solid limestone matrix without damaging the shell or spines. Figure 1b shows a specimen of the same type of brachiopod after it has been etched from the matrix with acid. All the fine details are perfectly preserved.

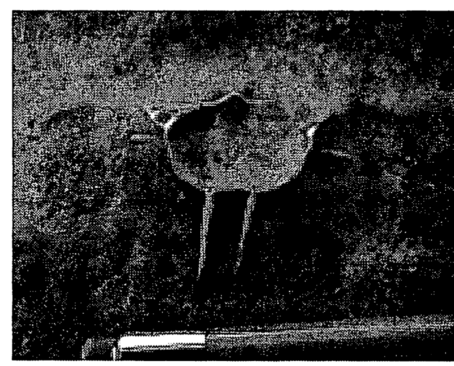

Figure 1a

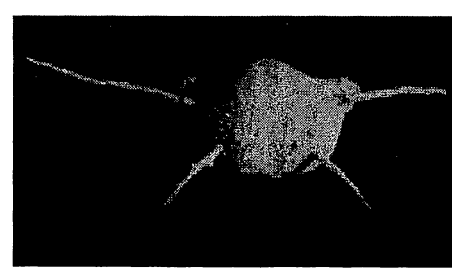

Figure 1b

The process begins with collecting the rocks. Once a suitable locality is found, someone has to carry the rocks to the field vehicle. At academic institutions, this person is usually a graduate student (Figure 2). Cooper and Grant (1972) described collecting one block from a particularly fossiliferous locality that weighed 186 pounds. Following Murphy's Law, the very best fossil

Figure 2

localities seem to be the furthest from the road or at the highest point on the mountain.

Back at the lab, one side of each limestone block is painted (Figure 3). If

Figure 3

unpainted blocks are dissolved the acid will dissolve the limestone from all directions, and the weight of the block will crush any specimens that are etching from the bottom side. The paint protects the bottom from the acid and allows the acid to dissolve the block from the top and sides inward and downward. Any acid-resistant coating will work, but latex paint is the cheapest. Several coats may be required on large specimens.

The process of dissolution of the limestone blocks is done in acid-proof containers. Smaller specimens can be put in dishpans, but larger specimens may require custom tubs (Figure 4). The lab illustrated belongs to A. J. Boucot at Oregon State University, and it is located outdoors for better ventilation.

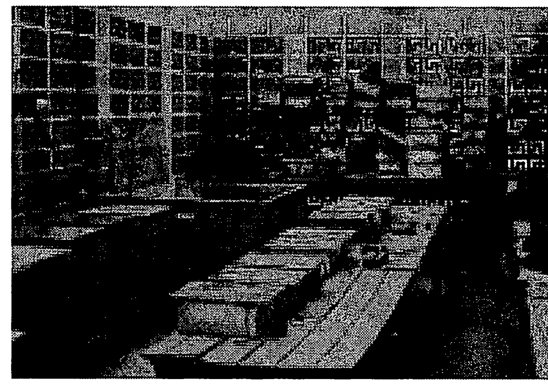

Figure 4

Blocks are placed on a piece of fiberglass window screen and then placed on a tray before being put in the acid. Several acids will dissolve limestone including acetic (vinegar), and formic acid (squashed ants), but hydrochloric acid (HCl or muriatic acid) is the least expensive and the most rapidly acting. Sulfuric acid (battery acid) does not work well because it produces a gypsum coating on the fossils. When exposed to acid, the

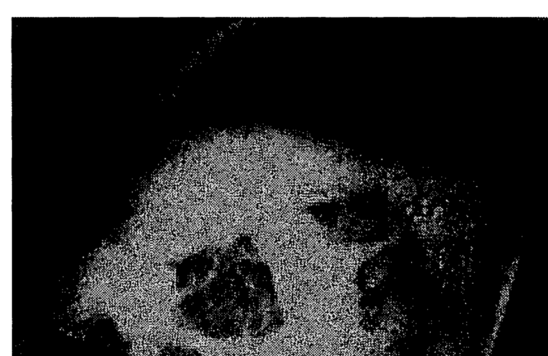

Figure 5

limestone matrix will bubble rapidly (Figure 5). The stronger the acid the more vigorous will be the action. Muriatic acid (pool cleaner) purchased at the hardware store is about 25-30 percent HCl, and it is advisable to dilute it with water. Remember to always add acid to water, and not vice versa. When working around acid, it is also advisable to use

Figure 6

gloves, a respirator, and safety glasses (Figure 6). Extended exposure to hydrochloric acid fumes will corrode most metals. When the bubbling action stops after a few hours, either the acid is spent or the matrix is all dissolved. If limestone matrix is still present, add more acid. When all the limestone is dissolved, remove the tray, screen and residue

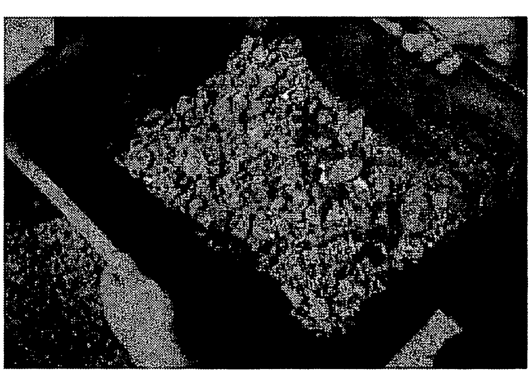

Figure 7

from the acid (Figure 7) and place in water. Gentle movement of the tray and screen in the water will wash out the fine mud that may be present. The residue should rinse in fresh water on the tray (Figure 8) for at least an hour to remove any acid residue and calcium chloride. Remove the residue and allow to air dry (Figure 9). Resist the urge to poke at the fossils while they are still

Figure 8

Figure 9

wet. Silicified fossils are delicate, and they are much heavier and easily damaged when wet.

How many fossils will you get from a block of limestone? It is much like an Easter egg, because you cannot tell what is inside until it is dissolved. Cooper and Grant (1972) recovered 10,000 useful specimens from the 186-pound block mentioned previously. The quality of preservation of brachiopods from the Permian of the Glass Mountains is also exceptional. Many of these tropical shells have elaborate ornamentation of fine spines (Figure 10), and even the smallest specimens are recovered (Figure 11). Delicate fossils such as

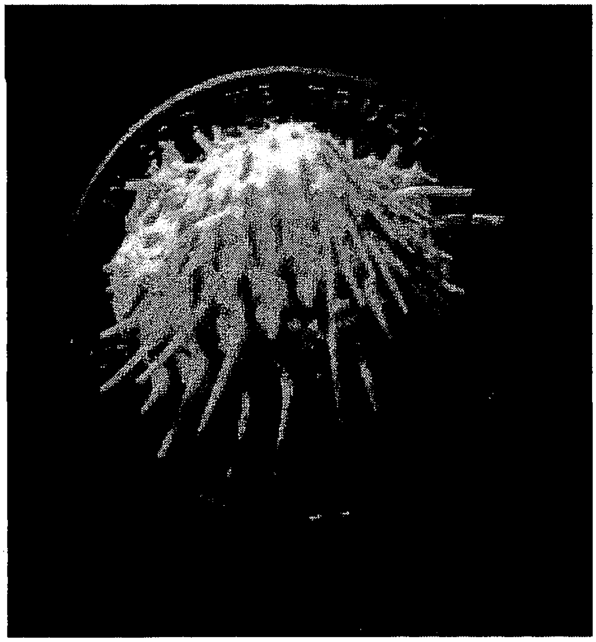

Figure 10

Figure 11

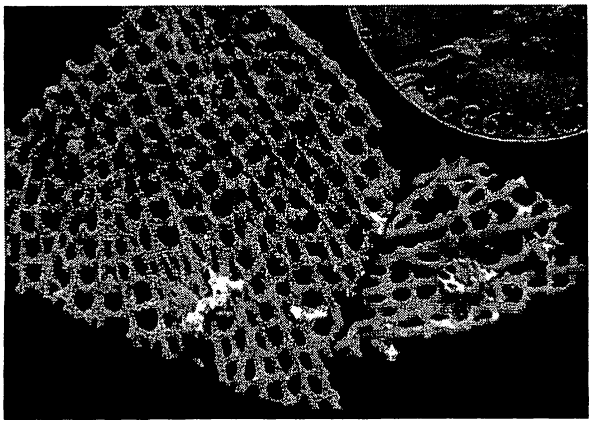

Figure 12

fenestrate bryozoans (Figure 12) show the finest details.

The specimens should not be handled with fingers. Flexible tweezers (Figure 13) can be used to pick and sort the specimens. Most silicified specimens should be hardened by a light spray of acrylic or dipped in a weak solution of hardener such as Alvar. Broken specimens can be glued back together with household cement.

As noted by Grant (1989), some paleontologists (including this author) spend their entire careers in the pursuit of silicified faunas and are generally rewarded with abundant and well-preserved specimens.

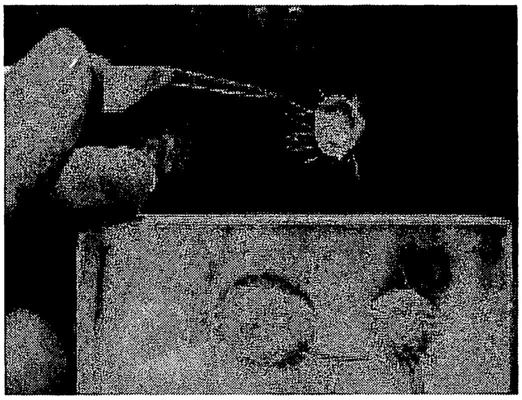

Figure 13

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MICROFOSSIL TECHNIQUES: TOOLS AND METHODS FOR ALL BUDGETS

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ABSTRACT—Often overlooked by the amateur collector, microfossils are abundant and can form a fascinating part of a fossil collection. While it does take extra effort and expense to extract, prepare, and study microfossils, equipment and methods are available to match a variety of budgets and levels of interest and expertise. This article details tools, preparation techniques, and storage methods for working with microfossils, along with techniques for photographing specimens and suggestions for where to turn for supplies and further reading to expand your knowledge and skills.

THE REWARDS AND ADVANTAGES OF COLLECTING MICROFOSSILS

I've lived in a lot of states so I've been privileged to sample from a wide variety of fossil sites, and I pride myself on having a decent collection of self-collected fossils of all sorts. Yet for most of my collecting career, it turns out I overlooked the vast majority of fossils out there. They were easy to overlook. Most are the size of a sand grain or smaller and blend right in with what we usually consider nothing more than annoying matrix. And most can't be appreciated without a lot of effort to isolate them and without specialized (and increasingly expensive) equipment to view them. I'm talking about microfossils!

But while microfossils take more effort to isolate and appreciate than larger macrofossils, the rewards of microfossil collecting are many. The actual collecting is relatively simple. A single chunk of rock from the right horizon at a locality may yield hundreds, if not thousands, of specimens representing a huge diversity of families, genera, and species. The level of detail is spectacular on these little creatures, making it well worth the extra effort to view those details. And, once the fossil is cleaned, catalogued, and ready for your collection, you need a whole lot less storage space (Fig. 1).

In earlier days of paleontology, paleontologists and their corporate sponsors such as Andrew Carnegie were often of the bigger-is-better mindset. Layers of matrix were blasted, shoveled aside, and discarded in an effort to get at ever bigger dinosaur remains. But today's paleontologists realize that to draw a picture of the complete environment in which these big guys lived, you need to think small and sift through what was once discarded as useless matrix. Pollen grains, forams, lilliputian clams and snails: these tell the story of a whole environment, from the base of the food chain on up, and of the climate of that environment. Once considered most important in stratigraphic correlations and the oil industry, microfossils are an essential component throughout paleontological investigation today.

As I noted at the beginning of this article microfossils can require specialized equipment to properly collect and

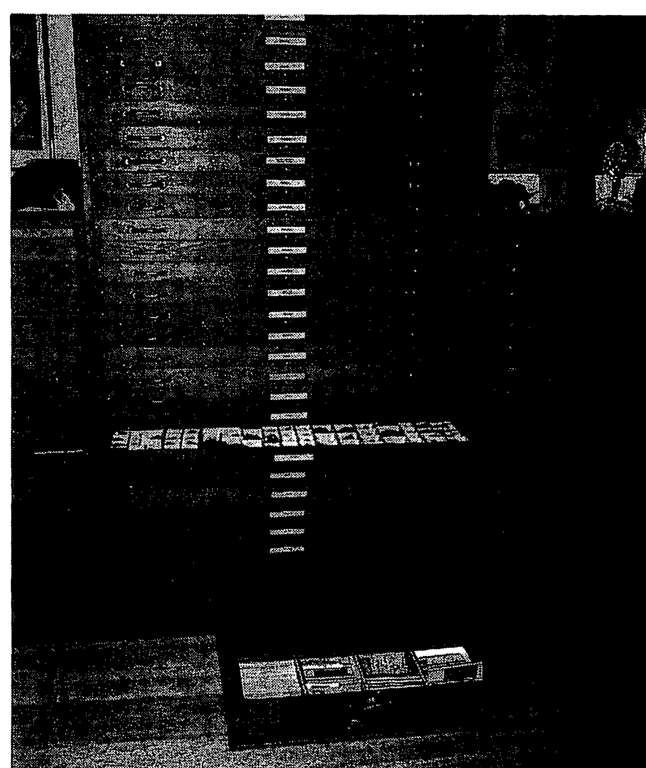


FIGURE 1 – While a collection of macrofossils might fill a roomful of tall cabinets, a microfossil collection with thousands of specimens fits compactly in a space no bigger than a bread box.

curate them. But don't let that scare you off! The hobby of microfossil collection and preparation doesn't need to be expensive. As with most aspects of life, there's a high-end/high-cost path but also a low-end/low-cost path; a path for the advanced collector, but an equally valid path for the beginner. Budget-conscious beginners can find it within their means to produce excellent results at bargain-basement prices until they've become hooked and decide it's time to graduate to bigger and better toys. To illustrate, let's take a look at those toys.

TOOLS OF THE TRADE

While all you may need is a pick, a chisel, and a good eye to spot and collect macrofossils and then a toothbrush to clean them back home, microfossil collecting does require a bit more in your toolkit. If you're really into this hobby, then you absolutely have to have everything listed in Table 1 and illustrated in Figure 2. (Prices listed for the more specialized materials are from the 2002 Ward's Natural Science Geology catalog and have likely gone up.)

If you think I've compiled the list in Table 1 to scare you, you're right! True, the ultimate connoisseur may find each and every one of those items to be absolutely indispensable. Then again, I started this hobby with just a baggie, a kitchen sieve, a magnifying glass, and tweezers.

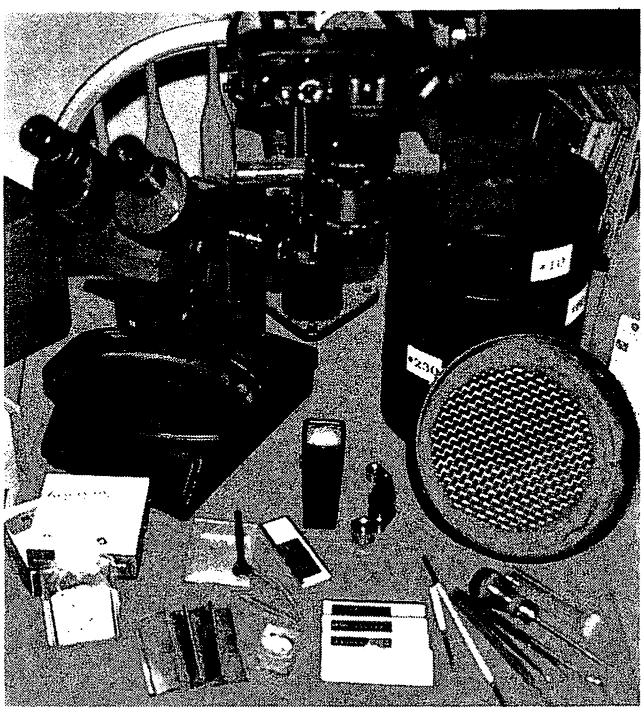


FIGURE 2 – The supplies you might eventually consider "essential" for collecting microfossils can be many – or they can consist of as little as a screen and a pair of tweezers.

I had been to a site in Kansas called Buffalo Mound said to have fusulinids, or little rice-shaped fossils. Sure enough, the ground at the site looked like the sidewalk of a church after a wedding party. I scooped up a handful of dirt and rice-shaped particles, took them home in a zip-lock baggie, screened out the dirt with my wife's kitchen sieve over the sink (didn't tell her that), and picked through the fossils with tweezers under a hand-held magnifying glass. With Elmer's glue, I mounted several choice specimens atop pins from the sewing basket. I made little labels on heavy cardstock from a piece of junk mail that had been delivered that day, ran the pins through the labels, and stored the collection on a leftover piece of Styrofoam I found in the garage. For a beginner starting out with larger microfossils that are clearly visible to the naked eye, that's all you really need.

Like any hobby, the more you get into it, the more expensive it proves, but it's not so big a hit if you progress gradually, purchase items only as the need arises, and keep an eye open for bargains. Although I had always collected small as well as large fossils, my microfossil collecting didn't take off in a big way until the day I located a used binocular or stereomicroscope for under $100 (the asking price for a similar microscope, new, is currently about $450). Unless you start photographing your specimens, this is probably the most significant investment required for the serious microfossil collector, and you don't really "join the club" until you have a quality bi- or trinocular microscope. But beyond that, as you'll see in this article, for almost every expensive way of doing something, there's a less expensive alternative.

EXTRACTING MICROFOSSILS

Some microfossils are just fine left in the matrix. For instance, specimens of mahogany ostracods speckling yellow Silurian limestone from Hollidaysburg, Pennsylvania, look stunning as is. But most microfossils need to be separated from matrix to be seen and appreciated to best advantage.

Some require little preparation. In my hometown of Ventura, California, I can scoop up loosely consolidated Pleistocene sediment and pick out fossils with tweezers under a magnifying glass. Similarly, while visiting my mother in Nebraska, I found Mississippian-period fusulinids, urchin spines, and other tiny fossils already weathered from their limestone and simply sitting on the ground to be picked up.

Usually, though, much more is involved. In fact, you have a host of techniques from which to choose depending on the nature of preservation and the matrix containing the microfossils, and you should experiment to find the technique that works best for sediments you collect. I have space to go into only a few techniques for the more commonly encountered types of microfossils. To learn many more, you should turn to books such as Brasier's

TABLE 1 – Supplies for Collecting, Preparing, Storing, and Photographing Microfossils

Supply	Typical Prices
Sample bags with draw cords and tags	$34.00 - $49.50 for package of 100
Heavy duck canvas sample bag	$33.50 for box of 10
Plastic zip-lock bags	$1.69 - $3.99 for box of 50 - 300, depending on size
Hand trowel	$6.39
Mortar and pestle set	$5.95 and up
Hot plate	$14.94 and up (up to $454.27 for lab-quality plates)
Five- and eleven-quart plastic buckets	$1.65 - $8.09
Pyrex measuring cups (1- and 4-cup measures)	$3.79 - $5.89
Glass beakers	$6.83 - $59.76, depending on size
Plastic funnels	$2.59 for set of 3 varying sizes
Acetic acid, or distilled white vinegar	$3.99 for 1-gallon bottle
Muriatic acid	$4.98 for box of two 1-gallon bottles
Sodium bicarbonate, or household baking soda	$0.75 - $0.99 for 1-pound package
Washing soda	$4.50 for 55-ounce box
Kerosene	$4.00 per gallon
Hydrogen peroxide	$0.86 - $0.97 for 16-ounce bottle
Vinyl lab apron	$3.59 - $8.99
Safety goggles	$3.69 - $13.95
Heavy-duty long-sleeve rubber or latex gloves	$0.79 and up
Face masks	$3.99 for package of 5
5-inch diameter wire kitchen sieve or strainer	$5.19 - $6.59
Stackable sieve set with mesh sizes #5, #10, #60, and #230	$58.60
Stackable brass sieves, two dozen sizes, 25.4 - 0.044 mm	$42.25 - $88.50 each individual sieve
Large paper coffee filters	$3.89 for package of 500
Plastic trays	$2.30 and up
Petri dishes	$0.18 for plastic; $4.05 for Pyrex
Micro-spoon or spatula	$4.25
Teasing needle	$2.28 for package of 12
Tweezers	$1.29 - $2.99
Fine 00 and 000 sable hair artist paint brushes	$4.19 - $5.29
Microscope slides	$7.75 for package of 72
Micropaleontology slide mounts, 1 mm deep	$24.50 - $36.00 for package of 100
Micropaleontology slide mounts, 2 mm deep	$61.00 for package of 100
Aluminum slide holders	$76.25 - $109.00 for package of 100
Pressure-sensitive lab labels	$1.69 - $1.99 for packages of 150 - 500 labels
Small vials with stoppers	$2.50 - $11.40 for packages of 12
Hinged-lid plastic boxes, 1-inch square	$2.90 for package of 10
Plastic magnifier boxes	$4.80 for package of 10; $33.60 for package of 100
Elmer's Glue	$1.85 for 4-ounce tube
Gum Tragacanth or Gum Arabic	$9.99 for 2.5-ounce bottle of Gum Arabic
2X to 4X reading magnifying glass	$5.49 - $12.99
10X to 20X triplet magnifiers	$4.75 - $55.00
Desktop magnifier lamp	$19.95 for basic, up to $275.00 for deluxe
20X to 40X stereomicroscope, binocular or trinocular	$149.00 - $4,925.00 and beyond
High-intensity illuminators	$17.95 - $229.00
35mm SLR camera	$300.00 and up; shop around and try a used camera
Macro lens for camera	$289.95 and up
Camera "T" adapter	$14.95
Microscope tube adapter for 35mm cameras	$15.95
Camera copy stand for macro photography	$125.00 (more expensive ones have lights attached)
Camera tripod	$22.95 and up

Microfossils or Kummel and Raup's *Handbook of Paleontological Techniques*.

The further you delve into the hobby, the fancier the equipment you'll find you need. However, while laboratories at universities and within the scientific offices of oil companies may be stocked with special facilities and exotic instruments, the most commonly collected microfossils can be extracted in your own pre-existing laboratory: the family kitchen. The exotic necessities include a screen, a sink, a stove, and a few containers.

The first step in any technique is to break your host rock into small fragments. Unconsolidated sediments might be crumbled by hand, and soft rock might be dissolved overnight in a bucket of water. Some hard calcareous and siliceous fossils might also be extracted from soft limestone, sandstone, or shale by scrubbing vigorously with a hard bristle brush. You can do this "dry" over a container or "wet" under running water, collecting the residue in a bucket under a hose or sink.

Harder rock samples need to be pulverized with a mortar and pestle or a hammer. You should pound, not grind. Pounding will help jar loose microfossils whereas grinding crushes fossils along with host rock. If using a hammer, place your rock sample inside several plastic baggies and then in a canvas bag, place on a hard surface (cement sidewalk) and strike. You don't need to pound the sample completely into powder, but down into manageable pea-sized chunks.

For some mudstone, siltstone or sandstone samples, further disaggregation can be accomplished in an ordinary bucket and a kitchen pot. (In my "lab," I use pots and pans I picked up for a dime at yard sales.) Dry the sample thoroughly under the sun or in an oven, cover it with hydrogen peroxide overnight in a plastic bucket, then pour off the peroxide and boil the sample in a pot of water. Adding a little baking soda to your fossil chowder also helps in breaking down the matrix.

A similar "solvent method" may be used for some shales, marls, and soft limestone using paint thinner or kerosene in place of hydrogen peroxide. After breaking rock into fragments, dry it in an oven and sprinkle it into a plastic bucket. Soak it for anywhere from several hours to several days in kerosene, then pour off the solvent (filtering and saving it in a jar, if you like, for use with your next sample) and pour on hot water. Let it soak for a day or two. The water will replace the kerosene in the sample, causing the matrix to disintegrate. To assist in the action, you can put the sample in a large jar and set it outside in the warm sunshine, like my grandmother used to do with tea bags to make iced tea. You'll end up with a layer of sludge that you can screen through a fine-mesh sieve and boil with water and a pinch of detergent to continue breaking down any remaining pieces of shale or marl before washing with clean water, decanting, and concentrating the remaining sample.

Soft and grainy limestone may be "cooked" in common washing soda from the laundry section of the grocery store, creating a pot of petrified chowder. Move to your kitchen stove or plug a hotplate into your workbench, and fire up a pot of water. While the water comes to a boil, break chunks of your sample into small pebbly fragments. Sprinkle your rock fragments and crumbs along with a couple tablespoons of washing soda into the boiling water. Simmer and continue adding water as the mixture boils down for half an hour or more, then rinse the resulting residue in pure water.

To retrieve microfossils replaced by silica (quartz) or phosphate from limestone, dolomite, and other carbonates, you can turn to acid baths, a procedure that involves soaking specimens over a period of several hours. (Don't do this with calcareous fossils as they'll simply dissolve along with the matrix!) Soft, chalky limestone may dissolve in a solution of very weak, 5% non-glacial acetic acid, or plain white vinegar. While weaker acetic acid may work with especially soft limestone, often you'll need to work with stronger acid, such as muriatic acid, found in a hardware store with swimming pool supplies.

WARNING: You need to exercise extreme caution in using acid (or any chemical) and handle with care. Use at your own risk! In working with acid, I always wear a work shirt, a vinyl lab apron, thick rubber gloves with long sleeves, goggles, and a face mask to protect skin, eyes, and lungs, and I work outside for maximum ventilation and do all possible to avoid breathing fumes (Fig. 3).

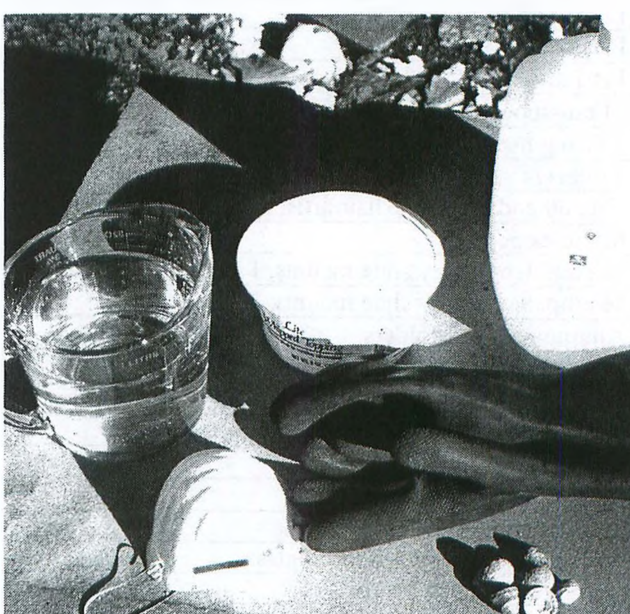


FIGURE 3 – Exercise care in working with acid and other chemicals. I work outside with plastic and glass containers and wear thick rubber gloves, goggles, and a face mask to protect skin, eyes, and lungs.

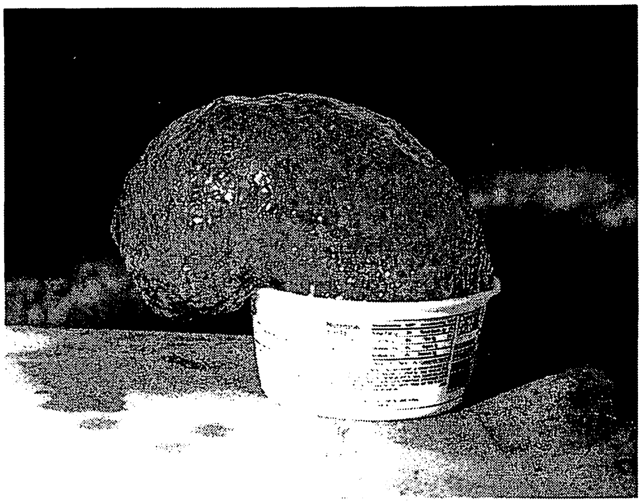


FIGURE 4 – Use too much acid to dissolve limestone and you may end up with an unwanted surprise!

I've also learned by experience to go light on the acid. Too much acid results in overly vigorous action that not only creates a mess (Fig. 4) and but also potentially damages fossils. Keep in mind that some of these fossils have been waiting around for 300 million years or more to meet you. Giving them a few hours or days to emerge from an acid bath undamaged is the least we can do.

For acid baths, I've used beakers, one-quart Pyrex measuring cups, and/or plastic tubs (the kind that Cool Whip or margarine comes in—as noted earlier, this hobby need not be expensive). The volume of acid used should be about two times the volume of rock, and it should be diluted with water (anywhere from five to nine parts water for one part acid) to slowly and gently dissolve the material. In working with acid baths, it's always best to work with small amounts of rock. You should pre-measure water in the tub or beaker, drop in your rock sample, and then add acid. Pouring water into pure acid can result in a violent reaction that splatters. Not a good idea! A handy rhyme to remember the proper sequence is, "Always add the acid to the water, like you otter."

Let your sample dissolve 6 to 24 hours in a well-ventilated area away from anything that might be corroded by acidic fumes. You should check your tubs periodically, and if fizzing has stopped, you may need to re-charge with a bit more acid. Once the rock has dissolved, pour off the acid solution. Take care in disposing of this. I use a plastic funnel to pour it into an empty plastic milk carton with a cap, and I take it to the hazardous waste station at the local landfill.

The final step involves rinsing and decanting the residue several times in fresh water mixed with a pinch of baking soda to neutralize any remaining acid. To decant, I use two small plastic margarine tubs or Pyrex beakers. I gently swish the residue around in a circular motion, briefly allow heavier particles to settle, and pour off the muddier water into the second tub to dispose of it. I add clean water to the residue, swish and pour off once again. I do this several times until the water is clear and then allow the residue to dry.

Some of the tiniest microfossils collected by amateurs are diatoms, marine algae with beautifully intricate silica tests or "skeletons" reminiscent of snowflakes. However, these are truly tiny: more than 60 million individual specimens might be found in a single cubic inch of pure diatomite. Working with them requires a higher power microscope than used with most other microfossils. (Scientists today opt for scanning electron microscopes, at a cost beyond the reach of most of us mere mortals.)

Given their tiny size and the extra equipment necessary to work with them, diatoms aren't so avidly collected by amateurs as other microfossils. Still, they are so very beautiful, even a small sample can make a splendid addition to a collection. To examine diatoms from deposits of nearly pure diatomaceous earth near Lompoc, California, I've found that all I need do is lightly tap the tip of my finger on a chunk of diatomite and then smear the dust over a microscope slide. However, in deposits of lesser purity, the small structures of diatom tests are often occluded by clay or other matter in the sediment. Clearing these structures requires processing with chemicals such as hydrogen peroxide, hydrochloric acid, or nitric acid. Then sprinkle a tiny amount of residue on a glass microscope slide and attach a cover slip with a mounting medium.

In any of the techniques I've described where you use acid, kerosene, hydrogen peroxide, washing soda, or other chemicals or solvents, good ventilation is essential. As noted, I do all my work with acid outdoors. Because I didn't consider washing soda fumes to be as hazardous as acid, I once cooked pieces of Salem limestone from Indiana on my kitchen stove. I ended up tasting soap on the roof of my mouth for the next two days. I now also do that particular technique outside, as well, on a hotplate.

CONCENTRATING MICROFOSSIL RESIDUES

So, you've broken and boiled your sample, dissolved it in acid or soaked it in kerosene, and your kitchen now smells like an auto shop. It's time to measure your success! You should have a small sample of grainy residue, and the next step is concentrating it in preparation for the final step of picking out fossils.

Decanting

I've already described one technique for concentrating fossil-bearing residue, namely, decanting. Place your residue in a small beaker or margarine tub, fill with water, and swish around with a circular motion to release dirt and clay. As fossils settle on the bottom, decant, or pour off the muddy water. Repeat until the water is clean, and drain the residue onto a cloth, paper towel, or newspaper and let it dry completely. (Newspaper tends to work better because fossils tend to cling more to cloth or paper towels upon drying.) Once your sample has dried, gently massage it with your finger to break it up and sprinkle it into a clean container for picking.

Dry Sieving

Another way to rid your dried residue of unwanted clay and other matrix is by shaking it through finely screened sieves. Prefabricated interlocking sieves in a variety of mesh sizes are available that allow you to simultaneously screen out clay particles and separate your fossil sample by size, which makes subsequent sorting and picking a lot easier.

Scientific supply houses like Ward's sell sieve sets of differing sizes and quality for differing budgets. They range from simple four-inch diameter plastic sets of four screens for $23.50 to deluxe eight-inch diameter sets made of polished and lacquered brass available in two dozen screen sizes (at a cost ranging from $42.25 to $88.50 for a single screen). If your arms get tired from shaking your sieves, for a mere $939 you can even buy an electric shaker for these brass sieves with vertical and horizontal tapping action and a 30-minute built-in timer. I've purchased an interlocking set of 6.5-inch diameter sieves through Ward's for about $50 (see Fig. 2). It includes four sieves of mesh sizes 5 (4 mm), 10 (2 mm), 60 (0.25 mm), and 230 (0.0625 mm) and a closed bottom pan. If I ever buy a fifth sieve, it will probably be a 100 (0.149 mm) or 120 (0.125 mm). No, I didn't buy the electric shaker!

Of course, another option is investing in a bit of gasoline, driving to your hardware store, and making your own sieve set from the window screen department, using a variety of screen sizes stapled to frames constructed from scrap wood. Nylon stockings are perfect for providing the finest mesh you'll likely ever need. (One technique for this is to stretch the nylon in an embroidery hoop.) Larger microfossils can also be captured through a wire kitchen strainer although a greater variety of microfossils are obtained by using a series of graduated screens.

Wet Sieving

Wet sieving is the same as dry sieving but done under running water, either at a kitchen or laundry room sink or outside with the garden hose. It's usually best to do this outside to avoid clogging your sink. Or, if you do work at the sink, work over a bucket to catch any clay or sand for disposal. Stack your screens, largest mesh on top, and spray gently with your hose or faucet.

However, wet screening doesn't work for all sediments. Some shale and clay turns into a sticky, gummy mess, and won't pass through the screens. If you run into sediment like this, your best bet is to dry sieve and later try one of the solvent methods to remove any clinging bits of clay. Then boil with water (either clean or with a bit of detergent) and decant.

MOUNTING, STORING, CURATING

If you've chosen the decanting or wet-sieving methods for concentrating your fossil residue, allow it to dry thoroughly. Now comes the fun part: hunting for fossils!

Sorting through the Residue

Once your residue has dried, transfer it to a flat "picking tray" with either a light or dark surface. Some folks use petri dishes, others use small plastic or enamel trays, and I've even seen one person use the lid of a 35 mm film canister. You want to take advantage of contrasting colors: a dark or black picking tray is best for sorting through light-colored fossils and a white one for sorting through dark fossils. If using a petri dish, you can slip either a white or a black card under the dish as appropriate. I do most of my sorting in the small black plastic trays from single-entrée frozen dinners. (A drawback of such plastic trays is that static electricity sometimes builds up if you shake the concentrate, and you end up with fossils that move about like jumping beans!)

With a micro-spoon, take just a pinch of residue for sorting under magnification. Don't dump a heap of sediment. It's far easier to take the patient route of limiting the quantity to examine every grain methodically and deliberately. Gently sprinkle a small amount evenly across the surface of the picking tray and search for fossils under a dissecting stereomicroscope (Fig. 5). A relatively

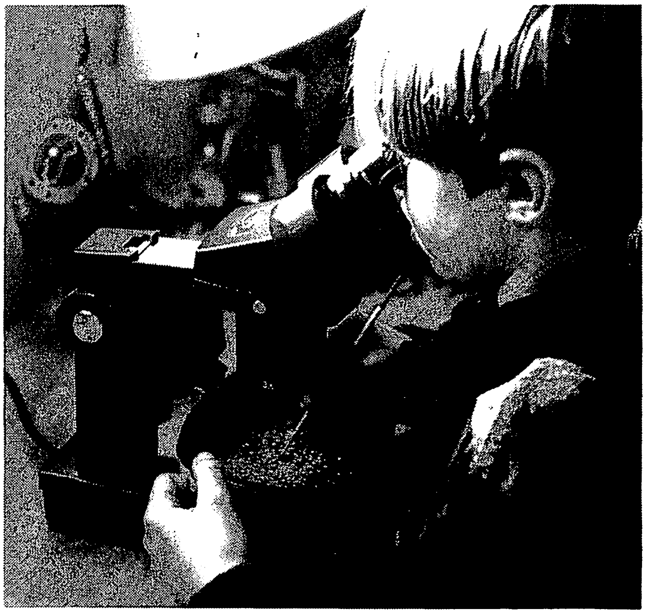


FIGURE 5 – Sorting through residue in a picking tray under a stereomicroscope to pick out microfossils with a fine sable hair paintbrush.

low-powered scope with 20X magnification generally serves well for most types of microfossils collected by amateurs.

A quick way to initially sort fossils from unwanted sediment is to clear a space on your picking tray with a teasing needle. Nudge fossils to this space. You can pick out larger microfossils with tweezers, but for most microfossils, it's easier to do your picking with 00 or 000 sable hair paintbrushes available from art stores. Moisten the brush by licking it or dipping it in clean water (tapping off excess drops); then touch the brush to the fossil you've selected. The fossil clings to the brush through surface tension. Initially, it may prove difficult to maneuver the brush accurately under the microscope, but just a bit of practice soon perfects your hand/eye coordination.

Dislodge your fossil from the brush by stroking it against the surface of the cleared area on your picking tray or dropping it in a container. Having several small vials next to your microscope allows you to do an initial sort as you work through the residue: ostracods in one vial, forams in another, gastropods in another. This allows you to move more rapidly through your sample, and you can later do a more detailed sort by species.

If you're a beginner focusing on larger microfossils and don't have a stereomicroscope, fossils may be picked using a desktop magnifier lamp with an adjustable arm that clamps to the side of your desk. A simple 10-, 15-, or 20X loupe might also be used although your scanning surface is obviously limited with such a small lens and you're sure to overlook a host of smaller species that show up under a microscope.

Containers and Mounts for Storing Your Finds

If you really get into microfossil collecting and your collection begins to grow, it's best to make an investment in microfossil slide mounts, also known as Franke slides. These are available through scientific supply houses such as Ward's Natural Science and come in two sorts: ones with round cavities for highlighting individual specimens and ones with rectangular cavities divided like graph paper with 40 or 60 tiny squares for multiple specimens. The cavities, in depths of 1 mm or 2 mm, are lined with either black paper with white grids or white paper with black grids. The fossils go in the cavity, a glass slide is fitted atop, and the cardboard mount and glass are held securely together with a slide-on aluminum plate.

If you go this route, be prepared to spend some bucks. The cardboard mounts, glass slides, and aluminum plates are all sold only in bulk, and all sold separately. By the time you've assembled one hundred 2 mm slides, your bill can easily reach nearly $200. But in the end, you'll find the mounts with rectangular cavities and their tiny numbered squares well worth it. You can hold an entire collection in a single mount, and the numbered spaces allow for cataloguing of individual specimens.

Purchasing just the glass slides, you can make your own mounts at much less expense. Get thick cardboard and a pencil and trace around a glass slide. Cut two strips of cardboard the size of your glass slide and make a window in one (a hole-punch works well, or you can cut out a square or rectangle with an Exacto knife). Glue a piece of black construction paper onto the bottom cardboard strip and glue the window strip on top. Once you've inserted your fossil into the little nook you've created with the window strip, you then cover with a glass slide, which can be held in place with masking tape or by clips at either end. Approximate cost: $10.00 for 100 glass slides, $1.99 for a roll of masking tape. The cardboard is essentially free if you recycle it from the back of a tablet of paper, and you can purchase 40 sheets of black construction paper for $2.35 or a 20-sheet pad of white engineering graph paper with grids for $2.29.

Other inexpensive storage methods are available (Fig. 6). If you're just beginning in the hobby or if microfossils will form but a small part of your overall fossil collection, the simplest method is to recycle pill bottles or purchase tiny glass vials with stoppers. You can glue a label to the outside of the vial with the name of the specimens, locality, etc., or roll the label and keep it inside the container with the fossil. Or, at your next gem show, pick up the 1-inch plastic cubes sold for thumbnail minerals. Insert a pin into the Styrofoam base and glue your microfossil to the head of the pin. Similarly, you can line the bottom of a small box with cork or Styrofoam to store a collection of pinned specimens. You can also store your collection in the little clear plastic boxes with the 3X magnifier lens molded into the covers. Or, for the most budget-conscious, fold paper into small square envelopes.

FIGURE 6 – The options for storing microfossils are varied, from professional slide mounts to homemade paper envelopes.

FIGURE 7 – Using a 00 or 000 sable hair paintbrush to transfer tiny fossils into a microfossil slide mount.

Adhesives for Securing Fossils to Mounts

While you may opt to keep your microfossils loose in vials or magnifier boxes, it's best to secure such tiny specimens in some way lest an accidental sneeze send them flying into the carpet. (I've seen it happen; it's not pretty.) Whether securing your microfossils in microfossil slides or atop pins, you want a bonding agent that will do the job of securely holding the fossils yet allow for removal and repositioning for studying all sides. Thus, use a water-soluble adhesive.

I've found that a single droplet of Gum Arabic, sold with watercolor paints at art stores, works well. A more common adhesive is a weak solution of Gum Tragacanth with a drop of clove oil (mold apparently likes this adhesive, and the clove oil helps combat fungal growth). The entire cavity of a microfossil slide mount is lightly painted with the solution and allowed to dry. To secure your fossil, you "activate" a spot on your mount with the tip of a wet 00 or 000 brush, then use the brush to select your fossil and carry it to your pre-selected spot (Fig. 7). The fossil is held securely yet may be removed later by simply touching with a wet brush. In place of Gum Tragacanth, some folks use Elmer's glue, painting a thin layer diluted with a little water on a mount and allowing it to dry clear.

Labeling

It's important to label your specimens with details like specimen name, locality, geological period or epoch and formation, stratigraphic unit, etc. You might also include the name of the collector and the date that the material was collected. While microfossils may be beautiful little gems in and of themselves, the scientific value of a collection of any sort is in its documentation. Such documentation may be glued right on the microfossil slide, especially with the wonders of word processors and the ability to produce tiny yet legible labels in 8-point type.

If you use the "pinning" technique for storing your specimens in a thumbnail cube or a cork-lined box, you can run the pin holding your fossil through small slips of paper with the name of the specimen, locality, age, etc., to keep this information right with the specimen. Folks who have chosen to store their microfossils in small paper envelopes can write such information directly onto the envelope.

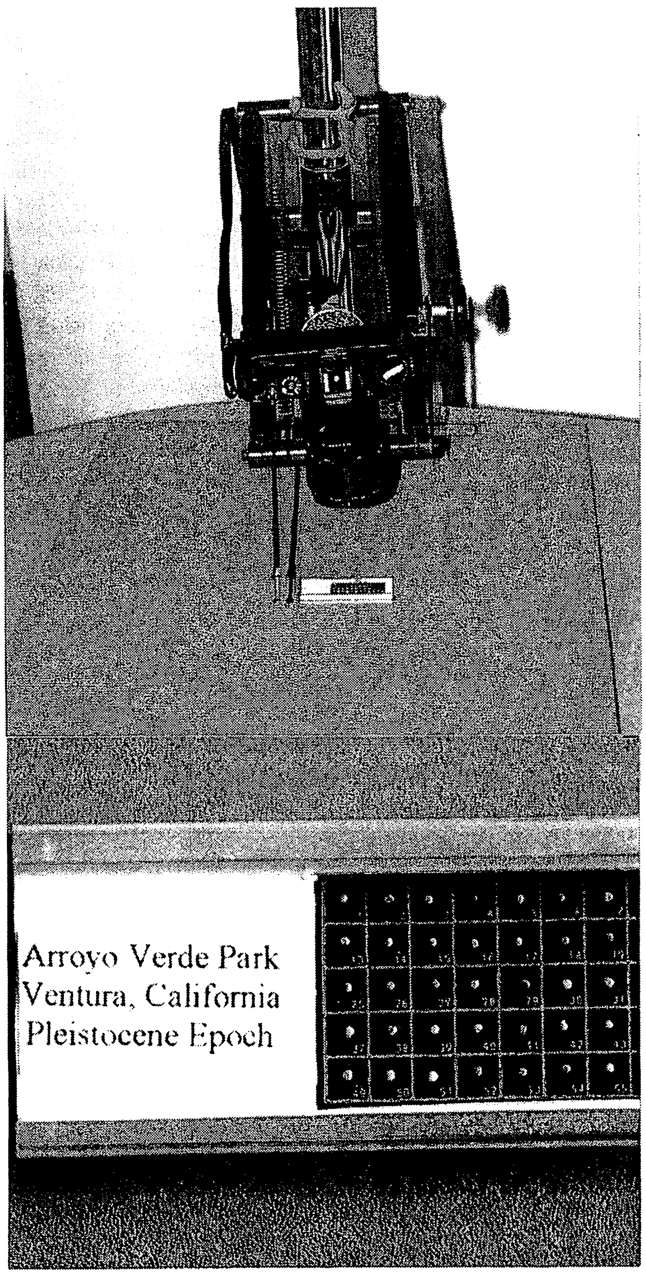
PHOTOGRAPHING YOUR FINDS

As your microfossil collection grows, so will you desire to share it with fellow enthusiasts. The best way is with photographs. However, be warned: this is where costs can really add up! The smaller the fossil you try to capture on film, the more elaborate the equipment you need. Optical microscopes with 500X magnification and scanning electron microscopes are best for truly tiny fossils, such as diatoms. However, it's not your average Joe who has a scanning electron microscope out in the garage. I've limited my work to microfossils large enough to be captured with either a macro lens or by attaching my camera to my stereomicroscope.

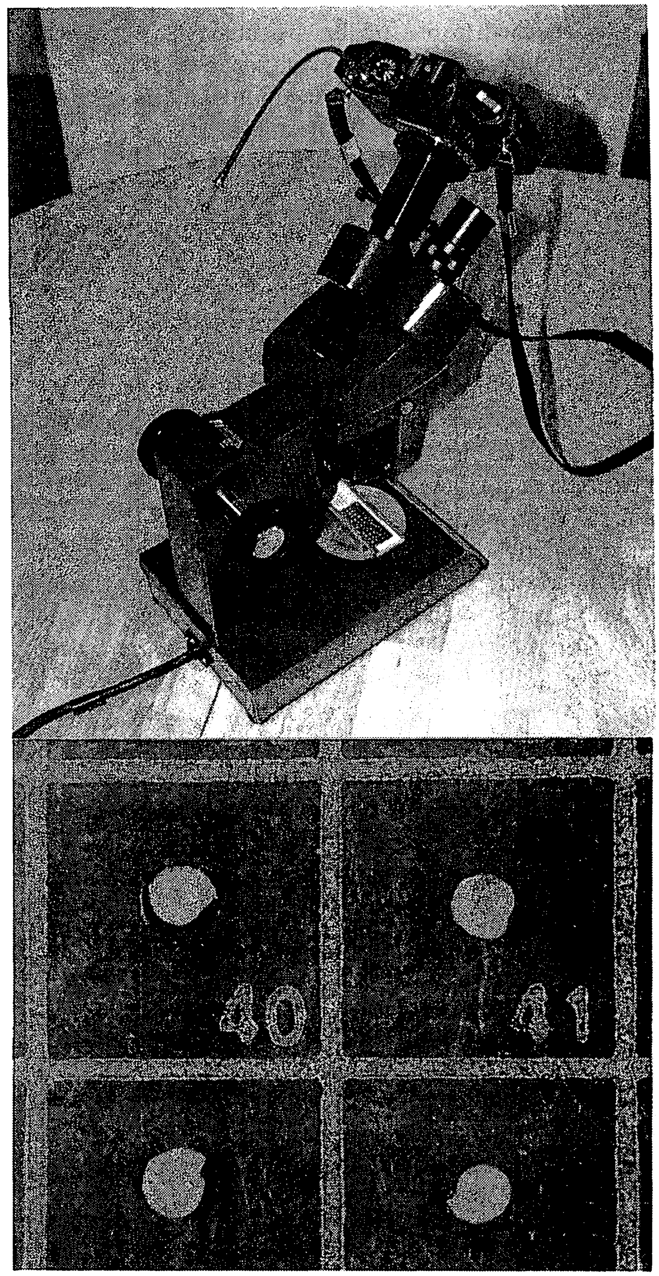
Photomacrography

For larger microfossils, a simple macro lens attached to a 35 mm camera will do the trick although the image you record will be small. This is how I started out, and the images I obtained were fine for a beginner. (Fig. 8.b.) In the few instances where I wanted a larger image, as for a display case at a local gem show, I simply had my print blown up and then trimmed the photo down.

In using a macro lens, you are practicing the art of photomacrography. Magnification is accomplished by extending the lens from the camera body. You can purchase a macro lens for most cameras at a local camera shop, and the price is typically around $290.00. Because you're shooting tiny objects at close quarters, even the slightest jiggle will blur your image. Thus, you should also invest in a sturdy tripod or a camera copy stand and a cable release. (Fig. 8.a.) Other options besides a macro lens that also extend the camera lens from the camera body to allow for close-up shots include supplementary close-up lenses, extension tubes and bellows inserted between a normal lens and camera body, and reversing rings. You can also make your own extension tubes using plastic pipe or heavy cardboard tubes painted flat black.



FIGURES 8.a. and 8.b. – A basic set-up for photomacrography and the resulting image.



FIGURES 9.a. and 9.b – A basic set-up for photomicrography and the resulting image.

Photomicrography

To really move in close and pick up fine details, you need to graduate from photomacrography to photomicrography (or photomicroscopy) and shoot through a microscope. (See Figs. 9.a. and 9.b.) The essential equipment include a T-ring adapter that screws into your camera body in place of a lens and a connecting tube to attach the camera and adapter to your microscope. You can get a T-ring adapter and a microscope connecting tube through your local camera store, which will probably need to special-order them, or scientific supply houses. Edmund Scientific's offers T-rings at the reasonable price of $14.95 and a microscope connecting tube for $15.95. The connecting tube slides over a microscope eyepiece and is securely attached with three tension screws. You can also make your own connecting tubes from cardboard mailing tubes painted flat black on the inside and glued to a T-ring or taped on with black masking tape.

Some "trinocular" microscopes have a third tube specifically for mounting a camera. My binocular microscope, unfortunately, does not, and I'm too cheap to buy a new one. Instead, I've made due with a camera adapter attached to one of the two binocular eye pieces (Fig. 9.a.), and thus far, it's worked fine, even if the image isn't as sharp as would be obtained through a photo tube. One day, I may graduate to the next level of the hobby and make the investment in a trinocular microscope with a photo tube. But not today.

In doing photomicrography, the most important elements, I've found, are minimizing vibration and providing ample lighting. You want to make sure your camera is securely attached and the whole set-up is on firm ground, and you should use a cable release to snap your shots. For lighting, a high-intensity desk lamp works but doesn't give you a lot of control in spotlighting your specimen, emits a great deal of heat (making for an unpleasant photo shoot), and results in an orange-yellow cast to your photos. A variety of lighting options (especially fiber-optic lights) are sold by microscope manufacturers that allow you to vary the intensity, focus the beam, and match color temperature to your film to avoid that yellow-orange cast. At present, I use a desk lamp, but the very next thing on my Christmas list is a lamp with a flexible neck designed specifically for use with a microscope. Also, in photographing microfossils you've mounted in a slide mount, remove the glass cover slide first to avoid glare from your lighting source and to improve focus.

Because of the expense involved in purchasing camera accessories and the limited space here to go into details, your wisest initial investment is in a book. I can recommend Jeffrey Scovil's *Photographing Minerals, Fossils, and Lapidary Materials.* Also, many general guides to photography line the bookshelves in the photography section of your local bookstore. Of course, if the expense and preparation of photomacrography and photomicrography aren't for you, there's always a set of tools and a technique that existed long before cameras entered the scene: pens and pencils, a sheet of paper, and a modicum of artistic ability (Fig. 10).

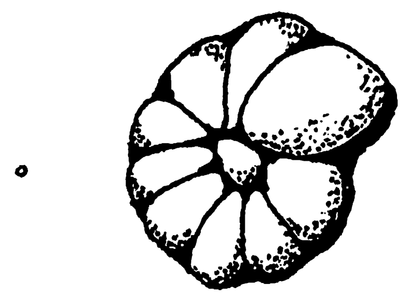


FIGURE 10 – As illustrated by this pen-and-ink drawing of a foram from Indiana, you don't need expensive cameras and accessories to capture an image of your microfossils.

SOURCES OF SUPPLIES

Those of you ready to make the leap into microfossil collecting in all its glory might be wondering where to get those many supplies I listed in Table 1 at the beginning of this article. For some supplies (teasing needles, petri dishes, lab aprons, glass microscope slides, engineering graph paper, etc.), I've journeyed to the campus bookstores of nearby colleges and universities, which stock such things for their biology and chemistry classes. Other supplies (rubber gloves, face masks, Pyrex measuring cups, plastic trays, acids, hydrogen peroxide, washing soda, screens, etc.) may be purchased through your local hardware store, grocery store, and drug store. Still other supplies (Gum Arabic, very fine 00 and 000 sable hair artists' paintbrushes, cardboard and paper for making your own microfossil slide mounts) may be found in art supply stores. Photographic supplies (35 mm cameras, along with accessories such as a cable release, macro lens, T-ring adapter, microscope tube adapter, copy stand for close-up photography, film, etc.), of course, may be purchased through a camera store.

For more specialized equipment, though, you need to turn to scientific supply houses. The two I've ordered from the most are Edmund Scientific's and Ward's Natural Science:

Edmund Scientific's
Web site: www.scientificsonline.com
Phone: 1-800-728-6999
60 Pearce Avenue
Tonawanda, New York 14150-6711

Ward's Natural Science
Web site: www.wardsci.com

East Coast office:
5100 West Henrietta Road
P.O. Box 92912
Rochester, New York 14692-9012
Phone: 800-962-2660

West Coast office:
P.O. Box 5010
San Luis Obispo, CA 93403-5010
Phone: 800-872-7289

Still other suppliers include:

Omni Resources
Web site: www.omnimap.com
Phone: 336-227-8300
1004 South Mebane Street
P.O. Box 2096
Burlington, North Carolina 27216-2096

NASCO
Web site: www.nascofa.com
Phone: 1-800-558-9595
Midwestern office:
901 Janesville Avenue
P.O. Box 901
Fort Atkinson, Wisconsin 53538-0901

West Coast office:
4825 Stoddard Road
P.O. Box 3837
Modesto, California 95352-3837

In contacting any of these supply houses, ask specifically for their geology or earth science catalog, if available.

In addition to supplies, you can purchase microfossils themselves from Ward's Natural Science. They offer sets with a variety of diatoms already mounted on glass slides and conveniently housed in a slide box and larger microfossils already set in micropaleontology slide mounts. In addition, you can purchase vials of conodont residue, foraminifera, and other microfossils you can pick through and mount yourself. Individual pre-prepared slides as well as washed residues of a variety of microfossil concentrates from all the major time periods may also be purchased through commercial suppliers of rocks, minerals, and fossils, such as Geological Enterprises:

Geological Enterprises, Inc.
P.O. Box 996
Ardmore, Oklahoma 73402
Phone: 580-223-8537
Email: geoent@ardmore.com

Prices through Ward's tend to be on the high side. For instance, a set of 6 labeled glass slides housed in a slide box with radiolaria, diatoms, and foraminifera goes for a whopping $125.00. A vial of unsorted conodont residue goes for $10.50. By contrast, microfossil concentrates are sold at $3.00 per unit through Geological Enterprises, which offers diatom strew slides at $5.00 per slide.

REFERENCES AND RECOMMENDED READING

To expand your skills in working with microfossils, I offer the following as recommended reading:

MacFall, Russell P., and Jay C. Wollin, *Fossils for Amateurs: A Handbook for Collectors* (Van Nostrand Reinhold Company: New York, 1972). Although no longer in print, for many years this was a standard guidebook for amateur fossil collectors. Chapter 12 offers a nice, basic overview of microfossil collecting. You can often find a copy in a used book shop.

Brasier, M.D., *Microfossils* (George Allen & Unwin: London, 1980). The appendix on pages 162-168 describes in detail a variety of techniques for retrieving microfossils from different sorts of matrix.

Kahrs, Margaret E., Editor, *Microfossils: M.A.P.S. Digest Expo XXI Edition* (Mid-America Paleontology Society, Volume 22, Number 4, 1999). A 230-page special issue of *M.A.P.S. Digest* devoted exclusively to microfossils, this issue provides tips from amateurs and professionals alike describing all sorts of microfossil locations and techniques.

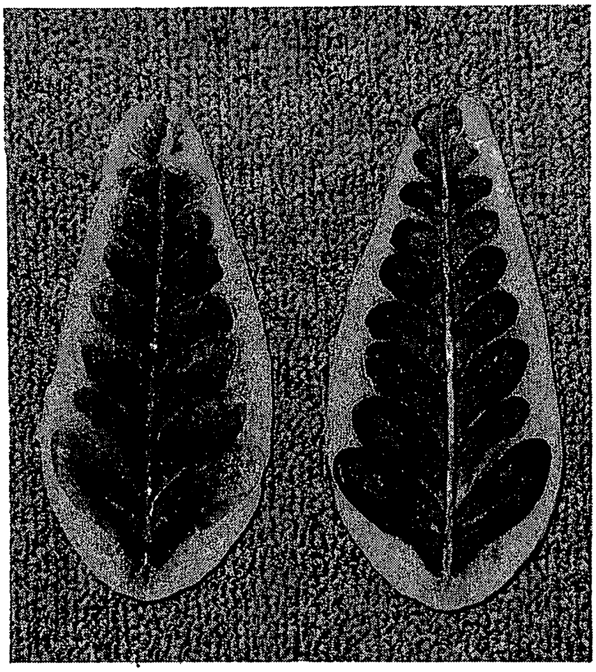
Kummel, B. and D. Raup, Editors, *Handbook of Paleontological Techniques* (W. H. Freeman: San Francisco, California, 1965). This guide for the professional details techniques for macro- as well as microfossils. Good luck finding a copy, though!

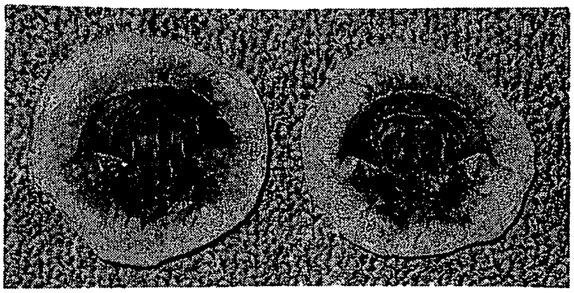
McNeil, D.W., "Photography Through the Microscope: Illumination, Stops and Optical Staining," *Science PROBE!*, July 1992 issue, pages 76-86. This magazine article provides a brief overview of photomicrography, with ideas for making your own equipment inexpensively.

Scovil, Jeffrey, *Photographing Minerals, Fossils, and Lapidary Materials* (Geoscience Press, Inc.: Tucson, Arizona, 1996). Chapter 12: Attaining Magnification and Chapter 13: Photomicrography provide great tips from one of the master mineral photographers of our time.

To identify your finds, a number of books provide overviews of the various sorts of microfossils with nice plates showing representative specimens. These include books such as Boardman's *Fossil Invertebrates*, Shimer and Shrock's classic *Index Fossils of North America*, or Fenton and Fenton's ever popular *The Fossil Book*. However, while these may help you identify your fossil down to a general level (Do I have an ostracod or a tiny clam?), you're likely to be frustrated in identifying finds down to the genus and species level with most of the guidebooks readily available to amateurs. Usually, you'll need to turn to professional journals and papers, state geological survey bulletins, and/or a professional paleontologist.

Armed with resources like these, you'll be well equipped to begin an enjoyable new phase of the fossil-collecting hobby. But for now, put aside the reading, head out into the field, and pick up a chunk of matrix from your favorite local fossil site. You may be surprised by what you find inside!





PREPARING MAZON CREEK NODULES FOR DISPLAY

The fossils of the Mazon Creek Area have been known for about 150 years. These beautifully preserved plants and animals come neatly packaged in their own container. These containers are known as concretions or nodules. A brief introduction on the formation of these nodules is in order. The ground in which these plants and animals live must contain certain chemicals, basically iron and pyrite, for the formation of these nodules to take place. After the organism falls to the ground it is covered by silt from flood waters, Figs. 1a & 1b.

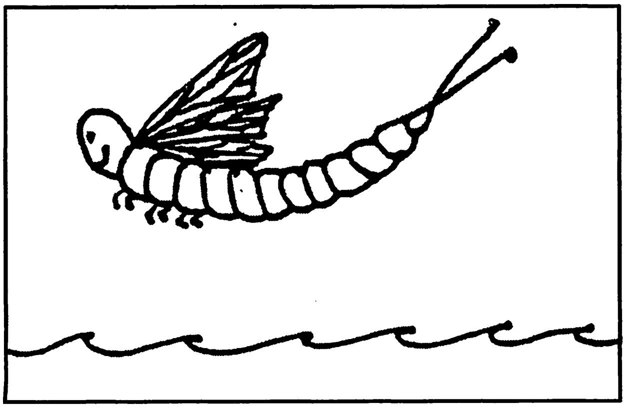


Fig. 1a An insect flies above the shoreline.

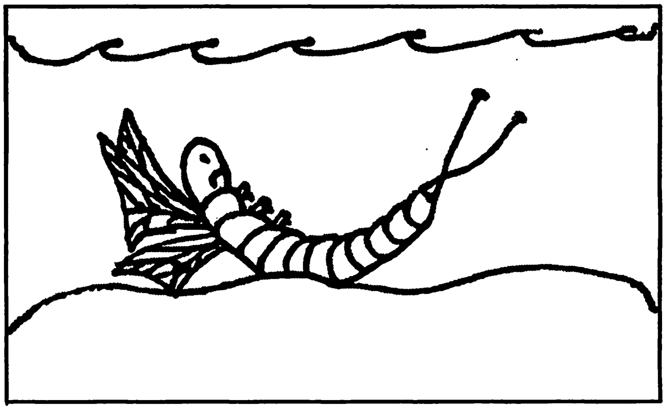


Fig. 1b A catastrophe strikes and kills the insect, plummeting him into the water and he sinks to the bottom.

The decomposing buried organism immediately begins a chemical action into the surrounding ground which in turn precipitates a reaction of chemicals in the ground towards the organism, Figs. 1c & 1d.

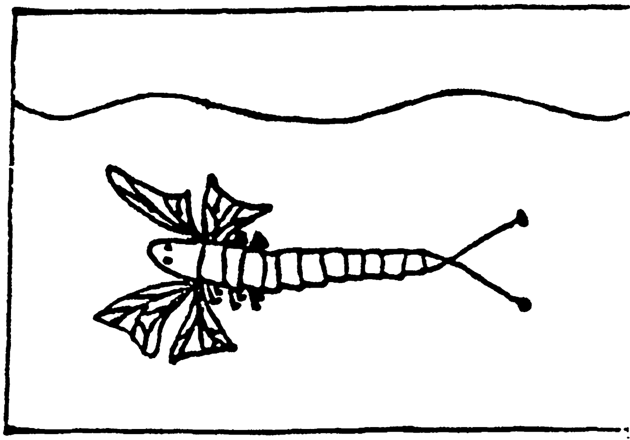


Fig. 1c. Sediments from flood waters have buried the insect.

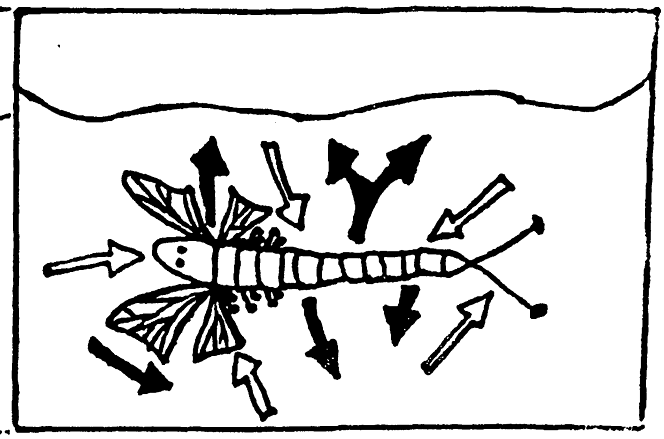


Fig. 1d. Chemical action starts quickly.

This combined action and reaction creates a type of gel equi-distantly surrounding the organism. Over time load pressure hardens this gel into stone. We have our nodule or siderite concretion, Figs. 1e & 1f.

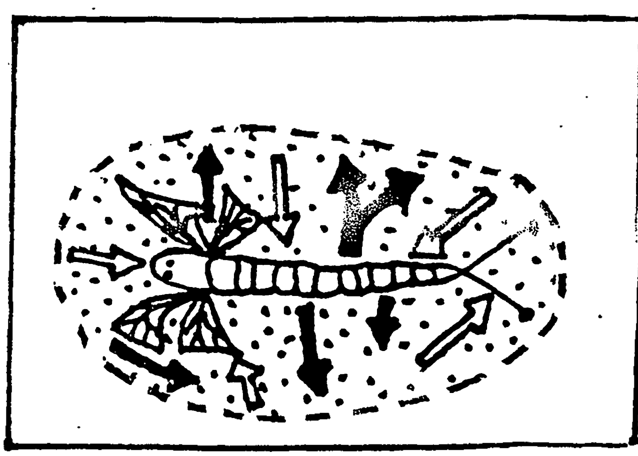


Fig. 1e. Continued chemical action has precipitated a type of gel around the body.

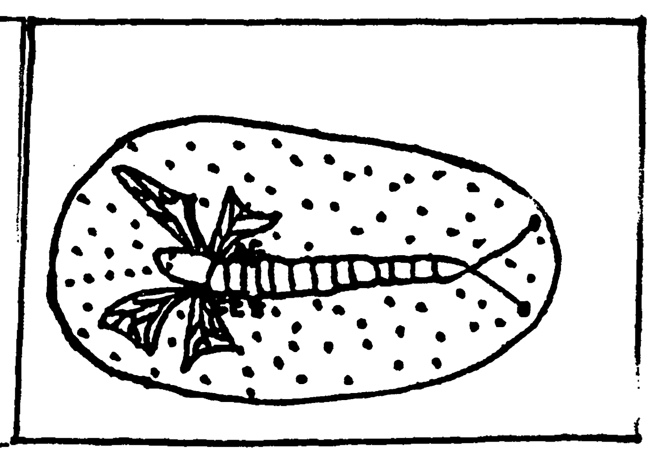


Fig. 1f. The concretion is complete.

This process has been replicated in a laboratory and it was found that any organic substance (slime, feces, mucus, etc.) can initiate this process. It took about two weeks for the gel to form.

For anyone interested in a more detailed and technical description of the formation of Mazon Creek and Mazon Creek Type concretions I recommend the references cited at the end of this article.

The organism within the nodule creates a plane of weakness through the center of the nodule. In order to expose the organism the nodule must be split open. For this the plane of weakness can be exploited. There are two methods that this can be accomplished. One, the original method, is to place the nodule on edge on a hard rock (ie granite, limestone, etc.) and strike it with a rock hammer, Fig. 2. Usually one blow will not be sufficient and several blows are required. The nodule should split along this plane. There are times when this plane of weakness is not constant throughout the nodule and it will not split fully along this line. It may run off on a tangent and only part of the organism will be exposed. In this case a little work with a chisel is required to expose the entire organism. This requires great care and only experience will tell you where to place the chisel. If the nodule breaks onto several pieces, use your favorite glue to mend it.

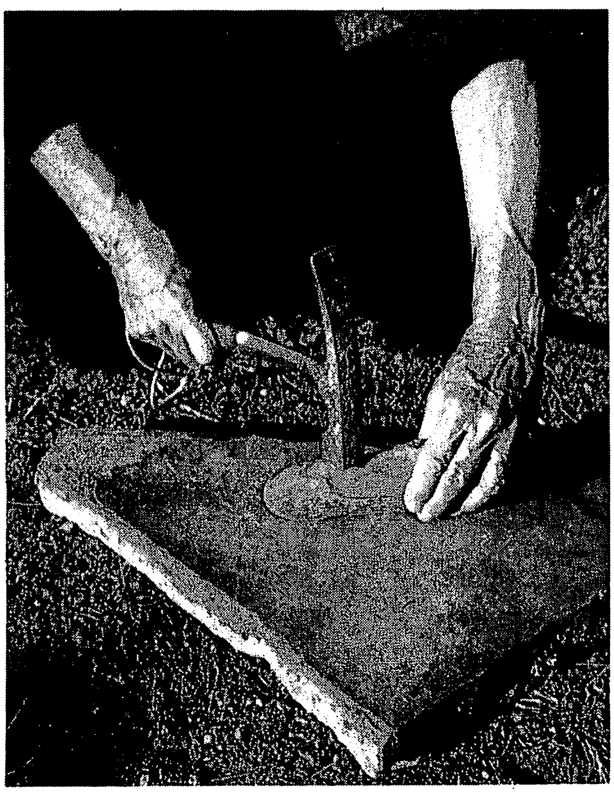


Fig. 2. Splitting the nodule.

The second method to split the nodules is the 'freeze-thaw' method. This method was developed by MAPS member Larry Osterberger in the early 1970's. Occasionally nodules in the field are found already split open. This was done by the various weathering agents. Larry decided to replicate this process by placing the nodules in a bucket and filling the bucket with water and leaving it outside over the winter to freeze and thaw naturally. Of course this can only be done in northern climates where the night time temperatures drop to well below freezing and rise to above freezing during the day. For those living in a mild climate this can be accomplished by placing the nodules in a pot of water and put into the freezer over night and then placed outside in the daytime. This process may have to be repeated as many as twenty to twenty five times - maybe even more. Be patient.

Occasionally the split faces of the nodule, especially those found already split open, may have a light grey coating covering them, thereby obscuring the details of the plant or animal. This coating is probably residue from dirty water and can easily be removed by placing the nodule into a weak acid solution of 1 part muriatic acid to 4 parts water. After about 30 to 60 seconds brush lightly with a soft tooth brush and place into a container of clear water. A few seconds in the clear water is all that is needed to neutralize the action of the acid. If you have sensitive skin you should wear rubber gloves when working with acid. This is especially important if you have a small cut or abrasion on your hand.

There is another kind of coating that is frequently encountered. This is a rather hard white substance which is an aluminum clay known as kaolin or kaolinite. I have not found a chemical that will dissolve it. A brisk brushing will usually remove it if the kaolin is soft enough. All of the nodules are not of the same hardness and some are soft enough that brushing will leave brush marks thereby ruining the specimen. I like to experiment by first brushing a clear portion on the split face using various hardness brushes. If the kaolin is hard and brushing will not remove it and if the nodule is hard, one can try gently scraping with a dental tool. However, extreme caution must be used so as not to

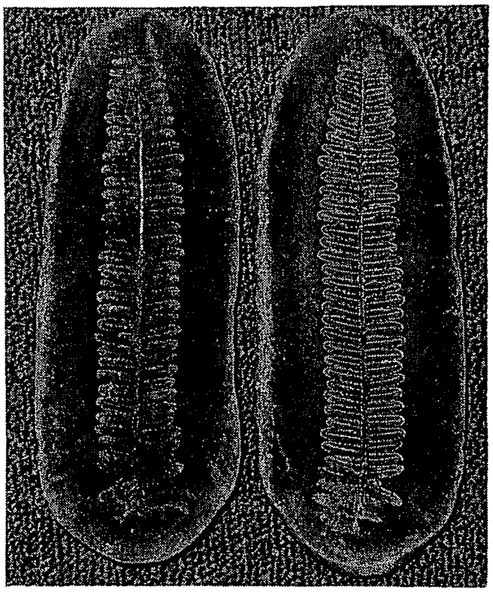


Fig.3 A fern beautifully outlined by kaolin.

scratch the surface. There are times when one must be content with leaving the kaolin in place. There are times when the kaolin is merely outlining the organism, Fig.3. This actually enhances the specimen so it is prudent to leave it in place.

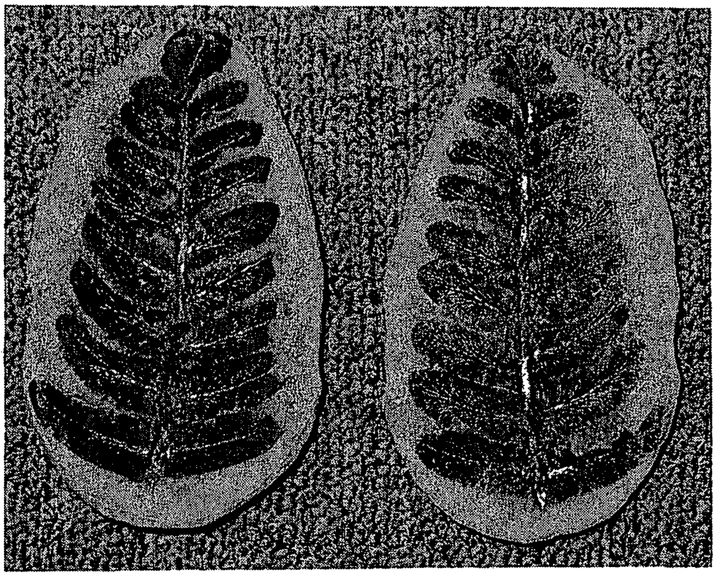


Fig. 4. Nodule with seed fern.

Most of the time the plant or animal is found preserved in a slightly darker or lighter shade than the surounding matrix. This contrast is exactly what we want for optimum display, Fig. 4. However, there are times when the organism is almost or exactly the same shade as the surrounding matrix and is difficult to discern, Fig. 5. In order to make the organism a contrasting shade, I mix a solution of 1 part dull varnish to 1 part turpentine. I use Pratt & Lambert brand dull varnish but I am sure that any brand of dull varnish will do. It must be a dull varnish - satin finish will not do. Using a fine artists brush I coat only the impression with this solution - not any part of the matrix. This darkens the organism without darkening the background. Thus obtaining the desired contrast that we want to make the organism more attractive, Fig. 6. For this reason it is imperative to use a dull varnish since any amount of glossiness will obscure fine detail. Care must be

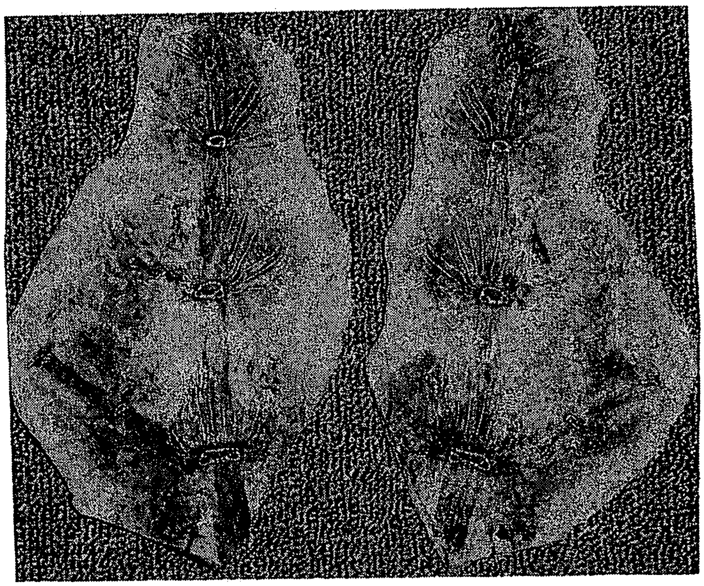


Fig. 5. Specimen with very little contrast.

taken not to get any of the mixture on the matrix. It can be a tedious procedure when working with specimens that have very fine, thin & small structures but the result is rewarding, Fig. 7. As can be seen in Fig. 6, I like to use a magnifying glass with a strong light when doing this coating. For those of you that may be leary of using the turpentine/varnish solution for fear that it might ruin the fossil for future research study, I have found that ordinary paint & varnish remover will remove the coating without doing any harm to the fossil. I also wish to stress the importance

Fig. 6. Applying the coating.

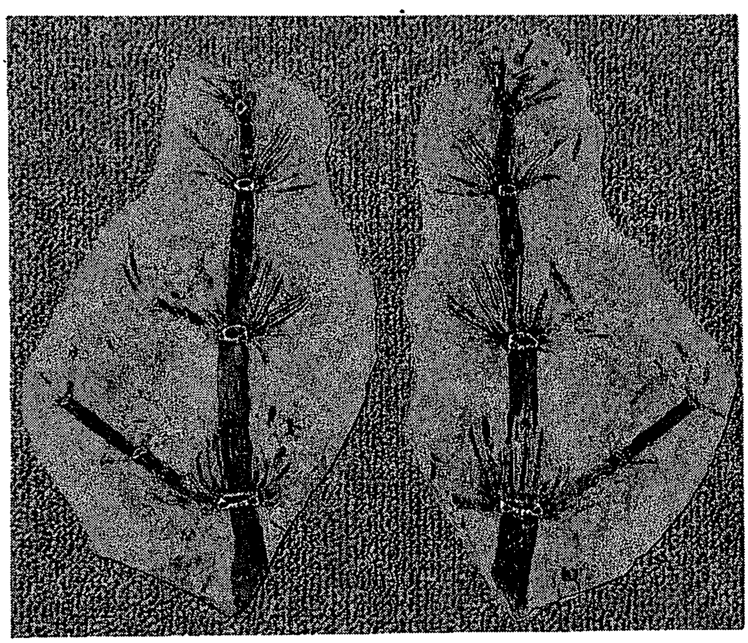


Fig.7 The coating is complete.

of using a good grade of artists brush. Do not use a cheap water color brush. Also, when you see that the bristles of the brush are starting to separate, discard it and use a new brush.

Your specimen is now ready for display. If you display your specimens in a case where the specimens are laid flat in a horizontal position there is nothing left to do but attach your label. I like to display my Mazon Creek fossils by hanging them in a frame on the wall, Fig.8. There are seven frames in our display room ranging in size from 32"X36" to 48"X48". In order to hang the nodules some sort of hanger must be fastened to the back of nodule. I use a thin canvas material and cut it into strips about ½" wide and about 4" long (shorter for smaller specimens). One end of these strips is then looped through a small brass (about ¾" diameter) ring and is folded over about 1". This is then sewed to hold the ring in place. Now it is glued to the back of the nodule, Fig.9. I like to use 'Mighty Tacky' and coat the entire back of the strip and also the back of the nodule. After the glue is dry it is ready to be hung in the frame. I use round head screws in the frame because the ridge on the head prevents the ring from slipping off, Fig.10. In the Fig.10 photo the rings on the backs of several nodules are visible so that the way the nodules are hanging can clearly be seen. Also visible are the ID tags I use. Each tag has the name and location. In the Mazon Creek Area there

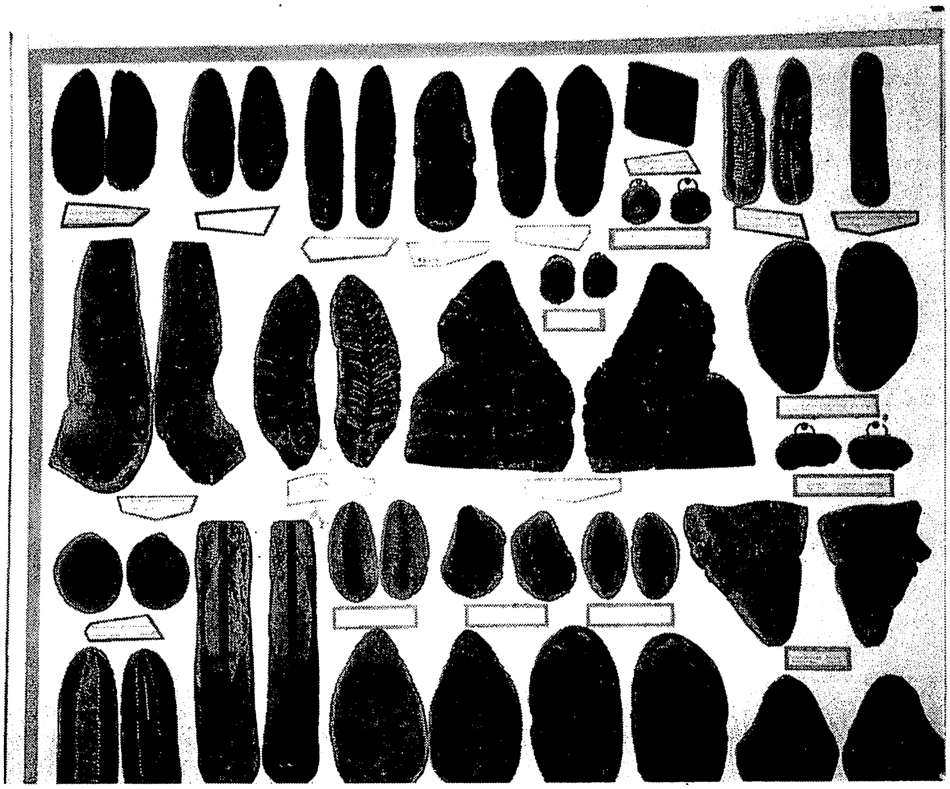


Fig. 8. One of the frames w/specimens.

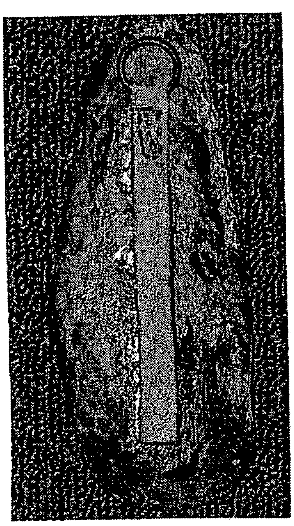


Fig.9. Finished hanger in place.

are actually 16 separate locations where nodules can be found. Hence the need for the ID tags showing locations. The backs of the nodules have an ID number written in India Ink.

No doubt there are collectors who have different methods of preparing and displaying their Mazon Creek material. However, in the 40+ years that I have been working with Mazon Creek fossils I find this to be the best method for me.

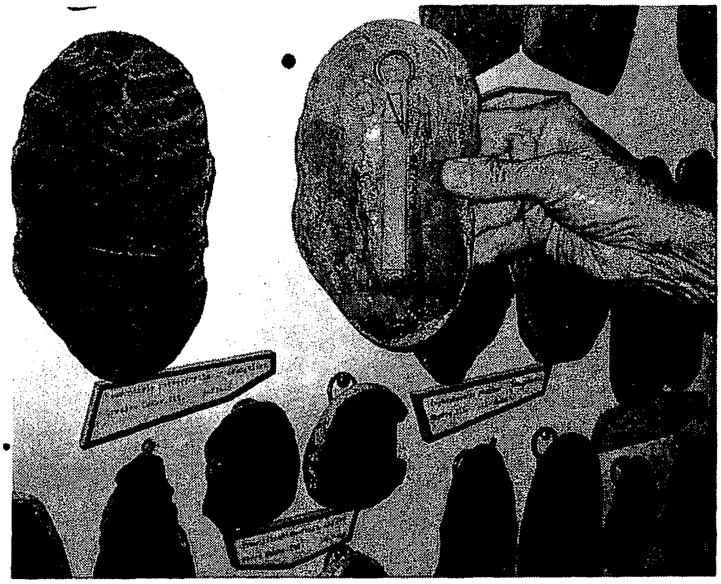


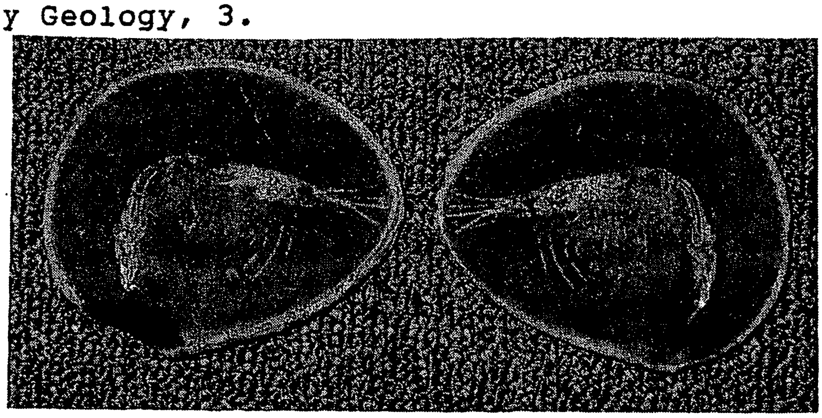
Fig. 10. Method of mounting the nodules on the frame.

AUTHOR: Jim Konecny
ASSISTANT: Sylvia Konecny

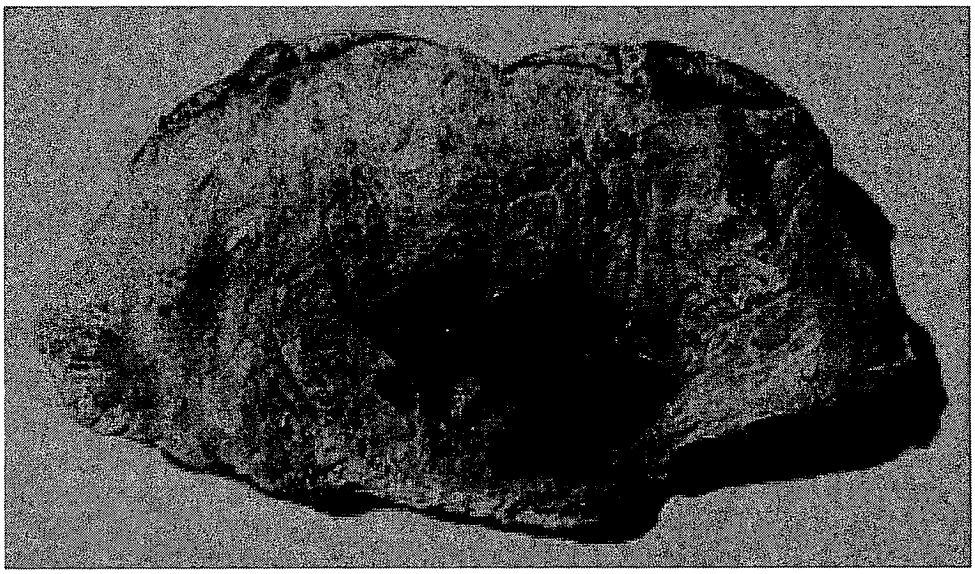
REFERENCES:

Woodland, Bertram G. & Richard C. Stenstrom, 1979. The Occurrence and Origin of Siderite Concretions in the Francis Creek Shale (Pennsylvanian) of Northeastern Illinois. In Mazon Creek Fossils, Matthew H. Nitecki, Ed.

Zangerl, Rainer, Bertram G.Woodland, E.S.Richardson, Jr. and D.L.Zachry, Jr., 1969. Early Diagenetic Phenomena in the Fayettville Black Shale (Mississippian) of Arkansas. In Sedimentary Geology, 3.



Fossil Preparation: Before and After



Crab, before preparation by Zarko Ljuboja

Crab, after preparation by Zarko Ljuboja

HOW TO PREPARE FOSSILS FOR PLEASURE AND PROFIT

Zarko Ljuboja
5521 Gibbs Rd., Andover, Ohio
zzarko@juno.com

Many millennia before the Egyptians, Minoans and other contemporaneous cultures, people collected fossils. Jurassic ammonites were drilled for suspension by Cro-Magnons in southern France. A Triassic lungfish has been found in a 15,000 year-old cave in Switzerland. The monster of Troy vase was painted in 560-540 B.C. depicting Heracles and Hesione confronting the legendary monster that appeared on the coast of Troy. The artist depicted a large fossil animal skull eroding out of an outcrop, which was most likely a Samotherium, a Miocene giraffe. Around the 4th century B.C., amber was recognized as fossilized tree sap. This is the first recorded identification of a fossil for what it really was. One could say that this discovery was the beginning of the study of paleontology.

Some of the fossils were so prized that wars were fought over them; people died to gain these fossils and other treasures for honor and political prestige. In 476 B.C. the Athenian general Timon captured the island of Skyros, advised by the Delphic oracle to hunt down the bones of local hero Theseus. Unearthing some large bones, Timon brought them back as Theseus's relics, which were welcomed with magnificent processions through the city and interred in the heart of Athens. Although people did not completely understand what fossils were, they were inclined to clean them up and display them in many ways. Possibly, they kept them as charms for good health or maybe good luck or just as some ceremonial talisman. But I'll bet that mostly people kept fossils because they were a mystery, something intriguing and fascinating to bring up in conversation. This is where the legends of giants and beasts originated, where people's imagination flared as they tried to explain the fossils' existence. In the postwar celebration, the victors would bring their treasures, which included fossils, out for public display. They were even paraded through the streets and placed in temples and other public retreats, where people could admire them in whatever way they wished.

Back then, fossils were more revered by the greater populace than they are today. People found them while plowing or just exposed sticking out of a cliff and took them back to town. Since the fossils still had mud and rock stuck to them, they were carefully scraped off. The encapsulating matrix was removed with another rock or a grinding wheel for the coarse matrix and a stick with sand stuck on the end to get at the tight spots, or a brush. Eventually, metal tools made their way to the fossil collectors and to better preparation by being able to remove more matrix than other tools. Later, early collectors had access to even stronger metal tools with which to prepare their specimens.

The following ancient secrets are some of the basic things you need to prepare a fossil: desire, patience, talent, coordination, time, equipment, good lighting, (luck) and, of course, a nice fossil. It does help to be a perfectionist in what you do. Paying attention to details separates the best from the just OK. In most cases spending a little more time can make a big difference.

Collecting fossils is a good part of the excitement, but if you think of preparing as smallscale exploration and excavation to expose the complete specimen, then preparing is a discovery process of its own.

In the excitement and pleasure of hunting for fossils, you will cover a lot of territory examining many rocks and layers. As soon as you find a specimen, the preparation starts. Save all the pieces, all those little pieces that seem too annoying to collect; it's likely the other chunk of rock that would have made the specimen nicely centered on the rock, or the counterpart or negative that has the eyes or spines still stuck in it. Don't think that little piece won't make a difference. That fossil might be the best thing you find at that locality, so take the time and look for that piece. Two or three minutes isn't much, and later you'll be really glad you did.

Fossils are not generally found clean of matrix. Although many are just fine the way they were collected, most of the time you have to remove some of the rock that still encapsulates the desired fossil. Concretions are usually the exception to this rule. The best start is deciding if the fossil is worth any prep beyond getting the shale and mud off. In most cases you can rinse it in water and brush off any crud that might be stuck on it. But most shales and some limestones and siltstones will fall apart in water. Some will fall apart completely and fairly quickly; others will crack and check after they dry, making them unstable. If they get wet again they will break up even more. So I can't stress enough, be familiar with the rock you are collecting!

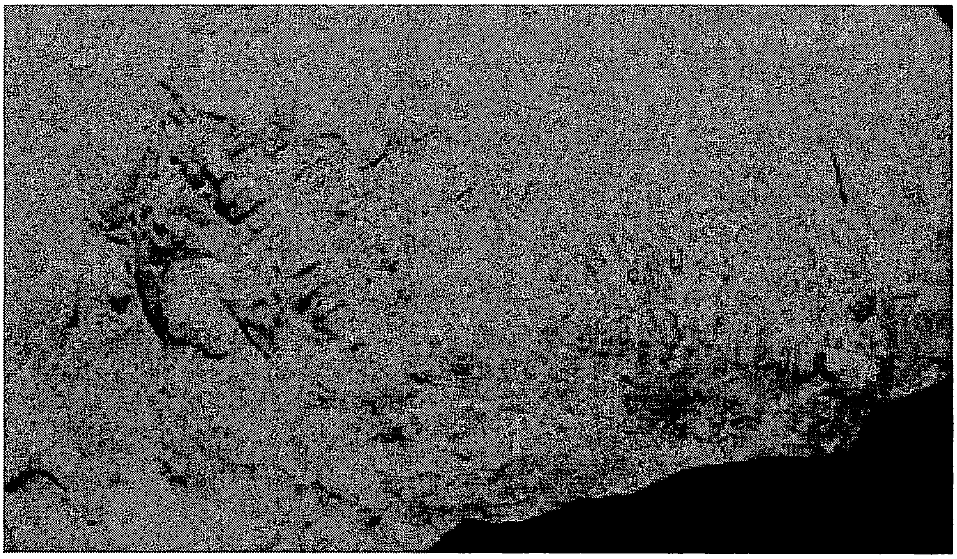
The main types of rock one might encounter are shales or limestones and a wide variation of the two, including marl, siltstone, argillites and other variations of grain size and cement types. Be familiar with which of these easily absorb water and fall apart rapidly or turn to mud. Fossils in sandstone or slate are much harder to prepare. Some places the preservation is in a slightly metamorphosed shale, like the Cambrian rocks out West or along parts of the East Coast. This stuff is harder yet to work with, but with patience and some skill, you can be prepare these very nicely.

One problem is that all these rock types can be found interbedded with each other. A nice specimen on a good hard layer of limestone could have a very thin seam of shale just under it. If you get it wet, the specimen just might come off the rock on a very thin piece resulting in lost parts and dangerously thin supporting matrix. Try experimenting on a not so good fossil, rinsing, immersing, and scrubbing it in water to see what happens. Also look around the collecting site to see how the stuff weathers. This is easier done in a quarry where the rock has been dug relatively recently, than in a stream where the rock has been weathering for years by water and nature.

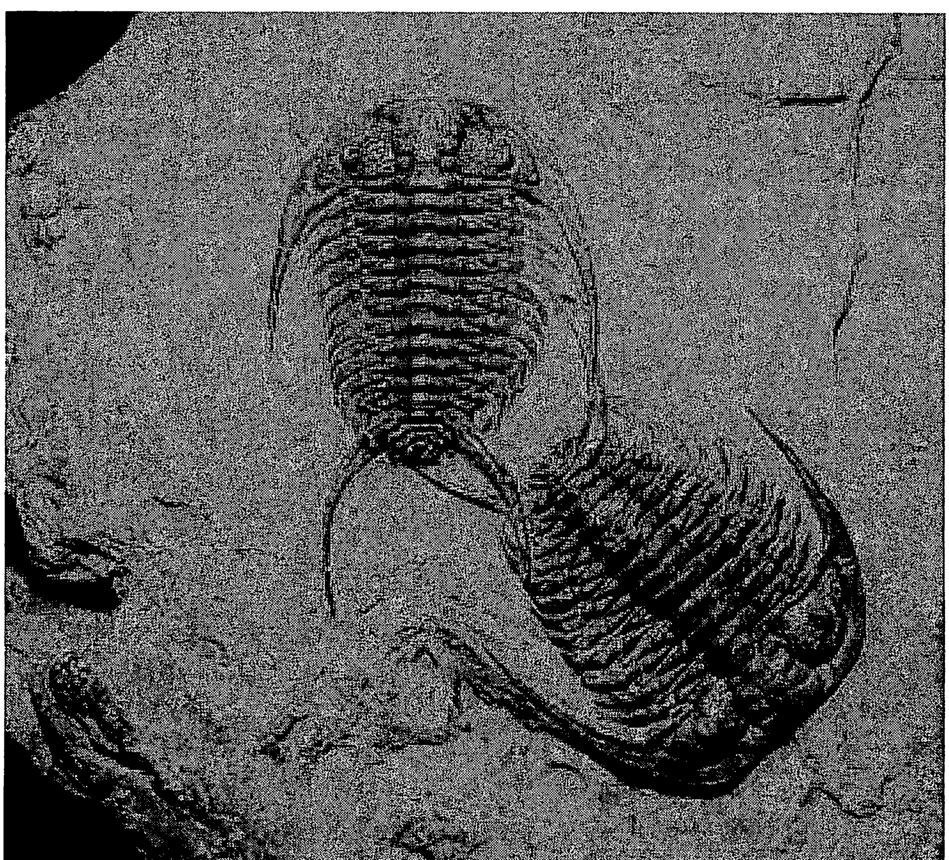
Using Glue

It's likely that in most cases you will need to glue parts back on and make sure that the specimen is firmly attached to the matrix. Remember to save the small pieces, if possible. The gluing should be done in the field, or if you are very, very careful to get it home intact without gluing, you can glue it together in a better environment and do a better job. You don't need a lot of glue to hold the pieces together. Besides, excess glue can be unsightly. After all, you're not trying to glue some guy's head to an I-Beam and hang him from a crane.

Fossil Preparation: Before and After



Double Ceraurus before preparation.



Double Ceraurus after preparation by Zarko Ljuboja: *Gabriceraurus*
Bobcaygeon formation, Middle Ordovician, Ontario

There are many types of glues available. The most commonly used are: (1) Elmer's, which is a water-soluble acetate, (2) cyanoacrylate or Super Glue, which is soluble in acetone, and (3) Butvar and Vinac, which are soluble in alcohol. Don't forget that the more glue you put on the specimen, the longer it will take to dry and to get off once you get it home. Just about any adhesive will work, but the ones I have mentioned have the best longevity for their respective types.

To properly stabilize a specimen, you have to feed in a lot of glue into the cracks as slowly as the rock drinks it in. I have spent as much as an hour filling tiny cracks in the matrix and under the specimen. If you have an accidental spill of glue, have ready a paper towel and a toothbrush to quickly absorb the excess and brush out any glue that may get into the cracks and deep spots. Accelerant will cause Super Glue to set up in a hurry, leaving a solidified skin, but the center may take a few days. Elmer's or other water-soluble glues are the safest to use and work well when dissolved one to one and up to ten to one or more, depending on how deep you want it to penetrate into the matrix. But the water could cause problems with certain shales if you dilute it too much.

Cutting Specimens

Diamond impregnated saw blades are the best things to use for cutting your specimens down to a more manageable size. The coarser the diamonds in the blade, the quicker it will cut and the rougher the edge. Typically, water is used as a lubricant, but if water affects the matrix, then try cutting with alcohol, or cut it dry. Be careful with the alcohol, which is flammable, and cutting dry will cause your diamond blade to wear out 3 to 5 times faster, but you won't ruin any specimens, and that is worth it. Keep in mind that the vibration from cutting can cause and propagate cracks in the specimen. "Murphy's law" seems to go double for fossils.

Once you've decided that the specimen is worth preparing, you have to decide how much time to put into it. There are a few different ways that fossils can be prepared, or the surrounding rock removed. These are by (1) physical removing the matrix by chipping, picking and air abrasion techniques, (2) ultrasonically spalling, or (3) breaking down the matrix with chemicals. The best way would be using some or all of these techniques, depending on the type of rock covering the specimen. No matter which technique you are using, common sense is by far the most useful tool in prepping fossils. Whichever technique you use, remember to keep your hands clean. Oil from perspiration and dirt on your hands will come off readily onto a fossil and the matrix. Also remember to guard the fossil against water, humidity, and dust before, during, and after prepping.

Using Hand Tools

When using hand tools in chipping and picking, be careful, watch where you are working. Be familiar with the fossil you're working on. If you should slip, know where the tool is going to end up. You don't want to start poking holes in your fossil. Better to jab your finger because your finger will heal, and you'll learn not to do that again.

This poking the finger process actually has to be repeated a few times before you really learn. Make sure your tools are sharp and stay that way. The tools will cut through the rock faster and lessen the chance of damaging the fossil. (An added benefit of sharp tools is that your cuts heal faster!) Use a good hard steel or carbide for the tip of the tool. A nail is too soft, but a sharpened drill bit will work great. A metal file ground down to a sharp point or edge is going to stay sharper a lot longer than an Exacto blade, especially the cheapos you get from that certain foreign country. Be sure you know when to poke and when to scrape.

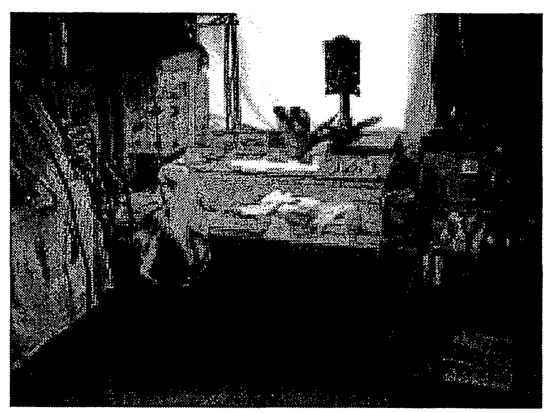
Most of the time you will want to work parallel to the fossil, trying to get as close to it as you can. Brush or blow off the rock dust frequently so you can see what you are doing and where you are going. When using a small pin or pick, work away from the fossil a few millimeters. That way you can remove larger pieces of matrix, reducing the chance of damage. Finish the last thin layer more carefully. Occasionally, a sharpened piece of wood or plastic can be used to pick off small pieces without a chance of scratching the fossil (which metal tools can do very easily).

Wetting and Drying Specimens

You can "artificially" prepare some fossils by wetting and drying them. Most of the fossils collected throughout the Midwest can be treated in this manner. A quick rinse does not allow much water to get too deep into the cracks. However, in some cases immersing fossils in water for a few hours or longer and letting them dry can produce small cracks. These can become big cracks with repeated wetting and drying. Choose carefully which specimens to prep this way; otherwise, you could end up destroying the specimen. Those cracks just love to go right through the fossil. Shales are the most likely to fall apart; interbedded limestones can be separated along the shale partings. This process is best for retrieving small fossils.

Using Air Abrasion

Air abrasion, also known as airdenting, is basically a fine powder propelled by a jet of compressed air. It will wear away anything you put in front of it, including your skin. Originally developed in the 1950s for use in the dentist's office for cleaning cavities, it was fairly painless, but a mouthful of powder got to be a problem. With air abrasion, the choices you have to make are: air pressure, volume of powder flow and hardness of the powder. Don't forget that the micro sand blaster is just that, a blaster. It's going to abrade the fossil as well as the rock covering the fossil, probably faster than the rock if you don't watch it. The fossil will be abraded by the process by only a microscopic amount if prepped correctly—I would guess in the .001 to .0001 inch range. If you are not careful, this could be in the .1 to .01 inch range, and that's really bad.



Zarko Ljuboja's shop

Once the powder hits the fossil, it's going some place else, so be aware where the back spray and over spray are going to go. You could damage something that you do not intend to damage. Do not start airdenting with the tip over the fossil because all machines have a tendency to blast an excess amount of powder when they first start up.

This is caused from the powder that collects on the bottom of the hose and base of unit during breaks in the use of the machine. If you do use that extra burst of powder to prep thicker areas, don't let the tip stay in one spot too long or else you'll end up with tiny round pits in the matrix all around your fossil, and very possibly in the fossil itself.

Try not to see how fast you can prep a fossil because then you are going to miss spots and over abrade other areas. Unless you want to get it done that fast! Then I all I can tell you is, turn up the air pressure and the powder flow. Even then, don't get too much powder flowing; you want to clean the specimen, not dump powder out of the machine. Most important of all, keep the tip moving or you'll wreck your fossil and ugly the matrix for sure. Angle and distance are important for a great job. I've been sent many specimens that have been badly glued or over prepared, with the request, "Can you fix this?" It cannot be done easily.

Speed in prep is OK if you are doing commercial work, but do not use 50 micron aluminum oxide at 125 lbs. pressure on any fossil and expect to get anything better than a fast job. The lower quality specimens cannot be restored in a practical amount of time. I frequently receive specimens that are considered by many to be unpreparable, too thin shelled, too hard or in too many pieces to be prepped. All fossils can be prepared. You have to ask yourself, is it worth the time or is it unusual enough to be prepped or do I really like it?

Ultrasonic Prep

Ultrasonic preparation uses ultrasonic "sound" waves to essentially shake off loose matrix from a specimen, and the specimen from the matrix if you are not careful. The sound waves are generated with a piezio-electric chip and a frequency generator that can make the chip vibrate thousands of times per second. Most use 110 volts, household current, as a primary power source. The ultrasonic bath works only with water. If you use the instrument without water it will fry itself. Vibrating at many 10,000's of cycles per second will spall off most shales and silts covering the fossil. But it's only effective on some limestones, dolomites, and sandstones. It's the small tub full of water you might see in a jewelry store for cleaning jewelry. The only drawbacks are that they are expensive, and many are very small, not being able to handle any rock much bigger than your fist.

Magnification

Magnification is a great help when you get to the small stuff. Replacing a tiny piece the size of the dot like the one at the end of this sentence greatly improves the quality of any specimen. Any kind of magnification helps, such as a loupe, optivisor or microscope. Even if you think your eyes are good enough, well, they are not. You cannot focus that close to something and expect it not to bother your eyes and eventually give you a headache.

Lighting

Don't forget the need for correct lighting. Improper lighting will make any task more difficult. The best and easiest way to light up your workplace is to use both incandescent and fluorescent light. Incandescent light is strongest in the range of 4700 angstroms, or the yellow end of the spectrum while most fluorescent light is strongest in the range of 5800 angstroms, or the blue end of the spectrum. I tried the new GE Reveal light bulbs recently. I liked the light they put out, but they burned out too fast. Not all fluorescent lights give off the same color of light. Your cheapo fluorescent shop light will give off more blue light than a better quality fluorescent intended for office or in home use. I use a regular 100 watt bulb and a clear 100 watt bulb with a short fluorescent light in the airdent cabinet, the kind of light you put under a cabinet.

Patching

Sometimes fossils need cracks patched to stabilize them or to cover up a nasty gap. I like to color the putty that I use for patchwork. It makes it easier to see contours and details that are not readily visible when you use the original color of the putty, when the need to carve it down arises. For instance if you need to restore a free cheek on a trilobite, it's easier to get the right shape when the restored area is close to the color of the trilobite. With a white or yellow wood putty, the off color makes it hard to really see the nuances of the proper contours. Epoxy gray is not so bad to work out the proper contours although it is much harder to carve, and in some cases it does not take color very well.

Chemical Preparation

Another method of preparation is with chemicals. The chemicals most commonly used and easiest to get are HCl (hydrochloric or muriatic acid) and acetic acid (vinegar). Kerosene, although not creating a chemical reaction, will easily break down really soft argillaceous shales when you dip the specimen in the kerosene first and then into water. This process is only for getting microfossils, as it will break the matrix down completely. The use of Quaternary-Olyl, although it is not a chemical reaction, is very effective on most shales and any other type of rock that has some clay content. The mixture that I use is approximately 100 milliliters or ¼ pound of Quarternary-Olyl to about 16 liters or four gallons of distilled water. For most of this type of prep, I will place stable and solid specimens in a plastic colander, with a three wire handle, cut down to fit in a 5 gallon plastic bucket. I then let it soak for a week or up to a month, checking it every five or six days and removing the specimens that are finished.

A Prepping Exercise

As we all know, some can read all the books on preparation and still not be able to prep anything. And just because you have the equipment does not mean you know how to use it. Before you begin prepping fossils, try this exercise called Prep-a-dot. Put a magic marker dot on a piece of matrix and try to prep (chip or airdent) around it and not destroy it. Most of all, don't give up, don't give that fossil to lousy matrix; it will look great after many hours of careful picking. If our ancestors could do it then you can also. Everyone has their own method of preparation, and the ones you choose will be the best for you. Keep an open mind to try new and different techniques. Using a combination of some or all of these techniques and ideas, you will profit from learning the how's, why's, and when's of paleontology, and, most importantly, from meeting the great people you will encounter is this unique field. The following books will give you a good start: *Handbook of Paleontological Techniques* edited by Kummel & Raup (1965), an excellent source although it is rather scarce; *Paleotechniques* edited by Feldman, Chapman & Hannibal (1989).

These are some of the tools I use to prep fossils:

- S.S.White air abrasive unit, a.k.a. Airdent, abrasive jet machine, micro sand blaster. Types I use: S. S. White Model, A, B, K, H & HME. And limestone, baking soda as the abrasive powder. Tips or nozzle orifice size: .007, .011, .015, .018, .026, .035, .045, in thousandths of inches.
- Microscope: stereoscopic with zoom. 10x - 40x power. With a 0.5x adapter, increases working distance.
- Lighting: 40w fluorescent inside the prep cabinet, 100w clear and soft white incandescent on swing arm lamps, 100w/150w halogen swing arm, a few 4' fluorescent shop light
- Air scribes: Ingersoll-Rand, Chicago pneumatic, Aro, Murray Engineering, Sanborn. I like to use 3/16" polyurethane tubing on the scribes, it's more flexible and you don't have to fight against the weight of the original tubing)
- Air compressor, 'Puma' 3hp, 12.9 cfm, 125 psi. and lots of 3/8" tubing.
- Foredom flex-shaft with 2 hand pieces with 1" - 3" diamond wheels, 4" and 4.5" slotted diamond cutting wheels on a pneumatic angle grinder (this is VERY dangerous use ALL precautions), plus a variety of other diamond files.
- Hand tools:

Picks— about 10 different dental picks ground to shapes from angular to rounded convex and concave, sharp pointed pick tool made by 'General' (the tips are replaceable).
Coarse-medium-fine sharpening stones.
sharp tweezers.
A few small files ground down to chisels and other shapes.
Paint brushes from 0000 to #4, flat and round.
Tile nippers, side cut wire cutters, 30" bolt cutters.

- Diamond saws: 6" table, 9" table & 16"drop saw.
- Blower for dust removal, a unit of around 200-250 cfm. or more would work.
- Glues: cyanoacrylate(super glue), Elmer's glue, epoxy putty, Durham's wood putty, Savogran wood putty.
- Final coatings: Krylon 1311 matte finish, neutral shoe polish, Glyptal 17.
- Work chambers: 24" X 24" flat top for microscope, 30" x 42" slant front for the big pieces, 12" x 12" flat top, foam covered bottom frame portable for the really big pieces.

DNA Recovered from Fossil Sources

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The publication of the book entitled *Jurassic Park* by Michael Crichton and the ensuing release of Steven Spielberg's blockbuster movie unleashed a flurry of interest in the potential of extracting deoxyribonucleic acid (DNA) from ancient sources. The seemingly simple recovery of large amounts of ancient DNA as suggested by those fanciful stories coupled with recent real life successes with the cloning of modern animals using nuclei from non-germ cell origins has fanned the imaginations of millions that the resurrection of wooly mammoths, if not dinosaurs, is not only feasible but literally just around the corner. This impression has been further encouraged by an overly exuberant and naive lay press and certainly not the least by a disappointingly over dramatized and unscientific presentation several months ago on the "Jarkov" mammoth by The Discovery Channel. This hyperbole has unfortunately left the general public with the impression that the purpose and goal of the study of "fossil" DNA is to resurrect long extinct fossil organisms. Indeed, there are hints of this expectation in articles written or statements made in some amateur paleontological newsletters. Most assuredly, this is not, or at least should not be, the goal of scientists who look for and study the remnants of DNA extracted from fossils. The purpose of this article is to attempt to provide a balanced consideration of both the promise and the limitations of the study of fossil DNA.

At the very outset, one must appreciate the fact that DNA, when it exists at all, is present in extremely minute amounts in fossilized forms. Therefore, the prospect of recovering and studying ancient DNA is heavily dependent on a procedure called the polymerase chain reaction, abbreviated PCR. When used properly, PCR is an exceedingly powerful technique that has been a major factor in the rapid progress of modern biology. Because of its phenomenal sensitivity, it has also become a powerful tool in law enforcement. It is possible, for example, to amplify sufficient DNA from the root of a single hair to identify the long dead, incriminate the culpable and exonerate the guiltless. For the same reason, PCR also holds out the promise of being an invaluable tool for modern paleontology. In fact, as will be discussed in more detail later, PCR has been used successfully to amplify portions of DNA from at least moderately old fossils and has contributed in a very meaningful way to the understanding of the relationships of ancient animals including men to both their ancient and modern counterparts.

As is so often the case with new technologies, it took the paleontological community some time to appreciate the limitations as well as the strengths of the PCR technique. For example, in the early 1990's there were a number of publications in highly respected scientific journals that reported the extraction of DNA from very old fossilized sources. Examples included fossil dinosaur bones [1], Miocene-aged plant leaves [2] and, yes, even insects preserved in amber [3;4]. As you may recall, insects in amber were the sources of dinosaur DNA in Michael Crichton's book *Jurassic Park*. In those giddy early days one can just imagine what the prospective dinosaur cloners must have been fantasizing. However, without exception, all of those early claims have failed to be substantiated. More carefully conducted studies have been unable, for example, to recover any credible evidence for the extraction and isolation of fossil DNA from organisms, including insects, entombed in amber [5;6]. (It made a good story, but sorry, Michael!) The DNA presumed to be from Miocene magnolia leaves was almost assuredly amplified from modern bacteria that heavily contaminated the fossil bed [7]. The sequence of the DNA extracted from the dinosaur bone was subsequently shown to be more likely mammalian in origin and was probably derived from human DNA that contaminated the specimen [8]. These embarrassing episodes resulted in large part from a combination of a desire for quick fame and a failure to appreciate the serious potential problems inherent in the injudicious use of PCR. These early episodes have belatedly led to guidelines to improve the credibility of reported recoveries of fossil-related DNA [9;10].

What is DNA?

The structure of DNA was deciphered over 5 decades ago by a couple of exceptionally bright scientists James Watson and Francis Crick, who, along with Maurice Wilkins, were awarded the Nobel Prize in Physiology or Medicine in 1962 for their accomplishment. DNA may be briefly described as a very long thread-like molecule which is itself composed of two linear strands that twist about one another in a coiled spiral or helix. Thus, DNA is often referred to as the double helix. The basic subunit or building block of DNA is the nucleotide, and each of the two strands of the DNA molecule is composed of literally many hundreds of thousands, or even millions, of nucleotides hooked together end to end just like beads on a string. The individual nucleotides differ only in that they each contain only one of four possible nitrogenous bases: adenine, thymine, guanine or cytosine.

What is the genetic code?

Stated very simplistically, the sequence of the nucleotides running along the DNA strand is the code or recipe that machinery within the cell uses to synthesize proteins, the building blocks from which all living things are constructed. Since DNA is replicable, this code or recipe is passed on from one generation to another. Thus, children tend to look much like parents and so on. It is now possible to read and understand the code. Therefore, if DNA can be recovered from fossilized organisms, then much could be potentially learned about the relationship of these fossil creatures to other organisms. This would be possible, because living things that are closely related tend to have DNA sequences that are more similar than organisms that are more distantly related.

How does PCR work?

In general, PCR uses the same principles and mechanisms that are used for normal DNA replication. Through a series of repetitious cycles, usually 25 to 40 in number, PCR produces many thousands of remarkably precise and complete replicates of a limited region of a DNA molecule. Using the methodologies currently available, the product of PCR may extend anywhere from less than a hundred to several thousands of nucleotides in length.

To appreciate the power of PCR, one must understand that at least theoretically the total number of amplified products produced by this process is equal to 2 raised to the power of the number of PCR replication cycles. For example, after the first replication cycle the number of replicated molecules should equal 2^1 or 2. After 2 cycles, the number of replicated molecules should equal 2^2 or 4. Therefore, a typical PCR that may involve 25 cycles could theoretically generate 2^{25} or 33,554,432 replicates. Clearly, the power of PCR is that it can start with a very tiny amount of DNA and generate a sufficient amount to study and analyze. This is why the DNA in a single human hair, in a swab from the inside of the cheek or a tiny spot of semen can be used to identify long dead and decomposed people, the parentage of children or the perpetrators of heinous crimes. If there is residual DNA in fossils, then it should be possible to amplify it by PCR.

What are the limitations?

Since PCR is such an extremely powerful tool for retrieving even very minute quantities of DNA, it seems to be a tool made to order for studying DNA from ancient sources. There are, however, a number of very serious limitations to the approach. One problem is that fossil DNA of amplifiable quality is very difficult to obtain. Contrary to the impression left by some, DNA is not immortal but rapidly decomposes after death. Even under conditions that encourage its preservation, e.g., exposure to low temperatures and/or to the virtual absence of oxygen, DNA is still slowly degraded by interaction with even minute amounts of other chemicals found naturally in the atmosphere or in the soil. Further, once specimens are excavated and collected, they are often stored in museum drawers or cabinets where they are exposed for many decades to the degradative effects of oxygen or other chemicals including varnish. At least in the past, it was not uncommon to apply the latter chemical to specimens in order to help preserve their gross morphology. The outward appearance of remarkable preservation is not necessarily a guarantee that amplifiable DNA is also present. For example, it is reportedly very difficult to amplify DNA from Egyptian mummified humans or animals [11]. Thus, by natural attrition of one form or another, the nucleotides that compose the DNA molecule may become altered or may degrade completely. Strands of DNA, which in life may have extended for many thousands or millions of nucleotides in length, are inevitably degraded, even in moderately aged fossils, into segments of at best a hundred or so nucleotides in length. Further, the nucleotides may be sufficiently altered such that the product amplified by PCR does not accurately recapitulate the sequence of the ancient template. Interestingly, lack of evidence of degradation during the amplification process is one of the suggested criteria for identifying a risk of contamination of supposedly "fossil" DNA with modern DNA [10]. It is hardly surprising; therefore, that the more recent reports of the amplification of ancient DNA are usually from fossil sources no more than roughly 50,000 years old [3;12-14]. It is also not surprising that DNA sequences are not always recoverable even from separate extractions from the same specimen or different specimens collected from the same site [13;15]. Even the preservation of protein fragments is not predictive of amplifiable DNA [11].

Because of the very poor preservation of DNA in fossil sources, almost all of the successful amplifications have been from DNA found in mitochondria. Mitochondria are the tiny structures found in all cells and are responsible for producing the energy needed to drive all of the processes of life. Without mitochondria we would be unable to move molecules around within our individual cells, maintain body temperature, digest our food, move the smallest muscle or cogitate about the glimmers of hanky panky that might have occurred between Neanderthals and humans (see below). Mitochondria have their own DNA, ten or so copies of it per mitochondrion, and a typical cell, be it human or geranium, may have thousands of mitochondria. Consequently, there are multitudes of copies of mitochondrial DNA per cell compared to only 2 copies of the DNA found in the nucleus. It is because of its much greater abundance that it is much easier to amplifiable mitochondrial DNA sequences from fossil DNA.

A second problem is inherent in the PCR process itself. The ability of PCR to amplify minute fragments of DNA is its greatest strength and also its greatest weakness. Because of it great sensitivity, PCR is very susceptible to producing false-positive results due to the amplification of minute amounts of contaminating DNA. The early reports of recovery of DNA from fossil sources with ages extending literally millions of years back in geological time resulted usually from the amplification of modern DNA that contaminated the fossil. At least in some cases the contaminant was of human origin [8]. This contamination may have come from the hands of the excited field worker who first retrieved the fossil, the multiple unprotected hands that subsequently examined it while it lay in a museum drawer or a tiny fleck of dried skin from the technician who pulverized the fossil in the attempt to extract DNA from it.

What has been learned?

Because the genetic code is carried with the structure of the DNA molecule, one of the major justifications and values for the study of DNA from ancient sources is the unique insight it may provide into the evolutionary relationships among living organisms, both extinct and extant. This application is clearly illustrated by several brief summaries of the findings of recent studies in which DNA has been successfully extracted and amplified from fossil specimens.

Was great great grandma a Neanderthal?

Neanderthals were a very robustly built type of mankind who inhabited and prospered in Europe for more than 100,000 years before perishing roughly 30,000 years ago. Since their occupation of Europe overlapped that of anatomically modern humans (sometimes called Cro-magnon man), it has been argued back and forth for many years whether Neanderthals and modern humans were completely separate species or whether by mating both contributed to the genetic pool of modern day people of European origin. As a fresh approach to the question, Krings et al. [16] used PCR to amplify a short sequence of mitochondrial DNA from a bone of the upper arm of a Neanderthal. There were sequences found within the amplified DNA from Neanderthal mitochondria that were unique and unlike any found in any known group of modern humans. They concluded, therefore, that it is unlikely that Neanderthals contributed to the modern human genetic pool. This conclusion was further supported when a separate region of mitochondrial DNA was subsequently amplified and sequenced from the same as well as additional extracts of this same Neanderthal bone [17].

Who is related to whom in the Proboscidea?

Based on morphological charac-teristics, mammoths are considered more closely related to Indian elephants as opposed to African elephants. In an attempt to gain further insight into the relationships among relatively recent groups of the Proboscidea, Yang et al. [18] used PCR to amplify a partial sequence of the DNA of the mitochondrial cytochrome b gene from preserved skin samples of both African and Indian elephants, a skin sample from a frozen wooly mammoth mummy, a skull fragment of a wooly mammoth and ribs from an American mastodon found in southern Michigan. Based on their analysis of the results, these investigators concluded that the mastodon diverted comparatively early from the evolutionary line that produced the wooly mammoth and both species of modern elephants. Further, although the comparison of the DNA sequences suggested a slightly greater association between the wooly mammoth and the modern African elephant, relationships between the mammoth and modern elephants could not be unequivocally resolved.

Sorting out the sloths

Although more than 40 genera of sloths existed in the Pleistocene, only 2 species, the two-toed sloth and the three-toed sloth, are alive today. Höss and his coworkers [19] tried to gain insight into the interrelations among both modern and extinct sloths by using the PCR approach. Their findings were informative not only with regard to the family tree of sloths but also with respect to the difficulties associated with the PCR analysis of fossilized materials. Of the 35 different specimens of extinct sloths that were investigated by Höss and his coworkers, only 2 produced PCR products. The successful amplifications were obtained from two separate samples of the extinct ground sloth, Mylodon darwinii, that were collected from the same cave in Ultima Esperanza, Chile, an environment described as subantartic, i.e., cold and dry. From the DNA results, these investigators included that Mylodon darwinii was more closed related to modern two-toed sloths as compared to 3-toed sloths and that the two modern species are only distantly related to one another.

A little ado about cave bears

As is amply illustrated by a visit to the Tucson International Gem and Fossil show, cave bears represent one of the most commonly collected mammalian vertebrate fossils found in the Pleistocene of central Europe and Western Asia. Based on the analysis of a short sequence of a mitochondrial gene amplified from extracts of cave bear bones, Loreille et al. [20] were able to confirm that European cave bears were distantly related to the modern day brown bear but that the lineages had diverged from one another roughly 1 million years ago.

In a separate study, Hofreiter and his colleagues [12] evaluated the genetic diversity of cave bear populations. In the course of their study this group successfully amplified mitochondrial DNA sequences from 12 of 36 samples of cave bear bones or teeth that were collected from 9 different caves in central Europe. Their results suggested that cave bears were separated into many small groups that showed relatively limited interbreeding. They also concluded that a smaller variety of cave bears that populated higher elevations in the Alps were probably ancestral to at least two separately derived forms of large cave bears that lived in central Europe during the Pleistocene.

Delving into sloth dung

A recent study suggests that the PCR amplification of DNA sequences from fossil dung or coprolite may provide insight into the dietary habits of extinct animals. Poinar and coworkers [21] successfully amplified DNA sequences of plant chloroplasts, the tiny structures in plant cells that contain chlorophyll and convert energy from sunlight into usable energy, from a sample of coprolite believed to be from an extinct ground sloth *Nothrotheriops shastensis*. By comparison with the known DNA sequences found in chloroplasts of modern plants, these investigators were able to identify seven plant families that were included in the diet of this particular species of ground sloth.

New mammoths from old mammoth bones?

Since it is such a "hot" topic, a discussion of the fossil DNA would not be complete without at least some consideration of the feasibility of resurrecting long extinct fossil animals. Given the natural vulnerability of DNA to degradation and the lack of any credible evidence that any dinosaur DNA yet remains, the rejuvenation of even one dinosaur seems improbable, if not outright impossible. Further, given the enormous obstacles, the task of bringing back even a more recently extinct species, for example, the wooly mammoth, seems equally remote. The first and greatest problem has to be the lack of DNA as even that found in relatively young fossils is highly degraded. Even if there were a source, DNA alone is simply not enough. In all organisms, even bacteria, DNA is highly organized into thread-like structures called chromosomes, and the order of the DNA both in terms of which chromosome it is located on and where it is located along the length of the chromosome is very important. Assuming you had the full and complete complement of DNA for a mammoth, you could not just mix it together willy-nilly and hope for a mammoth. Among other things, we have no idea even how many chromosomes a mammoth nucleus had.

A second problem is that the cloning of animals, even modern ones, is a very inexact science. The current state of cloning technology requires that an intact nucleus, including the chromosomes, their associated complement of highly organized DNA and all kinds of regulatory proteins, be injected into an egg cell that has had its own nucleus deleted. Given the natural decay process of all organically derived molecules, the prospect of finding an intact and functional nucleus, even in a frozen mammoth mummy is at best extremely unlikely. The odds are probably considerably better of winning the Texas lottery. It would help if a mammoth at its demise had fallen into a large pool of liquid nitrogen and remained there waiting for at least 10,000 years until a reputable cloner could come along and find it. Unfortunately, the maintenance of nitrogen in a liquid state requires a temperature below -320 degrees Fahrenheit, and it just doesn't stay that cold for very long even in Siberia.

History clearly teaches that things that appear totally infeasible today may become achievable tomorrow. However, even if one could resurrect a mammoth, what, other than as a publicity stunt, would be the purpose? Admittedly, it would make one whopper of a zoo attraction, but both the attendance and the admission would have to be enormous just to help recover the cost of completing the project in the first place. Since the creature would be far removed from what had been its original environment and social support, it is questionable how much could be reliably learned from studying the physiology and behavior of this poor isolated beast that could not be learned from the continued study of modern elephants, assuming that they survive. For a lot less money and with far greater prospect of success, one could set a reasonable goal like returning modern day bison to the Great Plains.

Summary

Studies conducted within the past decade or so have shown that it is possible to amplify short sequences of DNA from fossilized forms. The DNA found in fossilized material is extremely degraded such that the successful recoveries of primitive sequences have come primarily from mitochondrial DNA and even then from only a limited number of samples. The current state of technology is plagued with problems of contamination of DNA from more modern sources; and as a result, only a handful of laboratories have adequately mastered the procedures for recovering "fossil" DNA properly. On the other hand, when properly done, the study of DNA recovered from fossil sources has provided unique and valuable information regarding the interrelationships between various fossil forms as well as with their modern day descendants. Among the exciting prospects for the near future are the development of better procedures for recovering DNA sequences that are currently too tightly chemically bound to other types of organic molecules to be amplified [21].

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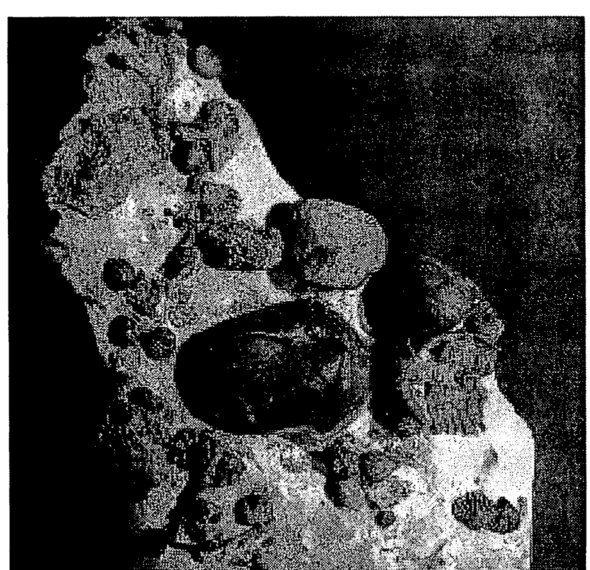
Fossil Preparation



Waldron Shale slab prepared by Kenneth Karns.

FOSSILS—PALEONTOLOGICAL DATA OR CURIOUS ARTIFACTS

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Those of us who ferret out our own collecting localities by researching professional publications (journals, various geological survey publications, fieldtrip guidebooks, etc.) are familiar with the vast amount of data given by authors. The reason for this is twofold. First, as with any scientific paper, the results must be repeatable. Giving the precise location of the collecting site along with complete fossil lists allows other qualified researchers to continue and expand the stratigraphic or faunal study. Second, the data presented in the paper must be able to be placed in the correct temporal, spatial, and systematic context so that a more complete picture of the evolution of life through time, over a geographic area, and within the appropriate phylum can be achieved. In this paper, I will attempt to survey the information critical to any paleontological investigation and some suggestions on how to accomplish the determination and archiving of such information.

If you were like me, you first started collecting fossils at an early age and there never appeared to be a compelling reason to write down more than just the basic information such as which quarry or road cut the fossils came from (if even that). Since the collection most likely represented only a few localities and the specimens were stored in separate shoeboxes (or whatever), the need for additional information probably seemed unimportant—after all, you remembered what part of the quarry or road cut the fossils came from. Then, all of a sudden it seemed, the 2 localities grew to 5, then 10, then 20, and you had trouble remembering the details of the first 2. It was at this point, if not much earlier, that you began to realize the importance of complete documentation of the sites and specimens so that you could organize your growing collection and place it in a meaningful context. Fossils, by their mere presence, represent a data set that, if documented fully, can contribute to the fundamental purpose of paleontology—a complete-as-possible inventory of prehistoric life.

Also, like me, you probably began collecting fossils near your hometown, particularly if the immediate area presented ample collecting opportunities such as the Cincinnati area or my hometown of Rockford, Illinois. Your initial collection, therefore, most likely consisted of fossils from the same geologic system (Ordovician, Mississippian, etc.) or even the same formation and they all looked pretty much the same. Documenting all of your fossils is, of course, important—which is why I am writing this article. However, complete documentation of faunas that resemble one another (same formation or group) but are from different localities is even more critical so that information such as spatial or geographic distribution will not be lost if the specimens are somehow mixed. That's the point. Even if these faunas were collected only a few miles apart they are *similar* but not exactly the *same.* My most recent research involves an incredibly important fauna from a very large quarry. Deposits that contain the unique type of preservation that makes the fauna so significant occur only sporadically throughout the quarry with some exposures already, unfortunately, destroyed or reclaimed during quarrying operations. I have found that the specific faunal make up of these separate deposits varies by not only abundance of individual taxa but also species and even, although rarely, genera present—remember, this is the *same* quarry. If this fauna is indeed, as I believe, significant to science, I have, by documenting the differences, insured the preservation of the information for any future studies by researchers much more qualified than myself. A systematic collection of fossils from the same formation but from many different locations can provide you with data on the spatial occurrence of taxa that no one else has. This data can be useful not only to any professional involved in research in your area but also to yourself should you decide to specialize and elevate your collecting to a new level (which some of you may know I have done with Ordovician Platteville nautiloids). Remember, since we amateurs usually have an opportunity to collect more often than professionals, particularly if our localities are close to home, we have a responsibility to document as completely as possible our collections so that they may become a resource not only for ourselves but also for current professionals and future generations.

About 20 years ago I was made very aware of the importance of documenting locality information for my fossil specimens when I brought my collection of Platteville nautiloids to the late Rousseau Flower, at that time the foremost authority on nautiloids, particularly those found in Ordovician rocks, in the world. It was early in my "career" and I had, through an exhaustive search of the literature, identified as many specimens as possible. There were, however, several specimen types that I could not identify—probably described in obscure publications that I did not have access to, I thought. After confirming (or, in a few cases, correcting) my identifications, he examined the ones I could not identify. I can still remember the gleam in his eye when he told me that the reason I could not identify them was because they had not been previously described (they were new to science) and would I like to write a paper with him describing these specimens. He quickly added, "You do know where each of these came from, don't you?" After the shock of realizing that I had found (as had several other amateurs I found out later) fossil nautiloid types that had never been collected previously despite a history of over 100 years of collecting in that area, I assured him that I did indeed have locality information on all of my specimens. Fortunately, I began labeling each specimen with a locality number right from the get-go (I freely admit that I am a compulsive organizer although not as compulsive as Monk). Imagine my embarrassment if I had been forced to reply to Rousseau, "Well, they came from somewhere in northern Illinois or southern Wisconsin—I just can't remember exactly where."

So, what type of information is needed to insure a collection is scientifically viable? Obviously, documenting as much site information as well as post-collecting information as possible makes your collection not only more valuable to science but also more satisfying to you personally. Remember, since collecting sites are often ephemeral, you cannot have too much information but you can have too little. Information documented in a locality description should include the following: 7.5 minute United States Geological Survey topographic map on which the site appears, township and range or other coordinates to pinpoint the site on the topo map, state, county, nearby city or town, detailed road log to the site, and the type of exposure (natural, road cut, quarry, etc.). Post-collecting information, based on your subsequent research of the area, should include as much of the following as possible: geologic system, formation, member, and any professional research of the geology and/or paleontology of your locality in particular or the local area in general. This post-collecting research can involve professional papers from journals such as the *Journal of Paleontology*, U.S. and state geological survey publications (nowadays most have their catalogs online), and field guidebooks published by state geological surveys, geological societies, or amateur clubs. Additionally, I include the dates each locality was visited to not only track my visits to each site but also document any changes to the quarry—the formation you collected at the lowest level of the quarry one year may be, as a result of further excavation resulting in a deeper pit, somewhere in the middle with a new formation exposed at the bottom of the quarry the following year (happened to me several times and three times at one quarry alone).

Developing a numbering system for your localities can also help to organize your collection. I began by simply numbering each locality in each geologic system sequentially. Thus, my first Ordovician locality (a Galena quarry at Rockford, Illinois) was numbered O#1, my sixth Silurian locality (the famous Waldron, Indiana) was S#6, and so on. That worked well when I had only a dozen or so localities. However, as my passion for collecting (as well as the collection itself) grew, I realized that I would have to develop a more comprehensive numbering system to both organize site data and facilitate entry into computer databases. The system I devised consists of a seven digit number: the first two designate the geologic system, the second two designate the state in which the site is located, and the final three indicate the sequential number of a site in a particular system located in a particular state. So, that first Ordovician locality became 0201001 (the first Ordovician site in Illinois) and the Silurian locality became 0403001 (first Silurian site in Indiana). I designated the Silurian as system 04 since, with so many Ordovician localities (almost 90), I felt the need to separate the Middle Ordovician from the Upper Ordovician. In hindsight, this may not have been such a good idea since the nomenclature position of several of the Ordovician formations and groups has been changed over the years due to more detailed stratigraphic, faunal, and K-bentonite (altered volcanic ash—there are several significant ones in the Ordovician of eastern North America) analysis—but it seemed like a good idea at the time and the system works for me. Clearly, any numbering system that you feel comfortable with will enhance your effort in documenting and organizing your collection.

There are obviously two ways in which locality data can be recorded and archived: written records and computer databases. We all began by writing down our locality information on a slip of paper and stuffing it into the bag that contained the fossils from that site. That works for field collecting but, once home, a formal record of the site needs to be recorded. I started out with one book that served as both field copy and archive copy. I soon realized that this was not a good idea and that multiple copies were needed as backups to insure piece of mind. I therefore decide to copy and expand locality information in both written locality books (I need two to accommodate the number of localities—221 and counting) and computer files. I still have the field book, which documents only the essential information for each site, and utilize it as my guide during collecting forays. I have documented complete site information on the two volume expanded home edition as well as various computer files (saved on my hard drives at both school and home as well as on several 3.5 floppy discs—on second thought, I may indeed be able to give Monk a run for his money) with each acting as both backup and permanent archive. For the comprehensive home volumes I chose loose-leaf books so that I could add pages easily as the number of localities grew. Additionally, I have also made section diagrams (in still another separate book) of my most significant or more active localities. Using these diagrams I can compare my sections to those published by professionals in journals and other publications as well as track quarry activities that alter the exposed section since most of my prime nautiloid localities are quarries.

The identification of specimens is often considered a separate data set from locality information but, in reality, both are needed to insure the maximum amount of information about each site that is represented in your collection. A faunal list for each locality is essential in documenting the spatial and temporal extent of each species or animal group. I have found that computer databases are the best method for recording specimen information since space would preclude including all but basic fossil types (brachiopods, bryozoans, etc.) in any written books you may employ. Once a specimen has been identified it can be entered into the computer and should include the following information: genus, species (if known), classification (phylum, class, etc.), geologic system, formation, member, and, of course, locality. Rather than entering *every* specimen into the computer (one hundred specimens of the same species of nautiloid found at the same locality is a bit redundant), I enter only each individual species (or just *genera sp.* if the species is indeterminate) that has been found at a specific locality. Thus, utilizing the flexibility offered by the database program, I can recall from the computer a complete list of every nautiloid species I have found at a specific locality or list all of the localities at which a specific species has been found. Such information represents a priceless historical record that not only documents specific sites (indispensable given the present state of access, or lack thereof, to collecting localities not to mention those that no longer exist) but is also essential to those of us involved in systematic and faunal-distribution studies, such as my nautiloid research.

Since identifying specimens is often the most time consuming research we amateurs undertake (aside from locality investigations—have to find the little critters first), a few helpful hints might aid in the identification process. I will confine my comments to invertebrates since, for most of us, this is the group we collect the most considering the difficulty nowadays of collecting vertebrates (most take up too much room anyway). The various volumes of the *Treatise on Invertebrate Paleontology* are a good place to begin your search since each phylum or class is given its own volume. There are problems and limitations with this series, however. First, to identify each type of fossil from a site you will need at least several (probably many) of the individual volumes. Second, the identification in each volume is to the generic level with only one or two species briefly described and illustrated. Third, many of the volumes are a bit dated and are in need of revision. In all fairness, the *Treatise* volumes do a good job of placing your specimens in a systematic outline (class, subclass, order, family) accurate, of course, up to the date of publication.

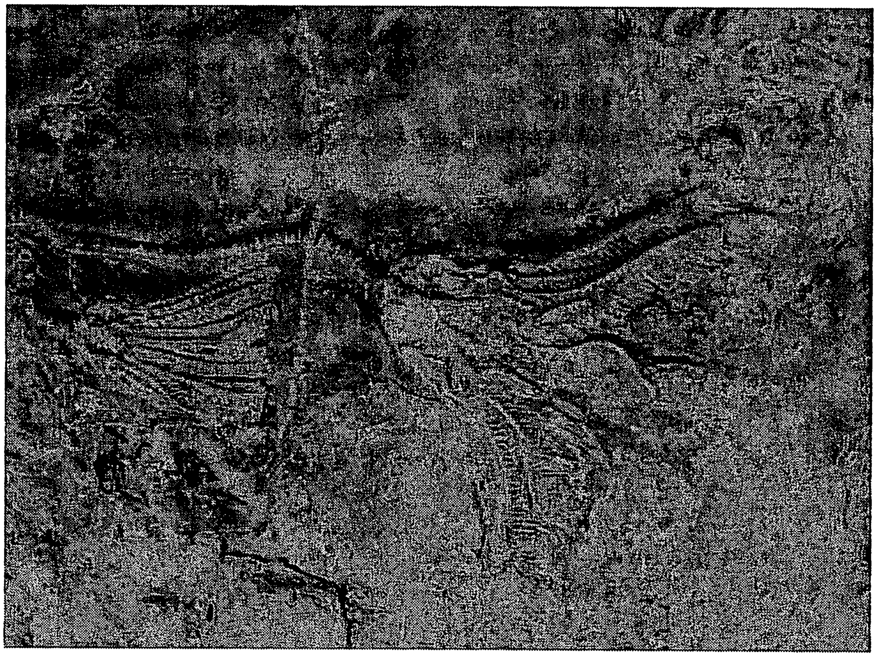
A frequently overlooked source because of its age (same age as I am so I have an affinity for this volume) is the *Index Fossils of North America*. Many species from all phyla are briefly described and pictured using the photographs or drawings from the original source in which the species and/or genus was first described. In this book, more species of a genus are often, but not always, described and illustrated than in *Treatise* volumes. Certainly there have been some name changes since the *Index* was published and it does not include every genus in a phylum or class as the *Treatise* does (at least at the time of publication of the individual volumes), but it is still, in my opinion, the best first-attempt source at identification available. In both books, references are given allowing for a more extensive search of the original publications in which the fossils were described. I cannot overly stress the importance of these primary sources since they provide the *complete* description and illustration of each taxa (besides, the original names stay valid more often than not). In addition to describing a particular type of fossil (nautiloid, crinoid, etc.), these references often give complete fossil lists of associated taxa found with the target group in a certain geographic area or, if you are lucky, specific locality—definitely aides in identifying the various fossils you found. I was fortunate in finding several publications by August Foerste at a used bookstore that described Ordovician nautiloids of the central states—made my job a bit easier. Original descriptions can be found in professional journals both domestic and foreign (many have annual indexes that list authors, subjects, and, occasionally, systematic names), publications of the United States Geological Survey (good source of monographs particularly for the Ordovician) as well as state geological surveys (particularly the older bulletins and monographs), and monographs published independently.

Another concern some have is just how to organize the collection itself. There are several organizing strategies available and I employ both. Which method I use depends on the type of fossil I am cataloging—Platteville nautiloids versus everything else. My eclectic collection is organized by site. I have placed all fossils of each species or type in separate small boxes and placed these in covered flats. The name and number of the locality is written on the outside of the flat and the number is written on the individual boxes inside. Thus, I can instantly pull out the appropriate flats and compare echinoderms from, say, the Mississippian Haney Formation in Indiana with those from the Fraileys Formation in Illinois. For my Platteville nautiloids, however, I have grouped them by species. This allows me to compare specimens from each locality to one another as well as search for any intraspecific variations. To do this, I have obviously numbered most of the individual specimens particularly those that represent my type examples of each species. I freely admit that I do not number *every* specimen I have collected—there is just not enough time (for some nautiloid genera I have actually found enough specimens from *one* locality to *fill* an individual flat). For those nautiloids that I do number individually, I place only the locality number on each specimen. Early in my career I began by numbering the specimens sequentially and recording the numbers in a book (which would have been transferred to computer files had I continued this practice). I know many collectors that do this and it works just fine for them. However, sequential numbering has, in my opinion, a few disadvantages: the numbers get very large for large collections and placing these large numbers on small specimens is a challenge, one must maintain and protect still another record book (or computer file), and to find the locality of specific specimens you need to keep referring to the record book. For me, placing locality numbers on specimens works best.

So, with a little effort and patience you can turn your collection into a well-managed resource of paleontological information that is available not only to current researchers but also to the museum, university, or institution that will, hopefully, become the eventual repository of your fossils. In addition, in my opinion a well managed collection is more personally satisfying to the collector—after all, being amateurs we do this for the love of fossils. Considering the lack of museum money to collect and/or acquire virtually any fossil (except, of course, large dinosaurs with humannames) and the decrease in the number of professionally employed paleontologists, our "amateur" collections represent the most current paleontological data available. Without such new data, professional paleontologists may be forced to analyze the same data set over and over (and there is, of course, a limit to the amount of information that can be squeezed out of the same set of fossils). Collection management insures that you will be leaving a legacy to future generations—a legacy that turns curious artifacts into not only an important source of paleontological data but also a testament to the time and effort you put into collecting and organizing your fossils. To paraphrase a Native American philosophy, "We borrow these fossils from our grandchildren."

Fossil Preparation: Before and After

Fossil Crinoid, Ordovician, Ontario, Canada before preparation



Fossil Crinoid, Ordovician, Ontario, Canada after preparation by Marc Behrendt

Access Makes an Old Collection New

Brian Bisbee
Assistant Curator of Information Technologies
Illinois State Museum, Springfield, IL

Somewhere in a drawer lies the fossil your museum visitor wants to see—somewhere in one of a few hundred drawers of neatly labeled, but similar looking specimens. Not to worry: far in the past, a meticulous curator had arranged all of the specimens in this collection alphabetically be genus and species. It should be just about ... here!

Only, perhaps it's not. Unbeknownst to you, your visitor has requested the fossil under its new name, assigned in a paper only last year, instead of the old name under which it was cataloged 60 years ago. A quick trip to the library reveals the change and, sure enough, there is the specimen, seven cabinets away and four drawers down.

As any collector knows, managing the information associated with large groups of objects is a difficult chore. When you are charged with managing and preserving an ever-increasing amount of data—and are legally bound to do so in perpetuity, as museums are—the chore takes on an entirely new dimension. How do you plan for future expansion! How can you make sure that information stays up-to-date year after year? How will important institutional knowledge be maintained as different staff members with different specialties come to care for varied collections? And most importantly, how can this store of information be made accessible for public benefit?

These problems are not new for museums, nor are they uncommon.

The Illinois State Museum maintains a sizable collection of fossil plant and animal specimens from the famous Mazon Creek area of northeastern Illinois. This collection is important for two reasons. First, it contains numerous type and figured specimens—those first examples used to describe a new species or illustrate it in a scientific paper. Also, some of the specimens are among the museum's founding collections received from the original Geological Survey of Illinois in the late 1800s.

These collections have supported considerable scholarly work. Unfortunately, in recent years, work on the museum's geological collections had shifted to other areas and the Mazon Creek materials were falling into disuse. With the recent retirement of a curator expert in these specimens, it has been difficult to keep catalogs updated and to provide interested researchers access to the collections.

I was asked to devise a plan for revitalizing the collection by increasing its availability and utility to researchers and the public. By trade I am a technologist, not a geologist, and I opted to hit the problem with the largest hammer at my disposal: the Internet. Museums have been experimenting with online technologies since the early days of the public Internet because constructions such as "virtual exhibits" and online collections databases are ideally suited to meeting museums' two primary, and sometimes conflicting, duties: preserving objects for posterity and making them available for the public to use. Access via the Internet to digitized collections often can provide enough information to answer a question without requiring a researcher to handle the actual objects, thereby avoiding risk of damage. The same technologies allow information to be disseminated to a global audience, instead of only people living near a museum or having the means to travel there.

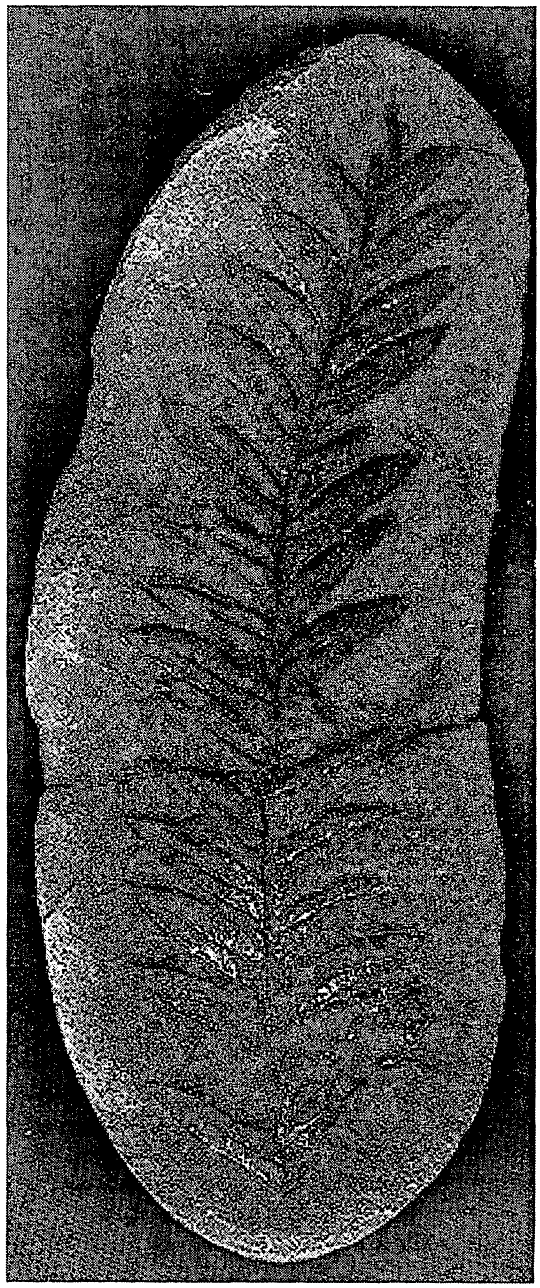
At the same time, I wondered whether an online database could also provide a third function: assisting in the upkeep of collections information by allowing users to add new information or commentary about existing information in the digital collections.

A project such as the one I undertook has three components: identifying the information that the system must hold; designing and implementing an appropriate architecture for the system; and, digitizing the collections objects and their associated information.

I began with part of the third component. In this early phase of the project, I chose to work with only a portion of the Mazon Creek materials: the George Langford Collection, 1,672 Pennsylvanian fossil specimens from the Francis Creek Shale of Will and Grundy counties in northeast Illinois given by a single donor in 1938.

Fossils from this area are notable for the level of fine anatomical detail preserved, even in soft-bodied organisms. The collection is mostly botanical, but does include some animal fossils. The specimens themselves are mostly in the form of split ironstone concretions, with the fossil revealed in part and counterpart along the plane of separation. They range in size from small buttons to large dinner plates, and in weight from a few grams to several kilograms.

My intent was to provide a digital image for each specimen at about 600 dots per inch, sufficient detail for figuring or presenting an argument about taxonomic description. I tried digital photography and scanning prints of conventional photographs, but the



Alethoptoris sp.

method that rendered the specimens in the best detail and at the most efficient cost and schedule was to scan the specimens in directly on a flatbed scanner. For all but those specimens with very irregular surfaces, where more than a centimeter lies between high and low surface points, direct digitization produces fine results. Color fidelity and contrast in these images are as good as or better than the results achieved through conventional photography, and reproduction of details is excellent.

Determining what information to include in the database was not difficult, because the museum already maintained a thorough paper record of cataloging information about each specimen. I duplicated this paper record in the database design, making alterations at certain points in order to form a more flexible, relational structure among the data. I also surveyed records pertaining to specimens outside the Langford Collection, so that data not needed initially, but necessary for future expansion, could be included early. To this basic database structure, I added facilities for referencing any literature where particular specimens had been published. Finally, and unusually for museum collections databases, I added a tool whereby users of the database could annotate the records where they wished to provide additional information abut a specimen of dispute the existing information. Users are not able to alter the existing data, but their comments will be permanent.

The architecture I designed for the system has three layers. The top layer is the code forming the Web interface and is what the user actually sees. The middle layer is an intermediate database, accessed by the Web interface and containing the collections information to be served online. The bottom layer is the database used within the museum, configured to provide the intermediate database with information automatically. This structure shelters sensitive information in the internal database, such as appraisal values, from the Web interface. It also makes it possible to expand the scope of information available through the system, simply by connecting additional collections databases to the middle-layer database as necessary.

The most difficult part of this architectural design was selecting a suitable data model for the intermediate database. A data model, in database parlance, is the framework used to arrange the information and link it relationally. I investigated several existing models from large museums and universities, but was not entirely satisfied with any of them. Ultimately, I had to construct one from scratch that was based on the museum's record keeping practices. It is flexible enough to accommodate all of the information identified for inclusion in the data base, and expandable enough to accept data from the museum's other collecting areas, if required.

The Mazon Creek Collections Database made its first appearance on the museum's Web site in early 2001. It quickly has become one of the most frequently visited portions of the site.

Visit the database at www.museum.state.il.us/exhibits/ mazon_c.

Caring for Fossils: Suggestions for Long-term Care of Private Collections

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For centuries fossils have been capturing the attention of people from very diverse backgrounds. Fossils have been used as building stones, jewelry, currency, research specimens, pieces of art, sacred stones, and as indicators of important resources like oil. Because so many people have different ideas about how best to utilize fossils, disagreements about the care and collection of specimens often arise. So, the question becomes: how can we truly define the value of these special objects? Further, how can we, as collectors and caretakers, maximize the value of the specimens that we have accumulated?

In order to maintain the value of any object, you must preserve it in a way that preserves its original integrity and its appeal for the majority of those who may be interested in acquiring it in the future. The purpose of this article is three-fold. First, we will determine what groups of people have an interest in acquiring fossils. Next, we will gain an understanding of each group's definition of value. Once value has been defined, I will discuss the most appropriate measures to take to conserve your collection to ensure its value and preserve it for the future.

WHO CARES?

There are three main categories of people who have an interest in collecting fossils. These are: academics, collectors, and business owners. There are, of course, sub-groups within these categories that share similar definitions of value with one another. That is a good thing! The more agreement between different types of collectors, the easier it will be to come up with a plan to care for your own collection.

The academic category consists primarily of two groups: researchers and educators. Researchers, (professional, non-professional, or student) all collect for the same basic reason: to gain a better understanding of a bigger issue through the use of fossils. Educators, including teachers from all age levels, as well as museums workers, exhibit designers, and public programmers, all collect fossils to help teach people more about the world around them.

Collectors most often gather fossils as objects rather than for scientific or educational purposes. They collect as a hobby or for their inherent beauty and form. This is perhaps the most broad category of collectors, with the most diverse reasons for gathering natural history specimens.

Businesses that utilize fossils include wholesalers, retailers, preparators, or the makers of casts and replicas. This group of collectors may also have any number of reasons for choosing to deal in fossil-related material. Their true interest in dealing in fossils may be to cater to educators or artists, or they may have always had an interest in natural history. The main thing that separates this group from the others is that a part of the motivation for their collecting is financially driven.

No matter which group of fossil collectors you examine, you will find that most, if not all of them, have a genuine interest in paleontology or natural history. In addition to interest, many also have a deep curiosity about these objects' histories, origin, and their relationships to the rest of the natural world.

WHY DO THEY CARE?

Just as there are three main groups of fossil collectors, there are three primary definitions of value given to fossil specimens: intellectual or educational, aesthetic, and monetary.

Researchers, educators, and museum workers have a common interest, and a common definition of value. Context and documentation of specimens are essential to the mission of the professional academic. Without important data such as locality, date of collection, and geologic formation, the specimen cannot be used for research, exhibits, or educational programs.

Aesthetic value is perhaps least important to the academic community, though I don't know any researcher whose heart doesn't skip a beat when he or she sees an exceptionally preserved specimen, especially if it's in their chosen field of study. It is hard to deny the inherent beauty that can be found in fossilized organisms. The seemingly random forms and shapes that come from the sea and land are not random at all, but dictated by the complex order of nature. There is beauty in the endless colors that appear as the result of mineral replacement; the flash of an ammonite replaced by pyrite or the fire of a snail replace by opal. These are all things that command awe and respect from even the most unobservant person.

Once one is swept away by the beauty of fossils, it is easy to understand why they have monetary value, but beauty and perfection are not the only factors that increase monetary value in the case of fossils. As is the case with any "antiquity," the rarity of the specimen plays a large role. Also, the laws of supply and demand can be determined by popular culture, the notoriety of the collector or locality, and certainly by the overall stability of the economy.

CONSERVATION AND STORAGE

STABILIZATION:

The first thing to do with any fossil you acquire is to make sure it is stable. Fossils are obviously worthless to everyone if they crumble to dust. The first rule of conservation is, make sure that anything you do to a specimen is reversible. If the process is removable, be it an adhesive or a mount, you leave yourself the option of replacing or upgrading your original work if technology improves.

There are currently two consolidants that are commonly used to harden matrix or solidify specimens that are crumbling. *Butvar* and *Acryloid B-72* are most commonly used for this purpose. Both are usually in the form of beads that must be dissolved in a solvent such as acetone. These products dry clear and are not brittle. The ability to change the viscosity of the hardener by adding or deleting solvent is also helpful. Thin, watery mixtures are able to permeate bone and rock, hardening it from the inside out, while thick mixtures can be used as a temporary glue during preparation work. Neither of these products are able to be used with wet specimens.

If specimens have any trace water in them, an emulsion must be used to ensure consolidation. Do not use emulsions in situations where water is not present, however. They are not as reversible and have a tendency to yellow with time, even if they are considered to be conservation grade, like *Rhoplex.*

DOCUMENTATION:

I cannot stress enough the importance of documenting your fossil collection. Documentation gives your collection the historical, geographic, and geologic context necessary to understand the greater importance of the specimens. People have a deep interest in knowing the stories behind objects. Who collected it? Who previously owned it? What materials were used to conserve it? Where is it from? From whom was it purchased? These are just a few of the many things that are not only interesting bits of information, but necessary for anyone who might want to use them for educational programs, research, or display. Document everything you know about the fossil and keep that information with the fossil at all times.

It is best to use acid free paper and pens that contain acid free ink. These items can be obtained at any paper supply store. If using a computer printer, it is best to use a laser printer rather than an ink jet. Ink jet ink is not water proof and will run or fade if it is exposed to humidity. Any pen that is acid free or archival will work, but common brand names to use are *Micron .01* or *Uni Ball micro*. To further safeguard your specimens from losing valuable data, it is best to connect the specimen to its information using a number. Write identical numbers on the data label and its corresponding specimen so the two can be reunited in the event that they get separated from one another.

In addition to specimen data, it is imperative that the necessary collection permits or legal importation documents accompany specimens at all times. Many countries, including the United States, consider fossils to be part of their cultural heritage and, because of this, strict laws have been passed restricting the collection and export of such artifacts. Make sure you are familiar with all laws pertaining to areas in which you collect.

PREPARATION:

If the first law of conservation is "make everything reversible," the second law is "modify the fossil as little as possible." Obviously, some fossils would have no value to anyone without some sort of preparation, and most collectors do tend to focus on the aesthetic nature of their collections, but minimizing the action taken on a fossil can dramatically increase the desirability of the specimen.

If restoring a specimen that is broken, it is best to use a Cyanoacrylate glue, which is very similar to Super Glue. The difference is that Cyanoacrylates dry clear and do not yellow, or become brittle with time, while Super Glue does. There are many good brands of Cyanoacrylates. I usually use *Insta-Cure*, which comes in three different viscosities; super thin, gap filling, and extra thick. An accelerator can be used to make the bond instantaneous, which is very helpful in situations where there is no good way to keep the two pieces together the entire duration of the regular dry time. I have found that using accelerators usually makes the glue more brittle and less reversible. Cyanoacrylates are ideal for repairing breaks that are obvious fixes, when two pieces fit cleanly together.

When looking for a product to fill large gaps and reconstruct missing sections of vertebrate specimens, look for an epoxy that does not shrink or expand upon drying. A common product used in professional prep labs is *All Game Epoxy*, which can be found in most taxidermy supply stores and catalogs. It is best to make any reconstruction or modeling distinguishable from the real specimen by either leaving the areas unpainted or by painting them a solid, neutral color. If painting areas that have been reconstructed, acrylic paint is the best choice. If any reconstruction is done on a specimen it is essential that it be noted on the data label. Reconstruction, especially when it is done for the purpose of stabilization or restoration, is fine, but if the fossil ever leaves your possession, the new owner must be aware that part of the specimen has been reconstructed. The same rule applies if you decide to make a composite piece (one specimen made from many different individual fossils). Good composites are can be difficult to spot and since they have little value, except as models, some people take advantage of the fact that they can get more money for specimens if they sell them as real fossils. Even experts can be fooled.

One of the most recent, and most famous, cases of composite confusion involves the *Archaeoraptor*, purchased from a Chinese dealer by a museum in Utah, later published on the cover of the November, 1999 issue of *National Geographic*. *Archaeoraptor* was hailed as the true missing link between the dinosaurs and the birds. The magazine published an article on the bird with a dinosaur tail before it had been properly introduced to the entire scientific community. There was an almost immediate backlash. Upon further investigation of the fossil itself, it became obvious that it was a composite of not two, but up to six different creatures from the same locality. Some of the pieces were even counterparts of each other, yet in the excitement of finding such an important specimen, everyone had failed to notice such an obvious sign of a fake. It is extremely important to prevent such scenarios, out of fairness to private collectors and scientific researchers alike.

Other types of preparation are somewhat destructive or can irreparably alter the specimen. These techniques include air abrasion, polishing, and matrix removal using air scribes or rotary tools. There is no doubt that matrix removal and air abrasion often expose fossils in such a way that they are more beautiful and displayable, but keep in mind, the matrix is keeping your fossil safe as well. By removing matrix you are making the specimen more susceptible to damage and degradation. An air prepared specimen is almost always worth more money than one that has not been prepared, but in taking away matrix and associated specimens, you are also taking away some of the fossil's context. It is always a good idea to photograph a specimen prior to preparation and several times during the preparation process to document its change in physical appearance.

Cutting and polishing specimens, though an eye catching technique, is the most detrimental preparation technique with respect to the fossil. When a single, large fossil is broken down into many small pieces and polished for sale, virtually all educational value of that piece is gone. In some cases, extraordinary fossils with considerable monetary value are cut down because it is faster and easier to sell hundreds of small pieces than one large piece for a large sum of money. I cannot expect that this type of preparation will ever stop, but I can't help but try to dissuade people from doing this to their private collections.

Storage of fossils is a difficult topic, because the most ideal situation is cost prohibitive for most people and businesses. Gasketed metal cabinets, such as *Lane Cabinets*, are the ideal. They prevent airflow and dust build up on specimens, and also help prevent damage from excessive light, temperature fluctuations, and insects. Since these cabinets are so expensive, many people opt for a wooden alternative or open shelving. Wooden cases are fine, but should be lined with an acid free, closed cell, ethafoam. Do not use regular Styrofoam or upholstery foam. These can go through structural changes with temperature and humidity fluctuations and can ruin your specimens. Ethafoam comes in varying thicknesses, and can be used to make support forms for odd-shaped specimens. If open shelving is used, dust can be minimized by hanging sheets of plastic poly over the front. Strong magnets are sufficient to hold the poly in place. Finally, individual specimen boxes should be acid free cardboard. If you store your specimens in stacked boxes, it could be cost prohibitive to purchase acid free storage boxes. Consider buying lidded ledger boxes from an office supply store, making sure to get those made with no coloration or dyes.

RECAPPING THE RULES:

When determining the value of your specimens, consider the points of view of all people who might potentially be interested in your fossils in the future. In order to best conserve your collection, it is beneficial to take measures that will increase the value in the eyes of the majority. The things to keep in mind when caring for your fossils are:

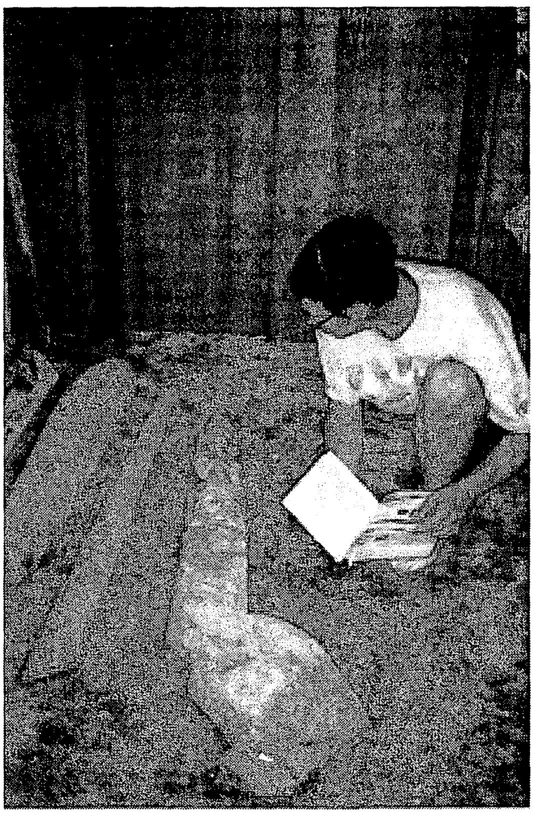
1. Stabilize your fossils using archival materials and reversible processes.
2. Document everything you know about the specimen, and keep that information with the specimen at all times.
3. Prepare specimens keeping context in mind. Don't take preparation too far.
4. Store your collection with materials that will not degrade through time.
5. Enjoy your collection. Show it to people!

Everything from beauty to a better understanding of life on Earth is available to us through fossils. But fossils are a limited resource. Many famous localities have already been eaten up in the name of progress and expansion. If we take steps to better preserve these natural phenomena and all the information they have to offer us, our fascination with fossils can continue for many years to come.

How to Catalog a Fossil Collection

Phil Burgess
Prairie du Chien, Wisconsin

Cataloging is probably the single most important factor to consider when assembling a fossil collection, or a collection of anything for that matter. Without proper accurate specimen documentation, even the most beautiful museum quality fossil will lose its scientific value and will only be suitable for use as a pretty conversation piece.



Phil Burgess recording fossil information

The cataloging process starts out in the field, when the collector is actually gathering specimens at a collecting locality or when he or she obtains them from other collectors through purchase or trade. As much information as possible should be gleaned for each individual piece and recorded in some manner. For a fossil, you will want to know its scientific name (genus and species, if known), and you will also possibly want to list the phylum and class to which this specimen belongs. Other things that are absolutely essential to know are: (a) the rock unit (formation, member, and age) the fossil was found in, (b) the locality at which the fossil was collected, and (c) the date of collection. If a fossil specimen is purchased, the date of purchase, and from whom, needs to be known, as well as the purchase price. If obtained through trade, this should also be noted.

Incidentally, collecting localities can be assigned their own individual letter or number and can be described in-depth in a separate collecting localities catalog. Detailed information on the rock formations present at each locality, as well as other miscellaneous information, can be kept here. I use Township and Range mapping method to determine the exact location of each of my collecting localities.

The final step in the cataloging process is to place a catalog number on the specimen itself. The best way to do this is still the old-fashioned time-tested way, which also involves patience. First of all, you need to apply a dab of quick-drying white gloss enamel paint (preferably Testors) on an inconspicuous place on the specimen. This painted-on label should be allowed to dry for a day. Then, using a fine tipped pen dipped in india ink, write the desired number on the label and allow it to dry for several minutes.

Never use a so-called permanent marker pen to apply a label since these do not contain pigment ink and will gradually fade over time. I found this out the hard way! Finally, to protect the label, apply a coat of Duco cement with a small brush. Do this in one stroke since repeated swipes will remove the number from the label. A painted label only ¼ to ½ inch long can accept up to several digits if you write small and carefully.

There are numerous ways to number specimens in a fossil collection, but I've found that the easiest method is simply to take a specimen at random, enter it in the catalog as #1, and go on from there. I'm up to about 14,000 cataloged specimens in my personal collection at present.

If a specimen is too small to accept a label, that piece is then placed in a small plastic display box and the label is then applied to the box instead.

I use the traditional 3" x 5" typed index card catalog filing system for recording my specimen information. Since I started with this system nearly 35 years ago, I have no plans to switch over to using a computer, although my card catalog could readily be scanned and entered on a disc, should someone decide to take the time to do so. My system worked fine before the age of computers, and it still serves me just fine.

```
# 7672      Brachiopoda
 Loc.24     Articulata
            Oepikina inquassa (Sardeson)

  Lower Dunleith (Ion sh.) fm., M. Ord.
associated Acanthocrania setigera.



                    4 specimens in case.
```

Anyone who decides to catalog a collection by computer should make certain they have a back-up copy in reserve, just in case. No one knows how many years plastic will last without degenerating into uselessness. Stored paper index cards last indefinitely (mine have lasted over 30 years with no change). Also, with a card catalog system you don't have to worry about power surges or outages, computer viruses or hitting the wrong key and erasing everything. My cards are ALWAYS available.

Now that you have the basic steps involved in creating a personal catalog system, good luck with your own collection.

M.A.P.S. Symposium on Fossil Cataloging

I have made several collections over a period of about 40 years. Each has been cataloged differently. However, the most important collection I have put together over these years is the "Ciurca Eurypterid Collection." I started the collection using the date of discovery with a number added—for example, CIURCA 033084-15 (the fifteenth specimen collected that day). If I also was able to collect the counterpart of the specimen, I added—15A and -15B (usually the positive specimen was 'A' and the negative 'B.' Using this format for eurypterid specimens was important because it directly connected the catalog number to the notes prepared for the day of collecting. In addition, I was interested in the rock sequence (stratigraphy) of the eurypterid-bearing sites so collected many lithological samples. These I could easily recover in the collection because I added 'L' to its catalog number—for example, CIURCA 033084-L4). In other words, I wanted my catalog numbers to provide information. Lacking, however was locality data recorded on each specimen.

After finding many new eurypterid-bearing sites, over several years, I decided it was time to add locality data to each specimen. I collected topographic maps showing regions from Buffalo, New York, to Albany in the east. I numbered localities from near Buffalo (#1) and worked eastward on the map numbering each locality. For example, Locality NY57 is Passage Gulf, near Spinnerville, in eastern New York. Localities discovered after this compilation were simply numbered upward no matter where the locality occurred. In a similar manner, localities in adjacent Ontario, Canada, were numbered using #1 at the Niagara River and working westward. Prefixes were used for areas—for example, NY57 (Passage Gulf), ONT 1 (Niagara River). For other states I would use Oh for Ohio, PA for Pennsylvania. I would usually surround a locality number (on a specimen) with a circle.

Since most eurypterid specimens are found on very fine-grained rocks, I often actually wrote the locality on the specimen itself with india ink. A specimen might have written upon it—for example, CIURCA 033084-15 NY57 (with a circle around it) and Passage Gulf, NY written in india ink.

Some of my specimens are in museums. Most museums use their own cataloging system. So when a museum receives a specimen out of my collection, they get my catalog number, which relates to my notes and maps, and documents the specimen with the most data I can provide. The number is also directly related to articles I may have written—for example, contributions to the New York State Geological Association Annual Meeting Field Trip Guidebooks and other publications.

My petrified wood collection was numbered starting with 0001. Miscellaneous fossils (from all over) I started with 'F' and often used the date method—for example, FO33084-13. These were mostly Devonian trilobites, brachiopods, and the many types of fossils found in the Middle Devonian of New York.

Collectors should come up with their own cataloging procedures. Numbers should not just be numbers; they should provide data. Soon we will be sticking little 'chips' on our specimens that provide all the data we have recorded. Recently, I entertained the idea of using bar codes, but the future of the little chips is here. Museums will be the principal benefactors of the new technology, but everyone else should have access to it soon.

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http://eurypterid. net
http://eurypterids.net

Currently, we keep handwritten tags with each fossil (or group of same ones) and have no indexing system. We display them or put them in various sizes of plastic bags and/or storage boxes, sorted by type and location. We've created an elaborate computer database (using Appleworks), with digital photos and pulldown menus for entering repetitive data (class, age, location found, etc.)—but keep procrastinating on entering the data. We plan to mark each specimen with a simple ID code.

Bill & Cheryl Wildfong
wildfong@ktc.com

In response to your survey, each of my specimens are numbered and the corresponding number is affixed to a 5x7 index card with scientific name, geological period, stratigraphic location and provenance if known, and, if purchased, where & when & at what cost. I hope this is helpful.
Bob Rondinelli

I organize my fossils in several ways. What I like to do most is to label them, and then display them in drawers. I have been fortunate to get several old mahogany dental cabinets, which also have some deep drawers. I have refinished them and displayed my collection. Sometimes the sheer number of specimens is so large that I can only put them in divided compartments in large drawers with identifying labels as to type of beast and location.
Phil Bobrove

I'm very scientific. The vast majority are wrapped in newspaper and placed in boxes and stored in the basement until one day when I get organized enough to get display/specimen cases to put them out. They all have label info wrapped up with them.

I don't have time for field collecting any more. So, I buy pieces for my collection – mostly it's ammonites & echinoids. But there are also shark's teeth, plants, and anything else I like at the time. I'm particularly interested in fossils that the average person can look at and know what they are – then I blow their mind away when I tell them how old it is.

This is a hobby. Something that I enjoy and have fun with. I'm not a paleontologist – I'm a fossil collector.
Randy Faerber
Manager Marketing Info Systems
LTD - Market Planning
913-762-1390

I catalog my collection in a file of photographs (digital) stored as Jpeg files, with species, collecting info (site and fm.), year acquired, and purchase price if it was bought. The photo file is arranged phylogenetically (starting with a stromatolite, ending with mammals). This allows me to share photos with others via e-mail, and acts as a resource if any fossils are ever stolen or lost (e.g., for legal documentation if a stolen fossil ends up on E-Bay, for insurance documentation if there is a house fire, etc).
Mark Mehle

I have items separated several ways, by higher taxonomic levels (phylum or class), or by geologic period and formation. Some are by state or country. I try as much as possible to make sure an identification w/ relevant data is included. I then have everything listed on a data base. Hope this helps.
Ron Garney

My fossils are arranged on shelves in white boxes labeled as to: where (very specifically), what, and geology. The boxes are all keyed by a large two letter code (same as the USPO) or by a three letter nation code for those outside the US. My six cats hold these boxes in place by sleeping on them.

Now that I have physical problems that limit my collecting, I am considering a more detailed system on my computer or on file cards.
Rik Hill

I have been numbering my "good" individual specimens more or less numerically/ chronologically in the order I find or acquire them. Lately, on many of my specimens, I actually do a small label on my printer with all the information - date, location, identification, and chronological number and glue it to the back of the specimen and then put a preservative coating of glue or shellac over the label to preserve it. I have this thing about identification numbers only—what happens if the specimen gets separated from the book where the numbers are recorded with the locations, etc.??? I keep my numbers recorded on a simple Excel spreadsheet on my computer backed up periodically with CDs. When I have a large box of more common material from a site, I may assign a number to the box and also label the box and store it for the future. I keep my boxes by location only. My best specimens I display in my office, some I hang on the walls like pictures, others I have in a large drawer cabinet.
Craig Tipton

Unfortunately, I am terribly unorganized when it comes to my "collections." I have "stuff" in boxes, pails, wrapped in newspaper. Some have pieces of paper in the receptacle stating where it came from, when collected, and some have been labeled by others as to what and where it came from because I purchased them. I have one piece I prized and labeled with name and location in quarter/quarter sections because I was being taught by a person from a local museum. Otherwise, I collect and have not gotten back to the project to clean or properly label. I think I am not the only one in this situation. Hopefully when I retire, I will have time to do it right. By the way, What is the RIGHT WAY?
Bad Dee
DEEIS@aol.com

I tend to be a little obsessive. One of my interests is trying to understand interrelationships between organisms. Therefore, I make some effort to classify each specimen as much as possible. I keep my records on my computer in a word file. I also keep a separate zip disk. Each specimen has a number followed by the scientific name. Then, I try to complete the systematic classification as much as possible, i.e., Kingdom, phylum, class, order, family. If it's known, I list the formation, geologic time, locality. I also try to include additional comments as to the date that I found it. If the specimen is purchased, I include who I purchased it from, when, where and how much I paid. Just to show you how obsessive I can be, I have started to record GPS coordinates for vertebrate specimens that I collect in the badlands.
Bill Morgan

It is only in the last three years or so that my wife and I have begun collecting fossils. At the moment, our collection is rather spread out, pieces on display in several rooms. There really is no organization to it. The same applies to our labeling. When we started, we didn't realize the importance of labeling, and did not always demand a card from the seller. Therefore, some of our earlier acquisitions are of unknown location (or even scientific name!).

Since then, we have learned better. We now insist on a label that identifies the specimen and indicates the location where it was collected. In the near future, we plan to get better organized. Although it is still up for grabs how we will organize items for display, we will definitely develop a master list showing all the information we have about each piece.
Homer Eshbaugh
bombastus@worldnet.att.net

I keep notebooks for work in the field. I take photos of the site and make sketches of the section and locality. I take GPS information as well. I also put all of my localities on topo maps using the Delorme Topo map software. I make a short faunal list of the most common species that I can identify in the notebooks. I have a spreadsheet with links to my logbooks, which I have scanned in. I list the GPS, site name, number, formation, member, age, etc. My fossils are arranged in boxes in stratigraphic order, about 600 of them. I also link to the logbooks of a friend who usually accompanies me. I have a separate file with the names or types of fossils as I slowly work my way through them.

I also have an html file which contains all the links to my photos and scanned logbooks, as well as summaries of the site. Jim Preslicka and I have identical structures for storing fossils. We have only one database, kept in my PC. I leave a yearly copy of the database with Ann Molineaux (collections manager) of the Texas Non-vertebrate Paleontology collections of the Texas Memorial Museum. There are two independent sets of logbooks, one by a friend (B. Yurke) whom I collect with and my own. Jim adds to my logbook. My friend's logbook is in the traditional field note style. My logs are organized by site and are intended to complement B. Yurke's logbooks, not copy it. We record information somewhat independently in order to maximize the information content.

I also label my boxes with a waterproof labels and permanent ink with locality name, number, age, stage, formation and member. Fossil names, when known, are on a slip in the cardboard tray in the plastic box. I hope this is sufficient. I have spent a lot of years figuring out the best way to organize my system.

Charles Newsom

I've adopted the labeling system invented by fellow MAPS member Charles Newsom. I used to have my own system, but found his to be much simpler, and more logical. I store specimens by fossil collecting site and by geologic age, using two sizes (15qt and 4.5 qt) of Sterilite plastic boxes, which are durable and easily stackable. Productive sites require the larger boxes; less productive or rarely visited sites can get by with a 4.5 qt box. I stack the site boxes on heavy duty utility shelving, with the oldest fossils on the lower left and progressively younger boxes as you move to the right and up. I put labels on each shelf to facilitate locating certain geologic ages, i.e., "Middle Devonian - Givetian, Upper Devonian – Frasnian," and so on. This way, I can quickly locate boxes of specimens from a given age for sorting or comparison, etc.

Each individual box is marked with a permanent label, with info written in permanent waterproof ink. Each label includes the following: Upper left corner - Site number; upper right corner - geologic age; Middle section of label - informal site name; lower left corner - geologic formation or group; lower right corner - member or unit of formation.

Sample label form:

IA47 U.Ordovician

El Dorado, Ia
Hwy 150

Maquoketa Fm. Clermont Mb.

The site number refers to pages in our log books which contain a hand drawing of the exposed section, geologic information, directions on how to reach the site, GPS coordinates of the locality, a summary of what was found, date of visit(s), and who visited that day. Each page is then scanned into a database, along with digital photos of the site. This way, when we eventually pass our collections on to repositories, they will have a very clear record of where the specimens came from, or, in the eventsomething happens to one of us, a complete stranger could tell where each box of

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fossils was from. Also, the GPS coordinates would allow sites to be revisited by any interested researcher well into the future (even if roads are moved or street names changed, etc.), long after either of us would be available to take anyone on a "guided"tour.

We number sites by state mailing abbreviation followed by a sequential number. For instance, the 10th site we visited in Iowa would be numbered "IA10" in our log books, the second site visited in Missouri would be "MO2", etc. Once sites are in the database, you can sort/search for various things, such as find all sites in the Frasnian, or all sites with a certain type of fossils, and so on.

Keeping detailed records is very important, since a fossil with no information is essentially scientifically useless. The system that Charles developed is simple, logical, and allows us to have a hard hand-written copy (in case of computer problems), and a database copy (in case anything happens to a log book).

Jim Preslicka

There are a lot of different systems that people use. Most of them are card files in a box, which takes up a lot of room. All my fossils are identified, but I don't use a card file. I have a small book, 5" by 8." Each different fossil is listed in alphabetical order and the page where they start; then, on that page, they are listed in numerical order.

I find this works better for me. I can take the book along. If I'm giving a program, I just put in one of my boxes of fossils or put in my purse. Anyway, this works for me. Use whatever works for you—just be sure you record them. Put down the place, city or town, and county where you were and the directions to the location. You might not know what kind of fossil, its age, or formation. All this you can find out later. Mark your fossil "A-1, 2, 3," and so on. I mark my specimens with white out and when it dries, I write the letter and number on it.

Margaret Kahrs

My collection is, politely, eclectic! It was done (and there's a lot of it) in the years my husband and I were crisscrossing this interesting country of ours because we lived on the East coast, but our three daughters opted for the West coast. We are now relocated in Oregon and have aged (87 and 91), so that most of our fossiling consists of admiring what we have. Our garage walls have a display of Wyoming fish and Pennsylvanian fern slabs, and we have an echinoid display on top of some file cabinets. Also, one wall is mounted with narrow shelves which hold a representative assortment of miscellaneous fossils grouped as much as was possible by period and then family. AND THEN! . . . there is a bank of storage shelves with BOXES . . . These are labeled, some by family and some by locality . . . I told you this is eclectic! I pride myself on the fact that these fossils are either self-collected or by swap. Incidentally, Sam was a birder primarily; I the fossil hunter. Our kids said that they could always recognize their parents in the distance because one was always looking up and the other looking down!

Love & Peace,

Sam & Bess Hamers

I keep my collection in drawers and boxes. Labels contain important information as to species (if known) and locality and age. If I collected the specimen myself or talked to the collector, I have also included whatever biographical and other interesting historical information is available. My fossils are mostly arranged by age and locality, but I do have some small sub-collections of some classes.

Nathaniel Ludlum

My name is Eric Kendrew, CEO & Owner of the Fossil Store. Labeling of our fossils is a very serious affection with us. As we have over 10,000 fossils in our private collection, it is essential for us to keep track of what we have.

I have set up a data base on the computer using Microsoft Windows Excel. Our fossils are listed by Family. Each fossil has a number, genus, species, author who first described the fossil and as much geological information as possible, then the place where the fossil was found and last we place a retail value on each item. Then we make several copies. The copies go into one binder for quick reference, and another binder goes into the safe for security and insurance purposes.

With each fossil we have a numbered label with the same information as on data base, except for the price.

Our large fossils are kept in glass cases, on shelves and hanging on the wall. Our smaller fossils are stored in museum storage cabinets that contain multiple drawers. These fossils are placed in individual boxes. Outside the drawer is a label that identifies the fossils that are inside by family or by country of origin.

The process of labeling is essential for all collectors of fossils, artifacts and minerals. I do appraisals and I am constantly running into folks with collections of fossils that have no labels on the collections that have been left to them. If it's only a few dozen pieces, I do not mind sitting down with them to help label their pieces. But when it's several hundred items, I tell them to go to a local museum or library to get this information. Then, once they have labeled their fossils, I will do an appraisal for them. I also give them an option of me doing the labeling for a fee. This process can get expensive for a family that knows nothing about fossils. If they try to sell the collection, they would probably lose a lot of money on what the true value of the collection is worth.

I had a call one day from a gentleman who wanted to sell his collection. After I arrived at his home, the first thing he asked was whether I would do an appraisal for him. I told him let's have a look at what you have first. The collection was left to him by his mother. He had several large home made cases mixed with fossils and recent skulls. The cases were full of roach droppings and dust. Nothing was labeled. Then he had 5 gal. buckets of broken bones and partial teeth and boxes of the same with roaches still inside. He went on telling me about how he was partial to much of this material because he had helped his mother collect it. Then he wanted me to tell him what it was all worth without looking at the rest of the material that was stored in boxes that I had not even looked in yet. I explained to him that in order for me to do an appraisal, I would have to make a list of each item and place a retail value on it.

"Well," he asked, "How do you determine a price?"

I explained that value is determined by the type of fossil, the condition of the fossil, where it was found and if it has a proper label.

Then he started telling me about someone he knew who was thinking about mortgaging his home to buy this collection. That's when I started backing off. I saw, maybe, at the most, $800.00 worth of material. Then his wife came in, and she wanted to know what I thought the collection was worth. I explained to her the same as I had explained to her husband. Then I kindly gave them my card and told them when they were ready for me to do an appraisal to call me.

As a business we also do Ebay. If you ever go into Ebay and look at the material people are trying to sell it is somewhat humorous. Many do not know what they are selling and have no information on their items they are selling. Some think their pieces are worth a fortune and many have the wrong names on their fossils. If you try and correct them by sending them a message, some will thank you and others will get pretty nasty. Since the Dinosaur Sue was discovered and was so well published, especially how much she sold for, many people think all fossils are worth a fortune now. You have people trying to sell artifacts, minerals and even gold as fossils on Ebay. Several years ago, there was someone who was trying to sell rocks as dinosaur skulls and was asking thousands of dollars for them.

I hope this gives some insight as to why it is so important to label your fossils and try and put a fair market value on each piece you have. Scientifically, fossils are not worth anything without proper information.

Erik Kendrew

I use a very simple system, if you can call it that. If it is a special specimen, I label it with white ink. If not, then I save it to give to school kids as part of a geoscience demo.
John McLure

I number my fossils by period and phylum. A Silurian brachiopod would be sb 1. A Cretaceous cephalopod would be kc 1. I then keep separate files on my computer for each period and phylum. I number each fossil on the fossil and have enough drawers and display areas so I don't need boxes.
Gil Norris

What I do with my collection, when I have time, is to label the specimen with the phylum, genus, species (if possible), location of find, and date of find. Before they are properly labeled, I put a piece of paper with date and location until I can get to them and box them up properly.
Melissa Cole

I keep notebooks, with photos and short descriptions of my fossils, but other than that, I display as many of them as I have bookcases for, and I looooooooove bookcases!
Mike Wirkus

I number each specimen (on the specimen) and catalog it in a book and also describe the specimen by name, period, formation, location, and any other known scientific information on a numbered index card. I also photograph the most important and valuable specimens.
Karl Stuekerjuergen

I catalog my fossils strictly by number: 1-13,000 something. I use 14 x 20 cases. Each one contains a certain type of fossil. I have a file for each case, giving all the information about the fossils in the case. I keep another file that is a list of numbers only.
Allyn Adams

We catalog by period and then number—keep that in a large journal—for example, Devonian 1, 2, 3, etc. We tried to organize by creature first: brachipods, crinoids, etc., but found that doing it by period was easier.
George and Wanda Aldred

For a while, I used my own initials and then a number. Now I organize with Ziploc bags with information in them. These are placed in boxes by location and year. Each year has a different box.
Irene Broad

I collect primarily trilobites. I keep them in cardboard boxes with the info on top of the box. I have a computer list in a text file in which I list them alphabetically by genus.
James Cook

I keep my fossils in boxes with a separate box for every trip and in calendar order. This may not be the most efficient organization, but when I look into a box, it brings back the whole trip for me.
Barbara Blagen Ermler

Here's the way I do it. The larger specimens are arranged on shelves and in storage boxes by category. Smaller specimens are in smaller organizers arranged by stratigraphy.

Each specimen has a number glued to it. The smaller ones are glued on a small piece of cardboard with a number attached, or are in small envelopes with the number placed inside and written on the outside.

After trying various numbering systems, I just started out with #1 and am not up to #15,000.

I save one or two typical examples, the rest are in boxes in the garage arranged by stratigraphy and locality.

Information on the specimens is stored on 3X5 cards, which are arranged by category and locality.

Information on the sites is stored on computer files backed up with a hard copy. I have not found a good way to organize information about the specimens on the computer.

Robert Wolf
midnightwriter@dodgenet.com
Author of *Fossils of Iowa*

The system that I use is a State Location # System. I start with the state, then I give the location a number, and then I give the particular genus and species a number. For example, if I collected a particular brachiopod at Madison, Indiana, I would start with IN. If this is the first place that I collected in Indiana I would then call that site 01 and the particular Brachiopod 01 Thus the tag would be IN0101. If I collected the same species at another location a mile away,it could end up with the tag IN0201.

When I collected at Mazon Creek material at Pit 11 and other locations in NE Illinois, I modified the system slightly and gave the species a two or three letter designation. If I collected a Tully Monster at Pit 11, it happened that Pit 11 was IL11 so the Tully Monster became IL11TM. I also found a Tully Monster at Chowder Flats near Morris. It became IL09TM because Chowder Flats was IL09 in my system.

If I got a specimen by trading I named these specimens on the basis of whom I got them from. If I got four specimens from Tom Jones, they became TJ01, TJ02, etc.

When I collected in Ontario, Canada, they became CAO____; Nova Scotia became CANS____, etc.

John Fagan

Thanks for your inquiry. Using a fine point felt marker, I write the period and a number next to it. For example, if I found a gastropod in an Ordovician deposit, I write O-14 on the fossil. That is the reference number that directs me to O-14 in a loose leaf binder. The information listed there includes: common name, period, location of find, formation, and date. Below that I identify the specimen by phylum, class, order, genus, and species.

This system has worked quite well for me. After each field trip I prepare the fossils, and then meticulously identify and catalogue every fossil that I plan to display. I normally use the North American Fossil Guide, which I find at my library. It is an excellent reference; however, it is out of date, and some classifications have since been changed. I rely on other sources as well to cross-reference.

Dave Kreiter

I try to have a GPS location or at least a unique location description of where I collected the fossil. I also try to have the formation name it came from. I then display/store my specimens in flat wood trays 1' x 2' x 1" or 3" deep. I stack the trays on top of each other. It's cheaper and faster but less convenient than drawers.

Bob Peck

I use labeled boxes with topographic locations. When my husband was alive, he started numeric locations on cards and put some into the computer.

Mardelle Lee Couch

Storing and Displaying your Treasures

Joseph J. Kchodl
Midland, Michigan
paleoed@aol.com

It has been said that displaying and storing collected items goes back to Neanderthal times. When the Neanderthals wanted to store and display bones they artistically tossed them around the cave and cave entrance. This was thought to be the first Museum. Well, technology and the science of storage and display have come a long way since then.

Displaying and storing fossils, in my case, goes all the way back to my childhood. When I was 10 years old in the fossil rich areas around Western New York, I would put the fossils in cardboard shoeboxes and stuff them under my bed for storage. I'd put them on top of my dresser, nightstand, and when Mom and Dad let me, in the living room on the fireplace mantel and coffee table.

Things have changed just a bit. Now my fossils are stored in specially built storage containers with foam and or etha-foam. Each fossil has its own space specially cut in the foam, its own label, identification number and locality information. My displays have become more elaborate as well with custom-built display cases and now I've even created my own traveling museum exhibit so others can enjoy the fossils from my collection. The exhibit travels to small museums and components sometimes travel separately to schools and rock and gem shows.

Before we begin describing the storage and display of fossils, perhaps we should spend some time with the handling of fossils.

Sure, sure.... they are rocks aren't they? Yes, but they are also sometimes very brittle. In the case of some of my trilobites, they have numerous freestanding spines that can easily be broken off just by jostling them or handling them roughly.

Handle your fossils with care, like you would handle something that is millions of years old. These precautions may seem silly and overly cautious, but don't learn the hard way by damaging or destroying your prized and rare fossil.

Your hands secrete various oils to keep them soft and supple. These same oils can be left behind on your fossil after handling and can over time begin to deteriorate it. The oils left behind also attract dust and dirt. Wear thin cotton museum gloves when touching and handling your fossils. When you remove dust from your fossil, it is desirable to use a can of compressed air that is suitable for computer applications to gently blow the dust away. Latex or rubber examination gloves are not desirable as they have a powder residue on them that may attach itself to your specimen. The cotton gloves are very inexpensive and are available from various suppliers.

Don't wear loose fitting clothes or have pens or tools in your pockets. Clothing can catch on protrusions and "stuff" in your pockets can fall out on to the fossils when you bend over. Try to carry only one fossil at a time as any bumping or jostling may cause damage to these fragile pieces of natural history.

When transporting your fossil after removing it from its container or storage location, have a plan in mind where you will put it. Try not to double or triple handle your fossils. The more you move them, the greater the chance of damage.

Storage of Fossil Specimens

First we'll begin with storage of fossil specimens. Generally, all specimens may be stored in the same way. I specialize in Trilobites, so I may slip from time to time when describing storage, but in most cases the concepts are the same; it is just the fossil and its size that may change.

Cost may or may not be a consideration for you in your work. There are many archival companies that specialize in museum storage containers and materials. These materials are generally acid free and the best mediums for storing your precious finds. At the end of this article I will list several companies that deal with materials such as this and let you explore them on your own. I will list, as well, companies that supply schools with geology materials that are also suitable for use. I do not, by way of this article, endorse one product over another or one source over another. I will describe what I use and some of what is available on the market and leave the decisions up to you, the collector.

Number and Identify your Specimen

Once a specimen has been purchased, found, prepared and preserved, storage of that specimen becomes important. Identification is important as well. When a specimen is collected, try to gain all pertinent information possible. Geographically where it was found, stratigraphically, what period, what formation, what compass heading it is oriented to, what genus and species the find is and any other information relevant to the find. Is it commonly known that amateurs make many of the spectacular new discoveries in paleontology. Gathering all this information may prove to be scientifically significant and relevant data.

Once identified it will become necessary to number and catalog your find. Numbering systems vary from museum to museum, from individual to individual. I will briefly describe a commonly accepted numbering system and then describe the one I use. You will make the decision what system you will use. It needs to be something that is understandable and usable by you.

A sequential number system is simple (1, 2, 3 ...) but does become cumbersome as the collection increases in size, and it does not make it easy to expand the collection. It does not adapt well to an ever-increasing collection. One of the major accepted numbering systems used by the American Association of Museums is as follows:

The first number in the system denotes the year you acquired the specimen. This can either be done by using the whole year—2003—or shortening it to 03 or 003. This number is then separated by a period or hyphen from the next, which is the sequential number in which you acquired the specimen. 1, for the first acquisition of the year, 2, for the second, and so on. This is then separated from the third number again by a period or hyphen. The final number is a group number. If you acquire many items on the same day, from the same collection or collecting locality, you distinguish these pieces by another sequential number.

2001.03.02

Year . Third Item of the year . second item of a group

Now after all that, I have a system that I use which differs slightly. For all my trilobites, I follow a similar system. I used the last 2 numbers of the year through 1999. In 2000 I began using the first number and the last number 21 = 2001, 22 = 2002 etc. I also used a three-place number for the specimens 001, 002 etc. Occasionally I do collect other fossil material and I want to distinguish them by listing them separately.

21 003

Year - Third item of the year

Other fossils are a minor part of my collection, but I still want them recorded and cataloged. I use the first letter of what the fossil is and then the numbers as above. E – echinoderms, P – plants, V – vertebrate material and so on. Again this is a small portion of my collection so I do not spend a great deal of time with it. I also have been known to collect artifacts such as original prints, antique tools and equipment, original manuscripts, trilobite jewelry and trilobite postage stamps. In this case I use the prefix ART. – short for artifact.

Let me reiterate, choose a number system that you are comfortable with. The system is something that must be user friendly for you. Once you have numbered your collection, take some time to transfer the information into a written compilation. Use this as a quick reference to your collection. It also makes a wonderful document for insurance purposes.

Once you have assigned a number to your specimen, it is necessary to mark, number or label the specimen itself.

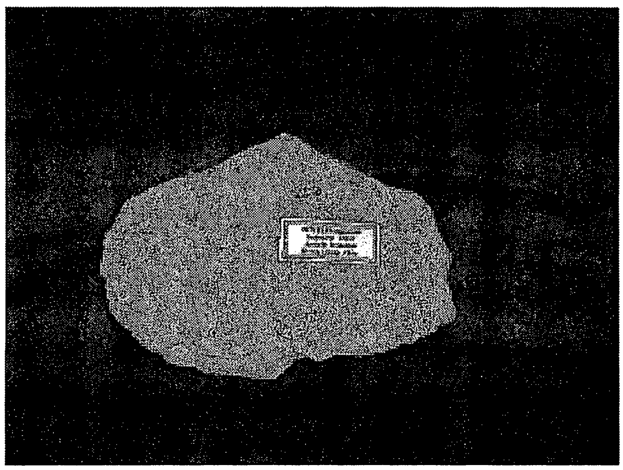
This can be done in several ways.

- One way is to paint a white rectangle on the bottom of a specimen, let it dry and then paint the number in black on the white rectangle. This is the old tried and true method for numbering in many museums around the world. This is also necessary if the specimen or matrix is black and the Sharpie® method below doesn't show up.
- Using a sharp point Sharpie® you can write directly on the backside of the specimen or on the bottom of the matrix. I use this method along with another.
- I also affix a paper label to the back of the specimen. With computers we can make paper labels any size. I affix the label to the back of the matrix with white glue in the following manner. Put a thin coat of white glue on the matrix in the general shape of the label. Put the label on and press it into the glue. Don't worry about extra glue. Use the extra and rub it on top of the label covering it. The excess glue dries clear and then a thin film of glue protects the label. White glue is water-soluble so if you ever want to remove it – all you have to do is wash it off.

Some specimens are quite small and numbering them is not possible. In that case label the box and do not label the specimen. The specimen is best stored in a sealed vial or polyethylene bag. You can label the bag as well with a Sharpie®.

ISOTELUS maximus
Ordovician 21003
Arnheim Formation
Brown County, Ohio

Label example I use in addition to a number written on the specimen.

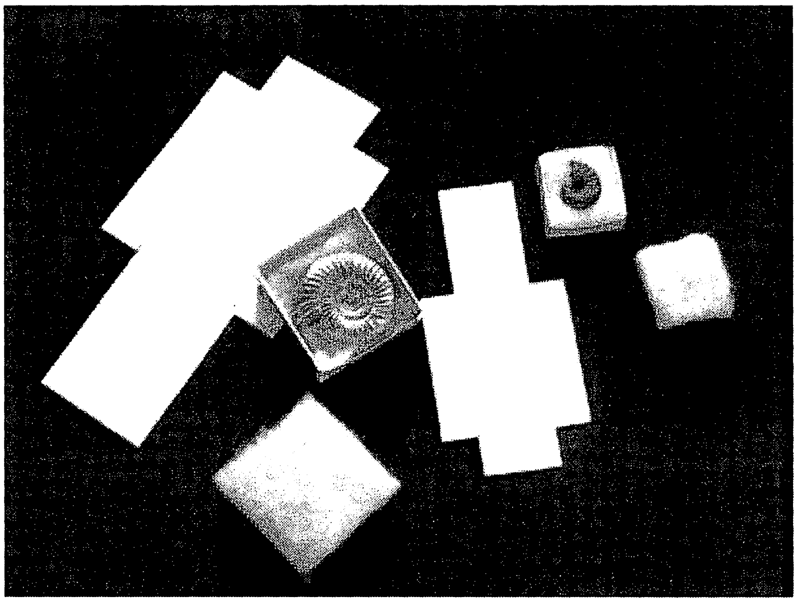


Isotelus maximus with paper label and identification number

Boxed Storage of Your Specimen

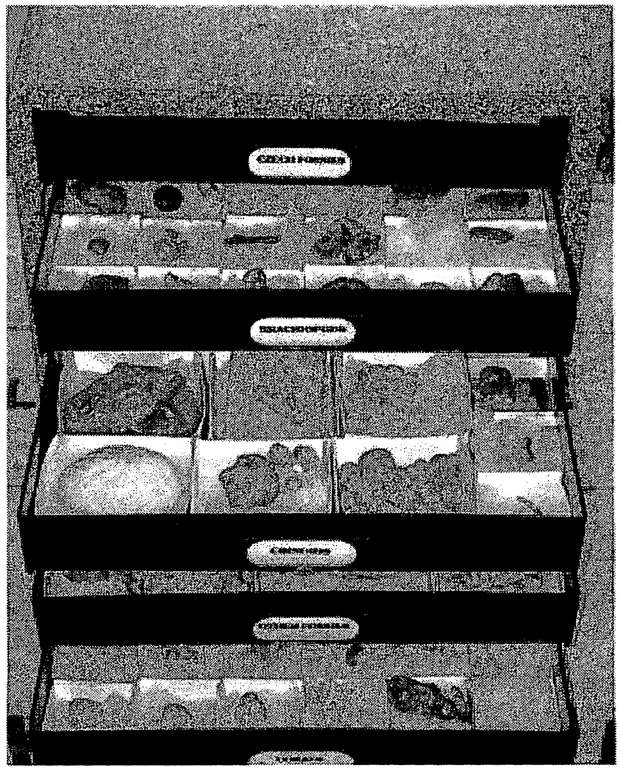
POP CAN SHELL STORAGE There are many ways to store the fossils you find. Some people prefer to use pop and beer can shells to store large and coarse material. In many cases Paleontologists use these boxes for the unprepped material. Just by inverting another shell and placing it on top you can create a box for your material. These stack very easily with a minimum of space utilization. Many dealers use this method to transport material to and from shows.

SPECIMEN BOX STORAGE Specimen boxes may be the most common methods to store fossils. These boxes are fairly inexpensive and available in large quantity from scientific supply houses, gem and mineral outlets and some hobby shops. They are unassembled boxes you must assemble yourself. Because of the large variety of sizes, this method is very attractive. Each specimen can reside it its own box. Once these boxes are assembled it is quite easy to prepare a nice safe home for your fossil. You can purchase sheet batting material from any fabric supply store and cut it to fit each box. I recommend the flat or sheet batting rather than the loose fiber batting or cotton. This makes a nice presentable platform for your fossil and the fossil is easily seen. Should you require more padding around the fossil, you can add the fiber batting or cotton to the box, securing the fossil. This is recommended for longer periods of storage. Labels can also be affixed to the box, thereby aiding in identification of the specimen and identifying where the specimen belongs if they are removed for long periods of time.



Preassembled and assembled specimen boxes

These small cardboard specimen boxes can then be placed into a wide variety of permanent storage boxes. I have purchased and used several over that last few years. Filing cabinets work well, as do large plastic storage boxes that are available at any major discount retailer. They also do the trick for long-term storage. Between each layer of specimen boxes, place a flat piece of cardboard to protect the layer below and to give the next layer a stable base.
Several years ago a major discount retailer sold 1 foot square plastic cubes that had five 2-inch drawers in it. They were sold during back to school time and are PERFECT for storing the wide variety of specimen boxes available. I haven't seen them in a few years, but I hope they will return soon. They are stackable and very presentable. You may be able to find something similar.



Plastic storage case

If you are lucky enough to find a good antique store, you may be able to purchase an old wooden map storage cabinet. Also available are antique dental tool storage cases and even optometrist cases. These are just the right depth to arrange the boxes and close the drawer. I have not yet been lucky enough to find one. I'm still looking. They would make an excellent addition to anyone's furniture and especially a paleontologist's collection room.

Modern versions of these cases can be found in major scientific supply houses and are made of metal. The top of the cabinets can be used as work space to write on or just to place the specimens on while you inspect them or show them off. They have a large price range but work very well for fossil storage. I'm still holding out for a wooden one.

POLYETHELYNE BAGS For many small specimens, storage in a polyethylene bag is best. All necessary information can be written on the bag with a Sharpie® and also you can place a paper label in the bag with the specimen.

Numbered and labeled polyethylene bags

This type of storage will allow you to keep the fossil in a clean and dust free environment. It does not protect the fossils well unless you wrap them in tissue, but it is a good way to store and see the fossils.

CUSTOM BUILT BOXES For long-term storage, for the protection of fossils and a more permanent storage medium it may become necessary to build or have built a custom box for your specimens. If you are as handy with woodworking tools as I am, **NOT**, there could be a friend of yours, or a friend of a friend, who loves carpentry and can easily put a box together for you. These boxes are actually simple to create and are durable and will protect your treasures from damage.

The size of the box will depend on the size of the collection, the weight of the collection and the space you have to store it. I have several sizes that work well for me.

The first is a rolling storage box for my trilobite collection. The size is quite handy and the weight is not as bad as one may think. I also added rolling casters to the bottom for ease of mobility from place to place. It is 32 inches long by 18 inches wide and 18 inches high. I found that this is a very manageable size for me.

Collection storage box

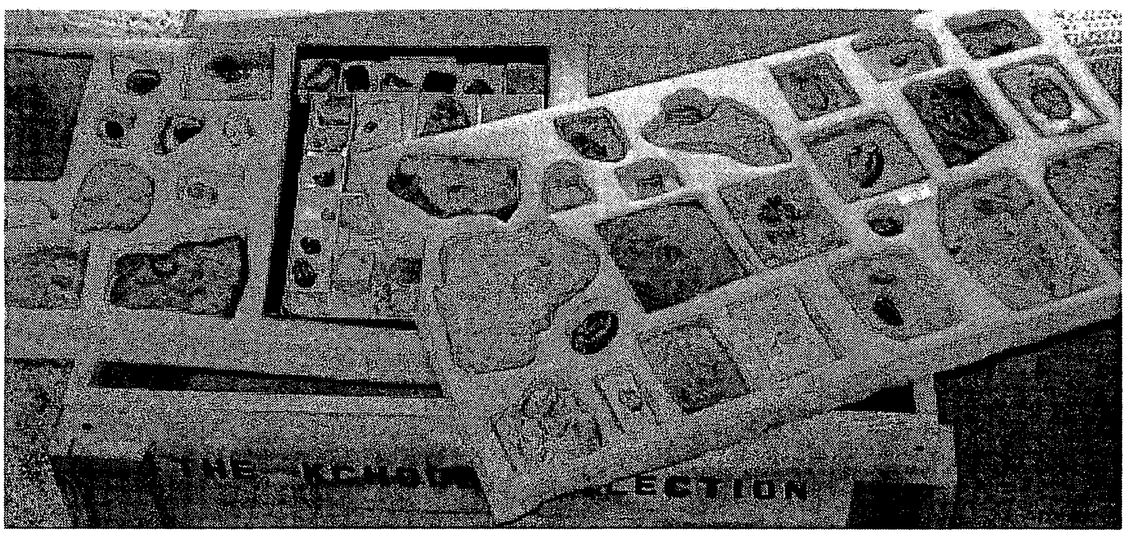
Start with lumber, 3 inch wide and ½ inch thick boards will do nicely. Choose whichever wood you desire. Pine actually works very well. Decide on the size of box you require and then get cutting. To protect the corners from banging into things add pieces of lumber supports as can be seen in the photograph.

Once you have constructed, or like me, had someone construct it for you …the fun begins.

You have two options for protecting your fossils from damage. You can purchase Ethafoam®. It is a harder type of foam that has a hard texture and protects the fossils quite well, or you can go to any fabric shop to purchase soft foam. Ethafoam® can be purchased from museum suppliers. It is a bit more difficult to work with and requires a special tool to cut.

Foam purchased from the fabric store can be cut with an Exacto® or hobby knife. It can be expensive but works extremely well. The foam comes in long sheets and can be purchased in thickness from ½ inch to 2 inches.

Cut the foam in sections to fit in your box. Purchase some Luan® or thin plywood to act as a base for each layer of your storage box. You will in essence be constructing a lift-out tray for the fossils. Cut the Luan® so it is approx 1 to 2 inches smaller than the inside dimension of the box. This will allow you to reach in and remove each layer easily. Then, depending on the size of the fossils you have, glue a piece of pre-cut foam onto the board. I normally use the 4" thick foam because it allows me to set the fossil deeply into the foam, thereby protecting it fully. White glue is perfect for attaching this foam to a surface. Place beads of white glue on the bottom of the box and place at least a one-inch thick foam pad on the bottom to cushion your first layer of fossils.



Collection storage box

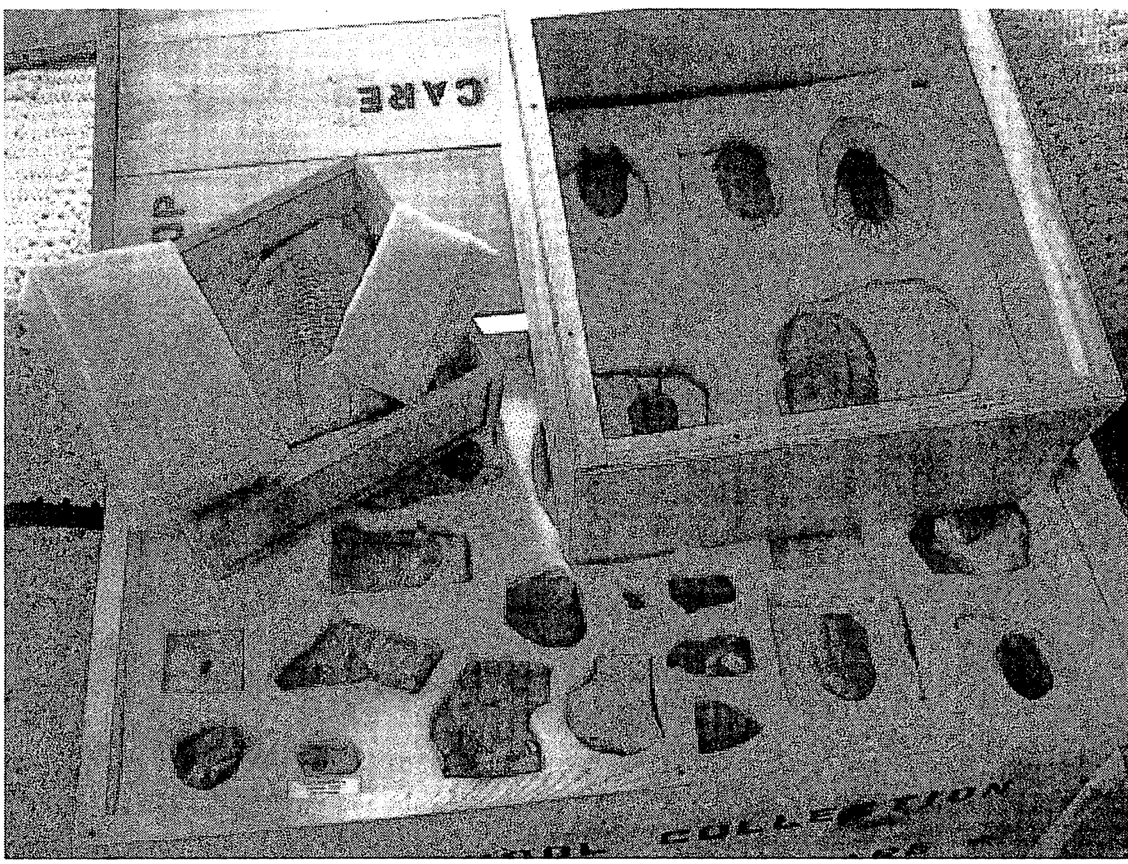
Then arrange the fossils on the foam the way you want them. Trace each fossil on the foam with a thin line Sharpie®, pencil or pen. Then use a hobby knife and cut out the area where the fossil will rest. Make sure it is deep enough to accept the fossil and not let it extend above the foam. The bottom of the hole you cut may also be shaped to fit the specimen or matrix. DO NOT cut the hole so large that the fossil rolls around in the hole. This defeats the purpose of what you are trying to do – rather cut it just a little smaller so that the fossil is snugly held in the foam. I also take one of the paper labels and glue it to the bottom of the hole. Use white glue and rub any excess glue on top of the label. This allows me to replace the fossil in the correct spot every time.

For several smaller fossils it is not practical to put a paper label in the space, so I have glued the paper label adjacent to the hole, again putting white glue on top of the label. This protects the label and keeps it from yellowing.

Also place a 1 inch thick piece of foam between each layer for added protection.

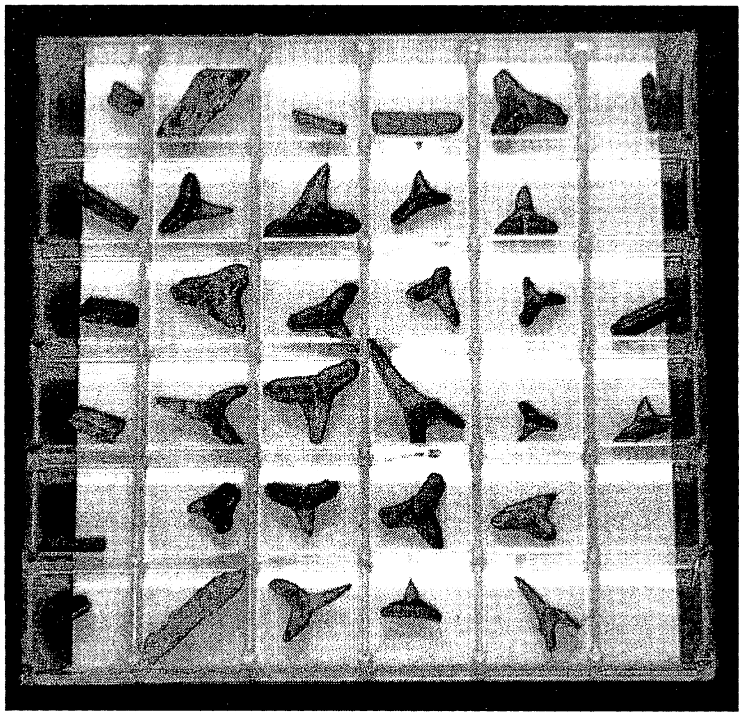
Repeat the above steps until the box is filled. As you acquire new specimens, also repeat the above steps.

No matter what size wooden case you have these steps work very well. Several of my most prized trilobites are stored separately in their own case so that they are not damaged. These smaller cases are treated with extra special care, but are made in the same way.



3 various wooden box sizes

As Paleontologists we are sometimes very open to unique opportunities for storage. I have been known to hawk retail outlets for their discarded displayers. Here is an example: Lipstick tube displayers made of plastic. Lipstick tubes are placed upright in these holders. Usually the trays are discarded after all the tubes are sold. It seems silly but they work great for smaller fossils like shark teeth. I could go on for hours. Sometimes there is joy in the hunt, the quest for that perfect storage box. Just use your imagination and enjoy the opportunities for storage that come your way.



Lipstick displayer tray holding fossil shark teeth

Another catalog I use is *Jule-Art* listed at the end of this article. Although they primarily have display paraphernalia, they also have several storage units to choose from depending on the level of sophistication you want to achieve. Many of the school supply catalogs also list various types of storage units and boxes.

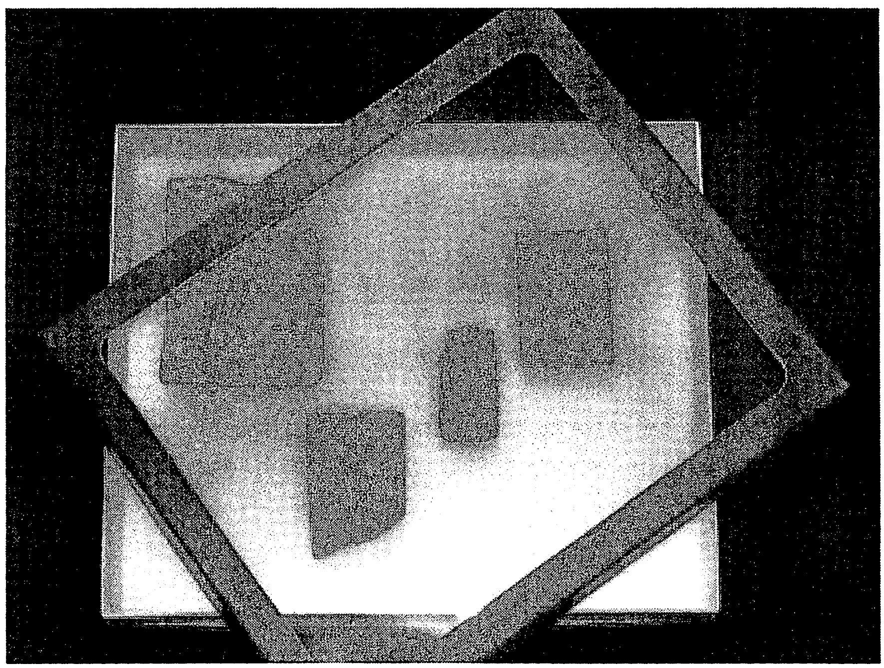
Riker mounts also readily available can solve several problems. These can be used to store fossils as they stack exceptionally well, or can be used to display fossils as they have a clear plastic or glass top. There are even economy collection boxes made of lighter cardboard for the beginners. In short there is a wide variety of material available for you to use to store those magnificent remnants of prehistoric life. Collect some of the catalogs available – most are free, set yourself a budget and enjoy.

DISPLAYING YOUR TREASURES

As many as there are ways of storing your fossils, there are as many if not more ways to display them. Cost again may be a determining factor in how you choose to display your fossils. Over these many years I have displayed them in Riker mounts, just set them on bookshelves, coffee tables, end tables and on top of TV sets, small plastic magnifying cubes, curio cabinets and on and on.

Let us begin with some basics: RIKER MOUNTS. These are exceptional display cases for the beginning fossil collector as well as for some advanced collections. They do not work well for very dimensional pieces or very highly ornamented pieces. But as was stated above, they are exceptional when it comes to storing them away. They can be stacked and the specimens will remain safe and secure. When you want to see them you can place them almost anywhere and get a great view of the specimens inside. Riker mounts are available from nearly any school biology supply catalog.

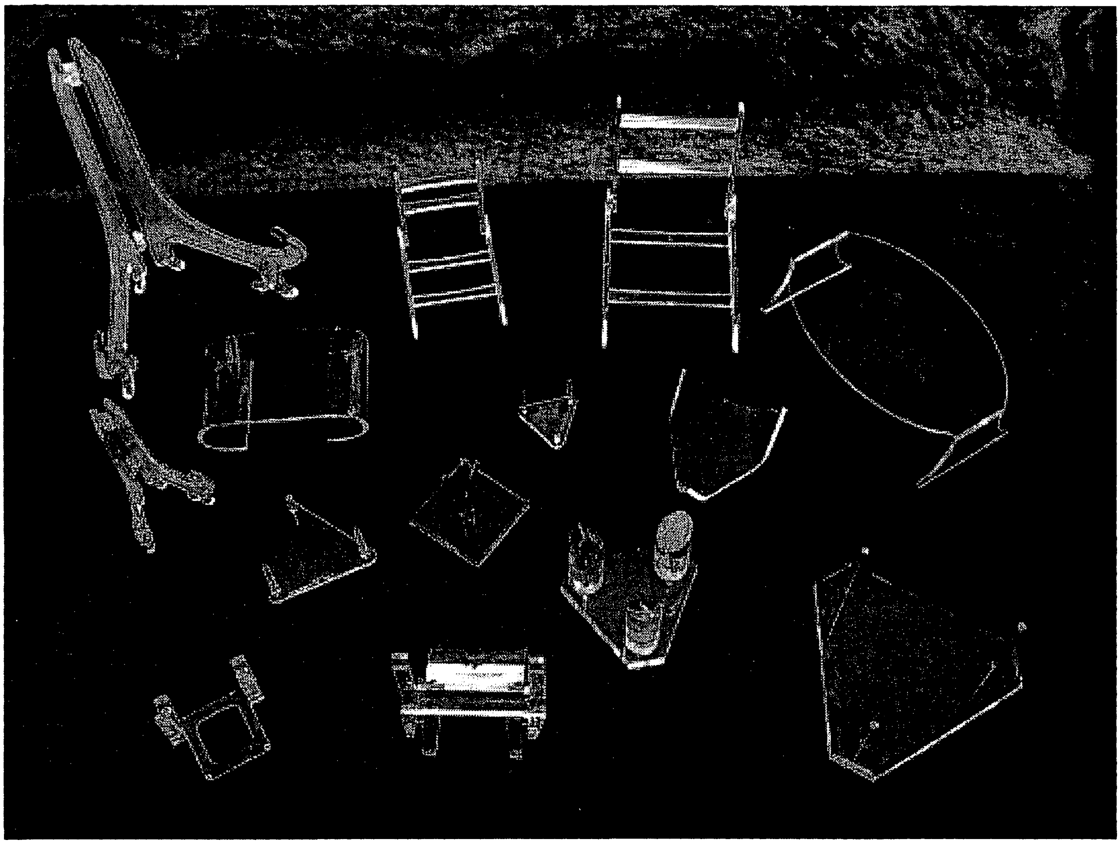
A cheaper alternative to the Riker is the cardboard specimen boxes available from the same catalogs. These boxes are similar to the Riker mounts but made with less durable materials.



Cardboard specimen box with clear top.

DISPLAY STANDS

There are probably many companies that sell these types of stands. I came across one early on and have not seriously looked for another. It is *Jule-Art*, listed at the end of this article. Again there may be others, but to me this catalog has it all....!!!! They specialize in acrylic stands of all types. As you can see by the photo below, they have plate holders, cardholders and even specifically designed geological material stands. I have purchased large numbers and different types of these specimen stands. They work for many specimens depending on the situation. When you are placing specimens in curio cabinets, these stands can easily and safely present the fossil in its most attractive position. You can turn and prop your fossil up so that it can be easily seen and adored. At times, these acrylic stands even seem to disappear behind the fossil you are showing.



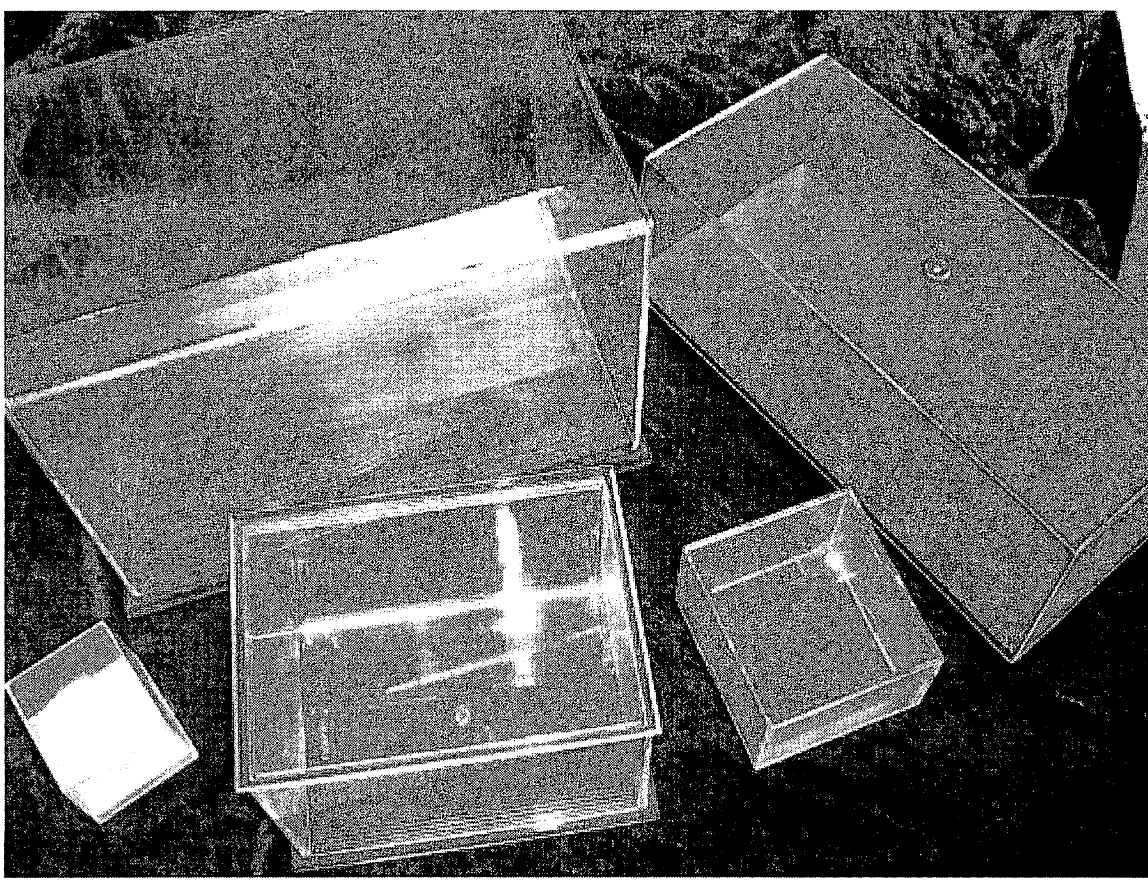
Small array of acrylic specimen stands

Cheaper alternatives to these plastic holders are clay and Filo® clay. Regular hobby clay is very moldable and versatile. If you don't like it a certain way – just remold it until you are happy. The disadvantage is that the clay, due to its moisture level, leaves a wet and greasy stain on whatever surface you put it on. If it's glass, that's no real problem, but if it's wood, well, you have a stain. Also the clay does introduce moisture onto the fossil leaving a stain and possibly allowing moisture to get into the fossil. Not a very desirable situation.

Filo® clay can be found at nearly every hobby store. It is a clay that you can shape and mold, then bake it in your oven and create a custom holder for your item. It is very durable, hard as rock and it comes in many colors so you can match the fossil or background. If you go the clay route – this is the way to do it.

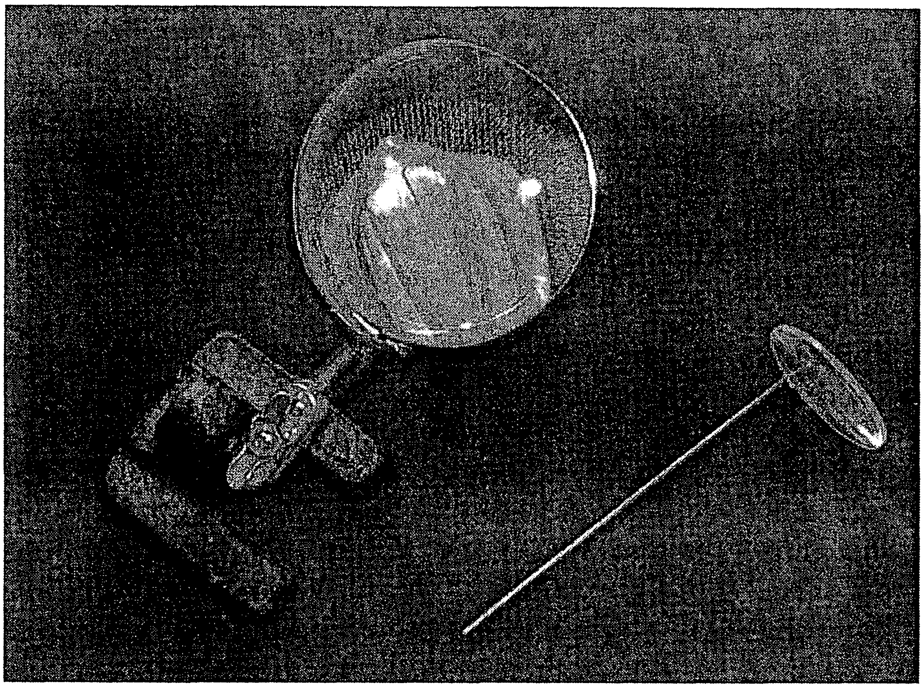
DISPLAY BOXES

These boxes come in a variety of models, shapes, sizes, materials and manufacturers. Some can be found in hobby shops, craft stores and others can be purchased from various companies. Some of these boxes include; Beanie Baby® boxes and Mini Football helmet Boxes that are readily available in most collectable hobby shops. These boxes offer dust-free display and a good deal of protection from damage. The boxes themselves need to be dusted and cleaned, but the specimen will remain clean. When using these plastic boxes, you may combine acrylic display stands to place your specimen in a desired position showing it off in its best possible way. The clear plastic or acrylic is very unobtrusive and can hardly be seen, thereby offering little distraction. In some cases you may wish to place Styrofoam® on the base and then some material covering it. This can set your specimen off by introducing a contrasting color to the matrix or specimen itself. Sometimes for that very special specimen velvet can make it look chic and elegant in the display case. Again a plastic display stand can be placed either under the cloth or right on top, holding the specimen up for your viewing enjoyment. In the photo below are several boxes from various manufacturers.



Acrylic display boxes

Placing Styrofoam® under the cloth will also serve another purpose. Styrofoam® provides an excellent base to insert pins and other things into. Insect pins with the tips bent in a 90° angle, can be pinned into the Styrofoam® to hold a specimen down so that it doesn't move. Also, an acquaintance of mine made some magnifying stands for me in order to allow me to display smaller trilobites under magnification. I can just stick these into the base and they will stay put in the Styrofoam base. In the photo below are two of the magnifiers I use to magnify small fossils in my displays.



Hands free hobby magnifier left. Custom-built magnifier right.

CURIO CABINETS

This is a very popular way to display your fossils. If you can bribe your spouse with something else, perhaps a new car or something like that, your spouse may relinquish the curio cabinet for those dusty old rocks. Curio cabinets come in many sizes and shapes. Corner cabinets are popular as they can take up a dead corner and give it life. Make sure you purchase a curio cabinet with lights. It is so nice to turn off the lights in the room, turn on the curio cabinet and see your fossils in that dramatic low light environment. Also it is best to have a curio cabinet with glass shelves. This allows light to pass to shelves below. Acrylic stands will offer the best opportunity to showcase the fossil within the cabinet.

CUSTOM CABINETRY

I recently found a retired carpenter who still loves to work with wood. He actually builds display cases for a local museum. Needless to say, I save my nickels and dimes and have him create several cabinets, actually display cases, for me from time to time. They are a bit expensive, but I do like them. I have also begun to create cabinets and cases of my own, as you will see later. I have also constructed carpeted display walls.

Here we should discuss where you would display your fossils. I travel with them from time to time, to shows and to schools so my collection and display methods are quite versatile and highly mobile.

We are finally empty nesters; my youngest just went away to college, so I'll soon be using one room for my fossils. You may be lucky enough to have an extra guest room, a large dry basement, or even a dedicated display room in your house or garage. If so you are truly lucky. You can build custom cabinetry and cases you will not have to move. You can build carpeted walls. Yes, I said, "Carpeted." You'll see the advantage of this a bit later.

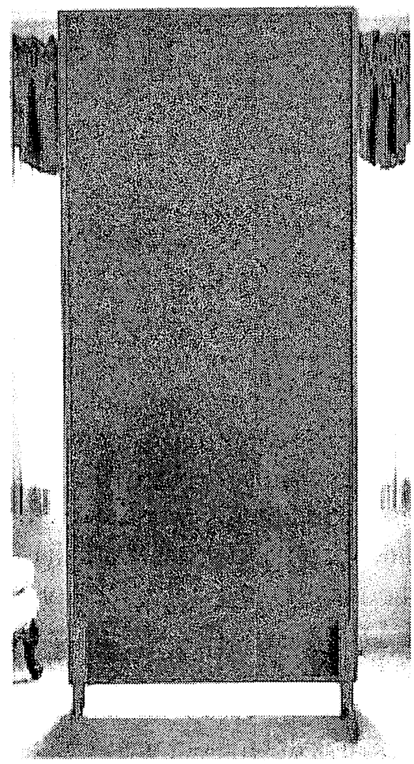
The following principles will apply to those of you with dedicated exhibit space as well as the rest of us who do not have a great deal of space.

OK, let us start with the carpeted walls. I have constructed some wall panels 3 feet wide by 7 feet high and about 2 inches thick. They have been covered – both sides with an all-purpose carpet. This all-purpose industrial carpet works great with Velcro®. I have several poster size photographs as well as posters that I have mounted onto foam core. It is easily obtained from craft or frame stores. I used the "hook" side of the Velcro® because it catches and holds to industrial carpet. All I have to do is place the picture, photo or poster on the carpet, use my level to get it level, and the display is done. The walls are very versatile. I have several wall cabinets that I also mount on these walls. Text labels backed with Velcro® can also be affixed very easily. The neat thing about this system is that you can change it anytime you want with a minimum of effort.

To build the walls I went to a local lumber company and had them cut some ¼ inch plywood for me into 3x7 foot sheets. Since I am woodworking challenged, it is nice that many of the lumber suppliers will actually cut wood to one's specifications. I purchased some furring strips, cut those myself, short sheet rock screws, and industrial gray carpet, and I was on my way.

I attached the furring strips to one of the sheets of plywood. I also put some reinforcing strips in the middle. Short sheet rock screws attached the furring strips. I then flipped the unit over and attached the other piece of plywood, making quite a solid panel.

Then the carpet was stretched around the panel, attaching it on the sides by staples. Carpet glue was also used on the panels to permanently adhere the carpet. Finally, I had my carpenter friend make two legs for each panel and a simple but beautiful wood trim.



Custom built carpeted wall panel

The wall panel units are very stable, fairly easily transported very versatile and look great. Should you have the room or ability in your basement, hobby room, collection room or wherever you wish to display your fossils, you could install the carpet directly to the existing walls. It is not even necessary to cover the whole wall, you could easily just install it from the middle of the wall to the ceiling based on your personal preference.

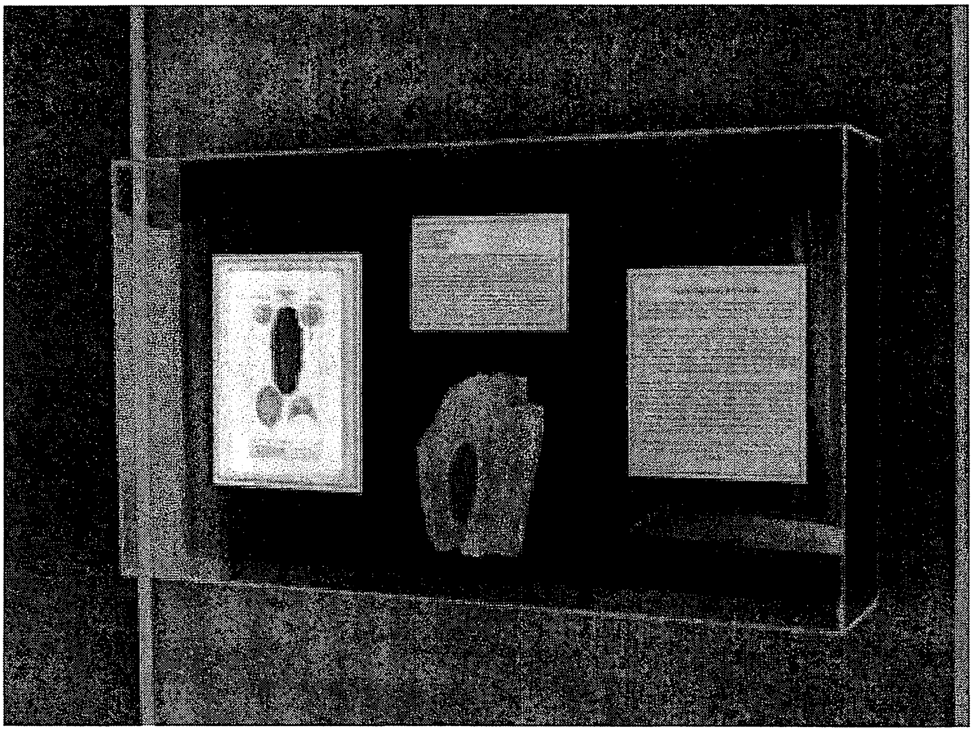
CUSTOM DISPLAY CASES

I like small wall-mounted cases. Display cases that are freestanding on the floor tend to be big, bulky and take up a great deal of room. An advantage of freestanding cases is that visitors can walk around the case and see the specimens from all angles. A large case also costs a great deal to build. However, they are fairly easy to construct, laminate and purchase Plexiglas® for. Again if you have the luxury of having dedicated rooms for your collection, go ahead and choose this route and build yourself a small museum. You can easily take one wall and install built in cabinetry. This method does make great use of available wall space, but is fairly permanent. Again depending on the level of sophistication and funds you have available, you could purchase plywood and paint it, or install laminate glass or Plexiglas® and have a wonderful built-in display case.

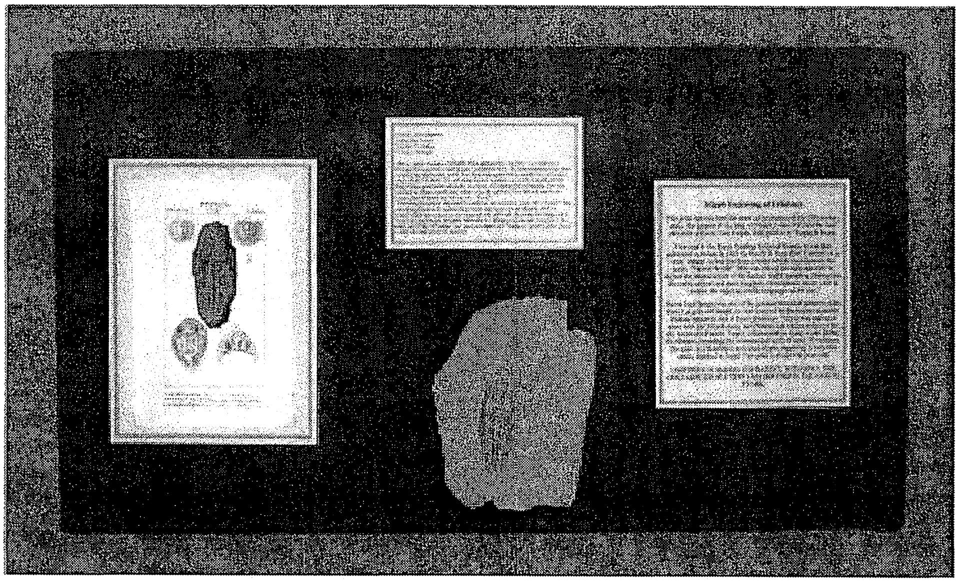
Locally we have a company that does have the ability to build Plexiglas® tops for cases and cabinets. These are surprisingly not that expensive. The Plexiglas® tops really set off the display cases well. The cases look much better than a flat top case cover or frame. Explore your area to see if there is a glass or plastic company that can make the tops for you.

I like small wall mounted cases. In many instances these cases can be just as lovely as paintings hung on a wall and actually not much bigger than that. Yes, they do stick out away from the wall a bit, but if you have the wall space and the desire, these make great displays.

The one I built for myself, remember, I'm carpentry challenged, is very simple to construct. Again I go to the local lumberyard and have them cut up some ¾ inch plywood into pieces 18 inches wide by 26 inches long. I went to a local fastener manufacturer and sales company to buy special anchors and special security screws. I use security screws because my cases do travel, and I do not want people opening the cases and helping themselves to fossils. I put the screw anchors in the edge of the wood – 2 on top and 2 on the bottom. I purchased several yards of black felt from a local fabric store. You can choose any material and color that suits you. I cut the material several inches larger than the board. I sprayed the board with adhesive and placed it on the board, wrapped the cloth onto the back and then stapled it to the back. Next I cut holes where the screws would pass through and took the units to the local Plexiglas® company. They made a Plexiglas® cover that was 4 inches high. I had them drill holes in the Plexi to match where the screws would pass through. Now I had my own wall unit. (See photo below.) I use one of these cases for my Stipple-Turpin 1800's print and accompanying trilobite. For the trilobite mount I just took an extra piece of foam (from making the storage boxes), covered it with felt and sewed the back. Gluing this to the back wall of the case with white glue secured it so I could mount the trilobite. I then placed Velcro® on the back of the fossil so it would latch into the cloth to make it steady. I also used Velcro® on the back of the text labels to hold them on, as well. The text labels were prepared on my computer, printed on almond colored paper and mounted on Foam board.



ISABELINIA glabrata artifact display case



Isabelinia glabrata artifact display case front view

Stipple Engraving ***Specimen and descriptive label*** ***Stipple engraving descriptive label***

The wall cases are attached to the wall by a very neat system using interlocking wood. If you take a piece of wood 1 inch by 3 inches and cut it as shown in the diagram, you will create a mounting system for the case. Mount one piece on the wall as shown. Next, mount the second on the case as shown. Then slide the case down on the wooden support and...you have a wall-mounted unit. Gravity and the weight of the case will do the rest.

Wall angle mount, mounted to a carpeted wall

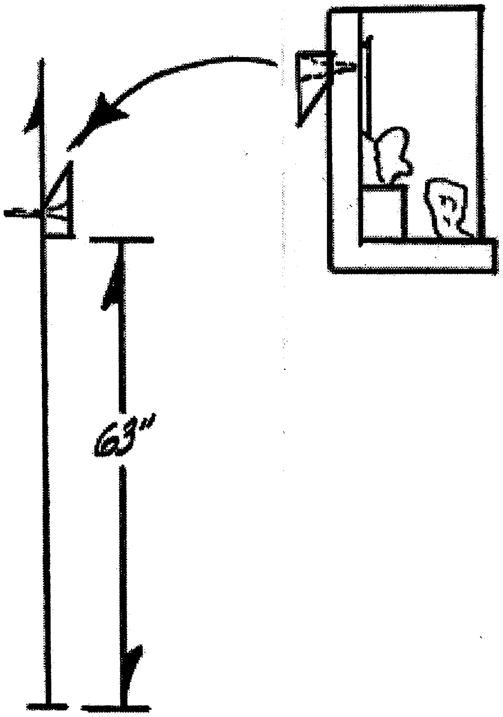


Diagram of case mounting to a wall

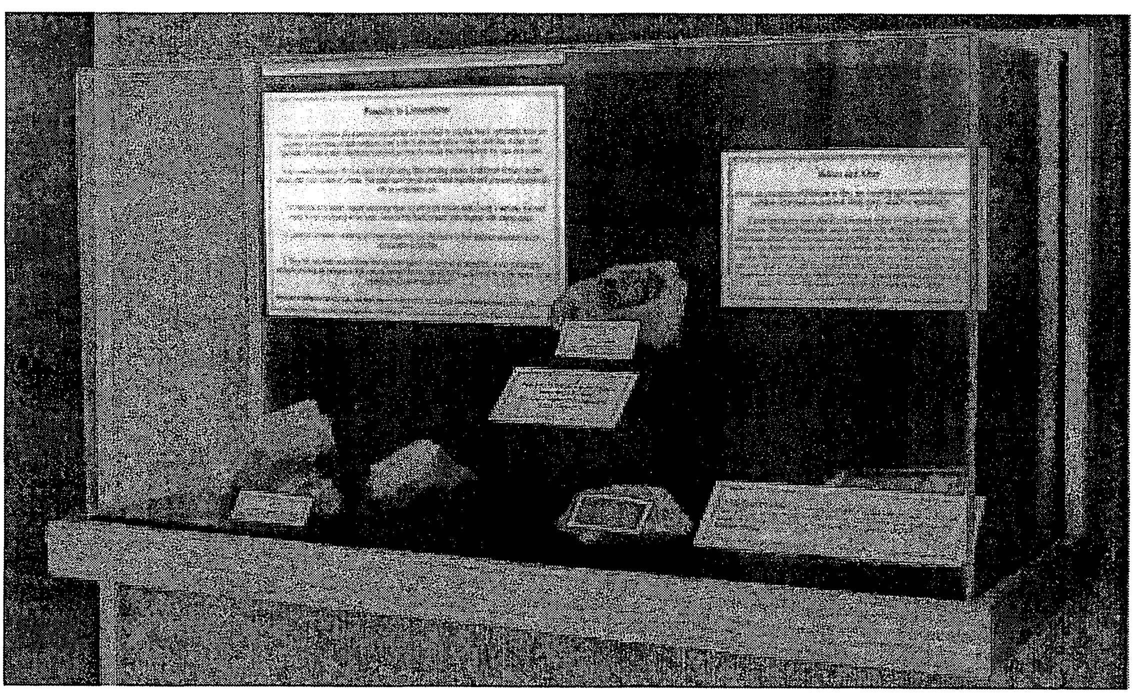
CUSTOM WALL CASE with BASE

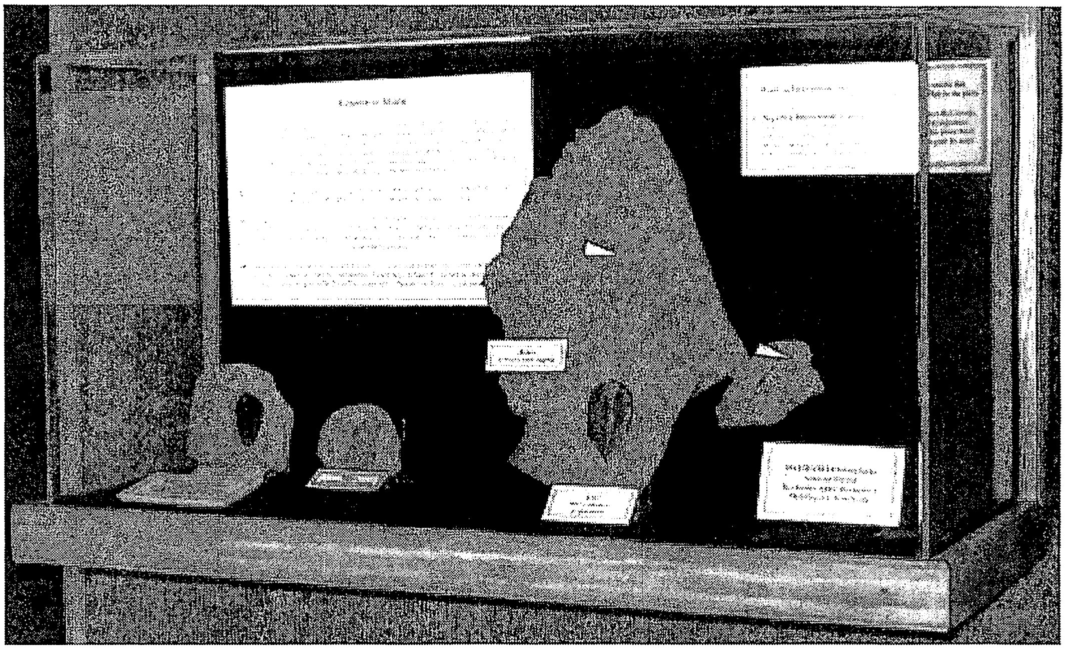
I went to my carpenter buddy and asked him to construct several cases similar to the simple ones I created except they had a base. I could easily modify the ones I built, but Lou is so good, I let him do it.

The cases were built with an L- shaped base coming away from the back of the case. There was a channel all the way around the case so that the Plexi top would fit into the channel for security. The back and bottom were laminated with almond linoleum. This was done in order to present a finished surface that needed no additional finishing if needed. I still put black felt on the case as it sets a dramatic tone with the low-level light and spotlights that I use.

The text labels are mounted on Foam core and then attached to the felt with Velcro®. I used a variety of acrylic and wooden holders to vary the level of specimens within the case for a more dramatic appearance.

Also one other neat thing that you can do if you do woodwork is to secure the top of the Plexi case by a piece of wood with a groove routed in it. It locks into the back of the case and makes a wonderful finished look to the case. Also there are two screws holding the top of the case – for security.





LABELING YOUR CASES

There are as many ways to label the specimens in your case as there are specimens in the world. I will briefly cover some things I do, but you are on your own on this one.

Computers have helped museums and private individuals immensely. Varying sizes and styles of fonts, sizes of text and borders all helps with the aesthetics of your display. In most instances I use a very simple label printed on card stock.

Included on the label is the Genus and Species name on line one in bold, the geological period on line 2, the formation in which it was found on line 3 and finally the location, or city in which it was found. I put a border around it and print it on card stock. I cut it out leaving more room at the bottom so that I can fold over a small tab. This tab acts as a base to hold up the label.

Text labels can be used to add more information. I use these to help tell the story. In the case of museum exhibitry it is recommended to use as few words as possible in text labels. Sometimes that is very difficult if you are trying to explain something complicated. Still use as few words as possible. You can also vary the size of the text itself. It has been shown that a certain percentage of people don't read text, a certain percentage read only the large bold text and a certain percentage read it all. By varying the size of the text messages, you can add more text for those who want to read it and others will just read the bold.

I mount all my text, diagrams, photographs, in short, anything on paper, directly to Foam-Core with spray adhesive. Then I put Velcro® on the back so that I can mount it on the cloth in the case. Sometimes I will even use the carpeted panels to hang wall cases on and then place the text labels directly outside the case mounted to the carpet wall panel. Opportunities are endless when it comes to labels.

Have fun with your collection. Many people collect to ...well...just collect. Others collect to share with other people and the best way I have found to share is by showing off the collection. Whether it is in your own home, office, a local school display case, a rock and mineral show or a museum, share your collection with others. Who knows, your collection may just be the spark needed to motivate a student to join the ranks of paleontologists worldwide searching for ancient treasures. Hope these ideas have been a spark for your imagination to look at different ways to show your stuff.

RESOURCES

Resource book for Museums
The New Museum Registration Methods
Edited by Rebecca A. Buck and
Jean Allman Gilmore
1998 American Association of Museums
1575 Eye St. N.W., Suite 400
Washington, DC 20005

School Supply Catalog
Sargent-Welch
P.O. Box 5229
Buffalo Grove, Il 60089-5229
1-800-727-4368
www.sargentwelch.com

School Supply Catalog
Wards Natural Science
P.O. Box 92912
Rochester, New York 14692-9012
1-800-962-2660
www.wardsci.com

Acrylic Display Manufacturer
Jule-Art
Box 91748
Albuquerque, NM 87199
1-800-833-8980
www.jule-art.com

Archival Quality Materials
517 Main St. P.O. Box 101
Holyoke, MA 01040-0101
1-800-628-1912
www.universityproducts.com

Acrylic Plastic Displays

George Aldred, the Plastic Smith
R. R. 2, Box 175
Shoals, Indiana 47581
812-247-3780

Many years ago (about 30 or so) a man came to our Lawrence County Rock Club meeting at Bedford, Indiana, too put on a program called, "Making Your Own Display Stands." I watched him very carefully. I thought, "I can do that." He used a small portable oven to heat the plastic so that he could form a stand to hold specimens.

When we arrived home, I put more thought into what he had demonstrated. I cut some pieces of clear acrylic plastic—Plexiglas, made a jig about the size he had and proceeded to form a display stand in my wife' oven. The first stand wasn't perfect, but it was usable. The first jig I made was of soft wood. It scratched the plastic some. I then made a jig from acrylic plastic, adjusted the angles some and produced a better-looking stand. These stands are made from a triangular piece of acrylic plastic with the corners turned up to hold fossils, minerals, geodes, etc. I make five sizes and have two thicknesses of plastic. These stands are called *specimounts.*

After people saw these stands at shows, they asked, "Could you make this kind of stand?" They would describe what they wanted made. In most cases, I have been able to make what they wanted. A lot of my development of acrylic plastic displays was by trial and error. Many first-made items were adjusted until the final product was acceptable.

My daughter asked me if I could make an acrylic plastic display box for the Bride and Groom from the top of their wedding cake. This I did, and that box developed into making several sizes and styles of display boxes.

The same question was asked when people saw my display boxes at shows. "Can you make a box this size, length, width, and height?" I have made many special order boxes in addition to the standard ones I have made. In some cases, there was enough interest in a certain size that I added it to my inventory. Yes, I have turned down some requests. What the person wanted was either too large or too complicated for me to handle.

The man who put on the program at our rock club meeting also built sliding door display cabinets of different sizes and shapes. After he saw the display boxes that I was making, he asked, "Could you make cabinets like mine?" He continued, "I'm getting too old and too tired to keep up with the requests."

I told him, "I think I can."

I did, and have been making sliding door cabinets ever since.

I make flat shelf cabinets and slant cabinets, all with sliding doors. Some doors are mirror plastic. I also make Thumbnail Cabinets for the 1 ¼ " cube Perky Boxes or fossils, minerals, geodes, etc. I have two sizes. One is a 28-space cabinet that fits a book case shelf and a larger 50-space cabinet. I can also drill holes in the backs of cabinets so that they can be hung on a wall.

I make several types of stands besides the specimounts. There are stands to hold different sizes and thicknesses of fossil slabs, stands for larger, thicker slabs, such as fossil fish slabs. I make display risers to raise specimens up on a display table. There are fossil egg and sphere stands of several sizes, as well as business card and label holders.

I also handle the Perky Boxes that I make the cabinets for, two sizes of magnifier boxes and Mini-grip plastic bags in seven sizes. The last three items I handle at the request of individual collectors and dealers at shows.

Some of the advantages of using clear acrylic plastic display boxes and cabinets are:

1. There is light enough to see what is inside without taking the specimen out of the box or cabinet.
2. The box or cabinet keeps the dust off the specimens.
3. The boxes or cabinets help to organize the collection;
4. Showing the specimens in the boxes or cabinets keeps people from handling the specimens.

George Aldred at the MAPS EXPO

At one show the dust from the floor was quite bad. Each day I would clean the boxes and cabinets several times. I left the dust on one half of the top of one of the large cabinets. One person came by and commented rudely that I had a lot of dust on that cabinet and that it didn't look good. I explained to him that the dust you see could be settling on your specimens if you don't protect them in a box or cabinet. His attitude changed and he bought a large cabinet.

Acrylic plastic is soft and easily scratched. Be careful! Wash your hands thoroughly before handling acrylic plastic items. Most acrylic plastic items can be cleaned with water. For more difficult cleaning, wipe them clean with a weak solution of mild detergent and water. Dampen a cloth in the solution, wipe, and let dry. Anti-static cleaners for acrylic plastic, such as K-Lux, Plaskolite plastic cleaner, and Lite Touch are available at janitorial supply businesses. Price stickers and other sticky labels can be removed by using pure mineral spirits. Do not use gasoline, solvent base cleaners or abrasive powdered cleaners.

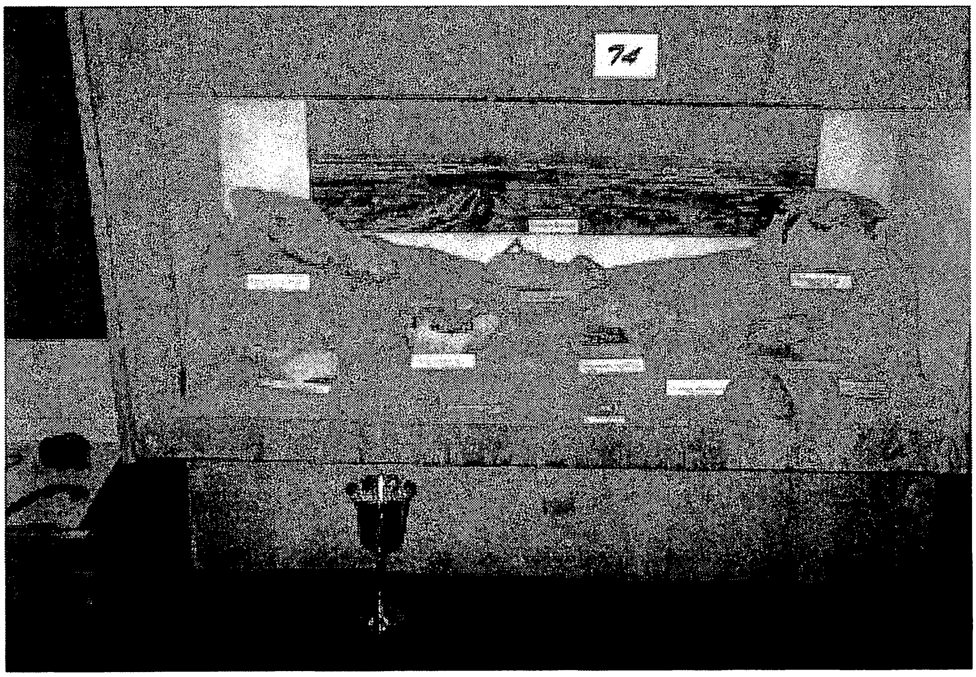
All the acrylic plastic display boxes, sliding door cases and stands that I make are not readily available on the market. If the product is already on the market, I don't make it.

AND THE WINNER IS . . .
HOW TO DESIGN THE WINNING EXHIBIT

Nancy Mathura
3925 Lake Oakland Shores, Waterford, MI 48329

The Michigan Mineralogical Society hosts the Greater Detroit Gem, Mineral, Fossil, and Jewelry Show each October. In 2002 more exhibits were needed, and my club, Oakland County Earth Science, was approached. With two weeks to prepare I assembled an exhibit and won "Best of Show." Here is my strategy:

Electrified cases 41 ½ x 21 x 22 inches are provided. I made a mockup of the case using cardboard and newspaper for the bottom. Next, a variety of sizes and shapes of fossils were put in a balanced array while I tried to decide which to use. Less is definitely more. To increase interest and make some fossils more important, I varied their elevation by using fifteen 9 x 12 x 2 inch boxes saved from Priority Mail. After I decided what to take and where to put it, I made paper templates of the specimen bases, labeled them and taped them to the newspaper. The entire sheet was taken to the show and used as a guide in setup.



"Best of Show" exhibit, Greater Detroit Gem, Mineral, Fossil, and Jewelry Show, 2002

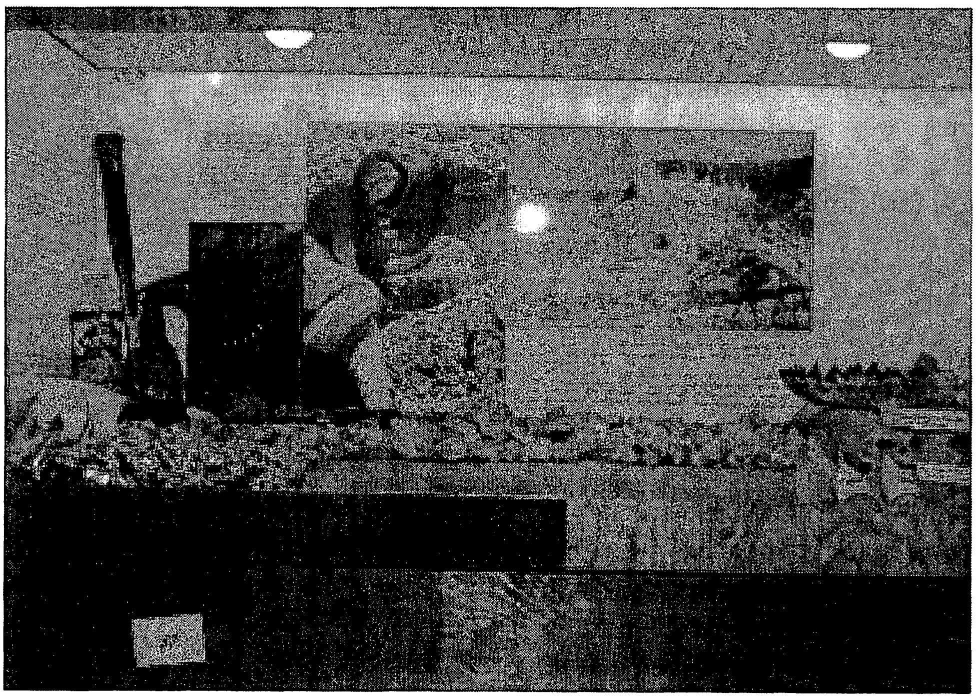
To cover the boxes I bought burlap the color of the fossils' matrix, cut it to fit over the boxes and ironed it. Across the back of the case, I put a panoramic photo of the badlands. This was enlarged and mounted on white ¼ inch foam at Kinkos for $20.00. It didn't fill the space but was large enough because the fossils across the back were elevated up to it. The picture was labeled "Crawford, Nebraska."

All writing was done on posterboard with a black fine-tipped "Sharpie."This was easy to see and was large enough for seniors to read without glasses. All specimens had the Latin name and common name on the label—e.g., Stylemus nebrascensis (Tortoise) . All pieces of posterboard and the photo were held in place by "Sticky Back Velcro" (from the fabric store) cut in ½ inch pieces.

Since the theme for the 2002 show was "Treasures of the Earth," I used that as a partial title for the case followed by "Vertebrate Fossils." This short description was placed on the left wall.

"These 30 million year old fossils are from the middle Oligocene sediment of the White River badlands of Nebraska. Their North American Land Mammal Age is Orellon. During the Oligocene the land changed from subtropical swamp to grassy plains with woods and river valleys. Grazing animals proliferated and became the prey of the saber-cats, pigs and dogs. The specimens were excavated from the Brule formation on private deeded land. (From the collection of Nancy and Ravi Mathura.)"

A good exhibit is arresting: the "Wow" factor. It is neat, uncluttered and leads the eye across the case. All information should be clear and concise and appropriate for the audience. This show has adults with varying levels of sophistication in paleontology, plus hundreds of school children who are bused in on opening Friday. If all these things mesh, the judging criteria of "furthering interest in and knowledge of paleontology" will be met.



"The Little Pig Dig" exhibit, Greater Detroit Gem, Mineral, Fossil, and Jewelry Show, 2003

THE EVOLUTION OF DON AULER'S
ILLUSTRATION TECHNIQUE

Don Brazda
239 Oakland Grove, Elmhurst, IL 60126

A friend to all rockhounds and amateur paleontologists, Don Auler (1918-2002) is remembered as a person you could bring your rock, fossil or mineral to, and he could usually not only identify it, but also give you a good idea where came it from. He could do this because he did not specialize in one type of material or area and because of his extensive travels with Dorothy, his wife of sixty years.

Don is also remembered as a talented artist. He was the "Principal Artist" for Richardson's *Guide to The Fossil Fauna of Mazon Creek*, and did all of the artwork for the popular *Keys to Identify Pennsylvanian Fossil Plants of The Mazon Creek Area* and *Keys to Identify Pennsylvanian Fossil Animals of The Mazon Creek Area*, published by the Earth Science Club of Northern Illinois, of which he was a Past President.

His passion for learning was well known, and his willingness to share that knowledge was unparalleled.

He is also remembered for his political cartoons, and work in many other media.

In 1984 when the Earth Science Club Of Northern Illinois (ESCONI) formed a committee to prepare a book on the fossil plants of Mazon Creek, there was one area of responsibility that was already set. Don Auler would do the artwork. He had proven that he had the talent and ability by virtue of the many illustrations he had done for the club bulletin, *The Earth Science News.*

In the book, *Keys to Identify Pennsylvanian Fossil Plants of The Mazon Creek Area*, Don created his illustrations using pen and ink, drawing in a linear style and using a unidirectional hatching technique, occasionally crosshatching for additional emphasis of form. When you look at Mazon Creek plant fossils, you will see that they are defined by lines, which may be curved, straight, erose etc., all outlining the various parts of a given plant. A particular problem arose with *Neuropteris scheuchzeri* (Fig. 86),

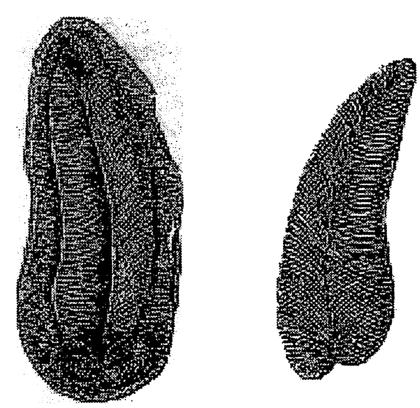


Fig. 86 Fern *Neuropteris scheuchzeri*

which sometimes has fine hairs that appear to be scratches across the veins. Showing them would mean black lines crossing black lines, which would be confusing. He resolved this problem by drawing a detailed magnified view (Fig. 88), showing the hairs in contrasting white. This aided in recognizing the crosshatch pattern caused by the hairs.

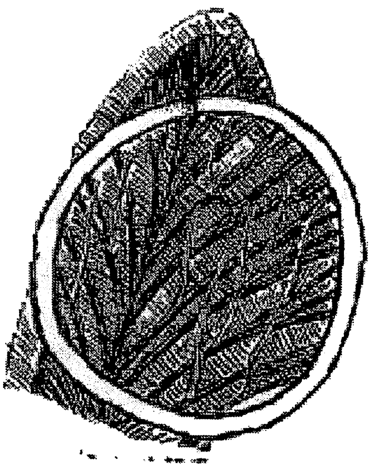


Fig. 88 *Neuropteris scheuchzeri* detail

In 1987 it was decided to publish a book on the animals of Mazon Creek titled, *Keys to Identify Pennsylvanian Fossil Animals of The Mazon Creek Area.* Don again agreed to do the artwork. This presented a new challenge. As opposed to plants, which are usually sharply defined, animals are mostly represented by sometimes vague shading and are usually not sharply defined. To portray these subtleties he used a stipple technique combined with an outline drawing to accurately render the subtle values that distinguish these types of

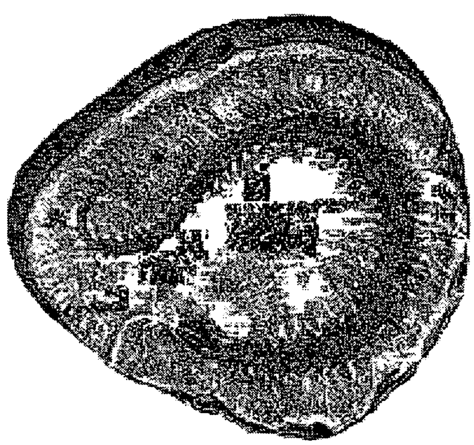


Fig. 30 Worm *Esconites zelus*

fossils. Stippling is a method of rendering in pen and ink, using dots to describe value changes. The closer the dots are to each other, the darker the value, and visa versa (Figs. 9 and 30).

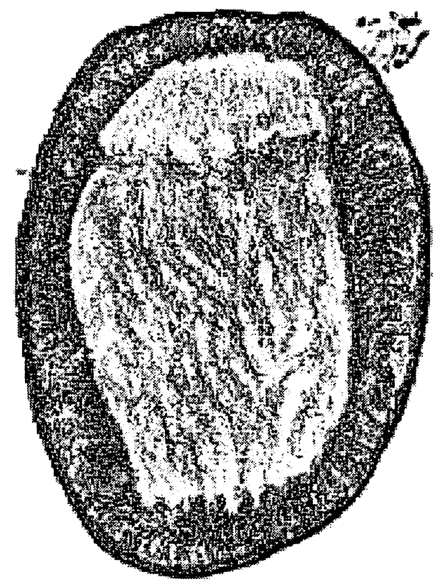


Fig. 9 Jellyfish *Essexella asherae*

When Northeastern Illinois University decided to publish a book based on the work of the late Dr. Eugene Richardson titled, *Richardson's Guide to The Fossil Fauna of Mazon Creek,* Don was asked to provide some of the artwork and soon became the "Principal Artist."

Rather than a field/guide identification book, this was to be a collection of essays by several recognized professionals, necessitating another change in technique.

Fortunately, Don was always working on improving and modifying his technique, and was able to join the two previous techniques together. This evolved technique allowed him to describe subjects with more varied textures and details (Figs. 7A,12.42).

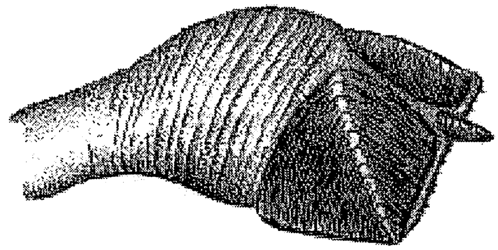


Figure 12.42 Barnacle *Illilepas damrowi*

This additional complexity in his illustrations allowed him to portray the varied life forms as they were three hundred million years before the present.

Don always liked working with people, especially children, helping them learn about the earth sciences, and it seems he has left us with one final lesson. Keep working and refining your skills, and your technique will evolve.

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Richardson's Guide To The Fossil Fauna Of Mazon Creek.

Technical Advisor:
Craig Kiefer M.A.M.S.

On next page: Fern *Neuopteris scheuchzeri.* Shows nearly actual size. Discovered by Dorothy Auler when opening nodules in her back yard. Don was in the house working on illustrations for *Keys to Identify Pennsylvanian Fossil Plants of the Mazon Creek Area* when he heard Dorothy let out a shriek. When he came out and saw the fossil, he said, "That will be my back cover." It wonderfully fills the cover. –Ed.

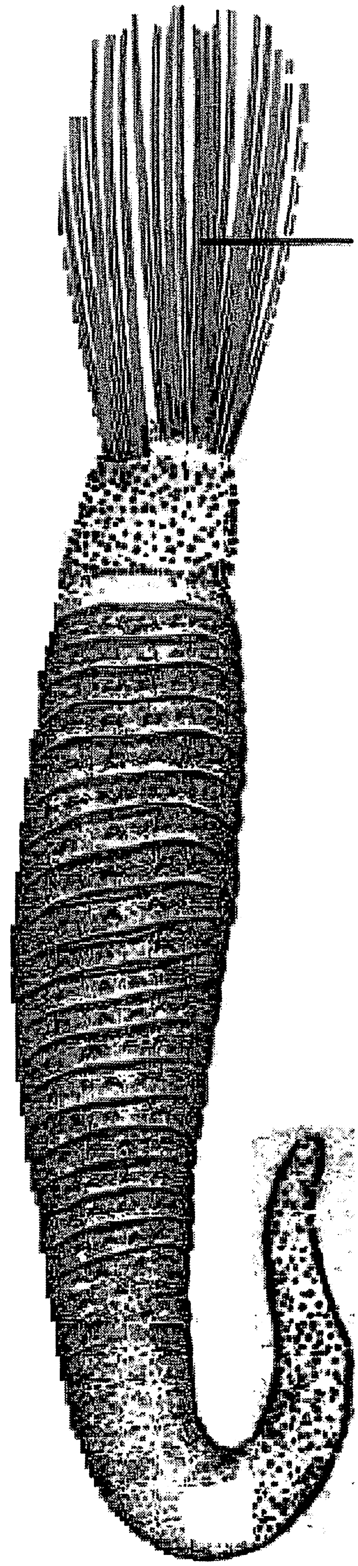
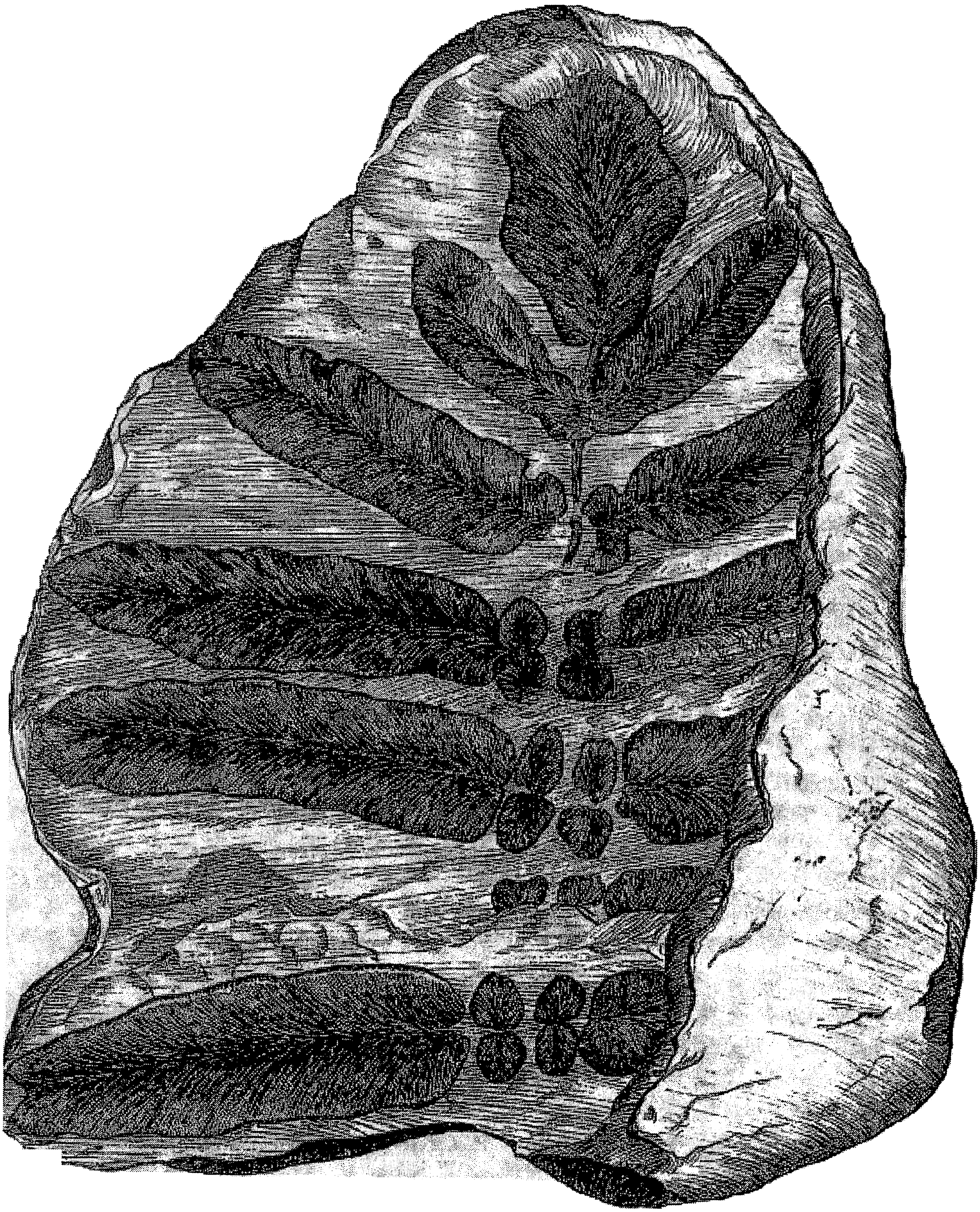


Fig. 7A Worm *Flabelligeridae sp.*



Neuropteris scheuchzeri Drawing by Don Auler Copyright © 1999 Earth Science Club of Northern Illinois. Used by permission.

THE RECONSRUCTION OF ANCIENT LANDSCAPES: AN EXAMPLE FROM THE LATE CRETACEOUS HELL CREEK FORMATION OF NORTH DAKOTA

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INTRODUCTION

In the paper I will delineate the scientific, artistic, and practical steps that we took to conceive, research, and build the upper Hell Creek ecosystem as an immersion diorama in the *Prehistoric Journey* exhibit at the Denver Museum of Natural History.

Since the early 19th century, there have been artistic attempts to reconstruct the ecosystems of the distant past (1). Usually these undertakings were two-dimensional illustrations based on collaborations between artists and paleontologists. Some of these efforts included three-dimensional renderings known as dioramas. Many reconstructions of ancient worlds have focused on animals and have represented the ancient vegetation with a miscellany of modern plants masquerading as their ancestors. Although life-like animal reconstructions are an admirable goal, ecosystems and landscapes are primarily characterized by their plants and topography, not their animals. The *Prehistoric Journey* exhibit at the Denver Museum of Natural History (DMNH), which opened October, 1995, took the approach of reconstructing prehistoric scenes as three-dimensional habitat dioramas using detailed studies of the sedimentology and fossil vegetation of specific fossil sites to create more realistic reconstruction of the ancient ecosystems.

The *Prehistoric Journey* exhibit was planned and built between 1989 and 1995. Each diorama was based on a specific fossil site that contained fossils of both plants and animals and sedimentary evidence of the site's original geomorphology. Between 1990 and 1994, DMNH paleontologists selected and visited the sites and collected the fossil specimens and associated data. These specimens, data, and resulting publications provided constraints and authenticity to the site-specific reconstructions (2). Work on the dioramas began in early 1991 and was completed in late 1995. The final exhibit has seven such dioramas and one additional partial diorama with skeletons mounted in front of it.... This paper documents some of the decisions that were made in building the 66 myo Cretaceous Creekbed diorama.

PREVIOUS VISIONS OF THE LATE CRETACEOUS

The latest Cretaceous Period has long been ecologically confusing because its flora appears "modern" due to the abundance of flowering plants relative to gymnosperms and ferns. This confusion was compounded by generations of paleobotanists who used modern plant generic names to describe angiosperms that are now known to belong to extinct genera. If the paleobotanists were using names of modern plants, then it should be no surprise that the artists painted modern vegetation. Rudy Zallinger's spectacular "Age of the Reptiles" mural, painted in 1949 on the wall of the Great Hall of Dinosaurs at the Peabody Museum, Yale University, is an example of this type of reconstruction (3). Behind the classic dinosaurs of the Late Cretaceous Period are weeping willows, Virginia magnolias, Chilean monkey-puzzle trees, and flowering dogwoods, all modern trees. The effect is a Cretaceous fauna in a modern botanical garden. An additional problem has been the difficulty of rendering latest Cretaceous ground cover. Aware that grasses were an innovation of the Cenozoic, artists have routinely left bare ground in their images of the Late Cretaceous. While the omission represents an effort at accuracy, the result is the phenomenon that the animals in the images appear to be wandering around on parking lots.

PALEOENVIRONMENT AND BIOTA OF THE UPPER HELL CREEK FORMATION

The Hell Creek Formation exposed in Slope and Bowman Counties in southwestern North Dakota is a 100-meter-thick unit that is well-suited for the demands of a diorama builder. The formation is well-exposed and extremely fossiliferous. These rocks have been extensively studied in the past 20 years and the resulting papers and subsequent field work were the basis for the reconstruction at DMNH (4-8). The formation contains a fossil flora that varies throughout its thickness (6,7), and we chose to use the biota that occurs in the uppermost 20 meters of the formation. The site chosen for reconstruction was DMNH1.428, which is located near Mud Buttes in Bowman County. At this site, a megaflora of more than 50 species is associated with abundant vertebrate microsites that contain typical Lancian vertebrate assemblages. The sedimentology suggests a medium-sized meandering river setting with poorly drained but not swampy floodplains. These observations in concordance with recent analyses of Hell Creek paleosoils indicate that soils were moderately to poorly drained and conditions were generally humid (4,5,9). Coal seams are rare and thin in the Hell Creek Formation, suggesting that although the area was moist, it was rarely swampy.

A modern analog stream system was discovered in Connecticut (6,10). The forested flood plain of the Quinnipiac River in North Haven, CT was mapped and monitored. Channel size is similar to the upper Hell Creek channels, and observations made in the modern system helped to constrain the prehistoric reconstruction. The muralist and primary foregrounds artist visited this analog site and made observations and sketches to constrain the Hell Creek reconstruction.

The known megaflora of the Hell Creek Formation (7,10-12) consists of 190 plant morphotypes (1 bryophyte, 6 pteridophytes, 1 ginkgo, 1 cycadophyte, 9 conifers, and 172 angiosperms). Angiosperms represent about 90% of the flora both in number of species and specimens collected. Important angiosperm families include the Lauraceae, Platanaceae, Magnoliaceae, Berberidaceae, and Arecceae (palms), but a great number of the Hell Creek leaves have yet to be assigned to families. The majority of Hell Creek angiosperms belong to extinct genera. Although it is commonly reported in textbooks and popular articles, modern plant groups such as oaks, maples, willows, and grasses are not present in the Hell Creek. Conifers are represented by members of the Taxodiaceae, Araucariaceae, and Cheirolepidiaceae (extinct). *Ginkgo* is known from only a few localities. The sole cycad, *Nilssonia*, is present throughout the formation but very rare and ferns are extremely uncommon.

An extremely large fossil leaf collection from DMNH1.428 provided a reasonable assessment of the local vegetation. These were counted and calibrated with the results of studies of leaf litter in modern forest floors. Counts of the relative abundance of forest floor leaves in modern forests of known species composition and structure provide additional data about the structure of the ancient plant communities (10,13-14). The large sample size also provided insight into the variability within a single fossil species, allowing for realistic reconstructions of ancient plants.

Angiosperms dominate the upper Hell Creek megaflora and were clearly the primary vegetation on the landscape (Fig. 1). Ferns and fern allies are extremely rare as megafossils though more abundant in the palynoflora, suggesting that ferns were present but were primarily herbaceous. Conifers are locally abundant but rarely dominate. Fossil trunks and logs are present but extremely rare. Their near absence seems to be a function of their not being preserved since deep rooting horizons are abundant and tree leaves are common. The few trunks that are preserved are usually carbonized rather than petrified (Fig. 2). Trunk diameter is rarely larger than 30 cm. These observations suggest that the Hell Creek landscape was forested by small trees with trunks smaller than 30 cm. And height probably less than 20 m. The ground cover was probably sparse as it is in modern broad-leaved forests but the surface was likely covered with leaf litter.

The fauna of the Hell Creek Formation has been studied for nearly a century, and a comprehensive review has recently been provided by Archibald (8). Extensive fieldwork by the Pioneer Trails Regional Museum in Bowman led by Dean Pearson (15) has documented that the common elements of the Hell Creek Formation in Montana are also present in the upper Hell Creek Formation at Mud Buttes.

PRACTICALITIES OF BUILDING A CRETACEOUS DIORAMA

Exhibit designers determined the outer dimensions of the roughly oval space to be occupied by the diorama. Sculptors used a variety of materials to build a stream bed and cutbank, and forest floor. The stream bed was designed to carry flowing water and was cast from an actual sandy stream bed near Denver. A cast of a *Triceratops* dinosaur skull was set in the modern stream bed and water was allowed to flow around it for several hours. The resulting stream location had ripple marks that had actually formed downstream from a *Triceratops* skull.

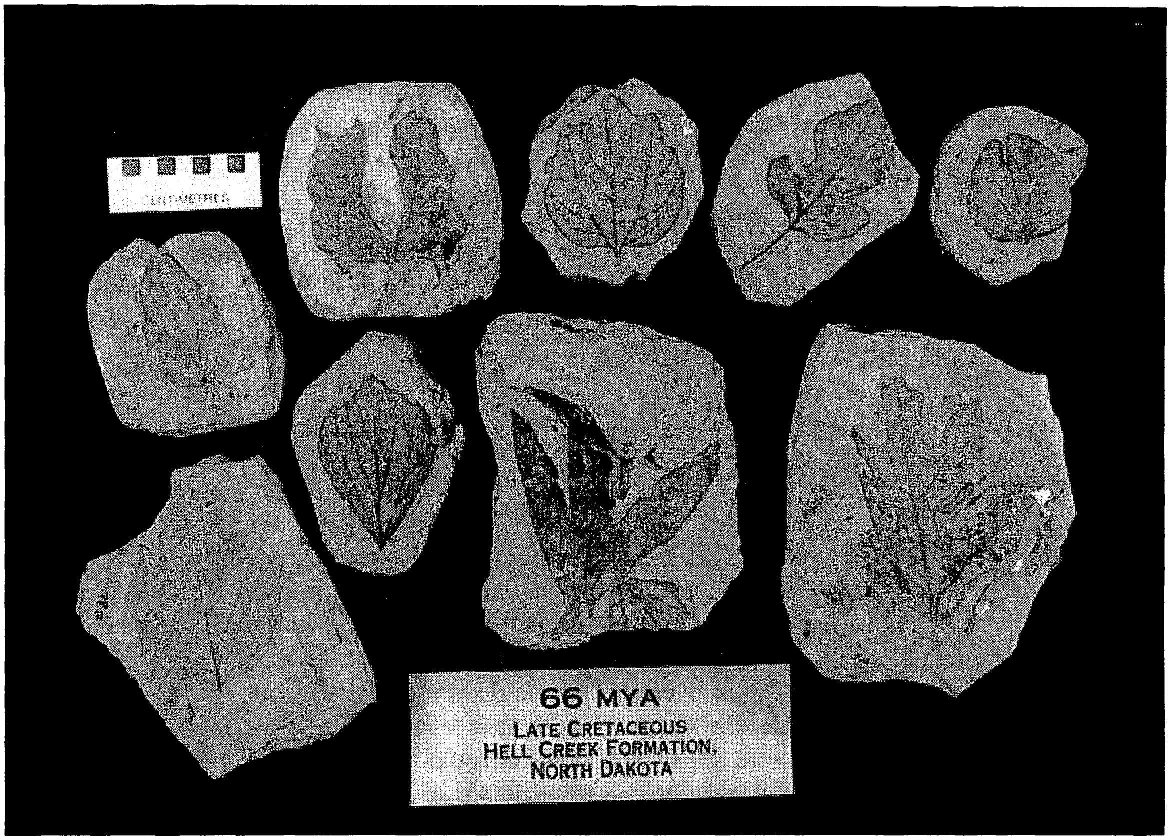

Figure 1. Examples of angiosperm leaves from the upper Hell Creek Formation, from top left to right these are *Zizyphus fibrillosus, Liriodendrites bradacii, Marmathia trivialis*, an unnamed lobed *Lauraceae*, an unnamed leaf, an unnamed leaf, *Platanites marginata, Erlingdorfia Montana*, and *"Artocarpus" lessigiana.*

The plant reconstructions began with a collaboration between paleobotanist Kirk Johnson and botanical illustrator Marjorie Leggitt. The seemingly straight forward task of creating leaves and plants from fossil material offered many unexpected challenges. Several factors inhibit the ready construction of ancient plants. Not only do plants usually fall apart before they are fossilized, there are also plant parts that rarely become fossilized. For example, it is extremely uncommon to find fossilized bark. Also, leaves, twigs, and cones are usually found detached from their stems or trunks and even these parts are frequently incomplete. With extinct plants, it is not always clear which parts go with which plants unless they are found attached, a rare condition. And since the size of leaves are not necessarily proportional to the size of the plants, and petrified trunks are often missing, it can be difficult to tell if the leaves grew on large trees or small shrubs.

On the basis of what was discovered at the selected prehistoric sites, particular ancient plants were chosen to research and reconstruct. With fossils in hand (Fig. 1, 3), the botanical illustrator rendered detailed tracings of up to 25 fossils per species to document the main features of each leaf. Many different fossil leaves were drawn to account for the variation of leaf shapes found on individual plants and within species. In some cases, 6x camera lucida illustrations were created to understand venation patterns to the highest available level of detail. In other cases, india ink renderings, drawn on acetate by laying a sheet of glass over the fossil and tracing the leaf"s outline and major vein patterns, provided adequate information. Additional features, such as insect herbivory damage were captured on these drawings. Next, detailed pencil renderings on tracing vellum were developed. These halftone drawings depicted the reconstructed leaves. Missing or damaged portions were speculatively reconstructed. Decisions, such as whether a leaf was simple or complex were based on comparison with the plant's living relatives. The reconstruction and comparison of many variable leaves from a single source supplied enough information to establish a set of "rules" about the leaves and plants to be fabricated. At each step, the paleobotanist checked all illustrations for accuracy.

Library research and discussions with paleobotanists, specializing on specific plant groups, provided the information required to draw a reconstructed leaf-bearing branch. In some cases, the nature of the leaf attachment was known from the fossil record; in most cases it was not. In the latter situation, leaf attachment was hypothesized using common types of attachment found in the nearest living relatives of the fossil. This information was used to create a life-size pen and ink illustration. Finally, schematic pencil drawings of whole plants, prehistoric forest profiles, and diorama sketches were created using all available information.

Figure 2. A fossil trunk preserved in the upper Hell Creek Formation near Mud Buttes, Bowman County, North Dakota. The trunk is replaced by organic-rich clay.

A portfolio for each plant and environment, including all the tracing and outline drawings, the reconstructed leaf and branch illustrations, and the schematics, was then passed on to sculptors and muralists. Final diorama design, plant fabrication, and painted background decisions were based on this visual information.

Foreground sculptors and volunteers constructed the individual plants. Leaf molds were created by cutting modern leaves into small pieces bound by major leaf veins, then composing the pieces to match the detailed drawing of the fossil. Casting plaster, poured on the composite leaf, provided a mold that was accurate in shape, size, and major and minor venation patterns. Heated mylar sheets were vacuum-formed over the blocks (Fig. 4), generating detailed plastic leaves that were cut out and painted by hand (Fig. 5). Up to fifteen different leaf shapes were made for each plant. Plastic-sheathed wire, attached to each leaf, simulated the petiole (Fig. 6). In the Cretaceous diorama alone, 21,467 plastic leaves were created! The finished leaves were attached to preserved or fabricated tree branches which themselves were attached to trunks modeled from fossils or cast from living trees. Finally, the completed tree was situated in the diorama. In some cases, individual plastic leaves were "distressed" and painted to mimic decaying leaf litter. These and other fabricated fallen plant parts such as fallen seed cases were added towards the end of construction. A Cretaceous poppy fruit, *Palaeoaster*, was reconstructed from several extremely well-preserved petrifactions (16). The resulting fruits were placed in the leaf litter because we had not information about the nature of the parent plant.

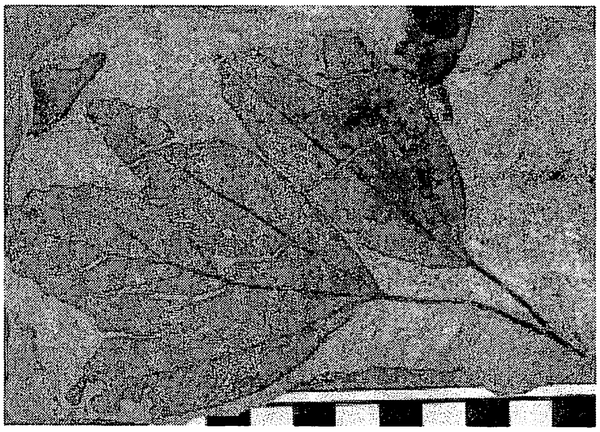

Figure 3. A fossil leaf of *Erlingdorfia Montana* showing leaflet attachment.

The portfolios of plant illustrations were also used as blueprints by Kent Pendleton, the painter who created the background mural for the diorama. By providing accurate and consistent drawings to both the foregrounds sculptors and the mural painter, each of the dioramas displayed an accurate and consistent final product with a smooth transition between the foreground and the background. The Hell Creek diorama required more than two years of work to install. During this time, the muralist painted from the distant background towards the foreground, integrating and blending with foregrounds sculptures so that the transition between the two-dimensional mural and the three-dimensional mural appeared seamless.

Table 1. Plant species represented in the Hell Creek diorama

Species	**Habit**
Liriodendrites bradacii	small tree
Marmarthia trivialis	small tree
Marmarthia pearsonii	small tree
Platanites marginata	small tree
Cissites panduratus	small tree
Bisonia niemii	small tree
Erlingdorfia montana	small tree
Paranymphaea hastata	vine
Zizyphus fibrillosus	vine
Philodendron-like Araceae	vine
Nilssonia yukonenesis	understory cycad
Onoclea sensibilis	understory fern
Palaeoaster inquirenda	woody fruit
Parataxodium cuneatum	conifer tree

The animals reconstructed in the diorama were based on fossils collected in the Hell Creek Formation (8, 15). In most cases, the reconstructions were relatively straightforward due to the completeness of the known skeletal material. In the case of the feature animal, the *Stygimoloch* pachycephalosaur, the reconstruction was based on two partial skulls. This work was supervised by Ken Carpenter whose used the post cranial anatomy of the Mongolian pachycephalosaur *Homocephale* as a model. Subsequent discovery of a nearly complete *Stygimoloch* skeleton from the Hell Creek Formation of northwest South Dakota did not modify this reconstruction. The animal models were built by DMNH taxidermists who constructed clay models which were molded in latex and cast in fiberglass (Fig. 7). Final coloration of the animals was based on best guesses and an acknowledgment that these were forest animals. The sole exception to this was the *Neurankyus*-turtle. The same species of turtle had previously been discovered in New Mexico with a spotted coloration preserved (17, 18).

Figure 4. Vacuum press with molds of reconstructed Cretaceous leaves. Mylar sheets are sucked down on these molds and heated to conform to the molds. Then the leaves are hand-cut from the sheets by teams of volunteers.

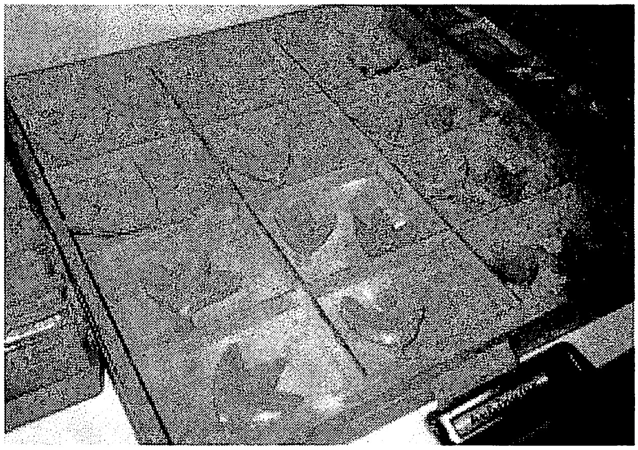

Figure 5. Unpainted mylar leaflets of *Erlingdorfia Montana.*

CONCLUSIONS

The goal of the Hell Creek diorama in *Prehistoric Journey* is to immerse the visitor in an accurate reconstruction of North Dakota as it was 66 million years ago (Fig. 8). The diorama is realistic enough that the visitor can momentarily suspend disbelief and time travel to a different place and time, one populated with accurately revived plants and animals (19).

Figure 6. After being hand cut from the sheets of mylar, the plastic leaves are glued to stems made of wire with plastic sheaths. Each leaf is painted several times.

The visitor descends the stairs from the mezzanine and down a steep stream bank into a lush riverside forest composed of broad-leaved trees. Across the small waterway on a sandy point bar, two twelve-foot long, brightly-colored male *Stygimoloch* dinosaurs challenge each other in an impressive mating ritual. With lusty fervor they aggressively display the formidable array of bony spikes that crowns their thick bony skulls. Near their feet, a *Triceratops* skull, leaves and woody debris lie partially buried in the sand deposited by a recent flood. Gigantic *Tyrannosaurus rex* footprints trap pools of water. Above the stream bank, small cycad-like *Nilssonia*, ground ferns, and leaf litter cover the forest floor while mushrooms emerge in sheltered niches. Bird and insect sounds are heard as a turtle's nest is invaded by two marsupials. A larger river can be seen in the background and a distant ostrich-like *Ornithomimus* dinosaur browses on *Nilssonia* leaves.

Table 2
Animal species represented in the Hell Creek diorama

Species	Type of animal	Rendering
Stygimoloch spinifer	pachycephalosaur dinosaur	3-D whole body
Triceratops horridus	horned dinosaur	3-D rotting skull
Ornithomimus sp.	ostrich dinosaur	2-D
Tyrannosaurus rex	carnivorous dinosaur	2-D body, 3-D tracks, and sound
Edmontosaurus annectens	duckbilled dinosaur	2-D bodies
Indet pterosaur	flying reptiles	2-D bodies
Birds	birds	2-D bodies
Neurankylus eximius	turtle	3-D whole body
Didelphodon vorax	marsupial mammal	3-D whole body
Mesodma sp	multituberculate mammal	3-D whole body
misc. insects	insects	3-D whole bodies

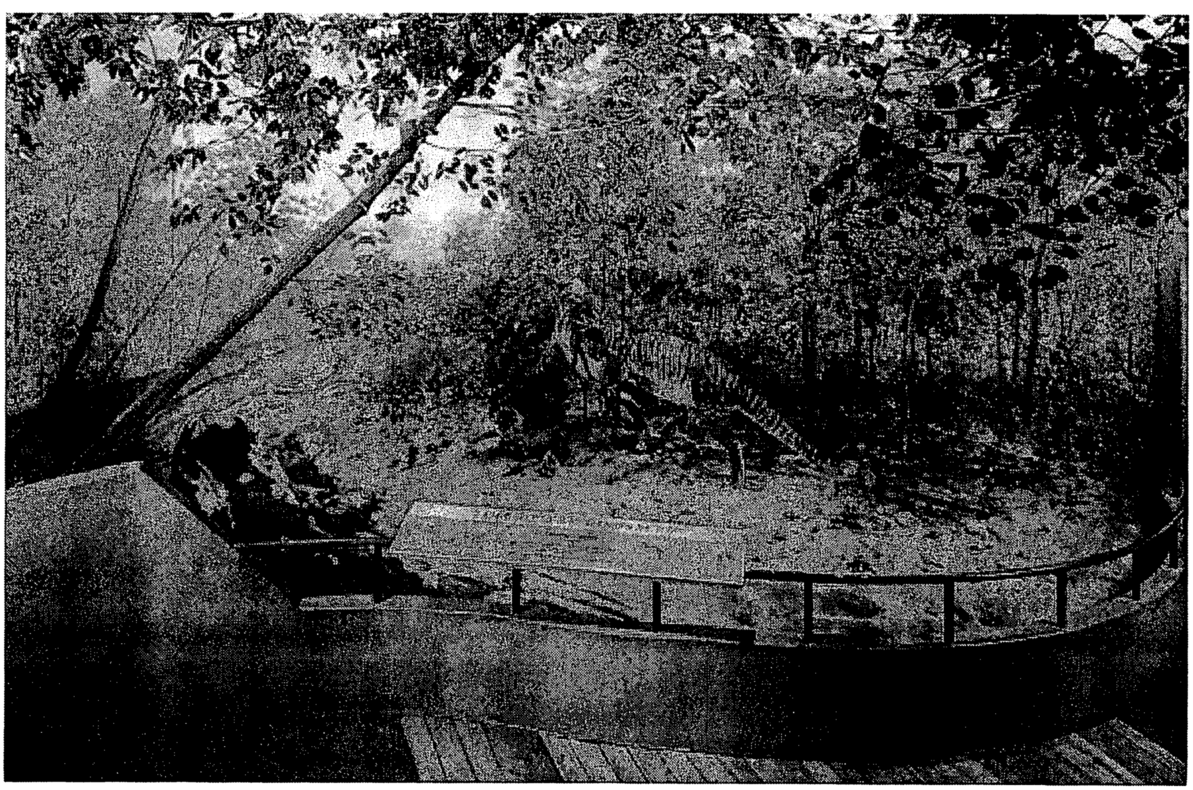

Figure 8. Dioorama of the Cretaceous Hell Creek Formation

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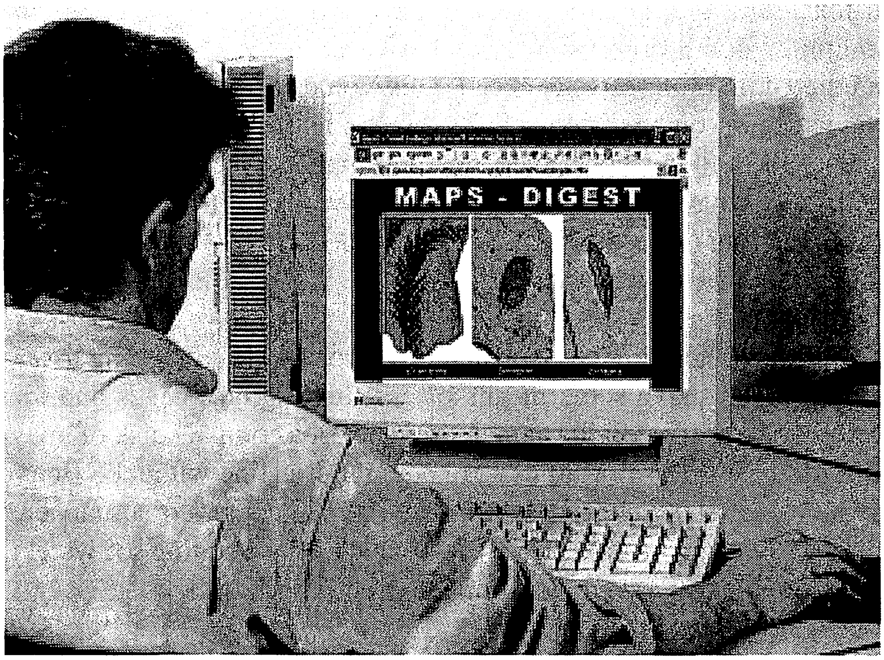
Figure 9. Kirk Johnson in field.

Figure 7. The clay head of *Stygimoloch spinifer*, a pachy-cephalosaur known from two partial skulls and one complete skeleton from the Hell Creek Formation.

From Beer Flats to Cyberspace -

How to Create an Online Fossil Gallery on the Internet.

By Janet Burgart of CurioGrove.com



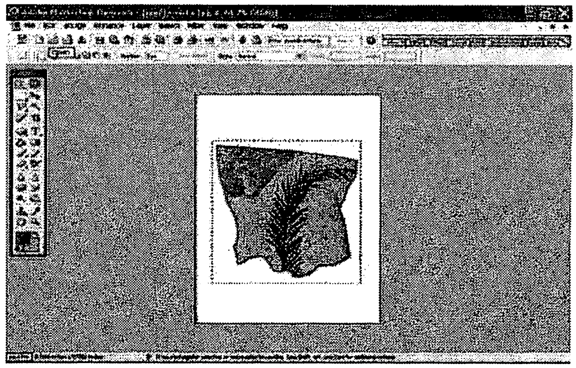
When I agreed to write an article about building a website for displaying fossils on the Internet, I thought that would be a pleasure to do, no problem, that it sounded like fun! Surely, someone who has worked as a professional Webmaster for 8 years, who owns her own Internet consulting business and has built hundreds of websites over the years, should be able to put something together that would be helpful to my fellow fossil collectors. So this should be a piece of cake...right?

I have heard many comments over the years about web development, "Oh, building a website is easy; my high school kid can do it!" Now there's a good sock in the arm to help build a sense of pride and accomplishment about your vocation of choice!

And then on the other side of that stance are the folks who say they "wanted to throw their computer off the roof and watch it shatter into a gazillion pieces while dancing on the roof to celebrate the end of agony as we know it!" I figure that comment would make writing this article a public service and save the angst shared by many cybernauts!

But the truth of the matter is, I have scrapped 4 or 5 articles before I came up with something I felt would work for the MAPS Digest. I could have suggested various web development applications that make building websites fast and easy, but who wants to spend $300 or $400 to test the waters? I wasn't comfortable taking folks down that road without being able to support them more intimately along the way.

I had to find a way to break this down so that creating the Fossil Gallery would give people a little insight about how a web page works, yet not lose them glazed over and spaced out! So I started with the basics. You see, an Internet web page is actually just a text document. Most text documents end with the suffix of .txt. A web page is a text document with the suffix changed to .htm (or html, which means HyberText Markup Language). Now don't get too excited; it's not like you can just type something in a text file and then change the .txt to .htm and voila! you have a web page. The text file needs to have certain <tags> in the file to communicate with web browsers so that the page



will display properly when viewed in Internet Explorer or Netscape. So I thought we could split the work down the middle. I could write the html part, noting the places in the page where you could type in your fossil information while using Notepad (a text editing application that comes with most computer operating systems) and save us a few hundred dollars on software costs! This would allow you to see if you have a knack for this kinda thing! Then, the money you saved not purchasing the website editing software, you could put towards a new Estwing rock hammer or some nice display boxes for your collection! ☺ After all, collecting rocks, fossils and minerals was my first love long before the Internet was ever born!

A Gallery without images is just an inventory. So, I am going to assume that if this article caught your eye, you have some means of creating digital images and loading them to your computer. Whether it is with a digital camera, scanner or a compact disk of images prepared for you from your film prints at the Wal-Mart camera counter, it is fine with me. But you will need digital images to create this Fossil Gallery. If you own a digital camera or a scanner, you probably already own an image editing application. If you do not have image editing software, I have made a recommendation in the Frequently Asked Questions section of the article.

This article will walk you through gathering 9 fossils and the pertinent information for each fossil by using the "**Fossil Gallery Worksheet**." We will move into preparing three graphics for each fossil in the "**Graphics Guide – Step-by-Step**" section. Once your graphics are prepared, we will move on to the "**Fossil Gallery Preparation Guide – Step-by-Step,**" where we will transfer the information from the "**Worksheet**" to the detail web pages of our Fossil Gallery. Once everything is edited and assembled, we will explore places on the Internet where you can launch your Fossil Gallery to the Public.

But before we get started, let's go over a few **Frequently Asked Questions** about building this Fossil Gallery that may better prepare you for the adventure ahead!

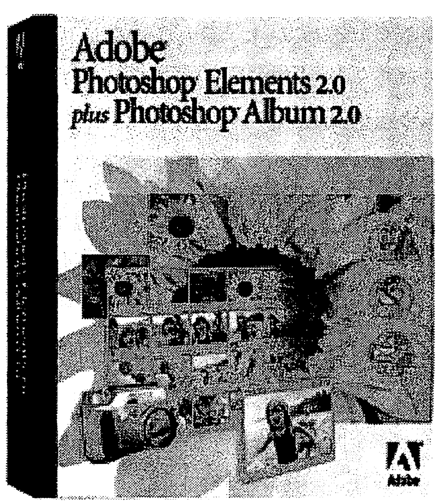
Fossil Gallery - Frequently Asked Questions

Q. How savvy do I need to be to create this Fossil Gallery?
A. There are a few basic computer skills that I will assume the Gallery Owner is already comfortable with performing:

1. Ability to create a folder on your computer.
2. Ability to open a document in Notepad or any basic text editor.
3. The ability to load digital image files to your computer (via Scanner, Digital Camera or copied from a CD Rom) and copy them into a designated folder.
4. The ability to rename files.
5. Access to the Internet to download starter html documents.

Q. What type of images can I use in my Fossil Gallery?
A. The Internet will display Gifs, Jpegs and Png formats; however, to simplify this project we will be using the Jpeg format only.

Q. Are there any rules I need to follow when it comes to naming my files and folders?
A. It is best to use all lowercase names, with no spaces or symbols. On occasion, when I need to put a break in a file name, I will use an underscore (Ex: fossil_gallery). There are some web servers that are case sensitive when it comes to file names. It will see "specimen1a.jpg" as a different file from "Specimen1A.jpg". These two names are virtually the same in alpha and numeric characters, but the difference between their case sensitivity makes the files unique to these web servers. The html that I have used for this Fossil Gallery has been created using all lowercase names as the rule. So, if the web page is looking for a graphic called "specimen1a.jpg" and you have named the file "specimen1a.JPG," in some internet environments, this will create a broken link and not display the graphic. To avoid problems, let's use lowercase names, no symbols, no spaces in all of our file and folder names.



Q. Do I need any fancy graphics program to manage my graphics?
A. Most scanners and digital cameras come with a graphics editing software. I use Adobe Photoshop CS to edit my graphics, but this program is rather expensive. However, Adobe has come out with a very nice graphics program that will handle everything you need to optimize your graphics for the Internet. **Adobe Elements 2.0** has all the cool features of Photoshop for a fraction of the cost. Adobe

Photoshop CS costs over $650, but Elements costs less than $99.00. If you visit Adobe.com, you can download a 30-day free trial of the software to test before you buy. While you are on the website, visit their rebates area for current rebates. I often find $30 rebates for Adobe Elements. Right now, Amazon.com is offering Adobe Elements bundled with Photoshop Album for $84 after rebate. Photoshop Album is a nice images organization tool if you have tons of graphics that you want to manage.

There are other great graphics programs such as Ulead, PaintShopPro, CorelDraw, and Adobe Deluxe (Older version of Photoshop Elements). What you need to make sure of is that the graphics program will allow you to do the following:

a. Crop your image (cut a portion of your image out to better isolate its presentation), not just "shrink" it. We want to actually control the size of the graphics so that we can make them load quickly if your Gallery is viewed on the Internet and your visitor is using a dial up connection. Slow loading graphics will often bore your audience and they will navigate away from your website.

b. Size your image (we want to size the "a" and "b" versions to 400 pixels wide at 72 dpi/low resolution and the thumbnail image "t" to 200 pixels at 72 dpi/low resolution).

c. Save the images out to a Jpeg format.

Features that are nice but not required:

a. Color correcting to better optimize the colors of your digital image

b. A Lasso Tool to help cut away the background to better isolate the specimen

Q. Do I have to place my files on the Internet to build this Fossil Gallery?
A. No, you can create your gallery right on your computer and keep it for private use. The way this Gallery is designed, it does not require the files to "live" on a web server to function. You can build several of these galleries in separate folders on your desktop and link them together to create a reference library. Or burn them to a CD Rom to share them with friends and fellow collectors. If you decide to make your Gallery public, you will need to load them to the Internet. Review the section on Launching Your Fossil Gallery for ideas on how to load your website to the Internet.

Q. Do I need to know HTML to do this project?
A. If you download the Fossil Gallery Starter from www.CurioGrove.com/fossil_gallery, you will not have to type any HTML tags. The Starter files already have everything bricked up and ready for you to customize with the information you gather about your fossils.

Q. What is a Fossil Gallery Worksheet and what do I do with it?

A. I included the Fossil Gallery Worksheet so that you can gather the information that will be added to your Fossil Gallery. It is much easier to sit down and work on this project, especially the first time through, and have all the information you need readily available for transferring over to the pages. I have included a copy to be printed with the article and you can also download an Adobe PDF or a Word Document version from the www.CurioGrove.com/fossil_gallery web site.

FOSSIL GALLERY WORKSHEET GALLERY NAME: ____________________

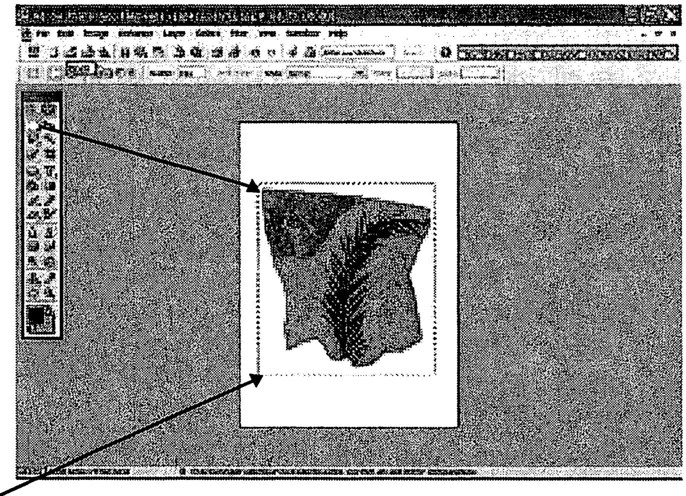
Sequence	Specimen Name	Specimen Age	Formation	Location	Size	Comments
specimen1.htm Image Check list: _specimen1a.jpg (400) _specimen1b.jpg (400) _specimen1t.jpg (200)						
specimen2.htm Image Check list: _specimen2a.jpg (400) _specimen2b.jpg (400) _specimen2t.jpg (200)						

FOSSIL GALLERY WORKSHEET **GALLERY NAME:** ______________________

Sequence	Specimen Name	Specimen Age	Formation	Location	Size	Comments
specimen1.htm Image Checklist: __specimen1a.jpg (400) __specimen1b.jpg (400) __specimen1t.jpg (200)						
specimen2.htm Image Checklist: __specimen1a.jpg (400) __specimen1b.jpg (400) __specimen1t.jpg (200)						
specimen3.htm Image Checklist: __specimen1a.jpg (400) __specimen1b.jpg (400) __specimen1t.jpg (200)						
specimen4.htm Image Checklist: __specimen1a.jpg (400) __specimen1b.jpg (400) __specimen1t.jpg (200)						
specimen5.htm Image Checklist: __specimen1a.jpg (400) __specimen1b.jpg (400) __specimen1t.jpg (200)						
specimen6.htm Image Checklist: __specimen1a.jpg (400) __specimen1b.jpg (400) __specimen1t.jpg (200)						
specimen7.htm Image Checklist: __specimen1a.jpg (400) __specimen1b.jpg (400) __specimen1t.jpg (200)						
specimen8.htm Image Checklist: __specimen1a.jpg (400) __specimen1b.jpg (400) __specimen1t.jpg (200)						
specimen9.htm Image Checklist: __specimen1a.jpg (400) __specimen1b.jpg (400) __specimen1t.jpg (200)						

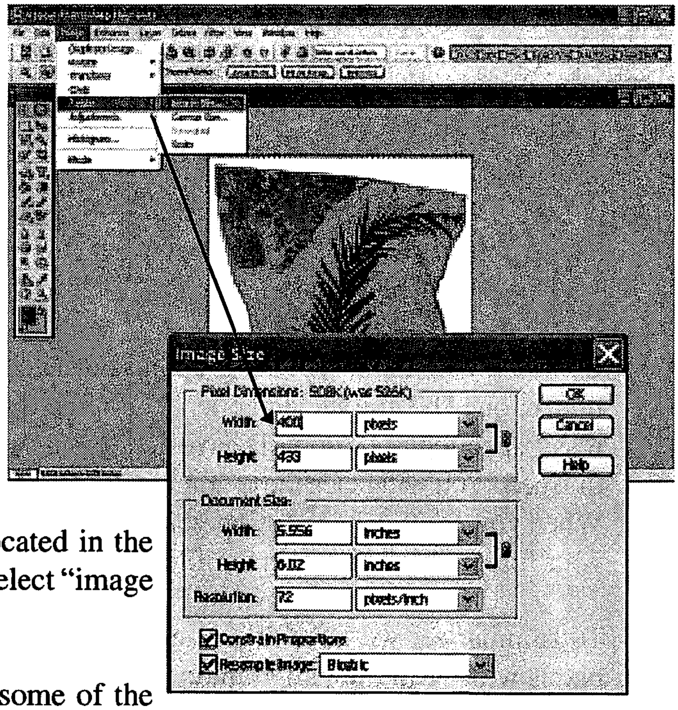
Starter Location: http://www.CurioGrove.com/fossil_gallery

Graphics Preparation – Step by Step:



1. **Place in your folder the two graphics you have selected for the detail images of gallery.** The graphic title specimen1a.jpg will be the top graphic of the detail page and the one you will create your thumbnail picture will be called specimen1t.jpg.

2. **First you want to crop your image to better emphasize the fossil.** I like to get in very tight and eliminate any background clutter. Use the "Rectangular Marquee Tool" from the Top Left Tools Pallet. Click and Drag a dotted box or "Dancing Ants" framing your fossil. From the "Image" menu, select "Crop". This will clip away anything that is outside of the box you drew.



3. **Next is to size your graphics.** It tends to be a better artistic presentation to have both of your images on your detail page be the same width. I recommend using 400 pixels wide for the graphic. This would work on almost any monitor and browser that are being used to view your gallery. Length is not so important to be uniform since the graphics will be situated one above the other. (If the graphics were side by side, then you would want the images to be the same height.) The "Crop" tool is located in the "Image" drop down menu, and then select "image size."

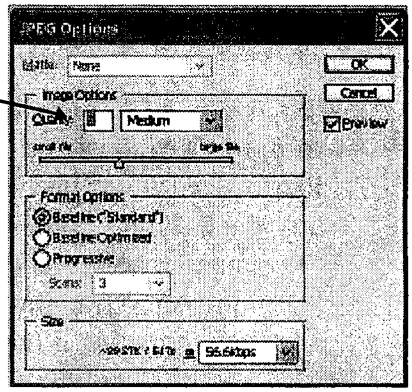
4. At this point, you may want to use some of the advanced features to color correct your graphic ("Enhance" Menu, then "Auto Levels") or sharpen the image ("Filter" Menu, then "Sharpen").

5. Then "Save" your enhanced graphic, but do not close it. We will use the same graphic to create the Thumbnail image (specimen1t.jpg). I like to just use a close up of the most prominent part of the image. So I will use the crop tool again (See Step 2 above) and isolate the leaf.

6. Then "Size" new Thumbnail image to 200 pixels wide (See Step 3 above).

7. If you have advanced options, then repeat Step 4 about sharpening the image, but there is no need to do another color correction feature. You want your thumbnail to match your detail graphic, and if you do a new "Auto Levels" at this point, the tool may provide different and unwanted results due to the cropping of the image.

8. It's now time to save the image back to your Fossil Gallery folder with a new name. It is important to select from the File Menu the "Save As" function (so you can rename it to specimen1t.jpg) and not override your original version of specimen1a.jpg.



9. When prompted for the Jpeg Options, I usually choose a "Level 5," which will compress the file so that it loads quickly but does not compress it so much that the detail area suffers from lack of clarity.

10. Close the thumbnail1t.jpg.

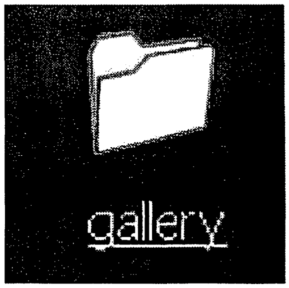
11. Open the second detail graphic called specimen1a.jpg and follow Steps 2 through Step 4 above. I will sometimes include a ruler in the second graphic to help the viewer determine the size of the specimen. You can also use the "b" graphic for a close up of a detail part of the fossil or use it for a different angle of the fossil. For this project, we are only using 2 detail images and 1 Thumbnail graphic.

12. Continue with the rest of the graphics until you have one "a" image, one "b" graphic and one "t" graphic for each of the 9 fossil specimens. You will have 27 graphics when you are finished. You will place these graphics into your gallery folder. When you are finished placing your 27 graphics in the folder, your folder should contain the files as illustrated here.

13. To summarize, we have formatted 2 detail graphics of 400 pixels wide, 1 thumbnail graphic that is 200 pixels wide; we have placed them in the same Gallery folder where we have placed the 9 html documents and the one thumbnail page called Index.htm that was downloaded from http://www.curiogrove.com/fossil_gallery.

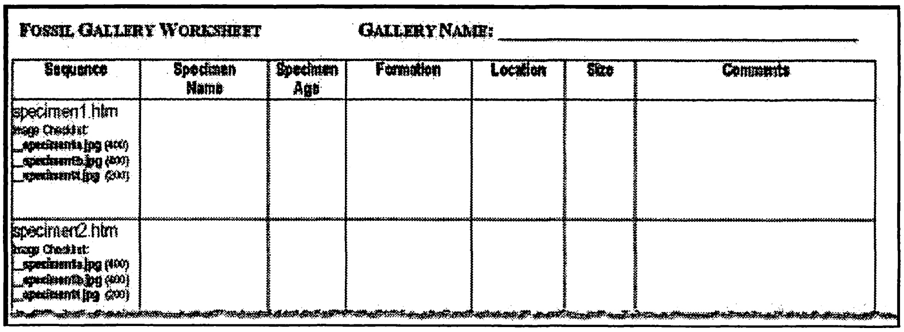
Fossil Gallery Preparation – Step by Step:

1. Create a folder on your hard drive called "**gallery.**" Everything you download or create for your gallery will be stored in this folder, so please note the location on your computer. I usually place my work-in-progress gallery right on my desktop. As long as you leave everything in this original folder, you can move it or transfer it in its entirety without breaking any links. This allows you to transfer the folder to an Internet server, burn it to a CD/RW ROM or file it away on your computer.



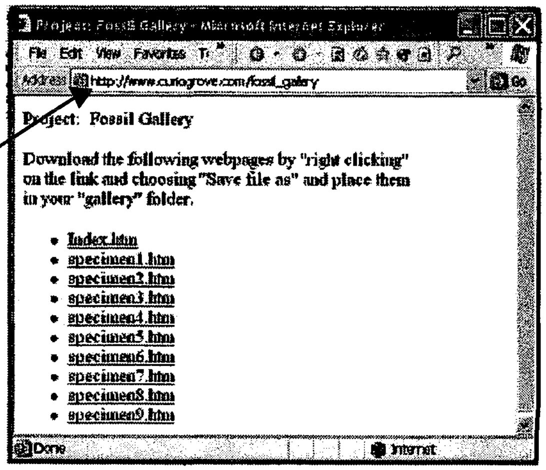
2. Place the 27 graphics that you created by following the **Step-by-Step Graphics Guide** into this folder. The graphics consist of 1 thumbnail image (200 pixels wide) and 2 detail images (400 pixels wide) for each fossil in your gallery. Be very careful to use the correct image naming sequence: specimen1t.jpg for the thumbnail and specimen1a.jpg and specimen1b.jpg for detail, changing the sequence number for each of the 9 fossils in your gallery.

3. Gather the following information for the 9 fossils that will go into your Galley: Specimen Name, Age, Formation, Location, Size, and any Comments that are pertinent to the fossil. You can use the **Fossil Gallery Worksheet** to help organize this information. This Fossil Gallery is designed to showcase 9 fossils; however, you can create several galleries and link them together if you want to extend your display. Just give each Gallery a new folder name such as gallery1, gallery2, gallery3 or vertebrates, invertebrates, marine and so forth.

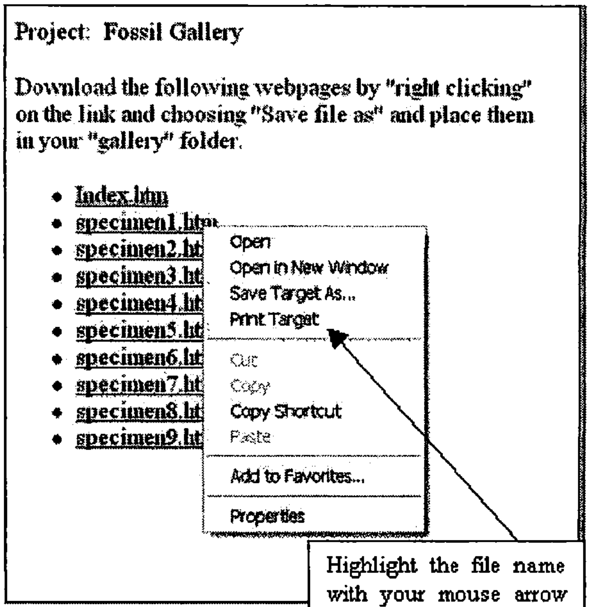

FOSSIL GALLERY WORKSHEET GALLERY NAME: ______

Sequence	Specimen Name	Specimen Age	Formation	Location	Size	Comments
specimen1.htm Image Checklist: specimen1a.jpg (400) specimen1b.jpg (400) specimen1t.jpg (200)						
specimen2.htm Image Checklist: specimen2a.jpg (400) specimen2b.jpg (400) specimen2t.jpg (200)						

4. Log onto the Internet and go to **http://www.curiogrove.com/fossil_gallery**. (Or if you are brave and like to type, see the "HTML Samples" section for text that can be typed into Notepad or any standard text editor to create your Fossil Gallery.)

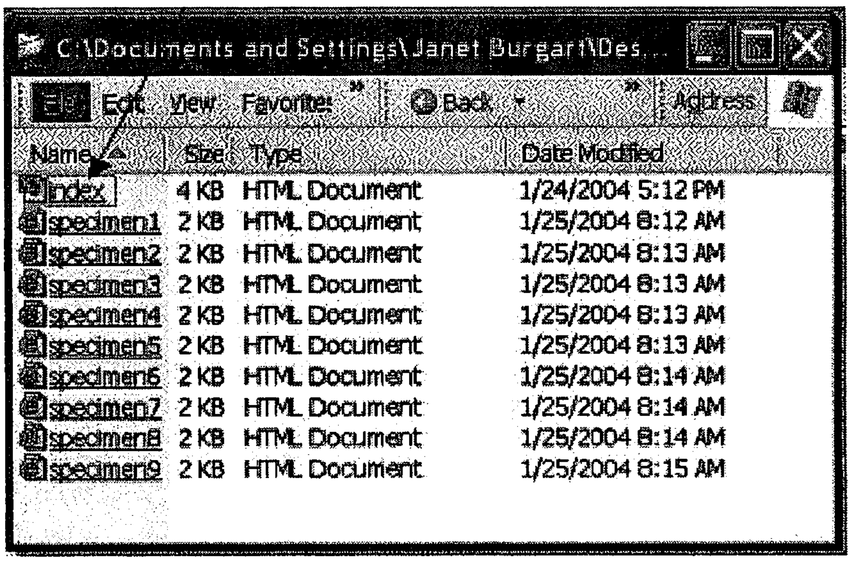


5. Download the "**Gallery Starter**" consisting of 10 html pages starting with **index.htm** (this will be your "Homepage" displaying your thumbnail images), and proceed to **specimen1.htm** through **specimen9.htm** (these will be the fossil detail pages) and place them into the "**gallery**" folder. When downloading these pages, it is easiest to highlight the link, then "right-click" your mouse button (or mouse over/hover if you are using a Mac) and select "**Save Target As**" or "**Save File As**" and save the file in your "**gallery**" folder. Do not change the name of the files or use uppercase file names. All files for this project will use lowercase file names. This includes all of the web pages, thumbnails and details images.

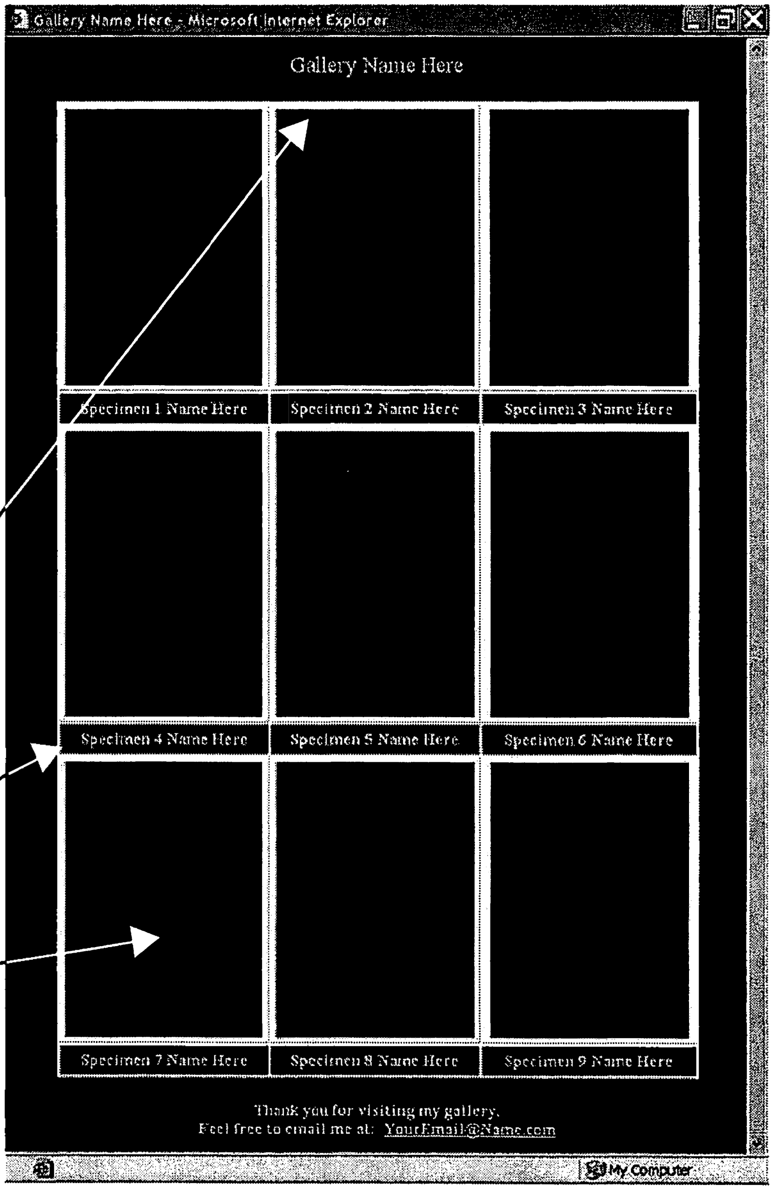


Highlight the file name with your mouse arrow and click the right mouse button to create the "options" menu. Then scroll down to select "**Save Target As...**" and download the file to your "**gallery**" folder. Repeat this procedure for each of the 10 web pages.

To take a sneak peak at the **Fossil Gallery layout**, go to your "**gallery**" folder and double-click on the "**index.htm**." This will open the index.htm thumbnail page into your Internet browser.



6. With the **"index.htm"** layout opened in your Internet Browser, you will notice the grid of the thumbnail image area. This is the first page that we will edit. We will add the name of the Fossil Gallery to the top of the page and add the name of each fossil beneath the cell designated for the thumbnail image. But for the moment, I want you to see what the layout will look like before we proceed to customizing the page in Notepad.



This is the layout for the thumbnail images. We will open this web page in Notepad to edit the name of the Gallery and to add the names of the 9 fossils beneath the area designated for the thumbnail image.

Your thumbnail images will show up here.

Okay, we are ready to start editing the web pages. This is usually where people start using lots of colorful metaphors and pound on their keyboard requiring a little time in the "comfort corner." It's best just to bite the bullet and move on at this point! *So let's go!*

7. Almost every computer has a text editor. **Notepad** is the most common text editor. Windows users will often find this application in the "Start Menu" under "Accessories." Mac users should see this listed in the Apple Menu. I chose this editor because it is a simple program that does not try to be "intuitive" and auto format what you are working on. We want straight text without any little funky character added that might cause trouble with our pages when viewed with an Internet browser. Debugging can be a time consuming and often-frustrating task, requiring us to make a second trip to the comfort corner. So if you have Notepad, let's stick with it for this project. Open your Notepad application.

8. Using the **"File"** drop down menu in Notepad, select "**Open**." Then target the **"index.htm"** page that is located in your gallery folder.

9. Only replace the text that I have **bolded** in the illustration. You need to actually replace the **bolded** area with the information you collected on your worksheet. Do not edit any of the html text, shown here in gray. You will not actually see any **bolded** or gray text when you open the files in Notepad. So refer to the example here if you need help identifying the areas requiring editing.

```
<html><head><title>

GalleryName Here

<title></head><body link="#FFFFFF" vlink="#FFFFFF" alink="#FF0000"
ext="#FFFFFF" bgcolor="#000000" text="#FFFFFF"<p align="center">
<p align="center"><font size="4"><b>

GalleryName Here

</font></p><b><div align="center"><center><table border="0"
cellpadding="5" elspacing="3" style="border-collapse:
collapse" bordercolor="#000000" bgcolor="#FFFFFF"
bordercolorlight="#CCCCCC" bordercolordark="#666666">
<tr><td width="33%" align="center"><a href="specimen1.htm">
<img border="0" src="specimen1t.jpg"></a></td><td width="33%"
align="center"><a href="specimen2.htm"><img border="0"
src="specimen2t.jpg"></a></td><td width="34%" align="center">
<a href="specimen3.htm"><img border="0" src="specimen3t.jpg">
</a></td></tr><tr><td width="33%" align="center" bgcolor="#000000">
<b><font color="#FFFFFF" size="2">

Specimen 1Name Here

</font></b></td><td width="33%" align="center" bgcolor="#000000"><b>
<font color="#FFFFFF" size="2">

Specimen 2Name Here

</font></b></td><td width="34%" align="center" bgcolor="#000000"><b>
<font color="#FFFFFF" size="2">

Specimen 3Name Here
```

10. Replace the words "**Gallery Name Here**" with the name of your gallery. Example: Invertebrates

11. Looking back at your Fossil Gallery Worksheet, **replace** the text "**Specimen 1 Name Here**" with the name of the first fossil; continue replacing the text for each fossil in your gallery. Make sure you keep track of which fossil goes into which "slot" by following the numeric sequence on your worksheet. When you are finished replacing the text with the names of your fossils, save and close the "**index.htm**" file. You are finished editing your thumbnail page. *So far so good?*

12. Using Notepad again, open the file called "**specimen1.htm**."

13. Replace the words "**Fossil Gallery**" with the name of your Gallery and the name of the fossil. This is the title that will show in the upper left corner of your Internet browser's menu bar. Example: **Invertebrates–Orthoceres**

14. Replace the words "**Write Specimen Name Here**" with the name of the first specimen.

15. Continue replacing the **bolded** text with the rest of the information from your worksheet regarding Fossil 1.

16. Repeat this process for the web pages **specimen2.htm** through **specimen9.htm**.

17. There is no need to change the numeric value at the bottom of the page. These numbers correspond with the sequence number in the names of your files and images. I isolated this as a reference to whichever fossil sequence number you are currently working on.

```
        <html><head><title>

Fossil Gallery

        </title></head><body link="#FFFFFF" vlink="#FFFFFF" text="#FFFFFF"
        bgcolor="#000000"><table border="0" cellpadding="3" cellspacing="0"
        style="border-collapse: collapse"><tr><td width="35%"
        bordercolor="#FFFFFF" valign="top"><table border="0"
        cellpadding="2"        cellspacing="0" style="border-collapse: collapse;
        font-size: 10pt" width="100%"><tr><td nowrap>
        <b>Specimen:</b></td><td><b>

Write Specimen Name Here

        </b></td></tr><tr><td nowrap><b>Age:</b></td><td><b>

Write Age Here

        </b></td></tr><tr><td nowrap><b>Formation:  </b></td><td><b>

Write Formation Here

        </b></td></tr><tr><td nowrap><b>Location:</b></td><td><b>

Write Location Here

        </b></td></tr><tr><td nowrap><b>Size:</b></td><td><b>

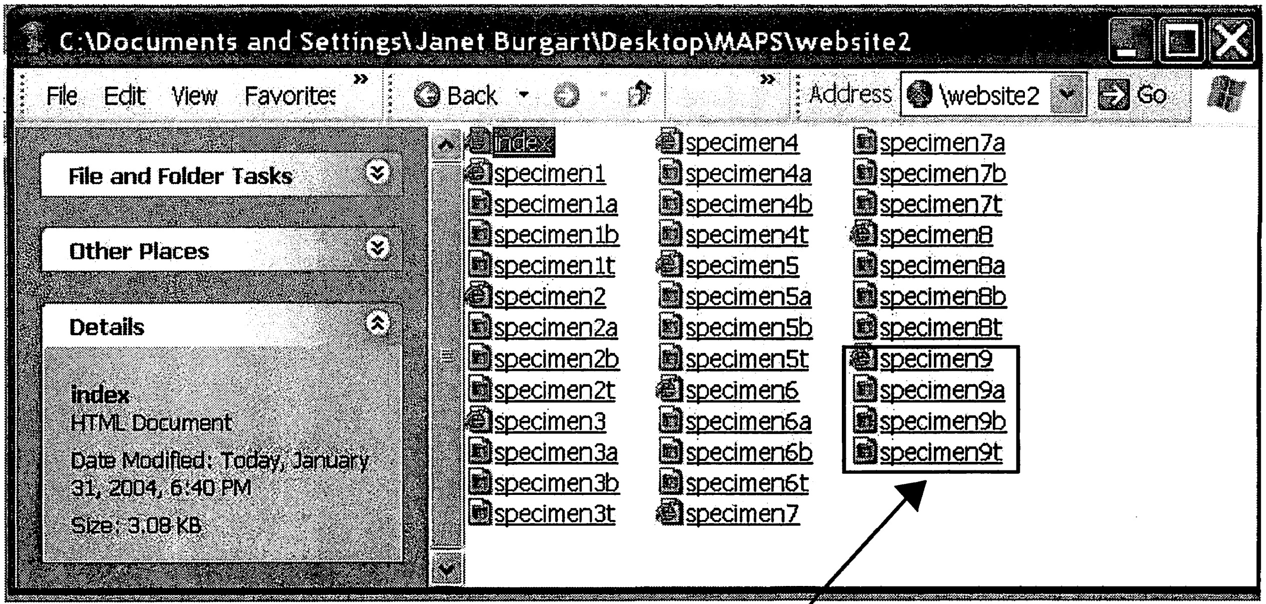
Write Size Here

        </b></td></tr><tr><td colspan="2"><b>Comments: 

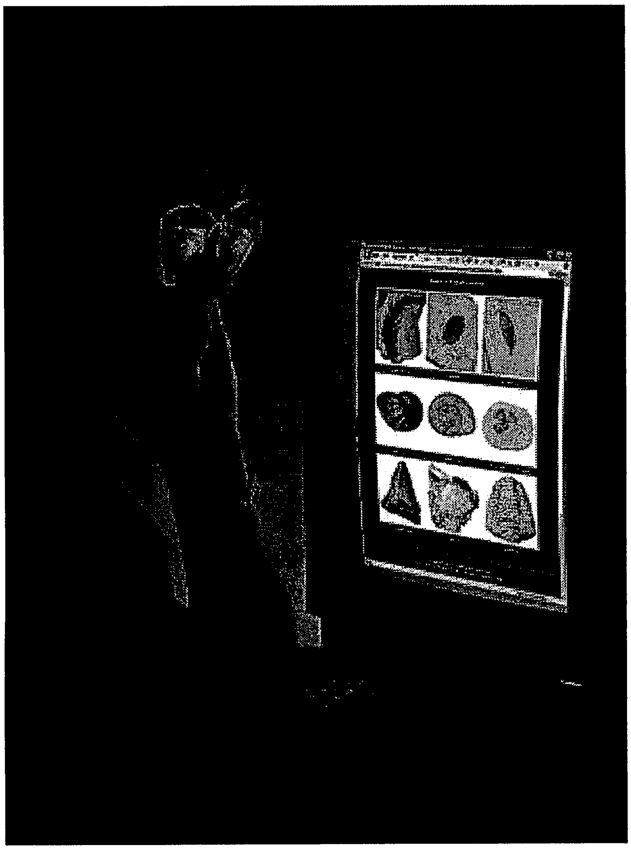
Write Comments Here

        </b></td></tr></table></td><td width="65%" valign="top">
        <p align="center"><a href="index.htm"><img border="0" src="specimen
1       a.jpg">
        </a></p><p align="center"><img border="0" src="specimen
1       b.jpg"></td></tr><tr><td width="35%" bordercolor="#FFFFFF"
```

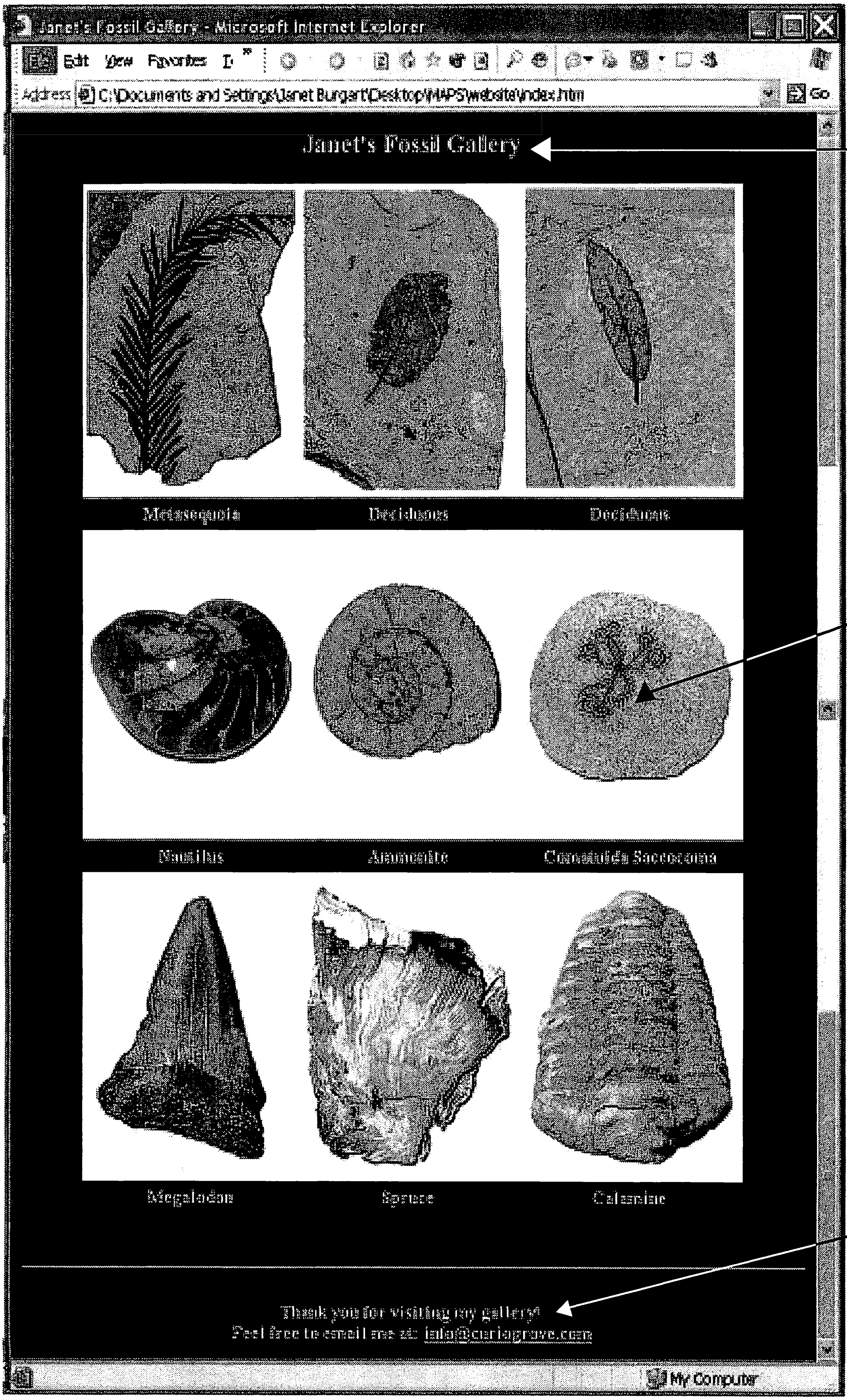
18. Now that you have all 10 of your pages edited and your images prepared and everything is placed in your "gallery" folder, we are ready to debut your **Fossil Gallery**. To view your new gallery, open your "**gallery**" folder and double click on the **index.htm** file. The folder view you see here is Windows XP; your folder view may look different depending on your computer's operating system (Win98, Win2000, WinMe, Mac OS, etc.)



For each of the 9 fossils in your gallery, you should have 1 html page, 1 thumbnail image ("t") and 2 detail images ("a" and "b"). The completed gallery will consist of 37 files.



Are you ready to view your new Fossil Gallery?



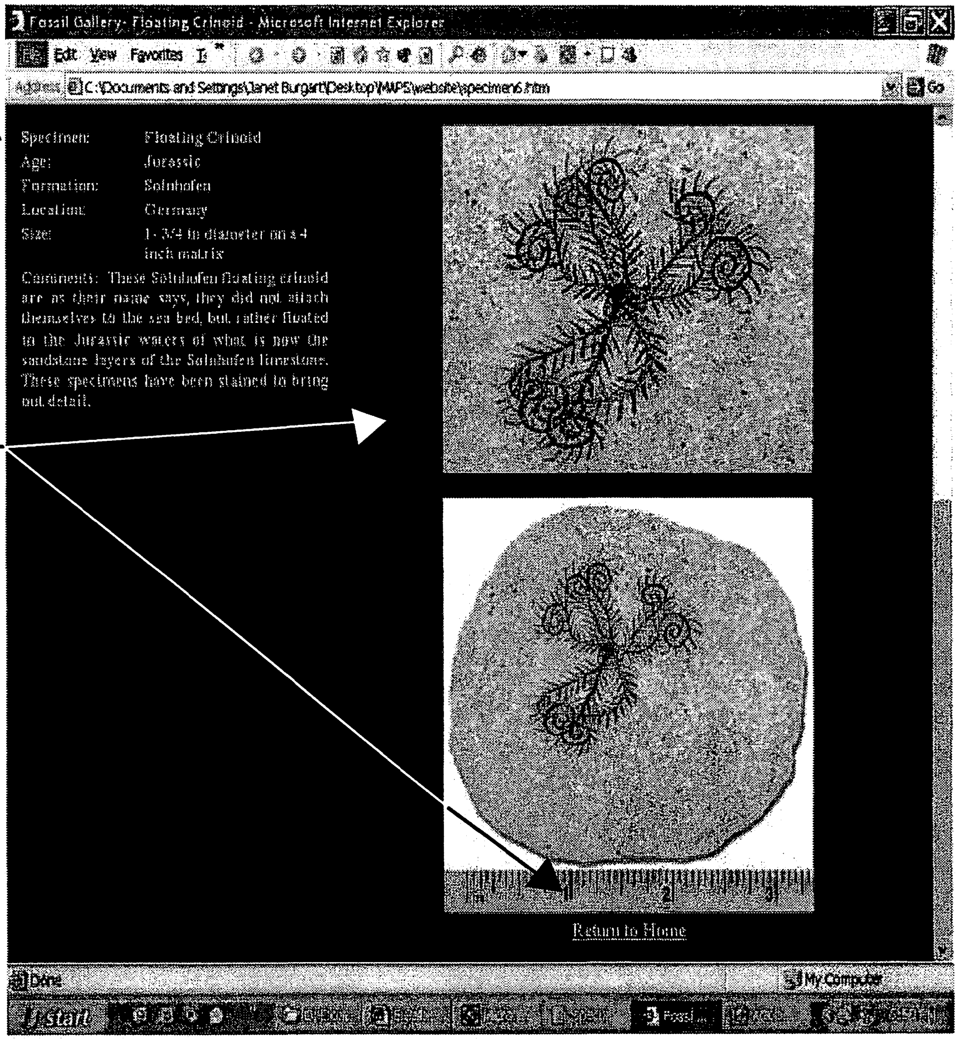
Your Gallery Name should show up at the top of the page. The name of the fossil should show up beneath each thumbnail image.

To see the detail page, click on the image of the fossil to navigate through your gallery.

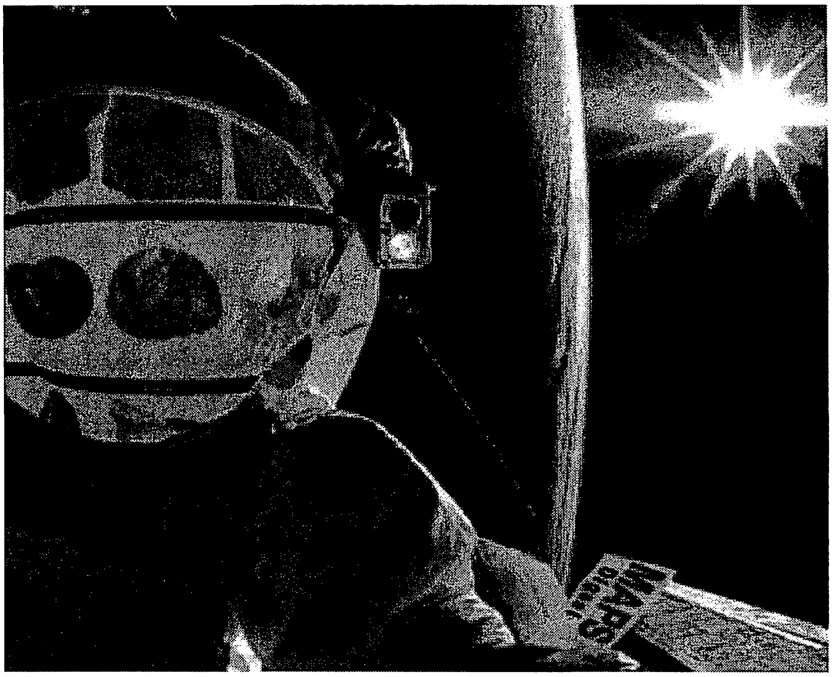
If you click onto your email address, it should open up your email application and pre-address the email header with your email address in the "to" box.

All of the fossil detail information that you transferred from your worksheet to the web page (during the Notepad editing stage) should display here.

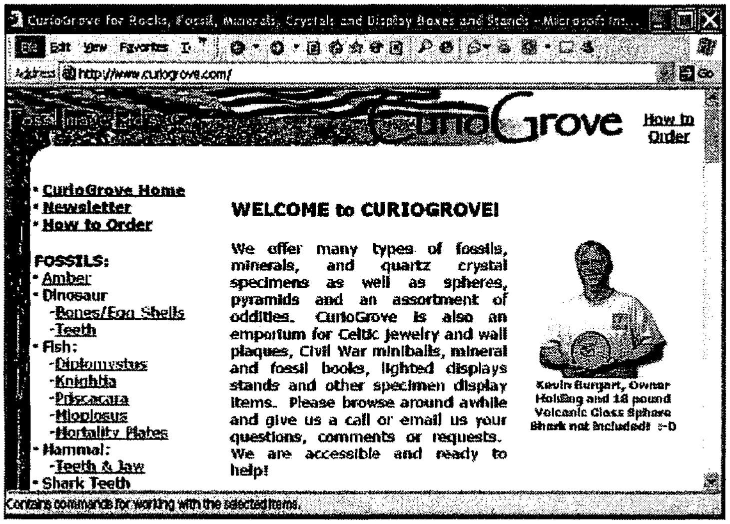
To return to the thumbnail page, you can either click onto the **top** detail image or use the **"Return to Home"** link at the bottom of the page.



Launching Your Fossil Gallery



No, we are not going to contact NASA to launch our Fossil Gallery on the Internet, although the process can often feel alien to many of us. There are several ways to publish your website to a web hosting space so that your gallery can be shared with others, literally, around the world! Our website, www.curiogrove.com has been on the Internet since the turn of the Millennium. I was working on the Y2K project for a major hospital company on New Year's Eve 1999. I was one of those unlucky ones who had to sit up all night looking for possible malfunctions due to several computer systems not being able to handle the new 2000 date. We had spent the previous 2 years preparing for this night, and I was monitoring the network and the integrity of our intranet system that connected all of our hospital facilities together. The night went off without incident, but it was not the most exciting way to celebrate something that only happens every 1000 years! My husband Kevin did join me in our computer room, and he brought in the new Millennium by sitting up most of the night building a fossil website so that we could connect with other collectors to buy, sell or trade fossils. The CurioGrove.com website created a major change in the way we connected and communicated with our fossil friends and customers. We have had over 3 million accesses to our website over the last 4 years.



So how do you get your Fossil Gallery out on the Internet? Well, let's explore a few possibilities. The "space" on the Internet where you store your web pages and image files is actually on a web server. This is a special computer that is set up to be on the Internet 24 hours a day, every day and has all the security and functionality to "serve up" your web pages when someone accesses your Internet address. When the owner of this server space provides for you to store your files, this is called "Web Hosting." The owner of the server is your "Web Host." Often times your "Web Host" is also your Internet Server Provider (your ISP). *Are you lost* *in cyber-space yet? Hang in there*! Your ISP will give you a dial up phone or a cable connection to the Internet, issue you an email address and segregate a small area on their web server for you to load your website. If you are in need of more space than your ISP allows, or you want to turn your Fossil Gallery into a commercial website, or you would like to have your own unique domain name (this is your "Dot Com" and in our case, we are www.curiogrove.com and www.basicpage.com), then you will need to turn to a "Web Hosting" service. A web hosting service can provide you with a larger amount of webserver space along with several additional features to make your website more functional such as a shopping cart, a chat room, a message board, an email distribution list, Pop email connections or email alias, etc. Let's look at these options a little more closely.

1. **Using your current Internet Service Provider** (Your ISP): Most companies that will connect you to the Internet and give you an email address also have a small area of web space available for their customers' use. Please note that most of these types of website spaces are for non-commercial use only and do not allow commercial activities. Be sure to read the details carefully before loading your website to the server space. ISPs usually include 2 to 15 megabytes of space. This is enough space to load the Fossil Gallery that we created in this article, which is approximately one half of a megabyte. So in the case of the 2 megabyte server space, you could create 4 separate galleries and link them together for a mini-website. To load to your server space, you will need to identify the FTP procedures. FTP stands for File Transfer Protocol. Some ISPs, such as the popular AOL, have their own FTP tool where you can load your webpage and images one file at a time to your webserver space. Other ISPs, such as Earthlink or Comcast let you choose your own FTP tool. There are several good applications. My favorite is WS_FTP by IPSwitch. I have used this FTP application since the very beginning. It is simple to use, inexpensive, and has worked with every webserver I have ever had to load to; and it will keep a log of your transfer should you want to keep a history of your loading activities. The current version of WS_FTP Pro is Version 8. You can download a trial version from their website to test drive before you buy. Their website address is: http://www.ipswitch.com/products/ws_ftp/index.html. The software costs less than $45 for a single user license.

2. **Free Web Hosting Services**: There are several companies on the Internet that will provide you with free web hosting space. Two of the most popular ones are GeoCities.com and AngelFire.com. With these types of companies, you usually get a web address that is a derivative of their name and yours. In the case of GeoCities.com (acquired by Yahoo!), your website address would be: www.GeoCities.com/yourgalleryname. They provide you with templates to create web pages and tools to load existing web files, or they will let you use your own FTP tool to transfer your website to the Internet. There is a trade-off when using a Free Web Hosting Service. They will often require you to place a banner advertisement or use pop-up advertisements that intrude every time you navigate around your website. These can be annoying at times and make the visit rather unpleasant.

3. **Renting Hosting Space**: Here is where I get to make a shameless plug for our company! :-D BasicPage.com offers full feature webserver space starting at $25 per month. This

includes 350 megabytes of server space with an abundance of features, such as true domain (www.yournamehere.com), secured shopping cart, FrontPage extensions, chat room, email distributions lists, Pop email boxes, email aliases, 24/7 support and online training tools, etc. End of plug! :-D

When choosing a Hosting Company, it is good to ask them how reliable their servers are? A good service company will know their downtime for the previous year and should be happy to share this with you. You want a server that is going to stay up 24/7. You want your server company to stay current with their hardware and software. I have had a couple of my websites online since 1997. Can you imagine what it would be like if my website were stuck on some server that ran on 16 megs of ram and a 33mhz processing speed? That was the standard when I first started. You want your server company to be forward thinking, offering you solid equipment and current server features.

You also want to know how much traffic the server can handle. You want your server to be able to operate properly for everyone who visits your website, especially if they are all visiting at the same time. It's a nice dream that your website will generate a good amount of traffic and become a popular place for fellow collectors, but it would be a nightmare should the server fail to work properly and your visitors bail out before experiencing your web offerings. Speaking of popularity, check with your Hosting Company to see how much traffic is allowed on your website before they start charging you more money each month. I have seen folks go with server companies and a year later their site becomes popular, generating a good amount of traffic, and then the Hosting Company starts charging for overages. Check to see if they charge for overage on space as well as visitation. If you have something like an online guest book or an image upload area, it starts to build up quickly and take more server space than allotted. It could put you over the top and double your monthly server rate as a consequence.

I think the most important issue with embarking on your first hosting space is to find out what type of support is provided. Do they have 24-hour customer service? Is it available by phone or email only? Do they have a good online support area to help you learn about the various features on the server and how to use them? It is of no benefit to have the features if you cannot incorporate them into your website.

Creating a website based on something you enjoy doing can be very exciting. It is such a thrill when you receive your first email from someone who visits your website. I have come to know some wonderful people over the Internet who have transitioned into offline friends. I have received email from all over the world striking up conversation about the content of my websites or containing wonderful personal accounts by other enthusiasts. There is something special about being a fossil hunter and seeking out others with the same appreciation. It's the nature of the fossil hunter.

I hope this article helps you to make the leap online! Please send us an invitation to visit your online gallery at info@curiogrove.com. I look forward to seeing you in cyber-space!

Above is our first booth at MAPS in 1997. Below is Janet (seated) and one of her best friends, Gary Rakes (in vest) at a gathering of MAPS members who belonged to several online rock and fossil newsgroups.

Kevin and Janet Burgart live with their two children Cassie and Ray in Pleasant View, Tennessee. Each member of the family is an avid rock, fossil, mineral and crystal collector. The Burgart Family are co-owners of Fossil Image Ltd, CurioGrove.com and BasicPage.com Internet Development. Everyone participates at one level or another with running the family businesses. Kevin and Janet are both graphic image developers and digital photographers. Kevin provides much of the creative writing and content creation while Janet designs the website's "look and feel" and the back-end structure. Cassie helps out with general office duties and assists Kevin with our Fossil Image inventory. Ray helps with bagging and labeling fossils and the entire family does several fossil and mineral related trade shows each year. The Burgart Family can be reached at Info@CurioGrove.com

Sample HTML – Thumbnail Page

Web Page: “index.htm”

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Gallery Name Here

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Specimen 1 Name Here

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Specimen 2 Name Here

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Specimen 3 Name Here

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Specimen 5 Name Here

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Specimen 6 Name Here

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Specimen 7 Name Here

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Thank you for visiting my gallery!

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<br>
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Feel free to email me at:

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<a href=”mailto:
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YourEmail@Name.com

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“>
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YourEmail@Name.com

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Sample HTML – Detail Page

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Fossil Gallery

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Write Specimen Name Here

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</b></td><td valign="top"><b>
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Write Formation Here

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</b></td></tr><tr><td nowrap valign="top"><b>Location:
</b></td><td valign="top"><b>
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Write Location Here

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</b></td><td valign="top"><b>
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Write Size Here

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</b></td></tr><tr><td colspan="2" valign="top">
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> NOTE: Change this number to match the number in the web page name. Example, for "specimen1.htm" change this number to "1". Follow suite with each page.

Write Comments Here

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  </b></td></tr></table></td><td width="65%" valign="top">
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1 a.jpg"></a></p><p align="center"><img border="0" src="specimen
1 b.jpg"></td></tr><tr><td width="35%" bordercolor="#FFFFFF"
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```

MICROFOSSILS AND THE SCANNING ELECTRON MICROSCOPE

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Introduction

As a collector of microfossils as well as being an electron microscopist, I am extremely fortunate to have access to a scanning electron microscope (SEM) to photograph my finds. The SEM allows one to photograph microfossils at high resolution with great depth of field. The cost of such an instrument puts it out of reach for most amateur collectors.

The SEM operates by scanning a sharply focused beam of electrons across the surface of the object being examined (1). Electrons hitting the specimen generate secondary electrons which are converted into a digital signal.This signal is displayed on a cathode ray tube (CRT). Surface features of the specimen determine the strength of the signal, which is collected by the secondary electron detector. These differences are displayed as differences in contrast and brightness in the final image. Because an electron beam will not travel in air, the specimen and electron optics must be operated under a high vacuum. Recording the image was originally done by photographing the image on the CRT using a conventional camera and sheet or Polaroid film. This has largely been supplanted by recording the digital image on a CD.

Advantages of the SEM over an optical microscope include much higher resolution and a maximum magnification around 200,000x. The three dimensional quality of the final picture is due in large part to the large depth of field, up to 500 times greater than that of an optical microscope at the same magnification. The stage of the SEM is designed so that the specimen can be rotated through 360 degrees and tilted almost 90 degrees, allowing examination of almost any surface.

Disadvantages include the fact that only surface features can be examined and photographed. Because the electron beam utilizes wavelengths outside of the visible spectrum, it is not possible to see color in the fossil. Color SEMs that appear in print have been artificially colored.

Processing of microfossils or the SEM is relatively straightforward. After an initial cleaning, the desired specimens are selected using a binocular dissecting microscope. The more robust fossils can be handled with watchmakers forceps while the delicate ones are manipulated with a very fine artist's paint brush or an eyelash glued to a toothpick. To avoid problems with static electricity, I prefer to use the bottom of a glass petri dish for sorting the fossils. A final cleaning is usually done by sonnicating the samples in an ultrasonic bath. This does not seem to damage even the most delicate specimens.

The microfossils are mounted on holders called stubs. These are aluminum discs which are about 5/8 inch in diameter. The fossils can be attached to the stubs with any of a number of adhesives including glue, double stick tape and epoxy. It is important to remember that the quality of the background in a SEM photo will be determined by the adhesive used. For the larger fossils, a two part epoxy adhesive gives a very smooth background. The epoxy is mixed and a small amount is spread across the top of the stub. It is allowed to partially harden before use, so that the fossils will not sink into the adhesive before it hardens completely.

Next the stubs are coated with a thin layer of evaporated metal in a device called a sputter coater. This conductive coating prevents electrical charges from building up on the surface of the sample, which can cause image distortions. The electron beam of the SEM generates secondary electrons when it hits the coating. It is these secondary electrons that actually form the image.

Notes on figures:

To illustrate this article, I have chosen fossil ostracods and silicified Miocene insects from the Barstow formation, San Bernardino Co., California (2,3). The ostracods are highly ornamented and show a wealth of three-dimensional detail. The exoskeleton of insects is composed of chitin, which is resistant to decay. From personal observations of extant insects it is evident that pieces of cuticle from dead insects will persist for some time, especially in a dry environment. It is likely that some of the insect fossils seen here represent animals that had been dead for a period of time before they were ultimately fossilized.

The magnifications given are those at which the original micrographs were taken.
The stereo pairs consist of two pictures of the same specimen with a tilt angle of 6-7 degrees between the two. When viewed so that each eye sees only one micrograph, the brain can fuse the two to produce a true three-dimensional image. With a little practice, most people can see this stereo image without resorting to using a viewer. In all of the pictures, note the extreme depth of field and the high resolution. The SEM used was a JEOL Model JSM-5800LV operated at 15kv and a working distance of approximately 45 mm.

References:

1. Hayat, M.A., 1978, Introduction to Biological Scanning Electron Microscopy, University Park Press, 323p.

2. Kirby, S. and R., 1999, Recovering Microfossils By Acid Etching, MAPS Digest, vol. 22, no.4, p 93-105.

3. Seiple. E, 1986, Where the Insects are in Stone, Rocks and Minerals, p.19-24.

Plate I

Stereo pair micrographs:

Fig.1 Mississippian ostracod, Indiana x110

Fig. 2 Mississippian ostracod, Indiana x70

Fig. 3 Mississippian ostracod, Texas x130

Fig. 4 Eocene ostracod, Mississippi x140

Plate II

Stereo pair micrographs of silicified Miocene insects from the Barstow formation, San Bernardino, California:

Fig. 1 Ventral view of a mite x300

Fig. 2 Lateral view of a dipteran x50

Fig. 3 An insect partially embedded in acid insoluble matrix x55

Fig. 4 Ventral view of a different dipteran x70

Plate III

These higher magnification pictures were chosen to show the incredible amount of detail preserved by replacement of the original insect cuticle with pure silica..

Fig. 1 Stereo pair micrographs showing the front feet of the insect in Plate II, Fig. 4, x950

Fig. 2 Portion of a thrip showing preservation of the wings x350

Fig. 3 Portion of a leg joint showing scaly cuticle x700

Fig.4 Higher magnification image of the haltere of the insect shown in Plate II, Fig. 4, x700

Fig. 5 A small portion of well preserved abdominal cuticle x2,500

Fig. 6 Portion of an insect eye showing evidence of dessication in some of the omatidia prior to fossilization x1,000

Fig. 7 An unusual example of different degrees of preservation within a single eye. While most of the omatidia show replacement by amorphous silica, a few show signs of definite crystalline structure x1,000

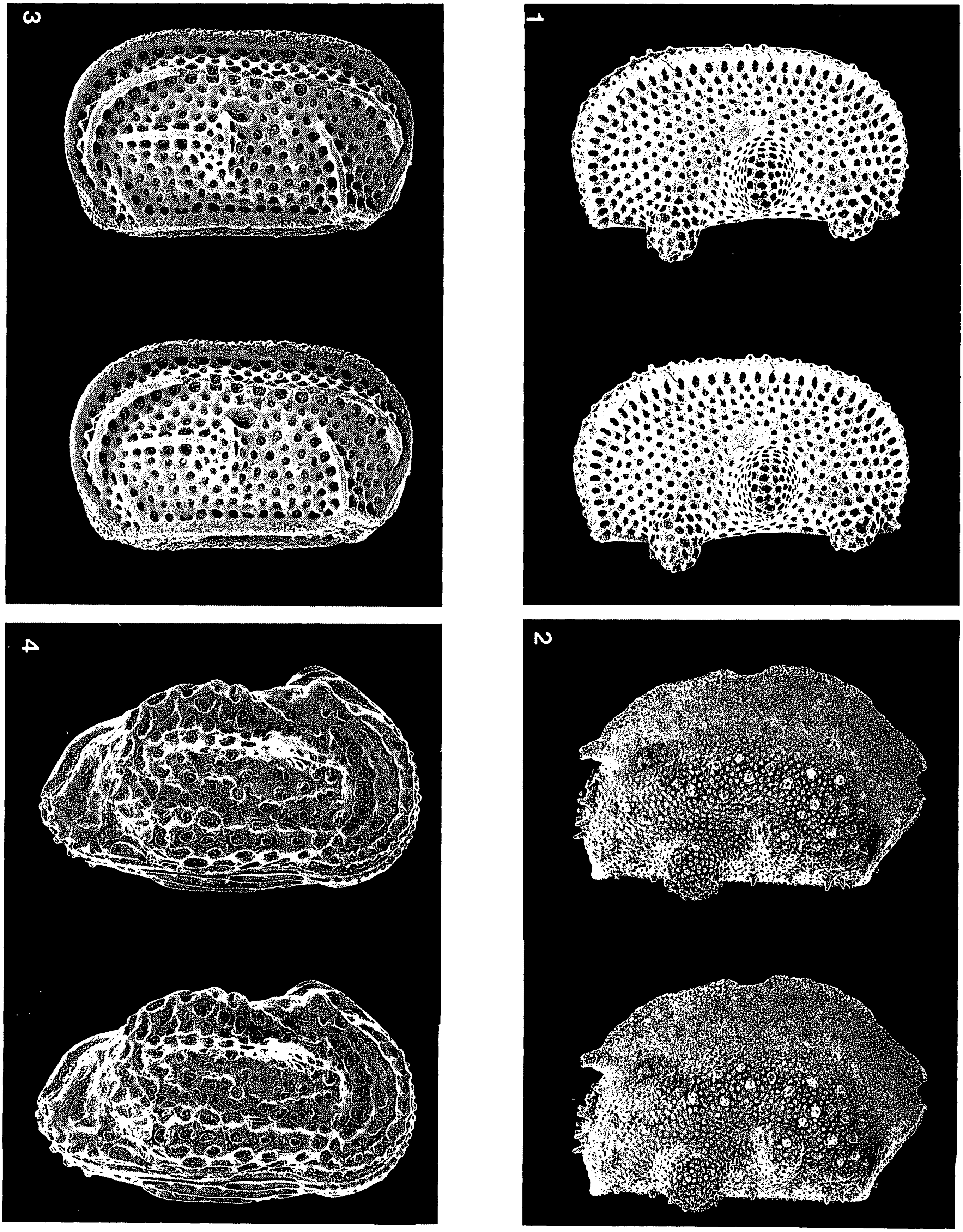
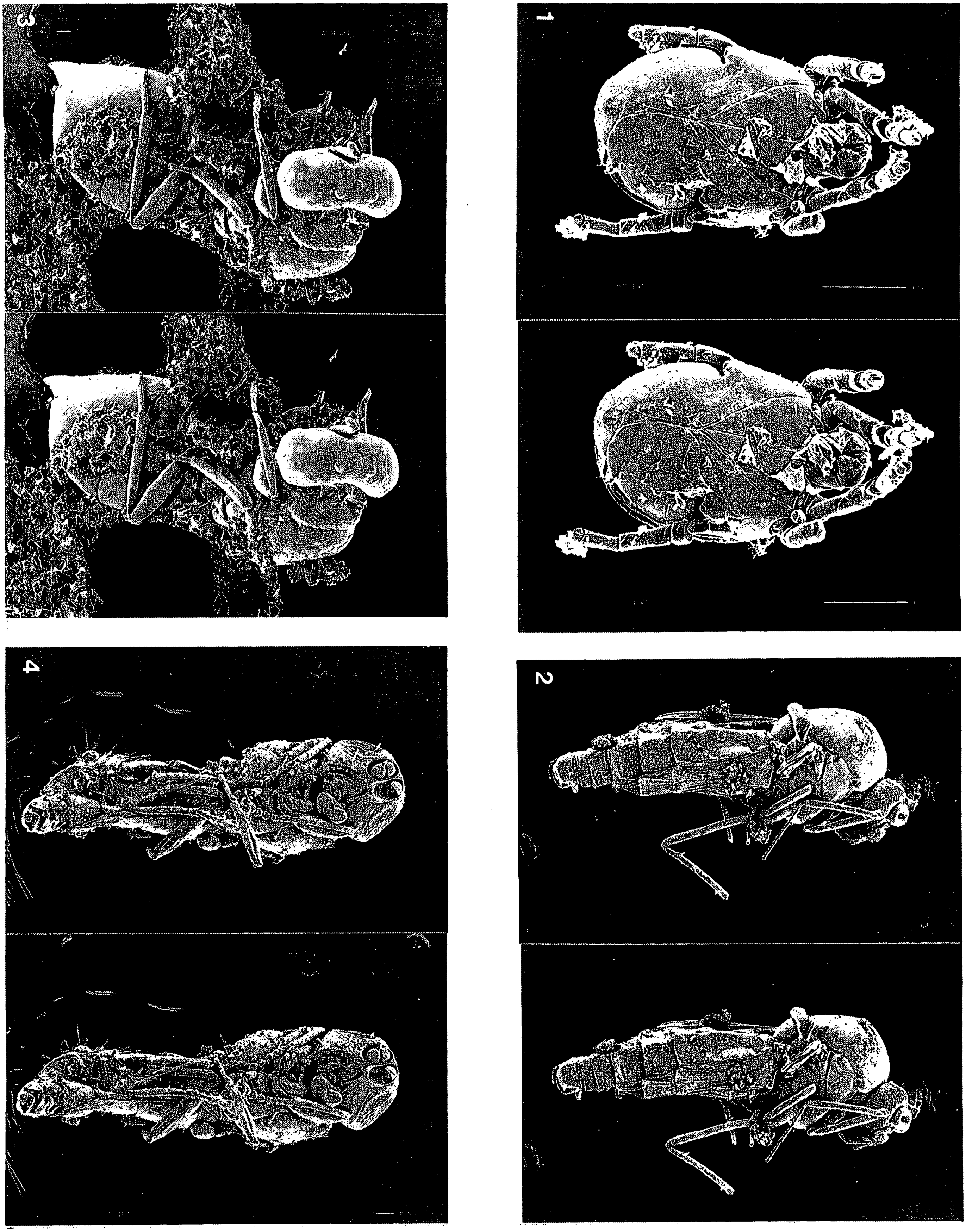


PLATE I

PLATE II



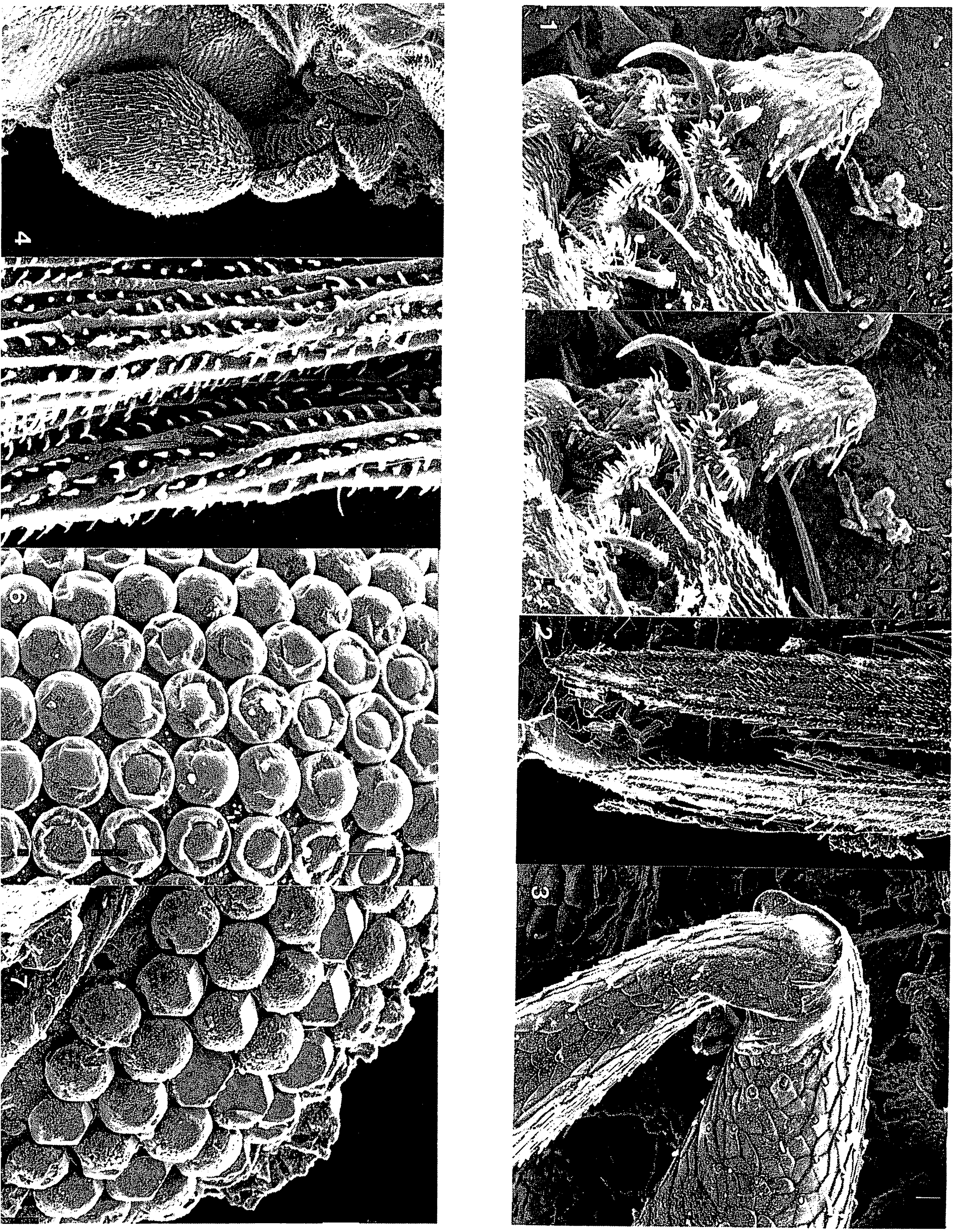


PLATE III

Realizing a Dream: Construction of a Home Museum

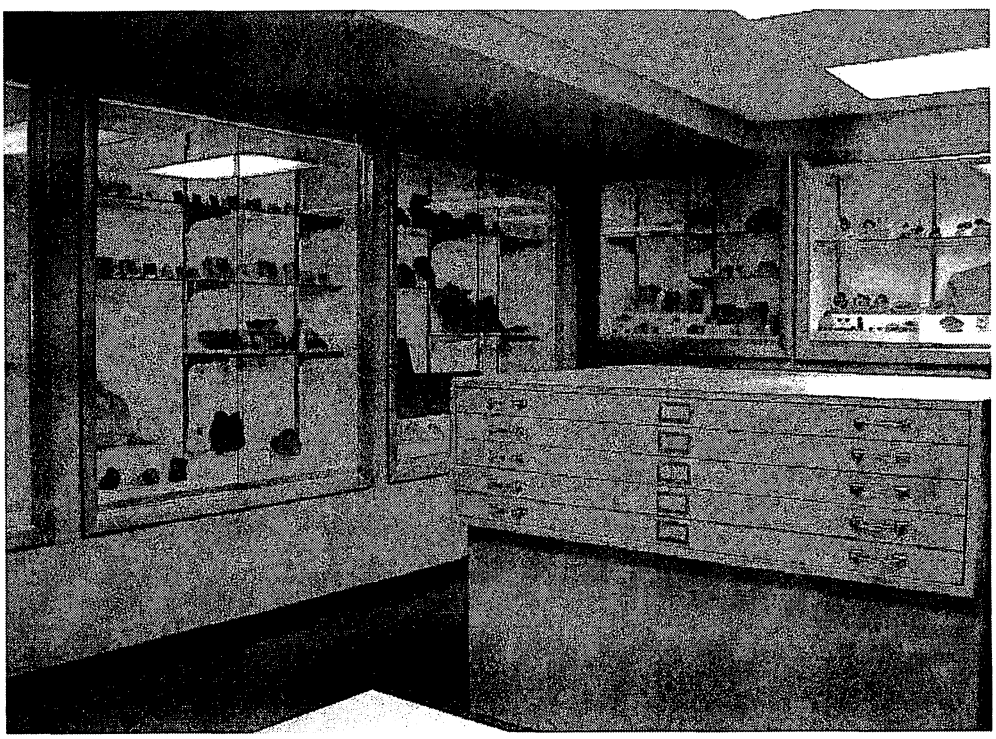
Ken Karns

My affliction with the "fossil bug" began a mere 29 years ago when, at the age of five, I was provided the first glimpse of a life long gone, but not forgotten by the creek beds and hillsides of Athens County, Ohio I credit my mother for providing me the direction and support of my hobby and for taking me on a collecting trip where I discovered my first complete Trilobite specimen.

Over the years, my collection grew to a large accumulation of carefully wrapped specimens in cardboard flats stacked in the basement. Each time, a review of specimens resulted in a ritual of unwrapping and wrapping specimens under a clip-on floodlight suspended from the overhead rafters of the basement. The lack of proper equipment for preparation and adequate space for study and display created a sense of disappointment for me for many years.

Finally, I decided that the situation was at a critical stage. My nephew, who had also begun collecting at an early age, agreed. With him going off to college in another two years and me at the age of 33, something had to be done to get the collection in some kind of order. I am not one to do things only half way! If we were going to set-up a preparation shop and an area for display, we would do it right!

The initial planning consisted of numerous discussions, or "bench racing," over how this project was going to come together and what basic requirements were needed. We wanted a combination of well-lit display cases and storage cabinets to house our collections. We researched the idea of commercial display cases and quickly discounted the idea, mainly due to the cost involved. Following some discussion, we opted to construct our own "built-in" display



cases. I personally prefer "built-in" cases versus the "stand alone" variety as they give a more permanent and finished appearance. Each of our cases would have its own light source along with glass shelving and sliding glass doors. We wanted to have the ability to display attractive slabs without taking room in the display cases. A wall would be constructed in such a way as to provide a display area for slabs. I have seen museum displays where slabs were mounted on the wall and, with proper lighting, made a very attractive display.

Next, we would need a preparation shop. This room would have to be carefully planned to provide a proper environment for cleaning and preparing our specimens. The shop would need general overhead fluorescent lighting along with specific task lighting. Adequate bench space would be needed in addition to storage for specimens awaiting preparation. Equipment would be needed for preparation and a list was developed as follows: An abrasive machine, Chicago and Arrow air scribes, microscope, prep box, and a wet saw. An air supply would be established and would provide the power necessary to run the air scribes and abrasive machine.

Final planning began in earnest during the winter of 1992. The area of the basement chosen for the "Museum" (as we now call it) was 28 ft. x 21 ft. with plans made for the construction of three separate areas: a preparation shop, an office, and a display area. The office area did not pose any real problems with an area 13 ft. x 14 ft. to include a desk, bookshelf, and printer stand. I also had a computer that we would be placing in the Museum for cataloging specimens. The office would also house several small drawered cabinets for storage of small specimens, reference, and study material. The shop was designed against an outside wall to allow for the exhaust of the prep box that would come later. The dimensions of the shop area were 14 ft. x 8 ft. The final room, the actual display area, was given 21 ft. x 14 ft. As virtually all the construction was going to be done by my nephew and me, plans to finance this venture were undertaken. I began working weekends as a private contractor with 20 day stretches without a day off becoming common! I continued at this pace for over a year. To this day I am not sure how, as the thought of working like that again makes me nauseated.

Construction began with the studding of the walls for the different rooms. The display area required walls to be constructed approximately 14 inches in from the basement wall to allow for 12 built-in display cases. The prep shop was given a separate door due to the noise and dust in that area. The office and display areas were connected via a 4 ft. entry way. The entire museum area was separate from the rest of the basement by a standard size door entering into the office. Once the walls were up, attention was focused on the construction of the display cases. Thirteen cases in all were constructed utilizing finished 3/4 inch plywood. The east wall was fitted with 4 cases (45" x 50"), the south wall with five cases (the top three 38" x 32" and the bottom two 28" x 52"), the west, on either side of the entrance, with two cases (45" x 50"), and the north wall with two cases (28" x 52"), and the north wall also with two cases (28" x 52") located near the floor. A shelf was constructed above the floor level cases on which three slant front cases were constructed. The wall above these slanted cases was faced with solid plywood prior to drywall to allow for the mounting and display for slabs. These slabs would be fastened to the wall with "L" hooks screwed into the plywood. The constructed cases were then placed in the rough openings and secured.

The next major project was to complete the wiring. Due to the size of the project and the amperage requirements to accomplish what we wanted, I began by installing a breaker box just for the Museum. This breaker box was a 100 amp unit and would provide the power requirements needed without putting any stress on the existing system. All 12 display cases were given two recessed spot lights in the top, with each light taking a 75 watt spot light bulb. The display cases were wired utilizing two switches. This would allow part of the collection to be viewed without lighting the entire room. The "slab wall" was treated to a series of track lights mounted to the ceiling. These six lights would provide lighting as needed for the mounted slabs. The slant front cases mounted on top of the shelf along the North wall would need lighting, so four recessed spot lights were mounted in the ceiling. These lights would illuminate the cases and assist the track lights in illuminating the slab wall as well.

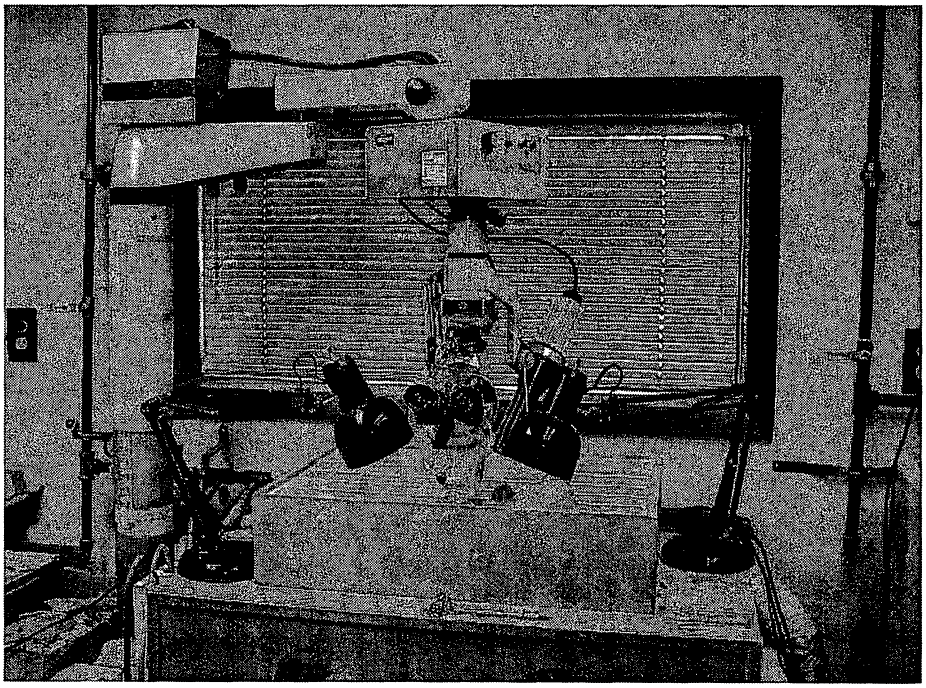
The next major job was the installation of electric baseboard heat throughout the Museum. I wanted a comfortable and usable facility all year round and was determined to have the temperature and humidity adequately controlled! I felt the specimens would benefit from a controlled atmosphere as much as I would! The rest of the wiring project proceeded with the installation of overhead florescent lights for general lighting. Convenience outlets were installed with dedicated circuits for the abrasive machine and dehumidifier due to the somewhat higher amperage these two items would draw. A total of nine, 4-bulb overhead florescent lights were used in the display area, office, and shop. All the wiring, including the installation of the 100 amp breaker box, was done by my nephew and I. We exceeded the local building code by soldering all wiring connections prior to installing wire nuts followed by the taping of each connection with electrical tape. The wiring was finally completed after several months of work and the "smoke test" passed with flying colors! We had adequate lighting to finish the project for the first time. We had been working with only a couple of clip on flood lights!

During the construction, the process of acquiring the necessary shop equipment was being planned. It just so happened that Trilobite Times came out right at the beginning of our project and proved invaluable as a resource guide for the selection of preparation equipment. Many evenings were spent pouring over the many excellent articles on prep equipment. It became apparent that a significant outlay of funds would be required to set-up a first rate prep shop! I devoured the first few issues and quickly placed my order for the Trilobite preparation video offered by Gary Chilson. Following its arrival, Trilobite Times quickly became the top seeded show on our VCR, passing up Godzilla vs The Sea Monster as the most frequently watched video, much to the dismay of my two boys.

The search for an abrasive machine was underway. As luck would have it, I located an old SS White Model "A" complete with dust collector. Negotiations were under way and I purchased the unit for $800. The model "A" was purchased in a non-running condition. However, the seller was a very reputable individual whom I respect and thank very much for the opportunity to acquire this unit. The unit was brought home and was immediately and thoroughly cleaned. I then went through the entire unit replacing pinch valves, tubing, and various fittings. The stock pressure regulating system required modification and that was done following the assistance from Gary Chilson, as I had noticed an aftermarket regulator on the Model "A" featured on the Trilobite preparation video. After everything looked in order, I hooked up the air line to my compressor in the garage and fired it up! The old Model "A" worked wonderfully! I carefully moved the unit to the basement to await its new home in the prep shop.

I was able to purchase a Chicago Pneumatic air scribe and an Arrow scribe from Tom Witherspoon, Sr., at the MAPS show in 1992. A cut-off saw was purchased from a local hardware store. This cut-off saw would enable us to trim slabs and larger specimens, with plans to purchase a wet saw for the more detailed work. A prep box was constructed without any difficulties. So after this flurry of equipment acquisitions, we sat back and thought about what else we needed? Ah yes! A Microscope...this piece of equipment was going to be a must and probably the most expensive! Our funds, at this point, were not prepared for a purchase like this. We began to realize that all the equipment we had assembled would be of little value in a quality prep job without a good scope! I began to research the feasibility of taking out a loan, only to be quickly reminded by my wife Cathy, how patient she had been so far! I had just about given up on the idea of locating a microscope at anything close to a reasonable price when I happened onto a deal I still cannot believe.

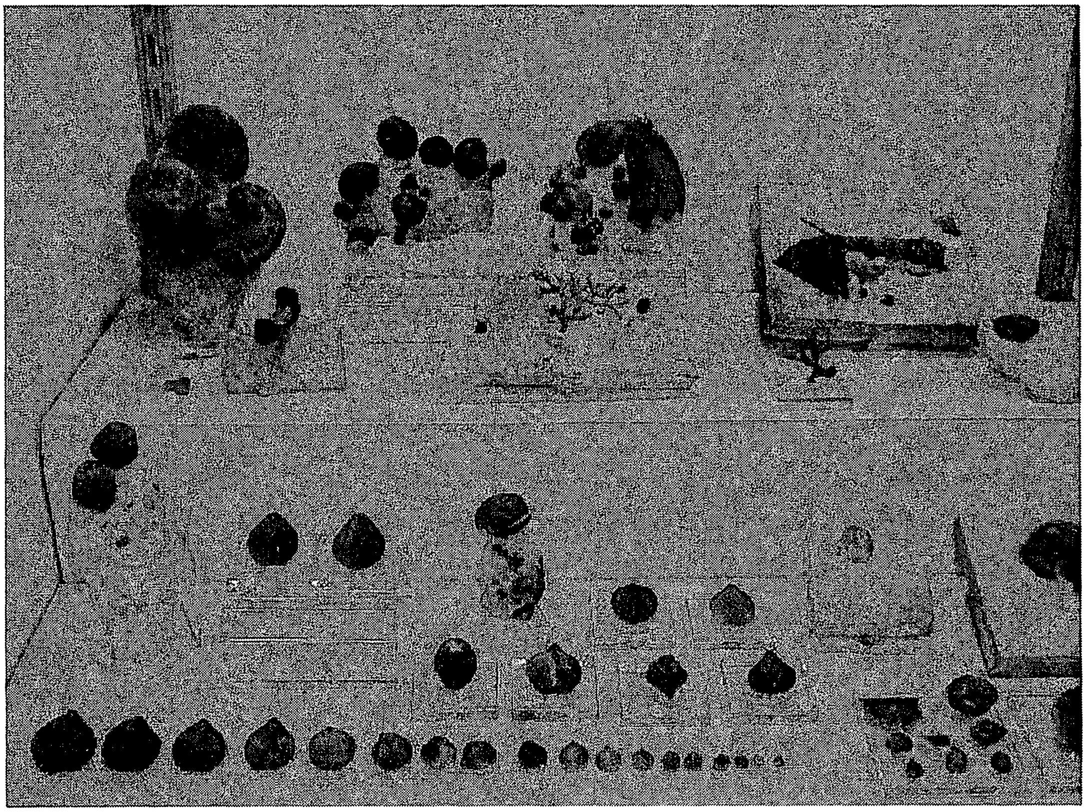
Talk about being in the right place at the right time! I came into work at the hospital along my normal route, which takes me through the basement, when I noticed a large accumulation of equipment sitting by the elevators. This was not an unusual occurrence as the hospital was going through a major expansion project. As I casually looked at the equipment while waiting on the elevator, my eye caught site of a microscope on a large stand. Upon further investigation, it



turned out to be an old J.K. Hoppel eye operating microscope system with not one, but two microscopes! The one scope was mounted to an arm that was attached to the base. The other scope was attached as a teaching scope. I looked through both scopes and found the optics to be in perfect shape with a working distance of 6 to 8 inches! To top it off, the main scope had its own adjustable fiber-optic light source, a foot pedal operated focus, and automatic zoom! I immediately inquired as to the disposition of this microscope and was told it might have already been purchased by another hospital. Over the next few weeks, I inquired almost daily about the scope and finally found out that the deal did not go through! I was told I could purchase the unit following approval from the department Vice President. Two days later, I was the owner of two complete microscopes! The missing link had been found. I carefully stored the unit and proceeded to move on with the museum construction with a sense of a new found energy.

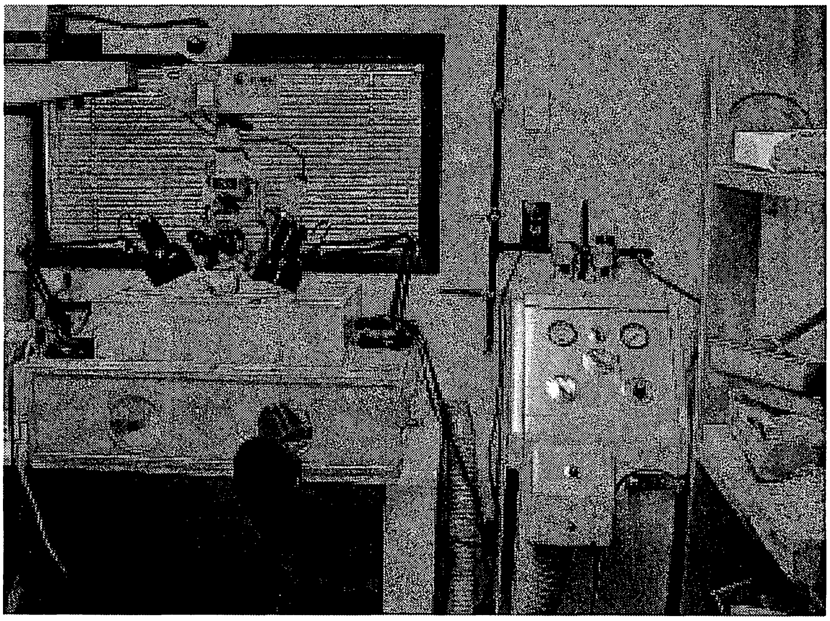
Work continued at a fast pace with the rough constructed walls in place, cases made, and the electrical work done. The next obstacle was going to be the air source to power the air scribes and the abrasive unit. I decided to run an air line from my detached garage to the basement. I have a 5 horsepower, two stage air compressor in my garage that would be more than adequate to handle any air requirements. I had a local plumbing contractor run an underground air line 90 feet through the basement wall and into the prep shop.

Once the air line was roughed in, we began the task of insulating and hanging drywall. I cannot recall exactly how many sheets of drywall we carried down the basement stairs, but my back hurts just thinking about it! Once drywall was hung, sanded, and painted, the museum began to take on a finished look. Counter tops were installed in the workshop, quickly followed by the installation of the final air lines, regulators, filters, and water traps that would supply the scribes and abrasive machine with their air requirements. A shelf unit was constructed in the shop for specimens stored in cardboard flats prior to preparation. Doors were hung in their rough openings, the display cases were painted, and a suspended ceiling was installed.



Each display case was carefully measured and sliding 1/4 inch plate glass doors were ordered. Shelf brackets were installed and plate glass shelving was also ordered. The bottom of each display case was accented with a series of risers, in various dimensions, constructed out of cabinet grade plywood. About $1500 in glass was needed to complete the cases! Furniture was purchased for the office consisting of a bookshelf, two pedestal desk, desk chair, and computer printer stand. We would be placing a computer in the office for location files, a data base for cataloging specimens, etc. We purchased several specimen storage cabinets including a five-drawer blueprint storage cabinet which was purchased at an auction for $300. This cabinet had drawers that were only three inches tall with an overall height of 18 inches, so a large riser had to be built to bring the cabinet up to a usable height. The cabinet did require some minor work to make it presentable. In fact, we sandblasted the outside, welded some areas and spray painted it in the original color. This cabinet is perfect for specimen storage with its very large, flat, and low profile drawers.

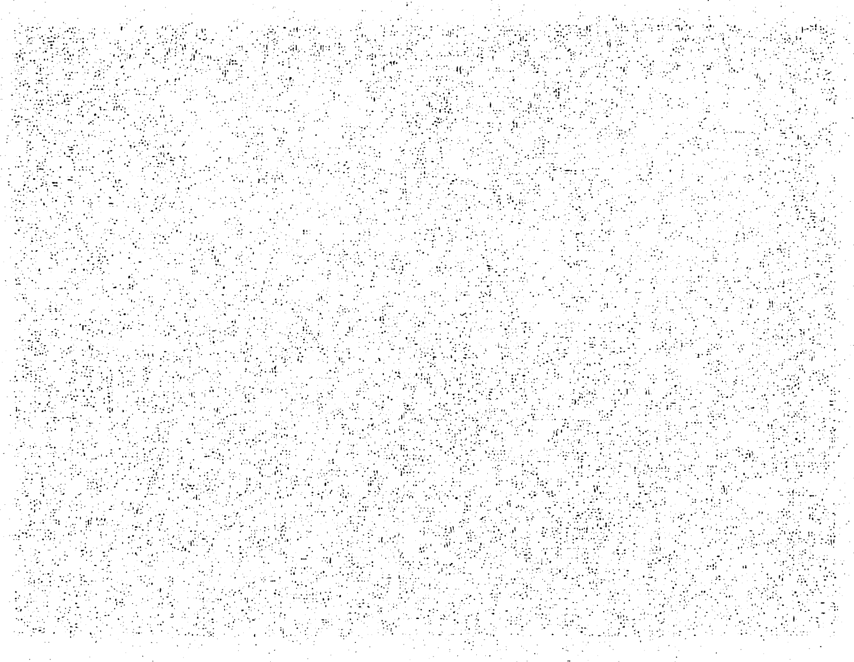
Next all the equipment was moved into the shop for a trial fit. The preparation cabinet was placed on the counter top, the SS White Model "A" was moved in along side. I routed the exhaust from the dust collector through a vent to the outside. The microscope was placed in its final position over the prep cabinet. I had removed the teaching scope and utilized the adjustable arm that came with the SS White Model "A" to provide an additional scope on the other work bench for specimen examination and prep work not done inside the prep box. The air scribes were connected to the air source by individual quick connects. This way each air scribe could be removed for storage or maintenance very easily. All equipment was operated and checked. Everything worked perfect! We were in business!!



Following this initial test of the equipment, everything was moved out in preparation for the final stage of construction...the carpeting. Again, I pleaded to my wife's sense of common decency to not allow the museum to go without this final, finishing touch! In all, 55 yards of short pile office style carpeting was installed along with vinyl baseboard molding.

My nephew and I could hardly believe it! After two years of planning, research, and construction, the Museum was finally finished! My dream had come true.....

I would like to dedicate this article to my family and to long time friend and professional Thomas T. Johnson. I attribute Tom with fostering my knowledge and appreciation of collecting. Through the 16 years I have known him, I have yet to see a more dedicated individual to the field of paleontology. Thanks, Tom!



Three boys sat on rough plank boards and emptied their pockets of beautiful fossils.

"Mom, there are lots and lots of them!"

As I knelt there, I could smell the summer heat caught in their hair.

I still see the freckled faces—eyes round and blue green, and the sound of hushed wonder still echoes in my memory.

Finding those "magic stones" helped my children. Shy Timmy's "Show and Tell," proud of his own "finds." Reading, reports written, other hunts and outings through the Black Hills and Badlands of South Dakota were for this single mother of four (there is a younger sister) the magic of discovery, mine as well as theirs.

Where we traveled and they examined—on beaches of California, in petrified forests of Arizona. Stones in shoeboxes, on shelves, stones on kitchen windowsills, in bathtubs, and in the bottom of the washing machine—the debris of memory.

And now in New Mexico, gleaming in firelit memories of forty years ago, my children's treasures.

I am not a fossil collector, but I am told that the fossils my boys collected in Hot Springs, SD in the 1960s were from the Cretaceous Era, so I have depicted Cretaceous fossils in the wash that frames this memoir. *–Jan Terry*


9 a.m.


10:30 a.m.


10:50 a.m.