Appendix U: Curatorial Care of Paleontological and Geological Collections

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APPENDIX U: CURATORIAL CARE OF PALEONTOLOGICAL AND GEOLOGICAL COLLECTIONS

SECTION I: PALEONTOLOGICAL COLLECTIONS

A. Overview

1. *What information concerning paleontological collections will I find in this appendix?*

This appendix will:

- introduce you to the preventive conservation of paleontological specimens
- provide you with the information necessary for the day-to-day management of your fossil collections
- prepare you to carry out the duties associated with the long-term storage of a paleontological collection
- not teach you the skills of fossil preparation or conservation, as practiced by trained preparators and conservators

The appendix includes:

- a discussion of the characteristics of paleontological collections
- tools to help you recognize deterioration
- information about proper storage environments
- health and safety concerns
- a listing of NPS resources and outside organizations that can provide you with additional information

2. *Why is it important to practice preventive conservation with paleontological specimens?*

Fossils may seem to be "hard as stone." You might then assume that fossils require little monitoring or preventive conservation. This isn't the case. Paleontological collections <u>do</u> require an appropriate level of preventive conservation. Without routine monitoring (including good baseline information), the first indication of a problem is usually when a specimen starts to crumble. Often, little can be done at this point. The deterioration is irreversible. This results in:

- damage to the specimen
- the loss of scientific information.

3. *How can I learn about preventive conservation?*

Read about the agents of deterioration in Section E and the proper storage of paleontological specimens in Section F. See Chapter 3: Preservation: Getting Started, and Chapter 4: Museum Collections Environment, for a discussion on the agents of deterioration. For information on exhibits, refer to *Museum Handbook*, Part III (*MH-III*), Chapter 7: Using Museum Collections in Exhibits and NPS CD-ROM publication, *Exhibit Conservation Guidelines*, available from the Harpers Ferry Center (see

Section III. References).

4. *Where can I find the latest information on care of paleontological specimens?*

See Section III. References. This section lists contact information for NPS resources, professional organizations devoted to paleontology and geology, a glossary, Internet resources, and a bibliography.

B. Paleontological Collections and Fossils

1. *What are paleontological collections?*

Paleontology is the study of ancient life. It includes the five kingdoms of life (Monera, Protista, Fungi, Plantae, and Animalia), but most paleontological collections are identified as:

- vertebrates
- invertebrates
- plants

NPS paleontological collections cover the entire span of geological time and represent all five kingdoms of life.

2. *What is a fossil?*

A fossil is any evidence of past life preserved in the earth's crust. Fossils can be divided into two main categories:

- body fossils are the preserved remains of a plant or animal
- trace fossils are indications of past animal activity such as:
  - tracks
  - burrows
  - borings
  - gnaw or bite marks
  - coprolites (fossilized feces)

The study of trace fossils is called ichnology.

3. *Are there other types of fossils?*

Unaltered fossils result from burial conditions that prevent decomposition, such as low temperatures or low humidity. The classic example of an unaltered fossil is a frozen woolly mammoth. Bison and horses also have been found preserved in Alaskan permafrost. In arid environments, mummified specimens may be preserved in caves or in pack rat middens.

Unaltered fossils are extremely sensitive to changing environmental conditions. If you remove such specimens from the field, you must duplicate the field environment within the museum (temperature, humidity, etc.). This will ensure their continued preservation.

4. *How can I identify the fossils in my collection?*

Because a wide variety of plants and animals have fossilized, it's very difficult for anyone to identify every type of fossil. You can consult a paleontologist, but remember that even the experts can't identify all fossils. Most paleontologists specialize in one (or several) plant or animal group(s), fossils from a specific geologic time, or fossils in a given geographic area.

There are many "popular" guides to fossils, but you'll probably need to consult the scientific literature to confirm a fossil's identification.

C. Body Fossils

1. *How did body fossils develop?*

Body fossils formed when an organism died and was rapidly buried. This minimized decomposition and destruction from scavengers. (These fossils escaped the natural recycling process!)

Common burial sites include rivers and lakes or other areas of rapid sedimentation. The death either occurred there or the specimen was quickly transported to the area shortly after death. After burial, the specimen was protected from further transport, scavenging, and some types of decay. Eventually, minerals from ground water cemented the surrounding sediments. Body fossils were preserved by:

- permineralization
- replacement
- carbonization
- molds and casts
- nodules
- amber

Organisms, particularly vertebrates with a skeleton made of numerous parts often are represented by isolated bones and teeth. Individuals that died at the site of deposition and were quickly buried are more likely to be preserved as complete, well-preserved specimens.

Organisms that were transported are more likely to be incomplete. They also may show signs of transport such as abrasion.

2. *What is Permineralization?*

Permineralization is what we commonly associate with fossils. "Petrified" or "fossilized" are words used to describe a fossil preserved this way. Minerals have been deposited in the specimen. It has "turned to stone." Even though minerals were deposited in the specimen, it still may retain part of its original organic structure. If you examine the fossil under a microscope at high magnification, you may see the original organic material with minerals deposited in spaces. The logs at Petrified Forest

National Park are a good example of permineralization.

3. *What is replacement?*

Replacement is similar to permineralization, except that none of the original specimen survived. Minerals *replaced* the original components. The replacement occurred at the molecular level, so all of the original details may be preserved.

4. *What is carbonization?*

Carbonized fossils are often preserved on the bedding planes of shale. These shales were often deposited in water that is low in oxygen. This permitted the preservation of soft-bodied organisms that would not otherwise have been preserved. Heat and pressure of sediments reduced the original plant or animal to a carbon film. Many types of plants and animals that would not normally be preserved in other environments are preserved this way. The best examples are fossil fish from the Green River Formation at Fossil Butte National Monument and the insects and leaves at Florissant Fossil Beds National Monument.

5. *What are molds and casts?*

- A mold formed when the original fossil dissolved. This left a cavity within the surrounding rock. This negative impression preserves the external details of the original specimen. One rare form of mold can form when lava flows around a living tree. Tree molds are found at Craters of the Moon, El Malpais, and Lava Beds National Monuments.
- A cast is formed if this negative impression later filled with sediment. The cast may preserve all of the external morphological details of the original specimen but lacks any microscopic details.
- A steinkern is another type of mold. Steinkerns can result when a shell (such as a snail or clam) filled with sediment and then dissolved. The hardened sediment preserves a reverse image of the formerly hollow inside of the shell.

6. *What are nodules?*

During preservation the original organic material may serve as a nucleus around which minerals are deposited. The minerals may be deposited in layers and eventually the original specimen becomes completely encased in a nodule. Depending on the types of minerals and environment of deposition, the original fossil may be preserved or only an impression may be left. Often the fossil can only be seen when the nodule is cracked open.

7. *What is amber?*

Amber is fossilized resin produced by various trees. Amber results from the evaporation of volatile organic compounds, and oxidation and polymerization. Amber often includes insects or other arthropods and pieces of plants.

D. Trace Fossils

1. *How did trace fossils form?*

Trace fossils result from an animal disturbing sediments (such as burrowing worms, a dinosaur leaving footprints in the mud, or depositing dung). These specimens are usually found in rock.

2. *How are trace fossils usually exhibited?*

Because there are no hard parts to be preserved, trace fossils are generally found as molds, casts, and infillings. They may be difficult to distinguish from the surrounding rock. Larger trace fossils, such as track sites of multiple tracks, are usually left *in-situ*.

Smaller specimens, such as large pieces of rock containing trace fossils, are sometimes transported to the visitor center for an outdoor display. Such specimens may not have been accessioned and cataloged into the museum collection. If not, you should accession and catalog them. Remember: If such fossils are displayed outdoors, or within reach of visitors, the specimens are subject to consumptive use, including wear, deterioration, vandalism, or environmental damage.

Trace fossils are not expendable. Take proper steps to ensure their long-term preservation. Even tracks displayed in a "structure" that prevents visitors from touching them can suffer deterioration, due to environmental fluctuations (Shelton et al, 1993). Ensure that all paleontological exhibits at your park have addressed preventive conservation issues to the extent possible. For additional information, refer to Section I. "Exhibiting Paleontological Specimen" below, and the National Park Service CD-ROM publication, *Exhibit Conservation Guidelines* (see Section III. References).

> *For a more conservation-friendly approach to outdoor exhibits, use reproductions of fossils for visitor center design elements and interpretive dinosaur "track walks."*

3. *What else should I know about trace fossils?*

Trace fossils generally require less preparation than body fossils. Different kinds of trace fossils may require different types of care. For example, caves in the Grand Canyon and the Guadalupe Mountains preserve unaltered dung of the extinct ground sloth. Dung of mammoths and extinct brush-ox are found in alcoves in Glen Canyon. This type of original organic material requires a different preservation approach than slabs of rock with tracks. Such specimens are extremely fragile and break easily; handle them with extreme care.

For storage of dung or other trace fossils of original organic material:

- Store the specimens in cabinets with low humidity.
- Protect the fossils from insect pests.

You may need to build a microclimate within the storage cabinet using desiccants (see *Conserve O Gram* [*COG*] 1/8 "Using Silica Gel in Microenvironments").

E. Factors that Contribute to Specimen Deterioration

1. *How can I minimize deterioration of paleontological specimens?*

Preservation of paleontological collections is a collaborative effort between field paleontologists, laboratory preparators, and curators. Everyone brings a different perspective and expertise to the matter. It's important to understand the concerns and needs of each professional when making decisions about how to care for the specimens.

Preservation begins in the field. You should:

- Work with the paleontologist who collects the specimen and the preparator who prepares it in the laboratory.

- Address conservation issues throughout the project.

- Ensure that everyone is using current conservation techniques. When in doubt, contact the NPS Geologic Research Division (GRD), Paleontology Program Coordinator or the Senior Curator of Natural History for advice.

- Make any necessary notations to catalog records or other documentation, such as:

  – conservation information from the paleontologist or preparator

  – type of glues and preservatives used to stabilize the fossil, both in the field and in the lab

  Note: Be sure to request <u>all</u> preparation data from the preparator. This includes a list of solvents and any other chemicals used on a specimen.

- Follow through with proper curatorial care and museum storage conditions.

2. *How can I identify active deterioration of a paleontological specimen in storage?*

The best way to detect active deterioration is careful, routine observation:

- Note the condition of specimens when they arrive for storage.

- Create a baseline photograph of every specimen upon arrival.

- Are there small bits of unattached bone associated with the specimen, or is the specimen completely intact?

- Is the specimen well supported and padded with an appropriate material such as polyethylene foam?

- Are some delicate parts prone to damage from gravity or mishandling?

- Previously attached bone or rock pieces under/around a specimen are a sign of deterioration and crumbling!

3. *How can I stop active deterioration of a specimen once it's started?*

First, determine the cause of the deterioration:

- Was the specimen mishandled?

- Are the environmental conditions in storage appropriate?

- Did the deterioration occur because of routine cleaning?
- Is the specimen properly supported (such as cavity packing using

polyethylene foam)?

- Is the specimen crumbing due to glue failure or a preservative used during preparation?

You should be able to eliminate some of these causes of deterioration. Others require the skills of an experienced paleontologist. When in doubt, contact the GRD Paleontology Program Coordinator or the Senior Curator of Natural History for advice. Be prepared to discuss:

- the type of paleontological specimen
- what formation it came from
- who collected it
- its present storage environment
- types of preservatives used

The GRD Paleontology Program Coordinator or the Senior Curator of Natural History may suggest that you contact the person who collected or prepared the specimen, or possibly a professional paleontologist who works at another park.

> *Do not undertake any type of conservation procedure on a specimen unless you are an experienced paleontologist with appropriate training.*

4. *What is pyrite disease?*

Pyrite disease is common in some fossil collections. Pyrite disease results from the oxidation of iron pyrite ("fool's gold") in a fossil. Pyrite can be present in bone, invertebrate shell, or plant fossils. The oxidation of pyrite will affect microcrystalline or framboidal pyrite far more than it does larger crystals. The resultant iron sulphate ($FeSO_4$) causes fossils to crumble as the crystals grow and expand. The damage is preventable, but irreversible once it begins.

5. *How can I protect my specimens from pyrite disease?*

Keep the fossils in a stable environment. Temperature and humidity fluctuations promote pyrite "rot." Consolidants, coatings, or adhesives can be of use only if they are introduced to the specimen under vacuum conditions to coat all surfaces internally and externally. Even carefully conserved specimens can explode spectacularly due to pyrite "rot" building up under the protective skin of preservatives.

The only way to slow the oxidation is to lower the relative humidity. If the reaction has not started, keep RH at 45% or lower; if it has started, reduce it to 30% or lower. It's possible to clean the reaction products off the surface of a specimen. This requires a very specific procedure and specialized training. Untrained personnel can easily inflict further damage to, or destroy the specimen.

Remember: Prevention is always better than treatment.

6. *What should I do if I*

Follow these steps:

notice pyrite disease?

- Remove the specimen from its storage environment to a work area.
- Brush away and discard the dry powdery reaction product with a dry, soft brush. If you're fortunate, you may need to do nothing more than rehouse the specimen at this point.
- If you can't keep the RH below 45%, and pyrite problems exist, you'll have to upgrade your storage environment. Possible solutions:
  - Build a microclimate within the storage cabinet using desiccants (see *COG* 1/8 "Using Silica Gel in Microenvironments").
  - Create an anoxic (low- or no-oxygen) environment (see *COG* 3/9 "Anoxic Microenvironments: A Treatment for Pest Control"). For a collection of known reactive specimens, anoxic film enclosures will help slow the reaction. But be aware that it never stops.
  - For a large collection, consider installing climate-control equipment for an entire case or cases.

7. *What else should I consider when confronting pyrite disease?*

Cross-Contamination

The pyrite oxidation reaction liberates sulfuric acid. This can damage other specimens and storage materials. Do not let other specimens touch infected ones. Also, encapsulate specimen labels (don't laminate them) so that they are not in direct contact with the specimen.

Susceptibility to pyrite disease

A fossil's susceptibility to pyrite disease may depend on the types of rock in which it was preserved. Holmberg (2000) noted a good example of this principle:

> Two fossil whale skeletons containing pyrite were obtained from Miocene clay. They were found in different states of preservation, though they had been stored under identical conditions. One of the skeletons was embedded primarily in light-colored clay dominated by the mineral smectite. (Smectite has a high absorption capability and low pH.) The other embedding medium consisted of other clay minerals, mainly kaolinite and illite. (These minerals have a neutral pH resulting from the presence of carbonates, which work as buffers.) Pyrite in the fossil bones from smectite-rich clays was more susceptible to deterioration after exposure than bone containing pyrite preserved in clays dominated by other clay minerals.

F. Handling and Storage of Paleontological Specimens

1. *What factors should I consider when accepting paleontological specimens for storage?*

Specimens collected and prepared by experienced paleontologists should arrive well supported, padded, and stable. The fossils can range in size from less than a millimeter to thousands of pounds. They are stored in many different ways, including:

- attached to the head of a pin inserted into a polyethylene stopper in a vial
- "cavity packed" in their own form-fitted plaster cradle
- in specimen trays of various sizes with polyethylene sheeting used as padding
- small microfossils mounted on special slides that can be stored in a slide cabinet

When accepting collections for storage, be sure to:

- inspect each specimen and make sure each one is well supported and padded
- ask the paleontologist about the materials used for padding:
  - Do they off gas?
  - Are they durable?
  - If the materials used to pad the specimens have loose threads or fibers, such as cotton and cheesecloth, these can easily snag on delicate parts of the fossil. Ask the paleontologist about other options.
- ask the paleontologist to demonstrate how the specimens should be handled.
- see how easily the specimens return to the storage container.
- note if the specimen label can be seen without handling the specimen. If not, discuss other options with the paleontologist.

Remember: Don't accept the specimens if they have not been properly prepared for storage. You can contact the GRD Paleontology Program Coordinator, the Senior Curator of Natural History, or your regional/SO curator for advice.

2. *How do I ensure the preservation of specimens in storage?*

Practice preventive conservation. Be sure to:

- House the specimens in a proper environment. See the CD-Rom publication *Exhibit Conservation Guidelines*, available from the Harpers Ferry Center.
- Use standard geology/paleontology cabinets for most specimens (see *Tools of the Trade* for additional information). As with other collections, you can store small specimens in trays, and cavity-pack them in polyethylene foam.
- For larger specimens, you'll probably need to use open shelf storage.
  - Very large specimens such as sections of petrified logs may require their own pallet for support.
  - To move these specimens, you'll need a pallet jack.
- Protect the collection from dust and excessive light levels.
- Always use proper handling techniques.
- Pad and support each specimen appropriately.
- Use appropriate storage equipment (see *Tools of the Trade*).

> *Improper storage and handling is a leading cause of specimen deterioration. Fossils are often more fragile than they appear, even if they are mostly rock. Many specimens cannot support their own weight, which makes them extremely vulnerable to improper handling.*

3. *What temperature and humidity levels should I maintain in storage?*

For a mixed paleontological collection, keep a stable:

- temperature between 59° and 77°F.
- relative humidity at 45-55%.

4. *Should I be concerned about light levels?*

There is no evidence that light levels (UV or visible) adversely affect fossils. However, they do affect glues and preservatives used to preserve specimens. So be sure to keep light levels as low as possible.

5. *What about dust?*

Airborne dust that settles on specimens is highly abrasive. Cleaning fossils, even with the gentlest techniques, causes damage too. To help eliminate dust in storage areas:

- keep circulating air as clean as possible (use primary and secondary filtering systems whenever possible)
- keep museum cabinet doors closed
- use dust covers on open rack shelving

- practice good housekeeping procedures:
  - consistently carry out all specified duties
  - use appropriate methods as approved by your park's Housekeeping Plan
  - use proper equipment, such as a HEPA vacuum cleaner and a HEPA air purifier (if needed). See *Tools of the Trade* for information concerning supplies and equipment.

6. *What is the proper way to handle paleontological specimens?*

Contrary to standard museum practice, <u>DO NOT</u> wear cotton gloves when handling paleontological specimens. Fossils may be slippery. You can easily drop a specimen. Use your clean, bare hands to assure a good grip.

Some specimens may have special handling requirements. Discuss these issues with the paleontologist who collected or prepared the specimens. Call the GRD Paleontology Program Coordinator or Senior Curator of Natural History if questions arise. Have enough staff available to assist with especially vulnerable or heavy specimens.

In general, handle specimens as you would other museum objects:

- Handle specimens as infrequently as possible.
- Handle each specimen as though it's irreplaceable and the most specimen valuable in the collection.
- Never smoke, eat, or drink while handling specimens.
- Don't wear anything that may damage the specimen. To avoid scratching and snagging surfaces, be careful of breast pocket contents, jewelry, watches, and belt buckles.
- Use only a pencil when examining specimens.
- Save all information that is associated with the specimen, such as tags and labels.
- Know the condition of a specimen before moving it.
- Lift and/or move the specimen by supporting its strongest structural component. Do not lift it by protruding parts, small bones, or attachments. These areas are weak.
- Use a utility cart with padded shelves and raised sides to transport specimens from one room, area, or building to another. See *Tools of the Trade* for additional information.
- Handle only one specimen at a time and use both hands. Use one hand for support and the other hand for balance.

- If you need to temporarily place a specimen in an unstable position for examination, be sure to support it. Exercise extreme caution in these situations. Return the specimen to a stable base or surface as soon as possible.

- Never hurry when handling specimens. Move slowly.

> *If part of a specimen is broken, reattach it as soon as possible to prevent it from becoming separated or lost.*

7. *Are there any other handling issues?*

Researchers will need to handle specimens in order to study them. But don't assume that every paleontologist who requests collections access is aware of all the proper handling procedures.

Be sure that you:

- know how to appropriately handle all of the specimens in your collection.

- thoroughly brief all collections users on proper specimen handling techniques. A good way to do this is to provide all researchers with a copy of your park's "Collections Handling Guidelines."

- require all collections users to sign a statement agreeing to abide by these and any other applicable rules, as a condition of access.

For additional information, refer to:

- Chapter 6: Figure 6.14, "Example of Written Handling Rules for NPS Collections" on page 6:30

- Appendix G: Figure G.6., "Sample Visitor Log" on page G:32, and Figure G.7., "Conditions for Access to Museum Collections" on page G:33

8. *What type of storage equipment should I use?*

Paleontological specimens can vary in size from less than a millimeter to thousands of pounds. You may need to use several different types of storage equipment. Options include:

Standard museum cabinets offer an added measure of security and environmental control. Use cabinets for all specimens small enough to fit safely in a drawer. Take care not to overload cabinets or drawers. As with other collections, use cavity packing and padding to keep specimens in place and eliminate any movement when someone opens a drawer. See Figure U.1. below.

Figure U.1. Cabinet storage of paleontological specimens. Individual specimens are cavity-packed in polyethylene foam-lined specimen trays. Courtesy of John Day Fossil Beds National Monument.

Open rack shelving with a steel frame and ¾ inch plywood shelves, will safely hold moderate size specimens. Use exterior grade plywood and completely seal all surfaces. You can use either a 2-component water-based epoxy paint or a water-based urethane sealant. Line each shelf with polyethylene foam and pad/support each specimen with foam or another suitable material. Another option is to use custom-made reinforced fiberglass jackets (see Figure U.2. below). This is the same principle as cavity packing, but on a much larger scale.

Figure U.2. Paleontological Specimen cradled in polyethylene foam-lined fiberglass jacket. Courtesy of John Day Fossil Beds National Monument.

Remember: Unsupported components of specimens can easily be damaged by gravity. Also, do not over-pack shelves. This will increase the likelihood of damage from handling.

Pallets are a safe technique to store large specimens. Some fossils may weigh thousands of pounds. Pallets are a relatively inexpensive alternative to specially designed, heavyweight shelves. You'll need a pallet jack, a front-end loader, or a forklift to transport these large specimens. Be sure to properly support all specimens, especially before moving them. You will also need to have room for the forks of a loader to get under the pallet without damaging the specimen or support structure. Discuss methods for moving the specimens with the paleontologist who collected or prepared them. You can also contact the GRD Paleontology Program Coordinator or the Senior Curator of Natural History for assistance.

9. *How should I label fossil specimens?*

Labeling Directly on Specimens

You can directly label bone, shell, and other specimens with a hard, fairly smooth surface. Be sure to use a stable acrylic resin (such as Acryloid B-72) to the seal the surface below the number. If you don't, inks can penetrate many surfaces. This can cause permanent alteration or require aggressive scraping to remove labeling errors. See *COG* 1/4 for additional information.

If the surface is too rough or irregular to permit writing directly on the specimen:

- Place a small square of enamel paint (usually white) on the specimen to provide a surface for the catalog number.
- Make sure the paint is completely dry before writing the catalog number.
- Keep the painted area as small as possible in order not to obscure anatomical details.

> *Be careful not to write the catalog number in a place that will obscure any critical anatomical details.*

Other Labeling Strategies

For other types of fossils (those that lack a hard surface), such as the trace fossils discussed above, you'll have to use different labeling methods. Such techniques are similar to those used for other types of collection materials, and may include:

- paper labels tied to the specimen with string
- catalog numbers written on storage containers (using permanent ink)
- labels attached to storage containers
- labels otherwise attached to the specimens in a non-permanent way, such as:
  - a twill tape label (with the catalog number written on the tape in permanent ink) tied to or gently, *but not tightly!* tied around the

specimen
- a similarly-used Tyvek® label

For additional labeling strategies, refer to Appendix T: Curatorial Care of Biological Collections, *COG* 1/4, your regional/SO curator, the NPS Geologic Research Division (GRD), Paleontology Program Coordinator or the Senior Curator of Natural History.

G. Health and Safety Issues

1. *What health and safety issues are related to paleontological specimens?*

Many fossils are oversized and heavy. Don't injure yourself or others. Always:

- Lift properly (use your legs to avoid back strain). For moving and lifting heavy specimens use a:

  – pallet jack

  – forklift

  – other equipment

  Note: Before using any such equipment, be sure that you and others are properly trained in its safe operation.

- Maintain a good grip; don't drop a specimen on someone's foot.

- Wear personal protective equipment (PPE), if needed, such as:

  - Hard hats when working beneath large full skeleton exhibits or whenever you're below overhead hazards that:

    a) might fall on you

    b) you might bump your head against.

  - Respirators if a specimen is being prepared. This will protect you from inhaling hazardous mineral dust.

    Note: Before you can use a respirator, you must first undergo a medical evaluation, formal training, and fit testing. For additional information concerning respirator use, see *COG* 2/13.

Be aware that some specimens may be radioactive.

2. *What types of specimens might be radioactive?*

Fossils from any of these deposits may be radioactive:

- The Morrison Formation and the Glenns Ferry Formation contain uranium.

- Black Shales can emit radon.

- Phosphate deposits like the Phosphoria Formation may include radon-producing minerals.

- Carnotite, which contains uranium, is often found in fossil logs in the Morrison Formation, present in many western parks.

- Sandstone often contains petrified trees and other fossils, which may be radioactive

Ask the collector if the specimens were checked for radioactivity. If not, you'll need to arrange for testing.

3. *How do I test fossils for radioactivity?*

Use a Geiger Counter or a Scintillator. If you do not have this equipment, perhaps a local university's geology department or the state geologist's office can help.

Another option is this low-cost test:

> Place a small piece of unexposed black and white photographic film in a lightproof sleeve and place the specimen on the sleeve. When the film is developed, any fogging will indicate that the specimen is radioactive (Blount, 1990).

4. *What is radon?*

Radon is a radioactive gas resulting from the radioactive decay of radium. Radium is formed by the decay of uranium. As radon decays, it forms radioactive by-products called progeny, decay products, or daughters. These radioactive by-products, if inhaled, can damage lung tissue and cause lung cancer.

Radon is invisible and odorless. It is a dangerous health hazard when it accumulates to high levels inside homes or other structures. Radon is deadly. Indoor radon exposure is estimated to be the second leading cause of lung cancer deaths each year in the United States.

If your park's collection contains radioactive fossils, be sure to monitor radon levels in specimen cabinets and storage areas. Your park safety officer can arrange for appropriate radon testing.

5. *How should I protect staff and the public from radioactive specimens?*

Never be careless around radioactive materials. Follow these general rules:

- Minimize all contact with radioactive specimens.

- Protect everyone from breathing in radon or inhaling or ingesting other radioactive particles.

  - Do not crush, saw, or grind radioactive minerals so as to cause their dust to enter the air, especially indoors.

- As with all museum specimens, never smoke, drink, or eat while handling radioactive minerals.

Note: Inhalation of radon or breathing in or ingesting radioactive minerals or their dust is the most likely method of radiation exposure.

- Wear latex or nitrile gloves whenever handling radioactive specimens.

- Always wash your hands after handling radioactive minerals.

- Work to minimize deposits of radioactive particulates on staff:

  - Always wear a labcoat or other protective outer wear.

- Store all radioactive specimens appropriately. Post proper labels and signage (see Figure U.3. below). Make sure that everyone knows the nature of the materials that they might be handling. Be sure to provide everyone accessing these collections with guidance on handling, precautions, and procedures.

- You may need to store radioactive specimens in a special cabinet with a venting systems (see Figure U.3. below). Refer to *Conserve O Gram* 2/5 "Fossil Vertebrates as Radon Sources: Health Update" for additional information.

- If possible, store radioactive specimens in a separate, secured room that is vented to the outdoors.

Additional Important Safety Notes:

The general rules stated above are NOT adequate for specimens emitting high levels of radiation. Consult an industrial hygienist or the National Institute for Occupational Safety and Health (NIOSH) for assistance developing appropriate control measures.

Contact NIOSH by telephone at: (800) 356-4674 or on the web at: <http://www.cdc.gov/niosh/homepage.html>.

NIOSH also conducts Health Hazard Evaluations (HHE). A HHE is the study of a workplace to see if workers are exposed to hazardous materials or harmful conditions. To request a HHE, or for more information, see the HHE Program website at: <http://www.cdc.gov/niosh/hhe/default.html>. Requests for a HHE must be in writing. The HHE Program website includes an on-line HHE Request Form.

For additional information concerning a HHE relative to paleontological collections, refer to:

> Jiggens, Timothy, E., John J. Cardarelli, and Steven H. Arhrenholz. *NIOSH Health Hazard Evaluation Report: Hagerman Fossil Beds National Monument, National Park Service, U.S. Department of the Interior, Hagerman, Idaho*, HETA 96-0264-2713. Cincinnati:

National Institute for Occupational Safety and Health, 1998. Available on the web at: < http://www.cdc.gov/niosh/hhe/reports/pdfs/1996-0264-2713.pdf > .

Remember:

- There is an inverse square relationship between the level of exposure to radiation from a mineral and the distance you are from it. Radiation levels drop off dramatically the farther you are from the specimen.

- If you plan to use shielding for a radioactive mineral on exhibit, build it using wood and/or acrylic (Plexiglas®).

Figure U.3. Radioactive Specimen Cabinet with Venting System and Safety Signage. Courtesy of Hagerman Fossil Beds National Monument.

> *Always store specimens appropriately and use proper labels and signage that identifies ALL hazardous materials.*

6. *Who should I consult for additional safety information?*

For more information, contact your park safety officer, park or regional public health specialist, regional/SO curator, GRD Paleontology Program Coordinator, or the Senior Curator of Natural History.

7. *Are there any special requirements for loans and shipping of radioactive specimens?*

Yes. The U.S. Department of Transportation (DOT) regulates commercial shipments of hazardous materials, including radioactive articles. These regulations also apply to naturally occurring radioactive substances, such as some fossils. All commercial shipments of radioactive specimens must be in accordance with the shielding, packaging, labeling, and other requirements noted in 49CFR173.426.

Note: The DOT regulations do not apply to shipments of specimens by

NPS (or other Federal) employees in a park (or other U.S. Government) vehicle.

> *If you plan to ship radioactive specimens via commercial carrier (Federal Express, UPS, or another firm), and no one at your park has received hazardous materials transportation training, you will need to hire a certified contractor to prepare any such shipments for commercial transport.*

H. Security and Fire Protection of Paleontological Collections

1. *What are the fire and security considerations for paleontological collections?*

Fire and Disasters. Fossils are just as susceptible to damage due to fire and natural disasters as many other collections. Be sure to:

- Always practice fire prevention, including staff training (such as annual extinguisher training).
- Have an appropriate level of fire protection in every structure where specimens are stored and exhibited, preferably a fire suppression system.
- Have an up-to-date Emergency Operations Plan (EOP). Your EOP should include information about the museum collection, including:
  - the special needs of all collections, including paleontological resources
  - all hazardous collections and materials, including locations and any special requirements

Security. Paleontological specimens have a very high monetary value. The market for fossils is similar to the art market. Collectors compete for prize fossils. There is a thriving black market for fossils. As a result, you may need to implement increased security protection for your collection. Discuss the options with your regional/SO curator, park protection staff, and/or regional law enforcement specialist.

Type specimens. Your collection may include type specimens. Type specimens represent a specimen upon which the description of a new type of fossil taxon is based. As such, it is the specimen to which all future specimens will be compared. As a result, they are priceless to science. Designate all type specimens as controlled property.

> ***Designate all type specimens, monetarily valuable specimens, and all exhibited fossils that are particularly vulnerable to damage or theft as controlled property.***

For additional information, contact your regional/SO curator, regional structural fire management officer, and regional law enforcement specialist.

2. *How can I determine if certain specimens are monetarily valuable?*

You don't have to hire a professional appraiser. You can obtain a good estimate of a fossil's current "market" value by consulting the web catalogs of commercial fossil dealers. When in doubt, contact the GRD Paleontology Program Coordinator or the Senior Curator of Natural History for advice.

Note: Once you've determined a specimen's market price, be sure to note that information on the ANCS+ catalog record.

3. *Are some specimens at increased risk of theft and/or vandalism?*

Yes. There is an ever-increasing commercial market for fossils. Some types of fossils tend to remain popular. These include trilobites, dinosaur parts, amber, and shark's teeth. Skulls, teeth, leaves, and insects can also command high prices.

As with any item, "commercial value" depends on rarity, quality and type of preservation, completeness, or a unique attribute. Some petrified wood can be considered gemstone quality.

Ultimately, all fossils can be potentially sold. Consider all paleontological resources as vulnerable.

4. *How should I best protect specimens at risk?*

Ensure that all museum areas have an appropriate level of security and fire protection. This includes:

- security, access, and other relevant standard operating procedures
- locks (which are always used) on doors, exhibit cases, and storage cabinets
- electronic fire and intrusion detection systems
- a fire suppression system
- fire prevention and fire and security awareness training for all staff
- an up-to-date Structural Fire Plan, Security Plan, and Emergency Operations Plan

These are just a few of the fire and security measures that your park should undertake. For additional information, consult your regional/SO curator and Chapter 9: Museum Collections Security and Fire Protection.

I. Exhibiting Paleontological Specimens

1. *What should I consider when planning or rehabilitating an exhibit?*

Fossils come in all shapes and sizes. First and foremost, consider how you'll place the specimen in the exhibit. Many specimens like shells are simple in shape and can support their own weight. For other specimens, you may have to construct special supports. You should also consider:

- Does the design specify placing the specimen on the floor of the case or attached to the wall?
- Is there a particular part of the fossil that should be clearly visible to illustrate a certain exhibit topic? The exhibit's theme may determine how to display the specimen.

- Does the fossil have projections that are easily broken or snapped off? If so, you may need to build a custom support to position the specimen for easy viewing.

- In some cases adhesives have been used to attach fossils to the exhibit case's interior.

  – Will the adhesive damage the fossil?

    Note: Only use adhesives to mount fossils inside exhibits as a last resort. Be sure to consult with an experienced conservator before using any adhesives.

  – Can it be easily removed or dissolved without damaging the fossil?

  – What is the life of the adhesive?

  – If it becomes dry and brittle, is there the potential for the specimen to fall and become broken?

2. *Are there any other exhibit planning considerations?*

Conservation: Be sure that your exhibits are conservation-conscious. Everyone on the planning team (including contractors) must understand that the preservation of the specimen is paramount.

Security: If you plan to mount a complete skeleton, it's critical that you construct a barrier. The barrier must effectively place the specimen beyond the reach of visitors. There is a strong tendency on the part of visitors to want to touch exhibited specimens. Some parts, such as ribs, can be easily grabbed and ends snapped off. Tails are likewise vulnerable.

Also, as noted above, commercially valuable fossils are at increased risk of theft. For unusual or rare specimens on exhibit, you may need to implement additional security measures. Discuss this matter with your regional/SO curator and park law enforcement staff.

3. *Are there any particular environmental concerns for specimens on exhibit?*

Yes. Fossils that retain their original organic constituents, particularly those from the Pleistocene (Ice Age), may be sensitive to high humidity or ultraviolet light. To ensure their preservation, keep relative humidity levels at 45-55% and eliminate all sources of UV light.

4. *Where can I obtain additional information about exhibiting paleontological specimens?*

Consult the following resources:

- Chapter 7: "Using Museum Collections in Exhibits," in the NPS *Museum Handbook*, Part III: Museum Collections Use

- *Exhibit Conservation Guidelines* CD-ROM, available from HFC.

See Section III. References, for ordering information

- NPS Geologic Research Division, Paleontology Program Coordinator
- NPS Senior Curator of Natural History
- your regional/SO curator
- conservation staff at the NPS Harpers Ferry Center (HFC)
- paleontological/curatorial staff at other NPS units
- paleontological, curatorial, and conservation staff at university, state, or regional natural history museums

J. Preparation and Conservation of Specimens

1. *What is preparation?*

Preparation is the process of readying a paleontological specimen for exhibit, curation, or research use. Preparation can include:

- Removing the rock matrix surrounding some fossils. This enables scientists to conduct a more detailed study of the specimen. It also minimizes the amount of dirt and rock introduced into a specimen cabinet.

  Note: Some specimens must be left in the rock matrix. This provides critical support and stability to the fossil. Also, it may be impossible to remove some fossils from the surrounding rock, such as a fossil leaf or insect.

- Re-attaching broken pieces.
- Applying some type of preservative or consolidant (also called a hardener). This can strengthen the specimen and make it more durable for handling.

2. *Who can I contact to prepare my park's fossil specimens?*

Consult a trained fossil preparator for assistance. Only an experienced fossil preparator (or a curator who has received such training from a preparator) should prepare specimens. If you do not possess such training, contact the NPS GRD Paleontology Program, your regional/SO curator, the Senior Curator of Natural History, or a local university's paleontology department for assistance, recommendations, and/or training opportunities.

Figure U.4. Preparator preparing a specimen. Courtesy of Hagerman Fossil Beds National Monument.

3. *Why should I contact a preparator?*

Fossils differ from other natural history collections; they often require preparation. This is an important intermediate step between their collection in the field and final cataloging and exhibit or storage for research. Only trained professionals should attempt to collect and prepare fossil material. Well-meaning but untrained individuals can easily damage or destroy a specimen. This can rob science of vital data and diminish its value for display, education, or future research.

Protect your collections from such avoidable damage:

- <u>Do not</u> attempt to work on fossils unless you are a trained preparator.

- <u>Do not</u> allow additional preparation to be done by anyone without proof of their qualifications.

- Always document all work done to a specimen and all preservatives used. Keep such documentation in the specimen's catalog folder, accession folder, and/or catalog record. Also, record treatments in the Conservation Module and/or the Preparation Treatment Module of ANCS+.

- Be sure that you obtain all associated records about any fossil deposited in your collection. These records should include all pertinent preparation data. In addition to the general provenience and catalog data required for ANCS+, you should maintain a complete preparation history for each specimen. This record should include:

  - any chemical used to clean the specimen

  - a list of all glues and fillers used

  - any comments the preparator may have recorded. Many labs that do fossil preparation maintain preparation record cards (see Figures U.5 and U.6).

Note: ANCS+ contains a Preparation Treatment Module.

> *Only trained professionals should attempt to collect and prepare fossil material. Unnecessary damage to the specimen can rob science of vital data and diminish its value for display, education, or future research.*

4. *Are there preparators that my park can hire under contract to prepare specimens?*

Yes. You can contract with a museum or university with a fossil preparation laboratory. Parks with paleontology as their focus may have a fully functioning preparation lab. If so, they may be able to assist your park to prepare specimens.

You can hire a trained private practice fossil preparator to work for your park under contract on a project. Check with the Paleontology Program Coordinator in the GRD, the Senior Curator of Natural History, or with paleontologists at other parks on how to proceed if extensive preparation of a specimen is required.

Another option is to use qualified volunteers. Perhaps your park can recruit a retired paleontologist, graduate student, or other individual with fossil preparation skills for the Volunteers-In-Parks (VIP) program. Contact the Paleontology Program Coordinator in the GRD or the Senior Curator of Natural History for assistance.

5. *Are there any special considerations regarding preparation?*

Yes. Fossils should be prepared as quickly as possible. Unprepared fossils are unusable for research, exhibit, or educational purposes and may introduce dust and dirt into storage cabinets.

Also, be aware that:

- Not all glues and consolidants are reversible. Those that contain either alcohol or acetone as a solvent may be reversible. Epoxy adhesives, sometimes used for larger specimens, may not be easily reversed.

- Certain preparation treatments can affect the utility of the specimen:

  - Some hardeners can affect chemical testing.

  - Organic hardeners may contaminate a specimen. This will prevent the use of the Carbon 14 dating technique (for specimens younger than 50,000 years).

  - The ability to extract fossil DNA or study isotopes (to determine the animal's diet) also can be impaired.

  Remember: Many specimens were initially prepared according to the original project's research design and/or the specimen's intended use. Be sure that any proposed treatments (including preventive conservation) will not alter or compromise the specimen's relevance to such research or hinder future investigation.

> *It's impossible to predict what scientific sampling techniques will be developed in the future. Therefore, be sure to keep a permanent record of <u>all</u> chemical treatments applied to the specimen. It then may be possible to remove a chemical at some later date (in order to conduct further analysis).*

6. *How much time does it take to prepare a specimen?*

Preparation time depends on the fossil's size, type of preservation, and nature. Such work can be time consuming. A single dinosaur skeleton such as the *Allosaurus* found at Dinosaur National Monument required 7000 staff-hours of preparation over 4 years. Other types of fossils, such as plant impressions in rock, may require little to no preparation. Other fossils might be ready for exhibit or storage within a matter of days or weeks.

7. *Should I have damaged and/or incomplete specimens repaired?*

Yes, if you don't make necessary repairs, any broken parts can easily become separated and lost. Contact an experienced fossil preparator to repair any broken specimens as soon as possible.

8. *Are there occasions when I should not have a preparator repair a damaged specimen?*

Yes. In some cases repair may not be possible. Store the loose pieces in a properly labeled vial or other container. Depending on the nature of the break, the pieces may be too large or heavy to be reattached (like dinosaur bones).

On rare occasions, breakage may be seen as fortuitous: it permits examination of the specimen's internal structure. In these instances, you may decide against repairing the break.

9. *What's the best way to repair specimens?*

Avoid the need for repair. Make certain that specimens are not damaged in the first place:

- Consistently practice preventive conservation.
- Ensure that all collection users know and use proper handling techniques.

If breakage does occur, take time to determine the cause. Was the breakage:

- accidental (someone bumped into the specimen)?
- due to mishandling (the specimen was handled inappropriately)?
- a result of improper storage or exhibit design? Is the specimen:
  - not in a cradle or other support structure?
  - not properly supported or protected?
  - in a support that needs to be modified?

Remember: The best conservation approach is a preventive one. Once a specimen is broken, it is likely to be broken in the same spot again.

10. *What about applying protective coatings to specimens?*

As noted above, it's appropriate and sometimes necessary to use a hardener or consolidant to strengthen a fossil. This can ensure its long-term stability. However, while the anatomical features may be preserved, such treatments can impact research utility (Carbon 14 dating, isotope studies, or the extraction of DNA).

The best protection for fossils on a flat surface (such as leaves, insects and fish on the bedding plane of shale) is a thin clear coating.

For three-dimensional fossils such as bones, the preparator may need to saturate the specimen with a hardener in order to increase its structural integrity. In these cases, a thin covering may not suffice. If this protective shell is damaged or broken and the specimen lacks internal strength, the entire specimen may crumble.

Once again, you need to consider the intended use of the specimen (exhibit, research, or possibly both) before you make any treatment decisions.

11. *Who should clean specimens?*

To a paleontologist, the cleaning of fossils means the removal of the surrounding rock or matrix during the preparation process, as previously discussed. Once the specimens are prepared, they are subject to accumulating dust, just like other museum objects. To minimize dust on specimens:

- house small specimens in closed storage cabinets
- cover open shelving with plastic sheeting

These actions cannot eliminate all dust. Unless you conduct periodic housekeeping, dust and dirt will accumulate. Consult your park's Museum Housekeeping Plan to determine the frequency that fossil specimens should be periodically cleaned. If you do not have a Housekeeping Plan, or if it is out of date, consult your regional/SO curator, the GRD Paleontology Program Coordinator, the Senior Curator of Natural History, and/or a natural history conservator to establish recommended cleaning guidelines.

From time to time, you'll need to gently vacuum and/or use a soft brush to dust certain specimens. Many larger bones may have fragile processes that are easily broken or snapped. As with all other collections, be very careful whenever removing dust from

SECTION II: GEOLOGICAL COLLECTIONS

A. Overview

1. *What information concerning geological collections will I find in this appendix?*

In this section of the appendix you will find:

- a discussion of the characteristics of geological collections
- guidelines and resources to aid in identifying different types of geological specimens
- tools for recognizing deterioration
- information about proper storage environments
- health and safety concerns
- additional sources of information

2. *Why is it important to practice preventive conservation with geological specimens?*

The general impression that “rocks” are inert, strong, and durable is false. Many geological specimens can be:

- fragile
- chemically active
- easily damaged

3. *How do I learn about preventive conservation?*

Read about the agents of deterioration in Section C and the proper storage of specimens in Section D. See Chapter 3: Preservation: Getting Started, and Chapter 4: Museum Collections Environment, for a discussion on the agents of deterioration. Also refer to *Museum Handbook*, Part III (*MH-III*), Chapter 7: Using Museum Collections in Exhibits.

4. *Where can I find the latest information on care of geological specimens?*

Several professional organizations focus on the care of natural history collections, including geological specimens. Such organizations’ publications often contain articles on the care of geological specimens. Examples include:

- The Society for the Preservation of Natural History Collections (SPNHC) publishes *Collection Forum*
- The Geological Curators’ Group in England publishes a newsletter, *The Coprolite* and a technical series, *The Geological Curator*.

Refer to Section III of this appendix for additional information.

B. Geological Collections

1. *What types of geological specimens are generally found in park collections?*

Since all parks have geology, there's always the potential for geological specimens in a park's collection. Geological collections can include:

- rocks (igneous, sedimentary, and metamorphic)
- mineral specimens (including crystals)
- ores
- cave formations and minerals
- samples of geological formations
- soils
- building stone samples

2. *What is a rock?*

A rock is an aggregate of one or more minerals or a body of undifferentiated mineral matter. Rocks are divided into three different types:

- Igneous Rocks solidified from molten or partly molten material. Examples include:
  - basalt lava flows found at Hawaii Volcanoes, Craters of the Moon, El Malpais, Lava Beds, and Devil's Postpile
  - lava bombs (features associated with lava flows)
  - granite at Yosemite
  - obsidian at Yellowstone
- Sedimentary Rocks result from the consolidation of loose sediment that has accumulated in layers. Sedimentary rocks are divided into:
  - clastic rocks formed by the mechanical breakdown of fragments of older rock, such as sands and shales
  - chemical rock formed by the precipitation of minerals such as gypsum or limestone from solution
  - organic rock formed by the secretions of plants or animals or accumulations of organic matter such as coal or shell fragments called coquina used in the construction of the fort at Castillo de San Marcos

  Examples include sandstones in Glen Canyon, limestones at Guadalupe Mountains, dolomites, shales, clays like bentonite at Bighorn Canyon and Cuyahoga Valley, and coal at New River Gorge.

Some parks have loose sands and sand dunes. Samples of sand may be collected and placed in the park collection such as the gypsum sand at White Sands or silica sands at Great Sand Dunes or Sleeping Bear Dunes.

- Metamorphic Rocks are modifided pre-existing rocks. They undergo metamorphosis in response to marked changes in temperature, pressure, shearing stress, and chemical environment. Examples include:

  – gneiss and schist in the Grand Canyon

  – marble at Oregon Caves, Great Basin, and Mojave

3. *What is a mineral?*

Characteristics of minerals include:

- naturally occurring inorganic element or compound
- orderly internal structure
- characteristic chemical composition
- crystal form
- physical properties

Examples include pyrite (also known as "Fools Gold") from Prince William Forest and borate minerals from Death Valley. Today, over 4,200 different types of minerals are known to science.

4. *What are ores?*

Ores are the natural material from which a mineral of economic value can be extracted at a profit. In general, the term is used to refer to metal-bearing rock. Many parks have historic mines and samples of ores from these mines may be present in the park collection. Copper ores are known from Delaware Water Gap, Keweenaw, and Wrangell-St. Elias. Prince William Forest has a historic pyrite mine.

5. *Why do some collections include cave formations?*

Even though NPS policy is to ensure that all cave minerals and formations are managed in place, many parks with caves will have examples of cave formations (stalactites, stalagmites, cave pearls) or minerals in their collections. Often these specimens were salvaged during trail construction or other similar activities.

Most cave formations are composed of calcium carbonate but may be formed by either calcite (more commonly) or aragonite (rarer) crystals. Cave formations composed of aragonite are more fragile and subject to damage. There are a variety of cave minerals. Depending on their chemical composition, they may require special conditions for their preservation.

Cave formations and minerals are in the collections at Mammoth Cave and Carlsbad Caverns. A good reference for helping with the identification of cave formations and minerals is *Cave Minerals of the World* by Carol Hill and Paolo Forti (1997).

6. *Why do some collections contain quarried stone?*

Some parks like Harpers Ferry and Acadia have historic stone quarries that were used in building construction. Examples of the rock types from these quarries may be placed in the park collection. Other parks, such as Alibates Flint Quarries, may have prehistoric quarries where chert or flint was mined by Native Americans or the catlinite quarry at Pipestone. Reference samples of this rock material may be placed in park collections.

7. *How do I identify the different types of specimens?*

You may need a geologist or mineralogist to help you identify a particular mineral, but the standard reference for mineral identification is: *Dana's New Mineralogy: The System of Mineralogy of James Dwight Dana and Edward Salisbury Dana* by Richard V. Gaines et. al. (1997).

C. Factors That Contribute to Specimen Deterioration

1. *What agents of deterioration affect geological specimens?*

Deterioration can result from:

- Physical damage resulting from improper storage or handling
- Chemical changes, depending on the chemical composition of the specimen and the environment in which it is stored.

2. *How can I identify active deterioration?*

Look for:

- physical changes in the specimen, such as changes in size or shape
- “growth” of new minerals on the surface
- spalling
- breakage
- powdery residues
- change in color
- change in translucency
- swelling
- uncharacteristic odors

> *Also, look for darkening, embrittlement, and shrinkage of old coatings and adhesives. These can be very damaging to geological collections.*

3. *How can I protect my specimens from deterioration?*

The best approach is to maintain:

- proper storage
- climate control systems
- an active environmental and Integrated Pest Management (IPM) monitoring program

Begin at the microenvironmental level and work outward. If you have a limited budget, you may have to start small. First, invest in archival-quality enclosures and trays. If you have additional funding available, perhaps you can purchase new storage cabinets. The perfect scenario, if funding is appropriate is:

- a heating and cooling system that maintains appropriate environmental conditions facility-wide
- proper storage cabinets
- archival-quality enclosures and trays

No matter what your park can afford, be sure to take the time to maintain accurate records of your museum facilities' environments, including:

- temperature
- relative humidity
- visible and UV light
- IPM

4. *What is the best relative humidity and temperature for my specimens?*

Maintain a stable storage environment:

- temperature of 59° - 77°F
- relative humidity at 45-55%

Relative humidity may not be a critical factor in the storage of most geological specimens. However, some anhydrous (water-free) minerals will absorb moisture from the atmosphere. Store these specimens in a cabinet or room that is maintained in a low humidity environment. You may need to place trays or packages of silica gel or some other desiccant in the cabinet to help reduce humidity levels. Conduct regular monitoring. Remember to regularly check and recondition or replace the silica gel, as needed. For additional information, see *COG*s 1/8 "Using Silica Gel in Microenvironments" and 2/15 "Cobalt Indicating Silica Gel Health and Safety Update."

5. *Should I be concerned about atmospheric pollution?*

Yes. Both gaseous and particulate pollutants can accelerate deterioration, especially if they are acidic or caustic. Many minerals, including calcium carbonate, are highly susceptible to reactions with acids. Particulates can lodge on surfaces and surface coatings, which you'll need to clean off (this is never a risk-free procedure [see below]).

In addition, some geological specimens are themselves sources of gaseous pollutants:

- mercury vapor is readily liberated from cinnabar
- a number of uranium-series minerals release radon
- asbestos-containing minerals may break down enough to release inhalable particles

> *Monitor all specimens known to contain hazardous substances. Seek expert advice. Remember that such items may require separate storage (or transfer to a more appropriate facility).*

6. *Does cleaning contribute to deterioration?*

Yes. Both custodial (room-level) cleaning and specimen (preparation-level) cleaning can expose the specimen to rough handling and caustic materials. Maintenance chemicals that can cause severe damage to specimens include: chlorine bleach, ammonia, other cleaning agents, waxes, and related materials. Whenever possible, utilize nontoxic cleaning alternatives (see *COG* 2/21 "Safer Cleaning Alternatives for the Museum and Visitor Center"). Carelessness and improper techniques can cause damage through vibration and impact.

Remember that specimen cleaning is an irreversible process in many instances. Cleaning can cause loss of:

- matrix
- parts of the actual specimen
- associated trace material

Don't clean a specimen just to keep up a routine. Ask yourself if cleaning really is necessary. If not, don't do it.

7. *Are there any other deterioration concerns?*

Some sulphate-based cave minerals such as selenite (calcium sulphate) and epsomite (magnesium sulphate) readily absorb water from the atmosphere and can disintegrate. To prevent deterioration, any mineral that can potentially absorb water must be stored in a low humidity environment. For additional information, see Holmberg (2000) and Jerz (2000), noted in the bibliography.

D. Handling and Storage of Geological Collections

1. *What do I need to know about handling specimens?*

Weight
Depending on the size of the specimen, weight can be a major factor. You may need to access heavily loaded cabinet drawers. Be sure not to overload drawers; consult the manufacturer's recommended weight loads and do not exceed them. Always use extreme caution; due to its weight, if a specimen

shifts it may cause the drawer to tip.

Transport

Never carry specimens to a table or other area. Use a wheeled, sturdy cart with a padded surface to transport specimens between storage cabinets and exhibit or research areas.

Handling

Protect the specimen. Practice limited handling. Specimens should spend as little time outside storage cabinets or exhibit cases as possible. Only handle specimens on or over a work surface.

Gloves

Contrary to standard handling practice with other museum collections, DO NOT wear cotton gloves when handling geology specimens. The specimen may be slippery, and you could easily drop it. Use your clean, bare hands to assure a good grip.

Lab Coats and Other Protective Outerwear

Wear a labcoat or other type of protective outer garment when handling collections. This will help to minimize deposits of particulates and dirt on your clothing. Wearing a labcoat also helps to protect the specimen from damage due to contact with badges, jewelry, and belt buckles. Another option is to wear a Tyvek® "jumpsuit," sold in paint stores.

2. *How should I store specimens?*

Use standard geology cabinets for most specimens (see *Tools of the Trade* for additional information). As with other collection items, you can store small specimens in trays, cavity-packed in polyethylene foam. This is a good idea for items that may require more frequent access and transport for research purposes.

For larger specimens, you'll probably need to use open shelf storage. Very large specimens such as pieces of building stone or larger ore samples may require their own pallet for support. To move these specimens, you'll need a pallet jack.

Since a specimen may spend well over 95% of time in storage, proper storage systems are a wise long-term investment. As with all collections, inappropriate storage materials put the specimen at risk. Always use acid-free, inert storage materials and housings. Cabinetry should be of steel construction, with high gloss, epoxy powder coatings.

3. *What additional protection do geological specimens need in storage?*

- In general, don't leave a specimen on a bare surface exposed to the open lab conditions.
- Make sure that specimens (particularly large ones) are not supporting their weight on appendages, attachments, or other weak areas.
- Pad surfaces with inert closed-cell polyethylene foam (such as Volara® or Plastizote®).
- Use closed storage wherever possible.
- For large specimens, use custom-made reinforced fiberglass jackets (the same principle as cavity packing, but on a much larger scale).

This facilitates open shelf storage.

- Place smaller specimens in specimen trays.

Protection from high and/or fluctuating temperature and relative humidity are important for all specimens. Other threats include:

- UV exposure
- water
- fire
- theft and vandalism
- related factors

E. Health and Safety Issues

1. *What health and safety issues are related to geological specimens?*

Some minerals may contain elements that are toxic. The most common ones are:

- Aluminum
- Antimony
- Arsenic
- Beryllium
- Bismuth
- Bromine
- Cadmium
- Lead
- Mercury
- Selenium
- Thallium
- Uranium

Handle all of these minerals with care.

Many parks have historic mines that extracted minerals that may be considered hazardous to human health. Some examples include:

- Cinnabar, which is a mercury sulfide (HgS) mineral.

- Arsenopyrite (FeAsS), which includes arsenic.
- Asbestos, which is a variety of fibrous, nonflammable minerals with flexibility and high tensile strength. Asbestos includes minerals such as chrysotile, amphibole, and crocidolite.

Specimens of these economically important minerals related to historical mining in the parks may be present in park collections and used in park exhibits.

2. *How can I best protect the health of staff and researchers using potentially toxic collections?*

Make sure that a mineral has been properly identified and that you are aware of its chemical composition. If a mineral does contain potentially toxic elements, always wear neoprene gloves when handling it. Be sure to wash your hands after you finish handling any other minerals with bare hands, as a precaution. As with all collections, never allow food or drink around mineral specimens.

> *Always wear neoprene gloves when handling minerals that contain potentially toxic elements.*

3. *What other safety concerns should I consider?*

Take into account the following:

Heavy Metals
Heavy metals cause problems by displacing or replacing related minerals that are required for essential body functions. For example, cadmium can replace zinc, and lead displaces calcium. When this happens, cadmium or lead is stored in the bones or other tissues and becomes difficult to remove from the body. At the same time, the important functions of the minerals that are replaced cannot be carried out.

Toxic Gases
Some minerals may release gases or vapors. In a closed specimen cabinet, this can generate high concentrations of toxic gases. These can include:

- acidic vapors (thought to be primarily carboxylic acid vapors)
- mercury vapor
- sulfur dioxide
- hydrogen sulfide, the gas that tarnishes silver

Label all cabinets housing such minerals with the appropriate National Fire Protection Association (NFPA) Hazard Warning Symbol. This will ensure that all personnel (staff, visitors, and emergency workers) are aware of these potential hazards.

Note: See Chapter 11: Curatorial Health and Safety, Figure 11:4 on page 11:45, for an example of the NFPA Hazard Warning Symbol System.

Also, be sure to note the presence of these minerals in relevant emergency planning documents (such as your Museum Emergency Operations Plan [MEOP]) and brief all first responders on their presence and locations.

Mineral Dust

Inhaling mineral dust may be more of a hazard than handling the specimen. The amount of dust depends on how friable the specimen is and how it is handled. For example, handling may release asbestos fibers. Although mineral dust may not be a primary problem in museum collections, at times it may be important to use a good quality respirator when handling specimens, especially if they are being cut or trimmed.

Note: Before you can use a respirator, you must first undergo a medical evaluation, formal training, and fit testing. For additional information concerning respirator use, see *COG* 2/13.

4. *Could some specimens be radioactive?*

Yes. Many parks contain radioactive minerals or ores. Some examples of common radioactive minerals include:

- Autunite (hydrated calcium uranium phosphate)
- Brannerite (uranium titanate)
- Carnotite (potassium uranium vanadate)
- Monazite (a mixed rare earth and thorium phosphate)
- Thorianite (thorium dioxide)
- Uraninite (uranium dioxide)

The vast majority of the radioactive content in minerals or ores is either uranium-238 or thorium-232, although other radioactive elements may be present. Uranium minerals are found in Blue Ridge Parkway, and many western parks such as Canyonlands have abandoned uranium mines, so it is possible that uranium minerals will be present in park collections.

5. *What terms should I know that are relative to radioactivity?*

Radioactivity is the spontaneous release of particles and energy by the nucleus of an unstable atom. This is part of a natural decay process in which an unstable element is transformed into a stable element, such as uranium-238 becoming lead-206. There may be a number of intermediate stages or daughter elements.

Radiation in the common sense refers to *ionizing radiation*: a term for invisible particles or waves with enough energy to strip electrons from atoms, causing chemical changes. The three basic types of natural radiation are alpha, beta, and gamma. There are also X-rays and neutrons.

An alpha particle is composed of two protons and two neutrons-essentially it's a helium nucleus, an ionized helium atom (a helium atom devoid of its electrons and having a net charge of +2). Alpha particles are comparatively large and cannot penetrate much more than a sheet of paper or a few inches of air. However, they are extremely potent ionizing agents because they interact with plenty of matter in their [short] path.

A beta particle (actually a "beta-minus" particle, since it has a charge of -1) is a stray electron originating from an atom's nucleus as the result of neutron breakdown. "Beta-plus" particles are positrons or "positive electrons," something seldom encountered in nature. Beta radiation can be stopped by a few centimeters of wood, plastic, or glass. A few millimeters of aluminum will also stop most beta particles.

Note: Do <u>not</u> use lead or other highly dense materials to shield from beta radiation. Certain types of shielding can actually be worse than none. Lead and other dense metals (including tungsten) can emit X-rays when exposed to beta particles such as those thrown out by the natural decay products of U-238 and Th-232. This phenomenon is called *bremsstrahlung*. If the lead is thick enough, the X-rays won't get out the other side of it. Nevertheless, if you're going to use shielding for a mineral display, it's best to make it out of wood or acrylic (Plexiglas®).

Gamma radiation is composed of high-energy photons (invisible light; electromagnetic waves). It has no charge, but its high energy means that it can cause ionization. Fortunately, gamma rays move so fast and have such energy that they often pass right through matter without interacting at all.

6. *How can I determine if specimens are radioactive?*

It's vital to correctly identify a mineral's composition. If you have a specimen that you suspect is radioactive, confirm its identification with a trained mineralogist. Most university geology departments include a mineralogist on the faculty. The crystal structure, color, and other physical properties may permit a quick identification. If a Geiger counter or scintillator is available, you can use it to detect the presence of radioactive particles. If you do not have access to a Geiger counter or a mineralogist, use the procedure to detect radioactivity in specimens proposed by Blount (1990):

> Place the specimen on a small piece of unexposed black-and-white photographic film in a lightproof sleeve and then have it developed to check for fogging.

7. *What is radon?*

Radon is a naturally occurring radioactive gas that is colorless, odorless, tasteless, and chemically inert. It is found in soils, rock, and water throughout the U.S. Because radon occurs throughout the nation, it's possible that specimens in your collection emit radon. Radon has a half-life of only 3.5 days, but when a radon-emitting sample is stored in a closed specimen cabinet, radon levels may come to equilibrium over time. The actual amount of radon will depend on the number, volume and chemical composition of the radioactive mineral specimens stored in the cabinet.

30 CFR, Part 57, Subpart D regulates occupational levels of alpha and gamma radiation in underground uranium mines. Occupational yearly exposure per individual shall not exceed 4 WLM (working level month) alpha or 5 REM (Roentgen Equivalent Man = the amount of ionizing radiation that when absorbed by a person is equivalent to one roentgen or x-ray or gamma radiation) gamma. While these levels may not exist in most park collections, they do provide a standard by which staff safety can be measured. Generally the EPA typically recommends 10% of occupational limits for the general public.

If you have concerns regarding occupational exposure to radioactive specimens in your park's collection, consult with an industrial hygienist, NIOSH, and/or the U.S. Public Health Service specialist duty-stationed in your park or region.

8. *How should I protect staff and the public from radioactive specimens?*

<u>Never</u> be careless around radioactive materials. Follow these general rules:

- Minimize all contact with radioactive specimens.
- Protect everyone from breathing in radon or inhaling or ingesting other radioactive particles.
  - Do not crush, saw, or grind radioactive minerals so as to cause their dust to enter the air, especially indoors.
  - As with all museum specimens, never smoke, drink, or eat while handling radioactive minerals.

  Note: Inhalation of radon or breathing in or ingesting radioactive minerals or their dust is the most likely method of radiation exposure.
- Wear latex or nitrile gloves whenever handling radioactive specimens.
- Always wash your hands after handling radioactive minerals.
- Work to minimize deposits of radioactive particulates on staff:
  - Always wear a labcoat or other protective outer wear.
- Store all radioactive specimens appropriately. Post proper labels and signage (see Figure U.3. above). Make sure that everyone knows the nature of the materials that they might be handling. Be sure to provide everyone accessing these collections with guidance on handling, precautions, and procedures.
- You may need to store radioactive specimens in a special cabinet with a venting systems (see Figure U.3.). Refer to *Conserve O Gram* 2/5 “Fossil Vertebrates as Radon Sources: Health Update” for additional information.
- If possible, store radioactive specimens in a separate, secured room that is vented to the outdoors.

<u>Additional Important Safety Notes</u>:

The general rules stated above are NOT adequate for specimens emitting high levels of radiation. Consult an industrial hygienist or the National Institute for Occupational Safety and Health (NIOSH) for assistance developing appropriate control measures.

Contact NIOSH by telephone at: (800) 356-4674 or on the web at: <http://www.cdc.gov/niosh/homepage.html>.

NIOSH also conducts Health Hazard Evaluations (HHE). A HHE is the study of a workplace to see if workers are exposed to hazardous materials or harmful conditions. To request a HHE, or for more information, see the HHE Program website at: <http://www.cdc.gov/niosh/hhe/default.html>.

Requests for a HHE must be in writing. The HHE Program website includes an on-line HHE Request Form.

For additional information concerning a HHE relative to geological and paleontological collections, refer to:

> Jiggens, Timothy, E., John J. Cardarelli, and Steven H. Arhrenholz. *NIOSH Health Hazard Evaluation Report: Hagerman Fossil Beds National Monument, National Park Service, U.S. Department of the Interior, Hagerman, Idaho*, HETA 96-0264-2713. Cincinnati: National Institute for Occupational Safety and Health, 1998. Available on the web at: <http://www.cdc.gov/niosh/hhe/reports/pdfs/1996-0264-2713.pdf>.

<u>Remember</u>:

- There is an inverse square relationship between the level of exposure to radiation from a mineral and the distance you are from it. Radiation levels drop off dramatically the farther you are from the specimen.

- If you're going to use shielding for a radioactive mineral on exhibit, it's best to make it out of wood and/or acrylic (Plexiglas®).

> *Always store specimens appropriately and use proper labels and signage that identifies <u>ALL</u> hazardous materials.*

9. *Are there any other human health risks associated with geological specimens?*

Some specimens of rocks or minerals are large and difficult to move. You may want to store such specimens on pallets and use a pallet jack or forklift to move them. Always follow proper safety precautions. Use appropriate techniques and equipment.

F. Security Concerns

1. *Are some types of specimens at increased risk of theft and/or vandalism?*

Gold nuggets and silver specimens have commercial value; store them in a safe. Other minerals may be vulnerable, including:

- certain rare and valuable mineral specimens
- minerals with good crystal structure
- some minerals of gemstone quality
- small specimens, which are easier for a thief to pick up and steal

2. *How should I best protect specimens at risk?*

You may wish to have a professional mineral appraiser examine your collections. An appraiser can provide an indication of the market value of specimens. Appraisals can help you to decide which specimens may require increased levels of security.

As noted above, some specimens should not be stored with other items. Rather, they require their own secure storage areas. Specimens that may require separate storage include radioactive specimens and those that produce gases.

For additional information concerning museum security, refer to Chapter 9: Museum Collections Security and Fire Protection.

G. Exhibiting Geological Specimens

1. *What should I consider when planning an exhibit?*

Geology exhibits usually focus on two broad interpretive themes:

- Processes. The specimens illustrate a process such as erosion or volcanic activity.
- Objects. The exhibit focuses on the specimens themselves, such as examples of different rock types or mineral ores.

Do not select specimens for exhibit until the exhibit planning team has developed interpretive themes. As the Exhibit Plan progresses, the planning team can then decide how each specimen can best illustrate the story being told.

> *Always consider the durability of a specimen and its value when deciding how to exhibit it (either as a touch specimen or in an exhibit case).*

2. *Are there any particular concerns for exhibiting geological specimens?*

Many geological specimens are relatively inert; they don't require any special conditions. Often, because of their durability, geological specimens are used as touch exhibits. Make sure that specimens selected for use as touch specimens do not contain any toxic or radioactive substances. Place fragile specimens (such as some smaller crystals) inside an exhibit case. Massive crystals such as quartz may be suitable for a touch exhibit.

3. *Are there any specific situations that I should avoid when exhibiting geological specimens?*

Do not assume that all objects classified as geological specimens are the same. Know the properties of each specimen and how these different properties can affect the potential for damage. This includes damage from environmental conditions, improper display, or inappropriate handling.

4. *What should I know about cleaning geological specimens?*

The care and cleaning of specimens on exhibit is similar to that of other objects. Dry dusting and vacuuming may be appropriate for larger specimens but not for smaller fragile specimens. A damp cloth may be appropriate for some rock types but not water-soluble minerals like certain types of salts.

Practice preventive conservation. A proper exhibit case design can prevent dust accumulation. This approach is preferable to cleaning specimens after they become dusty. Know the composition of the specimen and its degree of durability prior to any decision on how it should be cleaned.

H. Conservation of Specimens

1. *When should I contact a conservator?*

Contact a geological conservator if you notice any signs that the specimen is reacting to environmental conditions such as:

- new crystal growth
- deterioration of labels or storage materials

A trained geological conservator may be able to provide simple corrective steps that will address the immediate problem or determine if more serious treatment is warranted. For example, if there is active deterioration of the specimen, the conservator may be able to determine if it is the result of environmental conditions in storage or other causes. Proper diagnosis of the problem is critical in order to correct the situation.

2. *Should park staff repair damaged and/or incomplete specimens?*

Do not attempt any specimen repairs yourself. The various glues and adhesives in common use can cause long-term damage to the specimen. If the specimen is intended solely for exhibit, you may be able to have a conservator repair it. However, it's vital to ensure that specimens used in research are not chemically contaminated. Do not use any adhesives (or any other chemical additives) on such specimens.

> *Remember: Many specimens were initially prepared according to the original project's research design and/or the specimen's intended use. Be sure that any proposed treatments (including preventive conservation) will not alter or compromise the specimen's relevance to such research or hinder future investigation.*

3. *What types of repairs can a conservator undertake?*

A conservator <u>can</u>:

- recommend what can (and cannot) be done for the specimen
- advise you if conservation work is necessary
- do advanced cleaning and stabilization. Such work may be beyond even the resources of a park that has its own laboratory and trained staff.
- undertake delicate repairs and infills of specimens. Note: Infills, reconstructions and replacement of missing parts may be acceptable for exhibition and interpretive uses. Any such repairs should be:
  - easily distinguishable from the original specimen
  - inert
  - reversible

Exhibiting repaired specimens also may require you to alter or revise related interpretive elements. Each specimen creates its own set of concerns and issues.

4. *What type of damage is beyond repair by a conservator?*

A conservator <u>cannot</u> undo irreversible damage. Such examples include:

- fading caused by UV exposure
- breaks

> *Breaks are irreversible. They do not "go away" when the specimen is glued back together.*

5. *Should protective coatings be applied to specimens?*

As a general rule, protective coatings are not currently applied to geological specimens. Older specimens may have been coated with a variety of poor-quality substances, including shellac, waxes, oils, films, and spray-on polymers.

6. *What about cleaning specimens?*

Many larger, hardier specimens (like rocks and ores) can withstand occasional cleaning. In some cases, trained park staff can clean specimens. Appropriate methods, techniques, cleaning supplies, and equipment vary with the chemical composition of the specimen. For example:

- Don't use water to clean certain minerals, such as salt minerals like halite (sodium chloride) or gypsum (calcium sulfate) because they are soluble in water.
- Specimens with small delicate crystals may require procedures to remove dust and dirt.
- Ultrasonic cleaners can be used to clean some small crystal specimens. The technique used depends on the minerals (Hansen, 1984).

Before starting, be sure to consult your park's Museum Housekeeping Plan. It will help you determine:

- which specimens you can safely clean
- which specimens should only be cleaned by a conservator (or some other specially trained individual)
- the frequency that specimens should be cleaned
- appropriate method, techniques, supplies, and equipment.

If you do not have a Housekeeping Plan, or if it's out of date, consult your regional/SO curator, the NPS Geological Resources Division, and/or a natural history conservator to establish recommended cleaning guidelines.

SECTION III. REFERENCES

A. National Park Service Resources

- Geologic Resources Division, Paleontology Program
  P.O. Box 25287
  Denver, Colorado 80225-0287
  www2.nature.nps.gov/geology/paleontology

- Senior Curator of Natural History, Park Museum Management Program
  1201 Oakridge Drive, Suite 150
  Fort Collins, Colorado 80525
  (970) 267-2167

- Your regional/SO curator

B. Professional Organizations

The Society of Vertebrate Paleontology has a preparators' group and a special session at their annual meetings to discuss fossil preparation and related topics. Contact the society at:

Society of Vertebrate Paleontology
60 Revere Drive
Suite 500
Northbrook, IL 60062
www.vertpaleo.org

The Society for the Preservation of Natural History Collections (SPNHC), represents the interests of natural history collections and the people associated with the management and care of these collections. Publications include *Collection Forum* and *SPNHC Newsletter*. SPNHC's annual meetings include formal presentations and workshops. Contact SPNHC at:

Society for the Preservation of Natural History Collections
PO Box 797
Washington, DC 20044
www.spnhc.org

The Paleontological Society is an international association dedicated to the science of paleontology. The organization publishes the *Journal of Paleontology*, *Paleobiology*, *The Paleontological Society Memoirs*, *Short Course Notes*, and various other special publications. The society holds an annual meeting, as well as regional meetings. Contact the society at:

The Paleontological Society
PO Box 7075
Lawrence, KS 66044
(785) 843-1235 ext. 297
www.paleosoc.org

The Paleobotanical Section of the Botanical Society of America is an organization of individuals concerned with fossil plants. The section publishes the *Bibliography of American Paleobotany*, as well as other materials and special publications. The Paleobotanical Section holds workshops and conferences at the annual meeting of the Botanical Society of America. For additional information, refer to their website at: < www.dartmouth.edu/ ~ daghlian/paleo > .

The Mineralogical Society of America promotes scientific research, teaching, and educating the public concerning mineralogy. The Society publishes *American Mineralogist*, *Reviews in Mineralogy and Geochemistry*, monographs, a newsletter, and books. It holds courses, lectureships, symposia, and meetings. The organization also gives grants and awards. For further information, contact the society at:

Mineralogical Society of America
1015 18th Street, NW, Suite 601
Washington, DC 20036
(202) 775-4344
www.minsocam.org

The Geological Curator's Group in England was established in 1974 to improve the status of geology in museums and raise the standard of geological curation. Their goals are to advise, inform, and create a forum for discussion for all aspects of the care of geological collections as an irreplaceable part of our scientific and cultural heritage.

The Geological Curator's Group is affiliated to the Geological Society of London. For further information, refer to the Group's website at: <http://www.hmag.gla.ac.uk/gcg > .

C. Glossary

Body fossil: the preserved remains of any anatomical part of a plant or animal.

Carbonization: the accumulation of residual carbon from a plant or animal by changes in the organic matter and decomposition products.

Consolidant: any type of material, often a plastic or shellac, used to hardened and strengthen a specimen. Applied by either specimen immersion or surface application.

Fossil: any remains, trace or imprint of a plant or animal that has been preserved in the earth's crust since some past geological time.

Mineral: a naturally occurring inorganic element or compound having an orderly internal structure and characteristic chemical composition, crystal form, and physical properties.

Ore: the natural material from which a mineral or minerals of economic value can be extracted at reasonable profit. Usually applied to metalliferous material.

Permineralization: a process of fossilization whereby the original hard parts of a plant or an animal have additional material deposited in their pore space.

Pyrite disease: humidity-driven oxidation of pyrite (iron sulfide) that affects the microcrystalline or framboidal forms that change the iron sulfide to iron sulfate.

Replacement: a process of fossilization involving the substitution of inorganic material for the original organic constituents of an organism.

Rock: an aggregate of one or more minerals or a body of undifferentiated mineral matter. Rocks are divided into three different types: igneous, sedimentary and metamorphic.

a. Igneous Rock: rocks or minerals that solidified from molten or partly molten material.

b. Sedimentary Rock: a rock resulting from the consolidation of loose sediment that has accumulated in layers. Sedimentary rocks are divided into:

- clastic rocks formed by the mechanical breakdown of fragments of older rock such as sands and shales
- chemical rocks formed by the precipitation of minerals such as gypsum or limestone from solution
- organic rocks formed by the secretions of plants or animals or accumulations of organic matter such as coal.

c. Metamorphic Rock: any rock derived from pre-existing rocks by mineralogical, chemical and/or structural changes, essentially in the solid state, in response to marked changes in temperature, pressure, shearing stress, and chemical environment.

Trace fossil: a sedimentary structure resulting from the life activity of an animal such as a track, trail, burrow, tube, boring or tunnel, or marks on other fossils indicating feeding or chewing activities or the preserved feces of an animal.

D. Web Resources

The National Institute for Occupational Safety and Health (NIOSH)
http://www.cdc.gov/niosh

NIOSH Health Hazard Evaluation (HHE) Program
http://www.cdc.gov/niosh/hhe

Quality Condition Score for Paleontology/Geology collections
http://fenscore.man.ac.uk/Formspage1.htm
http://fenscore.man.ac.uk/FORMF3.htm.

Fossil Plant Preservation
http://www.ucmp.berkeley.edu/IB181/VPL/Pres/Pres2.html
http://www.korrnet.org/kgms/feb-01/feb01-8.htm

Radioactive Minerals
http://www.crscientific.com/radiation.html

Mineral Dust
http://www.minsocam.org/MSA/RIM/Rim28.html

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National Park Service
Paleontological Specimens
Preparation/Conservation Record

Catalog Number JODA 8499 Accession Number 248 Field Number DF8001

Taxon: *Stylemys Sp*.

Description: Cranium and shell fragments

1. Permanent Location: Collection Storage, Cabinet 56, Drawer 3

2. Field Observations: when collected it was not recognized as a turtle skull immediately because it was in about 13 pieces and caked with loose sediment.

3. Condition on Receipt: In several pieces and in need of a good wash to reveal the broken surfaces.

4. Development Notes: Prep by Matt Smith

2000

11th Sept	15 min	Started exploring the matrix on the occipital portion of the cranium, removing loose bits and probing and cleaning obvious foramina. Vinac
12th Sept	7 hours	Continued with occipital portion of cranium. Cleaned out right otic capsule. Portion that I had attached before with a drop of vinac loosened and dropped off I cleaned both surfaces and reattached. Removed matrix from ventral surfaces and the right quadrate. The posterior portion of the skull has suffered some wear and tear pre-burial. The occipital condyl is missing as is bone from the area just behind the right otic capsule. The squamate bone I believe? Also the posterior portions of the parietals and supraoccipital. Just started work on the left post-orbital, jugal, and quadratojugal (pojq) portion of the skull. Vinac
13th Sept	5 hours	Worked mainly on pojq today. Started by cleaning off as much of the exterior surface as possible to ascertain if the fractures would allow me to clean out the interior surfaces or just what. Also worked on left otic capsule and discovered that even more of the squamatic bone is missing on this side. Also, it appears that the articular surface of the quadrate has been damaged. The fracturing of the qj is quite extensive and I don't believe it will allow me to clean out the interior surfaces as I had hoped. Vinac
14th Sept	5:45 hours	Continued cleaning out the left otic capsule today and discovered the stapes is present and intact!! Also the large mass of matrix on the dorsal surface of the prootic and the opisthotic was easily removed revealing the suture where the squamosal would have been. The whole area was easily freed of matrix leaving the posterior portion largely exposed. I have decided to limit the amount of matrix in

		the left postorbital area by confining it to a series of arches to provide strength. There are also impressions of missing bone on these arches that I thought may be worth preserving. Worked a bit on the right orbit. Vinac
15th Sept	7:15	Continued on the right orbit and external surface of the fore part of the skull. I made a supportive jacket for the edge of the maxilla and premaxilla and started to expose the knife like edge of these bones. This was done mainly with a pin-vise to avoid damage. I then started to work down onto the premaxilla at the end of the day. Vinac
16th Sept	2 hours	Worked on premaxillae and maxillae. Vinac.
18th Sept	4:15 hours	Continued on palate working backwards exposing crenellations on maxillae. Injected thick vinac into break in left maxilla. This should hold it if I am careful enough. The matrix is hard and then becomes strangely soft about 1/8 to 1/16 of an inch away from the bone. Vinac.
19th Sept	3:45 hours	Continuing on palate. I am now starting to dip into the internal nares and vomerine area. Exposed an area on the posterior most portion of maxilla or perhaps the pterygoid. It was an extremely thin lip of bone and wanted to shatter. I had to preserve it with paleobond because the vinac was too soft and would soften every time I applied more vinac or 'washed the fossil with acetone. The vomer seems to form a knife like ridge that extends all the way back to the pterygoids from the premaxilla area.
20th Sept	2:45 hours	I have removed the supportive jacket because the danger to the maxillae is over and I need more mobility to reach the areas around the vomer and the orbits. I removed the matrix all along the vomer with a needle and the thing is a amazingly thin ridge of bone over most of its length. I have started to try and work behind the jugal and post orbital of the right orbit and clean that area out entirely. It seems stable enough to do this. Vinac.
21st Sept	5 hours	Worked on right orbital and post orbital areas. It has been exceedingly difficult because of the angles involved in getting under the cheekbones. Also the huge foramen in-between the eyes was a challenge be cause of the ridges of bone along the ventral surface. The anterior portion of one of these ridges began to shatter an I stabilized it with paleobond. Also there is a slight wing of bone that I had to leave some matrix on in the posterior portion of the temporal area. This wing broke off and I reattached it with paleobond. It is too fine and the matrix is too well adhered to attempt to remove it. the corresponding area on the posterior portion of the cranium is broken away and so it looks like it is just hanging out in space but in reality that would not have been the case. Washed the shell fragments and tried to look for further skull fits but found none. Vinac.
22nd Sept	1:40 hours	Did some final picking and probing. Tried to remove as much of the dirt and such as possible that was caked on by too much vinac. Then I tacked it all together in order to store it. I also tacked together two portions of the shell that fitted together. By 'tacked' I mean a drop of thick vinac here and there that will easily come apart with the application of acetone.

Figure U.5. Example Preparation Record #1 (continued)

Preparation/Conservation Record
National Park Service
Hagerman Fossil Beds NM
Paleontological Specimens

Catalog #: ________________ **Accession #:**________ **Field #:**_______

Preparator's Name:______________________________ **Date to begin work:**__________

Specimen (Family, Genus, Species):____

Element:____

Permanent Location:____

Field Observations:____

Condition Upon Receipt:____

Development Notes:____

____

____

____

____

Consolidants: _______B15 _______B72 _______PVA _______Glyptal _______B76

_______B98 __________PaleoBond Other:________________________________

Adhesives:____B76 _______B98 _______B15 _______DUCO _______PVA

_______Cyanoacrylate _______PaleoBond Other:________________________________

Stabilizers and Fillers: _______Plaster _______Carbowax _______Plastic

_______Mache Other:________________________________

Casting/Molding Notes:____

____

Attachments (photos, drawings, etc):____

Comments:____

____

____

____

Date Complete:_____________ **Total Hours (see reverse side):**_____________

Figure U.6. Example Preparation Record #2

Date	Hours Worked (round to nearest quarter hour)	Date	Hours Worked

Preparation/Conservation Record Page 2

Figure U.6. Example Preparation Record #2 (continued)