Lite Geology

A publication for educators and the public featuring contemporary geology topics, issues, and events

EARTH BRIEFS

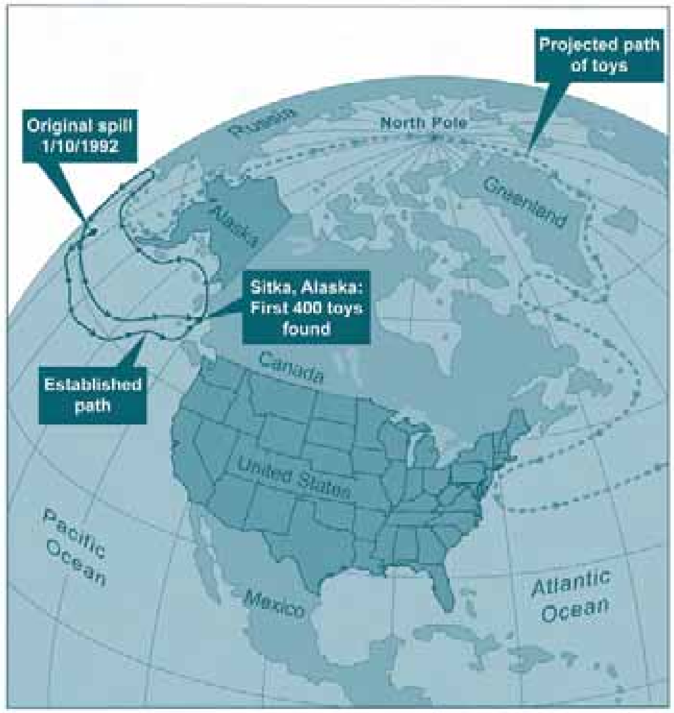
SPRING 2004 NUMBER 25

TOYS ON THE RUN

Gretchen Hoffman
Senior Coal Geologist

In Fall 1994 *Lite Geology* explored the story of wayward bathtub toys afloat in the North Pacific Ocean. Several containers of First Years® toys, called Floatees, were en route from China to Seattle in January 1992 when the cargo ship carrying the load encountered a severe storm. During the storm several containers of bathtub floaters were washed overboard and broke open, setting 29,000 red beavers, blue turtles, green frogs, and yellow ducks adrift. By November 16, 1992, six of these colorful floating toys had washed up on the shore near Sitka, Alaska. Over the next ten months about 400 bathtub animals were found along a 530-mile stretch of beach from Kodiak Island to Coronation Island in the southeastern Gulf of Alaska.

To study ocean surface currents, researchers often launch their own drift bottles, but this accidental spill in the ocean launched many more objects than are normally released by investigators. Oceanographers Curtis Ebbesmeyer and W. James Ingraham saw this flotilla as an unexpected opportunity to help refine the modeling of ocean currents in the North Pacific through a computer program called OSCURS (Ocean Surface Current Simulations). The OSCURS model, developed at the National Oceanic and Atmospheric Administration (NOAA) Alaska Fisheries Science Center, measures the movement of surface currents over time. The program also models the movement of objects in and on the surface of the water. One of the objectives of the model is to investigate the influence of ocean currents on



After Jim Ingraham, NOAA

Toy Trek
Researchers expect some of the 29,000 bath toys lost at sea in 1992 to make the ice-covered trek over the North Pole and to the North Atlantic by this summer.

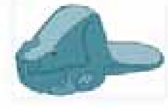
In This Issue

various fish populations in the North Pacific Ocean and Bering Sea. Using the cargo ship's log book, Ebbesmeyer and Ingraham determined the time and place that the tub toys were released. Additional data from the U.S. Navy provided wind speed and direction. With some fine tuning of the model, allowing for how the wind influenced the floating duckies, the program accurately predicted the first reported landfall. Ebbesmeyer expanded the search for more recovered toys through news releases and notices to beachcombers on his Beachcombers' Alert! Web site at: http://www.beachcombers.org/

The oceanographers predicted the drift trajectory of the toys from January 1992 through January 1997. The path taken was a counterclockwise drift around the Subarctic Gyre (a surface current loop). After 1993 there were a few sporadic sightings at Shumagin, Unalaska, along the Alaska Stream, through Unimak Pass to the St. Paul Islands in the Bering Sea. The OSCURS model predicted a path across the Bering Sea, along the Kamchatka Current, turning eastward off the Kuril Islands, continuing back past the original spill site by January 1995. Currents the following year could have carried the toy flotilla back along the Alaska Stream, and then continued westward along the Aleutian Island chain instead of going into the Bering Sea. Along the way, currents dispersed the group and, instead of remaining in a concentrated cluster of bathtub friends, the collection became separated by hundreds of miles. Some of the plastic toys made their way northward through the Bering Sea into the Arctic Ocean. Ebbesmeyer predicted the frozen flotilla would take five or six years to reach the North Atlantic going through these icy waters. Some of the bathtub toys may have gone south toward eastern Asia and eventually Hawaii. These floating toy animals may have headed across the Indian Ocean eventually reaching the Atlantic Ocean, possibly washing ashore on the west coast of England. These predicted trajectories were made on the basis of other flotsam travels recorded by Ebbesmeyer and Ingraham. Earlier research indicated that floatees following the southerly route would travel ten times faster than those trapped in the slow-moving ice flows in the Arctic Ocean.

Curtis Ebbesmeyer displays examples of the plastic turtles, ducks, beavers, and frogs that were lost at sea in January 1992. Photo courtesy of Jim Ingraham.

By early 1995 a blue turtle and faded yellow duck made their way to the coast of Washington State, having traveled over 15,000 miles. In July 2003 the First Years Company, located in Avon, Massachusetts, offered a $100 savings bond to anyone finding one of these wayward toys along the coast of New England, sparking a flurry of news articles about the well-traveled cargo. Monetary awards also were offered for toys from the spill found along the Canadian and Icelandic shores, and signed certificates were offered for the first 250 found in Britain ("England braces for rubber duck invasion," July 26, 2003, CNN.com). This inducement to report sightings and send in the Floatees (offer good from July 2003-December 2003) would help verify projected paths, giving the oceanographers more data points for their model. Recent sightings reported to Ebbesmeyer included a duck and turtle on the beach at Kennebunk, Maine, in July 2003 and a green frog along the west coast of the Outer Hebrides, Scotland, in August 2003. These sightings have not been completely confirmed, so the reward goes unclaimed, but they fit with the known drift routes. Some of these later sightings show that the yellow duckies and red beavers did not fare as well as the blue turtles and green frogs after many years at sea, fading as a result of exposure to sunlight.



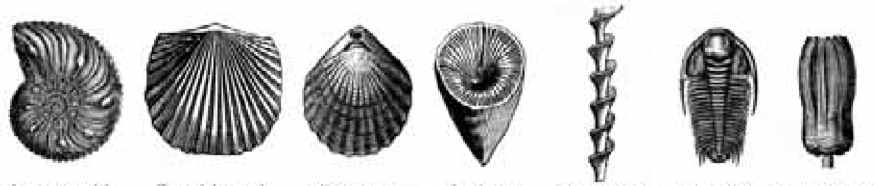
The bathtub toys are just some of many accidental floaters—including sneakers, Legos®, logs, and hockey equipment—washed overboard and used by researchers to better understand the ocean currents and the wind influences on the rates at which objects travel. Ebbesmeyer, through his network of beachcombers and his own experience, recognizes that there is an amazing amount of material floating in the oceans. Of the 100 million containers crossing the world's oceans, an estimated 2,000 to 10,000 cargo containers are lost at sea annually. Many of these cargo containers break open, releasing their contents. This flotsam, depending on its size and composition, can pose problems for wildlife and vessels. Some wreckage, such as chemicals, can be toxic and should be handled with care. Other material, made of plastics, can cause problems for wildlife if ingested. In February 1996 logs were lost overboard and became a hazard for fishing vessels in the Gulf of Alaska. Ebbesmeyer says: "Thirty percent of ocean trash goes around for thirty years before landing, and even 50-year-old ocean trash has been found." ("Wanted dead or alive: Rubber ducky," CDNN Eco News, Oct. 3, 2003, http://www.cdnn.info/eco/e031003/e031003.html).

The scale of the trip taken by these bathtub toys and the fact that they have survived for at least 11 years says a great deal about how the oceans are connected by the different currents and about the indestructible nature of these man-made objects. For more information about OSCURS visit NOAA's Alaska Fisheries Science Center Web site at: http://www.afsc.noaa.gov/refm/docs/oscurs/get_to_know.htm. You can learn more about ocean currents and the drifters used to investigate these currents at http://vathena.arc.nasa.gov/curric/oceans/drifters/index.html. ■

Have You Ever Wondered...

Why Geologists Study Fossils?

Bill Raatz
Geologist with Oxy Permian in Houston



Ammonoid | Brachiopod | Bivalve | Solitary Coral | Bryozoan | Trilobite | Echinoderm

When most people think of fossils, they think of dinosaurs: the terrible lizards like *Tyrannosaurus rex* that ruled Earth for 200 million years and whose skeletons tower above us at museums. These animals certainly were dramatic, capturing the imagination of children and adults alike. However, it may surprise you to learn that of people who study fossils for a living—a subset of geologists known as paleontologists—only a small fraction specialize in dinosaurs. Many more study fairly ordinary animals or plants, even microscopic ones, that carry none of the grandeur of a raptor or giant sauropod. Why is this? The answer lies at the heart of what geologists use fossils for, and understanding the answer goes a long way toward understanding how geologists interpret Earth's history.

Fossils are used for three main reasons: to determine the relative ages of rocks, to interpret environments of deposition, and for paleobiology/evolution studies.

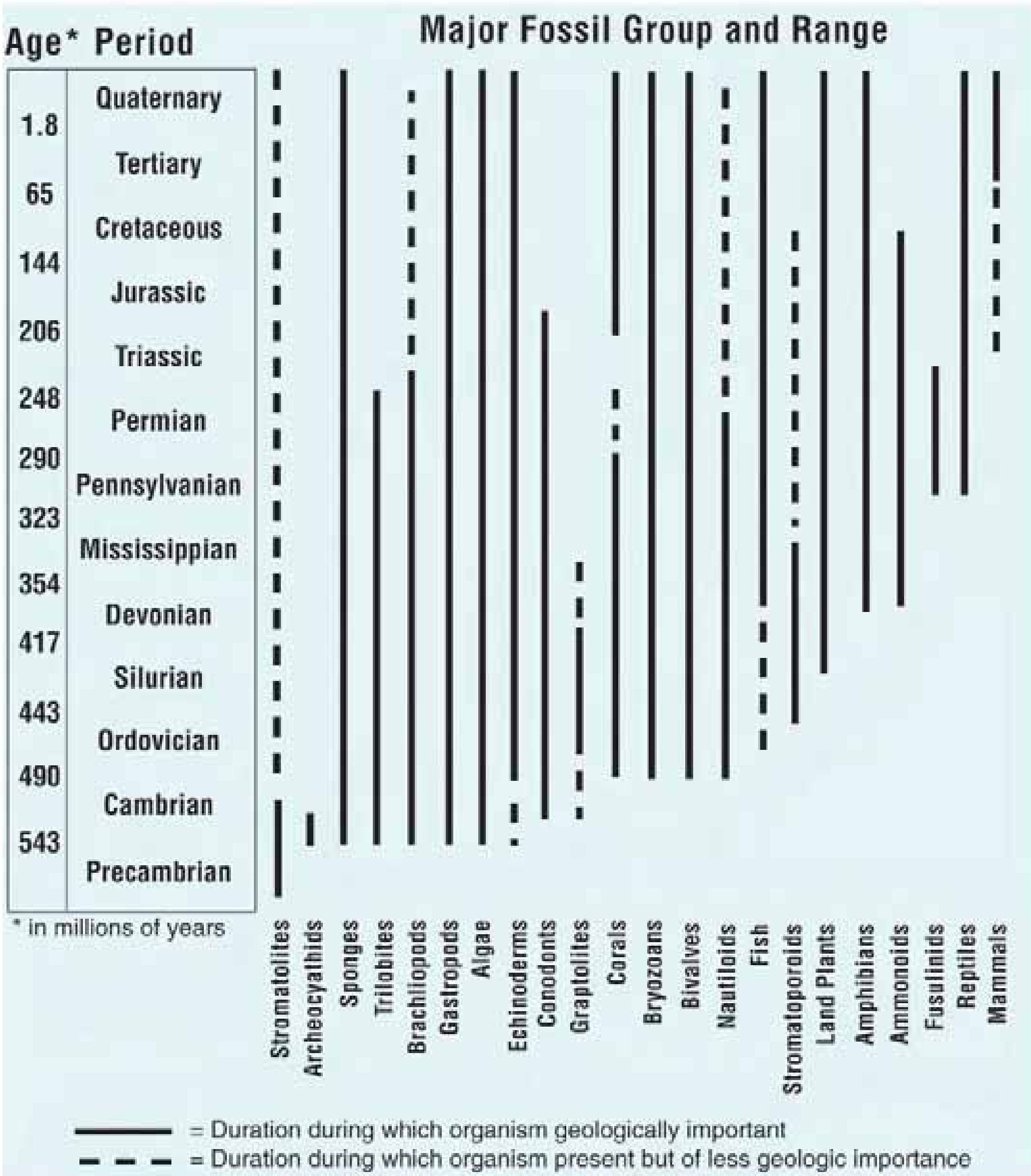
Determining the Relative Ages of Rocks

Long before expensive, high-tech geochemical equipment allowed some rocks to be dated with absolute numbers, scientists reconstructing Earth's history used fossils to piece together the relative ages of rock strata. Relative age dating places rock strata in the correct order, but does not reveal their numerical (or absolute) ages. Even with the advent of absolute age dating technology (radiometric dating), fossils remain a critically important method for dating rocks.

How Does This Work?

All species change or evolve through time and ultimately disappear altogether (become extinct). Fossils represent species that lived during a discreet period of time. Through a long process of identifying first and last occurrences of fossil organisms at locations throughout the world, accurate time ranges have been established for all important fossil groups: Identifying a particular fossil allows you to bracket the age of the host rock. Some species or groups lived for a very long time, so finding their fossils is not much help in determining a rock's age, but others lived for only a very short period, so finding them allows you to determine very precisely the age of a rock.

Let's make an analogy to fashion. Suppose you were given a video and asked to determine what year the movie was made. You quickly notice that most of the actors are wearing bell bottom pants, flowery shirts with wide collars, and have long hair. You deduce that the movie was probably made in the late 1960s or early 1970s. You then notice an actor wearing a shirt that reads "Minnesota Vikings NFC Champions 1974." This is quite a find, as it allows you to determine that the movie was made after the 1974 football season, probably in 1975 or 1976. Many fashions in the movie—a pair of white socks, for



example—do not allow you to say much about the time in which it was made, whereas the bell bottoms and shirts allow you to narrow the date down to a 10 or 15 year window. Finally, the football shirt gives you the critical clue that narrows your guess to a couple of years. Just as knowing the time frames during which certain fashions were popular allows you to date the movie, knowing the age ranges of different fossils allows scientists to date rocks. The best method of relative dating is to use an assemblage of many fossils, with the age of the rock pinpointed to the limited time span when all of the different age ranges overlap.

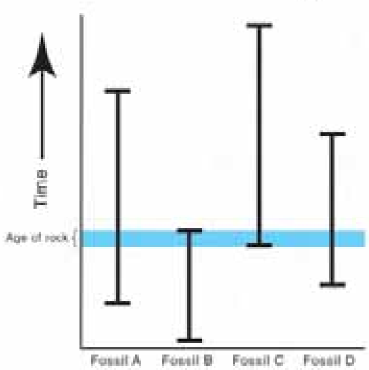
Determining Environments of Deposition

A second major use of fossils is to determine the environment in which sediments were deposited. Many organisms live only in very specific environments: polar bears near the Arctic Circle; alligators in warm, swampy waters; colonial corals in tropical shallow marine waters; and so forth. Let's say we are looking at an outcropping of rock and we see fossil corals, sea lilies (crinoids), and various shells (brachiopods). If we assume that these creatures lived in the past largely as they do today, we can interpret the outcrop as containing sediment deposited in shallow, warm ocean waters. If we can also date the outcrop using radiometric dating techniques, we can reconstruct a piece of Earth's history: at that particular time and place, a warm, shallow sea once existed, teeming with tropical organisms. This is of importance because Earth is ever changing, though often very slowly. What today is a mountain top in southern New Mexico was an ocean reef 250 million years ago. Fossils allow us to reconstruct paleocommunities of organisms and determine in great detail the environmental conditions in which they lived. As Earth changes through time, the distribution of the organisms follow suit, allowing us to track the movements of continents, the rising of mountains, the changing of climate, and the drying and flooding of the land.

Paleobiology

Finally, some paleontologists study fossils because they are interested in the paleobiology of the animals themselves—how they lived, how they moved, what they ate, were they warm-blooded or cold-blooded, etc. This is what most people think of paleontologists doing, but, in fact, fewer researchers specialize in pure paleobiology than in the more practically oriented field of relative age determination.

Another important facet of paleobiology is the study of evolutionary processes. Although we know that organisms change through time because of the combined effects of random genetic mutation and changing environmental stresses, a number of fundamental questions remain, such as whether these modifications occur gradually or rapidly. The study of how organisms evolve and adapt to different types of environmental changes, or fail to adapt and become extinct, has serious implications for us today, as we experience global warming, deforestation, increased pollution, and massive population expansion.



Overlapping age ranges for a number of different fossils found at a single locality—what paleontologists call an assemblage—allow you to determine the relative age of a rock more precisely than any single fossil.

How Are Organisms Preserved as Fossils?

For an organism to become a fossil at all, it must be preserved. There are a number of criteria that determine whether an organism is likely to be fossilized:

It must have hard parts that will survive after the animal dies. Soft tissue is only rarely preserved in the fossil record, therefore some hard part (shell, teeth, bone) is normally required.

It must be buried quickly after death so that the organic material is not scavenged, physically broken, or chemically dissolved. In general, terrestrial environments are dominated by erosion and burial is not common, whereas marine environments are dominated by deposition, making burial much more likely. Animals living in water, therefore, have a greater chance of being preserved than those living on land.

Mineralization. In some cases hard (or even soft) parts undergo a chemical transformation that aids the preservation process. A well-known example is petrified wood, where organic woody material and the void space within the woody cellular structure is replaced by the much harder mineral silica.

Which Fossils Are the Most Useful?

Now that we know how fossils are used and how they are preserved, let's see which fossils are the most useful. Before getting into specifics, let's look at the general characteristics of a useful fossil. As we previously discussed, fossils are used by different people for different things, so different criteria may apply depending on the specific use. Those criteria include:

Rapid evolution. Species with short time ranges offer the most precise age determinations.

Abundance. For a fossil to be useful in age dating or determining environments of deposition, a lot of them must be preserved. If only one or two individuals of a species are preserved what are the odds that you would ever find them? And if you did find them, how could you establish an accurate age range with only two samples? If there are lots of preserved fossils of a single organism it makes them much easier to find and to establish exactly when they first appeared and when they went extinct. Also, if there are a lot of individuals, you are much more likely to find the same fossil type at different localities, which allows correlation of rocks of similar age across large areas.

Small size. Often geologists must work with small samples, such as drill cuttings from an oil well. Complete large organisms simply cannot be recovered from such small samples, but fossils of microorganisms can. Many paleontologists specialize in using these microscopic fossils to determine a rock's age and environment of deposition. Also, organisms of small size tend to be much more abundant than larger ones (there are a lot more ants than elephants!), so abundance and small size are both positive features, whereas rarity and large size are negative features.

Cosmopolitan vs. provincial. If an organism's population is spread over large parts the world, it is referred to as cosmopolitan. Such organisms are excellent for comparing and correlating rocks of the same age from different geographic areas. Sometimes, however, these organisms can be so widespread and live in so many different places that they tell little about the sediment's environment of deposition. Organisms that are more selective about where they live may be less common, but they tell us more about the environments in which the animal lived. Some organisms only lived in certain geographic areas (such as kangaroos today) and are termed "provincial." These fossils can aid in reconstructing paleogeography, and may be useful for age determination and interpreting depositional environments, as well.

Our general picture of the ideal fossil is now complete. It had hard parts to preserve, was of small to microscopic size, had an abundant population, lived in a marine environment, and evolved rapidly. Our friend the dinosaur meets some of these criteria, but unfortunately its large size, relatively low abundance, and (mostly) terrestrial lifestyle means they were too few and too often destroyed before burial to be ideal. Ideal fossils are known as "index" fossils because of their importance. Through the process of evolution, index fossil types change through time. Some popular index fossils are listed on page 4, the very best of which include conodonts (microscopic jaw parts from a small eel-like animal), foraminifera and fusulinids (tiny single-celled animals with shells of calcite), other microscopic marine organisms (radiolarians, coccoliths, etc.), ammonoids (shelled squid-like animals related to modern pearly *Nautilus*), brachiopods (shelled animals that resemble clams but are unrelated), trilobites (arthropods related to modern horseshoe crabs), and corals. Note that the high-order taxonomic divisions (phyla and orders) shown are long-lived, but they are composed of thousands upon thousands of shorter-lived, lower taxonomic groups (genera and species) used for detailed age determination.

What about those geologists working in rocks that are not from ideal environments and don't contain index fossils? Researchers who study terrestrial rocks or other sedimentary deposits formed during times or in places that do not contain index fossils still often use fossils for both age and environmental determinations. Fossils from these strata may be harder to find and may not yield age ranges as precise, but they are still valuable. If the rocks are completely barren of fossils, geochemical methods that measure age by the radioactive decay of certain elements, or the magnetic methods that measure the polarity of metallic minerals may be used.

Why Does Anyone Care?

Why do geologists care about fossils? It is enough that many fossils are beautiful and fascinating in their own right, and tell us the story of how animals no longer living looked and even how they behaved. But there is much more. Fossils tell us how old sedimentary rocks are and in what environment they were deposited. This information goes to the heart of what many geologists try to do: interpret Earth's history. Rocks must be placed in the correct chronological order so that the history of Earth can be read page by page, rock layer by rock layer, in the correct sequence. Once the pages are in the correct order, the plot can be read. The plot of Earth's history is partly in the form of fossils and sediments that tell us what environments existed in ancient times. As environments changed, the fossils and sediments changed, allowing us to track and interpret the complex physical and biological history of our planet through time.

Preservation of Soft Parts

Very rarely the soft parts of organisms are preserved as fossils. This usually occurs under extraordinary circumstances such as extremely rapid burial in an environment devoid of oxygen, where very early mineralization of the soft tissue has occurred, or where the organism has been encased in amber, tar, or ice. When soft tissue is preserved, it offers a wonderful view of an extinct organism, giving scientists a much greater understanding of its true shape and lifestyle, and allowing them to better interpret normally preserved fossils of that organism that only have the hard parts preserved.

Firefly preserved in amber.

Coralville, Iowa?

If you look at a map of eastern Iowa you will find the city of Coralville. Why would citizens of a place so far from the ocean and any living corals decide to name their city in such a strange manner? Were they shameless speculators attempting to deceive naïve settlers into buying "oceanfront" property? No. The actual answer reminds us that Earth is not a boring, static ball, but rather a dynamic place with immense time at its disposal to change slowly but dramatically. In 1866 when the foundations for a woolen mill were being dug in the new town, workers unearthed large, complete, beautifully preserved fossil coral heads. It turns out that for much of the period between 500 and 250 million years ago the central U.S., including Iowa, was near the equator and covered by a warm, shallow sea. The corals of Coralville are real, as are many other tropical marine fossils in the limestone bedrock of the Midwest, attesting to the ever-changing world we live in. ■

Summer Programs for Teachers

The Minerals Connection: Mining in our Everyday Life

A Professional Development Course for K-12 Teachers

New Mexico Institute of Mining and Technology
Socorro, New Mexico
July 12 to July 17, 2004

This professional development course will focus on our human connection to the natural resources of New Mexico and will explore the end uses of minerals mined in our state, mining and processing methods, and the history of mining, along with related environmental, technological and economic issues. The program will address New Mexico's content and performance standards by integrating language arts, math, science, and social studies to examine natural resource use and management as it relates to society's needs.

A $120 stipend and lunches will be provided. This course will provide one (1) professional development or graduate credit hour. Students wishing to receive graduate credit from New Mexico Tech will be responsible for paying tuition and applicable fees directly to Tech. A poster presentation will be required for all participants.

For further information, contact
Professor Cathy Aimone-Martin
505-835-3863 (evenings)
e-mail: cathya@sdc.org

The Master of Science Teaching Program at New Mexico Tech is offering several other exciting geology classes this summer. Check the Web site for schedule updates and further information on these classes. Visit www.nmt.edu/~eodi or call toll-free 866-644-4887 to learn more.

ST 547 – Field Techniques in Geology, with Dr. Steve Hook: May 31 – June 4. Wondering how to use your GPS, how about tried and true map and compass? In this Socorro-based course, you will learn how to use the tools of geology, basic rock and mineral identification, terminology, geochronology, stratigraphic succession, mapping, and more.

ST 548 – Geology of the Southwest, with Dr. Bill Chavez: June 7–18. This field geology course will focus on the Four Corners region this year. Topics include geologic environments and interpretation of geologic field data. Students should expect to camp as they explore the region.

ST 571 – Geology of the Colorado Plateau, with Dr. Kent Condie: June 7 – 16. Join Dr. Condie on his annual river rafting trip, where students will explore geological phenomena as well as plant life and local history. Expect primitive camping and great food.

ST 571 – Rockin' Around New Mexico, with Dr. Bill Chavez: July 7 – 9. This 3-day annual summer workshop on geology is for K-12 teachers, with optional MST credit available. Rockin' is based out of Albuquerque this year, and will cover local geology including volcanics, seismic hazards, mountain-building processes, and mineral resources.

ST 589 – Field Paleontology, with Dr. Don Wolberg: July 26 – August 13. This Wyoming field class will explore techniques for locating and removing dinosaur bones. Students should also expect lectures on the habits of different species, anatomy, and pre-history of the local area. Students will be camping and working outside most days.

Lite Geology is published by the New Mexico Bureau of Geology & Mineral Resources (Dr. Peter Scholle, Director and State Geologist), a division of New Mexico Tech (Dr. Daniel H. Lopez, President).

Purpose: To build earth science awareness by presenting educators and the public with contemporary geologic topics, issues, and events. Use *Lite Geology* as a source for ideas in the classroom or for public education. Reproduction is encouraged with proper recognition of the source.

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Visit our Web sites at these URLs:
http://geoinfo.nmt.edu
http://tremor.nmt.edu

New Mexico's Most WANTED MINERALS

ARAGONITE

DESCRIPTION: Crystals most often acicular (needle-like) and commonly twinned. Also seen in globular, coralloid, fibrous, stalactitic and incrusting forms. Easily confused with calcite since they are polymorphs (same chemical formula, different crystal form). Mohs Hardness: 3.5 to 4. Cleavage: one distinct with a weaker second. Optical properties: transparent to translucent. Chemical properties: reacts with weak acid to form CO_2. Color: white is most common but any color is possible due to impurities. Chemical formula: $CaCO_3$, calcium carbonate. The name originates from Aragon, Spain, where the famous geologist Abraham Gottlob Werner first defined it in 1790.

WANTED FOR: The relative rarity of the material at Earth's surface makes this mineral mainly of interest to the collector.

HIDE OUT: Creatures that secrete their shells (snails, clams, etc.) make them of aragonite. The "mother of pearl" in many shells (also known as nacre) is composed of aragonite. The mineral is also found as stalactites and stalagmites in caves. It also forms as pisolites, sinters, and travertines in hot springs.

LAST SEEN AT LARGE: Aragonite is found in a number of places in the state with the most notable localities listed below (counties in parentheses). Exceptional examples of crystallized specimens include cave types (*Flos ferri*) at Carlsbad Caverns (Eddy), Organ (Doña Ana), and Magdalena (Socorro). Museum-quality hexagonal tablets or "triplets" more than an inch across can be found in gypsum deposits near Roswell (Chaves), Ramon and Dunlap (De Baca), Santa Rosa (Guadalupe), Lovington (Lea), and Nara Visa (Quay).

ALIASES: Satin spar, *Flos ferri*, tarnowitzite, zeyringite, nicholsonite, conchite and ktypeite.

VISIT THE MINERAL MUSEUM

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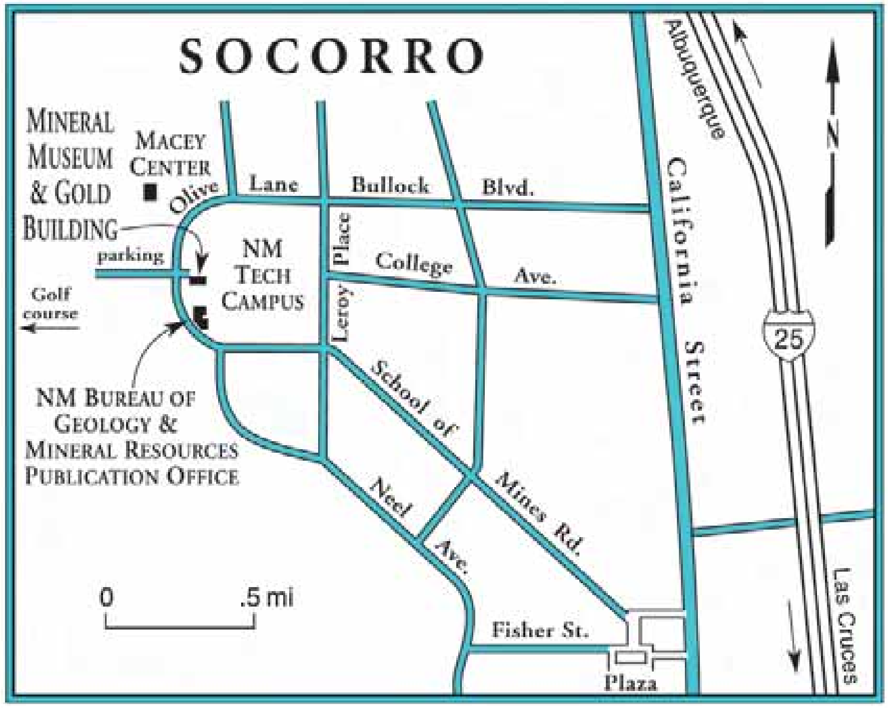


Museum Hours:
Monday thru Friday 8 am–5 pm
Saturday & Sunday 10 am–3 pm
Closed Institute Holidays

MINERAL MUSEUM
New Mexico Bureau of Geology & Mineral Resources
New Mexico Tech, 801 Leroy Place, Socorro, NM 87801
(505) 835-5154, 835-5420

The Mineral Museum is located in the Gold Building on the campus of New Mexico Tech in Socorro. The bureau's mineralogical collection contains more than 16,000 specimens of minerals and rocks, along with mining artifacts and fossils.

In the past three years we've added more than 2,000 specimens to our permanent collection, and many of these specimens are on display. The systematic collection is a mineral enthusiast's dream, with 483 different mineral species on display. We call it the Dana Display after J. D. Dana, who wrote the first decisive work on minerals and their properties back in 1837. If you should ever wonder what the mineral strashimirite looks like, this is a good place to start.

The lapidary display is a real eye-catcher: We have placed rough material next to polished pieces, and it's impressive to see what jewelry is made of: petrified wood, coral, amber, dinosaur bone, jasper and chert, sandstone, granite, and of course minerals such as turquoise, malachite, and opal.

Our newest display is Gold & Silver from New Mexico, which includes turn-of-the-century photos, artifacts, and a large variety of historic gold & silver ores. Several of the specimens are from mines that have been closed for nearly a hundred years, and it's amazing that some of these pieces have survived in private collections until today. The largest, third largest, and fourth largest gold nuggets ever found in New Mexico are also on display.

Our museum continues to grow. Short term goals include finishing the gemstone display, which includes a faceting machine, tutorial, and dozens of rough and faceted gemstones. Also under construction are the fossil displays. For teachers and other groups, we continue to offer free tours of the museum; contact Patricia Frisch (at 505-835-6609) or Susie Welch (at 505-835-5112) to schedule a tour. We like to show off our home state minerals, as well as give students an idea of what minerals end up in consumer products. New Mexico science teachers who have a mineral identification curriculum can get a free mineral identification kit ($5 for the general public). We are also happy to identify rocks for visitors, so don't hesitate to have your class bring samples to show off and have identified. For more information visit our Web site at: geoinfo.nmt.edu/education/museum/

POSTCARD FROM THE FIELD

STUDYING ICE AND VOLCANOES IN ANTARCTICA

Nelia Dunbar, *Geochemist*
New Mexico Bureau of Geology & Mineral Resources

Nelia Dunbar, assistant director and geochemist with the New Mexico Bureau of Geology and Mineral Resources in Socorro, is one of a team of people working in Antarctica this winter under a project funded by the National Science Foundation. This letter came to us in November from the base at McMurdo Station, just days before the team headed to their high-altitude camp for six weeks of field work. It is summer at the South Pole, but the rigors of working in the polar climate, even during summer, are apparent.

When working in remote parts of Antarctica, we travel to the field in a ski-equipped airplane called a Hercules (LC-130). This plane can land on the snowy surface of the ice sheet without a prepared runway. The plane can hold 10,000 pounds of cargo, which is about the amount of equipment, food, and fuel required for a 5-person, 6-week field expedition.

GPS mapping of volcanic ash layer. Source volcano, Mt. Berlin in background.

Hello from McMurdo! We were supposed to have flown out to our deep field site yesterday, but because of various weather and aircraft delays, we're a bit behind schedule. We're hoping to get in some time in the next day or two, but it might be a bit longer. So I have plenty of time to write about our field program, as well as what we've been doing since arriving in McMurdo two weeks ago.

The main goal of our field project this year is to collect climate-related ice samples at a field site in West Antarctica using a portable drill. We will also be sampling volcanic ashes at the same site and mapping the geometry of ash layers in the ice, using high-precision GPS measurements. The place where we'll be working is called Mt. Moulton. It's very remote, about 1,000 kilometers (600 miles) from the main U.S. base, McMurdo Station. We will be taken to the base of Mt. Moulton in a large, ski-equipped aircraft called an LC-130, then shuttled up to our high-altitude camp using a smaller ski plane called a Twin Otter. We'll be working at the field site for about six weeks, living in tents, getting around on foot or on Skidoos (our snowmobiles), and using solar power to generate electricity. Because the sun never sets at this time of year, on a clear day we can collect plenty of solar energy; we even do OK on a cloudy day.

Our team consists of five people: Bill McIntosh and myself from

Field team holding ice core with drill in the background.

Emperor penguins on sea ice with active volcano, Mt. Erebus in the background.

New Mexico Tech, Todd Sowers and Pratigya Polissar from Pennsylvania State University, and Trevor Popp from University of Colorado. Bill and I provide the volcanology experience; we've also had the most field experience in Antarctica in general, and Mt. Moulton in particular. Todd, Pratigya, and Trevor all come from a climate-study background. Trevor has worked for a number of seasons as an ice driller on the Greenland ice sheet, so he's our drilling pro. Some of us had not met until arriving in Antarctica, and it's a relief to find that we all get along.

We arrived in McMurdo about two weeks ago and spent the first ten days in a frenzy of checking, testing, and packing field equipment; planning and sorting out food for our trip; and learning to put together and use our portable "Eclipse" drill. Weighing 1,400 lbs, it's only portable in the loosest sense of the word, but it can be broken down into a number of boxes, the heaviest of which weighs a back-straining 300 lbs. As part of this preparation process, we had a couple of fun days out of town doing test trips, called "shake-downs." One trip was just to test the Skidoos; we drove around on some hills near McMurdo, then headed out to a place called Cape Royds, where there is a hut that was built for the Shackleton expedition in 1907–1909. The hut's a cozy little place, but it must have been pretty crowded with the men from that expedition living in it. There's a lot of food left behind from that expedition. Much of it is in pretty good shape, even after 100 years. I had to ask myself: How could they possibly think they would use so much salt? There are cases of it left behind, all in nice glass jars. Cape Royds is also the site of an Adelie penguin rookery, so we got a chance to see some of them on their nests. We also saw some of the larger Emperor penguins, who were parading along on the sea ice in front of Mt. Erebus, an active volcano.

Shackleton's hut at Cape Royds. Active penguin rookery, ocean, and the Antarctic continent are visible in the background.

Our second shakedown trip was mainly to test the drill and our camping gear. This was a good chance for the new people in our group to get used to Antarctic camping. It was also a chance for all of us to get used to setting up the drill in the cold. In the course of our workday, temperatures fluctuated from a high of about +5^{o} F to a low of about –30^{o} F. The place we chose as our destination is a blue ice field about 13 kilometers (8 miles) from McMurdo. The place is called the Pegasus site because an airplane named Pegasus crashed while trying to land there some time in the 1960s. Much of the plane is still there, preserved in the deep freeze. Pegasus is also the emergency landing strip for McMurdo, so we were careful not to camp on the runway. We transported all of our camping and drilling equipment to Pegasus on sleds pulled by snowmobiles. Once there, we set up camp and started assembling the drill. By late the next day, we were successfully drilling ice cores! This was quite exciting, because the drill is pretty complicated, and we were hoping that we'd be able to set it up and get it to work properly.

On November 24 there was a partial (75 percent) solar eclipse in McMurdo. This really caught people's attention! Everyone was outside, looking through x-ray film or welder's glass and taking pictures. The most striking thing was how dim and cold it got when the sun

Our camp at Mt. Moulton.

was 75 percent covered. The dimness was particularly striking in a place where it hasn't been truly dark for months.

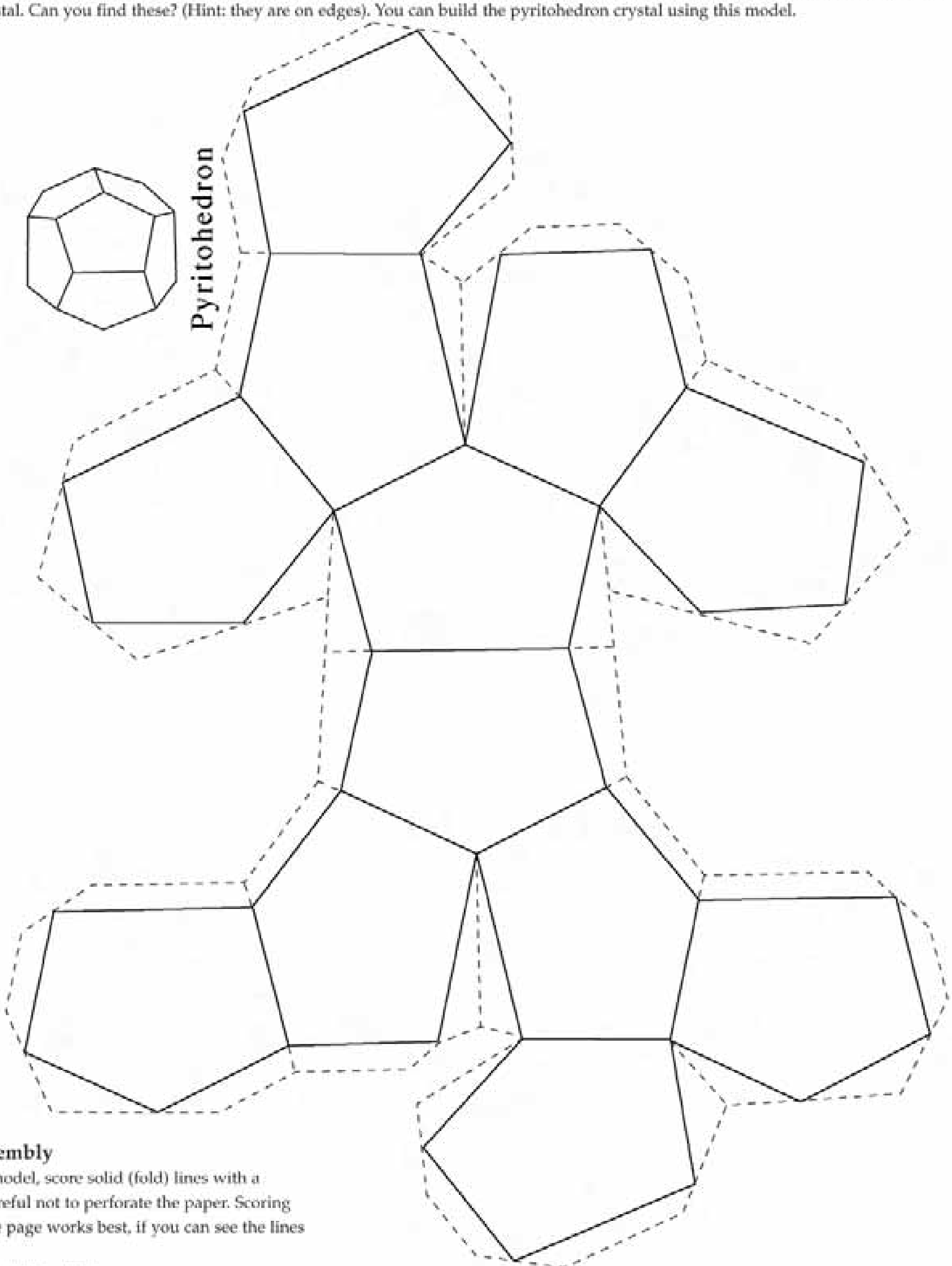
Once we had all of our field gear and the drill under control, the next step was to think about getting out to our field site. The Air National Guard, who is responsible for our initial field put-in using the large LC-130 aircraft, decided that they wanted to have a close look at the site before actually landing there. So they scheduled a reconnaissance flight for Mt. Moulton, and four of us were able to go along for the ride. The flight went at night. There are 24 hours of daylight in this part of the world at this time of year, and it never gets even remotely dark. Flying at night, however, does take advantage of the lower angle of the sun at that time, which allows for better shadows. We were lucky enough to have perfect weather. Mt. Moulton is about 1,000 kilometers (600 miles) from McMurdo, and during the flight we had a good look at the edge of the Ross Ice Shelf and some of the small mountain ranges on the flight path. The best thing about the flight for us was that we were able to take pictures of our field site from the air, as well as taking pictures of Mt. Berlin, the volcano that produced the volcanic ashes that we find at Moulton. The field site looked great, and we could see the trench that we cut last time we visited Moulton, during the 1999-2000 field season. It also looked like the blue ice was a bit less snow-covered than the last time we were there, which should make our field work easier. Now it's just a matter of the weather coming right so that we can get there!

Nelia and her team were able to make it to base camp shortly after this letter was written. She returned to New Mexico in mid-January. ■

Mt. Berlin, the volcano that produced the volcanic ashes found at our field site.

Pyritohedron Crystal Model

The mineral pyrite (FeS_2; iron bisulfide) crystallizes in the isometric crystal system (three axes of symmetry of equal length and at right angles to each other). The simplest form is the cube. In a cube all of the faces are same distance from an imaginary point in the center of the crystal. The faces intersect imaginary axes (lines at right angles to each other) radiating from the center – these axes are in the centers of the faces. We also find pyrite in other geometric forms like octahedrons (four-sided double pyramids). In this form, the points define the same distances as the faces of in the cube and are the position of the axes. The pyritohedron is a more complex form, yet there are features on the form that define the unit distance and where the axes "come out" of the crystal. Can you find these? (Hint: they are on edges). You can build the pyritohedron crystal using this model.



Directions for assembly

1. Before cutting out model, score solid (fold) lines with a dull point, being careful not to perforate the paper. Scoring from the back of the page works best, if you can see the lines through the paper.
2. Cut along all outside (dashed) lines.
3. Fold along scored lines, always folding inward.
4. Apply glue to flaps and attach adjacent flaps together so that they are hidden inside the model. A glue stick works well.

Source: Modified from *Three Dimensional Models of the Basic Crystal Forms-Construction Kit* by Arthur Gude.

Earth Science Curricula available from the American Geological Institute (AGI)

New Mexico educators who are seeking new curricula to address the earth science content in the new science standards (August 2003) will find the curriculum modules developed by AGI very helpful. Here are descriptions and Web site addresses for the modules available now, along with some under development.

Available now

EarthComm: Earth System Science in the Community is an earth science curriculum developed by AGI and supported by the National Science Foundation and donors of the American Geological Institute Foundation. Through EarthComm, AGI focuses attention on the national deficiency in high school Earth Science education (grades 9-12). The EarthComm vision is the teaching, learning, and practice of Earth science by all students in all U.S. high schools. The EarthComm Web site at http://www.agiweb.org/earthcomm/ contains supplemental resources for teachers, students, and parents as well as ordering information.

Investigating Earth Systems is a new, standards-based, earth science curriculum for the middle grades developed by the American Geological Institute in association with It's About Time Publishing. Investigating Earth Systems is part of AGI's ongoing efforts at implementing effective Earth Science education reform. AGI recognizes the need for students in the middle grades to have a solid understanding of the world they live in. On the Web site at http://www.agiweb.org/ies/ you will find resources that will supplement the text.

Soon to be released

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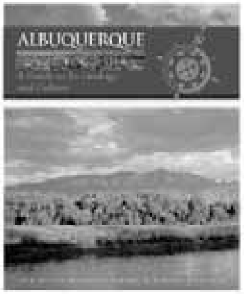
Understanding Our Changing Earth is an innovative, geoscience-based curriculum that uses a learning-cycle based approach to develop five core concepts that students need to understand the relationship between themselves and the Earth upon which they live. *Understanding Our Changing Earth* will feature the integration of USGS Global GIS datasets and technology into activities and assessments. AGI's research indicated the need for an earth systems-based environmental science text that provides the opportunity for all students to develop an understanding of the interconnectedness of the Earth, nature and human society. Understanding Our Changing Earth will be piloted by select teachers August through December 2004 and field tested nationally August 2005 through June 2006. More information can be found on the Web site at http://www.agiweb.org/education/hses/index.html.

Visit the Collections at the Museum of Natural History Virtually Anytime!

The 42,000+ fossils in the paleontology collections at the New Mexico Museum of Natural History and Science in Albuquerque are now available for browsing on the Internet, 24 hours a day. This includes 500,000 bones, teeth, shells, impressions, stems, shoots, fronds, and other pieces. Ever wondered if there were fossils near your home? Try a search by county. Want to know how many specimens of Pentaceratops we have? Try a genus search. Wish to learn about fossils from the Morrison Formation, like Seismosaurus? Try a Formation search. Over 39,000 fossils are presently online; 1,400 of these include photographic images of the actual fossil. Visit us at http://164.64.119.14/NMMNH/web/default.html. We recently added a map to search the database by New Mexico County; go directly to http://164.64.119.14/NMMNH/web/countymap.html, click on a county, and start browsing localities. We have something from every county in New Mexico except Curry.

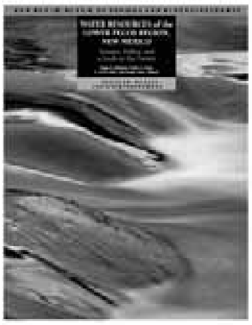
NEW MEXICO MUSEUM OF NATURAL HISTORY & SCIENCE

New Publications of Interest to Teachers

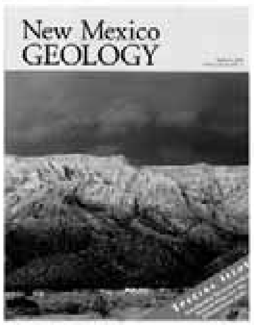


The following recent publications of the New Mexico Bureau of Geology & Mineral Resources will be of interest to educators in New Mexico. All may be obtained through our Publications Sales Office by calling us at (505) 835-5920. We offer a 20% discount to teachers on all materials purchased for classroom use.

Albuquerque: A Guide to Its Geology and Culture by Paul W. Bauer, Richard P. Lozinsky, Carol J. Condie, and L. Greer Price, 2003. Number 18 in our popular Scenic Trip series, this guide provides and overview of the rich geologic and cultural history of the region, as well as six detailed road trips that offer an in-depth look at specific features of interest. $14.95 plus shipping and handling.



Water Resources of the Lower Pecos Region, New Mexico: Science, Policy, and a Look to the Future, edited by Peggy S. Johnson, Lewis A. Land, L. Greer Price, and Frank Titus, Decision-Makers Field Guide 2003. This anthology of 30 short articles is a timely look at water issues along the lower Pecos River, from Sumner Lake to the Texas state line. Produced in conjunction with the third annual Decision-Makers Field Conference in October 2003, this volume is an authoritative look at the historical framework and a summary of where we are—and where we're going—on the Pecos River in New Mexico. $15 plus shipping and handling.



The February 2004 issue of **New Mexico Geology** features earthquake ground-shaking hazard maps for the Albuquerque area. The 10 oversized (11" x 17") maps in this special issue have been printed in full color as foldouts. Single issues are available for $ 3.50 each plus shipping and handling. This quarterly journal has been serving the New Mexico geoscience community for over 25 years. Subscriptions to New Mexico Geology are available for $12 for a 1-year subscription and $22 for a 2-year subscription.

Geologic Map of New Mexico 1:500,000, 2003. Published in two oversized sheets (54" x 47" and 50" x 42"), this full-color map is the first geologic map of the state published at this scale since 1965. Over 100 geologic units are represented. Sheet two includes a detailed key, correlation charts, and references. $20.00 rolled plus $10.00 for cardboard tube & shipping.

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