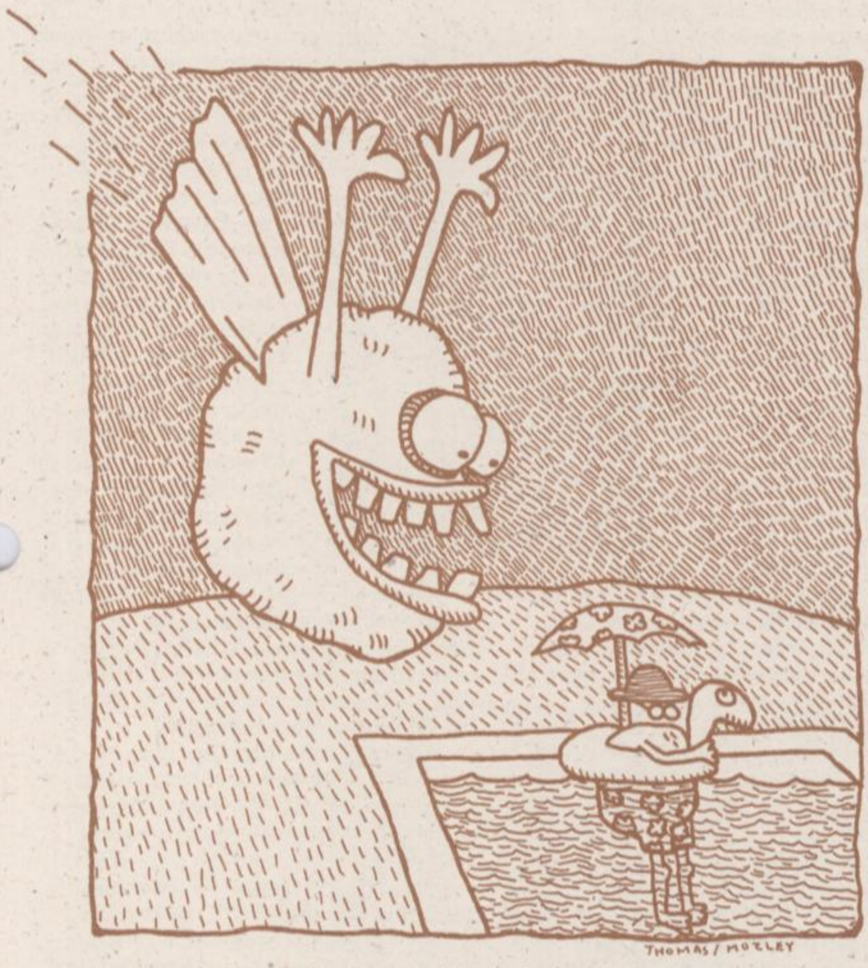
Summer 1993

LITE geology

A quarterly publication for educators and the public–
contemporary geological topics, issues and events

New Mexico Bureau of Mines and Mineral Resources (NMBM&MR)



cosmic debris makes dramatic entrance

This Issue:

Earth Briefs

Cosmic Debris Makes Dramatic Entrance

One autumn evening, 18-year-old Michelle Knapp was at her home in Peekskill, New York, watching TV when she heard a crash outside. She and many of her neighbors called the police to report what they believed was a car crash. There was no sign of a wreck, but when police arrived, they discovered a mysterious hole punched through the trunk of Michelle's car. An initial police report suggested that the damage resulted from an incident of "malicious mischief by a very strong male." The neighbors and police puzzled over how someone could accomplish such a feat.

After listening to the evidence and conjectures, one of Michelle's neighbors, a blind woman named Rose Colluci, deduced that the disturbance must have been caused by the arrival of a **meteorite**. Sure enough, a piece of cosmic debris was found underneath the car. The meteorite, which was discovered about 20 minutes after it landed, was still warm.

On its journey to Michelle's driveway, the 27-pound **meteor** (as it was called *before* it landed) was estimated to have been travelling so fast that it streaked over Washington D.C., about *one second* before it slammed into the Earth in Peekskill, N.Y. That same evening, October 9, 1992, several "shooting stars" were sighted at various places along the Atlantic Coast. The **meteor shower** was even video-taped by a man at a football game in western New York.

The meteorite found under Michelle's car was a **stony meteorite,** or **chondrodite**. It remained relatively intact after the impact, although several small pieces broke off as it passed through the car trunk, and several other pieces were removed by police.

Three persons collectively purchased the meteorite with plans to slice it into three sections–one for each purchaser. Michelle also has sold her 1980 red Malibu with the hole in its trunk. The car, along with one of the slices of meteorite, is destined for display at the American Museum of Natural History in New York City.

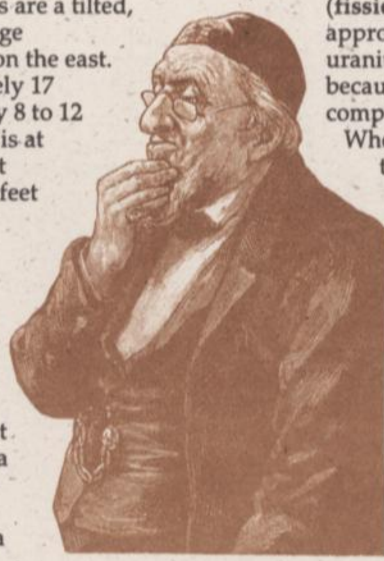
Frazier, Si, and Frazier, Ann, 1993, The sky is falling—and everybody wants a piece of it: Lapidary Journal, vol. 46, no. 11, pp. 79–80, 82, 84.

Have you ever wondered. . .

How old are the Sandia Mountains?

Charles E. Chapin
NMBM&MR Director and State Geologist

The Sandia Mountains are a tilted, fault-block mountain range bordering Albuquerque on the east. The range is approximately 17 miles long north-south by 8 to 12 miles wide. The summit is at an elevation of 10,678 feet compared to about 6,000 feet at its western base. The west side looks spectacularly steep, but between the base and the crest the slope averages 22° or less. In comparison, the east side slopes about 15° east. Most of the west face consists of the Sandia Granite, a large intrusion emplaced about 1,445 million years ago. Over a billion years of earth history is missing in the rock record of the Sandia Mountains between **intrusion** of the Sandia Granite and **deposition** of the marine limestones (305-320 million years old) that form the layered crest of the range.



But if the Sandia area was once beneath the sea (and it was as recently as 70 million years ago) when did it become a mountain range and how can we tell? One method is to determine the age of sediments eroded from the mountains and deposited in adjacent basins. Sometimes distinctive rock types, exposed to erosion by uplift of the mountains, tell us which sedimentary layers were laid down in nearby basins during rise of the mountains. Such layers may be dated by determining the age of fossils or volcanic rocks contained in the layers. But datable materials are not always present.

Dr. Shari Kelley at Southern Methodist University in Dallas has used an interesting high-tech method to determine not only *when* the Sandia Mountains were uplifted but the approximate *rate of uplift*. The method is called <u>fission-track</u> **dating**. A fission track is a microscopic tube-shaped path (Fig. 1) of radiation damage in a mineral's **crystal lattice** (a 3-dimensional array of atoms bonded together in a distinctive pattern). Fission tracks form in minerals containing uranium when the nucleus of a uranium atom spontaneously splits (**fissions**) into two approximately equal parts. The uranium nucleus fissions because it is too large to be completely stable.

When a fission event occurs, the two parts of the nucleus recoil from each other in opposite directions at high velocity. Passage of these fission products damages the crystal lattice, leaving a track. The most abundant isotope of uranium (atomic weight 238) fissions at a constant rate that has been very accurately measured by nuclear scientists.

Fission tracks are invisible to the naked eye, but can be observed through a microscope in a thin, highly polished slice of a mineral after etching with acid has widened the tracks (Fig. 1). The number of tracks present is proportional to the uranium content, the fission rate, and the age of the mineral. The mineral **apatite** (calcium phosphate) is present in many common rocks and contains sufficient uranium to produce abundant fission tracks. At temperatures *below* approximately 100°C (actually a temperature range of 60–140°C) fission tracks in apatite are relatively stable, but at temperatures *above* 120–140°C diffusion of ions in the crystal lattice is fast enough to repair the fission tracks and they disappear (are **annealed**).

When a mountain range rises, rocks at depth cool as they are uplifted toward the Earth's surface. At temperatures above 120–140°C, fission tracks that form in apatite are quickly erased. As the rocks cool below approximately 100°C, fission tracks in apatite start to become stable and the rock begins to accumulate a track history. Rock temperatures decrease toward the surface of the earth at a rate (**geothermal gradient**) generally between 20 and 40°C per kilometer (3,280 feet). Assuming a geothermal gradient of 30°C per kilometer and a mean annual surface temperature of 10°C, fission tracks in apatite contained in rocks beneath the Sandia Mountains would begin to become stable as they rose above a depth of approximately 3.0 kilometers (9,840 feet).

Dr. Kelley collected samples of the granite making up the west face of the Sandia Mountains from near the top to the lowest bedrock outcrops. The fission-track ages for the mineral apatite in these samples ranged from 30 ± 5 million years near the top of the mountain to 15 ± 2.6 million years near the bottom. In other words, rocks near the top of the Sandia Mountains cooled below 100°C 30 million years ago. At lower and lower elevations the samples yielded progressively younger ages because these samples started their journey to the surface from deeper (hotter) levels in the earth. The fission tracks are long, indicating that the rocks cooled rapidly. If the rocks had cooled slowly, partial annealing would have shortened the fission tracks.

The difference in elevation between the highest and lowest samples is 920 meters (3018 feet) and the difference in fission-track ages is 15 million years. This gives an apparent uplift rate of 61.3 meters (201 feet) per million years. If uplift continued at the same rate since 15 million years ago (the fission-track age of the lowest elevation sample), the Sandia Mountains would have risen an additional 920 meters (3,018 feet) for a total uplift of 1,840 meters (6,036 feet) in 30 million years. However, we know that approximately 3,050 meters (10,000 feet) of sedimentary strata have been removed from the Sandia Mountains since the last sea retreated from the area about 70 million years ago. Some of these rocks may have been removed before the Sandias began to rise, but other geologic evidence indicates that most were removed during uplift of the mountain range. Thus, uplift rates must have been considerably faster since 15 million years ago to allow for erosion of so much rock and still have a bold mountain range towering 5,000 feet above Albuquerque.

Several assumptions were made during this application of the fission-track method: 1) cooling was accomplished primarily by uplift towards the earth's surface accompanied by erosion of the overlying rock cover, 2) the geothermal gradient was constant, and 3) the 100°C **isotherm** (surface of equal temperature) was horizontal. Thus, Dr. Kelley's age determinations are approximations because some of these conditions may not have been present during the entire uplift history. Also, the fission-track method only yields the time and apparent rate of uplift of a mountain range *relative* to the surrounding area. The entire region may also be uplifted in an *absolute* sense (relative to sea level) independent of the relative uplift of individual mountain ranges. Absolute uplift is a much more difficult problem to solve and may be the subject of a future column.

Readers desiring more information about fission-track dating are referred to NMBM&MR Bulletin 145 titled *Late Mesozoic to Cenozoic cooling histories of the flanks of the northern and central Rio Grande rift, Colorado and New Mexico* by Kelley, Chapin, and Corrigan (1992). The Bulletin sells for $7.50 plus $2.50 postage, and is available from the NMBM&MR, Publication Sales Office, Socorro, NM 87801.

Figure 1–Fission tracks in a crystal of apatite from the large dike that extends south from Shiprock (about 27 million years old). The photograph was taken of a thin slice of the mineral after the tracks had been etched with acid to enlarge them (width of field of view is 0.2 millimeter). Photograph courtesy of Dr. Charles Naeser, U.S. Geological Survey.

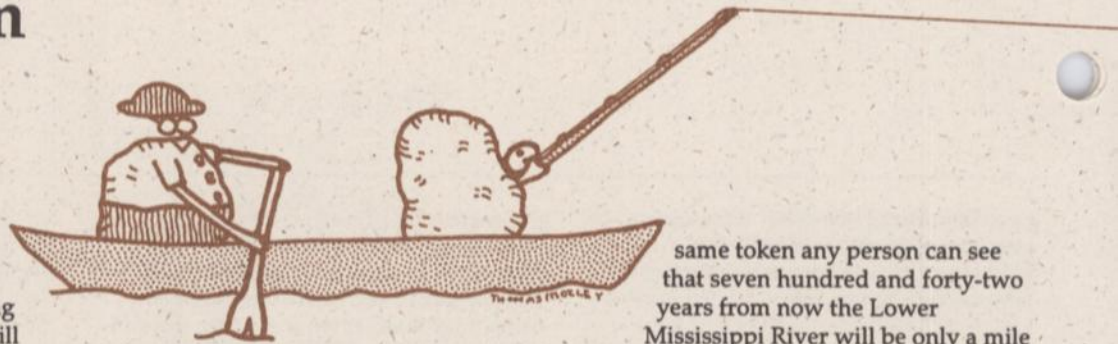
Excerpts from "Life on the Mississippi"

by *Mark Twain*, 1883

"...give me the opportunity of introducing one of the Mississippi's oldest peculiarities—that of shortening its length from time to time. If you will throw a long, pliant apple-paring over your shoulder, it will pretty fairly shape itself into an average section of the Mississippi River; that is, the nine or ten hundred miles stretching from Cairo, Illinois, southward to New Orleans, the same being wonderfully crooked, with a brief straight bit here and there at wide intervals. The two-hundred-mile stretch from Cairo northward to St. Louis is by no means so crooked, that being a rocky country which the river cannot cut much.

"The water cuts the alluvial banks of the 'lower' river into deep horseshoe curves; so deep, indeed, that in some places if you were to get ashore at one extremity of the horseshoe and walk across the neck, half or three quarters of a mile, you could sit down and rest a couple of hours while your steamer was coming around the long elbow, at a speed of ten miles an hour, to take you aboard again. When the river is rising fast, some scoundrel whose plantation is back in the country, and therefore of inferior value, has only to watch his chance, cut a little gutter across the narrow neck of land some dark night, and turn the water into it, and in a wonderfully short time a miracle has happened: to wit, the whole Mississippi has taken possession of that little ditch, and placed the countryman's plantation on its bank (quadrupling its value), and the other party's formerly valuable plantation finds itself away out yonder on a big island; the old water-course around it will soon shoal up, boats cannot approach within ten miles of it, and down goes the value to a fourth of its former worth....

"Pray observe some of the effects of this ditching business.... the Mississippi between Cairo and New Orleans was twelve hundred and fifteen miles long one hundred and seventy six years ago. It was eleven hundred and eighty after the cut-off of 1722. It was one thousand and forty after the American Bend cut-off. It



has lost sixty-seven miles since. Consequently its length is only nine hundred and seventy-three miles at present.

"Now, if I wanted to be one of those ponderous scientific people, and 'let on' to prove what had occurred in the remote past by what had occurred in a given time in the recent past, or what will occur in the far future by what has occurred in late years, what an opportunity is here! Geology never had such a chance, nor such exact data to argue from! Nor 'development of species,' either! Glacial epochs are great things, but they are vague—vague. Please observe:—

"In the space of one hundred and seventy-six years the Lower Mississippi has shortened itself two hundred and forty-two miles. That is an average of a trifle over one mile and a third per year. Therefore, any calm person, who is not blind or idiotic, can see that in the Old Oolitic Silurian Period, just a million years ago next November, the Lower Mississippi River was upwards of one million three hundred thousand miles long, and stuck out over the Gulf of Mexico like a fishing-rod. And by the same token any person can see that seven hundred and forty-two years from now the Lower Mississippi River will be only a mile and three quarters long, and Cairo and New Orleans will have joined their streets together, and be plodding comfortably along under a single mayor and a mutual board of aldermen. There is something fascinating about science. One gets such wholesale returns of conjecture out of such a trifling investment of fact."

Mark Twain, 1883
Life on the Mississippi
(public domain)

Questions and answers about stream meanders

Dave Love
Environmental Geologist, NMBM&MR

What does meander mean?

Stream meanders are one of the most notable and intriguing aspects of many drainages in New Mexico (Fig. 1). Meanders are the sinuous paths many streams take back and forth along their course.

Figure 1–Aerial photograph of meanders along the Rio Puerco south of Cuba, New Mexico. State Highway 44 and vehicle for scale. Note older and impending cutoffs. (Photo courtesy of New Mexico Highway and Transportation Department)

What determines a stream's path?

The formation and persistence of stream meanders depends on several factors related to the development of streams over geologic time as well as physical principles of energy use and self-regulation in complicated systems. All streams operate within an area called a watershed, and all streams have a history. Streams gather and move water and sediment in their headwaters, transport and temporarily store sediments downstream, and distribute water and sediments at their mouths. The removal and movement of sediment is called erosion while the storage of sediment is called deposition. All stream systems consist of channels and adjacent flood plains. The movement of water and sediment requires work to be done (energy is used to move masses of water and sediment across the landscape). The amount of work depends primarily on the amount of water and the gradient (vertical drop per horizontal distance) of the stream. Through time, streams adjust their gradients, velocities, sediment loads, stream-bed roughness, widths, depths, and pathways. Streams that meander have a common range in gradients, sediment loads, and amounts of mud in banks and beds, each determined by the streams' history and adjustments made along the way.

How are meanders described?

Meanders consist of straight and curved segments of a channel. The banks of the curved bends are described as outside, or concave banks and inside, or convex banks. Convex banks are commonly called point bars. The pattern of meanders along a valley (Fig. 2) can be described by 1) sinuosity, or the ratio of channel length to straight-line length, 2) wavelength, or distance between repetitive arcs of channel, and 3) radius of curvature, the length of the radius of an arc of a circle drawn around the tightest part of a meander loop. Sinuosities may range from 1.1 to more than 22. The wavelength of most meanders is seven to ten times the channel width. Radii of curvature are only two to three times the channel width. Stream meanders commonly follow paths that show the minimum variation in changes in direction along the channel length. Such curves are known mathematically as "sine-generated" curves. Sine-generated curves describe the most probable random path between two points (a straight line is not the most probable path between two points when you only know you're headed generally down hill).

Does the sine-generated meander follow the laziest path?

A sine-generated curve is also the curve that minimizes the work in forming a bend. The form of meanders within a stream valley is the result of a balance between doing the least amount of work and equalizing the distribution of work between two points. In other words, the work done along each segment of the stream is uniform, while a minimum amount of total work is done.

What determines the shape of the stream bottom in a meandering stream?

The shape of the stream bottom along meandering streams, as most anglers and canoeists know, consists of shallow riffles and bars along straight channel segments between meander bends and deeper pools in the meander bends themselves. The pools are deepest along the outer edges of the meander and are shallow on the inside bank or point bar (Fig. 2). Water and bottom-moving sediment flow fairly uniformly down the straight riffles, but the bulk of the water and bottom-moving sediment separate and reorganize as both move through the bend. The water tries to continue flowing straight, but as the bank forces it to turn, it crosses to the outer bank, piles up and moves more quickly around the outside of the bend. Deep cross-channel currents are set up in a counter-balanced motion to move some water back toward the slower-moving side near the inner bank of the channel. As a result, there is a net corkscrew-like motion of water in the deeper part of the channel around the bend. The corkscrew motion erodes the outside of the bend, and helps move

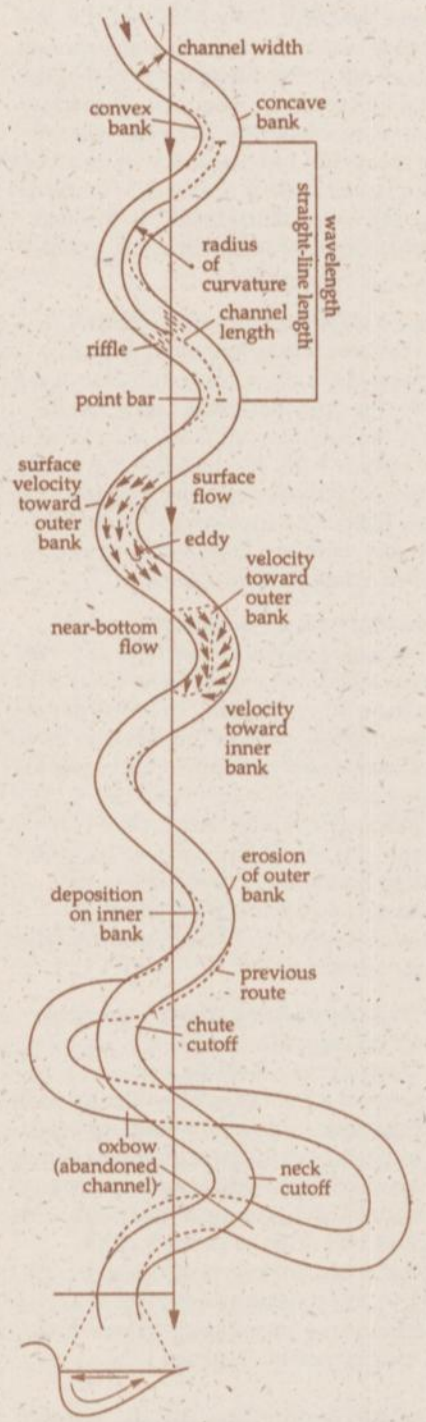


Figure 2–Common terms and measurements applied to stream meanders, water flow directions around bends, and places of erosion and deposition.

coarse sediment along the channel in fast-moving water. Both water and sediment spread out at the downstream end of the bend and enter the next riffle. Secondary eddies are also set up along the sides of the meanders, moving some water across the channel or even upstream. The slower moving water on the inside of the bend tends to deposit sediment on the point bar.

Once a meander forms, is it stable?

The corkscrew movement of water, erosion of the outer bank, and deposition along the point bar mean that through time, the meander shifts laterally, eroding the outside bank and building the inside bank. Meanders along major streams in New Mexico may move several meters per year, both in a cross-valley direction and in a down-valley direction.

What happens when meanders move?

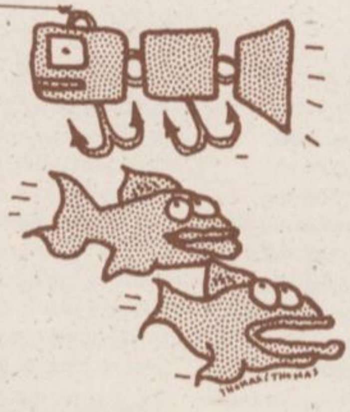
Because meander loops tend to move across and down valley, some loops may overtake others, causing channels to cut across narrow parts of the meander loops and form a new pathway. The process is called neck cutoff (Fig. 2) and the abandoned meander loop is called an oxbow (Fig. 2). Cutoff can also happen during floods when high water takes short cuts across low parts of the stabilized point bar. This process is called chute cutoff.

What happens when stream meanders erode downward?

Many stream channels and even canyons and valleys in New Mexico have become incised into the underlying rock or sediment, while the stream maintained a meandering pattern. As a result the meanders have become entrenched, with high arroyo walls or bedrock cliffs towering above present stream channels (Fig. 3). These features reflect the persistence of meandering stream flow for long periods of time.

Suggested activities and questions:

1. Take a long piece of stiff fiberglass strapping tape or spring steel, hold it at two points and bend it into loops. It will assume the shape of least work and least



Did you see the look on that guy's face?

Figure 3–Entrenched meanders of streams in the Guadalupe Mountains, southeastern New Mexico. County road for scale cuts diagonally from upper center to lower left.
(Photo courtesy of U.S. Geological Survey)

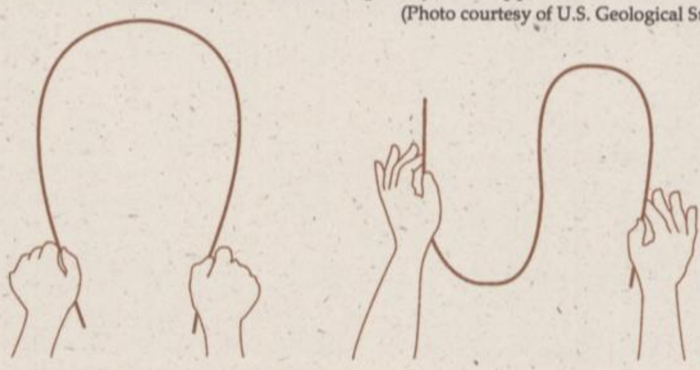


Figure 4–Bends formed by steel tape (redrawn from Leopold and Wolman, 1966).

deflection from the main direction between the two points (Fig. 4). Steel cables draped between towers across rivers to form suspension bridges also take on the configuration of least work. Stream meanders maintain a similar shape. Describe some obvious differences between streams and stiff fiberglass or steel.

2. After looking at Figure 2, describe in which directions the stream current would tend to move a canoe along as you try to maintain the canoe in a center line around a meander bend. Describe the deflections a mini-submarine would experience if it tried to follow the same center line near the bottom of the meander bend.

3. Should you buy property with a meandering river as one property-line boundary? Why?

4. Work (**W**) is defined in basic physics as force (**F**) times distance (**S**) over which the force operates

$$W = F \cdot S$$

Force (**F**) is defined as mass (**m**) times acceleration (**a**).

$$F = m \cdot a$$

For streams, acceleration down slope is a fraction of gravitational acceleration (**g**) depending on the stream gradient (note: **g** is a special designation of **a**). Could equal amounts of work be done by a large stream with an extremely small gradient and a smaller stream with an extremely large gradient? What limits the amount of work done?

Suggested Reading:

Bloom, A.L., 1978, Geomorphology, a systematic analysis of Late Cenozoic landforms: Prentice-Hall, Englewood Cliffs, NJ, 510 pp.

Dietrich, W.E., and Smith, J.D., Processes controlling the equilibrium bed morphology in river meanders, *in* J. E. Glover and others, (eds.), River meandering, proceedings of the Conference Rivers '83: American Society of Civil Engineers, New York, pp. 759–769.

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A Boulder Lesson

Jacques Renault
Senior Geologist, NMBM&MR

Down a wash here's what I see:
This humongous boulder in a tree,
Stuck in a crotch a yard or so
Above where the tree decided to grow.
Probably weighed two hundred pounds.
Been there long before I came round.

Was there a giant awfully bored,
With no one watching to record
The terrible strain and pain to place it
Where I'd have to wondering face it?
Or did it drop right out of the sky,
A meteorite passing by?
Perhaps the tree, from a tiny sprout,
Just grew and lifted it right out
Of its rocky sand and gravel bed
Just to make me scratch my head.

Instead of puzzling on thin air,
I looked to see what else was there.
High as my head on the rocky wall,
Driftwood hung from nothing at all.
The wash was a narrow granite pass;
Water had to travel fast
And deep when storms were really great,
Rolling boulders through that gate.
Hey, I think I've got it! See,
The boulder rolled into the tree.
But how did it get up into it?
Well, here's the way it had to do it.

The tree trunk was a little buried
In all the sand and mud that hurried
Down the wash, you know. So when
A flood came rushing through again,
The crotch was in the way and caught
That boulder just as quick as thought.
Another storm came washing by
And left the boulder high and dry.

Now, after this I hope you'll know
One way that rocks and water go,
But better yet you learned from me
To look beyond the bouldered tree.

Fireworks and Natural Resources

Virginia T. McLemore
Field Economic Geologist, NMBM&MR

Fireworks, or **pyrotechnic devices,** have become an important part in our celebration of national holidays. However, few people may realize that more than two dozen different materials are required to produce the sparkling displays we all enjoy. *Pyrotechnics* are manufactured materials or devices that produce noise, light, smoke, heat, or motion when ignited. In addition to fireworks, some common pyrotechnics include matches, flares, and torches; less common but equally important pyrotechnics include igniters, incendiaries, fuses (flares used as danger signals), and dispersing materials for substances such as insecticides.

Fireworks are a combination of gunpowder and other combustible ingredients that explode with loud noises and emit colorful sparks and flames when burning. Today fireworks are divided into two classes: (1) force and spark, and (2) flame (rockets). They consist of **oxidizers, fuels, and binders**. Oxidizers allow for the ignition of the fuel to burn or explode and include compounds containing nitrates, perchlorates, chlorates, and peroxides of barium, potassium, and strontium. The materials that act as fuels include sulfur, charcoal, boron, manganese, aluminum, titanium, and antimony sulfide. Binders, typically paper, hold the fireworks together.

The discovery of fireworks is attributed to the Chinese before 1000 AD during the Sung dynasty. Firecrackers (consisting of a black powder) and simple rockets, (containing black powder plus a propellant) were used during festivals and celebrations. Fireworks were introduced in Europe prior to 1242, when Roger Bacon's formulas were used. By 1320, black powder was used as a propellant in firearms and the European militaries controlled its manufacture until the 19th century. In 1677, black powder was used as a blasting agent in mines in Hungary. The first black powder was a mixture of saltpeter (potassium nitrate), charcoal, and sulfur. Saltpeter was common in the arid Middle East. Later other nitrates, including bat guano, were used in place of saltpeter.

Compounds that produce *special colors* were not added until the 19th Century. Green colors are produced by barium, nitrate, and copper; reds are achieved by adding strontium and calcium. Blue can be obtained by combining copper with calomel (a mercury compound). Yellow is produced by sodium, whereas sodium plus strontium generates orange. Silvery white colors are created by the addition of titanium, zirconium, and magnesium. Iron filings and charcoal yield gold sparks; magnalium (a mixture of magnesium and aluminum) produces silvery-white flashes. Lithium produces purple red.

don't smoke

Other materials and combinations yield *special effects*. Fine aluminum powder is the fuel that produces a loud flash. Larger particles yield longer, shower-like effects. The combination of organic dyes and coolant results in colored smokes. Potassium benzoate, with its characteristic unstable burning, produces a whistle. Charcoal generates a sparkling, flaming tail. Sand and potassium sulfite are used to modify combustion.

Where do these materials come from? *Mines, of course*. Aluminum is derived from bauxite (aluminum oxides and hydroxides). Barium comes from barite ($BaSO_4$). Magnesium and sodium come from brines, magnesite ($MgCO_3$), and dolomite ($CaMg(CO_3)_2$). Titanium is extracted from ilmenite ($FeTiO_3$) or rutile (TiO_2). Strontium is derived from celestite ($SrSO_4$). Most of the materials used in fireworks come from the ground. Even the clay used in making the paper binders has to be mined.

Today, fireworks are used worldwide and continue to grow in popularity. In the last decade in the United States, nearly 30,000 tons of fireworks were used each year. Private consumers buy approximately two-thirds of fireworks and public displays account for the rest. Other uses of pyrotechnic devices include fuses (flares used as danger signals on the highways), torpedoes (used by railroads to warn of an approaching train), and other signal flares. About 85% of consumer fireworks and half of those used for public displays are imported from China, Japan, Korea, and Europe (France and Italy). In the United States fireworks are manufactured in New Mexico, Maryland, Oklahoma, and a few other states. Many materials used in fireworks manufacturing are mined throughout the United States or are imported from other countries.

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World Book Encyclopedia, 1990: World Book, Inc., Chicago, Illinois, v. 22.

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EARTH SCIENCE UPDATE

Teachers' Resources: more free stuff

"Energy Education Resources—Kindergarten through 12th Grade" contains a listing of free or low-cost energy related educational materials for educators and students. A free copy is available from the National Energy Information Center. Call (202) 586–8800. **Here are just a few of the resources listed in the booklet:*

***The National Energy Foundation** offers a variety of energy education materials for grades K–12, including in-service training programs and materials packets. To receive a free catalog, write to the National Energy Foundation, National Office, 5160 Wiley Post Way, Suite 200, Salt Lake City, UT 84116 or call (801) 539–1406.

***Kids For A Clean Environment (Kids F.A.C.E.)** provides free membership to teachers and children. The membership includes "Our World, Our Future: A Kid's Guide for a Clean Environment" and a subscription to a bimonthly newsletter "Kids F.A.C.E." focusing on projects for home or school. For a free membership, write to Kids for a Clean Environment, P.O. Box 158254, Nashville, TN 37215 or call 1–(800) 952–3223.

***The American Coal Foundation** provides classroom materials (some available for free) on coal production, distribution, and use, along with a kit containing several coal samples with descriptions. A slide presentation is also available for purchase or free loan for grades 7–12. Contact the American Coal Foundation, 1130 Seventeenth Street NW, Suite 220, Washington D.C. 20036–4604, or call (202) 466–8630.

***The American Solar Energy Society** offers sample copies of its magazine, "Solar Today," and has two science project books available for purchase. Write to the American Solar Energy Society, 2400 Central Avenue, Suite G–1, Boulder CO 80301, or call (303) 443–3130.

also...

Free lesson plans and materials titled **"Dinosaurs and Power Plants,"** for use in grades 5–8, are available from the Department of Energy's Office of Fossil Energy. Study areas include fossil fuel history, extraction, transportation, use, and environmental effects. To receive a copy, write the Office of Fossil Energy Communications, FE-5, Room 4G–085, U.S. Department of Energy, Washington D.C. 20585 or call (202) 586–6503.

Upcoming Geological Meetings and Events

August 7—February 4, 1994
Ring of Fire, a movie about volcanoes in the Pacific Ocean, will be shown daily in the Dynamax Theater of the New Mexico Museum of Natural History and Science, Albuquerque, NM. For information on show times, etc., call the Museum at (505) 841–8837.

September 18–November 7, 1993
Dinotopia, a display featuring original art from the fantasy world of Author/Illustrator James Gurney will be shown at the New Mexico Museum of Natural History and Science. More information is available by calling the Museum at (505) 841–8837.

October 6–9, 1993
the New Mexico Geological Society will hold its *Annual Fall Field Conference* in the Carlsbad, NM region. For information contact John Hawley, (505) 255–8005 (NMBM&MR, Albuquerque), or Dave Love, (505) 835–5146 (NMBM&MR, Socorro).

October 27–29, 1993
The *Rocky Mountain Ground Water Conference* will be held at the Hilton in Albuquerque, New Mexico. Contact Michael Campana, (505) 277–3269, William J. Stone, (505) 827–3434, or Douglas Earp, (505) 768–2000 for more information.

what is...

fossil ice?
Ice formed in and remaining from the geologically recent past. It is found in glaciers, permafrost regions, and ice caves.

oxbow lake?
A crescent-shaped body of standing water situated in an abandoned stream channel after the stream cut a new path across a meander loop.

road log?
The descriptive record of the route taken on a field trip and the geology observed along the way.

Reference–Bates, R.L., and Jackson, J.A. (editors), 1980, Glossary of Geology: American Geological Institute, Alexandria, VA, 2nd edition, 749 pp.

NMBM&MR publications profile...

An exquisite collection of display-quality mineral specimens, featured in full-color photographs, is presented in a set of 10 postcards titled ***New Mexico Minerals I.*** The showcased specimens are azurite, sceptered amethyst, wire gold crystals, smithsonite, cassiterite, cerussite, cyanotrichite, Japan-law-twin quartz, aurichalcite, and wulfenite. Each 4" x 6" postcard lists both dimensions of the specimen and its locality. The postcards are enclosed in a cover that features three additional minerals, linarite, smoky quartz, and copper crystals. Inside the cover is an index map showing the localities of the 13 minerals, and information on ore deposits and mineral specimens from each locality. Photography is by D.L. Wilson, text written by M.L. Wilson, 1990. To order the set of 10 postcards, ***New Mexico Minerals I,*** send your request along with $3.25 plus $1.50 shipping to: Publications, New Mexico Bureau of Mines and Mineral Resources, Socorro, NM 87801. Please mention *Lite Geology* when ordering.

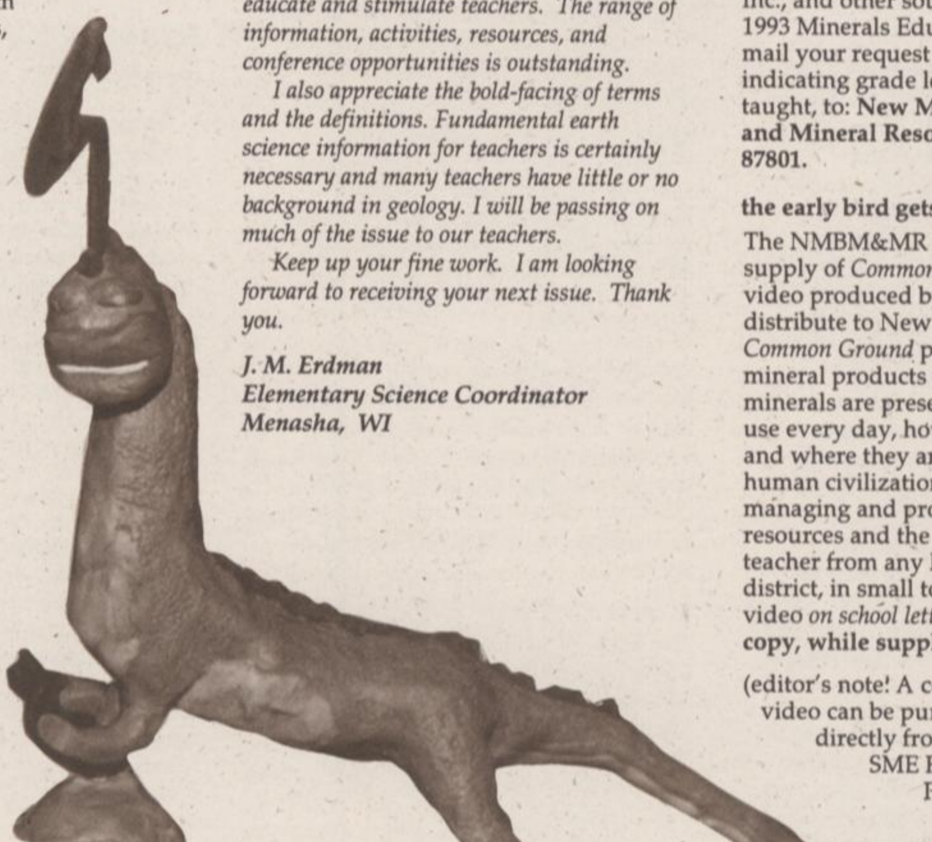
Earthlinks for Educators

Water Ecology Project—Summer 1993 Overview

This summer, youngsters in the seventh and eighth grade got wet and learned about water ecology, thanks to a grant from the U.S. Fish and Wildlife Department and the New Mexico Museum of Natural History and Science. Sue McGuire, Director of Public Programs for the Museum, designed the Water Ecology Project (WEP) to integrate science disciplines, history, math and social skills.

Students in the project conducted research on the water quality of rivers and irrigation ditches at four New Mexico locations—Albuquerque, Isleta, Cochiti, and Las Vegas. The student researchers collected data on water chemistry and silt load, and analyzed the quality of molds, algae, microscopic animals, and aquatic insects. They also identified stream-side plants and insects.

At the end of the three-week session, participants from all four locations convened at the Museum for the student congress, where they presented their results and interacted with each other and with the professionals involved in the program. For information on the WEP in 1994, contact Sue McGuire at the NewMexico Museum of Natural History, phone (505) 841-8837.



Dinosaur by: Robert Savenelli and Adrian Des Georges, 8th Grade, Taos Jr. High

Lite Geology mailbox...

Just a quick note to let you know that your time and effort in producing Lite Geology is appreciated by this science teacher. With each issue, I learn something new about the state of NM, and resource use. The addresses and contact persons listed are helpful in obtaining cheap and free teaching tools-an imperative in these tight economic times. Your illustrations are humorous and light, the factual info solid, and the format is entertaining and easy to use. I'm always glad to see a fresh issue in my mailbox at school.

George Jewett
Teacher, Koogler Middle School
Aztec, NM

Thank you very much for sending the Winter 1992 issue of Lite Geology. It is a super publication—just what is needed to educate and stimulate teachers. The range of information, activities, resources, and conference opportunities is outstanding.

I also appreciate the bold-facing of terms and the definitions. Fundamental earth science information for teachers is certainly necessary and many teachers have little or no background in geology. I will be passing on much of the issue to our teachers.

Keep up your fine work. I am looking forward to receiving your next issue. Thank you.

J. M. Erdman
Elementary Science Coordinator
Menasha, WI

a new service at the NMBM&MR....

The New Mexico Bureau of Mines and Mineral Resources announces the opening of its Earth Science Library/ Geotechnical Information Center (ESL/ GIC), a lending library containing videos, slides, and printed material. Topics range from geology and mining to environmental concerns and natural resources. To obtain a current listing of available titles, write to **Theresa Lopez, ESL/GIC, New Mexico Bureau of Mines and Mineral Resources, Socorro, NM 87801.**

NMBM&MR 1993 Minerals Education Packet

The New Mexico Bureau of Mines and Mineral Resources is pleased to offer New Mexico Teachers a collection of Minerals Education materials from the U.S. Geological Survey, U.S. Bureau of Land Management, U.S. Bureau of Mines, Society for Mining Education, Caterpillar, Inc., and other sources. To receive the 1993 Minerals Education Packet, please mail your request *on school letterhead*, indicating grade level and subjects taught, to: **New Mexico Bureau of Mines and Mineral Resources, Socorro, NM 87801.**

the early bird gets the video!...

The NMBM&MR has acquired a limited supply of *Common Ground*, an educational video produced by Caterpillar, Inc., to distribute to New Mexico teachers. *Common Ground* presents the story of the mineral products of our planet: what minerals are present in the products we use every day, how they are formed, how and where they are found, their role in human civilization, and how we are managing and protecting our mineral resources and the environment. The first teacher from any New Mexico school (or district, in small towns) to request this video *on school letterhead* will receive a **free copy, while supplies last.**

(editor's note! A copy of *Common Ground* video can be purchased for $10.00 directly from Carl Haywood at the SME Foundation for Public Education, (303) 973–9550, or through your local Caterpillar, Inc. dealer.)

Sources for Earth Science Information

Teachers can receive free materials including curricula, student handouts, and reference materials for school resource media centers by contacting:

U.S. Bureau of Mines
Guy Johnson, Staff Engineer
Building 20
Denver Federal Center
Denver, CO 80225–0086
(303) 236–0747

For answers to questions on economic mineral deposits and the extractive mineral industry, contact:

Mine Registration & Geol. Serv. Bur.
Bill Hatchell
Mining and Minerals Division
2040 South Pacheco
Santa Fe, NM 87505
(505) 827–5970

A free teacher's packet including a poster, lesson plans, activities, and a list of mineral resource information can be obtained by calling or writing:

Mineral Information Institute
Jackie Evanger: Vice President
475 17th Street; Suite 510
Denver, CO 80202
(303) 297–3226

For information about state environmental programs in New Mexico, contact:

John Geddie, Administrative Asst.
Public Information
New Mexico Environment Dept.
P.O. Box 26110
Santa Fe, NM 87502
(505) 827–2850

The Environmental Protection Agency provides a free information hotline for radon. Call:

1-(800) SOS–RADON.

Information on earth science projects, programs, reports, products and their sources is available from:

Earth Science Information Center (ESIC). Call 1–(800)–USA–MAPS.

oops...

The last sentence in exercise 2 following the article ***Ground-water Overdraft and Land Subsidence (Lite Geology, Spring 1993)*** should read "The specific gravity of the rock is its weight in air divided by the difference between its weight in air and its weight in water, which is between 2.5 and 3.0 for most rocks."

Dinosaur by: Charlene Abeyta, Jessica Franzetti, and Abbey Janosko. 8th grade, Taos Jr. High.

Lite Geology

Subscription Order Form

Please confirm my free subscription:

Name ______________________________

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How did you hear about *Lite Geology*? ______________________

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At what school do you teach? ______________________

Grade level? ______________

Subject(s) ______________

Note: if your mailing label lists you as a **Teacher** (in New Mexico), your subscription is automatic, and you need not return this form.

"geologic time" flies when we're having fun!...

This Summer 1993 issue of *Lite Geology* marks the completion of our first year in existence. We now look forward to another year dedicated to the exploration of exciting topics such as earthquakes, global climatology, volcanoes, and our precious mineral resources. We encourage our readers to save each copy of *Lite Geology* for reference; future articles will build on the concepts introduced in earlier issues. In the past year, our subscription list has nearly doubled, and the range of subscribers includes professionals in education, geology, and resource-related fields as well as the public. We thank our readers for the many wonderful letters, and will print some of them as we have space.

The New Mexico Bureau of Mines and Mineral Resources (NMBM&MR) would like to help New Mexico teachers launch another school year with our new Minerals Education Packet for 1993 (see the special offer inside this issue) and lending library. We hope to continue to hear from teachers and others who are interested in earth science education.

Susan J. Welch
Editor, *Lite Geology*

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LITE geology

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Purpose: to help build earth science awareness by presenting educators and the public with contemporary geological 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 source.

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