

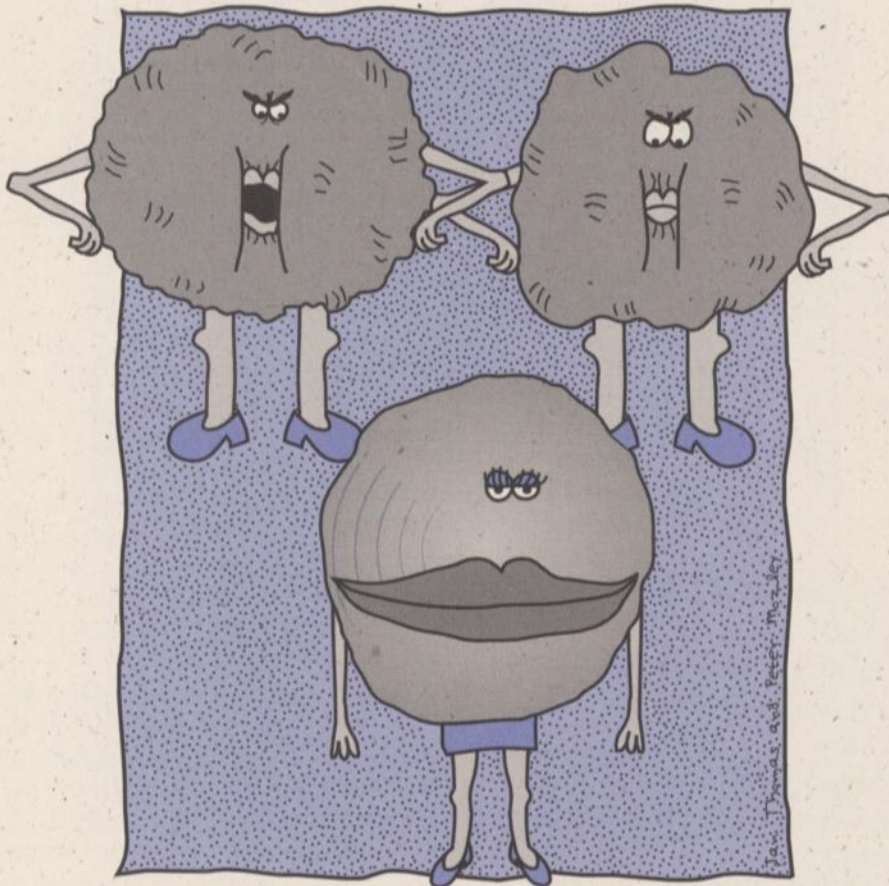
# L I T E geology

Number 22  
1999

New Mexico Bureau  
of  
Mines and Mineral  
Resources  
a division of  
New Mexico Tech

## Earth Briefs

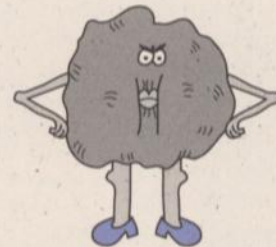
A publication for educators and the public—  
contemporary geological topics, issues and events



She's older than they think. . . I heard she's had  
three vesicle lifts and has gone in for sandblasting  
five times!

**Carrizozo Lava Still a  
Youngster at 5,000 Years  
Old:** *Flow was too young for  
traditional dating methods, so  
geologist tried a new way*

By John Fleck, *Journal Staff Writer*  
(Reprinted with permission from the  
*Albuquerque Journal*, issue for August  
29, 1999)



Like an aging  
movie star who's  
been lying about  
her age for years,  
the Valley of Fires  
lava flow outside  
Carrizozo is older

than we thought. In geologic terms,  
it's still a youngster at 5,000 years of  
age. But that's considerably older  
than the 1,000 years scientists once  
thought it was, said Nelia Dunbar, a  
geologist at the New Mexico Bureau  
of Mines and Mineral Resources.

Dunbar's age calculations add to a  
growing body of knowledge in the  
1990s about New Mexico's youngest  
volcanic features, the jagged  
badlands known as "malpais."  
The Carrizozo lava flow stretches  
some 50 miles from its volcanic  
source at Little Black Peak, north of  
Carrizozo in central New Mexico.  
It varies in depth from 30 to 50 feet  
and appears to have oozed out across  
the landscape in two separate  
eruptions within a few hundred years  
of one another, according to Dunbar.  
The black lava flows still bear the  
sinuous look of a type of lava named  
"pahoehoe" by the Hawaiians.

So short has the rock's time on  
Earth been that plants have only

## This Issue

*Earth Briefs—Better age estimates on  
some New Mexico volcanic rocks*

*Have You Ever Wondered...What do  
geologists learn from drilling wells?*  
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(page 7)*

*Magnification of microscopic miner-  
als and glass (page 8)*

begun to take a foothold. The erosion that will eventually weather the rocks down into dirt has barely begun. But, because they're so young, Dunbar explained, determining their ages is difficult. Radioactive decay of rare elements in volcanic rocks is frequently used to date them, but the Carrizozo flow isn't old enough for the decay products to have built up enough to make it datable by that technique, she said. So Dunbar turned to a technique developed by New Mexico Institute of Mining and Technology geologist Fred Phillips. Phillips found that a type of chlorine is produced by rocks when they're bombarded by cosmic rays that penetrate the atmosphere and bang into rocks sitting on Earth's surface. Measuring the chlorine in a rock allows the scientists to determine how long a rock's been sitting on the surface, exposed to cosmic rays.

Estimates in the 1950s and '60s, based on visual observation of the rocks, put the flow's age at 1,000 to 1,500 years, but Dunbar came up with an estimate of 5,200 years for the flow, give or take 700. That makes the Carrizozo flow slightly older than the McCarty's flow, located along Interstate 40 east of Grants, which Dunbar and Phillips date at 3,900 years old [compared to radiocarbon dates of 3,160 to 3,200 years old]\*.

While that might seem like a long time in human terms, they're mere youngsters compared with some of the more noticeable volcanoes in New Mexico. The Jemez Caldera west of Los Alamos, for example, blew up in spectacular eruptions 1.6 million and 1.2 million years ago, and the volcanoes on Albuquerque's west mesa are estimated to be more than 100,000 years old [156,000 years old]\*.

*\*Age estimates in brackets provided for comparison by Lite Geology editors*



*Lite Geology introduces our newest cartoonist, Bonnie Reiter!*

## Have You Ever Wondered...

### ...What geologists learn from drilling wells?

**Dr. Brian Brister**

*Petroleum Geologist, NMBMMR*

"Boreholes" are holes drilled into the ground for all sorts of reasons. They are often necessary for constructing building foundations, bridge supports, and billboard legs. They yield samples of ores that host desirable minerals in mining areas. Environmental testing of soils and ground waters requires holes to be drilled. "Wells" are deep boreholes drilled for the purpose of producing water, oil, or gas. When a hole is being drilled, a geologist is probably not far away. Although the hole in itself inspires strange fascination, it is

the material that was removed from the hole while drilling, the borehole wall, and the fluids that might fill up the hole that geologists are most interested in studying.

While an outcrop of rock might extend some distance horizontally and be mappable over an area of the Earth's surface, it reveals limited information about what is below the surface. Information from a borehole, on the other hand, yields significant vertical information about what is below the surface at one given point, but contributes only one data point to a map. When the information is available, geologists attempt to combine surface data from outcrops and subsurface data from boreholes to gain a 3-dimensional geological perspective.

Wells are drilled by a number of different methods: hand-dug (shovel), auger (screw), percussion (raising and dropping a weighted bit), rotary (rotating a drill bit), and some day soon perhaps, by laser. Rotary-drilled wells can be steered to drill an inclined, or even horizontal borehole. Whatever the method used, geologic materials (soil, rocks, etc.) are broken and removed. Of course the removed material does not look like it did before being drilled. Such material is referred to as "cuttings," which typically range from fine powder to chips a few centimeters across. Removing crushed and broken rock from the borehole is usually accomplished by bailing it out with some container or by "circulation." Circulation is achieved by pumping water, air, or viscous mud down the inside of the drill pipe, through holes in the bit at the bottom, and up the outside of the pipe back to the surface (Figure 1). The circulating liquid or air cools the bit, suspends the cuttings, and carries them to the surface where they are separated and washed, then examined with a microscope (Figure 2).

Geologists record their observations on a "log" of the well, which includes information such as the estimated depth from which the cuttings were derived, rock type, color, texture, fossils, porosity, odor, and other characteristics. The geologist's log also typically includes data on the exact location of the well, record of daily drilling activity and progress, results of formation pressure tests, shows of oil, gas or minerals, and description and measurement of any fluids that might flow into the borehole from porous rocks. Cuttings are often retained for further laboratory study and reference in the future.

Some wells are drilled with a special coring bit, shaped like a

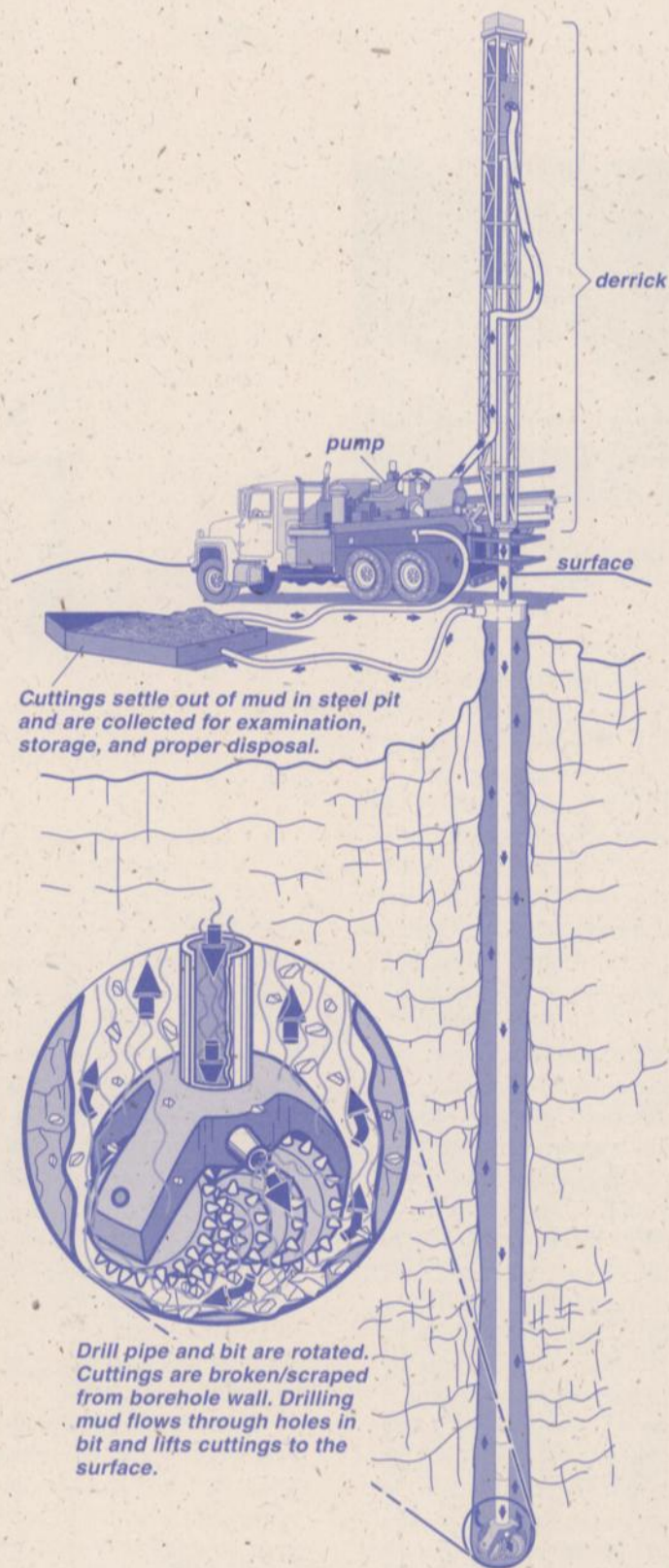


Figure 1—Diagram of rotary drilling operation demonstrating circulation of drilling mud. Illustration by L. Gabaldon.



Figure 2—Typical drill cuttings of a volcanic rock as seen through a microscope.

doughnut, that drills around, and preserves, a long cylinder of rock called a “core” (Figure 3). Imagine how much more information an unbroken core of rock would provide compared to sand-size cuttings! For example, a core might reveal structural information such as faults and fractures, sedimentary structures like crossbedding, formation contacts, or items too large to survive intact as cuttings such as mineral crystals, fossils, or large pores.

Often once a well is drilled, “geophysical tools” are lowered in the hole with a wire cable. With these tools, information about subsurface formations such as temperature, natural gamma radiation, electrical conductivity, rock density, and other properties can be measured. These measurements help the geologist to determine additional information about the rock types in which the well was drilled. Additionally, the depths of contacts between different rock units can be determined accurately. Information gathered by the geophysical logging tools is recorded digitally and plotted as paper “well logs” that can be compared with the geologist’s log (Figure 4).

Well information is expensive to

obtain. The cost of drilling a well can range from tens of thousands to millions of dollars. Such data is invaluable, however, for understanding subsurface geology, especially when data from different wells in an area are compared. More than a hundred thousand wells have been drilled in New Mexico by tens of thousands of different companies and individuals. Drilling is a regulated activity requiring permits, land reclamation, and record keeping. Some of this well information is made available to the public.

Where would a geologist look to find well information for an area of interest? The New Mexico Bureau of Mines and Mineral Resources maintains an archive of subsurface information from wells drilled throughout New Mexico. The Bureau’s Subsurface Library archives historical records from more than 95,000 wells,

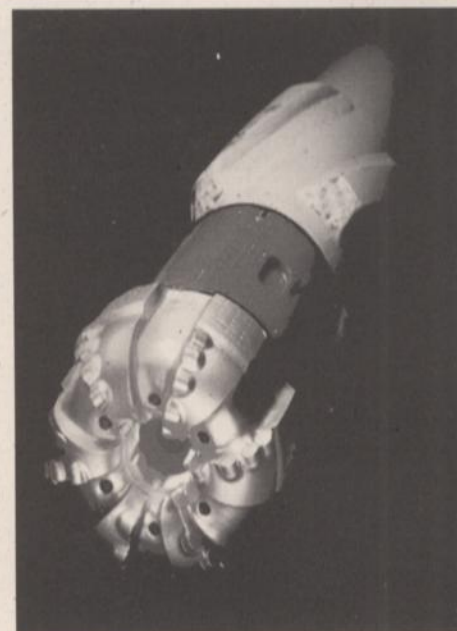
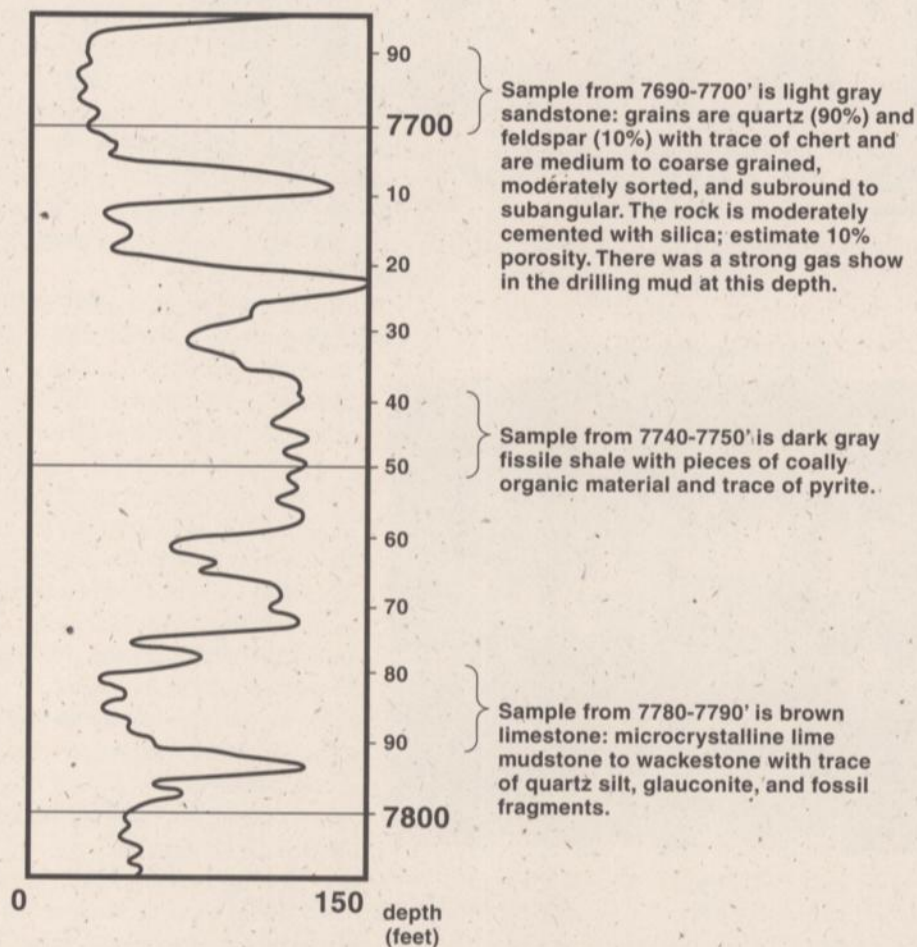


Figure 3— Doughnut-shaped coring bit. Photo courtesy of Baker Hughes Inteq, Houston, Texas.



### NATURAL GAMMA RADIATION

(AMERICAN PETROLEUM INSTITUTE STANDARD UNITS)

Figure 4—Geologist's description accompanied by well log measured in the borehole following drilling. The log demonstrates that different rock types have different levels of natural gamma radiation (gamma radiation levels increase to the right on log; expressed in API Standard Units).



well logs from over 48,000 wells and well cuttings from more than 15,000 wells stored in a three story warehouse. The Core Library houses many tons of core from more than 2,000 wells stored in six warehouses and includes cores from water, mineral, coal and petroleum boreholes. This publicly-available information is free to access and widely used by geologists in their subsurface studies.

### Resources:

For information on drilling activities or subsurface data collections, contact the New Mexico Library of Subsurface Data at NMBMMR in Socorro:

### Drilling activity in New Mexico:

Ron Broadhead (505) 835-5202

email: [ron@gis.nmt.edu](mailto:ron@gis.nmt.edu)

### Well logs and cuttings:

Annabelle Lopez (505) 835-5402

email: [alopez@gis.nmt.edu](mailto:alopez@gis.nmt.edu)

### Core Library:

Elizabeth Fleming (505) 835-5139

email: [efleming@gis.nmt.edu](mailto:efleming@gis.nmt.edu)



### References and Recommended Reading:

- Clark, L., 1988, The field guide to water wells and boreholes: Halstead Press, New York, 155 pp.
- Fleming, E. R., Hoffman, G. K., and Read, A. S., 1999, Drill core, cuttings, & well information available at the New Mexico Bureau of Mines and Mineral Resources: NMBMMR, Socorro, 67 pp.
- Swanson, R. G., 1981, Sample examination manual: American Association of Petroleum Geologists, Tulsa, 118 pp.

## Postcard from the Ice: Working on the global climate puzzle

This email message was sent by Dr. Nelia Dunbar on November 21, 1999 from McMurdo Base in Antarctica, where it is now summer! Dr. Dunbar, together with Dr. Bill McIntosh and Rich Esser from the Geochronology Laboratory at New Mexico Bureau of Mines and Mineral Resources/New Mexico Tech, are working on a National Science Foundation funded project to sample a 600-m-thick, horizontally exposed section of ice that dates back nearly 500,000 years. Geochemical analyses of the ice will provide a very long and detailed record of climate variations.

*How's everything in Socorro?*  
We've been down in McMurdo for almost a week, after a smooth trip south. The field team this year is made up of 3 people from NM Tech, and 3 from University of New Hampshire. We've all settled in well to the grueling process of sorting and packing our 12,000 pounds of camp gear, science equipment, fuel, snowmobiles, chainsaws, food, etc... So, I think that we have a pretty good, competent crew, which will be important because of the difficult place we're working this year.

Our scheduled put-in flight is on Nov. 24. We'll be going from McMurdo to a place called the Ford Range, in Marie Byrd Land, in an LC-130 "Hercules" aircraft. The Hercs haven't been distinguishing themselves this year, mainly because of regulations that were put in place last year after the "Herc in the crevasse" incident. But, they've already landed at Ford Range this year, and shouldn't have any trouble going back.

We'll spend one night at Ford Range, and will then be shuttled by Twin Otter [see photo] to a camp at the base of Mount Moulton to acclimatize for our final high altitude camp. This might

seem kind of complicated, but it's what we have to live with because the Hercs are doing a limited number of "open field landings" this year (going into a place where no other landing has taken place). We'll spend about 3-4 days at the acclimatization camp, and will then move up to the final high camp (2,800 meters or 9,186 ft) where the real work will begin.

Our final camp is pretty isolated, and although it's not really that high, we're



trying to be well prepared because if we do have an altitude problem, it would be impossible to get someone down to lower elevation until the Twin Otter could come and get us. Obviously, if we had a medical problem, we'd have first priority on the use of the Otter, but if the weather's bad, the Otter wouldn't be able to get to us.

So, we're taking two Gamov bags, as well as an altitude drug called Diamox. The Gamov bag is a pretty good invention. It is a big, tightly sealed bag that a person can fit in. There's a pressure regulator in the bag, and a foot pump that can be used to pump the bag up to pressures higher than the local pressure. So, if you put someone in the bag at an altitude of 10,000 ft, you can effectively bring them down to about 6,000 ft. This can clear up a lot of altitude problems, but you pretty much have to leave the person in the bag until you can actually get them down to lower

elevation. One of our crew was with a team climbing Denali last summer, and they were pinned down by a storm at 17,000 ft. Someone in another party had such bad pulmonary edema that he was coughing up blood, but after a day and a half in the bag, he was able to walk down under his own steam. So, it sounds as if they work.

When we're at our final camp, we'll be collecting a "horizontal ice core." The ice at this place is pushed up against a rock outcrop, and the whole section is turned up on its side, resulting in ice with a wide range of ages being exposed at the surface. We'll be collecting ice from a trench along the surface. We know the ages of the ice because there are dated volcanic ashes interlayered with the ice. We'll also be resampling the ash layers, redating the ones that we've already dated (for more precise ages) and recollecting ones that proved undateable before, possibly due to surface contamination.

The ice cutting is going to take place with a mighty ice trencher designed by Bill. If we can get some of our digital photos downloaded, I'll attach one to a future message. We've had it out on some frozen lakes around McMurdo, and it has worked well, and has also attracted a lot of attention! The ice trencher holds two chain saws, with the blades at about a 60 degree angle to the ice surface. The saws can be lowered into the ice, and then the trencher can be pushed along, resulting in the cutting of a beautiful wedge of ice 60 cm deep at the point. We then pry the wedge out of the hole, and trim it to get the 10 cm by 10 cm block of ice that becomes our final sample. Whenever a new person sees the ice trencher, horror movies are mentioned, and I can see why!

Well, that's about all from here.  
—Nelia

# New Mexico's Most **WANTED** **MINERALS**

Dr. V. W. Lueth, NMBMMR Mineralogist & Curator

Specimen from the  
Continental mine, Grant County, NM



## **CALCITE**

**DESCRIPTION:** This mineral is notorious for its vast number of rhombohedral crystal forms (more than 300!). Crystals can vary from obtuse, acute, thin tabular or long prismatic rhombs and scalenohedrons (photo). Many modifications of the crystal form are possible, and crystal twinning is common. Other forms include fibrous, lamellar, granular, earthy, tuberoze, nodular, and pseudomorphs (false forms). Luckily, other physical properties help to identify this mineral. Mohs Hardness: 3. Cleavage: 3 at inclined angles (rhombohedral). Optical properties: transparent to translucent, double refraction observed in transparent pieces. Chemical properties: reacts with weak acid to form  $\text{CO}_2$ . Color: white is most common, but any color is possible due to impurities. Chemical formula:  $\text{CaCO}_3$ , calcium carbonate. The name originates from the Latin word, *calx*, lime.

**WANTED FOR:** The most important use for calcite is in the manufacture of cements and lime for mortar. Also used as a flux for refining metal ores and as a soil amendment. Buildings are commonly constructed out of marble and limestone. Clear "iceland spar" was used to polarize light before the invention of Polaroid plates.

**HIDEOUT:** Calcite is a common rock-forming mineral, especially in sedimentary rocks where it is commonly known as limestone. When composed of microscopic organisms it is called chalk. It forms most cave deposits called speleothems. When metamorphosed it becomes marble.

**LAST SEEN AT  
LARGE:** Calcite is found almost everywhere in the state. Exceptional examples of crystallized specimens include: Carlsbad Caverns and the mines at Magdalena, San Pedro, and Organ. Optical calcite (Iceland spar) was mined near the Harding mine.

**ALIASES:** Spar, dog-tooth spar, nail-head spar, Iceland spar, and numerous rock names (e.g. limestone, travertine, tufa, onyx, caliche, etc.)

# Magnification of microscopic minerals and glass

**Nelia Dunbar**  
*Geochemist, NMBMMR*

**Gretchen Hoffman**  
*Coal Geologist, NMBMMR*

Secondary electron imaging is a technique that allows high magnification of very small samples. Rather than using light to magnify a sample, as is done with a conventional microscope, the electron microprobe uses a finely focused beam of electrons that sweeps back and forth across a sample surface, producing secondary electrons that are then measured by a detector. The signals from the measured electrons are reconstituted as an image on a television screen.

Because secondary electron images are usually magnified very highly, it is difficult to express the size of the image in conventional measurement units, like centimeters or inches. As shown here, the scale of secondary electron images is typically measured in microns. There are 1,000 microns in 1 millimeter, or 10,000 microns in a centimeter. The grooves and ridges on a fingerprint are about half a millimeter, or 500 microns, apart.

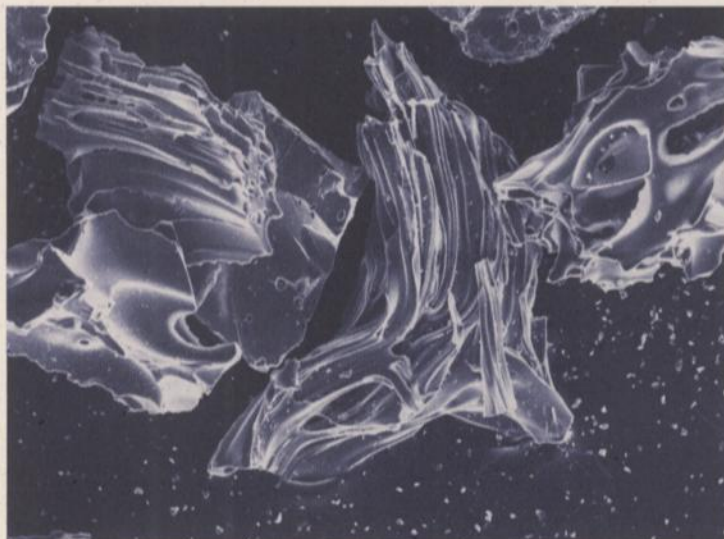


Figure 1—Field of view = 400 microns; photo by C. Harpel.

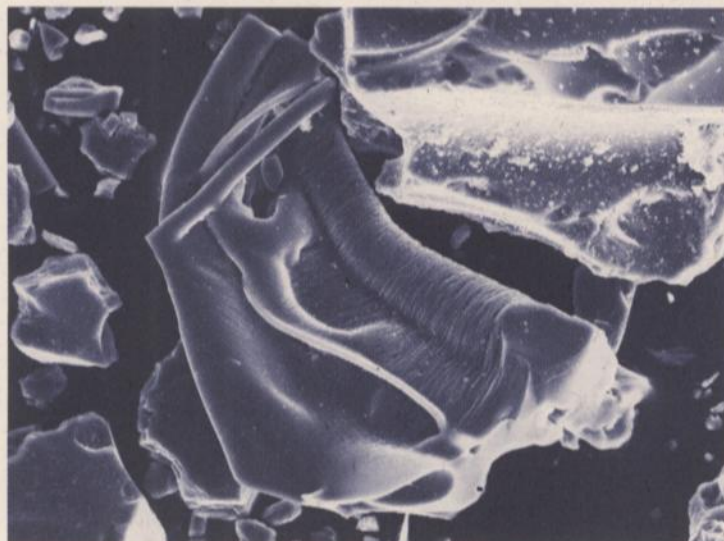


Figure 2—Field of view = 400 microns; photo by C. Harpel.

Figure 1 shows a secondary electron image of volcanic ash from Mount Erebus, Antarctica. Mount Erebus is a volcano that erupts several times a day, often producing ash such as that shown here. These ash shards, each about the size of a fine grain of sand, show features typical of glass from a volcanic eruption. The glass appears stretched; this stretching occurred during the volcanic eruption, while the glass was still molten. Many bubbles are visible also. These were formed by volcanic gas. The fibrous and spiky appearance of these particles is typical of volcanic ash.

The image in Figure 2 also shows volcanic ash particles from Mount Erebus, Antarctica. The main ash shard exhibits a distinctive wrinkling along the top side. This wrinkling appears very similar to the ropy surface of basaltic pahoehoe lava flows, and in fact, these type of flows are found on Mount Erebus. However, the wrinkles, or ropes, on the pahoehoe lava flows are about 10 centimeters across, rather than 10 microns or less, as on the particle. This illustrates that similar geological processes can take place on many different physical scales.

The images shown on this page are also glass, but rather than being ash from a natural volcanic eruption, these are "fly ash" produced by burning coal. Fly ash represents part of the inorganic material in coal. Fly ash is formed from minerals, such as clay, quartz and feldspar, that melt during the coal combustion process, and then solidify in the moving air stream leaving the combustion chamber. This moving airstream around the molten material helps to give most (greater than 60%) fly ash particles the striking spherical shape seen in these images. Fly ash ranges in size from >0-44 microns.

Figures 3 and 4 are secondary electron images of fly ash samples from Arizona Public Service Coronado Generating Station, near Springerville, Arizona. The coal burned to produce this fly ash is from Pittsburg and Midway's McKinley mine, north of Gallup, New Mexico. The hollow spheres packed with smaller spheres are called *plerospheres*, and the hollow and empty spheres are called *cenospheres*. It is believed the plerospheres were empty before being cracked, and then are filled with smaller spheres during the fly ash collection process. Analyses show most of the spheres are ~ 65%  $\text{SiO}_2$ , ~20%  $\text{Al}_2\text{O}_3$ , and 2-5%  $\text{FeO}$ , similar to glass.

Fly ash is used in cement and concrete products for its pozzolanic nature. A pozzolan is a siliceous or siliceous and aluminous material that in itself is not cementitious, but that will chemically react with calcium hydroxide in cement to form compounds possessing cementitious properties. New Mexico fly ash in particular is a beneficial admixture to cement because of its unique chemical properties. Fly ash also is used for large pours of concrete, as it acts like ball bearings in the cement and facilitates flow. It also lowers the curing temperature, reducing the potential for cracking. In 1997, 1.56 million short tons of fly ash from New Mexico coals were used in cementitious materials.

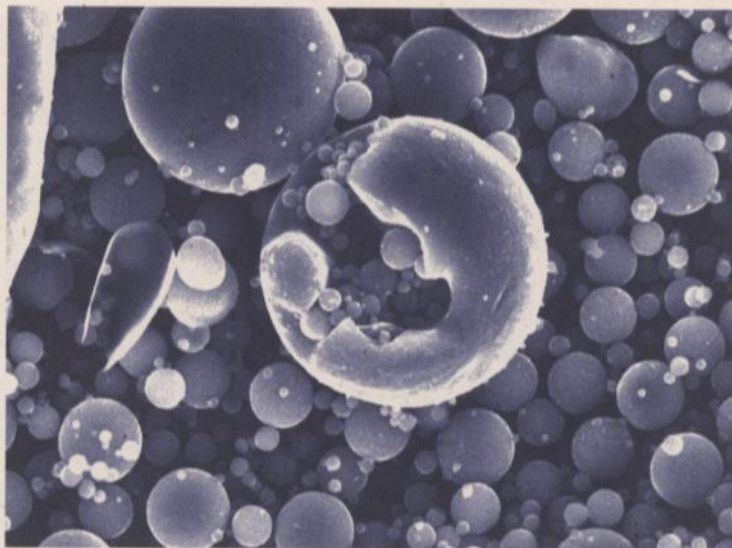


Figure 3—Field of view = 60 microns; photo by G. Hoffman.

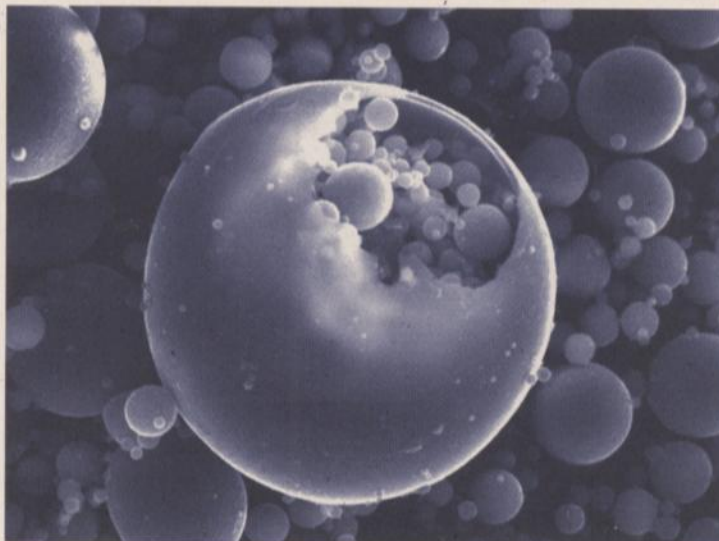


Figure 4—Field of view = 60 microns ; photo by G. Hoffman.

## Magnification of microscopic minerals and glass, cont.

Shown below are secondary electron images of natural minerals, rather than glass. Minerals and glass have fundamentally different chemical properties, and these are apparent in the shapes of the two materials. Minerals have a fixed chemical formula, and the atoms in minerals are organized in a framework structure. Glass, on the other hand, consists of randomly distributed atoms. Mineral grains, therefore, tend to have more regular, or boxy shapes, and straight edges, whereas glass particles tend to be randomly shaped, spiky or spherical.



Figure 5—Field of view = 110 microns; photo by M. Chapin.

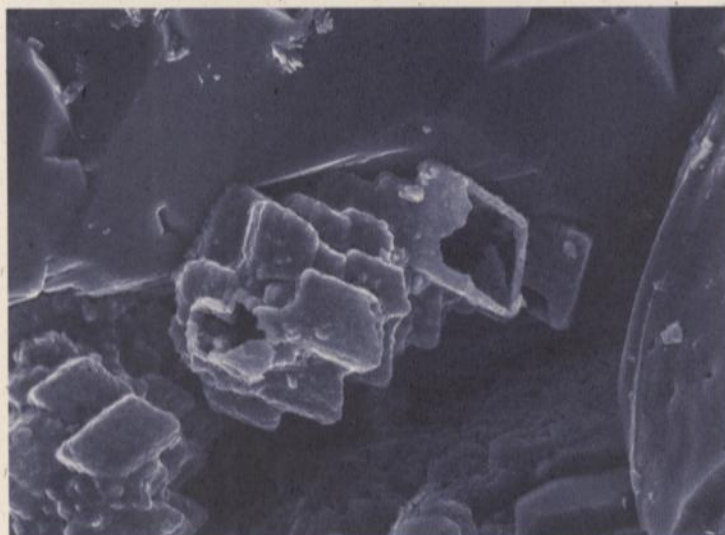


Figure 6—Field of view = 140 microns; photo by M. Chapin.

Figure 5 is an image of a field of very small quartz crystals. Note that the same crystal shape is repeated over and over and may look similar to quartz crystals that you have seen in larger rock samples. The repetitive shape and many straight edges are characteristic of crystalline minerals rather than glass.

The image in Figure 6 shows two types of mineral shapes. The first, in the upper part of the field of view, shows solid quartz crystals similar to those shown in the above image. In the center of the field of view is an unusual phenomenon, where one mineral (quartz) has formed a coating around a diamond-shaped mineral (calcite). The calcite then dissolved, leaving a hollow quartz coating in the shape of the former calcite crystals.



## Sources for Earth Science Information

### Mineral Information Institute

The Mineral Information Institute (MII) works in cooperation with a broad range of scientists and educators to develop mineral education materials for use in the classroom. Supported by corporations, foundations, scientific associations, and individuals from across the nation, MII distributes these materials free to classroom teachers to supplement existing curricula. Each year, more than 27,000 K-12 classroom teachers in all 50 states receive teaching materials from MII.

#### For more information, contact:

Nelson Fugate, President  
Mineral Information Institute  
501 Violet Street  
Golden, CO 80401  
(303) 277-9190/  
fax (303) 277-9198  
mii@mii.org  
<http://www.mii.org>

### Some websites for teachers

The American Association of Petroleum Geologists recognizes an outstanding teacher in Earth Science each year. Read about the current award winner at the address <[http://www.aapg.org/explorer/archives/04\\_99/teacher\\_98.html](http://www.aapg.org/explorer/archives/04_99/teacher_98.html)>.

The Geological Society of America has an informative website at <<http://geosociety.org>> that provides lots of material of interest to geologists and non-geologists too. This one is well worth exploring.

### Subscriptions:

*Lite Geology* began as a small Earth-science publication designed and scaled for New Mexico. Our subscription list now includes a large number of out-of-state readers. In order to keep up with the demand for this publication from outside of New Mexico, we now charge **\$4.00 per year for out-of-state readers**, which covers the cost of mailing. If you are a paid subscriber, you will find a number after your name on the mailing label. This number represents the last *Lite Geology* issue in your subscription. When the issue number is the same as that on your mailing label, it's time to renew your subscription. If you have questions, please call (505) 835-5490.

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## Visit the Mineral Museum

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 13,000 specimens of minerals and rocks, along with mining artifacts and fossils.

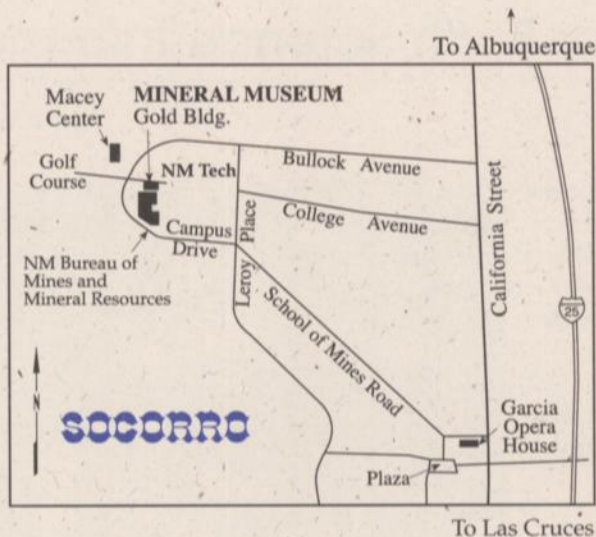
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### Museum Hours:

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10:00 to 3:00 most weekends  
Closed Institute Holidays



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