Lite Geology

New Mexico Bureau of Geology and Mineral Resources
Socorro—Geology and Outreach

Fall 2023

Volume 52

Socorro—Geology and Outreach

Greetings from Socorro, and welcome to the fall edition of *Lite Geology*! Autumn is arguably the best time of the year to visit Socorro. Our first two *Lite Geology* articles explore geology in Socorro County, from the ancient Lake Socorro to our present-day Socorro magma body. Our guest writers Samantha Pressman and Marc Roux are a student and a teacher duo from Rochambeau, the French International School, in Bethesda, Maryland. Marc brought his high school class to New Mexico to tour our desert landscape, and geologists Steve Hook and Dave Love led them on an amazing tour of Socorro County's Quebradas backcountry. Samantha wrote about her adventures in New Mexico, and her field trip descriptions and artwork are excellent! Marc Roux penned our "Through the Hand Lens" article and discusses his background and love of teaching. And Leah Tevis, New Mexico Tech Upward Bound teacher, rounds out this issue with her article about the New Mexico Tech mobile geoscience education outreach trailer.

Cover Photo

Quebradas backcountry Abo Formation red beds framed by Madera Group (foreground) and Yeso Formation (background) strata, Socorro County, New Mexico. *Photo by Linda Brown*

Preliminary Investigations of Lake Socorro

Daniel Koning

During a sabbatical that ended last spring, I focused on understanding a playa lake system in the central Rio Grande rift that I have called Lake Socorro (Fig. 1). It's been a fun challenge, one in which I had to closely study a lot of outcrops and think hard about what caused the sedimentary features in those outcrops. I am really grateful to build off of the mapping and observations of Richard Chamberlin, an outstanding field geologist. Two other notable geologists, Jack Oviatt (who has worked a lot on the geologic history of the Great Salt Lake) and Dave Love, both from Socorro, accompanied me in the field and assisted in lots of interpretations.

Sediment in Lake Socorro is 1,000 to 2,500 ft thick and is characterized by clays interbedded with minor sands and gypsum (Fig. 2). Since it does not overlie a 7-million-year-old volcanic flow southwest of Socorro, but rather just underlies it, the youngest possible age of the lake is 7 million years. Dating of ash beds indicates that an older version of the playa lake existed in the northeastern Socorro basin/southwestern Albuquerque basin as much as 14 to 15 million years ago.

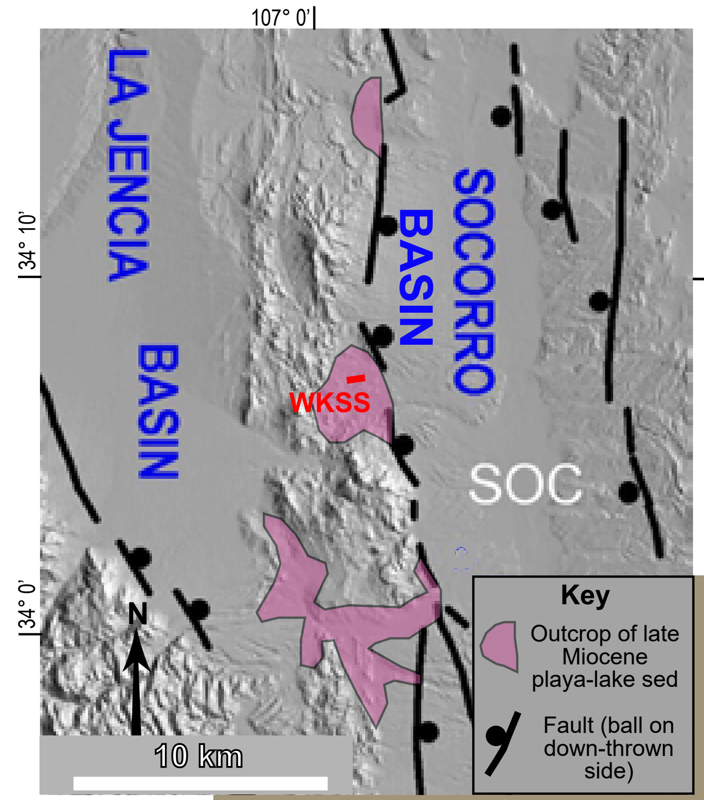


Figure 1. Map showing late Miocene playa lake sediment near Socorro on a shaded relief map. SOC = general location of the town of Socorro, WKSS = location of West Kelly stratigraphic section, and sed = sediments.

Figure 2. View of layered, clayey sediments deposited in Lake Socorro. The approximate area shown by the dashed red square is shown more closely in Figure 5. *Photo by Dan Koning*

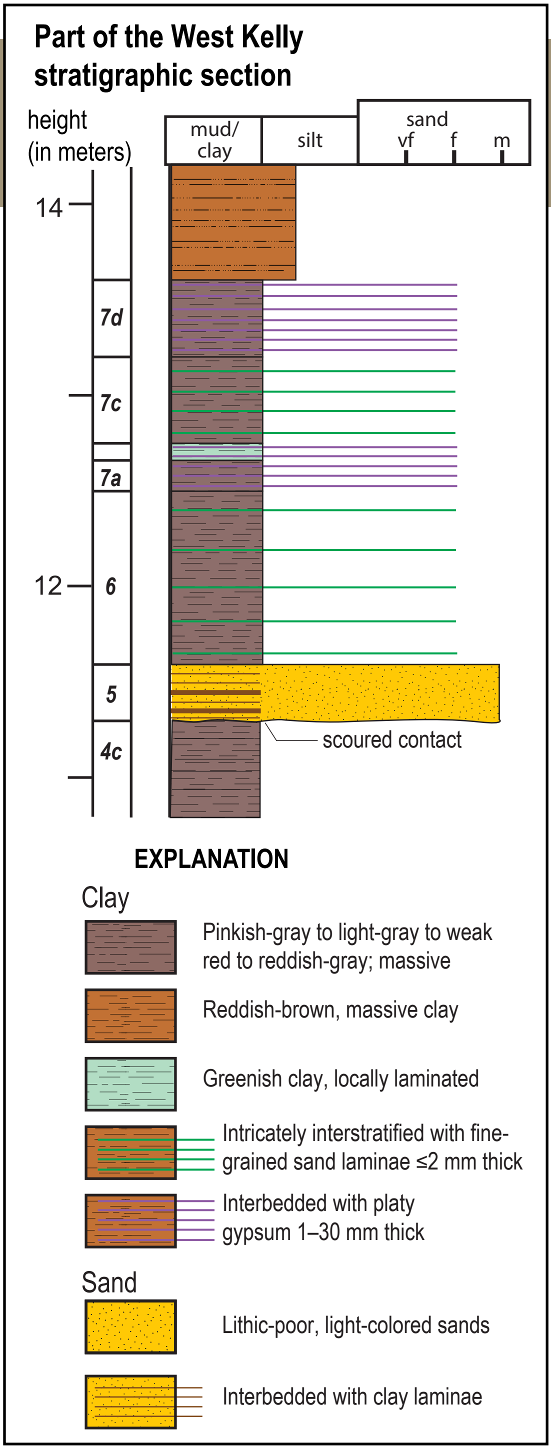


Figure 3. Stratigraphic section illustrating part of the layered sequence of the sediment of Lake Socorro. The thickness of the layers was measured progressively upward from an arbitrary point (0 stratigraphic height). The width of the boxes illustrating the layers is scaled according to whether the sediment is a clay, silt, or sands of various grain sizes. Other colors and patterns are explained below the graphic column. vf = very fine, f = fine, and m = medium grain size.

Several questions about Lake Socorro interested me: What were the depositional environments of the lake? How did these change with time? Was the lake shallow enough to occasionally dry up during ancient droughts, or did it have relatively deep, persistent water? So far, I have focused on the latter part of the lake's history, being particularly interested in when the Rio Grande began adding water to the lake.

Like many other sedimentology studies, mine entailed sequentially measuring and describing the stacked-up layers (beds) of sediment. The result is something that geologists call a stratigraphic section, as shown in Figure 3. Descriptive items associated with the section include color, sediment grain size, nature of the contacts separating the beds (scoured, gradational), and indications of current features such as ripple marks (note that current features are not present in the strata shown in Fig. 3).

During this investigation, I found that 11- to 7-million-year-old lake sediment can be conceptualized as being in two broad, pancake-like layers (Units 1 and 2), each of which is divided into two subunits (e.g., Unit 1a and 1b). The subunits are recognized by sediment characteristics and correspond to depositional environments in the lake. Their stratigraphic locations (positions) are illustrated by the red dashed lines in the schematic drawing of Figure 4. In the older interval, Unit 1a is characterized by relatively well-defined, tabular beds of clay, silty clay, minor darkish-tan sand, and minor gypsum (Fig. 5); these strata commonly exhibit light pinkish-gray to green-bearing pastel colors. I interpret that sediment deposition of Unit 1a occurred in shallow, relatively calm water subjected to small bursts of sedimentation from local, ephemeral drainages; these short-lived flood events deposited thin sheets of sands close to the shoreline. The interior of the lake (Unit 1b) is interpreted for areas where sand beds are lacking; there, the clay is reddish-brown and contains minor green zones and gypsum beds.

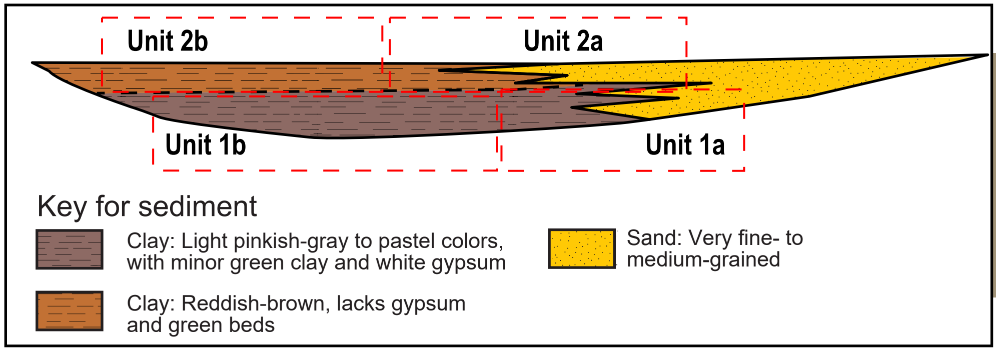


Figure 4. Schematic drawing illustrating interpreted depositional environments of Lake Socorro (dashed red boxes that are labeled Units 1a, 1b, 2a, and 2b) and the three sediment types that are present (explained in key).

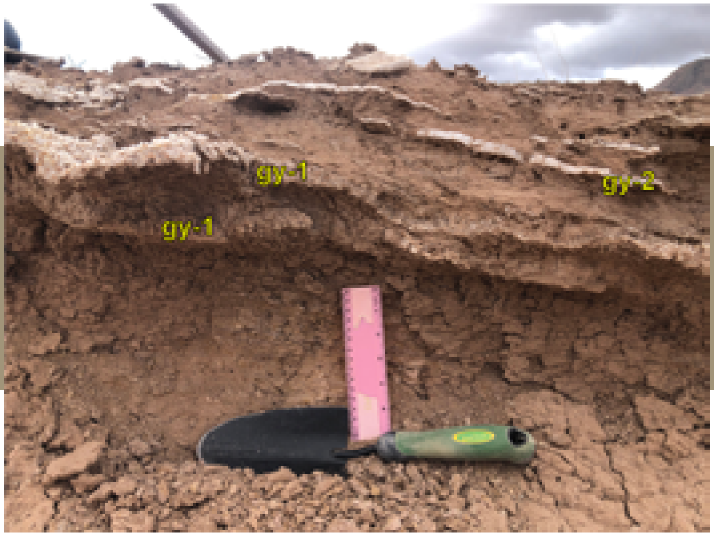


Figure 5. A photo of gypsum beds that characterize Unit 1 of Lake Socorro sediment. The gypsum is found in two types of beds. The first type (gy-1) is found in the lower two wavy beds (each 1–3 cm thick), just above the pink ruler; those beds are composed of randomly oriented, blade-shaped gypsum crystals one to several millimeters long. The second type (gy-2) is represented by the white beds about one ruler length above the top of the ruler, where the gypsum crystals are fibrous and oriented at right angles to the bedding. The first type probably reflects primary deposition of gypsum in the playa, whereas the second type is a secondary precipitate that fills fractures. Gypsum is the main precipitate found in this ancient playa, and is probably due, at least in part, to high-sulfate groundwater that discharged into the lake at the time. *Photo by Dan Koning*

In the higher (younger) stratigraphic interval (Unit 2), Unit 2a is typified by reddish-brown clays interbedded with light-colored sand tongues exhibiting well-defined sedimentary bedding, like ripple marks. The paleocurrents that deposited these sands were directed to the south. Unit 2b is like Unit 1b but lacks gypsum beds and commonly contains trace proportions of scattered sand grains in the clay.

The lake was relatively shallow and occasionally dried up, as indicated by mud crack features in Unit 1b (Fig. 6). Also, observations in Unit 1b of the lower contact of an interbedded lava flow indicate that the lava flowed into a dry lake with a moist surface. Another desiccation feature of Unit 1b is local shrink-swell shear faces preserved in the clay. However, no ancient soils are seen that would indicate prolonged times of being above the water and exposed to the air (subaerial). Unit 2 lacks notable desiccation features.

This investigation is ongoing and the results have yet to be published, but so far two interpretations can be made. First, sand bodies deposited in a deltaic environment of a south-flowing river(s) extended farther and farther southward with time, whereas the southern boundary of the lake was more or less the same. This suggests that the lake area decreased with time. Second, the youngest interval of the lake lacks desiccation features, indicating that water depth may have been greater and the lake was more or less perennial late in its history. How this relates to the evolution of the ancestral Rio Grande is still a work in progress.

Figure 6. This photo shows a light-green clay bed that is cross-cut by bands of reddish-brown clay. These bands are contiguous with the overlying clay bed and are interpreted to have filled fractures (mud cracks) that likely formed when Lake Socorro temporarily dried up. The cone-shaped hole in the green clay bed (labeled “cone”), locally exhibiting black streaks pointing to the bottom of the cone, is interpreted to have formed by shrink-swell processes during this time of desiccation. *Photo by Dan Koning*

Earth Briefs: Monitoring Earthquakes in the Socorro Seismic Anomaly

Mairi Litherland

Did you know that over 20% of the naturally occurring earthquakes in New Mexico happen in an area around Socorro? This area, which makes up less than 1% of the area of the state, was named the Socorro seismic anomaly by Dr. Allan Sanford, who established the first earthquake monitoring network in New Mexico at New Mexico Tech in 1960. Since then, the New Mexico Tech Seismological Observatory (NMTSO) has been monitoring earthquakes around Socorro using a network of seismic stations.

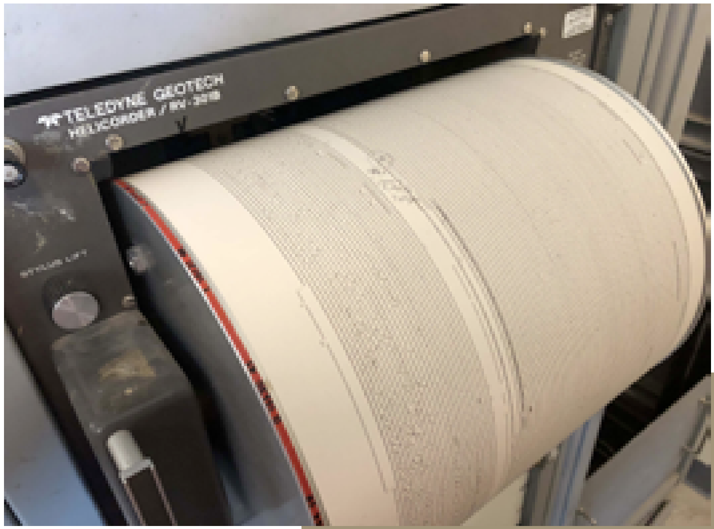


Figure 1. Historic analog seismic record for the NMTSO. *Photo by Mairi Litherland*

The first seismic station in the Socorro area was called SNM and was located in the mountains west of Socorro. This seismic station was installed in an abandoned mine tunnel to reduce the amount of noise that would interfere with the seismic signal. Back then, seismic signals were recorded using large rolls of paper that would slowly rotate as a pen traced a line along them. When the seismometer recorded a shaking motion in the earth, it would send a signal that caused the pen to shake as well (Fig. 1). Today we have a network of five stations operating in the Socorro area, and we record seismic waves digitally (Fig. 2). You can find real-time records of the seismic activity occurring in New Mexico at our website, geoinfo.nmt.edu/nmtso

Figure 2. Modern NMTSO station. *Photo by Mairi Litherland*

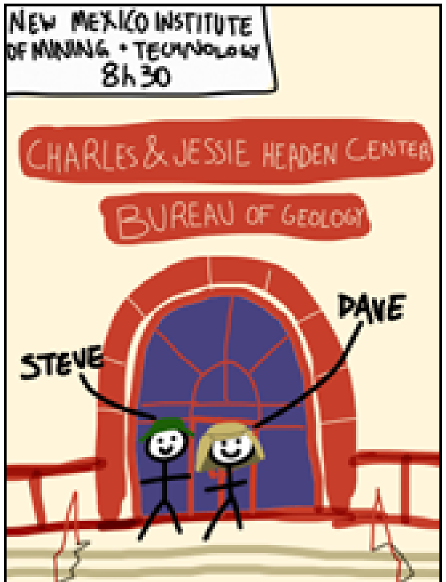
When Dr. Sanford started recording seismic signals around Socorro, he noticed something odd. Instead of recording a single waveform arrival in the seismograph when an earthquake happened, it looked like some of the seismic waves were bouncing off something in the subsurface before traveling to the seismometer, causing there to be an additional arrival. This was due to the energy from the earthquakes reflecting off the Socorro magma body, and was one of the earliest pieces of evidence for the existence of a large magma body beneath Socorro. This magma body is believed to be the reason for the elevated seismicity rate of the Socorro seismic anomaly. As the magma body slowly expands, it causes stress in the subsurface, which eventually causes faults to slip, producing earthquakes.

The earthquakes around Socorro tend to follow an unusual pattern. Instead of one large earthquake followed by smaller aftershocks, earthquakes in the Socorro seismic anomaly often occur in “swarms,” where many events of similar magnitude will occur in the same area over the course of a few months or years. Swarms are commonly observed in volcanic and magmatic provinces like the Socorro magma body.

The largest earthquake in New Mexico’s history happened on November 15, 1906. It was an estimated magnitude 6.2 event. (Since this earthquake happened well before any seismometers were installed in New Mexico, the size of the earthquake is estimated based on contemporaneous reports). It was large enough to be felt throughout the state and caused damage to some buildings in Socorro. However, it wasn’t the only large earthquake that happened in Socorro that year. Just like many other earthquakes near Socorro, it happened as part of a swarm. On July 12 and 16 of that year, there were earthquakes estimated at magnitude 5.5 and 5.7, respectively. There have been numerous other swarms since then, although none with such large earthquakes. Our seismic network continues to monitor the area because you never know when a large earthquake may happen again.

Voyage au Nouveau Mexique

Samantha Pressman



Our warm welcome from Dr. Hook and Dr. Love upon our arrival at New Mexico Tech.

Learning about the function of an electron microprobe.

Admiring the mesmerizing display cases in the Mineral Museum.

Visiting the NMBGMR Argon Lab, where we discovered how the half-life of potassium-40 is used to date rock samples.

Eighteen 11th graders and four chaperones from Rochambeau, the French International School, Bethesda, Maryland, arrived at the Albuquerque Sunport on March 28, 2023. This was the first of five whirlwind days of exploring the magnificent geology of New Mexico and meeting scientists specializing in fields we previously studied at school. The trip was guided by biology and geology professor Marc Roux, who has been taking students to New Mexico almost every year since 2004. Prof. Roux carefully curated each field trip with many recognized geologists from New Mexico Tech.

We observed and learned so much on this trip that I chronicled it in a daily art diary so the knowledge would stay with me. I used an iPad and the Tayasui Sketches app to create the drawings. This paper focuses on our experiences in Socorro at New Mexico Tech on days three and four.

On Thursday, March 30, our teachers drove us from Albuquerque to Socorro, where we met Dr. Stephen Hook and Dr. Dave Love at the New Mexico Bureau of Geology and Mineral Resources.

Before going to the field, my classmates and I visited the Mineral Museum, Argon Laboratory, and Electron Microprobe Laboratory. The collection of precious stones and rare minerals was mesmerizing, and I was fascinated by how the chemical composition and age of rocks is determined using spectrometers and the half-life of potassium-40 (1.25 billion years) or an electron microprobe.

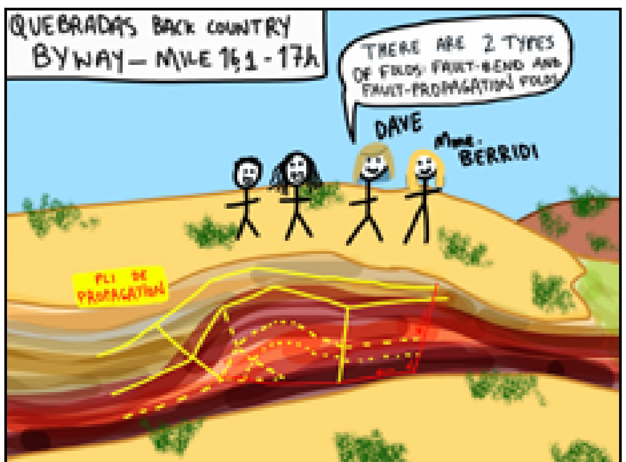
In a brief lecture, Dr. Hook and Dr. Love introduced us to fault-bend and fault-propagation folds—two of the ways rock layers fold over time. Equipped with our field guidebooks, we set off for the Quebradas Backcountry Byway, a dirt road east of Socorro that passes through remarkable rock formations.

At mile 9.7 of the byway, we left our cars to study a Z-fold—folded sandstone shaped like the letter Z that is part of the Yeso Formation. Dr. Hook and Dr. Love taught us to use Brunton compasses and measuring tape to determine the trends of the fold limbs along with their outcrop widths and lengths. They explained how to locate the synclines and anticlines (dips or arches in the compressed rocks), which allow geologists to identify the older and younger layers.

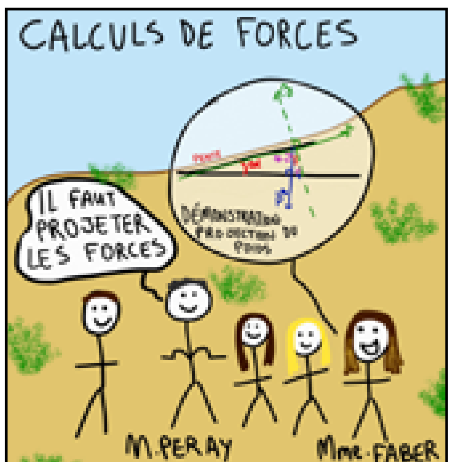
We stopped next at mile 16.1, where Dr. Hook and Dr. Love showed us an example of a small fault-propagation fold in a cross section of rock that forms the wall of an arroyo. The different hues of the thin layers of rock—burgundy, slate gray, and beige—were beautiful.

At sunset, near the eastern end of the Carthage coal field along Route 380, we examined the transition from continental to marine layers in Cretaceous strata. We eagerly searched for the fossil oyster *Lopha bellaplicata* in pieces of sandstone that had fallen from the cliff above the road.

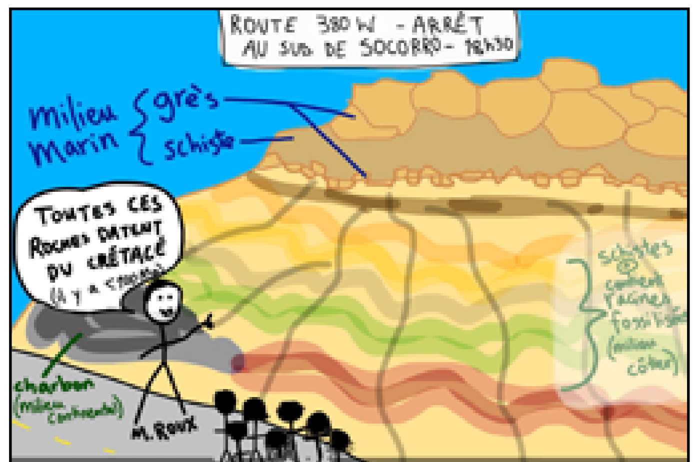
Field work—measurements of the Z-fold and introduction to geochronology.



Admiring the example of a fault-propagation fold at mile 16.1 of the Quebradas Backcountry Byway.



Applying math and physics concepts to the field.

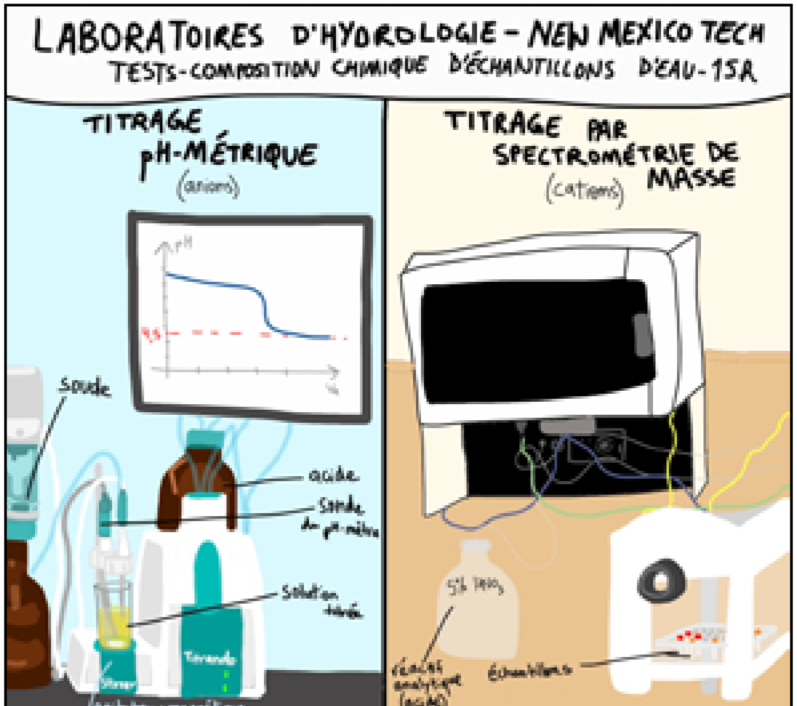


Eagerly searching for fossils from the Cretaceous Period on the side of the road.

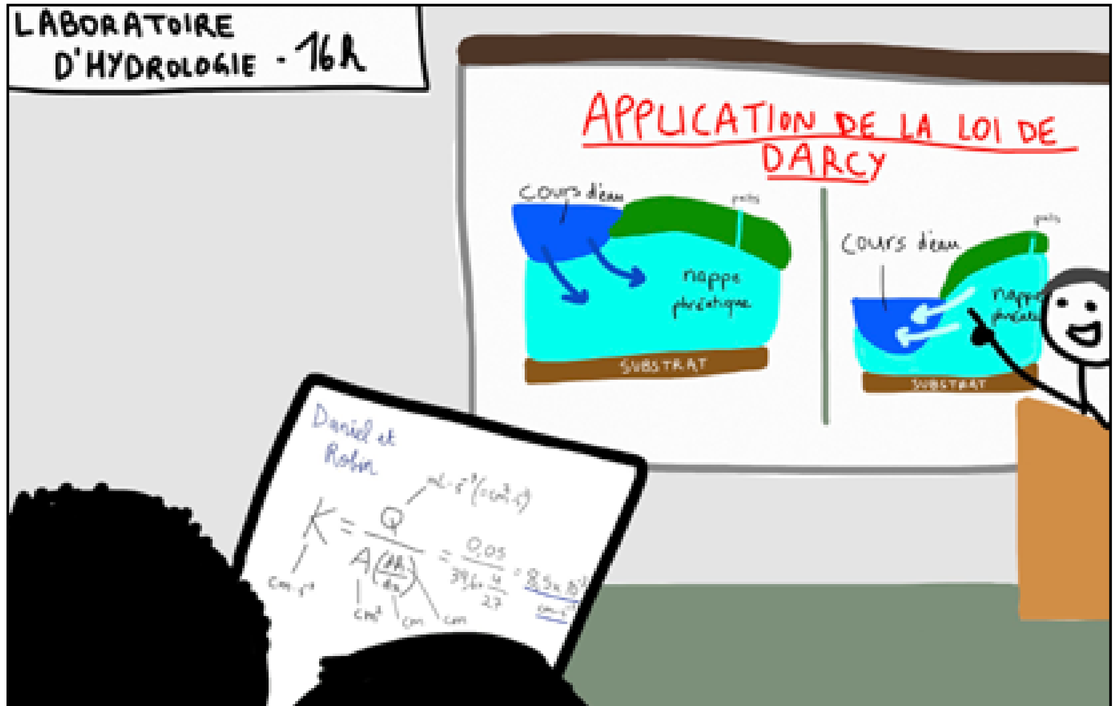
Enjoying the golden desert landscape on the way back to Socorro.

The following afternoon, scientists in the Hydrology Labs demonstrated how the chemical composition of water samples is determined through titration and mass spectroscopy. Finally, we learned how to calculate the flow of water underground using Darcy's law and investigated its application in modeling groundwater basins.

This trip was an unforgettable experience because of the gorgeous landscapes, the science we learned, and our enriching interactions with experts. On behalf of my classmates, I sincerely thank the faculty of Rochambeau who accompanied us and the faculty of New Mexico Tech who shared their passion for geology with us.



Learning about how titration and mass spectrometry are used in the NMBGMR Hydrology Labs to determine the chemical composition of water samples.



Calculating the flux of water in a model using Darcy's law.

Rock Riddler Puzzle Page

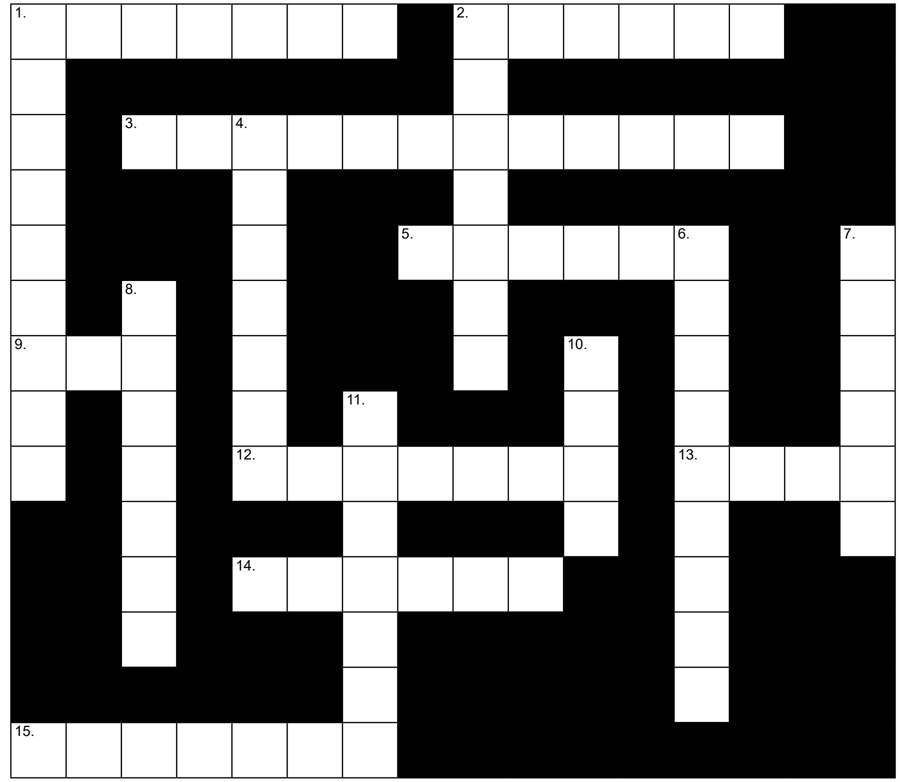
What Do You Know About the Geology of Socorro?

Across

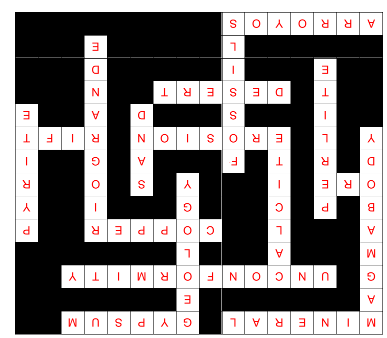
1. A naturally occurring, inorganic solid with a definite crystal shape and chemical composition.
2. Mineral composed of calcium sulfate dihydrate, with the chemical formula $CaSO_4 \cdot 2H_2O$, that is used in drywall and blackboard or sidewalk chalk.
3. A type of geologic contact that represents a break in time in an otherwise continuous rock record caused by a period of erosion or a pause in sediment accumulation, followed by the deposition of sediments—one of these is found at San Lorenzo Canyon in Socorro County.
5. Soft, ductile, malleable metal with the symbol Cu and atomic number 29.
9. A naturally occurring solid from which a metal or mineral can be profitably extracted.
12. Action of surface processes that removes material from one location and then transports it to another location where it is deposited.
13. Linear zone where the lithosphere is pulled apart.
14. Socorro is located in the Chihuahuan __________.
15. Watercourses that temporarily or seasonally fill and flow after sufficient rain (plural).

Down

1. The Socorro ________ ________ (two words) is a pancake-shaped mass of magma with a temperature of approximately 2,000°F that is situated about 12 miles below Socorro.
2. The study of the earth and earth processes.
4. Calcium carbonate ($CaCO_3$) mineral used to treat heartburn and as an ingredient in cement, paints, papers, plastics, and other materials.
6. River that provides major source of water for wildlife and agriculture in Socorro County.
7. Mineral that is commonly called fool's gold with a chemical formula FeS_2.
8. Aluminosilicate rock formed by the hydration of obsidian that expands and becomes porous when heated. Used in potting soil to improve aeration. One of the world's largest deposits of this rock is mined in Socorro County.
10. A loose, granular substance, usually pale brown, resulting from the erosion of rocks and forming a major constituent of Socorro riverbeds and desert.
11. Impressions or traces of any once-living thing from a past geologic age that are preserved in rock remains (plural).



Click here to access the online puzzle.



New Mexico Tech Geology Trailer Launches this Fall!

Leah Tevis

Teaching earth science in a K–12 classroom can be both exciting and challenging. Seeing a student's face light up when a concept like tectonics or fossilization clicks, or watching the wheels turn as they contemplate the processes and implications of climate change, is rewarding and necessary as we move deeper into our uncertain environmental future. The Earth and Environmental Science Department at New Mexico Tech and the New Mexico Bureau of Geology and Mineral Resources are working to bring hands-on geoscience activities, scientists, and community science projects to your classrooms (or, rather, parking lot) via a mobile geoscience education outreach trailer. This geoscience trailer will allow teachers to engage their students with scientists, current scientific studies, concepts, equipment/labs, and teaching tools without leaving their academic space. The geoscience trailer will also give classrooms access to teaching tools that may be unavailable in a typical classroom setting, and will show students how they are a part of the earth sciences and how they can be involved with local community science initiatives and earth science education programs.

The geoscience trailer launch is in the beginning stages, and it currently includes petrographic microscopes, allowing students to become comfortable using scientific equipment while examining thin sections of rocks and minerals and hand samples of various specimens. The trailer will be loaded with various rock, mineral, and fossil specimens for students to interact with while they learn to utilize the same tools that earth scientists use for identification. And no mineral collection is complete without fluorescent minerals to illuminate students' minds.

The trailer will also contain a stream table with natural sand where students can learn about the initiation of fluvial systems, how they form over time, and their various components. The stream table allows students to take a hands-on approach to a river system, experimenting with the landscape, variables, and the relationship between humans and water. Plus, it's never dull playing in a sandbox!

Another trailer component is a shake table that will allow students to learn about seismic waves, earthquake magnitudes, and how earthquakes affect us here on the earth's surface by determining how we build, where we live, and the greater global effects. Other features will include geoscience lesson plans, games, and mini-labs that encourage students to examine earth science through various educational approaches.

Jacob Newcomer, Evan Owen, and Kyle Gallant (left to right) display petrographic microscope thin sections, fluorescing mineral specimens, the latest New Mexico Tech swag, and minerals used in everyday products. *Photo by Leah Tevis*

Jacob Newcomer wows the small audience gathered to see fluorescing mineral specimens. *Photo by Leah Tevis*

By exploring earth sciences through the geoscience trailer, we hope to have students gain a better insight into the local landscape, geology, and how humans align with earth processes in the past, present, and future.

The geoscience trailer is planned to launch this fall and will visit local schools. Moving forward, we will continue to grow and expand the activities, lessons, and outreach methods to best fit the needs of New Mexico communities. Future expansion will include local water sampling and testing; climate change activities; additional scientific equipment, tools, and technology; and incorporating local cultural geology components into the experience to create an intersection for science and humanities.

If you are interested in having the geoscience trailer roll your way, please contact either cynthia.connolly@nmt.edu or leah.tevis@nmt.edu to discuss scheduling a journey on the geoscience express!

Through the Hand Lens with Marc Roux

What is your educational and professional background?

In June 1984, I obtained a master's degree in biology and geology at the University of Montpellier, France. In 1983, my goal was to continue my studies toward a PhD with Professor Francis Hallé, specializing in tropical biology. I also wanted to explore a special field: the coevolution between plants and birds. But this route didn't necessarily guarantee me a job. Therefore, in the spring of 1984, I decided to go for teaching biology and geology.

What inspired you to become a teacher?

At the beginning of 1984, I was reluctant to continue my studies toward research because I needed to have a secure job prospect. I was lucky enough to be able to substitute for my former biology teacher at my own high school. It was so nice to be among my teachers as their "colleague." This two-week experience introduced me to a profession I hadn't even thought of. I loved working with students and then decided to take a year to prepare for the competitive examination to become a natural sciences teacher. I succeeded in June 1985 and learned my profession for another year with mentors.

What are you most proud of professionally?

Although I enjoy laboratory activities, I'm above all a field naturalist, and throughout my life, I've seized every opportunity to expand the scope of my knowledge. To what end? To be able to share my knowledge and inspire my students to become biologists or geologists. So, I'm proud to have tried to fulfill this mission by getting students out of the classroom as often as possible to take them into the field, for anything from a day to a week. What a joy to see teenagers marvel at an organism and try to identify it, or solve a geological problem.

What inspired you to bring students to New Mexico?

In the French curriculum, geology is taught from elementary school onward. Rifting is covered in detail in high school. During my time as a student, I participated in some field trips in geology. However, all in all, most of my knowledge came from books. In 1999, I had the chance to participate in a spectacular 10-day field trip in South America guided by researchers from the French Bureau of Geology (BRGM). The topic was to make a cross section of the Andes from Isla Negra, Chile, to Mendoza, Argentina. First I fell in love with geology, and then I decided that teaching geology could only be done in the field. Since then, I have tried to offer that chance to my students.

In the summer of 2003, my family set off to discover the American West. We were simply going to cross New Mexico on Interstate 40, but when I saw the Sandia Mountains and the volcanic formations, I thought we might be crossing a rift. After I got the confirmation, I decided to bring students here. It was in line with my logic: It's better to go and discover the Rio Grande rift than to look at beautiful photos and maps of, say, Ethiopia.

How did you manage to set up the field trips in New Mexico?

First I read books and articles, then I contacted the University of New Mexico for local help. Then I entered into the Land of Enchantment. I got in touch with Nelia Dunbar, whom I met first in Bandelier with 50 students in March 2004. Then, through the years, I met other extraordinary geologists: Steve Hook, Richard Chamberlin, Dave Love, Bill McIntosh, Rick Aster, Dave Thomas, Lynn and Matthew Heizler, Bonnie Frey, and others.

Marc Roux in Guadeloupe climbing to the top of the volcano La Soufrière. *Photo by Florence Roux*

I came on my vacations, met geologists, explored sites, and visited the Chino mine, among other things. I have immense respect for all these researchers from whom I learned so much and who were always fantastic with the students. Nor can I forget the invaluable people involved in organizing the Socorro trips, such as Susie Welch and Cynthia Connolly. Without all of those doctors and managers, there would never have been a student from Rochambeau in Socorro. And I certainly can't forget all my French colleagues who came with me to help with the students or as participants in the training courses of 2005 and 2014.

Have any of the students from previous trips decided to study geology as a direct result of this New Mexico experience?

Yes, a few students have been inspired and are professional geologists today. I am very proud of Victor L., who participated in the field trip in 2011 and is now an expert geologist for the French Railroad National Company (SNCF).

Rochambeau students and staff arrive at the Albuquerque Sunport. *Photo courtesy of a kind bystander*

About

New Mexico Bureau of Geology and Mineral Resources

Museum and bookstore hours, excluding New Mexico Tech holidays:

Monday through Friday, 9 am to 5 pm
Saturday and Sunday, 10 am to 3 pm

Photo by Matt Zimmerer

Bookstore

Our bookstore offers a wide variety of popular and educational geology publications, topographic maps for the entire state of New Mexico, and a variety of field guides. We also carry a selection of great gifts like jewelry, children's science kits, puzzles, clothing, field notebooks, and more. Kids can check out the play space stocked with plushies of New Mexico animals. Visit us in the Bureau of Geology building on the corner of Bullock Boulevard and Leroy Place in Socorro, or shop online at geoinfo.nmt.edu/publications/featured/home.cfml

Photo by Frank Sholedice

Mineral Museum

Our world-class mineral collection contains over 20,000 specimens from New Mexico, the United States, and around the world. About 5,000 specimens are on display at a time. Exhibits include not only minerals but also mining artifacts, gemstones and lapidary art, fossils, and meteorites. We also offer educational programs like tours, demonstrations, and scavenger hunts for school groups and other visitors. Visit us in the Bureau of Geology building on the corner of Bullock Boulevard and Leroy Place in Socorro, or online at geoinfo.nmt.edu/museum/home.cfml

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Museum Curator:
Kelsey McNamara
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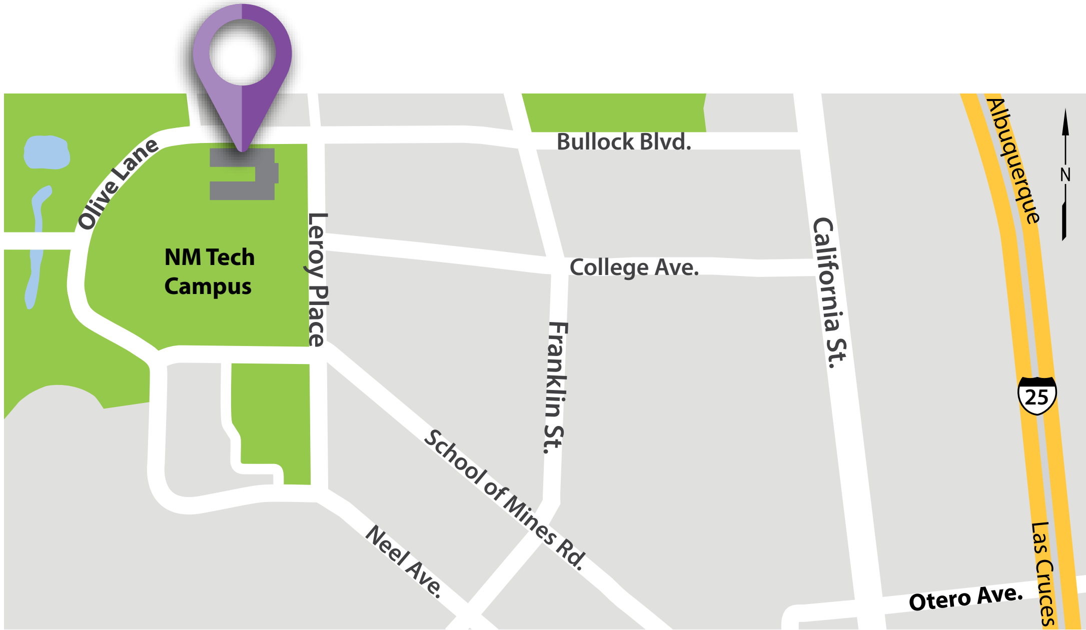
Publication Sales Office

A wide selection of resources for teachers is available, including publications on New Mexico's geology. Many are written for the amateur geologist and general public.

Teachers receive a 20% discount on Bureau of Geology and Mineral Resources and New Mexico Geological Society publications. For phone orders, please call (575) 835-5490. For more information, visit our website: geoinfo.nmt.edu/publications



New Mexico Bureau of Geology and Mineral Resources Mineral Museum and Publication Sales

The Mineral Museum and Publication Sales Office are housed in the Bureau of Geology and Mineral Resources building on the New Mexico Tech campus in Socorro, on the corner of Leroy Place and Bullock Boulevard.

Visitor parking on the east side of the building provides convenient access.

Lite Geology Credits

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