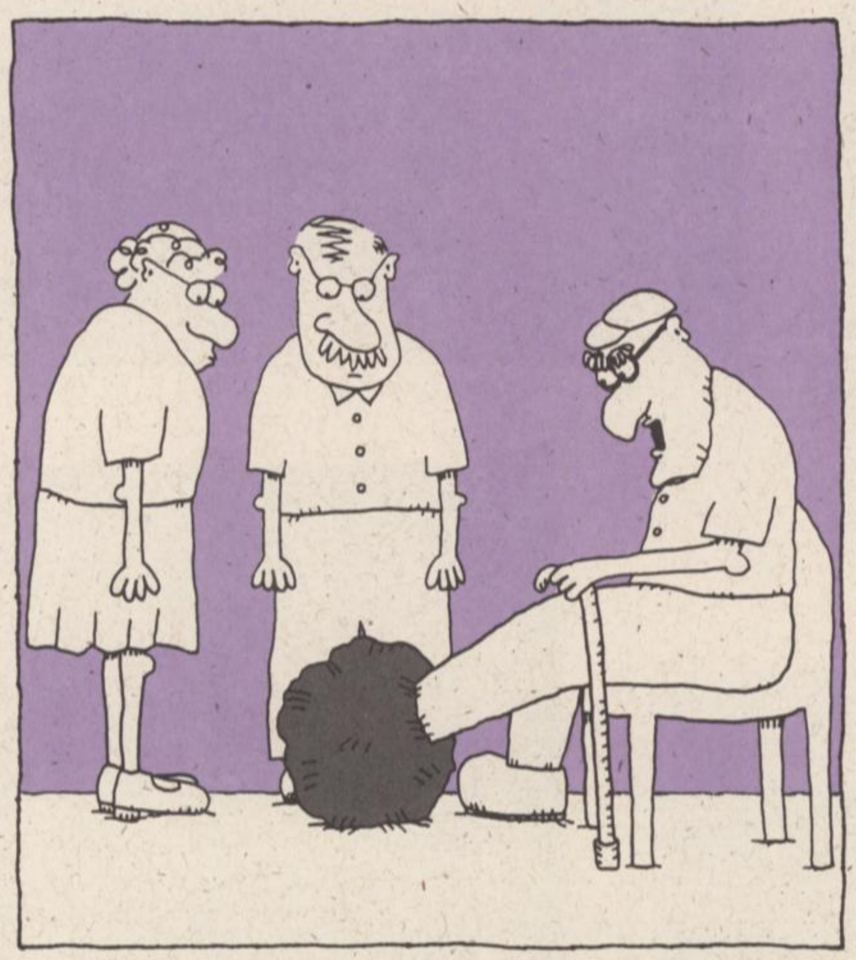
LITE geology

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

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



"I spent too much time in the same place in the back swamp and the danged concretion went and nucleated on me."

This Issue:

Earth Briefs

Concretions, Bombs, and Ground Water

Peter S. Mozley
Department of Earth and Environmental Science,
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Concretions are hard masses of sedimentary and, more rarely, volcanic rock that form by the preferential precipitation of minerals (cementation) in localized portions of the rock. They are commonly **subspherical**, but frequently form a variety of other shapes, including disks, grape-like aggregates, and complex shapes that defy description (Figs. 1, 2, and 3). Concretions are usually very noticeable features, because they have a strikingly different color and/or hardness than the rest of the rock. In some areas this is unfortunate, as the concretions have attracted the unwanted attention of local graffiti artists.

Commonly, when you break open concretions you will find that they have formed around a nucleus, such as a fossil fragment or piece of organic matter. For a variety of reasons, this nucleus created a more favorable site for cement precipitation than other sites in the rock.

Perhaps the most unusual concretion nuclei are found in a modern coastal salt marsh in England. Siderite ($FeCO_3$) concretions in the marsh formed around World-War-II era military shells, bombs, and associated shrapnel, including some large unexploded shells (Al-Agha et al., 1995). A British geologist studying these concretions realized this only after striking a large unexploded shell repeatedly with his rock hammer (yes, he lived to tell about it)! The concretions formed preferentially around the military debris because it provided an abundant source of iron for the siderite.

In shales, concretions often preserve

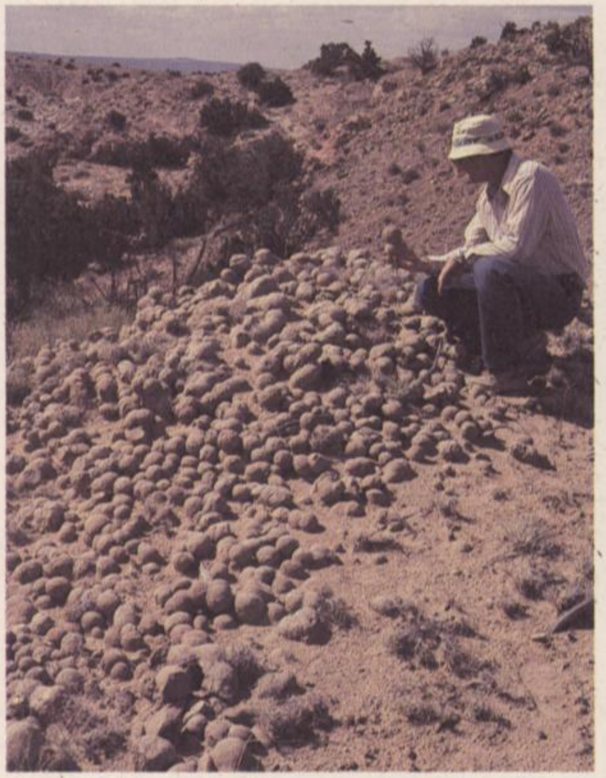

Figure 1—"Cannon ball" concretions in the Zia Formation (Miocene), NM. Photo courtesy of Dave Love.

Figure 2—Complex elongete concretions in the Zia Formation (Miocene), NM. Lens cap for scale.

Figure 3—Huge elongate concretions in the Zia Formation (Miocene), NM.

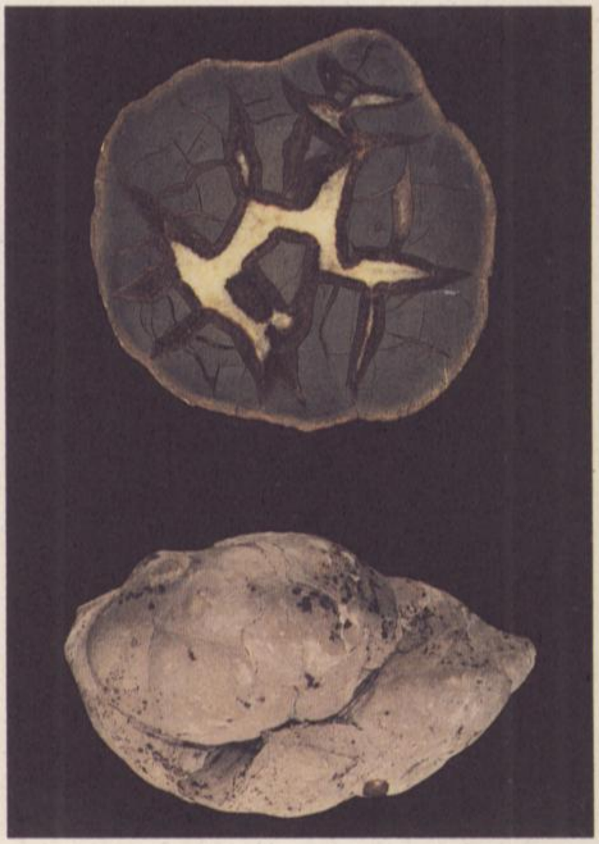

Figure 4—Septarian calcite concretion from the Mancos Shale, NM. Top concretion has been cut on a rock saw to reveal septarian fractures filled with several generations of coarsely crystalline calcite cement. Top concretion is 10 cm in diameter. Concretions courtesy of NMBM&MR Mineral Museum.

features of the original sediment—such as burrows, fossils, and sedimentary layering—that cannot be seen in the rest of the rock. Preservation of primary features occurs because concretions usually form relatively early, before sediment compaction and other processes disrupt the original sediment. Thus, cementation of the concretions "freezes" the early sediment structure, forming a rigid mass that resists later alterations. Examining the concretions is the only way of understanding these early features.

Septarian concretions are the most common type of concretion found in rock and mineral shops. In these concretions the fine-grained concretion body (usually composed of calcite, $CaCO_3$) is cut by a radiating network of fractures filled with coarsely crystalline calcite and other minerals (Figs. 4 and 5). The origin of the fractures is poorly understood, but they may result from internal shrinkage of the concretion body (like the cracks found in seasoned firewood). This shrinkage may be related to dehydration or transformation of a gel-like mineral precursor in the concretion interior (Raiswell, 1971; Astin, 1986). Alternatively, some authors have suggested that they originate as tensile fractures produced in response to burial and compaction (Astin, 1986). The name septarian originates from the Latin word saeptum (enclosure or wall), referring to the raised cracks on the outside of some septarian concretions. If you are interested in hunting for septarian concretions in New Mexico, many are found in the Mancos Shale, a marine Cretaceous unit found in northwest New Mexico.

Recently hydrologists have become interested in elongate concretions. These concretions range in size from pencil- and cigar-like bodies to those that resemble large fallen logs (Figs. 2 and 3). They are thought to form from flowing ground water, with the long axis of the concretion oriented parallel to the ground-water flow direction (McBride et al., 1994). In formations where such concretions are common, measuring concretion orientation can provide a direct measurement of the past ground-water flow orientation over a large area. Such concretions are common in the Santa Fe Group, New Mexico's most important aquifer (Mozley and Davis, 1996). Elongate concretions have even been found in faults cutting the Santa Fe Group, where they record the past flow orientation of ground water in the fault zone (Mozley and Goodwin, 1995).

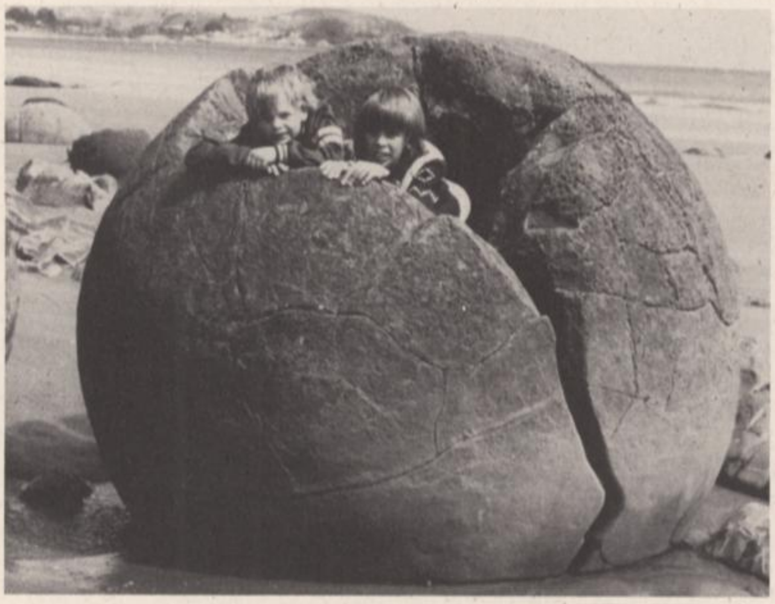

Figure 5—Moeraki boulders, Moeraki Formation, Paleocene, South Island, New Zealand. These huge septarian calcite concretions were exposed when the shale host rock was eroded by wave action. Photo courtesy of James Boles.

Acknowledgements

Thanks to Stuart Burley for relating his hair raising encounter with the Linconshire Wash concretions. This article benefitted from the comments and suggestions of Virgil Lueth.

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Have you ever wondered...

... How our climate has varied in the past?

Part 1: The El Niño effect

Charles E. Chapin
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Many of us have listened to grandparents and elderly neighbors tell of how when they were young the climate was different. Small streams were bigger then and had more fish in them, or winters were more severe, etc. Such stories are usually received with polite interest and considerable skepticism. But how variable is our climate. . . and how can we find out?

Widely publicized worries about the buildup of carbon dioxide in the Earth's atmosphere, as a result of burning fossil fuels, and the possibility of global warming, with the melting of ice caps and rise of sea level, etc., have elevated research on past climates to serious business. Climate change is now a major field of interdisciplinary research and a voluminous literature has developed around the subject. In fact, there is so much research being done, on such a wide variety of subjects, by such a diverse group of scientists, that it is reminiscent of the excitement and controversies during the plate tectonics revolution of the 1960s and 70s.

Determination of past climates (beyond historical records) generally requires two things: 1) a material, landform, or event whose age can be accurately measured, and 2) a characteristic or property of a material that can be reliably related to a climate variable, such as temperature or precipitation. A wide variety of opportunities exist to gain insight into past climates, both local and global. Beginning with this article, I will attempt to summarize where some of this research is leading and point out some examples pertinent to New Mexico.

Oceans and atmospheric currents

First-order effects on climate are the circulation patterns in the oceans and atmosphere. The two are strongly interrelated as has been graphically illustrated by the **El Niño** effects in recent years. The El Niño or ENSO (El Niño–Southern Oscillation) is a warming of surface waters in the eastern Pacific near the Equator (Fig. 1). It is caused by a weakening of the trade winds that normally blow westward across the equatorial south Pacific. As they weaken, warm Pacific surface waters that usually build up near Asia begin flowing eastward toward Central and South America (Fig. 1A) bringing unusually warm currents to the region. Why the trade winds weaken is not known.

The build up of warm surface waters, thousands of miles across, in the eastern Pacific causes the globe-circling, weather-shaping, upper-level winds called jet streams to alter their course (Fig. 2). The effects are often droughts in Australia, India, and Africa; floods in South America and California; and cold, wet winters in New Mexico. For example, the *Albuquerque Journal* on December 17, 1992 (an El Niño year) reported that November was the coldest in Albuquerque since 1938 (average temperature 39.7 °F versus normal average of 44 °F) and the snowiest since 1946 (5.9 inches versus 0.38 inches). Official snowfall in Albuquerque up to December 17th was 19.6 inches, making 1992 the fifth snowiest year of the past 100 years. What a contrast with 1995!

The El Niño–Southern Oscillation is actually a cycle with both warm and cold extremes. The warm extreme (El Niño) is driven by an eastward propagating, broad wave of downwelling warm surface water that depresses the **thermocline** (the thin layer of steep temperature gradient

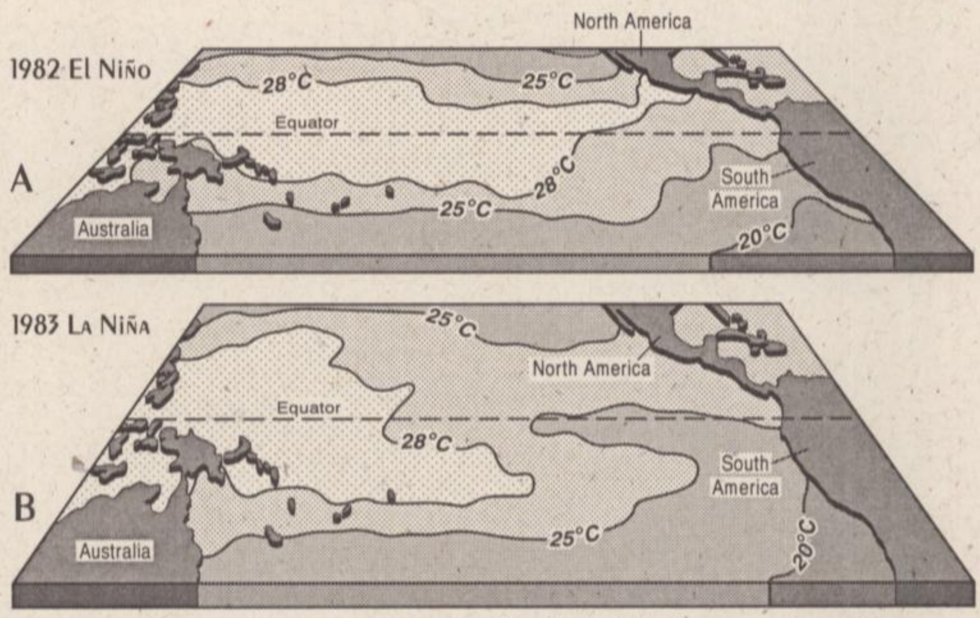

Illustration by Becky Titus
Modified from an original illustration by Steven Davis, *Earth*.

Figure 1—Map of the equatorial Pacific showing sea surface temperatures (A) during the 1982 El Niño event (when slackening of the westward-blowing trade winds allowed warm surface waters to "slosh" eastward toward Central and South America) and one year later (B) during the westward return flow (La Niña). Modified from Knox, 1992.

separating warm surface waters and cold deeper waters) and inhibits the normal upwelling of cold deep waters along the west coast of South America. The disappearance of the cold, nutrient-laden waters around Christmas time and its negative impact on fisheries led fishermen to call the phenomenon "El Niño," after the Christ child. During the other half of the cycle, the rejuvenated trade winds blow the warm surface waters westward away from South America so that they again accumulate in the western Pacific. The cold half of the cycle was called La Niña by the fishermen, meaning "the girl". But some scientists prefer the term El Viejo, meaning "old man."

How are El Niño–Southern Oscillation events defined and measured? The Japanese Meteorological Agency considers an El Niño (the warm extreme) to be underway when sea surface temperature in the tropical Pacific Ocean is a minimum of 0.5°C (0.9°F) warmer than normal for at least six consecutive months. Alternatively, an El Niño can be said to be underway when sea level at the Galapagos Islands in the eastern Pacific is 2 centimeters (0.8 inches) above its normal height for six or more consecutive months. As you can see, these waves of warm or cold water are very broad and of low amplitude, requiring sensitive measurements to detect them. It was the advent of satellites carrying very sophisticated instruments during the last 20 or 30 years that allowed scientists to gain an understanding of the El Niño–Southern Oscillation effect.

The roots of El Niño research, however, date back much earlier. The coast of Peru is normally bathed by cold waters of the Humboldt current that flows northward toward the Equator. Peruvian sailors who navigate these waters in small boats noticed long ago that a warm counter-current, flowing from north to south appeared immediately after Christmas some years. It was actually this current that was named El Niño by the fishermen. In 1891, Dr. Louis Carranza, President of the Lima Geographical Society, drew attention to the El Niño current in a short paper in the bulletin of the Society. And in 1895, Señor Federico Pezet of the Lima Geographical Society described the El Niño current and its effects in an address to the Sixth International Geographical Congress. The appearance of the warm counter-current coincided with heavy rains in arid regions where it seldom rains.

Prediction and measurement of El Niño

Early in this century, British meteorologist Sir Gilbert Walker, the Director-General of Observatories in India, began studying tropical climate fluctuations after the 1899 disastrous failure of the monsoon rains in India. The El Niño years of 1877 and 1888 also saw widespread famine in India and heavy loss of life. Walker's goal was to predict variations in the northward flow of moisture-laden air from the Indian Ocean that provides the summer monsoon rains so necessary to India's

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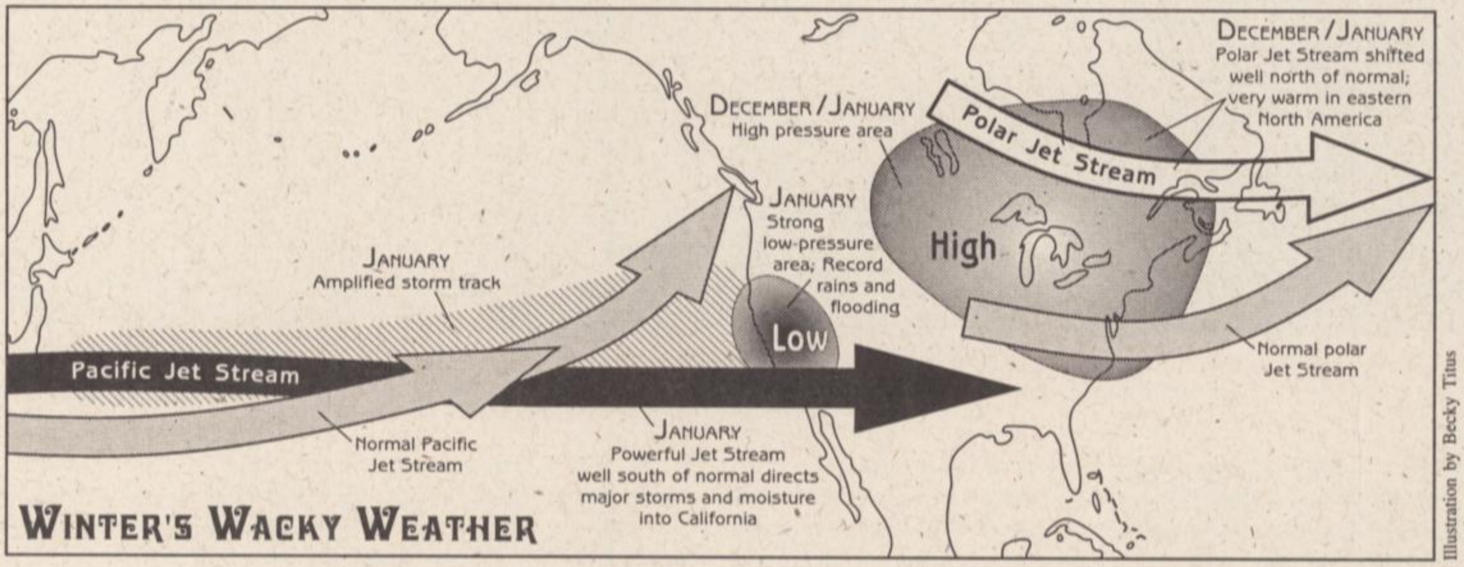

Figure 2—Map showing typical effects of an El Niño on winter weather patterns in the United States. The northern and eastern states enjoy unusually warm, dry weather because a displaced polar jet stream keeps cold Arctic air from reaching as far south as it normally does during winter. In the west, the Pacific jet stream is south of its usual route, driving El Niño-fed storms directly into California. The El Niño effect enhances Pacific storminess but other, unrelated weather patterns also help determine the paths of the jet streams. Drawing modified from National Oceanic and Atmospheric Administration/Climate Prediction Center data, (Monastersky, 1995).

Reptiles on the Rocks

Here are some horned lizards of New Mexico photographed in various geologic settings. Descriptions of the horned lizards are by Gary Stolz, National Interpretive Specialist, U.S. Fish and Wildlife Service. Photos are by Dave Love, NMBM&MR Senior Environmental Geologist.

Photo A—Short-horned lizard *Phrynosoma douglassi*

The short-horned lizard is the widest ranging of seven species of these curious reptiles native to the United States. Found from southwestern Canada to northern Mexico, short-horns are more cold-tolerant than other species. Short-horned lizards have adapted by giving birth to live young to help survive cooler temperatures and limited incubation seasons found within latitudes and altitudes of their home range (all other U.S. species lay eggs). Throughout the diverse range of native habitats, horned lizards depend on camouflage to escape predation. Over generations, natural selection gives a survival advantage to those that blend best with their surroundings. Here we see an individual from the Magdalena Mountains with coloration matching rocks and lichens on which it dwells, while the disruptive coloration of the dorsal stripe helps break up a recognizable body line.

Photo B—Short-horned lizard *Phrynosoma douglassi*
The short-horned lizard, like the individual shown here, can grow to four inches. It can be recognized by relatively short horns on its head with a U-shaped separation in the center, a single row of fringe scales on its sides, and light dorsal mid-line stripe. Note the different coloration of this specimen, blending well with its habitat of Cretaceous sandstones of Sand Canyon, east of El Malpais. Short-horns, like other horned lizards, spend much of their time hidden just below the ground surface where they find protection from predators and extremes in temperature.

agriculture. (New Mexico is also dependent on northward flow of moist air for most of its summer rainfall.) Walker noticed that the barometric pressures recorded by land-based stations between 1905 and 1937 on the eastern and western sides of the Pacific Ocean tended to seesaw back and forth. He called this periodic variation of atmospheric pressure the Southern Oscillation and linked it to many climatic variables around the world. Unfortunately, he was not able to use it to accurately predict monsoon failures; other factors apparently are involved.

Water Temperatures

The large body of warm water that straddles the Equator northeast of Australia (Fig. 1B) is called the Western Pacific Warm Pool (WPWP), which covers an area larger than the continental United States. The WPWP has a temperature consistently higher than 28°C (82°F) about 2°C to 5°C (3.6 to 9°F) higher than that of other equatorial waters, and is the largest single expanse of warm water on Earth. Between El Niños, the westward blowing trade winds drag warm surface waters into the western Pacific raising sea level there as much as 16 inches (40 cm) higher than sea levels near South America. When the trade winds weaken, the pool of warm water begins to drift eastward, which starts another El Niño. The position of the warmest water may vary from one oscillation to another and lead to different effects in separate El Niños, possibly causing floods one time and droughts the next.

Warm surface waters heat the overlying atmosphere, stimulating evaporation and pumping moisture and energy high into the atmosphere. When the moisture condenses into rain, it gives off heat, further warming the atmosphere. This fountain of heat and moisture provides a major engine for global atmospheric circulation. A series of low- and high-pressure cells radiate from the air overlying the pool of warm water. Variations in the pattern of these "highs" and "lows" at mid-latitudes may cause storms to divert from their normal paths and lead to unusual weather conditions in some locations. That the world's oceans should have such major influence on the atmosphere and weather patterns is not surprising when you consider the high capacity of water to store heat (a property of water utilized in many solar heated homes in New Mexico). The upper three meters (9 feet) of ocean water hold as much heat as the entire atmosphere!

Effects of El Niño

El Niños usually occur every three to seven years and last one to two years, but the latest El Niño was a double cycle that lasted from January 1991 to mid-1994 (Fig. 3), and some say it lasted until mid-1995. Weather around the globe was unusually severe during this interval. For example, heavy rains through the winter and spring of 1992 caused major flooding in Texas (remember the earlier description of what that winter was like in New Mexico). In December 1992 a "nor'easter" of hurricane velocity pounded the east coast from Virginia to Maine with waves up to 30 feet high. The summer of 1993 saw relentless rains inundate the Midwest, forcing thousands from their homes and flooding 23 million acres of farmland. The following winter saw a record blizzard with hurricane force winds that churned up the eastern seaboard, killing 270 people. Meanwhile, Australia was suffering a major drought. On the plus side, scientists have found that there are noticeably fewer Atlantic hurricanes during El Niño years.

Since the El Niño of 1991–94 ended, New Mexico has experienced two unusually warm and dry winters, a record-breaking summer heat wave in 1994, a partial failure of our summer monsoonal rains, and major problems for ranchers and the ski areas, which brings us to the subject of weather prediction and its importance. Understanding the El Niño–Southern Oscillation and detecting the changes in its cycle early can help reduce the economic devastation and loss of life that often accompanies extremes of weather. A speaker at a geological

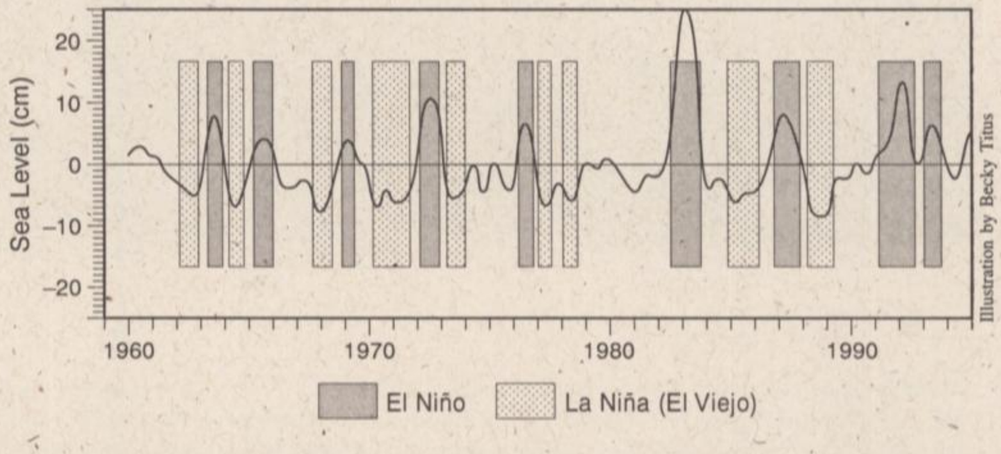

Figure 3—Graph showing the Southern Oscillation from 1963 to 1994. The dark-shaded regions indicate El Niño events; the light-shaded regions indicate La Niña (El Viejo) events. The solid line indicates the sea level anomalies in the Galapagos Islands near the South American coast. Note that sea level in the Galapagos is higher during El Niño events because of the arrival of a broad wave of warm surface waters from the western Pacific. Modified from Meyers and O'Brien, Dec. 5, 1995 issue of Eos, Transactions of the American Geophysical Union.

meeting in Denver has even correlated variations in the price of natural gas with El Niño events; he suggests that the El Niño cycles can be useful in strategic planning by both energy producers and large consumers. During El Niño years, the populous northeastern United States and southeastern Canada are unusually warm and dry. During El Viejo years, the southwestern United States is warm and dry and the northeast gets its normal cold and snowy winter, as it has this year.

Further Reading

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Fun for kids...

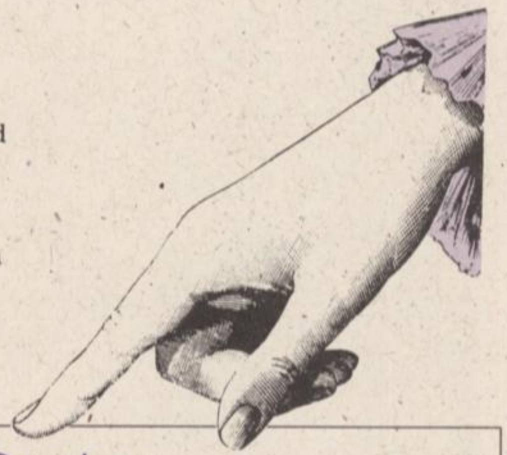
Falcon Magazine is for kids who are wild about wildlife. This bi-monthly publication is filled with fun stories, pictures, and amazing facts about wildlife, conservation, and the environment. To order Falcon Magazine, call 1-(800) 582–2665.

Fun for Earth science teachers

April 19, 1996; Albuquerque
National Association of Geology Teachers will present ***Geology and Earth Science workshops*** for teachers at the New Mexico Museum of Natural History in Albuquerque. The emphasis is on fun, geology, samples, and curriculum ideas. Staff from the Museum, NM Bureau of Mines, UNM College of Education and Department of Earth and Planetary Sciences, and other agencies will conduct sessions on a variety of topics. For more information, please contact Chris Whittle, Southwest Indian Polytechnic Institute (SIPI), at (505) 897–5380; or fax (505) 897–5713.

Free trip for a New Mexico teacher

June 19–22, 1996; Scottsdale, Arizona
The 5th National Minerals Education Conference is an opportunity for teachers to gather information and resources to help teach mineral science. The Central New Mexico Section of the Society for Mining, Mineral, and Exploration (SME) will send a New Mexico teacher to the conference with all expenses paid. To apply, call George Austin, SME, GEM Committee Chair, c/o New Mexico Bureau of Mines (505) 835–5230; fax (505) 835–6333. Applications are due May 1st, 1996.



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Reptiles on the Rocks

Photo C—Roundtail horned lizard *Phrynosoma modestum*
Looking like just another basalt pebble, near a volcanic crater in the northern portion of Jornada del Muerto, this roundtail horned lizard is barely visible to predators or prey. As fascinating and beloved creatures, horned lizards have long captured human curiosity and imagination. These harmless and beneficial reptiles have been celebrated by Native Americans on their pottery and rock art and by Hollywood in movies. Today horned lizards are faced with threats to habitat destruction, over collection, and the introduction of exotic species such as fire ants. Horned lizards have survived on the Earth for millions of years, yet like all wildlife species, they now depend on our stewardship of a shared planet for their future.

LITE geology

Teacher training on earthquakes is coming soon!

Seismic Sleuths: May 6–8, 1996

The first in a series of four workshops for teachers on earthquakes will be held in Socorro at the New Mexico Bureau of Mines and Mineral Resources (NMBM&MR). *Seismic Sleuths* features hands-on activities to integrate math, science, and social studies concepts as applied to earthquakes. The curriculum was developed for Federal Emergency Management Agency (FEMA) by the American Geophysical Union (AGU). New Mexico *Seismic Sleuths* curriculum will contain a special volcanic hazards section developed by NMBM&MR. The workshops are free, and travel and per diem are available if participants travel more than 30 miles to attend. For more information, or to register, call Bob Redden, New Mexico Department of Public Safety at (505) 827–9254; or call Susan Welch, NMBM&MR, at (505) 835–5112.

New Mexico/Princeton Earth Physics Project (NM/PEPP): July 8–12, 1996

Travel and per-diem funding are available for 20 New Mexico middle school, high school, and college science teachers to participate in an NSF-funded national program to develop and teach a series of curriculum modules focused on seismology. For a selected subset of workshop participants, NM/PEPP will purchase and install in schools Internet-linked, high-quality seismographs to facilitate teaching and collaborative research projects with other members of the academic community. For more information, contact Dr. Rick Aster, Dept. of Earth and Environmental Sciences, New Mexico Tech, by phone at (505) 835–5924; e-mail at aster@nmt.edu; or call Susan Welch.

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