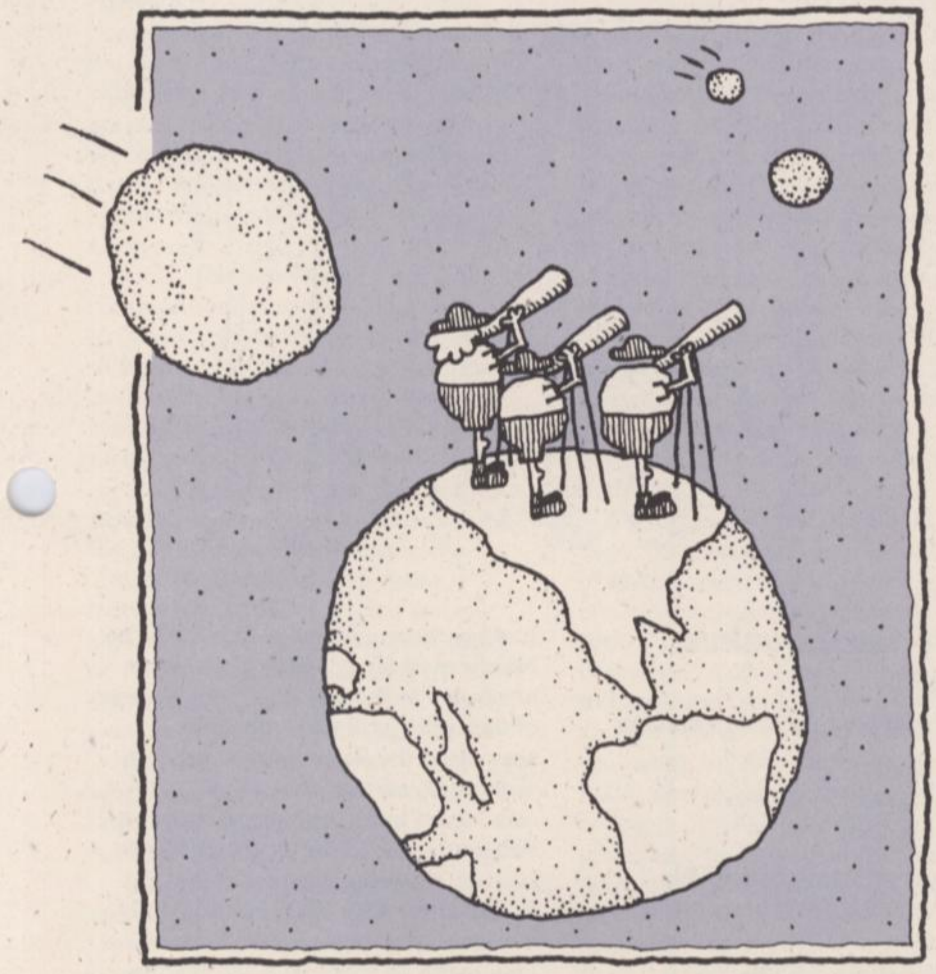
Spring 1994

LITE geology

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



The world watches as the comet collides with Jupiter.

This Issue:

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

Earth Briefs

World Watches as Comet Collides with Jupiter this Summer

Dave Finley
Public Information Officer
National Radio Astronomy Observatory

Collision is one of the most common astrogeological processes in our solar system. Landscapes covered by **craters**, the telltale marks of collisions, have been photographed by spacecraft throughout the solar system from Mercury, the closest planet to the sun, to the moons of distant Neptune.

Although collision is a common process in the solar system, we will get our first chance to observe such an event this summer. Astronomers last year discovered a **comet** that will strike the giant planet Jupiter this July. The comet, called **Shoemaker-Levy 9** after its discoverers, was found on March 25, 1993. As astronomers tracked the comet they learned that it is orbiting Jupiter itself, unlike most comets, which orbit the Sun.

In addition, calculations showed that the comet had passed very close to Jupiter on July 8, 1992—so close, in fact, that Jupiter's powerful gravity had broken it into pieces. During the comet's next approach to Jupiter this summer, its luck will run out and its pieces will slam into the planet. Between July 16 and 22, at least 21 comet fragments will hit Jupiter.

Unfortunately, the **impacts** of the comet fragments are now predicted to occur on the side of Jupiter facing away from Earth. However, most of the impact sites will rotate into view soon after the impact. Don't expect to see new craters, though—remember, Jupiter is a **"gas giant"** planet whose solid core (if it has one) is buried deep

(continued from front page)

under thousands of miles of thick gas and liquid.

The impacts should be spectacular. Each comet fragment, with a maximum diameter of about 500 yards, will hit Jupiter at a speed of about 130,000 m.p.h. The fragments are expected to disintegrate 60 to 70 miles below the tops of Jupiter's visible clouds, releasing **kinetic energy** equivalent to 200,000 megatons of TNT. That's more than 10 million times the energy of the Hiroshima bomb.

This tremendous release of energy is expected to produce a fireball that will rise 60 miles above Jupiter's cloudtops and send giant shock waves through the planet's atmosphere. Scientists hope to use these effects to learn about the composition of Jupiter's clouds and the structure of its atmosphere. In addition, the comet collision is expected to have possibly dramatic effects on the radio emission from Jupiter.

Amateur astronomers hope that the fireballs from the fragment impacts may be visible in small telescopes as flashes reflected off Jupiter's four largest moons. Radio enthusiasts will monitor Jupiter's shortwave "noise" to see if they can hear any changes when the comet pieces hit.

Scientists from New Mexico's state universities, astronomical observatories and national laboratories are deeply involved in the myriad of studies of this event. Some are running computer simulations to refine predictions of the impact effects. Others will be using a wide variety of instruments, on Earth and in space, to observe the event. New Mexico telescopes ranging from amateur backyard instruments to the National Radio Astronomy Observatory's Very Large Array will be aimed at Jupiter throughout mid-July. Around the world, scientists are preparing to make the most of this unique event.

(For more information, contact National Radio Astronomy Observatory, Array Operations Center, Socorro, NM 87801; (505) 835-7000—ed.)

Have you ever wondered...

...Why Earthquakes Occur?

A Very Brief History of Seismology

Richard Aster
Assistant Professor of Geophysics,
New Mexico Tech

What is an earthquake? This question probably has been asked ever since human beings have been able to wonder about the natural world. However, comprehensive insight into the causes of earthquakes has only been achieved during the past century, and mostly during the past 50 years.

Predating the scientific era, earthquakes and other natural phenomena were widely ascribed to divine influences (often involving gigantic manifestations of familiar animals). In Japanese tradition, for example, earthquakes were considered to be caused by the stirrings of an enormous catfish, the **namazu**, which lived in the mud beneath the Earth. In Hindu mythology, earthquakes were attributed to the shifting of one or more of the eight great elephants that supported the Earth. In the Old Testament, earthquakes were considered to be the instruments of a vengeful God. More secular thinkers, such as Aristotle, speculated that earthquakes were the result of winds accumulating in the Earth's interior. Like many of Aristotle's hypotheses, this, combined with the concept of earthly manifestations of God's displeasure with human beings, remained a widespread explanation for earthquakes in Europe throughout the Middle Ages.

Despite subsequent early attempts by natural philosophers during the Age of Reason to associate earthquakes with electrical, atmospheric, or vague subterranean volcanic effects, progress on understanding earthquakes remained ponderously slow throughout the 17th and 18th centuries. A run of notable earthquakes near populated areas in Europe and the New World [London (1750); Boston (1755); and especially the cataclysmic event near Lisbon (1755)] spurred new interest and observations. A particularly important observation documented during this time was that the destructive force of earthquakes was observed to propagate as a **seismic wave**. Analogous to ocean or sound waves, but traveling through the solid Earth, seismic waves are sometimes visible to the eye during very strong earthquakes.

Once it became clear to the scientific community that earthquakes were intimately related to the propagation of seismic waves through the solid Earth, understanding progressed relatively rapidly. The first **seismometers**, instruments for quantitatively measuring the motion of the Earth as a function of time, were constructed by the Englishman John Milne in the 1880's. These instruments were sufficiently sensitive so that seismic signals from large earthquakes could be recorded at quiet sites anywhere in the world. Milne's instruments were eventually deployed throughout the British empire, and the first crude world maps of earthquake source regions, or **epicenters**, were subsequently obtained.

What was happening at the epicenters that was generating seismic waves? The answer became evident from detailed studies of two notable earthquakes during this period that showed particular large and simple surface ruptures. Investigations into the great 1891 Japan and the 1906 San Francisco earthquakes confirmed that large earthquakes were caused by sudden slippage on zones of low frictional strength (earthquake faults) in the Earth. On such faults, strain energy builds up gradually until some critical strength is overcome and slippage begins. Slip then spreads unstably over a large region and a vast amount of stored energy can be released (the great 1960 Chile earthquake, which was the result of an average of 21 m of slip over a fault-plane area approximately the size of New Mexico, released the energy equivalent of about a 20,000 megaton bomb!). Most of the energy released during fault slip goes into local heating and alteration of the fault zone, but a few percent goes into seismic waves that radiate out from the source region and can circle the earth many times. This **elastic rebound** process, in which earthquake faults are gradually loaded, slip suddenly, and then are gradually loaded again, was first formally proposed by the American seismologist Harry Reid following his study of the 1906 San Francisco earthquake. Elastic rebound is an accurate model for most earthquakes and has withstood the test of time.

However, the elastic rebound model begs the question of the ultimate cause of earthquakes. How do earthquake faults form, and where does the energy come from to load these faults in the first place? A comprehensive answer to this question would have to wait another half century and would ultimately involve the overturning of many dearly held global geologic concepts. In 1912, Alfred Wegener postulated his theory of **continental drift**, in which the Earth was not statically cooling, with the continents and ocean basins remaining nearly fixed, but where continents somehow moved through the ocean basins, colliding and splitting, building mountain ranges, and generating earthquakes. Wegener's visionary hypothesis, although supported by fossil and geological evidence, particularly in the southern hemisphere, was largely dismissed by the scientific establishment for decades because he was unable to convincingly demonstrate how continents could somehow plow through the rocks of the ocean floor.

When the first relatively high resolution maps of the global distribution of earthquakes became available in the 1930's, it became abundantly clear that the Earth's seismic activity was not uniformly distributed, as might be predicted by a statically cooling Earth model, but mostly (approximately 90%) occurred in steeply dipping sheets plunging from near the continent/ocean margins to deep beneath the continents, reaching depths of over 600 km near the

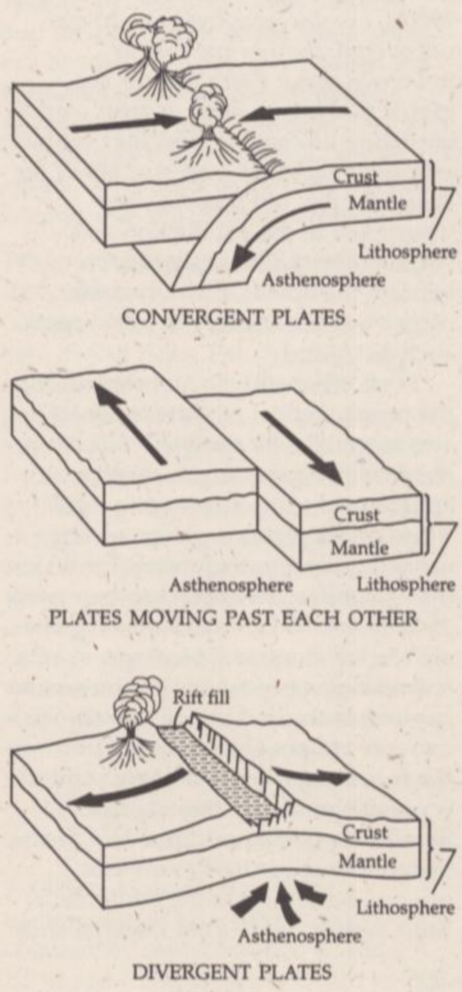


Figure 1—The three basic types of plate margins.

Pacific rim (about 10% of the way to the center of the planet!). These previously unimagined **Benioff zones** were soon recognized as enormous faults. Furthermore, examination of seismic waves coming from Benioff-zone earthquakes indicated that the ocean floor was diving into the interior of the Earth in these regions. If ocean floor was disappearing in these **subduction zones** (and the Earth wasn't shrinking!), where was new ocean floor being generated? The definitive answer to this question had to wait until detailed mapping of the ocean floor could be performed. Beginning in the mid-1950's, oceanic geophysical surveys uncovered another previously unknown major Earth feature, the **global mid-ocean ridge**, a great world-encircling volcanic system that supplies new material to the oceans at about the same rate that old oceanic crust disappears in the subduction zones. Although almost entirely hidden beneath the oceans, the mid-ocean ridge does see daylight in a few spots, such as Iceland.

From these and other observations, the present model of **plate tectonics** was assembled by the late 1960's. In it, the Earth's surface is visualized as a collection of a dozen or so thin rigid **lithospheric plates**, each containing **oceanic crust** (approximately 5 to 10 km thick), **continental crust** (approximately 25 to 60 km thick), or both. These plates are carried along at typical speeds of a few centimeters per year by **convection currents** in the underlying **mantle**. Such currents are possible because, although the mantle is overwhelmingly solid, it is capable of slowly flowing like a liquid over geological time. Hot, rising material from the Earth's interior reaches the surface at the mid-oceanic ridge system, while cold material sinks at the subduction zones. The relatively brittle plates together constitute the **lithosphere**, which extends to a depth of approximately 100 km and thus includes the outer crust and part of the upper mantle. The especially ductile zone underlying the lithosphere and extending to a depth of approximately 350 km is called the **asthenosphere**.

Earthquakes, then, are predominantly found at **plate margins** (Figure 1), where one plate is either plunging beneath another (as in subduction zones), where plates are rubbing side-to-side (as along the San Andreas fault in California), or where plates are pulling apart (as at the mid-ocean ridges). Because the lithospheric plates act like a brittle skin being carried along by ductile mantle flow, difficulties associated with Wegener's original continental drift hypothesis of continents somehow barging through the ocean basins were overcome in the plate tectonic model, and it is now universally accepted. Some of the material that goes down in the subduction zones melts and returns to the surface, spawning large arcs of volcanoes, such as the Aleutian Islands.

Finally, we must ask where all the energy comes from to keep the plates moving. The answer lies in the Earth's **geothermal heat budget**. The decay of radioactive elements in the mantle (primarily U^{235}, U^{238}, Th^{232}, and K^{40}) generates the bulk of this heat (lesser amounts are believed to come from the Earth's primordial heat and from the accumulation of the solid inner core). The amount of geothermal heat escaping to the Earth's surface is about 1/6000th of the amount of solar energy received and reradiated by the Earth. Thus the ultimate answer as to why earthquakes exist is that Earth has sufficient internal heat to sustain mantle convection and plate tectonics!

New Mexico had a large earthquake?

New Mexico Earthquake Preparedness Program (NMEPP)
Robert Redden,
NMEPP Program Manager,
New Mexico Department of Public Safety

What is the NMEPP?

In October 1992, the Emergency Management Bureau, Department of Public Safety, introduced a *new program to enhance the State's comprehensive system for emergency management and preparedness*. After almost two years of developing a program plan, New Mexico joined 31 other states as part of the National Earthquake Hazards Reduction Program (NEHRP), a program that was directed by the Earthquake Hazards Reduction Act of 1977.

Why does New Mexico need an earthquake program?

Several agencies have been conducting research and providing information on earthquakes in New Mexico for a number of years: New Mexico Bureau of Mines and Mineral Resources, New Mexico Institute of Mining and Technology, and the U.S. Geological Survey (USGS). Based on their information, the USGS and the Federal Emergency Management Agency (FEMA) designated New Mexico as a **moderate risk** state for earthquakes.

How is the this risk designation assigned?

New Mexico's seismic vulnerability was determined from three criteria based on the occurence of:

(1) historic large earthquakes (magnitude M7.0 or greater) that have occurred near the state and formed fault scarps;

(2) moderate earthquakes (M5 -M6) that have occurred in New Mexico but are unrelated to surface fault movement (i.e., random earthquakes, such as those that occurred in 1906 [Socorro], 1935 [Belen], 1965 [Dulce] and 1992 [Rattlesnake Canyon near Carlsbad]); and

(3) surface faults in New Mexico that have been active in the geologically recent past (within the last 250,000 years) and that could generate a large earthquake (M7.0 - M7.5) in the future.

How does New Mexico's moderate risk designation compare to other states?

California is categorized as having a ***very* high risk**, whereas Arizona is considered a **high risk** state.

How does this moderate-risk designation affect New Mexico?

The moderate-risk designation made New Mexico eligible for FEMA funding that will allow the state to develop an effective earthquake preparedness program. For the fiscal year 1994, FEMA allocated more than $50,000 for the New Mexico Earthquake Preparedness Program. FEMA supervises the administration of the funding for the program and provides program guidance, whereas the technical support at the national level is coordinated by the USGS, National Science Foundation, and the National Institute of Standards and Technology.

What will the New Mexico program accomplish?

The goal of the New Mexico program is to establish the foundation for an effective statewide earthquake hazard mitigation and preparedness program. These efforts will focus on reducing the state's vulnerability to the effects of damaging earthquakes. The program initially concentrates on hazard identification, vulnerability analysis, and public awareness and education. Mitigation, preparedness planning, and formation of a State Seismic Safety Council are other key elements of the program.

Program objectives for Fiscal Year 1993 supported the goals listed above and included the following: beginning initial hazard analysis and vulnerability studies, as well as conducting public awareness and education activities in cities and counties along the Rio Grande valley. These communities were selected because of their population densities and their proximity to the Rio Grande rift, an area of known active faults and earthquake activity. The rift extends from Colorado to the Mexican border and roughly follows the Rio Grande valley. Other areas of the state will be examined as the program evolves.

What is the future of the NMEPP in New Mexico?

The program is augmented by the activities of many individuals from educational and scientific institutions, public agencies and the private sector. Experts from many fields, such as the Earth sciences, engineering, education, utilities management, government, and emergency management are applying their considerable skills to help determine the program's direction, develop statewide seismic safety policy, and manage the volumes of data on seismic activity in New Mexico. Many state agencies have already set a lofty standard for cooperation and communication on earthquake issues by producing information, materials, advice, and technical expertise.

Additional information about earthquakes in New Mexico can be obtained by contacting Bob Redden, Earthquake Preparedness Office, at (505) 827-9254, or by contacting him at the Department of Public Safety, ATTN: EMPAC, P.O. Box 1628, Santa Fe, NM 87504.

Glossary for Understanding Earthquakes

Aftershock—An earthquake that follows a larger earthquake, or main shock, and originates within a few fault lengths of the main shock.

Amplitude—Half the height of a wave's crest (high point) above the adjacent troughs (low points).

Asthenosphere—The low-velocity, relatively ductile portion of the mantle that underlies the *Lithosphere*. Extends from approximately 100 km to 350 km depth.

Benioff zone—A plane of earthquake foci dipping beneath the continents. Benioff-zone earthquakes primarily indicate the top of a subducting lithospheric plate.

Body waves—Waves that move through the body (rather than the surface) of the Earth. P-waves and S-waves are body waves.

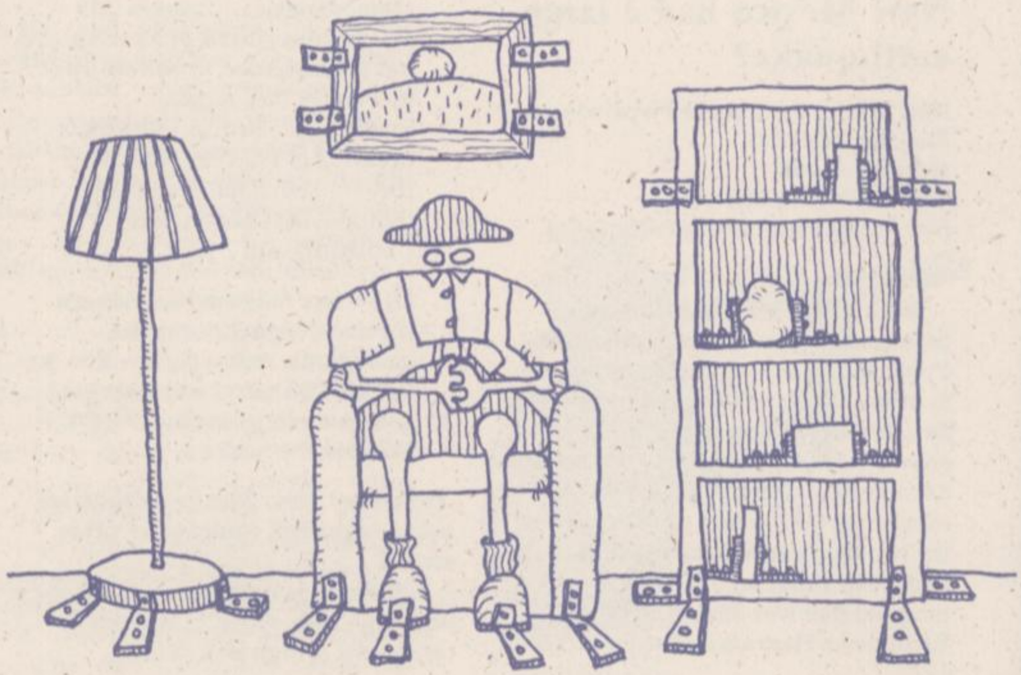
Compression—Squeezing, being made to occupy less space. P-waves are called **compressional waves** because they consist of alternating compressions and dilations.

Continental crust—The silica and aluminum rich, relatively light rocks underlying the continents. Thickness ranges from about 25 km to 60 km under mountain ranges.

Continental drift—The original theory of continental motion through geologic time. Superseded by plate tectonics.

Convection—A process of heat transfer in a liquid by vertical motion, with warm material rising and cold material sinking. Convection in the Earth's mantle is the root driving mechanism for plate tectonics.

Core—The region of the Earth from the base of the mantle (about 2900 km depth) to the center of the Earth (about 6370 km). Thought to consist of mostly iron-nickel alloy, the outer core is liquid and the inner core (beginning at about 5070 km) is solid. The main source of the Earth's magnetic field.



Gordon was prepared for an earthquake.

Crust—The outermost layer of the Earth, the base of which is globally indicated by an abrupt increase in seismic velocity. Two fundamental types exist, continental and oceanic.

Dilation—Expansion, being made to occupy more space.

Duration—The length of time that ground motion at a given site shows certain characteristics. Most earthquakes have a duration of less than one minute, in terms of human perceptions, but waves from a large earthquake can travel around the world for hours.

Earthquake hazard—Any geological or structural response that poses a threat to human beings and their environments.

Elastic rebound—A process of elastic strain buildup followed by sudden earthquake fault slip.

Epicenter—The point on Earth's surface directly above the focus of an earthquake.

Fault—A break or fracture of the Earth's crust along which movement has taken place. Faults are in some cases detected by observing offset strata or stream valleys.

Focus (pl. foci)—The point within the Earth that is the center of an earthquake, where strain energy is first released as wave energy (synonym: hypocenter).

Force—The cause or agent that puts an object at rest into motion or affects the motion of a moving object. Gravity is a vertical force; earthquake shaking includes both horizontal and vertical forces.

Foreshock—An earthquake that precedes a larger earthquake, called the **main shock**, and originates along the same fault as the main shock.

Frequency—The rate at which a motion repeats, or oscillates. In this context, frequency is the number of oscillations in an earthquake wave that occur each second. A building's frequency is the rate at which it swings.

Geothermal heat—Heat within the Earth, primarily thought to be due to the decay of long-lived radioactive elements. The ultimate cause of earthquakes and volcanoes on Earth.

Gravity—The force that causes objects to be attracted to each other. Gravity is especially noticeable when an object of great mass, such as the Earth, attracts objects of lesser mass, pulling them toward its own center.

Hanging wall—The overlying side of a fault.

Hazard—A risk; an object or situation that holds the possibility of risk or damage. Some geologists reserve the term "hazard" for natural processes, and "risk" for impacts on humans and structures.

Intensity—A subjective measure of the amount of ground shaking an earthquake produces at a particular site, based on human observations of the effect on human structures and geologic features. The Modified Mercalli Intensity scale uses Roman numerals from I to XII.

Isoseismal line—A line on a map that encloses areas of equal earthquake intensity. It is usually a closed curve containing the epicenter.

Joint—A break or fracture in brittle rocks along which differential movement has **not** taken place parallel to the break.

Landslide—An abrupt movement of soil and/or bedrock downhill in response to gravity. Landslides can be triggered by an earthquake or other natural causes.

Liquefaction—During earthquakes, fine-grained, water-saturated sediments lose their former strength and behave like a fluid.

Lithosphere—The outer, solid layer of the Earth that comprises the tectonic plates. The lithosphere extends to approximately 100 km depth and thus includes the crust and uppermost mantle.

Longitudinal waves—P-waves. This term is used to emphasize that P-waves move particles back and forth in the same line as the direction of the wave.

Love waves—Surface waves that move in a back-and-forth horizontal motion perpendicular to the line of propagation.

Mantle—The region of the Earth beneath the crust and above the core. Comprises more than 80% of the Earth by volume.

Magnitude—A number that describes the overall size of an earthquake, determined by measuring the motions recorded on a seismograph and correcting for the distance from the seismograph to the epicenter of the earthquake. Many different magnitude scales are in use, each based on a different attribute of the seismic signals from earthquakes.

Modified Mercalli Scale of 1931—a qualitative scale of earthquake effects that assigns an intensity to the ground shaking for any specific location on the basis of observed effects. Mercalli intensity is expressed in Roman numerals.

Natural hazard—Any of the range of natural Earth processes that can cause injury or loss of life to human beings and damage or destroy human-made structures.

Normal fault—A fault in which the hanging wall appears to have moved downward relative to the footwall.

Oceanic crust—The silica and magnesium rich, relatively heavy rocks underlying the continents. Thickness ranges from about 5 km to 10 km.

Oscillation, or vibration—The repeating motion of a wave or a material. Earthquakes cause seismic waves that produce oscillations, or vibrations, in materials with many different frequencies. Every object has a natural rate of vibration that scientists call its **natural frequency**. The natural frequency of a building depends on its physical characteristics, including the design and the building materials.

P-waves—Primary waves, so called because they travel faster than S-waves, or secondary waves. These waves carry energy through the Earth as longitudinal waves, moving particles back and forth in the same line as the direction of the wave.

Period—The time between two wave crests.

Plate tectonics—A model of Earth evolution in which rigid lithospheric plates migrate in response to mantle convection currents.

Prediction—A statement that something is likely to happen. A prediction is usually only as reliable as its source.

Qualitative—Having to do with perceived qualities; subjective.

Quantitative—Having to do with measurable quantities; objective.

Rayleigh waves—Surface waves that carry energy along the Earth's surface by elliptical particle motion, which appears on the surface as a ripple effect.

Recurrence interval—The approximate length of time between subsequent earthquakes in a specific area of seismic activity.

Resonance—A buildup of amplitude (a measurement of the wave crest) in a physical system (such as a building) that occurs when the frequency of an applied oscillatory force (such as earthquake shaking) is close to the natural frequency of the system.

Retrofitting—Making changes to a completed structure to meet needs that were not considered at the time it was built; in this case, to make it better able to withstand an earthquake.

Richter magnitude—The number that expresses the amount of energy released during an earthquake, as measured on a seismograph or a network of seismographs, using the scale developed by Charles Richter.

Richter Scale—The magnitude scale developed by Charles Richter in 1935 as a means of categorizing local earthquakes. The Richter scale uses a logarithmic decimal format; an earthquake measuring 7.0 moves the recording needle 10 times the distance as an earthquake measuring 6.0.

Risk—Probability of loss or injury as the consequence of a hazard.

S-Waves—Secondary waves; waves that carry energy through the earth in very complex patterns of transverse (crosswise) waves. These waves move more slowly than P-waves (in which the ground moves parallel to the direction of the waves), but in an earthquake S-waves are commonly of greater intensity.

Seismicity—Earthquake activity.

Seismic—Of or having to do with earthquakes or earthquake-like waves.

Seismic zone—A region in which earthquakes are known to occur.

Seismogram—The record of earthquake ground motion recorded by a seismograph.

Seismograph—An instrument that detects, magnifies, and records vibrations of the Earth, especially earthquakes.

Seismology—The scientific study of earthquakes.

Stick-slip movement—A jerky, sliding movement along a surface. It occurs when friction between the two sides of a fault keeps them from sliding smoothly, so that stress is built up over time and then suddenly released.

Strike-slip faulting—Fault movement in which the fault is close to vertical and the movement of each side is horizontal parallel to the fault plane.

Subduction—The process in which one lithospheric plate is moves down under another plate and drawn back into the Earth's mantle.

Subduction zone—The region where one lithospheric plate descends beneath another. Subduction zone earthquakes comprise a Benioff zone.

Surface waves—Waves that move over the surface of the Earth. Rayleigh and Love waves are surface waves.

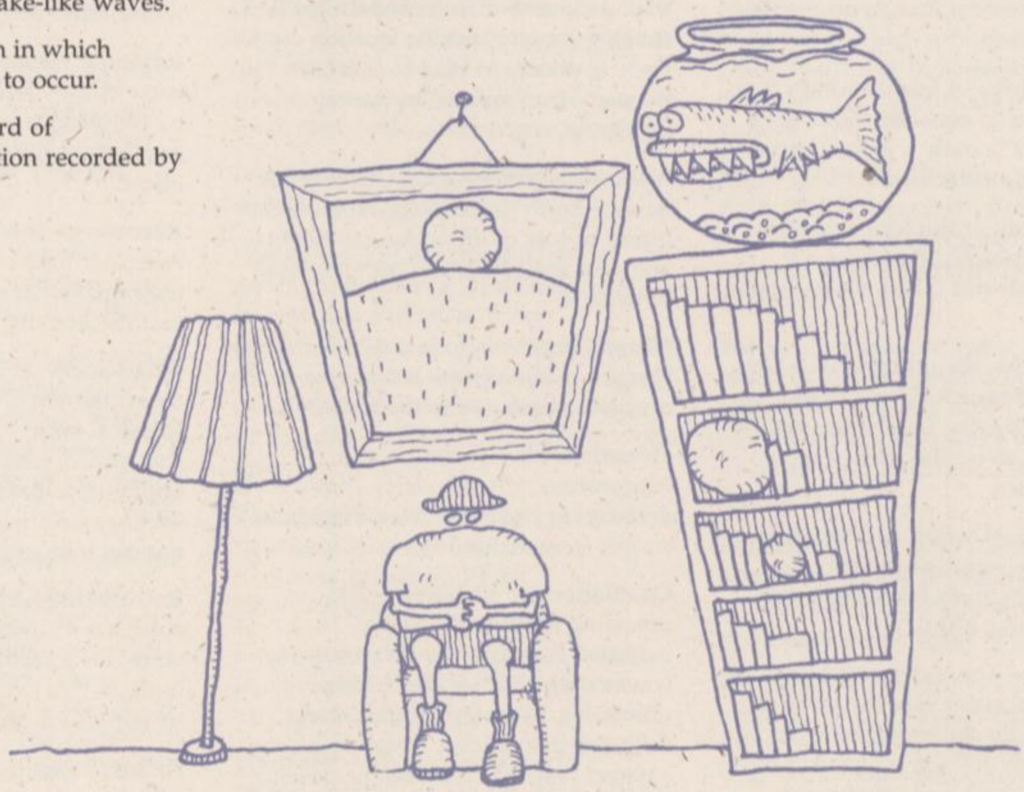
Thrust fault—A fault in which the hanging wall appears to have moved up relative to the footwall, and the dip is 45* or less over much of its extent.

Transverse waves—Waves that vibrate particles in a direction perpendicular to the wave's direction of motion (S-waves).

Wave height—The vertical distance from a wave's crest to its trough (this measurement will be twice the amplitude measured for the same wave).

Wavelength—The horizontal distance between two crests.

(Sources: Federal Emergency Management Agency; Richard Aster, New Mexico Tech; Bill Haneberg, Dave Love, and other staff, New Mexico Bureau of Mines and Mineral Resources)



Herbert was not prepared for an earthquake.

Tasty Quake

Materials for the teacher

- A fist-sized rock
- Silicone putty (widely available as Silly Putty™)
- One pan of prepared gelatin dessert (see recipe)
- Clear plastic wrap
- Sugar cubes or dominoes
- Spoon for serving dessert
- Paper cups and spoons for individual portions

Gelatin Dessert

Two 170-g (6oz) boxes of red or purple gelatin dessert

Two one-serving envelopes of unflavored gelatin

Four cups boiling water

One 23 x 30 cm (9 x 12 in.) metal baking pan

Empty the gelatin dessert and the unflavored gelatin into the baking pan. Add the boiling water and stir until all the powder is dissolved, then add the cold water and stir to mix. Chill on refrigerator shelf at least three hours or until set.

Teacher Take Note:
This recipe has been carefully tested. To transmit waves that can be seen easily, the pan *must* be metal, and it *must* be full nearly to the top with the gelatin mixture.

Procedure

1. Prepare gelatin desert in advance and refrigerate. These ingredients will make one pan. Prepare more if you wish to have several small groups performing the demonstration simultaneously.

2. Write the definition of an earthquake on the board.

3. Explain that under the soil there are rock layers. These layers are under stress because of activity within the Earth.

4. Explain that when these rocks are under extreme stress they react more like a plastic material, such as silicone putty, than like the hard rock we see above the ground. Show rock and putty.)

5. Demonstrate with Silly Putty™, or distribute several lumps so that each small group can do the activity for themselves. (The putty will be difficult to break if it has been warmed by too much handling, so work quickly.)

a. First, stretch the putty slowly to show how rocks react to slow twisting and pulling.

b. Next, shape it back into a ball and give it a sharp tug with both hands. The putty will snap into pieces.

c. Explain that this reaction is similar to what happens during an earthquake.

6. Explain that when rocks break in this sudden way energy is released in the form of waves. We can simulate this release of energy by watching what happens to a pan of gelatin.

7. Gently tap the side of the pan of gelatin, while holding the pan firmly with the other hand. Students should be able to see the waves traveling through the gelatin. Compare the gelatin to the ground, the tap of your hand to the rock breaking, and the waves in the gelatin to earthquake waves.

8. Ask the students to predict what will happen when you tap the pan with more force. Tap the pan harder. Is their prediction confirmed? Repeat these two steps several times, and be sure that all the students have a chance to see the waves.

9. Cover the top of the gelatin with plastic wrap so it will be clean enough to eat later. Be sure the wrap touches the gelatin. Ask the students what they think happens to buildings during an earthquake. Then let them distribute sugar cube or domino "buildings" over the plastic wrap.

10. Repeat steps 7 and 8 above. Replace any buildings that are knocked over during the first trial. Allow students to construct different kinds of buildings and predict their resistance to the "earthquake," then test their predictions.

11. Remove the plastic wrap and serve the gelatin to the students.

Teachers: the above exercise was extracted from: ***Earthquakes—a teacher's guide for K—6 grades*** *by the National Science Teachers Association, 1988. Copies of the complete curriculum, which was supported by the Federal Emergency Management Agency (FEMA), are available for New Mexico teachers for free through NMBM&MR. Please send your request for a copy (one per school) on school letterhead to: Susan Welch, New Mexico Bureau of Mines and Mineral Resources, Socorro, NM 87801. Teachers* ***outside*** *New Mexico can write to FEMA, Earthquake Program, 500 C Street, Washington, D.C., 20472; request information on curriculum price and availability, and teacher training in your state..*

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EARTH SCIENCE UPDATE

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

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 to:

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

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

1-(800) SOS-RADON

Information on Earth Science programs, projects, reports, products and their sources is available from:

US Geological Survey
Earth Science Information Center
(USGS ESIC)
Call 1-(800) USA-MAPS

or in New Mexico, contact:

Amy Budge
Earth Science Information Center
Earth Data Analysis Center
University of New Mexico
Albuquerque, NM 87131
(505) 277-3622

whats on line?

Teachers—Check out the US Geological Survey information available to the public through the Internet using Mosaic software program. We downloaded this pamphlet. The pathway we used is:

http://info.er.usgs.gov/public/disaster-day/pamphlet.html

(editor's note: Watch for more ideas on computerized geologic information in future issues. We would love to hear from our readers about what systems and programs they are using. We will soon have an email address)

YOU CAN HELP, TOO!

- ◇ Learn more about natural hazards
- ◇ Take first aid classes
- ◇ Make a disaster plan with your family
- ◇ Make a Disaster Supply Kit for your home

DISASTER SUPPLY KIT

Check Off Supplies

- ◇ water
- ◇ food
- ◇ first aid kit
- ◇ tools & supplies *including:*
  - ◇ eating utensils
  - ◇ radio (battery operated
  - ◇ flashlight
  - ◇ spare batteries
  - ◇ can operner
  - ◇ matches
  - ◇ fire extinguisher
- ◇ clothing & bedding
- ◇ special items such as medications

◆ For more detailed information, contact your local chapter of the American Red Cross or your local emergency manager.

◇ Get involved in your community. Make sure everyone is prepared for natural disasters. Include your school, local businesses and government offices.

publication Sources:

Earth Science Resource Center
Office of Special Programs and
Continuing Education
Colorado School of Mines
Golden, CO 80401
(303) 273-3038
FAX: (303) 273-3314

What's Under Your Feet? is an earth science activity book for grades 4-8. Its price is $3.00 (plus sales tax in Colorado).

Sharing Science with Children: A Survival Guide for Scientists and Engineers is a guide to help scientists and engineers who will be visiting a classroom. Its price is $1.50 (plus sales tax in Colorado).

Sharing Science: Linking Students with Scientists and Engineers—A Survival Guide for Teachers is a guide to help teachers prepare to host a visiting scientist in the classroom. Its price is $1.50 (plus sales tax in Colorado).

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The Borderlands - Past and Present
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contact:
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Golden, CO 80401
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FAX: (303) 273-3314

also...

National Energy Foundation
5160 Wiley Post Way, Suite 200
Salt Lake City, UT 84116
(801) 539-1406

The Mining Industry and Minerals is a publication filled with educational articles and activities for students. It costs 75 cents per copy, plus shipping & handling of $3.00 (or 10% of order if 40 or more copies are ordered).

From the Mine to My Home is a 23" x 35" poster published by the National Energy Foundation. It details the steps in mining from exploration to production to consumption to recycling. The price of this poster is $3.00, plus shipping & handling.

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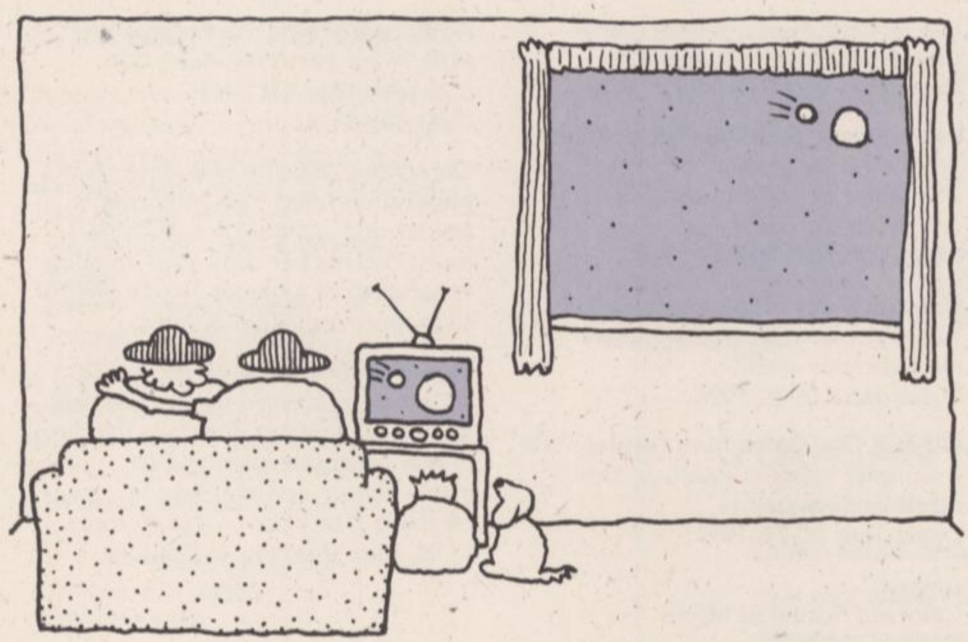
a parting shot...

The focus for this issue has been on earthquakes—why they occur, how they are studied, and how they could affect New Mexico. Educators and the public can obtain more information by contacting Bob Redden, NMEPP Program Manager in Santa Fe at (505) 827-9254. The Bureau (NMBM&MR) can supply earthquake and other natural hazards information in the form of maps, articles, publications, and videos. Please contact the Publications Office for a price list. We will continue to explore more earthquake topics in future issues, so save this copy for reference. See you next time.! (editor, Susan J. Welch)



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