SEISMIC SLEUTHS:

A REVISION OF THE TEACHER'S PACKAGE FOR GRADES 7-12

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Seismic Sleuths: A Teacher's Package for Grades 7-12

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ABSTRACT

Seismic Sleuths is an earthquake education curriculum originally published in 1995 by the American geophysical Union (AGU) and the Federal Emergency Management Agency (FEMA). In order to bring the curriculum to date with the current National Science Education Standards and make the lessons easier for teachers to use, it is now being revised under supervision of the Southern California Earthquake Center.

For the revision, the curriculum was reevaluated in terms of the final 1995 version of the National Science Education Standards. To increase usability, each of the six units was streamlined and reorganized so they may be used individually, and each laboratory activity was updated and redesigned if necessary. Also, printed and video resources lists for each topic have been updated and expanded to include electronic sources. The reorganization has resulted in five stand-alone units that follow a logical learning sequence.

The next step for Seismic Sleuths is a digital, online supplement to the written curriculum. As the first step, the entire package is being scanned and read using optical character recognition software. Also up-and-coming is a 60 minute video overview and supplement to Seismic Sleuths. Seismic Sleuths is a powerful tool for today's teachers. When revision is completed, it will allow students to understand the world around them and use that understanding to reduce risk from natural disasters.

INTRODUCTION

Seismic Sleuths was developed by the American Geophysical Union (AGU) and the Federal Emergency Management Agency (FEMA) in 1995. In order to reflect advances made in earth science, the National Science Foundation (NSF) funded the revision of the Seismic Sleuths curriculum in 1999 under the direction of the Southern California Earthquake Center (SCEC). The revision is currently supervised by Robert de Groot of SCEC with assistance from Kathryn van Roosendaal, a SCEC summer outreach intern.

The purpose of the revision is to update the material in terms of the new National Science Education Standards issued in 1995 and to create a curriculum that is easier for teachers to use. The original Seismic Sleuths package is separated into six units which are designed to be used together and in sequence, making it difficult for teachers wanting to use only one or two topics. Also, the sequence of lessons is awkward, forcing most teachers to reorganize on their own. Included in the revision is also an update of the resources sections for each unit.

CHANGES MADE TO SEISMIC SLEUTHS

National Science Education Standards

The Original Seismic Sleuths includes a breakdown of the relevance of each section to the National Science Education Standards. However, the curriculum was released before the standards were finalized in 1995. One of the first jobs we completed for the new curriculum was to review each activity and rate its relevance to the finalized standards. Relevance is listed by section and is given in a series of tables in the introduction section of the curriculum.

Revision of Activities

The first priority in revising the Seismic Sleuths curriculum was to ensure that each activity portrays accurate information and is easy for teachers to use. Each activity was read through and evaluated for content and usability. The majority of activities required only minor changes. Some activities, needed updating to include new information. For instance, the seismic waves activity needed updating to include Raleigh and Love waves. A synopsis of changes made is made in Table 1.

Table 1. Synopsis of changes made to Seismic Sleuths activities.

Sec	Title	Comments
1.1	What do you know about Earthquakes?	Add a new activity to the beginning: Earthquake Myths. Activity 2: current section with no changes.
1.2	It could happen here	No changes
1.3	Investigating community preparedness	No changes
2.1	Stick-slip movement	Change "sugar cubes" to a brick.
2.2	Shifting plates and wandering poles	No changes
2.3	Earthquakes in Geologic time	Activity one - rewritten. Activity two - very good, no changes.
2.4	Earthquake hazards	Activity 1 - reword B.2.a. to "cut off the bottom 5mm of the cup" Activity 2 - add a step in the demonstration to simulate an earthquake on a stable slope. Activity 3 - B. 1-4. Good. Omit the research section. Add a demo using a large zip-lock bag with water.
2.5	Quake-smart siting	No changes
3.1	The waves of quakes	P-waves - move the discussion on P & S waves in liquid to the main activity. Add the "human chain" demonstration to the adaptations and extensions. S-waves - change the cord references to a slinky. Add detailed sections on Raleigh and Love waves.
3.2	Pioneering ideas	Rewrite as "history of Seismology".
3.3	Sizing up earthquakes	Mercalli - no changes; Richter - no changes; Locating the epicenter - new seismograms. Add detailed section on Mw.
3.4	Distribution of earthquakes	Distribution - omit all but the notable earthquakes. Update notable earthquakes. The earthquake lists need major revision, some are listed as Richter magnitude, others as Mw. We need to find a common magnitude reference. This section is repetitious. The same activity is repeated with different scales. What can we do about this?

Table 1 (continued).

Sec	Title	Comments
4.1	Building fun	No changes
4.2	Structural reinforcement: the better building	No changes
4.3	The BOSS model: Building Oscillation Seismic Simulation	No changes
4.4	Earthquake in a box	No changes
4.5	The building challenge	No changes
5.1	Predicting earthquakes	Activity 1 - It is long and arduous. Omit this activity. Move the articles to the adaptations and extensions. Activity 2 - rewrite as "forecasting" instead of "predicting" earthquakes.
5.2	Starting here, starting now	Separate into two separate sections: earthquake drill and RVS.
5.3	Find and fix the hazards (wood frame homes)	Make this into either an extension of the RVS in the last section or part of the adaptations and extensions.
5.4	Rapid Visual Screening (RVS) in the community	No changes.
5.5	Are the lifelines open? Critical emergency facilities and lifeline utility systems	Combine with section 1.3
6.1	Preparing for the worst: a simulation	Set-up for the simulation. Combine with 6.2
6.2	Earthquake simulation: putting plans into action	Simulation. Combine with 6.1
6.3	What's your E.Q I.Q.?	Move to an appendix.
6.4	Hey, look at me now!	Evaluation of section 1.1. Move to the end of section 1.

Reorganization of Units

Seismic Sleuths was originally designed to be used as a whole and in sequence. However, feedback from teachers using the curriculum indicated that there is seldom time to teach all the sections. To assist teachers, the sections have been reorganized so each unit can be taught stand-alone as well as in sequence. To facilitate the reorganization, some activities were combined and others were moved. The final organization consists of five independent units and two appendices (Table 2).

Table 2. Reorganized Seismic Sleuths units and sections.			
Unit/Section		Activities	Original Section
What is an Earthquake?			
	What do we know?	Earthquake Myths	New
		How Much Do You Know?	1.1
	How do Earthquakes Happen?	Stick-Slip Movement	2.1
	Why do Earthquakes Happen?	Poles At Play	2.2
		Records in the Rock	2.2
		Mapping Prehistory	2.2
	Earthquakes in time	Geologic Time	New
		Paleoseismology	2.3
	Related Hazards	Liquifaction	2.4
		Landslides	2.4
		Tsunami	2.4
	What have you learned		6.4
How do we study Earthquakes			
	History of Tectonics and Seismology		New
	Earthquake Waves	Primary Waves	3.1
		Secondary Waves	3.1
		Surface Waves	New
	Measuring the Size of Earthquakes	The Mercalli Scale	3.3
		Richter Magnitude	3.3
		Moment Magnitude	New
		Find the Epicenter	3.3
	Earthquake Distribution	Where in the World?	3.4
		3-D Distribution	3.4
	Earthquake Forecasting		New
Building for Earthquakes			
	Building Fun		4.1
	Structural Reinforcement		4.2
	The BOSS Model		4.3
	Shake Table		4.4
	The Building Challenge		4.5
Earthquake Safety			
	What to do in an Earthquake	Earthquake Drill	5.2
	Rapid Visual Screening (RVS)	RVS at Home and School	5.2
		Find and Fix the Hazards	5.3
	Community RVS		5.4
	Smart Siting		2.5
Are You Prepared for an Earthquake			
	Personal Preparedness	It Could Happen Here	1.2
		3-Day Survival Pack	1.2
	Community Preparedness		1.3
	Community Lifelines		5.5
	Earthquake Simulation		6.1, 6.2
Appendix A: Earthquake Information Resources		Print, non-print, and internet references	All Sections
Appendix B: Earthquake I.Q. Game			6.3

Update of Earthquake Information Resources

Each unit of Seismic Sleuths contains a listing of print and non-print media that can be used as additional resources by teachers. In addition, Unit 1 contains a listing of contacts for the U.S Geological Survey, Federal Emergency Management Agency, and other government agencies that may be useful for teachers. All of these resources needed to be checked and updated.

First, the web sites listed for each government office were checked for validity. Unfortunately, most of them were no longer in existence so a search was conducted to find the current listings. The web pages for each office were then used to check and update office addresses and phone numbers. The updated listing contains the phone number, mailing address, email address and web address for each State Geological Society, USGS regional and state offices, FEMA regional offices, and state Emergency Management Agencies.

The media resources were also checked for availability. As is common for scientific texts, many of the print resources are now out of print. Library and publisher listings were used to compile a new list of references and, to aid teachers, ISBN numbers and ordering information were added to each reference. The final list is organized by subject and includes books, videos, slides, fact sheets, circulars, and web pages.

Scanning modules into digital format

To aid in editing of Seismic Sleuths, the entire curriculum was scanned into digital format and read with Textbridge Professional, an optical character recognition (OCR) program. Approximately 97% of the text was recognized correctly, so minimal cleaning was required. The curriculum was recognized as a rich text format and was subsequently converted to Microsoft Word format for cleaning and editing. The digitized curriculum will later be used as a base for the electronic Seismic Sleuths

WHAT COMES NEXT

The next step in the revision of Seismic Sleuths is an electronic, web-based version of the curriculum. This electronic version will support the printed version. It will contain additional resources specific to each state or region. It will also contain new modules on Geodesy and Earthquake Risk. Since it will be entirely on-line, it will be easy to update as new discoveries are made.

Soon to be available to teachers is a 60 minute video supplement to Seismic Sleuths. The video contains interviews from scientists and disaster victims, helping portray the human experience from both standpoints. The video also explores the limits and controversies in Earth Science. A shorter 30 minute video will also be produced for younger children.

APPENDIX A: Updated Earthquake Information Resources

GOVERNMENT OFFICES

State Geological Surveys

Alabama Geological Survey

Alaska State Geological Survey
794 University Avenue, Suite 200
Fairbanks, Alaska 99707
V: 907-451-5000
F: 907-451-5050
www.dggs.dnr.state.ak.us
dggs@dnr.state.ak.us

Arizona Geological Survey
416 W. Congress Street, suite 100
Tucson, Arizona 85701
V: 520-770-3500
F: 520-770-3505
www.azgs.state.az.us
McGarvin_Thomas@pop.state.az.us

Arkansas Geological Commission
Vardell Parham Geology Center
3815 West Roosevelt Road
Little Rock, AR 72204
V: 501-296-1877
F: 501-663-7360
www.state.ar.us/agc/agc.htm
bill.bush@mail.state.ar.us

California Division of Mines and Geology
655 south Hope Street, #700
Los Angeles, CA 90017
V: 213-239-0878
F: 213-239-0894
www.consrv.ca.gov/dmg
dmglib@consrv.ca.gov

Colorado Geological Survey
1313 Sherman Street, R. 715
Denver, CO 80203
V: 303-866-2611
F: 303-866-2461
www.dnr.state.co.us/geosurvey
cgspubs@state.co.us

Connecticut Geological and Natural History Survey

Connecticut Department of Environmental Protection
79 Elm Street
Hartford, CT 06106-5127
V: 860-424-3550
F: 860-424-4058
www.dep.state.ct.us/index.htm
dep.webmaster@po.state.ct.us

Delaware Geological Survey
University of Delaware
Delaware Geological Survey Bld
Newark, CE 19716-7501
V: 302-831-2833
F: 302-831-3579
www.udel.edu/dgs/dgs.html
delgeosurvey@udel.edu

District of Columbia

Florida Bureau of Geology
903 W. Tennessee Street
Tallahassee, FL 32304-7700
V: 850-488-9380
F: 850-488-8086
www.dep.state.fl.us/geo

Georgia Geological Survey
Georgia Department of Natural Resources
Environmental Protection Division
19 Martin Luther King Jr. Drive, Room 400
Atlanta, Georgia 30334
V: 404-656-3214
F:
www.ganet.org/dnr/environ/branches/geosurv/gsnar.htm

Hawaii Geological Survey
Department of Land and Natural Resources
Kalanimoku Bldg
1151 Punchbowl Street
Honolulu, HI 96813
V: 808-587-0400

F: 808-587-0390
www.kumu.icsd.hawaii.gov/dlnr/Welcome.html
dlnr@pixi.com

Idaho Geological Survey
University of Idaho
Morrill Hall, Third Floor
Moscow, ID 83844-3014
V: 208-885-7991
F: 208-885-5826
www.idahogeology.org
igs@uidaho.edu

Illinois State Geological Survey
615 E. Peabody
Champaign, IL 61820
V: 217-333-4747
F:
www.isgs.uiuc.edu/isgshome.html
webmaster@isgs.uiuc.edu

Indiana Geological Survey
Indiana University
611 North Walnut Grove
Bloomington, IN 47405-2208
V: 812-855-7636
F: 812-855-2862
www.adamite.igs.indiana.edu/indsurv/index.htm
IGSINFO@indiana.edu

Iowa Geological Survey Bureau
Iowa Department of Natural Resources
109 Trowbridge Hall
Iowa City, Iowa 52242-1319
V: 319-335-1575
F: 319-335-2754
www.igsb.uiowa.edu
webmanager@igsb.uiowa.edu

Kansas Geological Survey
University of Kansas
1930 Constant Avenue
Lawrence, KS 66047-3726
V: 785-864-3965
F: 785-864-5317
www.kgs.ukans.edu/kgs.html
webadmin@kgs.ukans.edu

Kentucky Geological Survey
228 Mining and Mineral Resources Building
University of Kentucky
Lexington, Kentucky 40506-0107
V: 859-257-5500
F: 859-257-1147
www.uky.edu/KGS/home.htm
chesnut@kgs.mm.uky.edu

Louisiana Geological Survey
PO Box G, University Station
Baton Rouge, Louisiana 70893
V: 225-388-5320
F: 225-388-3662
www.lgs.lsu.edu
chacko@vortex.bri.lsu.edu

Maine Geological Survey
22 State House Station
Augusta, Maine 04333
V: 207-287-2801
F:
www.state.me.us/doc/nrimc/mgs/mgs.htm
mgs@state.me.us

Maryland Geological Survey
2300 St. Paul Street
Baltimore, MD 21218
V: 410-554-5500
F:
www.mgs.md.gov

Massachusetts Office of the State Geologist
100 Cambridge Street
Boston, MA 02202
V: 617-626-1000
F: 617-626-1181
www.magnet.state.ma.us/envir/eoea.htm
eoea@state.ma.us

Michigan Department of Environmental Quality
Geological Survey Division
PO Box 30256
Lansing, MI 48909-7756
V: 517-334-6923
F: 517-334-6038
www.deq.state.mi.us/gsd
jelsener@state.mi.us

Minnesota Geological Survey
2642 University Avenue W

St. Paul, MN 55114-1057
V: 612-627-4780
F: 612-627-4778
www.geo.umn.edu/mgs
mgs@tc.umn.edu

Mississippi Office of Geology
PO Box 20305
Jackson, MS 39289-1305
V: 601-961-5500
F: 601-961-5521
www.deq.state.ms.us
Webmaster@deq.state.ms.us

Missouri Department of Natural Resources
Division of Geology and Land Survey
PO Box 250
Rolla, MO 65402
V: 1-800-334-6946
F:
www.dnr.state.mo.us/dgls/homedgls.htm
dnrdgls@mail.dnr.state.mo.us

Montana Bureau of Mines and Geology
1300 West Park Street
Butte, Montana 59701
V: 406-496-4167
F: 406-496-4451
www.mbmgsun.mtech.edu
pubsales@mbmgsun.mtech.edu

Nebraska Geological Survey
Conservation and Survey Division
University of Nebraska
113 Nebraska Hall
Lincoln, Nebraska 68588-0517
V: 402-472-3471
F: 402-472-4608
www.csd.unl.edu/csd.html
dmohlman1@unl.edu

Nevada Bureau of Mines and Geology
Mail Stop 178
University of Nevada
Reno, NV 89557-0088
V: 775-784-6691 x133
F: 775-784-1709
Nbmginfo@unr.edu

New Hampshire Geological Society
PMB 133
26 South Main Street
Concord, NH 03301
www.nhgs.org/NHGS/NHGS.html
tallen@keene.edu

New Jersey Geological Survey
29 Arctic Parkway
PO Box 427
Trenton, NJ 08625
V: 609-292-1185
F: 609-633-1004
www.state.nj.us/dep/njgs/index.html

New Mexico Bureau of Mines and Mineral Resources
801 Leroy Place
Socorro, NM 87801-4796
V: 505-835-5420
F: 505-835-6333
www.geoinfo.nmt.edu
nmbmmr@nmt.edu

New York State Geological Survey

North Carolina Geological Survey
Division of Land Resources
1612 Mail Service Center
Raleigh, NC 27699-1612
V: 919-733-2423
F: 919-733-0900
www.geology.enr.state.nc.us
Jeff.Reid@ncmail.net

North Dakota Geological Survey
600 East Boulevard Avenue
Bismarck, ND 58505-0840
V: 701-328-8000
F: 701-328-8010
www.state.nd.us/ndgs
jlefever@rival.ndgs.state.nd.us

Ohio Department of Natural Resources
Division of Geological Survey
4383 Fountain Square Drive
Columbus, OH 43224-1362
V: 614-265-6576
F: 614-447-1918
www.dnr.state.oh.us/odnr/geo_survey
geo.survey@dnr.state.oh.us

Oklahoma Geological Survey

100 E. Boyd, Rm. N-131
Norman, OK 73019-0628
V: 405-325-3031
F: 405-325-7069
www.ou.edu/special/ogs-pttc
cgsmith@ou.edu

Oregon Department of Geology and Mineral Industries
800 NE Oregon Street, Suite 965
Portland, Oregon 97232
V: 503-731-4100
F: 503-731-4066
www.sarvis.dogami.state.or.us

Pennsylvania Topographic and Geological Survey
Department of Conservation and Natural Resources
PO Box 8453
Harrisburg, PA 17105-8453
V: 717-787-2169
F:
www.dcnr.state.pa.us/topogeo/indexbig.htm
kwarner@dcnr.state.pa.us

Puerto Rico Bureau of Geology
Department of Natural and Environmental Resources
Box 9066600
Puerta de Tierra, PR 00906
V: 787-722-2526
F: 787-723-4255
www.kgs.ukans.edu/AASG/puertorico.html

Rhode Island Geological Survey
University of Rhode Island
Department of Geology
315 Green Hall
Kingston, RI 02881
V: 401-874-2191
F: 401-874-2190
www.uri.edu/cels/gel
Nasir@uriacc.uri.edu

South Dakota Geological Survey
Akeley Science Center, USD
414 E. Clark Street
Vermillion, SD 57069-2390
V: 605-677-5227
F: 605-677-5895
www.sdgs.usd.edu
tcowman@usd.edu

Tennessee Division of Geology
Department of Environment and Conservation
401 Church Street, 13th floor, L&C Tower
Nashville, TN 37243-0445
V: 615-532-1500
F:
www.state.tn.us/environment/tdg/index.html

Texas Bureau of Economic Geology
University of Texas
Box X, University Station
Austin, Texas 78712-8924
V: 512-471-1534
F: 512-471-0140
www.beg.utexas.edu
sigrid.clift@beg.utexas.edu

Utah Geological Survey
1594 West North Tempe
PO Box 146100
Salt Lake City, UT 84114-6100
V: 801-537-3300
F: 801-537-3400
www.ugs.state.ut.us
nrugs.geostore@state.ut.us

Vermont Geological Survey
103 S. Main Street, Laundry Building
Waterbury, VT 05671-0301
V: 802-241-3608
F: 802-241-3273
www.anr.state.vt.us/geology/Vgshmpg.htm
Marjieg@dec.anr.state.vt.us

Washington Department of Natural Resources
Division of Geology and Earth Resources
1111 Washington Street SE, Room 148
PO Box 47007
Olympia, WA 98504-7007
V: 360-902-1450
F: 360-902-1785
www.wa.gov/dnr/htdocs/ger/ger.html
geology@wadnr.gov

West Virginia Geological and Economic Survey

PO Box 879
Morgantown, WV 26507-0879
V: 800-984-3656
F: 304-594-2575
www.wvgs.wvnet.edu
webmaster@geosrv.wvnet.edu

Wisconsin Geological and Natural History Survey
3817 Mineral Point Road
Madison, Wisconsin 53705-5100
V: 608-262-1705
F: 608-262-8086
www.uwex.edu/wgnhs
Mcjames@facstaff.wisc.edu

Wyoming State Geological Survey
PO Box 3008
Laramie, MY 82071
V: 307-766-2286
F: 307-766-2605
www.wsgsweb.uwyo.edu
wsgs@wsgs.uwyo.edu

USGS Regional and State Headquarters

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USGS National Center
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Hours of operation: 6:30 a.m. to 6:30 p.m.

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Eastern Time

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Eastern Time

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Fax: (410) 238-4210
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Fax: (207) 622-8204
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Central Time

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Other USGS Offices

Earth Science Information Center
U.S. Department of the Interior
U.S. Geological Survey
12201 Sunrise Valley Drive, Reston, VA 20192, USA
URL: http://ask.usgs.gov /index.html
Page Maintainer: Ask USGS Web Team
Contact: ask@usgs.gov

Center for Integration of Natural Disaster Information (CINDI)
U.S. Department of the Interior
U.S. Geological Survey
CINDI, 570 National Center, Reston, VA 20192, USA, 703 648-6059
http://cindi.usgs.gov/index.html
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USGS Learning Web

U.S. Department of the Interior, U.S. Geological Survey, Reston, VA, USA
URL
http://www.usgs.gov/education/index.html
Earth science questions: ask@usgs.gov

Geographic Names Information System
GNIS Manager
U.S. Geological Survey
523 National Center
Reston, VA 20192
Phone: (703) 648-4544
E-mail: gnis_manager@usgs.gov

United States Geological Survey
National Earthquake Information Center
Box 25046, DFC, MS 967
Denver, Colorado 80225
Operations: 303-273-8500
FAX: 303-273-8450
E-MAIL: sedas@gldfs.cr.usgs.gov
http://neic.usgs.gov/

Additional USGS Web Resources

Biological Resources - Eastern Region
http://brdero.er.usgs.gov/

Biological Resources - Central Region
http://biology.usgs.gov/cro/

Water Resources Northeast Region
http://wwwrvares.er.usgs.gov/orh/nrwww/public/public.html

Water Resources Southeast Region
http://wwwrgaatl.er.usgs.gov/

Water Resources Central Region
http://wwwrcolka.cr.usgs.gov/

Water Resources Western Region
http://wwwrcamnl.wr.usgs.gov/

Volcano Information
http://volcanoes.usgs.gov/

Alaska Volcano Observatory
http://www.avo.alaska.edu/

Cascades Volcano Observatory
http://vulcan.wr.usgs.gov/

Hawaiian Volcano Observatory
http://hvo.wr.usgs.gov/

Long Valley Caldera: Monitoring Volcanic Unrest
http://quake.wr.usgs.gov/VOLCANOES/LongValley/

Volcano Hazards Program
http://volcanoes.usgs.gov/

FEMA Regional Offices

Region I - Connecticut, Massachusetts, Maine, New Hampshire, Rhode Island, Vermont
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Region II - New Jersey, New York, Puerto Rico, Virgin Islands
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Region IV - Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee
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Fax: 770-220-5230

Region V - Illinois, Indiana, Michigan, Ohio, Wisconsin, Minnesota
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312-408-5500
Main Switchboard 312-408-5500
312-408-5567
Michael G. Moline, Division

Region VI - Arkansas, Louisiana, New Mexico, Oklahoma and Texas.
Regional Office Main Number (940) 898-5399

Region VII - Iowa, Kansas, Missouri, Nebraska
John A. Miller, Regional Director
Federal Emergency Management Agency
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Kansas City, MO 64108-2670
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Fax: (816) 283-7582

Region VIII - Colorado, Montana, North Dakota, South Dakota, Utah, Wyoming
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Tel: 303-235-4812
Fax: 303-235-4976

Region IX - Arizona, California, Hawaii and Nevada; and the Territory of American Samoa, the Territory of Guam, the Commonwealth of the Northern Mariana Islands, the Republic of the Marshall Islands, the Federated States of Micronesia, and the Republic of Palau
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Building 105, Presidio of San Francisco
San Francisco, CA 94129
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Building T-112 - Stop 120
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Fax: (808) 851-7904

Region X - Alaska, Idaho, Oregon, Washington
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Federal Regional Center
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Fax: 425-487-4622

State Emergency Management Agencies

Alabama Emergency Management Agency
http://www.aema.state.al.us/
5898 County Road 41
P O Box 2160
Clanton, AL 35046-2160
V: 205-280-2200
F: 205-280-2495

State of Alaska (U.S.A.), Department of Military Affairs, Division of Emergency Services
http://www.ak-prepared.com/
PO Box 5750
Fort Richardson, AK 99505-5750
V: 907-428-7000
F: 907-428-7009

State of Arizona (U.S.A.) - Division of Emergency Management
http://www.dem.state.az.us

State of Arkansas Office of Emergency Services
http://www.oes.state.ar.us/

State of California (USA) - Governors Office of Emergency Services
http://www.oes.ca.gov/
2800 Meadowview Rd.
Sacramento, CA 95832
(916) 262-1843

State of Colorado (U.S.A.), Dept. of Local Affairs, Office of Emergency Management
http://www.state.co.us/gov_dir/loc_affairs_dir/oem.htm

State of Delaware (U.S.A.) Emergency Management Agency
http://www.state.de.us/dema/index.htm
165 Brick Store Landing Road
Smyrna, DE 19977
V: (302) 659-DEMA (3362)
F: (302) 659-6855

State of Florida, Division of Emergency Management
http://www.floridadisaster.org
2555 Shumard Oak Boulevard
Tallahassee, Florida 32399-2100
V: 850-413-9900

State of Georgia (U.S.A.) Emergency Management Agency
http://www.State.Ga.US/GEMA/
P.O. Box 18055
Atlanta, GA 30316-0055
V: (404) 635-7000 or 1-800-TRY-GEMA (In Georgia)
F: (404) 635-7205

State of Hawaii, Civil Defense System
http://www.scd.state.hi.us/
3949 Diamond Head Road
Honolulu, HI 96816-4495
V: (808) 733-4300

State of Idaho - Bureau of Disaster Services
http://www.state.id.us/bds/bds.html
Military Division
4040 Guard Street, Building 600
Boise, ID 83705-5004
V: (208) 334-3460 or (208) 422-3429
F: (208) 334-2322

State of Illinois Emergency Management Agency
http://www.state.il.us/iema
110 East Adams Street
Springfield, Illinois 62701-1109
V: (217)782-7860

State of Indiana (USA) - Emergency Management Agency
http://www.ai.org/sema/index.html
Indiana Government Center South
302 W. Washington St., Room E208
Indianapolis, IN 46204
V: (317) 232-3980
F: (317) 232-3895

State of Iowa Emergency Management Home Page
http://www.state.ia.us/government/dpd/emd/index.htm
Hoover State Office Building
Des Moines, IA 50319
V: (515)281-3231
F: (515) 281-7539

State of Kansas, Division of Emergency Management
http://www.ink.org/public/kdem/
Adjutant General's Department
2800 SW Topeka Blvd.
Topeka, KS 66611-1287
V: 785-274-1409
F: 785-274-1426

State of Louisiana Office of Emergency Preparedness
http://199.188.3.91/
P.O. Box 44217
Baton Rouge, LA 70804
(225) 342-5470
V: (225) 342-5472
F: (225) 342-5471

State of Maine (USA) -Emergency Management Agency
http://www.state.me.us/mema/memahome.htm
State House Station #72

Augusta, ME 04333
V: 1-800-452-8735 (207-626-4503)

State of Maryland (U.S.A.) Emergency Management Agency
http://www.mema.state.md.us/
State Emergency Operations Center
5401 Rue Saint Lo Drive
Reisterstown, MD 21136
V: 410-517-3600 or 800-422-8799

State of Massachusetts Emergency Management Agency
http://www.magnet.state.ma.us/mema/homepage.htm
400 Worcester Road
Framingham MA 01702-5399
V: (508)820-2000
F: (508)820-2030

State of Michigan Emergency Management Division -
Michigan Department Of State Police
http://www.msp.state.mi.us/division/emd/emdweb1.htm
Emergency Management Division - (517) 336-6198

State of Minnesota (U.S.A.) Department of Public Safety, Division of Emergency Management
http://www.dps.state.mn.us/emermgt/
Emergency Response Commission
444 Cedar Street, Suite 223
Saint Paul, MN 55101-6223
V: (651) 297-7372

State of Mississippi Emergency Management Agency
http:// www.memaorg.com

State of Missouri Emergency Management Agency
http://www.sema.state.mo.us/semapage.htm
P.O. Box 116
efferson City, MO 65102

State of Nebraska Military Department (U.S.A.)
http://www.nebema.org
1300 Military Road
Lincoln, Nebraska
V: (402) 471-7430.

State of Nevada Division of Emergency Management
http://www.state.nv.us/dmv_ps/emermgt.htm
2525 South Carson Street,
Carson City, NV 89711
V: (775) 687-4240
F: (775) 687-6788

State of New Hampshire (U.S.A) Office of Emergency Management
http://www.nhoem.state.nh.us/
107 Pleasant St.
Concord, NH 03301
V: 603-271-2231 or 800-852-3792

State of New Mexico - Department of Public Safety
http://www.dps.nm.org/emc.htm
13 Bataan Boulevard
P. O. Box 1628
Santa Fe, NM 87504-1628
V: (505) 476-9600

State of New York Emergency Management Office
http://www.nysemo.state.ny.us/
V: 518 457-2200
F: 518 457-9930

State of North Carolina (USA) Division of Emergency Management
http://www.dem.dcc.state.nc.us/
4713 Mail Service Center
Raleigh, N.C. 27699-4713
V: 919-733-3867

State of North Dakota, Department of Emergency Management (DEM)
http://www.state.nd.us/dem
PO Box 5511
Bismarck, ND 58506-5511
V: 701-328-8100
F: 701-328-8181

State of Ohio Emergency Management Agency

http://www.state.oh.us/odps/division/ema/
2855 West Dublin-Granville Road
Columbus, Ohio 43235-2206
V: (614) 889-7150
F: (614) 889-7183

State of Oklahoma (U.S.A.) Department of Civil Emergency Management
http://www.onenet.net/~odcem/
P.O. Box 53365
Oklahoma City, OK 73152-3365
V: (405) 521-2481
F: (405) 521-4053

State of Oregon (USA) - Emergency Management Division
http://www.osp.state.or.us/oem/oem.htm
595 Cottage St. NE
Salem, Oregon 97310
V: (503) 378-2911
F: (503) 588-1378
TTY: (503) 373-7857

State of Pennsylvania Emergency Management Agency (PEMA)
http://www.pema.state.pa.us
2605 Interstate Drive
Harrisburg, Pennsylvania 17110-9364
V: 717-651-2009
F: 717-651-2040

State of Rhode Island (U.S.A.) Emergency Management Agency
http://www.state.ri.us/riema/riemaaa.html
645 New London Avenue
Cranston, RI 02920
V: (401) 946 - 9996

State of South Carolina (U.S.A.) Emergency Preparedness Division
http://www.state.sc.us/epd/
1429 Senate Street
Columbia, SC 29201

State of South Dakota (U.S.A.), Dept. of Military and Veterans Affairs
http://www.state.sd.us/state/executive/military/military.html
Division of Emergency Management
500 East Capitol
Pierre, SD 57501-5070
V: (605) 773-3231
F: (605) 773-3580

State of Tennessee Emergency Management Agency
http://www.tnema.org
3041 Sidco Drive
Nashville, TN 37204
V: (615) 741-0001 (800) 262-3400 (In-State)
(800) 258-3300 (Out-of-State)
F: (615) 242-9635

State of Texas Department of Public Safety
http://www.txdps.state.tx.us/dem/
Division of Emergency Management
Box 4087
Austin, TX 78773-0220
V: 512-424-2138
F: 512-424-2444

State of Utah, Division of Comprehensive Emergency Management
http://www.ps.ex.state.ut.us/cem/cemhome.htm

State of Virginia (USA) Department of Emergency Services
http://www.vdes.state.va.us
V: (804) 897-6500

State of Washington (USA) - Emergency Management Agency
http://www.wa.gov/wsem/
V: (253) 512-7002

State of West Virginia Emergency Management Agency
http://www.state.wv.us/wvoes
1900 Kanawha Blvd. East, Building 1 Room EB-80
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V: (304) 558-5380
F: (304) 344-4538

State of Wyoming (U.S.A.)Emergency Management Agency http://132.133.10.9/

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Iacopi, Robert L., Fred W. Fisher (Editor), Robert L. Lacopi; Earthquake Country ISBN: 1555610862

King, Doug; Emergency Disaster Survival Guidebook ISBN: 1883736102

Komodromos, P. ; Seismic Isolation (Advances in Earthquake Engineering) ISBN: 1853128031

Lagorio, Henry J.; Earthquakes : An Architect's Guide to Nonstructural Seismic Hazards, ISBN: 047163302X

Leach, Joel, Greg McKenney (Illustrator), Kimberly B. Kilgore (Illustrator); Earthquake Prepared : Securing Your Home, Protecting Your Family. ISBN: 1882349423

Levin; Earth Through Time 6th Stdt edition ISBN: 0030217830

Levy, Matthys (Contributor), Mario Salbadori, Mario G. Salvadori; Why the Earth Quakes : The Story of Earthquakes and Volcanoes, ISBN: 0393037746

Levy, Matthys, Kevin Woest (Illustrator), Mario G. Salvadori (Contributor); Why Buildings Fall Down : How Structures Fail, ISBN: 039331152X

Levy, Matthys, Michael Lilly (Illustrator), Mario G. Salvadori (Contributor); Why the Earth Quakes, ISBN: 0393315274

Malin, Eleanor; Earthquake and Disaster Preparedness ISBN: 1884958109

National Academy Press; Active Tectonics (Studies in Geophysics) ISBN: 0309036380

National Educational Service; Containing Crisis : A Guide to Managing School Emergencies, ISBN: 1879639068

National Geographic Society; Our Violent Earth ISBN: 0870443887

Prager, Ellen (Editor); Furious Earth: The Science and Nature of Earthquakes, Volcanoes, and Tsunamis, ISBN: 0071351612

Sieh, Kerry E., Simon LeVay ;The Earth in Turmoil : Earthquakes, Volcanoes, and Their Impact on Humankind ISBN: 0716731517

Stewart, David, Ray Knox, Don Greenwood (Illustrator); The Earthquake America Forgot : Two Thousand Temblors in Five Months and It Will Happen Again (Earthquake Series : No 3) ISBN: 0934426457

Stewart, David; The Earthquake That Never Went Away (Gutenberg-Richter Earthquake Series, No 2) ISBN: 0934426546

Wegener, Alfred, Kurt Wegener (Designer), John Biram (Translator); Origin of Continents and Oceans ISBN: 0486617084

Yanev, Peter I.; Peace of Mind in Earthquake Country : How to Save Your Home and Life ISBN: 0877017719

Yeats, Robert S. ;Living With Earthquakes in the Pacific Northwest ISBN: 0870714376

USGS Publications

FACT SHEETS

Available online at http://geology.usgs.gov/fact-sheets/
For printed copies of these Fact Sheets contact:
Earthquake Information Hotline (415) 329-4085
U.S. Geological Survey, MS 977
345 Middlefield Road, Menlo Park, CA 94025

FS-071-00. Landslide Hazards [New as of 5-03-00]
FS-093-99. Natural Hazards; Minimizing the Effects
FS-110-99. The "Larse" Project--Working Toward a Safer Future for Los Angeles
FS-151-99. Progress Toward a Safer Future Since the 1989 Loma Prieta Earthquake
FS-152-99. Major Quake Likely to Strike Between 2000 and 2030
FS-002-97 What are Volcano Hazards?
FS-046-97 Monitoring Earthquakes Across the United States

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FS-114-97 Lahars of Mount Pinatubo, Philippines
FS-115-97 Benefits of Volcano Monitoring Far Outweigh the Costs--The Case of Mount Pinatubo
FS-125-97 Earthquake Information for the World
FS-165-97 Living With Volcanic Risk in the Cascades
FS-094-96 When Will the Next Great Quake Strike Northern California?
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FS-183-96 Hazard Maps Help Save Lives and Property
FS-097-95 Speeding Earthquake Disaster Relief
FS-167-95 Building Safer Structures
FS-168-95 The Mississippi Valley--"Whole Lotta Shakin' Goin' On"
FS-176-95 Saving Lives Through Better Design Standards
FS-225-95 Southern Californians Cope With Earthquakes
FS-242-95 Quake Forecasting--An Emerging Capability

CIRCULARS
Available online at http://geology.usgs.gov/circular.html
For printed copies of these circulars contact:
USGS Information Services
Box 25286
Denver Federal Center
Denver, CO 80225
Tel: 303-202-4700; Fax: 303-202-4693

Circular 1187. Surviving a Tsunami--Lessons from Chile, Hawaii, and Japan
Circular 1188. An Assessment of Seismic Monitoring in the United States--Requirement for an Advanced National Seismic System
Circular 1193. Implications for Earthquake Risk Reduction in the United States from the Kocaeli, Turkey, Earthquake of August 17, 1999

ONLINE BOOKS
Each book can also be ordered in print form from:
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Box 25286
Denver Federal Center
Denver, CO 80225
Tel: 303-202-4700; Fax: 303-202-4693

Earthquakes
http://pubs.usgs.gov/gip/earthq1/

Eruptions of Hawaiian Volcanoes: Past, Present, and Future
http://pubs.usgs.gov/gip/hawaii/

Eruptions of Mount St. Helens: Past, Present, and Future
http://pubs.usgs.gov/publications/msh/

Geologic Time
http://pubs.usgs.gov/gip/geotime/

The Interior of the Earth
http://pubs.usgs.gov/gip/interior/

Man Against Volcano: The Eruption on Heimaey, Vestmannaeyjar, Iceland
http://pubs.usgs.gov/gip/heimaey/

Monitoring Active Volcanoes
http://pubs.usgs.gov/gip/monitor/

Our Changing Continents
http://pubs.usgs.gov/gip/continents/

The San Andreas Fault
http://pubs.usgs.gov/gip/earthq3/

Volcanic and Seismic Hazards on the Island of Hawaii
http://pubs.usgs.gov/gip/hazards/

Volcanoes
http://pubs.usgs.gov/gip/volc/

Volcanoes of the United States
http://pubs.usgs.gov/gip/volcus/

The Severity of an Earthquake
http://pubs.usgs.gov/gip/earthq4/severitygip.html

Global and state seismicity maps
http://neic.usgs.gov /neis/pANDs/neic_maps.html

U.S. Earthquakes annual periodical
http://earthquake.usgs.gov/neis/pANDs/11.html

Slides

NOAA

A variety of earthquake slides are available from the National Oceanagraphic and Atmospheric Association (NOAA) at: http://nndc.noaa.gov/onlinestore.html
Or by mail at:
National Geophysical Data Center
NOAA Code E/GC2
325 Broadway
Boulder, Colorado 80303
FAX Number: (303) 497-6513

EERI
Slide sets on major world earthquakes and earthquake research topics are available from the Earthquake Engineering Research Institute (EERI) at:
http://www.eeri.org/Publications/SlideSets.html
Or by mail at:
Earthquake Engineering Research Institute
499 14th Street, Suite 320
Oakland, CA 94612-1934
Phone (510) 451-0905
FAX (510) 451-5411

Videotapes

EERI
These videotapes are available from the Earthquake Engineering Research Institute (EERI) at:
http://www.eeri.org/Publications/video.html
Or by mail at:
Earthquake Engineering Research Institute
499 14th Street, Suite 320
Oakland, CA 94612-1934
Phone (510) 451-0905
FAX (510) 451-5411

Kobe Earthquake of January 17, 1995 (46 min.)
Northridge Earthquake of January 17, 1994 (60 min.)
Loma Prieta Earthquake of October 1989 (57 min.)
Overview of Loma Prieta Earthquake (10 min.)
Armenia Earthquake of December 1988 (60 min.)
Soil and Structure Response to Earthquakes (4/100 min. tapes)

Web Sites

A comprehensive list of earthquake web sites for teachers can be found through the USGS at:
Earthquakes for Kids and Grownups http://pasadena.wr.usgs.gov/eqhaz/4kids/

About Earthquakes - UNR http://www.seismo.unr.edu/htdocs/abouteq.html
Books About Earthquakes http://www.seismo.unr.edu/books/
Earth Science Lessons - University of North Dakota
http://volcano.und.nodak.edu/vwdocs/vwlessons/lessons/lesson.html
Earthworks http://cires.colorado.edu/%7Ek12/earthworks/
Fault Animations http://www.iris.washington.edu/seismic/events/faults.html
Historical Earthquake Theories http://www.univie.ac.at/Wissenschaftstheorie/heat/heat.htm
Make your own Seismic Waves http://www.geo.mtu.edu/UPSeis/making.html
Mountain Maker, Earth Shaker - PBS http://www.pbs.org/wgbh/aso/tryit/tectonics/
Musical Plates http://njnie.dl.stevens-tech.edu/curriculum/quake/intro.html
National Association of Geoscience Teachers http://www.nagt.org/
National Science Foundation http://www.nsf.gov/
National Science Teachers Association http://www.nsta.org/

Network Montana Project http://www.math.montana.edu/%7Enmp/materials/ess/geosphere/
Plate Reconstruction Service http://www.odsn.de/odsn/services/paleomap/paleomap.html
Savage Earth - PBS http://www.thirteen.org/archive/savageearth/
SCIGN Education Module http://scign.jpl.nasa.gov/learn/
Seismic Waves http://www.geo.mtu.edu/UPSeis/waves.html
Shake, Rattle, and Roll http://quake.ualr.edu/schools/quakelsn.pdf
The EarthPulse Center
http://pasadena.wr.usgs.gov/eqhaz/4kids/%20http://www.riverdeep.net/earthpulse/data/earthpulse/welcome.html

EARTHQUAKE MYTHS

RATIONALE
Students will discuss myths people have used to explain earthquakes and earthquake related phenomenon.

FOCUS QUESTIONS
How did people explain earthquakes in the past?
How do people explain earthquakes today?

OBJECTIVES
Students will:
1. Discuss earthquake myths from different cultures around the world.

VOCABULARY
Myth: A traditional story presented as historical that proports to explain some natural phenomenon.

PROCEDURE
A. Introduction
Ask the students to define the word "myth". Distribute Master 1.1a, Turtle Myth, to the class and read or have a student read it aloud. Explain that this is an earthquake myth, a traditional story that is presented as historical fact that is used to explain some natural phenomenon, in this case earthquakes.

B. Lesson Development
Distribute the strips cut from Master 1.1b and have students take turns reading them aloud. Distribute student copies of the list as well.

After the last student has read, ask them to contribute any earthquake myths they know that are not on the list.

Next, ask the students if we still have earthquake myths today now that we can explain earthquakes scientifically. Distribute copies of Master 1.1c, modern myths. Ask students to contribute any modern myths they know.

C. Conclusion
Explain to the students that while ancient myths are the result of people trying to explain natural phenomenon before science was used. Modern myths, however, are usually the result of misinformation. Ask students for ideas on how to verify if an earthquake story is accurate or a myth. (Contact local scientists, check scientific journals, use common sense.)

Master 1.1a

THE TURTLE TALE

Gabrielino Indians, Southern California

Long, long ago, before there were people, there was hardly anything in the world but water. One day, Great Spirit looked down from heaven, He decided to make a beautiful land. But where could he begin? All he saw was water. Then he spotted a giant turtle. Great Spirit decided to make the beautiful land on the turtle.

But one turtle was not big enough. The land Great Spirit wanted to make was very large. So he called out, "Turtle, hurry and find your six brothers." Turtle swam to find them. It took her a whole day to find the first. It took another day to find the rest. After six days, turtle had found her six brothers. "Come," she said, "Great Spirit wants us."

Great Spirit called down. "Turtles! Form a line, all of you, head to tail, north to south. Umm three on the south, please move a little to the east. Hmm. Yes, that's just right. What a beautiful land you turtles will make! Now listen! It is a great honor to carry this beautiful land on your backs. So you must not move!"

The turtles stayed very still. Great Spirit took some straw from his supply in the sky. He spread it out on the turtles' backs. Then he took some soil and patted it down on top of the straw.

Great Spirit cleaned his hands on a fluffy white cloud. Then he went to work, shaping mountains and valleys, and lakes, and rivers. When he was finished he looked at the beautiful land he had made. Great Spirit was very pleased. But soon trouble came. The giant turtles grew restless. They wanted to stretch their legs. "I want to swim east," said one. "This beast goes east." "West is best. I'll swim toward the setting sun," said another.

The turtles began to argue. They could not agree on which way to move. One day, four of the turtles began to swim east. The others began to swim west. The earth shook! It cracked with a loud noise. But after a minute, the shaking stopped. The turtles had to stop moving because the land on their backs was so heavy. They had only been able to swim a little way from each other. When they saw that they could not swim away, they stopped and made up.

Every once in a while, though, the turtles argue again. Each time they do, the earth shakes.

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Master 1.1b

Earthquake Myths

Mexican, Vaqueros, California - El Diablo, one of the gods, made a giant rip in the ground so that he and his cohorts did not have to take the long way around, whenever they wanted to stir up mischief on the earth.

India (Hindu)- Eight mighty elephants held up the land. When one of them grew weary, it lowered and shook it's head, causing an earthquake.

Kamchatka, Siberia, Russia - A god named Tuli drove an earth-laden sled pulled by flea infested dogs: when the dogs stopped to scratch, the earth shook.

Mongolia, China - A gigantic frog which carried the world on its back, twitched periodically, producing slight quakes.

Peru - Whenever their god visited the earth to count how many people were there, his footsteps caused earthquakes. To shorten his task, the people ran out of their houses to shout "I'm here, I'm here!" (incorporating in their myth, the wisdom of leaving their houses during an earthquake).

Japan - A giant catfish lived in mud beneath the earth. The catfish liked to play pranks and could only be restrained by Kashima, a god who protected the Japanese people from earthquakes. So long as Kashima kept a mighty rock with magical powers over the catfish, the earth was still. But when he relaxed his guard, the catfish thrashed about, causing earthquakes.

Assam (Between Bangladesh and China) - There is a race of people living inside the earth. From time to time they shake the ground to find out if anyone is still living on the surface. When children feel a quake, they shout "Alive, alive!" so the people inside the earth will know they are there and stop the shaking.

Mozambique - The earth is a living creature, and it has the same kinds of problems people have. Sometimes it gets sick with a fever and chills, and we can feel its shaking.

West Africa - The earth is a flat disk, held up on one side by an enormous mountain and on the other by a giant. The giant's wife holds up the sky. The earth trembles whenever he stops to hug her.

India - Seven serpents share the task of guarding the seven sections of the lowest heaven. The seven of them also take turns holding up the earth. When one finishes its turn and another moves into place, people on earth may feel a jolt.

Latvia - A god named Drebkuhls carries the earth in his arms as he walks through the heavens. When he's having a bad day, he might handle his burden a little roughly. Then the earth will feel the shaking.

Central America - The square earth is held up at its four corners by four gods, the Vashakmen. When they decide the earth is becoming overpopulated, they tip it to get rid of surplus people.

Romania - The world rests on the divine pillars of Faith, Hope, and Charity. When the deeds of human beings make one of the pillars weak, the earth is shaken.

West Africa - A giant carries the earth on his head. All the plants that grow on the earth are his hair, and people and animals are the insects that crawl through his hair. He usually sits and faces the east, but once in a while he turns to the west and then back to the east, with a jolt that is felt as an earthquake.

Greece - According to Aristotle, and also to William Shakespeare in the play Henry IV, strong, wild winds are trapped and held in caverns under the ground. They struggle to escape, and earthquakes are the result of their struggle.

Belgium - When people on Earth are very, very sinful, sends an angry angel to strike the air that surrounds our planet. The blows produce a musical tone that is felt on the Earth as a series of shocks.

Columbia - When the Earth was first made, it rested firmly on three large beams of wood. But one day the god Chibchacum decided that it would be fun to see the plain of Bogota underwater. He flooded the land, and for his punishment he is forced to carry the world on his shoulders. Sometimes he's angry and stomps, shaking the Earth.

Scandinavia - The god Loki is being punished for the murder of his brother, Baldr. He is tied to a rock in an underground cave. Above his face is a serpent dripping poison, which Loki's sister catches in a bowl. From time to time, she has to go away to empty the bowl. Then the poison falls on Loki's face. He twists and wiggles to avoid it, and the ground shakes up above him.

New Zealand - Mother Earth has a child within her womb, the young god Ru. When he stretches and kicks as babies do, he causes earthquakes.

East Africa - A giant fish carries a stone on his back. A cow stands on a stone, balancing the Earth on one of her horns. From time to time, her neck begins to ache, and she tosses the globe from one horn to the other.

Master 1.1c

Modern Earthquake Myths

The Swallowing Earth - People all over the world believe that when an earthquake happens, a chasm may open up along the fault, and anybody standing over the fault will fall in and be swallowed-up by the violent earth. (Sudden movement along a fault may create a shallow crevice; however, there is no reliable account of anyone falling to his or her death in such a crack.)
Earthquake Immunity - Some people believe that they are protected from a large earthquake because their home is often shaken by small earthquakes that "let off steam". (A moderate earthquake, of Richter magnitude 5.0, releases only one thousandth of the energy of a large magnitude 7.0 earthquake. The moderate quakes may actually be precursors of larger earthquakes.)
Astrological Considerations - The idea that somehow Mars, Jupiter and Saturn govern the destructive action of the earth, and the notion of earth tides as possible triggers for earthquakes is gaining popularity. (Earth tides are caused as the rotating Earth is influenced by the combined gravitational pull of the Moon and Sun. The most careful scientific studies do not reveal statistically meaningful correlations of earthquake occurrence with tidal loading) (see U.S.G.S. circular 1083).

EARTHQUAKES IN TIME

Geologic Time Scale

RATIONALE
Students have a difficult time comprehending how short the span of human history is in relation to Earth's geologic history. This lesson sets the stage for paleoseismology by providing a context in geologic time.

FOCUS QUESTION
If no earthquakes have been recorded in my area since it was settled, does that mean earthquakes never happen here?

OBJECTIVE
Students will compare the time period of their own lives and that of human history to the age of the Earth and events in Earth's history.

MATERIALS
- 46 meter length of rope or cord
- flagging tape or masking tape
- waterproof marker
- measuring tape
- teacher copy of Master 2.3a

PROCEDURE
Teacher Preparation
Make a copy of Master 2.3a, Earth History Events, and cut it into strips along the dashed lines.

Introduction
Ask the students to tell you what they mean when they say that something happened "a long time ago." (answers will range from a few months to centuries and beyond.) Ask students if it was "a long time ago" that dinosaurs became extinct, and our earliest human ancestors first appeared. Then ask them to guess the order in which these events occurred. Record their guesses without comment.

Emphasize that scientists seek proof of how long ago different events occurred by studying things that record the passage of long periods of time, such as the layers in rocks (strata) and index fossils. Index fossils represent species that existed only during specific time periods, so their presence is an index to the age of the rocks. Radiometric dating techniques can also reveal how long ago rocks were formed. The dating of events that occurred a long time ago and the sequence in which they occurred are among the puzzles scientists must solve. We are constantly adding to our knowledge of Earth history.

Lesson Development
1. Stretch out the rope and tell the students that the 46 meter length of rope represents all of geologic time, 4.6 billion years. Ask them to guess where on the rope the origin of humans should be marked. Mark their guesses with flagging or masking tape.
2. Distribute the strips of paper cut from Master 2.3a, having each student choose one. Give the students these directions:
   a. Calculate how many years a foot of rope represents. (1 meter = 100 million years)

   b. Look at your paper strip and calculate where on the rope your individual event should go.
   c. Measure along the rope and attach flagging or masking tape at the appropriate spot and label it with the event number.
3. Have each student, beginning with the origin of the Earth, call out what event they represent.

Conclusion

Ask the class: Now that you have an idea of the age of the Earth, would you describe the human race as young or old? (young) Which occurred more recently, the extinction of the dinosaurs or the appearance of human beings? (the appearance of humans) Compare these facts with the students' earlier guesses. Emphasize that terms like young and old, long ago and recent can have very different meanings in different contexts. Because an event such as an earthquake has not taken place in historical time does not mean it is impossible given the great sweep of geologic time.

MASTER 2.3a

1. ORIGIN OF THE EARTH - 4.6 BILLION YEARS
2. OLDEST ROCK ON EARTH - 4.0 BILLION YEARS
3. POSSIBLE EARLIEST LIFE ON EARTH - 3.8 BILLION YEARS
4. FIRST DEFINITE EVIDENCE OF LIFE ON EARTH - 3.5 BILLION YEARS
5. FIRST SIGNIFICANT AMOUNTS OF OXYGEN IN THE ATMOSPHERE - 2.2 BILLION YEARS
6. FIRST COMPLEX CELLS - 2.1 BILLION YEARS
7. EARLIEST EVIDENCE OF GLACIATION ON EARTH - 2.0 BILLION YEARS
8. FIRST MULTI-CELLULAR ORGANISMS (SOFT BODIED) - 850 MILLION YEARS
9. FIRST MARINE ANIMALS WITH HARD PARTS - 545 MILLION YEARS
10. FIRST FISH - 500 MILLION YEARS

11. FIRST PLANTS AND INSECTS COLONIZE THE LAND 0- 435 MILLION YEARS

12. FIRST TALL TREES AND FORESTS - 380 MILLION YEARS

13. FRIST VERTEBRATE ANIMALS, THE AMPHIBIANS, COLONIZE THE LAND - 360 MILLION YEARS

14. FIRST PLANTS WITH SEEDS - 350 MILLION YEARS

15. FIRST REPTILES - 300 MILLION YEARS

16. FORMATION OF THE SUPERCONTINENT PANGEA - 250 MILLION YEARS

17. GREATEST MASS EXTINCTION ON EARTH: 90% OF SPECIES DIE OUT - 245 MILLION YEARS

18. FIRST DINOSAURS - 225 MILLION YEARS

19. FIRST MAMMALS - 220 MILLION YEARS

20. BREAK-UP OF PANGEA BEGINS - 205 MILLION YEARS

21. FIRST BIRDS - 200 MILLION YEARS

22. FIRST FLOWERING PLANTS - 140 MILLION YEARS

23. MASS EXTICTION OF MANY SPECIES, INCLUDING DINOSAURS - 65 MILLION YEARS

24. INITIATION OF THE SAN ANDREAS FAULT - 40 MILLION YEARS

25. EARLIEST HOMINIDS (AUSTRALOPITHECINES) - 5 MILLION YEARS

26. START OF THE MOST RECENT ICE AGE IN THE NORTHERN HEMISPHERE - 2.5 MILLION YEARS

27. ORIGIN OF THE SPECIES HOMO SAPIENS - 300,000 YEARS

NOTABLE EARTHQUAKES - 1900 to 2000

Date	Latitude	Longitude	Depth (km)	Richter Magnitude	Location	Deaths
4/18/06	38N	123W	-	8.3	San Francisco, CA	700
2/29/60	30N	10W	-	5.9	Morocco	14,000
3/28/64	61N	148W	33	8.5	Alaska	131
2/9/71	34N	118W	13	6.7	San Fernando, CA	65
12/23/72	12N	86W	5	6.2	Nicaragua	5,000
2/4/76	15N	89W	5	7.5	Guatemala	22,000
9/19/85	18N	103W	-	8.1	Mexico	9,500
10/10/86	14N	89W	8	5.4	El Salvador	1,000
3/6/87	0N	78W	33	6.9	Ecuador	1,000
10/18/89	37N	122W	19	7.1	Loma Prieta, CA	63
6/28/92	34N	117W	-	7.1	Landers, CA	1
10/9/95	19N	104W	33	8.0mw	Jalisco, Mexico	38
12/28/08	38N	15E	-	7.5	Messina, Italy	100,000
1/13/15	42N	13E	-	7.5	Central Italy	30,000
12/16/20	37N	1.6E	-	8.6	China	200,000
9/1/23	35N	140E	-	8.3	Kwanio, Japan	143,000
12/25/32	40N	97E	-	7.6	China	70,000
12/26/39	40N	40E	-	8.0	Turkey	23,000
6/28/48	36N	136E	20	7.3	Honshu, Japan	5,121
9/1/62	36N	50E	20	7.3	Iran	14,000
7/26/63	42N	22E	5	6.0	Macedonia	1,200
8/31/68	34N	59E	13	7.3	Iran	11,600
2/4/75	41N	123E	33	7.4	China	"few"
5/6/76	46N	13E	9	6.5	Italy	
7/27/76	40N	118E	23	8.0	Tangshan, china	655,000
3/3/77	46N	27E	94	7.2	Romania	2,000
10/10/80	36N	1E	10	7.4	Algeria	
11/23/80	41N	15E	10	6.9	Italy	3,000
6/11/81	30N	58E	33	6.9	Iran	3,000
7/28/81	30N	58E	33	7.3	Iran	1,500
5/28/83	41N	139E	24	7.8	Japan	107
10/30/83	40N	42E	33	6.9	Turkey	1,342
8/20/88	27N	87E	71	6.6	Nepal	1,450
11/6/88	23N	100E	10	7.6	Burma	730
12/7/88	41N	44E	10	6.8	Armenia	25,000
6/20/90	38N	50E	10	7.7	Iran	50,000
7/16/90	16N	121E	36	7.7	Philippines	1,700
10/4/94	44N	147E	14	8.3mw	Kuril Islands	10

1/25/39	36S	72W	60	8.3	Chillan, Chile	30,000
8/6/49	2S	78W	60	6.8	Ecuador	6,000
5/22/60	40S	73W	-	8.6	Chile	5,700
5/31/70	9S	79W	43	7.8	Peru	66,000
12/12/79	2S	79W	32	7.9	Ecuador	600
3/3/85	33S	72W	-	7.8	Chile	177
6/9/94	14S	67W	631	8.2mw	Bolivia	9
4/7/95	15S	173W	21	8.0mw	Tonga Islands	3
7/30/95	23S	70W	45	8.0mw	Chile	3
8/5/49	2S	119E	3	8.0	Indonesia	3
8/1/89	5S	139E	33	5.9	New Guinea	90
12/27/89	33S	153E	15	5.4	Australia	13
2/17/96	1S	137E	33	8.2mw	Indonesia	108
3/25/98	63S	149E	10	8.8mw	Balleny Islands	
11/29/98	2S	125E	33	8.3mw	Ceram Sea	41
5/22/60				9.5mw	Chile	2,200
11/4/52				9.0mw	Russia	0
1/31/06				8.2	Ecuador	1,500
8/15/50				8.6mw	India	580
11/11/22				8.5mw	Argentina	500
5/22/27				8.3	China	200,000
10/5/48				7.3	USSR	110,000
5/30/35				7.5	Pakistan	60,000

LOCATE THE EPICENTER

RATIONALE

Students can find the location of an earthquake by triangulation if they know the distances from at least three seismograph stations.

FOCUS QUESTION

How do seismologists use seismograms to locate the epicenter of an earthquake?

OBJECTIVES

Students will:

1. Calculate the distance from an earthquake to a seismograph station.

2. Use five calculated distances to triangulate the location of the earthquake's epicenter.

MATERIALS

- Student copies of Master 3.3f, Several Seismographs
- Student copies of Master 3.3g, Sample Seismograms
- Student copies of Master 3.3h, Map of Station Locations
- Transparency made from one page of Master 3.3g, Sample Seismograms
- Overhead projector
- Transparency made from Master 3.3h, Map of Station Locations
- Student copies of Master 3.3i, Time/Distance Reference Table
- Drawing compasses
- Metric rulers with millimeter scales

VOCABULARY

Epicenter: the point on Earth's surface directly above the focus of an earthquake.
Focus (pl. foci): the point within the Earth that is the origin of an earthquake, where stared energy is first released as wave energy.
Seismogram: the record of earthquake ground motion recorded by a seismograph.
Seismograph: an instrument that records vibrations of the Earth, especially earthquakes.
Triangulation: using data from three or more known points to locate an unknown point, in this case the epicenter of an earthquake.

PROCEDURE

Teacher Preparation

Make one copy of each of the masters (3.3f through 3.3i) for every two students in your class.

A. Introduction

Ask students chosen at random to explain the difference between an earthquake's focus and its epicenter and between a seismograph and a seismogram. Review these distinctions if necessary.

Distribute copies of Master 3.3f, Several Seismographs, then project a transparency of Master 3.3f and describe their operation.

B. Lesson Development

1. Divide the class into pairs of students. Distribute a set of seismograms (Master 3.3g, 3 pages), one map (Master 3.3h), and copies of the Time/Distance Reference Table (Master 3.3i) to each pair. Tell students that all the seismograms are from the same earthquake, a quake that occurred on January 14, 1993, with a magnitude of 3.3, but each was recorded by a different seismograph in the seismograph network.

2. Project transparencies of one seismogram and the map. Model the procedure for students as necessary.

3. Give these directions for finding the epicenter of the earthquake recorded on the five seismograms:
a. On the first seismogram, use the second scale to measure the time-distance from the nearest 10-second mark to the P wave arrival of the earthquake. Record the P wave arrival times in the table to the nearest second.
b. Repeat for the S wave, measuring from the same minute mark.
c. Find the Ts - Tp time by subtracting the arrival time of the P wave from the arrival time of the S wave. Record this time in the table.
d. Use the time/distance table on Master 3.3i to determine the distance to the epicenter.
e. Repeat this procedure for all of the stations.
f. For each seismogram, draw a circle on the map with the compass, using the distance you calculated as the radius of the circle. Place the point of the compass at zero on the map scale and adjust the compass width to the calculated distance. With the distance set, place the point of the compass on the station and draw a circle. Mark the outer edge of each circle with a letter to identify the station.
g. Repeat, setting the compass and drawing circles for all five stations.

4. Instruct students to circle the area where all the circles intersect. Ask: What is this area called? (It is the epicenter of the earthquake.)

C. Conclusion

Build a class discussion around these questions:

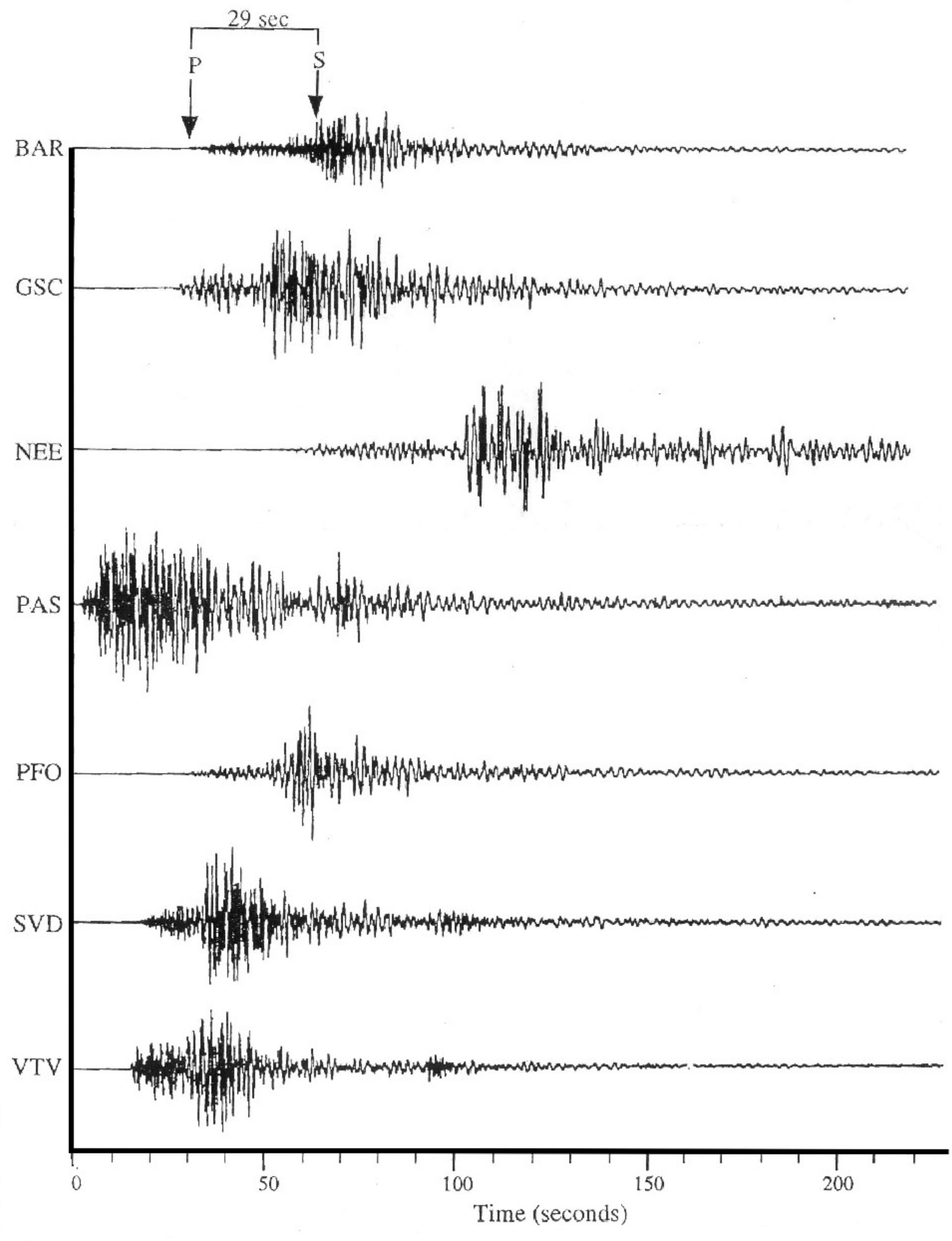
- What information can be obtained from one seismogram? (The distance from that seismograph in a 3600 circle.)
- After the arcs for stations TRYN and FGTN were drawn, where was the epicenter of this earthquake? Explain. (We don't know yet. It could be at either place where the two arcs cross. They are the common points.)
- After all the stations were drawn, where was the actual epicenter of this earthquake? Where was its focus? (In the area where the arcs cross just south of station BHT. Directly under the epicenter.)
- Why is it necessary to have measurements from at least three different stations to locate the epicenter of an earthquake? (Answers will vary but should relate to the above questions.)
- Why don't all of the arcs pass through the same point? (Answers will vary. Accuracy in measurement and drawing should be two most common. Also, an earthquake does not occur at one point but along a fault surface. Have students speculate as to the location and strike of the fault.)
- Which station was closer to the earthquake's epicenter, BBG or FGTN? Cite two kinds of evidence from the seismograms to support your conclusion. (BBG. Evidence: amount of lag time and amplitude difference.)
- Would it be possible for an earthquake at this location to be felt where you live? Why or why not? (Answers will vary; will depend on distance from the focus and the magnitude of the quake.)
- P waves travel at an average velocity of 6 km/sec in the Earth's crust. How long would it would take for the P waves from this quake to reach a seismic station in your city, if they continued to travel at a constant speed? (Answers will vary. Multiply 6 km/sec times the distance to your city.)

ADAPTATIONS AND EXTENSIONS

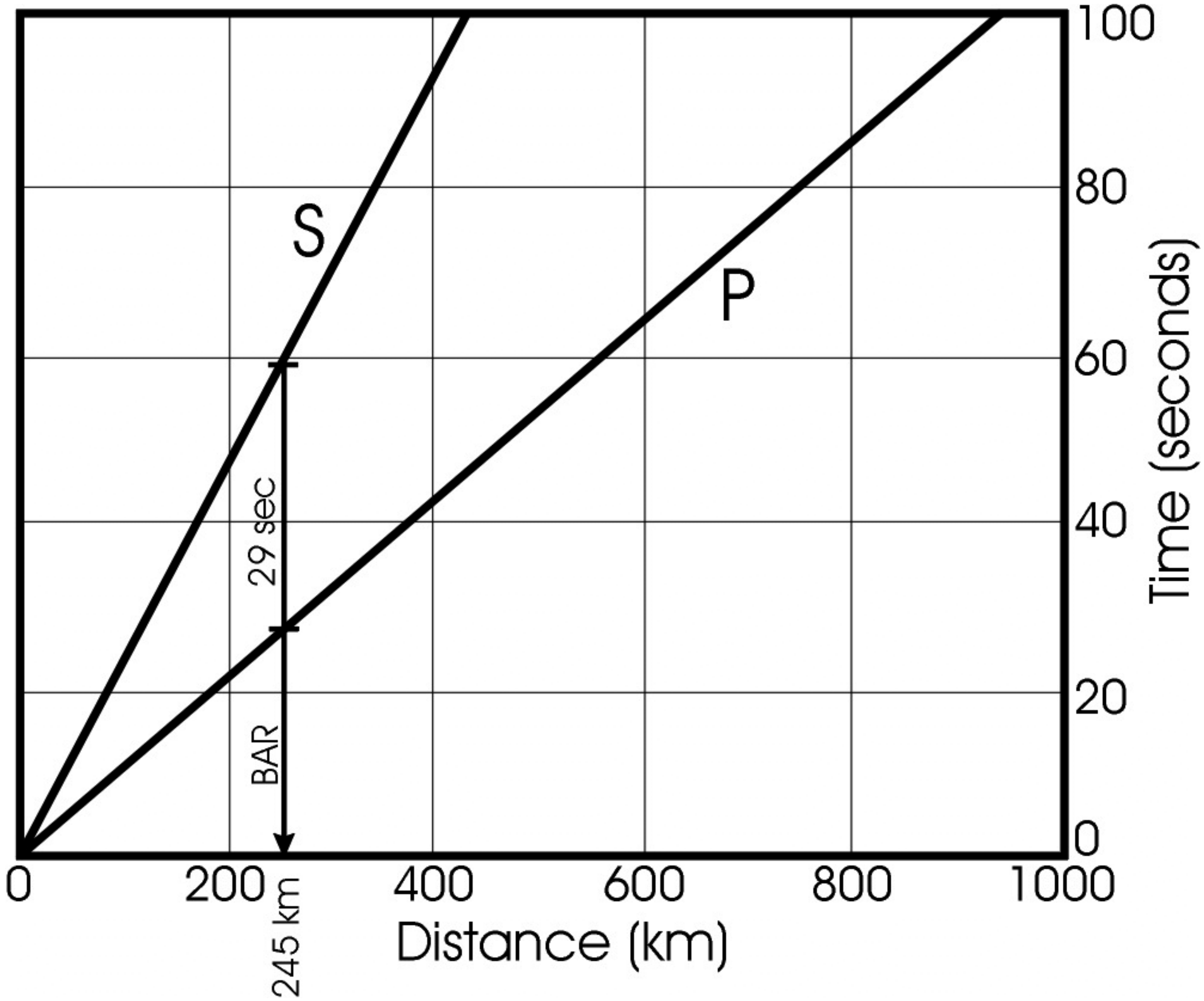
1. Challenge students to research these questions:
   - Would a seismograph work on the moon?
   - Have scientists placed seismographs on the moon and other planets?
   - If so, which planets? Have quakes been detected there?

2. Interested students may research several types of seismographs and build their own models.

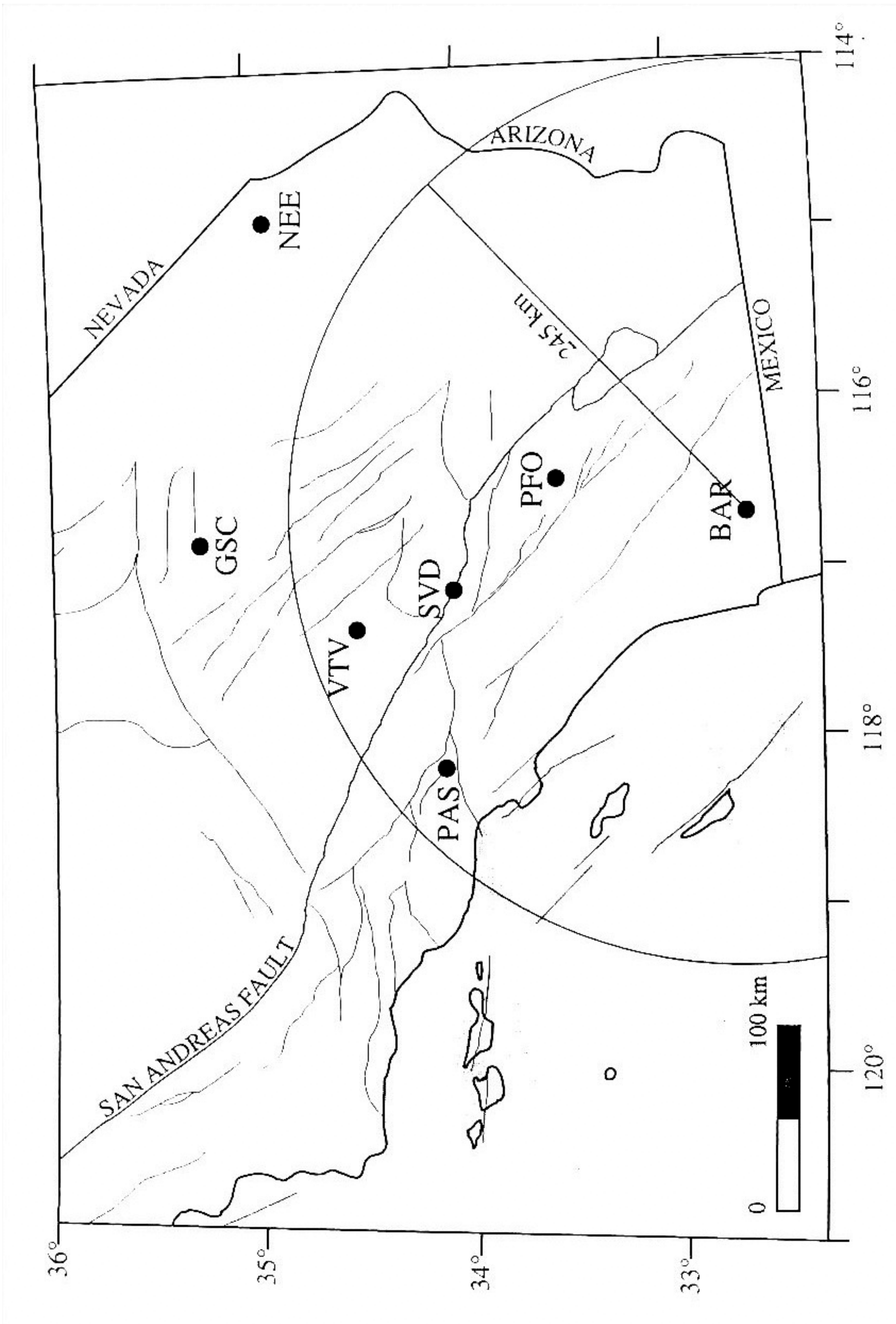
MASTER PAGE 1 - Seismograms



MASTER PAGE 2 – Time/Distance Graph



MASTER PAGE 3 – Station Map



APPENDIX C: National Science Education Standards

Science Content Standards - grades 5 through 8			
Unifying Concepts and Processes Systems, order, and organization Evidence, models, and explanation Constancy, change, and measurement Evolution and equilibrium Form and function	**Science as Inquiry** Abilities necessary to do scientific inquiry - Identify questions that can be answered through scientific investigations. - Design and conduct a scientific investigation - Use appropriate tools and techniques to gather, analyze, and interpret data. - Develop descriptions, explanations, predictions, and models using evidence. - Think critically and logically to make the relationships between evidence and explanations. - Recognize and analyze alternative explanations and predictions. - Communicate scientific procedures and explanations. - Use mathematics in all aspects of scientific inquiry. Understandings about scientific inquiry.	**Physical Science** Properties and changes of properties in matter Motions and forces. Transfer of energy	**Life Science** Structure and function in living systems Reproduction and heredity Regulation and behavior Populations and ecosystems Diversity and adaptations of organisms
Earth and Space Science Structure of the earth system Earth's history Earth in the Solar System	**Science and Technology** Abilities of technological design - Identify appropriate problems for technological design. - Design a solution or product. - Implement a proposed design. - Evaluate completed technological designs or products. - Communicate the process of technological design. Understandings about science and technology	**Science in Personal and Social Perspectives** Personal Health. Populations, resources, and environments Natural Hazards Risks and Benefits Science and technology in society	**History and Nature of Science** Science as a human endeavor Nature of science History of science

Science Content Standards - grades 9 through 12

Unifying Concepts and Processes	Science as Inquiry	Physical Science	Life Science
Systems, order, and organization Evidence, models, and explanation Constancy, change, and measurement Evolution and equilibrium Form and function	Abilities necessary to do scientific inquiry - Identify questions and concepts that guide scientific investigations - Design and conduct scientific investigations - Use technology and mathematics to improve investigations and communications - Formulate and revise scientific explanations and models using logic and evidence - Recognize and analyze alternative explanations and models. - Communicate and defend a scientific argument Understandings about scientific inquiry.	Structure of atoms Structure and properties of matter Chemical reactions Motions and forces Conservation of energy and increase in disorder Interactions of energy and matter	The cell Molecular basis of heredity Biological evolution Interdependence of organisms Matter, energy, and organization in living systems Behavior of organisms.
Earth and Space Science Energy in the earth system Geochemical cycles Origin and evolution of the earth system Origin and evolution of the universe	**Science and Technology** Abilities of technological design - Identify a problem or design an opportunity - Propose designs and choose between alternative solutions - Implement a proposed solution - Evaluate the solution and its consequences - Communicate the problem, process, and solution. Understanding about science and technology	**Science in Personal and Social Perspectives** Personal and community health Population growth Natural resources Environmental quality Natural and human-induced hazards Science and technology in local, national, and global challenges	**History and Nature of Science** Science as a human endeavor Nature of scientific knowledge Historical perspectives

NATIONAL SCIENCE EDUCATION STANDARDS BY SECTION

Science Content Standards - grades 5 through 8								
Section Number	**Unifying concepts and processes**	**Science as Inquiry**	**Physical Science**	**Life Science**	**Earth and Space Science**	**Science and Technology**	**Science in Personal and Social Perspectives**	**History and Nature of Science**
1.1	Evidence, models, and explanations Constancy, change, and measurement	Abilities necessary to do scientific inquiry Understandi ng about scientific inquiry	Motions and forces		Structure of the Earth system	Understandin gs about science and technology	Personal health Natural hazards Risks and benefits Science and technology in society	Science as a human endeavor Nature of science
1.2	Systems, order, and organization		Motions and forces			Understandin gs about science and technology	Personal health Natural hazards Risks and benefits Science and technology in society	
1.3						Abilities of technological design	Personal health Natural hazards Risks and benefits	
2.1	Evidence, models, and explanations Constancy, change, and measurement	Abilities necessary to do scientific inquiry Understandi ng about scientific inquiry	Motions and forces		Structure of the Earth system		Natural hazards	
2.2	Evidence, models, and explanations Constancy, change, and measurement	Abilities necessary to do scientific inquiry Understandi ng about scientific inquiry	Motions and forces Properties and changes of properties in matter		Structure of the Earth system Earth's history	Understandin gs about science and technology	Natural hazards	Nature of science

Science Content Standards - grades 5 through 8 (continued)								
Section Number	**Unifying concepts and processes**	**Science as Inquiry**	**Physical Science**	**Life Science**	**Earth and Space Science**	**Science and Technology**	**Science in Personal and Social Perspectives**	**History and Nature of Science**
2.3	Evidence, models, and explanation	Abilities necessary to do scientific inquiry Understandings about scientific inquiry	Motions and forces		Structure of the earth system Earth's history		Natural hazards	
2.4	Evidence, models, and explanation Constancy, change, and measurement	Abilities necessary to do scientific inquiry Understandings about scientific inquiry	Properties and changes of properties in matter Motions and forces Transfer of energy		Structure of the earth system		Natural hazards	
2.5	Evidence, models, and explanation	Abilities necessary to do scientific inquiry Understandings about scientific inquiry			Structure of the earth system	Abilities of technological design	Natural hazards	
3.1	Constancy, change, and measurement	Abilities necessary to do scientific inquiry Understandings about scientific inquiry	Motions and forces Transfer of energy		Structure of the earth system		Natural hazards	
3.2	Evidence, models, and explanation	Understandings about scientific inquiry	Motions and forces Transfer of energy		Earth's history	Understandings about science and technology		Science as a human endeavor Nature of science History of science
3.3	Constancy, change, and measurement	Abilities necessary to do scientific inquiry Understandings about scientific inquiry	Motions and forces Transfer of energy		Structure of the earth system	Abilities of technological design	Natural hazards	Science as a human endeavor Nature of science

Science Content Standards - grades 5 through 8 (continued)								
Section Number	**Unifying concepts and processes**	**Science as Inquiry**	**Physical Science**	**Life Science**	**Earth and Space Science**	**Science and Technology**	**Science in Personal and Social Perspectives**	**History and Nature of Science**
3.4	Evidence, models, and explanation	Abilities necessary to do scientific inquiry Understandings about scientific inquiry			Structure of the earth system		Natural hazards Risks and benefits	
4.1	Evidence, models, and explanation	Abilities necessary to do scientific inquiry	Properties and changes of properties in matter Motions and forces			Abilities of technological design	Natural hazards	
4.2	Evidence, models, and explanation Form and function	Understandings about scientific inquiry	Motions and forces			Abilities of technological design Understandings about science and technology	Natural hazards	Nature of science
4.3	Evidence, models, and explanation	Abilities necessary to do scientific inquiry Understandings about scientific inquiry	Motions and forces Transfer of energy			Understandings about science and technology	Natural hazards Risks and benefits	Nature of science
4.4	Evidence, models, and explanation	Understandings about scientific inquiry	Motions and forces Transfer of energy			Abilities of technological design Understandings about science and technology	Natural hazards	Nature of science
4.5	Evidence, models, and explanation	Abilities necessary to do scientific inquiry Understandings about scientific inquiry	Properties and changes of properties in matter Motions and forces Transfer of energy			Abilities of technological design Understandings about science and technology	Natural hazards	Science as a human endeavor

Science Content Standards - grades 5 through 8 (continued)								
Section Number	**Unifying concepts and processes**	**Science as Inquiry**	**Physical Science**	**Life Science**	**Earth and Space Science**	**Science and Technology**	**Science in Personal and Social Perspectives**	**History and Nature of Science**
5.1	Evidence, models, and explanation	Abilities necessary to do scientific inquiry Understandings about scientific inquiry				Understandings about science and technology	Personal health Natural hazards	Nature of science History of science
5.2			Motions and forces			Understandings about science and technology	Natural hazards	
5.3			Motions and forces			Understandings about science and technology	Natural hazards	
5.4			Motions and forces			Understandings about science and technology	Personal health Natural hazards	
5.5			Motions and forces			Understandings about science and technology	Personal health Natural hazards	
6.1	Systems, order, and organization Evidence, models, and explanation		Motions and forces			Abilities of technological design Understandings about science and technology	Personal health Natural hazards	
6.2			Motions and forces			Understandings about science and technology	Personal health Populations, resources, and environments Natural hazards Risks and benefits Science and technology in society	

Science Content Standards - grades 5 through 8 (continued)								
Section Number	**Unifying concepts and processes**	**Science as Inquiry**	**Physical Science**	**Life Science**	**Earth and Space Science**	**Science and Technology**	**Science in Personal and Social Perspectives**	**History and Nature of Science**
6.3	Evidence, models, and explanation							Nature of science
6.4	Evidence, models, and explanation	Abilities necessary to do scientific inquiry Understandings about scientific inquiry	Motions and forces		Structure of the earth system Earth's history	Understandings about science and technology	Personal health Natural hazards Science and technology in society	

Science Content Standards - grades 9 through 12								
Section Number	Unifying concepts and processes	Science as Inquiry	Physical Science	Life Science	Earth and Space Science	Science and Technology	Science in Personal and Social Perspectives	History and Nature of Science
1.1	Evidence, models, and explanations Constancy, change, and measurement	Abilities necessary to do scientific inquiry Understanding about scientific inquiry	Motions and forces		Energy in the earth system	Understandings about science and technology	Personal and community health Natural and human-induced hazards Science and technology in local, national, and global challenges	Science as a human endeavor Nature of scientific knowledge
1.2	Systems, order, and organization		Motions and forces			Understandings about science and technology	Personal and community health Natural and human-induced hazards	
1.3						Abilities of technological design	Personal and community health Natural and human-induced hazards	
2.1	Evidence, models, and explanations Constancy, change, and measurement	Abilities necessary to do scientific inquiry Understanding about scientific inquiry	Motions and forces		Energy in the earth system		Natural and human-induced hazards	
2.2	Evidence, models, and explanations Constancy, change, and measurement	Abilities necessary to do scientific inquiry Understanding about scientific inquiry	Motions and forces Interactions of energy and matter		Energy in the earth system Origin and evolution of the earth system	Understandings about science and technology	Natural and human-induced hazards	Nature of scientific knowledge
2.3	Evidence, models, and explanation	Abilities necessary to do scientific inquiry Understandings about scientific inquiry	Motions and forces		Origin and evolution of the earth system		Natural and human-induced hazards	Historical perspectives

Science Content Standards - grades 9 through 12 (continued)								
Section Number	Unifying concepts and processes	Science as Inquiry	Physical Science	Life Science	Earth and Space Science	Science and Technology	Science in Personal and Social Perspectives	History and Nature of Science
2.4	Evidence, models, and explanation Constancy, change, and measurement	Abilities necessary to do scientific inquiry Understandings about scientific inquiry	Motions and forces Interactions of energy and matter		Energy in the earth system		Natural and human-induced hazards	Historical perspectives
2.5	Evidence, models, and explanation	Abilities necessary to do scientific inquiry Understandings about scientific inquiry				Abilities of technological design	Natural and human-induced hazards	
3.1	Constancy, change, and measurement	Abilities necessary to do scientific inquiry Understandings about scientific inquiry	Motions and forces Interactions of energy and matter				Natural and human-induced hazards	
3.2	Evidence, models, and explanation	Understandings about scientific inquiry	Motions and forces Interactions of energy and matter		Energy in the earth system Origin and evolution of the earth system	Understandings about science and technology		Science as a human endeavor Nature of scientific knowledge Historical perspectives
3.3	Constancy, change, and measurement	Abilities necessary to do scientific inquiry Understandings about scientific inquiry	Motions and forces Interactions of energy and matter		Energy in the earth system	Abilities of technological design	Natural and human-induced hazards	Science as a human endeavor Nature of scientific knowledge
3.4	Evidence, models, and explanation	Abilities necessary to do scientific inquiry Understandings about scientific inquiry			Energy in the earth system		Natural and human-induced hazards	Historical perspectives

Science Content Standards - grades 9 through 12 (continued)								
Section Number	Unifying concepts and processes	Science as Inquiry	Physical Science	Life Science	Earth and Space Science	Science and Technology	Science in Personal and Social Perspectives	History and Nature of Science
4.1	Evidence, models, and explanation	Abilities necessary to do scientific inquiry	Structure and properties of matter Motions and forces			Abilities of technological design	Natural and human-induced hazards	
4.2	Evidence, models, and explanation Form and function	Understandings about scientific inquiry	Motions and forces			Abilities of technological design Understandings about science and technology	Natural and human-induced hazards	Nature of scientific knowledge
4.3	Evidence, models, and explanation	Abilities necessary to do scientific inquiry Understandings about scientific inquiry	Motions and forces Interactions of energy and matter			Understandings about science and technology	Natural and human-induced hazards	Nature of scientific knowledge
4.4	Evidence, models, and explanation	Understandings about scientific inquiry	Motions and forces Interactions of energy and matter			Abilities of technological design Understandings about science and technology	Natural and human-induced hazards	Nature of scientific knowledge
4.5	Evidence, models, and explanation	Abilities necessary to do scientific inquiry Understandings about scientific inquiry	Structure and properties of matter Motions and forces Interactions of energy and matter			Abilities of technological design Understandings about science and technology	Natural and human-induced hazards	Science as a human endeavor
5.1	Evidence, models, and explanation	Abilities necessary to do scientific inquiry Understandings about scientific inquiry				Understandings about science and technology	Personal and community health Natural and human-induced hazards	Nature of scientific knowledge Historical perspectives
5.2			Motions and forces			Understandings about science and technology	Natural and human-induced hazards	

Science Content Standards - grades 9 through 12 (continued)								
Section Number	Unifying concepts and processes	Science as Inquiry	Physical Science	Life Science	Earth and Space Science	Science and Technology	Science in Personal and Social Perspectives	History and Nature of Science
5.3			Motions and forces			Understandings about science and technology	Natural and human-induced hazards	
5.4			Motions and forces			Understandings about science and technology	Personal and community health Natural and human-induced hazards	
5.5			Motions and forces			Understandings about science and technology	Personal and community health Natural and human-induced hazards	
6.1	Systems, order, and organization Evidence, models, and explanation		Motions and forces			Abilities of technological design Understandings about science and technology	Personal and community health Natural and human-induced hazards	
6.2			Motions and forces			Understandings about science and technology	Personal and community health Natural and human-induced hazards Science and technology in local, national, and global challenges	
6.3	Evidence, models, and explanation							Nature of scientific knowledge
6.4	Evidence, models, and explanation	Abilities necessary to do scientific inquiry Understandings about scientific inquiry	Motions and forces		Energy in the earth system Origin and evolution of the earth system	Understandings about science and technology	Personal and community health Natural and human-induced hazards Science and technology in local, national, and global challenges	