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Earthquake Effects

A computer animation and paper model

By
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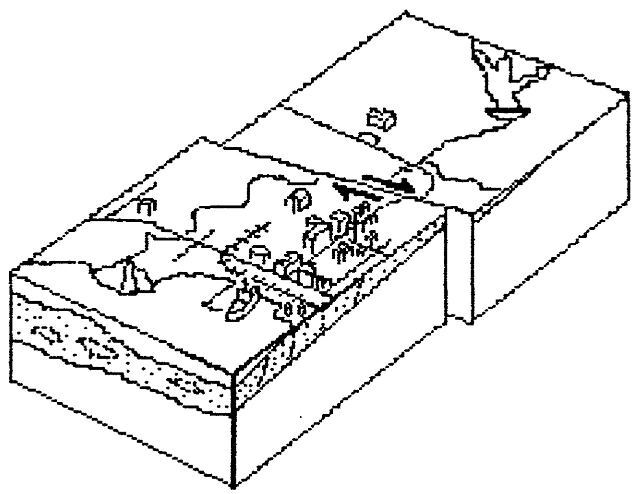
Open-file Report 92-200-A



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Description

In this report additional information can be viewed by clicking on asterisk (*) or **bold type.**

This report illustrates, by means of a computer animation, how an earthquake occurs and what types of damage may result*. The report is intended to help students and others visualize what causes earthquake shaking and some of the possible results of the shaking. By studying the animation and the paper model, students will come to understand that earthquakes result from faulting in the Earth and that the potential consequences of earthquakes are numerous and serious. Included in the diskette version of this report are the templates for making a paper model, instructions for assembly, educators' guide, and animations describing the effects of the earthquake, including the collapse of structures, fire, and a tsunami. The paper version of this report includes everthing except the animations.

Requirements for the diskette version are: Apple Computer, Inc., HyperCard 2.0™ software, and an Apple Macintosh™ computer with High-Density drive. If you are using System 7, we recommend using at least 3 MB of RAM with 1.5 MB of system memory available for HyperCard.

Purchasers of the diskette version of this report, which includes all of the text and graphics, can use HyperCard 2.0 ™ software (not supplied) to change the model (by adding geologic patterns, symbols, colors, etc.) or to transfer the model to other graphics software packages*.

To see the entire page (card size: MacPaint), use the mouse to move the cursor to the menu "Go" and click on "Scroll".

If you are experiencing trouble with user level buttons. Bring up the message box. Type "magic" in the message box and press return. Three more user level buttons should appear.

The date of this Open File Report is 1/22/1992. OF 92-200-A, paper copy, 22p. OF 92-200-B, 3.5-in. Macintosh 1.4MB high-density diskette.

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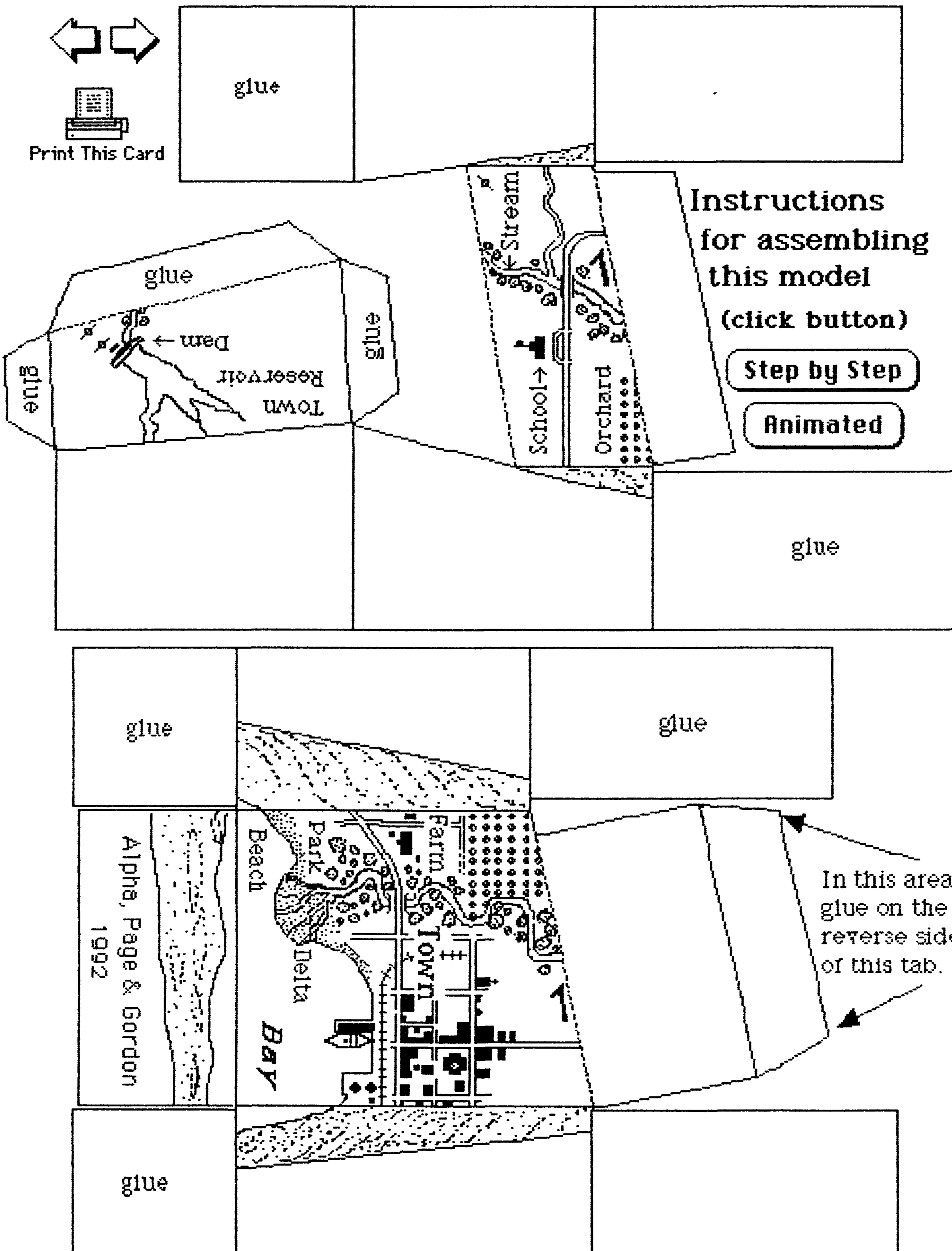
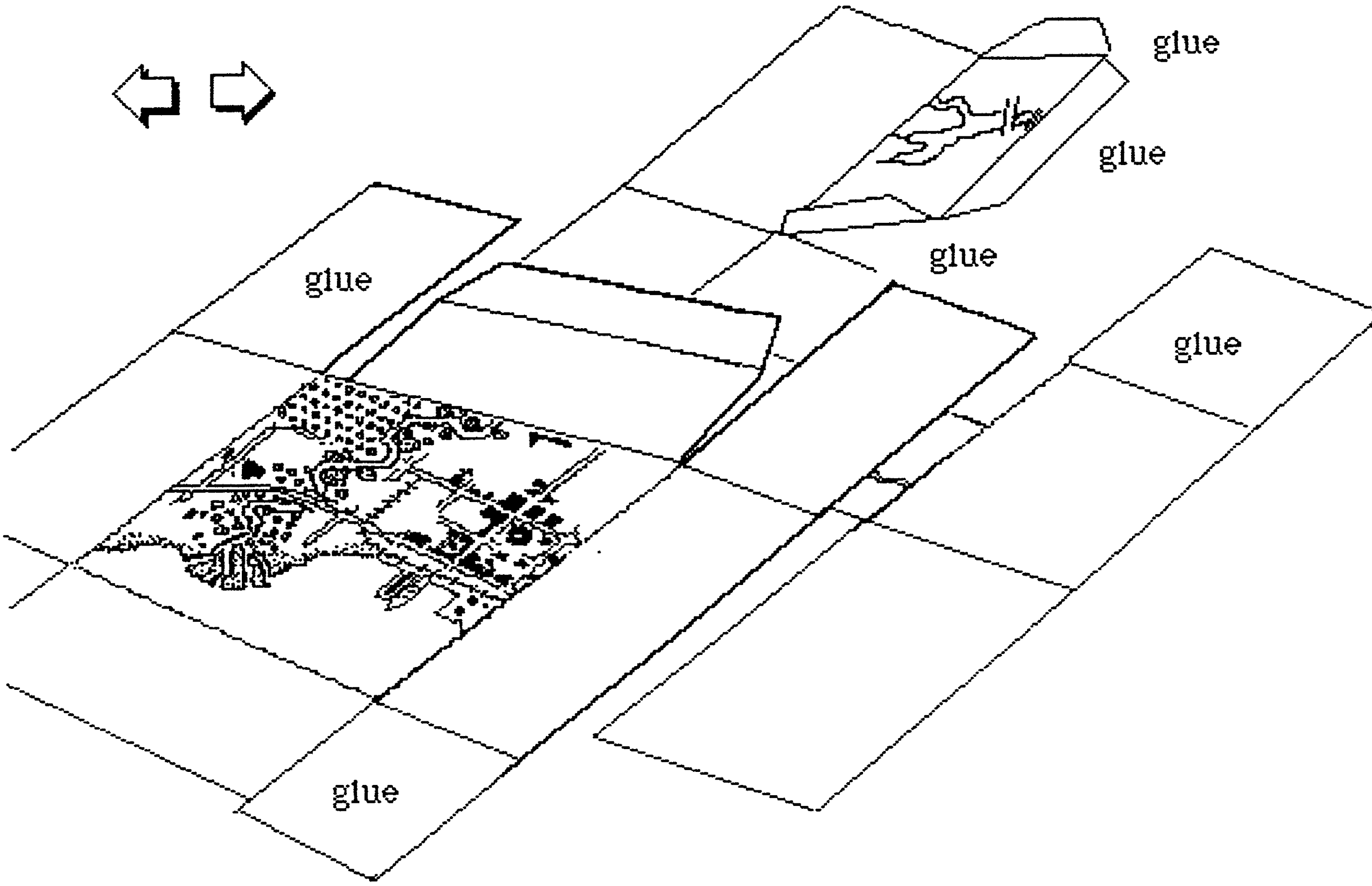


Instructions for assembling this model

(click button)

Step by Step

Animated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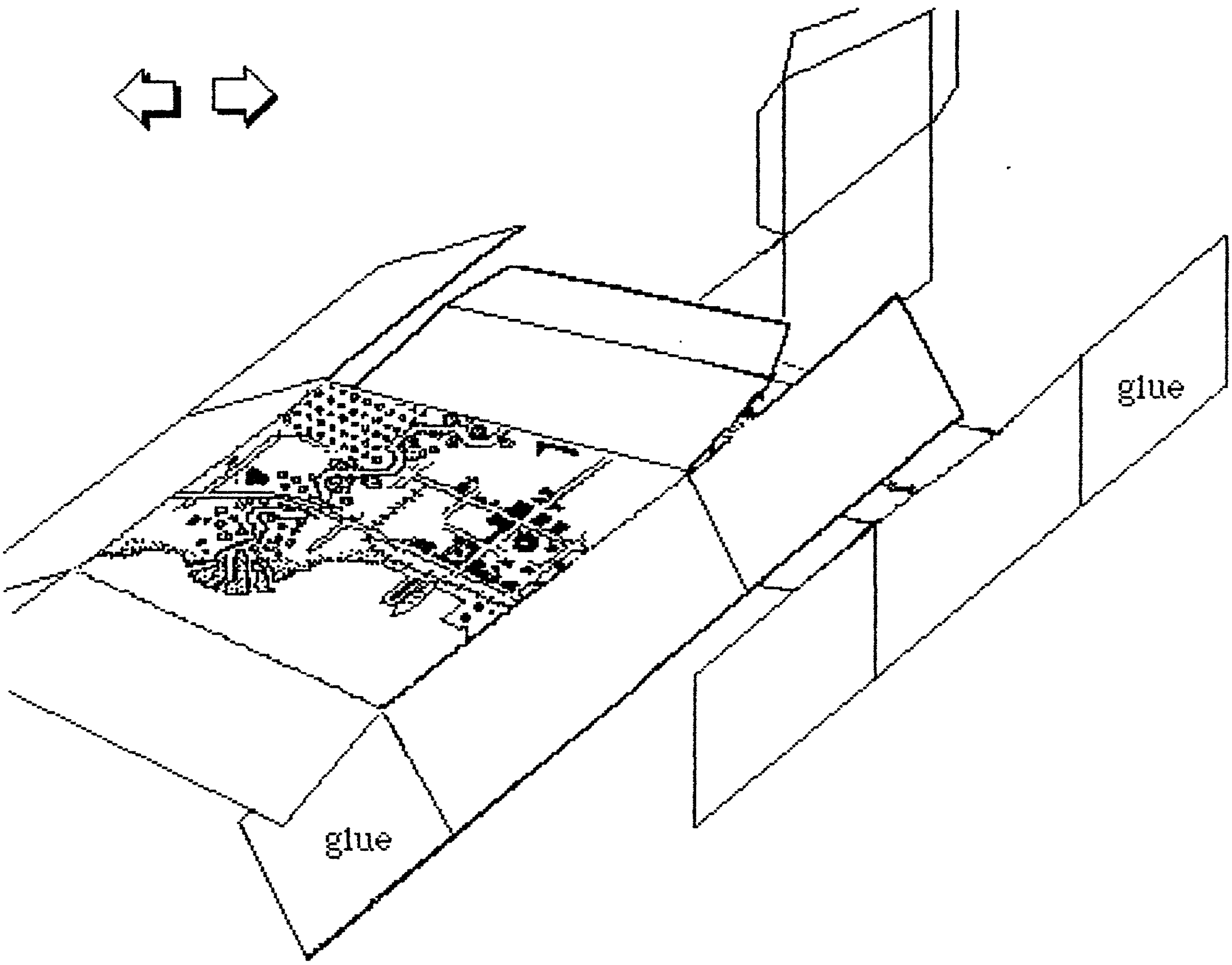
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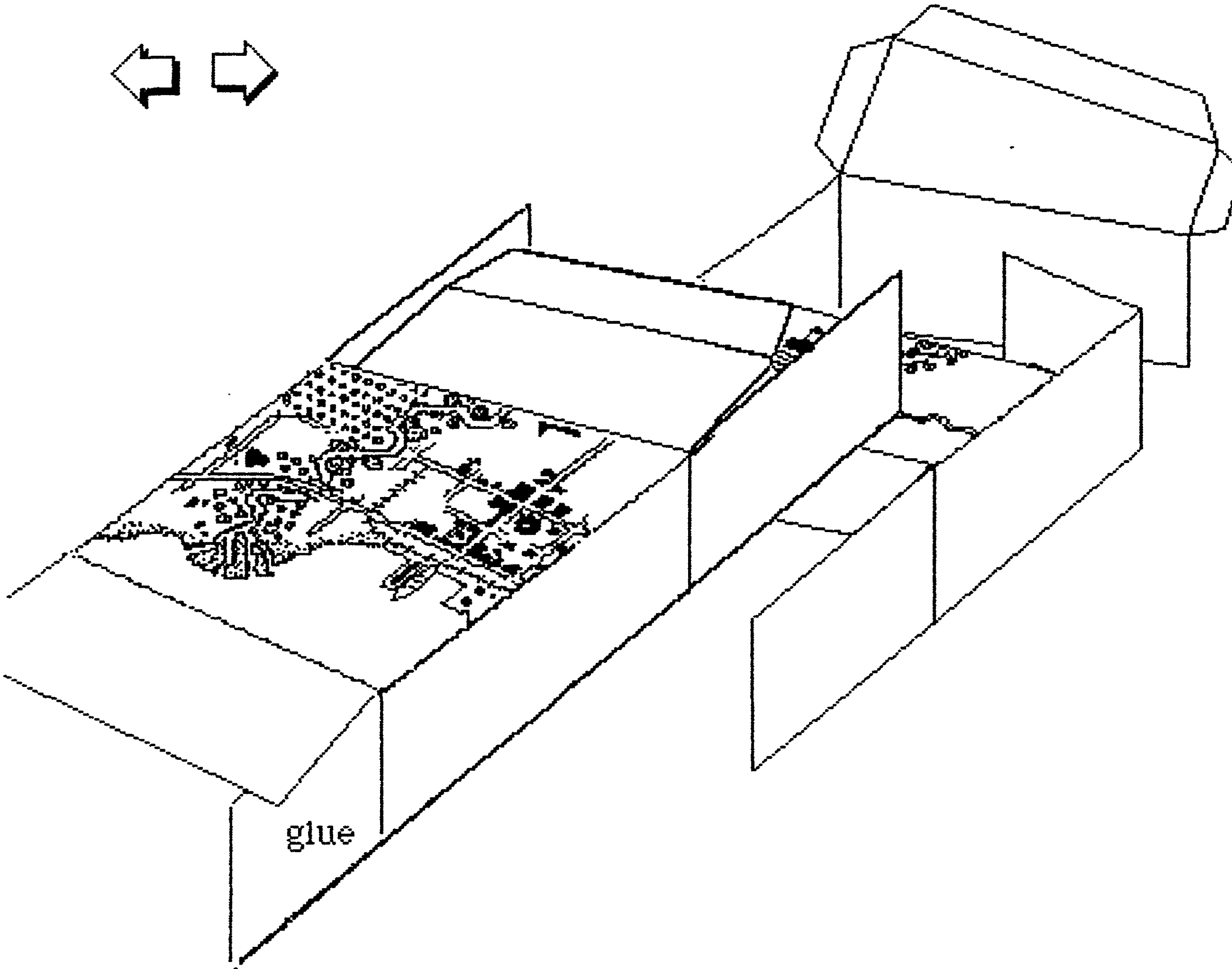
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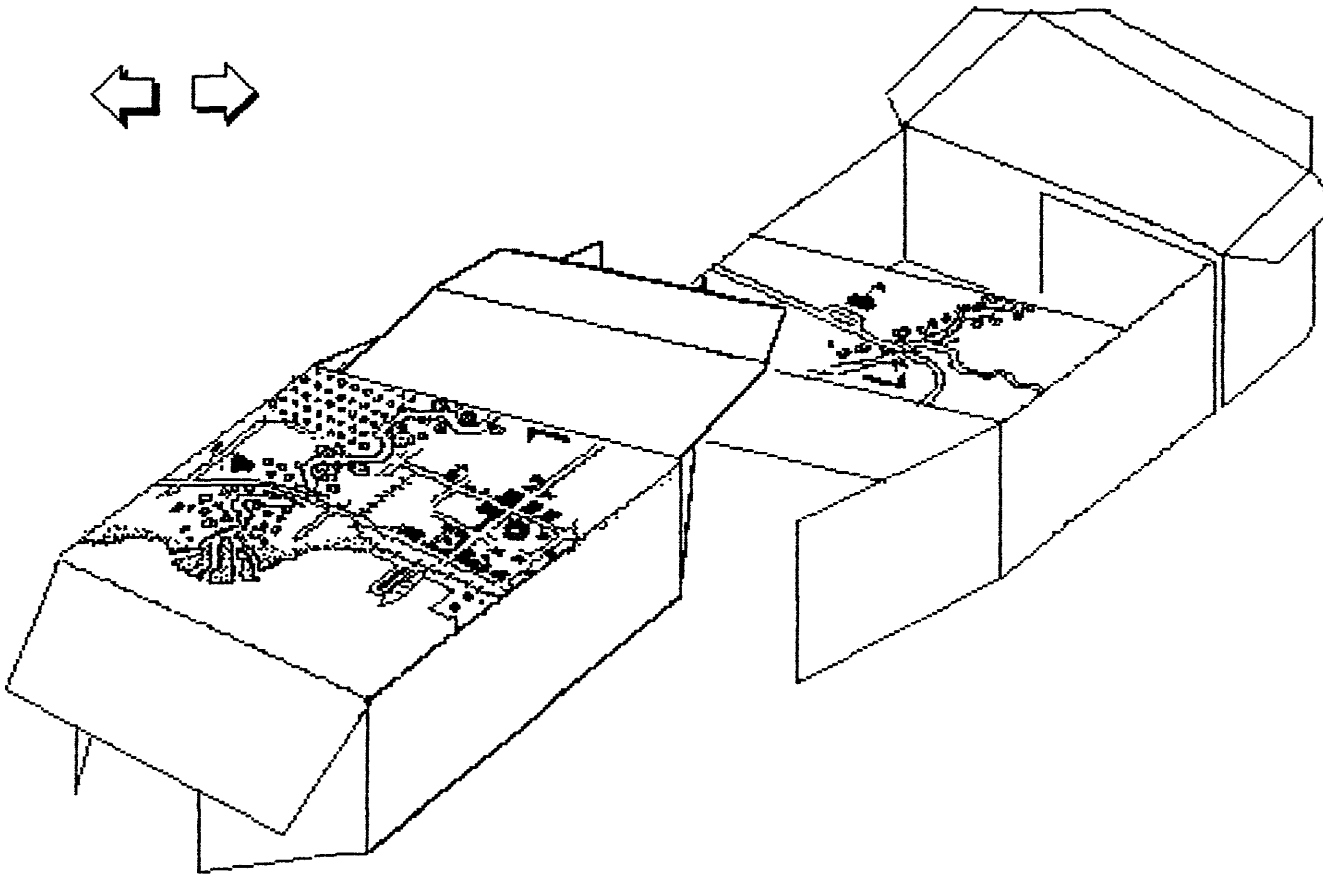

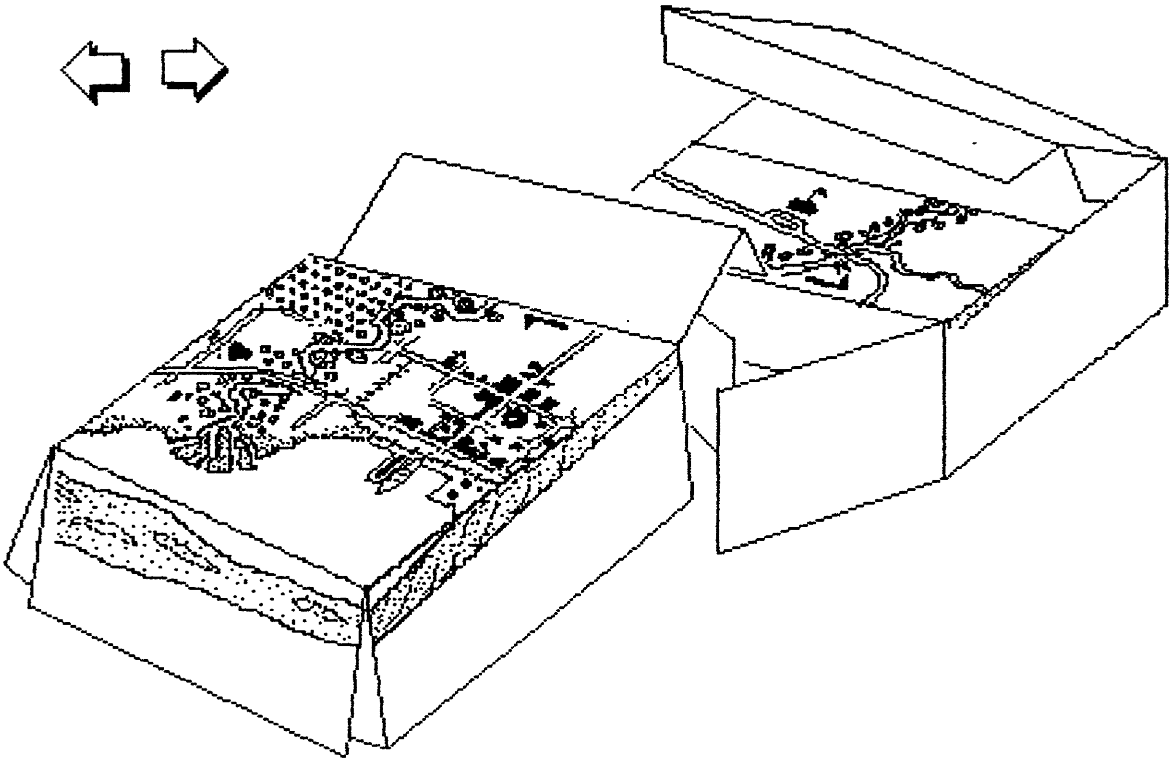

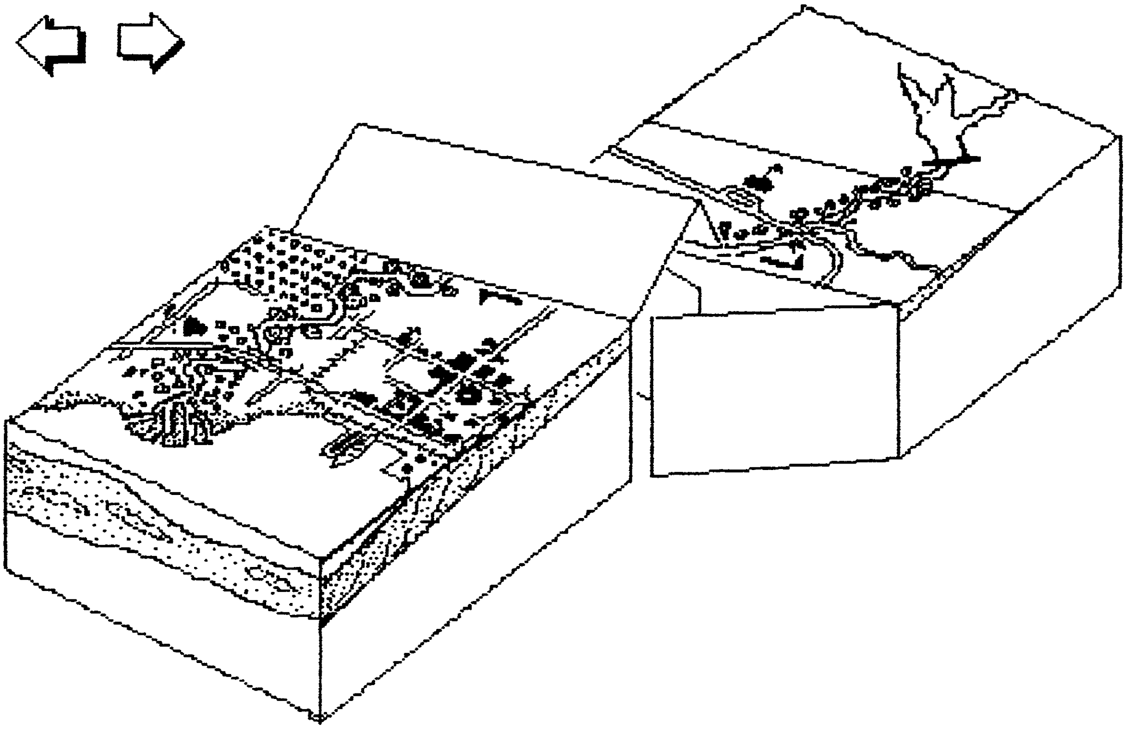

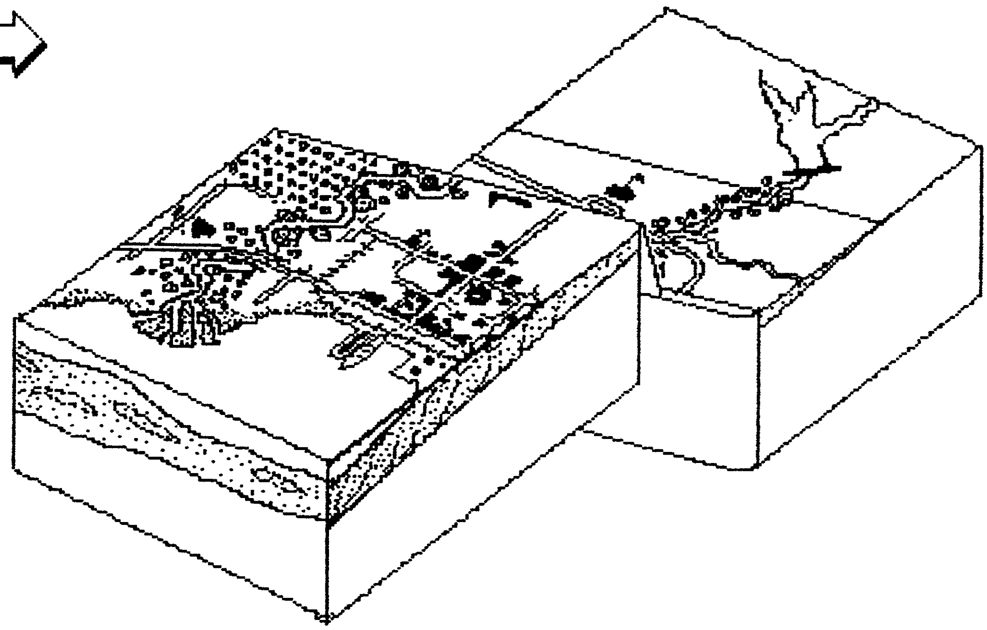

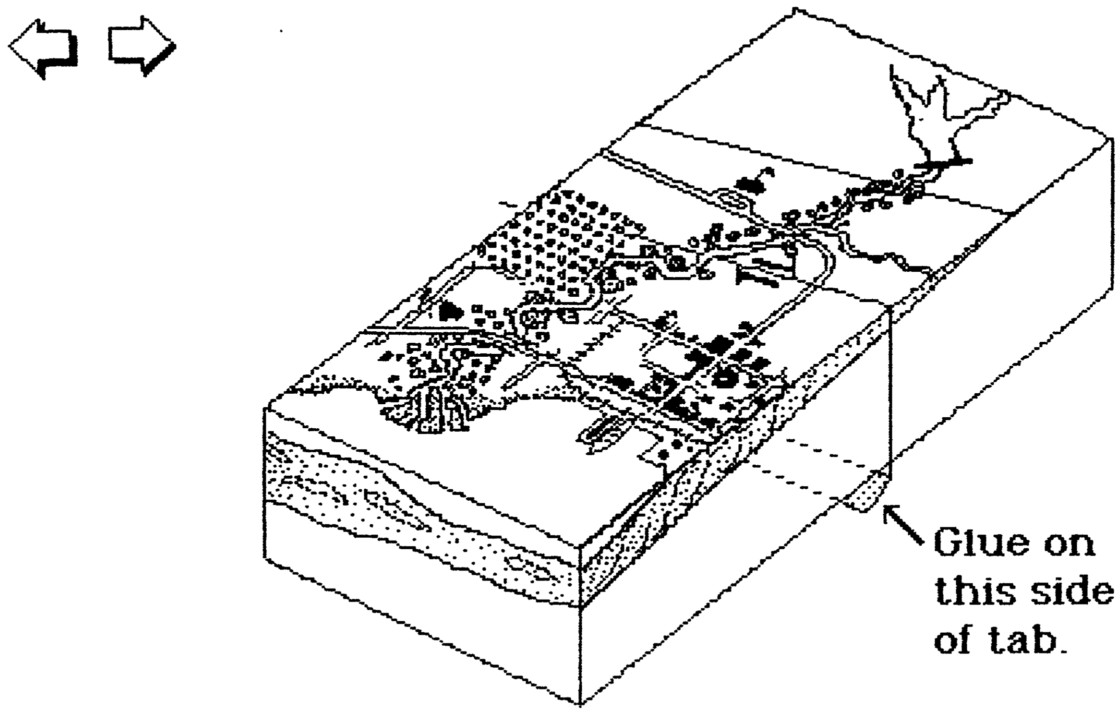
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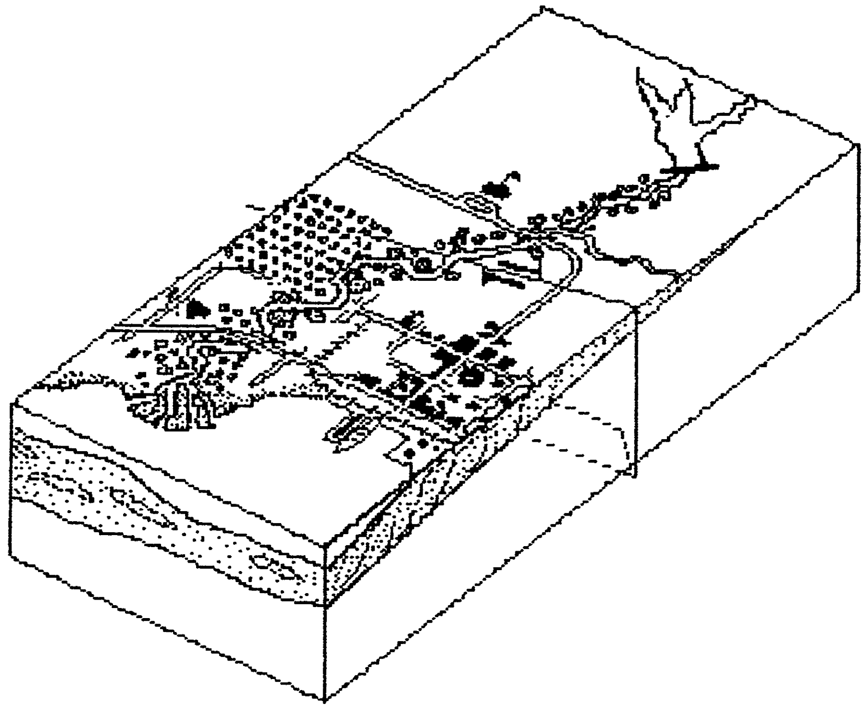
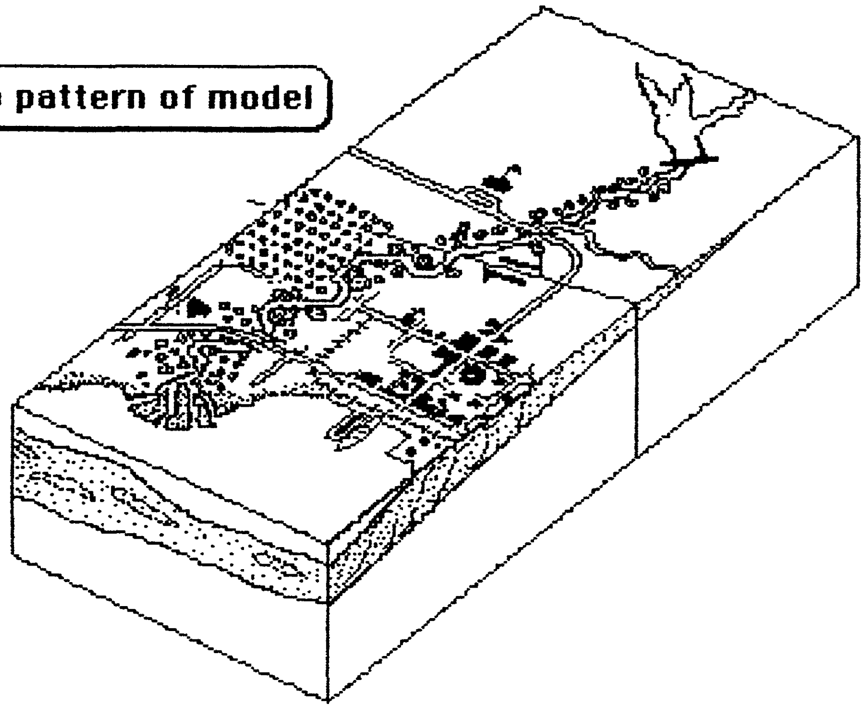


Back to pattern of model



An **earthquake** is a sudden shaking or vibration in the Earth caused by sudden release of energy from the Earth's surface. Most earthquakes result from movement between the large ridged blocks of rock, or **plates**, that compose the Earth's surface. This movement occurs on **faults**, the boundaries between blocks of rock.

The churning motion of the hot molten rock beneath the Earth's surface drives the plates, causing them to move toward each other, away from each other, or to slide past each other along faults. It is difficult for one plate to slip against another because of the great forces pressing them together. Consequently, the plates do not slip freely in constant slow motion; instead, they slip in a jerky fashion. Each jerk causes an earthquake. This continuous motion of the Earth's plates is called **plate tectonics**.

This report illustrates the motion of plates sliding past each other along what is known as a **strike-slip fault.** If the relative motion on the fault is such that the side opposite your point of reference moves to your right, it is called a right-lateral strike-slip fault. The San Andreas fault in North America is perhaps the most famous strike-slip fault in the world. Other strike-slip faults include the Denali fault in Alaska and the Dead Sea fault in the Middle East.

Before an earthquake, the tectonic forces that drive the plates cause the rock in the vicinity of a fault to distort and bend. Energy is stored in the rock as it deforms, in much the same way as energy is stored in a rubber band as it is stretched. This energy is called **elastic energy**. When the forces exceed the strength of the rock along the fault, the fault suddenly slips, just as the stretched rubber band snaps back to its original shape when it is let go. The point on the fault at which slip first occurs is the **focus** (or hypocenter) of the earthquake. The point on the surface of the Earth directly above the focus is the **epicenter** of the earthquake. The area of slip on the fault grows rapidly outward from the focus and may extend upward to the surface of the Earth.

When the fault slips, the elastic energy stored in the rock is released as **seismic energy** in the form of **seismic waves**, or earthquake waves. These waves spread outward from the fault. Close to the earthquake fault, the seismic waves can be strong enough to knock people to the ground. They are weaker the farther one is from the earthquake fault. Consequently, shaking is greatest near the source of the earthquake.

There are two classes of seismic waves: **body waves,** which travel at high speed through the deeper, denser rock within the body of the Earth, and **surface waves,** which travel at a slower speed through rock near the Earth's surface. The body waves precede the surface waves. There are two types of body waves: **P-waves**, which are similar to sound waves, and the slower but more damaging **S-waves**. P-waves travel about 4.8 to 8.0 km (3 to 5 miles) in one second, while S-waves travel about 3.2 to 4.8 km (2 to 3 miles) in one second. Surface waves are slower still and can cause even more damage due to their greater duration.

Earthquakes can cause severe and widespread damage to weak buildings or structures, or to those located on ground subject to fault breakage, strong shaking, or landsliding. The slip (movement) on the fault may break the surface of the Earth, offsetting roads and tearing apart buildings or pipelines built across the fault. Such damage can be spectacular, but it is limited to the vicinity of the fault.

Educator's Guide Continued

Most damage results from strong shaking during the passage of seismic waves, which spread out from the fault over a large region. Shaking may be severe enough and long enough to collapse weak buildings, overturn furniture, topple water heaters and storage tanks, and collapse unsafe dams. These effects can result in further damage through fires resulting from broken gas mains and fallen electric wires, the loss of water to fight fires because of broken water mains, oil spills caused by failure of storage tanks, and flooding resulting from dam failure. Shaking can also cause landslides. These in turn can damage buildings, roads, and pipelines built on slide areas or downhill from them. An underwater slide off the delta deposited by a river can cause a seismic sea wave, or **tsunami**. Such waves can be as large as 30 m (100 feet) high. If they occur when the tide is high, they can sweep inland into a town and destroy harbor facilities and buildings. In some of the largest earthquakes, such waves have stranded fishing boats in the middle of towns a few blocks from the harbor. The animation sequences in the diskette version of this report illustrate each of the above-mentioned effects of earthquakes.

People can do many things to protect themselves and their homes from earthquakes. They can fasten tall heavy objects in their homes to walls so they will not fall in an earthquake. Houses can be inspected to make sure the foundations, walls, and chimney are built to withstand the effects of possible shaking. When choosing where to live, a family can ask city or county officials what areas are subject to earthquake faulting, strong earthquake shaking, or landsliding. Finally, a family can plan what each member will do if an earthquake occurs while at home or while away from home, such as at school or at work.

Vocabulary

body waves A seismic wave that travels through the interior of the Earth and is not restricted to any boundary surface.

earthquake A sudden motion or trembling in the Earth caused by the abrupt release of slowly accumulated strain.

elastic energy The energy stored within the Earth during elastic deformation.

epicenter That point on the Earth's surface which is directly above the focus of an earthquake.

fault A surface or zone of rock fracture along which there has been displacement.

focus That point on a fault at which the sudden break resulting in an earthquake begins.

plate tectonics The Earth's surface is composed of large, semirigid sections (plates) about 50km (30 miles) thick that float across the mantle, with seismic acivity and volcanism occuring primarily at the junctions of these sections.

plates Large, nearly rigid, but still mobile segments of blocks involved in plate tectonics, that include both crust and some part of the upper mantle.

P-waves (or primary waves) That type of seismic body wave which is propagated by alternating compression and expansion of material in the direction of propagation.

seismic energy The energy that is released as vibrations during an earthquake.

seismic waves Waves produced by an earthquake, including both body waves and surface waves.

strike-slip fault A fault for which the movement or slip is parallel to the strike (direction) of the fault.

surface waves A seismic wave that travels along the surface of the Earth.

S-waves (or secondary waves) That type of seismic body wave which is propagated by a shearing motion of material perpendicular to the direction of travel.

tsunami A sea wave produced by any large-scale disturbance of the sea floor, principally by a submarine earthquake or by submarine earth movement.

Questions for further study

1. Name some other strike-slip faults and their locations around the world.

2. What is plate tectonics?

3. Investigate some historic earthquakes and report on them.

4. On the paper model, a small town exists near the epicenter of the earthquake. What are some of the problems or hazards the townspeople might have to face living so close to a fault? Dicuss possible solutions to these problems with your class.

Easy Reading

Gates, George O., 1990, Safety and survival in an earthquake: U.S. Geological Survey, General Interest Publication. 11 p. (also available in Spanish)

Shulty, Sandra S., and Wallace, Robert E., 1990, The San Andreas Fault, U. S. Geological Survey General Interest Publication, 16p.

Simkin, T. , Tilling, R. I. , Taggart, J. N., Jones, W. J. , and Spall, H., compilers, 1989, This Dynamic Planet: World Map of Volcanoes, Earthquakes, and Plate Tectonics: U. S. Geological Survey, Reston, VA, in cooperation with The Smithsonian Institution, Washington, D. C.

U. S. Geological Survey, 1990, The severity of an earthquake: U.S. Geological Survey, General Interest Publication, 15 p.

Walker, Bryce, 1982, Earthquake: Time-Life Books, Alexandria, Virginia, 176 p. (A factual, well-illustrated account of earthquakes and their effects, written for a layperson.)

Ward, Peter L., and others, 1990, The Next Big Earthquake in the Bay Area may come sooner than you think: U. S. Geological Survey in cooperation with other public service agencies, 23p. (Includes an especially good list of additional reading and sources of more information)

Yanev, Peter I., 1991, Peace of mind in earthquake country: Chronicle Books, San Francisco, California, 218p. (A discussion of earthquake hazards and practical steps to take before, during, and after earthquakes.)

Further Reading

Bolt, Bruce A., 1988, Earthquakes: W. H. Freeman, New York, 282 p. (A scientific primer on earthquakes, their causes, measurement, precursors, and effects.)

Gere, James M., and Shah, Haresh C. 1984, Terra non firma: W. H. Freeman, New York, 203 p. (An elementary scientific discussion of earthquakes and how to prepare for them.)

Kimball, Virginia, 1988, Earthquake ready: Roundtable Publishing, Santa Monica, California, 225 p. (A practical guide on how to prepare for earthquakes.)

Nance, John J., 1988, On shaky ground: America's earthquake alert: Avon Books, New York, 440 p. (An, absorbing, factual narrative of earthquake disasters and scientists efforts to understand and cope with earthquakes.)

The National Science Teachers Association, 1988, Earthquakes: a teacher's package for K-6th grades: The National Science Teachers Association, 280 p. (excellent for hands-on activities to teach children about earthquakes.)

Pakiser, Louis C., 1990, Earthquakes: U.S. Geological Survey General Interest Publication, 20 p.

Educator's Guide Continued

Additional Models

Alpha, Tau Rho, 1989, How to construct two paper models showing, the effects of glacial ice on a mountain valley: U. S. Geological Survey Open-File Report 89-190 A&B (This report is available on a 3.5-in. MACINTOSH disk and 30 p. report)

Alpha, Tau Rho, Lahr, John C., and Wagner, Linda F., 1989, How to construct a paper model showing the motion that occurred in the San Andreas fault during the Loma Prieta, California, earthquake of October 17, 1989: U. S. Geological Survey Open-File Report 89-640A&B (this report is available on a 3.5-in. MACINTOSH disk and 10 p. report)

Alpha, Tau Rho, and Lahr, John C., 1990, How to construct seven paper models that describe faulting of the Earth: U. S. Geological Survey Open-File Report 90-257 A&B (this report is available on a 3.5-in. MACINTOSH disk and 40 p. report)

Alpha, Tau Rho, 1991, How to construct four paper models that describe island coral reefs: U. S. Geological Survey Open-File Report 91-131A&B (this report is available on a 3.5-in. MACINTOSH disk and 19 p. report)

Alpha, Tau Rho, and Gordon, Leslie C.,1991, Make your own paper model of a volcano: U. S. Geological Survey Open-File Report 91-115A&B (this report is available on a 3.5-in. MACINTOSH disk and 4 p. report)

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