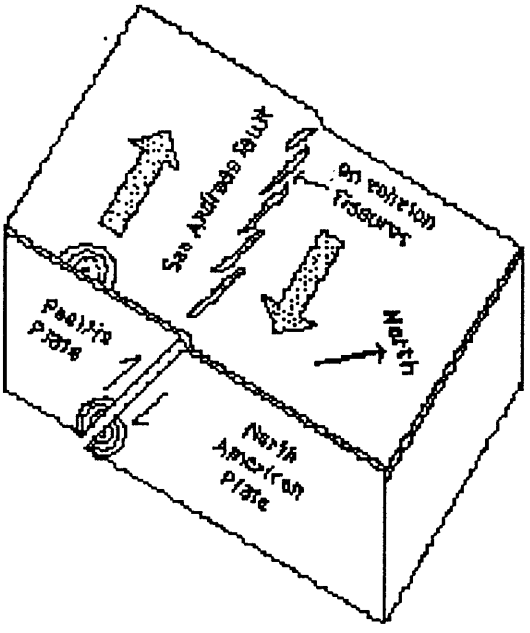
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

How to construct a paper model showing the motion that occurred on the San Andreas fault during the Loma Prieta, California, earthquake of October 17, 1989.

by

Tau Rho Alpha,* John C. Lahr,* and Linda F. Wagner**

Open-File Report 89-640A



*U. S. Geological Survey
Menlo Park CA. 94025
**Peninsula School Ltd.
Peninsula Way

Description

This report contains instructions and patterns for preparing a three-dimensional model that schematically illustrates the fault motion that occurred during the Loma Prieta earthquake of October 17, 1989, in California. The model is intended to help students and others visualize the process of fault slip during earthquakes. By constructing and examining this model, students will be better able to visualize fault motion on this part of the San Andreas fault and will have a better understanding of how the natural landscape evolves.

Although a small-scale paper model cannot do justice to the complexity of the deformation that accompanied the Loma Prieta earthquake, a model can serve as an aid in visualizing the faulting process and in understanding how a fault that did not rupture the surface of the darth could produce a zone of open fissures, as was observed a long the San Andreas fault above the northern end of this earthquake.

The date of this Open-File Report is November 20, 1989 (**version** 1). OF89-640-A, paper copy, 10 p. OF-640-B, 3.5-in. diskette.

The date of **version** 2 of this Open File Report is Feb. 7, 1992. OF 89-640-A, paper copy, 11p. OF 89-640-B, 3.5-in. diskette.

Purchasers of the diskette **version** 2 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.

Requirements for the diskette **version 2** are: Apple Computer, Inc., HyperCard 2.0™ software, and an Apple Macintosh™ computer. 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.

To see the entire page (card size: MacPaint), select "Scroll" from "Go" menu and move the hand pointer in the scroll window.

If you are experiencing trouble with user-level buttons, select "message" from the "Go" menu. Type "magic" in the message box and press return. Three more user-level buttons should appear.

To order this report, contact: U. S. Geological Survey Books and Open-File Reports Sales, P.O. 25425 Denver, CO. 80225, or call (303) 236-7476.

Fault motion during the Loma Prieta earthquake

The northern California earthquake of October 17, 1989, occurred in the Santa Cruz mountains between San Francisco and Monterey Bays, and was named after Loma Prieta, a nearby peak (Figure 1). With a magnitude of 7.1, this was the largest earthquake since 1906 on the San Andreas fault. The hypocenter, the point where movement began within the earth, was on the San Andreas fault at a depth of 18 kilometers (11 miles). The break expanded rapidly along the 70° dipping fault plane, moving at approximately 12,000 km/hr (7,000mi/hr). It extended upward to within 6 km (4 mi) of the surface and along the fault for 25 km (15mi) to the northwest and 25 km (15mi) to the southeast. With respect to the North American plate, the Pacific plate moved northwest 1.9 meters (6 feet), and upward 1.3 meters (4 feet) (Plafker and Galloway, 1989). The epicenter, the point on the surface of the earth directly above the hypocenter was about 16 km (10 mi) east-northeast of the city of Santa Cruz, within The Forest of Nisene Marks State Park.

Because the main fault rupture, or break, did not continue all the way to the surface, the upper layers of the earth were bent rather than broken. The area of fissures, or deep cuts in the earth, mapped near the north end of the rupture may have been a result of this bending. In the paper model a series of cuts, which form a "stepped" pattern that geologists call en echelon, is placed directly above the fault rupture. These cuts allow motion on the fault below and illustrate how surface layers might be deformed by underground fault movement. The actual pattern of bending and fissures, however, is more complicated and is not portrayed by the paper model.

This description is based on the preliminary interpretations of many geologists and geophysicists, and these initial conclusions will undoubtedly be refined as more data are gathered and analyzed. To learn about the Loma Prieta Earthquake, see Plafker and Galloway (1989) and Alpha, Lahr, and Page (1989). For paper models illustrating additional types of faults and faulting, see Alpha and Lahr (1990).

References

Alpha, T. R., Lahr, J. C., and Page, R. A., 1889, Oblique map of the northern half of the Loma Prieta, California earthquake rupture zone and environs: U. S. Geological Survey Open-File Report 89-633, 1 sheet.,

Plafker, George and Galloway, J. P., eds., 1989, Lessons learned from the Loma Prieta, California, earthquake of October 17, 1989: U. S. Geological Survey Cicular 1045, 48 p.

Alpha, T. R. and Lahr, J. C., 1990, How to construct seven paper models that describe faulting of the Earth: U. S. Geological Survey Open-File Report 90-257 A nd B, 10 p.

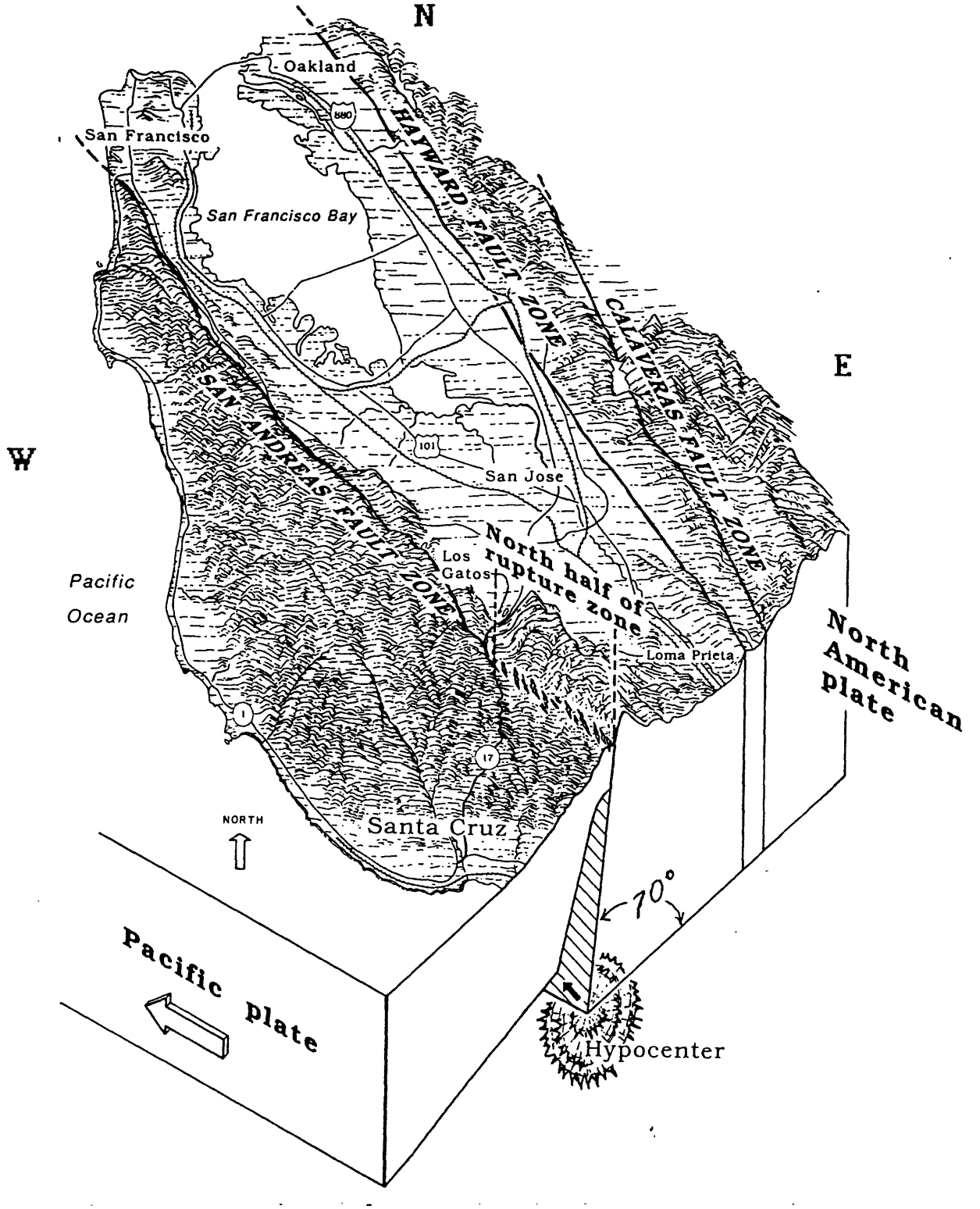


Figure 1. Oblique map of the Loma Prieta, California, earthquake of October 17, 1989, showing the motion that occurred on the San Andreas fault. Modified from Alpha and others, 1989.

Instructions

Cut out the three pieces of the model.

Fold the two large pieces into box-shapes, as illustrated.

Glue the tabs of the two boxes and assemble.

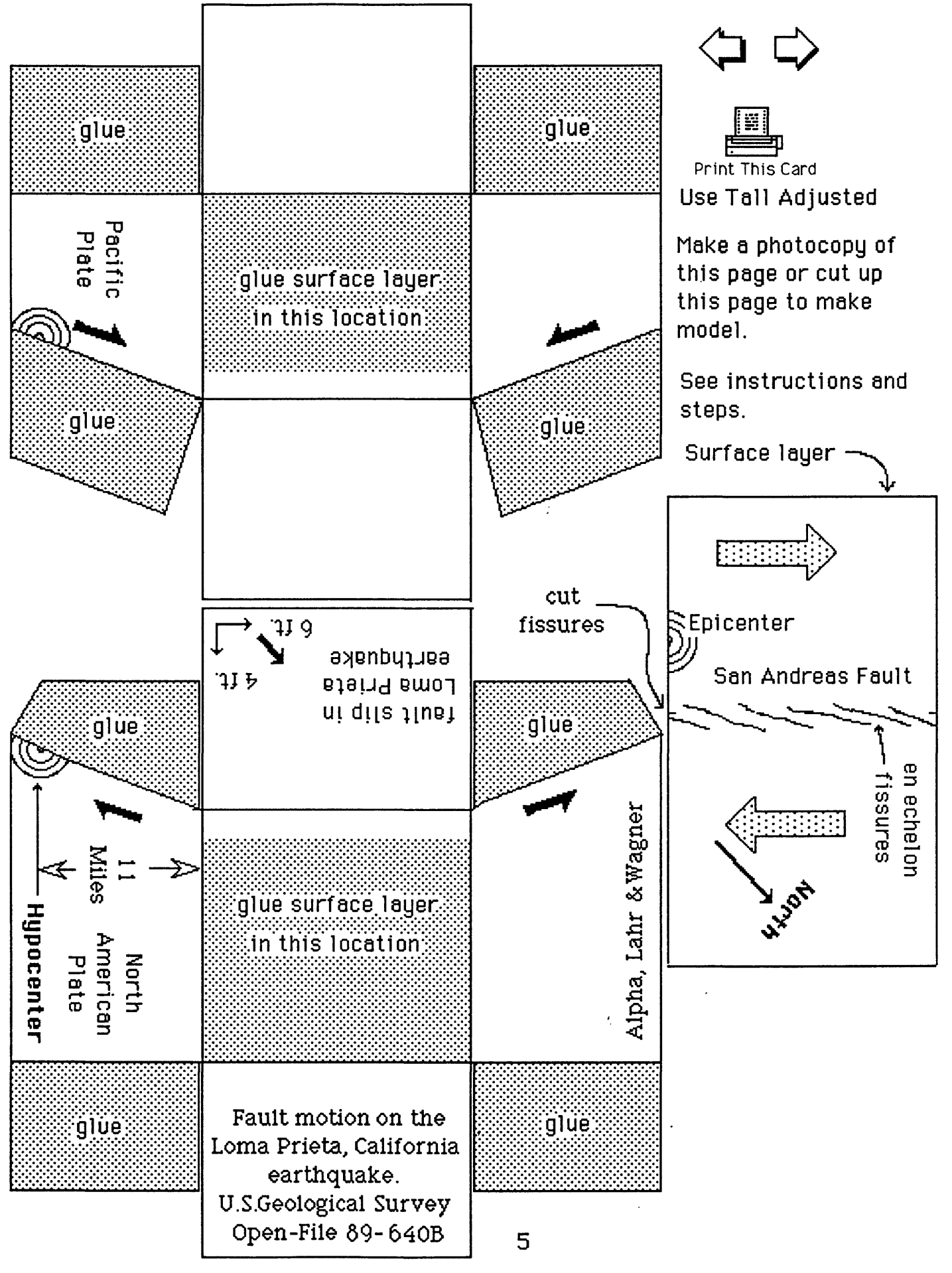
Glue the surface layer to the top of the two boxes, being careful that the area of the fissures remains free of glue.

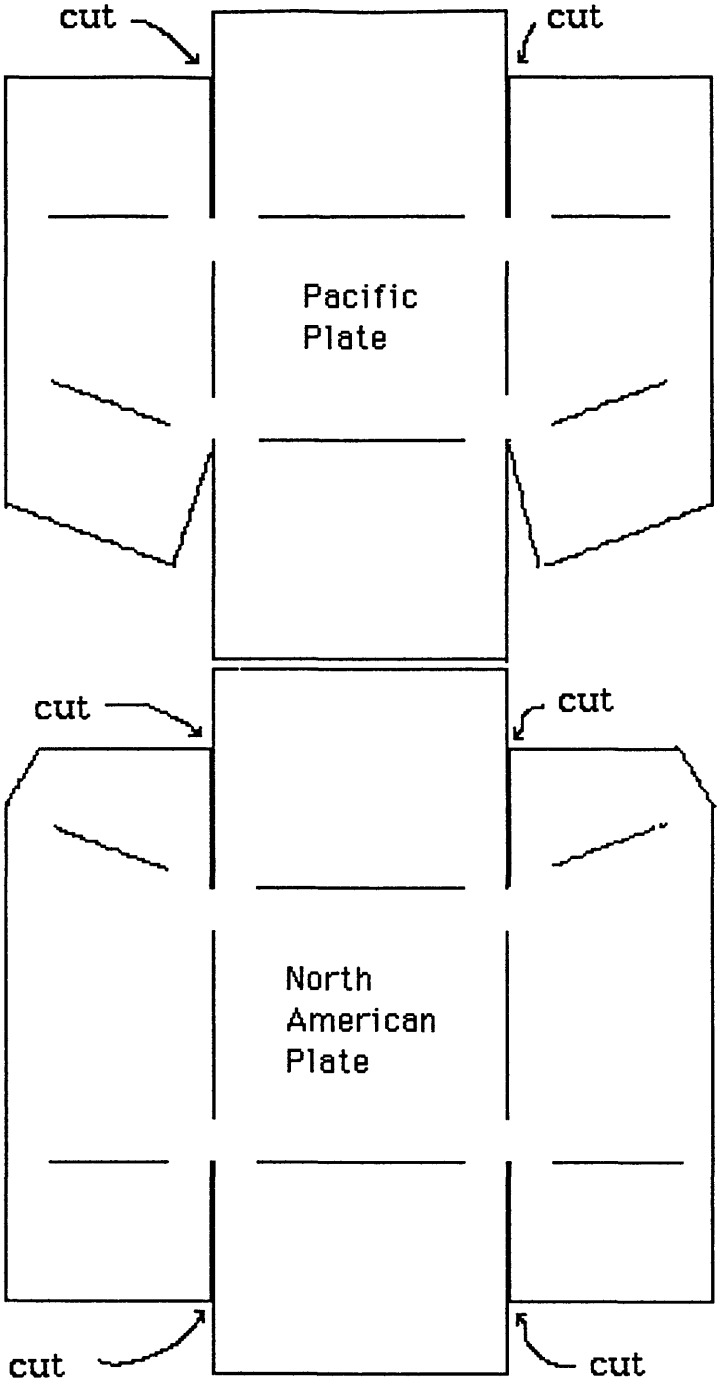
To simulate earthquake displacement, shift the "Pacific plate" box upward and to the north and notice how the fissures buckle.

Model variations

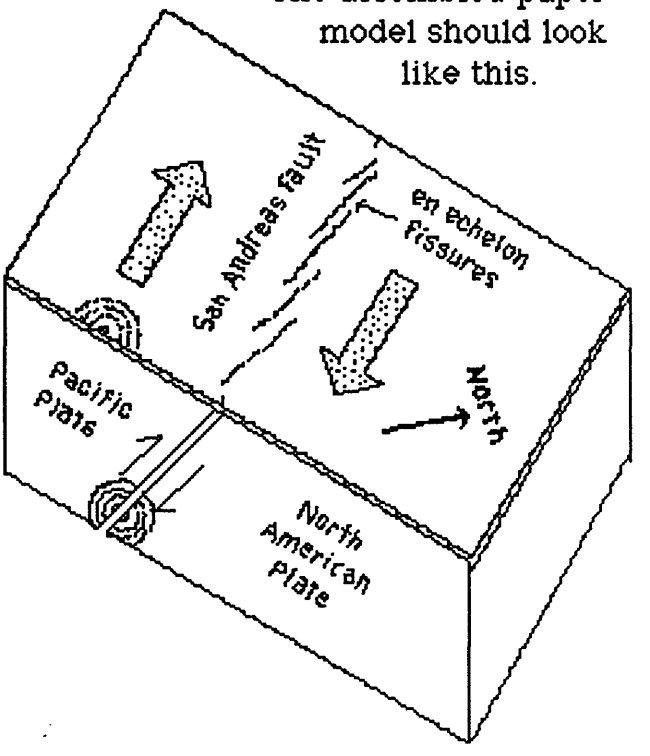
If you wish to show additional details, such as geological features, vegetation, or cities, the model can be colored with marking pens or water colors (which are best applied before the model is constructed). Black-and-white patterns can be applied to the model with your SuperPaint software.

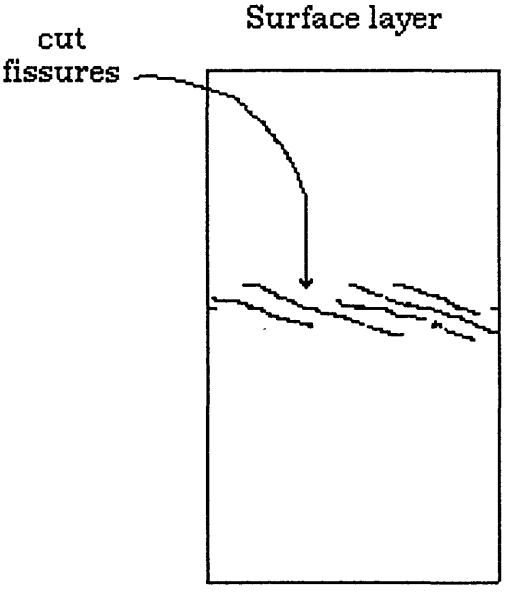
As an alternative to the paper model, you may wish to make a model from foam rubber. In this case the foam block should be cut along the fault to within about 1/2 inch of the surface. En echelon "fissures" can be made above the fault, which will open as the fault below is displaced .


glue
glue
Pacific Plate
glue surface layer in this location
glue
glue
Print This Card
Use Tall Adjusted
Make a photocopy of this page or cut up this page to make model.
See instructions and steps.
Surface layer
cut fissures
Epicenter
San Andreas Fault
en echelon fissures
North
6 ft.
4 ft.
fault slip in Loma Prieta earthquake
glue
glue
Alpha, Lahr & Wagner
11 Miles
Hypocenter
North American Plate
glue surface layer in this location
glue
glue
Fault motion on the Loma Prieta, California earthquake.
U.S.Geological Survey
Open-File 89-640B

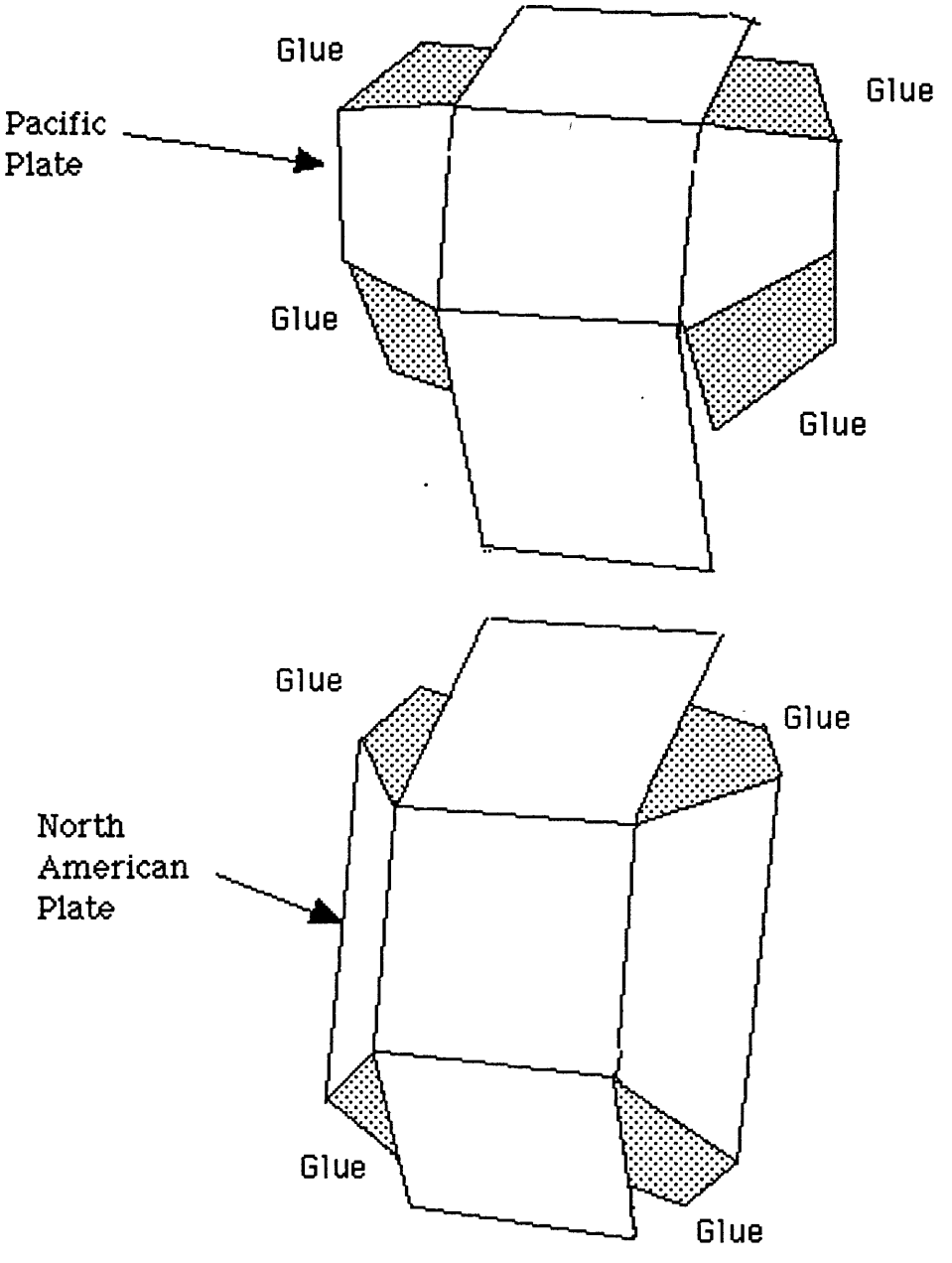


The assembled paper model should look like this.

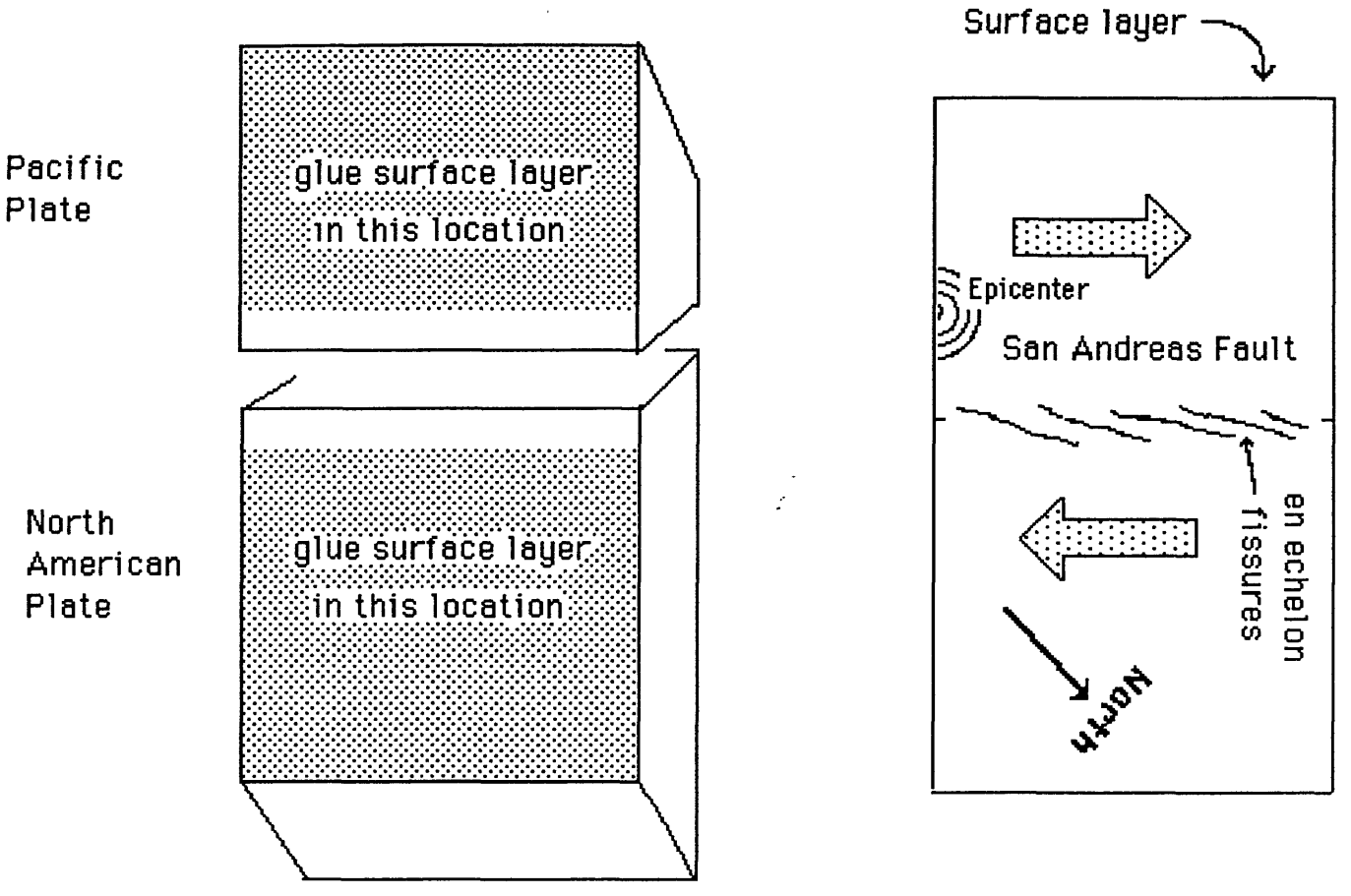




Step 1 Cut out the paper model by cutting along its borders. Cut fissures as shown.

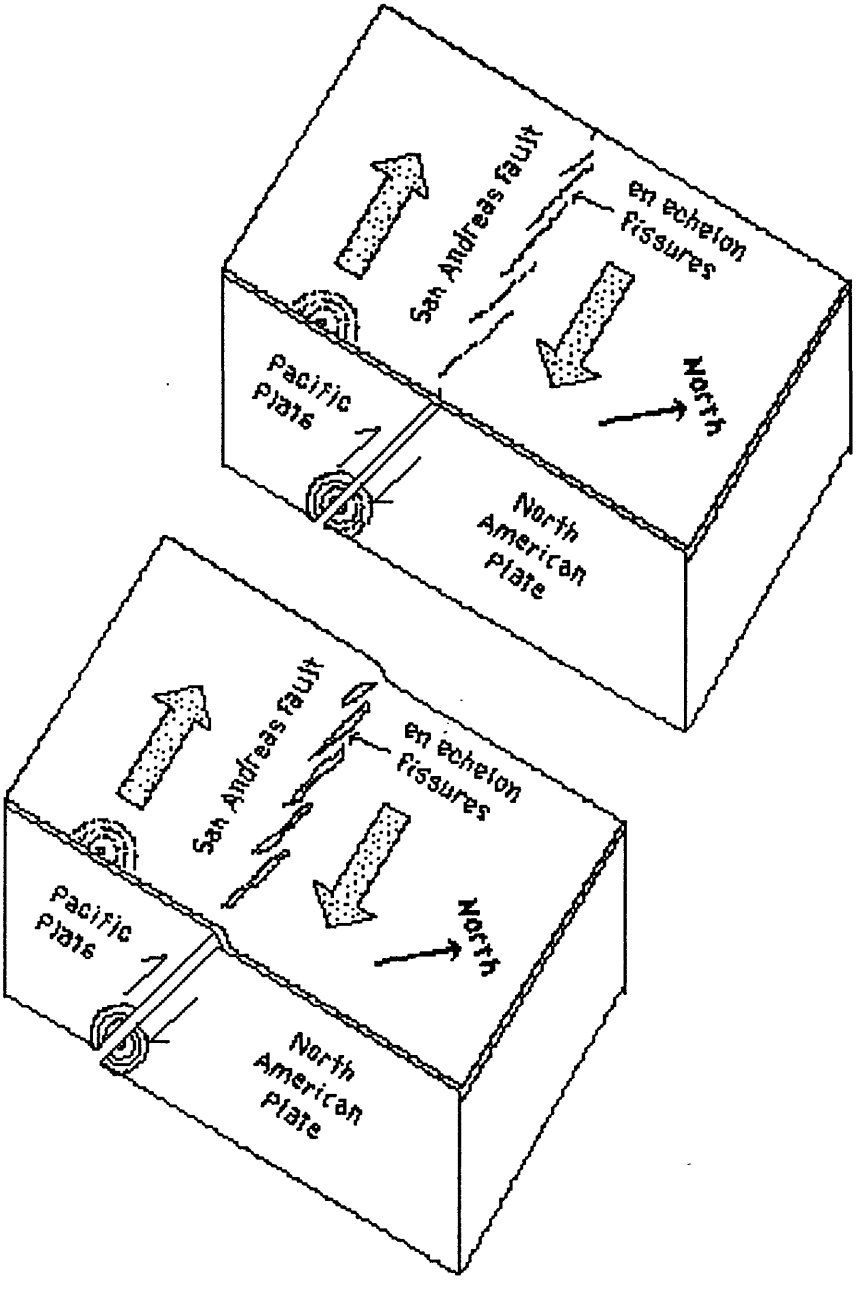


Step 2 Fold the paper model along the lines marked so that the printed side faces outward. Glue the marked tabs to make two small boxes.

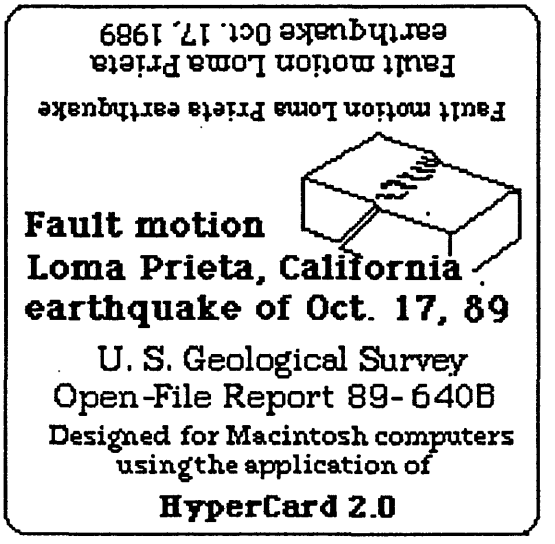


The assembled blocks should look like this.

Step 3 Glue the surface layer to the two paper blocks, being careful that the area of the fissures remains free of glue, so they will remain free to move.



Step 4 The assembled paper model should look like this.

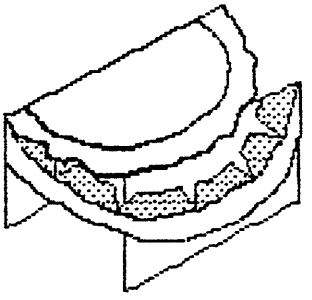

Fault motion Loma Prieta earthquake Oct. 17, 1989
Fault motion Loma Prieta earthquake
Fault motion
Loma Prieta, California
earthquake of Oct. 17, 89
U. S. Geological Survey
Open-File Report 89-640B
Designed for Macintosh computers
using the application of
HyperCard 2.0

Disk Label

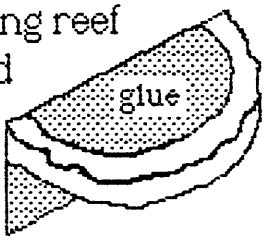
Fringing reef instructions

Step 5

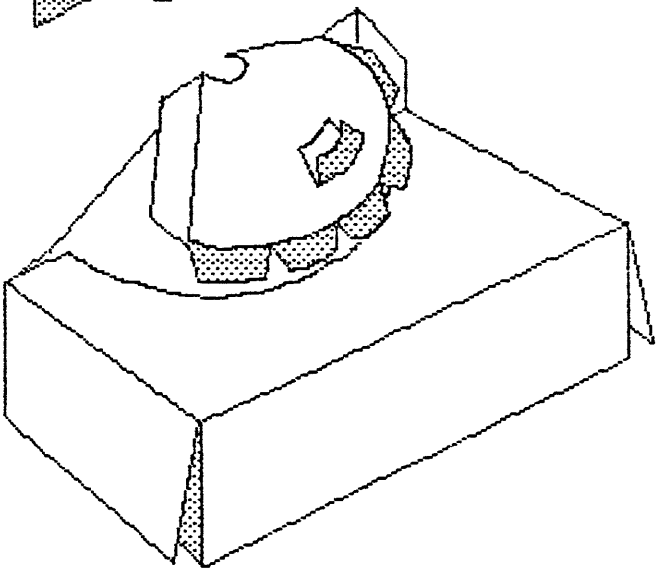
Assembling the model.



Finished Fringing reef should look like this.



Now glue the inside of Fringing reef on the back.



Step 6

The assembled model should look like this.