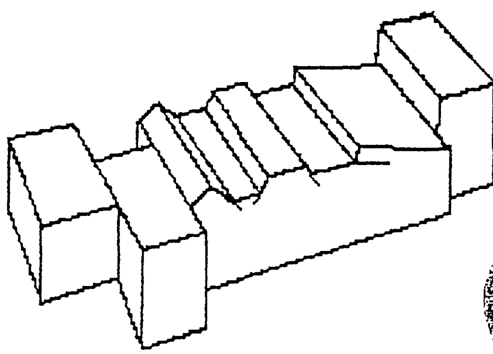
UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

How to construct seven paper models that describe faulting of the Earth

By

Tau Rho Alpha and John C. Lahr*

Open-file Report 90-257 A



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Description

This report contains instructions and patterns for preparing seven three-dimensional paper models that schematically illustrate common earth faults and associated landforms. The faults described are: normal, reverse, right- and left-lateral strike-slip, and oblique-slip. There are also models and discussions of two fault-produced landforms, a graben and a horst.

These models are intended to help students and others visualize the principal classes of faults and learn some of the terminology used by geologists to describe faults. By constructing and examining these models, students will obtain a greater appreciation of the relationship between fault displacements and the landforms that result.

The date of this Open-File Report is 4/12/90 **(version 1).**
OF90-257-A, paper copy, 40 p. OF90-257-B, 3.5 in. diskette.

The date of **version 2** of this Open File Report is Feb. 7, 1992.
OF 90-257-A, paper copy, 41p. OF 90-257-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.

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A fault is a fracture surface within the earth on which slip or displacement has taken place. The total displacement on a fault may be less than a few centimeters or may be measured in hundreds of kilometers. Large displacements are commonly achieved by a series of sudden slips associated with earthquakes, but under some conditions involving slow slip, called creep. Many possible fault configurations are possible; the fracture surface may be planar or curved, and the slip may be uniform everywhere or may change from place to place, as in a rotational displacement or a displacement that becomes smaller and smaller and finally dies out. In this report we will focus on those portions of faults with uniform displacement on planar fracture surfaces (figure 1) and will not discuss complex faults or the details associated with the edges or intersections of faults (figure 2).

The three fundamental fault types are normal, reverse, and strike-slip (figure 1). Normal faults involve a dipping fracture surface on which the block above the fault plane, the hanging-wall block, is downthrown with respect to the block below, called the footwall block. Normal faults are common in regions of crustal extension. In contrast, reverse fault displacements, which are common in regions of compression, are such that the block above the fracture surface is uplifted with respect to the block below. Strike-slip faults generally involve no vertical motion, but instead are produced by two blocks that are sliding laterally past one another. The sense of lateral motion can be right lateral (dextral) or left lateral (sinistral). Imagine that you are standing on one side of the fault. If the other side has moved to the right, as may be indicated by offset streams, ridges, roads, fences, or other features that cross the fault, it is a right-lateral fault. If the other side has been offset to the left, the fault is left lateral. Few faults are, in fact, purely normal, reverse, or transverse, but instead combine transverse motion with either normal or reverse motion. This combined motion is termed oblique slip.

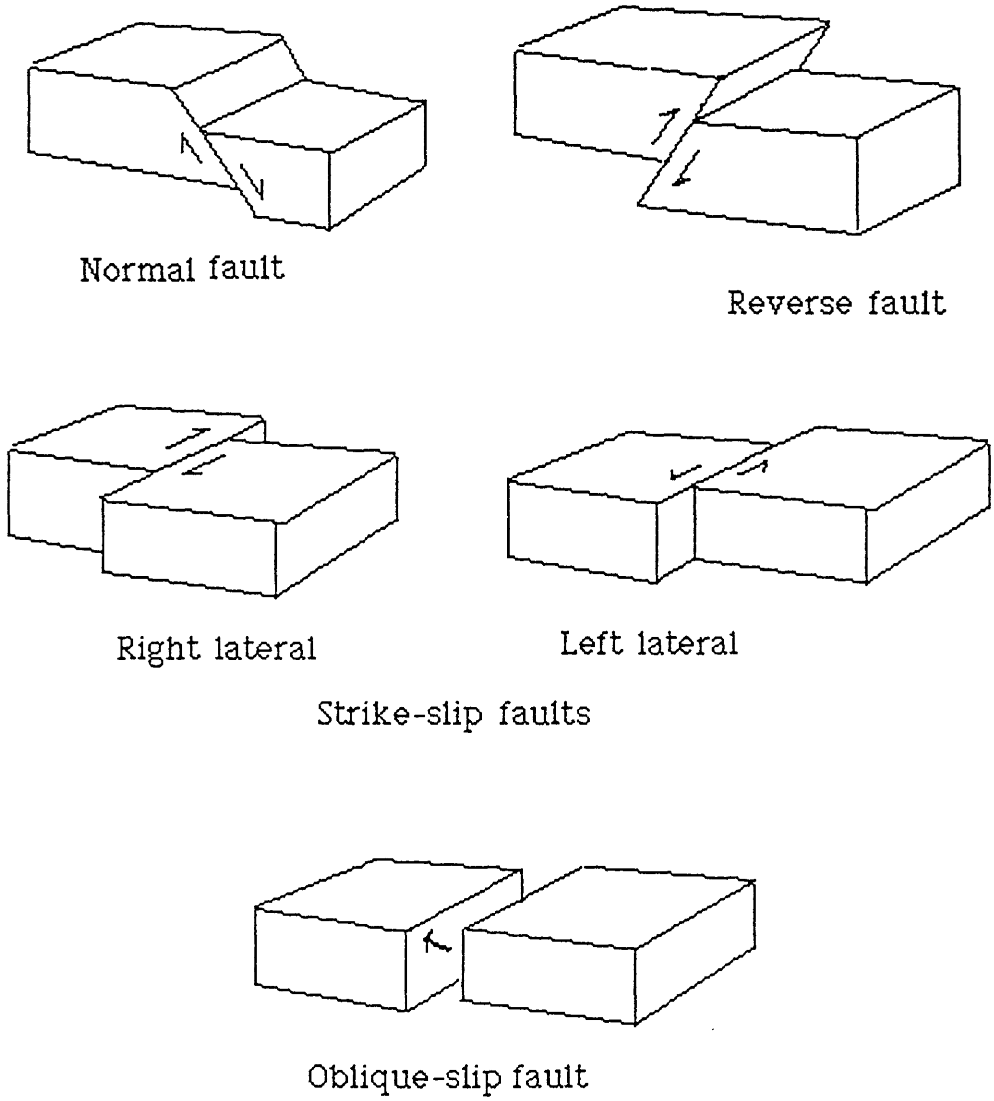
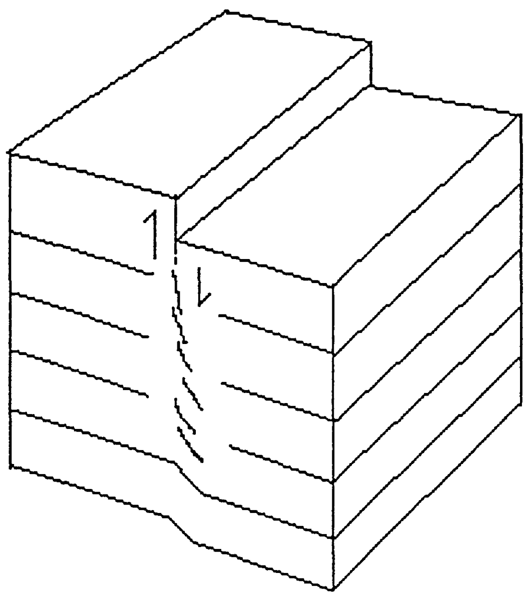
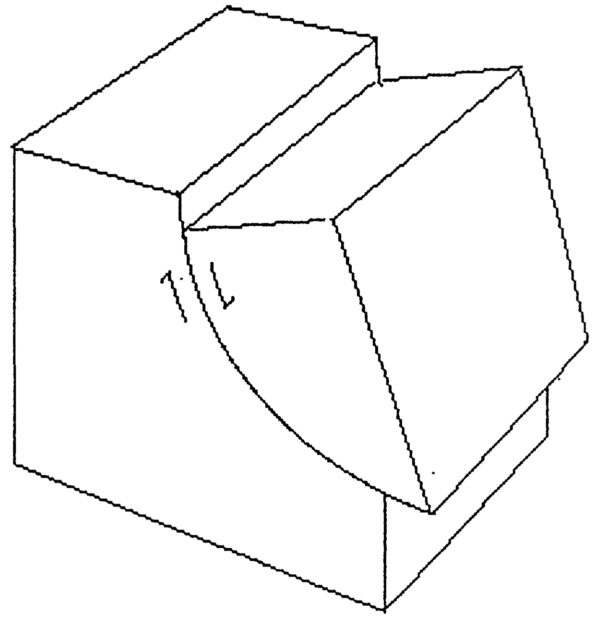


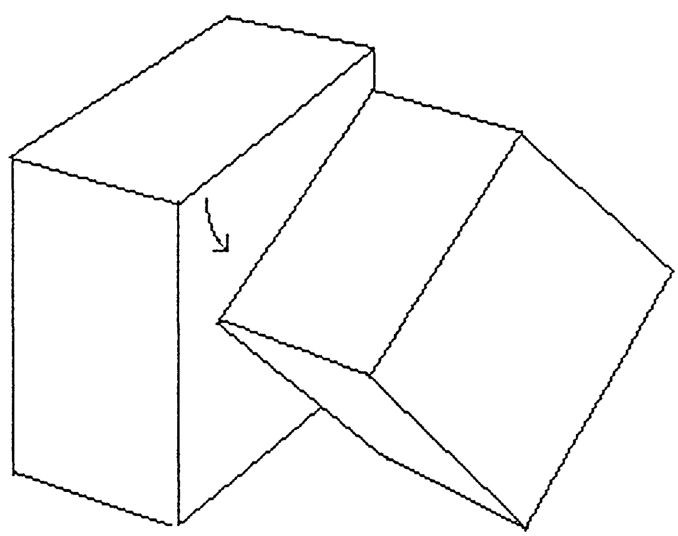
Figure 1. Simple fault types



Fault displacement decreases with depth and fault terminates in a fold.



Fault surface is curved, resulting in block tilting.



One block is rotated with respect to another.

Figure 2. Complex fault types.

When faults extend to the Earth's surface, displacing parts of the landscape, landforms are developed or modified. The portion of the fracture surface that is exposed by faulting is called the fault scarp (figure 3). Fault scarps may initially be angular and well defined, but over time they are modified by weathering and erosion on the upper portions while the lower portions become buried by eroded debris (talus). If a region is sliced by a series of subparallel normal faults with sufficient displacement, horst-and-graben topography may develop. A horst is a block that has remained high relative to those on either side, whereas a graben is depressed relative to the adjacent blocks (figure 4).

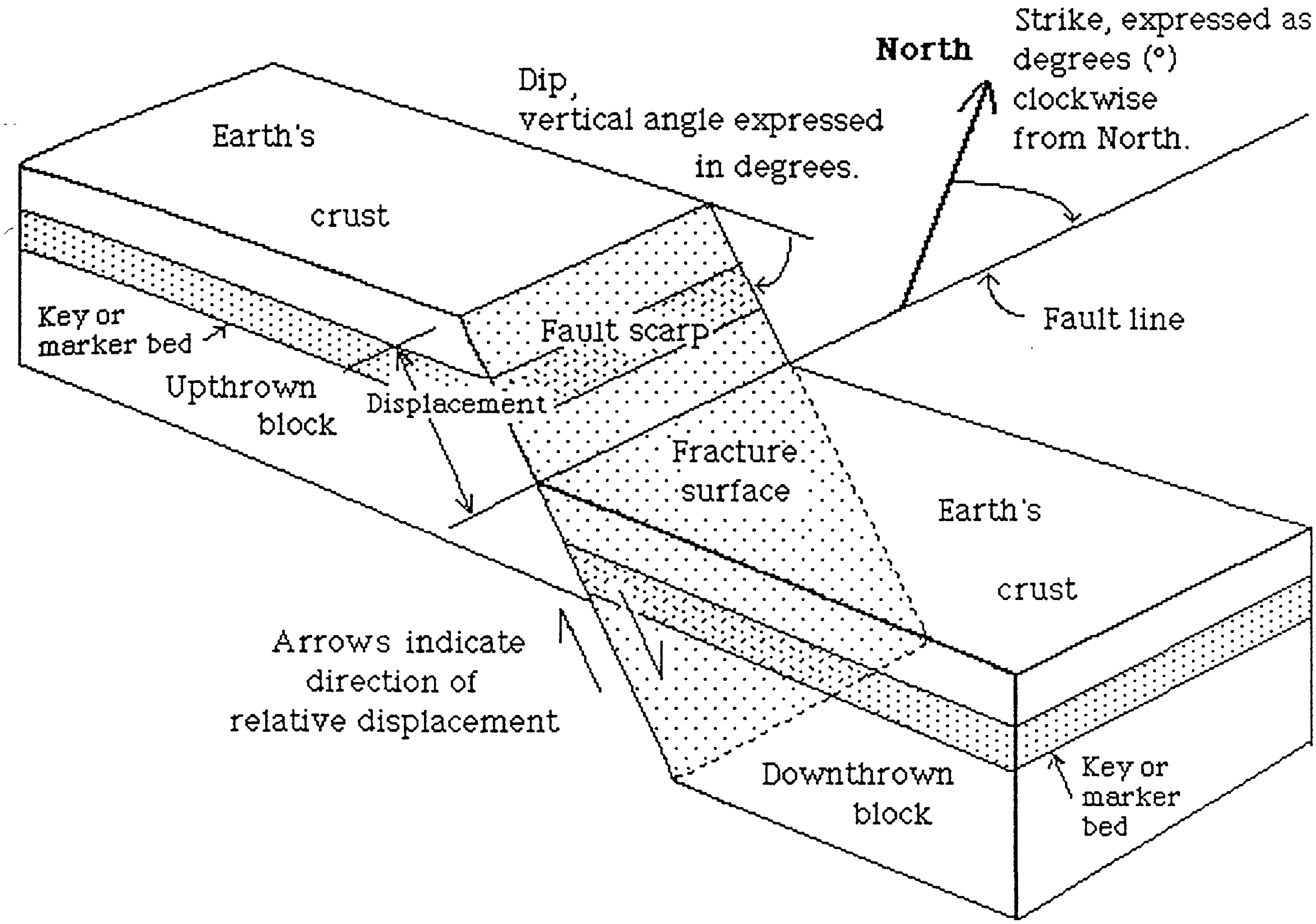


Figure 3. Elements of a fault.

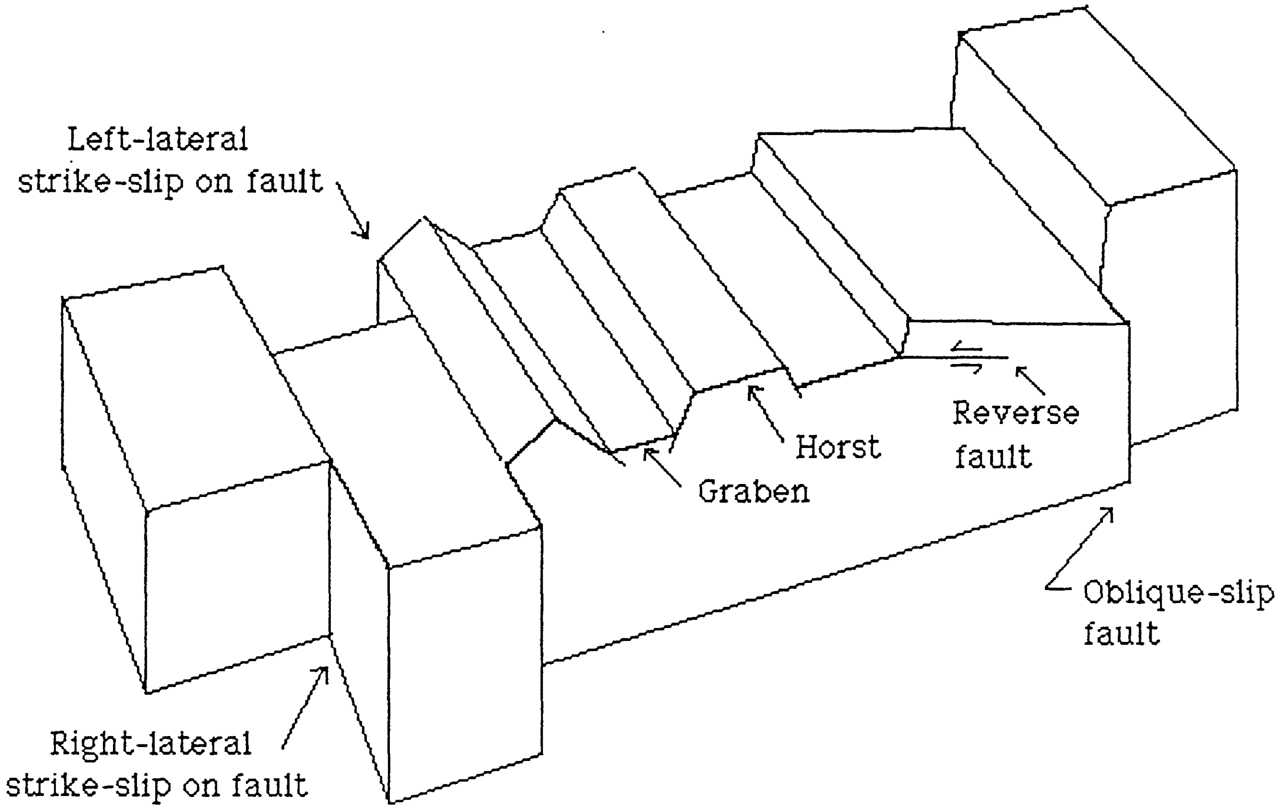


Figure 4. A collection of faults.

Assumptions made in the compilation of the models.

These paper models represent simple faults and illustrate some of the landforms associated with faulting of the Earth's crust. For scale, the models assume total displacement somewhere in the neighborhood of 40 feet or 12 meters. To make the models more realistic, some of the fault scarps are cut by gullies and are eroded in ways indicative of an arid landscape. All of the paper models show displacement on the fault by the use of arrows and by the offset of a marker bed or a stream.

1. Normal fault
2. Reverse fault.

The first two models represent recent fault movement with no erosion. The arrows indicate the direction of relative movement, and the marker bed gives a clue as to the amount of displacement of the blocks.

3. Right-lateral strike-slip fault
4. Left-lateral stricke-slip fault.

On these models there has been horizontal fault movement. The arrows indicate the direction of relative movement. Note the offset in the stream channels.

5, Oblique-slip fault

On this model there has been horizontal and vertical slip on the fault line. The arrows indicate the direction of relative slip, and the marker bed gives a clue as to the amount of displacement of the blocks. The fault scarp on the upthrown block has been eroded and a stream has eroded a small canyon into this block. Note the right-lateral offset of the stream channel.

6. Graben

This model portrays three fault blocks in which the middle block has fallen relative to the two blocks on either side. The movement on the two near-parallel faults is vertical, as indicated by the arrows, and displacement is implied by the marker bed. On one of the upthrown blocks, a stream has eroded a gully and deposited an alluvial fan.

7. Horst

Three fault blocks make up this model, with the middle block higher than the blocks on either side. The relative movement is indicated by the arrows, and the marker bed expresses the displacement of the faults. On the upthrown block (horst) there is an intermittent stream with associated gully and alluvial fan.

The authors thank Robert E. Wallace for reviewing an earlier version of this report

To cut out the models, scissors may be used, but a small knife, such as an X-ACTO knife with a number 11 blade may be the best. For constructing the models, a water-soluble glue, preferably a stick glue, works well. Read the special instructions and study the cutting and folding steps. Look at the folding diagrams to see how the patterns fit together to make the model landforms. Make a photocopy of the pattern, carefully cut out the pattern, and fold all corners and tabs. Fold the pattern into the model before applying glue, then glue the tabs, which are indicated with a dot pattern.

By using a computer and a graphics software program (not included) geologic patterns and symbols can be added to the models before construction to represent, rock types, surface material, or the influence of man. Color can be added to the models before or after construction. Have fun customizing your three-dimensional paper fault models.

Selected references for additional reading

Atwood, Wallace W., 1964, The physiographic provinces of North America: New York, Blaisdell Pub. Co., 536 p.

Billings, Marland P., 1946, Structural geology: New York, Prentice-Hall Inc., 473 p.

Johnson, D. W., 1930, Geomorphologic aspects of rift valleys, 15th. International Geologic Congress, Proceedings. vol. 2, p 354-373.

Lobeck, Armin K., 1939, Geomorphology: New York, McGraw-Hill Book Co. Inc., 731 p.

Strahler, Arthur N., 1969, Physical Geography, 3d ed., New York, John Wiley and Sons, Inc., 733 p.

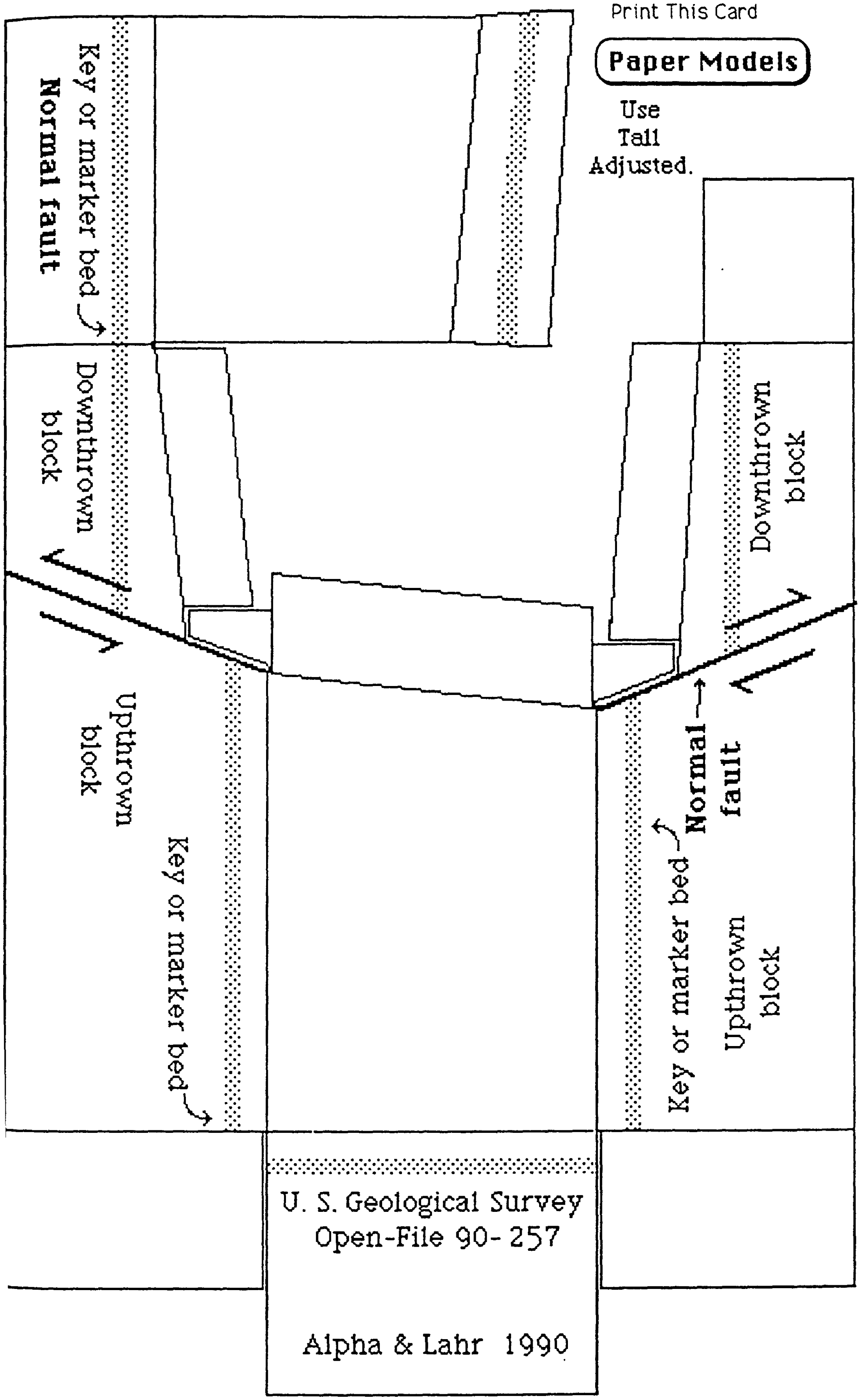
Wallace, R. E., 1968, Notes on stream channels offset by the San Andreas fault, southern Coast Ranges, California, in Dickinson, W. R., and Grantz, Arthur, eds., Proceedings of conference on geologic problems of San Andreas fault system: Stanford, California, Stanford University Publications, Geological Sciences, Vol. 11, p. 6-21.

Normal fault

Print This Card

Paper Models

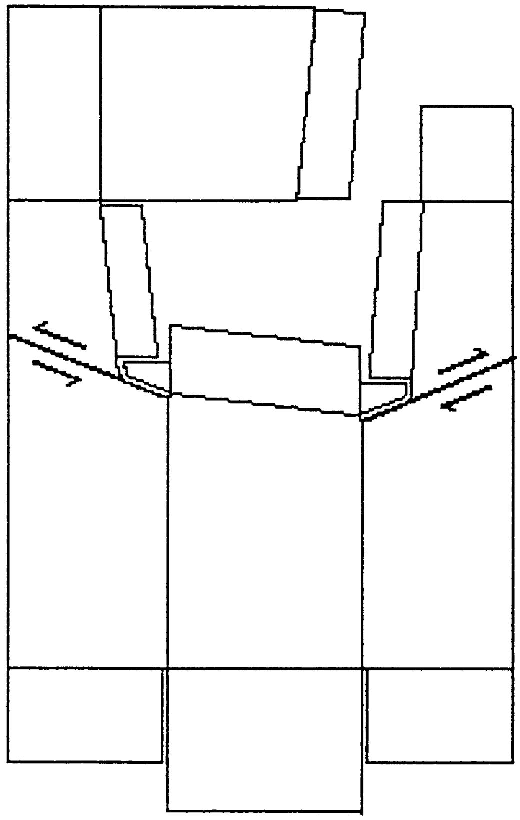
Use
Tall
Adjusted.



Normal fault instructions

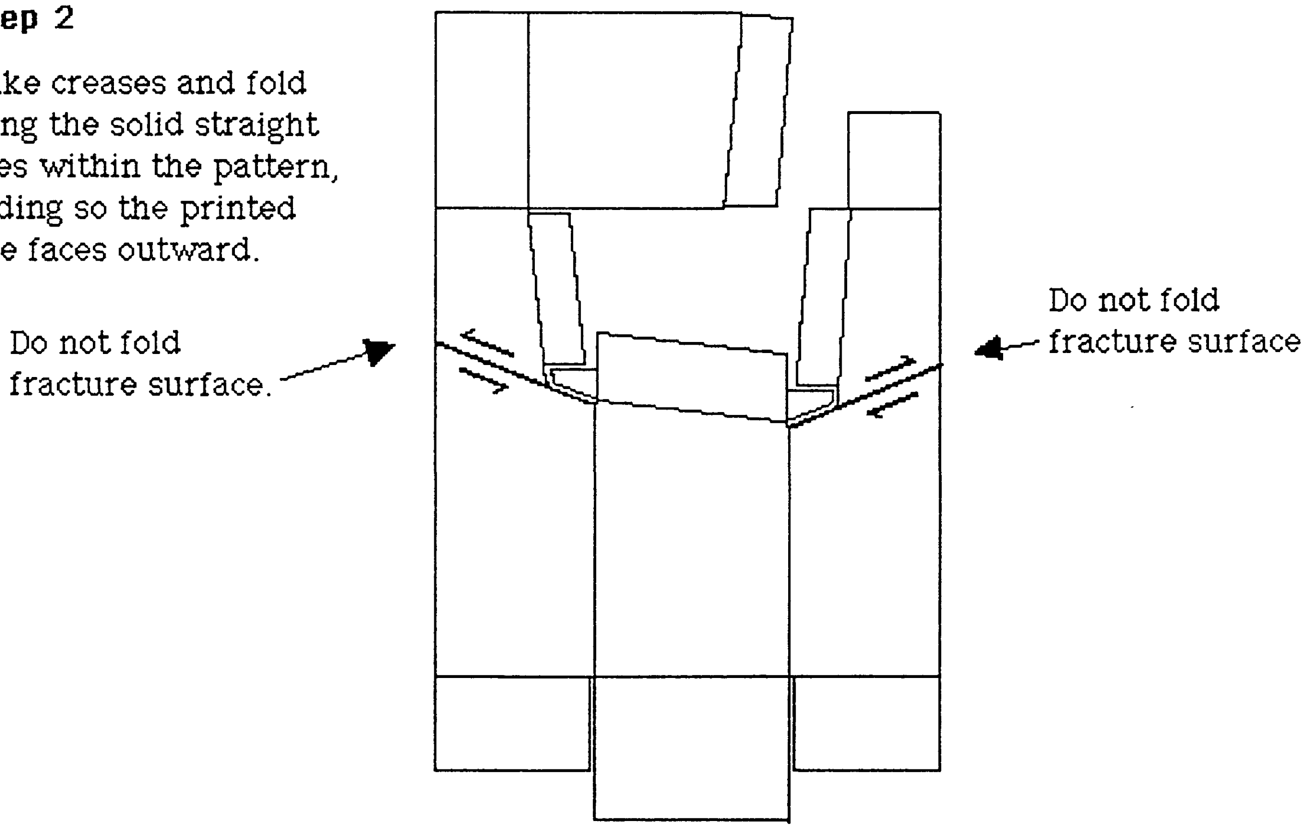
Step 1

Cut out the pattern of the paper landform by cutting along its borders.



Step 2

Make creases and fold along the solid straight lines within the pattern, folding so the printed side faces outward.



Normal fault instructions

Step 3

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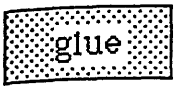
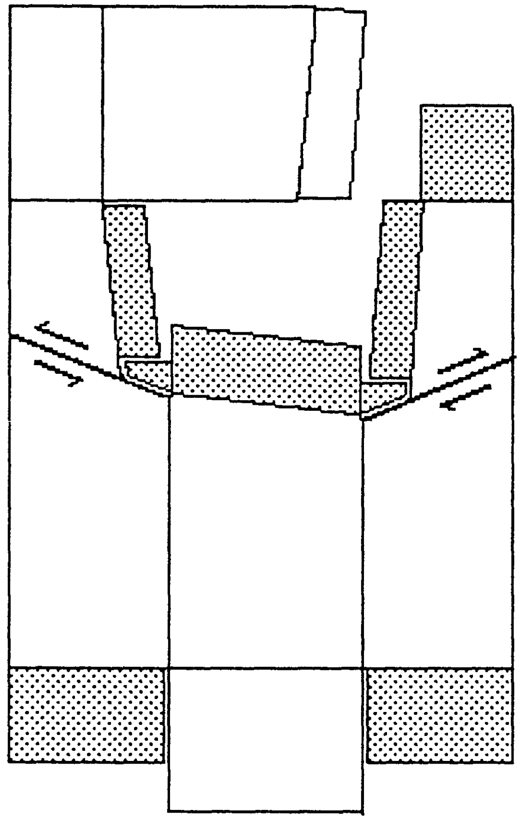
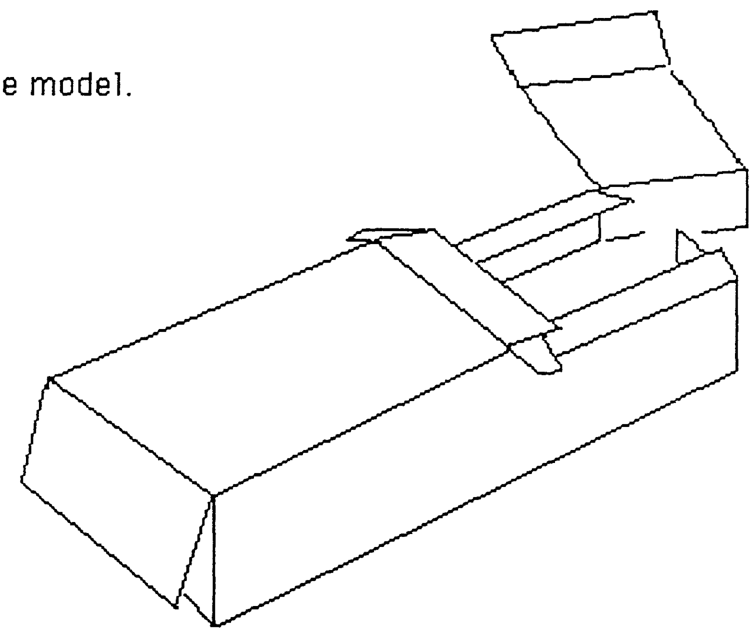




Step 4 Assembling the model.



Normal fault instructions

Step 5

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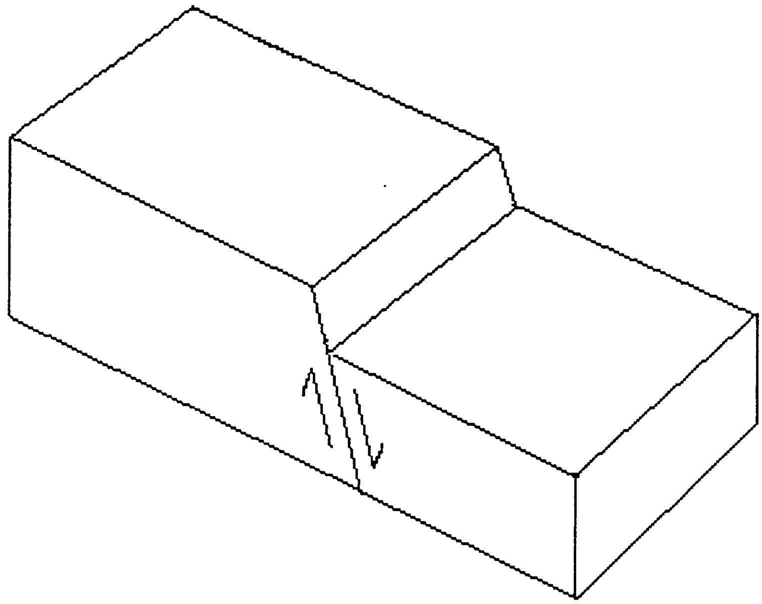
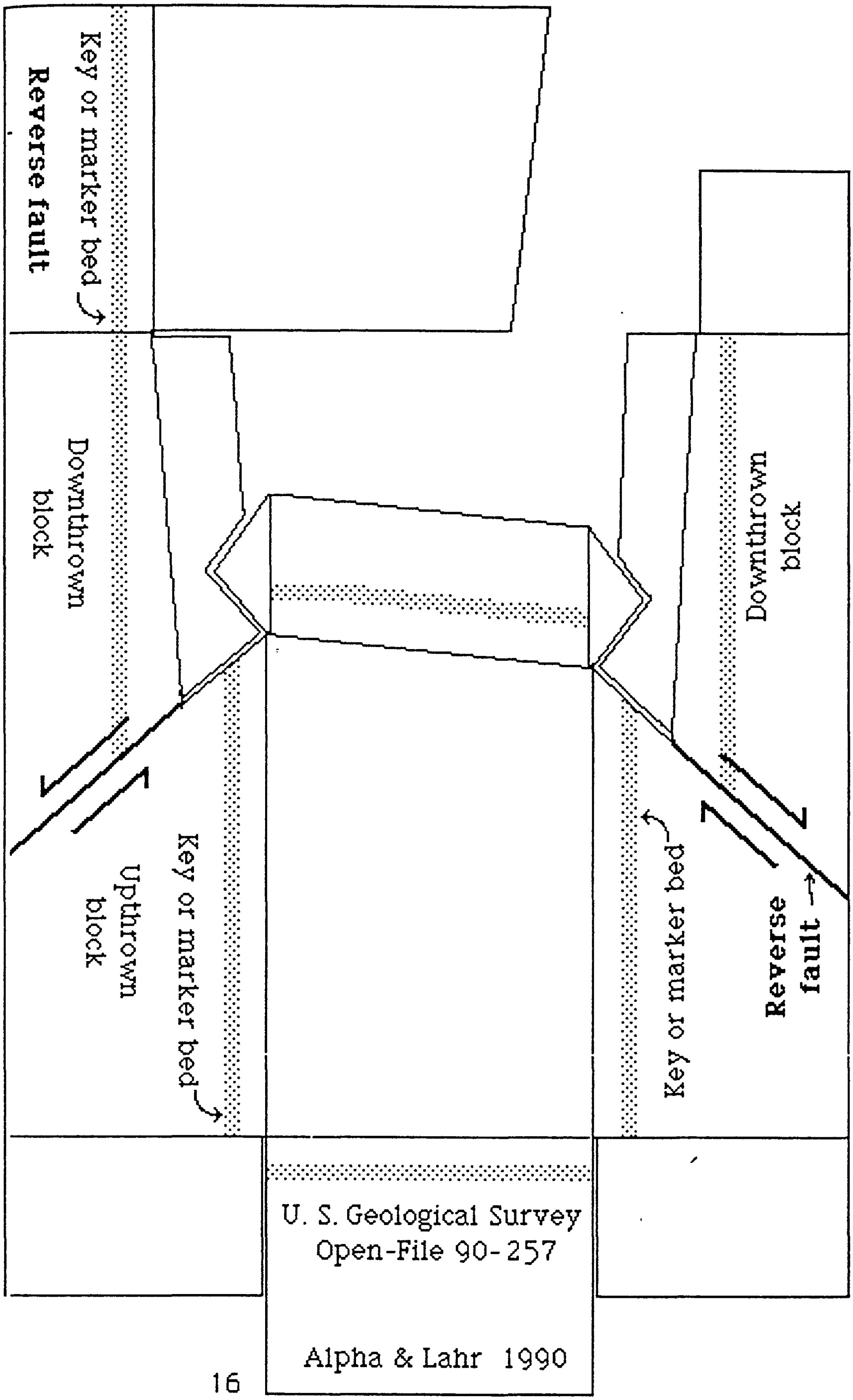


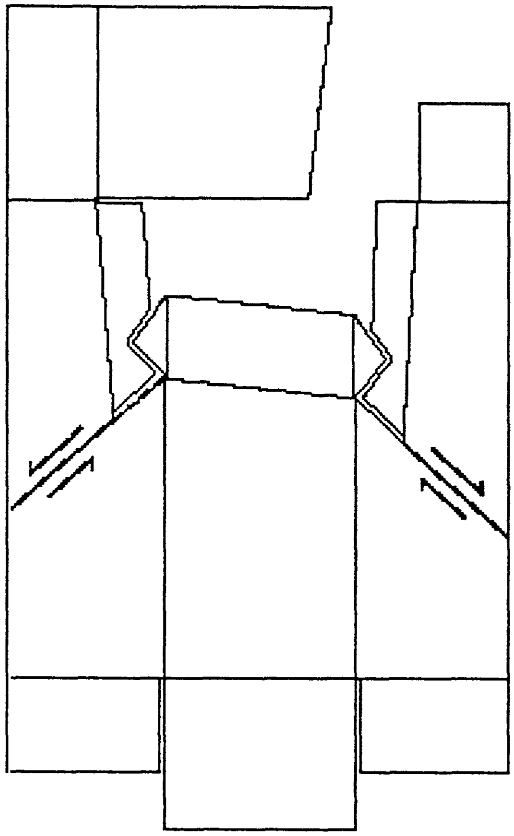
Reverse fault



Reverse fault instructions

Step 1

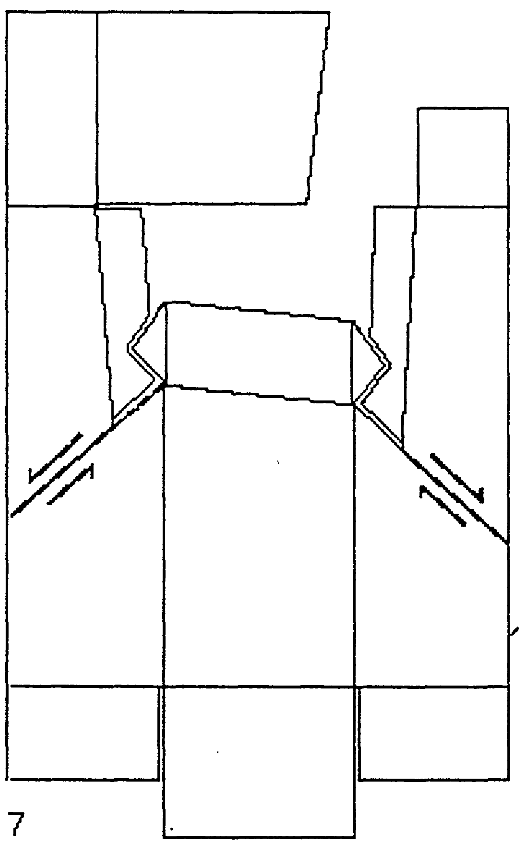
Cut out the pattern of the paper landform by cutting along its borders.



Step 2

Make creases and fold along the solid straight lines within the pattern, folding so the printed side faces outward.

Do not fold fracture surface.



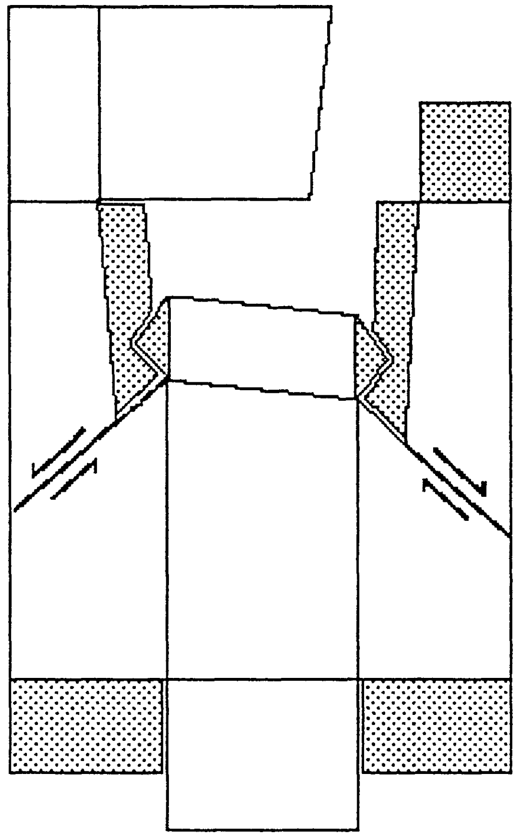
Do not fold fracture surface.

Reverse fault instructions

Step 3

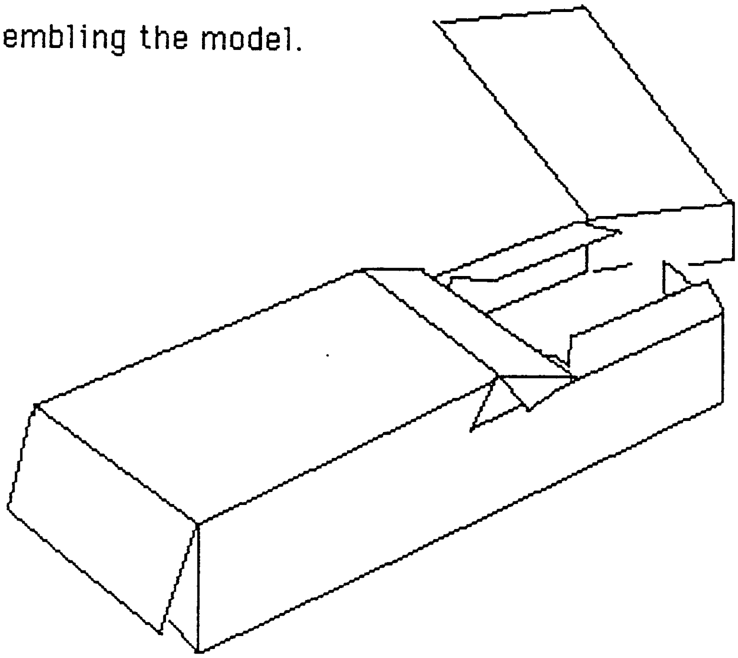
Glue the marked tabs.

glue



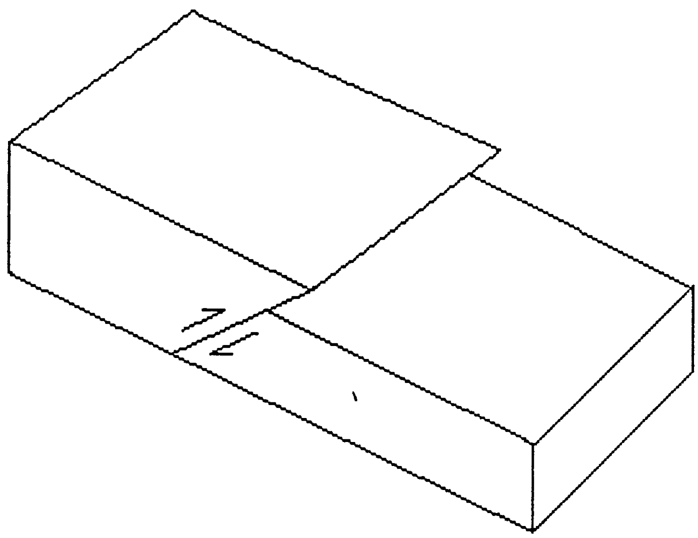
Reverse fault instructions

Step 4 Assembling the model.

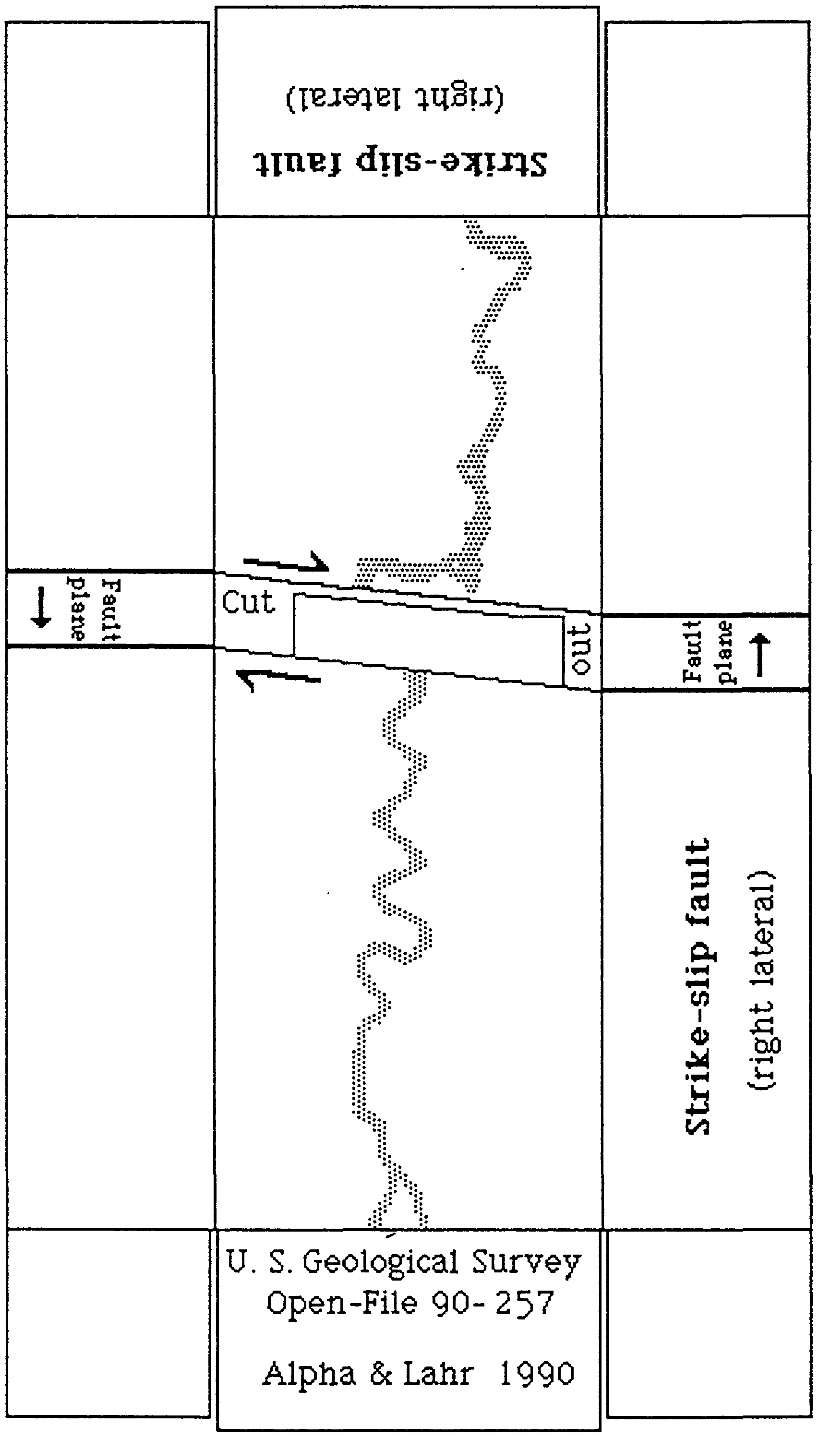


Step 5

The assembled model should look like this.



Strike-slip fault (right lateral) pattern

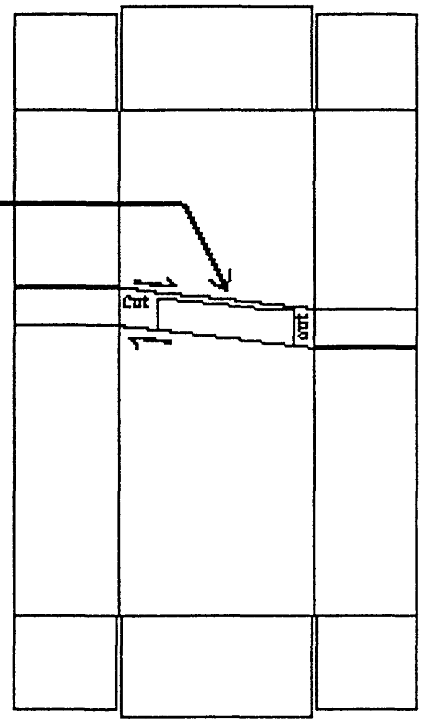


Strike-slip fault (right lateral) instructions

Step 1

Cut out the pattern of the paper landform by cutting along its borders.

Cut out this shape

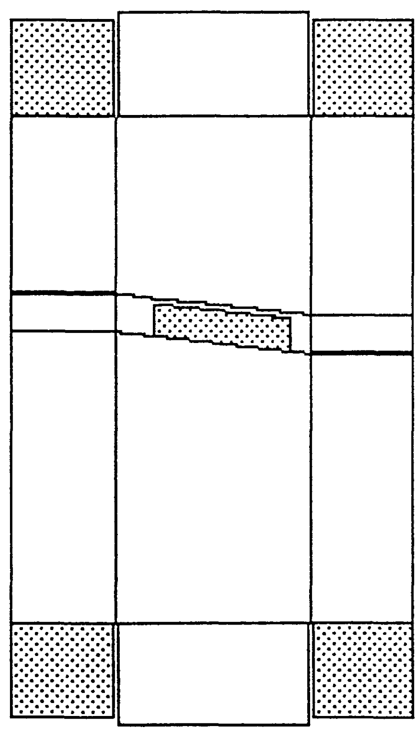


Step 2

Make creases and fold along the solid straight lines within the pattern, folding so the printed side faces outward.

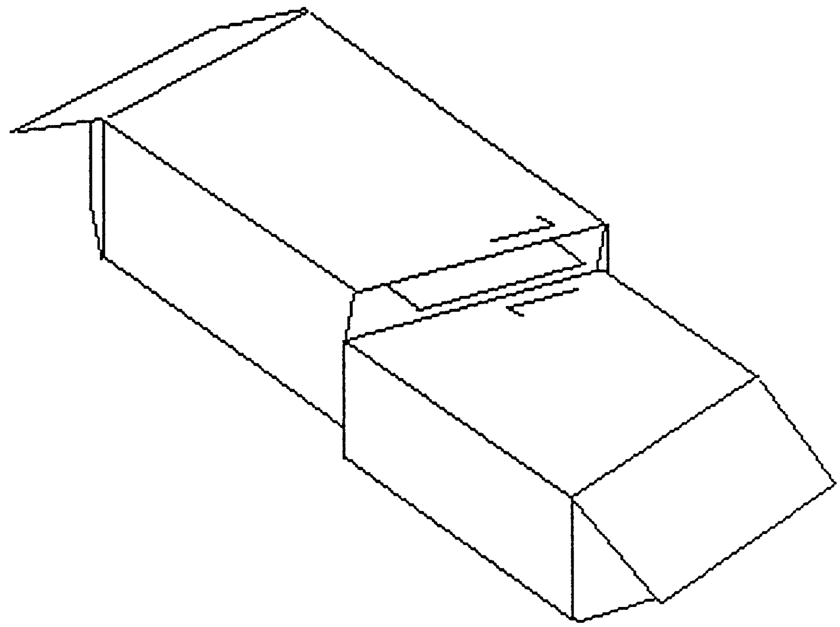
Step 3

Glue the marked tabs.

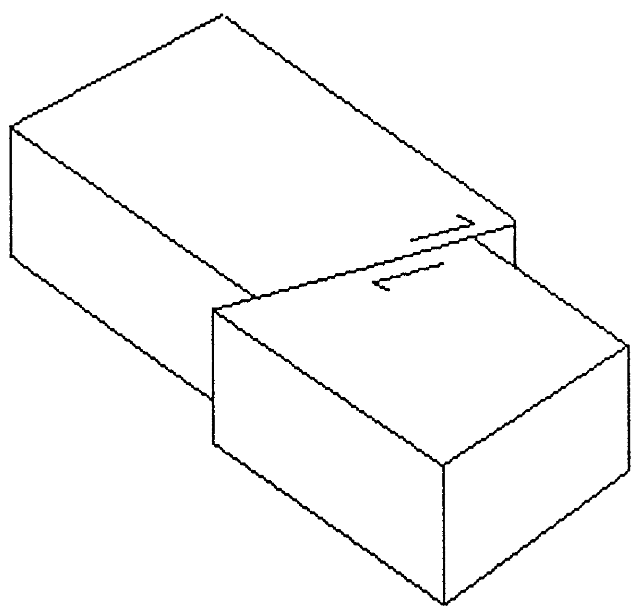


Strike-slip fault (right lateral) instructions

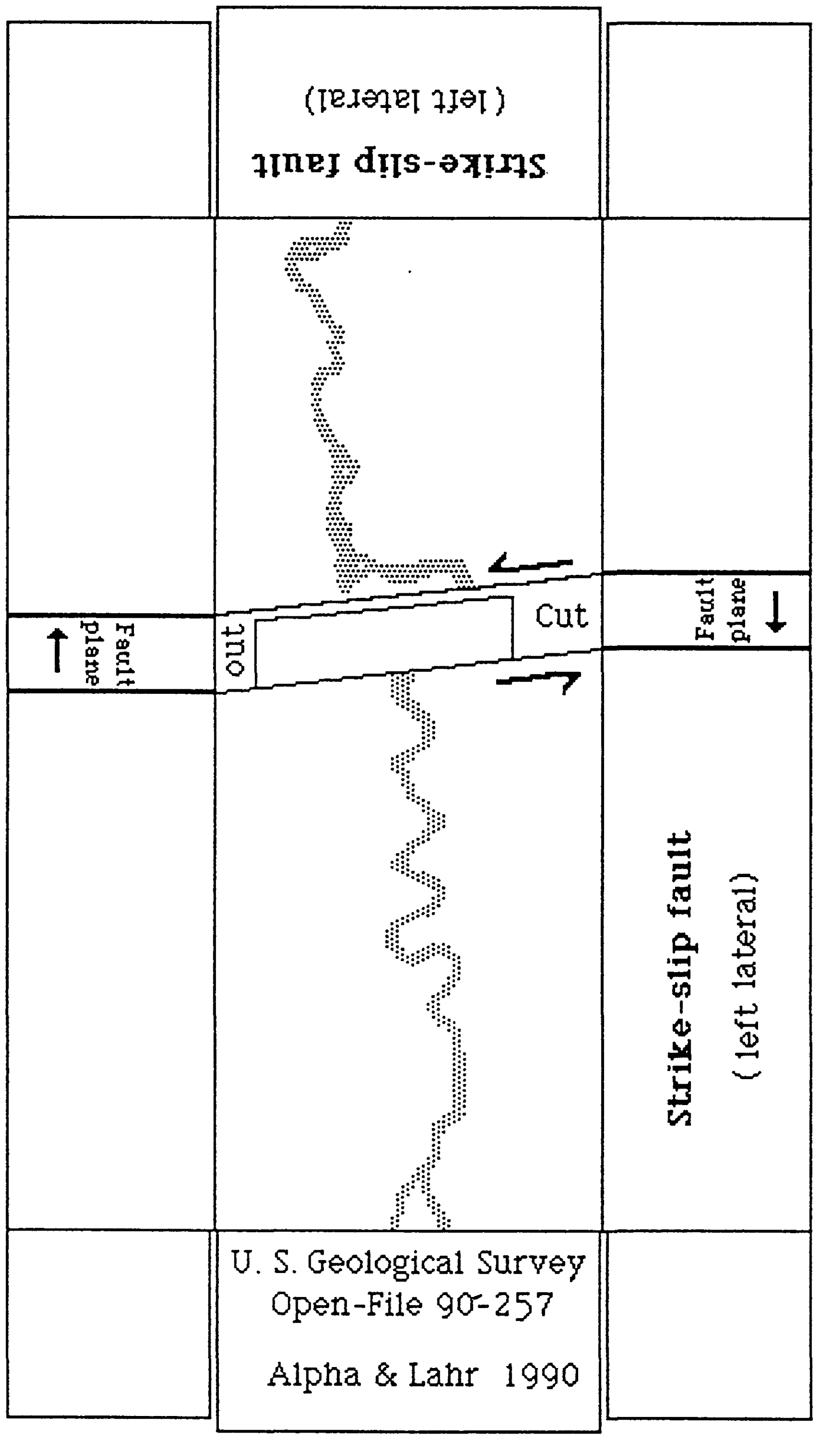
Step 4 Assembling the model.



Step 5 The assembled model should look like this.



Strike-slip fault (left lateral) pattern

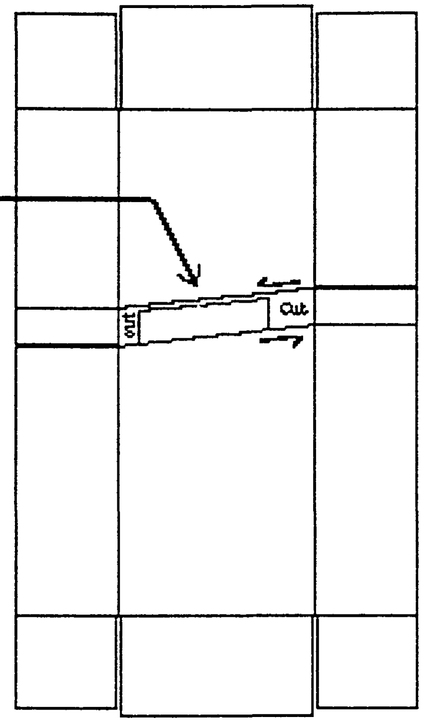


Strike-slip fault (left lateral) instructions

Step 1

Cut out the pattern of the paper landform by cutting along its borders.

Cut out this shape

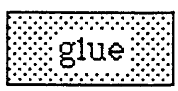


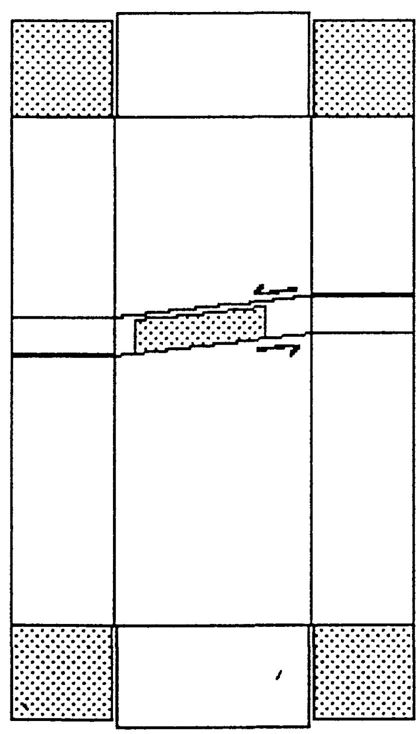
Step 2

Make creases and fold along the solid straight lines within the pattern, folding so the printed side faces outward.

Step 3

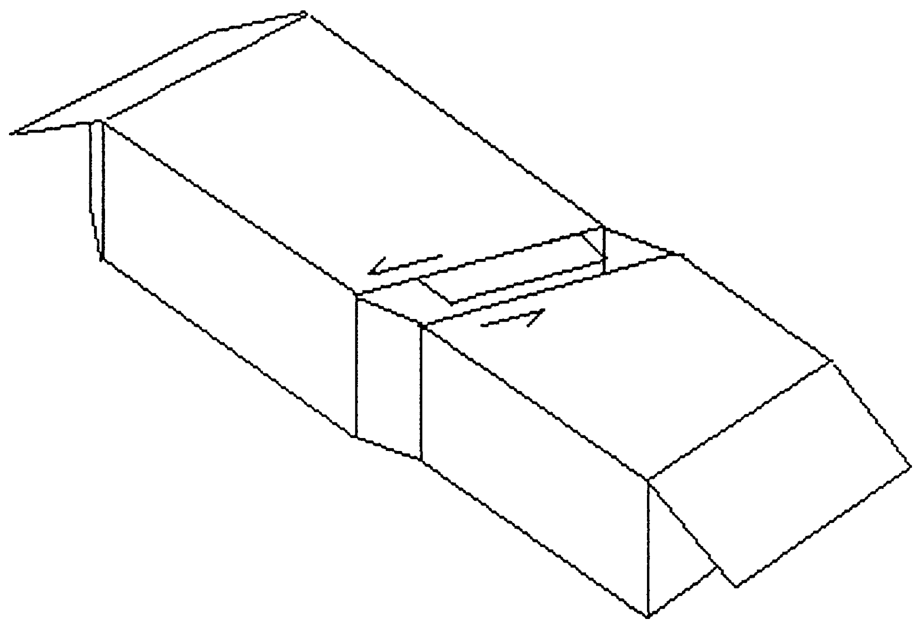
Glue the marked tabs.





Strike-slip fault (left lateral) instructions

Step 4 Assembling the model.



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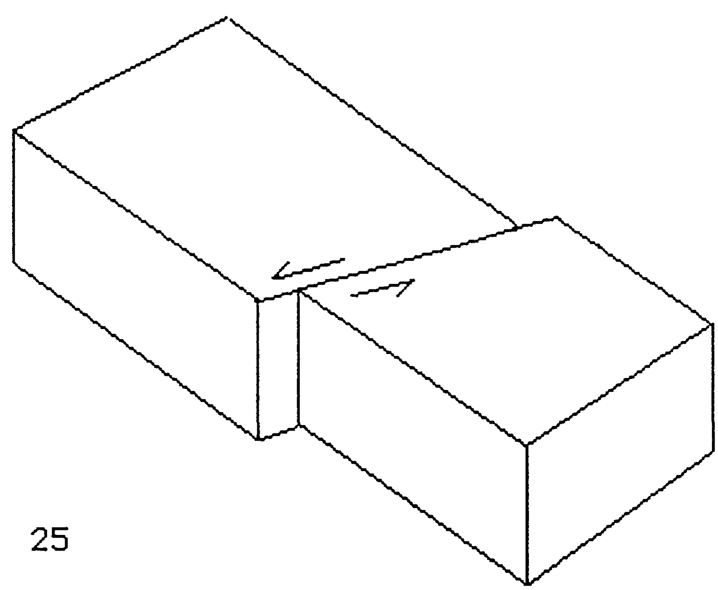
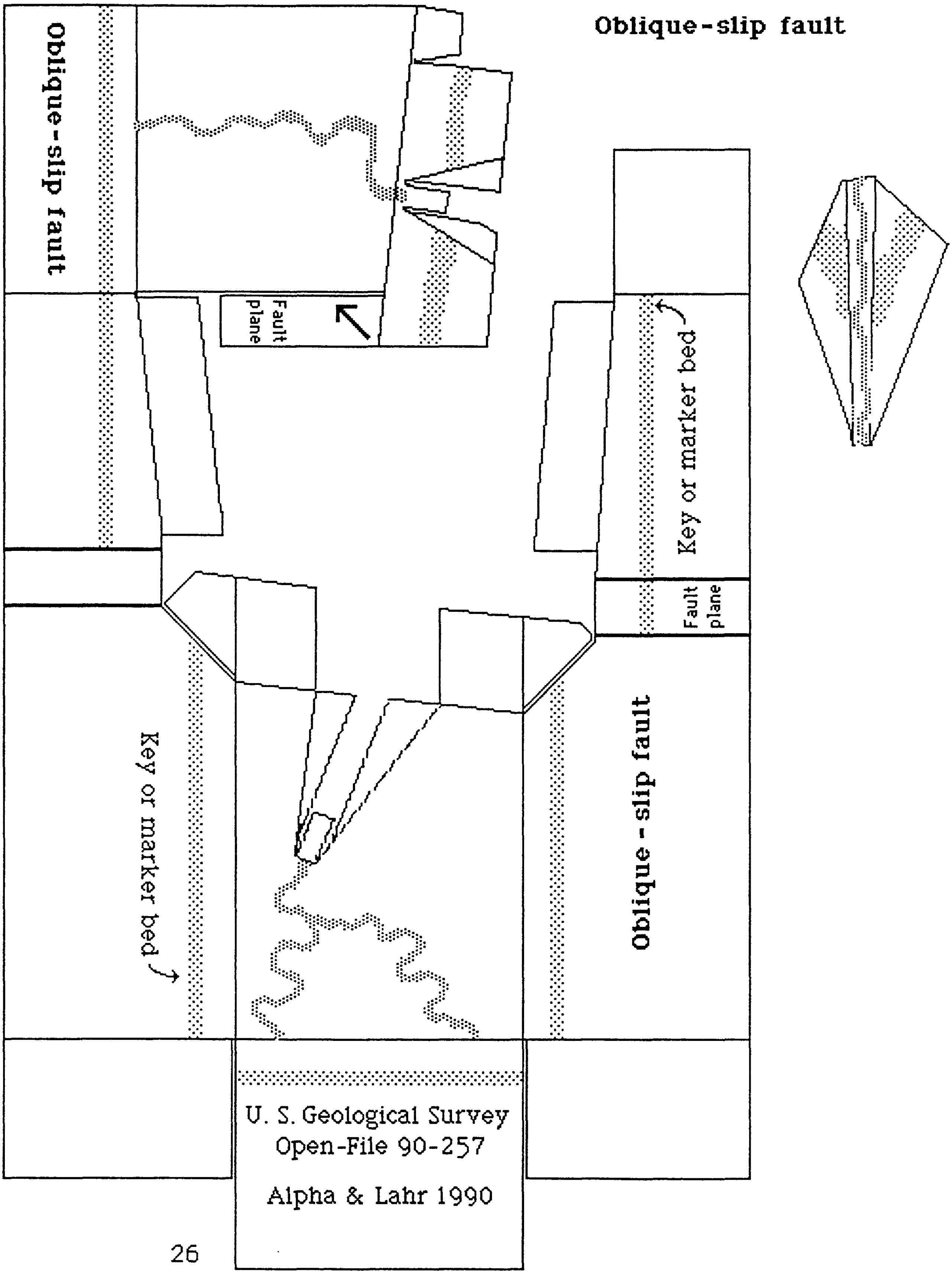
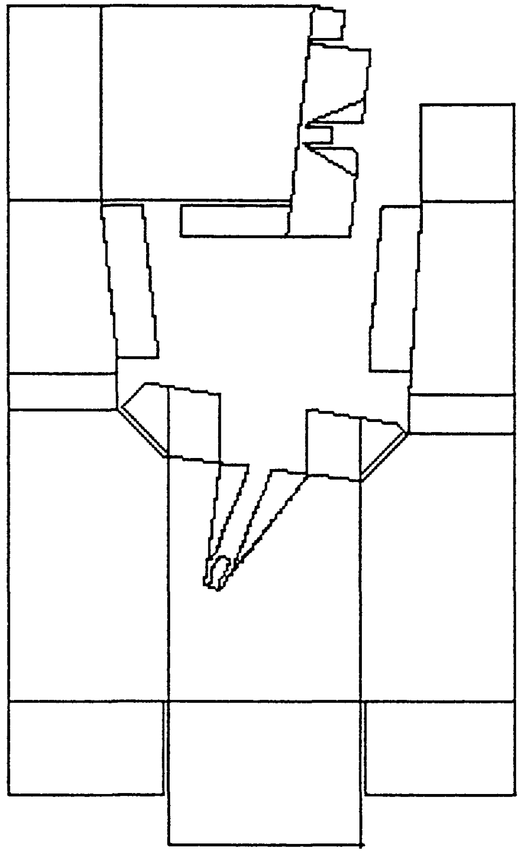


Oblique-slip fault



Oblique-slip fault instructions



Step 1

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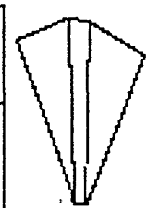
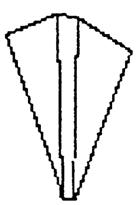
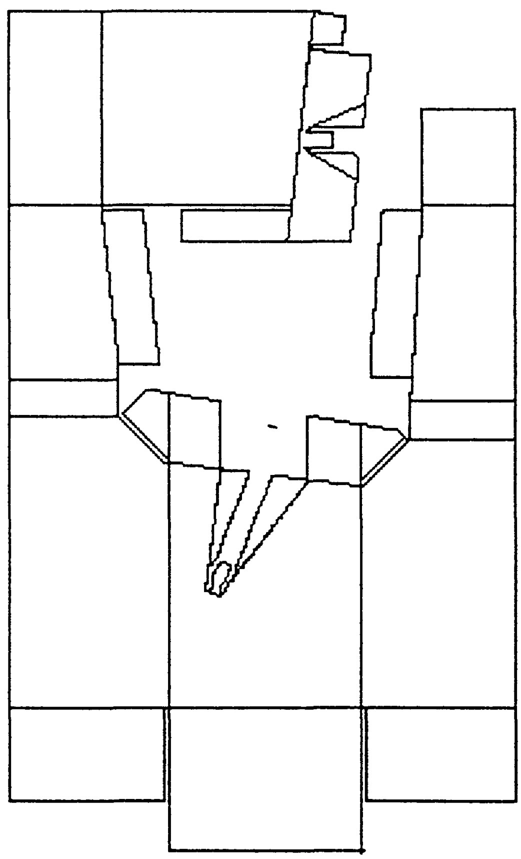


Step 2

Make creases and fold along the solid straight lines within the pattern, folding so the printed side faces outward.



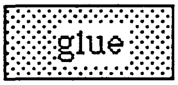
Fold gully in.

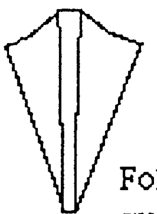


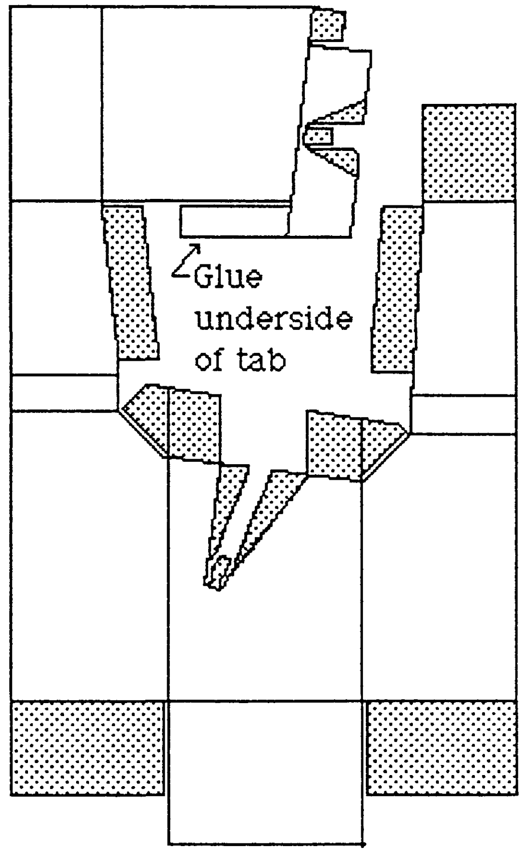
Oblique-slip fault instructions

Step 3

Glue the marked tabs.

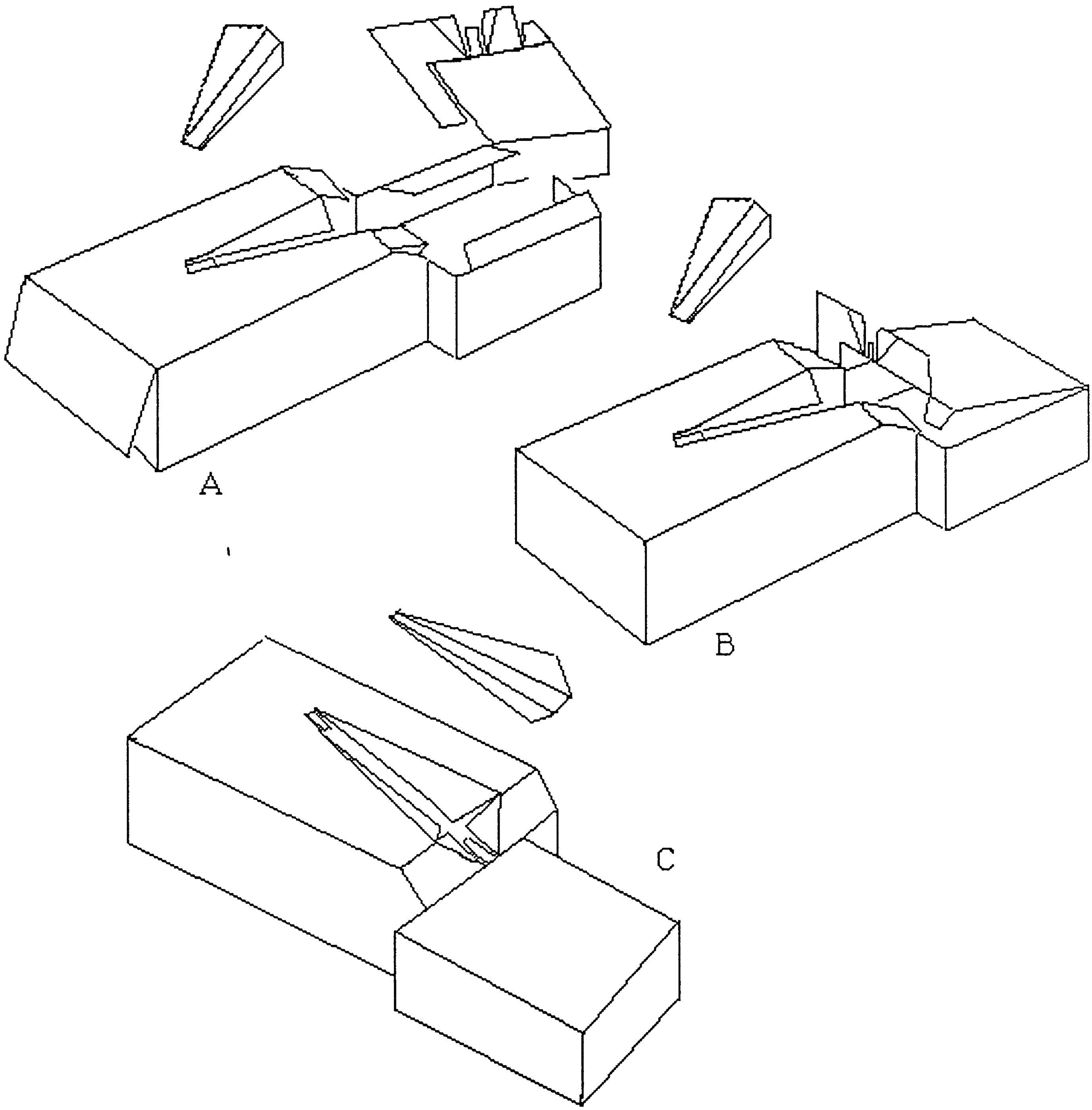






Oblique-slip fault instructions

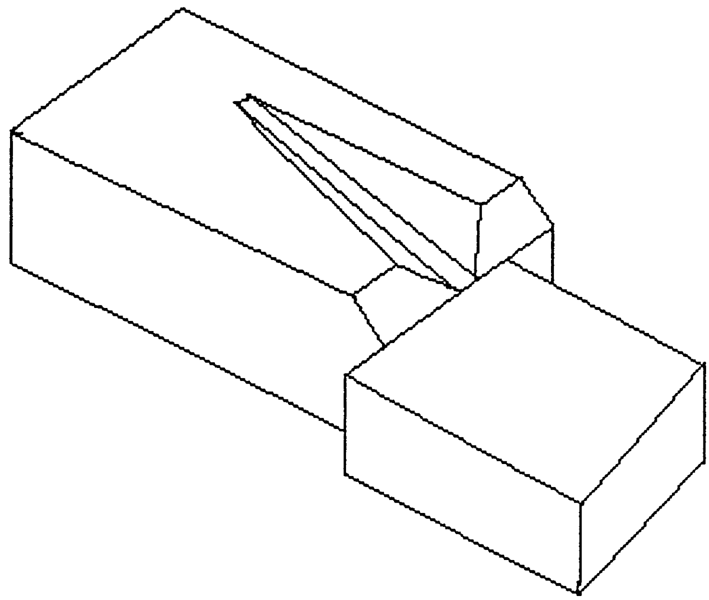
Step 4 Assembling the model.



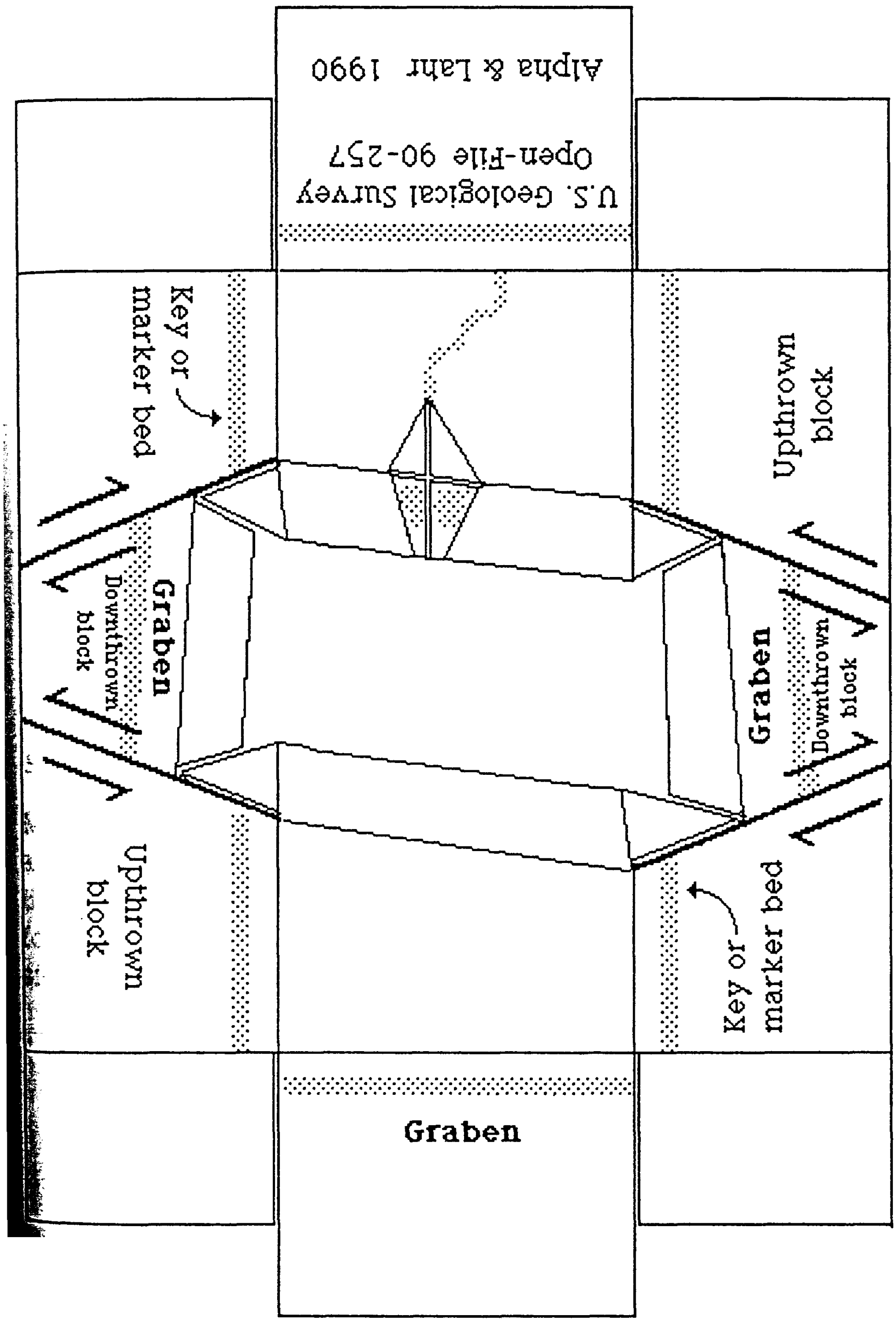
Oblique-slip fault instructions

Step 5

The assembled model should look like this.



Graben


Alpha & Lahr 1990
Open-File 90-257
U.S. Geological Survey
Key or marker bed
Upthrown block
Graben
Downthrown block
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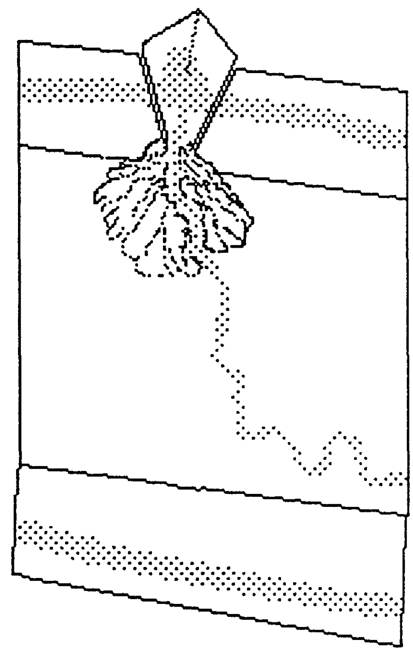
Downthrown block
Upthrown block
Key or marker bed
Graben



Graben instructions

Step 1

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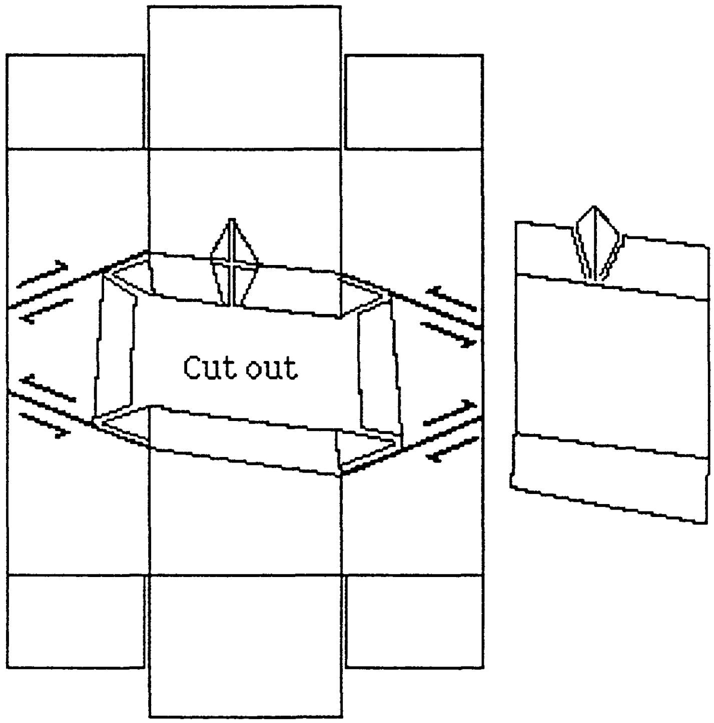
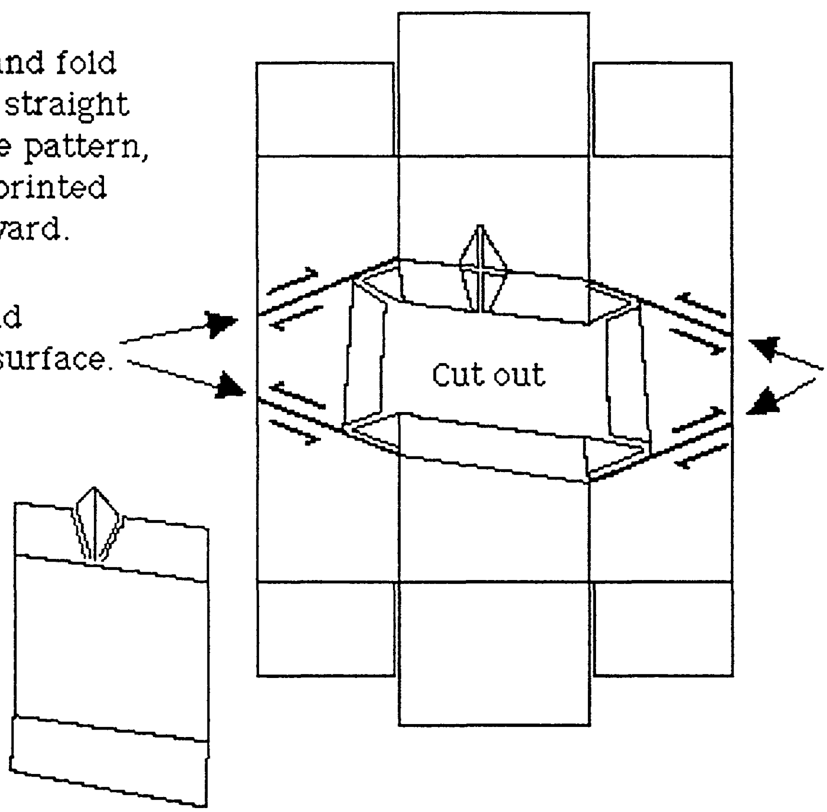


Step 2

Make creases and fold along the solid straight lines within the pattern, folding so the printed side faces outward.

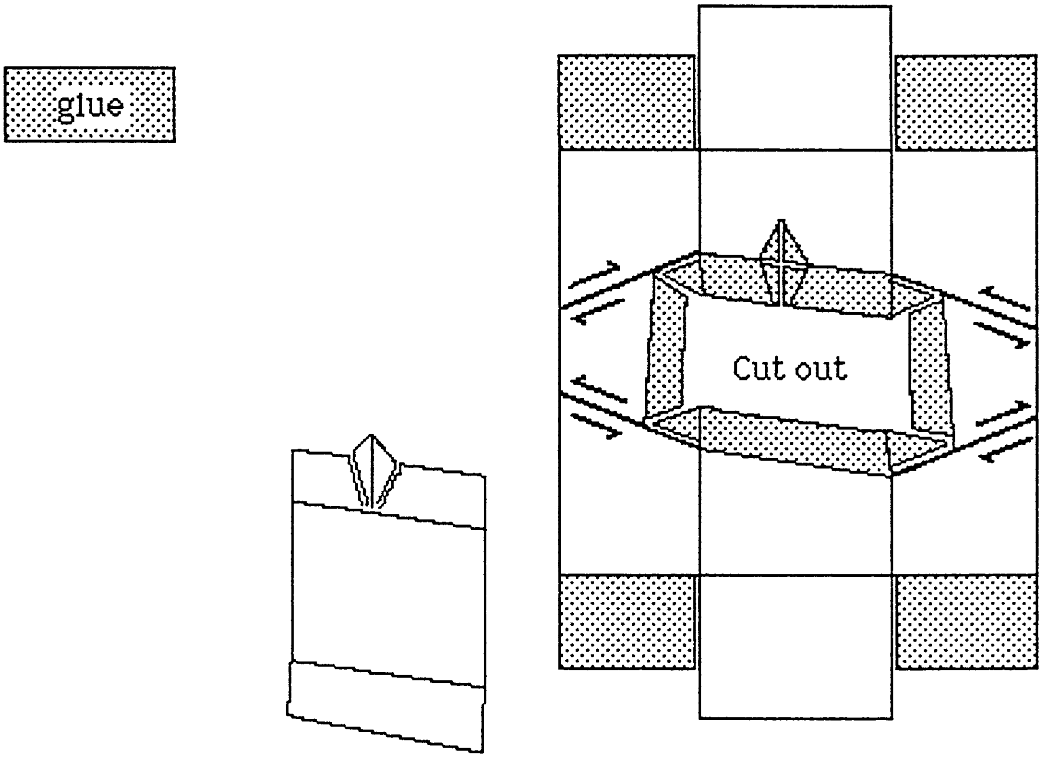
Do not fold fracture surface.



Do not fold fracture surface.

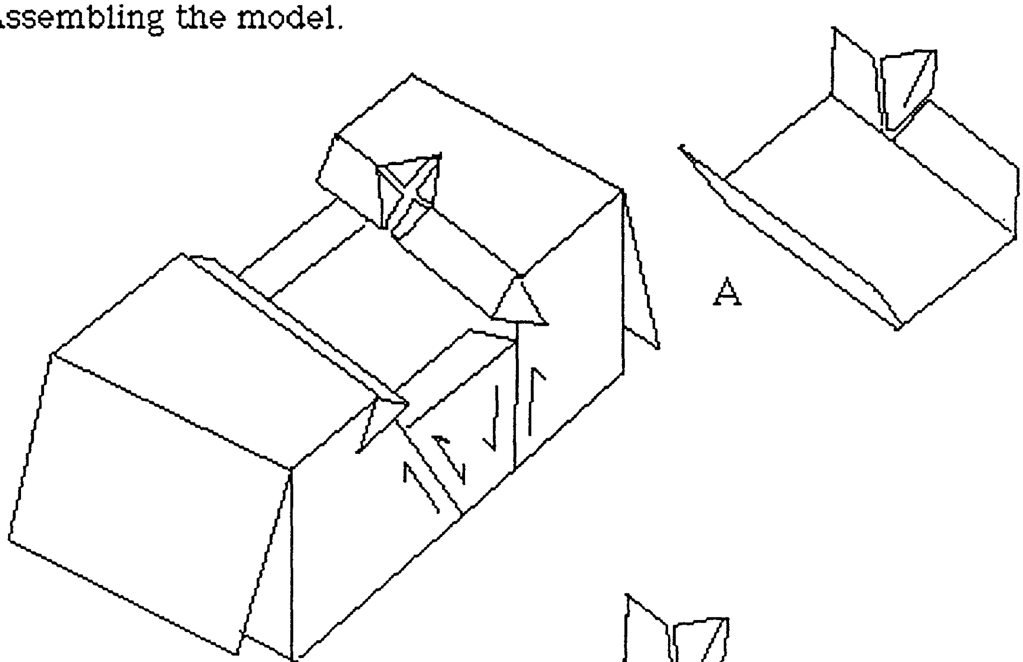
Step 3

Glue the marked tabs.



Graben instructions

Step 4 Assembling the model.



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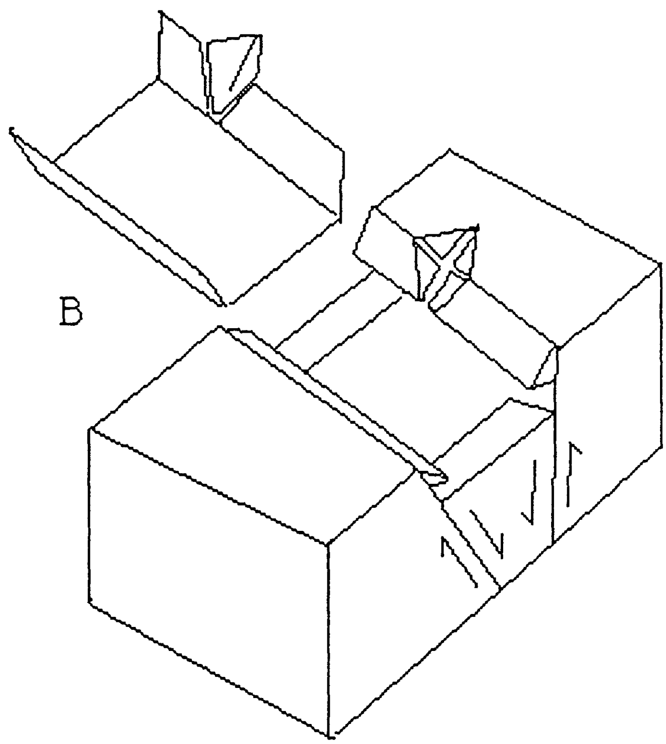
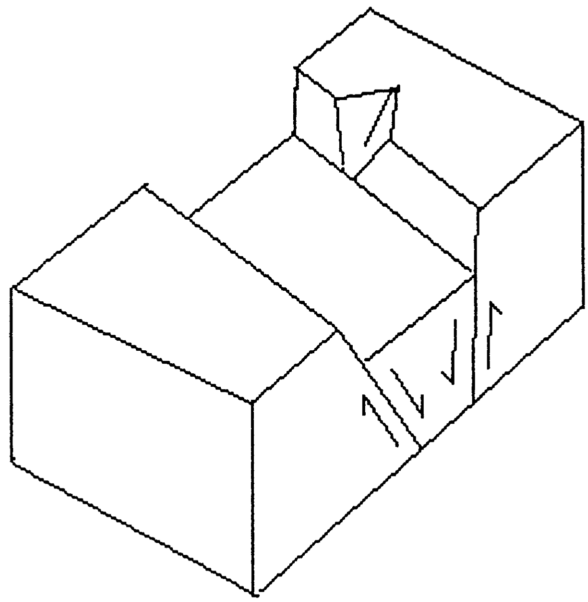


B

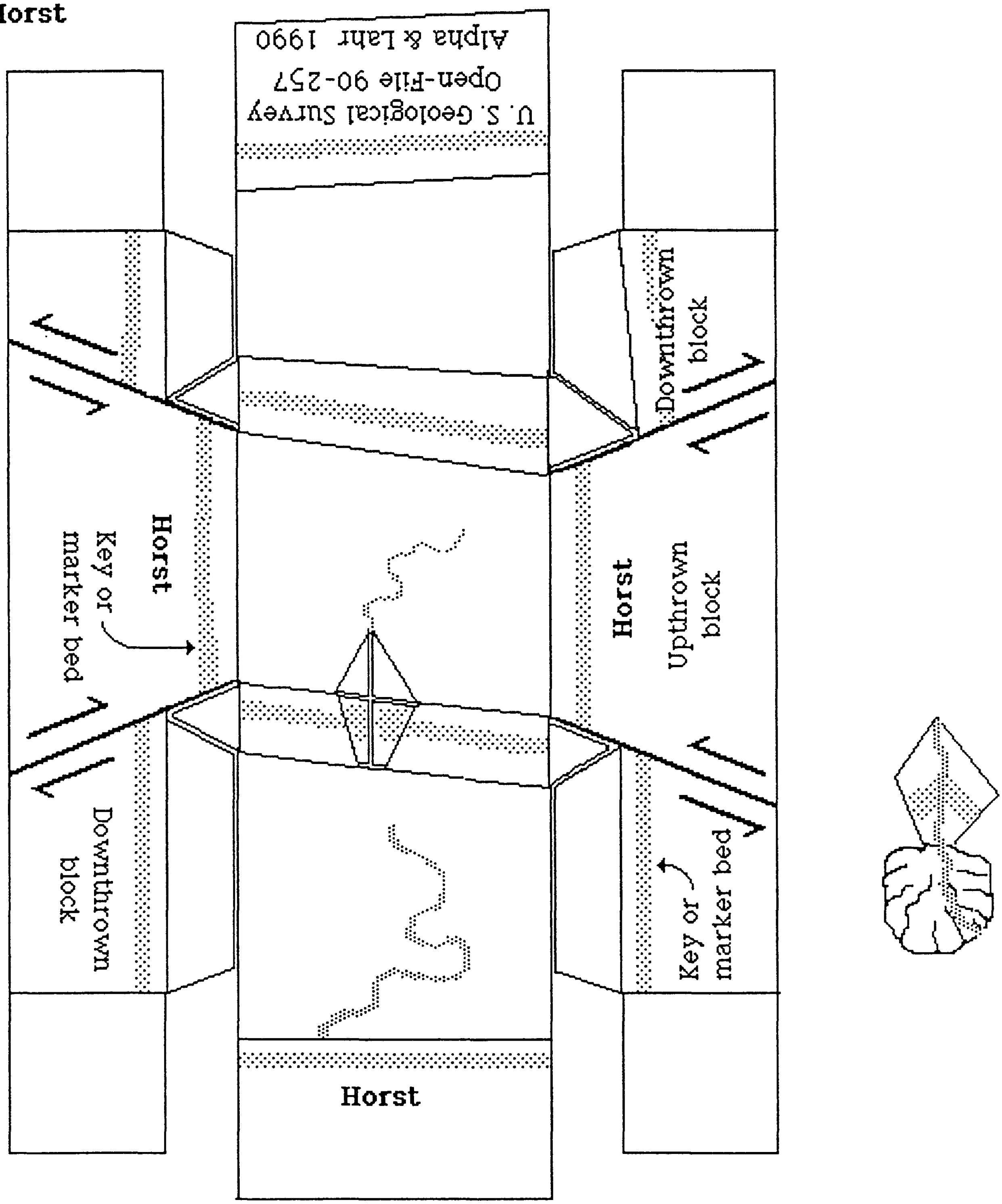
Graben instructions

Step 5

The assembled model should look like this.



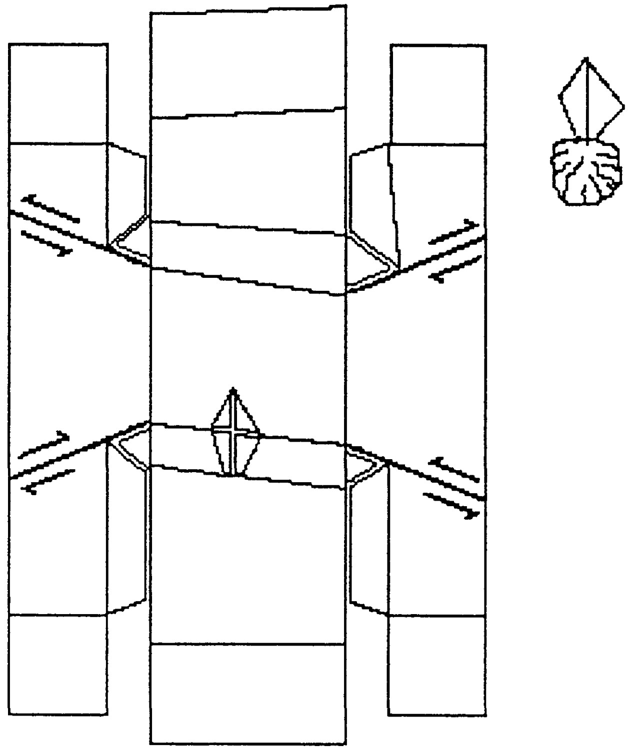
Horst


U. S. Geological Survey
Open-File 90-257
Alpha & Lahr 1990
Horst
Key or marker bed
Downthrown block
Horst
Upthrown block
Downthrown block
Key or marker bed
Horst

Horst instructions

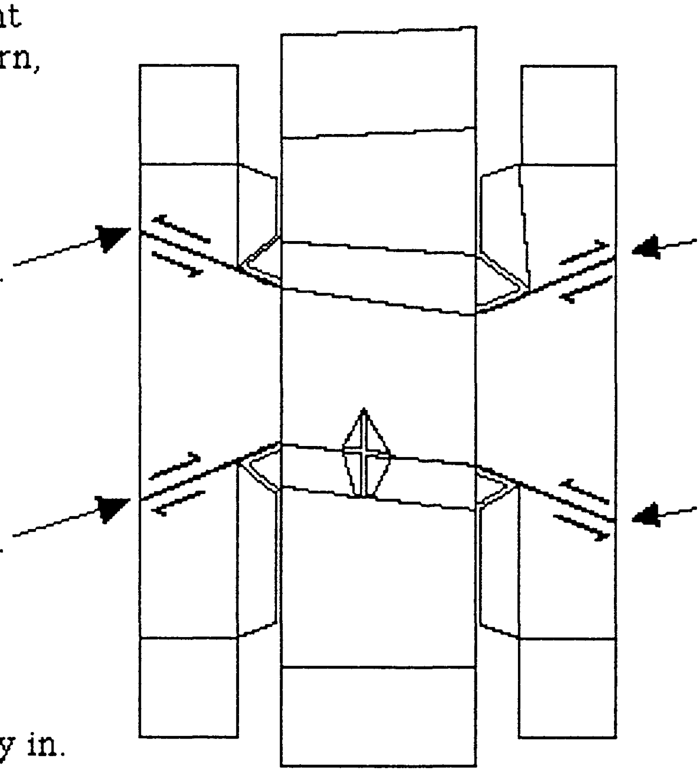
Step 1

Cut out the pattern of the paper model by cutting along its borders.

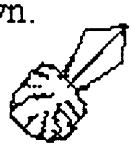


Step 2

Make creases and fold along the solid straight lines within the pattern, folding so the printed side faces outward.



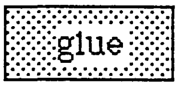
Fold gully as shown.

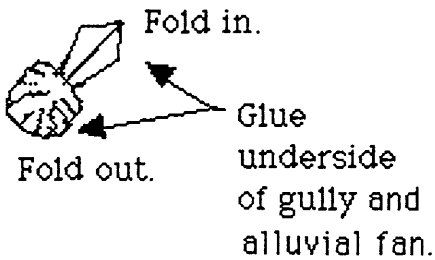


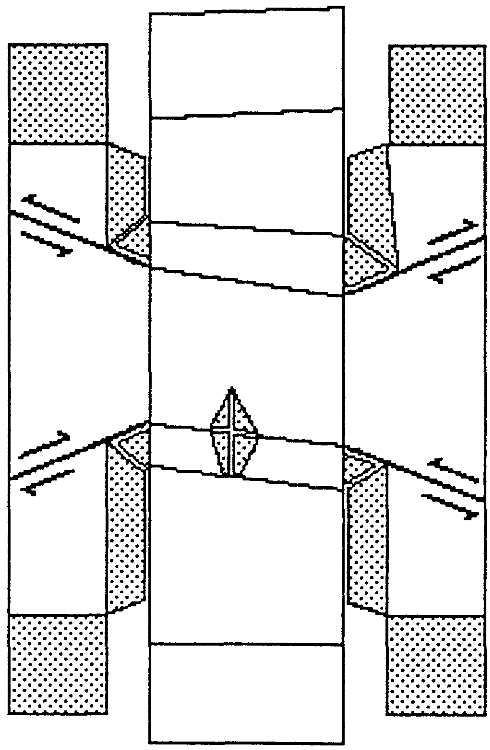
Horst instructions

Step 3

Glue the marked tabs.

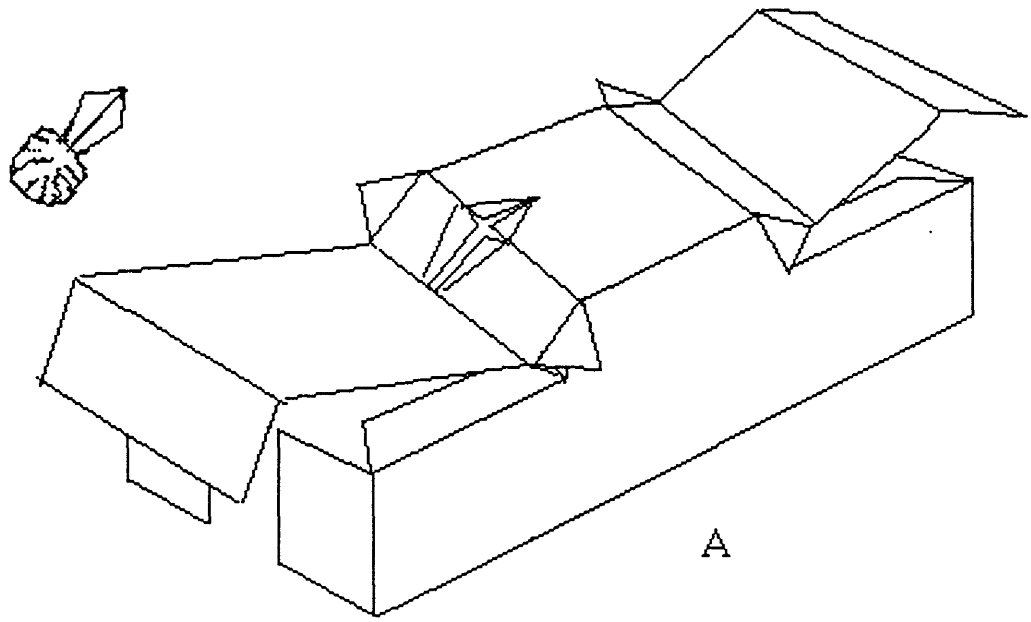




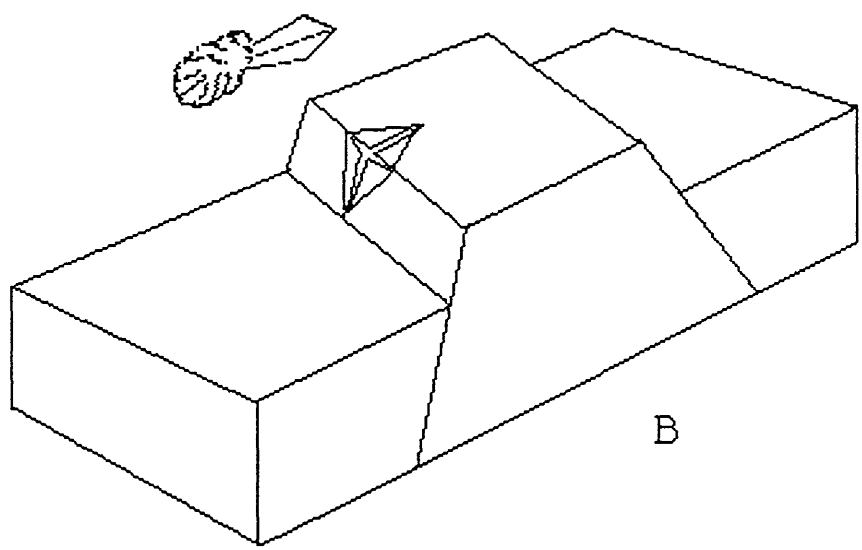


Horst instructions

Step 4 Assembling the model.

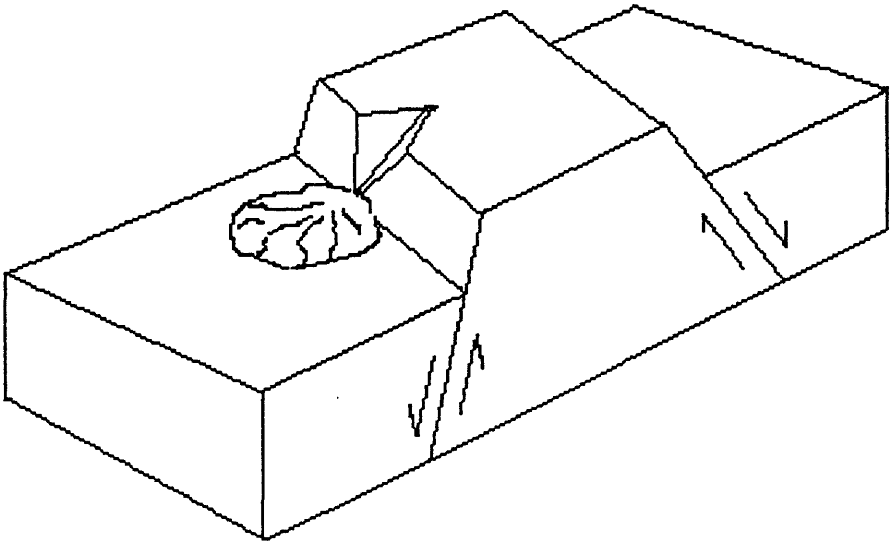


A



B

Step 5 The assembled model should look like this.



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The End