DOCUMENT RESUME

ED 216 910 SE 038 114

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TITLE Locating Active Plate Boundaries by Earthquake Data. Crustal Evaluation Education Project. Teacher's Guide [and] Student Investigation.
INSTITUTION National Association of Geology Teachers.
SPONS AGENCY National Science Foundation, Washington, D.C.
REPORT NO CEEP-MOD-TX5-1-4; ISBN-0-89873-034-1; ISBN-89873-035-x
PUB DATE 79
GRANT SED-75-20151; SED-77-08539; SED-78-25104
NOTE 20p.
AVAILABLE FROM Ward's Natural Science Establishment, Inc., P.O. Box 1712, Rochester, NY 14603 (or P.O. Box 1749, Monterey, CA 93940.)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS *Earth Science; Geology; Instructional Materials; Oceanography; *Science Activities; *Science Course Improvement Projects; Science Curriculum; Science Education; Science Instruction; Secondary Education; *Secondary School Science; *Seismology; Teaching Guides; Teaching Methods
IDENTIFIERS *Crustal Evolution Education Project; Earthquakes; National Science Foundation; *Plate Tectonics

ABSTRACT

Crustal Evolution Education Project (CEEP) modules were designed to: (1) provide students with the methods and results of continuing investigations into the composition, history, and processes of the earth's crust and the application of this knowledge to man's activities and (2) to be used by teachers with little or no previous background in the modern theories of sea-floor spreading, continental drift, and plate tectonics. Each module consists of two booklets: a teacher's guide and student investigation. The teacher's guide contains all of the information present in the student investigation booklet as well as: (1) a general introduction; (2) prerequisite student background; (3) objectives; (4) list of required materials; (5) background information; (6) suggested approach; (7) procedure, including number of 45-minute class periods required; (8) summary questions (with answers); (9) extension activities; and (10) list of references. Students prepare a strip map in this 2-3 period activity during which they mark the edges of plate boundaries using earthquake data, identify the kind of pattern that earthquake zones show on the earth's surface, and explain why earthquakes occur more frequently in some places than others. (Author/JN)

NAGT Crustal Evolution Education Project

Edward C. Stoever, Jr., Project Director

Welcome to the exciting world of current research into the composition history and processes of the earth's crust and the application of this knowledge to man's activities. The earth sciences are currently experiencing a dramatic revolution in our understanding of the way in which the earth works. CEEP modules are designed to bring into the classroom the methods and results of these continuing investigations. The Crustal Evolution Education Project began work in 1974 under the auspices of the National Association of Geology Teachers. CEEP materials have been developed by teams of science educators, classroom teachers, and scientists. Prior to publication, the materials were field tested by more than 200 teachers and over 12,000 students. Current crustal evolution research is a breaking story that students are living through today.

Teachers and students alike have a unique opportunity through CEEP modules to share in the unfolding of these educationally important and exciting advances. CEEP modules are designed to provide students with appealing firsthand investigative experiences with concepts which are at or close to the frontiers of scientific inquiry into plate tectonics. Furthermore, the CEEP modules are designed to be used by teachers with little or no previous background in the modern theories of sea-floor spreading, continental drift and plate tectonics.

We know that you will enjoy using CEEP modules in your classroom. Read on, and be prepared to experience a renewed enthusiasm for teaching as you learn more about the living earth in this and other CEEP modules.

About CEEP Modules...

Most CEEP modules consist of two booklets, a Teacher's Guide and a Student Investigation. The Teacher's Guide contains all the information and illustrations in the Student Investigation, plus sections printed in color intended only for the teacher, as well as answers to the questions that are included in the Student Investigation. In some modules, there are illustrations that appear only in the Teacher's Guide, and these are designated by figure letters instead of the number sequence used in the Student Investigation.

For some modules, maps, rulers, and other common classroom materials are needed, and in varying quantities according to the method of presentation. Read over the module before scheduling its use in class, and refer to the list of MATERIALS in the module.

Each module is individual and self-contained in content, but some are divided into two or more parts for convenience. The recommended length of time for each module is indicated. Some modules require prerequisite knowledge of some aspects of basic earth science; this is noted in the Teacher's Guide.

The material was prepared with the support of National Science Foundation Grant Nos. SED 75-20151, SED 77-08539 and SED 78-25104. However, any opinions, findings, conclusions or recommendations expressed herein are those of the author(s) and do not necessarily reflect the views of NSF.

In order to comply with U.S. Public Law 94-86, every school district in the U.S.A. using these materials agrees to make them available for inspection by parents or guardians of children engaged in educational programs or projects of the school district.

Locating Active Plate Boundaries By Earthquake Data

INTRODUCTION

This module is designed so that students can apply earthquake location data to find plate boundaries. In some respects this is a discovery activity because the students do not know how many plates there are until they mark the boundaries.

Why do some places on the earth have more earthquakes than others? To find out where earthquakes occur, geologists use a special machine called a seismograph (an instrument which records earthquake vibrations). Seismographs help geologists decide if the earthquake occurred in China or Alaska or California or Missouri. It is known that earthquakes occur more often in some places than others.

Many geologists believe they know why earthquakes occur more often in California than in Texas. They think the earth's crust is divided into huge plates. These plates fit together like a huge jig-saw puzzle. Information from seismograph records shows that most earthquakes occur along the edges of plates.

PREREQUISITE STUDENT BACKGROUND

The students will need to be familiar with the following words: earthquake, plate tectonics, trench and ridge.

OBJECTIVES

After you have completed this activity, you should be able to:

1. Mark the edges of plate boundaries using earthquake data
2. Identify the kind of pattern that earthquake zones show on the earth's surface
3. Explain why earthquakes occur more frequently in some places than others.

MATERIALS

Scissors—one pair for each student

Glue—one bottle for each group of students

Colored pencils—a set for each group of students

String (optional—see EXTENSION)

Map, *The Political World*, and map, *The Physical World*, National Geographic Society, Educational Services, Department 79, Washington, D.C. 20036—one of each map per class

BACKGROUND INFORMATION

Why do some areas have more earthquakes than others? According to the theory of plate tectonics, the earth's crust is divided into rigid plates of rock. The boundaries of these plates are commonly associated with geological activity, such as earthquakes, volcanism, and mountain-building. Plate boundaries are also associated with ocean trenches and ridges, island arcs, and subsurface gravity anomalies. Figure A shows the major plate boundaries. The exact locations of certain plate boundaries are the subject of debate.

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SUGGESTED APPROACH

A pre-activity class discussion (about 10 minutes) should include a brief introduction to the concept of plates. Students also should be familiar with the definitions of crust, trench, ridge, and earthquake. Briefly discuss the questions posed by the activity and the INTRODUCTION.

In a post-activity discussion, encourage the class to reach a consensus on the boundary locations by making use of *The Physical World* map. Stress the fact that not all geologists agree on the exact locations of some boundaries. Some students may have difficulty extrapolating boundaries where there are no earthquakes.

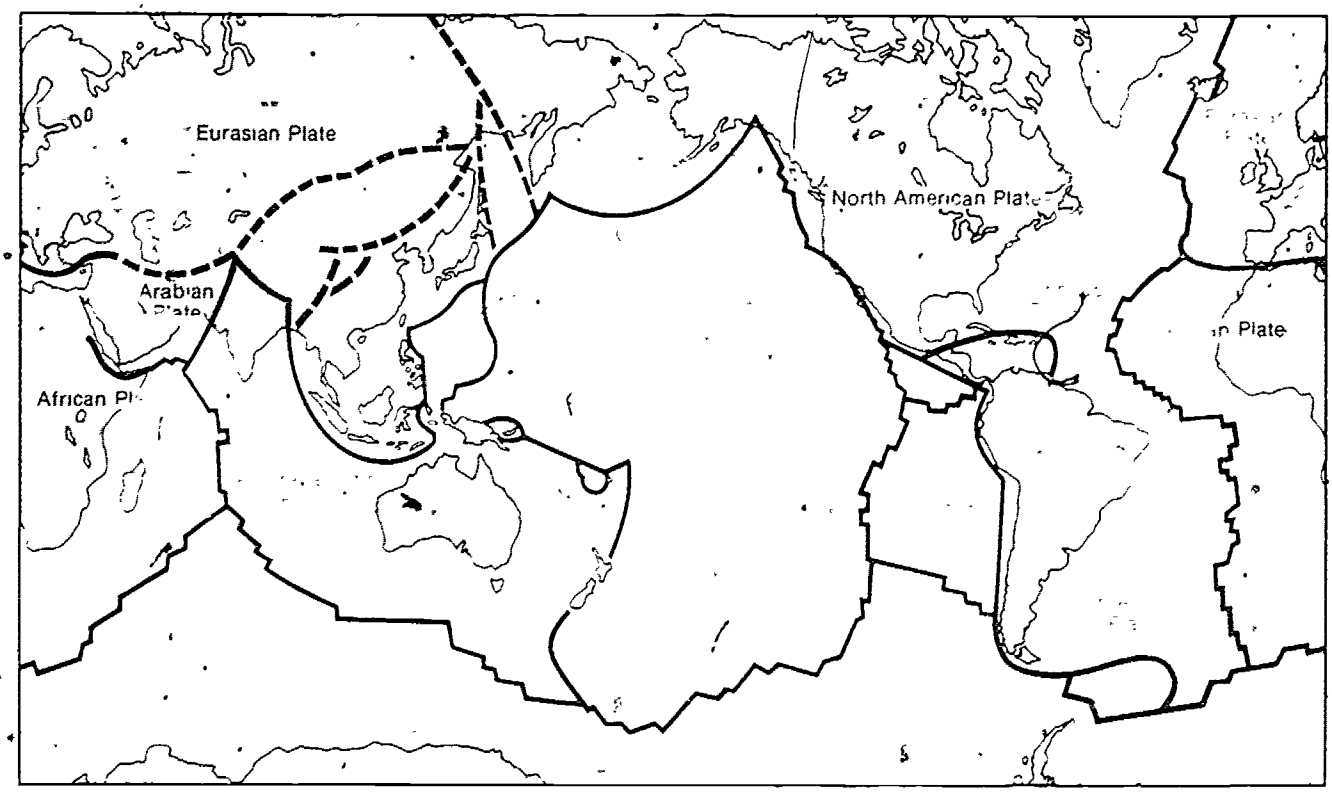


Figure A. Map showing proposed plate boundaries.

PROCEDURE

In this activity, the student will locate the boundaries of plates by relating them to the worldwide distribution of earthquakes.

Key word: seismograph

Time required: two to three 45-minute class periods, depending on whether the students color their maps.

Materials: scissors, glue, colored pencils, string (optional), map, *The Political World*, and map, *The Physical World*.

1. Five worksheets, labeled Panels 1-5, are located in the back of this module. Cut out all the panels carefully and place them on the table in front of you, in order, with Panel 1 on your left and Panel 2 to the right of it, etc.

If your students will not be doing the EXTENSION, direct them to skip Step 2. (However, see remarks under Step 7.)

2. Glue each panel onto a piece of heavy construction paper and cut out the construction paper along the edge of each panel.

3. Glue the panels to each other as shown in Figure 1. This will form a long strip map. Be sure that you glue Panel 1 to Panel 2 and Panel 2 to Panel 3, etc.

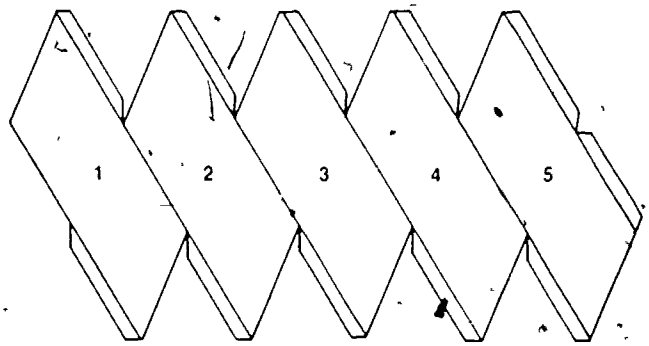


Figure 1. Diagram shows how to glue Panels 1-5 together.

A strip map should be constructed prior to class for display so the students may look at it if they are unsure of its construction.

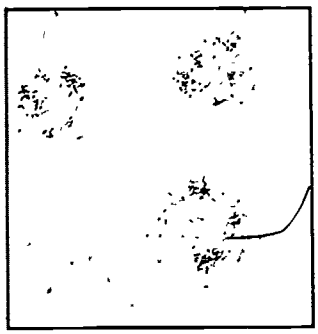
After the students have constructed their strip maps, you may want to instruct them to color the continents with colored pencils before going on to the next activity. Display a world map so the students can write the names of the continents on their strip maps.

The strip map which you have constructed shows all the continents of the world. You can also see thousands of dots on your map. Each dot represents where an earthquake has occurred. If the theory of plate tectonics is correct, most earthquakes occur at the edges of plates.

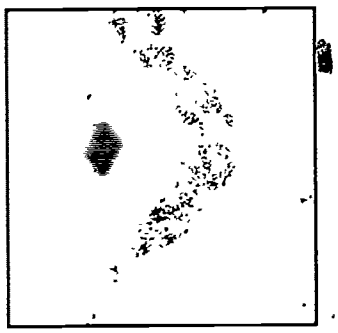
Along their boundaries, two plates are pushing against each other, pulling away from each other, or sliding past each other. Geologists also use the locations of deep ocean trenches and high ocean ridges to help locate plate boundaries.

4. Look at your strip map. Are earthquakes scattered evenly all over the earth? No

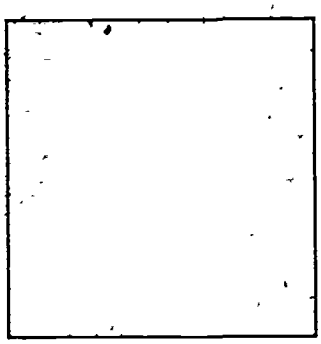
5. Which of the diagrams here most correctly shows the pattern of earthquake distribution? B



A Separate groups



B. Lines and curves



C Random spacing

6. Draw lines on your strip map where you think the plate edges might be, using earthquake patterns and ridge and trench locations to help you locate the boundaries. You may want to look at a map of the ocean floor to locate ridges and trenches. You will have to use educated guesses and some imagination in certain places. You should end up with a jig-saw design that might look something like Figure 2

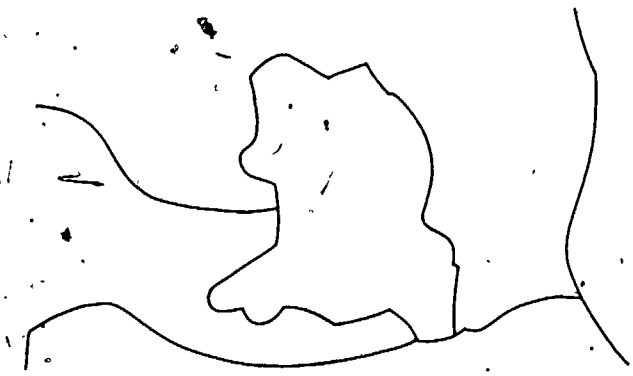


Figure 2. Schematic drawing of some plate boundaries.

7. How many plates did you outline?
At least 10. If your students have difficulty counting the plates direct them to do the EXTENSION. Then the count may be easier.

8. Did everyone in the class want to put the plate edges in exactly the same places? No
Why or why not?
Students often say they could not agree because they did not have sufficient number of earthquake locations. They feel they do not have enough information to make all the decisions they would like to make. For example, some students want to make a North American Plate and a South American Plate; however, on the map the evidence for this is weak.

SUMMARY QUESTIONS

1. It was difficult to mark certain plate boundaries because

there were not enough earthquake locations to clearly identify a plate boundary.

2. Earthquake zones are: 1) separate groups, 2) lines and curves, or 3) evenly spaced. **2**

3. Explain why you think earthquakes occur along plate boundaries.

Plate boundaries are places where plates are being pushed together, forced apart, or sliding past each other. This action produces earthquakes in the areas of compression and tension.

EXTENSION

Complete a twenty-sided globe using your strip map. Glue all tabs on each panel to the panel next to it. Then attach the tabs on Panel 1 to Panel 5.

Compare your globe to a spherical globe in your school.

The students may have a difficult time putting their globes together. A globe should be constructed before class so that students may look at it if they are unsure of its construction. As the students are putting their globes together, you may want to have them attach a string to the top of their globes to hang for display.

REFERENCES

Alexander, T., 1975, A revolution called plate tectonics has given us a whole new earth. *Smithsonian*, v. 5, no. 10 (Jan.), p. 30-39.

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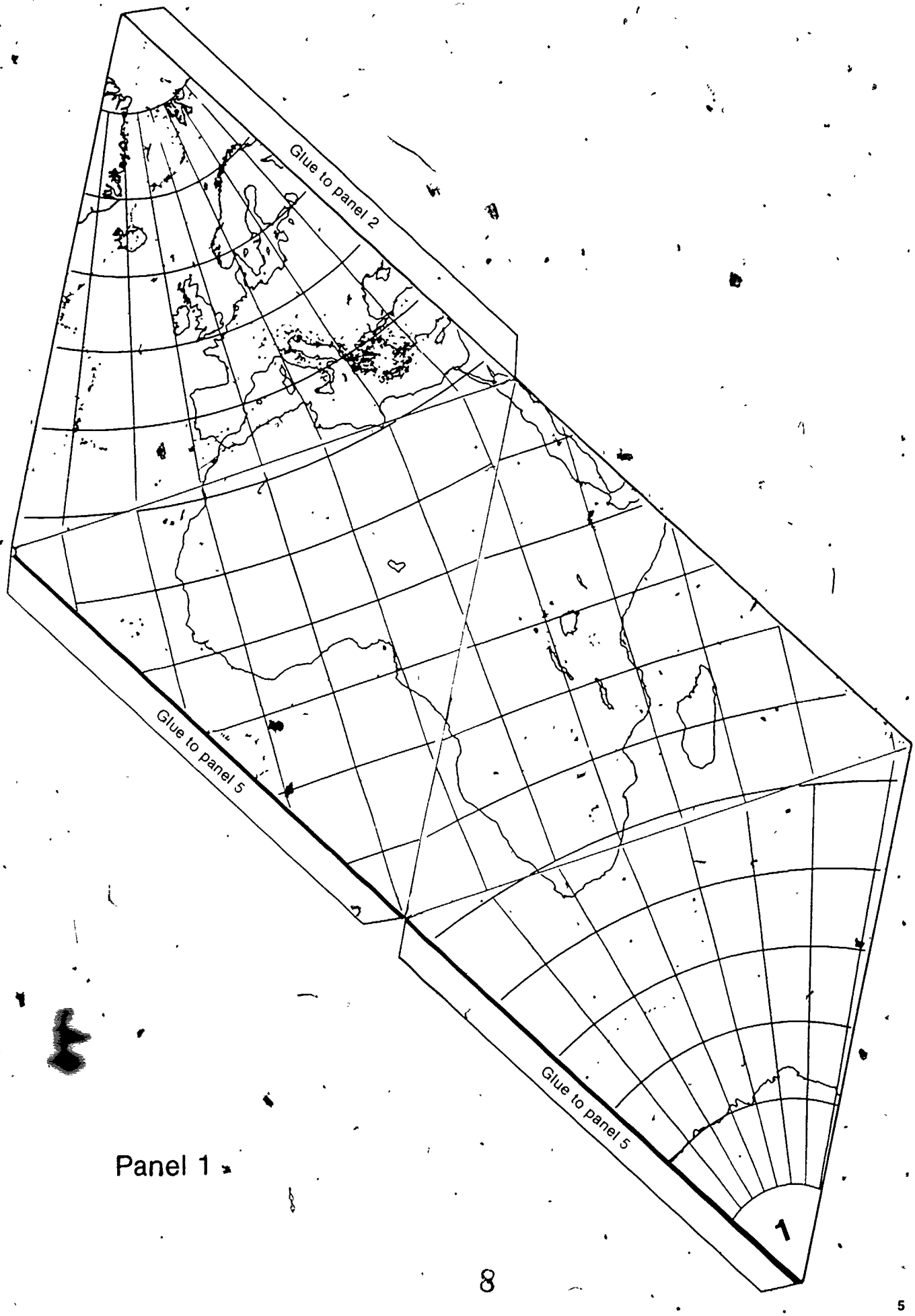
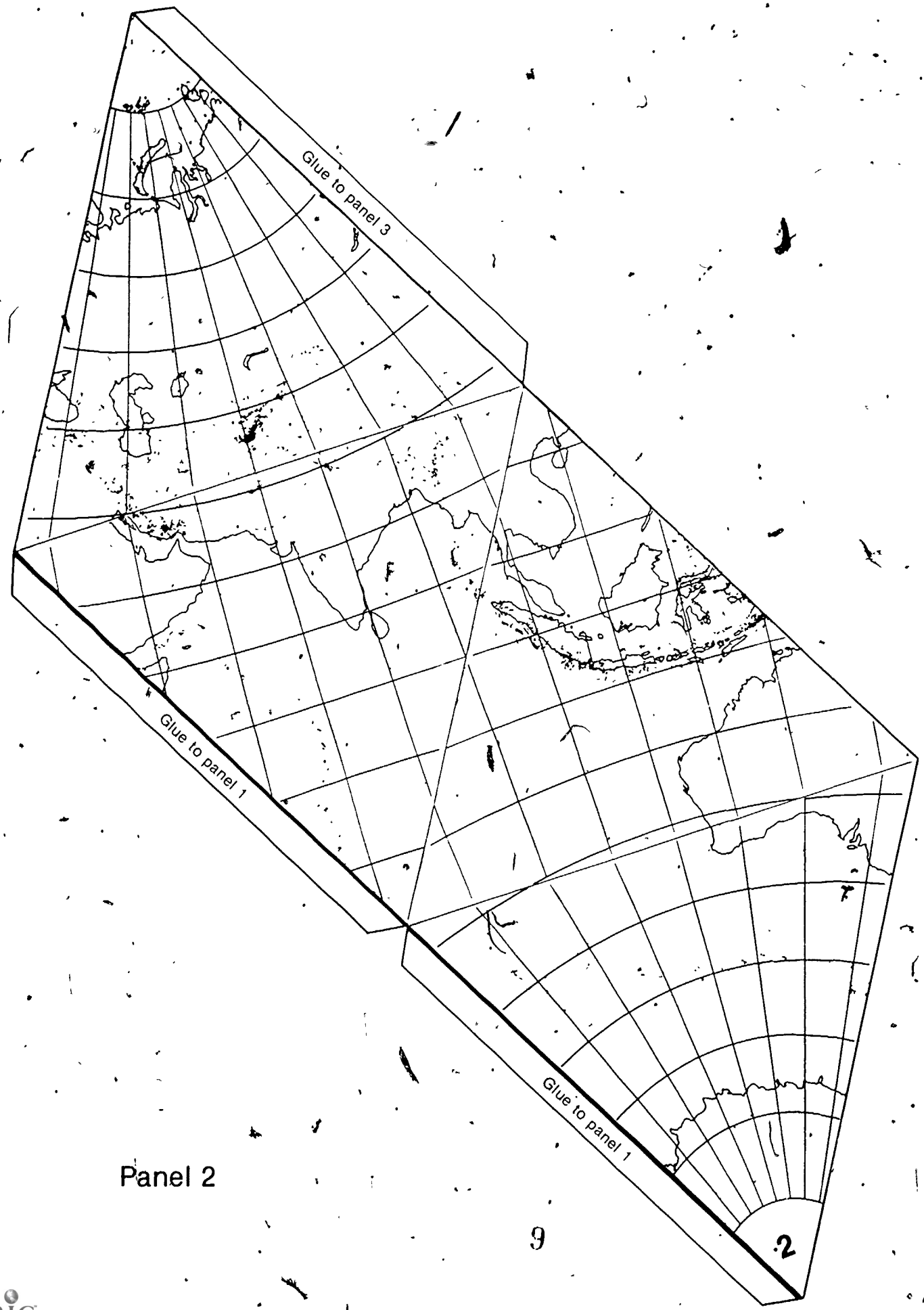


Panel 1



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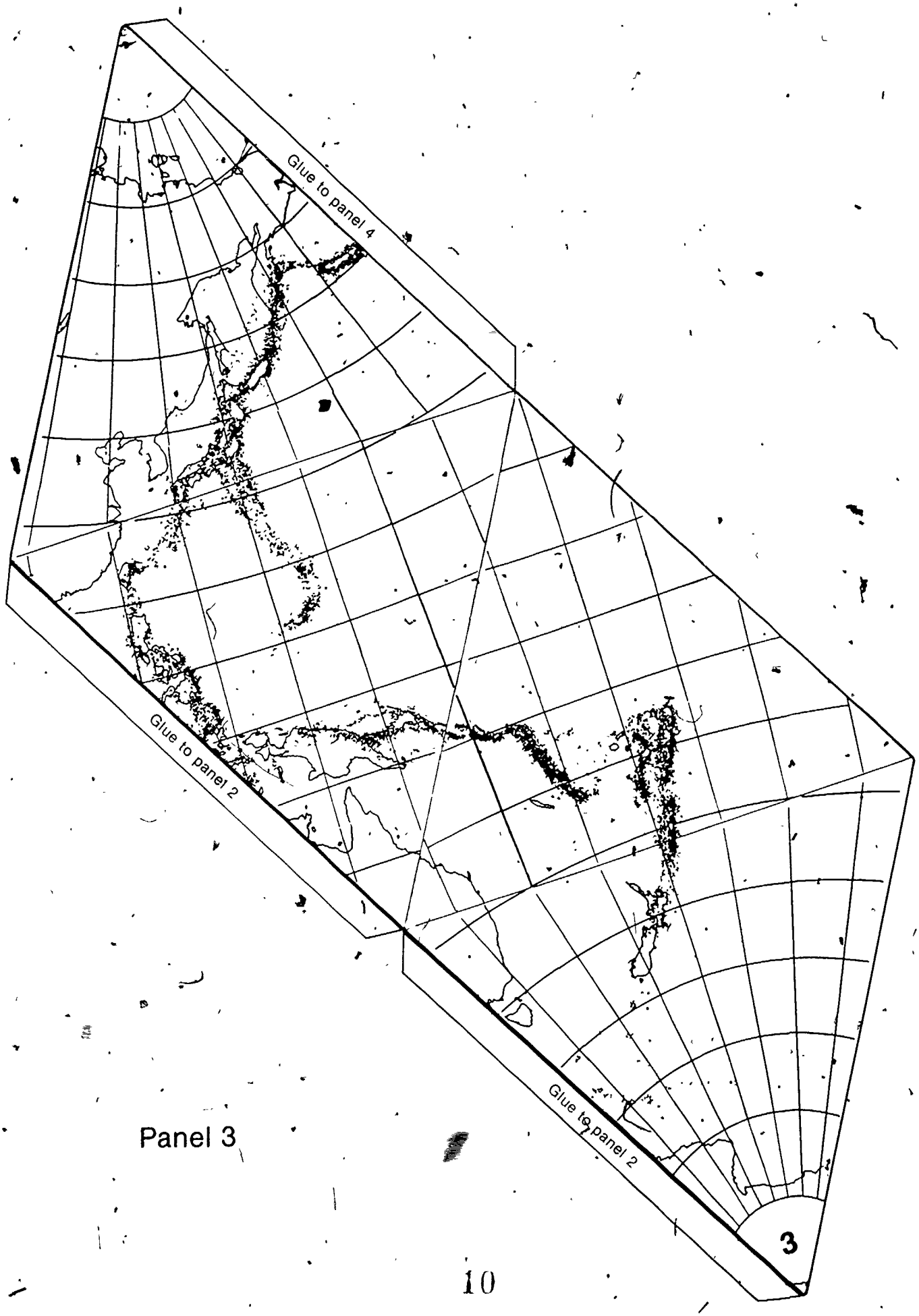

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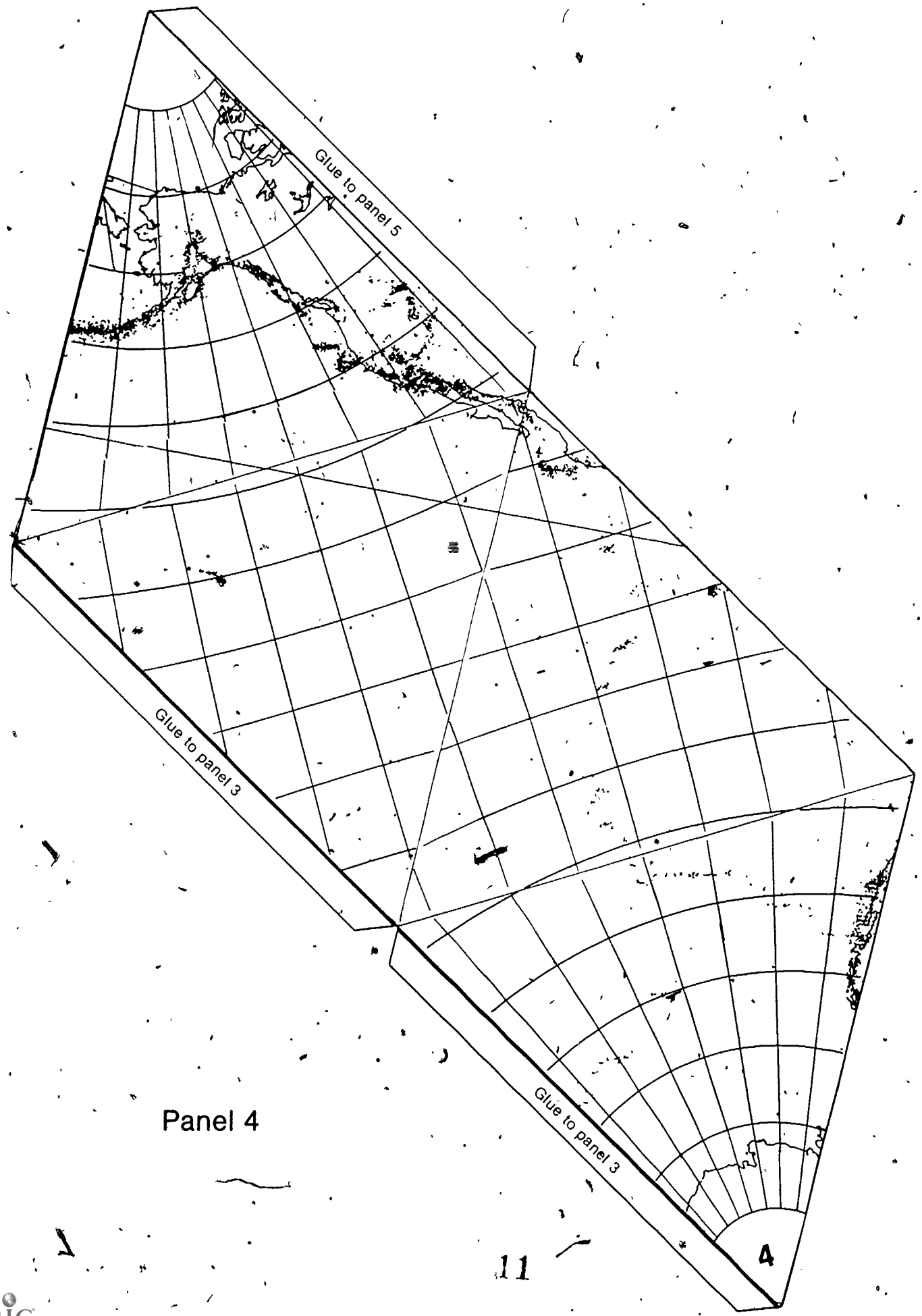

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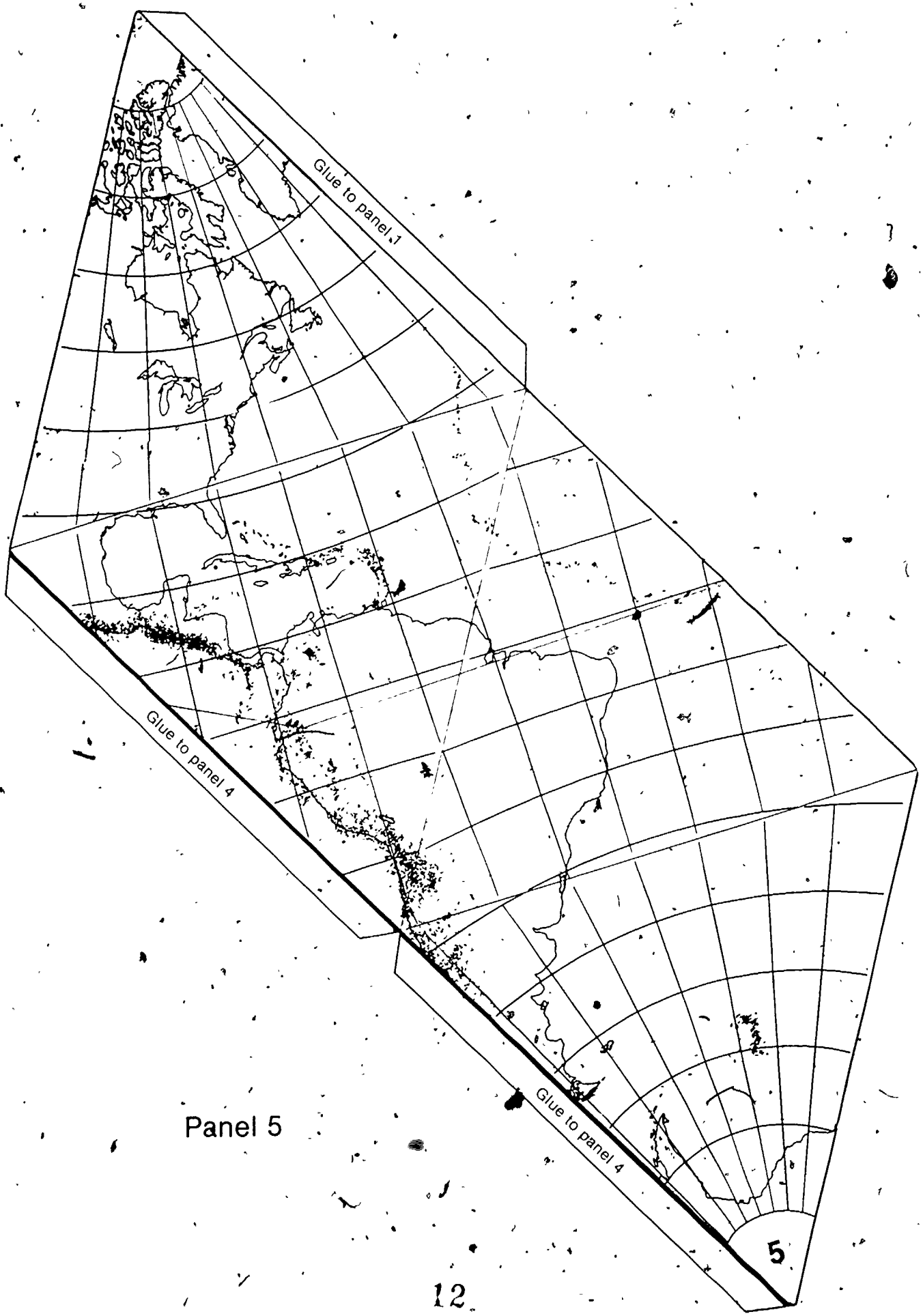

Panel 5

NAGT Crustal Evolution Education Project Modules

CEEP Modules are listed here in alphabetical order. Each Module is designed for use in the number of class periods indicated. For suggested sequences of CEEP Modules to cover specific topics and for correlation of CEEP Modules to standard earth science textbooks, consult Ward's descriptive literature on CEEP. The Catalog Numbers shown here refer to the CLASS PACK of each Module consisting of a Teacher's Guide and 30 copies of the Student Investigation. See Ward's descriptive literature for alternate order quantities.

CEEP Module	Class Periods	CLASS PACK Catalog No.
• A Sea-floor Mystery: Mapping Polarity Reversals	3	34 W 1201
• Continents And Ocean Basins: Floaters And Sinkers	3-5	34 W 1202
• Crustal Movement: A Major Force In Evolution	2-3	34 W 1203
• Deep Sea Trenches And Radioactive Waste	1	34 W 1204
• Drifting Continents And Magnetic Fields	3	34 W 1205
• Drifting Continents And Wandering Poles	4	34 W 1206
• Earthquakes And Plate Boundaries	2	34 W 1207
• Fossils As Clues To Ancient Continents	2-3	34 W 1208
• Hot Spots In The Earth's Crust	3	34 W 1209
• How Do Continents Split Apart?	2	34 W 1210
• How Do Scientists Decide Which Is The Better Theory?	2	34 W 1211
• How Does Heat Flow Vary In The Ocean Floor?	2	34 W 1212
• How Fast Is The Ocean Floor Moving?	2-3	34 W 1213
• Iceland: The Case Of The Splitting Personality	3	34 W 1214
• Imaginary Continents: A Geological Puzzle	2	34 W 1215
• Introduction To Lithospheric Plate Boundaries	1-2	34 W 1216
• Lithospheric Plates And Ocean Basin Topography	2	34 W 1217
• Locating Active Plate Boundaries By Earthquake Data	2-3	34 W 1218
• Measuring Continental Drift: The Laser Ranging Experiment	2	34 W 1219
• Microfossils, Sediments And Sea-floor Spreading	4	34 W 1220
• Movement Of The Pacific Ocean Floor	2	34 W 1221
• Plate Boundaries And Earthquake Predictions	2	34 W 1222
• Plotting The Shape Of The Ocean Floor	2-3	34 W 1223
• Quake Estate (board game)	3	34 W 1224
• Spreading Sea Floors And Fractured Ridges	2	34 W 1225
• The Rise And Fall Of The Bering Land Bridge	2	34 W 1227
• Tropics In Antarctica?	2	34 W 1228
• Volcanoes: Where And Why?	2	34 W 1229
• What Happens When Continents Collide?	2	34 W 1230
• When A Piece Of A Continent Breaks Off	2	34 W 1231
• Which Way Is North?	3	34 W 1232
• Why Does Sea Level Change?	2-3	34 W 1233

CEEP
CRUSTAL EVOLUTION EDUCATION PROJECT

NAME DATE

Student Investigation

Catalog No 34W1118

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INTRODUCTION

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OBJECTIVES

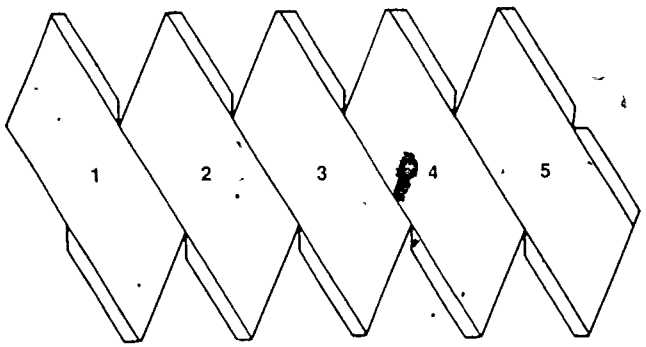
After you have completed this activity, you should be able to:

1. Mark the edges of plate boundaries using earthquake data.
2. Identify the kind of pattern that earthquake zones show on the earth's surface.
3. Explain why earthquakes occur more frequently in some places than others.

PROCEDURE

Materials: scissors, glue, colored pencils, string (optional); map, *The Political World,* and map, *The Physical World.*

1. Five worksheets, labeled Panels 1-5, are located in the back of this module. Cut out all the panels carefully and place them on the table in front of you, in order, with Panel 1 on your left and Panel 2 to the right of it, etc.
2. Glue each panel onto a piece of heavy construction paper and cut out the construction paper along the side of each panel
3. Glue the panels to each other as shown in Figure 1. This will form a long **strip map.** Be sure that you glue Panel 1 to Panel 2 and Panel 2 to Panel 3, etc



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4. Look at your strip map. Are earthquakes scattered evenly all over the earth? _____

5. Which of the diagrams here most correctly shows the pattern of earthquake distribution? _____

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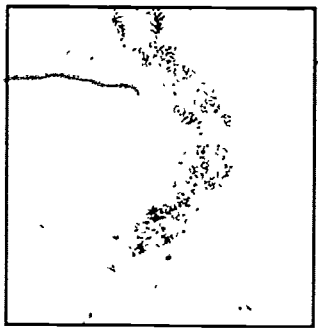

B Lines and curves

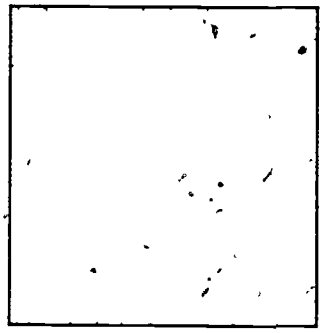

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Figure 2. Schematic drawing of some plate boundaries.

7. How many plates did you outline?

8. Did everyone in the class want to put the plate edges in exactly the same places? _____ Why or why not?

SUMMARY QUESTIONS

1. It was difficult to mark certain plate boundaries because

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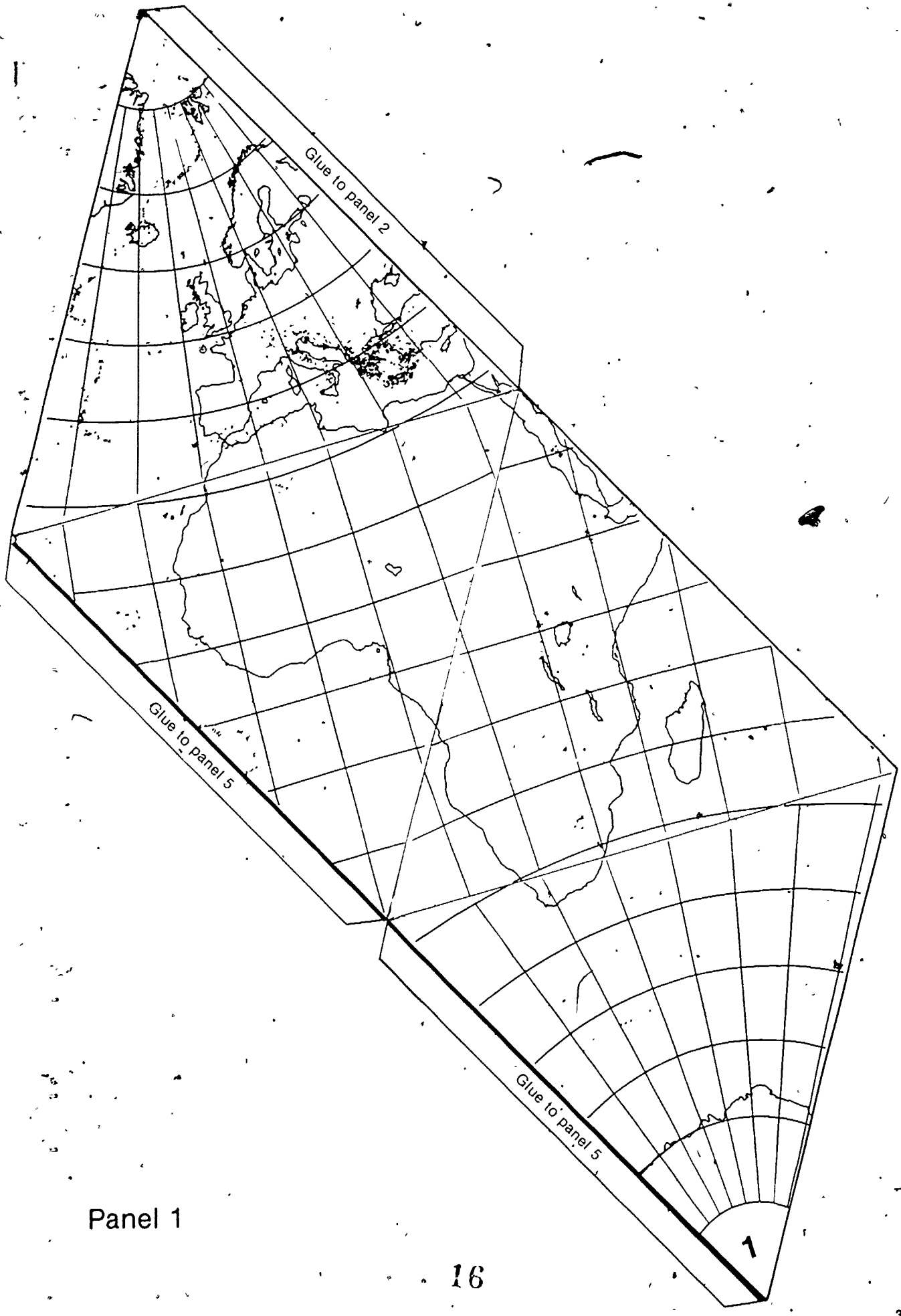

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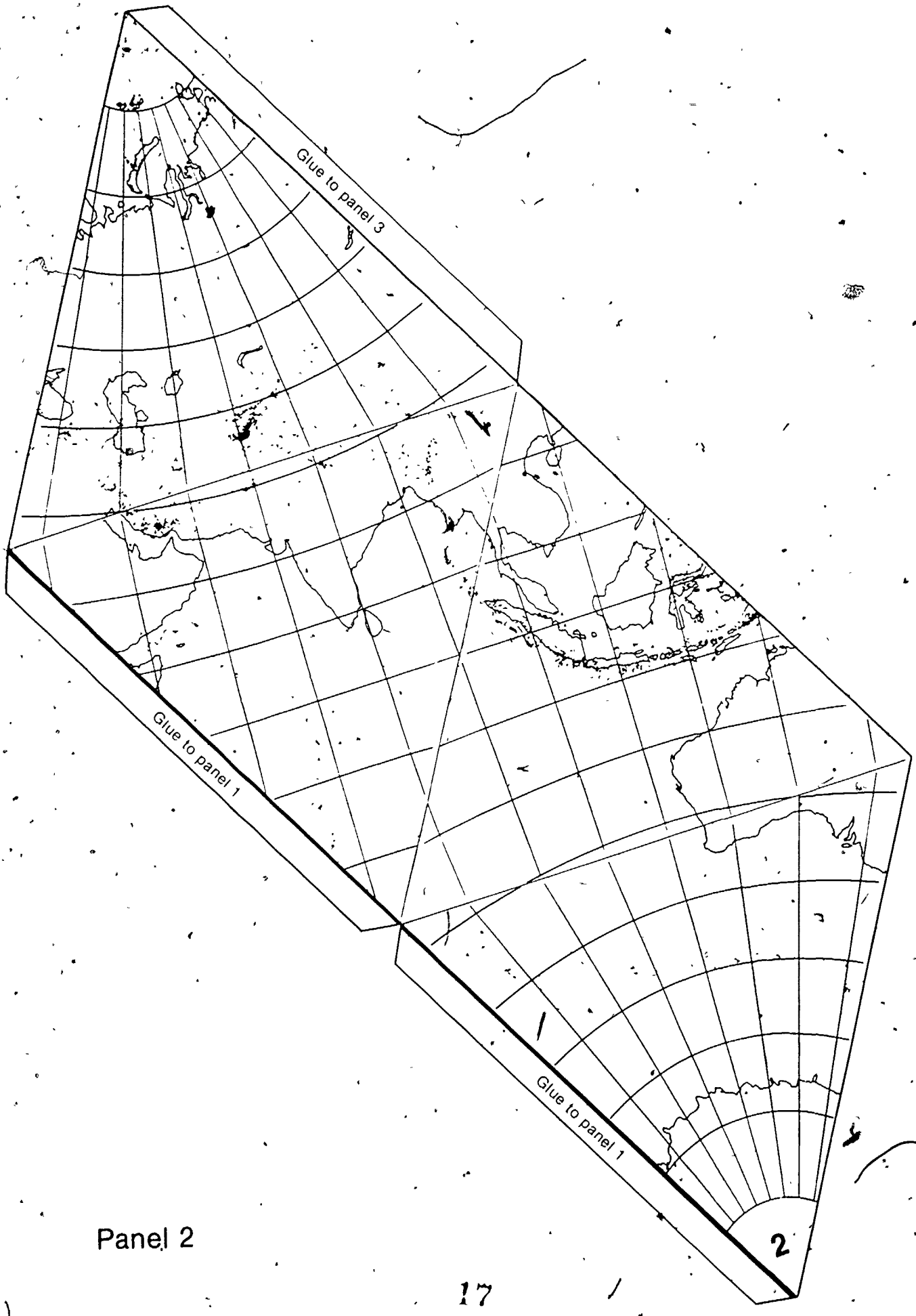

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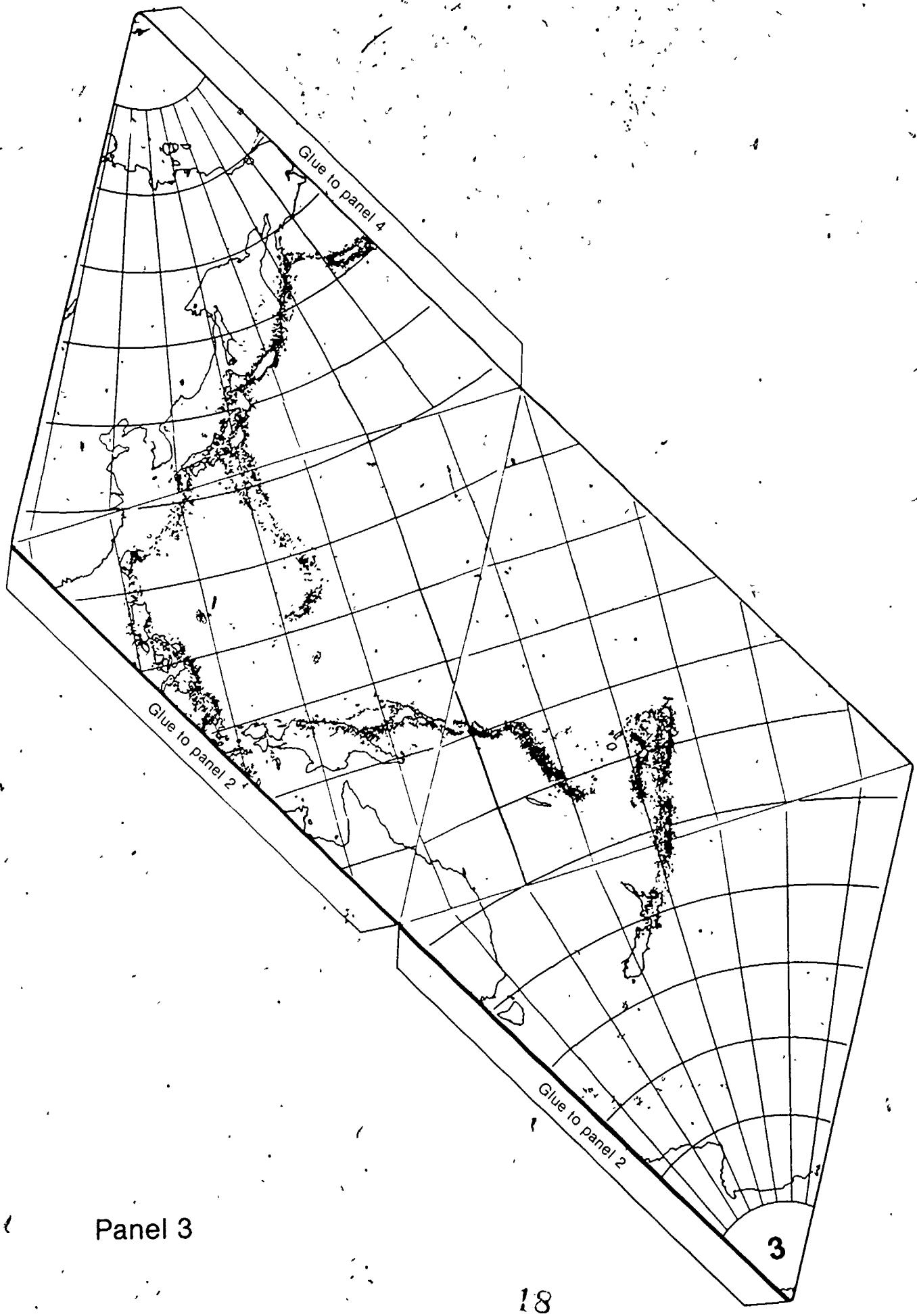

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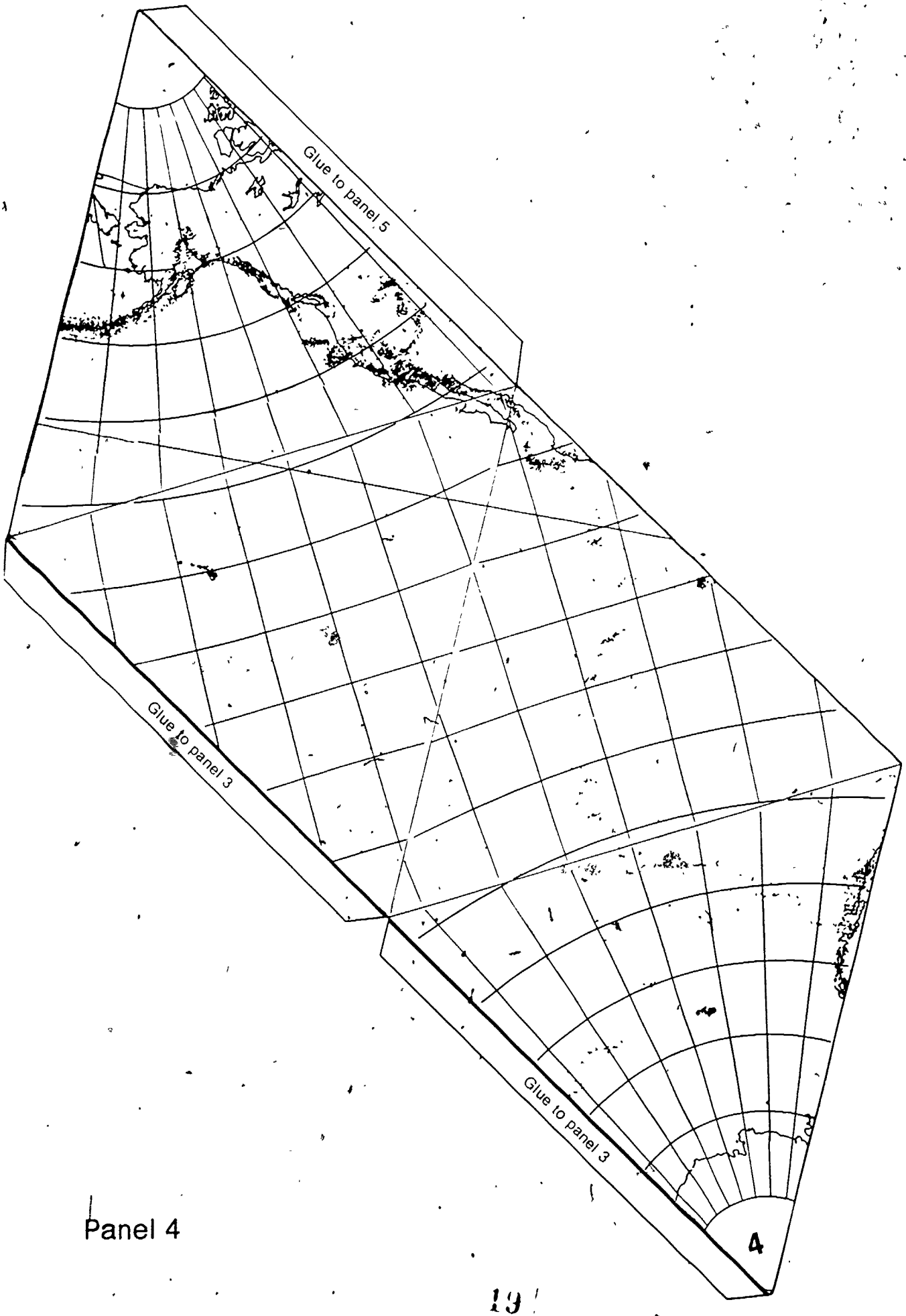

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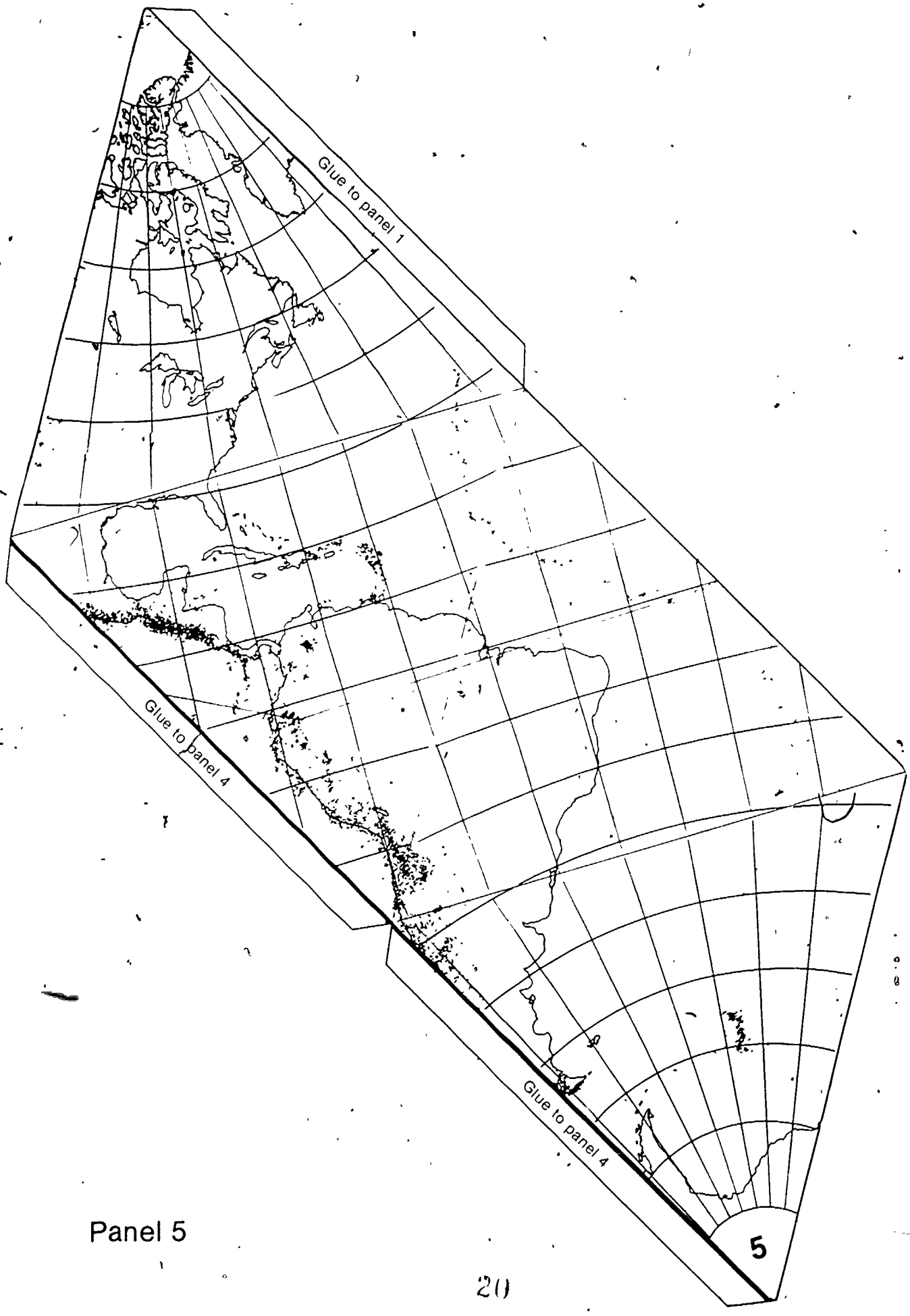

Panel 5