CEEP™

CRUSTAL EVOLUTION EDUCATION PROJECT

Deep Sea Trenches And Radioactive Waste

TEACHER'S GUIDE

Catalog No. 34W1004

For use with Student Investigation 34W1104
Class time: one 45-minute period

Developed by
THE NATIONAL ASSOCIATION OF GEOLOGY TEACHERS

Produced and Distributed by
Ward's Natural Science Establishment, Inc. Rochester, NY • Monterey, CA

Deep Sea Trenches And Radioactive Waste

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

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Deep Sea Trenches And Radioactive Waste

INTRODUCTION

What would you do if you had to get rid of thousands of tons (1 metric ton = 1000 kg) of used nuclear fuel, called **radioactive waste**? Where could you find a safe place to put it, a place where it could never hurt anyone?

This is not an easy question to answer. Many engineers and scientists all over the world have been trying to find an answer for a long time. Listed are five of the best ideas that scientists have come up with to get rid of radioactive waste.

1. Put it in rockets and shoot it into the sun.
2. Drop it into the mud in the middle of ocean basins.
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5. Dump it into deep ocean trenches.

Each of these ideas has both good and bad points. In this activity we are going to consider dumping the radioactive waste into ocean trenches to see if that would work out well or not.

PREREQUISITE STUDENT BACKGROUND

This module presumes an acquaintance with the physiography of the ocean basins (at least the continental margins and oceanic troughs) and the basics of plate margins and motions. It would help, though it is not necessary, if the students had some knowledge of radioactive decay.

OBJECTIVES

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

1. Plot the movement of a descending ocean floor plate on a graph, and discuss that movement.
2. Explain why it would be good or bad to dump radioactive waste into ocean trenches.
3. Explain some of the effects that subducting plates have on the edges of continents.
4. Tell the reasons why disposing of radioactive waste material is not an easy problem to solve.

MATERIALS

Pencils and scrap paper—one for each student
Metric rulers—one for each group of students

BACKGROUND INFORMATION

The question of proper disposal of nuclear waste is a difficult one because an acceptable method must be both inexpensive and safe. Of the five methods mentioned in this activity, shooting nuclear waste into the sun is surely best from a human safety point-of-view, but it would cost so much that the energy produced by the nuclear power plant would be prohibitively expensive. Burying dangerous wastes in oceanic trenches is superficially attractive because: 1) It would be relatively cheap. 2) Many trenches, being low areas on the sea floor and often near continents, are sites of deposition of large amounts of sediment. Canisters of radioactive waste would become buried more quickly there than elsewhere on the sea floor. 3) The subduction process would act to remove the dangerous material by carrying it into the mantle (asthenosphere) where it could harm no one. Is it feasible, then, to dispose of radioactive wastes in this way?

The answer depends on the relationship between the period of time the wastes stay dangerous and the rate at which they become buried. This exercise shows that the rate of burial by subduction is very slow. The depth in meters reached, say in 10,000 years, can be calculated by the formula 100 V sin θ, where V is the rate of subduction in cm/yr, θ is the angle of dip of the plate being subducted, and 100 is a factor to convert cm/yr into meters per 10,000 years (see Figure A).

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In 10,000 years subduction beneath Japan would carry wastes to a depth of only about 565 m, even though the Japanese trench is subducting relatively rapidly and at a fairly steep angle (45°). In an average lifetime, say 80 years, a canister of nuclear wastes would travel downward only about 4.5 m. Rates of burial by addition of sediment to the trench are of comparable slowness. The radioactive waste will decay to a relatively safe level in 1 million years, and be practically harmless in 10 million years.

SUGGESTED APPROACH

Basically, this activity should be carried out by the students as independent inquiry. The students can work through the various steps at their own pace. At the end of the activity a class discussion of their conclusions should be encouraged, and you may wish to contribute some additional information to the subject.

PROCEDURE

In this activity the students plot the position and rate of movement of a subducting oceanic plate.

Key words: ocean trench, radioactive waste, subduction, decay

Time required: one 45-minute period

Materials pencil, scrap paper, metric ruler

An **ocean trench** is a long, narrow depression with steep sides, located on the deep-sea floor Ocean trenches are located where the edge of an ocean plate is going down under a continent

The scientists who suggest that radioactive waste be dumped into ocean trenches say that it will sink into the deep bottom of the trench and will be carried down and away forever

Let's see what would happen if this plan were carried out in the Japan Trench The descending ocean floor plate in the Japan Trench is **subducting**, or moving down, at a rate of 8 cm/yr This rate is faster than most plates are moving It doesn't actually move straight down, but at more of a slant or slope Japan is located along the edge of the Eurasian continental plate, and the descending ocean floor plate slopes underneath this continental plate

The Worksheet is a cross-section of Japan and the Japan Trench The Pacific Ocean is to the right and Asia to the left Therefore, if radioactive waste material were dropped in the bottom of the trench at the place marked X, it should move down to the left with the descending plate.

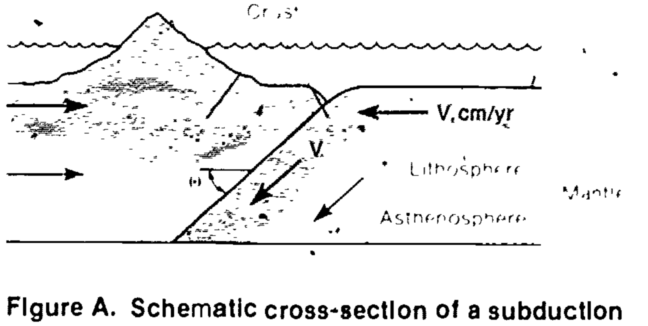


Figure A. Schematic cross-section of a subduction zone, showing quantities used for calculating rates of burial by subduction.

It has been figured out that in 3 million years the part of the ocean floor plate now under the trench would move to a position 200 km to the west and 200 km down. Put an X on your graph to show where the radioactive waste would be then In the next 3 million years, it would move 200 km more westward and 200 km more downward Put an X at that spot Put an X on your graph to show where the waste would be in 9 million years and in 12 million years if it kept moving at the same rate of 8 cm/yr Draw a line through these spots, connecting them all together

We are not too worried about what will happen to the radioactive waste 12 million years from now Most of the waste will have **decayed** before then When an element decays, it loses some energy and forms another stable element This new element will be fairly harmless But what about one-half million years from now? From your graph, can you estimate where the radioactive waste will be then?

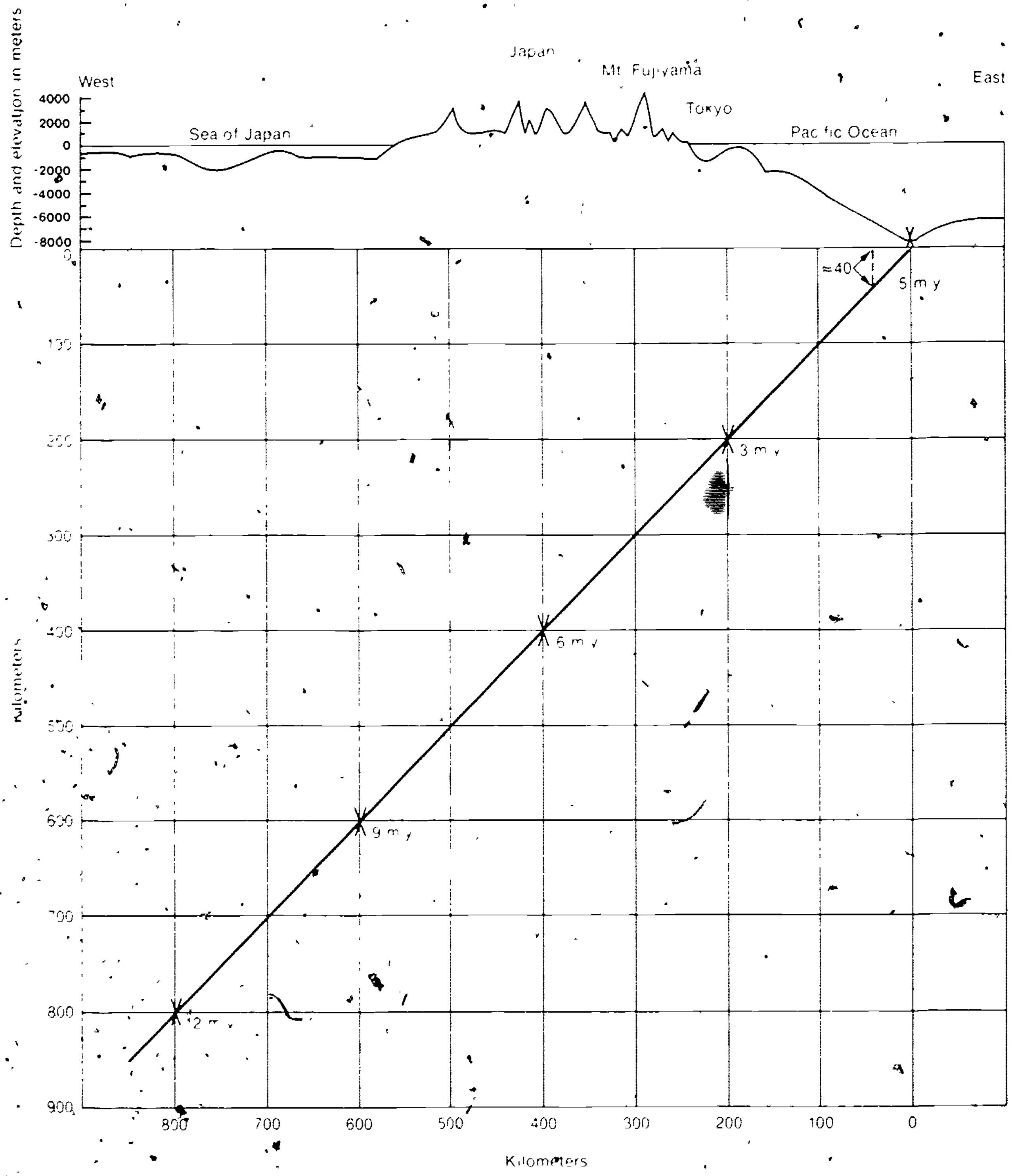
See Answer Sheet. Even though one-half million years seems far beyond our concern, the government has decreed that one million years is the length of time that radioactive waste disposal plans must guarantee against contamination.

1. a In one-half million years, will the radioactive material have moved away from or toward Japan?

From their graph plots, the students will see that the subducting plate moves toward and under Japan.

b. About how much lower than the bottom of the trench will it be then?

Since the line from the bottom of the trench to the first position represents 3 million years, one-half million years would be about one-sixth down that line. From this the students can see that at such a time the radioactive waste will be approximately 40 km below the trench-bottom level.



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Answer Sheet

2. Some of the ocean sediment on the subducting plate may be scraped off and added to the edge of the continent. What would this do to the radioactive waste?

Not all of the radioactive waste would go down with the subducting plate. Some would be added to the edge of the continent.

3. The subducting plates are the cause of molten rock that pours out of volcanoes on the land behind the trenches. What would happen to radioactive waste that was in or on those plates?

Some of the radioactive waste could come to the surface in the molten rock. However, it is likely that the waste would be diluted in the process.

4. What do you think of the idea of getting rid of radioactive material by dumping it into oceanic trenches?

From the answers to all four questions above, the students should conclude that you do not really get rid of radioactive waste by dumping it into ocean trenches. It would be advantageous to get a class discussion going on this point.

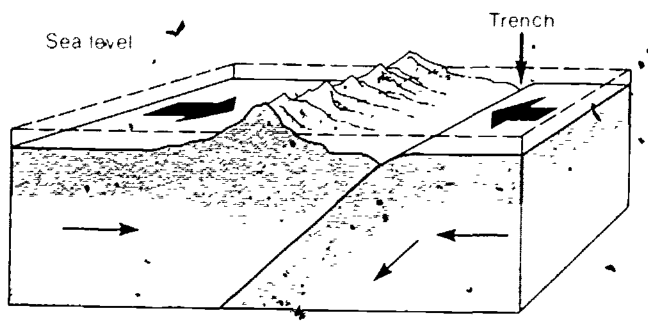

Figure 1. Schematic drawing of a trench, formed by a subducting ocean plate

SUMMARY QUESTIONS

The first two questions are fairly easy adaptations from questions 3 and 4, above. The third question, though, requires extrapolating to another place and, perhaps, different directions.

1. What happens to the sediment that is on subducting ocean floor plates?

Ocean sediment on subducting plates may be added to the edge of the continents, which may make the continent wider. Some sediment may travel downward with the subducting plate.

2. What do subducting ocean floor plates have to do with volcanoes near the coast?

The molten rock coming out of volcanoes behind trenches is caused by subducting plates.

3. Imagine a city on a coast next to an oceanic trench. Describe how the descending ocean plate is moving under the city.

This question requires that the students describe in a different context the plate motion that they plotted on the graph.

EVALUATION

In addition to written evaluations, you can observe the students' participation and performance as a means of informal evaluation. Alternatively, you may wish to ask the students if it would be a good idea to dispose of radioactive waste in a mid-ocean ridge rift valley, in a bore hole in the San Andreas Fault, or in the middle of the Pacific Ocean floor, and judge their responses in terms of their consideration of plate motions.

EXTENSION

At the time this activity was being written these five methods of disposing of radioactive waste have been, or were still being discussed. However, (and you can inform your class of this in their discussion) the idea of dumping the waste in ocean trenches was one of the first to be discarded as a workable solution for the very reasons your students discussed in answer to question 4. They may now want to find out for themselves what method was finally adopted.

REFERENCES

Frosch, R.A., 1977, Disposing of high-level radioactive waste. *Oceanus*, v 20, p 4-17

Hollister, C.D, 1977, The seabed option. *Oceanus*, v. 20, p 18-25.

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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

WARD'S

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P.O. Box 1712, Rochester, New York 14603 • P.O. Box 1749, Monterey, California 93940

CEEP MODULE NO. WA9 4-7
ISBN 0-89873-006-6

Printed in U S A

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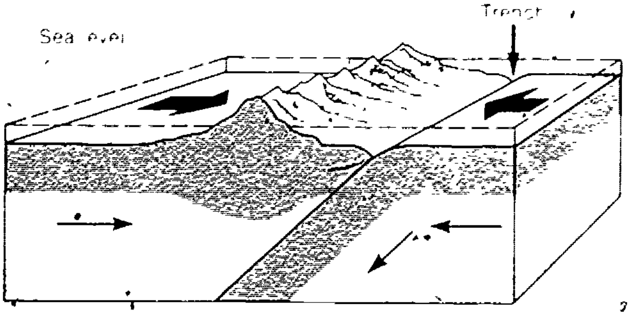

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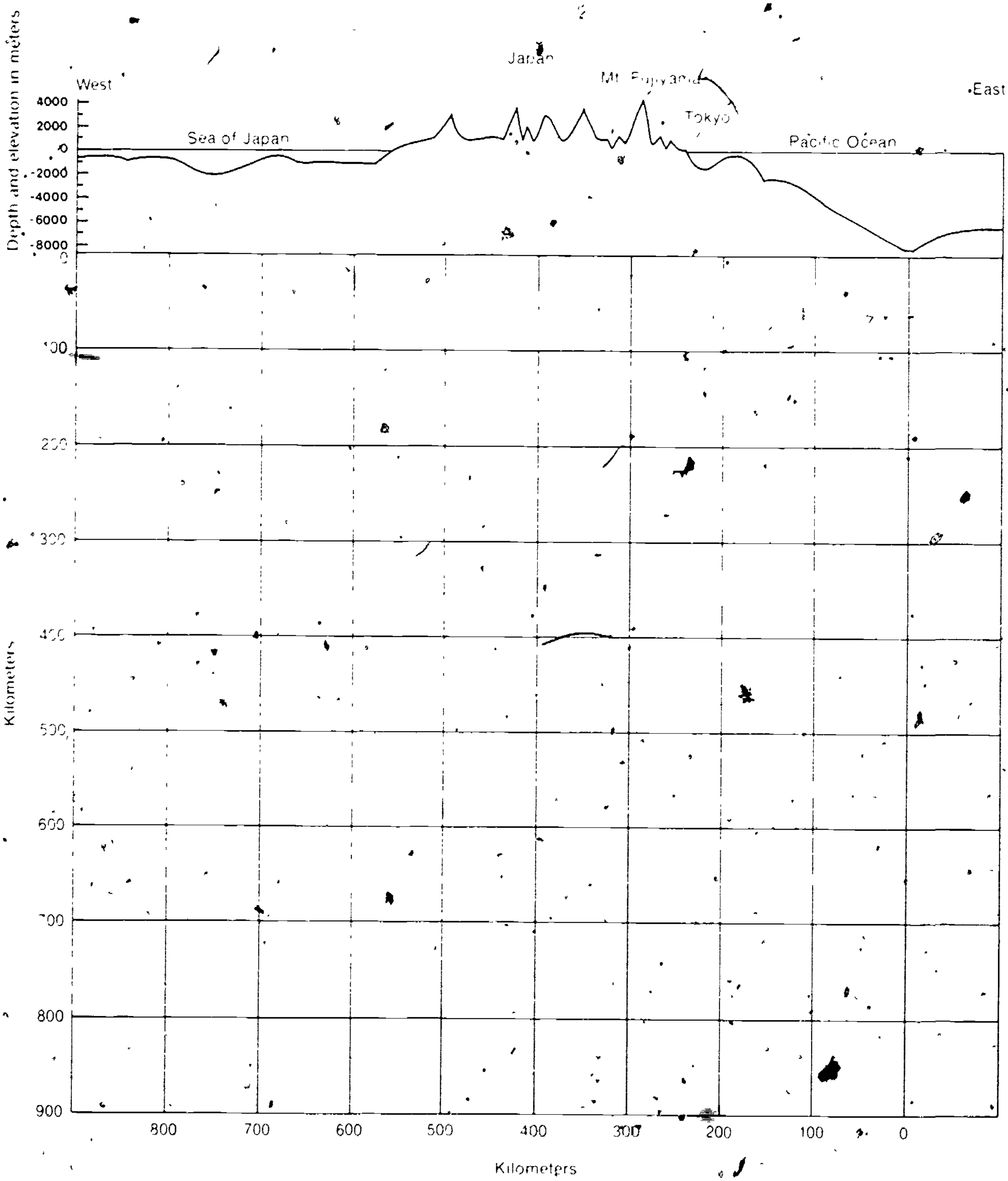

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