EXPERIMENT MANUAL

VOLCANOES & EARTHQUAKES

THAMES & KOSMOS

WARNING! Only for use by children over 10 years old. To be used solely under the strict supervision of adults that have studied the precautions given in the experimental set. Contains some chemicals which are classified a safety hazard. Read the instructions before use, follow them and keep them for reference. Do not allow chemicals to come into contact with any part of the body, particularly mouth and eyes. Keep small children and animals away from experiments. Store the chemistry set out of reach of small children. Eye protection for supervising adults is not included.

WARNING — Science Education Set. This set contains chemicals and/or parts that may be harmful if misused. Read cautions on individual containers and in manual carefully. Not to be used by children except under adult supervision.

WARNING!

Only for use by children over 10 years of age. To be used solely under the strict supervision of adults that have studied the precautions given in the experimental set.

- → Contains some chemicals which are classified as safety hazards.
- → Read the instructions before use, follow them, and keep them for reference.
- → Do not allow chemicals to come into contact with any part of the body, particularly the mouth and eyes.
- → Keep young children and pets away from experiments.
- → Store the chemistry set out of reach of young children.
- → Eye protection for supervising adults is not included.
- → Save packaging and instructions, as they contain important information.
- → We reserve the right to make technical changes.

CAUTION! Individual parts in this kit may have sharp points, corners, or edges. Do not injure yourself!

Please note: You should read the important information about first aid in case of accidents on the outer back cover, handling plaster and hazardous substances on page 5, using safety glasses on page 48, and further information on pages 1–6.

Poison Control Centers (United States)

In case of emergency, your nearest poison control center can be reached everywhere in the United States by dialing the number:

1-800-222-1222

Local Hospital or Poison Centre (Europe)

Record the telephone number of your local hospital or poison centre here:

Write the number down now so you do not have to search for it in an emergency.

When in doubt, seek medical advice without delay. Bring the chemical and its container with you. In case of injury, always seek medical advice.

Dear Parents,

This experiment kit is for use only by children over 10 years who are interested in learning more about geological science in a fun way. Not only is this kit fun, it can also provide an introduction to the exciting world of the natural sciences.

It is normal to have questions about the safety of a kit that contains chemicals.

The equipment in this kit meets U.S. and European safety standards, which specify the safety requirements for chemistry experiment kits and plaster hobby kits. These standards impose obligations on the manufacturer, such as forbidding the use of any particularly dangerous materials. The standards also stipulate that adults should assist their children with advice and assistance in their new hobby. We are addressing this information to you, so you can understand what this involves.

Take a look through this instruction manual and pay particular attention to the

→ **Basic rules for safe experimentation,**
→ **Information about hazardous materials** (pages 4–6), as well as
→ **First aid in case of accidents** (outside back cover).

Also read the safety information accompanying the experiments. Carefully select the experiments that are safe and appropriate for your child. Before starting the experiments, discuss the warnings and safety information with your child. Please be careful not to let the chemicals get into the hands of young children.

Advice for Supervising Adults

A. Read and follow these instructions, the safety rules, and the first aid information, and keep them for reference.
B. The incorrect use of chemicals can cause injury and damage health. Only carry out those experiments which are listed in the instructions.
C. This experimental set is for use only by children over 10 years.
D. Because children's abilities vary so much, even within age groups, you should exercise discretion as to which experiments are suitable and safe for them. The instructions enable you to assess any experiment to establish its suitability for a particular child.
E. You should discuss the warnings and safety information with the child or children before commencing the experiments.
F. The area surrounding the experiment should be kept clear of any obstructions and away from the storage of food. It should be well lit and ventilated and close to a water supply. A solid table with a heat resistant top should be provided.

When performing the experiments, your child should wear clothes that can take a little abuse (or an old smock) and wear safety glasses. After completing the experiments, he or she should clean up the work area and thoroughly wash his or her hands.

We wish you and your child a fun and interesting time with these experiments!

What's in your experiment kit:

Checklist: Find – Inspect – Check off

✔	No.	Description	Qty.	Item No.
☐	1	Plaster powder (250 g)	1	773675
☐	2	Sodium bicarbonate	1	033532
☐	3	Tartaric acid	1	033272
☐	4	Measuring cup	1	708166
☐	5	Wooden spatula	3	000239
☐	6	Red food coloring	1	705822
☐	7	Small bottle	1	702758
☐	8	Screw top for small bottle	1	702759
☐	9	Black plastic tube	3	701375
☐	10	Bag with volcanic rock	1	770951
☐	11	Die-cut sheet 1: seismograph, plate tectonics puzzle, volcano base, learning wheel frame	1	711074
☐	12	Die-cut sheet 2: globe, learning wheel disks	1	711075
☐	13	Lid remover for chemical vials	1	070177
☐	14	Bag of small parts: compass lead, push rivet, wooden beads, spring, screw Two-pronged clips	1 ea. 2	773710
☐	15	Safety glasses	1	052297
☐	16	Polystyrene insert	1	711072

Additional things you will need:

Table, water, scissors, knife, three or four empty plastic yogurt containers, paper towels, glue, glue stick, tape, ruler, ballpoint pen, pencil, piece of paper or sticky note, screwdriver, newspaper or washable table surface, heavy book, two rubber bands, three small play figures, two coins, flat block of wood, four equal-size blocks of wood (cubes or squares), clay

Any materials not contained in the kit are marked in *italic script* in the "You will need" boxes.

→ Before doing anything else, please check all the parts against the list to make sure that nothing is missing.

→ If you are missing any parts, please contact Thames & Kosmos customer service.

CONTENTS

CHECK IT OUT

You'll find supplemental information on pages 14, 28, 37, and 45.

Basic rules for safe experimentation:

Before beginning any of these experiments, please read carefully through the following list. Make an effort right from the start to work properly, so you can avoid any possible risks.

1. Read these instructions before use, follow them, and keep them for reference.
2. Keep young children, animals, and those not wearing eye protection away from the experimental area.
3. Always wear eye protection.
4. Store this experimental set out of reach of children under 10 years of age.
5. Clean all equipment after use.
6. Make sure that all containers are fully closed and properly stored after use.
7. Ensure that all empty containers are disposed of properly
8. Wash hands after carrying out experiments.
9. Do not use any equipment which has not been supplied with the set or recommended in the instructions for use.
10. Do not eat or drink in the experimental area.
11. Do not allow chemicals to come into contact with the eyes or mouth.
12. Do not replace foodstuffs in original container. Dispose of immediately.
13. Pay attention to the information on the chemical labels, the information about hazardous materials on page 5, and the safety notes accompanying each experiment.
14. Pay special attention to the quantity specifications and the sequence of the individual steps. Only perform experiments that are described in this instruction manual.
15. If you wear corrective eyeglasses, you will need protective goggles designed for use with corrective eyeglasses. When working, wear appropriate protective clothing, like an old smock and smooth gloves.
16. Close the chemical vials and the plaster pouch after use, and return them to their places in the kit.
17. Chemicals that accidentally get onto your skin must be rinsed off immediately under running water.
18. Do not use any eating, drinking, or other kitchen utensils for your experiments. Containers or equipment used in your work should not be used in the kitchen afterward.

Information about handling plaster

WARNING!

Plaster should only be used by children over 10 years of age. Use under adult supervision. Read the instructions before use, follow them, and keep them on hand for reference.

→ Do not place the materials in the mouth.
→ Do not inhale dust or powder.
→ Do not apply to the body.

→ When working or experimenting with plaster and red dye, follow the adjacent basic rules for safe experimentation. In addition, avoid dust buildup and inhaling dust. Leftover plaster can be disposed of in the household garbage. Before discarding, leftover liquid plaster mixture should be poured onto newspaper and allowed to harden. Clean equipment and containers immediately after you finish the experiment, before the plaster completely hardens, which will make final cleanup easier.

Note:

Keep all chemicals locked away. Do not allow any of them to get into the hands of children. This applies above all to young children, but also to older children who — unlike the ones performing the experiments — have not been appropriately instructed by adults about proper safety measures.

IN CASE OF SWALLOWING: Immediately seek medical advice or help and have the packaging or label of the swallowed chemical available for reference.

Information about hazardous materials

Please note the following risk and safety information for the chemicals contained in this chemistry kit. The following overview also shows the hazard symbol for the chemicals you will be using and identifies the hazards associated with it.

CAUTION
Tartaric acid

Do not allow this chemical to get in your eyes, on your skin, or on your clothing. IN CASE OF CONTACT WITH EYES: Rinse carefully with water for several minutes. If possible, remove any contact lenses. Continue rinsing. Immediately call the Poison Control Center or a doctor. IN CASE OF CONTACT WITH SKIN: Wash with plenty of water and soap.

Plaster (Calcium sulfate $*\frac{1}{2}H_2O$)

Avoid inhaling plaster dust. Do not let plaster get into your eyes or mouth or on your skin. Do not swallow.

Sodium bicarbonate ($NaHCO_3$)

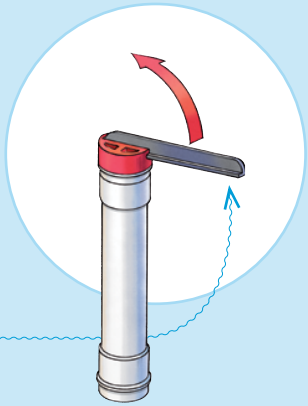
The Globally Harmonized System of Classification and Labelling of Chemicals (GHS) requires no special warning notice for this chemical.

What to do with waste?

The relatively small quantities of the chemicals included in this kit do not pose any particular risk to the environment. You can add any leftover solid substances to the household trash and pour any liquids down the drain and rinse with water. Please note the adjacent tips for disposal of plaster.

Chemical vials

Each of the chemical vials contains the quantity of chemical required for these experiments. The uniform size of the vials is determined by the size of the labels featuring the legally required information about each chemical. Use the lid lifter to open the chemical vials.



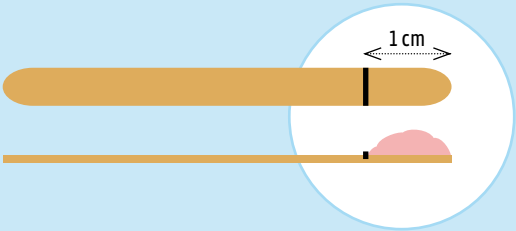
Prepare the table

To prevent "lava" from getting things dirty during your volcano experiments, choose an old table for your work surface and protect it with several layers of newspaper. Ideally, place a washable tablecloth under the newspaper first.

Prepare the wooden spatulas

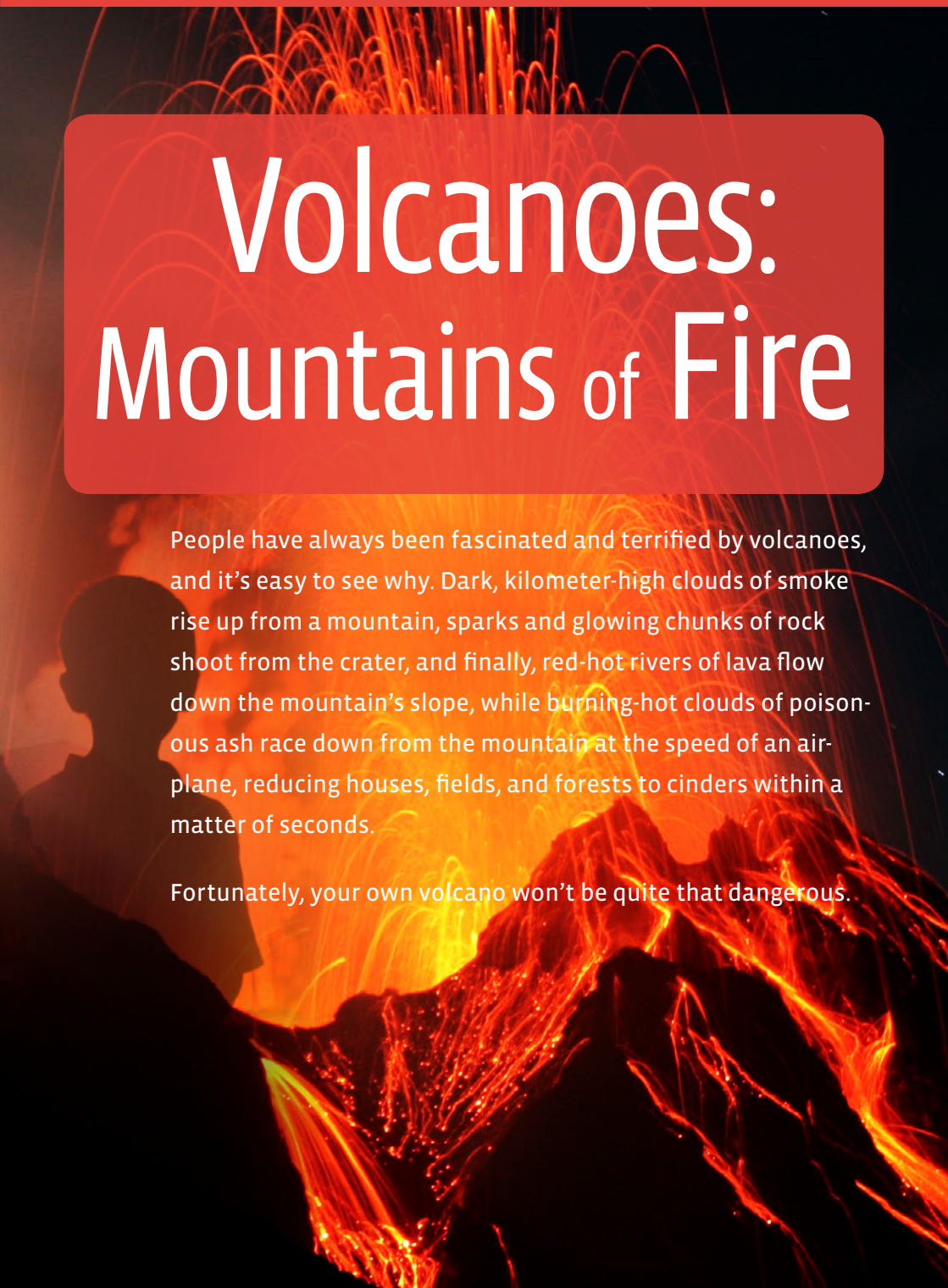
Prepare two wooden spatulas in advance by making a pencil mark one centimeter from one end of each one.

The mark will help you to measure out the proper amount of each chemical. "One spatula" means to heap the space with powder up to the mark.



Tip:

When you open a vial, some chemical substance may stick to the lid and fall onto your hand or the work surface. You can prevent this by banging the bottom of the vial several times against the work surface before opening it.



Volcanoes: Mountains of Fire

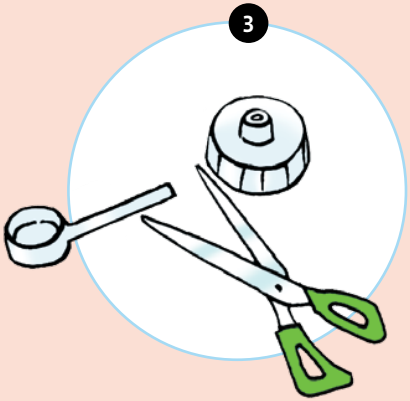
People have always been fascinated and terrified by volcanoes, and it's easy to see why. Dark, kilometer-high clouds of smoke rise up from a mountain, sparks and glowing chunks of rock shoot from the crater, and finally, red-hot rivers of lava flow down the mountain's slope, while burning-hot clouds of poisonous ash race down from the mountain at the speed of an airplane, reducing houses, fields, and forests to cinders within a matter of seconds.

Fortunately, your own volcano won't be quite that dangerous.

Your volcano takes shape

YOU WILL NEED

- → polystyrene volcano
- → polystyrene insert
- → cardboard sheet with rock design
- → small bottle
- → cap
- → black plastic tube
- → *scissors*
- → *knife*
- → *tape*
- → *glue*

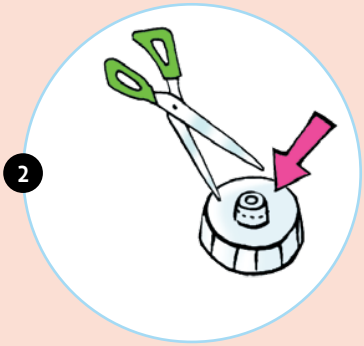


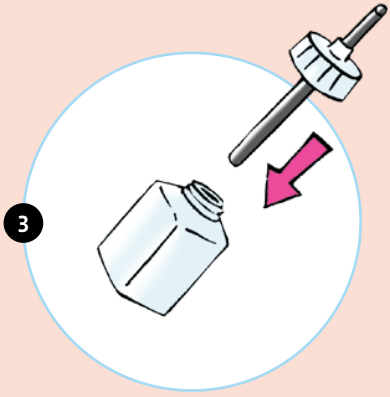
HERE'S HOW

1. First, prepare the bottle's lid by cutting off the closure, which you won't need. Let an adult help you cut it.

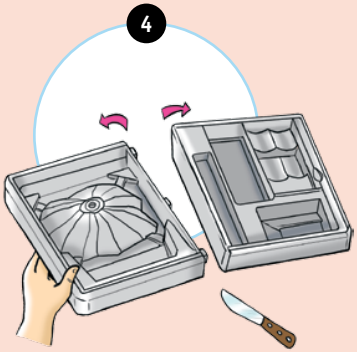
2. Then, use the scissors to cut off the end of the cap's tip just under the upper ring. Let an adult help you with this.

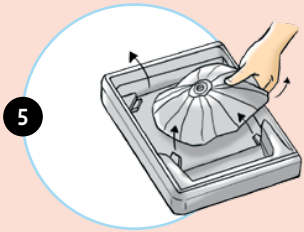
3. Use the scissors to shorten the black tube by 5.5 cm, and push the tube from below through the hole in the bottle's cap. When you screw the cap onto the bottle, there should be a gap about the width of a finger between the end of the tube and the bottom of the bottle.

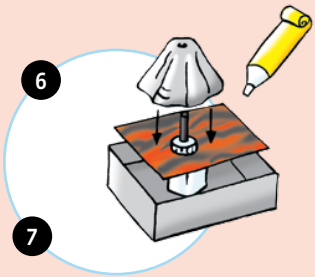


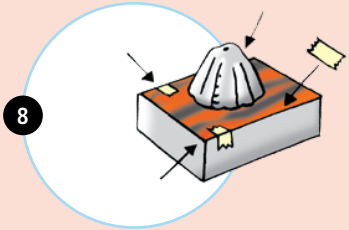


EXPERIMENT 1









4. To remove the volcano from the polystyrene frame, cut it with a knife along the thin line of the frame. Ask an adult to help you with this! Be careful not to damage the frame in the process, since you will need it for other experiments.

5. Then, carefully separate the volcano from the insert. Use the knife to smooth the edges, if necessary.

6. As a test, try creating your volcano landscape by arranging your polystyrene insert, cardboard sheet with hole, volcano, and bottle as shown in the drawing.

7. For the experiment, glue the volcano to the base with solvent-free glue.

8. Secure the cardboard sheet with tape to the corners of the polystyrene frame.

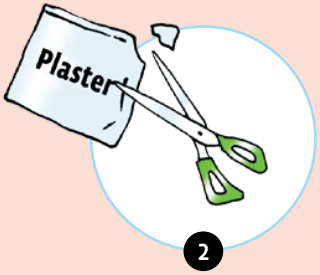
→ WHAT'S HAPPENING?

Now you'll have to wait for the glue to dry, securely affixing the volcano to the base with the rock design. Use the time to complete other preparations for your first volcanic eruption. Then your volcano will be ready for use.

Your volcano erupts

YOU WILL NEED

- → assembled volcano from Experiment 1
- → plaster
- → sodium bicarbonate
- → tartaric acid
- → red coloring
- → measuring cup
- → 2 wooden spatulas (one with and one without markings)
- → safety glasses
- → *paper towels*
- → *water*
- → *scissors*
- → *empty yogurt container*



HERE'S HOW

1. First, put on your safety glasses.

2. Cut off the corner of your plaster packet, being careful not to cut the label, so you don't forget what's in the packet.

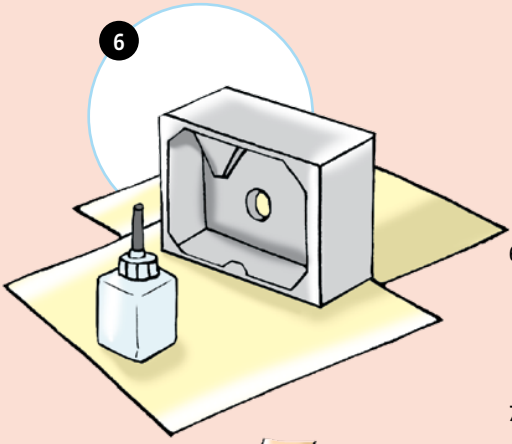
3. Carefully fill the measuring cup up to the 100 ml mark with plaster powder. This will make about 80 grams of plaster.

4. Pour the plaster powder into an old yogurt container. Then, add half a spatula of red coloring. Reseal the packet of coloring by folding the edge over twice.

EXPERIMENT 2

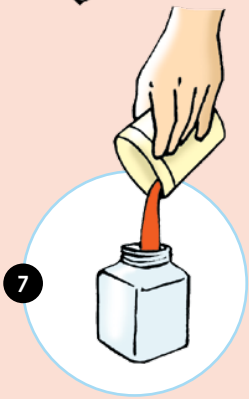
5. Use the measuring cup to measure a little over 50 ml of water (up to the "2" mark on the measurement scale), and carefully stir it into the plaster powder. Start by stirring carefully with the wooden spatula, so you don't lose any powder, then stir thoroughly.

   This mixture will form a light red plaster paste, about the consistency of cheese sauce. If it is thicker, add a little water and stir again.

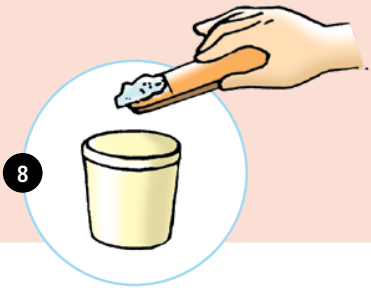


6. Take the bottle with the lid and tube out of the prepared volcano. Set the polystyrene insert upright on your work surface, resting on one of its long edges.

7. Now pour the colored plaster paste into the bottle, being careful not to spill any. Ideally, work on your prepared work surface.



8. Take a second yogurt container and use the marked wooden spatula to add two spatulas of sodium bicarbonate and one spatula of tartaric acid to it. Mix everything thoroughly with the spatula.



Safety note: For sodium bicarbonate, tartaric acid, and plaster, see the "Information about hazardous materials" on page 5.

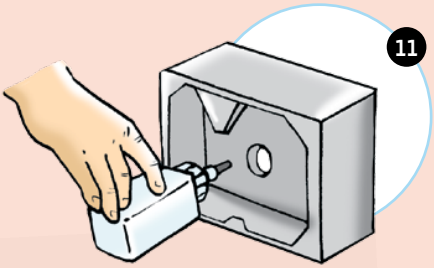
Your volcano erupts

HERE'S HOW IT CONTINUES

9. Use the spatula to add the complete fuel mixture to the plaster paste in the bottle. **Quickly** screw on the lid.

10. **Now you have to work fast:** Hold your thumb over the end of the tube and briefly shake the bottle so that the fuel mixture mixes well with the plaster paste.

11. Quickly push the bottle with the tube into the prepared volcano landscape from below, and set the base upright again. You should be able to see the tube sticking up through the crater.



→ WHAT'S HAPPENING?

After just a few seconds, a red, lava-like substance will come gushing up out of the bottle and spread over the sides of the volcano. Once the lava supply is used up, remove the bottle with the tube. Be sure that the hole in the middle of the volcano — the crater — remains clear. After a few minutes, the plaster will harden and form solid lava on the sides of your volcano.

NOTE!

Before the plaster hardens, you should thoroughly rinse the bottle and the tube with plenty of water, so no hardened plaster residue gets stuck there.

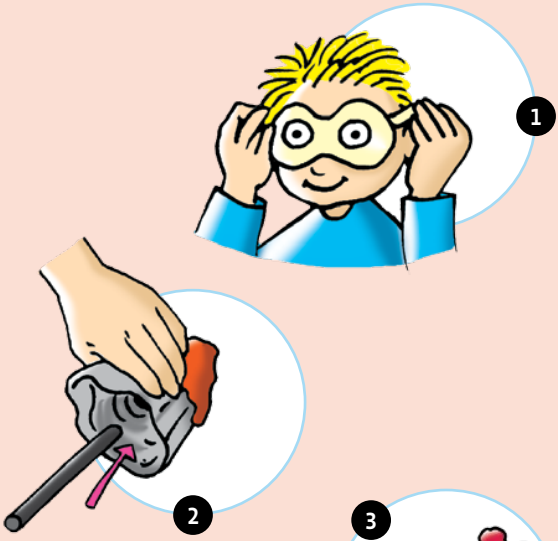
Safety note: For sodium bicarbonate, tartaric acid, and plaster, see the "Information about hazardous materials" on page 5.

EXPERIMENT 3

Your volcano grows

YOU WILL NEED

- → safety glasses
- → volcano from Experiment 2
- → sodium bicarbonate
- → tartaric acid
- → bottle
- → lid
- → black plastic tube
- → plaster
- → red coloring
- → measuring cup
- → wooden spatula
- → *paper towels*
- → *water*
- → *empty yogurt container*



HERE'S HOW

1. Put on your safety glasses again.

2. Insert the black plastic tube into the volcano from below to make sure that the crater remained clear after your first volcanic eruption.

3. If the opening is clear, then perform steps 3 through 11 from Experiment 2 again. You can mix your plaster paste to be a little thicker or thinner this time to create different lava effects.

Tip

If your volcano has grown too big, you can scrape off the plaster with a wooden spatula and toss it into the trash. Remove the polystyrene volcano from the base and rinse it thoroughly under the faucet. Gently bend the base to make the plaster crumble off.

Safety note: For sodium bicarbonate, tartaric acid, and plaster, see the "Information about hazardous materials" on page 5.

→ WHAT'S HAPPENING?

The new paste will flow over the older layers, and your volcano will gradually grow — just like in real life.

Volcano

The word volcano comes from **Vulcanus,** the name the Romans gave to their god of fire. They believed that he operated a blacksmith's shop at the bottom of a volcano called Vulcanus, on an island to the north of Sicily known today as Volcano. The Romans thought that whenever sparks and fire flew out of the crater, it was a sign that Vulcanus was hard at work.

In Zaire, people believed that the god Gongo lived in a volcano called Mount Nyiragongo.

The inhabitants of Hawaii worshipped and feared their volcano goddess, Pele. According to legend, she lived in Halema'uma'u crater.

Lava that has hardened into threads when blown by the wind is called Pele's hair.

CALDERA

During powerful volcanic eruptions, the entire magma chamber can become empty. When that happens, its roof often collapses under the weight of the volcanic mountain. That creates a broad, open crater known as a *caldera*. Calderas of island volcanoes often fill with seawater. Eventually, however, the pressure from magma builds up again from the depths of the Earth, and a new volcanic mountain pushes up through the caldera.

CHECK IT OUT

VOLCANIC CHEMISTRY

Just as in a real volcano, gas pressure in your volcano pushes the paste, representing lava, out of the crater in the top of the volcano. The gas that creates the pressure is carbon dioxide, released when tartaric acid, sodium bicarbonate, and water combine. This is the same gas that bubbles up in soft drinks!

After the carbon dioxide gas pushes the colored plaster paste through the plastic tube and out through the crater, the paste spreads out over the volcanic cone and hardens. Just like real lava, the paste contains gas bubbles that give it a sponge-like appearance.

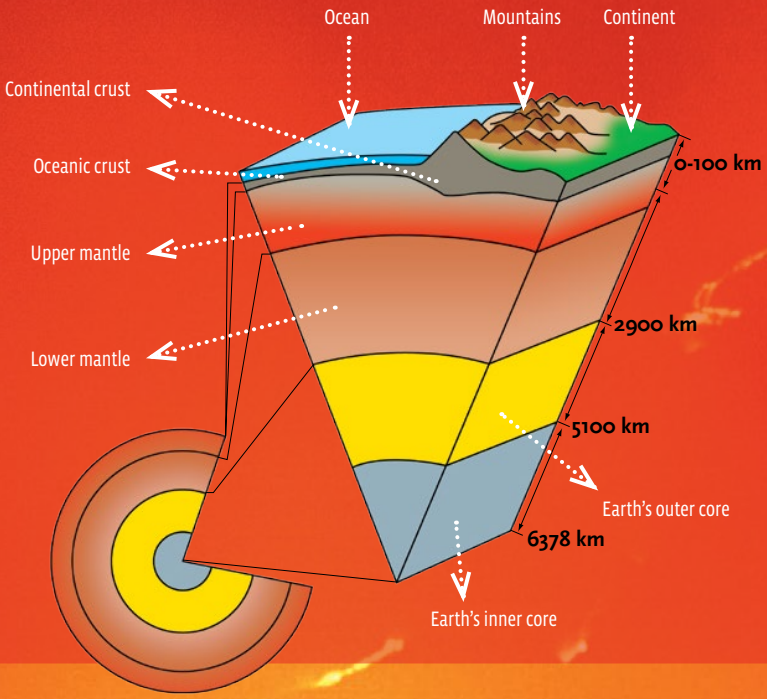
Water vapor, produced by volcanic heat, shoots the water of a geyser into the sky.

USEFUL VOLCANOES

Not all volcanoes cause harm. The Stromboli volcano north of Sicily has been spitting up sparks and glowing chunks of lava every half hour for over 2,000 years. And while the Kilauea volcano on the island of Hawaii does emit streams of lava quite often, they flow harmlessly into the sea. People just have to be careful not to get too close to the glowing red ribbons of molten rock.

All in all, volcanoes benefit humankind. When Earth was young, there were a lot more volcanoes than today, and they gave off huge quantities of water vapor and other gases. Those volcanoes supplied most of the water that fills our oceans today, and they provided our planet with its first atmosphere, even though it wasn't yet breathable.

In addition, volcanoes provide us with valuable rocks and minerals from the depths of the Earth. The ground around a volcano is particularly fertile, so it is often farmed despite the potential danger. We even have volcanoes to thank for diamonds, which are delivered to the surface from the depths of the Earth, where they formed under intense heat and pressure.



CHECK IT OUT

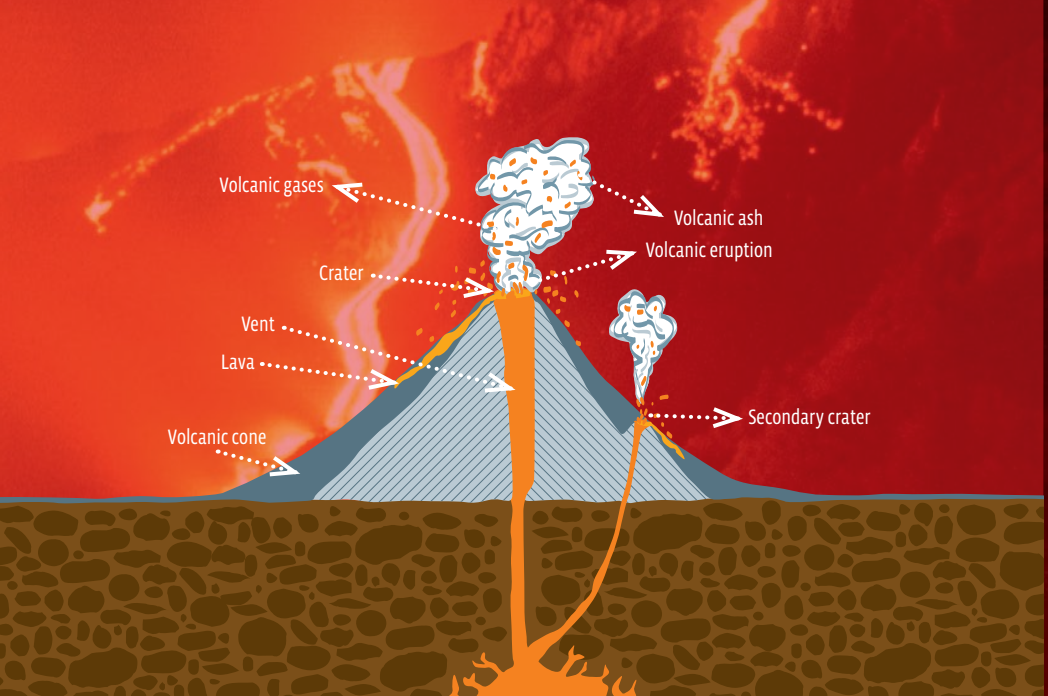
RED-HOT ROCK FROM THE DEPTHS

Volcanoes form in areas where glowing-hot liquid rock rises up from Earth's inner core and breaks through Earth's crust. The name for this sort of molten rock, which is always seething in the depths of Earth, is **magma**. Usually, the magma melts the solid rock of the Earth's crust beneath a volcano to form a hollow space called a **magma chamber**. A new volcano typically starts out as a crack in the ground that magma is pushed up out of. The magma is pushed up by the pressure of dissolved gases trying to expand, like when you open a bottle of soda or champagne. In time, the molten rock cools and forms a cone-shaped mountain — the actual volcano. Inside the volcano is a vent that forms a bowl-shaped opening — **the crater** — at the volcano's top.

Out of the crater rise gases, steam, smoke, fine rocks called **ash**, burning-hot rock debris, and glowing magma. As soon as the magma gets to the surface, its name changes: now it's called **lava**.

The hotter and thinner the lava is, the farther it can flow before it hardens. Volcanoes that expel more liquid lava have flatter shapes. Due to the fact that they look something like a knight's shield placed on the ground, they are called **shield volcanoes**.

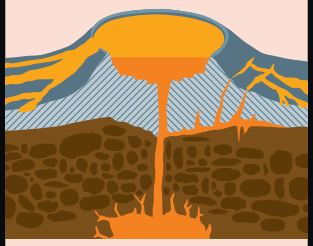
Stickier lava, on the other hand, forms volcanoes with steeper sides. These volcanoes are usually made up of alternating layers of volcanic ash and hardened lava. These are called **stratovolcanoes**.



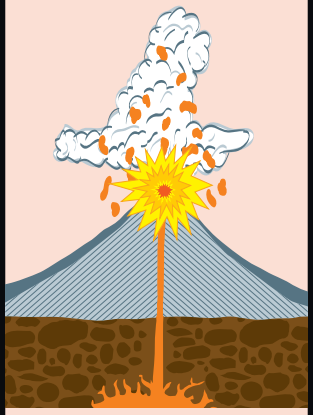
Vesuvius type: In these volcanoes, the vent becomes blocked. The mountain may lie dormant for centuries, and people may settle on its green, fertile slopes. But sooner or later, pressure will accumulate inside the volcano, pushing out the blockage and shooting out vast quantities of volcanic ash, pumice, and glowing-hot rocks. Vesuvius lay dormant for 800 years before destroying the Roman city of Pompeii, and Mount St. Helens was quiet for over 100 years until its eruption in 1980. Pinatubo in the Philippines belongs to this type as well.

TYPES OF VOLCANO

Each volcano is unique. The viscosity and gas content of the magma determine how the volcano will behave. That means that every volcano has its own "signature," which can change over the course of time.



Hawaiian type: These are the most harmless types of volcano, thanks to their thin lava that is low in gas content. While their lava often flows in large quantities, it does so quietly, creating shield volcanoes such as Hawaii's Mauna Loa.



Krakatoa type: These are the most dangerous volcanoes. They have thick, sticky lava and are capable of developing powerful gas pressure that can break open the entire mountain with unbelievable force after a long period of dormancy.

Pelée type: These fire-spewers are quite dangerous. They are named after Mont Pelée on the island of Martinique. Volcanoes of this type emit hot gas and clouds of ash over 800 degrees Celsius in a completely unpredictable manner, and send glowing-hot avalanches racing down their slopes. That happens when sticky lava blocks the vent and the mounting pressure seeks a way out through the volcano's side.

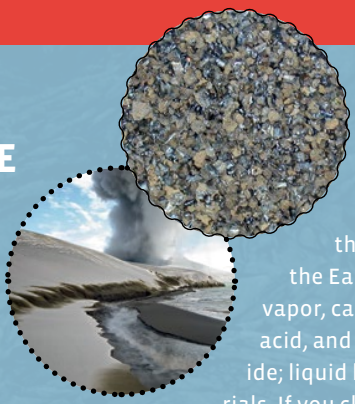
Stromboli type: These volcanoes, such as Stromboli north of Sicily, have fairly sticky lava. Stromboli erupts about every 30 seconds, shooting a few shreds of lava, sparks, and glowing rocks several meters into the air.

CHECK IT OUT

VOLCANOES IN SPACE?

The largest volcano in our solar system is Olympus Mons 1 on Mars, which has a diameter of 600 km, five times larger than Mauna Loa 5, the largest volcano on Earth, with a height of almost 27 km. Olympus Mons appears to be extinct, however. Venus and Jupiter's moon Io 2 3 4 are rich in active volcanoes. The latter is covered with yellow, white, red, and brown material, consisting chiefly of sulfur, which is spewed out by active volcanoes.

THE LANGUAGE OF LAVA



Gas-poor, thin-flowing lava forms a smooth, black surface, which is often pushed together into folds. The name for this type of lava, **pahoehoe,** comes from the Hawaiians, who have had a lot of experience with lava fields on their volcanic islands (photo in foreground).

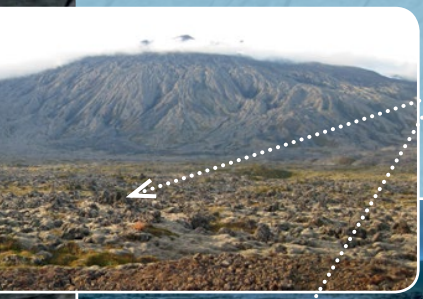
Gas-rich, thicker-flowing lava, on the other hand, hardens into individual, sharp-edged, twisted blocks. A walk through this kind of landscape can be painful in bare feet, hence the name **'a'a lava**. When you say it out loud ("ah-ah!"), you can really hear the way your bare feet would feel!

VOLCANIC ROCK

Volcanoes supply a lot of things from the depths of the Earth — gases such as water vapor, carbon dioxide, hydrochloric acid, and sharp-smelling sulfur dioxide; liquid lava; and other solid materials. If you climb up a volcano, you will cross large areas scattered with these kinds of materials. The smallest particles, with a diameter of under 2 mm, are called **volcanic ash**, and somewhat larger ones are called **lapilli**. Very large hardened rocks are called **volcanic bombs**.

Sometimes, sticky, gas-rich lava is ejected so quickly that it forms rock with lots of little gas bubbles trapped inside. This kind of rock, called **pumice**, is so light that it floats on water.

In your kit, the small plastic bag of stones contains a **lapilli sample**. Its many holes come from gas bubbles that were trapped inside the lava when it hardened. The general name for this kind of loose material is **tephra**. If tephra pieces solidify into soft rock, that rock is called **tuff**.



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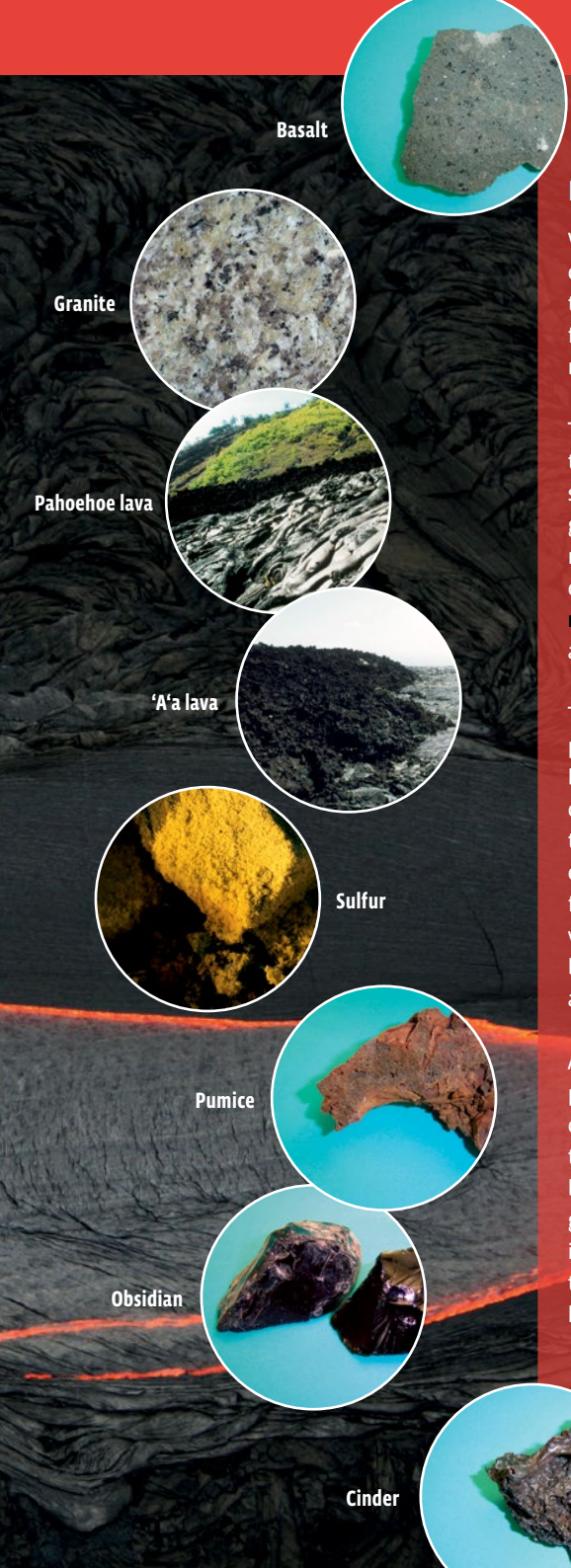


HARDENED ROCK PASTE

Volcanic forces also produce huge quantities of solid rock. Earth scientists (geologists) call them **igneous rock**, based on the Latin word for fire, because they are made from hardened magma or lava.

There are two types of igneous rock. Sometimes, magma hardens before it reaches the surface. In the Earth's core, the rock cools very gradually. The individual components of the magma have time to separate and form large crystals. Rocks like these, named **plutonic rocks** after the Roman god of the underworld, are always large grained.

The best known plutonic rock is **granite**, two pieces of which you will find in the kit's plastic bag. Granite can be found in many different colors, depending on its chemical composition. In many regions where the overlying layers of rock have been removed, it can also be found on Earth's surface. Granite is a highly valued building material for walkways and building façades due to its beautiful appearance.

At Earth's surface, flowing lava cools quickly, producing **extrusive volcanic rocks**. Their components have no time to form large crystals, so they have a uniform appearance. The best known representative of this group is gray basalt, a hard and tough rock often used in road construction. Sometimes, basalt forms tightly clustered, six-sided columns as it hardens.

Volcano Locations and Plate Tectonics

There are around 500 active volcanoes on Earth's surface. The names of most of them are only familiar to volcano researchers and those who live near them; only few of them are really famous. In this chapter, you will find out where these famous volcanoes are and why they came into existence in those locations.

EXPERIMENT 4

Plate tectonics puzzle

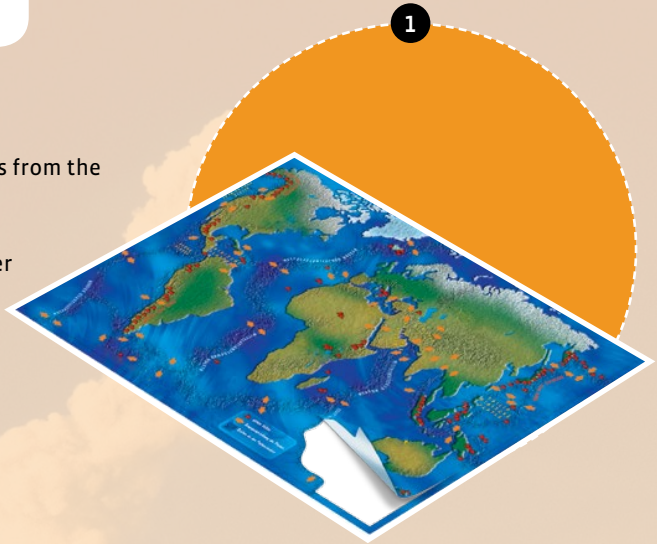
YOU WILL NEED

→ plate tectonics puzzle die-cut sheet

HERE'S HOW

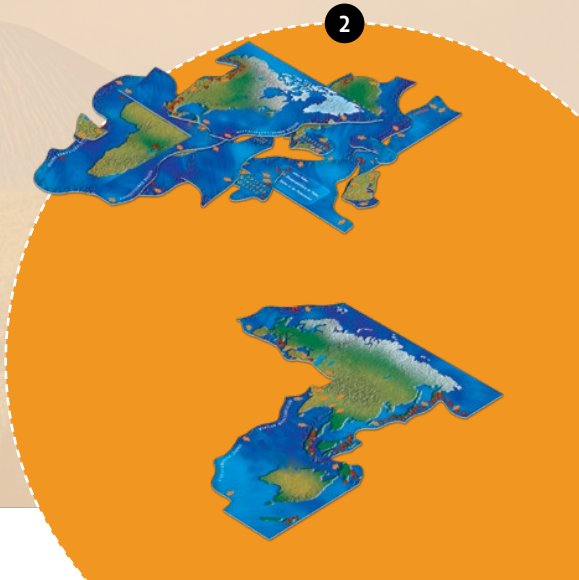
1. Carefully remove the pieces from the sheet.

2. Try to fit the pieces together the right way.



→ WHAT'S HAPPENING?

The edges of the individual puzzle pieces match the plate boundaries that actually exist on Earth's surface. You can see that volcanoes (the little red caps) usually occur at those plate boundaries.



Volcanoes worldwide

YOU WILL NEED

→ **globe die-cut sheet**
→ ***glue or glue stick***
→ ***pencil***

HERE'S HOW

1. Carefully remove the four globe sections from the sheet.

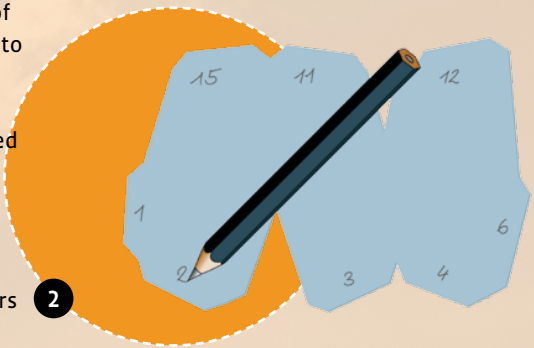
2. Write the numbers you see along the pieces' edges onto the gray back side of the each piece. This will make it easier to match things up later on.

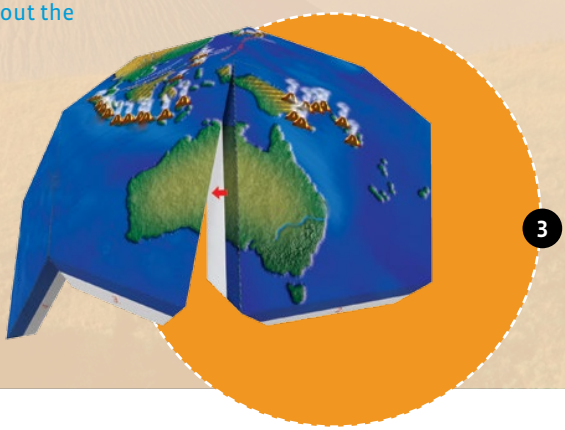
3. Gently bend the pieces along the dotted lines.

4. Glue all four sections together at the white flaps, following the diagram on the next page. Be sure that the numbers match up.

5. Now take a careful look at your globe.

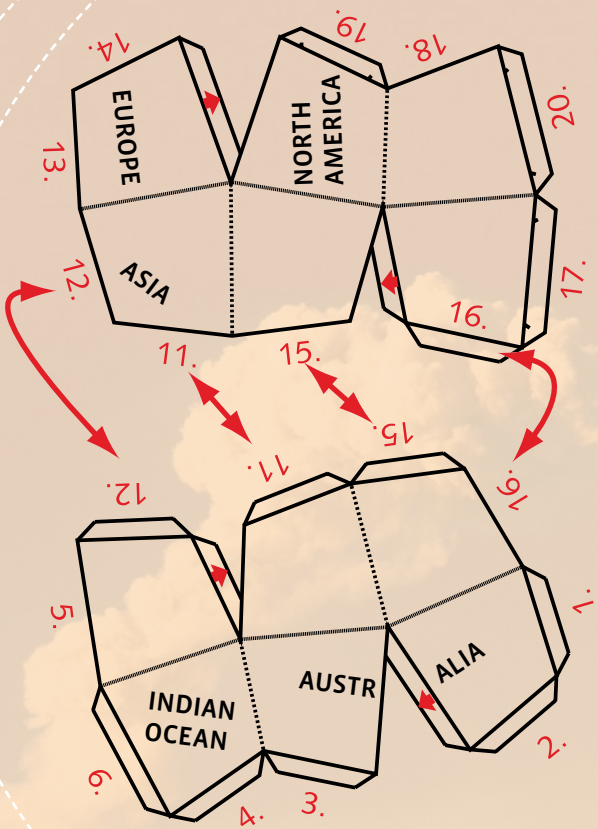
   Do you notice anything about the volcanoes?





EXPERIMENT 5

4



5

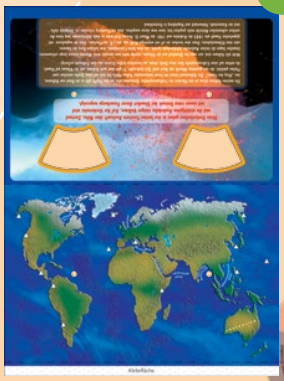
→ WHAT'S HAPPENING?

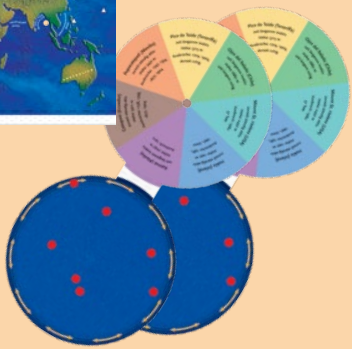
You can use the sections from the die-cut sheet to assemble a globe that, while admittedly not exactly round, is better than an ordinary globe at representing the world's volcanic regions. You can easily see that volcanoes usually occur lined up in rows.

The most famous volcanoes

YOU WILL NEED

→ volcano learning wheel die-cut sheets
→ 2 two-pronged clips
→ *glue or glue stick*





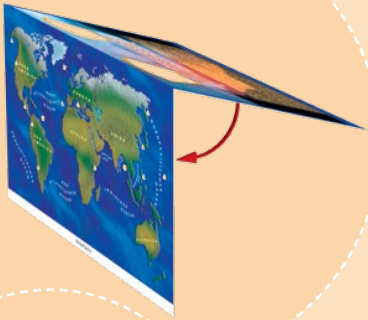
HERE'S HOW

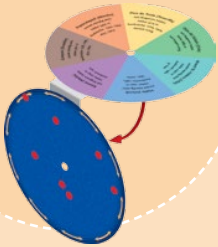
1. Push the four disks and the large section with windows and the world map out of the die-cut sheets.

2. Push out the small triangles, circles, and two orange-colored window placeholders.

3. Fold the large section with the world map along the dotted line.

4. Glue the large section together at the gluing flap. Also glue together the two pairs of round disks so that the markings match precisely.





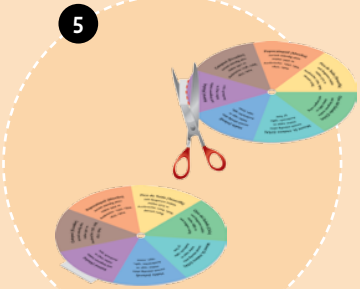
EXPERIMENT 6

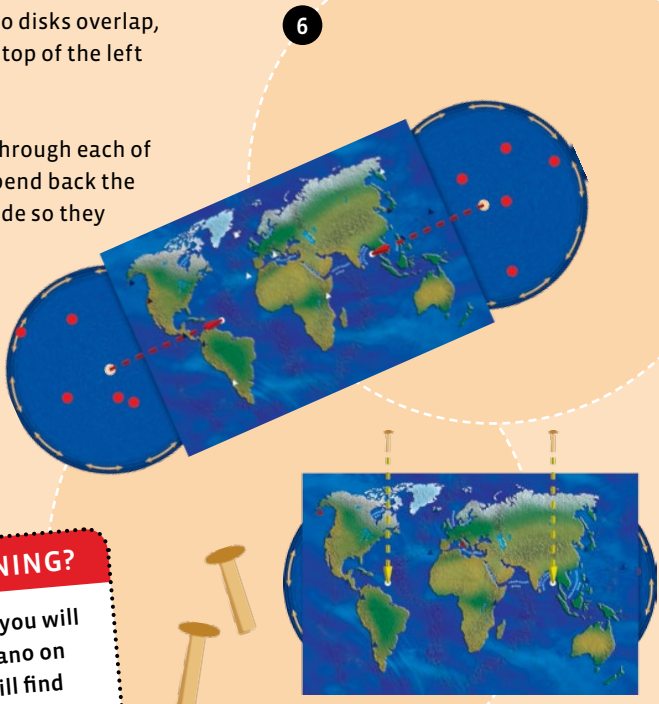
5. Carefully cut off the flap projecting from the edge of each disk.

6. Finally, push the two disks into the pouch created by the glued-together world map section so that you can see the writing through the large windows and the red dots through the small openings. Make sure the disk with “Pico del Teide” is on the left and the one with “Mount Fuji” is on the right.

   In the center, where the two disks overlap, the right disk should lie on top of the left one.

7. Insert a two-pronged clip through each of the two center holes, and bend back the metal prongs on the rear side so they stay in place.





→ WHAT’S HAPPENING?

When you turn the disks, you will see the location of a volcano on the front side, and you will find its name, height, and eruption history on the rear.

Once you learn about the various volcanoes, you can use this tool to quiz your friends and family!

A lava flow cutting through a forest in Hawaii

Volcanoes in your backyard

The United States is home to about ten percent of the world's volcanoes that have erupted in the past 10,000 years. The country ranks third in the number of volcanoes that have erupted in recorded human history, after Indonesia and Japan. Most of the volcanoes in the United States are found in Alaska, Hawaii, and along the west coast, in Washington, Oregon, and California. Very few of these volcanoes have erupted in the past 100 years, but there have been some very big, notable eruptions.

The most famous eruption in recent memory was Mount St. Helens, in Washington. On May 18, 1980, this volcano exploded when a magnitude 5.1 earthquake hit beneath it. First, a destructive and lethal blast of steam, gas, and rock was unleashed. The heat from the blast melted snow and ice from the mountaintop, releasing a landslide of water and earth. Hundreds of tons of ash were blown over the entire region.

Lava flowing into the ocean in Hawaii

Kanaga Volcano in Alaska

Mount St. Helens after its 1980 eruption

Mount St. Helens before its 1980 eruption

CHECK IT OUT

Mount Bromo (Indonesia)

Volcanoes everywhere?

Volcanic regions are not evenly distributed across the globe. Quite the opposite, in fact: Broad expanses of several continents are free of active volcanoes, such as Australia, northern Asia, and the eastern regions of North and South America.

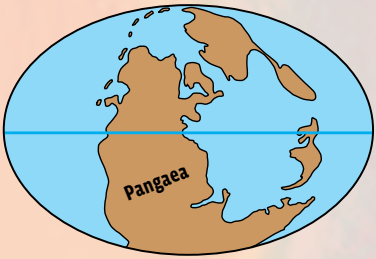
In other areas, though, volcanoes are lined up like pearls strung on a necklace. The coastal areas around the Pacific Ocean are particularly rich in volcanic activity, which has given rise to the name "Ring of Fire."

In Europe, active volcanoes are mostly found in the Mediterranean region, and on Iceland, in the Atlantic Ocean, an island of purely volcanic origin.

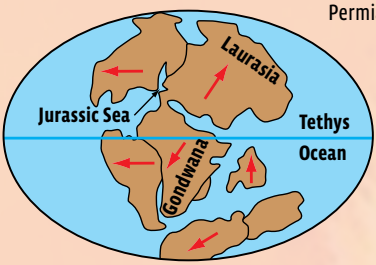
Eruption of Vesuvius (Italy), 1872

Tenerife, the volcanic island

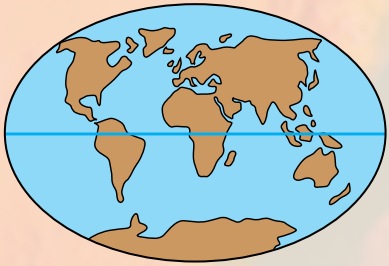
In April 2010, Eyjafjallajökull in Iceland erupted, sending huge clouds of ash up into the atmosphere. Air traffic across Europe was halted for several days as the ash threatened to damage airplane engines and scratch cockpit windows.



Permian world of around 280 million years ago



Jurassic world of around 190 million years ago



World today

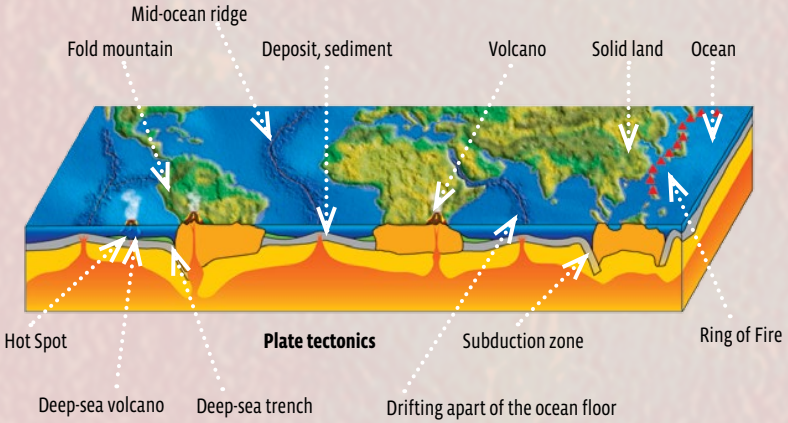
Shifting pieces of Earth

When you studied your globe, you probably noticed that volcanoes usually occur in rows. This fact also puzzled geologists. The solution to the puzzle was provided a few decades ago by the discovery of **plate tectonics**.

Our Earth's crust is not like a stiff piece of armor. It is more like a puzzle assembled of about ten large and numerous smaller plates. On these plates rest the floors of the oceans and the continents. The plates themselves float on the semi-fluid rock of Earth's **upper mantle**, and movements in the upper mantle cause the plates to drift around the globe at speeds of a few centimeters a year.

Sections of our continents move along with the plates, floating slowly around like sheets of ice on a river, pushing up against one another to form mountain ranges or pulling apart again to create crevasses.

CHECK IT OUT



Tearing and diving plates

In many areas, the flows of liquid rock in Earth's interior pull the plates apart. There, red-hot magma rises up and hardens into gray basalt, which collects on the plates and enlarges them.

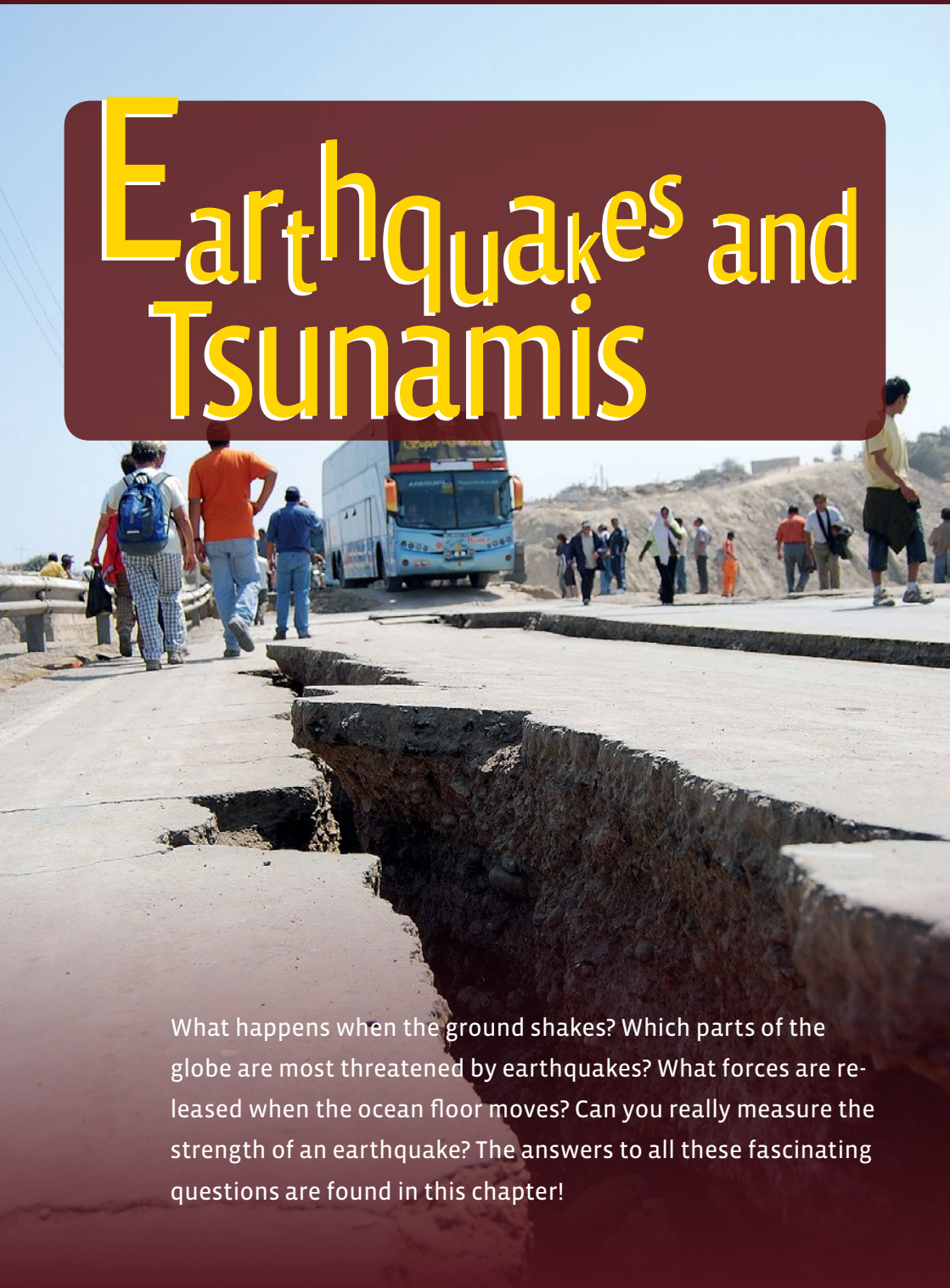
Most of these stress points, where the plates are pulled apart or pushed together, lie in the oceans. At one such stress point, hardening magma has piled up to form the **mid-ocean ridge**, which, at 65,000 km, is the longest mountain range in the world. It is also the least known, because it lies almost completely underwater. In the Atlantic Ocean, it's called the Mid-Atlantic Ridge. Iceland is one small part of this ridge that happens to rise up above the ocean's surface. This ridge is basically one extremely long volcano.

In other places on Earth, one plate sometimes drops below another one and plunges into the depths. Geologists call these areas **subduction zones**. There, you can find very deep chasms underwater, called **deep-sea trenches**. A portion of the plate's rock melts, rises up, and seeks a route to Earth's surface, resulting in active volcanoes. Zones like this are particularly common in a ring around the Pacific Ocean. However, not all volcanoes sit at the edges of plates.

Some well known examples of this phenomenon are found in the Hawaiian Islands, like the powerful Mauna Loa and Kilauea volcanoes. These volcanoes are fed by a **hot spot**. This is the name geologists give to a fixed zone where very hot rock rises up from great depths and melts through the plate — similar to a candle flame held under a piece of plastic wrap. As the plate moves, it creates a chain of volcanic islands of varying ages. Only the youngest volcanoes, the ones sitting on top of the hot spot, are active, while the older volcanoes created by the hot spot are extinct.

There are also hot spots under Iceland, the Azores, the Canary Islands, Easter Island, the Yellowstone volcanic region, and presumably under Germany's Eifel mountain range.

Earthquakes and Tsunamis



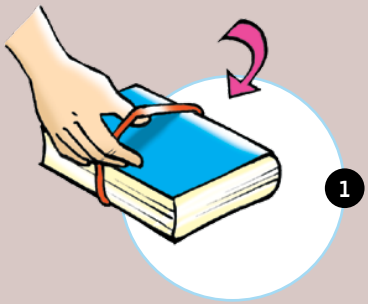
What happens when the ground shakes? Which parts of the globe are most threatened by earthquakes? What forces are released when the ocean floor moves? Can you really measure the strength of an earthquake? The answers to all these fascinating questions are found in this chapter!

EXPERIMENT 7

When the table shakes

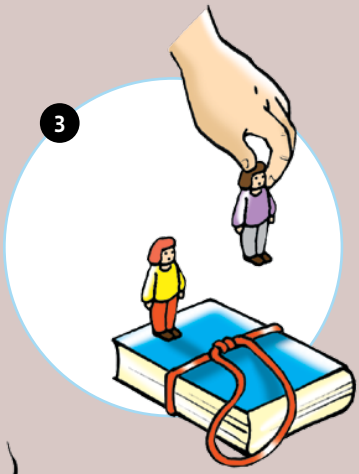
YOU WILL NEED

→ *book*
→ *2 rubber bands*
→ *3 small human figures*



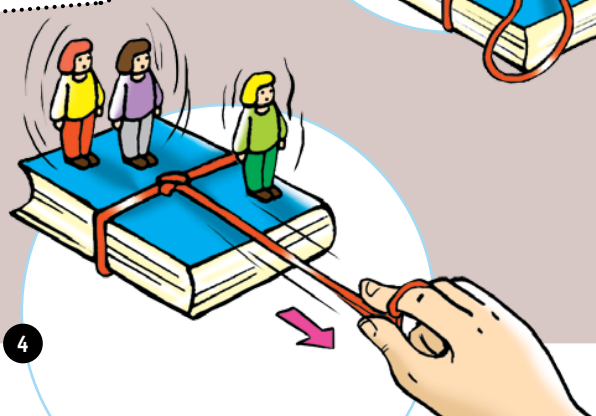
HERE'S HOW

1. Wrap one rubber band around the book.
2. Tie a second rubber band to the first one.
3. Set the human figures on the book.
4. Pull on the second rubber band to move the book slowly across the table.



→ WHAT'S HAPPENING?

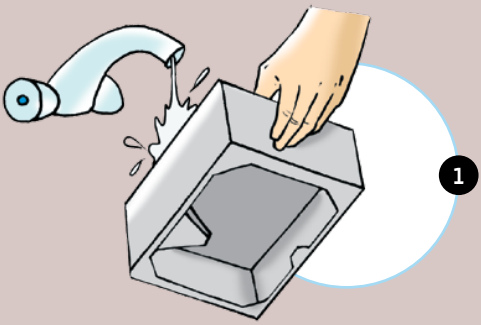
The book doesn't move smoothly, but in little jerks. When there's a relatively strong jerk, the human figures topple over — they experience an "earthquake."

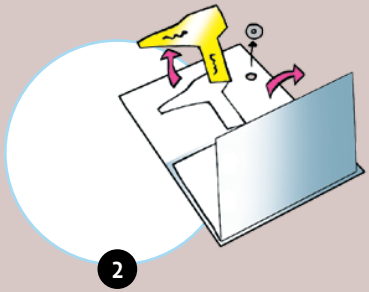


Your model seismograph

YOU WILL NEED

- → seismograph die-cut sheet
- → polystyrene insert (frame)
- → push rivet
- → compass lead
- → screw
- → wooden bead
- → spring
- → *2 coins*
- → *piece of paper*
- → *tape*
- → *ballpoint pen*
- → *screwdriver*





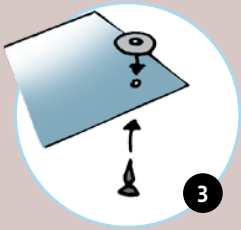
HERE'S HOW

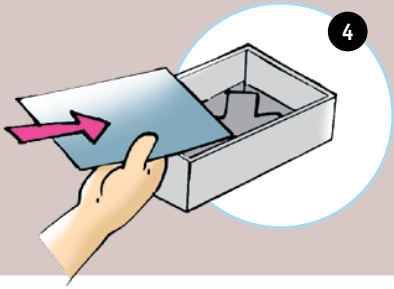
1. If you have already assembled your volcano, remove it from the polystyrene insert and run the insert under lukewarm water to remove any plaster residue. Then dry it.

2. Remove the three seismograph parts from the sheet and push out the excess cardboard pieces.

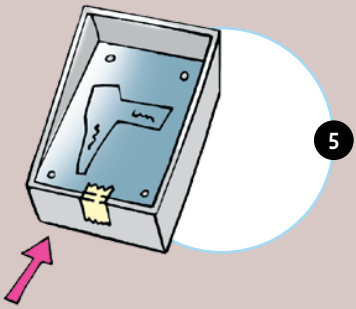
3. Insert the rivet into the hole provided for it. Place the cardboard washer over the rivet from the top.

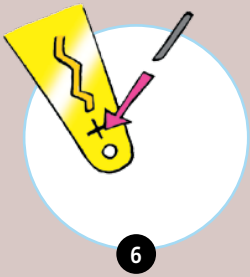
4. Now push the cardboard panel onto the polystyrene frame.





EXPERIMENT 8





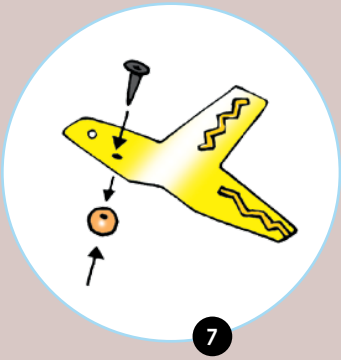
HERE'S HOW IT CONTINUES

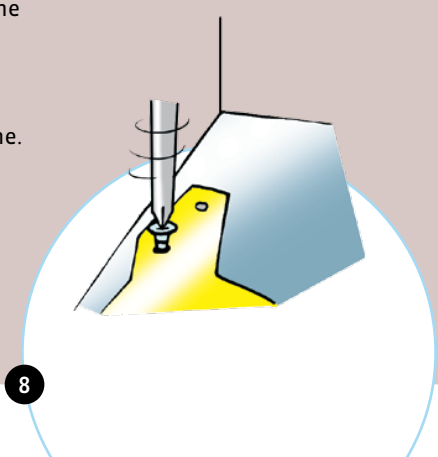
5. Secure the panel with a piece of tape, so it doesn't slip out of the frame!

6. Now get the yellow pointer ready. First, push the compass lead through the X-shaped opening provided for it. This will work better if you prepare the opening by making a hole through it with a ball-point pen.

7. Attach the pointer to the panel with the screw and wooden bead.

8. Twist the screw carefully into the slit provided for it in the polystyrene frame.





Your model seismograph

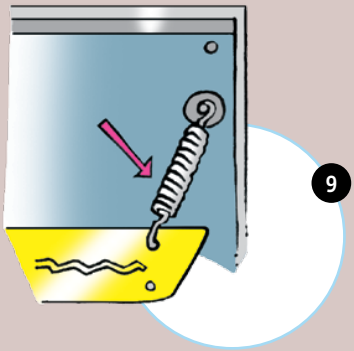
HERE'S HOW IT CONTINUES

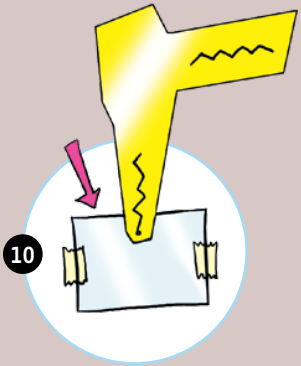
9. Attach the spring to the rivet and the upper hole of the yellow pointer arm.

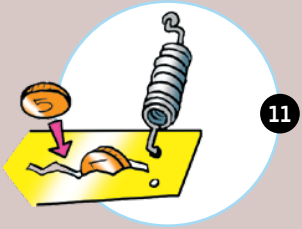
10. So you can record movement, tape a small piece of paper beneath the pointer arm with the piece of lead. You can use a sticky note for this if you have one.

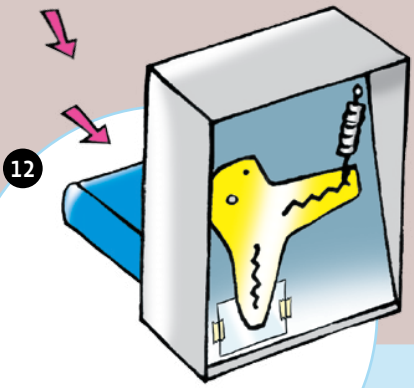
11. Now push one or two coins into the pointer slit. These will serve as a weight. To measure vertical movements, insert the coins in the horizontal slit.

12. This is how your completed seismograph will look.









→ WHAT'S HAPPENING?

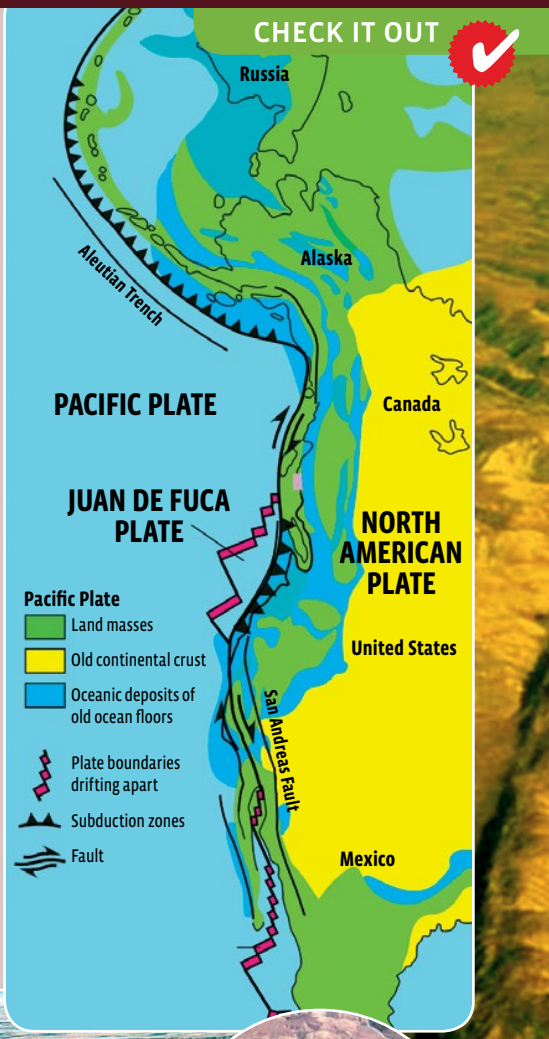
You can use your seismograph to test how strongly your table shakes in the next chapter's experiments. The tip of the pointer will record the shaking as a line. The greater the line's movement, the stronger the shaking.

WHEN THE EARTH SHAKES

In addition to volcanoes, your globe also shows you **areas threatened by earthquakes**. It is easy to see that where there are volcanoes, the Earth will often shake as well.

This is because volcanoes usually sit on the border between plates, and it is precisely at those same contact points between two or more plates that almost all earthquakes also occur.

The plates are not smooth, but have jagged edges and projections that grab onto each other as the plates slide by. The plates don't stay put when that happens; they keep getting pulled along. Tension accumulates in the rock until the jagged projections tear away with a jerk. It's this jerk that we experience as an earthquake.



San Andreas Fault

KILLER WAVES RACING THROUGH THE OCEAN

1 Tsunami damage in Malaysia
2 People in Thailand fleeing a tsunami wave in 2004
3 A powerful wave breaks on a harbor wall

A strong earthquake is a natural event that is never forgotten by the people who experience it. All of a sudden, they lose the trust they have in the safety of the ground beneath their feet. And the damage from a major earthquake can be devastating. Houses and bridges collapse, roof tiles and pieces of concrete tumble to the street, and power lines get ripped apart.

Often fires break out, and they can't be extinguished due to broken water lines. A giant black cloud of smoke and dust rises up above a city where an earthquake strikes, although the city has been instantly transformed into a broad expanse of rubble. Mountain slopes can slide down, rivers can change their course, dams can break and flood the land beneath them.

When the ocean floor shakes, it can create powerful killer waves known as **tsunamis**, which race through the ocean at the speed of a jet plane but can hardly be felt in the deep ocean water.

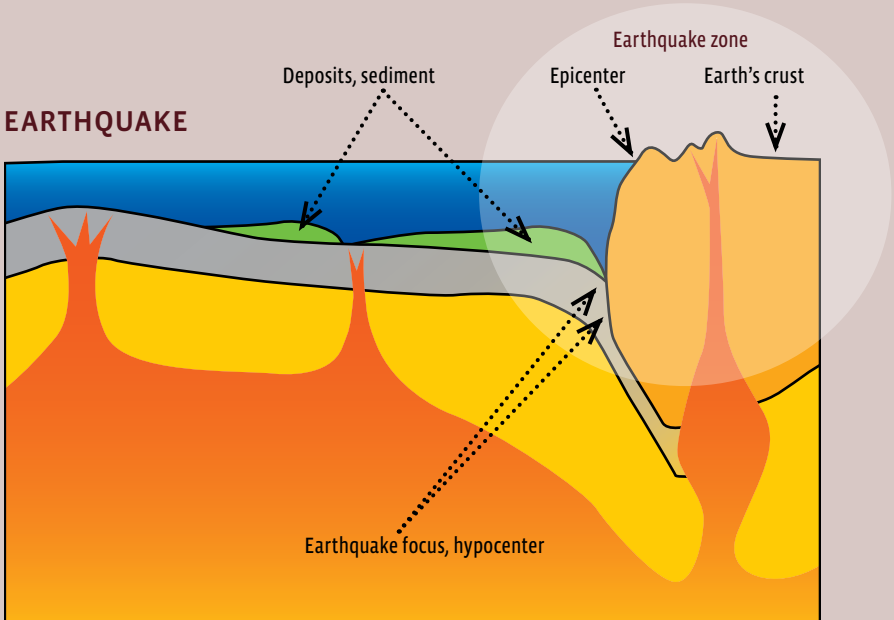
As they approach land, though, the waves rise up and collapse in gigantic destructive walls of water onto towns and cities along the coast — hundreds of kilometers away from the actual earthquake sites. Major quakes and tsunamis can kill thousands of people, render hundreds of thousands homeless, and instantly transform prosperous lands into disaster areas.

CHECK IT OUT

WAVES RACING THROUGH THE PLANET

The actual place where an earthquake starts is called the **focus** or **hypocenter**, which can lie many kilometers down inside the Earth. The place on Earth's surface directly above the focus is called the **epicenter**. This is where the quake is felt most strongly. A powerful earthquake will reverberate through the Earth like a ringing bell. It sends out waves that run through the entire globe. On Earth's surface, the waves move powerfully back and forth, up and down — a shaking that can cause buildings to collapse.

Earthquake researchers (or **seismologists**) measure the waves emitted by a quake and use those measurements to gain a wealth of information about the quake's source — even if it lies thousands of miles away — as well as its precise depth, strength, direction of movement, and much more.



CHECK IT OUT

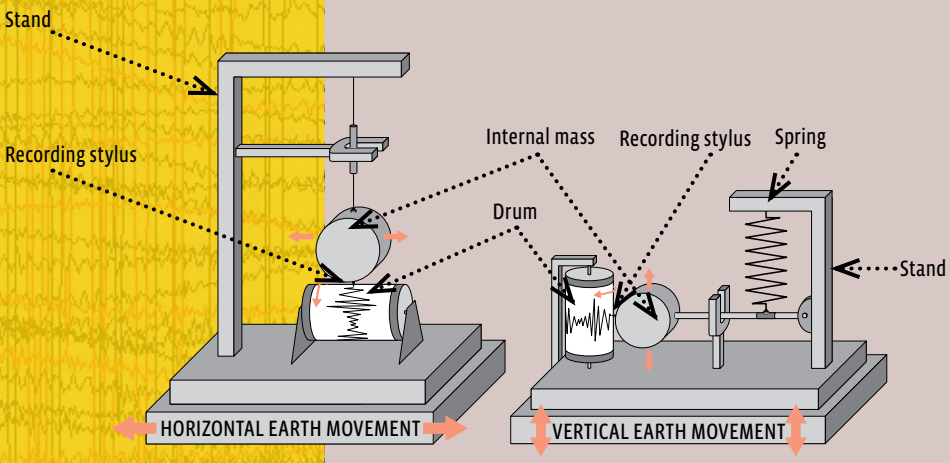
SEISMOGRAPHS

This is what a seismometer looks like on the inside.

The measuring device for earthquakes is also called a **seismometer**. It basically consists of a weight, or internal mass, such as a steel ball, suspended from a frame by a thin wire. Earlier models had a writing pen mounted at the bottom of the ball, which would press against a gradually unrolling strip of paper. If the ground moved even a little, the paper would move along with it, while the steel ball would remain in place due to inertia. The movements of the Earth would be recorded as a wave, called a **seismogram**.

Today, the movement of the seismometer's internal mass is detected electronically and recorded by computers so that the movement can be evaluated quickly. Earthquake activity is monitored by a vast network of seismometers located around the world.

SEISMOGRAPHS FOR DIFFERENT WAVE TYPES



Earthquake-safe Building

You can use small models made of wooden blocks to test the earthquake safety of various construction types, just as actual architects do on large shaking tables. With your seismograph, you can estimate the quake strength at the same time.

A collapsing house

YOU WILL NEED

→ seismograph from Experiment 8
→ *table*
→ *flat block of wood*
→ *heavy book*

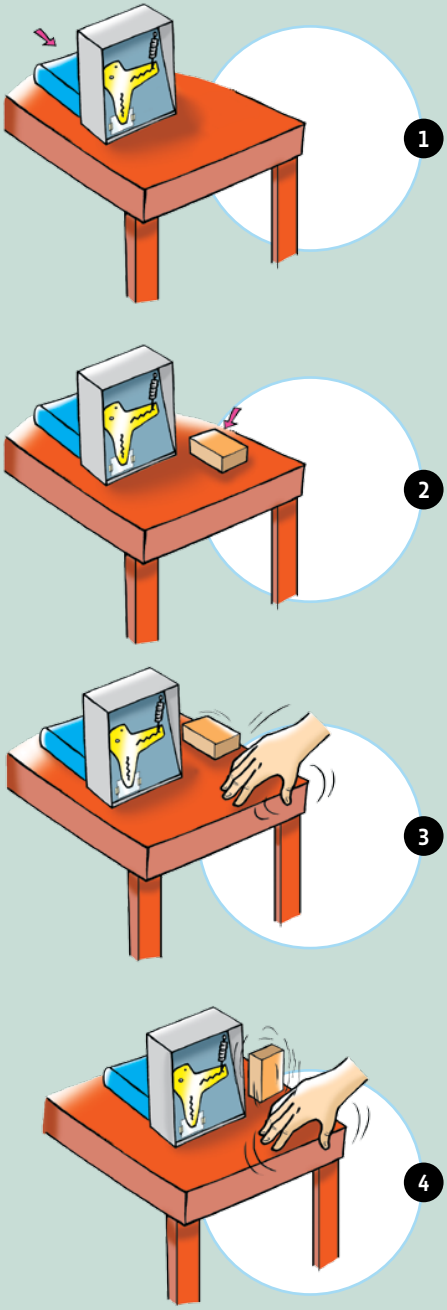
HERE'S HOW

1. Set your seismograph upright on the table. Secure it in place by pushing a book against the rear of the frame.

2. Place the block of wood flat against the table.

3. Jiggle the table gently at first, then more and more vigorously.

4. Now set the wooden block upright and shake the table some more.



→ WHAT'S HAPPENING?

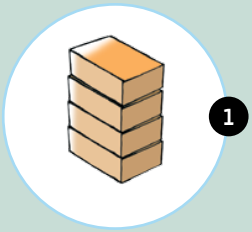
The wooden block topples much faster when it's set upright than when it's lying flat.

EXPERIMENT 10

A collapsing tower

YOU WILL NEED

→ seismograph from Experiment 8
→ *table*
→ *4 blocks of wood (squares or cubes)*
→ *tape*



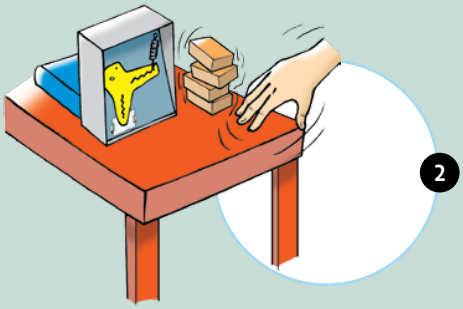
HERE'S HOW

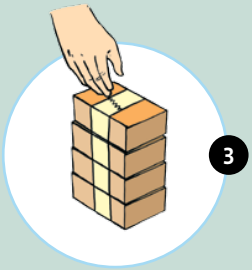
1. Pile the four blocks loosely on top of one another.

2. Shake the table again.

3. Stack the four wooden blocks again, but this time wrap them with tape.

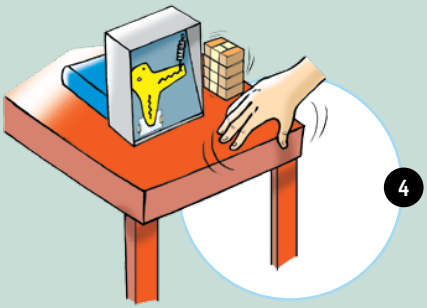
4. Shake the table once again.





→ WHAT'S HAPPENING?

Your first tower will topple over, but not completely. The top pieces are the first to be thrown to the ground. The tape on the second tower increases the tower's stability considerably.



Testing house shapes

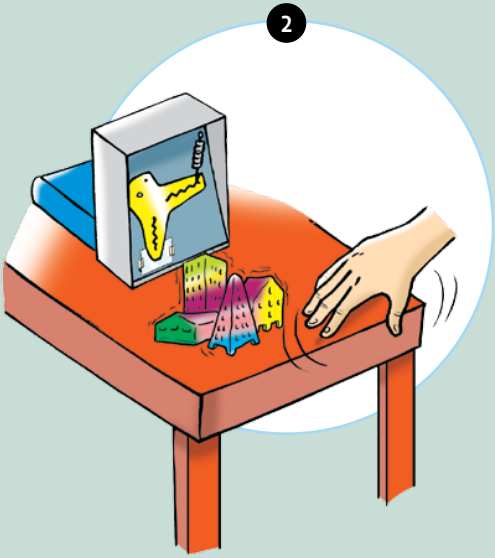
YOU WILL NEED

→ seismograph from Experiment 8
→ *table*
→ *clay*

HERE'S HOW

1. Create a variety of house models out of clay. Make a long, flat one with a pitched roof, a tall one with a flat roof, one in the form of a pyramid with feet, and a fourth with a pitched roof and feet.

2. Place the models on the table with your seismograph. Shake the table again, gently at first and then more vigorously. Which house tips over when you shake gently, and which only falls when you shake vigorously?



→ WHAT'S HAPPENING?

Your flat house will probably hold out the longest. Before it falls, the square high-rise will topple, and the model with the pitched roof and feet and the pyramid will also fall victim to the quake.

CHECK IT OUT

PROVEN BUILDING TECHNIQUES AND HOUSE SHAPES

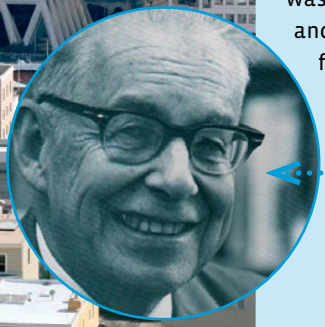
Flat buildings low to the ground are more secure than tall ones. High-rises and towers collapse when their upper sections tumble to the ground. Skyscrapers with a solid internal skeleton are more earthquake safe than ordinary brick houses.

The high-rise pyramid as a truly earthquake-safe building form has achieved reality in the 260-meter-high **Transamerica Pyramid** in San Francisco. This city was struck by a devastating earthquake in 1906, and seismologists expect more to come.

Earthquake in San Francisco, 1906

To indicate the strength of an earthquake, there are two scales that scientists use: the **Richter scale** and the **Mercalli scale**. Both are named after famous earthquake researchers.

Giuseppe Mercalli (born May 21, 1850, in Milan, Italy; died March 19, 1914, in Naples) was an Italian seismologist, volcanologist, and inventor of the scale named after him for determining the strength of earthquakes.



Charles Francis Richter (born April 26, 1900, in Overpeck, Ohio; died September 30, 1985) was an American seismologist.

Earthquake in Haiti, 2010

Degree of intensity	Description	Effects
I	only detectable with equipment	none felt
II	very mild shaking	only felt by very few people
III	mild shaking	like the shaking caused by a passing truck
IV	moderately noticeable shaking	windows rattle, pictures on the wall may sway
V	moderately strong shaking	felt by everyone, windows break, parked cars rock
VI	strong shaking	pictures fall off wall, cracks appear in walls
VII	very strong shaking	church bells swing, chimneys fall
VIII	destructive shaking	branches break off of trees, chimneys collapse, change in temperature
IX	highly destructive shaking	cracks in ground, considerable damage to buildings, partial collapse
X	devastating shaking	rails bent, damage to dams and dikes
XI	catastrophic shaking	bridges destroyed, wide cracks in ground, landslides
XII	extremely catastrophic shaking	surface of ground ripples, objects fly through the air

RICHTER SCALE

This scale indicates the energy released by an earthquake as calculated directly from a seismogram. The scale is structured logarithmically, meaning that an increase by one point means a ten-fold increase in intensity. It has no upper limit, although the highest earthquake intensity measured thus far was 9.5 — ten thousand times the explosive force of the Hiroshima atomic bomb.

A selection of strong earthquakes from the last several hundred years, along with their Richter scale measurements →→→→→

← Mercalli intensity scale (simplified)

MERCALLI SCALE

This indicates the intensity of an earthquake with respect to the destruction it causes. It has 12 levels, from **undetectable** through **damage to buildings** and **widespread building damage** to **alterations in the landscape**. Admittedly, it is only a limited measure of the actual energy released in an earthquake. The destructive force of an earthquake depends not only on its strength but also on the type of ground, the population density, and the stability of buildings.

CHECK IT OUT

Date	Location	Death toll	Earthquake strength
10/18/1356	Basel	-	strong destruction
01/23/1556	China	830,000	about 8
01/11/1693	Sicily, Italy	60,000	-
11/01/1755	Lisbon, Portugal	70,000	about 8.7
02/01/1780	Iran	200,000	-
02/04/1783	Calabria, Italy	50,000	-
08/16/1868	Colombia	70,000	-
04/18/1906	San Francisco, USA	20,000	7.8
08/17/1906	Chile	20,000	8.2
12/28/1908	Sicily, Italy	70,000	7.2
12/16/1920	China	200,000	8.6
09/01/1923	Tokyo, Japan	143,000	7.9
05/22/1927	China	200,000	7.9
12/25/1932	China	70,000	7.2
05/30/1935	Pakistan	60,000	-
12/26/1939	Turkey	33,000	7.8
10/05/1948	Turkmenistan	110,000	-
02/29/1960	Morocco	10,000	5.7
05/22/1960	Chile	5,700	9.5 + tsunami
05/31/1970	Peru	66,000	7.9
05/06/1976	Friuli, Italy	965	-
07/27/1976	China	260,000	7.5
09/03/1978	Albstadt, Germany	-	destruction
09/19/1985	Mexico City	9,500	8.0
12/07/1988	Armenia	25,000	6.8
09/29/1993	India	25,000	6.2
01/17/1995	Japan	5,500	6.9
01/25/1999	Colombia	1,185	6.2
08/17/1999	Turkey	17,000	7.6
01/26/2001	India	20,000	7.7
05/21/2003	Algeria	2,200	6.8
12/26/2004	Indian Ocean	300,000	9.0 + tsunami
05/28/2005	Sumatra	1,000	8.4
10/08/2005	Pakistan	86,000	7.7
05/26/2006	Java/Indonesia	5,749	6.2
05/12/2008	Sichuan/China	69,185	8.1
04/06/2009	Italy	308	5.8
09/30/2009	Sumatra	several hundred	7.6
01/12/2010	Haiti	around 300,000	7.0
02/27/2010	Chile	122	8.8
09/04/2010	New Zealand	-	7.1

Instructions for using the KOSMOS safety glasses (item no. 052347)

USE

→ The safety glasses are only to be used with the experiment kit. No other type of application is permitted.

→ Wear the glasses in such a way that the eye area is protected. If necessary, adjust the elastic band to the head circumference of the child.

→ The safety glasses should be used together with contact lenses. Wearers of corrective eyeglasses need special safety glasses designed for use with corrective glasses (not included).

DURATION OF USE

→ Always wear the safety glasses when performing your experiments. They are not intended for long-term use. The duration of wear should not exceed the time of the experiment.

STORAGE

→ Store safety glasses at room temperature in a dry room. After the experiment, return them to their place in the kit box, to keep them from being scratched.

CLEANING

→ Do not clean the safety glasses in a dry state. Clean them with clear water and, if necessary, with a mild household liquid detergent, and dry them off with a soft cloth.

MAINTENANCE

→ In case of defective safety glasses or scratched lenses, exchange them for an equivalently constructed pair.

INSPECTION

→ Check the safety glasses to make sure they are in good condition, and replace them if they are damaged.

WARNING

→ Some extremely sensitive individuals may, under some circumstances, experience an allergic reaction to skin contact with some materials in these glasses.

REPLACEMENT

→ These safety glasses are available as a replacement part.

The safety glasses are tested per EC guideline 89/686/EWG (personal protective equipment) and EN 166, as well as EC guideline 88/378/EWG and EN 71-4.

TEST CENTER :
Certification Center 0197
TÜV Rheinland Product Safety GmbH
Am Grauen Stein
D-51105 Cologne, Germany

Franckh-Kosmos Verlags-GmbH & Co. KG
Pfizerstraße 5-7
70184 Stuttgart, Germany

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First Aid

When conducting experiments with chemicals:

→ In case of eye contact: Wash out eye with plenty of water, holding eye open if necessary. Rinse from the nose outward. Seek immediate medical advice.

→ If swallowed: Wash out mouth with water, drink some fresh water. Do not induce vomiting. Seek immediate medical advice.

→ In case of inhalation: Remove person to fresh air. For example, move person into another room with open windows or outside.

→ In case of skin contact and burns: Wash affected area with plenty of cold water for at least 10 minutes. Cover burns with a bandage. Never apply oil, powder, or flour to the wound. Do not lance blisters. For larger burns, seek immediate medical help.

→ In case of cuts: Do not touch or rinse with water. Do not apply any ointments, powders, or the like. Dress the wound with a germ-free, dry first-aid bandage. Foreign objects such as glass splinters should only be removed from the wound by a doctor. Seek the advice of a doctor if you feel a sharp or throbbing pain.

→ In case of doubt seek medical advice without delay. Take the chemical and/or product together with the container with you.

→ In case of injury, always seek medical advice.

In case of emergency, contact the United States Poison Control Centers at

1-800-222-1222

Elsewhere, record the telephone number of your local hospital or poison center here:

711051 US