

rocks shaped by water and wind

Exploring Land and Water



hot springs



volcanoes

mountains and valleys carved by glaciers



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Exploring Land and Water



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ISBN: 978-1-68380-605-9

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America's Amazing Landscape

It's finally summer in Boston, Massachusetts! Logan is excited for his family's vacation. This year, they are driving all the way across the country and back. It is a journey of nearly 8,000 miles! They will leave their home on the east coast of the United States. They will travel all the way to California on the west coast of the country and back again.



Logan and his family will stop at six different national parks along the way. On their road trip they will see mountains. They will see places that are nearly flat for hundreds of miles. They will see deserts. They will see lakes and streams. They will even see snow in the summertime! What makes the land in one country so different from place to place? Maybe Logan will find out.



First Stop—Mount Rushmore

Logan's family's first stop is Mount Rushmore National Memorial in the state of South Dakota. Logan thinks that with a name like "Mount Rushmore," they must be visiting a mountain. He learns that one side of this mountain is unusual, though.



Mount Rushmore is a monument. It is a giant sculpture that people carved into the mountain rock. The carving shows the faces of four United States presidents. They are George Washington, Thomas Jefferson, Theodore Roosevelt, and Abraham Lincoln. The sculpture was completed in 1941. It took a team of many people about fourteen years to carve.

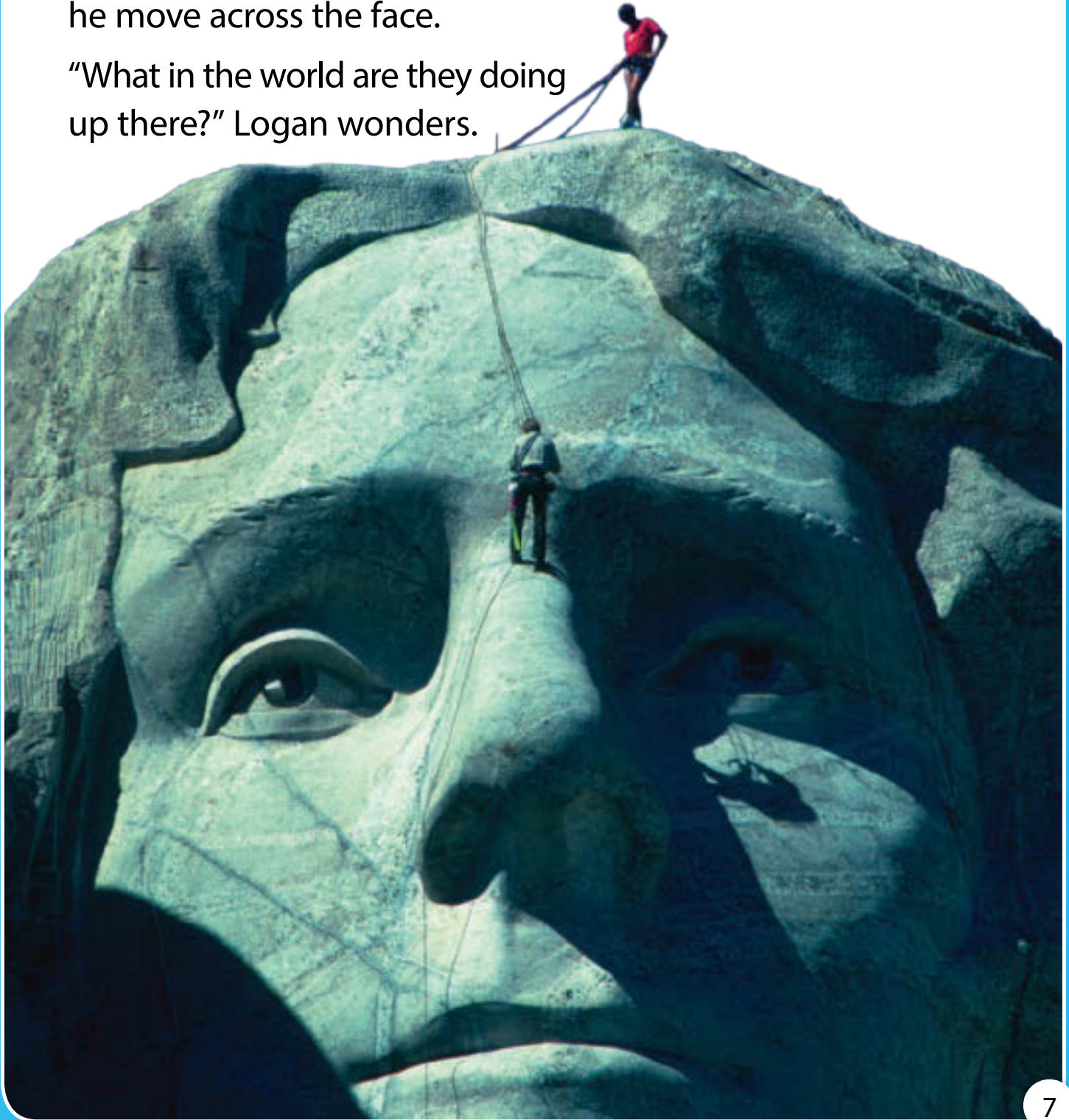


When they arrive at the park, Logan's family walks down a long stone path. It is lined with flags on both sides. The faces of Mount Rushmore loom above them. Logan feels as tiny as an ant. The carved rock faces are huge!



As Logan gets closer he notices two specks on a president's faces that seem to be moving. When he looks through binoculars, he sees that they are people! One person is hanging from ropes. The ropes hold the person in place while he move across the face.

"What in the world are they doing up there?" Logan wonders.



Protecting Stone from Changes

Logan asks a park guide about the people he saw climbing the sculpture. The guide explains that the workers are protecting the monument from the weather. This seems strange to Logan. This whole place is outside. The monument is stone that has been outdoors forever. Why would such a thing need protection from the weather? And how would people protect a giant stone carving?



Logan learns that the people who work to preserve the monument check the stone for cracks. The faces at Mount Rushmore are carved into a kind of rock called granite. Water can seep into cracks in the rock. During cold weather, the water freezes into ice. As ice becomes solid, it expands, or gets a little bigger. Ice inside cracks in rock pushes the granite apart little by little. The cracks can get bigger. Over time, small cracks could cause large chunks of rock to break off and fall. This happens to carved stones and to natural rock, too.



Water gets into a crack.

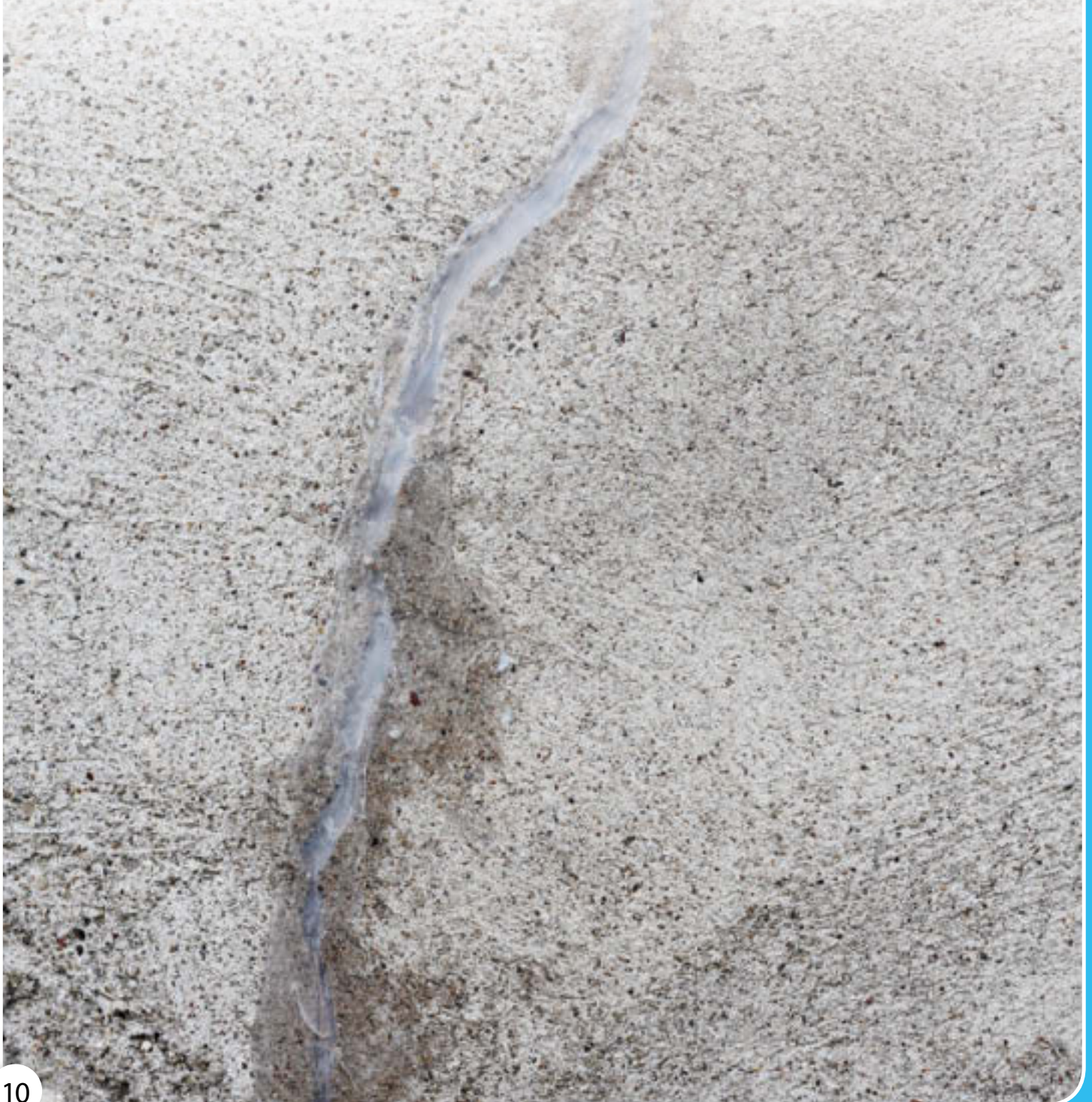


Ice gets bigger and pushes the crack wider.



The rock can break.

To preserve Mount Rushmore, workers fill cracks so water cannot get into them. This protects the sculpture. They fill the cracks with a material called silicone. Silicone is like a thick glue. It is hard and rubbery when it dries. Silicone is waterproof. It keeps water out of the cracks.



During his trip, Logan reads more about how stone can be damaged. He learns that stone monuments can also be changed by wind. The Great Sphinx is another giant rock carving. It is a very old monument in Egypt. There is little rain and no ice to break the rock apart there. But it is hot, windy, and sandy. Wind blows tiny grains of sand against the monument. It grinds away at the stone. Over many years, the stone has worn away.



Workers try to protect the Sphinx from changes caused by wind. The Sphinx is much older than Mount Rushmore. Wind has been blowing sand against it for a very long time.



Next Stop—Glacier National Park

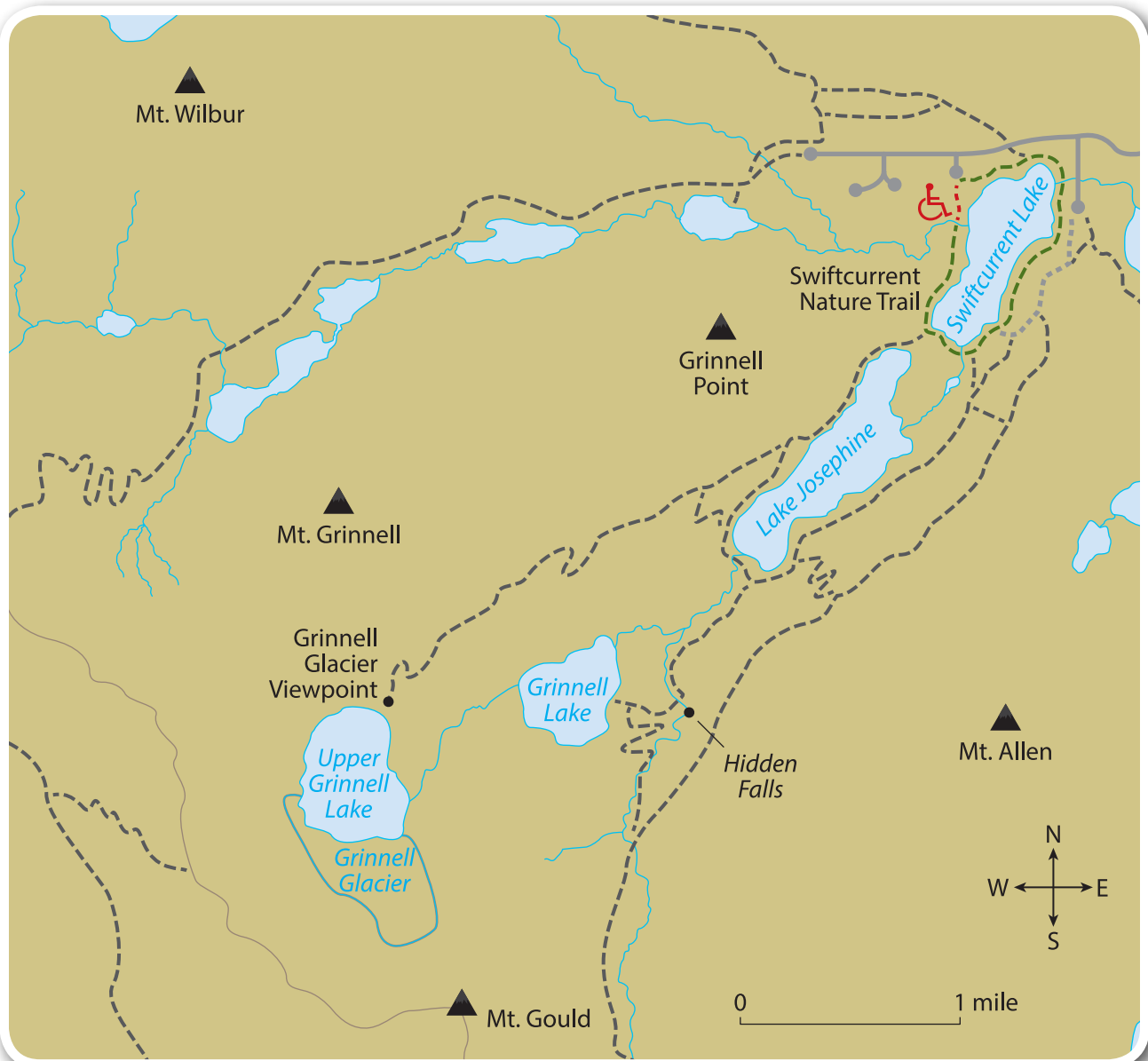
Logan and his family continue their road trip. Their next stop is Glacier National Park in the state of Montana. Logan has learned that a glacier is made of ice. He supposes that must mean it will be cold and snowy there.

When they arrive, Logan is surprised to see a colorful summer landscape. The grass is green. Wildflowers are in bloom. The only snow he sees is near the tops of the tall mountains in the distance.



Logan's family decides to hike. They want to see a glacier up close. They also want to see some of the beautiful lakes and streams here. How will they find them?

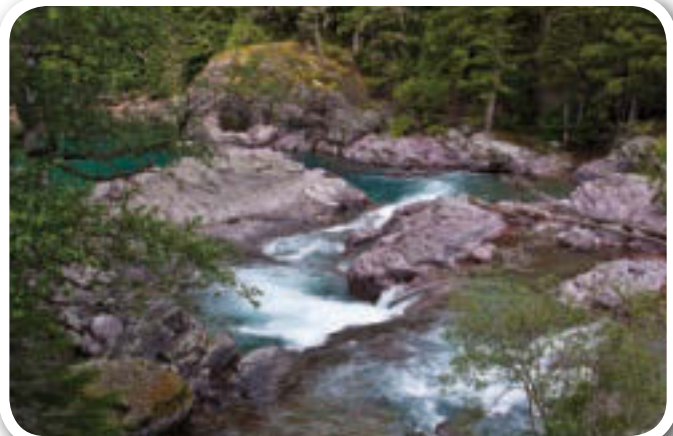
They will use a map. The map shows where the mountains are. The map shows where the glaciers are. The map shows lakes and streams, too. The map also shows trails Logan will walk on to find these things.



Logan's family finds their trail and starts walking. The trail first leads to a large lake. The lake is a bright turquoise blue. When Logan touches the water, it is very cold. It is so clear that he can see the bottom. The sides of the lake are steep and rocky.



Their hike continues along a stream that runs next to the trail. The water in the stream is deep. It is moving quickly! It flows downhill over and around rocks and small boulders.



The trail ends at a lookout. Logan and his family can see for miles! There are tall mountains. There are also deep valleys that are shaped like the letter U. Suddenly, Logan sees a large mass of snow and ice. He's found the glacier!

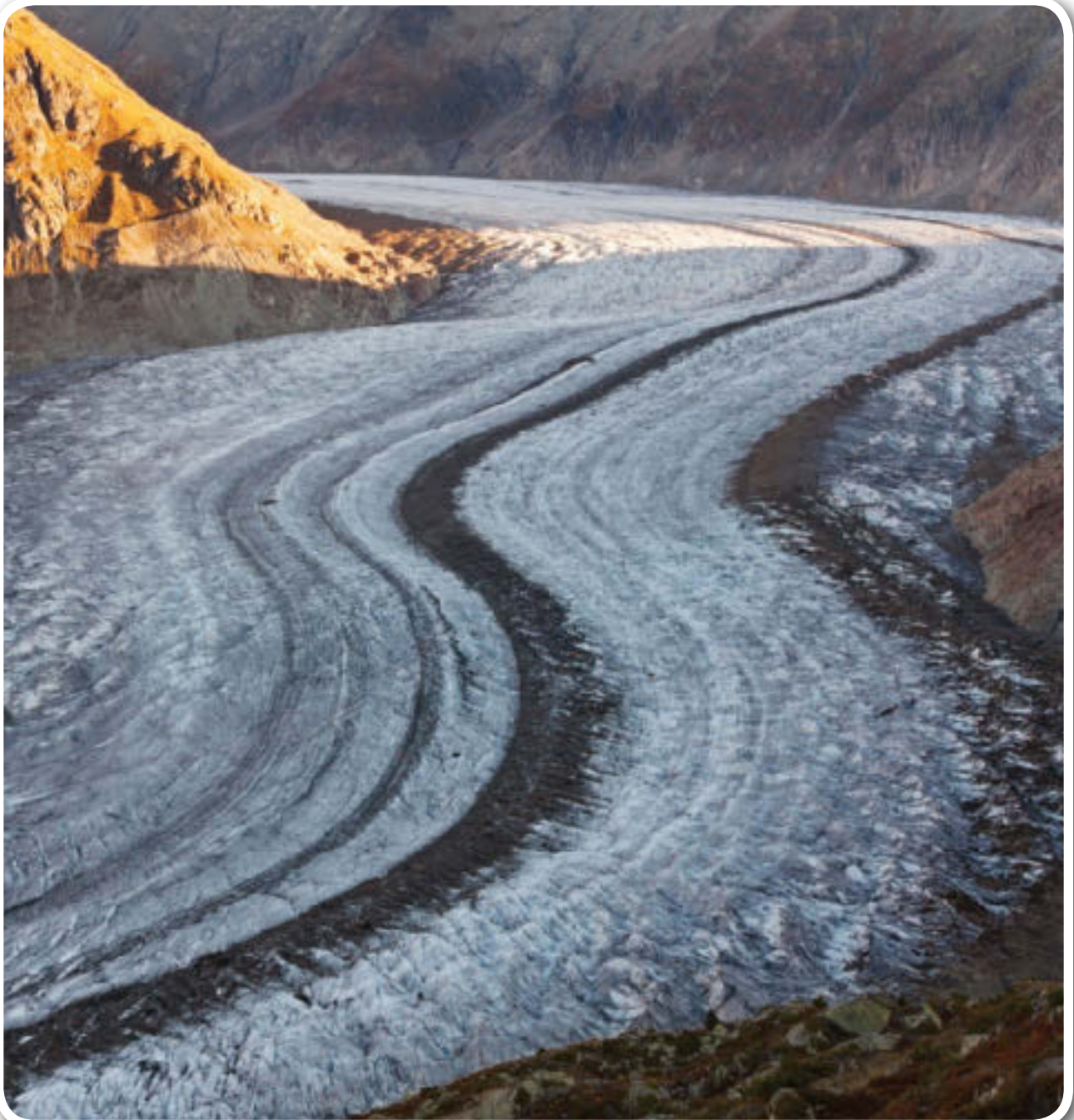


Mountains, Ice, and Water

Is it strange for Logan to see a glacier in the summertime? Not really! Glaciers are very large. They may become smaller during the warm summer months. But usually they do not melt completely. Year after year, new snow gets added to a glacier. The new snow is heavy. The layers underneath pack together.



Many glaciers form high in the mountains where it stays cold all year. The weight of the snow and ice and the melted water underneath it cause a glacier to move. Like any object on a steep hillside, a glacier can slide downhill. A glacier slowly flowing downhill can look like a river of ice.



Glaciers move rock and soil as they move. They can change the land around them in different ways. They can push and pile up large and small boulders. They can carve out U-shaped valleys. They can leave steep peaks at the tops of mountains.



This bowl-shaped land shows where a glacier used to be.



Matterhorn is a steep mountain peak in Europe that was carved by glaciers.



A glacier melted here long ago. It left behind boulders. It pushed these rocks down from the mountain.

Glaciers shaped the land in Glacier National Park. They also helped form its water features. Many glaciers melt a little in the summer. Water flows out from them. It flows into streams, rivers, and lakes. Some glaciers melt completely over time. When this happens, the hollow shape of the glacier is left behind. It fills with water, and a lake is formed.



Sliding glaciers can grind rock into a fine powder. The powder mixes with water in lakes. It can make them appear blue or green.



Next Stop—Yellowstone National Park

Logan's family hits the road again. They make their way to Yellowstone National Park. Yellowstone spreads out over parts of three states—Wyoming, Montana, and Idaho. In Glacier National Park, Logan saw how snow and ice can shape land. In Yellowstone National Park, Logan sees some very hot water too!

This huge geyser called Old Faithful is Yellowstone's most famous feature. A geyser is an underground pocket of water that gets heated. When it gets hot enough, the water shoots out of the ground. This happens the way a pot can boil over on a stove.



Once again, Logan's family uses a map of the park. The map shows the land and water features they have come to see. There is one very large lake in the park. There are a few smaller lakes, too. The map shows mountains. The area in the middle of the park seems flatter, though. This part is full of places called geyser basins.



The family visits a place called Midway Geyser Basin. Logan can feel heat as he and his family cross the boardwalk over Midway Geyser Basin. He can see steam rising off the hot springs around them. Where does the heat come from? It comes from inside Earth, beneath their feet. Logan and his family are walking across the top of a giant volcano!



Next, the family visits Yellowstone Lake. The lake sits in part of an area known as the Yellowstone Caldera. A caldera is the bowl-shaped crater at the center of a volcano. A volcano erupted here thousands of years ago. Logan can see mountains and forests around the lake. The lake is formed in the low area in the center of the caldera.



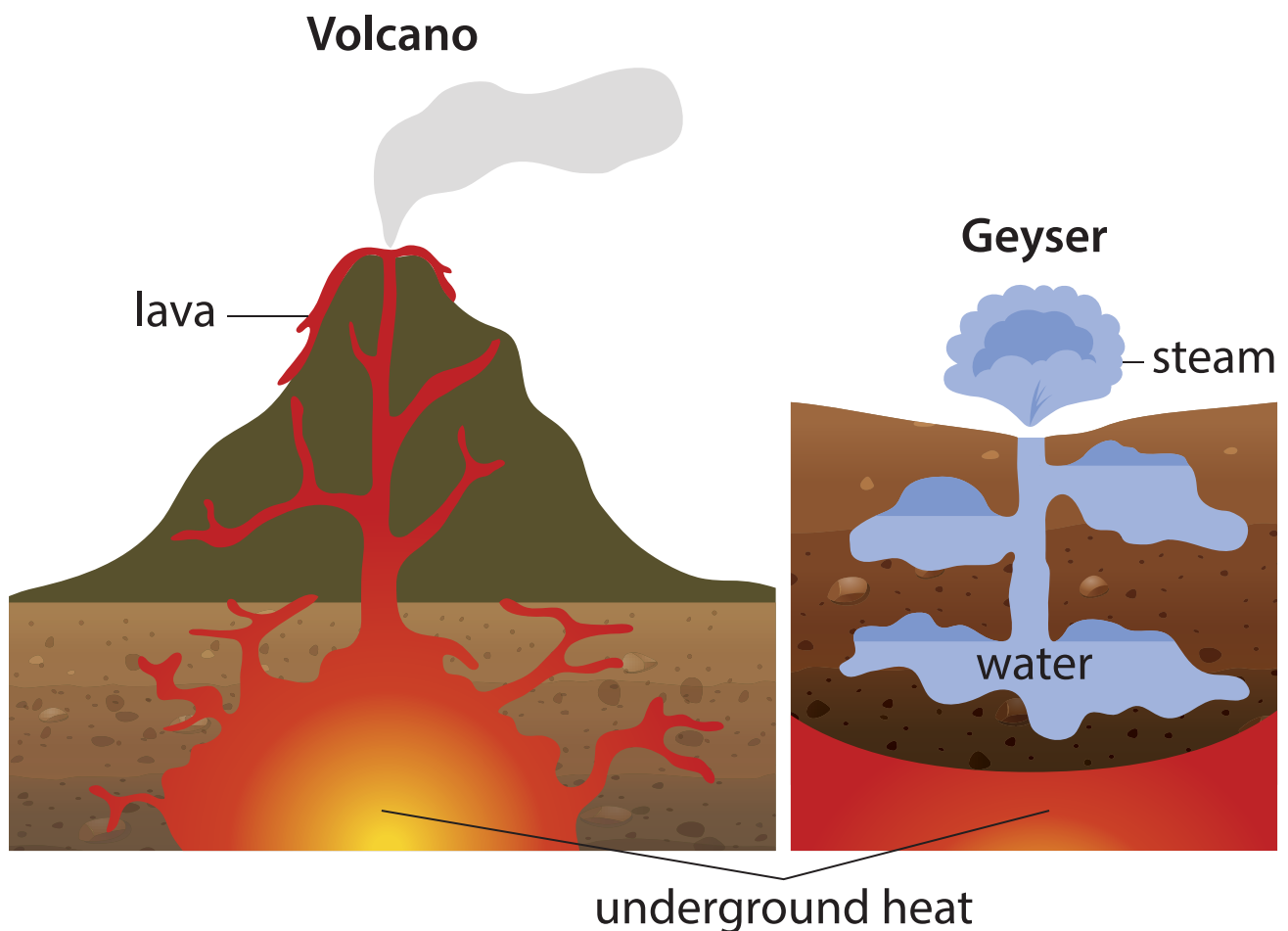
Heat Below Earth's Surface

Yellowstone National Park does not look like the pictures of volcanoes that Logan has seen. What do you think of when you imagine a volcano? Do you picture hot lava pouring from a tall mountain? Do you see smoke and ash bursting into the sky? Or do you imagine a hot, glowing liquid bubbling inside a deep crater?



There are different kinds of volcanoes. Some are steep mountains. Others are hidden under the ocean. But the volcano in Yellowstone is under the ground.

Volcanoes and geysers are produced by heat from below Earth's surface. Volcanoes occur where hot melted rock from underground pushes up and out through an opening. The hot rock can also heat underground water. Logan saw signs of underground heat as he walked around the park.



Millions of years ago, huge eruptions happened where Yellowstone is now. The ground caved in after each one. Deep craters were suddenly left behind. Hot liquid still flows miles under these craters. Heat from the liquid causes many of Yellowstone's features.



A hot spring is a pool of hot water. The water is heated from beneath the ground.

Steam vents do not have pools of water like hot springs. Hot water underground turns into steam and flows out of cracks in the earth.



A geyser forms when hot water bubbles up to the surface. The small opening does not let the water move around like it can in a hot spring. Pressure builds until steam and water explode from the ground.



Hot water and steam mix with clay soil to form these mud pots.



Next Stop—Yosemite National Park

Logan's family has arrived in California! Their next stop is Yosemite National Park. Movements of the Earth's surface pushed up the park's tall mountains. Glaciers carved out the park's land. They also helped fill the park's many lakes with water.



As Logan's family enters the park, they drive over a road through a very rocky area. In the past, rain, wind, and ice broke off chunks of rock along the side of the hill. Gravity pulled the loose rock and soil down the hill. The road is safe now, but what if there is another rockslide?



Yosemite is full of other natural wonders. It is known for its many waterfalls. They roar to life in spring and summer when snow melts. Waterfalls form when water from rivers and streams pours over high rock ledges. Over time, the flowing water can carve a groove there. Yosemite Falls is one of the tallest waterfalls in the world! It is over two thousand feet high.



Logan and his family visit a strange rock formation called Half Dome. It is tall and wide and curved at the top. One half of Half Dome is smooth and steep. The other half is round. Logan is surprised to see people trying to climb the steep side! He wonders why one side of this rock is shaped so differently from the others.



Fast and Slow Changes Shape the Land

Half Dome began as a giant underground rock that was pushed to the surface. The rounded areas became curved as layers of rock were ground away by rock, ice, wind, and water. The steep flat wall got its shape when huge pieces fell off. These processes took millions of years. But did some changes take place quickly?



It took many years for rain, wind, and ice to weaken the rocks on the hill in Yosemite. But then a rockslide happened suddenly. It caused a fast change to the land around it. Rockslides are dangerous because they happen with no warning. Buildings that are close to steep rock walls, like this little cabin in Europe, can be hit by falling and sliding rocks during a rockslide.



People have found a few ways to prevent rockslides. Workers can put wire netting over the loose rocks to keep them from falling.



They can use a wall to hold a slope in place.



They can use giant bolts to keep large slabs of rock from moving.



Like rockslides, mudslides and landslides can happen very fast.

Mudslides happen when a lot of water mixes with soil on a hill. The soil loosens. It can suddenly slide down a steep slope. A mudslide can flow over anything in its path.



A landslide can also happen when soil is dry or when plants have been destroyed by fire. Plant roots hold soil in place on a hill. If the roots are not strong enough, the earth can slide downhill.



Next Stop—Arches National Park

On the road again! Next Logan's family arrives at Arches National Park in Utah. It is different from the other parks they have visited. It is sandy, and the summer weather here is hot. There are few trees. It feels and looks like a desert. Tall red rocks rise from the land. The rocks are all different shapes and sizes.



Logan sees how this park got its name. He notices that many of the rock formations are shaped like arches. Most of them stand alone. Others, like Double Arch, have formed right next to each other. All of the rock formations in Arches are made of a kind of rock called sandstone. Sandstone is made up of tiny grains of rock and other materials.



Arches are a common rock shape in the park. But there are others too. Some rocks are shaped like tall columns. They are called pinnacles.



Other areas have many thick walls of standing rock. They are called fins. Some fins eventually become arches. Logan wonders how this happens.



Water and Wind Shape the Land

What caused these unusual rock shapes to form? Arches National Park is in a desert. But it gets about nine inches of rain per year. That is all that is needed for the rocks to change little by little. Wind and water wear away at surfaces of the sandstone. Tiny pieces break off and blow away or wash away. Unusual rock shapes form.



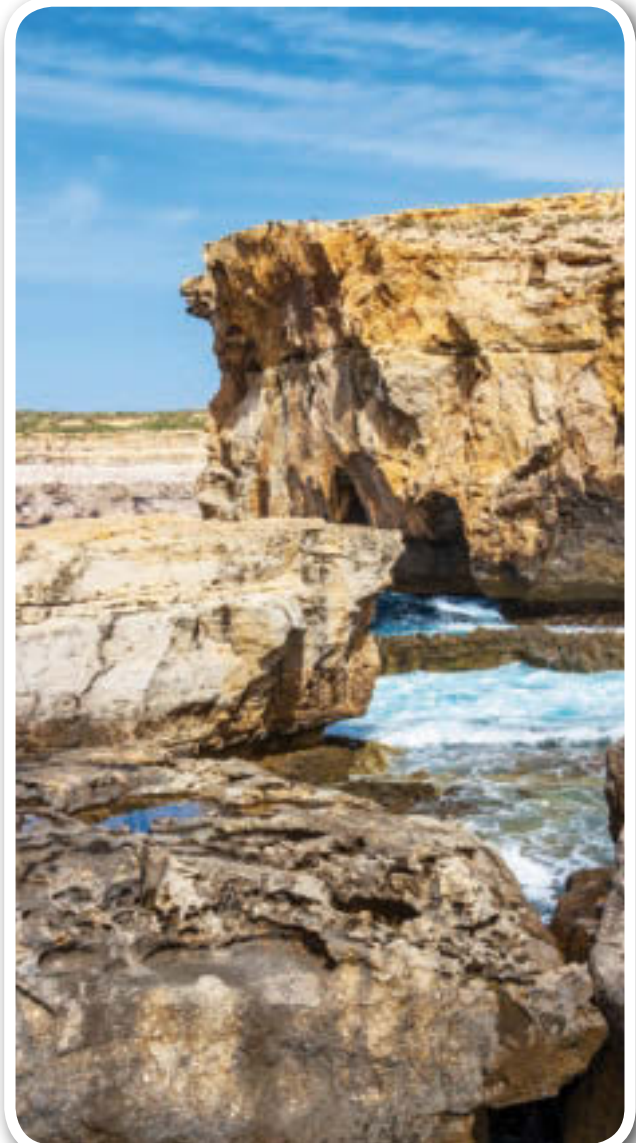
Water soaks into the tiny spaces in a rock's surface. Wind carries tiny bits of sand that grind against rock from the outside. A hole begins to form when enough of the rock wears away. A small hole can turn into a big arch. This takes a long time.



The top of an arch can fall. The collapse can leave two pillars and a pile of boulders. This happens suddenly.

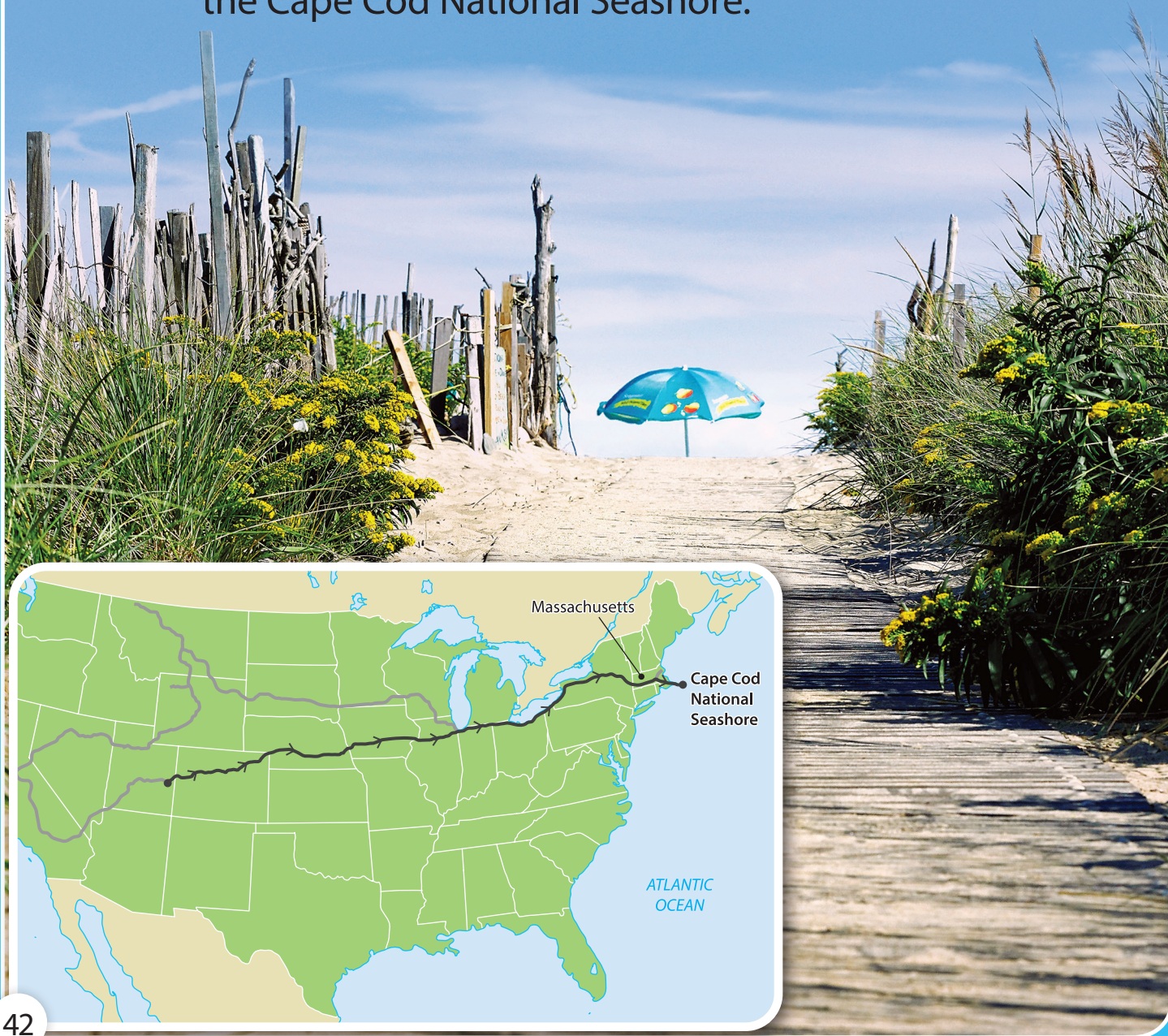


Rock arches can form in other places besides the desert. Wind and water along the rocky ocean shore can produce arches. Like the desert arches, these also take a long time to form. But they can change quickly, too. Arches become weaker as water and wind wear them away. They can suddenly crumble. An earthquake recently caused a rock arch in Puerto Rico to fall. A storm caused the top of the arch pictured below to fall into the sea.



Last Stop—A Day at the Beach

The end of summer break is near. Soon Logan will be back in school. Logan and his family have finally returned home from their adventure. On Saturday morning, Logan's mom asks if they would like to spend one last day at the seashore. Logan loves the beach and dunes! They pack up the car and head to the Cape Cod National Seashore.



Logan and his family make their way to the beach. They walk a long sandy path with grassy mounds of sand all around them. They reach the place where the ocean meets the land. Ocean waves roll onto the beach, one after the other, never stopping. Sand stretches along the waterline as far as Logan can see.



The beach and the dunes here are never silent. Logan can hear the steady sound of ocean waves splashing onto the beach. But often, the sound of the water is covered up by the even louder steady wind. Logan notices that it seems to be windy here all the time. Down on the beach, the umbrella flaps in the breeze. Up on the dunes, the grasses rustle and sway.



Logan also notices some things here in this natural area that were built by people. He sees wooden fences along the paths that cross the dunes to the beach. He sees more fences across the tops of many dunes. He sees signs telling people to keep off the dunes. And every so often along the beach, Logan notices a long pile of large rocks. The rocks are arranged in a narrow pile extending from the beach out into the ocean water.



Wind, Water, and Moving Sand

Cape Cod National Seashore has forty miles of sandy beaches and eight thousand acres of sand dunes. That is a lot of sand! Waves, wind, and storms change land that is made up of loose sand. Compared to most changes of rock, changes to sand landforms take less time.

Sand is made up of tiny pieces of rock and broken seashells. Ocean waves push rocks and shells around under the water. The pieces crash into each other. They break apart. Waves wash sand to the shore. It collects there. A beach forms. Wind blows sand into piles away from the waterline. The dry sand piles up to form dunes.



Beaches and dunes are always changing. Wind and water move sand easily. Waves that push sand up to form a beach also wash the sand away. This can take a long time. Or it can happen very quickly.

Waves don't always come straight into the shore. They often come toward the shore at an angle. They push sand up or down the shoreline. People build structures to protect beaches. A jetty or wall can keep waves from pushing sand away from a beach.

Big storms like hurricanes can cause waves to be much larger than usual. Big waves can move a lot of sand at once. A large storm can completely wash a beach away in just a day or two.



Sand dunes change shape and size with the wind. Sometimes people want to keep dunes from blowing away. Dunes are home to plants and animals. Dunes also keep ocean water from flooding dry land where people live.

Grasses that grow on dunes help protect the dunes. Their roots hold some of the sand in place. Their leaves block some of the wind from pushing on the sand. Plants keep rain from washing sand away from a dune. Beach grass grows naturally in dunes by beaches. People also add plants to dunes that they want to protect.



Do you remember the fences that Logan saw when he explored the dunes? Fences are another way that people prevent changes to sand dunes. Fences keep people on narrow paths that cross the dunes to reach the beach. That way, people don't walk on the beach grasses that help hold the dune in place. Fences can block the wind, too. They keep too much sand from blowing away from a dune. A fence can also help a dune form where there isn't one. A fence in a flat area where sand blows can cause the sand to collect into a pile. Over time, the pile grows large enough to form a dune.



Science in Action

Mapping the Ocean Floor

Back at school, Logan is excited to tell his teacher and classmates about his big summer trip. He learned a lot about land and water. He shows the other students the places that he visited on a map. He shares some of the pictures he took.



Today Mr. Clark has a surprise planned for his students. They will have a video call with a scientist over the internet. Mr. Clark says to the class, "Remember the mountains, valleys, and volcanoes that Logan described from his trip? And how he showed us where they are on a map? Think about those things when we are talking with our guest, Dr. Ross."



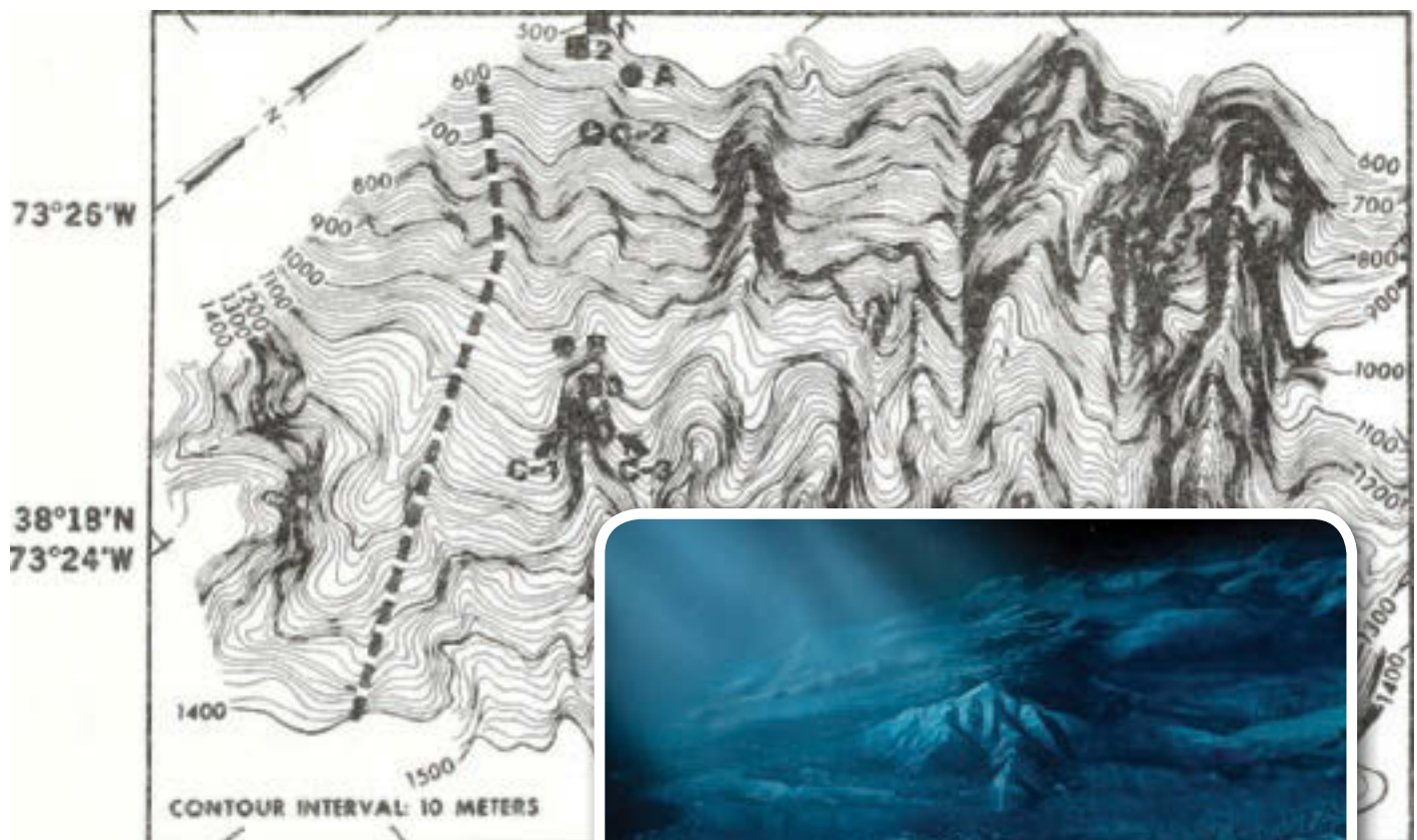
The scientist they see on the screen shows them a globe and points out how most of it is blue. “The globe is a model of Earth,” he says, “and most of Earth is covered by the ocean. “But land features don’t end where the ocean meets the shoreline,” he continues. “What is beneath all that water?” he asks. “More land! The land below the ocean’s water is called the seafloor.”



Then Dr. Ross says some words that really catch Logan's attention. "The seafloor has mountains and valleys just like dry land does," he says. "It even has volcanoes."

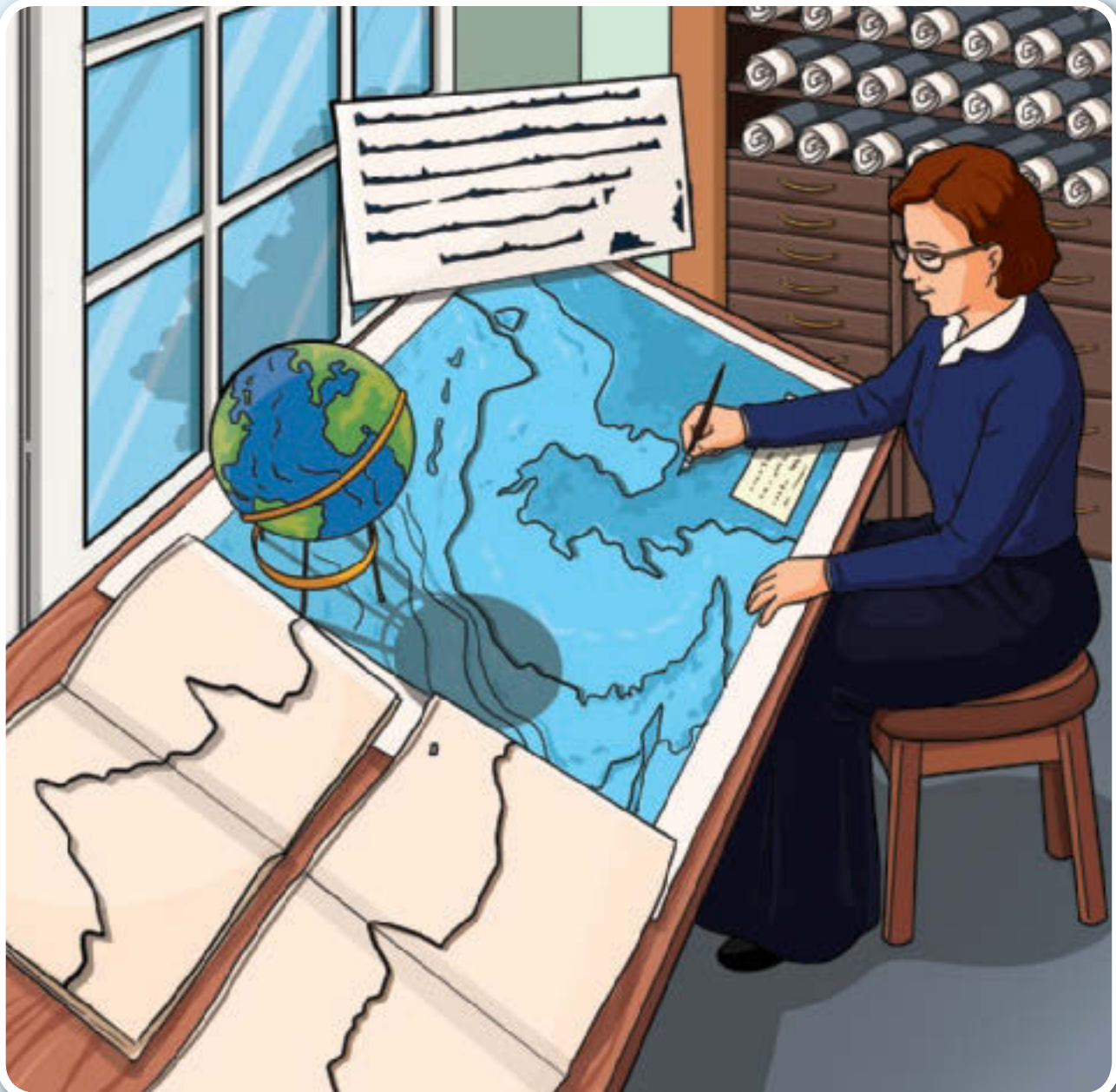
Dr. Ross is a scientist who makes maps of the seafloor. He shows the students some seafloor maps. The maps show hills and flat places. They show mountain peaks and valleys.

Dr. Ross explains that many areas of the ocean floor still have not been mapped with much detail. He tells students that he is continuing the work of another seafloor mapmaker named Marie Tharp.

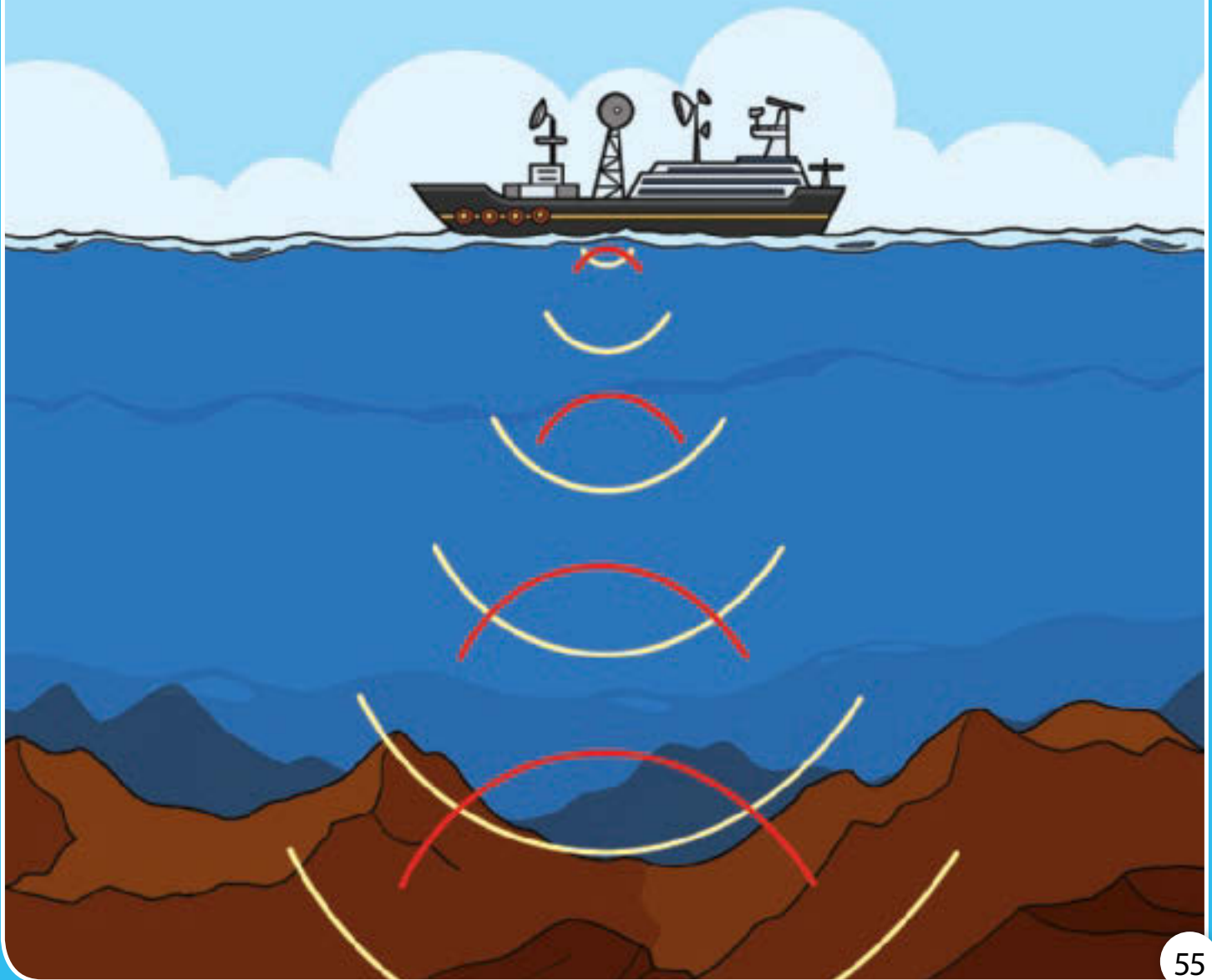


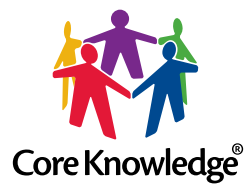
Marie Tharp

For a long time, people thought the ocean floor was flat. But a scientist named Marie Tharp helped prove that it wasn't. She was the first person to map the bottom of the Atlantic Ocean. She proved that it was covered with mountains and canyons, just like Earth's land surface.



Marie Tharp could not actually see the ocean floor. She used data. Scientists on a boat used a system called sonar to collect the data. Sonar can tell how deep the water is beneath a boat. Marie Tharp combined many, many depth measurements. She used them to draw the high and low places on the seafloor.





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