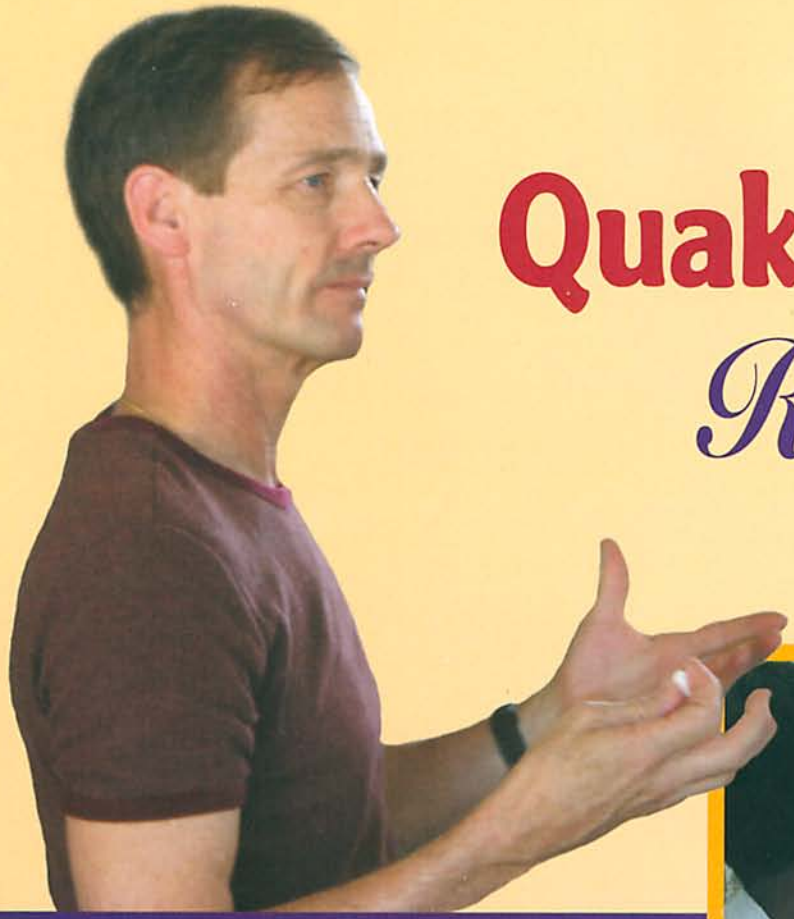
Quaking Earth, *Racing Waves*



by Rachel Young
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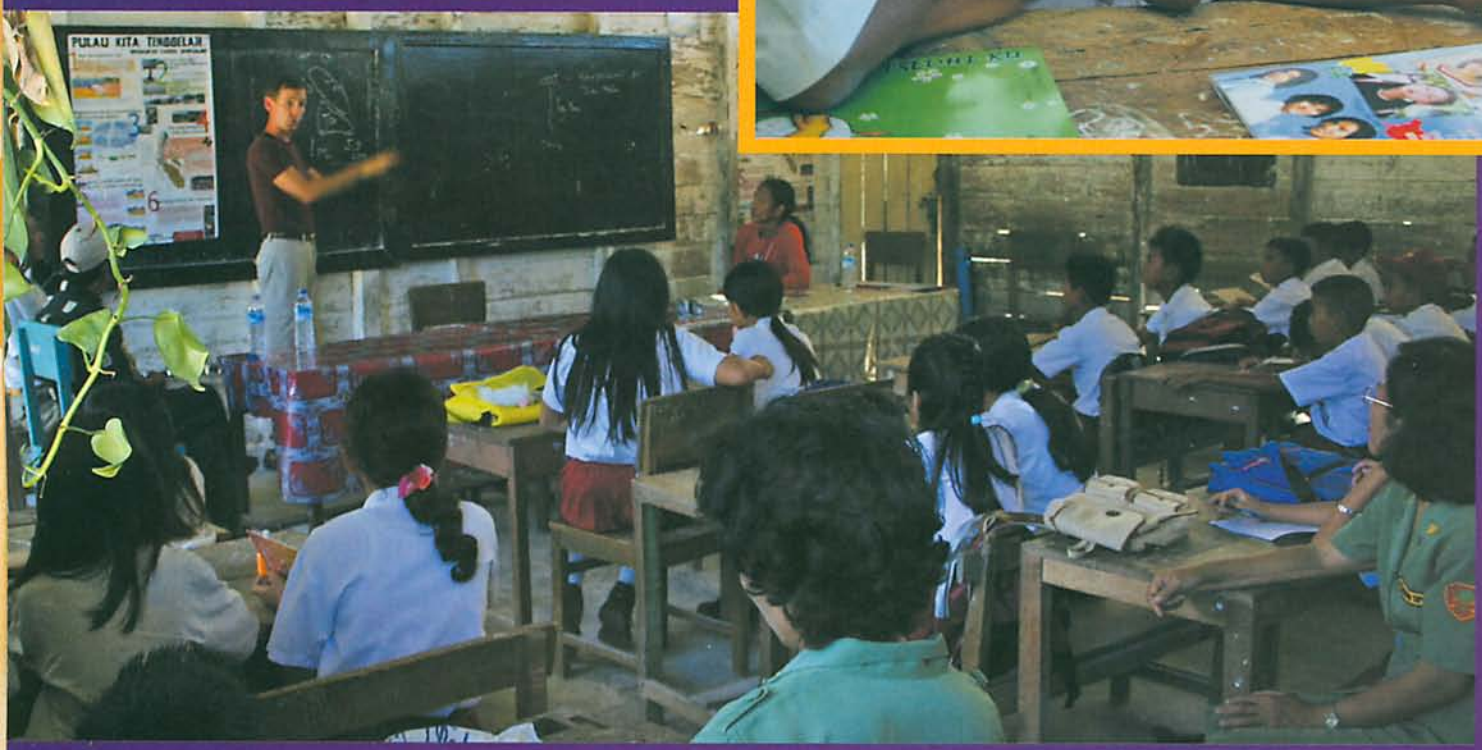


In July 2004 the village school on Tello Island, Indonesia, had a visitor with a startling story to tell. As the students in their red and white uniforms sat quietly listening, geologist Kerry Sieh explained that under the ocean, 60 miles from their island, was a ticking time bomb.

For hundreds of years, the Sunda Megathrust Fault had been storing energy that would be released in massive undersea earthquakes. The powerful quakes would likely cause tsunamis, fast-moving waves that could wipe out the entire seaside village.

The students and their teachers were surprised by Sieh's warnings. They'd never felt giant earthquakes or seen tsunami waves. How did he know that the earth was going to shake?

Sieh explained that, for more than a decade, scientists from the California Institute of Technology had been studying a section of the fault just to the south. They'd figured out that major earthquakes shook the region about every 200 years. The last big quake was in the early 1800s, which meant another could come at any time. Though Sieh couldn't say exactly when it would happen, he was almost certain there would be at least one major earthquake in the students' lifetimes.

But no one could have known that the next big quake would hit just a few months later.

poster design by Catharine Stebbins

On Tello and four other islands, Kerry Sieh and his colleagues passed out posters that described why earthquakes and tsunamis happen and what to do if you feel the earth shake: cover your head until the shaking stops, then run as fast as you can to high ground to escape the coming waves.

Rising Corals

Shifting water levels between earthquakes cause a giant coral head to grow in rings. Snorkel-wearing scientists use chainsaws to saw off slices of coral.

Scientists know a lot about earthquakes after they happen, but they can't predict what hour, day, year, or even decade an earthquake will hit. So how did Kerry Sieh know to warn the Tello islanders that an earthquake might happen soon? He read the corals.

In the Indian Ocean, big corals called *Porites* grow from the sea floor to the water's surface, then outward. The ocean floor sinks slowly between earthquakes, dragging the coral down, then rises quickly during a quake, raising the coral up again. Over hundreds of years, all this up and down causes the coral to grow outward in doughnut-shaped rings. Sieh discovered that by looking at the growth patterns of *Porites* coral heads near the fault, he could pinpoint the dates of past earthquakes, and maybe find a pattern that would help predict future quakes.

Using underwater chainsaws, Sieh and other scientists sliced off slabs of coral heads that were hundreds of years old. Sure enough, they found that, on a section of the fault just to the north of the Mentawai Islands and just to the

When it reaches the ocean's surface, a coral head stops growing upward. Only the sides, which are still underwater, continue to grow outward in rings, like the growth rings of a tree. You can tell how old a coral is by counting the rings.

Between earthquakes, the ocean floor is slowing sinking. And the coral, which is attached to the ocean floor, is sinking, too. The coral head drops below the water line, and the sides grow up to the water's surface.

During an earthquake, part of the ocean floor springs up, and some coral heads are lifted half out of the water. The section of coral above the sea dies, while the part still under the sea keeps growing. From above, the coral looks like a little doughnut inside a series of bigger ones.

south of Tello, earthquakes occurred in pairs about every 200 years. One pair of quakes hit in the 1300s, another in the 1500s, and a third in 1797 and 1833—almost 200 years ago. According to the corals, it was time for another big quake.

Sinking Islands

The corals weren't the only evidence of underground rumblings in Indonesia. The Sunda Megathrust Fault at the bottom of the Indian Ocean marks the collision between two of the plates that make up the earth's surface, one oceanic, the other continental. Between earthquakes, the plates are stuck together. As the oceanic plate slips slowly downward, it squeezes the continental plate sideways about half an inch a year, and drags it down a few inches a year as well. The islands on top of the continental plate are dragged down too, as much as half an inch a year. The more years between earthquakes, the more the islands sink—and the more stress builds up at the fault.

The islanders could tell that the water line was shifting. "They can see their boardwalks and harbors sinking," Sieh said. Trees that once grew tall on shore were now underwater, and wells that once gave freshwater were full of salty seawater instead. But no one thought that this had anything to do with earthquakes or tsunamis.

Evidence from Global Positioning System, or GPS, stations they'd set up to measure island sinking also had convinced the scientists that a big quake could rock the area at any time. "As we came to realize what we were learning, and how much at risk people were," said Sieh, "we couldn't keep quiet."

In July 2004, Sieh visited five islands and gave presentations at schools,

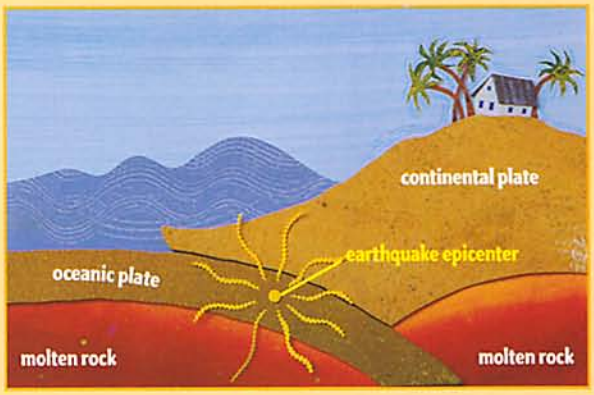
GPS stations, like this one on Tello (left), capture data from satellites. Scientists use the data to measure how much islands are sinking between earthquakes. Even without GPS, islanders knew the water level was changing. On Siberut Island (below), 29-year-old Tulik shows Kerry Sieh a well that gave freshwater when he was young. As the island sank, the well was flooded with seawater.

What Makes the Earth Quake?

Next time you're outside, jump up and down. Stomp your feet a few times. The ground seems solid, right? Well, not entirely.

The part of the earth you're standing on, called the lithosphere, is rock-solid. But the lithosphere is very thin—if the earth were the size of an apple, the lithosphere would be about as thick as the apple's skin. If you dug a hole through the earth, you'd find that as you went deeper, what's inside becomes hotter and more gooey. The solid lithosphere is broken up into close-fitting plates that drift on top of the molten rock underneath. We don't feel the plates moving because they're usually drifting only a few centimeters a year—about as fast (or slow) as your fingernails grow.

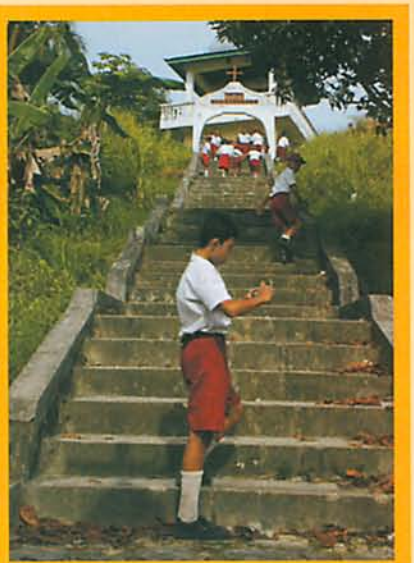
Earth's plates don't all move in the same direction. At the boundary where two plates meet, called a fault, they bump and push into each other. They're wedged together most of the time, but stress builds up as the plates bump and grind together. Finally the plates break free along a section of the fault, releasing pent-up energy in an earthquake.



There are several different types of faults. The Sunda Fault offshore from the Batu and Mentawai islands is called a megathrust, where the underwater oceanic plate dives under the continental plate.

churches, mosques, and village squares. Sieh and his colleagues planned to return the following year to visit more islands and teach more people about their research.

Then, six months later, a quake struck.



Kerry Sieh tells children on Tello what to do in case of earthquakes. First, they practice ducking and covering their heads. Then, they run to the high ground of a village church, where they'd wait for tsunami waves to pass.

December 26, 2004

The ground shook so violently that people were knocked off their feet. Dishes fell from shelves, roofs collapsed, trees toppled. Two minutes after it began, the shaking stopped. It had been the biggest earthquake anywhere on the planet in 40 years.

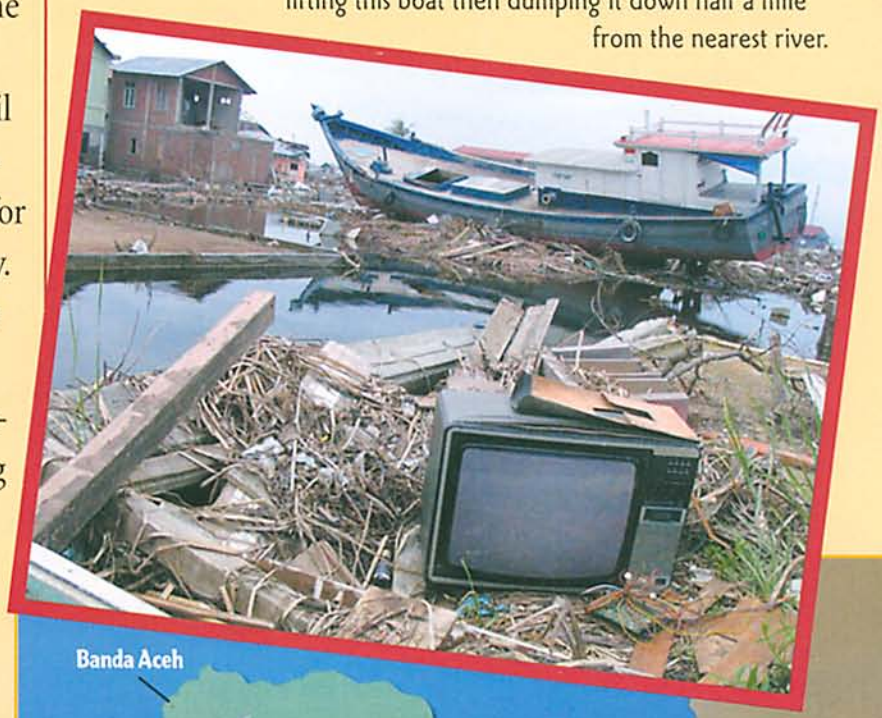
Like a twig you bend and bend until it breaks, pressure that had been building along the Sunda Megathrust Fault for hundreds of years had finally given way. Along a section of the fault longer than the state of California, the oceanic and the continental plates suddenly, violently separated, sending out earth-shaking waves. But the worst was still to come.

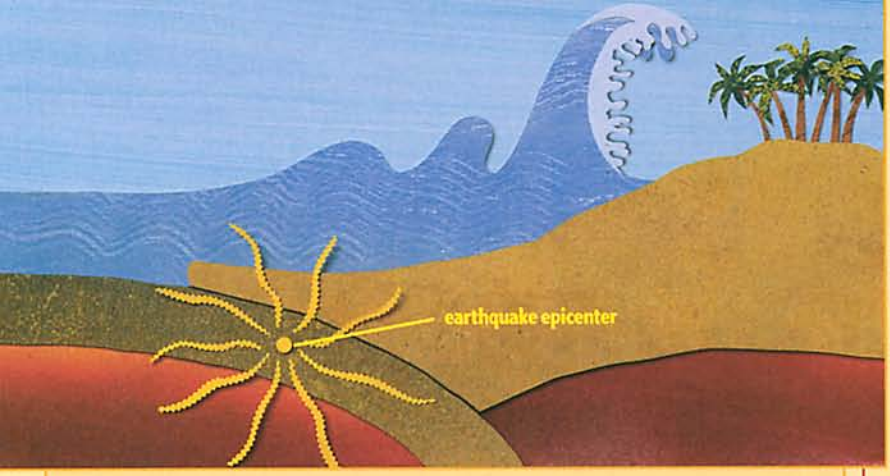
The continental plate sprang up as much as 20 feet, pushing up the water above it. Tsunami waves rippled out in all directions, gaining power as they raced across the open ocean as fast as jet airplanes. The first wave, 100 feet tall in some places, hit the Indonesian island of Sumatra 15 minutes after the earthquake. Waves swamped the coast of Thailand 75 minutes later, then India and Sri Lanka, and even Africa, 3,000 miles from the quake's center.

The deadly waves kept flooding beaches for hours. Hundreds of thousands of people were killed, and millions were left homeless.

Kerry Sieh was at home in California when he heard the news. Immediately, Sieh thought of his friends on the islands he'd visited. Had they escaped the

The December earthquake devastated the city of Banda Aceh on the island of Sumatra. Tsunami waves rushed through the streets, lifting this boat then dumping it down half a mile from the nearest river.





No Ordinary Waves

Most waves are formed by wind that blows across the ocean's surface, pulling water with it. But a tsunami is started by a disturbance, such as an undersea earthquake, that shifts water at the ocean floor. Water is pushed up from the bottom of the sea all the way to the ocean's surface, and waves begin to roll out in all directions. As a tsunami wave hits the shallow water near land, it slows down but grows taller. Water at the shore is sucked into the giant wave, exposing fish, shells, and corals that were underwater moments ago. Then, suddenly, a towering wall of water crashes onto the beach.

quaking ground and giant waves? Had their homes and villages been destroyed? Communication by phone or email was impossible. On January 1, he flew back to Indonesia, uncertain of what he'd find.

Safe for Now

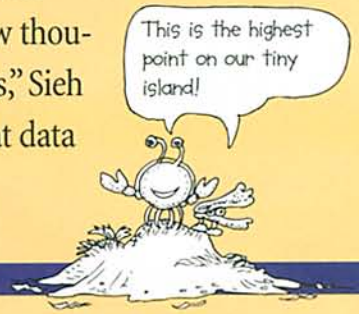
People in Tello were lucky. Their island was more than 200 miles from the epicenter of the quake, the most powerful point. On Tello during the quake, the earth shook, but not violently. Later, a small tsunami, three to six feet high, swept through the village, flooding houses. People were shaken and scared, but unharmed.

As he traveled to the other islands he'd visited in July, Sieh was relieved to hear the same story. Few homes had been destroyed, and no lives were lost. But danger still lurked. An earthquake on one section of a fault can increase stress along the rest of the fault. And the thousands of miles of the Sunda Megathrust Fault that hadn't ruptured in December were still ripe for another quake.

Sure enough, another earthquake shook an area to the south on March 28. This quake was 10 times less powerful than the one in December, yet it was still the second-biggest quake to rock the world in 40 years.

Again, Sieh's friends escaped harm. But the quakes were proof that what the scientist had said was true, and they convinced some islanders to take action. Today, on the island of Simuk, people are leaving their homes near the shore and rebuilding their town at the island's highest point, the hill where Sieh erected his GPS station.

The quakes also provided Sieh with a lot of work to do. On Sumatra, the rising continental plate pushed up vast stretches of beach that had been underwater. "We saw thousands of dead corals," Sieh said. He is looking at data



Data from the Tello GPS station (below) will tell scientists exactly how the island moved during the December earthquake. Islands near the earthquake's center sprang up during the quake, exposing coral heads (right) that had previously been underwater and stranding fish on the new beach.

from the GPS stations to find out exactly how the nearby islands moved during the quakes.

As they travel the islands by boat and helicopter, Sieh and his colleagues will explain why earthquakes and tsunamis happen and what people can do to prepare. They can build their houses out of light-weight wood or bamboo rather than heavy concrete, which would cause more damage if it toppled during a quake. They can move their villages away from the beach, or build pathways to higher ground.

Sieh doesn't know exactly when or where it will hit, but he's certain another big quake is coming along the section of the fault south of Tello. Until it does, he'll try to understand as much as he can about why and how the earth moves, and he'll teach the people who live nearby about the danger that lurks under the waves.