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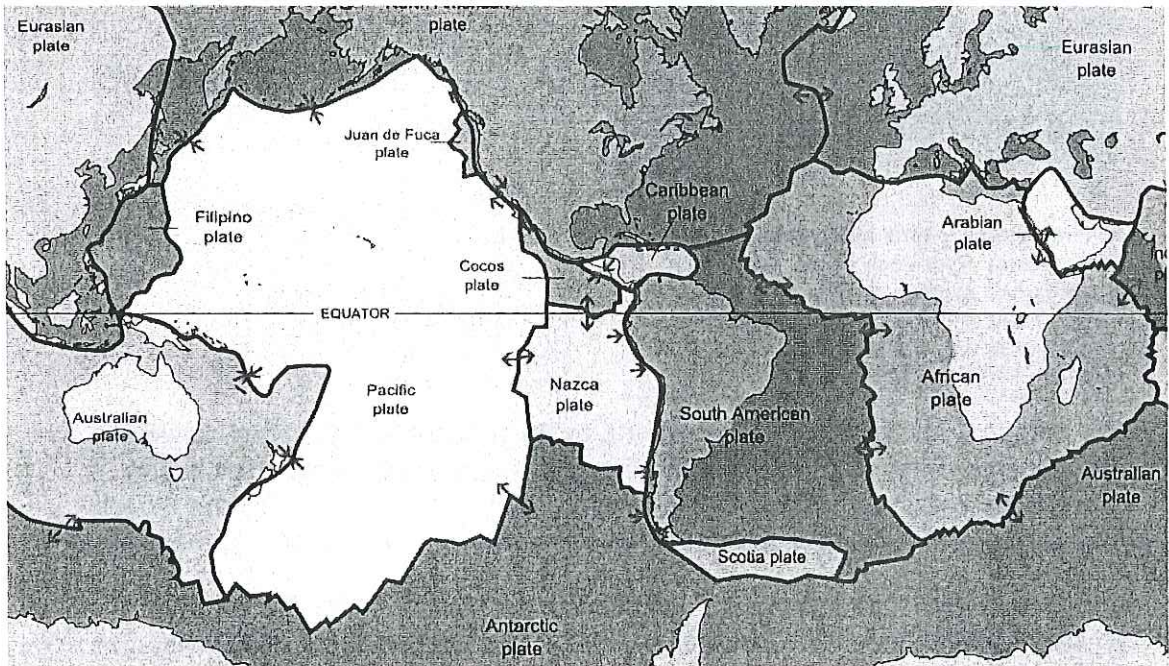
EARTH

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Explainer: Understanding plate tectonics

Earth slowly refashions itself over and over

BY KATHIANN KOWALSKI MAR 26, 2015 — 7:00 AM EST



Earth is covered in about a dozen major tectonic plates. Their movement causes earthquakes and volcanic eruptions.

USGS/WIKIMEDIA COMMONS

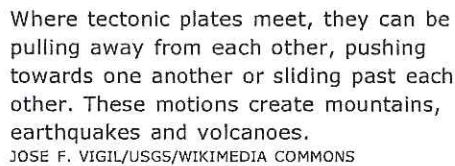
For billions of years, Earth has been remodeling itself. Huge masses of molten rock rise from deep inside Earth, cool into a solid, travel along our planet's surface and then sink back down. The process is known as plate tectonics.

pk - Convection currents!

The term *tectonics* comes from a Greek word meaning "to build." Tectonic plates are huge moving slabs that together make up Earth's outer layer. Some span thousands of kilometers (miles) on a side. In all, a dozen major plates cover Earth's surface.

? I wonder how big the largest plate is.
? Were they ever all one plate?

Earth's hot, liquid innards also are always in motion. That's because warmer materials are generally less dense than cooler ones, notes geologist Mark Behn. He's at the Woods Hole Oceanographic Institution in Massachusetts. So, hot stuff in Earth's middle "rises up — kind of like a lava lamp," he explains. "Once it gets back to the surface and cools off again, then it will sink back down." *INF It must be hotter near the core*



"It's like a giant conveyor belt," explains geophysicist Kerry Key at the Scripps Institution of Oceanography. It's at the University of California, San Diego. That conveyor belt drives the movement of the plates. The plates' average speed is about 2.5 centimeters (roughly an inch) or so per year — about as fast as your fingernails grow. Over millions of years, though, those centimeters add up.

Although some people mistakenly talk about "continental drift," it's the plates that move. Continents are just the tops of plates that rise above the ocean.

Moving plates can trigger huge impacts. "All the action is mostly at the

PK edges," notes Anne Egger. She's a geologist at Central Washington University in Ellensburg.

I Colliding plates can crush against each other. Abutting edges rise as ^{Visual} mountains. Volcanoes can form when one plate slides beneath another. Upwelling also can create volcanoes. Plates sometimes slide past each other at places known as faults. Usually these motions happen slowly. But large movements can trigger earthquakes. And, of course, volcanoes and earthquakes can cause massive destruction.



The more scientists learn about plate tectonics, the better they can understand these phenomena. If scientists could warn people when these events were coming, they also might help limit damage.

Power Words (for more about Power Words, click here)

continent (in geology) The huge land masses that sit upon tectonic plates. In modern times, there are six geologic continents: North America, South America, Eurasia, Africa, Australia and Antarctic.

earthquake A sudden and sometimes violent shaking of the ground, sometimes causing great destruction, as a result of movements within Earth's crust or of volcanic action.

fault In geology, a fracture along which there is movement of part of Earth's rocky, outermost shell, or lithosphere.

geology The study of Earth's physical structure and substance, its history and the processes that act on it. People who work in this field are known as geologists. Planetary geology is the science of studying the same things about other planets.

geophysics The study of matter and energy on Earth and how they interact.

Pangaea The supercontinent that existed from about 300 to 200 million years ago and was composed of all of the major continents seen today, squished together.

plate tectonics The study of massive moving pieces that make up Earth's outer layer, which is called the lithosphere, and the processes that cause those rock masses to rise from inside Earth, travel along its surface, and sink back down.

subduct or **subduction** The process by which tectonic plates sink or slide back from Earth's outer layer into its middle layer, called the mantle.

subduction zone A large fault where one tectonic plate sinks beneath another as they collide. Subduction zones usually have a deep trench along the top.

tectonic plates The gigantic slabs — some spanning thousands of kilometers (or miles) across — that make up Earth's outer layer.

upwelling The process by which material rises from Earth's middle layer into its outer layer, where it will become part of the tectonic plates.

volcano A place on Earth's crust that opens, allowing magma and gases to spew out from underground reservoirs of molten material. The magma rises through a system of pipes or channels, sometimes spending time in chambers where it bubbles with gas and undergoes chemical transformations. This plumbing system can become more complex over time. This can result in a change, over time, to the chemical composition of the lava as well. The surface around a volcano's opening can grow into a mound or cone shape as successive eruptions send more lava onto the surface, where it cools into hard rock.

Ocean of the future: an East African desert will one day become an ocean

S Science World, March 15, 2010

[ILLUSTRATION OMITTED]

1 The land in East Africa is full of hazards. Stinky toxic gas leaks out of the ground. Earthquakes frequently rattle the region. Active volcanoes there spew molten lava. Scientists say these activities are signs that an even bigger event is in the works.

2 The plate, or slowly moving giant slab of rock, that makes up Africa is tearing in two (see map, p. 26). A giant system of faults, or cracks, more than 6,400 kilometers (4,000 miles) long is breaking the slab apart. Eventually, a piece of East Africa will rip off from the continent and a new ocean will form in the gap left behind. "The same processes that created the Atlantic Ocean millions of years ago are happening in Africa right now," says James Wood, a geologist at Michigan Technological University. Scientists are studying the region to better understand how oceans are born.

? will Africa
one day
have an ocean in
it?

CRACKING UP

3 The African plate was once a cold, stiff rock slab roughly 40 km (25 mi) thick. Now, as part of the plate rips apart, a dramatic display of lava lakes and earthquakes appears. How does a huge chunk of rock break in two?

4 Scientists think the eastern part of the African plate is sitting above a particularly fiery spot in Earth's mantle, or the layer of hot, solid material between Earth's crust and its core. The sizzling rocks in this zone are less dense than the rocks around them. As a result, they are rising toward the surface. That upward movement is breaking the African plate into two pieces.

PK INF
They rise
up and
puncture the
surface.
So the area is higher
like the mid-ocean
ridge(?)

[ILLUSTRATION OMITTED]

5 "It's like there is a balloon that is slowly inflating beneath the continent," says Wood. "As the balloon expands, it cracks apart the rock above it." Those cracks form what is known as the East African Rift.

6 The East African Rift is slowly widening. A deep valley is forming as the chunks of rock on either side are being pushed apart. One day, water from the nearby Red Sea will flood the valley, creating a new ocean. But don't grab your swimsuit yet! The plates are moving at a slothlike 6 millimeters (0.2 inches) a year. It will be at least 10 million years before the ocean appears.

DANGER ZONE

Scientists have found that the ocean-building processes are creating many bizarre--and dangerous--features in Africa today. As the hot zone's sizzling magma rises toward the surface, it forces rocks apart. Earthquakes rattle the ground.

The previous reading says at plate boundaries that have upwelling we get volcanoes

In some places, magma bursts through the surface from volcanoes in the form of lava. In a remote desert in northern Ethiopia, this molten rock formed one of the world's only lava lakes, in a volcano called Erta Ale. This sea of lava stretches more than half a mile across. Normally, magma cools and hardens as soon as it reaches Earth's surface, but according to Simon Klemperer, a geologist at Stanford University in California, Erta Ale's lava typically stays molten.

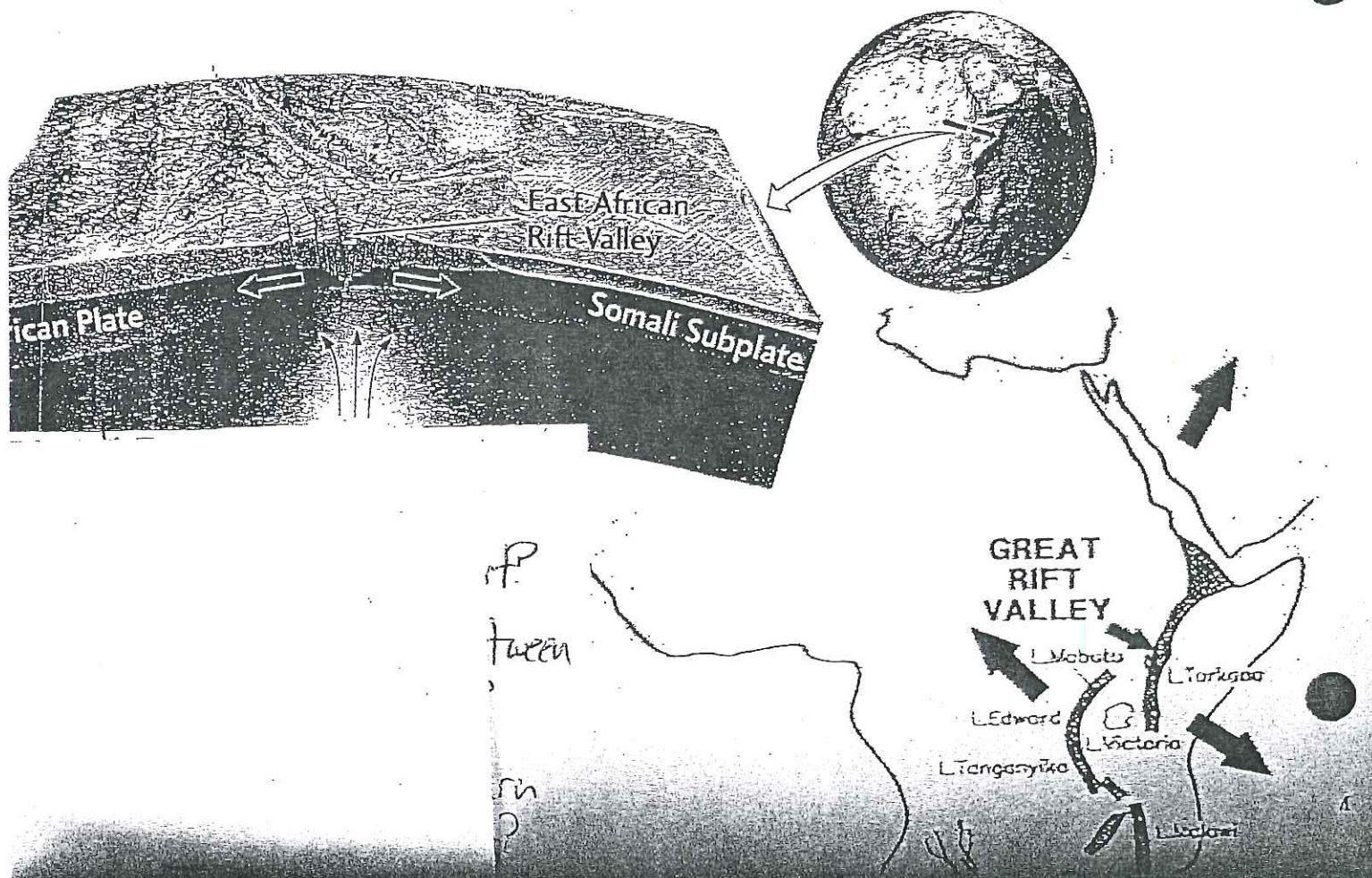
Rising magma sometimes brings toxic substances to the surface. "There are some pretty nasty gases that can come up," says Wood. The gases can contain acids, which mix with minerals in the water and soil. The resulting mixture can turn water holes into a deadly cocktail for thirsty animals. *INF There aren't m*

s. INF There aren't many people or animals living there

Despite the hazards, geologists often visit this changing landscape to examine its features. By studying how magma moves and faults open, they're learning more about how continents can break apart. "We are seeing the birth of an ocean," says Wood. "There aren't many places where you can see that happening right now."

"T-S. there wasint a plate boundary on this area in the plate poundary lab

it's your choice



ScienceNews_{for}Students

WEATHER & CLIMATE ENVIRONMENT, EARTH

Volcanic rocks can quickly turn pollution into stone

Transforming 'greenhouse' gas into solid rock may be better than other methods at fighting climate change

BY THOMAS SUMNER JUN 24, 2016 — 7:00 AM EST



A test program in Iceland successfully turned a power-plant's emissions of carbon-dioxide gas into solid stone. The program injected the gas into basaltic lava rocks.

Sigurdur Gislason

Greenhouse gases are a major contributor to climate change. But a new technique can turn one of these gases into solid rock before it floats up into the atmosphere. If widely adopted, such a move might just help slow global warming.

As part of a test program, researchers in Iceland injected gaseous carbon dioxide (CO₂) into basalt (Bah-SALT). It's the type of rock that lava turns into

INF It could cool quickly at mid-ocean ridges.

when it cools quickly. About two years later, the scientists checked back. More than 95 percent of the gas had turned to stone, they found. !

Solidifying the gas effectively locked it away. Now the gas is no longer a threat to Earth's climate. Such a relatively fast process could help counteract the world's greenhouse-gas emissions, the researchers conclude.

Explainer: Global warming and the greenhouse effect

"It's working," says Jeurg Matter. "It's feasible and it's fast enough to be a permanent solution for storing CO₂ emissions," he adds. As a geochemist, Matter studies the chemical composition of solid material on Earth — and how it changes. He works at the University of Southampton in England.

Can we lock it away faster than we make it?

Matter's group published its new results in the June 10 *Science*.

What makes basalt special

People have tried different approaches for storing CO₂. Many rely on pumping the gas into rocky vaults underground. But sometimes the gas can leak back to the surface. That's unlikely to happen with basalt, however. As much as one-fourth of basalt is made up of elements that react with CO₂. This allows them to form solid minerals, such as limestone. I

PK-Karst!

This process is called mineralization. It occurs naturally as basalt is exposed to harsh weather. Researchers had thought this process took hundreds to thousands of years. That would make it far too slow to be useful for combating the immediate threat of climate change.

For their new experiment, Matter and his colleagues mixed groundwater with 230 tons of CO₂. The gas had been emitted by a geothermal-energy power plant. Combining that gas with the water created a mixture that was a lot like *seltzer water*. The researchers injected this bubbly liquid into basaltic rock some 400 to 800 meters (about 1,300 to 2,600 feet) below ground. When the team sampled that rock about two years later, almost all of the CO₂ had mineralized.

How do they store the 230 tons of CO₂ to transport it?

Do they just let it go down or pressurize it like fracking?

Turning CO₂ emissions into minerals is not cheap. I It costs \$17 per ton. That's roughly twice as much as existing storage methods. But it doesn't require long-term monitoring to prevent leaks, Matter notes. A second benefit: This technique requires only water and basalt. And in theory, he adds, "We have enough basalt globally to take care of all anthropogenic CO₂ emissions."

Countries may decide to do this someday

A second group's work seems to back up the new findings. Peter McGrail is a geochemist at the Energy Department's Pacific Northwest National Laboratory in Richland, Wash. He and his colleagues did similar tests using pure CO₂, no groundwater added. They haven't yet published their results. But McGrail says their findings resemble those that Matter's group has just reported.

How come they didn't add groundwater?

Power Words

(for more about Power Words, click here)

anthropogenic An adjective that describes a human influence on something. It was coined by putting together the prefix "anthro," meaning human, and suffix "genic," meaning caused by.

atmosphere The envelope of gases surrounding Earth or another planet.

basalt A fine-grained rock that forms when lava cools quickly.

carbon dioxide (or **CO₂**) A colorless, odorless gas produced by all animals when the oxygen they inhale reacts with the carbon-rich foods that they've eaten. Carbon dioxide also is released when organic matter (including fossil fuels like oil or gas) is burned. Carbon dioxide acts as a greenhouse gas, trapping heat in Earth's atmosphere. Plants convert carbon dioxide into oxygen during photosynthesis, the process they use to make their own food.

climate The weather conditions prevailing in an area in general or over a long period.

climate change Long-term, significant change in the climate of Earth. It can happen naturally or in response to human activities, including the burning of fossil fuels and clearing of forests.

geochemistry A science that deals with the chemical composition of and chemical changes in the solid material of Earth or of another celestial body (such as the moon or Mars). Scientists who study geochemistry are known as geochemists.

geothermal energy The internal heat of the Earth or other planet. It can be tapped as an energy source to heat buildings at the surface.

greenhouse gas A gas that contributes to the greenhouse effect by absorbing heat. Carbon dioxide is one example of a greenhouse gas.

groundwater Water that is held underground in the soil or in pores and crevices in rock.

lava Molten rock that comes up from the mantle, through Earth's crust, and out of a volcano.

limestone A natural rock formed by the accumulation of calcium carbonate over time, then compressed under great pressure. Most of the starting calcium carbonate came from the shells of sea animals after they died. However, that chemical also can settle out of water, especially after carbon dioxide is removed (by plants, for instance).

mineral The crystal-forming substances, such as quartz, apatite, or various carbonates, that make up rock. Most rocks contain several different minerals mish-mashed together. A mineral usually is solid and stable at room temperatures and has a specific formula, or recipe (with atoms occurring in certain proportions) and a specific crystalline structure (meaning that its atoms are organized in certain regular three-dimensional patterns).

mineralization The process by which gas and other organic matter turns into minerals.

seltzer water Another name for the soft drink known as carbonated water or club soda

Readability Score:

7.3

NGSS:

- MS-ESS3-3
- HS-ESS3-4
- HS-ETS1-3

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Citation

The New York Times<http://nyti.ms/2d51XtK>

WHAT IN THE WORLD

Australia Is Not as Down Under as Everyone Thinks It Is

What in the World

By MICHELLE INNIS SEPT. 23, 2016

SYDNEY, Australia — That map of Australia you have? It's wrong. And the whole country is going to officially relocate to correct the error.

The trouble is caused by plate tectonics, the shifting of big chunks of the earth's surface. Australia happens to be on one of the fastest-moving pieces of all, and by geological standards it's practically flying: about 2.7 inches northward a year, with a slight clockwise rotation as well. ✓

T-T The first reading said average is 2.5 cm a year (1 inch)

AG - You wouldn't feel it.

People on the ground may not notice, but the Global Positioning System does. So Australia needs to adjust its longitudes and latitudes so they line up with GPS coordinates.

Four times in the last 50 years, Australia has reset the official coordinates of everything in the country to make them more accurate, correcting for other sources of error as well as continental drift. The last adjustment, in 1994, was a doozy: about 656 feet, enough to give the delivery driver an alibi for ringing your neighbor's doorbell instead of yours.

The rate of motion isn't fast enough to make that change in 50 years

? what other sources of error

"You might think, 'Where's my pizza?'" said Dan Jaksa of Geoscience Australia, the government agency that worries about the coordinates. But something bigger is at stake, he said: intelligent transportation systems that rely on the finer accuracy

T-W = Driverless cars need good coordinates or they will drive off the road.

that will come with the next generation of GPS technology.

The next adjustment, due at the end of the year, will be about 1.5 meters (4.9 feet) — not really enough of a discrepancy to throw off consumer-grade satellite navigation systems, which are generally accurate only to within 15 to 30 feet.

But the next generation of GPS devices, using both satellites and ground stations, will be accurate to within an inch or less, and new technologies that depend on precise location will be important to Australia's future.

The mining company Rio Tinto already has 71 immense ore trucks rumbling around iron mines in the remote Pilbara region of Western Australia that are guided remotely from an office in Perth, 930 miles away. *T*

Pilots who patrol the Anna Creek cattle ranch in South Australia must pick out small water bores in the ranch's 8,880 square miles of dry pasture, an area larger than Israel, where small errors can equate to big misses. "If we get a new pilot, he's relying on GPS until he finds his way around landmarks," said the ranch manager, Norm Sims.

Not to mention driverless cars. "If you're 1.5 meters out," Mr. Jaksa said, "you're potentially on the wrong side of the road." *T-W car crashes could happen.*

Follow Michelle Innis on Twitter @MichelleInnis.

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