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How Earthquakes and Volcanoes Reveal the Beating Heart of the Planet

The Smithsonian Global Volcanism Program has stitched together a visual archive of the world’s earthquakes and volcanoes

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Your face looks fine. Trust me. But if you zoom in and take a time-lapse, you'll see a landscape in motion: zits erupting, pore-craters forming, ridges of skin stretching apart and squashing together as you smile and frown. Similarly, the Earth outside your window might appear quiet. But that’s because you’re looking at a tiny slice in time and space. Expand your view and you'll see plates shift, earthquakes ripple and volcanoes erupt along tectonic boundaries. The world snaps, crackles and tears asunder. Nothing stays the same.

To illustrate these dynamic patterns, the Smithsonian Institution's Global Volcanism Program, hosted within the National Museum of Natural History, has created a time-lapse animation of the world's earthquakes, eruptions and emissions since 1960. Drawing from the first compiled database of sulfur emissions dating to 1978, the animations show how the seemingly random activity of volcanoes and earthquakes form consistent global patterns over time. Understanding those patterns gives researchers insight into how these dramatic events are entwined with the inner workings of our planet.

Earthquakes and volcanoes can conjure up images of widespread destruction. But for those who study Earth's deepest reaches, like Elizabeth Cottrell, a research geologist at the Smithsonian's National Museum of Natural History and director of the Global Volcanism Program, volcanoes are also "windows to the interior." Their activity and emissions provide a taste of what's inside, helping researchers to untangle the composition and history of the planet's core. That's crucial, because we still don't know exactly what the inside of our planet is made of. We need to understand the interior if we are to disentangle the global carbon cycle, the chemical flux that influences our planet's past and future.

We know a lot about carbon, the element that forms the chemical backbone of life, in our crust and oceans. We know far less about it in Earth's core and mantle. It's so far proved challenging to sample the Earth's mantle, which extends up to 1,800 miles below the surface. This means that Earth's interior plays a huge—and mysterious—role in the global carbon cycle. The interior contains perhaps 90 percent of our planet's carbon, bound up in pure forms like graphite or diamonds. Gleaning the movements of this elusive deep-earth carbon has been called "one of the most vexing problems" in our quest to understand the global carbon cycle.

Fortunately, we have volcanoes. As a planetary geologist, Cottrell thinks of these magma-makers as a "sample delivery system" that gives us a peek into the planet's core. "Earthquakes and eruptions are the heartbeat of the planet," she says. The emissions from these events, which have influenced global climate, are the planet's respiration. (Worldwide, volcanoes release about 180 to 440 million tons of carbon dioxide.) By studying the chemistry of lava and the makeup of volcanic gases, Cottrell and others can get an idea of what lies within—like studying human burps to figure out what's in your stomach.

Volcanoes belch out about mostly water vapor in the form of steam, along with carbon dioxide and some sulfur (by contrast, humans breathe out about 16 percent oxygen, 4 percent CO2 and 79 percent nitrogen). Understanding the "normal" levels of these volcano emissions would help scientists determine what the baseline is—and thus, how drastically human activity is impacting it. Yet pinning down those emissions is a tricky business. Collecting volcanic gas is downright dangerous, requiring researchers to get up close and personal to hot, pressurized emissions. When it erupts from the mantle, molten lava is a searing 1000 to 1300 degrees Celsius.

No wonder scientists would rather read gas signatures in the atmosphere using satellites from space. Unfortunately, that technique also has its problems. In the past three centuries, anthropogenic emissions from sources like factory farming and burning fossil fuels have drastically overtaken the emissions from volcanoes—meaning that volcanic CO2 gets lost in the background noise. As a workaround, scientists use sulfur, which is easier to measure from space, as a proxy for carbon. In the past decade, technological advancements have also made us possible to tease apart some of these emissions.

"Global satellite monitoring of volcanoes will transform our understanding of gas fluxes from Earth's interior to exterior in the coming decade," says Cottrell, who has been working along with Michigan Tech researcher Simon Carn and data manager Ed Venzke to incorporate volcanic emissions into the Smithsonian database since 2012.

In the visualization above, you can see earthquakes and volcanic eruptions not just as individual events, but as indicators of those regions of frenzied activity in Earth's crust where plates push up against each other and are torn asunder. The key is timescale. By zooming out to the past 50 years, you can see that volcanoes aren't merely catastrophic blips, but a steady pattern: the living heartbeat of a dynamic planet. "When we look on a long timescale, we see the constant pulse of the planet," says Cottrell, who recommends watching the animation with the sound on to get the full effect. It is a "constant unrelenting beat punctuated by periods of high and low activity."

Zoom in again, and you can see how volcanoes link us all on a very personal level. Every time you breathe, you inhale volcanic gas, which rapidly mixes with the atmosphere and diffuses. By knowing when and where recent volcanic eruptions have occurred, you can even pinpoint the volcano that flavored your last inhalation. Now that's intimate.

Learn about this research and more at the Deep Carbon Observatory.

About Rachel E. Gross

Rachel is the Science Editor, covering stories behind new discoveries and the debates that shape our understanding of the world. Before coming to Smithsonian, she covered science for Slate, Wired, and The New York Times.

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