MOVERS, SHAKERS and SHAPERS

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New studies of the forces that sculpt our planet offer groundbreaking ideas about how these geologic events occur.

Breaking Boundaries

Giant plates form an interconnected jigsaw puzzle of continental and oceanic crust. The pieces can slide past each other, collide or move apart. Even a small movement of one influences the others, with effects seen up to thousands of miles away.

According to Monash University researcher, Wouter Schellart, "The Earth's surface is covered with tectonic plates that move with respect to one another at centimeters per year. These plates converge at deep-sea trenches, plate boundaries where one plate sinks (subducts) below the other at so-called subduction zones. The velocities of these plates and the velocities of the boundaries between these plates vary significantly on Earth." In total there are three kinds of plate boundaries: convergent, divergent and transform.

Areas where plates collide are called convergent boundaries; these can occur in three different ways. First, plates colliding above the earth create majestic mountains like the Himalayas and Mount Everest. These get taller every year because the collisions never stop. Second, subduction occurs when a plate located in an ocean dives under a landmass. This causes the overlying plate to lift up and the diving plate to melt. The diving plate often turns into molten lava that erupts out of the mouth of an active volcano, becoming mountains similar to those in the Andes of South America. Third, in ocean-ocean convergence, one plate dives beneath the other, forming deep trenches.

Divergent boundaries create new oceanic crusts from the magma that rises to the Earth's mantle between two or more plates that are being pushed apart, causing mountains and volcanoes to rise along the seam. This type of activity is responsible for the creation of new continents. According to *National Geographic*, "Giant troughs such as the Great Rift Valley in Africa form where plates are tugged apart. If the plates there continue to diverge, millions of years from now eastern Africa will split from the continent to form a new landmass. A mid-ocean ridge would then mark the boundary between the plates."

Transform Boundaries, typically found in deep oceans, often trigger large earthquakes as two plates "grind past each other along strike-slip faults," according to *National Geographic*. On land, these boundaries may be identified by linear valleys or stream beds that have been split and no longer connect. One of the most famous transform boundaries is the San Andreas Fault in California, which caused the 1906 earthquake that devastated San Francisco.

The Force Is With Them

Earth scientists have long debated how powerful geological forces shape the planet, but a team of scientists at Scripps Institution of Oceanography at UC San Diego identified a new mechanism driving the Earth's massive tectonic plates: plumes of hot magma pushing up from deep inside the earth.

According to a press release from the Scripps Institute, scientists Steve Cande and Dave Stegman now have analytical methods that can track mantle plume "hot spots" ranging from tens of millions of years old to ones that are currently active. These new methods have allowed the scientists to see a "clear connection between the arrival of a powerful mantle plume head around 70 million years ago and the rapid motion of the Indian plate that was pushed as a consequence of overlying the plume's location. The arrival of the plume also created immense formations of volcanic rock now called the 'Deccan flood basalts' in western India, which erupted just prior to the mass extinction of dinosaurs. The Indian continent has since drifted north and collided with Asia, but the original location of the plume's arrival has remained volcanically active to this day, most recently having formed Réunion Island near Madagascar."

Their research also indicates that the "plume-push" force affected other tectonic plates as well, including movement against the African plate, but in the opposite direction.

"Prior to the plume's arrival, the African plate was slowly drifting but then stops altogether, at the same time the Indian [plate] speeds up," explains Stegman, an assistant professor of geophysics in Scripps' Cecil H. and Ida M. Green Institute of Geophysics and Planetary Physics. "It became clear the motion of the Indian and African plates were synchronized and the Réunion hotspot was the common link."

Once the initial force of the plume died down, the African plate eventually returned to its faster speed and the Indian plate slowed to its normal speed.

"There is a dramatic slowdown in the northwards motion of the Indian plate around 50 million years ago that has long been attributed to the initial collision of India with the Eurasian plate," said Cande, a professor of marine geophysics in the Geosciences Research Division at Scripps. "An implication of our study is that the slowdown might just reflect the waning of the mantle plume — the actual collision might have occurred a little later."

By: Gwen Myslinski

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