

Breakthrough Achieved in Explaining Why Tectonic Plates Move the Way They Do

Researchers at Monash University and Scripps Institution of Oceanography identify movements of plate and plate boundaries; could substantially improve models of tectonic motion

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A team of researchers including Scripps Institution of Oceanography, UC San Diego geophysicist Dave Stegman has developed a new theory to explain the global motions of tectonic plates on the earth's surface.

The new theory extends the theory of plate tectonics - a kinematic description of plate motion without reference to the forces behind it - with a dynamical theory that provides a physical explanation for both the motions of tectonic plates as well as motion of plate boundaries. The new findings have implications for how scientists understand the geological evolution of Earth, and in particular, the tectonic evolution of western North America, in the past 50 million years. The research, led by Monash University's Wouter Schellart, is published in the July 16 issue of the journal *Science*. These findings provide a new explanation as to why tectonic plates move along the Earth's surface at the speeds that are observed, the details of which were previously not well-understood.

"The earth's surface is covered with tectonic plates that move with respect to one another at centimeters per year," Schellart said. "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."

Schellart and his team, including Stegman and Rebecca Farrington, Justin Freeman and Louis Moresi from Monash University, used observational data and advanced computer models to develop a new mathematical scaling theory, which demonstrates that the velocities of the plates and the plate boundaries depend on the size of subduction zones and the presence of subduction zone edges.

"The scalings for how subducted plates sink in the earth's mantle are based on essentially the same fluid dynamics that describe how a penny sinks through a jar of honey," said Stegman, who developed the computer models that helped the team reenact tens of millions of years of tectonic movement. "The computer models demonstrate that the subducted portion of a tectonic plate pulls on the portion of the plate that remains on the earth's surface. This pull results in either the motion of the plate, or the motion of the plate boundary, with the size of the subduction zone determining how much of each."

"In some ways, plate tectonics is the surface expression of dynamics in the earth's interior but now we understand the plates themselves are controlling the process more than the mantle underneath. It means Earth is really more of a top-down system than the predominantly held view that plate motion is being driven from the bottom-up."

This discovery explains why the Australian, Nazca and Pacific plates move up to four times faster than the smaller African, Eurasian and Juan de Fuca plates.

"It also provides explanations for the motions of the ancient Farallon plate that sank into the mantle below North and South America. This plate slowed down during eastward motion from about 10 centimeters (four inches) per year some 50 million years ago to only 2 centimeters (0.8 inches) per year at present," Schellart said.

The decrease in plate velocity resulted from the decrease in subduction zone size, which decreased from 14,000 kilometers (8,700 miles) to only 1,400 kilometers (870 miles).

"This had a dramatic effect on the topography and the structure of the North American continent," said Schellart. "Until 50 million years ago, the west coast of North America was characterized by a massive mountain chain similar to the present day Andes in South America, and ran from Canada in the north to southern Mexico in the south."

As the subduction zone decreased in size, the compressive stresses along the west coast of North America decreased, resulting in destruction of the mountain range and formation of the Basin and Range province, a 2 million-square-kilometer (772,000-square-mile) area of elongated basins and ridges that characterizes the present-day western North American landscape.

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