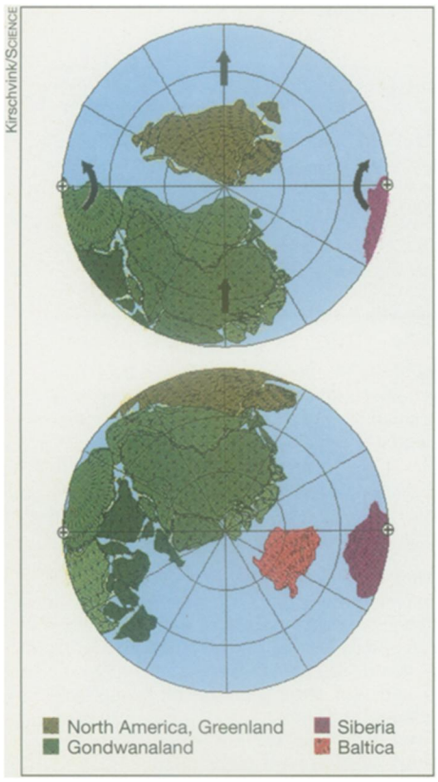
When Earth Tipped, Life Went Wild

More than 500 million years ago, Earth may have lost its balance and listed to one side, causing the continents to reposition themselves at breakneck speed, according to a team of geophysicists. This hypothesized event, they claim, sparked the evolutionary big bang known as the Cambrian explosion, when almost all major divisions of animals first appeared in the fossil record.

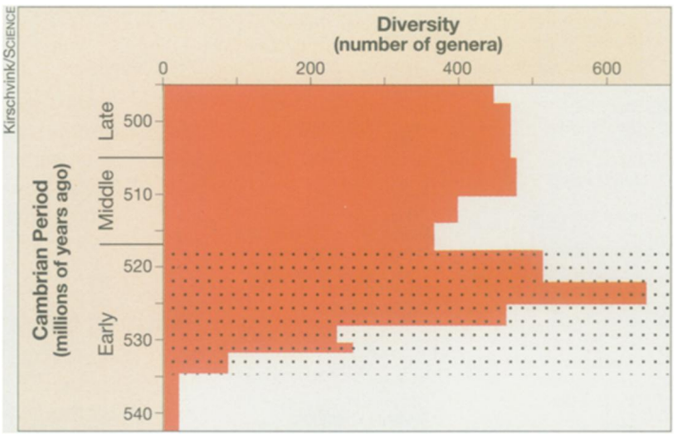
"It's a wild idea, if it's right," says the leader of the team, Joseph L. Kirschvink of the California Institute of Technology in Pasadena.

The proposal has drawn mixed responses from other scientists, who caution that such a grand claim will require geologists to collect firmer evidence from this critical period. "If it's true, it's incredibly important. But it is based on a somewhat scarce database that is open to many different interpretations," comments Ian W.D. Dalziel, a geophysicist at the University of Texas in Austin.

Before the Cambrian period, almost all life was microscopic, except for some enigmatic soft-bodied organisms. At the start of the Cambrian, about 544 million years ago, animals burst forth in a rash of evolutionary activity never since equaled. Ocean creatures acquired the ability to grow hard shells, and a broad range of new body plans emerged within the geologically short span of 10 million years. Paleontologists have proposed many theories to explain this revolution but have agreed on none.



View of the planet before the proposed global tilt (top) and after (bottom). The South Pole is at the center. Arrows indicate direction of motion.



The timing of the proposed tilting (stippled area) matches a jump in life's diversity.

Kirschvink and his colleagues now implicate Earth itself. During this time, shifting masses within Earth's interior mantle unbalanced the spinning globe, and the entire surface of the planet reoriented itself. As a result, the mantle and the crust tilted with respect to the axis of rotation, they propose in the July 25 SCIENCE.

To understand this process—called true polar wander—think of a ball with a half-dollar, a quarter, and a dime taped onto different spots. If the ball were set spinning on ice, it would naturally orient itself with the greatest masses, the half-dollar and the quarter, along the ball's equator. If the quarter suddenly fell off, the unbalanced ball would adjust. In the end, the new equator would run through the half-dollar and the dime, with the axis of rotation still pointing in the original direction.

According to the new hypothesis, the same kind of true polar wander occurred during the Cambrian. It carried ancestral North America from a position close to the South Pole all the way to the equator. At the same time, the giant continent of Gondwanaland—Africa, Antarctica, Australia, India, and South America—traveled clear across the Southern Hemisphere.

Geophysicists have identified relatively minor instances of true polar wander in recent geologic times, but they have never documented such a dramatic case.

The evidence supporting the new hypothesis comes from records of Earth's magnetic field. As rocks form, the minerals inside align themselves with the existing magnetic field. By analyzing the orientation of the grains, scientists can tell the position of the ancient continents relative to the magnetic north pole, which almost always lies close to the rotation axis.

By charting the motion of the continents during the Cambrian, Kirschvink and his colleagues found a brief period of major motion consistent with the idea of true polar wander. North America completed its journey from pole to equator sometime between 540 million and 515 million years ago, they claim. Gondwanaland shifted between 535 million and 500 million years ago. Putting these and other data together, the researchers suggest that most of the continental motion occurred between 535 and 520 million years ago.

The researchers invoke true polar wander as their explanation because the continents moved at least two times faster than ever documented in plate tectonics, the process that shuttles thin blocks of Earth's outer skin around the globe.

The quick Cambrian motion "would violate the plate tectonics speed limit. You can't make plates move that quickly," says Kirschvink.

If the entire surface of the planet turned by almost 90°, it would have drastically altered the climate and disrupted ecosystems. This would have opened the door to rapid evolution of new species, setting off the Cambrian explosion, speculate Kirschvink and his colleagues.

Geologists say that the available data are too sparse to tell whether all of Earth's continents moved that quickly. Other interpretations of the same paleomagnetic data draw the continental motion out over a much longer span.

Even if the globe started tilting 535 million years ago, that shift could not explain the initial biological burst, which began some 10 million years earlier, at the opening of the Cambrian. "The explosion was certainly set off long before this global tilting," says Stefan Bengtson of the Swedish Museum of Natural History in Stockholm. He notes, however, that such a drastic change "certainly would have influenced conditions for life. It could have strengthened an event that was already occurring." —*R. Monastersky*