Obituary

W. Jason Morgan
(1935–2023)

Geophysicist and discoverer of plate tectonics.

In 1967, Jason Morgan presented a groundbreaking paper at the annual meeting of the American Geophysical Union (AGU) in Washington DC. It showed that Earth's surface consists of about a dozen rigid plates. They are created at mid-ocean ridges, destroyed in subduction zones where they converge, and move past one another along great faults, such the San Andreas Fault in California. Other papers followed, explaining that volcanoes occur where plates subduct, mountains rise where and when continents collide, and earthquakes result from jostling and shearing at plate margins.

Within a decade, the theory of 'plate tectonics' was broadly accepted. Morgan had presented the geological equivalent of Charles Darwin's theory of evolution soon after being appointed as an assistant professor at Princeton University in New Jersey and had transformed geology forever. He has died aged 87.

Morgan was born in Savannah, Georgia. After secondary school, he fell in love with physics at the Georgia Institute of Technology in Atlanta. He spent two years in the US Navy as an instructor at the Naval Nuclear Power School in New London, Connecticut, before moving to Princeton to study for a doctorate in the physics of relativity with Robert Dicke. After obtaining his PhD in 1964, he became a postdoc in the geosciences department, where he was promoted to assistant professor in 1966.

Dicke was interested in the force of gravity and, in particular, whether the 'gravitational constant' (*G*; a fundamental parameter in gravitational theory) was actually constant. If this force weakened, Earth would expand like a balloon. He tasked Morgan with looking for evidence of this in the pattern of earthquakes across Earth, which Morgan was studying to search for geophysical signs of gravitational waves. Harry Hess, the chair of the geosciences department, had mapped the topography of the sea floor and discovered mid-ocean ridges — the great chain of submarine mountains that wraps itself twice around the globe like the seams on a baseball. He had proposed that new crust forms at the ridges and moves away, a mechanism known as sea-floor spreading. In the end, earthquakes supported Hess's ideas and the concept of plate tectonics much better than they did Dicke's balloon hypothesis.


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Meanwhile Fred Vine, a graduate student at the University of Cambridge, UK, had discovered that the ocean crust is magnetically striped: Earth's magnetic field changes polarity, the north pole becoming the south pole and vice versa, on timescales from tens of thousands to millions of years. The direction of the magnetic field is frozen into the sea floor when the ridge lavas cool and spread, producing stripes parallel to the ocean ridges — confirming Hess's idea. Hess hired Vine and gave him a desk in the same office as Morgan. Although the pair did not publish together, decades later Morgan told *Quanta Magazine* that, of the many people who contributed to the theory of plate tectonics at Princeton, "the person who was most helpful for me was Fred Vine". Vine and his Cambridge supervisor Drummond Matthews are well recognized for the contribution that their magnetic studies made to the discovery of plate tectonics.

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Remembering the spherical trigonometry he had learnt at school, Morgan knew how to define the motion of the plates — as rotating around fixed points or 'poles' on a sphere. The poles might change occasionally with time, but the interiors of the plates did not deform. His model explained all the observations. Thus, all of geology could be summarized with astounding elegance. He presented his findings in his 1967 AGU talk and a subsequent paper, both entitled Rises, trenches, great faults, and crustal blocks (W. J. Morgan *J. Geophys. Res.* **73**, 1959–1982; 1968).

Morgan's second important contribution to geophysics was in investigating convection in the mantle, Earth's hot, fluid interior, and addressing what made plate motions possible. He interpreted chains of volcanoes in terms of poles and plate rotation, a spectacular example being the Hawaiian Island chain of volcanoes. An abrupt bend in the chain near Midway Island indicates that the adjacent plates had reorganized about 40 million years ago.

Morgan proposed that these volcanic chains were tracks — when hot upwellings in the mantle (called plumes) approach the surface, they trigger volcanism in the plate above it. As the plate moves, linear chains of volcanoes are produced. Because the plumes don't move much, the history of plate motion can be inferred from these tracks. Morgan also made computer models — an innovative approach at the time — that compared where the tracks should be theoretically to where they were geologically. All the evidence was consistent with rigid plates moving over a fixed set of plumes.

Jason spent his entire career at Princeton, living on campus with his family and retiring in 2004. He spent his last years living outside Boston as a visiting scholar at Harvard University in Cambridge, Massachusetts. Jason was awarded the National Medal of Science in 2002, and many other awards. It would be fair to say that no one in recent times has contributed more to understanding geology, and he did so with such modesty. Jason always had time to talk and help; he was remarkably thoughtful, and a highly effective teacher. You had to be aware that it could take him a minute to respond when conversing, and had to wait patiently for his reply. But his response was always worth the wait.

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