

The fit of the coastlines

How an idea dismissed for half a century became the ground beneath geology.

A Look at a map of the Atlantic and a coincidence is hard to miss: the eastern bulge of South America seems made to nest into the western hollow of Africa, like two pieces of a single torn sheet. Others had remarked on the resemblance before him, but in 1912 the German meteorologist Alfred Wegener turned the observation into a theory. The continents, he argued, had once been joined in a single great landmass, which he called Pangaea, and had since drifted slowly apart. He named the idea continental drift.

B Wegener did not rest his case on the shape of the coastlines alone. He gathered evidence of a kind that was difficult to explain any other way. Identical fossils of land-dwelling creatures, such as the reptile Mesosaurus and the fern Glossopteris, turned up on continents now separated by thousands of miles of ocean that the animals could not have crossed. Bands of rock and ranges of mountains ended abruptly at one coast and resumed, matching, on another. Glacial deposits lay in regions that are now tropical, and coal, which forms in warm swamps, lay beneath the polar ice. Each oddity dissolved if the continents had once sat together and drifted to their present places.

C The objection that sank the theory was not about this evidence, which few disputed, but about cause. Wegener could not say what force moved a continent. The mechanisms he proposed, a drift driven by the tides and a 'pole-fleeing' force, were calculated by physicists to be orders of magnitude too weak to push a continent through the solid rock of the ocean floor. To the geophysicists of the day, the prominent Harold Jeffreys among them, a process with no plausible engine was no process at all, however suggestive the fossils. The evidence was real; the explanation was missing.

D So the theory was set aside for the better part of fifty years. It did not help that Wegener was an outsider to geology, a meteorologist proposing to overturn the earth sciences from beyond their walls, and his idea was treated in many quarters with open ridicule. He died in

1930 on a research expedition across the Greenland ice, his theory still in disrepute. The matching fossils and coastlines did not go away in those decades; they were simply filed under puzzles to be explained some other way, because the one explanation on offer had no mechanism behind it.

E The break came not from new fossils but from the floor of the sea. As naval surveys after mid-century mapped the ocean bed, they revealed a continuous chain of submarine mountains, the mid-ocean ridges, running down the middle of the oceans. In the early 1960s the American geologist Harry Hess proposed what these ridges were doing. New ocean crust, he suggested, is created at the ridges from molten rock rising from the mantle, and spreads slowly outward to either side, a process he called seafloor spreading. The continents did not have to plough through the ocean floor after all; they rode upon it as it moved. The decades-old objection, the want of a mechanism, suddenly had its answer. The notion of a churning, convecting mantle that Arthur Holmes had floated years earlier now had a place to act.

F Proof of the spreading came from an unexpected quarter: magnetism. Iron-bearing rock, as it cools, locks in the direction of the Earth's magnetic field at that moment, and the field is known to reverse its polarity from time to time. If the seafloor was spreading, each reversal would be frozen into the new crust as it formed, producing matched, symmetrical stripes of normal and reversed magnetism running parallel to a ridge on both sides. When surveys found exactly that pattern, mirror-image bands flanking the ridges, the seafloor was shown to be a slow tape recording of its own creation, and spreading was no longer a hypothesis but a measurement.

G By the end of the 1960s these strands had been drawn together into the theory of plate tectonics, which holds that the Earth's surface is broken into rigid plates that move, carrying continents with them. Wegener, it turned out, had been right about the drift and wrong, or simply silent, about its cause, and the gap had cost his idea two generations. What had been missing was never more evidence; it was a mechanism, and the patience to wait for the tools that would reveal it. The continents do fit together, as the map suggests. It just took the floor of the ocean to explain why.

ANSWER THE QUESTIONS

Questions 1–5 · True / False / Not Given

Do the following statements agree with the information in the passage? Write True, False, or Not Given.

- 1 Wegener was the first person ever to notice that the Atlantic coastlines appear to fit together.
- 2 Wegener supported his theory with fossil evidence as well as the shape of the coastlines.
- 3 Wegener significantly revised his theory in response to his critics before he died.
- 4 Seafloor spreading supplied the mechanism that continental drift had lacked.
- 5 The magnetic stripes on the seafloor are arranged at random with no clear pattern.

Questions 6–9 · Multiple choice

Choose the correct answer, A, B, C or D.

- 6 Which of the following did Wegener offer as evidence for continental drift?
 - A Magnetic stripes running parallel to the mid-ocean ridges.
 - B Identical fossils on continents now separated by wide oceans.
 - C Direct measurements of the continents moving apart.
 - D A force, driven by the tides, strong enough to move a continent.
- 7 According to paragraph C, why did geophysicists reject continental drift?
 - A The fossil evidence was shown to be mistaken.
 - B Wegener refused to publish his calculations.
 - C No known force was strong enough to move a continent through the ocean floor.
 - D The coastlines did not in fact match closely.
- 8 What was the central claim of seafloor spreading?
 - A New ocean crust forms at the ridges and spreads outward, carrying continents with it.
 - B The continents are fixed and have never moved.
 - C The ocean floor is gradually sinking into the mantle everywhere.
 - D The Earth's magnetic field never changes direction.
- 9 What did the symmetrical magnetic stripes demonstrate?
 - A That the Earth's magnetic field has always pointed the same way.
 - B That the continents were not moving at all.
 - C That fossils could survive on the ocean floor.

- D That the ocean floor was spreading and had recorded reversals of the magnetic field.

Questions 10–11 · Sentence completion

Complete each sentence using no more than two words from the passage.

- 10 Wegener proposed that the continents had once formed a single landmass, which he called .
- 11 Harry Hess argued that new crust forms at the ridges and moves outward in a process he called seafloor .

Questions 12–14 · Matching information

The passage has seven paragraphs, A–G. Which paragraph contains the following information? Choose the correct letter.

- 12 Examples of identical fossils found on continents now divided by ocean.
- 13 A reference to Wegener's training in a field other than geology.
- 14 A description of evidence that recorded reversals in the Earth's magnetic field.

ANSWER KEY

1. False
2. True
3. Not Given
4. True
5. False
6. B
7. C
8. A
9. D
10. Pangaea
11. spreading
12. B
13. D
14. F