**Evidence of Plate Tectonics**

There was one other major problem with Earth theories that no one had resolved, or even come close to resolving. That was the question of where all the sediments went. Every year Earth’s rivers carried massive volumes of eroded material—500 million tons of calcium, for instance—to the seas. If you multiplied the rate of deposition by the number of years it had been going on, it produced a disturbing figure: there should be about 19 kilometers of sediments on the ocean bottoms—or, put another way, the ocean bottoms should by now be well above the ocean tops. Scientists dealt with this paradox in the handiest possible way. They ignored it. But eventually there came a point when they could ignore it no longer.

In the Second World War, a Princeton University mineralogist named Harry Hess was put in charge of an attack transport ship, the USS Cape Johnson. Aboard this vessel was a fancy new depth sounder called a fathometer, which was designed to facilitate inshore maneuvers during beach landings, but Hess realized that it could equally well be used for scientific purposes and never switched it off, even when far out at sea, even in the heat of battle. What he found was entirely unexpected. If the ocean floors were ancient, as everyone assumed, they should be thickly blanketed with sediments, like the mud on the bottom of a river or lake. But Hess’s readings showed that the ocean floor offered anything but the gooey smoothness of ancient silts. It was scored everywhere with canyons, trenches, and crevasses and dotted with volcanic seamounts that he called guyots after an earlier Princeton geologist named Arnold Guyot. All this was a puzzle, but Hess had a war to take part in, and put such thoughts to the back of his mind.

After the war, Hess returned to Princeton and the preoccupations of teaching, but the mysteries of the seafloor continued to occupy a space in his thoughts. Meanwhile, throughout the 1950s oceanographers were undertaking more and more sophisticated surveys of the ocean floors. In so doing, ***they found an even bigger surprise: the mightiest and most extensive mountain range on Earth was—mostly—underwater***. It traced a continuous path along the world’s seabeds, rather like the stitching on a baseball. If you began at Iceland, you could follow it down the center of the Atlantic Ocean, around the bottom of Africa, and across the Indian and Southern Oceans, below Australia; there it angled across the Pacific as if making for Baja California before shooting up the west coast of the United States to Alaska. Occasionally its higher peaks poked above the water as an island or archipelago—the Azores and Canaries in the Atlantic, Hawaii in the Pacific, for instance—but mostly it was buried under thousands of fathoms of salty sea, unknown and unsuspected. When all its branches were added together, the network extended to 74,000 kilometers.

A very little of this had been known for some time. People laying ocean-floor cables in the nineteenth century had realized that there was some kind of mountainous intrusion in the mid- Atlantic from the way the cables ran, but the continuous nature and overall scale of the chain was a stunning surprise. Moreover, it contained physical anomalies that couldn’t be explained. Down the middle of the mid-Atlantic ridge was a canyon—a rift—up to a twenty kilometers wide for its entire 12,000-mile length. This seemed to suggest that the Earth was splitting apart at the seams, like a nut bursting out of its shell. It was an absurd and unnerving notion, but the evidence couldn’t be denied.

Then in 1960 core samples showed that the ocean floor was quite young at the mid-Atlantic ridge but grew progressively older as you moved away from it to the east or west. Harry Hess considered the matter and realized that this could mean only one thing: new ocean crust was being formed on either side of the central rift, then being pushed away from it as new crust came along behind. The Atlantic floor was effectively two large conveyor belts, one carrying crust toward North America, the other carrying crust toward Europe. The process became known as seafloor spreading.

When the crust reached the end of its journey at the boundary with continents, it plunged back into the Earth in a process known as subduction. That explained where all the sediment went. It was being returned to the bowels of the Earth. It also explained why ocean floors everywhere were so comparatively youthful. None had ever been found to be older than about 175 million years, which was a puzzle because continental rocks were often billions of years old. Now Hess could see why. Ocean rocks lasted only as long as it took them to travel to shore. It was a beautiful theory that explained a great deal. Hess elaborated his ideas in an important paper, which was almost universally ignored. Sometimes the world just isn’t ready for a good idea.

Meanwhile, two researchers, working independently, were making some startling findings by drawing on a curious fact of Earth history that had been discovered several decades earlier. In 1906, a French physicist named Bernard Brunhes had found that the planet’s magnetic field reverses itself from time to time, and that the record of these reversals is permanently fixed in certain rocks at the time of their birth. Specifically, tiny grains of iron ore within the rocks point to wherever the magnetic poles happen to be at the time of their formation, then stay pointing in that direction as the rocks cool and harden. In effect they “remember” where the magnetic poles were at the time of their creation. For years this was little more than a curiosity, but in the 1950s Patrick Blackett of the University of London and S. K. Runcorn of the University of Newcastle studied the ancient magnetic patterns frozen in British rocks and were startled, to say the very least, to find them indicating that at some time in the distant past Britain had spun on its axis and traveled some distance to the north, as if it had somehow come loose from its moorings. Moreover, they also discovered that if you placed a map of Europe’s magnetic patterns alongside an American one from the same period, they fit together as neatly as two halves of a torn letter. It was uncanny.

Their findings were ignored too.

It finally fell to two men from Cambridge University, a geophysicist named Drummond Matthews and a graduate student of his named Fred Vine, to draw all the strands together. In 1963, using magnetic studies of the Atlantic Ocean floor, they demonstrated conclusively that the seafloors were spreading in precisely the manner Hess had suggested and that the continents were in motion too. An unlucky Canadian geologist named Lawrence Morley came up with the same conclusion at the same time, but couldn’t find anyone to publish his paper. In what has become a famous snub, the editor of the Journal of Geophysical Research told him: “Such speculations make interesting talk at cocktail parties, but it is not the sort of thing that ought to be published under serious scientific aegis.” One geologist later described it as “probably the most significant paper in the earth sciences ever to be denied publication.”

At all events, mobile crust was an idea whose time had finally come. A symposium of many of the most important figures in the field was convened in London under the auspices of the Royal Society in 1964, and suddenly, it seemed, everyone was a convert. The Earth, the meeting agreed, was a mosaic of interconnected segments whose various stately jostling’s accounted for much of the planet’s surface behavior.

The name “continental drift” was fairly swiftly discarded when it was realized that the whole crust was in motion and not just the continents, but it took a while to settle on a name for the individual segments. At first people called them “crustal blocks” or sometimes “paving stones.” Not until late 1968, with the publication of an article by three American seismologists in the Journal of Geophysical Research, did the segments receive the name by which they have since been known: plates. The same article called the new science plate tectonics.