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Maurice Ewing and the Lamont-Doherty Earth Observatory

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By the end of World War II, physicists and chemists, including many at Columbia University, had penetrated the molecular and subatomic worlds, revealing the fundamental structures and forces that compose matter and set it in motion. Similarly, biologists spearheaded by Columbia's Thomas Hunt Morgan had identified the gene, launching sweeping breakthroughs in the study of heredity, evolution, the development of complex organisms, and a wide range of other biological processes.

But of the larger world—our home planet, Earth—we knew relatively little. The earth sciences languished in a state approaching astronomy before Copernicus and Galileo. No one knew what created the oceans, continents, mountains, islands, and volcanoes. The prevailing theory at the time—that the earth's surface was rigid and relatively permanent—was about as off-base as an earth-centered solar system.

In 1915, the German scientist Alfred Wegener had proposed that the continents were once connected but had separated and drifted apart. But Wegener had neither an underlying mechanism to explain the scenario nor the convincing evidence to support it, and his continental drift theory was declared scientific heresy.

Locked into the idea that the earth's surface was fixed and immobile, geology before the war "was not a study of processes except on a lilliputian scale; it was a historical science with causes left out," wrote H.E. LeGrand, a University of Melbourne science historian, in his book *Drifting Continents and Shifting Theories: The Modern Revolution in Geology and Scientific Change*. "The caricatured academic geologist was an elderly professor mumbling an interminable catalogue of the common fossils of the Carboniferous, occasionally stirring a cloud of dust as he produced a specimen."

Geologists were landlocked—not only conceptually but literally. Most people at the time nourished a comfortable notion that the globe had been largely explored. World maps had been filled in with details—mountains, rivers, lakes, deserts, and jungles—but all these were framed by a featureless blue border. Scientists and everyone else overlooked 70 percent of the planet that was covered by a vast, formidable, opaque barrier—the oceans.

"Geologists could not apply traditional field methods to the seafloors," LeGrand wrote. "There was also an unstated presumption that there were no problems or data unique to the ocean floors. Any general theory which could cope with the continents could surely be extended sight unseen to the seafloor. Why do underwater what could be done more easily and more cheaply on land?"

Thus, in 1946, virtually anything that wasn't terra firma was terra incognita.

But that same year, a brilliant, entrepreneurial, relentlessly driven young professor named William Maurice Ewing came to Columbia with little patience for traditional geologists. "Annoying fellows," he called them, "who spend their time poking around trying to explain this or that little detail. I keep wanting to say, 'Why don't you try to see what's making it all happen?'"

Answering that question with traditional explorations limited to Earth's small dry fraction, he said, was "like trying to describe a football after being given a look at a piece of the lacing." To pursue a radically different approach—to study earth processes on a brobding–nagian scale—Ewing immersed himself and his colleagues in unprecedented explorations of the intimidating oceans. And, for the first time, he forcibly applied the disciplines of physics and chemistry to the study of geology.

Such was his impact that in two decades the methods he introduced, the instruments he built, the students he trained, the scientists and ships he marshaled, and the institution he created—now called Columbia's Lamont-Doherty Earth Observatory—essentially launched whole new scientific fields and revolutionized our understanding of our planet almost as dramatically as Copernicus did centuries before. He went by his middle name (pronounced "Morris"), but anyone who knew him just called him "Doc."

Born in 1906, Ewing was the eldest surviving child of a large family that led a happy but hardscrabble existence on a farm in the Texas panhandle.

At sixteen, he won a scholarship to Rice Institute (now Rice University) in Houston, where he earned a Ph.D. in physics. To support himself, he tutored classmates and worked in an all-night drugstore, somehow finding time to play first trombone in the marching band throughout graduate school. During summers, he worked in grain elevators and for oil prospecting companies. His lifelong habit of working all day, every day, was already entrenched.

In 1930, he became a professor of physics at Lehigh University, zealous to do research. In those Depression-era days before government-sponsored research, he improvised physics experiments. He used magnetic measurements to look for buried apparatus. When local quarries were blasting, he recorded the seismic waves they generated. Ewing's summer jobs had made him familiar with emerging techniques employed by oil companies to reveal the thickness, composition, and contours of buried rock strata (and the oil hidden within them) by studying seismic waves traveling through and reflecting off rock layers.

Wrangling some dynamite of his own, Ewing concocted further rudimentary experiments. He spent weekends setting off explosions in the wilds of New Jersey, using sound energy to explore subsurface geology. He analyzed seismic waves traveling across "a solid interface between a gas and liquid"—the frozen surface of a nearby lake.

Ewing's modest but singular research attracted the attention of two geologists, Professor Richard Field of Princeton and Major William Bowie of the U.S. Coastal and Geodetic Survey. One snowy November day in 1934, they showed up at Lehigh to ask Ewing whether the seismic measurements he was pioneering on land could be adapted to investigate the geology of a completely unknown landscape—the seafloor. Ewing had already proposed the same thing to several oil companies, asking them to "support a modest program of research."

"This proposal received no support whatever," Ewing wrote in 1955. "I was told that work out in the ocean could not possibly be of interest to the shareholder and could not rightfully receive one nickel of the shareholder's money."

Bowie and Field encouraged Ewing to seek a grant from the Geological Society of America (GSA). “If they had asked me to put seismic equipment on the moon instead of the bottom of the ocean I’d have agreed, I was so desperate for a chance to do research,” Ewing told his biographer, William Wertenbaker, in his book *The Floor of the Sea*.

In fact, decades later Ewing and Columbia colleagues did put such equipment on the moon aboard Apollo flights. But in 1936, with a $2,000 grant from the GSA, Ewing and a handful of students—none of them geologists—began to work on experiments that no one had ever imagined, let alone performed. As in New Jersey, they would use sound energy—explosions—to generate seismic waves to probe the seafloor.

“Geophysics as a science didn’t really exist at the time,” says J. Lamar Worzel ’49GSAS, who was one of Ewing’s undergraduate students in 1937. He followed Ewing to Columbia to earn his Ph.D. and later was a professor of geophysics at Columbia until 1972. “Commercially available geophysical instruments certainly didn’t exist at the time.” So Ewing and his students designed and built them all themselves. It was the Depression, and so the group begged, borrowed, and bartered to get whatever they needed. They jury-rigged equipment, using fruit salad cans, drinking glasses from diners, and electric motors from toy trains. They detonated their explosives with caps from toy pistols. They sneaked into Lehigh’s machine shop to work all night, slept in fields to save money, and washed photographic records in bathtubs. They gladly accepted castoffs and converted them into breakthroughs. Out of a surplus navy artillery shell, for example, they fashioned a device to test equipment at the high pressure they expected on the seafloor. They had only two precious weeks of ship time each summer to conduct experiments, as guests on Woods Hole Oceanographic Institution’s *Atlantis*—–the first, and at that time only, U.S. dedicated oceanographic research vessel.

“We did everything we could to improve our instruments and methods during the year, then had one brief chance to see if they worked,” Worzel says.

The landlubber’s scourge, sea sickness, would not deter them. Ewing’s ability to overcome it “was largely from fury,” he told Wertenbaker. “Seasickness is like a toothache, you know—you don’t notice it if your house is burning. This was the chance of my life.”

Their first year's experiments were hopelessly distorted because the rolling ship couldn't avoid tugging on a line of explosives and recorders laid on the seafloor—a difficult seagoing maneuver never previously attempted. The next summer, they instead devised a system to retrieve their instruments from the seafloor by attaching them to buoyant gasoline-filled hoses, blocks of salt, and weights. When the salt dissolved, the weights were released, and the instruments floated to the surface. That worked well, but high seafloor pressure caused the detonators to misfire.

Ewing could not stomach wasting any precious ship time, so while they waited for their turn to do experiments, they put together the first deep-sea camera, housed in a glass test tube about eight inches in diameter and four feet long, affectionately called the "Pyrex Penis." Its watertight seal was made from inner tubes, its reflectors out of coffee cans.

The following year, only one of their seismic instruments worked. By sheer accident, it contained a battery that operated at cold seafloor temperatures. Another brand of battery used in all the other instruments did not. Both had worked fine at the surface.

"We were physicists and engineers, using our wits and flying by the seats of our pants to bring these sciences to bear on the study of the earth, working out the methods as we went along," Worzel says. "Most physicists and geologists thought our exploratory efforts were bastardizations of each of their sciences."

Then came World War II, and suddenly the navy was extremely interested in the work of Ewing and colleagues. They remained at Woods Hole throughout the war, applying their nascent techniques to reveal for the first time how sound is transmitted through the oceans. The navy immediately put that knowledge to good use in antisubmarine and mining operations, and Ewing's team went on to design new apparatus that saved ships, submarines, and lives.

They discovered, for example, that sound waves transmitted down into the ocean would bend and split in two directions, some horizontally and some vertically, creating a "shadow zone" in between, where submarines could escape detection from sonar. Deeper down, they found that sound waves bounced off a layer in the ocean where water temperatures dropped sharply (the colder water was denser).

Farther down was another sound-reflecting layer. These two layers created a kind of channel, with a floor and a ceiling. Sound caught in this channel bounced off the floor and ceiling, and proceeded without losing energy throughout the world's oceans, carrying thousands of miles.

This fundamental property of the oceans, now called the SOFAR (sound fixing and range) channel, was wholly unexpected and led to the navy's SOSUS (Sound Surveillance System) array of underwater hydrophones to monitor great expanses of the ocean. (Today scientists use it to monitor marine mammals, seafloor volcanoes and earthquakes, and global ocean temperatures.)

As the war ended, Columbia offered Ewing a professorship to expand the beachhead he had established in geophysics. In 1946, he and a handful of graduate students established an academic base for their young science in hastily refurbished rooms in Schermerhorn Hall, outfitted with desks and equipment from government surplus lists. In one room, a trapdoor led to a small space hollowed out of Manhattan's bedrock, where they intended to install seismic equipment toobserve earthquakes. Ewing hired Angelo Ludas, a veteran of the Manhattan Project at Columbia, to establish and run a machine shop to translate into metal and wires all their instrumental visions.

In early 1947, Ewing undertook a Sigma Xi lecture tour with the official purpose of finding bright students to work in oceanography. But "actually he was scouting for a group of technicians from wealthy families to whom he could offer adventure instead of pay," says Marie Tharp, one of the few women geologists at that time, who came to Columbia in 1948. After one Ewing talk at the University of Iowa, a bright-eyed junior named Bruce Heezen introduced himself, and Ewing immediately invited him on an expedition he was planning for that summer. Ewing's pursuit of knowledge was contagious: Heezen signed up, earned his Ph.D. under Ewing in 1957, and later became a Columbia professor. He and Tharp spent the next thirty years on a quest to map the seafloor.

The First Eye-Opening Cruise

Ewing had been granted use of the *Atlantis* for two months in the summer of 1947.

“I felt an obligation, with an expedition entrusted to me for two months, to get data of every conceivable kind,” Ewing told Wertenbaker. He took underwater cameras, dredges to collect seafloor samples, and a seismic array to explore subseafloor rock layers. Rather than stop the ship to take measurements, Ewing tried an unprecedented technique to get the most data as quickly as possible. As the Atlantis continued sailing, it towed hydrophones to receive reflected sound generated by explosives that crew members pitched overboard at precise intervals.

He also took an echo sounder to reveal the seafloor’s contour. Of particular interest was a broad but vague rise in the middle of the Atlantic Ocean seafloor, which had been hinted at by nineteenth-century depth soundings that used long ropes and lead weights. Ewing also took along a sediment corer—a narrow metal cylinder that could be lowered on a line to the seafloor to collect a “plug” of sediment. Until that cruise, scientists’ prevailing view was that the seafloor was stable, featureless, and uniform—a basket that caught the gentle, steady rain of particles that sank from the ocean surface, mostly remnants of dead microscopic marine plants and animals. Thus, anywhere one looked in the ocean, one would find the same constantly accumulating column of sediment, which represented the whole of geologic time.

In 1947 that theory was literally blasted out of the water by the jumbled sediments that Ewing and company observed in the first core they retrieved. When a young Woods Hole scientist, David Ericson, subsequently examined preserved plankton shells in the sediments, he found that sediments with modern plankton lay directly atop sediments with forty-million-year-old shells. It was obvious that great unknown processes were at work, transporting sediments and disrupting the way they were deposited on the ocean bottom.

The other instruments also produced surprises. It was like going for the first time into a dark attic with a proper flashlight—unexpected discoveries were inevitable.

The echo sounder suggested that huge tracts of the seafloor were almost impossibly flat—the so-called abyssal plains. But then near the ocean’s middle, the floor precipitously rose thousands of feet high. Dredges scraping the seafloor brought up basalt, a relatively fresh volcanic rock that is rare on land—not granite, the stuff of which continents were made. The seismic arrays indicated that the seafloor’s crust was inexplicably thin—only about three miles thick, compared with the more than twenty for continents. The seafloor was clearly much more complicated than had been imagined.

A New Research Institute Is Born at Columbia

The 1947 cruise raised so many profound questions that the research exploded, and by the summer of 1948, Columbia's geophysicists already needed more space. "We even went so far as to design a new building for ourselves between Schermerhorn and Columbia's powerhouse," Worzel says. "About then, Ewing had received an offer to establish a geophysics research group at the Massachusetts Institute of Technology and to bring all his students there. MIT offered us a former estate near New Bedford to house our operations."

Ewing toured the grounds with his graduate students. He talked with Dwight D. Eisenhower, then Columbia's president, and Paul Kerr, chairman of the geology department. They countered MIT's proposal by offering an estate about to be donated to Columbia by Florence Lamont, the widow of financier Thomas Lamont. It was fifteen miles north of Columbia, across the Hudson River in Palisades, New York. Kerr promised to raise $200,000 to establish a new research institution. Ewing and his students debated between Columbia and MIT and then voted unanimously to stay at Columbia. Kerr kept his promise, and he and Eisenhower persuaded mining companies to provide funding to establish Columbia's Lamont Geological Observatory.

"Without Kerr's effort, Lamont never would have gotten off the ground," Worzel says. "In late December of 1948, Columbia received the deed for the property. The estate had 125 acres—actually more like 135 acres, but we had to give up ten acres that lay across the New Jersey state line. Robert Moses, New York's infamous road, bridge, and parks builder, wanted the ten acres for his new Palisades Interstate Park system. Columbia wanted to close West 116th Street across its campus from Broadway to Amsterdam Avenue. They struck a deal."

Not long after, Ewing and his merry band were installing seismometers in the estate's root cellar and abandoned indoor swimming pool, thrilled that they would no longer have to contend with confounding vibrations from subways and trucks on Broadway. They converted estate bedrooms into offices, the greenhouse into a machine shop. They moved into cottages formerly used by the estate's chauffeur and groundskeeper, creating a village of scientific homesteaders.

Spread beneath splendid chandeliers in a former dining room was an embryonic sediment core collection, overseen by Ericson, who followed Ewing and the scientific action. The kitchen, with its gas line, running water, and drains, naturally suited a budding corps of Columbia geochemists, led by Professor J. Laurence Kulp. Much the way Ewing was applying physics to study geology, the geochemists were poised to unleash modern postwar chemistry techniques and equipment to study the history and causes of climate change on Earth, to chart the ocean’s circulation, and to confront a host of environmental problems.

In 1949, Columbia also established a station in Bermuda to continue research on the SOFAR channel. When the U.S. navy submarine Scorpion mysteriously sank, the station helped pinpoint the disabled vessel. The station also located very precisely where test missiles (equipped with sound sources that exploded in the SOFAR channel) landed, helping the navy assess missile accuracy. (When Columbia discontinued classified military research in the late 1960s, Ewing, Worzel, and others continued to operate the station as an independent, non-profit entity.)

The Columbia geophysicists had peeked through the veil obscuring the seafloor, but to see it fully, they needed better tools. As always, they designed and built what they needed.

“Ludas, the machine shop head, had that ‘can-do’ spirit,” Worzel says, “and probably was the most naturally mechanically knowledgeable person I’ve ever met in my life. We worked together for the next 25 years, and there was no end to the things we built.”

With Frank Press ’49GSAS ’90HON, Ewing designed new instruments that took advantage of a type of seismic wave that most scientists had overlooked or ignored. These were surface waves (usually generated by the shaking caused by earthquakes or underground nuclear weapons tests) that traveled along Earth’s surface, rather than through its body. Ewing had remembered his early experiments tracking seismic waves across a frozen lake, and he exploited newfound understandings of sound transmission through the oceans. He and Press developed modern seismometers to reveal Earth’s crustal skin in greater detail. In 1957–58, these Press-Ewing instruments were deployed in 125 locations to establish the World-Wide Standardized Seismograph Network—the first global earthquake-monitoring system.

To comprehend the seafloor fully, the Columbia geologists knew they would have to collect cores from all over the ocean. Existing coring systems were expensive and took a full day to lower to the seafloor and retrieve—for one core. Lamont created the economical and efficient Ewing Piston Corer, and a winch system that could get a core in a few hours. It “brings up samples of the ocean floor just as a housewife cores an apple,” Ewing said.

Similarly, existing echo sounders would not produce sufficient detail to capture the subtleties and textures of the seafloor’s intriguing topography, so Ewing assigned Bernard Luskin ’50E the task of building a more capable instrument. He invented the precision depth recorder (PDR), which gathered continuous profiles of seafloor topography in unprecedented detail.

The Final Necessary Piece

Established on land, the observatory needed just one thing more. Frustrated by having to beg and borrow limited, intermittent ship time, Ewing and company craved the freedom to conduct a boundless smorgasbord of experiments over a seemingly infinite ocean on a full-time, dedicated presence at sea—their own ship. In one desperate move, they got one.

She was originally christened *Hussar*—a 202-foot, three-masted schooner with teak decks and a wrought-iron hull built in 1923 in Copenhagen for the investment banker E.F. Hutton. Below deck, she was luxuriously appointed, with a Louis XV bedroom, an Edwardian sitting room with a marble-rimmed fireplace and Oriental rugs, a dining salon with stained-glass windows, and bathrooms with gold faucets. In 1934 she was bought by Georg Ungar Vetlesen, a shipping magnate, who renamed her Vema after the first two letters of his family name and his wife’s name, Maud. Like all oceangoing yachts in this country, she passed to government ownership during World War II, at first patrolling coastal waters for the Coast Guard. Later she underwent a drastic conversion to a floating barracks and training ship for the U.S. merchant marine, losing her gold faucets and other amenities. After the war, she lay abandoned and aground on mud off Staten Island for several years, until she was salvaged by a Nova Scotian captain for use as a charter vessel.

Worzel found her in a yachting magazine ad during a last-minute search to replace another ship that had suddenly become unavailable. He chartered the Vema for $20,000 and, almost as an afterthought, suggested adding an option to buy her for an additional $80,000.

After her maiden research cruise, Ewing and company wanted to buy her, but on the last day of charter, which expired at midnight, Ewing told Worzel that he could not raise the additional $80,000. Worzel argued that Lamont would never again get such a good ship so cheaply.

Ewing decided to call Joseph Campbell, Columbia’s treasurer at the time. When his secretary said Campbell was gone for the afternoon, Ewing called Campbell’s home and got his wife, who said that her husband was playing golf. He then persuaded Campbell’s wife to drive to the golf course.

An hour later, Campbell called Ewing, who told the treasurer that the budding observatory had to have the ship. Ewing guaranteed that it would make Columbia proud and that somehow he would raise $80,000 to pay Columbia back. It was after 3:00 p.m.—too late in the day to secure Columbia funds. Campbell agreed to put up his own money temporarily to buy the Vema before the midnight deadline. He asked Ewing to let him break the news to the Columbia Trustees.

Shortly after 5:00 p.m., still in his golf clothes, according to Worzel, Campbell bought the Vema. He immediately covered Columbia’s new ship with an insurance policy. When Ewing returned to Lamont, the phone was ringing. It was an irate Columbia Trustee, whose insurance company had been contacted to insure the ship. (The navy eventually reimbursed Columbia for the ship.)

“Columbia garnered a great deal of pride and the navy got more than its money’s worth, because no research vessel collected more data from more parts of the unexplored ocean as efficiently as Vema,” says Dennis Hayes, professor of earth and environmental sciences at Columbia and former department chair, who studied with Ewing and earned his Ph.D. in 1966.

To captain the Vema, Ewing hired a hard-nosed, old-school Nova Scotian seaman named Henry Kohler. He was as expert and canny about running a ship as Ludas was about running a machine shop. And like Ludas, Kohler saw obstacles as challenges and enlisted for the long haul in a scientific crusade. Kohler and the Vema retired together in 1981, after the two completed more than one million miles of oceanographic research—the first ship ever to achieve that mark.

Soon the pieces and people were in place. Columbia's geophysics and geochemistry programs comprised more than a dozen faculty members, who were highly active researchers, as well as scores of scientists and technicians supported by government research grants, and scores more graduate students—many of whom became scientific pioneers, because their field was as young as they were.

In 1955 Ewing wrote, “I believe that we have built up here a unique team of scientists, unique in the diversity of techniques which it can bear on problems and in the fundamental importance of the problems in which the group is interested. ”

“I believe that this integrated group of scientists, this group of facilities, which includes the ship, the chemical laboratory, the collection of sediment cores, and the great seismograph station, constitutes a facility comparable with the greatest cyclotron or the greatest telescope, and it is unique. It is as though there was just one cyclotron in the world and we had control of it, or just one big telescope in the world, and we had control of it.”

Go Forth and Collect Data

The new institution was called an observatory for good reason. Its mission was to venture the world's oceans, make observations, and accumulate the volume of data necessary to reveal the earth.

Ewing set the tone and pace. The light burned late in his office every night. He waged a personal daily battle against wasteful sleep, often scribbling furiously in little books just to keep himself awake. He cut short the only vacation he ever took after two days—because it unnerved him so much. James Heirtzler, newly hired by Ewing to run a nascent program to study the seafloor's magnetic properties, recalled the first three times Ewing called him in for meetings: The first two were on Sundays; the third was on Christmas Day.

“From Ewing emanated the Lamont personality: a Spartan life of hard work and dedication; a career driven by an intense need to explore; and a certain attitude of not giving in to the idea that you couldn't go someplace or do something, in the quest for clues to understand the earth,” says Arnold Gordon, professor of earth and environmental sciences at Columbia and former department chair, who earned his Ph.D. at Columbia in 1965. “Along with every other graduate student, I fell into the Lamont style of working weekends and late into the night, driven by the quest to know, to divulge something new.”

Under her bowsprit, the Vema had a huge, determined-looking eagle, which well represented Lamont’s indomitable spirit. (Today it hangs in the front hall of Lamont’s Geoscience Building.) Never forgetting the days when ship time was precious, Ewing drove his research vessels as relentlessly as he did his students and himself.

In these early days of oceanography, ships of other great oceanographic institutions did not venture very far from their homeports and territorial waters, Hayes says. But from the start, the Vema circled the globe 320 days a year, embarking on nearly boundless missions to explore every ocean. So did Lamont’s second ship, the Robert D. Conrad, a new research vessel built by the navy and given to the observatory to operate in 1962. The Conrad became the second ship in history to log more than one million miles of oceanographic research. For a time, Lamont also staffed and supervised geophysical research in the southern oceans surrounding Antarctica aboard the Eltanin, owned by the National Science Foundation. To get measurements from the ice-covered Arctic Ocean, where ships could not go, Lamont stationed scientists and instruments for months on drifting ice floes.

When a scientist from a rival institution chided Ewing that Columbia didn’t have a proper port, Ewing replied matter-of-factly, “You don’t collect much data when your ship is in port, tied to the dock.”

“Ewing expected scientists to use the ship every minute of every day,” Hayes says. “From the time we left port, the watches started, the equipment went into the water and was turned on and kept running until we got to another port. It was unusual on a thirty-day, port-to-port cruise to have as much as six hours without data.” As they cruised, Columbia’s ships continuously collected magnetic, gravity, seismic, and seafloor topography data.

The ships had standing orders to stop once or twice every day to collect a wide range of samples from wherever they happened to be. To do that, crews had learned how to lower two instrument-laden wires simultaneously from rolling ships to the seafloor. The instruments sampled seawater, detected currents, photographed the bottom, measured seafloor heat flow, and of course, collected sediment cores.

Ewing’s dictum was “a core a day.” In 1948, some 100 deep-sea cores existed. By 1956, Lamont had collected 1,195. (Today the core lab holds nearly 19,000—a library of the seafloor available to the scientific community.)

“This strategy saved a lot of time, but it could be risky and had to be carried out with skill and care,” says John Diebold, who started in Lamont’s machine shop, served as a shipboard technician, later earned his Ph.D. from Columbia in 1980, and is now Lamont’s marine science coordinator. “It was routine on Lamont ships, but was absolutely unheard of on ships operated by other oceanographic institutions.”

“Quite unlike anyone else, we were collecting all that data all the time,” Hayes says.

The work wasn’t without danger. In 1954, while trying to secure fuel drums that had broken free on deck in heavy seas off Cape Hatteras, Ewing, his brother John, First Mate Charles Wilkie, and Second Mate Mike Brown were swept overboard by a huge wave. Somehow, the Vema’s captain turned the ship around and rescued John Ewing. Meanwhile, Brown had floated a fuel drum toward Ewing, and the two held on. The Vema approached again, and someone threw a rope. Ewing could not grab it because he had taken a blow to the neck and his left side was paralyzed. Brown seized it and was pulled to the ship, hauling the drum and Ewing with him. The ship rolled so severely, its rails reached the sea. Brown snatched a rail and was rolled upward with the ship. The ship rolled back down, and someone reached under Ewing’s armpits and swept him aboard. First Mate Wilkie was never found. Ewing walked with a limp from then on, but the incident in no way slowed him down or curtailed his time at sea.

In 1961, chief scientist John Hennion was killed in an explosives accident, the only such fatality through all the years of using explosives for their work. The accident precipitated John Ewing and Lamont technicians to develop safer air gun technology to create sound waves in water.

Assembling a New Picture of Earth, Piece by Piece

Each datum collected by Columbia scientists from one part of the ocean was like a dot in a pointillist painting or a tiny piece in the massive planetary jigsaw puzzle. Analyzing thousands of depth readings collected between 1947 and 1952, Tharp created six profiles across the Atlantic seafloor. Put together, they revealed a line of mountainous ridges, rising miles high and running north to south down the middle of the ocean. The ridges had a continuous V-shaped rift at their crests.

At the same time, Heezen and Tharp constructed maps locating earthquake occurrences in the oceans. Superimposing one map on the other, they found that the earthquake epicenters lined up within the rift valley.

Continuing on from one sounding and one earthquake to the next, and then from one ocean to the next, Heezen, Tharp, and Ewing discovered that the mid-ocean ridge system extended throughout the world’s oceans for 40,000 miles, encircling the globe like the seams on a baseball. Never before seen or imagined, it was the largest geological feature on Earth.

After Heezen gave a presentation on mid-ocean ridges in 1957, the eminent Princeton geologist Harry Hess stood up and said, “Young man, you have shaken the foundations of geology!”

The ridges served as borders separating the face of the earth into sections, or plates. At the edges of some oceans, however, particularly in the Pacific Ocean, Hess and others had discovered trenches plunging miles below the seafloor. Hess assembled the emerging assortment of geological clues to fashion a comprehensive theory, coined “seafloor spreading” by another researcher, Robert Dietz.

Earth’s crust lies atop a hot interior region called the mantle, and as Hess explained it, hot buoyant magma from the mantle emerges in volcanic eruptions at the mid-ocean ridges—hence the fresh basalt and earthquakes. The magma cools and solidifies upon hitting cold seawater to create the volcanic subsea mountain chain, as well as new ocean floor crust, which spreads outward from both sides of the ridges.

Over millions of years, the ocean crust moves outward, becomes denser as it cools, and begins to sink back into the mantle, forming deep trenches that also serve as plate borders. The thick, permanent continents simply rode atop a conveyor propelled by a thin sliver of impermanent seafloor that was created at the ridges and recycled in the trenches. The continents drifted apart, as Africa and South America did to form the intervening Atlantic Ocean, or collided, as India did with Asia to uplift the Himalayas.

Hess called his paper “an essay in geopoetry”—an elegant image to ponder, but unsubstantiated by data. The new data had raised provocative questions that only more data could answer. But by the middle 1960s, all those years of relentless and systematic global data collecting by Lamont had added up.

“It was clearly payoff time,” Hayes says. “We alone were sitting on the mother lode [of data] with all the tools needed to mine it.”

Ewing’s compulsive core collecting proved the value of knitting together disparate clues from various locations. Among the first mysteries solved was the one inherent in that first core in 1947—why recent sediment lay directly on ancient sediment.

A series of cores was collected from the Hudson Canyon—a vast submarine canyon as remarkable as the Grand Canyon on land—which emerges from the mouth of the Hudson River, bites deeply into the continental shelf, and extends all the way to the flat abyssal plains hundreds of miles off the coast. Other cores were taken on the Grand Banks off Newfoundland, where several undersea transatlantic telegraph cables were mysteriously severed during a 1929 earthquake. Another core from the deep Puerto Rico Trench curiously contained the shells of a microscopic plant that lives in coastal waters.

The pattern that emerged from these series of cores all pointed to a phenomenon called turbidity currents. These are torrential underwater currents of water and sediments, set into roiling motion by a landslide on the slope or by an undersea earthquake. They thunder through the oceans with enormous speed and force and carry huge loads of material great distances until the currents lose momentum and the material at their front edges settles meekly into a flat plain. Turbidity currents in the ocean explain how canyons were cut, cables were broken, sediments were transported, abyssal plains were formed, and how offshore oil deposits (ultimately formed when organic matter is buried by sediments) were created.

With the discovery, earth scientists could factor out disruptions in the sequence of sediments and reconstruct Earth’s history. Columbia geochemists then radiocarbon-dated preserved planktonic shells in various sedimentary layers, providing a way to establish the timing of events thousands of years in the past.

The cores also contained evidence that Earth’s magnetic field had reversed several times in the past, with the north and south poles exchanging places. The sediments preserved a signature of the field that existed when they were made. Columbia professors Neil Opdyke and James Hays, along with graduate students Billy Glass ’68GSAS and John Foster ’70GSAS, embarked on a mission to identify a record of Earth’s magnetic reversals in the cores—to provide a geological calendar extending millions of years into the past.

Jim Heirtzler and Walter C. Pitman III ’67GSAS analyzed data of seafloor magnetic properties collected aboard the *Eltanin*. In 1966, they found a striped pattern of rocks, parallel to a South Pacific mid-ocean ridge and extending hundreds of miles on either side of it. Rocks imprinted when the earth’s magnetic field was in one position alternated with rocks imprinted when the field was reversed. The pattern was astonishingly symmetrical on either side of the ridge. The mirror image could be created only if new seafloor—created at the ridge crest and quenched there with the prevailing magnetic signature—then spread outward in both directions.

At most labs at the time, data were controlled by individual scientists who collected them. But at Lamont, all data collected were institutional data, available to everyone.

Opdyke says that Pitman sat “in the next office to me and what he knew, I knew within a day.” Opdyke realized instantly that the timetable of magnetic reversals extending down inches in the sediment cores he was working on could be used to verify the record of magnetic reversals that Pitman and Heirtzler saw extending laterally over hundreds of miles of seafloor.

A young graduate student named Lynn Sykes ’65GSAS, now Higgins Professor of Earth and Environmental Sciences at Columbia, also soon heard about Pitman and Heirtzler’s so-called magic profile and began to apply data that was newly emerging from the recently established worldwide seismograph network. The network was largely funded by the Department of Defense, which was eager to apply the new science of seismology to monitor Soviet underground nuclear weapons tests. Today the expanded modern descendant of this original system provides the means to verify a Comprehensive Test Ban Treaty— a goal toward which Sykes and Paul Richards, the Mellon Professor of Natural Sciences, have devoted much of their research careers.

But as a graduate student in the early 1960s, Sykes examined the influx of seismic data streaming into Lamont to locate earthquakes near mid-ocean ridges. He proved that earthquakes occurred along recently discovered large seafloor faults, called transform faults. These ran perpendicularly between (and connected) parallel ridge segments. The earthquakes revealed friction and motion along transform faults—whose cause was best explained by new seafloor spreading outward from the ridges.

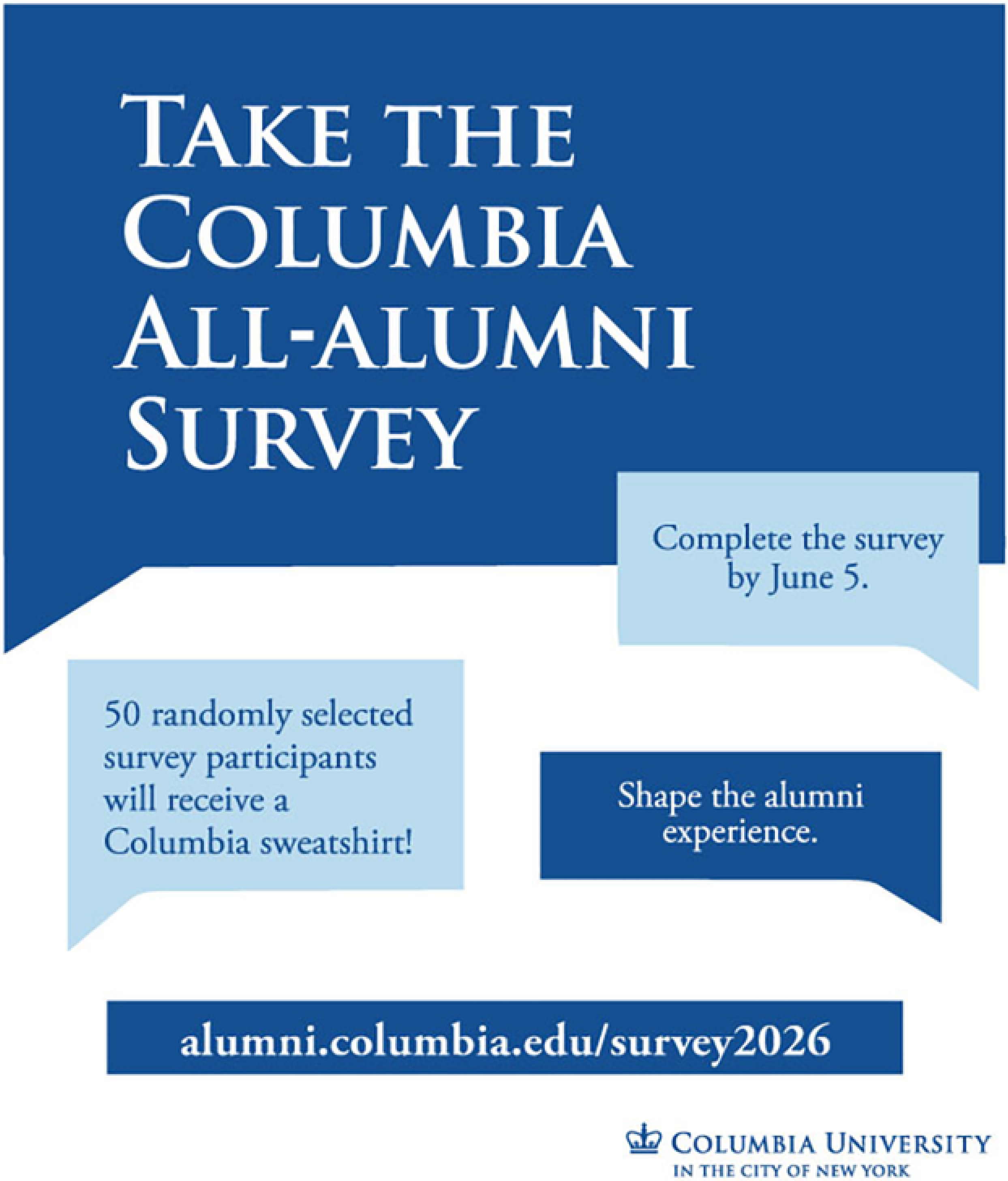
Sykes, along with Columbia Professor Jack Oliver and graduate student Bryan Isacks ’58C ’65GSAS, precisely located earthquakes in Pacific trenches. The earthquakes marked out the passages of one oceanic plate plunging down and thrusting under another plate—a process that was soon named “subduction.”

The mass of accumulated, diverse evidence was overwhelming and convincing. The old frame of reference that Earth’s surface was fixed and rigid was discarded. A new dynamic framework—plate tectonics—swept in. And, as Ewing and company at Lamont had averred, most of the action occurred in the oceans.

In just about two decades, Columbia scientists had dissected the planet and reassembled it in a revolutionary new way. The earth, and the study of it, were never the same.

Read more from ***Laurence Lippsett***

Guide to school abbreviations



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