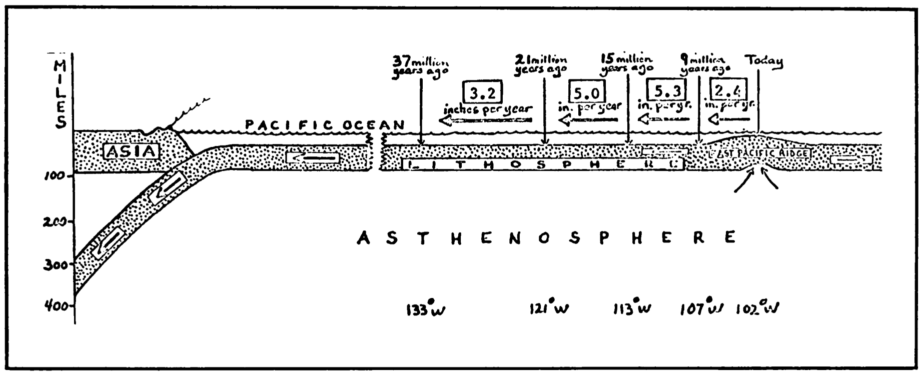
Gravity's tug on the ocean floor

Latest deep-sea drilling results point to a third mechanism for spreading



Columbia University

Spreading rates imply that the plates are being pulled by force of gravity.

Earth scientists have advanced two main theories to try to explain the movements of vast crustal plates of the planet's surface. In one, sea-floor spreading results from the pushing apart of two crustal plates by the up-welling of basaltic material along the ocean ridges. In the other, thermal differences beneath the surface produce convection currents of molten rock within the mantle that carry the crustal plates along like a conveyor belt.

There are several recognized deficiencies in both of these views, and no one has been completely happy with either as an exclusive mechanism for the movements (SN: 11/8, p. 430; 2/7, p. 153).

Alongside these two traditional explanations, a third mechanism now has to be given roughly equal prominence. Results of Leg 9 of the Deep Sea Drilling Project, which was completed Jan. 27, provide the strongest evidence yet that the floor of the Pacific Ocean is being pulled away from the East Pacific Ridge by the force of gravity, rather than being pushed from behind or carried along by convection currents.

The new evidence is not likely to overthrow the two other proposed mechanisms; the findings pertain only to the Pacific, and no similar signs have yet been found for other different ocean floors.

But the chief scientist for the Glomar Challenger's ninth leg, Dr. James D. Hays of Columbia University, believes that in the Pacific at least gravity is the dominant mechanism. In this view the extrusion of basalt to create new crust at the ocean ridge is more a result than a cause of the splitting apart of two plates. The work raises the possibility that around the planet all three mechanisms have been in action at various times and in varying combinations.

The scientific team on Leg 9 drilled into the ocean floor at nine sites west of the East Pacific Ridge. At eight of the locations they managed to penetrate all the way through the sediments to basement rock.

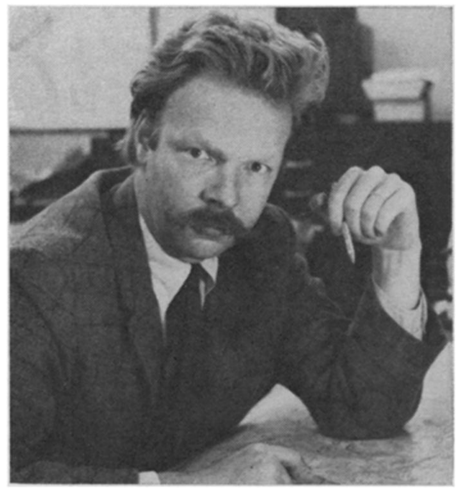
Their dating of the cores obtained at successively greater distances westward from the ridge revealed a continually accelerating rate of sea-floor spreading for a 25-million-year period beginning about 35 million years ago. First the spreading proceeded at an average of 3.2 inches a year, then at 5 inches a year and then at 5.3 inches a year, one of the fastest rates ever recorded for movement of the ocean floor.

About 10 million years ago the spreading abruptly slowed to its present rate of about 2.5 inches a year.

This behavior can best be explained, believes Dr. Hays, by gravitational acceleration on the leading edge of the plate, where it is sinking into the earth along the chain of deep ocean trenches around the western Pacific. Such downward thrust of the edge of the crustal plate at certain areas of the world is one of the principal tenets of plate tectonics. As the underthrust edge of the plate extended farther down into the earth, suggests Dr. Hays, the gravitational force on it became greater, causing it to pull with increasing speed on the portion still on the surface. The acceleration continued until a critical point about 10 million years ago, perhaps when the plate bottomed-out to some degree at a depth of about 400 miles.

Dr. Hays suggests a bathtub analogy: "It's like laying a terry cloth towel on water," he says. "It sinks first at the edge, and the more towel that goes under water the faster it sinks and the faster the part on the surface is pulled along."

An acceleration of spreading is difficult to explain by convection currents,



Columbia University

Hays: Pull more important than push.

he observes. The currents would have to move in a stop-and-go fashion to account for the varying rates of plate motion.

The finding is thus the first sedimentary evidence to support a gravitational theory, though evidence from seismic studies was reported last fall (SN: 10/11, p. 331). In that work two colleagues of Dr. Hays at Columbia's Lamont-Doherty Geological Observatory, Drs. Bryan Isacks and Peter Molnar, showed that the upper portion of the plate descending into trenches is undergoing extensional stresses, as though it is being pulled from below, while the lower portion is being compressed, as though it is hitting bottom. At that time they concluded that the pull of the downgoing slab of lithosphere on the portion remaining on the surface might prove to be an important driving force in global tectonics. They proposed that changes in rates and directions of spreading might occur when the descending slabs reach bottom.

The drilling studies led by Dr. Hays

detected such a change. The abrupt slow-down of spreading in the Pacific 10 million years ago was accompanied by a shift in direction. Prior to that time the motion was almost due west; then it shifted to the northwest, possibly as a consequence of uneven bottoming-out.

The evidence for this shift came from cores drilled on either side of the zone of biological productivity along the equator (SN: 12/27, p. 590). Small sea organisms thrive on nutrients brought to the surface in this zone by strong equatorial currents. For geophysical reasons these currents must remain at the equator. The organic sediments that accumulate beneath the zone then act as a good marker of the past positions of the equator.

The pattern of accumulation of organic sediments brought to the surface in Leg 9 showed that points on the sea floor south of the zone moved beneath the zone about 10 million years ago; those that had been beneath it moved out from under it to the north. □

TECTONICS

Continent building

Whatever the mechanisms are for the world-wide movements of the crustal plates, the major role they have played in earth history is becoming increasingly clear. In the Feb. 7 NATURE, the University of Cambridge geologist John F. Dewey and co-worker Brenda Horsfield suggest that the plate motions have been responsible for the growth and evolution of continents for at least three billion years.

Early in the Precambrian, they suggest, numerous thin plates of oceanic lithosphere controlled the growth of continental crust by eruption of basalts and other rocks to form island arc complexes. Continents gradually grew around such nuclei. They believe this continent-building process is today going on in the southwest Pacific at the New Hebrides-Fiji-Tongo island system.

The British investigators classify major mountain units into four types and explain how each may be the product of plate interactions. One type, for example, is represented by the Andes and the mountains of the western United States, where a deformation, caused by underthrusting of a plate near the foot of a continental rise, moves toward the continent, thrusting sediments onto the land.

The scientists also believe that the oceans have undoubtedly contracted and expanded numerous times in the last three billion-plus years, each time dividing the continents in a slightly different way. □

MANPOWER

Job cuts at the national laboratories

The Atomic Energy Commission, like other Government agencies, has in recent years been faced with stationary or declining budgets for scientific research. This has meant an especially increasing pinch for the branches of physics that are the particular responsibility of the commission: nuclear or medium-energy physics, high-energy or particle physics and controlled thermonuclear fusion.

These studies are outgrowths of the wartime Manhattan District Project which the AEC inherited along with the weapons technology it spawned. Over the years the commission has built them up generously, and it houses them in national laboratories from Massachusetts to California. They represent the heart of the nation's physics establishment and are being particularly hard hit by the current cutback.

Translating dollars into jobs, the decline in support embodied in the AEC's budget request for fiscal year 1971 will mean the disappearance of about 1,400 jobs in the national laboratories, the commission figures. Its managers are now reviewing their operations and giving layoff notices in preparation for the beginning of the fiscal year on July 1. The cuts seem to be hitting high-energy physics particularly hard.

Although the total AEC research budget for fiscal 1971 (which begins July 1, 1970) is down by about $5.5 million, medium-energy physics shows an increase of $350,000, and controlled fusion is in for an increase of almost $2 million. High-energy is down by slightly more than $1 million, a figure that fails to reflect the hard cuts being made in some programs to make room for others.

The trimming of effort will not be exactly across the board: One aspect of high-energy physics, the construction of a 200-billion-electron-volt accelerator at the National Accelerator Laboratory, continues to grow. This, says Dr. Paul McDaniel, director of the AEC's division of research, requires more than proportionate readjustments elsewhere.

The cuts range from about five percent in some places to the closing of an entire accelerator laboratory, the Princeton-Pennsylvania Accelerator at Princeton, N.J., which may limp along into 1972 on maintenance money; its operating funds will entirely run out by the end of fiscal 1971.

The body count among scientists and support personnel will range from the entire staff at the Princeton-Pennsylvania Accelerator, 120 persons, to figures like 300 out of 5,800 at the Lawrence Radiation Laboratory at Livermore, Calif., or 400 out of 8,100 at Sandia Corp. of Albuquerque, N.M., and Livermore, a major AEC contractor.

Most laboratory directors will apply the same proportion of loss to all categories of jobs from custodial employes to Ph.D.'s. At LRL in Livermore 100 professionals and 200 nonprofessionals are being dropped. The professionals are about one-third physicists, one-third chemists and one-third engineers. Sandia expects to apply a five-percent reduction roughly in all categories; the corporation employs 241 physicists.

Other figures include:

- Los Alamos Scientific Laboratory—loss of 100 to 150 positions.
- Argonne National Laboratory—87 positions lost, more expected.
- Oak Ridge National Laboratory—350 positions lost, though many have been transferred to other operations of Union Carbide Corp., which manages the laboratory.
- Cambridge Electron Accelerator—about 60 positions lost.
- National Accelerator Laboratory—none lost, for the moment, but no increases.

The major alternative for physicists released by these cuts, especially for high-energy physicists, is the universities. But the universities aren't hiring either; their Government money is down too.

For example, the AEC has about 500 university research contracts. According to Dr. McDaniel, the commission will probably not be able to replace the 50 or so of these that will end for one reason or another in fiscal 1971.

"It looks very grim," says Dr. William W. Havens, executive secretary of the American Physical Society. The APS, he says, is discussing with other professional societies what might be done to help, but the organized concern is only a few weeks old, and no program has yet been worked out.

Dr. Havens feels that Ph.D. physicists will be taking jobs such as junior college or high school teaching, in which very few Ph.D.'s have been found recently, or in industrial research. Another out is computers: "Some high-energy physicists are outstanding systems programmers," he says.

The money for jobs of this kind has been rising in recent years so that the financial impact for individuals is not likely to be dramatic, but the changes will take people from the research they like to do. "They won't be happy," says Dr. Havens. □