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## Restless Earth

We live on a restless planet. Few weeks go by when there are not earthquakes or volcanic activity. A great heat engine, fueled at least in part by radioactive decays deep in the earth, relentlessly moves pieces of crust the size of continents. Motions of tectonic plates relative to each other averaging 2 to 10 centimeters per year are common. Such motions persist and their cumulative effects are drastic changes in oceans and land.

New crust is being formed under the oceans at the mid-ocean ridges, and the ages of the oldest rocks on the sea bottom are only about 200 million years. In contrast, the age of the earth is about 4600 million years, and that of the oldest rocks found on the continents is about 3800 million years. Accompanying the movements of the plates have been collisions of land masses, mountain building, and repeated hot and cold geochemical and biological processing of enormous amounts of material. While most of the continental areas have been tremendously deformed, parts of them have been miraculously left little changed from the distant past.

Employing careful observations and the concepts of uniformitarianism, geologists and paleontologists made great progress in deciphering Earth and biological history. During this century, and especially within the last 30 years, simple observation has been supplemented by tools derived from the physical sciences. In the United States in the 1950's a small minority of earth scientists believed that the continents had moved great distances. It was after geophysical exploration of the oceans, including measurements of magnetization of bottom rocks and deep-sea drilling, that the concept of moving tectonic plates won acceptance.

Analysis has shown that the composition of the magma reaching the earth's surface has changed since earliest times. For this and other reasons, the concept of uniformitarianism must be qualified. How and to what extent are questions to be studied further? Of special interest is the history of the movement of the earth's crust. Earlier, radioactive heat was released at four times the present rate. Surely in the past the earth's engine was more violently active, but in what ways?

To answer questions about events that occurred before 200 million years ago, one must seek testimony preserved on the continents. There one can find evidence of both great lateral and vertical motions and of collisions of tectonic plates. Additional knowledge about the complex structure of the continental crust is being accumulated with new tools. For example, the Consortium for Continental Reflection Profiling has discovered that ancient crystalline rocks of the Appalachian Piedmont and Blue Ridge appear to have been thrust 260 kilometers westward over younger, sedimentary rocks. The data also suggest that the thrusting was related to multiple opening and closing of a proto-Atlantic Ocean.

The articles in this issue are designed to portray the current status of geodynamics and opportunities for further research. The group was selected by Charles Drake, who is an international leader in the field. In an introductory essay prepared jointly by Drake and John Maxwell, highlights of the other articles are discussed and relevant international arrangements in geology and geophysics are described. Close worldwide cooperation is essential if the past is to be deciphered. At best, evidence is scattered and fragmentary. For example, in this country there are only limited outcrops of early Precambrian rocks. Good occurrences are seen in Greenland, Zimbabwe, and Brazil. Similarly, while California experiences some earthquakes, a better place to study them is Japan, where the frequency is an order of magnitude greater.

Most of the work described in this issue was stimulated by the International Geodynamics Project, which ended in July 1980. A new Inter-Union Lithosphere Program has been organized which will emphasize studies of the continents and their margins. Out of this project will come better understanding of the past, better knowledge of earthquakes and allied natural hazards, and an improved basis for discovery of mineral and petroleum concentrations.—PHILIP H. ABELSON