GEODYNAMICS: LOOKING TO THE FUTURE

This tripartite article incorporates Professor Drake's sketch of the origins, objectives and achievements of the successful interdisciplinary Geodynamics Project. His summary acts as an excellent introduction to Dr. Illies' outline of both the major scientific challenges still remaining in geodynamics research, and the steps taken to date by IUGS and IUGG toward planning a possible future inter-union program. The last section focusses on the recommendations presented in the report "The Lithosphere: Frontier for the 1980's", which has just been submitted to the Executive Committees of both IUGS and IUGG.

THE GEODYNAMICS PROJECT

by

Charles L. Drake

The term "geodynamics" was originally used by A.E.H. Love in his essay "Some Problems of Geodynamics" which was awarded the 1911 Adams Prize at the University of Cambridge in England. The essay appeared in a volume devoted to the fundamental problems of the earth's physics, including isostatic balance, earth tides, the figure of the earth and the propagation of seismic waves. Geodynamics, in the sense used by the Geodynamics Project, incorporated these areas of investigation but enlarged upon them to include the chemical and geological evolution of the earth, mass transport in the earth's interior and the kinematic history as revealed by geological structures.

The Project was a logical successor to the International Upper Mantle Project (UMP), which had in turn followed the International Geophysical Year (IGY) of 1957-58. The IGY had grown out of earlier "International Polar Years", expanding on them to include studies of the solid earth and oceanographic investigations. These were to a large extent exploratory, since many areas of the oceans were almost completely unknown and since, up to that time, there had been no coordinated earthquake seismograph network with matched long period instruments. Seismic refraction studies of continents had been carried out prior to IGY using explosions of opportunity (such as quarry blasts), but during

the program extensive studies were started, especially in the U.S.S.R., to determine the properties of the continental crust and upper mantle.

The Upper Mantle Project devoted its attention to the tectosphere, the outer 1000 km shell of the earth which appeared to be the portion involved in the tectonic processes that created the earth's surface features. It started as a project of the International Union of Geodesy and Geophysics (IUGG) and was organized along interdisciplinary lines, drawing together the different elements of solid earth geophysics (represented by the Associations of IUGG) to better understand the nature of the earth's interior and the development of its surface features. When IUGS was formed, the Union became a junior partner in this project, for it had become obvious that the world rift system and the seismically active belts associated with continental margins, island arcs and young mountain systems deserved special attention. Commissions were formed to investigate the special problems of these areas.

The plate tectonics model was developed during the time of the Upper Mantle Project. This model was attractive to a great many earth scientists. It offered a framework that accounted for most large-scale phenomena that had been

The timing of major tectonic events is fundamental to geodynamics. Here, two scientists select samples for isotopic analysis from a high grade metamorphic terrain in western North America in order to determine both the age of metamorphism and the possible source of the strata.

The dynamics of plate tectonics (Photo courtesy Mosaic, NSF, U.S.A.)

observed over the years, a framework with which new data could be associated, and a concept that led to new questions about the development of the crustal rocks and new techniques of acquiring data to respond to these questions. The simple model first conceived has been and will continue to be modified through time, but this does not detract from its primary value of bringing earth scientists of all disciplines together.

The Geodynamics Project was initiated at a very opportune time. IUGS was by the mid-1960's firmly established, and a basic model had been developed to which geologists, geophysicists and geochemists could relate. The model was in accord with the gross surface features and the time was ripe for a coordinated effort to refine it, to study the dynamics of the system and its driving mechanism, to bridge the gap between phenomena of global scale and those of local scale, and to increase communication among earth scientists of several disciplines.

Thus in 1969, the Geodynamics Project came into being, organized jointly by the IUGS, IUGG and the International Council of Scientific Unions (ICSU), with the Inter-Union Commission on Geodynamics (ICG) set up to coordinate the Project's activities. Countries adhering to the Unions were invited to establish National Committees for the Project.

Whereas IGY was oriented toward exploration in its solid earth investigations and UMP was initiated on a disciplinary basis, the Inter-Union Commission on Geodynamics was organized along problem lines. Working Groups were established to plan symposia and stimulate research in the different areas of geodynamics. Some, for example, were geographically oriented, focussing on the geodynamic problems of continental margins of different types; others were more problem-oriented, concerned with the causes of vertical movements, or the properties and processes in the Earth's interior. The results of 37 of these symposia have been published.* They vary in content from discussions of regional aspects of geodynamics through mechanisms of movement to theoretical studies of processes and the chemistry of the Earth's interior. These symposia

have been supplemented by publications and other symposia on the results of geodynamic investigations within regions or within individual countries.

The Geodynamics Project has been a loosely run activity, held together by the mutual interest of the participants in deciphering the dynamics of the Earth. It is difficult to measure quantitatively the success of such an undertaking. Perhaps the best evidence of success lies in the continued enthusiasm of the Project's many participants. Its value as a communication mechanism, not only among different countries, but among scientific disciplines, cannot be overrated. For as they evolved, the earth sciences have also fragmented into many specialities, each with its own scientific jargon, and the exchange of information within the world geological community has at times been rather limited. The Geodynamics Project, with its focus on problems rather than disciplines, has been instrumental in reducing these communication barriers.

The Geodynamics Project has supplemented the activities of the various Committees and Commissions of IUGS and the Associations of IUGG by pulling together investigators to work on resolving problems to which all of these disciplines can contribute. This is so logical an approach in studying an organism as complicated as the Earth, that if the Project did not exist, a similar project would surely have been invented.

As the Geodynamics Project draws to its scheduled end over the next year or so, it is not surprising to find IUGG and IUGS discussing the nature of future cooperative programs which may be of interest to both Unions. This is an indication of the progress that has been made under the Geodynamics Project and the earlier cooperative programs. It is also a reminder that continued progress in our science will demand the best efforts of all earth scientists, whether they work on land or in the oceans, as well as the collaboration of astronomers, planetologists and others interested in the history of the Earth and the development of its surface features.

* A list of published ICG scientific reports is available, on request, from the ICG Secretariat, Department of Geophysics and Astronomy, University of British Columbia, 2075 Wesbrook Place, Vancouver, B.C., Canada, V6T 1W5 or from the IUGS Secretariat.

ABOUT THE AUTHOR: Professor in the Department of Earth Sciences, Dartmouth College, N.H., U.S.A., **Charles L. Drake** has played a leading role in international geodynamics research over the last 20 years, participating actively in both the Upper Mantle Project and the Geodynamics Project. President of the Inter-Union Commission on Geodynamics from 1969 to 1976, Professor Drake is also a past President of the Geological Society of America.