GEOLOGICAL OCEANOGRAPHY: INTRODUCTION AND HISTORICAL PERSPECTIVE

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Summary

The floor of the ocean features evidence of global tectonics which accounts for geological forces that continuously shape the planet. Early geologists have explored the ocean floor for understanding the distributions of rock properties, sediment types, and marine skeletal organisms. Recent investigations in Deep-Sea Drilling Program and Ocean Drilling Program have advanced our knowledge on the evolution of the lithosphere, the interior structure of the crust, the climate/environment evolution of the earth system, and the deep-sea biology and resource. The ocean floor was more complex than ever imagined.

1. Introduction

The surface area of our planet Earth is covered by approximately 70% water that perhaps would have been named as a super water continent Oceania. The total area of the oceans and adjacent seas, forming a series of interconnected saline bodies is over 375.55 x 10^6 km^2. The oceans and seas are not evenly-distributed in the Northern and Southern Hemispheres: approximately 61% of the surface of the Northern Hemisphere is covered by ocean waters; about 81% of the Southern Hemisphere is covered. If calculated by volume, the total water of the oceans and seas is nearly 1.5 x 10^9 km^3. Our planet Earth is the only known body in the Solar System that is surrounded by waters filled with unique geological structures. The average depth of the ocean waters is approximately 4 km, but the depths of the oceans vary over a very wide range. In contrast to our general thinking, the oceans are not the deepest in their middle portions, but rather the great depths occur in trenches found along the continental margins. The greater depths of the oceans are found in trenches at the margins of the oceans. Excepting the Indonesia, Antilles, and Scotia deeps, major trenches are found in the Pacific Ocean floor. The greatest known depth is the Mariana Trench of the western Pacific Ocean, which is over 11km below sea level. The oceans are shallow near the sea level on continental shelves

(~200 m). The continental slopes and rises are of intermediate depths (1 - 5 km) which are connecting the shelves and the deep sea, the abyssal plain, with average depths 4 km. The deep-sea morphology of the abyssal plain is characterized and shaped by channels, seamounts, mid-ocean ridges, and rift valleys, which are important components involved in the dynamics of the Earth. Detailed descriptions for marine deep-sea structures are reviewed in *Morphology of Ocean Floors and Plate Tectonics*.

The morphology of the sea floor features a rugged landscape which is not parallel to anywhere on the continents. Vast deep-sea mountains such as the mid-ocean ridge range are much more extensive than those on the continent. The mid-ocean ridge is the most prominent feature on the planet, occupying over an area larger than that covered by all continental mountains combined. The sea floor is continuously being created at the mid-ocean ridge, where newly-generated rocks of the oceanic crust melted out the mantle, and being consumed in the deep-sea trenches along the continental margins. The processes of ocean crust generation / consumption, called sea floor spreading / subduction, play fundamental roles in global tectonics and account for ultimate geological forces that continuously shape the planet. The concept of the dynamic processes that shape the sea floor, being called plate tectonics, is now used for explaining most of the important morphological features of ocean basins. The observation of collecting data for supporting the concept of plate tectonics is mainly based on marine geological exploration, which was started in the 1970s. Marine geophysicists who generate, process, and interpret measurements of the Earth's physical properties, such as magnetic, gravity, seismic, electrical, electromagnetic, thermal, or radioactive patterns of the sea floor, have made great contributions in the studies aimed at predicting the dynamic nature of the Earth. The history and development of marine geological exploration will be provided in the next section. One of the most powerful investigation tools for penetrating and deciphering the deep structure of the Earth, the seismic process and imaging of the ocean floor will be reviewed in *Seismic Imaging in the Oceans*.

Most exploration geophysics is conducted to find commercial accumulations of oil, gas, coal, or other economical minerals. Oil and gas are finite, non-renewable resources. Most of the oil and gas are believed to be formed under special conditions by the decay of marine planktonic remains in sedimentary basins. It is hardly surprising that oil reservoirs should exist in the basins beneath the sea. The applications of marine geophysical techniques are by the reason, still important, as human population grows inexorably and the demand for energy rises. Advanced drilling technology has thus developed for exploring oil resources in basins of deeper waters.

Geological oceanographers are greatly benefited by the stride of systematic exploration of the sea floor by scientific drilling since 1970. Beginning from the first scientific cruise by GLOMAR *Challenger* by 1968, our knowledge on sediment distributions on the sea floor has greatly accumulated. The still on-going drilling program ODP (Ocean Drilling Program), evolving from many different phases of scientific drilling projects and using drilling vessel JOIDES *Resolution*, is the creation of an international community of marine geologists and geological oceanographers. By the drilling platform used in ODP, scientists are able to sample sediments and oceanic crusts to understand scientific problems such as how the ocean / atmosphere systems evolved since late Mesozoic; the complex interactive tectonic, magmatic, hydrothermal, and biological processes involved in the formation of new oceanic crust and lithosphere; and the geophysical and geochemical structures of oceanic crust and of more deeper lithosphere layers. A review of scientific drilling programs in the past, present, and future will be provided in one of the next sections.

The Earth's environment, the fluid outer shell and land surface, appears to be changing rapidly and human activities are contributing to these changes. We now are gradually accept that the Earth's system is high-dynamic and is characterized by multiple interactions among atmosphere, hydrosphere, lithosphere, and biosphere. The sediments accumulated on ocean basins provide us historical archives over geological time scales to understand the long-term behaviors of the dynamic geo-marine environment. Scientific drilling such as ODP enables us to better understand how the global environmental system operates and how sensitive the life-supporting system is to perturbations to its boundary conditions. In the last section, an introduction to the dynamic geo-marine environment with emphases on the information obtained from studies of marine sedimentary sequences will be presented. The latest development on the finding such as atmospheric composition, wind field, surface and deep ocean circulations, biological productivity and evolution will be documented.

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Biographical Sketch

Min-Te Chen obtained his B.Sc degree from the Department of Geology, National Taiwan University, Taiwan, Republic of China, in 1984 and his Ph.D. degree in geological sciences from Brown University, Providence, Rhode Island, U.S.A., in 1994. From year 1994 to 1999, he returned to Taiwan and was appointed as an Associate Professor in the Institute of Applied Geophysics, National Taiwan Ocean University and was appointed as a Professor in the same institute in year 1999. He is teaching marine geology, marine micropaleontology, and paleoceanography in the university and doing research of late Quaternary western Pacific paleoceanography and paleoclimatology. He is intensively involved in the projects of IMAGES (International Marine Past Global Change Study) and ODP (Ocean Drilling Program) in Taiwan.