

DEEP SEA DRILLING PROJECT
UNIVERSITY OF CALIFORNIA, SAN DIEGO
SCRIPPS INSTITUTION OF OCEANOGRAPHY

Fact Sheet
General Information

Phase I

On June 24, 1966, the Regents of the University of California and Scripps Institution of Oceanography of the University of California, San Diego, received a \$12.6 million contract from the National Science Foundation, an agency of the U. S. Federal Government, to fund an 18-month Deep Sea Drilling Project.

The Project is a part of the National Science Foundation's National Ocean Sediment Coring Program.

The scientific goal of Phase I was to gather scientific information which would aid in the determination of the age and processes of development of the ocean basins. The primary strategy employed to secure this information was to drill and core deep holes in the ocean floors, relying on technology already developed by the petroleum industry. Cores were collected and in-hole measurements of physical properties made.

Cores from beneath the ocean floor provided reference sections for future studies in biostratigraphy, physical stratigraphy and paleomagnetism and afforded new scope for studies of the physical and chemical aspects of sediment origin, transportation, deposition and change after burial. In-hole measurements provided information which permitted inference of the kind of sediments in intervals where no cores were secured.

Phase II

On October 28, 1969 - long before Phase I operations were completed - the National Science Foundation announced that Scripps Institution of Oceanography had been awarded

an additional \$22.2 million in the Prime Contract for a three-year extension (Phase II) of the deep ocean probe, which, at that time, had already produced information of such significance as to make it as one of the most successful scientific expeditions of all time.

Termination date of the contract was extended from June 30, 1970, to June 30, 1973, a period that included 30 months of additional drilling and coring conducted in the Atlantic, Pacific and Indian Oceans, the Gulf of Mexico and the Mediterranean, Caribbean and Red Seas, and allowed another ten months for completion of scientific and technical reports.

An additional \$490,000 was made available to DSDP during Phase II to achieve a re-entry capability, making a \$22,690,000 contract for the Phase II work. This brought total funding for Phase I and II to \$35,290,000.

In announcing the Phase II extension, Dr. William D. McElroy, then Director of the National Science Foundation (July 1969 - Jan. 1972), said, "The Deep Sea Drilling Project, producing a growing volume of information vital to our understanding of this dynamically changing earth and its history, has proven to be an outstanding scientific and technological success. It has excited not only the more than 300 scientists of this country who have been involved in the Project's planning and execution, but many others throughout the United States and abroad who are following the progress of this National program. Undoubtedly in years to come, research on the core materials will contribute to the interest and enthusiasm of graduate students, bringing many more into this field of work.

"The success of the Deep Sea Drilling Project to date has put the United States in the forefront of deep ocean exploration. The continuance of this Project will contribute significantly to the world's scientific knowledge. "

In addition, Dr. McElroy said, industry should also benefit greatly from the Project, both through technological advances that are being made and through the information on natural resources that is being produced.

Dr. McElroy credited the success of DSDP to the close cooperation among scientists, academic institutions, industrial organizations and the Federal Government, pointing especially to the work done by Scripps Institution of Oceanography.

Dr. William A. Nierenberg, Director of Scripps Institution said, "We naturally are gratified at this recognition of the success and importance of the Deep Sea Drilling Project. There is much more to be done both geographically and technologically. The agreement to extend the operations will permit the scientific community to perfect their ideas with regard to development of ocean basins, the engineers to advance the necessary drilling and retrieving technology, and industry to better assess the resource potential."

Scientific objectives of Phase II were directed largely toward an understanding of the interaction of the continents and ocean basins and was prosecuted mainly in outer fringes of the ocean areas, or in places that were intermediate between oceanic and continental.

Phase III

On March 29, 1972 - more than three months before the termination date for drilling during Phase II - Dr. H. Guyford Stever, Director, National Science Foundation (Feb. 1972-), announced another three-year extension to the drilling contract for the Deep Sea Drilling Project (Phase III) with additional funding of \$33,010,000, or an estimated total cost of \$68.3 million for the full seven years of DSDP drilling and coring in the oceans of the world.

Dr. Stever said, "The investigations conducted under the Deep Sea Drilling Project have provoked the interest and respect of scientists throughout the United States and abroad. The extension of this productive expedition reflects the fact that important work in these oceanic studies remains to be done.

"In this regard, the DSDP drilling vessel, GLOMAR CHALLENGER, will probe the ocean floor beneath Arctic and Antarctic Ocean waters for the first time. For a number of

years, United States and visiting scientists aboard the NSF-supported research ship ELTANIN have conducted extensive investigations of the ocean floor in areas surrounding Antarctica.

"Now, in complimentary studies, it will be possible to probe much more deeply to study continental drift, ancient climates, and even the geology of the largely ice-buried Antarctic continent itself. It is of great scientific priority to obtain similar information concerning Arctic areas as well.

"The success of DSDP reflects many factors, including the good management by officials of Scripps Institution of Oceanography, the effective and dedicated planning and advisory work of the many scientists working with the Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES); and the outstanding ship operation and drilling jobs conducted by Global Marine Inc., of Los Angeles, California, "Dr. Stever concluded.

Responding to the Phase III extension announcement, Dr. Nierenberg said, "The Deep Sea Drilling Project represents the very cutting edge of the developing combination of support and talent between government, science and industry. The contributions of the Project have been fundamental in oceanic technology and in our understanding of our Earth, its history, and its resource potential. I am particularly impressed by the interest shown the Project by our colleagues in foreign countries.

Concerning the Phase III program, Dr. M. N. A. Peterson, the Principal Investigator and Manager of the Deep Sea Drilling Project commented: "Phase II of DSDP officially ended and Phase III officially started while D/V GLOMAR CHALLENGER was peacefully enroute between sites at midnight, August 11, 1972 Pacific time during Leg 25.

"Leg 26 will proceed once again into the Indian Ocean and Phase II will continue with the world-wide reconnaissance drilling, as planned by JOIDES, that will see her extending her efforts into quite high southern and northern latitudes and into considerably enhanced efforts to achieve penetration into Layer 2 of the oceanic crust, beneath the

covering of sediments on the floor of the ocean.

"It should be emphasized that sites and broad itinerary of the drilling vessel are subject to continual updating and re-evaluation; plans should be accepted as subject to change as needed to accommodate new ideas and new information as they develop.

"The following are major goals in global geology:

- 1) The origin and history of the marginal basins behind island arcs and in other small ocean basins.
- 2) The history of motions of major plates of the Earth's crust, particularly regarding that history prior to the past 100 or so million years. Groups of magnetic lineations, with significantly different orientations have been mapped in western (Mesozoic) Pacific Ocean. The most efficient way to establish ancient plate motions would be to drill on these magnetic lineations to establish crustal ages, age gradients and anomaly correlations. In areas where magnetic anomaly patterns are not clear, crustal ages and paleomagnetic data, preferably with oriented cores, can be effectively used. It should be recalled that magnetic lineations trace clearly the history of the spreading out of the oceanic crust from active mid-ocean mountain chains over the past 100 million years.
- 3) Plate motion relative to Earth's spin axis or equator of rotation. Particularly, the mark of the equatorial current system in the sediments is clear, because of the myriad small organisms that live and die in these nutrient-rich tropical waters. The rate of sedimentation is commonly 10 times that of the waters north of south of the equator. This effect marks, in chalk - if you will - (it is chalk) the trace of the equator, both now and in prior

times. The entire floor of the Pacific Ocean can be seen to have moved with a northward component of motion, during the past 50 or more million years.

- 4) Origin and evolution of linear island and seamount chains. It has been proposed that linear island chains or seamounts in the Pacific are generated by movement of the crustal plate over "hot spots" or generally permanent sources of volcanic lava, in the underlying layers of the Earth. This problem may be approached by drilling a series of holes along the chain to determine if an age gradient for the on-set of volcanic activity exists.
- 5) The nature of processes at plate margins. Particular emphasis is placed on the interaction between oceanic and continental crust. An understanding of the materials, processes and rates at now active margins is fundamental to any geologic model mountain building.
- 6) The nature or manner of emplacement of igneous rock in Layer 2, of the oceanic crust. It should be feasible to drill deeply into Layer 2 with GLOMAR CHALLENGER, but in actuality there may be some unknown, as well as suspected, problems. It is therefore the intention to drill a number of shallow holes into basalt, extending the depth of penetration at each site, where possible. This plan has the advantage of not only seeking the problems and solutions prior to committing on a really deep attempted penetration but at the same time providing a wide geographic coverage of the variations of rock type in the uppermost crustal layer over the floor of the ocean.

Ultimately, it is hoped that a hole in excess of 1,000 meters of penetration into Layer 2 could be drilled before the end of Phase III.

"Other Studies:

"During Phase I and II, substantial insight was gained into ocean sedimentary processes and changes in conditions through time. In particular, studies were related to aspects concerning fluctuations in the depth of calcium-carbonate, or lime, dissolution, vertical movements of the sea floor, variations in biological growth rates, structural and volcanic effects and ocean bottom currents; studies of compaction and sediment change also will be pursued during Phase III. Work in the high latitudes where oceanic bottom water is formed and where deep circulation patterns are largely initiated, may provide valuable data that should relate to paleocirculation and sedimentation problems posed by the previous drilling in lower latitudes.

"One of the major problems is the establishing and linking together of continuous geologic sequences in all the major biogeographic regions of the oceans and on the adjacent continents. These sequences should include not only the younger but also the oldest sediments found in the ocean basins and should be located in both low and high latitude regions. These will serve as standards for study and comparison with less complete sections drilled in the region and also for continental sections from land geology.

"Cores from a network of sites will provide the basis for reconstructing the ancient oceanographic environment that could be described in terms of surface currents, deep-ocean circulation, ancient calcium-carbonate (lime) dissolution depths, and water temperatures. Deep-sea drilling is the sole source of such data from deeper than surface samples.

"The planned program in the Antarctic and Arctic requires special mention: From models of the reconstruction of Gondwanaland, the single large continent of about 200

million years ago, it appears that areas adjoining parts of the Antarctic coastline may consist of ocean crust that existed prior to the continental breakup. This may be one of the last undrilled areas that has been identified as ancient oceanic crust. In addition to being in an operationally difficult area, to say the least, it is also a first order problem. Present plans place this drilling late in the program, in order to assure maximum Antarctic drilling experience prior to attempting this important work.

"Paleo-oceanographic studies will be focused on the history of two major water masses, the Antarctic Bottom Water and the circum-polar current; these influence deep and shallow water circulation in all the major ocean basins. Scientists from a recent cruise of GLOMAR CHALLENGER believe they can identify the time the circum-polar current became established around Antarctica. Were these currents in some way responsible for a major gap in the sedimentary record of up to 70 million years in the Atlantic Ocean, Caribbean and Pacific Ocean, and if so, how?

"Holes have been planned on the deep continental shelf of the Ross Sea to investigate the onset and the waxing and waning of the Antarctic ice sheet. These sites have been coordinated with those holes planned by the Ross Ice Shelf Project and the Dry Valley Drilling Project. There may be a relationship between the separation of Antarctica from Australia, the formation of the circum-polar current and the onset of glaciation in the southern hemisphere.

"In the Arctic, plans call for investigation of the opening of the Norwegian and Greenland Seas and the examination of paleo-oceanographic conditions leading up to and through the arctic glaciation. There are several ridges that restrict circulation from the Arctic to the Atlantic and interpretations of paleo-oceanographic conditions may provide a solid basis for determining the cause of glaciation in the northern hemisphere.

"CHALLENGER's proposed track and operations will carry her into the Indian Ocean,

thence south of Australia and New Zealand for a first Austral Summer's work near Antarctica this next year. Following almost a year in the Pacific will be a second season of Antarctic work out of South America. A largely North-South run will bring her to the far north Atlantic for the following Northern-Summer, following which she will once again operate in Antarctic waters south of Africa, to return stateside by the end of Phase III."

Scripps Institution of Oceanography of the University of California, San Diego, is managing institution for the Deep Sea Drilling Project.

Phase III plans call for 19 more approximately two-month scientific cruises.

The Joint Oceanographic Institutions for Deep Earth Sampling (JOIDES) consortium, consisting of Columbia University's Lamont-Doherty Geological Observatory, Woods Hole Oceanographic Institution, The Rosenstiel School of Marine and Atmospheric Science of the University of Miami, (Florida), The Department of Oceanography of the University of Washington (Seattle), and Scripps Institution assisted in the formulation of the plans for the Deep Sea Drilling Project and continues to give scientific advice.

Scientific planning is being provided by JOIDES' panels whose members are broadly representative of the world-wide scientific community, drawn from many universities, governmental and industrial organizations.

Many individuals from the petroleum industry have also furnished technical advice and assistance to the Project.

Dr. William A. Nierenberg is Director of Scripps Institution. Dr. Melvin N. A. Peterson is Principal Investigator for the Project. Dr. Peterson is also Project Manager. Chief Scientist for DSDP is Dr. N. Terence Edgar.

Mr. A. R. McLerran is DSDP Field Project Officer for the National Science Foundation.

Global Marine Inc., of Los Angeles, California, owns D/V GLOMAR CHALLENGER and holds a subcontract with DSDP to do the actual drilling and coring work at sea.

D/V GLOMAR CHALLENGER is a unique vessel whose highly sophisticated dynamic positioning system makes DSDP possible. Special electronic and computer equipment controlling side thrusters and two regular propellers enable the vessel to remain over a drilling site on the ocean floor in water more than 20,000 feet deep.

Conventional rotary drilling techniques are used in the coring operations. Sea water serves as the drilling fluid and cores can be retrieved on an almost continuous basis on a wire line which is run inside the drill pipe.

The drill pipe string is conventional in design. A significant aspect is the fact that in the deeper locations, the longest drill string ever suspended from the CHALLENGER has been 22,192 feet.

The drilling system utilizes existing and proven equipment, design-principles, materials and standard engineering practices to the fullest extent. However, engineering personnel continuously check the drill string to see how it fares since it is subjected to the repetitive dynamic loads imparted by a floating vessel exposed to the open sea while drilling for cores at great depths.

Scientists involved in the Deep Sea Drilling Project have expressed great satisfaction with drilling operations. One difficulty experienced was the unexpected discovery of layers of an extremely hard rock called chert or flint in the sediments of both the Atlantic and Pacific Oceans. The chert layers found, sometimes at fairly shallow levels, dulled drilling bits and prevented complete penetration through all the sediment at a number of sites.

A re-entry capability, designed to permit replacing a dulled drilling bit, was achieved on June 14, 1970, when a 10,000 foot drill string was punched into a re-entry cone on the bottom of the Atlantic Ocean 180 miles southeast of New York. A background paper on re-entry and drill string behavior in the deep ocean is available.

The first Operational re-entry was accomplished on Leg 15 in the Caribbean Sea on December 25, 1970, in water 13,000 feet deep. DSDP now has the capability of re-entering any bore hole as necessary to continue drilling until scientific objectives have been achieved.

With the development of better drilling bits, DSDP can now drill through chert and reach older sediments with relative ease. Stabilizing the hole to prevent its closing on the drill string, and removing large fragments of rock still remain as technical problems to deep penetration.

Some of the deep sea engineering principles DSDP has answered are:

Dynamic Positioning System

In the words of a DSDP engineer, "The dynamic positioning system operated far better than we anticipated." With acoustic beacon strings of 111 decibels (db), D/V GLOMAR CHALLENGER can hold position in Sea State 5, with wind gusts up to 45 knots.

Drill Pipe

Questions asked before DSDP became operational on August 11, 1968 were: What would be the optimum configuration of the drill string? What would be the effect of the enormous unsupported length in deep water? How would the large interior diameter necessary for coring affect the needed strength of the drill string? Would fatigue accelerated by the vertical motion of the vessel greatly reduce drill string life? Would the stress reducing design satisfactorily reduce fatigue and weakening of the drill pipe during drilling?

Drill pipe inspection through Phase I and II has proven DSDP operational procedures to be correct. Some of the original stands of pipe are still in service after four years of drilling and coring in a hostile environment.

Core Recovery

Conventional oil field wireline retrievable coring equipment and techniques have

been very successful - a 58% overall core recovery rate. The equipment has been modified to operate in both the unconsolidated and very hard sediments encountered. Before acceptance trials, questions asked were: Could soft sediment be recovered intact? Would possible intrusions or flow of hard volcanic or igneous rock present problems that could be overcome? Would the vessel's movement affect coring operations? What would be the maximum sea state in which the vessel could operate? Hard chert layers in the Atlantic and Pacific Oceans did prevent drill bit penetration at some sites, but re-entry and improved drill bits overcame this obstacle.

Re-entry

When very hard layers of chert, which prematurely dulled core bits, were encountered in the deep oceans worked by DSDP, scientists and engineers realized that re-entry into a bore-hole thousands of feet beneath the surface of the oceans was a necessity in order to achieve scientific objectives. Briefly, here's how DSDP re-entry works when D/V GLOMAR CHALLENGER is firmly established by dynamic positioning at a drill site: The system consists of a high resolution scanning sonar system, 16-foot re-entry cone, and a drill pipe positioning system. Re-entry is accomplished by acoustically locating the re-entry cone with the scanning sonar transmitter-receiver, which protrudes through the center bit hole at the lower end of the drill pipe. The drill pipe is then maneuvered over and into the re-entry cone by surface maneuvering of the drilling vessel. A water jet could be used to produce small movements of the lower end of the drill string. The scanning sonar consists of an underwater transmitter-receiver, a control display unit on the bridge of the vessel and a remote display unit at the drilling derrick. The underwater transmitter-receiver (transducer) is lowered down the inside of the drill pipe and protrudes through the center bit opening in the drill bit. The underwater package is connected to the control display unit by 25,000 feet of underwater electrical cable. The control-display unit commands

the underwater unit to acoustically scan the ocean floor. Information, in the form of underwater sound echoes is received by the underwater electronics package, amplified and transmitted to the control display unit for processing and display. The display is similar to the more familiar radar scopes which in more technical terms is known as a plan position indicator (PPI Scope). Maximum range for target acquisition is 500 feet. The re-entry cone is 16 feet in diameter and 14 feet tall with three acoustic reflectors located 120 degrees apart and approximately four feet beyond the periphery of the top of the cone. The cone is keel-hauled to a position directly beneath the opening in the vessel under the drilling derrick and lowered to the ocean floor on the drill pipe. It remains on the ocean floor when the drill pipe is pulled to the surface for a change of drill bits. When the acoustic reflectors on the re-entry cone have been located on the PPI Scope, the dynamic positioning system is used to maneuver the vessel and drill pipe to the re-entry cone. When the reflectors are equidistant from the center of the PPI Scope, the drill pipe is lowered into the cone, completing the re-entry maneuver.

Drill Bits

Tungsten-carbide drag-type core bits were expected to be adequate for most core recovery work when the Deep Sea Drilling Project became operational in August of 1968; where some basalt was to be recovered, the use of diamond-studded core bits was planned. It was discovered early in the Project that extensive layers of chert commonly of Mid-Eocene Age, in both the Atlantic and Pacific Oceans, rapidly dulled drag and diamond bits before the entire sediment section was penetrated. This situation forced Project engineers to look for improved designs. During Leg Seven, a tungsten-carbide insert roller bit, salvaged from Project Mohole, was tried with encouraging results. High cost and long delivery times for this style of bit lead to the development of a core bit design using standard bit components. By Leg Eleven, this bit was used in over one-half of the coring operations. Standard rock

bits used in the drilling industry to penetrate chert provide no means to cut a core, so the roller cutters were moved apart to leave a core of the desired sediment. Operations Manager Valdemar F. Larson played a major role in designing the new bit. When he first asked bit manufacturers to move the cones apart, they were reluctant to do it since it was a major departure from accepted design practice. Modifications of standard designs have been required. However, the resultant core bit has proven to be rugged and has an enviable penetration record.

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