

WOODS HOLE OCEANOGRAPHIC INSTITUTION  
Woods Hole, Massachusetts

Technical Memorandum #1-64

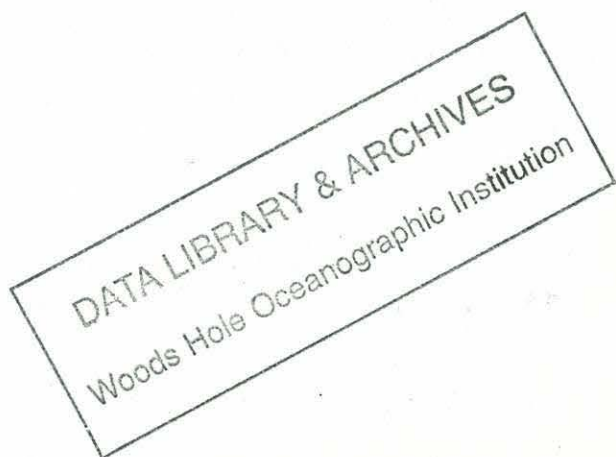
Cruise Plans for R/V CHAIN Cruise #43 - Indian  
Ocean Expedition

by

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January 1964

This work was performed under NSF Grant 2370 with the National Science Foundation, and ONR Contract 4029(00) with the Office of Naval Research.



## R/V CHAIN Cruise 43 - Indian Ocean Expedition

### INTRODUCTION

The proposed cruise of R/V CHAIN to the Indian Ocean will take place from February to June 1964. Following the Indian Ocean section of the cruise, R/V CHAIN will proceed to the Mediterranean Sea and will do further work in this area. The latter program will be covered in a separate cruise plan.

The background and objectives of the scientific program in the Indian Ocean are detailed in the research proposal submitted to the National Science Foundation, found in Appendix A.

## CRUISE PLANS FOR CHAIN CRUISE #43, Indian Ocean, February - June 1964

Elizabeth T. Bunce

R/V CHAIN will depart from Woods Hole February 15, 1964 en route to the Indian Ocean via the Atlantic Ocean, Mediterranean Sea, and Red Sea. It is proposed that the first section of the cruise be concerned with routine observations that can be made underway during the transit of the Atlantic Ocean. The crossing will be made along latitude 28°N, from 64°W longitude to 28°W longitude, enabling observations of a section across the mid-Atlantic Ridge not yet surveyed in detail.

The underway observations to be conducted continuously on this and on all other sections are: measurements of gravity field and of magnetic field, temperature structure of the ocean water to a depth of 600 feet, surface temperature, bathymetry, and sub-bottom structure with the continuous seismic profiler.

A stop will be made at Ceuta, Morocco, to fuel the ship. From Ceuta the ship will cross the western Mediterranean Basin en route to visit La Spezia, Italy, and part of the eastern Mediterranean Basin en route to Port Said, Egypt. As in the Atlantic Ocean, only underway observations will be made in the Mediterranean Sea.

Detailed studies will commence in the Red Sea. A chart is attached (CHART I) showing the proposed tracks. These are laid out to intercept and cross the seismic refraction profiles made by R/V ATLANTIS and R/V VEMA in 1958, to study the relations of the sub-bottom structures using the continuous seismic profiler. Additionally, we plan to make 4 or 5 heat flow measurements along the Red Sea track and possibly to land on Zebirget, (St. John's Island) to investigate its geological structure.

Chart II shows the proposed areas of investigation in the Indian Ocean.

Following a visit to Aden, Aden Protectorate, for the purpose of exchanging members of the scientific party and for supplies, we will investigate in detail an area of the Somali Abyssal Plain before proceeding to the Seychelles Islands (Area I of Chart II). Two

recent E-W crossings of this plain by R/V VEMA have produced profiler records showing a thick layer or series of layers of sediments above a deep reflecting horizon. At some places there are peaks apparently thrusting through the sediment cover. We hope to dredge one or two of these peaks for rock samples, and to core sediments if the peaks are sediment covered. If topographic and profiler studies of the eastern side of the Abyssal Plain indicate scarps and possible rock outcrops we plan to dredge this area. The surface of the plain, the seamounts, and the eastern slope will also be photographed. We plan to make oblique reflection profiles, using the acoustic telemetering buoys, in a small section of the Abyssal Plain. This will enable us to determine the compressional wave velocity in the shallow sedimentary layers.

In the Seychelles area we will make a detailed survey north and east of the island to investigate the areal extent of the Seychelles granite and the relationship of the Seychelles structure to the surrounding ocean basin. This portion of the work will be conducted mainly by underway observations, but time is allowed for dredging and coring if suitable locations are found.

From the Gulf of Aden to the Seychelles a number of heat flow measurements will be made, their exact locations being dependent upon locations of recent RRS DISCOVERY stations not available at this writing. A stop will be made at Port Victoria in the Seychelles Islands at the conclusion of this phase of the program.

Departing Port Victoria, we will continue the detailed survey to the south and east across the Seychelles-Mauritius Ridge, then proceed to the location of Vema Trench, approximately 09°08'S latitude, 67°15'E longitude. This contains the greatest known depth in the Indian Ocean, 3501 fm, (6402 m). It is a narrow trench, cutting across the axis of the mid-oceanic (Carlsberg) ridge. The steep-walled trench trends 055°T, its depth below 3000 fm extending for 60 miles. We plan a detailed study of this feature, to include heat flow measurement and coring, underwater photography of the trench floor, and dredging with associated photography of the walls.

From Vema Trench to Mauritius the work is planned to study further the Seychelles-Mauritius Ridge area using both underway observations and lowerings designed to obtain photographs and bottom samples. The island of Mauritius will be visited at the conclusion of this section of the cruise; there will be changes in the scientific party at this time.

The next area of operation is shown in Section III of Chart II. We will investigate the relationship of Madagascar with the Seychelles-Mauritius Ridge and the ocean basin between, and the apparent fault zone extending along the east coast of Madagascar through the Seychelles Islands. Broad-scale underway survey work will alternate with more closely spaced survey tracks and with core sampling and heat flow measurements. Of specific interest in this region is a small arcuate trench to the southwest of the Amirante Islands. It is planned to investigate this feature with dredging and photography.

A second stop will be made at Port Victoria for supplies. This will mark the conclusion of the detailed scientific investigation of this relatively small area of the Indian Ocean. The ship will proceed from the Seychelles to Beirut, Lebanon, via the Red Sea. The return track to the Gulf of Aden will cross the Somali Abyssal Plain, or will be located east of the plain, dependent upon the observations made on the initial passage southwards.

## APPENDIX A

The Institution proposes to investigate the structure of the earth's crust in the northwestern part of the Indian Ocean during the period March - June 1964. The area in which such investigations will take place is that north of 25°S, west of 80°E, and includes the Arabian Sea. This area and the subjects for investigation are too large to be completely covered in these proposed cruises. However, new and important information about the area can be obtained by selecting certain problems discussed below and concentrating much of the effort on them. While this cruise is primarily planned to solve these problems, there are certain oceanographic and geophysical measurements that can be taken almost continuously while the ships are in the area. These measurements include meteorological observations, precision echo sounding, near surface temperature and water shear velocity data. Study of the bottom substructures with the Continuous Seismic Profiler, magnetic field and gravity field measurements will be undertaken whenever feasible.

It is proposed that the cost of the first four months of continuous operation beginning in Woods Hole and ending in Suez after the Indian Ocean portion of the expedition be supported by the National Science Foundation. The support of the Office of Naval Research is being sought separately for the return to Woods Hole, which is planned to require two months and is intended to include a considerable scientific program in the Mediterranean Sea and the North Atlantic Ocean.

The principal subjects to be investigated in the Indian Ocean are:

- (1) Areal extent of Seychelles granite
- (2) Relationship of the Seychelles (continental crust?) to the surrounding ocean basin
- (3) Relationship of the Seychelles to the ridge extending to the south and east toward the Mascarene Islands

The basin located between Africa and the Seychelles will be studied by the Cambridge University Geophysical Group. We plan to supplement their geophysical study of this area with a seismic reflection and gravity profile across the basin; but the most intensive geophysical activity will be concentrated in the area surrounding the Seychelles and extending south to Madagascar and southeastward along the ridge to the Mascarene Islands. This work will be planned to supplement previous research there by several geophysical groups that have visited the region in the recent past.

The area of the Carlsberg Ridge would be investigated less intensively en route to the Seychelles.

These subjects will be investigated by means of seismic refraction and reflection profiles, bottom sampling by dredging and coring, bottom photography, heat flow measurements, magnetic, and gravimetric measurements.

The structure and petrology of the island of Madagascar indicate that continental type crust underlies the island. Isolated patches of continental crust of this size are unusual and warrant detailed study in an effort to determine the nature and extent of the crust beneath these features. Oceanic depths surround Madagascar essentially on three sides, and on the fourth side a shallower channel links the island to the African continent. We propose to make seismic refraction and reflection profiles in the channel and in the ocean basins bordering Madagascar, in order to determine the crustal structure in these regions. Gravity measurements, taken at the same time in the areas around the profiles, will permit extension of the seismic results to a larger area and will assist in determining locations of different crustal types.

Continental type crust may also underlie the Seychelles Islands; a conclusion based on reports of Pre-Cambrian granite outcropping in the island group. Steep submarine scarps border the island of Madagascar on the east; a northern extension of these features appear to border the western edge of the Seychelles group some 600 miles away. The structural and tectonic relationships of this area will be studied. During the program it is proposed to detail the topography, to study some of the sections by seismic means, to conduct heat flow measurements across the ridges, and to make magnetic and gravimetric measurements over the ridge system.

The ridge system defines ocean basins that are essentially isolated from each other. Studies of sediments in these basins by coring and continuous seismic profiling will be made. The deeper substructure will be investigated by refraction and reflection seismic techniques.

Several programs in physical oceanography will be pursued by means of continuous underway observations and special observations as follow:

(1) Surface water temperature will be measured down to approximately 600 feet by means of the towed thermistor chain. Horizontal fluctuations of the water temperature will be studied along with the vertical temperature gradients and inversions. The temperature gradient in the mixed layer will permit determination of the stability of the surface water. These temperature measurements will also permit a study of the internal waves. One problem of especial interest is the understanding of small thermal fronts which have been the object of study for several years under Contracts Nonr-4029 and Nonr-2866 with the Office of Naval Research. These are rapid steplike changes in near-surface temperature, which have been found in the vicinity of 30 °N, 70 °W (southwest of Bermuda). On every occasion that temperature profiles have been recorded there (five occasions since 1959), the change has always been found to be one wherein water warmer by 1.5 ° - 3.0 °C exists on the southern side of the front which is only 2 to 5 miles wide. Since the recordings were made at quite different times on the year the occurrence does not seem to be seasonal, but there may be seasonal effects now unknown. The front extends at least through the mixed layer, which is usually isothermal to within 0.1 to 0.2 °C at any one location there. The horizontal temperature gradient can be as high as 1 °C per mile. A few current measurements made by means of von Arx's GEK during CHAIN Cruise 34 indicated north-eastward flows along the front, of nearly 1 knot which is about 10 times the noise background. During the same cruise one front was traced for a distance of about 40 miles and was found to trend east - west through the position cited above. Later when the GEK measurements were made the orientation of the front was ENE - WSW. At the present time we do not know whether these



fronts are permanent or recurring. Possibly similar thermal fronts are to be found elsewhere in the oceans. As opportunity affords throughout this expedition we propose to seek clues leading to general understanding of small thermal fronts in the ocean. For example, in the parts of the Indian Ocean that will be visited for the geophysical program, especially the broad area south of the equator and east of Madagascar, we shall try to discover the frequency and location of thermal fronts.

(2) Sound velocity profiles will be made from surface to bottom in the areas of special interest. It is expected that a ship-board digital computer will be available for converting the data continuously to sound velocity versus true depth.

(3) Other studies will include recordings of ambient noise, measurements of the acoustic properties of the bottom, and observations of the scattering layers. These studies are of particular interest for evaluation of the acoustic properties of the Indian Ocean.

Throughout our scientific program the fullest possible use will be made of an on-line computer which has been in use in the Geophysics Department for slightly over a year.

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It is not planned to make scientific observations within foreign territorial waters (3 mile limit) in the course of the cruise of R/V CHAIN except for specific request to land on Zebirget (St. John's I.) at Latitude 23°40'N, Longitude 36°08'E, in the Red Sea. All entries into foreign territorial waters will be made en route to port stops as indicated.

Depart Woods Hole, February 15, 1964

Transit Strait of Gibraltar, March 2, 1964

Arrive Ceuta, Morocco, call for fuel only, March 2, 1964

Depart Ceuta, March 2, enroute La Spezia, Italy

Course from Ceuta to La Spezia, straight tract to approximate area 37°30'N, 00°30'E, thence alter course to La Spezia.

Arrive La Spezia, Italy, port visit, 6 or 7 March depending on ETD  
Ceuta at conclusion of fueling.

Routine underway observations will be conducted in the Mediterranean Sea, outside territorial limits, during this transit. These consist of: Gravity, Magnetics measurements; Echo-sounding (bathymetry), Continuous seismic profiling (Sparker or Boomer) and continuous temperature recording (thermistor chain).

Personnel changes will take place at La Spezia.

Depart La Spezia, 9 - 10 March, (Dependent on 6 or 7 March as arrival date.)

Transit Tyrrhenian Sea to approximately 37°20'N, 11°30'E, there alter course for Port Said, Egypt.

Routine underway observations as previously during transit of deep water areas.

Arrive Port Said, Egypt, to clear for Suez Canal transit, 16 March.  
Assume clearance and transit require 2 days. Enter Red Sea 18 March.

Underway observations as before, but tracks being made (see Chart I) for series of crossings of Red Sea; (Straight transit Gulf of Suez and into Red Sea. Start zig-zag courses  $26^{\circ}40'N - 34^{\circ}00'E$ ). Arrive vicinity of Zebirget ( $23^{\circ}40'N, 36^{\circ}08'E$ ) on or about 20 March 1964.

Ship to profile Easterly while geologists on Zebirget. Continue zig-zags and other observations to about  $13^{\circ}N, 43^{\circ}05'E$ .

Arrive Aden, 25 March. Port visit: fuel; personnel changes.

Depart Aden, Aden, 28 March.

en route to Seychelles Islands, working in Area I. (Chart II)  
Enter Seychelles region from north, and approach Port Victoria from east (probably).

Arrive Port Victoria, Mahe', Is. (Seychelles Is.) 13 April for port stop.

Depart Port Victoria, 15 April.

En route for Port Louis, Mauritius: work in Area II (Chart II).  
Enter territorial waters about  $20^{\circ}S - 57^{\circ}20'E$ .

Arrive Port Louis, Mauritius, 1 May.

Port stop, fuel, personnel changes.

Depart Port Louis, Mauritius, 4 or 5 May.

En route Port Victoria, Seychelles. Work in either Area II or Area III depending on results of Seychelles - Mauritius transit prior to this.

Arrive Port Victoria, Seychelles, 22 May.

Port stop, fuel.

Depart Port Victoria, Seychelles, 25 May.

En route Beirut, Lebanon. Transit through Area II to region of Socotra I., about 13°S, 57°E, thence transit Gulf of Aden, Red Sea, to Suez. Routine underway observations only (as Mediterranean previously) en route to Suez.

Transit Suez Canal, Port Said, clearance formalities only, 8-9 June, 1964

Arrive Beirut, Lebanon, 10 June

Port stop; fuel, personnel changes.

Depart Beirut, Lebanon, 13 June.

En route La Spezia, Italy

Arrive La Spezia, 29 June

Port stop, etc.

Depart La Spezia, 1 July

En route Monaco  
work---

Arrive Monaco, 13 July, port stop, etc.

Depart Monaco, 15 July

En route Ceuta for fuel

Arrive and Depart Ceuta, 24 July; fuel only.

Transit Strait of Gibraltar 24 or 25 July, dependent on fueling time.

Arrive Woods Hole 17 August 1964.

Chart I  
Chain I O E F  
Proposed Rad  
San Track



