

# UC San Diego

## Scripps Institution of Oceanography Technical Report

### Title

Expedition CIRCE (Argo 68-1)

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**Scripps Institution of Oceanography  
Office of the Director**

**Expedition CIRCE (Argo 68-1)**

14 February, 1968

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**La Jolla: Scripps Institution of Oceanography Office of the Director**

**14 February, 1968**

To: Distribution

On or about 7 March, 1968, R/V *Argo* will sail from San Diego on a twelve-month scientific exploration in the Pacific, Indian, and Atlantic Oceans. The cruise, designated CIRCE, in large part coincides in time span with the Centennial Year of the University of California. The work is sponsored primarily by various contracts with the Office of Naval Research and grants from the National Science Foundation.

CIRCE Expedition is primarily a deep-sea geological-geophysical cruise, similar in scientific program to S.I.O.'s MONSOON (1960-61), LUSIAD (1962-63), and DODO (1964) Expeditions to the Indian Ocean. The scientific program is described in detail in Section C, below. The aim is to investigate bottom topography (by precise sounding and photography), magnetic patterns, heat-flow, sediment thicknesses in basins and on shelves, hard rock distribution and type, chemical properties of sediments and the overlying water, and variation in the earth's magnetic field near the magnetic equator. Hydrographic casts will be made on some parts of the cruise; BT observations will be collected routinely throughout the expedition. Biological tows will be made, particularly in the Indian Ocean and across the Atlantic. Hence the emphasis, and the chief scientist on board, will shift, segment by segment. Dr. Robert L. Fisher is in over-all charge of CIRCE Expedition.

*Argo* can carry eighteen scientists, and already is fully staffed for several segments. Qualified investigators from other laboratories and agencies may be accommodated on some sections, if their programs complement and do not interfere with *Argo's* work as proposed.

A. ITINERARY - please see Attachments 1 and 2.

B. PERSONNEL - please see Attachment 3.

**C. SCIENTIFIC PROGRAM**

1. San Diego to Honolulu, 7-17 March, 1968 — Scientific leader: George G. Shor, Jr.

The initial segment of CIRCE Expedition will provide a field test of the newly-installed IBM 1800 computer and a shakedown of underway equipment. Several hours of bathymetric, magnetic, seismic-reflection and bottom-sampling (by corer or dredge)

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reconnaissance will be made on one or both of two proposed JOIDES drilling sites. A deep, detailed hydrographic cast, the first of five such en route to Penang, will collect samples for calcium carbonate compensation depth study; similarly, continuous air samples and rain water samples will be analyzed for lead and iron content.

2. Honolulu to Penang, 20 March-22 April — Scientific Leader: Dan Karig

On this 32-day run, reconnaissances of five proposed JOIDES sites will be made. Ten to twelve heat-flow stations will be occupied. Seismic reflection surveys, coring and dredging will be undertaken in the arcs of the South Philippine Sea, and in the Celebes and Sulu Seas.

3. Penang to Colombo, 26 April-27 May — Scientific leader: Joseph R. Curaray.

Principal program on this segment is the examination of the deep-sea fan of the Ganges River, occupying most of the Bay of Bengal and the adjacent continental shelves and slopes. This fan, a semi-enclosed and well-developed kind of continental rise, is probably the largest deep-sea fan in the world, in area if not, perhaps, in volume. The few precise sounding lines run across it to date show a well-developed turbidity current channel system, but essentially no geophysical work has been done, except by Soviet vessels. A grid of bathymetric, magnetic, and seismic-reflection profiles will be run in the western three-quarters of the Bay of Bengal, and sediment cores up to 15-20 meters in length will be collected, at about one station per day. Principal objectives of the survey are the internal structure, sources, thickness and tectonic history of this fan and the adjacent continental shelves and slopes, and to provide acoustical data on the nature of the sea floor in this region. The survey will be run in collaboration with David G. Moore and associates at NELC, San Diego, who have developed and tested a large

arcsource reflection-profiling system (up to 180 kilo-joules) with a correlation system of data processing. The correlation system should enable not only retrieval of low-frequency, deep-penetration information but also higher-frequency, higher-resolution information on the shallow sedimentary layers. The NELC gear will be off-loaded at Colombo; for the balance of CIRCE Expedition the standard airgun reflection-profiling system will be used.

Completion of installation of *Argo's* satellite navigation receiving system, and coupling with computer, at Penang is expected. Precise navigation is fundamental to the Bay of Bengal work, and to later programs on the Mid-Indian and Mid-Atlantic Ridges.

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4. Colombo to Colombo, 1–24 June — Scientific leader: Charles S. Cox

In addition to the magnetic, heat-flow, dredging and seismic-reflection study of the partially-buried northern portion of the Ninetyeast Ridge (see 5, below), the principal aim of this segment is a reconnaissance of electric and magnetic fluctuations at the geomagnetic equator. The program is designed to discriminate between anomaly fluctuations in the geomagnetic field produced by electric currents induced within the ocean or by induction within a shallow layer of highly conducting rock within the upper mantle. Two self-contained electric field recorders will be placed on the deep seafloor (see Enclosure 1 for approximate locations) to record fluctuations in earth currents for about two weeks while *Argo* carries out precisely-located, long-legged GEK surveys at the surface, as well as her geological-geophysical sampling of the ridge. The recorders will be retrieved and their recordings analyzed together with concurrent measurements ashore provided by the Trivandrum Magnetic Observatory and temporary magneto-telluric stations.

5. Colombo to Port Louis, 29 June–28 July — Scientific leader: A. E. J. Engel

The Ninetyeast Ridge, recognizable as a narrow, smoothish-topped topographic entity from 10°N, where it may pass beneath the sediments of the Bay of Bengal, to about 35°S may be the longest essentially-straight, probably fault-bounded, mountain range on the face of the earth. Currently aseismic, it has — from seismic refraction studies made on LUSIAD Expedition in 1962 — a crustal structure intermediate between that of continents and oceans. Topographic and seismic-reflection profiling to date indicates that the steep eastern flank and, probably, the gentler western slope, are fault scarps. The locally-precipitous east flank, in places with a crest lying 4000 meters shoaler than the 5500–6000 meter deep seafloor, provides opportunities to sample systematically through much, perhaps all, of the intermediate oceanic layer. Seismic-reflection profiling will help locate outcrops. Samples obtained by dredging will be examined with emphasis on composition, age, mode of emplacement, metamorphic over-prints, magnetic characteristics, weathering as a function of age, related interactions of the rock systems with seawater, and possibly analysis to determine radioactive isotope ratios. The latter, specifically for thorium-uranium, may provide means of ascertaining heat flow in submarine areas where the usual probe method fails. Heat flow measurements adjacent to the ridge may detect systematic variation, south to north, along its 4500-kilometer length. Additional closely-controlled PDR lines can test the reality of the apparent *en echelon* nature of the ridge north of 8°S, or a continuation of such character to the south. Orientation of linear, aseismic

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Ninetyeast Ridge relative to the nearly ubiquitous magnetic lineations of the deep seafloor, today commonly taken to indicate seafloor-spreading, will be tested by magnetic profiling chosen to incorporate earlier, in-passage traverses.

6. Port Louis to Capetown, via Port Louis and Tamatave, 1 August–7 October — Scientific leader: Robert L. Fisher

The aim of this two-month program is to detail and extend the topographic, magnetic, structural, petrologic and dating studies — begun on *Argo* in 1960 and *Argo-Horizon* in 1962, supplemented by recent data from other 110E vessels — of a portion of the Mid-Indian Ocean Ridge, the area between that ridge and the Mascarene Plateau, and the region of apparent bifurcation of the ridge just south of the east-west Rodriguez Fracture Zone. The northern area, from 10°S to 20°S, has a single, seismically-active mid-oceanic ridge. The topographic and magnetic character of this portion of the ridge is not well-known: recently other workers have suggested that this shoal feature, and its possible continuation southwest far south of Africa, is a major fracture zone off-setting a single north-west-trending Carlsberg Ridge — southeast Mid-Indian Ocean Ridge. The crestal area is shallow, but the usual rift-valley, often taken as characteristic of mid-oceanic ridges, is not well-developed on the few crossings yet available. There are apparently large cross-cutting northeast-trending deeps or fractures that may be transform faults; the magnetic pattern should reveal these and their sense of offset. A characteristic portion will be surveyed in detail, with satellite navigation to fix bathymetric, magnetic and seismic reflection lines. Expected regions of outcrop, particularly on the lower parts of scarps, will be dredged. This will be done both in the expected central rift-valley and in the deep cross-fractures. Relative amounts of fill in depressions near the crest, on the flanks and just outside the ridge, together with magnetic patterns, should indicate relative rates of spreading, if this has occurred, and, together with dating of samples, possible long-time discontinuities in spreading.

The branching mid-oceanic ridge south of Rodriguez Fracture Zone will be similarly studied as far south as 28°S. There the crest is generally deeper, heat flow is rather higher (but seismic activity lower), there are many topographic lineations paralleling the southwest branch, and the pattern of intersection near Rodriguez is not clear. Data to date suggests 300 km of left-lateral offset of the mid-oceanic ridge at Rodriguez Fracture Zone, with volcanic Rodriguez itself being Plio-Pleistocene in age. Dredging of scarps on that ridge will be attempted, and magnetic, topographic and reflection studies should establish the kind of faulting

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(transcurrent or transform?), the sequence of ridge development, and the absolute offset or spreading.

Exigency in schedule prevents more than a rather direct Tamatave to Capetown passage, with the standard observations underway. However, two or three short seismic reflection profiles across the steep continental slope of Madagascar will be made, attempting to detect the postulated fault system forming the extremely linear eastern border of that continental block.

7. Capetown to Luanda, 12 October–4 November — Scientific leader: Tj. H. van Andel

Work on this segment, and the one following, will be carried out in collaboration with scientists from Woods Hole Oceanographic Institution, from the United Kingdom and from South Africa. A detailed study of a small portion of the Walvis Ridge will be made, to compare the relief and geologic characteristics of this aseismic ridge with detailed surveys made previously of the crest and upper flanks of the Mid-Atlantic Ridge. This study involves (1), a bathymetric, magnetic, and seismic-reflection survey of an area, perhaps 100 x 30 nautical miles in extent, on the crest and southeastern flank and (2), a program of coring and dredging to study the bio-stratigraphy of Cenozoic and late Mesozoic sediments outcropping on the Ridge, and to obtain, if possible, samples of igneous rocks. A second program is the reconnaissance study of the continental margin of Africa from Luderitz to Cape Frio, with special reference to the petrology, geochemistry, depositional processes, and spatial distribution of the organic-rich sediments in this area of up-welling and high organic productivity. Alternating seismic-reflection and coring lines will be carried across the shelf from the near-shore zone to the 1000 meter isobath. On five crossings, one of which will extend to the deep basin floor, several hydro-casts each will be taken to establish salinity, oxygen, temperature, hydrogen sulfide and nutrient profiles. Thirdly, large-volume water sample casts, for the study of the distribution of radioactive fallout, will be made at five locations.

8. Luanda to Fortaleza, 8 November–3 December — Scientific leader: Tj. H. van Andel

Bilateral symmetry of the Mid-Atlantic Ridge, required by the currently-accepted seafloor spreading hypothesis, has been demonstrated for magnetic anomalies, but detailed correlations with topography, sediment type and thickness, igneous rock distribution, and general geologic configurations have not as yet been established. Earlier detailed surveys, asymmetrically located with respect to the ridge, have been inconclusive, though they have raised serious problems regarding the compatibility of the observations with the hypothesis. Hence, on CIRCE Expedition *Argo* will measure depth, magnetic field,

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sediment thickness, and geologic structure on four profiles perpendicular to the crest, 320 miles long and spaced 5 to 8 miles apart. On completion of this survey, with processing of data by shipboard computer, *Argo* will sample, by dredge, piston corer, and dart corer, across the center of the strip to establish the distribution of igneous, metamorphic and sedimentary material. The two sectors shown as alternatives on the track chart (Attachment 1) were chosen as areas likely to be free of transverse disturbances or structures. As on the previous segment of the cruise, a few large-volume water sample and hydrocasts are planned.

9. Fortaleza to Colón, 6–23 December — Scientific leader: Joseph R. Curray

*Argo* will continue, detail, and extend the seismic-reflection and sampling survey of the South American shelf and slope begun on *Thomas Washington* late in 1965. On the present cruise, work will be concentrated between the mouth of the Amazon River and Trinidad. Important rock units, seen from reflection records to outcrop, will be dredged. One such locality is on the lower slope off the French Guiana-Surinam border, here interpreted as a subsided margin of the granitic shield forming a marginal plateau. Another lies east of Trinidad where outcropping pinnacles protrude through the sediment cover. The pinnacles are in line with a ridge of Mesozoic metamorphic rocks forming the northern coast of Trinidad.

At the close of this survey *Argo* will remain in Colón from 23 December to perhaps 5 January; her crew will be given a holiday furlough.

10. Colón to Colón, 6–22 January, 1969 — Scientific leader: Francis P. Shepard

The principal aim of this 16-day program is to gather information about the diapiric intrusions off the Magdalena Delta, Colombia. These hills, found by work on *Thomas Washington* early in 1966, rise as much as 200 meters above the pro-delta slope. They will be examined by coring, dredging, and bottom photography; closely-controlled surveys—precise sounding, magnetic and seismic-reflection—will be made to look for more diapirs and to uncover a pattern if any exists.

11. Balboa to Puntarenas, 25 January–17 February — Scientific leader: Arthur D. Raff

The principal aim of this portion of CIRCE Expedition is to examine the patterns of magnetic lineations of the seafloor near the Galapagos Islands, to the south beyond the equator,

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and from there to the East Pacific Rise. Previous work—by Raff and others—indicates patterns not consistent with simple spreading from that rise, and indicative of transverse structure. Precise sounding, heat-flow and seismic-reflection studies will accompany the magnetic exploration.

12. Puntarenas to San Diego, 20 February–13 March — Scientific leader: John G. Sclater

The final segment of the cruise will be very similar in program to that immediately preceding it. Magnetic lineation exploration will be continued west to about 105°W, between 2°S and 8°N, together with heat flow and seismic-reflection profiles. Several seamounts will be surveyed bathymetrically and magnetically to permit computation of their direction and intensity of magnetization, and dredged to obtain samples for dating and petrologic study. The program is a continuation of that carried out by *Argo* on Expedition TRIPOD, October–December, 1966.

Attachments

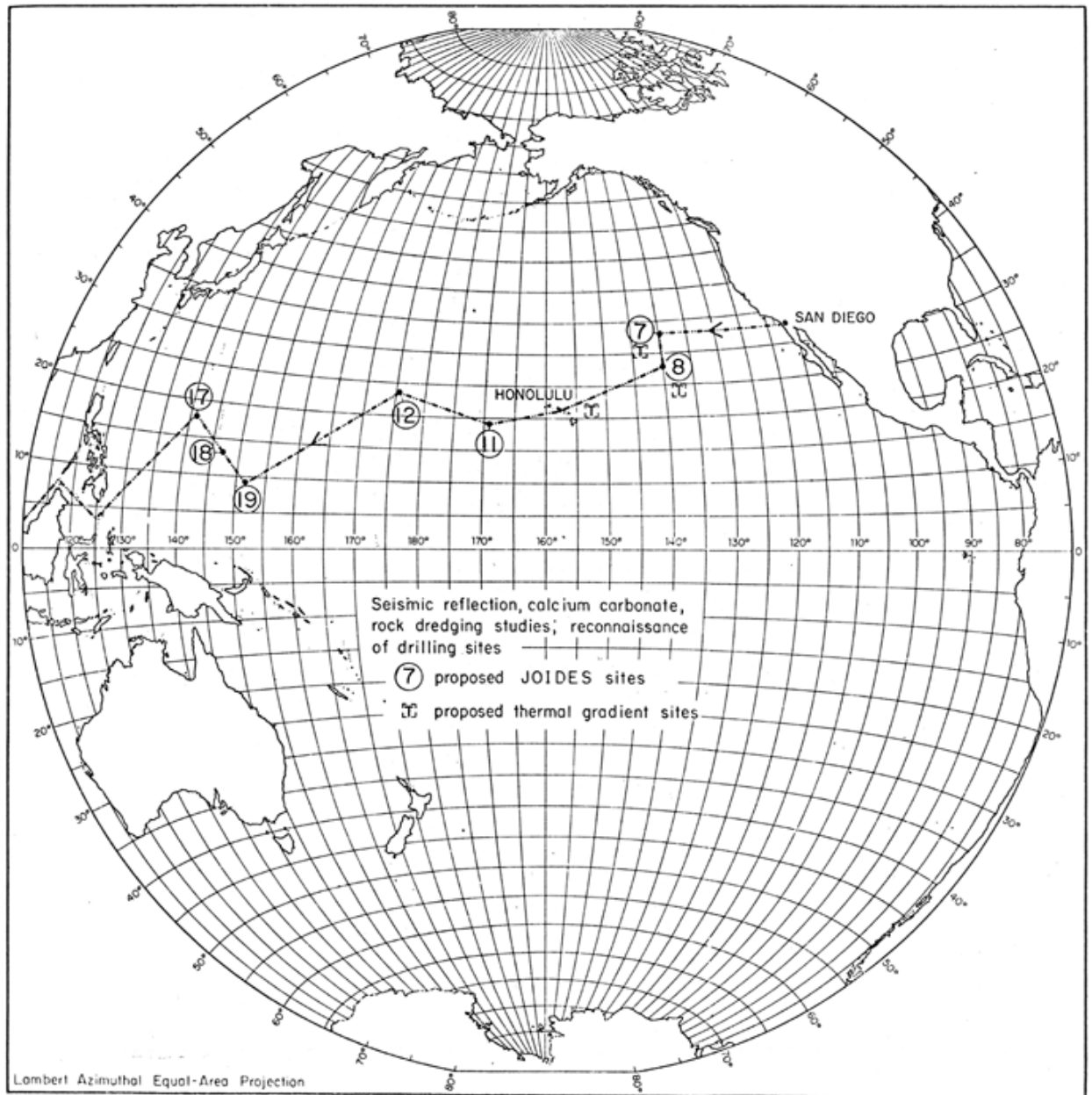
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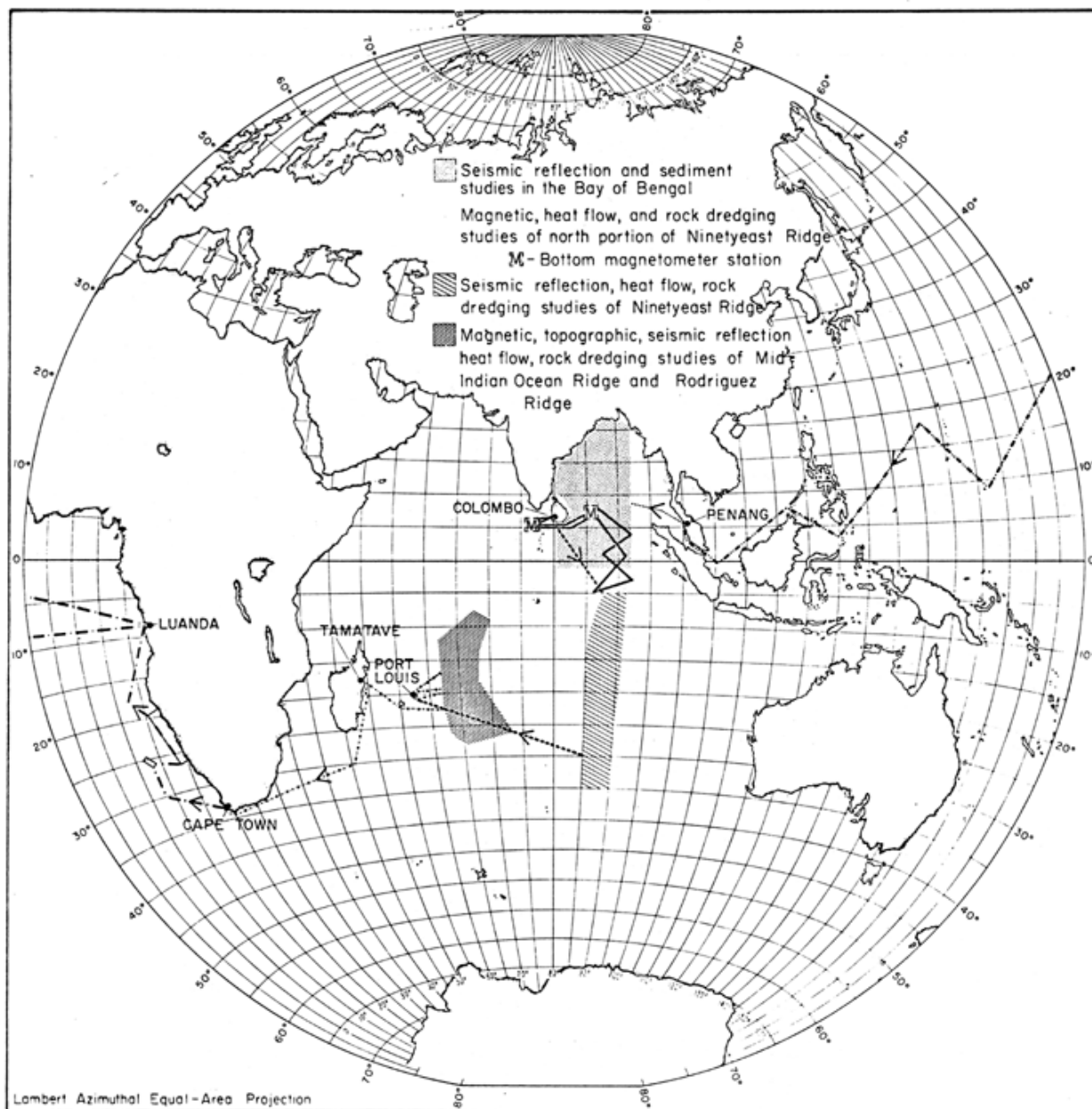
— 8 —

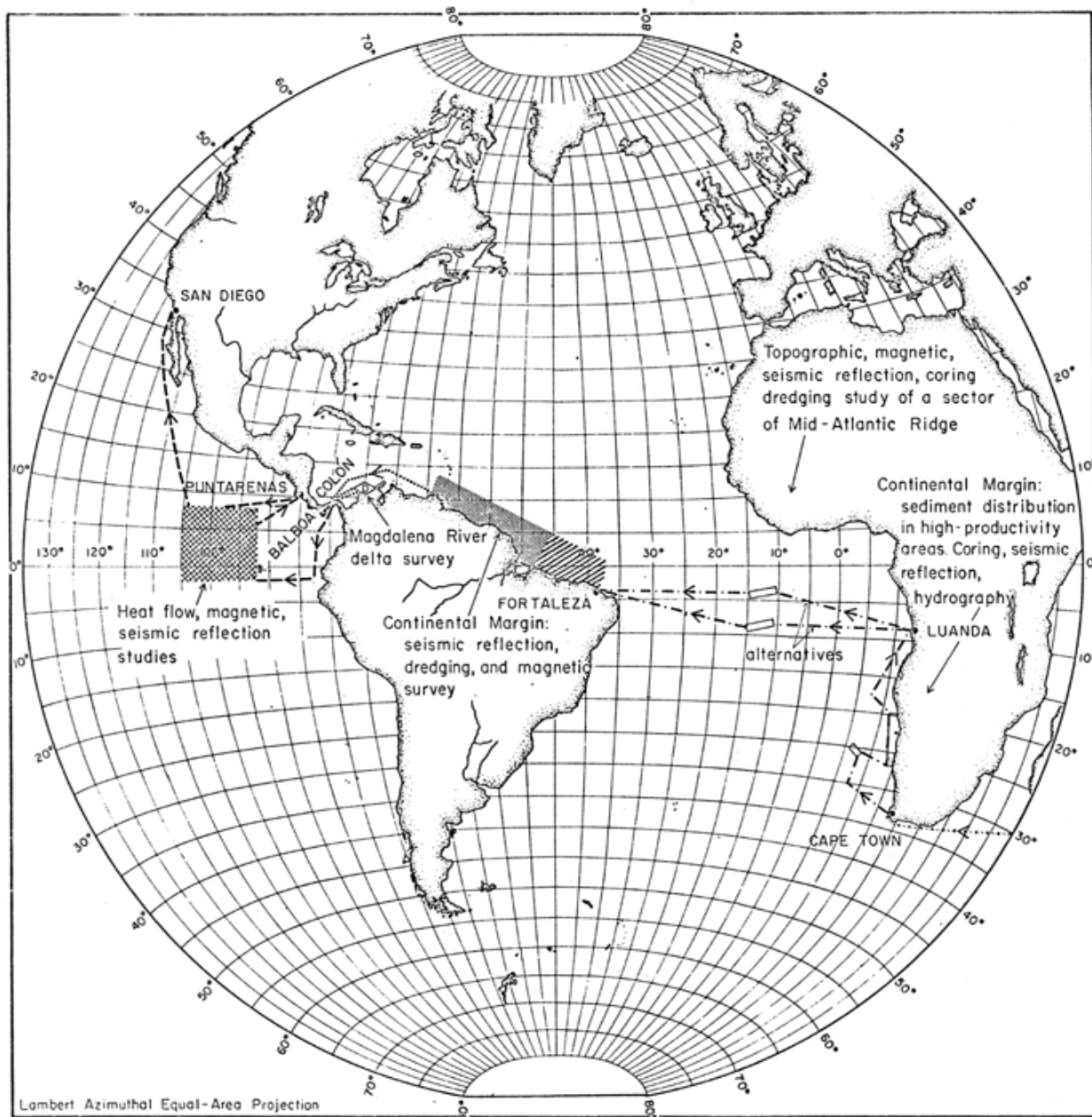
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Attachment 1: Schematic track chart







Attachment 3

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Suggested itinerary for CIRCE Expedition (R/V *Argo*, March 1968 – March 1969)-- R. L. Fisher

|                          |                                                           |                                                       |
|--------------------------|-----------------------------------------------------------|-------------------------------------------------------|
| 7 March (Thurs.)         | Depart San Diego                                          |                                                       |
|                          | 10 days                                                   | Shor                                                  |
| 17 March (Sun.)          | Arrive Honolulu                                           |                                                       |
| 20 March (Wed.)          | Depart Honolulu 4 (2)                                     |                                                       |
|                          | 32 ½ days                                                 | Karig                                                 |
| 22 April (Mon.)          | Arrive Penang                                             |                                                       |
| 26 April (Fri.)          | Depart Penang 5 (3)                                       |                                                       |
|                          | 31 days                                                   | Curray-Moore                                          |
|                          |                                                           | (Possible brief fueling stop in Visakhapatnam, India) |
| 27 May (Mon.)            | Arrive Colombo via northern Bay of Bengal                 |                                                       |
| 1 June (Sat.)            | Depart Colombo 6 (4)                                      |                                                       |
|                          | 23 days                                                   | Cox-Sclater                                           |
| 24 June (Mon.)           | Arrive Colombo, via north end Ninetyeast Ridge            |                                                       |
|                          | Partial (16 member) crew rotation                         |                                                       |
| 29 June (Sat.)           | Depart Colombo 6 (4)                                      |                                                       |
|                          | 29 days                                                   | Engel                                                 |
| 28 July (Sun.)           | Arrive Port Louis, via Ninetyeast Ridge                   |                                                       |
| 1 August (Thurs.)        | Depart Port Louis 5 (3)                                   |                                                       |
|                          | 28 days                                                   | Fisher                                                |
| 29 August (Thurs.)       | Arrive Port Louis, via Rodriguez Fracture Zone            |                                                       |
|                          | Partial (16 member) crew rotation                         |                                                       |
| 2 September (Mon.)       | Depart Port Louis 5 (3)                                   |                                                       |
|                          | 24 days                                                   | Fisher                                                |
| 26 September (Thurs.)    | Arrive Tamatave, via median ridge Y                       |                                                       |
| 29 September (Sun.)      | Depart Tamatave 4 (2)                                     |                                                       |
|                          | 8 days                                                    | Fisher                                                |
| 7 October (Mon.)         | Arrive Cape Town                                          |                                                       |
| 12 October (Sat.)        | Depart Cape Town 6 (4)                                    |                                                       |
|                          | 23 days                                                   | van Andel                                             |
| 4 November (Mon.)        | Arrive Luanda, via Walvis Ridge                           |                                                       |
| 8 November (Fri.)        | Depart Luanda 5 (3)                                       |                                                       |
|                          | 25 days                                                   | van Andel                                             |
| 3 December (Tues.)       | Arrive Fortaleza, via Mid-Atlantic Ridge                  |                                                       |
| 6 December (Fri.)        | Depart Fortaleza 4 (2)                                    |                                                       |
|                          | 17 days                                                   | Curray                                                |
| 23 December (Mon.)       | Arrive Colon                                              |                                                       |
| 6 January (Mon.)         | Depart Colon                                              |                                                       |
|                          | 16 days                                                   | Shepard                                               |
| 22 January (Wed.)        | Arrive Colon, via Magdalena River Fan                     |                                                       |
| 23–24 Jan. (Thurs.–Fri.) | Fuel, transit Canal                                       |                                                       |
| 25 January (Sat.)        | Depart Balboa (?)                                         |                                                       |
|                          | 23 days                                                   | Raff-Sclater                                          |
| 17 February (Mon.)       | Arrive Puntarenas, via Cocos Ridge-Galapagos-E. Pac. Rise |                                                       |
| 20 February              | Depart Puntarenas 4 (2)                                   |                                                       |

|                         |                  |  |
|-------------------------|------------------|--|
| (Thurs.)                |                  |  |
|                         | 21 days ?        |  |
| by 13 March<br>(Thurs.) | Arrive San Diego |  |

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### **Attachment 3: Tentative list of participants**

#### ***CIRCE EXPEDITION, 1968–69***

#### ***SCIENTIFIC PERSONNEL ABOARD R/V ARGO***

##### ***San Diego - Honolulu, 7–17 March***

###### ***San Diego - Honolulu, 7–17 March***

- 1. G. G. Shor, *Chief Scientist*
- 2. J. Cornelius
- 3. F. Dixon
- 4. J. Donovan
- 5. J. Earl
- 6. B. Johnson
- 7. A. Jones
- 8. J. Lucas
- 9. J. Mudie, United Kingdom (or M. Benson)
- 10. D. Newhouse
- 11. J. Pine
- 12. A. Rowe
- 13. W. Smith
- 14. L. Abbott (computer)
- 15. J. Bach (computer)
- 16. S. Morris (computer)
- 17. M. Smith (computer)
- 18. J. Edmond (s), United Kingdom
- 19. T. Osborn (s)

##### ***Honolulu - Penang, 20 March – 22 April***

###### ***Honolulu - Penang, 20 March – 22 April***

- 1. D. Karig (s), *Chief Scientist*
- 2. R. Busch
- 3. J. Cornelius
- 4. J. Earl
- 5. J. Pine
- 6. A. Rowe
- 7. W. Smith
- 8. J. Bach (computer)
- 9. V. Kolesnikov (computer)
- 10. M. Smith (computer)
- 11. J. Edmond (s), U.K.
- 12. J. Francheteau (s), France
- 13. E. Samora (computer)
- 14.

##### ***Penang - Colombo, 26 April – 27 May***

###### ***Penang - Colombo, 26 April – 27 May***

- 1. J. Curray, *Chief Scientist*
- 2. P. W. Benson, NEL

- 3. E. Coughran, IBM, SCR
- 4. P. Crampton
- 5. F. Emmel
- 6. E. Goldberg
- 7. R. Gowdy, NEL
- 8. G. Hohnhaus
- 9. W. Huckabay, NEL
- 10. M. Koide
- 11. D. Moore, NEL
- 12. L. O'Mara, NEL
- 13. J. Pine
- 14. V. Kolesnikov (computer)
- 15. J. Bach (computer)
- 16. . . . . (Magnavox Engr.)
- 17. J. Francheteau (s), France

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***Colombo - Colombo, 1–24 June***

*Colombo - Colombo, 1–24 June*

- 1. C. Cox, *Chief Scientist*
- 2. J. Coatsworth
- 3. P. Crampton (or L. O'Mara)
- 4. F. Dixon
- 5. D. McKenzie, U.K.
- 6. J. Pine
- 7. J. Sclater
- 8. C. Worrall
- 9. L. Abbott (computer)
- 10. M. Smith (computer)
- 11. S. P. Srivastava, Canada
- 12. T. Atwater (s)
- 13. J. Francheteau (s)
- 14. B. Hickey (s), Canada
- 15. D. Summerville (s)

***Colombo - Port Louis, 29 June – 28 July***

*Colombo - Port Louis, 29 June – 28 July*

- 1. A. E. Engel, *Chief Scientist*
- 2. J. Coatsworth
- 3. F. Dixon
- 4. H. Sammulu
- 5. C. Worrall
- 6. L. Abbott (computer)
- 7. M. Smith (computer)
- 8. S. Anderson (s)
- 9. J. Francheteau (s) -?
- 10. R. Huggett (s)
- 11. T. Johnson (s)
- 12. D. Summerville (s)
- 13.
- 14.

***Port Louis - Port Louis, 1–29 August***

*Port Louis - Port Louis, 1–29 August*

- 1. R. L. Fisher, *Chief Scientist*
- 2. J. Coatsworth
- 3. J. Donovan
- 4. R. Mann
- 5. H. Sammuli
- 6. J. Wadsworth, U.K., Univ. of Manchester
- 7. C. Worrall
- 8. S. Morris (computer)
- 9. . . . . (computer)
- 10. T. Atwater (s)
- 11. S. Anderson (s)
- 12. B. Hickey (s), Canada
- 13. R. Huggett (s)
- 14. T. Johnson (s)
- 15. D. Summerville (s)

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***Port Lois - Tamatave, 2 – 26 September***

*Port Lois - Tamatave, 2 – 26 September*

- 1. R. L. Fisher, *Chief Scientist*
- 2. J. Coatsworth
- 3. J. Donovan
- 4. R. Mann
- 5. A. Rowe
- 6. C. Worrall
- 7. S. Morris (computer)
- 8. . . . . (computer)
- 9. T. Atwater (s)
- 10. B. Hickey (s), Canada
- 11. S. Anderson (s)
- 12. T. Johnson (s)
- 13. . . . . (U.K., Univ. of Manchester)
- 14.

***Tamatave - Cape Town, 29 September – 7 October***

*Tamatave - Cape Town, 29 September – 7 October*

- 1. R. L. Fisher, *Chief Scientist*
- 2. J. Coatsworth
- 3. J. Donovan
- 4. R. Mann
- 5. J. Mudie, U.K.
- 6. A. Rowe
- 7. C. Worrall
- 8. S. Morris (computer)
- 9. . . . . (computer)
- 10.
- 11.
- 12.

***Cape Town - Luanda, 12 October – 4 November***

*Cape Town - Luanda, 12 October – 4 November*

- 1. Tj. H. van Andel, *Chief Scientist* [1]
- 2. R. Beer [1]

- 3. W. H. Blow, British Petroleum, U.K.
- 4. V. T. Bowen, WHOI
- 5. S. E. Calvert, Univ. of Edinburgh
- 6. G. Hohnhaus
- 7. J. Mudie, U.K.
- 8. M. J. Orren, Univ. of Cape Town
- 9. N. Price, Univ. of Edinburgh
- 10. R. Scheltema, WHOI, Netherlands
- 11. B. Schroeder, WHOI
- 12. A. Rowe
- 13. C. Worrall
- 14. L. Abbott (computer)
- 15. . . . . (computer)
- 16. J. Edmond (s), U.K.
- 17. G. R. Heath (s), Australia<sup>[\*]</sup>
- 18. T. C. Moore (s)<sup>[\*]</sup>

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***Luanda - Fortaleza, 8 November – 3 December***

*Luanda - Fortaleza, 8 November – 3 December*

- 1. Tj. H. van Andel, *Chief Scientist*
- 2. R. Beer
- 3. W. H. Blow, British Petroleum, U.K.
- 4. V. T. Bowen, WHOI
- 5. J. Coatsworth
- 6. W. G. Melson, WHOI -?
- 7. A. Rowe
- 8. B. Schreder, WHOI
- 9. L. Abbott (computer)
- 10. G. R. Heath (s), Australia
- 11. T. C. Moore (s)
- 12. J. Edmond (s), U.K.
- 13. G. Hohnhaus
- 14. . . . . (computer)
- 15. C. Worrall

***Fortaleza - Colon, 6 – 23 December***

*Fortaleza - Colon, 6 – 23 December*

- 1. J. Curray, *Chief Scientist*
- 2. J. Coatsworth
- 3. P. Crampton
- 4. F. Emmel
- 5. A. Rowe
- 6. V. Kolesnikov (computer)
- 7. J. Bach (computer)
- 8. W. Normark (s)
- 9.
- 10.
- 11.
- 12.

***Colon - Colon, 6 – 22 January 1969***

*Colon - Colon, 6 – 22 January 1969*

- 1. F. P. Shepard, *Chief Scientist*
- 2. E. Shepard
- 3. J. Coatsworth
- 4. N. Marshall
- 5. ....(airgun tech.)
- 6. V. Kolesnikov (computer)
- 7. J. Bach (computer)
- 8. J. Roselius, Colombia
- 9.
- 10.
- 11.
- 12.

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***Balboa - Puntarenas, 25 January – 17 February***

*Balboa - Puntarenas, 25 January – 17 February*

- 1. A. D. Raff, *Chief Scientist*
- 2. J. Coatsworth
- 3. C. G. A. Harrison, U.K., Univ. of Miami -?
- 4. J. G. Sclater, U.K.
- 5. .... (airgun tech.)
- 6. S. Morris (computer)
- 7. M. Smith (computer)
- 8. .... (geol. tech.)
- 9. .... (student)
- 10. .... (student)
- 11.
- 12.

***Puntarenas - San Diego, 20 February – 13 March***

*Puntarenas - San Diego, 20 February – 13 March*

- 1. J. G. Sclater, U.K., *Chief Scientist*
- 2. J. Coatsworth
- 3. C. G. A. Harrison, U.K., Univ. of Miami -?
- 4. A. D. Raff -?
- 5. .... (airgun tech.)
- 6. S. Morris (computer)
- 7. M. Smith (computer)
- 8. .... (geol. tech.)
- 9.
- 10.
- 11.
- 12.

## Footnotes

1. Address after June, 1968: Department of Oceanography, Oregon State University, Corvallis, Oregon 97331