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Caribbean Atlantic Geotraverse, NOAA-IDOE 1971, Report No. 1, Project Introduction - Bathymetry

G. PETER
G. MERRILL
S. BUSH

BOULDER, COLO.
OCTOBER 1973

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Frederick B. Dent, Secretary

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
Robert M. White, Administrator
ENVIRONMENTAL RESEARCH LABORATORIES
Wilmot N. Hess, Director

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CARIBBEAN ATLANTIC GEOTRAVERSE,
NOAA-IDOE 1971,
REPORT NO. 1, PROJECT INTRODUCTION—BATHYMETRY

G. Peter, G. Merrill, and S. Bush

Studies of the Lesser Antilles Island Arc, the adjacent Atlantic Basin, and the Mid-Atlantic Ridge were performed in 1971 as part of the NOAA-IDOE-supported Caribbean Atlantic Geotraverse (CAG) project. During these investigations, approximately 30,000 km of bathymetric, magnetic, and gravity data and 1,500 km of seismic reflection data were collected in an area bordered by latitudes 14° and 17°30'N and by longitudes 42° and 62°W.

Bathymetric investigations of this project established that: (a) the Barracuda Ridge is an isolated feature which does not extend to the Mid-Atlantic Ridge; (b) another ridge system exists east-southeast of the Barracuda Ridge which was named the Researcher Ridge after the survey ship; (c) a "typical" Mid-Atlantic Ridge topography extends from the northern Atlantic to the east of the Lesser Antilles Island Arc; and (d) east-west-trending topographic lineaments suggest faulting of the Atlantic Basin east of the Barbados Ridge.

Magnetic and gravity studies confirmed the findings above and established that, during the Tertiary, the development of the Mid-Atlantic Ridge in the study area was similar to that of the rest of the North Atlantic.

This report contains: (1) the introduction of the CAG project; (2) a summary of the major accomplishments; (3) a description of the bathymetric data; and (4) a presentation of data profiles and an interpretive bathymetric contour map. Similar treatments of the magnetic and gravity data are contained in *Caribbean Atlantic Geotraverse Report No. 2* and *Report No. 3*, respectively.

INTRODUCTION

The Caribbean Atlantic Geotraverse (CAG) project outlined a series of studies which required a systematic geophysical data coverage between the Lesser Antilles Island Arc and the Mid-Atlantic Ridge. To establish this high-density geophysical data traverse and to test the "Funnel-Smith" (1968) hypothesis, support for 3 years was requested from the National Science Foundation Office for the International Decade of Ocean Exploration (NSF-IDOE). The work was planned to provide the first phase in a series of systematic scientific investigations directly north of the equatorial Atlantic region where fracture zones and a generally complex tectonic pattern made the interpretation of existing geophysical data difficult. The proposed studies were designed to provide critical tests of working models that are generally proposed to explain the evolution of the Atlantic and Caribbean Basins.

NOAA received only 1-year support from NSF-IDOE, and the project commenced in 1971 aboard the NOAA ship *Researcher*. Because of the reduced support, a system of east-west-oriented tracklines, spaced 38 km apart, was established in an area bordered by longitudes 42° and 62°W and by latitudes 14° and 17°30'N (fig. 1). The distance between the north-south tielines varied between 200 and 360 km. Four north-south crosslines were extended southward to about latitude 10°N to provide reconnaissance information for future investigations.

Processed and original data collected during this project are available from the NOAA National Geophysical and Solar-Terrestrial Data Center (NGSDC) in Boulder, Colo. This report contains the introduction of the project, its scientific objectives and major results, and the description of the bathymetric data acquisition and processing methods. The appendix contains a series of bathymetric profiles which provide an easy overview of the data. Introduction and presentation of the magnetic and gravity data are contained in *Report No. 2* (Peter et al., 1973a) and *Report No. 3* (Dorman et al., 1973), respectively. Copies of the seismic data are available from NGSDC. These data serve as the basis for a number of interpretive publications presently in preparation.

SCIENTIFIC OBJECTIVES

The overall objective of this study was the establishment of the regional geophysical and geological trends between the islands of the Lesser Antilles Arc and the Mid-Atlantic Ridge. Under this broad definition, the following specific objectives were sought.

(1) To establish the magnetic anomaly pattern south of the Barracuda fault to test the Funnell and Smith (1968) hypothesis and to gain insight into the evolution of the Atlantic Basin east of the Lesser Antilles Island Arc.

(2) To study the crustal structure of the Atlantic Basin east of the island arc both in terms of the evolution of the area and the proposed underthrust (Chase and Bunce, 1969) of the Atlantic floor beneath the Lesser Antilles Island Arc.

(3) To examine the Desirade fault and its possible relation to the Barracuda fault.

(4) To study the transition zone between the Puerto Rico Trench and the Barbados Ridge. The possible role of the Barracuda fault zone, forming an abrupt structural barrier of the trench as opposed to the gradual termination of the trench caused by increasing sediment fill toward the south, was to be established.

(5) To study the possible relation between the east-west faults of the Atlantic Basin and those similar faults intersecting the Lesser Antilles Island Arc.

BATHYMETRIC DATA INSTRUMENTATION AND ACQUISITION

Bathymetric data were recorded aboard the *Researcher* along approximately 30,000 km of trackline. The principal sounding system aboard consisted of 12-kHz Harris narrow-beam echo sounder with a 3°-wide single-vertical effective beam. Progressive electronic failure necessitated the use of a conventional (60° beam width) sounding system during the second half of the cruise (profile 28 onward; fig. 1).

During the use of the narrow beam system, the depths were sampled automatically and stored in the shipboard computer with other geophysical data at 1-minute intervals. When using the wide-beam sound source, 5-minute values as well as peaks and troughs were manually entered into the shipboard computer system and stored on the raw-data tape. Spurious values were later checked and edited out or corrected on a processed data tape aboard the *Researcher*.

DATA REDUCTION

Data reduction in the laboratory consisted of: (1) further editing of the processed data tape to obtain data at 5-minute intervals, plus the peaks and troughs; (2) keypunching on cards and adding to the data file the bathymetric highs, lows, and the inflection points that were missed previously; and (3) merging the smooth navigation tape with the data tape and computing the geographical coordinates for each data point.

A final data tape was provided that contained the following information: (1) index number; (2) Julian day (JD); (3) Greenwich Mean Time—GMT (hour, minute, and 0.1 minute); (4) latitude; (5) longitude (items (4) and (5) in degrees and decimal fractions); (6) nautical miles traveled; (7) kilometers traveled; (8) uncorrected fathoms; (9) correct fathoms; and (10) corrected meters.

Velocity corrections were computed from the Matthews Tables. The limits of this project fall within four echo-sounding areas: 11, 12, 16, and 19. Corrections for these areas were plotted and, because of the great similarity noted, an average velocity correction curve was drawn for the entire study area. The corrections applied are indicated in table 1. From the final processed data tapes, data listings and displays were prepared.

NAVIGATION

The position of the *Researcher* during this project was controlled by an SRN-9 satellite navigation system (Guier, 1966). Fixes from the satellites were available on the average of about every 2 hours. Between the satellite fixes, the shipboard computer interpolated dead-reckoning positions, based on the previous satellite data, on new input of course and speed information when pertinent, and on Loran-C data.

Table 1. Depth corrections applied to sounding data

Depth in fathoms	Correction
0 to 400	0 to 11
400 to 1,200	11 to 27
1,200 to 1,800	27 to 46
1,800 to 2,500	46 to 77
2,500 to 2,800	77 to 98
2,800 to 3,600	98 to 128

The satellite navigation system was inoperative between JD 295 and JD 302. During this interval, a combination of Loran-C, Omega, and star fixes provided the navigation control.

A position data tape of the ship and computer plots of the tracklines were provided by the ship at each port stop.

DATA DISPLAY

In the appendix, bathymetric profiles are shown in corrected meters. Depths are plotted against latitude or longitude, depending on the dominant heading of the profile. The scales are such that the vertical exaggeration of the bathymetry is approximately 50:1. Index numbers on the profiles refer to the trackline chart (fig. 1) where the location of each profile is indicated. Table 2 gives the time intervals for each profile that will be helpful in requesting specific data from NGSDC.

An interpretive bathymetric contour map is included in this report as figure 2. During the preparation of the map, other data available for this area were also consulted (Collette and Rutten, 1972) and were incorporated when they did not contradict *Researcher* data. Over the Mid-Atlantic Ridge, the rapidly changing topography clearly demonstrated the inadequacy of the 38-km east-west line spacing. While admittedly other interpretations are possible, the authors believe that their presentation is consistent, and that it complements other maps and data available for this area.

Table 2. Profile start and stop times for Project RP-12-RE-71

Profile number	Start JD	Start Time	Stop JD	Stop Time
1	261	0800	262	0130
2	262	0405	263	1515
3	263	2330	264	1740
4	264	1835	265	1230
5	265	1420	266	0600
6	266	1010	266	1620
7	266	1625	267	0740
8	267	0745	267	1610
9	267	1615	268	2200
10	268	2205	269	1330
11	269	2125	270	1240
12	270	1245	271	0420
13	271	0425	271	1920
14	271	1925	272	0310
15	272	1315	272	1320
16	272	1325	274	1005
17	274	1010	274	1535
18	274	1540	274	2240
19	274	2245	275	1730
20	275	1835	276	2240
21	276	2245	277	0815
22	277	0820	277	1400
23	277	1405	279	1710
24	279	1725	279	2200
25	279	2205	280	1230
26	280	1505	280	1910
27	280	1915	281	0055
28	286	0100	286	0830
29	286	0905	290	2040
30	290	2300	294	1505
31	294	1717.5	299	0100
32	299	0240	302	0555
33	306	2115	309	2240
34	310	0015	312	1645
35	312	2230	315	1835
36	315	2005	318	1710
37	318	1715	320	1830
38	320	2000	322	1650

DISCUSSION OF RESULTS

The CAG project successfully accomplished the majority of the pre-set scientific objectives. Although the shorter timespan of the project did not allow for planned high-density data acquisition, sufficient data were obtained to establish the magnetic anomaly pattern in the study area. This pattern suggested that the Cenozoic evolution of the Mid-Atlantic Ridge east of the Lesser Antilles Arc was essentially similar to that of the rest of the North Atlantic (Lattimore et al., 1973; Peter et al., 1973b; and Peter et al., 1973c).

North of the Barbados Ridge, several seismic profiles show that the Atlantic basement (second layer) and the entire overlying sediment column dip below and eventually are overlain by apparent slump material from the island arc. This sediment column appears undisturbed several kilometers west of the Puerto Rico Trench (its southeastward extension) without any indication that the column is in the process of being "scraped off" due to the commonly proposed underthrust of the sea floor below the island arc.

We found that the northern boundary fault of the Barracuda Ridge can be extended west-northwestward. No connection was observed, however, between it and the Desirade fault (Schubert and Peter, 1973). The seismic reflection work was unsuccessful in providing a definitive answer to this question and to the question of the nature of the transition zone between the Puerto Rico Trench and the Barbados Ridge. The lack of success is attributable to the combination of the following: (1) The sediments covering this part of the sea floor underwent repeated slumping and became so deformed that they are devoid of reflecting horizons; (2) the sediments below the sea floor consist of uniform, dense material that quickly absorbs all acoustic energy; and (3) the basement is so deep that it is beyond the capacity of our seismic system. The topography of the sea floor does suggest, however, that the transition is structurally controlled.

Numerous faults have been observed east of the Lesser Antilles Arc both in the bathymetric and seismic data. Further careful studies are required to establish whether these faults are related in any way to similar east-west-oriented faults noted on the Barbados Ridge.

The bathymetric map (fig. 2) clearly shows the Mid-Atlantic Ridge province, the Demerara and Barracuda abyssal plains to the west of the ridge province, and the complex topography of the Barbados Ridge. The axis of the Mid-Atlantic Ridge is indicated by heavy arrows; the offset of the ridge crest is along the 15°20'N fault zone (Collette and Rutten, 1972). North of this fault, the depression following the same trend is the Royal Deep (Collette and Rutten); to the south of the fault zone, the elongated trough is the Researcher fault zone (Lattimore et al., 1973; Peter et al., 1973b; and Peter et al., 1973c). Directly south of this fault trough, between longitudes 48° and 51°30'W, lies a complex ridge system which we have named the Research Ridge (Lattimore et al., 1973; and Peter et al., 1973b, and 1973c).

The clearest evidence of the inadequacy of the 38-km east-west trackline spacing is shown between the Royal Deep and the Researcher Ridge. We expect that the topography in this area is just as complex as the flank of the Mid-Atlantic Ridge north of the Royal Deep. Within this same area the westward extension of the Royal Deep, the 15°20'N fault zone, and the Researcher fault zone to approximately longitude 51°W is permitted by available data; however, because we had only a few north-south lines available to establish this trend, it is possible that a more detailed survey would indicate that the termination of these features is closer to the crest of the Mid-Atlantic Ridge than is indicated in figure 2.

The contours in the area between longitudes 41° and 54°W are also ambiguous because, outside of the Researcher Ridge, the relatively subdued topography can be contoured with a north-south trend (as shown) or with a trend parallel to the Researcher Ridge. The contours in figure 2 were adopted after careful studies of these alternatives and of the broader, more regional bathymetric trends.

A somewhat unexpected result of the bathymetric survey involves the Barracuda Ridge (located between long. 54° and 59°W and lat. 16°30' and 17°N). It had generally been assumed that this feature is part of a major transform fault cutting across the Atlantic Basin. Our results indicate that the Barracuda Ridge is an isolated feature, without any obvious extension toward the east-southeast to the flank of the Mid-Atlantic Ridge. A closer look at the bathymetric contours suggests that both the Barracuda and Researcher Ridges contain east-west-trending components which are probably the results of east-west faults. Seismic as well as magnetic data support this conclusion, with correlations of the major east-west bathymetric trends either with normal faulting or with major offsets of the magnetic lineations (Lattimore et al., 1973; Peter et al., 1973b; and Peter et al., 1973c).

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REFERENCES

Chase, R. L., and E. T. Bunce (1969): Underthrusting of the eastern margin of the Antilles by the floor of the western North Atlantic Ocean, and origin of the Barbados Ridge, *J. Geophys. Res.* 74(6): 1413-1420.

Collette, B. J., and K. W. Rutten (1972): Crest and fracture zone geometry of the Mid-Atlantic Ridge between 10° and 16°N, *Nature Phys. Sci.* 237(78): 131-134.

Dorman, L. M., B. G. Bassinger, E. Bernard, S. A. Bush, O. E. DeWald, L. A. Lapine, R. K. Lattimore, and G. Peter (1973): Caribbean Atlantic Geotraverse, NOAA-IDOE 1971, Report No. 3, Geodesy, *NOAA Tech. Rept.* ERL 277-AOML 11, 35 pp.

Funnell, B. M., and A. G. Smith (1968): Opening of the Atlantic Ocean, *Nature* 219(5161): 1328-1333.

Guier, W. H. (1966): Satellite navigation using integral Doppler data—the AN/SRN-9 equipment, *J. Geophys. Res.* 71(24): 5903-5910.

Lattimore, R. K., O. E. DeWald, and G. Peter (1973): NOAA-IDOE equatorial Mid-Atlantic Ridge investigations (abstract), *EOS, Trans. Am. Geophys. Union* 54(4): 326.

Peter, G., O. E. DeWald, and B. G. Bassinger (1973a): Caribbean Atlantic Geotraverse, NOAA-IDOE 1971, Report No. 2, Magnetic Data, *NOAA Tech. Rept.* ERL 288-AOML 12, 19 pp.

Peter G., O. E. DeWald, G. Merrill, and L. M. Dorman (1973b): NOAA/IDOE equatorial Atlantic studies 1971 (abstract), *EOS, Trans. Am. Geophys. Union* 54(4): 326.

Peter, G., R. K. Lattimore, O. E. DeWald, and G. Merrill (1973c): Development of the Mid-Atlantic Ridge east of the Lesser Antilles Island Arc, *Nature Phys. Sci.* 245(148): 129-131.

Schubert, C., and G. Peter (1973): Sea floor tectonics west of the Barracuda Ridge (abstract), *EOS, Trans. Am. Geophys. Union* 54(4): 326.