THE PROBLEM OF THE BARTLETT TROUGH

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ABSTRACT

Little is known concerning the great submarine troughs, although they must be classed among the major tectonic features of the earth. The Bartlett Trough offers many advantages for purposes of research. The present status of the problem is here briefly outlined and methods are suggested for continuing the investigation of its origin and structure.

INTRODUCTION

The great submarine troughs are topographic features comparable in magnitude with mountain ranges. Some of the more important are closely paralleled by ranges and there is much evidence of a close genetic relationship between them. Any theory attempting to explain the major structural features of the earth as a whole must take into consideration the great troughs. While geologists have given much study to mountains, the troughs have been relatively neglected. Several theories have been advanced to explain their origin, but very few facts are known; and, as yet, no accurate detailed contour map has been constructed for one of the major troughs. It is, perhaps, more than probable that they have been formed in several different ways.

In recent years new methods have been developed which will be of great aid in the investigation of deep submarine areas. They include the seismograph for the location of earthquake loci, the method of echo sounding for rapidly mapping submarine topography, and a method of accurately determining gravity at sea. Therefore, the time seems ripe to begin a concerted attack on the problem of the great submarine troughs.

The ideal trough for purposes of study should have land areas on both sides and at the ends, so that from a study of the structural geology of the surrounding region something can be inferred regarding the structure of the trough. It should be of recent origin and should have no streams carrying terrigenous materials into it, which would mask topography developed by tectonic processes. Of all the

troughs, probably the Bartlett Trough most closely approaches this ideal, and, therefore, offers the best opportunity for research (see Fig. 1).

THE BARTLETT TROUGH

The Bartlett Trough extends in a flat arc, convex toward the north, from the Gulf of Honduras eastward as far as Gonaive Gulf between the two western peninsulas of Haiti, a distance of 15°, or 1,570 kilometers. It is about 1.5° (160 kilometers) in maximum width and the deepest sounding is 3,506 fathoms (6,412 meters), or over 8,275 meters below the higher peaks of the Sierra Maestra in Cuba and the Blue Mountains in Jamaica.

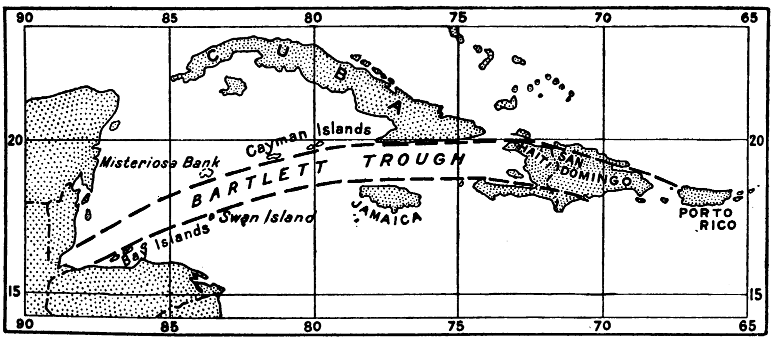

FIG. 1.—Map of the Greater Antilles showing unstable zones enclosing the Bartlett Trough.

It is now generally agreed that the Bartlett Trough, as well as similar features elsewhere, is tectonic in origin. There has, however, been considerable difference of opinion as to the relative importance of folding and faulting in the formation of the Bartlett Trough. Also, as to whether the faults are normal or thrust faults; whether the formative stresses acted vertically or tangentially.

It is probable that structures of this magnitude are seldom, if ever, formed exclusively by folding or by faulting. Moreover, with a feature that is so persistent, it would not be surprising to find some variation in the structure and history of the areas through which it extends. And, since little geological work has been done on the land areas bordering the trough, it may readily be understood why the evidence that has been published is somewhat conflicting.

ORIGIN AND STRUCTURE

The evidence bearing on the origin and structure of the trough may be briefly summarized under four headings.

1. *Seismological evidence.*—Nearly all of the earthquakes of high intensity recorded in the land areas around the Bartlett Trough, during the last four centuries, have had their origin in one or the other of two belts: one following close to the northern border of the trough along the south coast of Cuba and thence across the Island of Haiti by way of its great northern valley; the other following the southern margin of the trough past the north coast of Jamaica and across the Island of Haiti by way of the great southern valley.[1]

This localization of seismic activity is especially noticeable in Cuba where a large land area, that has been settled for several centuries, extends away from the trough in a northwesterly direction. The earthquakes are proof that faulting is going on in these belts at the present time, and the sea waves, that have accompanied many of the shocks, are indicative of vertical displacements. Little is known concerning the distribution of earthquakes at a distance from the land areas, but, through seismograph records, the position of such shocks may be determined in the future.

Seismograph stations are now located at Port-au-Prince, Haiti; Kingston, Jamaica; Havana, Cuba; Merida, Mexico; and other places more distant from the trough. It would help if seismographs could be installed at Santiago, Cuba, and on Grand Cayman Island.

2. *Topographic evidence.*—The precipitous scarps on both sides of the trough and the abrupt changes in slope indicate faulting rather than folding. The scarp terminating the great submarine plateau that connects Jamaica with Honduras is especially striking, for flat areas are very extensive both above and below it. The soundings now available indicate the presence of large flat areas over much of the central part of the trough, with ridges and subsidiary troughs near the base of the boundary scarps. The two belts of subsidiary troughs apparently continue eastward beyond the Bartlett Trough,

[1] Stephen Taber, "Jamaica Earthquakes and the Bartlett Trough," *Bull. Seis. Soc. Amer.*, Vol. X (1920), pp. 55–89; "The Great Fault Troughs of the Antilles," *Jour. Geol.*, Vol. XXX (1922), pp. 89–114; "The Seismic Belt in the Greater Antilles," *Bull. Seis. Soc. Amer.*, Vol. XII (1922), pp. 199–219.

and, on the Island of Haiti, are represented by the great northern and southern valleys. They coincide with the belts of high seismicity. The deepest soundings recorded in the Bartlett Trough have been obtained in the depressions near the boundary scarps.

Closely spaced soundings over the boundary zones should reveal the shape of the submerged ridges and, perhaps, determine whether they are tilted fault blocks, such as have been found near Santiago, Cuba. On land, it would be possible to observe and photograph the topographic results of block faulting from airplanes where these features are as freshly exposed as they are in the Santiago area. In areas that are as difficult of access as is most of the Sierra Maestra, this would be the easiest method of obtaining such data.

3. *Geological evidence.*—Almost no detailed studies have been made of the structural geology of the land areas immediately adjacent to the Bartlett Trough. The Sierra Maestra has usually been attributed to folding, and this view has been advocated recently by Woodring.[1] In the vicinity of Guantánamo Darton has mapped a broad synclinal basin opening toward the east.[2] In the Santiago area the writer has mapped tilted fault blocks and found additional geological evidence of recent faulting. Practically no work has been done on the tectonics of the north coast of Jamaica.

As a result of his geological reconnaissance in Haiti, Woodring reached the conclusion that the tectonic features of a large part of that republic are due to the folding and crumpling during Miocene and Pliocene times.[3] He thinks that the great valleys of Haiti, including the Cul-de-Sac plain, are synclines bounded in part by high-angle thrust faults; and he suggests that the Bartlett Trough was likewise deepened, if not formed, by compressive forces at the close of Miocene time and during Pliocene time.[4]

[1] W. P. Woodring, "Tectonic Features of the Caribbean Region," *Third Pan-Pacific Sci. Cong., Tokyo* (1926), pp. 401–31.

[2] N. H. Darton, "Geology of the Guantánamo Basin, Cuba," *Jour. Wash. Acad. Sci.*, Vol. XVI (1926), pp. 324–33.

[3] W. P. Woodring, J. S. Brown, and W. S. Burbank, "Geology of the Republic of Haiti," *Port-au-Prince* (1924), pp. 331–32.

[4] W. P. Woodring, "An Outline of the Results of a Geological Reconnaissance of the Republic of Haiti," *Jour. Wash. Acad. Sci.*, Vol. XIII (1923), pp. 117–29; "Tectonic Features of the Republic of Haiti and Their Bearing on the Geologic History of the West Indies," *Jour. Wash. Acad. Sci.*, Vol. XIV (1924), pp. 58–59.

Although Southern Cuba was uplifted in late Tertiary time, the writer believes that the present topography of the Sierra Maestra is largely due to tectonic activity during post-Pliocene time.

One of the most interesting results of the geological investigations carried out in the Greater Antilles during the last few decades has been the gradual appreciation of the great extent and importance of the volcanic materials piled upon the earth's surface during Cretaceous and Tertiary time. In some areas, as in Haiti, this material consists mostly of lava flows; and in other areas, as in Cuba and Porto Rico, it is chiefly volcanic *ejectamenta.* The total volume is enormous, and it is inconceivable that so much material could be brought up from the interior of the earth and deposited on the surface without some accompanying or subsequent subsidence of the surface. Moreover, the superficial, volcanic activity has probably been associated with deep-seated differentiation and crystallization of magmas, which have resulted in additional volume changes. It seems not unlikely that in a broad way there is some genetic relationship between the tectonic movements of the region and the igneous activity.

4. *Evidence from gravity anomalies.*—The United States Coast and Geodetic Survey has made three gravity measurements, in the eastern part of Cuba, at Alto Cedro, Cayo Mambi, and Chaparra, where the isostatic anomalies, as deduced from the Bowie formula, are +65, +73, and −48 millidynes, respectively.

Two profiles with gravity determinations were made near the eastern end of the Bartlett Trough during the cruise of the U.S. Submarine S-21, in 1928.[1] One profile extends from the entrance of Santiago Bay in a southerly direction for 52 miles. At depths of 5, 2,867, and 1,582 fathoms, the gravity anomaly values were +16, −57, and −4 millidynes. Along the other profile, located about 80 miles west of Santiago Bay, at depths of 942, 3,770, 2,530, and 1,737 fathoms, the gravity anomalies were +55, +20, +29, and +33. The results obtained from these two profiles are conflicting and additional observations will have to be made before it is possible to draw any conclusions.

[1] F. A. V. Meinesz and F. E. Wright, "The Gravity Measuring Cruise of the U.S. Submarine S-21," *Pub. U.S. Nav. Observ.*, 2d Ser., Vol. XIII; Appendix I (Washington, 1930), pp. x+94.

Large negative anomalies (−121, −103, −165, −109, −114, −35, and −45) were obtained in the Brownson Trough and its westward extension north of the islands of Haiti and Cuba. Earthquakes have been rather numerous along the steep slopes of the Brownson Trough, but no important shocks are known to have originated in its westward extension along the coasts of Haiti and Cuba during the last four centuries. The contrast in seismicity is very great between the north and south coasts of the province of Oriente in Cuba, or of the north coast of San Domingo and its great northern valley.

In the region of the Greater Antilles, therefore, great caution should be used in trying to determine unstable areas by means of gravity measurements; and, certainly, more observations are essential before it will be possible to draw valid conclusions.

The origin and structure of the Bartlett Trough is a big problem that will require the co-operation of geologists, geodesists, and seismologists.