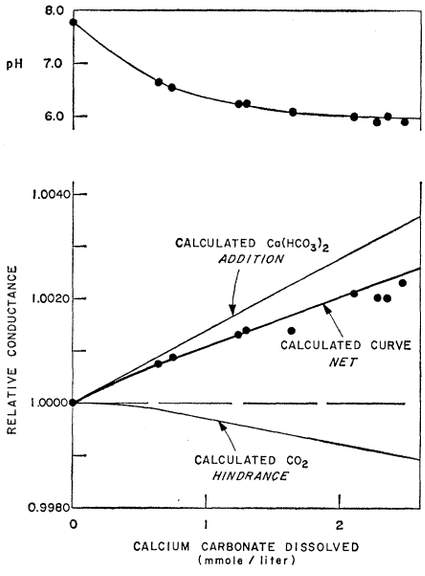

Fig. 1. Changes in *p*H and electrical conductance of sea water with calcium carbonate dissolution.

bicarbonate conductance data (*1*) may be used to show that replacing one equivalent of carbonate by bicarbonate will increase the specific conductance by 2.4×10^{-2} $ohm^{-1}cm^{-1}$ (*2*). Since the initial carbonate ion concentration was calculated to be only 13×10^{-5} mole/liter, the maximum specific conductance change by the transformation would be 6×10^{-6} $ohm^{-1}cm^{-1}$, which is 0.01 percent of the specific conductance of the sea water. This transformation effect is much smaller than the calcium bicarbonate effect on the conductance.

The effect of uncharged carbon dioxide on the decrease in conductance (*4*) was reported to be approximately 0.013 percent per millimole of carbon dioxide in a liter of sea water (*2*). In this experiment, the molecular carbon dioxide concentration was calculated from the carbonate alkalinity, the *p*H, and the apparent dissociation constants of carbonic acid in sea water. Independent gas chromatographic determination of total carbon dioxide (*5*), instead of carbonate alkalinity, gave similar calculated values for the concentration of molecular carbon dioxide. The calculated decrease in conductance due to the addition of uncharged carbon dioxide is shown in the lower part of Fig. 1 as a function of calcium carbonate dissolved.

The net conductance change by this experiment is the summation of the three effects already described. This is shown by the calculated net curve in Fig. 1. The observed values agree fairly well with the calculated curve.

In the world oceans, specific alkalinity (the ratio of alkalinity to chlorinity) generally increases with depth, and has a range of about 0.12 to 0.13 meq/g (*6*). If we assume the observed specific alkalinity increase is mainly due to the dissolution of calcium carbonate (*7*), then the maximum dissolution of carbonate is about 0.1 millimole per liter of sea water for deep sea water.

The *p*H of sea water is generally in the range of 7.6 to 8.3. In the deep sea, the *p*H range narrows to below 8. At such *p*H, most of the carbonate ion formed from the dissolution of calcium carbonate is transformed into bicarbonate. Therefore, the conductance increase from the carbonate dissolution can be interpreted as the introduction of calcium bicarbonate into sea water. The effect of uncharged carbon dioxide may be neglected because it is quite small at *p*H near 8. The maximum conductance change due to the dissolution of calcium carbonate in the present oceans, therefore, may be as large as 0.014 percent of the conductance of sea water. When conductivity measurements are used to estimate salinity, this calculated change will correspond to about 0.006 parts per thousand.

KILHO PARK

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4. The exact mechanism of the effect of uncharged carbon dioxide on the conductance of sea water has not been elucidated experimentally. In earlier paper (*2*), we attempted to explain the mechanism by partial molar volume of carbon dioxide.
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7. Most of calcium carbonate deposition in the world oceans is biological. Therefore the dissolution of organogenic calcium carbonate is not a simple process, since most carbonate crystals are embedded in organic matter. However, increase in specific alkalinity in deep sea appears mainly due to the dissolution of carbonate, which is supported by disappearance of calcium carbonate crystals with increase of depth. J. Murray and J. Højort [*The Depth of the Oceans* (Macmillan, London, 1912), p. 173] observed that approximately 90 percent of the calcium carbonate deposit from the shell of pelagic organisms remain in the deposit around a depth of 1500 m, 66 percent at 3500 m, 20 percent at 5000 m, and 1 percent at 7000 m, respectively. Their observation indicates that organogenic calcium carbonate is being dissolved in deep sea.
8. Supported by NSF grants GP-2232 and GP-2876 and by Office of Naval Research contract Nonr 1286(10), Project NR 083-102.

29 July 1964

Guinea Fracture Zone in the Equatorial Atlantic

Abstract. *The east-west Guinea fracture zone is situated off Sierra Leone, West Africa. The estimated topographic left lateral displacement is about 230 kilometers. This fracture zone is the eastern analog of the Vema fracture zone, with its associated troughs, and of the Barracuda Fault. The Guinea fracture zone marks the northern boundary on the African coast of a wide zone of left lateral shear in the equatorial Atlantic.*

Fracture zones characterize the eastern Pacific (*1*, *2*), and it has been reported (*3*, *4*) that in the Atlantic there are fracture zones in the region of the Mid-Atlantic Ridge, especially near the Equator. Heezen *et al.* (*3*) postulate that the Mid-Atlantic Ridge has been offset in a left lateral direction

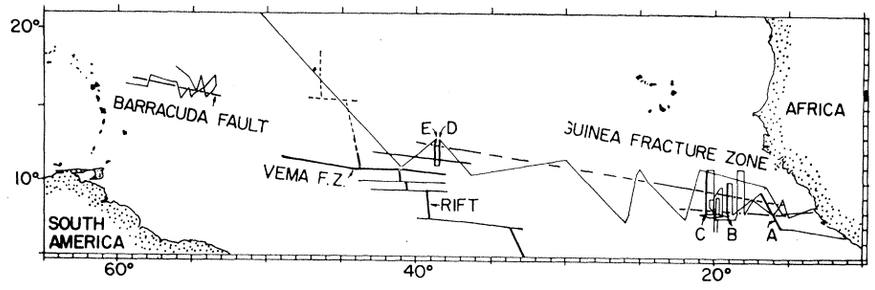

Fig. 1. Some of the structures in the equatorial region of the Atlantic Ocean. Lines at the Guinea fracture zone show approximate limits of this zone. Lines near Vema fracture zone show additional troughs along the north-south rift in the crest of the Mid-Atlantic Ridge. Lines are dashed where uncertain. Survey tracks of the R.V. *Trident* are shown. Letters refer to the profiles shown in Fig. 3.

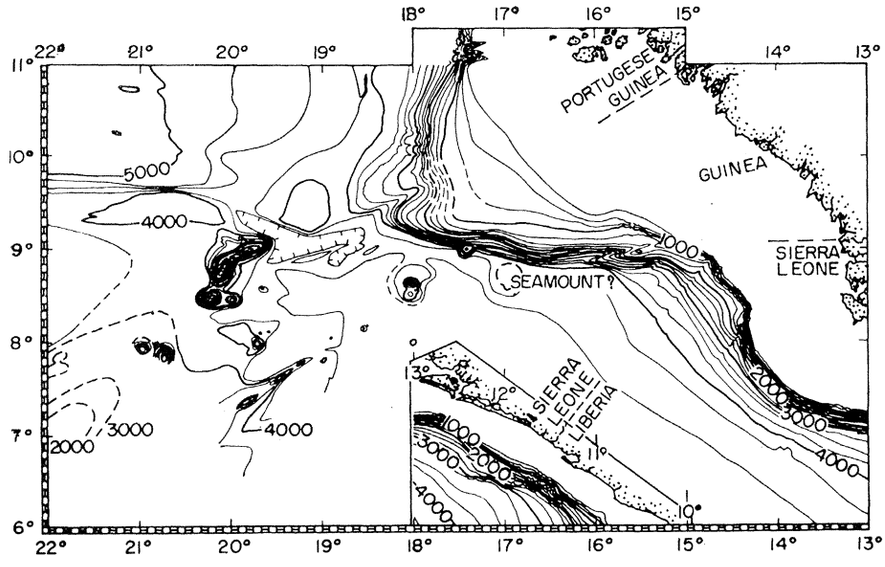

Fig. 2. Bathymetry of the Guinea fracture zone off West Africa. Depths are in meters and are corrected for sound velocity. Contour interval is generally 250 m. Data based on *Trident* soundings and published chart soundings.

along several zones between latitudes 1° South and 11° North. Sparse information from atlases and charts suggested that the sharp southern edge of the Guinea shelf off West Africa, in the region of the bend of Africa, marks a possible fracture zone with an east-west trend similar to the Gorda escarpment and the Mendocino fracture zone off northern California. The existence of the fracture zone was confirmed by a bathymetric and geomagnetic study of the sea floor off West Africa in the latitude of Sierra Leone during April and May 1963 with the R.V. *Trident* (*5*).

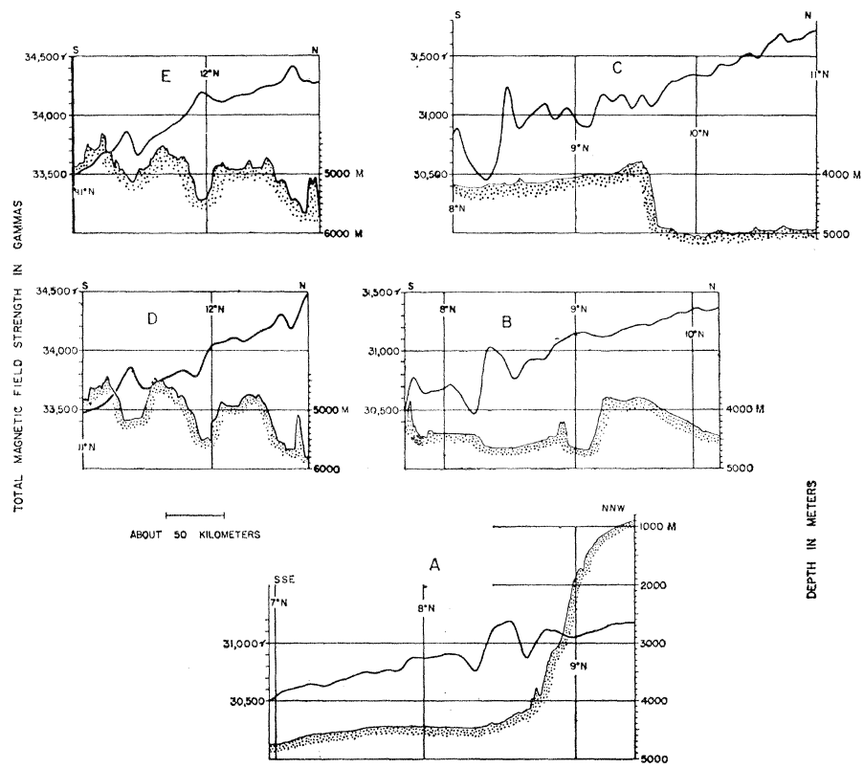

Fig. 3. Bathymetric (dotted track) and magnetic profiles across Guinea fracture zone (*A, B, C*) and across east-west troughs in the Mid-Alantic Ridge (*D, E*). Figure 1 shows the location of the profiles.

Work was conducted between latitudes 7° and 11° North and was concentrated between latitudes 8° and 9° North (Figs. 1 and 2). The main study was between latitudes 15° and 22° West, although reconnaissance was carried west to 43°. The distance between survey tracks varied from 10 to 55 km (Fig. 1). A typical north-south bathymetric and magnetic profile (profile *B*, Figs. 1 and 3) shows a zone (between 8° and 9° North) of accentuated magnetic anomalies and of topographic ridges and troughs which trend in an east-west direction. To the north, where the sea floor is flat, the anomalies decrease in intensity. Features on profiles separated by 28 km or less are easily correlated; profiles separated by more than 28 km do not allow such detailed correlation, although they do indicate the presence of the zone. To the east, the topographic evidence is displayed only in the steep south-facing scarp of the Guinea shelf (profile *A*, Figs. 1 and 3) while the magnetic anomalies continue beneath a covering abyssal plain. To the west, the zone is obscured in the irregular abyssal hills on the north flank of the Mid-Atlantic Ridge. The zone appears to exist between longitudes 22° and 39° West, but the available evidence is not conclusive. However, the brief survey near 12° North, 39° West (profiles *D* and *E*) shows that the east-west trend continues, although perhaps with interruptions. The troughs and ridges of this trend lie just north of the Vema fracture zone (*4*) and are similar but smaller features.

The characters of the Guinea fracture zone follow closely those considered typical of fracture zones by Menard, except in length. "Individual zones range from at least 1400 to 3300 miles long and average 60 miles wide. The zones follow great circles for most of their lengths. . . . Topography within the fracture zones is characterized by great seamounts, deep narrow troughs, asymmetrical ridges, and escarpments. Two fracture zones separate regions which differ in depth by a quarter or half a mile" (*1*).

The Guinea fracture zone has a minimum left lateral displacement of 230 km, this being the offset shown by the Guinea shelf. The Guinea frac-

ture zone is well developed for a length of 850 km west of the Sierra Leone shelf.

The Guinea fracture zone has the same trend as the Vema fracture zone, has the same sense of displacement (*4*), and is the eastern analog of the Vema fracture zone and its associated fractures. The lack of evidence for continuity between the two fracture zones is due partly to the fact that more detailed surveys are required, and partly to a probable difference in response of the oceanic crust to the deforming stresses. The Barracuda Fault (*5*) (Fig. 1), east of Guadeloupe in the Antilles, is also analogous to the Guinea fracture zone. Our survey of the eastern extension of the fault (December 1963) showed that it extends eastward to at least 53° West longitude as a low, east-west, nonmagnetic range of abyssal hills which has apparently dammed the northward flow of turbidity currents, the abyssal plain to the south being shallower than the sea floor to the north of the range. The amount of horizontal displacement is unknown. The fault seems to be part of the same pattern exhibited by the Vema fracture zone with its associated troughs, and by the Guinea fracture zone, thereby indicating that a zone of deformation exists across the whole of the Atlantic Ocean. The Guinea fracture zone shows that the shear zone intersects the African continent and marks the northern limit on the African coast of a wide zone of left lateral shear whose southern limit is roughly the Equator (*3*).

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25 May 1964

Meteorological Evaluation of the Sources of Iodine-131 in Pasteurized Milk

Abstract. *An examination of possible sources of radioiodine found in samples of milk in the midwestern states during May and early June 1962 shows that atmospheric testing at Christmas Island was the principal contributor to incidents of significant concentrations of iodine-131 in milk (exceeding 300 picocuries per liter). Underground testing at Nevada played at most only a minor role during this period. There is a cause-and-effect relationship between the penetration of thunderstorms into high concentrations of nuclear debris in the lower stratosphere and the subsequent amount of iodine-131 in milk. Analyses of samples of rainwater confirm the importance of this "scavenging" mechanism. The relative contributions of atmospheric and underground testing to the iodine-131 found in milk samples from September 1961 to December 1963 has been reviewed and only one incident in which the amount of iodine-131 exceeded 300 picocuries per liter could be attributed to an underground test.*

Several attempts have been made recently (*1–3*) to explain the increased amounts of iodine-131 that were found at certain times during 1961 and 1962 in samples of milk analyzed in laboratories of the U.S. Public Health Service Pasteurized Milk Network (*4*, pp. 82–83) and to attribute the source of the radioiodine to specific nuclear tests. A review of the radiologic and the meteorologic evidence, together with the available data concerning nuclear tests (*5*), shows that a reasonable and consistent explanation can be made for each of the observed instances of greatly increased radioiodine content in pasteurized milk (that is, more than 300 pc of I^{131} per liter of milk) (*3*).

It has been postulated (*2*) that underground nuclear tests in Nevada, which were contained to the extent that no visible cloud of debris was formed at the test site, could have been the major contributors of I^{131} to the milk in the Midwest in May 1962. We now report that the principal contribution to the amount of radioiodine found in midwestern milk samples was made by the atmospheric tests conducted by the United States near Christmas Island, rather than the underground tests conducted in Nevada.

Atmospheric testing of nuclear devices was halted with the end of the U.S.S.R. series in early November 1961, and was not resumed until the United States began testing in the vicinity of Christmas Island on 25 April 1962. During this hiatus in atmospheric testing, 25 underground tests and 1 cratering event were announced in Nevada. (The term "underground test," as used in this report, refers to those tests designed to have their radioactivity contained underground. Although also detonated underground, cratering detonations are not intended to completely contain the radioactivity produced.)

It is estimated that each kiloton equivalent of fission energy produces about 125,000 curies of I^{131} (*6*). This radioactive isotope has a half-life of 8.1 days and, if it is deposited on pastures, feed, or in water supplies, it can be expected to reach maximum concentrations in milk after a lag of 2 to 4 days (*6*). During the winter months, dairy cattle are not on pasture and would be expected to experience little exposure to fresh deposits of I^{131}. After about 1 March, on the average, dairy cattle south of about 37°N derive 75 percent or more of their roughage from grazing or fresh chopped green feed (*7*). Farther north, cattle go on pasture somewhat later depending on local weather conditions.

In view of these farming practices, the most significant portion of the interval between atmospheric tests is March and April. During this period, 11 underground tests and 1 cratering event were announced. Of the 11 underground tests, 3 were announced as being not fully contained, yet during this period, the concentrations of radioiodine were near or below the levels of detectability in the samples analyzed. Of 490 samples taken in the continental United States during March and April 1962, 441 showed I^{131} concentrations below the threshold of detectability (10 pc/liter), 38 had values be-