Columbia University in the City of New York

LAMONT GEOLOGICAL OBSERVATORY

PALISADES, NEW YORK

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Bruce C. Heezen, Robert Gerard, and Marie Tharp

Technical Report No. CU-4-63 to the Atomic Energy Commission
Contract AT(30-1)2663

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## FIGURE CAPTIONS

Figure 1. Equatorial Atlantic Fracture Zones.

This is a portion of The Physiographic Diagram of the South Atlantic, published by The Geological Society of America (Copyright 1961 by Bruce C. Heezen and Marie Tharp. Reproduced by permission).

Figure 2. Bathymetric Sketch of Vema Fracture Zone.

Contours in fathoms at 800 fms/sec. Demerara Abyssal Plain (stippled area) extends into the fracture zone trough. Precision Depth Recorder soundings by R/V VEMA are shown by lines of dots.

Figure 3. Topographic profiles in the vicinity of Vema Fracture Zone.

Vema Fracture Zone indicated by letter V. Letters T, U, W, X, Y, and Z indicate the location of possible other parallel zones.

Figure 4. Vertical potential temperature profiles in and near Vema Fracture Zone.

A = ATLANTIS, C = CRAWFORD, M = METEOR, and V = VEMA. The vertical line at each station represents 2°C.

Figure 5. Bottom photographs of Vema Fracture Zone (Station V-16-70, 2700 fms, 5100 m) on the north wall of the trough.

Figure 6. Graphic logs of sediment cores from Vema Fracture Zone.

Figure 7. Graph of thermograd station V-15-8 in Vema Fracture Zone.

ABSTRACT

A series of fracture zones displace the axis of the Mid-Atlantic Ridge in the equatorial Atlantic. Near 11°N Latitude the crest of the ridge is offset about 150 miles to the left by the Vema Fracture Zone. The Demerara Abyssal Plain extends into the fracture zone from the west. A low oceanographic sill is provided by the fracture zone. Bottom photographs and cores indicate strong bottom scour through the trough in depths exceeding 5000 meters.

In 1956 G. R. Hamilton aboard R/V VEMA ran a Precision Depth Recorder sounding line along the crest of the Mid-Atlantic Ridge between 6° and 16°N Latitude. Certain chart makers had doubted the existence of the Mid-Atlantic Ridge in this area, but Hamilton's soundings amply confirmed the general continuity of the Mid-Atlantic Ridge. Near 11°N a deep and remarkably flat-floored trough was found. In 1959 Gerard, detecting a flat-floored trough about one degree directly east of the previous crossing, ran a zigzag track westward for about 180 miles. The trough was easy to distinguish from other depressions due to its flat floor, which gently slopes from west to east. In 1959-60 two additional crossings of the feature were made 60 miles and 150 miles east of the previous crossings.

Wüst (1936) proposed that two low sills exist in the equatorial Mid-Atlantic Ridge. Wüst located one sill in or near the Romanche Trench and another eight or ten degrees north latitude. The east-west trough of the Vema Fracture Zone probably provides the deep sill for this latter circulation route (Metcalf, Heezen and Stalcup, 1964).

Each of the east-west fracture zones or faults which cuts the equatorial Mid-Atlantic Ridge into a series of displaced slices is characterized by a deep depression in which depths exceed by a few hundred fathoms the average depths found in the vicinity. Since the topography of the Mid-Atlantic Ridge is extremely rugged, it would be difficult to trace these features on the basis of a few scattered profiles were it not for another peculiarity of the area, (Heezen, Bunce, Hersey and Tharp, 1964). The abyssal plains of the western North Atlantic have extended for long distances into some of the fracture zone troughs. In Vema Fracture Zone the flat-floored trough extends eastward 300 miles from the normal limits of the abyssal plain, reaching as

far as the axis of the Mid-Atlantic Ridge (Heezen and Tharp, 1961). The maximum depth in the smooth portion of the Vema Fracture Zone slightly exceeds 2747 fathoms (5189 m) and is found at 42 1/2°W. From this location eastward to the end of the flat floor near 41°W, the floor of the trench is virtually level, but the eastern end of the flat floor lies a few fathoms above the maximum depth. At 41°W, where the floor of the trench reaches a depth of 2742 fathoms (5179 m), the adjacent scarps rise 1500 fathoms above the floor.

It is not possible, due to the lack of detailed sounding profiles, to make a firm morphological comparison of the physiographic provinces north and south of the fracture zone; however, a left-lateral displacement of the ridge of approximately 150 miles is suggested.

An earthquake epicenter belt coincides with the crest of the Mid-Atlantic Ridge. In the region of Vema Fracture Zone six epicenters line up along the portion of the Vema Fracture Zone which lies between the displaced crests of the Mid-Atlantic Ridge (Figure 2).

The trough of the fracture zone ranges between four and fifteen miles in width. The bounding scarps range from a few hundred fathoms to over 1500 fathoms in height. The declivity of the scarps is extremely steep with gradients of 1:5 to 1:2. East of 41°W the fracture zone trough lacks a flat floor and is, therefore, more difficult to trace. The bounding scarps become lower on the flanks of the Mid-Atlantic Ridge, and it is difficult to identify positively the fracture zone on the eastern flank of the Mid-Atlantic Ridge. It appears that on the western flank of the ridge the bounding scarps disappear beneath the floor of the abyssal plain. On Figure 3 a half dozen other suggested fractures are indicated by letters on the profiles.

A series of bottom photographs were taken at Station V-16-70 on the wall

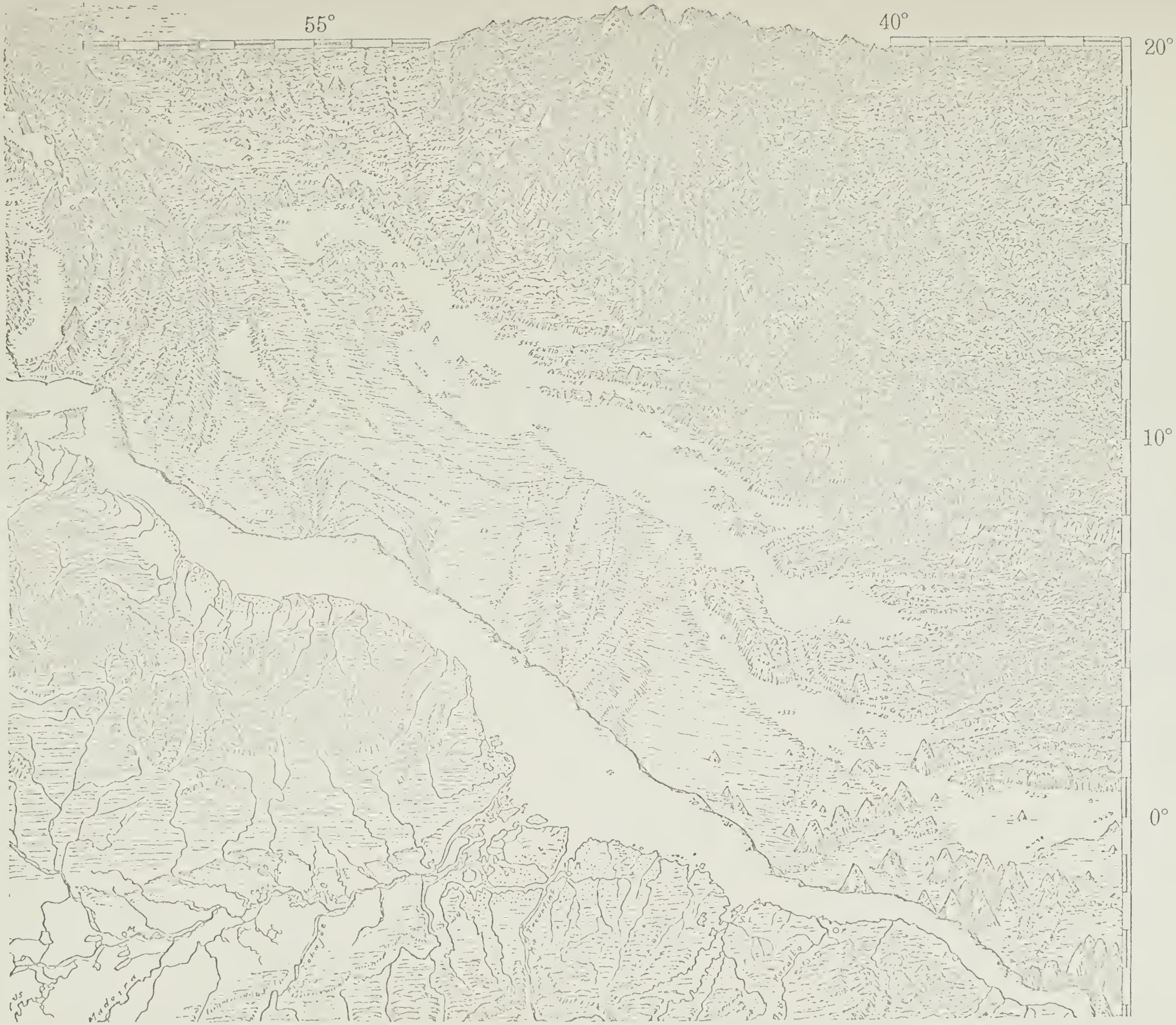
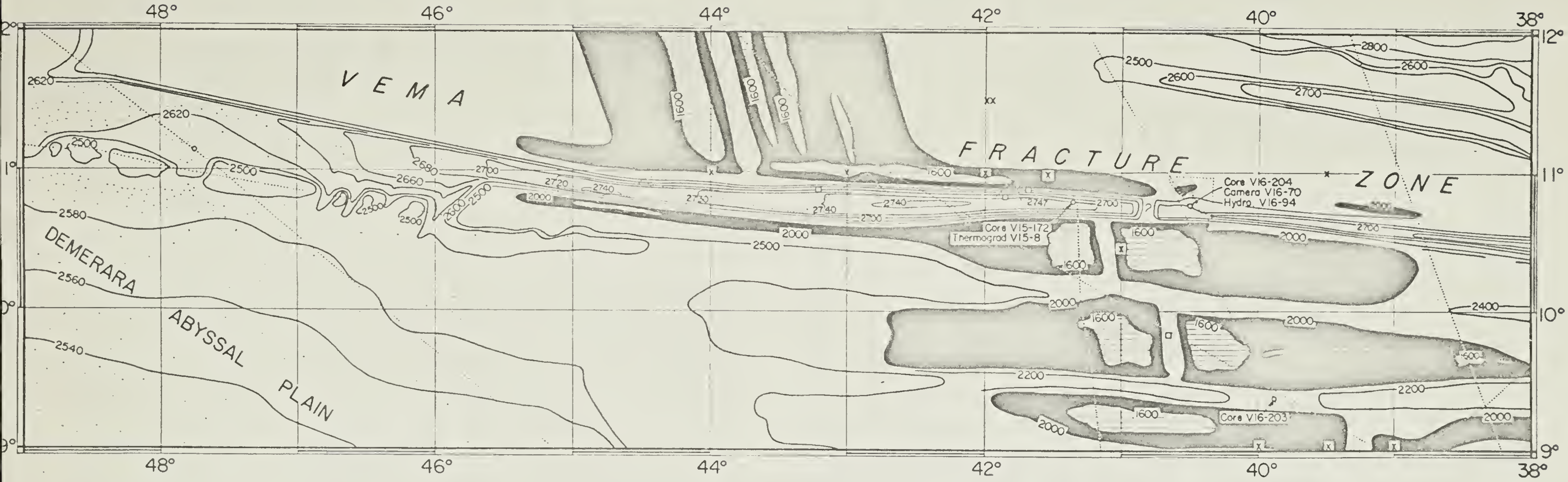



FIGURE 1




x EARTHQUAKE EPICENTER TO AUG. 1960
□ EPICENTER DETERMINED BY COMPUTER PROGRAM

FIGURE 2

of the Vema Fracture Zone just to the east of the point where the flat floor ceases to exist. These photographs, taken at depths of 2690-2710 fathoms (5058-5116 m), showed rock bottom with sand, scour marks, winnow marks, and some ripples. Although bottom photographs of seamounts and other rocky prominences of the Mid-Atlantic Ridge often show dramatic evidence of rock outcrops and ocean-current scour, such strong and dramatic indications at a depth of 5100 meters are extremely rare and suggest that these photographs were taken in an area of a uniquely strong and localized bottom current. Photographs taken a few hundred miles away in similar depths, but outside of the fracture zone, form a sharp contrast to those of the trench, showing no ripples but simply smooth muddy bottom well covered by organic tracks (Heezen and Hollister, 1964).

A piston core (V-16-204) was taken at the same location as the photographs. Another core (V-15-172) was taken from near the base of the north scarp in a depth of 2735 fathoms (5165 m). Both cores were quite similar in composition (Figure 6). Each core contains several thick beds of sand made up almost entirely of heavy minerals and fragments of ultrabasic rocks. The cores contain no continental detritus, and it can be safely concluded that this sediment could not have been transported by turbidity currents from the continental margin and must have been locally derived. Unfortunately, no cores were taken from the flat floor of the trench, where one would expect a considerable contribution of continentally-derived turbidity current material. The silty lutite in Core V-15-172 may represent a deposit of turbidity current transported continental debris carried in the upper portion of a turbidity current. The swept rock bottom, current-rippled sand, and scoured bottom seen in the photographs must be due to bottom currents acting on material derived from

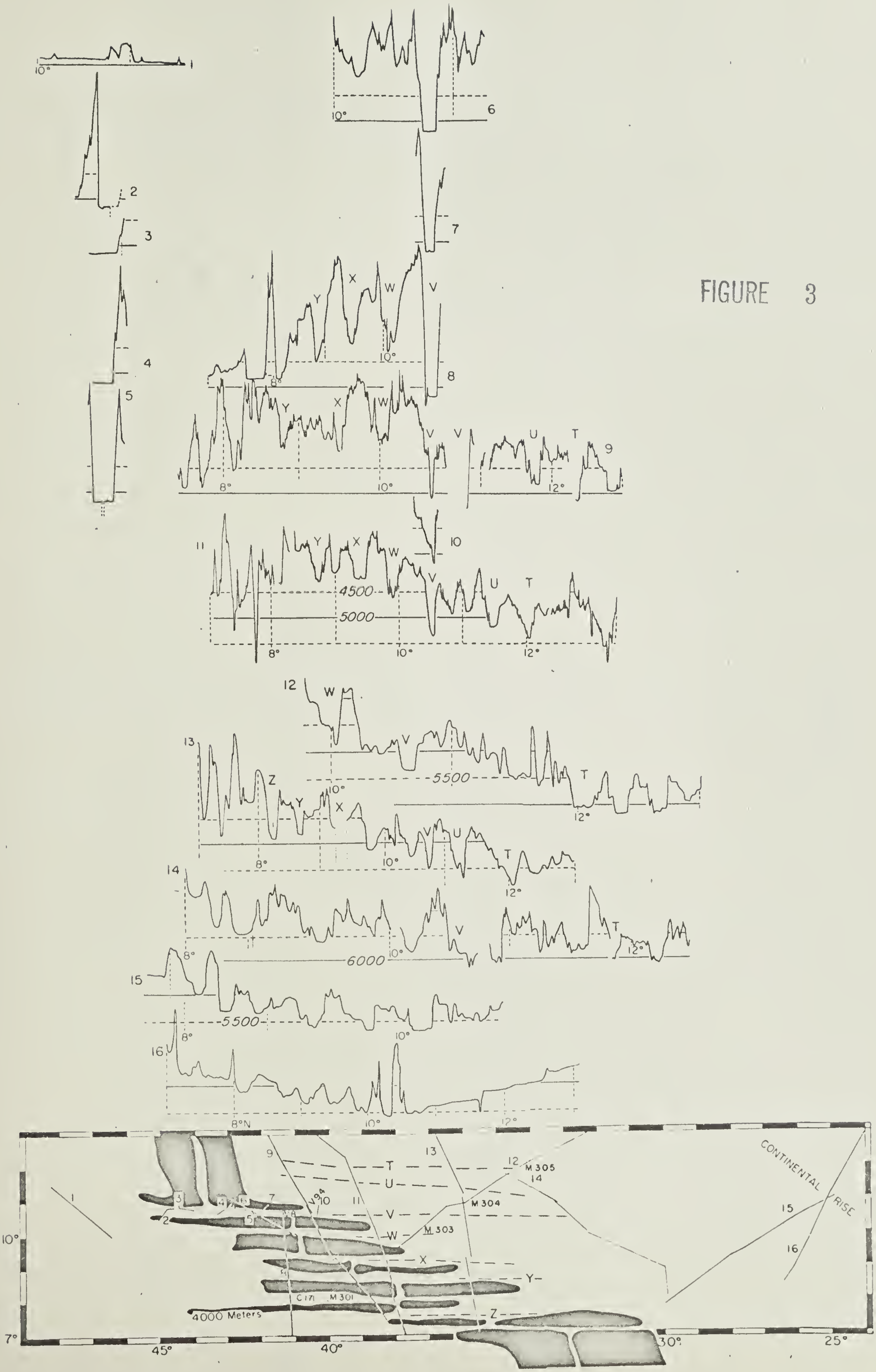
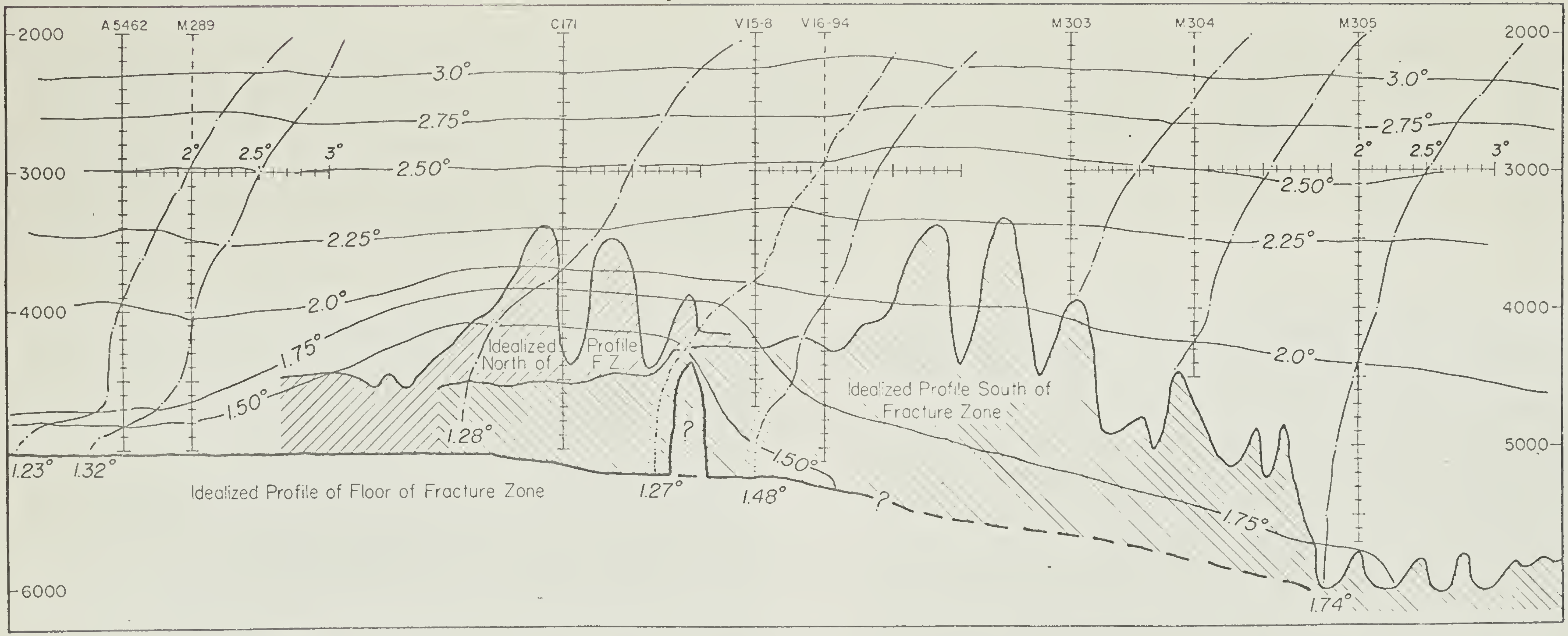



FIGURE 3

Fig 3



A5462
M289
C171
V15-8
V16-94
M303
M304
M305
2000
3000
4000
5000
6000
3.0°
2.75°
2.50°
2.25°
2.0°
1.75°
1.50°
1.28°
1.23°
1.32°
1.27°
1.48°
1.74°
2°
2.5°
3°
Idealized North of Profile F Z
Idealized Profile South of Fracture Zone
Idealized Profile of Floor of Fracture Zone


FIGURE 4


V16-70-2


V16-70-7

FIGURE 5

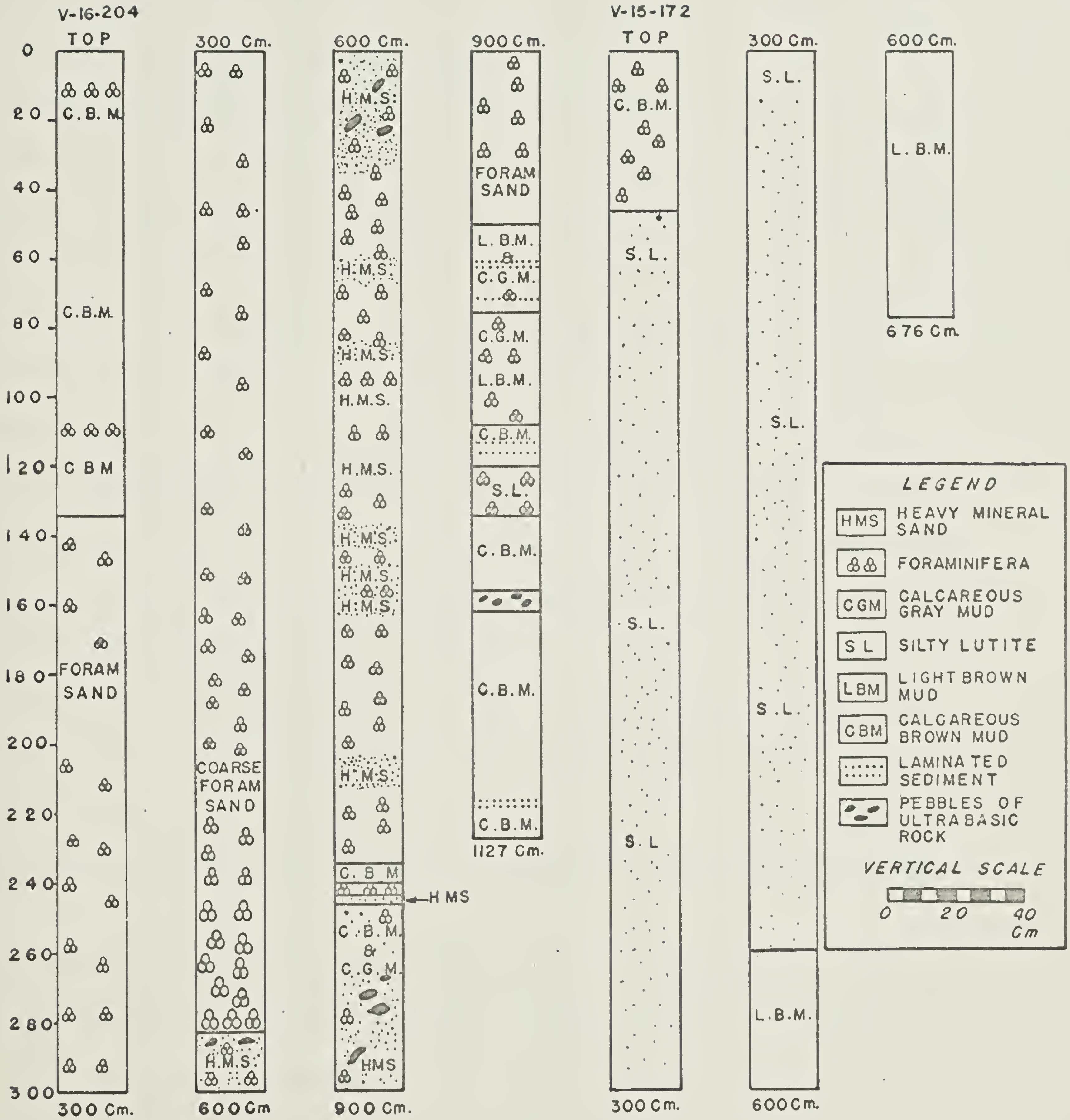
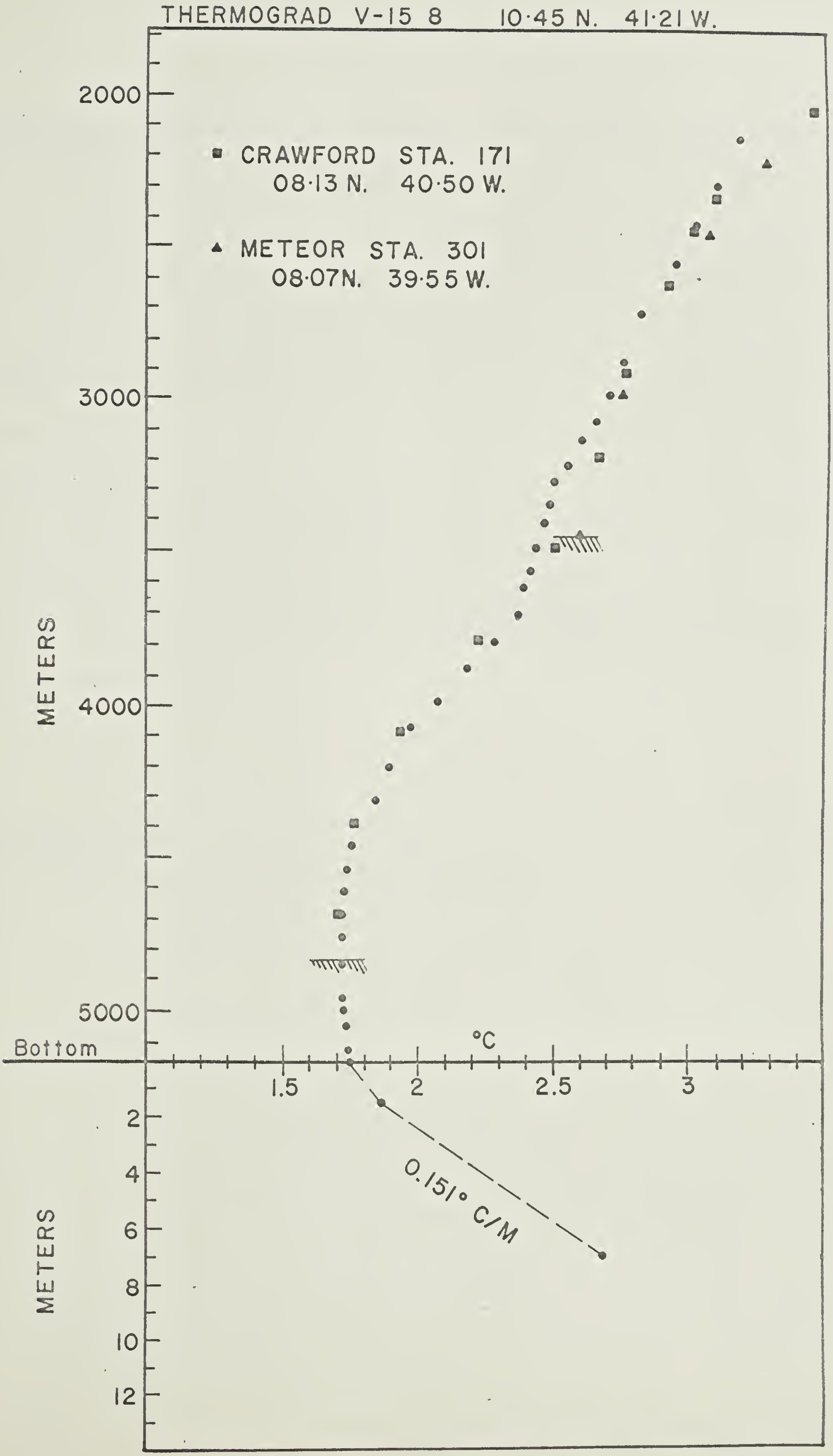

V-16-204
TOP
300 Cm.
600 Cm.
900 Cm.
1127 Cm.
V-15-172
TOP
300 Cm.
600 Cm.
676 Cm.
C.B.M.
FORAM SAND
COARSE FORAM SAND
H.M.S.
L.B.M.
C.G.M.
S.L.
HMS
LEGEND
HMS HEAVY MINERAL SAND
FORAMINIFERA
CGM CALCAREOUS GRAY MUD
SL SILTY LUTITE
LBM LIGHT BROWN MUD
CBM CALCAREOUS BROWN MUD
LAMINATED SEDIMENT
PEBBLES OF ULTRABASIC ROCK
VERTICAL SCALE
0 20 40 Cm

FIGURE 6

very local sources. These photographs are very similar to some taken in the Romanche Trench by Edgerton (Cousteau, 1958).

Several oceanographic stations have been taken in and around Vema Fracture Zone. One temperature profile was made with the thermoprobe at Station V-15-8. The potential water temperature measured on the trench floor at 41°W was 1.27°C. At 40.5°W (Station V-16-94) in Vema Fracture Zone the bottom potential temperature was 1.48°C. The minimum potential temperature found elsewhere in the eastern basin in the vicinity was 1.74°C (METEOR 305). It appears that at least two controlling sills exist somewhere within Vema Fracture Zone. In profile 9 the maximum depth obtained was 5100 meters, and to the east in profiles 10 and 11 the maximum depth on each profile increases to over 5300 meters. Therefore, we have no confirmation from echo soundings as to the actual sill depth. The continuity of a tectonic feature over hundreds of miles does not prove its oceanographic continuity, as a single isolated volcano could block the flow of water through a trough which, on a tectonic basis, would be considered continuous. It would appear from the limited data in the area that a local blockage must exist in the trench at a depth of somewhat less than 4500 meters.

At thermograd station V-15-8 the value of heat flow through the ocean floor was determined as $2.6 \times 10^{-6}$ cal/cm$^2$/sec (Gerard, Langseth, and Ewing, 1962). This value is approximately two times the value found in the ocean basin floor. High heat flow values are commonly found near the crest of the Mid-Oceanic Ridge.



THERMOGRAD V-15 8 10·45 N. 41·21 W.
CRAWFORD STA. 171
08·13 N. 40·50 W.
METEOR STA. 301
08·07N. 39·55 W.
2000
3000
4000
5000
METERS
Bottom
°C
1.5
2
2.5
3
2
4
6
8
10
12
METERS
0.151° C/M


FIGURE 7

Discussion. The discovery of a fracture zone near 11°N was anticipated by Wüst's analysis of the bottom temperatures of the eastern and western Atlantic. At the present time it seems likely that the deepest sill for circulation in this area lies in the fracture zone. On the basis of the temperature profiles available, it seems likely that a sill depth of somewhat less than 4500 meters (2400 fathoms) lies between 40 1/2°W and 41 1/3°W. The Vema Fracture Zone apparently provides a deep sill for water passing from the western to the eastern basin of the Atlantic. The ripple and scour marks in a depth of 5100 meters east of the probable position of the sill are in agreement with this interpretation. The Vema Fracture Zone is one of the more prominent of a series of fracture zones which offset the equatorial Mid-Atlantic Ridge, an aggregate of over 2000 miles.

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