10. UNDERWAY OBSERVATIONS LEG 24, *GLOMAR CHALLENGER*[1]

PART I: DJIBOUTI TO SEYCHELLES ISLANDS

Elizabeth T. Bunce, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts

INTRODUCTION

The underway geophysical observations made during Leg 24 between Djibouti, French Territory of the Afars and the Issas, and Mauritius presented here include the reduced bathymetric and magnetic anomaly profiles (Figures 1a-6a) and photographic reductions of the seismic reflection profiles (Figures 1b-6b). The observations are grouped by geographic area: the Gulf of Aden, the Somali Basin, and the Mascarene Plateau-Central Indian Ridge-Chagos/Laccadive Ridge. The procedures used in reduction of the first group of data are those in standard use at the Deep Sea Drilling Project where both original records and the results of the cruise may be consulted.

The reflection profiles at vertical exaggeration of about 15:1 are reproduced at a scale that enables reasonable examination and are thus expanded horizontally in comparison with the magnetic-bathymetric profiles.

GULF OF ADEN

The lack of site surveys in the Gulf of Aden necessitated reconnaissance tracks in the three site areas to insure that the final selections met the specifications of the Advisory Panel.

The track from Djibouti to Site 231, located in the Half-Degree Square of Laughton et al. (1970), is generally east-southeast, almost normal to the bathymetric contours (Laughton) and south of the West Sheba Ridge structure. The magnetic profiles over the first 500 miles show minor excursions superimposed on broader but also small-scale anomalies; the latter are probably generated in the acoustic basement structure observed on the seismic profile. The broad feature between 0 and 80 nmi may be part of the Tadjura Trench structure, since the track cuts across its southern margin. The reflection profile here shows at least 1 sec of sediment and at 75 nmi what appears to be a deep (1.5 sec) "valley" occurs. Between 200 and 300 nmi both magnetic and seismic character change; the former to typically oceanic type, the latter to a southeast-dipping sequence of sediment-filled flat-floored basins confined by basement ridges. Basement is first detected near 80 nmi and is observed continuously from there to Site 231. The uppermost sequence contains layered sediments along almost the entire track. Except over the initial 75 to 100 nmi, all these exhibit some degree of deformation, partly the result of uplift by basement structure, partly independent of such activity (see the section from 150 to 250 nmi, for example). Tectonically related structure is not surprising, since the area lies south of and parallels West Sheba Ridge, the spreading center. Structures not related to basement might perhaps be attributed to current activity.

Site 231 to Sites 232 and 233: from Half-Degree Square to the Alula-Fartak Trench. From Site 231 the track runs north a short distance before turning northeast, semiparallel to the West Sheba Ridge structure which it crosses normal to the axis in one of the offset regions. The approach to the trench was made from south of the planned site locations to enable several enroute crossings to reconnoiter both margins and both sites prior to drilling.

The magnetic information in general resembles that observed between Djibouti and Site 231, at least as far as the Ridge where the magnetic signature of the median valley is rather broad, with peak-to-peak amplitude of about 1000 gammas. The remainder of this profile is extremely subdued, with minor anomalies (about 200 gammas) observed over the eastern margin of the trench.

On the reflection profile the acoustic basement is traced apparently continuously to the western margin of the trench. (The qualification "apparently" is based on the drilling results and has been elaborated upon elsewhere in this volume.) Both basement and overlying sediments change appearance near the ridge. Basement relief is subdued in the two basins crossed, in comparison with that of the bordering (enclosing) structures; in both basins the sediments ponded above basement are layered at the top and acoustically transparent beneath. The layering terminates abruptly against a bordering basement rise where the upper surface of the transparent material that covers the lower rise shows deformation, possibly the result of compression. There are no visible sediments in the median valley, although they extend thinly to within 300 fathoms of the top of the east-flanking ridge and somewhat higher on the back slope of the lower western ridge. From here to the Alula-Fartak Trench, the semitransparent sediments again are deformed and are not necessarily conformable with the underlying basement structures; in this they resemble the appearance of sediments on the flanks of the Mid-Atlantic Ridge.

The two margins of the trench differ in seismic structure as well as magnetic character. On the west the sediments are layered and somewhat deformed, on the east they are semitransparent, with no visible evidence of deformation. Faint reflectors possibly representing thin layers appear in the semitransparent material (near 0300, 1000, 10 May).

[1] Contribution No. 3231 of the Woods Hole Oceanographic Institution.

The acoustic basement of the eastern margin is a stronger reflector than that on the west, where there is also the hint of an even deeper reflector about 0.75 sec below sea floor (1300, 10 May and site location).

GULF OF ADEN–NORTHWEST SOMALI BASIN

From the Alula-Fartak Trench to the next site (234) which lies on a ridge bordering the western side of the Somali Basin, the track is southward, roughly on longitude 52°E, in the Gulf of Aden and between Socotra and the Horn of Africa, thence trending generally south-southwesterly along the abyssal plain.

The magnetic profile is significant chiefly for its informative contribution on the quiet-zone character of the northwest Somali Basin. The small amplitude anomalies in the Gulf of Aden terminate abruptly at the rise between Africa and Socotra (between miles 800 and 850), with this distinctive topographic feature showing only minor magnetic activity that also ceases midway down the south slope (mile 990) toward the abyssal plain.

The seismic profiles show the Gulf of Aden sediments to thicken toward the African coast and be deformed where they flank the Socotra Rise (mile 800). Except for a central sediment pocket (850 nmi), the Continental Rise appears to be acoustically opaque. From this point to the flat-lying plain the track crosses the features at an oblique angle, thus exaggerating the apparent effects of slumping, incision, and reflector truncation. Basement (basaltic) cannot be detected beneath the abyssal plain. A distinctive reflector 1.25 sec beneath the sea floor appears suddenly at 8.0 sec (1700, 18 May). This feature has been observed on other profiles across the area, and it may be a continuous zone of reflectors traceable throughout the basin. Sampling this reflector was a primary target of drilling at Site 234.

The west-east reflection profile between Sites 234 and 235 that crosses both the basin and Chain Ridge is typical of profiles in this region. Basement is not observed beneath the thick sedimentary western section, yet the structure of the deeper horizons is obvious. The records on either side of Chain Ridge show all the features significant to these sites' selections: the slightly deeper sea floor on the east (left); the similarity of the reverberant uppermost (0.25 sec) sediment sequences; the basement structure obvious on the east, but too deep for detection with this profiling equipment to the west; and the distinctive reflector visible above basement on the east and only a trifle deeper than its possible analog on the west. The apparent abrupt truncation of the uppermost sediment sequence against the transparent outcrop on Chain Ridge (east) is probably due to track angle. Other crossings made more normal to the ridge lineation in this area are not so dramatic. On the magnetic profile very small-scale excursions occur over the ridge topography, otherwise it is quiet.

Between Sites 235 and 236 the track is southeastward through the Somali Basin. The magnetic anomalies reflect the abrupt change in both sea floor and subbottom structure that occurs east of Chain Ridge. Somewhat farther to the southeast the abyssal plain terminates equally abruptly where it is ponded between basement rises (1700-1900, 26 May). Beyond these the thinner sediments (less than 0.5 sec) are acoustically semitransparent; some layering being observed where ponding occurs between topographic highs. The basement resembles unusually low-relief oceanic layer 2 with some hills rising above the sea floor.

The profile from Site 236 southwest to the Seychelles should cross the hypothesized oceanic basalt-Seychelles granite transition or demarcation. This particular section, however, because of the inability to "see" deeper, only serves to raise further speculation.

An arguable and still unanswerable question is raised by the similarity in appearance of the peaks observed at 1500 and 2200, respectively (record of 1 June). That at 1500 can be interpreted as a continuation of the ocean-acoustic basement material observed and drilled at Site 236 where in its upper portion it was tholeiitic basalt. The hill at 2200 rises from an apparently (seismically) invisible source but does closely resemble the earlier peak. Between the two there appear to be hints or traces appearing as faint hyperbolic echoes. Thus, oceanic basement material may exist very near the almost vertical rise of the platform to form a constraint on the extent of the Seychelles granite.

REFERENCE

Laughton, A. S., Whitmarsh, R. B., Jones, M. T., 1970. The evolution of the Gulf of Aden: Phil. Trans. Roy. Soc. London, Series A, v. 267, p. 227-266.

FIGURES

To facilitate correlation of significant features the records have been annotated (date, time, and distance along the track), along the bottom of each profile. GMT time, marked hourly and half-hourly, is annotated at 5 hour intervals, cumulative distance at intervals of 100 nautical miles, and course and course changes are also indicated. All of these records were made at a 10 second source repetition rate; the depth scale is indicated in one-second intervals of two-way travel time. Subbottom depth (sediment thickness) can be estimated assuming 2 km/sec velocity (or 1 km for 1 sec of travel time). Vertical exaggeration is about 15:1.

The records are continuous, each one reading from right to left.

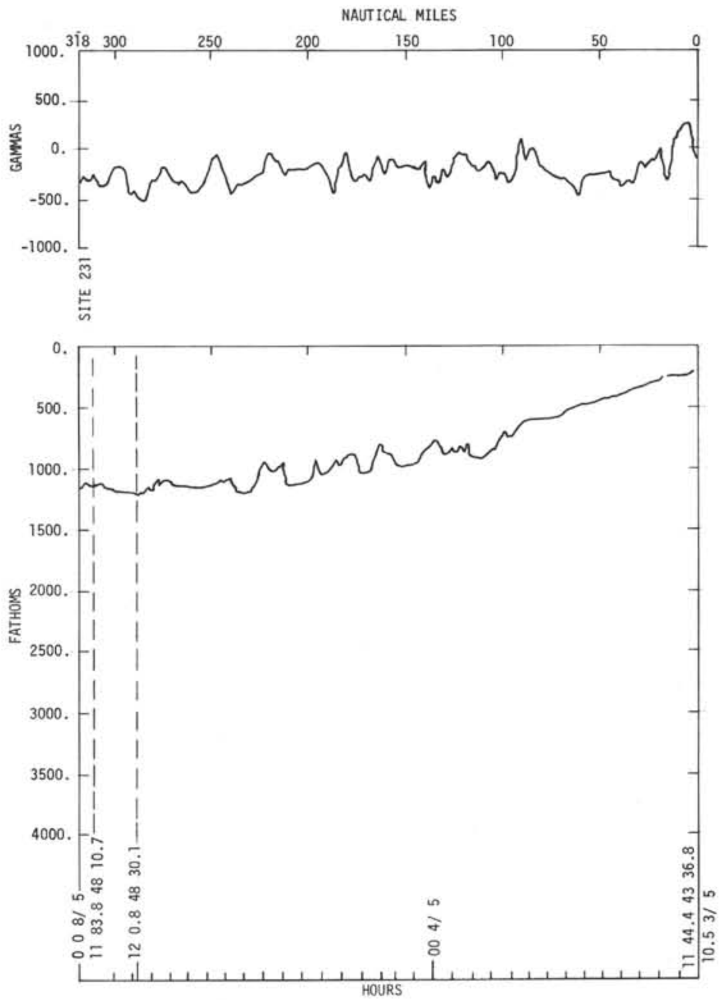

Figure 1a. *Djibouti to Half-Degree Square, Site 231 (magnetic anomaly).*

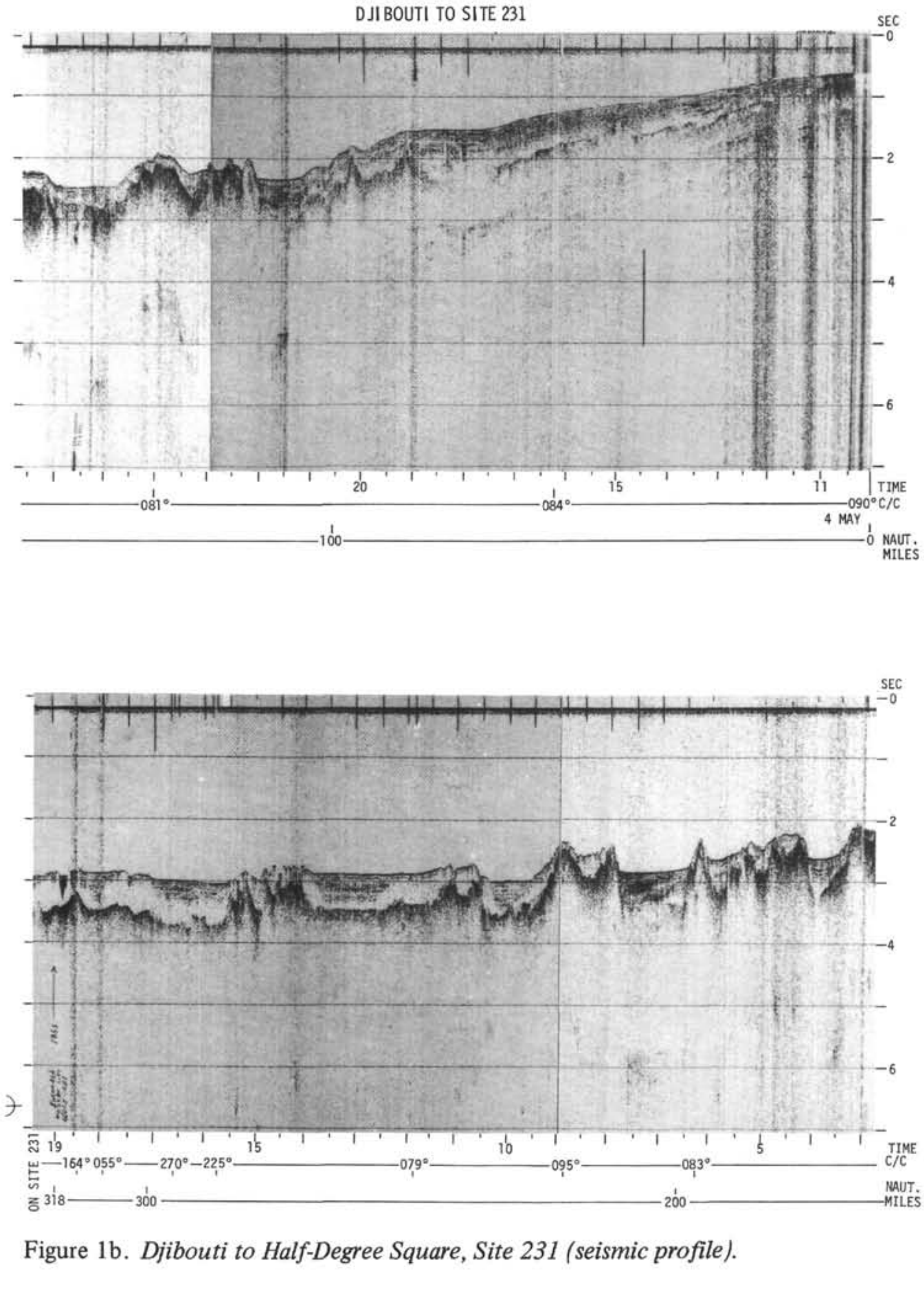

Figure 1b. *Djibouti to Half-Degree Square, Site 231 (seismic profile).*

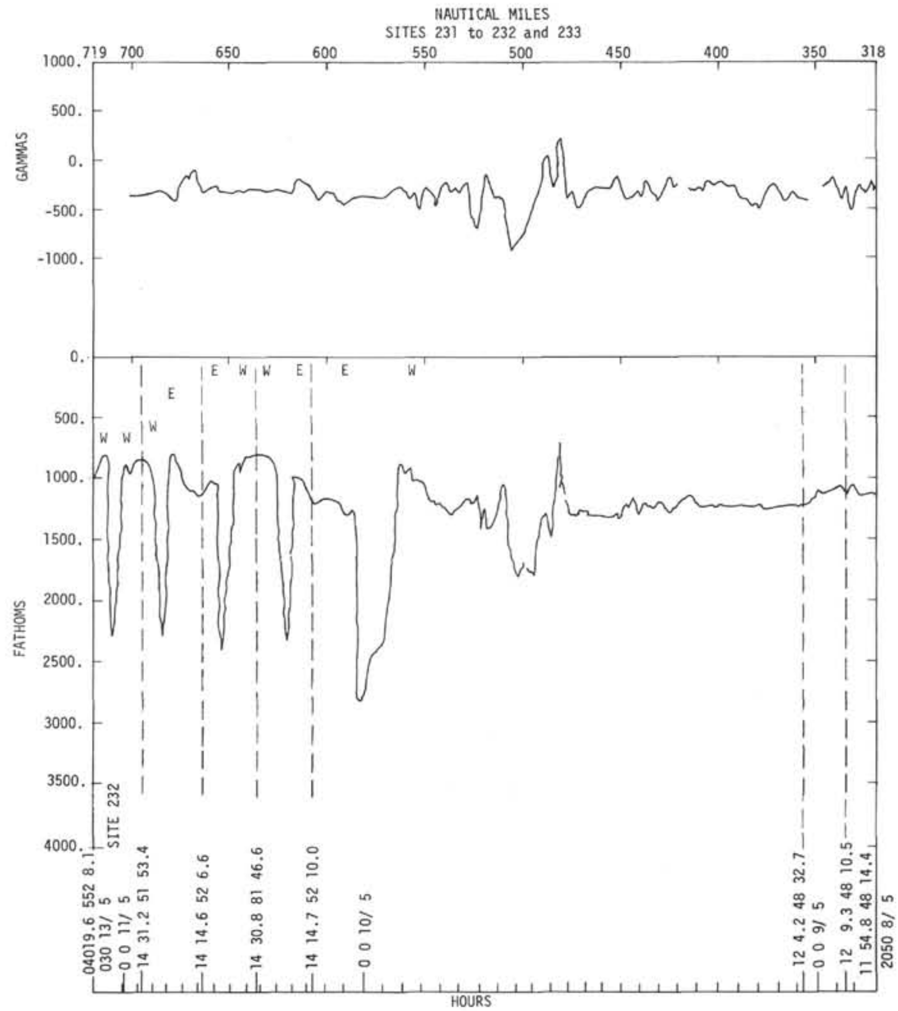

Figure 2a. *Site 231 to Alula-Fartak Trench, Sites 232 and 233 (magnetic anomaly).*

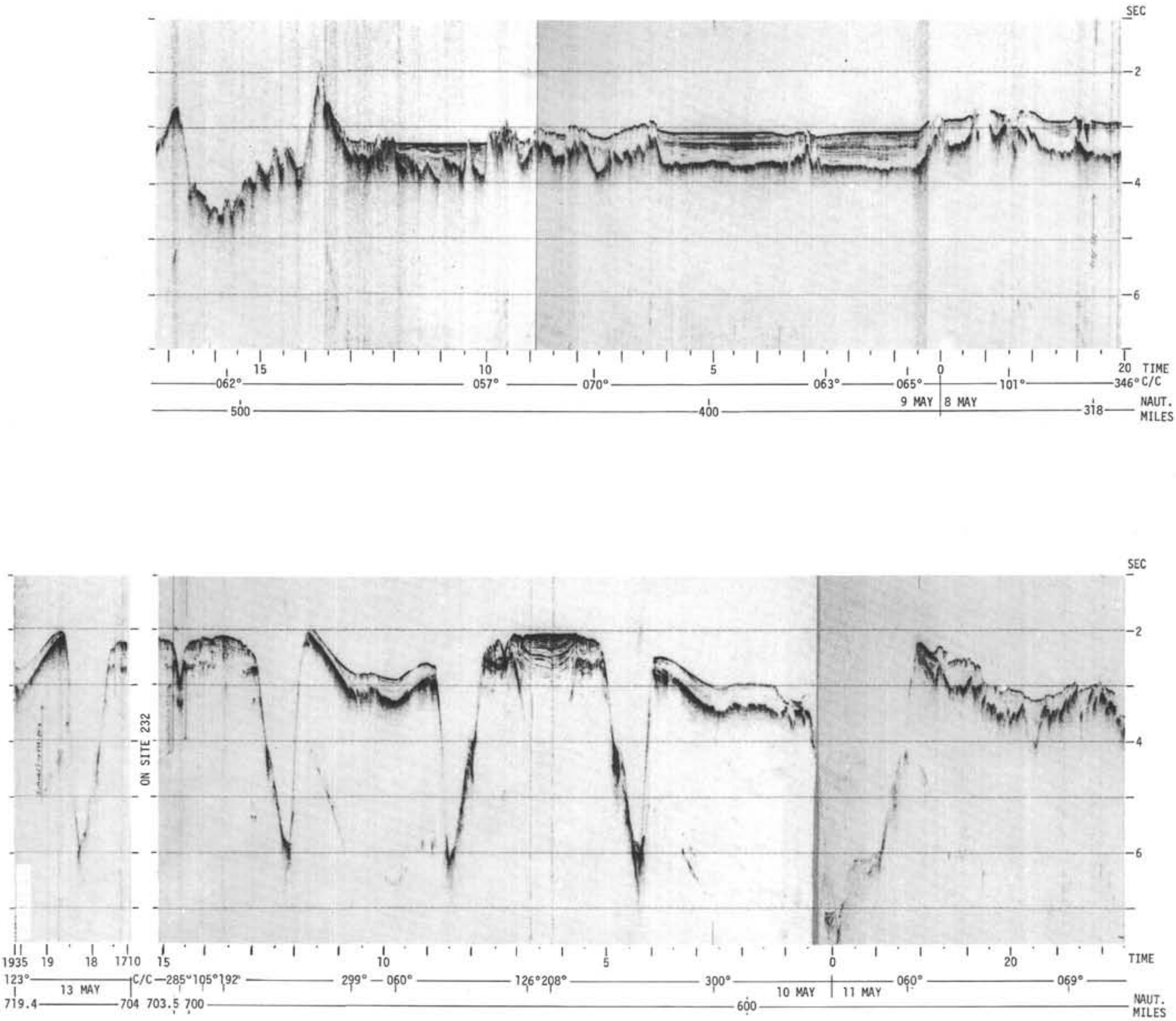

Figure 2b. *Site 231 to Alula-Fartak Trench, Sites 232 and 233 (seismic profile).*

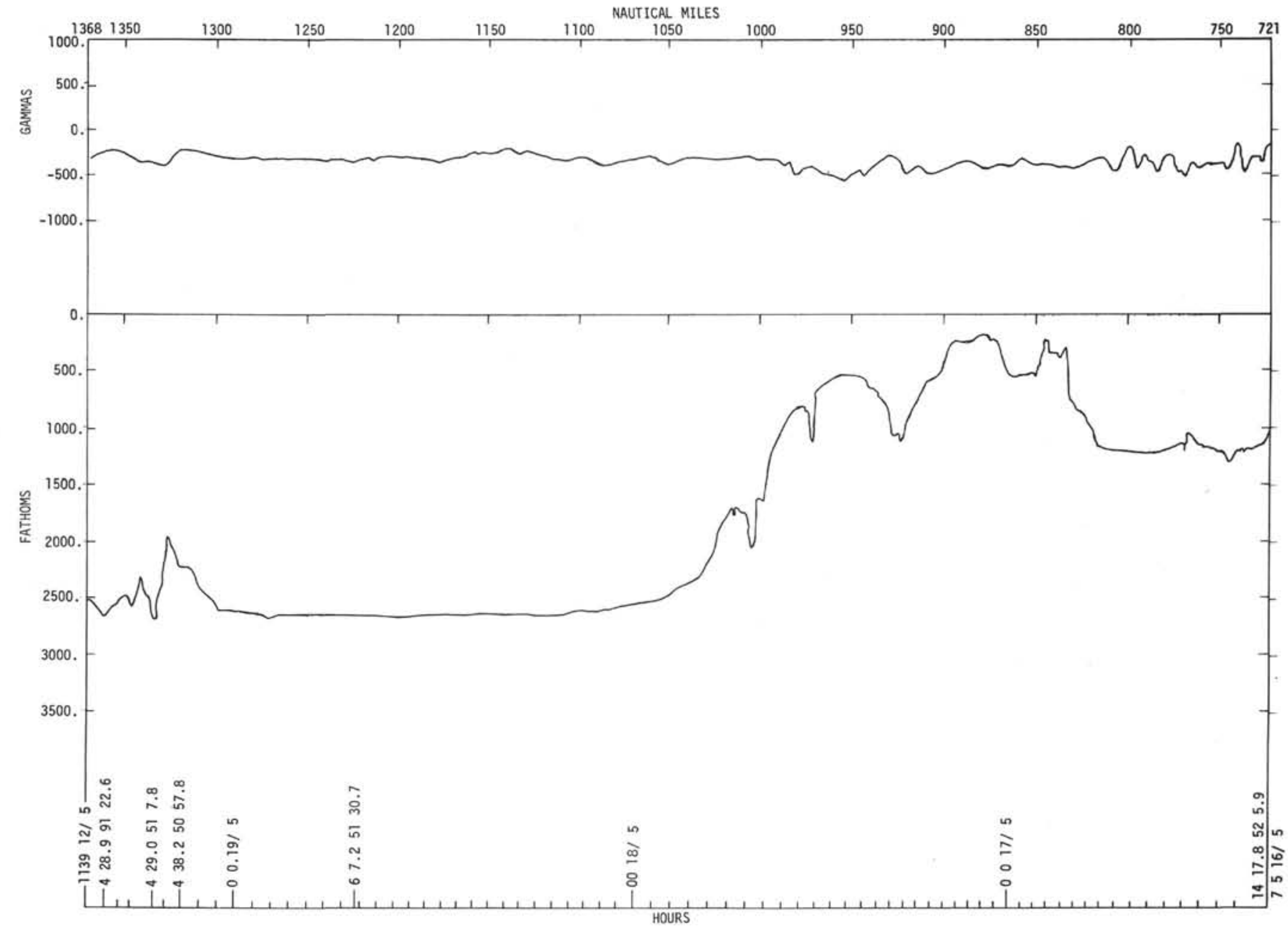

Figure 3a. *Site 233 to Somali Basin, Site 234 (magnetic anomaly).*

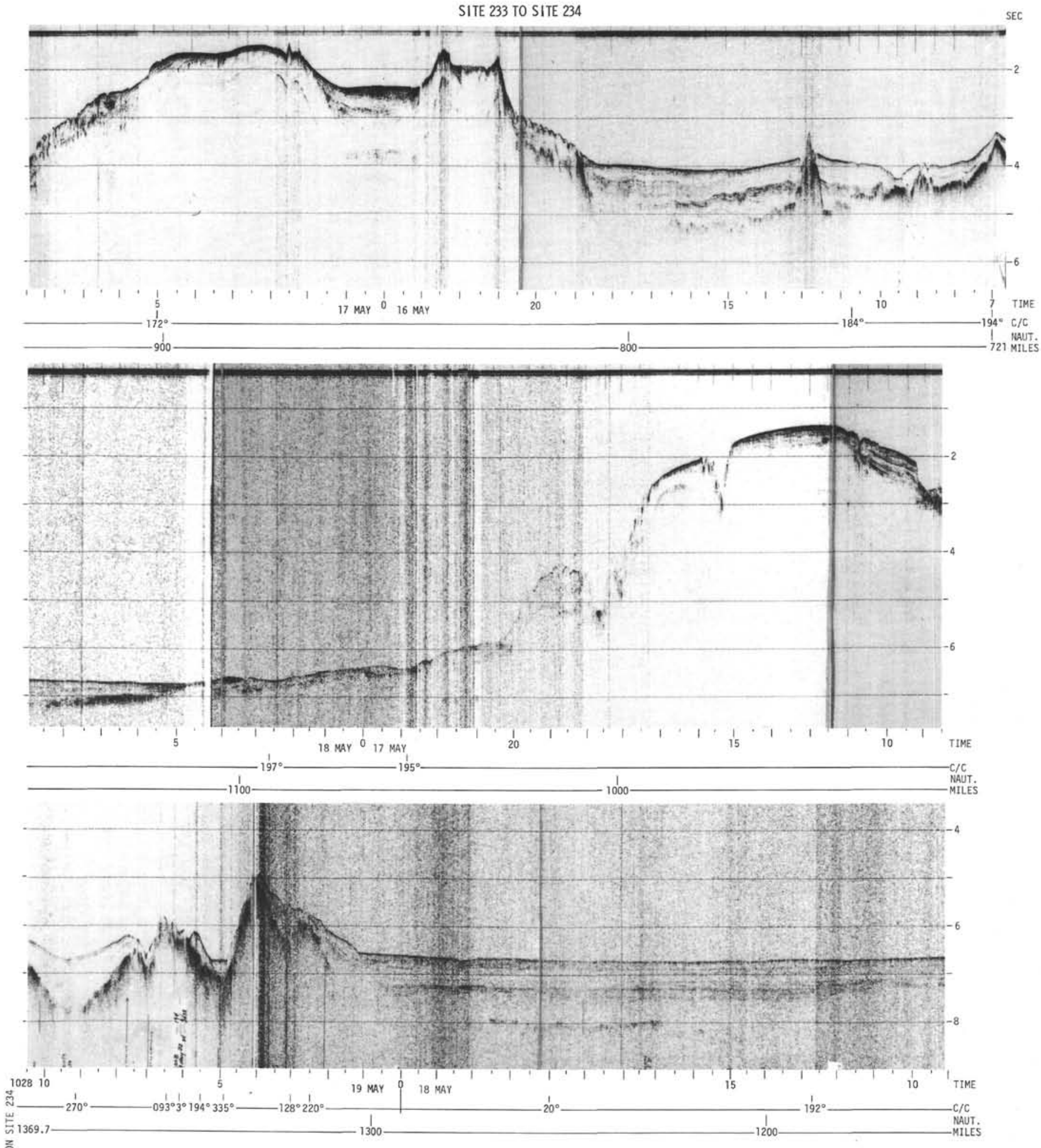

Figure 3b. *Site 233 to Somali Basin, Site 234 (seismic profile).*

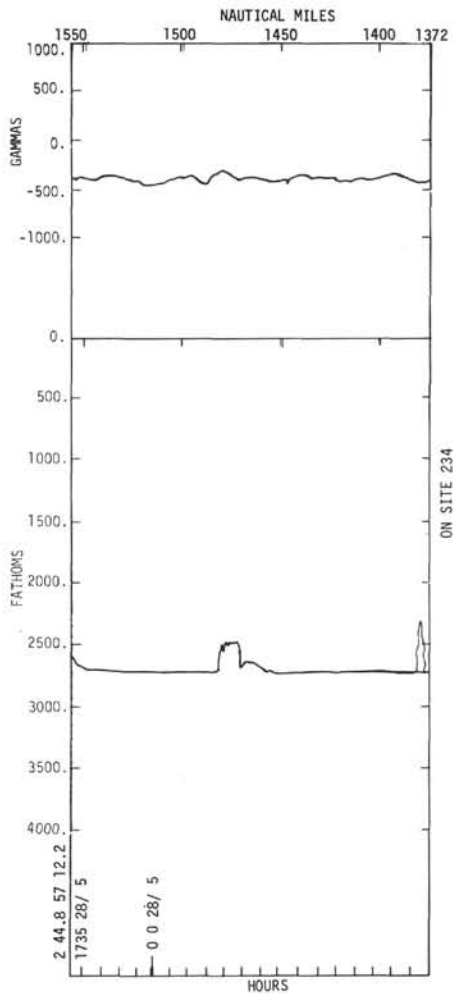

Figure 4a. *Site 234 to Site 235 (magnetic anomaly).*

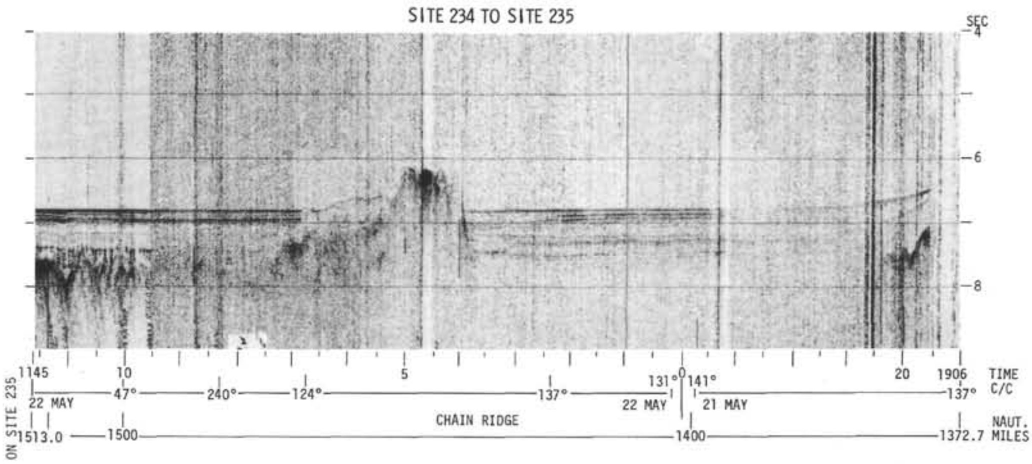

Figure 4b. *Site 234 to Site 235 (seismic profile).*

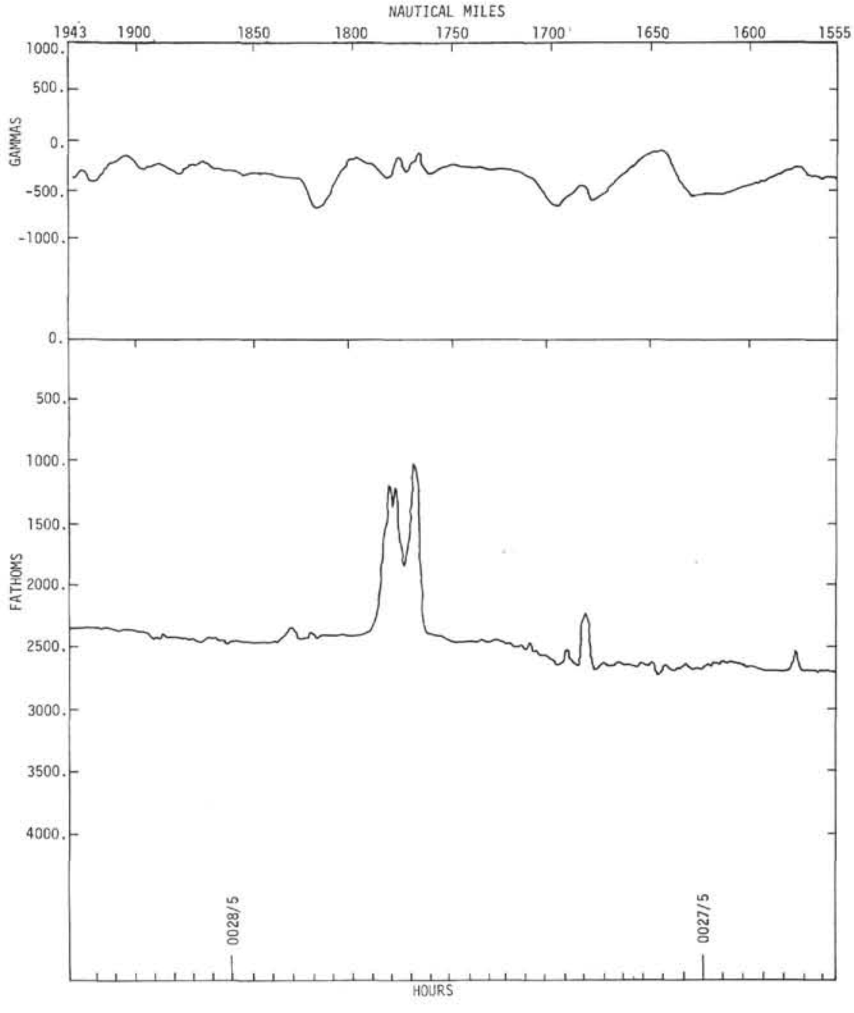

Figure 5a. *Site 235 to Site 236 (magnetic anomaly).*

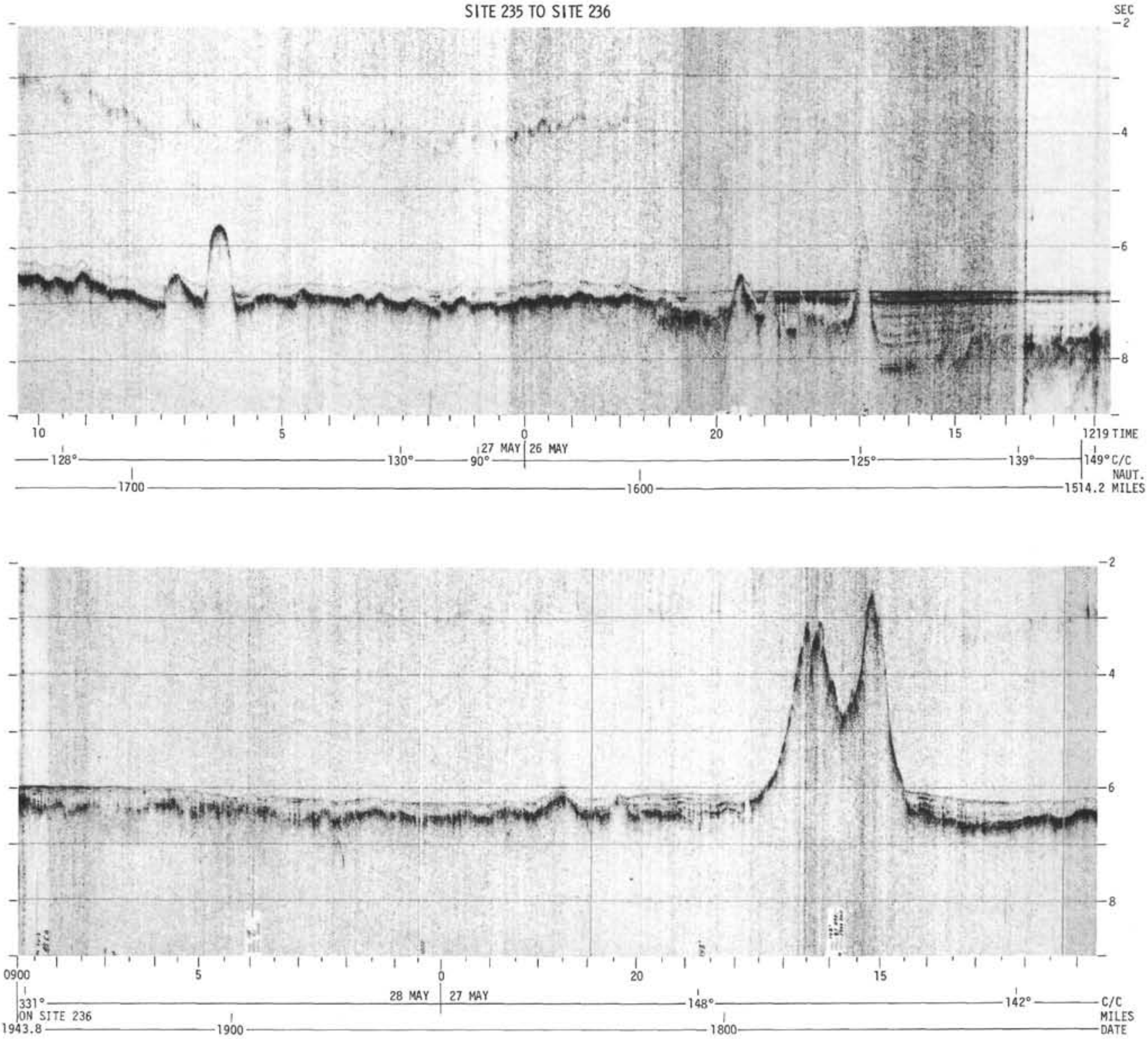

Figure 5b. *Site 235 to Site 236 (seismic profile).*

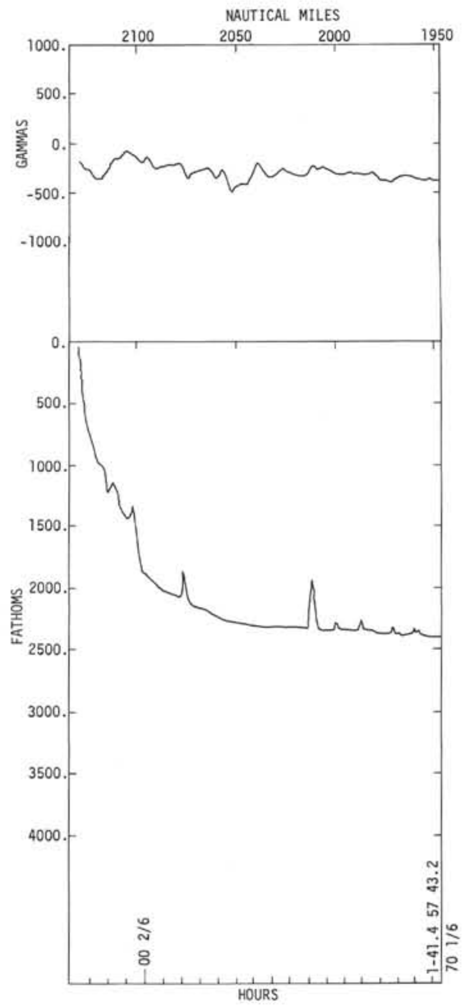

Figure 6a. *Site 236 to Mahé (magnetic anomaly).*

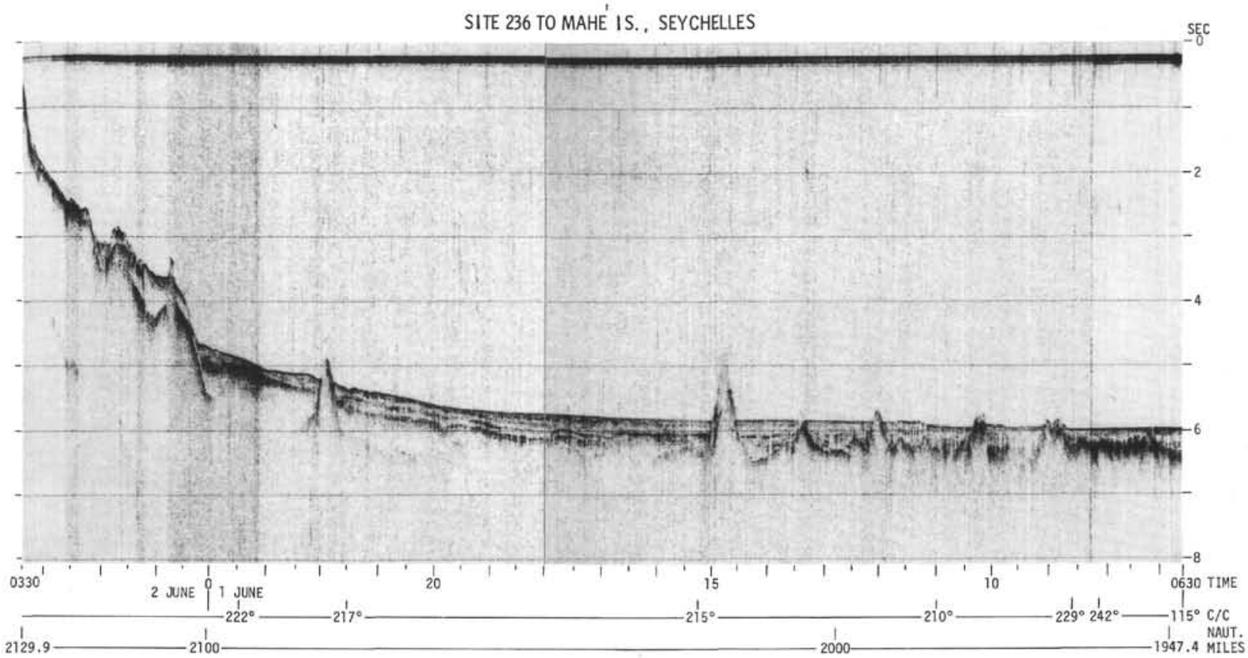

Figure 6b. *Site 236 to Mahé (seismic profile).*