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MAGNETIC, GRAVITY AND DEPTH SURVEYS IN THE
MEDITERRANEAN AND RED SEA

by

T.D. ALLAN and H. CHARNOCK

15 APRIL 1965

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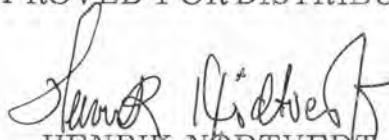
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HENRIK NØDTVEDT

Director

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INTRODUCTION

This report is a copy of a paper published in "Nature", Vol. 204, No. 4965, pp 1245-1248, December 26, 1964, by T.D. Allan of this Centre, H. Charnock of this Centre at the time of the surveys but now of the National Institute of Oceanography, Wormley, Godalming, U.K., and C. Morelli of the Osservatorio Geofisico Sperimentale, Trieste, Italy. It provides a summary of part of the geophysical work carried out by the SACLANT ASW Centre during the period from 1959 to 1963.

MAGNETIC, GRAVITY AND DEPTH SURVEYS IN THE MEDITERRANEAN AND RED SEA

Although a relatively small and land-locked basin, the Mediterranean has many oceanic features. About three-quarters of the area is deeper than 1,000 fathoms, with extensive areas deeper than 1,500 fathoms and isolated depths of more than 2,500 fathoms. The western and eastern basins are geophysically different.

In both western basins there are extensive areas of abyssal plain, whereas the floor of the eastern basin, in spite of the sediment from the Nile, is characterized by an unusual type of small-scale relief. To the north of the eastern basin the Cretan island arc bounds the irregular topography of the Aegean Sea. Geophysical investigations of the differences between the eastern and western basins may provide clues as to their origin.

The Red Sea is another area where systematic observations may be of more than local interest. Previous observations have shown the similarity between the rift valley of the southern Red Sea and that of the mid-Atlantic Ridge.

The SACLANT ASW Research Centre was commissioned in 1959 and its Oceanography Group formed the following year. Submarine geophysical observations in both the Mediterranean and the Red Sea have formed part of

the group's programme. A summary of the geophysical work is given in this article.

FACILITIES

S. S. ARAGONESE, a freighter 293 ft. long, displacing 3,000 tons, was chartered for conversion into a marine research vessel. Radar, gyrocompass, precision depth recorder and other essential equipment were fitted initially. A LORAN-C receiver and an electromagnetic log were fitted later.

The number of scientific personnel directly involved with the geophysical programme was small and the group frequently co-operated with other research establishments.

An agreement was reached with the Osservatorio Geofisico Sperimentale, Trieste, on a joint programme of gravity, magnetic and bathymetric survey work. The gravity meter, a Graf-Askania, was owned by the Osservatorio and operated by its staff throughout the cruises.

The gravity values were usually tabulated at 15-min intervals. The accuracy of the free-air gravity value depends not only on the performance of the meter and stabilized platform but also on the accuracy of the Eötvös correction which is calculated from the ship's speed and course. In this respect the Mediterranean has presented fewer problems than those in the ocean generally. In the earlier cruises radar signals on numerous islands provided good control: for most of the work the probable error in position was ± 0.25 mile. For the later surveys, in areas far from land, LORAN-C positions proved reliable to better than ± 0.5 mile.

The magnetometer was the nuclear spin model described by Hill⁽¹⁾ and manufactured by Bruce Peebles, Ltd. It had a sensitivity of $\pm 0.5 \gamma$. Readings were taken every 30 sec and recorded on punched paper for later reduction on the Centre's computer. The greatest inaccuracy in the measurement of the absolute value of the field lay in the uncertain knowledge of its diurnal variation.

Depth was recorded on a precision depth recorder which could be read to ± 1 fathom.

During the period July 1961 - March 1963 seven cruises were made. These were devoted almost entirely to magnetic, gravity and depth surveys of selected areas, but brief trials of other techniques, such as coring and seismic reflexion profiling, were also made.

About 40,000 miles of track have been covered; the distribution in the Mediterranean and Red Sea is shown in Figs. 1 and 2.

WESTERN MEDITERRANEAN

The first cruise was used to compare the performance of different types of gravity meter. The Trieste Graf-Askania and a LaCoste-Romberg instrument provided by the U.S. Office of Naval Research were installed in the ship. Observations were made in three areas between La Spezia and Sicily where earlier bottom gravity readings⁽²⁾ provided a precise reference. Consequently, not only relative but absolute comparisons of the surface-ship meters were possible. In the area near La Spezia precise navigational control was achieved by using theodolites on nearshore hills.

The gravity meters agreed within 10 mgal in calm conditions, but modifications to the LaCoste-Romberg were necessary to allow for the "Browne" corrections in rougher weather. An account of the comparisons has been published⁽³⁾.

Other cruises in the western basin have examined the continental slopes which border the Balearic and Tyrrhenian abyssal plains. These slopes are cut by submarine canyons resembling those found in other parts of the continental margin but which have been interpreted as former sub-aerial valleys.

Between Sicily and Malta the survey did not appear to change the existing conception of the geology of the area. There were large magnetic anomalies around volcanic islands such as Pantelleria and the negative Bouguer gravity anomaly known to exist in western Sicily was shown to change to a positive anomaly in the centre of the Strait.

EASTERN MEDITERRANEAN

In the eastern Mediterranean the islands of Crete, Scarpanto and Rhodes appear to form an island arc structure with contrasting geophysical properties in the areas to the north and south of the arc. These areas have been extensively surveyed during three of our cruises. Dr. K.O. Emery took part in one of these, during which a relief map of the sea-floor was prepared from a study of the type of bottom displayed on the echo-sounder.

Much of the sea-floor in the eastern basin is characterized by the type of small-scale relief shown in Fig. 3. The lack of deposition appears to be caused by a series of trenches which borders the area and acts as a trap for sediment spreading from the Nile.

Perhaps the most interesting aspect of the eastern basin, in spite of the lack of sedimented area, is the dullness of its magnetic field. Thus, apart from the latitudinal variation, there is no significant change of magnetic field between North Africa and Crete. This can be seen from Fig. 4, which shows a typical north-south profile of magnetic field, gravity and depth across the island arc. To the north there are several isolated magnetic anomalies, probably associated with vulcanism.

The gravity field is broadly similar to that associated with the island arcs of the major oceans. Generally negative in the southern part of the eastern basin, there is a free air anomaly of about -100 mgal. in a band associated with the deep trenches just to the south of the arc. To the north the gravity field is generally positive, reaching $+140$ mgal.

THE RED SEA

A survey of the Red Sea and Gulf of Aqaba was made between October and December 1961. A second Graf-Askania gravity meter, supplied and operated by scientists of the German Hydrographic Institute and the Bundesanstalt für Bodenforschung, was embarked for this cruise and provided a good opportunity of comparing the performance of two meters of the same type. Over most of the cruise the agreement was excellent.

Preliminary surveys in the Red Sea^{(4),(5)} had shown the existence of a magnetic anomaly associated with a steep-sided medial valley about 30 miles wide. This anomaly was studied in much more detail during the 1961 cruise. A total of fifty-four transverse crossings were made. Records from a typical crossing (20° N.) are shown in Fig. 5.

A preliminary analysis of the results shows that the median valley, which is more fully developed in the south, is underlain by a considerable thickness of dense, magnetic rock. The lateral extent of this material appears to be confined to the width of the valley.

At the northern end of the Red Sea the Gulf of Suez is shallow and dull both in its magnetic and gravity structure. The Gulf of Aqaba, however, provides an interesting contrast. The Aqaba rift is everywhere less than 15 miles wide and about 600 fathoms deep. It is flanked on both sides by steep mountains. There is a strongly negative gravity anomaly, reaching -200 mgal (free air) and -100 mgal (Bouguer), while the magnetic field is featureless. The structure of the Gulf of Aqaba resembles that of the Gulf of Corinth; both may be thickly sedimented grabens.

The contrasting geophysical properties of the Gulf of Aqaba and the Red Sea, shown in Fig. 5, must be taken into account in any attempted interpretation of the origins of the Rift system.

We thank Dr. E. T. Booth and Dr. J. M. Ide for their advice during their service as scientific director of the SACLANT ASW Research Centre, our colleagues, ashore and afloat, and the captain, officers and crew of S.S. ARAGONESE for their assistance.

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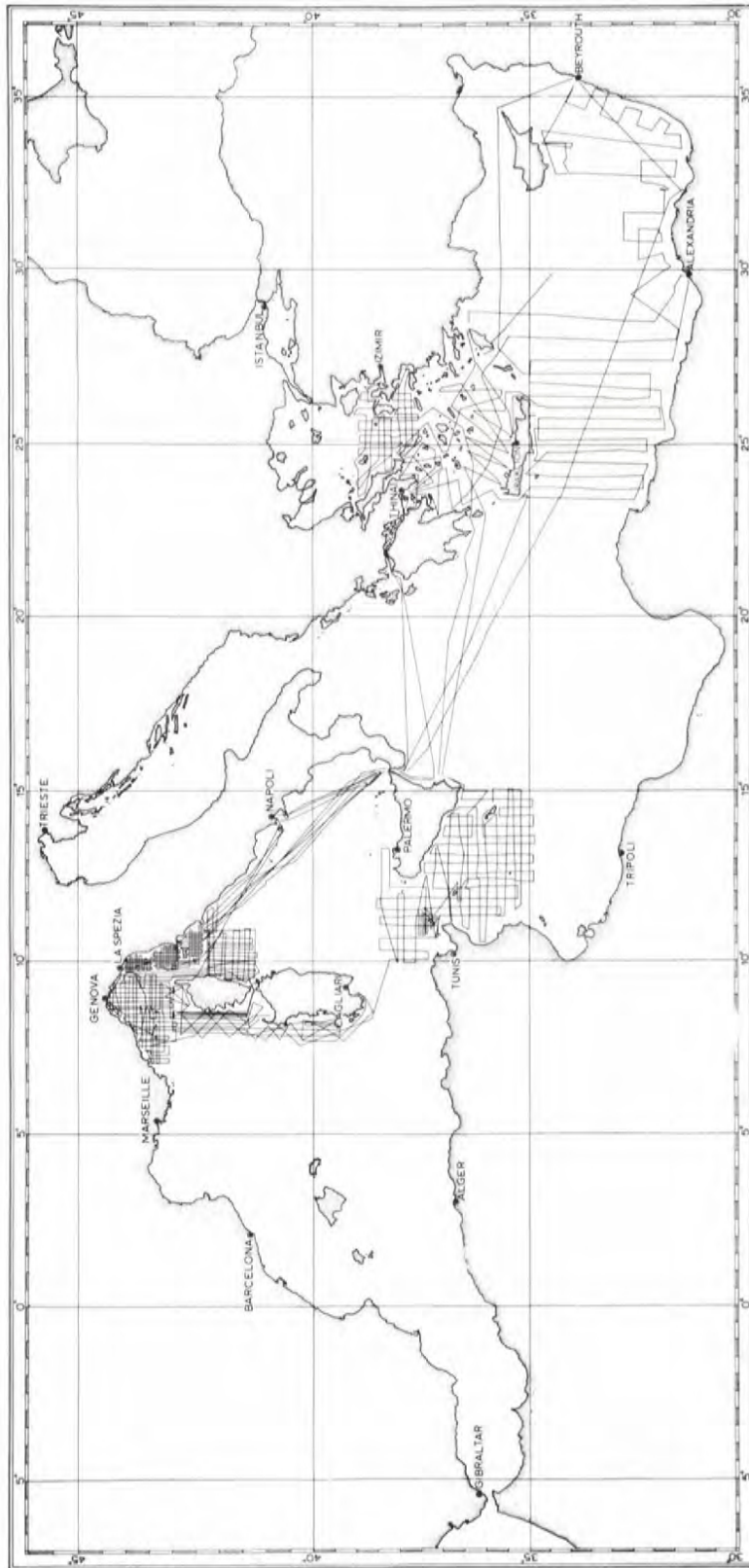


Fig. 1. Tracks of S. S. ARAGONESE in the Mediterranean Sea during the period July 1961 - March 1963

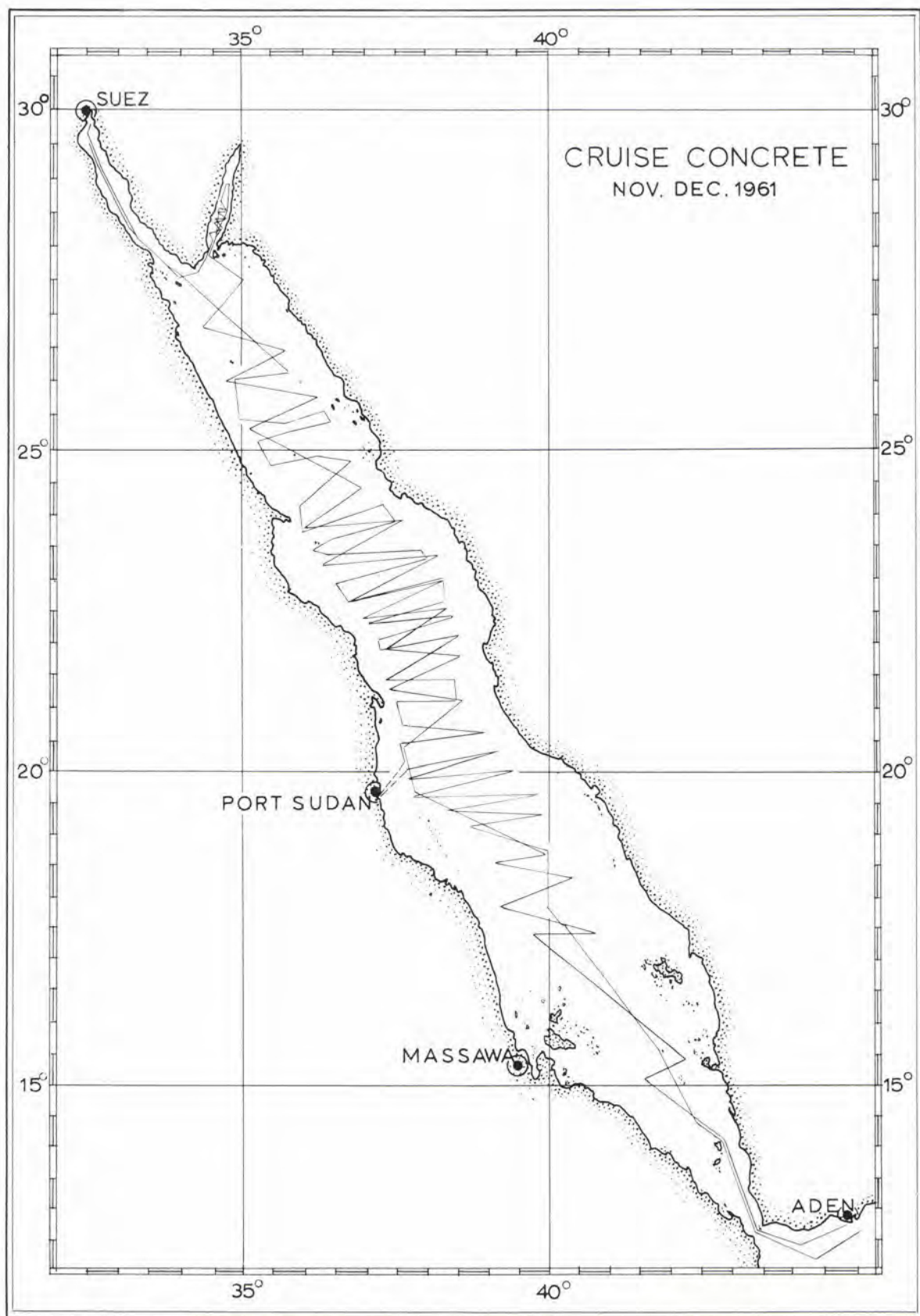


Fig. 2. Tracks of S.S. ARAGONESE in the Red Sea during November-December 1961

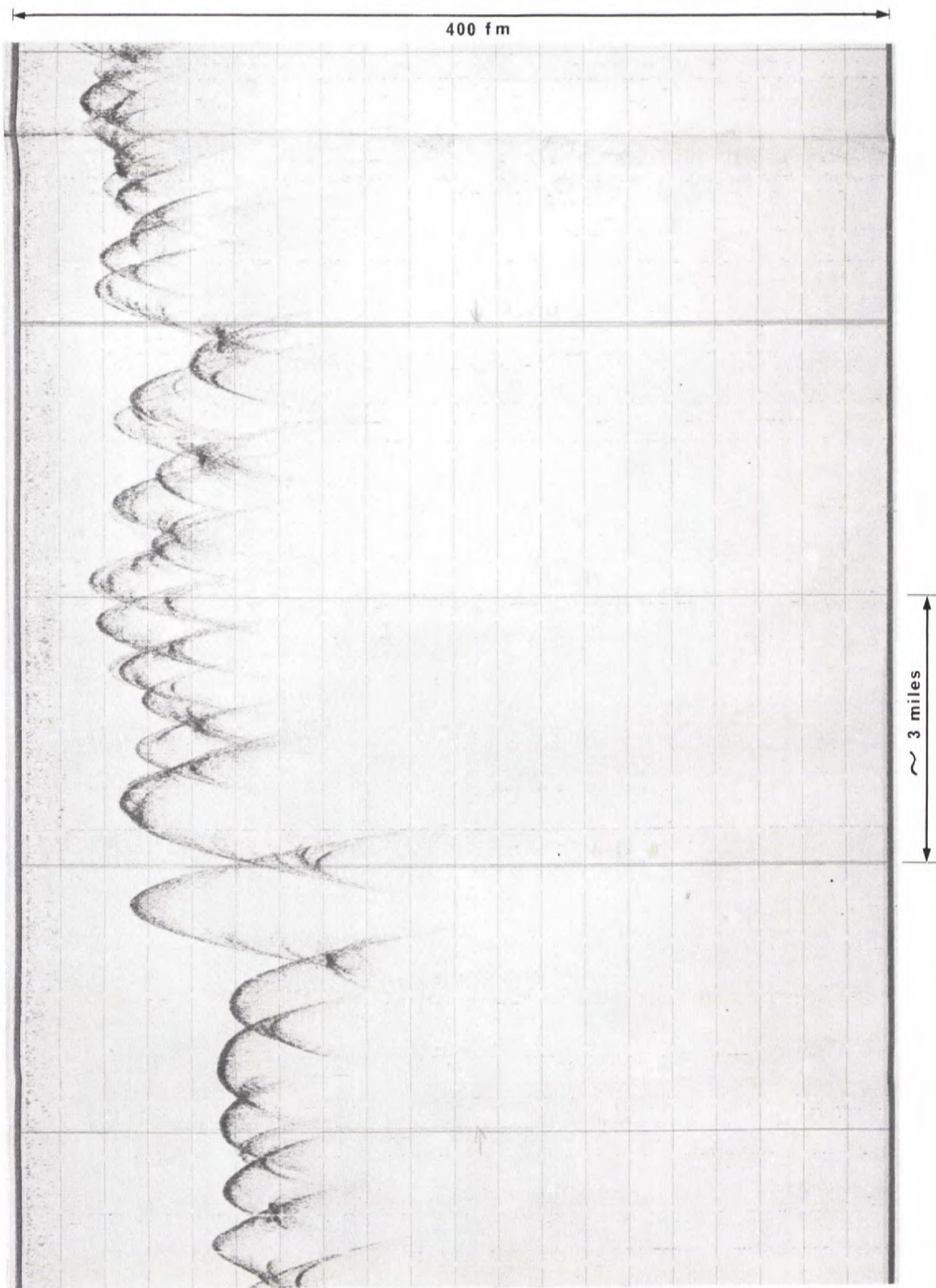
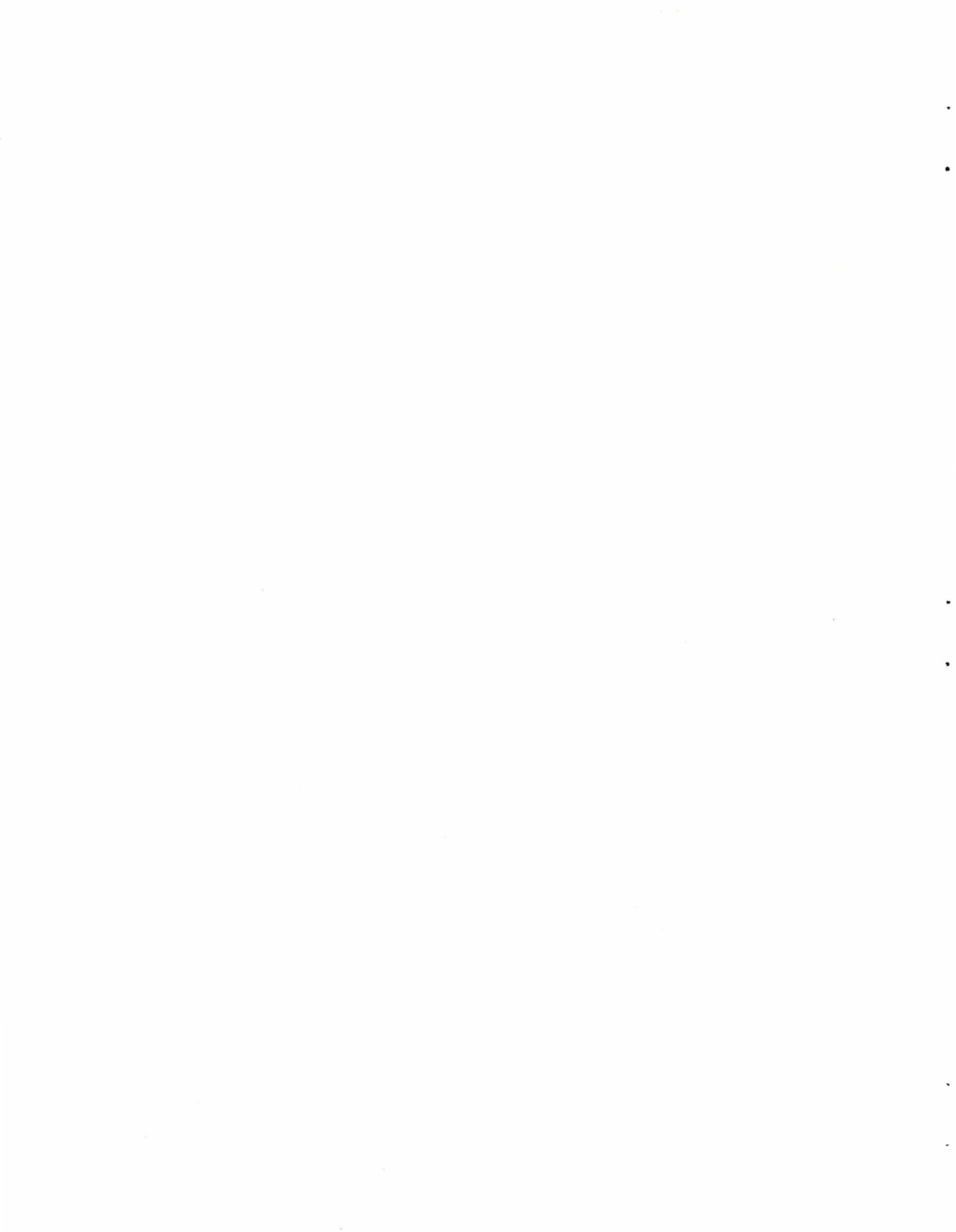


Fig. 3. Profile across the unusual floor of the eastern Mediterranean Sea.



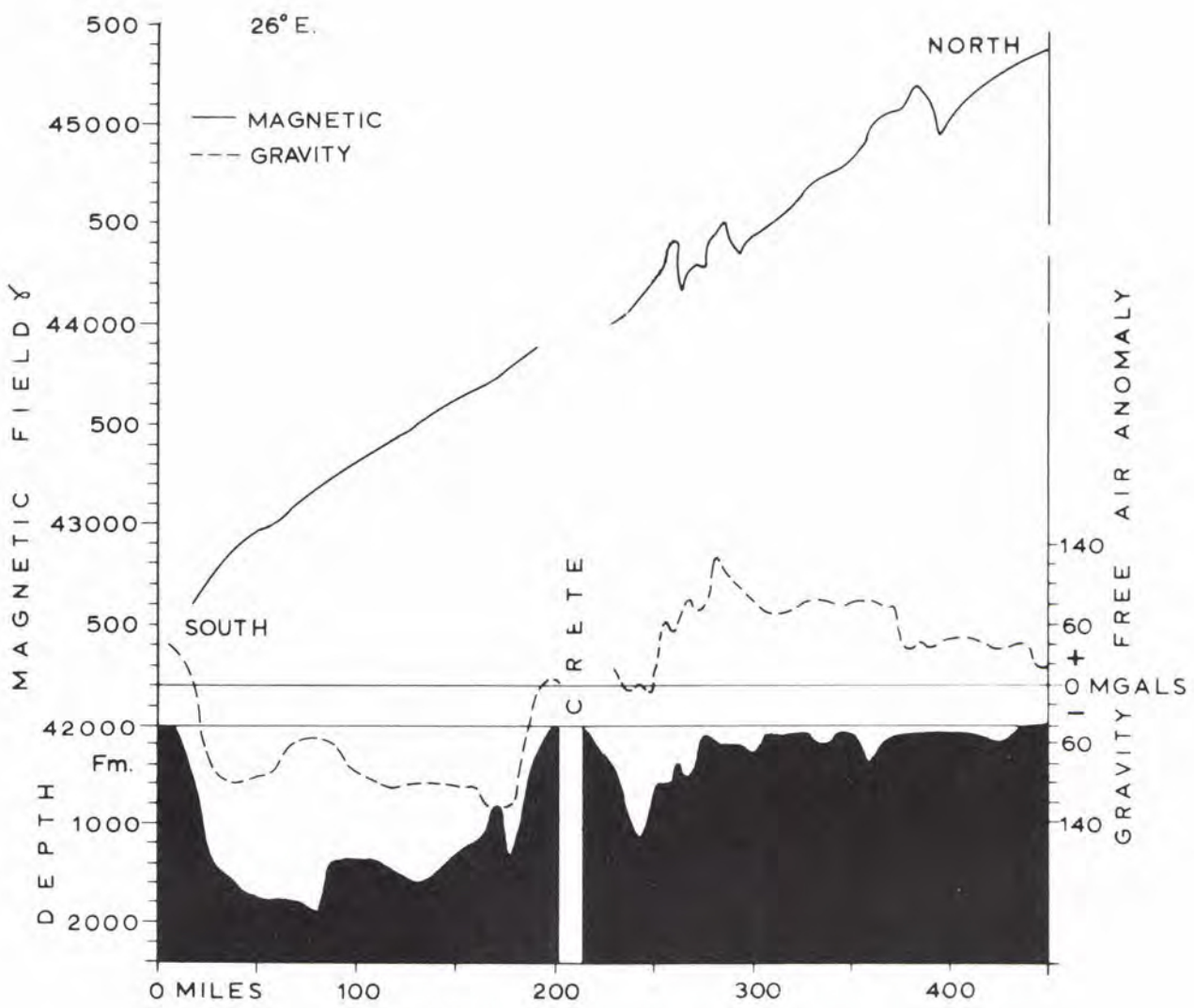
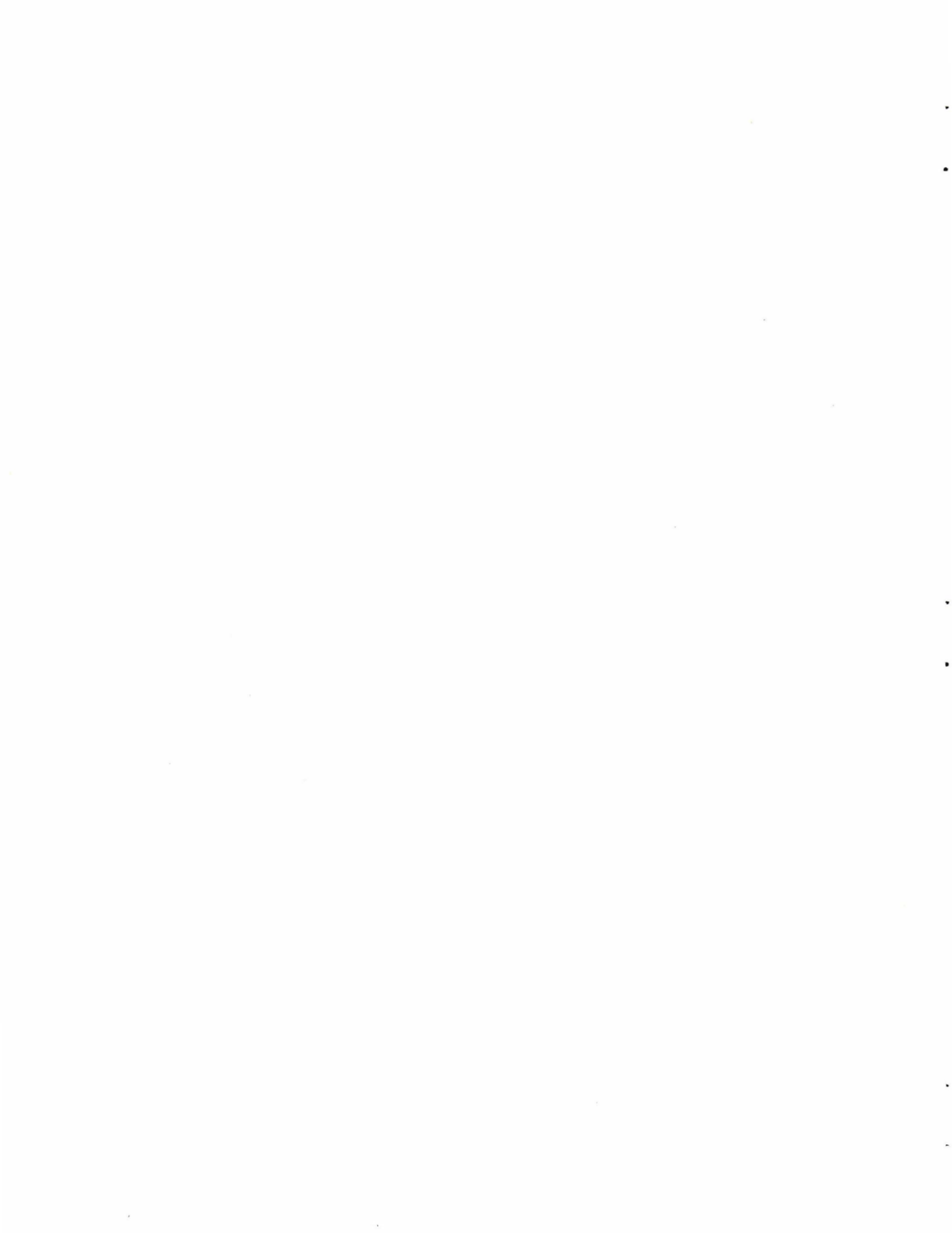


Fig. 4. Profile along meridian 26° E. of gravity (free-air) anomaly, total magnetic field and depth. The southern limit is the African coast and the northern limit lies at latitude 39° N. in the central Aegean.



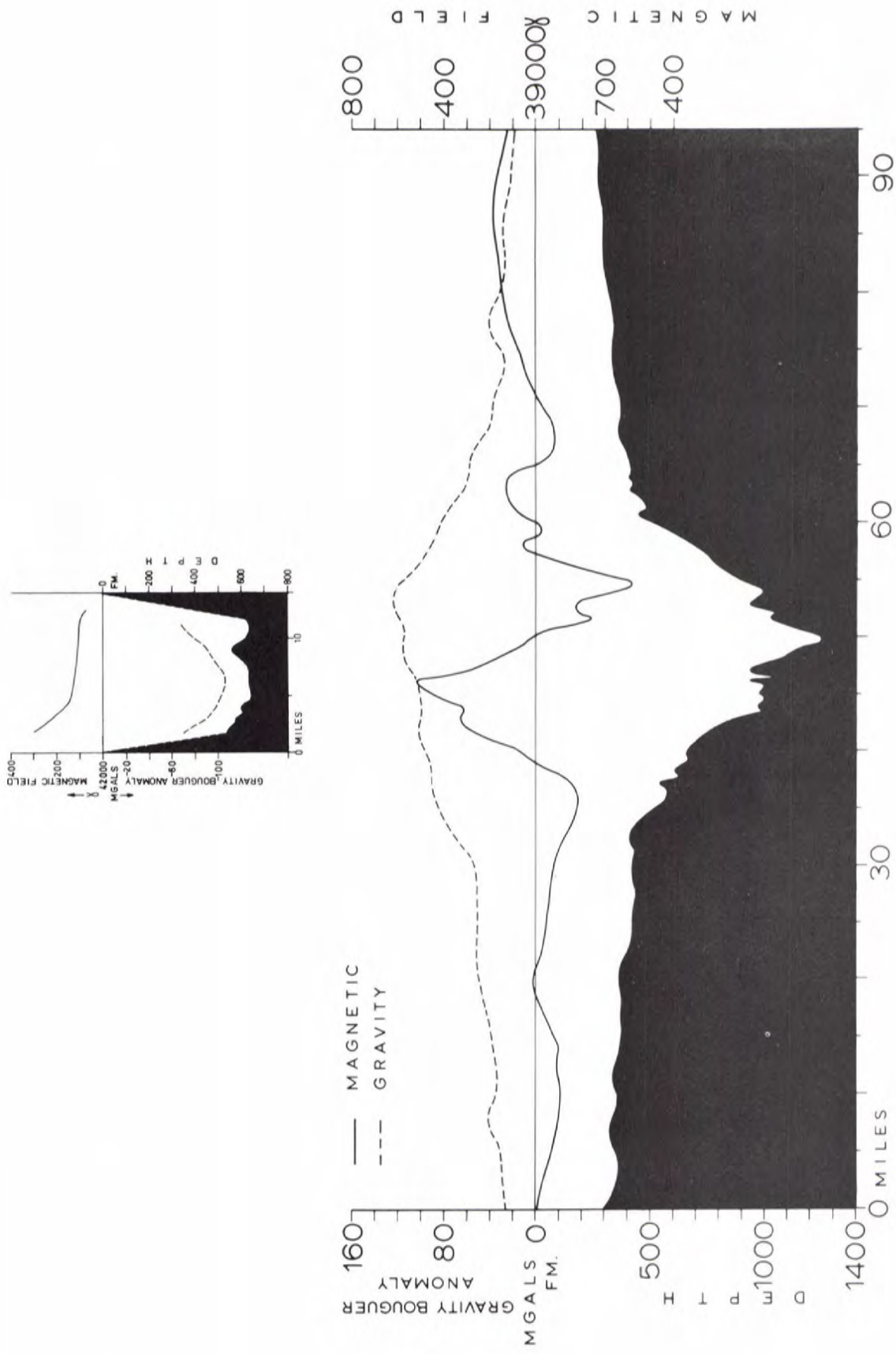
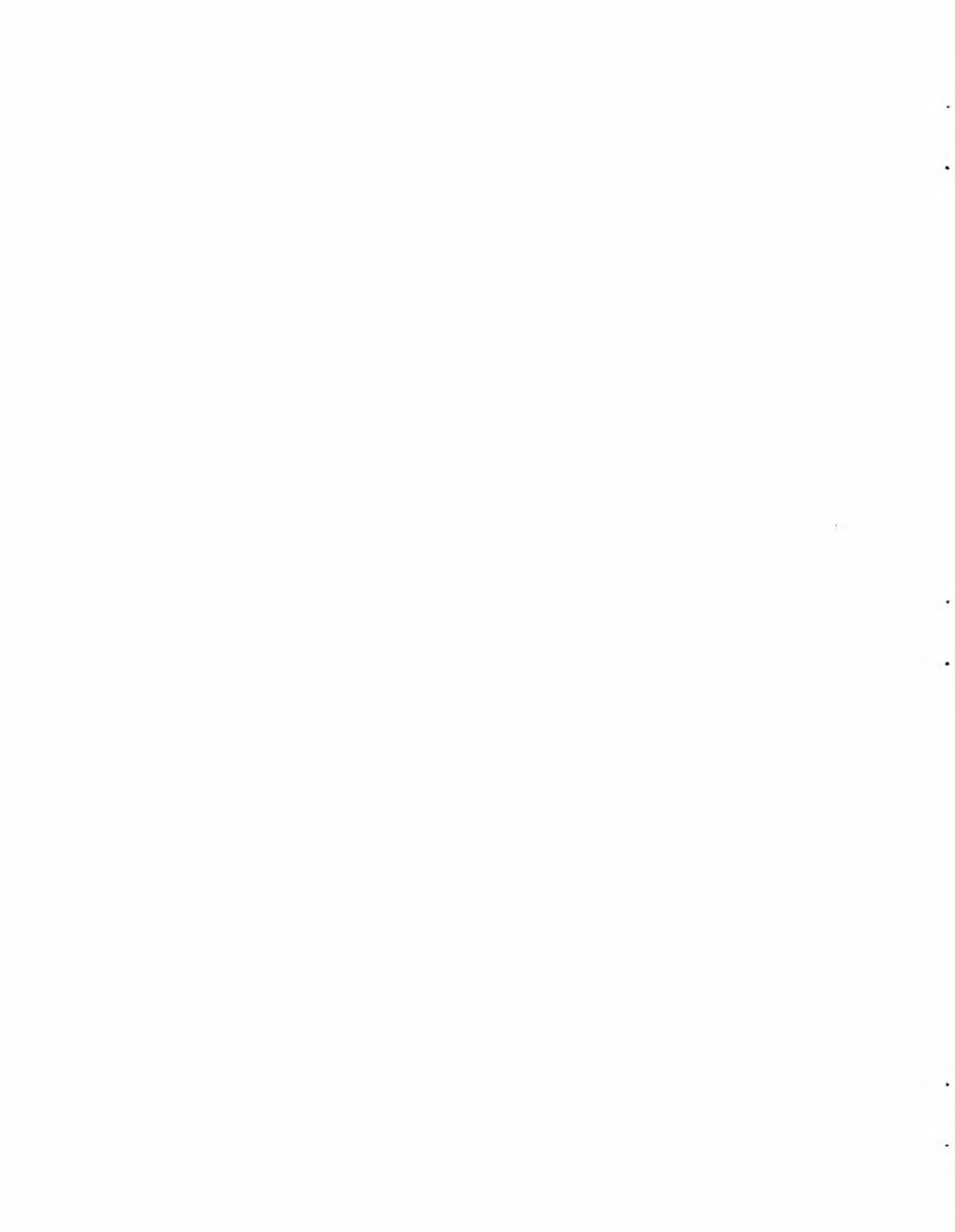


Fig. 5. Gravity and magnetic profiles across the Gulf of Aqaba (top), and across the Red Sea at 20° N. (bottom). The profiles are drawn to the same scale.



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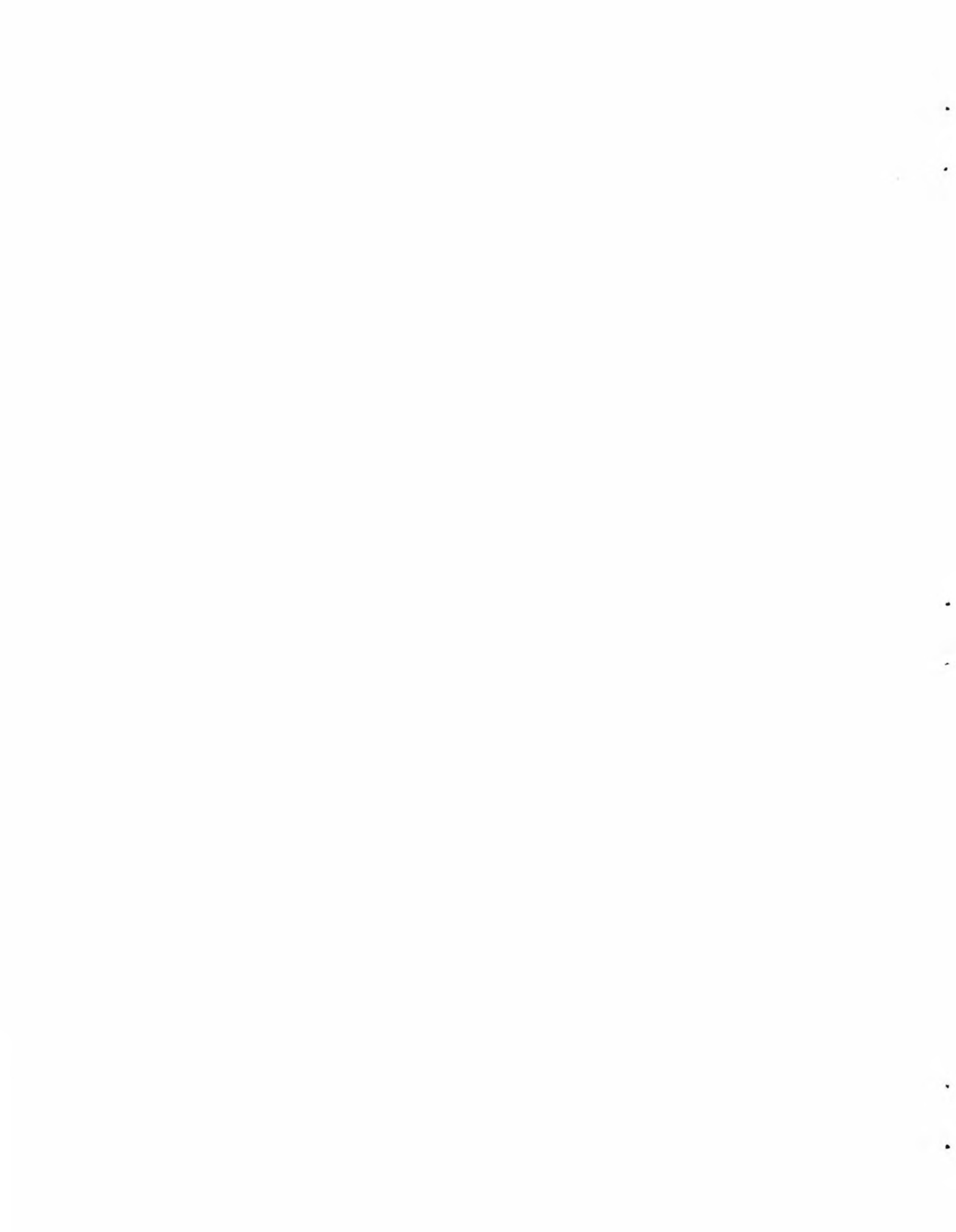
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