BATHYMETRY, GRAVITY AND MAGNETISM IN THE STRAIT OF SICILY

by

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1. INTRODUCTION

In cooperation with SACLANTCEN, O.G.S. started in 1961 the geophysical survey of the Mediterranean Sea (Allan, Morelli, 1971), which after 1966 was continued in the seas around Italy on the oceanographic ships of C.N.R. : "Bannock" and "Marsili".

The bathymetric, gravimetric and magnetic survey of the Sicily Channel was initiated during the "Codicil" Cruise in 1962 (6744 miles): the data were utilized for the compilation of the four maps of "Area 7" (Strait of Sicly), already published (Allan, Morelli, 1971).

The results presented here have been obtained mainly from the following cruises under the sponsorship of the Consiglio Nazionale delle Ricerche:

Year	Cruise	Ship	Area of Sicily Channel
1965	BACHELOR	BANNOCK	S
	BARRISTER	"	S
1966	BACIN	"	E
	BALEARIC	"	N
1967	BANISH	"	E
1968	BASTARD	"	N
1969	BANJO	"	N-E
	BANJONET	"	E
1970	BALLAST	"	E
1971	MARIO	MARSILI	E
	MARIONETTA	"	E

All the cruises took advantage of a good Loran C positioning.

2. BATHYMETRY

The bathymetry of the Strait of Sicily [Fig. 1] is actually characterised by an extended continental shelf that occupies most of the Sirte Gulf, and is a southwestern extension of western Sicily and a southern extension of southern Sicily.

Morphologically speaking, all the area is mainly an epicontinental sea, vast parts of which have been exposed during the sea-level lowering (of the order of 150 m) during the major glacial cycles. This is confirmed by numerous deeply incised canyons along the Malta Escarpment, which correspond to periods of direct sediment embouchment over the edge of the shelf in this area.

Along the eastern edge of the submerged platform several wave-cut terraces can be traced as continuous benches for tens of kilometres, even though they have been tectonically tilted to the southwest since the time of their formation in the Pleistocene epoch. This shallow region is characterized in general, however, by sediment accumulation of the order of 100 to 200 m.

The sharp faults system which to the east delimitates Sicily and the Strait of Sicily from the Ionian Abyssal Plain can be clearly seen from the bathymetric map.

The central part of the Strait of Sicily is a foundered area, where narrow grabens exist, delimited by steep NW SE faults. Most of them exceed depths of 1000 m, reaching the minimum values (from NW) of:

Pantelleria Graben	:	1317 m ,
Malta Graben	:	1721 m ,
Linosa Graben	:	1529 m .

Most of the central area is deeper than 600 m, but the exchange of the deeper waters, between the Western and the Eastern Mediterranean, is restricted to a narrow saddle with depths between 510 m and 600 m eastwards ("Eastern Sill"), and a very narrow one with depths between 410 m and 500 m northwestwards ("Western Sill").

The above-mentioned intermediate basins in the Strait of Sicily can therefore form stocks of the Levantine Water.

3. GRAVITY

The Free Air gravity anomalies [Fig. 2] are positive in the Strait of Sicily, thus confirming the general tendency of the area to sink. They are interrupted by narrow strips of negative anomalies, corresponding to the above-mentioned grabens.

The Bouguer-anomaly [Fig. 3] gives perhaps the key for the understanding of the tectonics in this area. Indeed, in the central part of the Strait of Sicily a strong positive Bouguer anomaly (+ 90 mgal) dominates between Pantelleria and Linosa, and the areal extension of the + 50 mgal Bouguer anomaly covers most of the Strait of Sicily and continues northeastwards to the Ragusa plateau, which in turn is joined to the Malta high.

This uplift of denser material is confirmed by the volcanic activity (delimited also by the Total Magnetic Intensity map), which in the central part of the Strait is all contained within the + 50 mgal contour line (see Zarudski, 1969).

The area of the Sicily Strait is therefore one in which the magmatic activity has affected the sialic (continental) curst, but with less intensity than in other areas around the western Mediterranean where oceanic crust has been revealed by seismic refraction studies: the present Balearic and Tyrrhenian Basins. The magmatic activity also reached the surface as a consequence of the post-orogenetic distension phase, which produced the troughs and the collapse also in the Strait of Sicily.

4. MAGNETISM

The magnetic field in the Strait of Sicily [Fig. 4] is mainly regular, in agreement with the thick sedimentary layers which constitute the upper part of the earth's crust in the area (see Finetti, Morelli, 1972).

But in the central area of the Strait of Sicily many intense magnetic anomalies indicate the presence of a magmatic activity. Geologic evidence of this are:

- the emerged volcanic islands (Pantelleria, Linosa);
- the submarine volcanos, mostly in the area north-eastern to the Pantelleria - Linosa line (they are 12, listed by Zarudzki, 1969).

They are Pliocene to Quaternary in age, but for most of the submarine volcanos an activity in historical times is reported, ending with the 1891 eruption of the Foerstner submarine volcano 4 km west from Pantelleria, which at the same time was accompanied by an uplift of the northern coast of Pantelleria, of the order of 1 m (Segre, in Gantar et all., 1961).

The Graham Shoal (approximately halfway between Pantelleria and Porto Empedocle) is presently a submarine volcano but during the eruption of 1831 it formed an emerged cone of 65 m height above sea level that lasted as such for only a few months.

The interpretation of the magnetic anomaly in Pantelleria suggests that the mesosoic and tertiary sediments, which constitute the island, were uplifted and faulted by an intrusion dome, forming now the core of the island, the top of which is only a few hundred metres below the sea level [Fig. 5]. The high density ($3.0\ g/cm^3$) and the high magnetic susceptibility ($\approx 2400 \times 10^{-6}$) suggest basic intrusives (Segre, loc. cit.). Other intense magnetic anomalies are lined N-S on the eastern margin of the Strait of Sicily platform. They are in correspondence, on the northern part, with the strong faults system which separates the same platform from the Ionian Bathyal Plane, and represent the continuation of the extended magmatic activity on the eastern side of Sicily (Etna, Iblei, C. Passero). But they continue southwards (in the direction of Misurata), also when the above mentioned margin is bending to the southeast, in correspondence with the flexures and faults indicated by Burrolet [see Fig. 7].

5. GEOLOGY

The Strait of Sicily has been studied from the geologic-tectonic point of view by Castany (1956) and by Burrolet (1967); from the geophysical point of view by Zarudzki (1969), who considered also the work of previous geophysicists, summarized by Harrison (1955) and Gantar *et al*. (1961).

Accordingly to Castany (1956), Tunis and Sicily constitute a common orogenic frame, an out-building of the African stand, affected by transversal irregularities. Although this "mosaic structure" allowed the compartment working, it shows common features, and both areas produce great analogies. As a whole the folds are sloping south and southeast, as also the southern front important overthrusts of the Peloritan massif, of the Palermo mounts, of the Sicani and of the Kabylian and South-Tellian Algeria ranges. The deformation permanence on the same axes results in a superposed tectonic. The extrusions of the calcareous massives are frequent.

The Siculo-Tunisian block tectonic is dominated by two large structural features — the vast central subsident basin and the Zaghhouan submeridian transverse. The latter, affecting the Atlas and its continental shelf, gives rise to two compartments: Constantinois-Tunis and East Tunis-Sicily. From both sides, a joining attempt of the large tectonic zones can be made. The Kabylian massives are the equivalent of the Peloritan mounts. The Tellian ranges correspond with the littoral range of Sicily (mounts of Trapani-Palermo-Termini-Madonie). The northwestern Tunisian Atlas is continued by the synclinorium of the isolated Mesozoic massives, and the Sicani. In the southeast, East Tunis and south-central Sicily belong to a same structural zone.

The above mentioned Zaghhouan transverse can be probably connected with the Anzio-Ancona line (Morelli et al., 1970), and form the fundamental lineament indicated by Ogniben (1969) affecting all the Apenninian structure [see Fig. 6].

Burrolet (1967), starting from the NW [sill between the Sardinia Channel and the Tyrrhenian Sea: strong positive (+ 150 mgal) Bougue anomaly: probably oceanic crust] outlines the following tectonic provinces [see Fig. 7]:

(A) The submarine continuation of the Tunisian Central Atlas "Sillon Tunisien", which according to Ogniben (1969) would correspond to the original eugeonsynclinal axis of the Gondwana geosyncline, and accordingly to Morelli (1970) would correspond to the powerful (volcanic) external ridge to the North of Sicily. This is very clearly confirmed by the positive F.A. - gravity and total magnetic intensity anomalies [see Figs. 2 and 4].

(B) Flysch and Numidian zones, linking the gravity-sliding features of N. Tunisia (from NW) and Sicily (from N).

(C) The Miocene troughs, which accordingly to Ogniben (1969) would correspond to the Gondwana miogeosyncline.

This province is, as known, confirmed by the extended trough of negative gravity anomalies in Sicily, which continues into the sea southward [see Figs. 2 and 3], but cannot definitely be recognized in the sea in its northern arc (between Bizerte and Granitola). However the Bouguer-anomaly map [Fig. 3] indicates this continuation, although interruped by a sill between Cap Bon and I. Marettimo.

(D) The submarine continuation of the Tunisian, positive, N-S Axis, a relic of the Alpine orogeny. Midway between N. Tunisia and W. Sicily this feature would be sharply bent to the southeast, as indicated in Fig. 7: this would be confirmed by Fig. 2.

(E) The peri-Atlasis basins, of which Pantelleria Trough is the most striking. The trough is formed by the Pantelleria, Linosa and Malta grabens and the horsts separating them.

Our bathymetry map [Fig. 1] does not confirm this arc: on the contrary, from Pantelleria it would bend northward, towards the Tyrrhenian Abyssal Plain.

ACKNOWLEDGMENTS

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SUMMARY

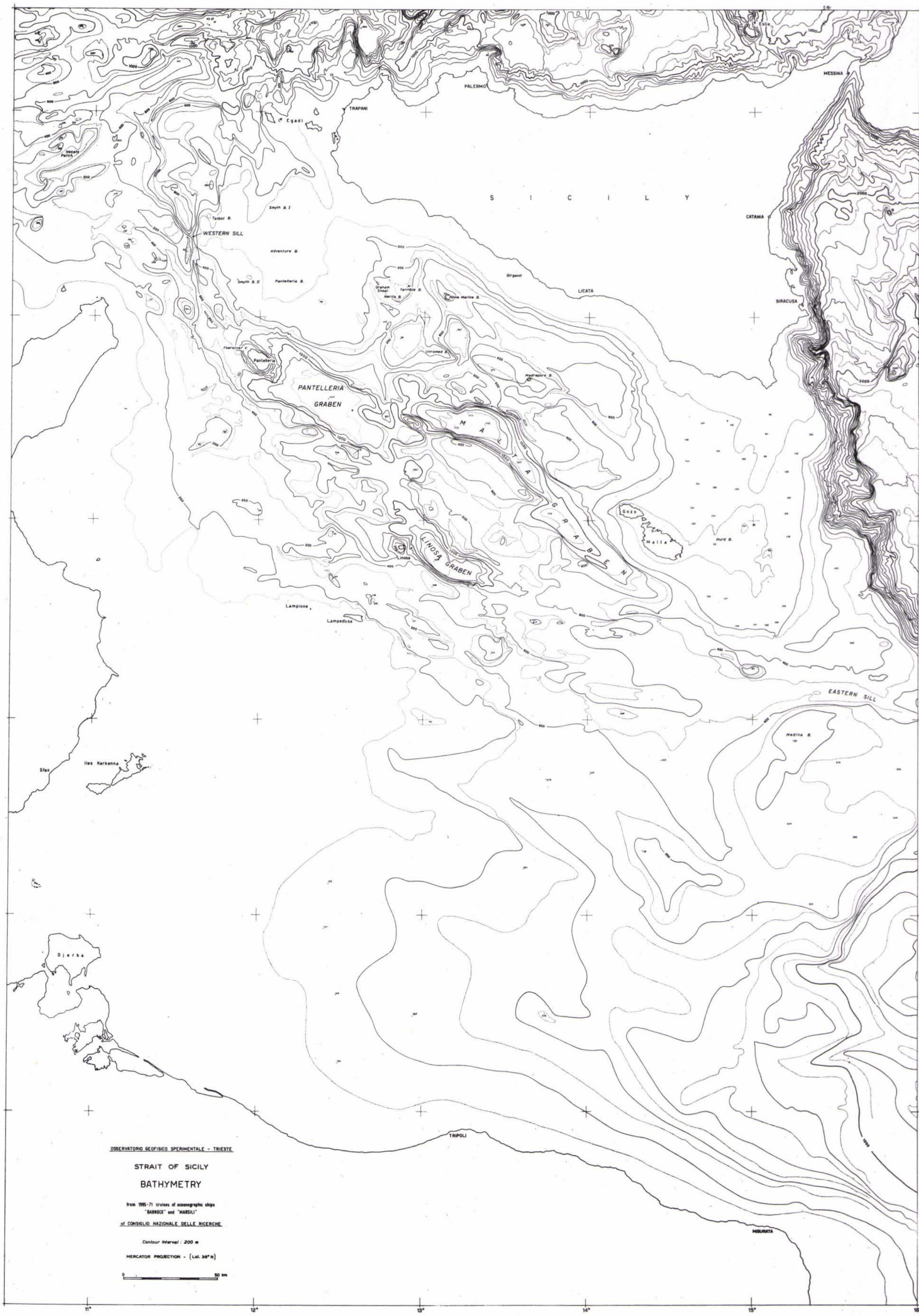
After the geophysical work 1961-1965 in cooperation with SACLANTCEN in the Mediterranean (published by Allan, Morelli, 1971), O.G.S. continued these surveys with C.N.R.'s ships "BANNOCK" and MARSILI"; 11 cruises covered the Strait of Sicily, from 1965 to 1971. Results are presented in form of the following maps, scale 1:750000 : Bathymetry, Free Air Gravity Anomalies, Total Magnetic Intensity.

Bathymetry gives the details for the continental bridge between Sicily and Africa, delimited by a steep N-S fault system to the east, foundered in the central part ("intermediate basin"), with three main grabens (Pantelleria - 1317 m; Malta - 1721 m; Linosa - 1529 m) and affected by a fault system oriented mainly NW-SE; and communicating with the rest of the Mediterranean over two sills (western : - 410 m; eastern - 510 m).

Free Air anomalies are in general positive, so confirming the general tendency of the area to sink.

The magnetic field is mainly regular, in correspondence with the thick sedimentary layers. But magnetic anomalies of magnetic origin are aligned:

N-S in correspondence with the eastern meridian faults system seen from bathymetry, and its submerged continuation towards Africa; NW-SE connected with the central area faults system, most of them in correspondence with the volcanic islands and submerged volcanos. Other ones are spread near the African coast.
The geological synthesis and correlations between Sicily and Tunisia by Castany and Burrolet agree well with the above-mentioned geophysical results.



TRAPANI
PALERMO
MESSINA
S I C I L Y
CATANIA
LICATA
SIRACUSA
WESTERN SILL
Pantelleria
PANTELLERIA GRABEN
M A L T A G R A B E N
LINOSA GRABEN
Linosa
Lampione
Lampedusa
Gozo
Malta
EASTERN SILL
Iles Kerkenna
Sfax
Djerba
TRIPOLI
MISURATA
OSSERVATORIO GEOFISICO SPERIMENTALE - TRIESTE
STRAIT OF SICILY
BATHYMETRY
from 1965-71 cruises of oceanographic ships
"BANNOCK" and "MARSILI"
of CONSIGLIO NAZIONALE DELLE RICERCHE
Contour interval : 200 m
MERCATOR PROJECTION - (Lat. 38° N)
0
50 km
11°
12°
13°
14°
15°
16°
32°
33°
34°
35°
36°
37°
38°

FIG. 1

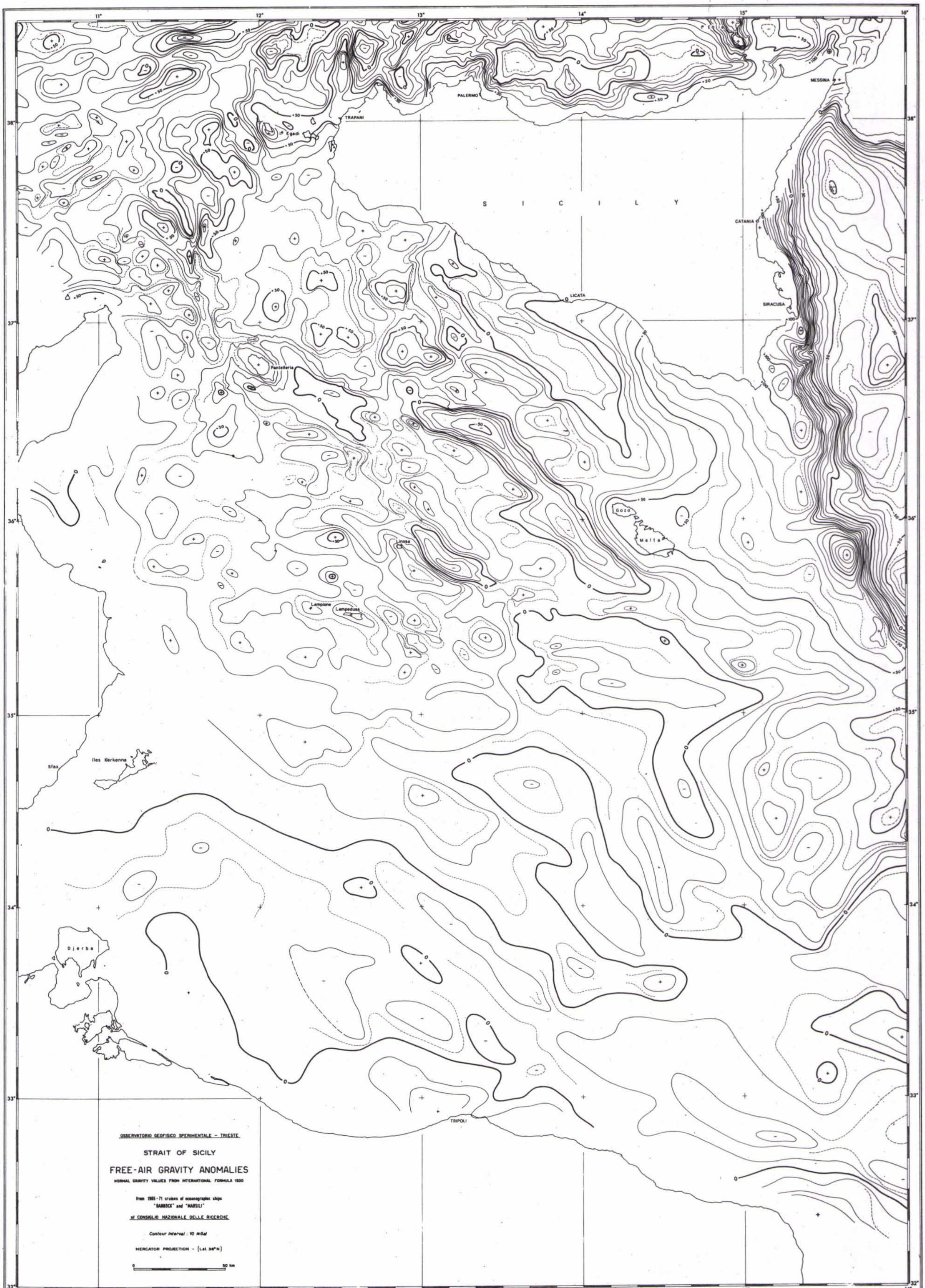

PALERMO
TRAPANI
Is. Egadi
MESSINA
S I C I L Y
CATANIA
SIRACUSA
LICATA
Pantelleria
Gozo
Malta
Linosa
Lampione
Lampedusa
Iles Kerkenna
Sfax
Djerba
TRIPOLI
OSSERVATORIO GEOFISICO SPERIMENTALE - TRIESTE
STRAIT OF SICILY
FREE-AIR GRAVITY ANOMALIES
NORMAL GRAVITY VALUES FROM INTERNATIONAL FORMULA 1930
from 1965-71 cruises of oceanographic ships
"BANNOCK" and "MARSILI"
of CONSIGLIO NAZIONALE DELLE RICERCHE
Contour interval : 10 mGal
MERCATOR PROJECTION - (Lat. 38° N)
0 50 km

FIG. 2

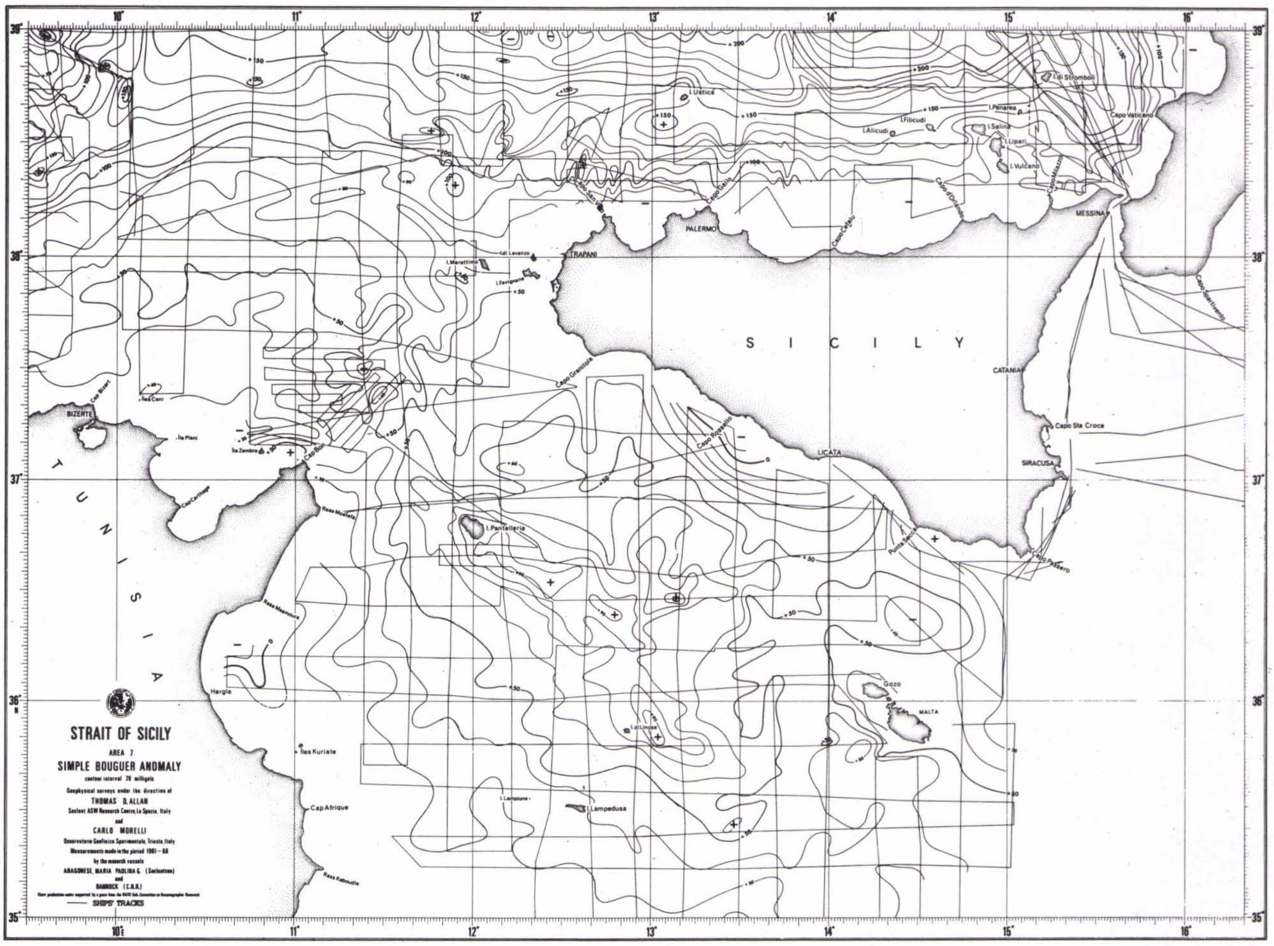

STRAIT OF SICILY
AREA 7
SIMPLE BOUGUER ANOMALY
THOMAS D. ALLAN
CARLO MORELLI
SHIPS' TRACKS
S I C I L Y
T U N I S I A
I. Ustica
I. di Stromboli
I. Panarea
I. Salina
I. Filicudi
I. Alicudi
I. Lipari
I. Vulcano
Capo Vaticano
MESSINA
PALERMO
TRAPANI
I. Marettimo
CATANIA
Capo Sta Croce
SIRACUSA
LICATA
I. Pantelleria
BIZERTE
Cap Bon
Hergla
Iles Kuriate
Cap Afrique
I. Lampione
I. Lampedusa
Gozo
MALTA
10°
11°
12°
13°
14°
15°
16°
35°
36°
37°
38°
39°

FIG. 3

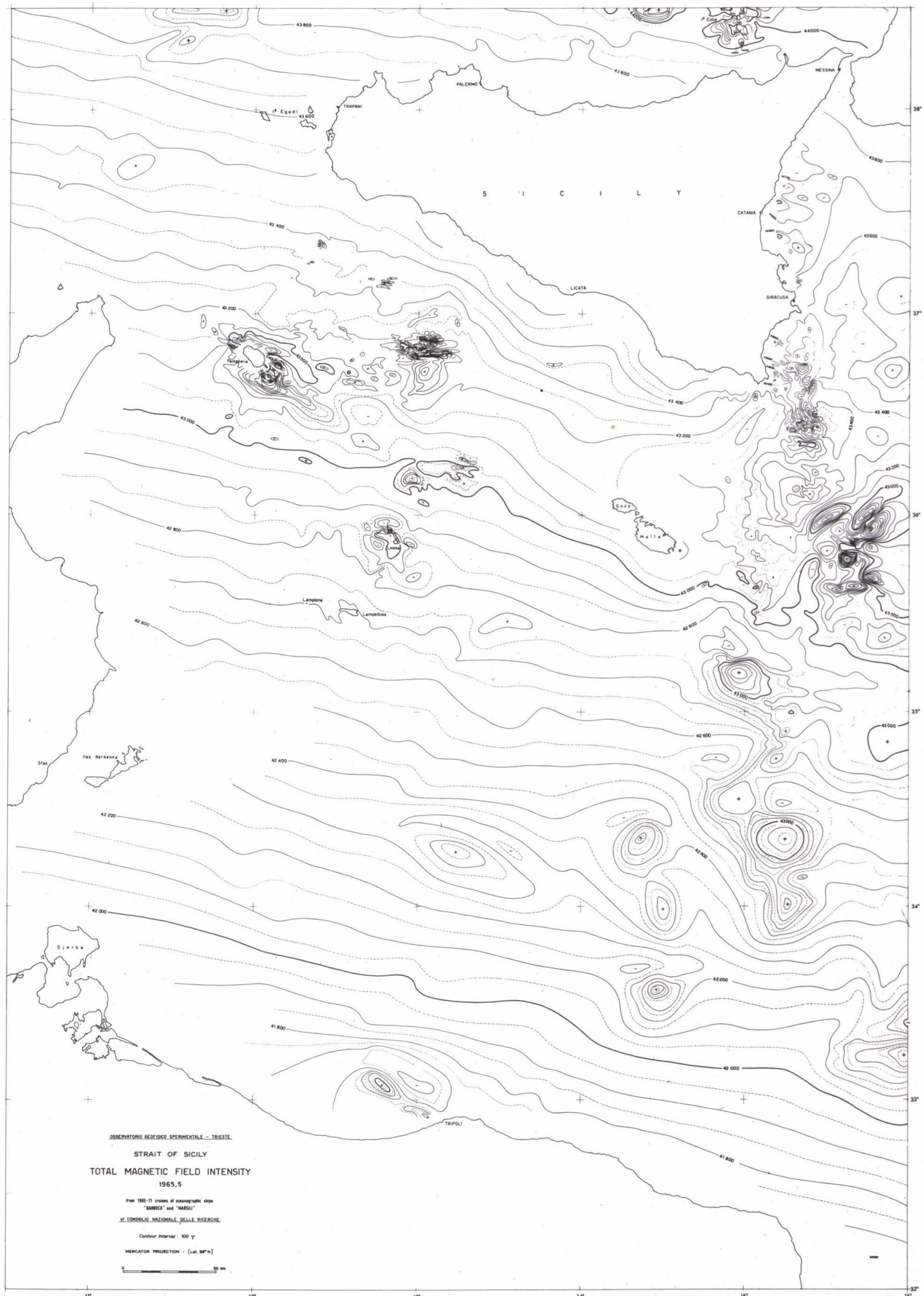
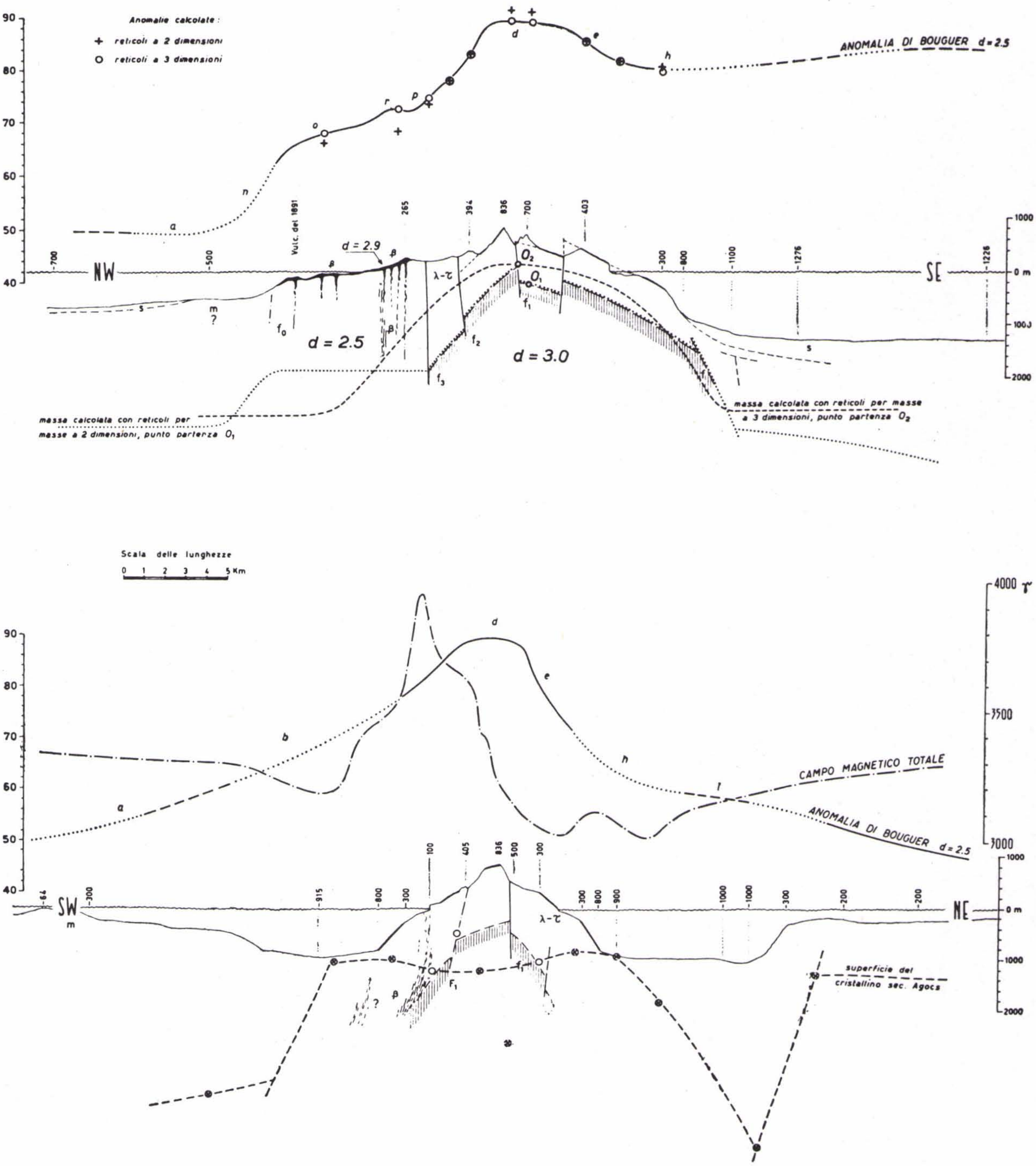

OSSERVATORIO GEOFISICO SPERIMENTALE - TRIESTE
STRAIT OF SICILY
TOTAL MAGNETIC FIELD INTENSITY
1965,5
from 1965-71 cruises of oceanographic ships
"BANNOCK" and "MARSILI"
of CONSIGLIO NAZIONALE DELLE RICERCHE
Contour Interval : 100 γ
MERCATOR PROJECTION - (Lat. 38° N)
0
50 km
S I C I L Y
PALERMO
TRAPANI
MESSINA
CATANIA
SIRACUSA
LICATA
Pantelleria
Linosa
Lampione
Lampedusa
Gozo
Malta
Iles Kerkenna
Sfax
Djerba
TRIPOLI
11°
12°
13°
14°
15°
16°
38°
37°
36°
35°
34°
33°
32°
43 800
44 000
43 600
43 400
43 200
43 000
42 800
42 600
42 400
42 200
42 000
41 800

FIG. 4



Anomalie calcolate:
reticoli a 2 dimensioni
reticoli a 3 dimensioni
ANOMALIA DI BOUGUER d = 2.5
NW
SE
d = 2.9
d = 2.5
d = 3.0
massa calcolata con reticoli per masse a 2 dimensioni, punto partenza O_1
massa calcolata con reticoli per masse a 3 dimensioni, punto partenza O_2
Scala delle lunghezze
CAMPO MAGNETICO TOTALE
ANOMALIA DI BOUGUER d = 2.5
SW
NE
superficie del cristallino sec. Agoca

FIG. 5

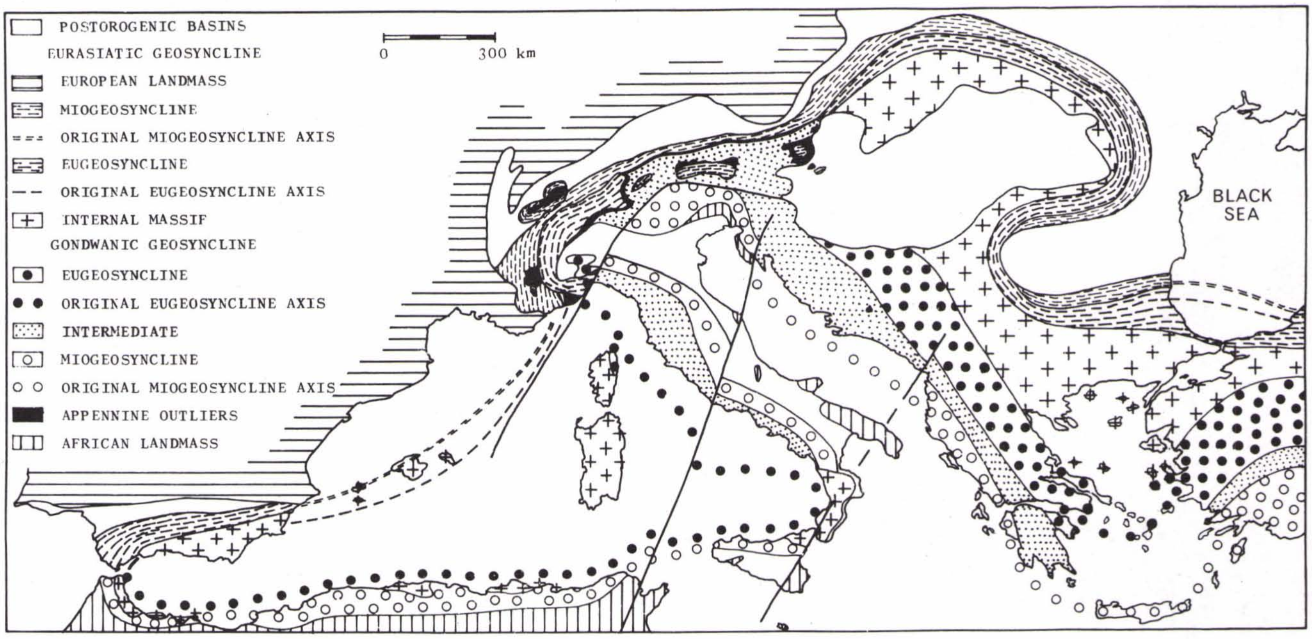

POSTOROGENIC BASINS
EURASIATIC GEOSYNCLINE
EUROPEAN LANDMASS
MIOGEOSYNCLINE
ORIGINAL MIOGEOSYNCLINE AXIS
EUGEOSYNCLINE
ORIGINAL EUGEOSYNCLINE AXIS
INTERNAL MASSIF
GONDWANIC GEOSYNCLINE
EUGEOSYNCLINE
ORIGINAL EUGEOSYNCLINE AXIS
INTERMEDIATE
MIOGEOSYNCLINE
ORIGINAL MIOGEOSYNCLINE AXIS
APPENNINE OUTLIERS
AFRICAN LANDMASS
0
300 km
BLACK SEA

FIG. 6

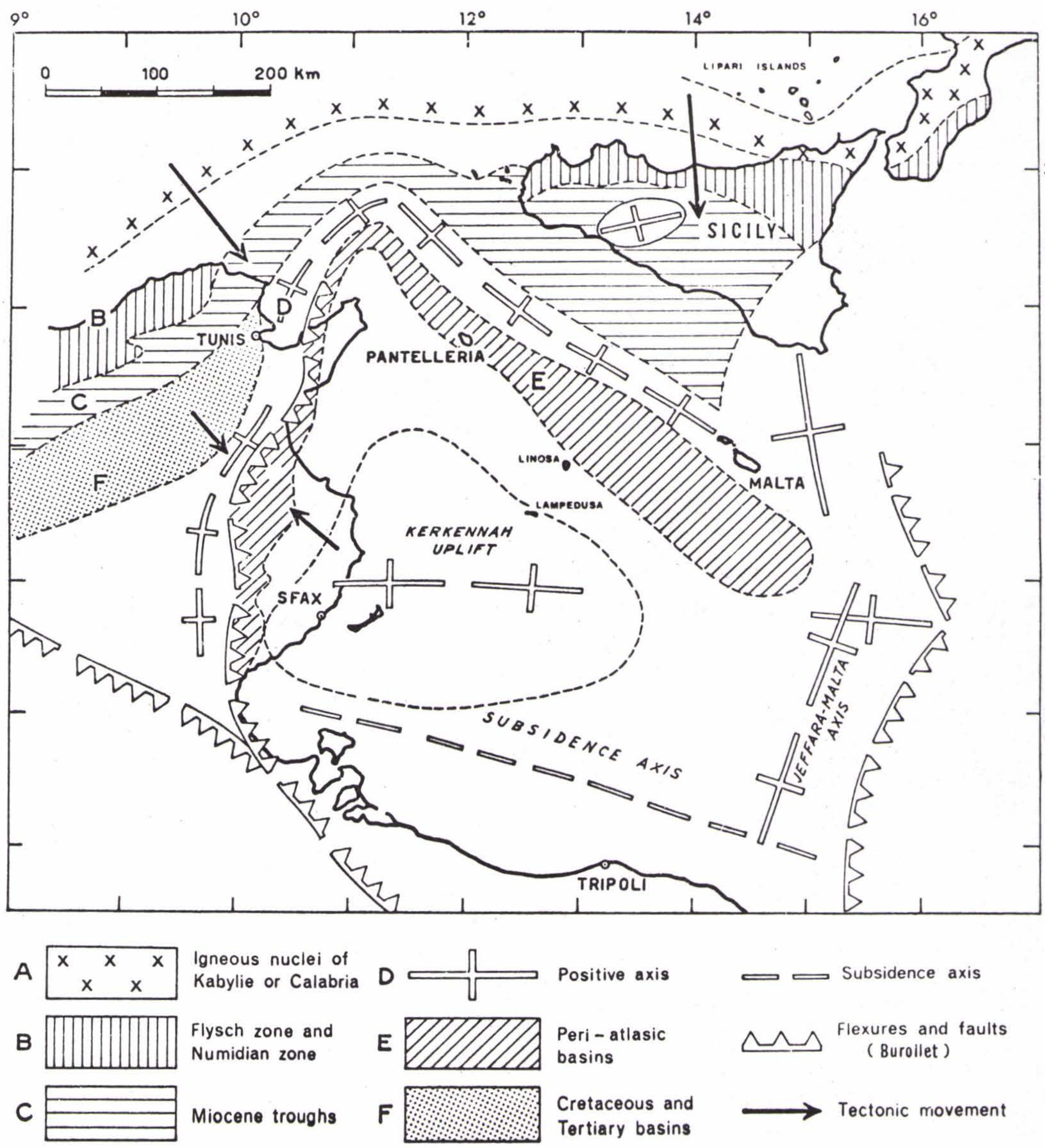

9°
10°
12°
14°
16°
38°
36°
34°
0
100
200 Km
LIPARI ISLANDS
SICILY
B
C
D
E
F
TUNIS
PANTELLERIA
LINOSA
LAMPEDUSA
MALTA
KERKENNAH UPLIFT
SFAX
SUBSIDENCE AXIS
JEFFARA-MALTA AXIS
TRIPOLI
A
Igneous nuclei of Kabylie or Calabria
B
Flysch zone and Numidian zone
C
Miocene troughs
D
Positive axis
E
Peri - atlasic basins
F
Cretaceous and Tertiary basins
Subsidence axis
Flexures and faults (Burollet)
Tectonic movement

FIG. 7