GRAVITY SURVEY OF THE CONTINENTAL SHELF AROUND ITALY (WITH AN APPENDIX ON THE MAGNETIC SURVEY OF SOUTHERN ITALY (1)

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INTRODUCTION

The underwater gravity survey around the italian coasts is the extension to the sea of the italian national gravity net: therefore, having the purpose of contributing to the study of the geophysical and tectonical features of the peninsula and the seas surrounding Italy, it is also a contribution to the more general program of study related to the mediterranean Sea.

In carrying out the underwater gravity program, initiated in 1953 under the sponsorship of the Italian Geodetic Commission and with a financial grant of the national research Council, the Osservatorio geofisico sperimentale of Trieste realized from 1953 to 1960 several offshore surveys for a total of 3453 gravity stations, measured on the bottom till a maximum depth of 222 meters.

Year	Ship	Stations					Total
		Adriatic	Jonic	Tirrenian	Sicily	Sardinia	
1953	m/v « Seismo »	331	—	—	—	—	331
1954	m/v « Seismo »	586	—	—	—	—	586
	mine-sw. « Abete »	157	—	—	—	—	157
1955	m/v « Seismo »	114	—	—	—	—	114
	gun-b. « Alano »	32	—	—	—	—	32
1956	m/b « Vercelli »	—	151	314	37	—	502
1957	m/b « Vercelli »	188	112	—	—	—	300
	mine sw. « Mango »	244	—	—	—	—	244
1958	m/b « Vercelli »	23	—	—	—	—	23
1959	m/b « Vercelli »	164	—	194	414	—	772
1960	m/b « Vercelli »	—	—	74	—	318	392
	Total	1839	263	582	451	318	3453

Table 1. — *Gravity measurements at sea*, 1953-1961.

The results of this work and the gravity data are summarized in a previous publication (Ciani, Gantar, Morelli, 1960) where technical detail are reported: only the 318 stations observed around Sardinia Island in 1960 are now under computation and their values and results will be published within short time.

Statistical data are summarized in table 1.

(1) Osservatorio geofisico sperimentale Trieste, contribution n° 120 bis.

Technical data.

The gravimetric equipment is essentielly a Western gravimeter sealed in a water tight housing and remotely controlled with a device developed by the Robert H. Ray Co. (Houston, U.S.A.). This remote control permits the gravimeter to be normally employed as on land, making easily all the required operation such as leveling, resetting, unclamping, dialing and reading, clamping.

The greatest source of trouble arose from the fact that the cable connecting the control panel to the batysphere employed for the 1953-1956 surveys was too often subject to electric leakages. Another cable, employed in the 1957 and 1958 surveys with more insulated copper wires, behaved better, but it was necessary to employ a third strongest type in the 1959-1960 works to avoid internal breakings of the wires due to the great depths reached. With this new cable, composed with steel wires, the performance of the gravimetric equipment was always very good, a gravity measurement being made in few minutes after having lowered the batysphere also to the maximum depths.

The inaccuracy of a remotely-controlled measurement is not substantially greater than that of an ordinary land measurement, provided working conditions are normal (that is, principally, if bottom waves disturbances are small).

Gravity reference points were established in the harbours and connected with the italian first-order gravity net by means of Worden gravimeters.

The depth of the stations has been measured by echo-sounding, except for the first stations during the 1954 surveys with the « Abete » mine-sweeper : before equipping the ship with echo-sounding apparatus, a sounding-line has been employed. Later on, an Atlas echo-sounding of hydrographic class (± 0,1 m of reading error) has been employed.

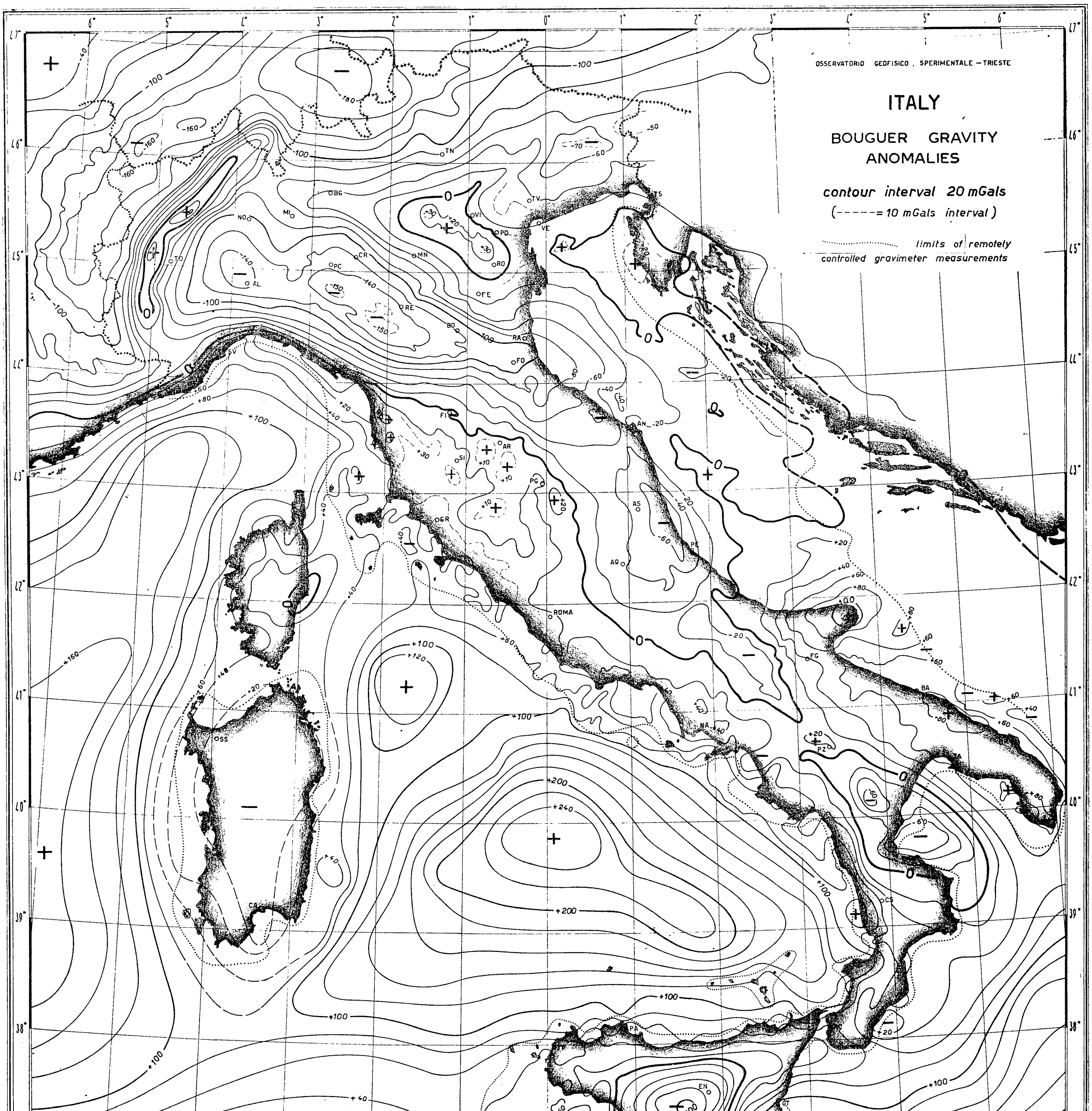
The determination of the position for the offshore gravity stations was the most difficult problem, owint to the fact that no modern system of radio-location was available. Therefore, several systems were adopted, following the conditions of work and the distances from the coasts. The points nearer to the coast were determined by inverse triangulation, but the main part of the stations was located by inverse trilateration with a CR 103-RCA radar equipped with a targetfinder device and with an additional distance measuring apparatus with readings to ± 0, 01 miles : the best defined main features of the shore and in some cases noticeable buildings were used as targets.

At greatest distances from the coasts, specially constructed reflecting-buoys were adopted with their position previously determined by inverse trilateration : these buoys gave really good radar reflections and were used also in case of no-caracteristic and too flat coastal lines. The causes of errors in planimetric determinations are discussed in other papers (Morelli, 1954, 1955); we may remember here that the mean position error may be regarded as variable from ± 20 to ± 50 and ± 100 meters respectively for the various procedures described; in the case of successive chains of reflecting-buoys, an error of ± 200 m may be reached at the very large distance from the coasts (till 60-70 miles in northern Adriatic).

In central Adriatic Sea, the « Mango » expeditions (1957) has worked with an other type of radar device (with lowest resolution) and part of the intermediate stations have been located with estimated routs, checked at the end points of the profiles and with reoccupation of previous stations in which little buoys were anchored for control purposes. In these cases a maximum error of ± 600 meter is expected after compensation.

Results.

The results are shown on the Bouguer anomalies map in figure 1. This map assembles also the gravity data in the Italian peninsula published by various Authors up-to-day, and is comprehensive of Cassinis (1942) marine pendulum stations. The area covered by the underwater gravimeter measurements is bounded by dotted lines.


OSSERVATORIO GEOFISICO SPERIMENTALE – TRIESTE
ITALY
BOUGUER GRAVITY ANOMALIES
contour interval 20 mGals
(-----= 10 mGals interval)
limits of remotely controlled gravimeter measurements
this map is based on values published till 1961.3 by various Authors.

The gravity anomalies around Italy have been already discussed in details elsewhere (Ciani, Gantar, Morelli, 1960). I would like to recall here the attention only to the major facts evidenced by the sea gravity work.

First of all, the general gravity feature of the italian peninsula is dominated by the big Tyrrenian positive anomaly (oceanic crust), which continues with a positive anomaly also on land on the Tyrrenian side of the Peninsula and of Sicily. Structurally this side is a « high », and is all contoured by an external arc of sedimentary basins, practically from the Po Plain to Sicily.

In the whole, this is a typical « Island arc » structure. In the inner side of the arc, vulcanic activity is dominating; on land, most parts of this are olystostromic in type, with big expansions also on the external arc.

The sea gravity anomalies have indicated :

a) *in the northern and Central Adriatic:*

the continuation into the sea of the Po Plain sincline;
his delimitation against NE by the Istria shield, which is connected through a saddle to the big positive anomaly of the Euganei-Lessini-Berici eruptive region;
the limits of the sedimentary basins on the sea sides;
the structures of the Middle Adriatic;

b) *in the southern Adriatic:*

the Gargano structure;
the positive anomaly of the Puglie;

c) *in the Ionian Sea:*

the continuation against SE of the big sedimentary basin;

d) *in the Sicily Channel:*

the delimitation of the sedimentary basin;
the epicontinental structures between Sicily and Tunisia;

e) *in the Tyrrenian Sea:*

the epicontinental structures between Corsica and Elba.

We can conclude that the structural features of the Italian Peninsula could not be understood without the knowledge of the gravity anomalies in the Seas around Italy.

Plans are therefore now made to realize also the gravity measurements in the open seas with a surface ship gravity-meter.

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Appendix

MAGNETIC SURVEY OF SOUTHERN ITALY

INTRODUCTION

Since geophysical methods of interpretation normally integrate each other, we are going to complete the above picture of the gravity field in Italy with the magnetic anomalies, only for part of it and only on land : with the purpose of indicating their importance and the necessity of magnetic measurements on sea.

The magnetic survey in the vertical component of Southern Italy, from Gaeta-Vasto to Calabria, is the extension of the same survey in Puglia (ZACCARA and others, 1956). Initiated in 1957, by the Institut of Geodesy and Geophysics of the University of Bari, and with a financial grant of the National Research Council, it may be regarded as a beginning of a more complete magnetic survey of the vertical component for all the italian peninsula.

In fact, the magnetic data up-to-day known are only those related to the 1496 stations measured for the D, H and I components by the Geographic Military Institut in the far 1933-1937 years. Being the vertical component the more interesting for a contribution to the study of the tectonics of Italy, it is now advisable that this systematic survey could be extended to the remaining part of the peninsula.

In the meantime, this short paper may give an account of the results of this first part of a magnetometric survey of Italy : a more detailed paper, containing also the observed values, will be published within short time (GANTAR, MORELLI, SEGRÉ, ZAMPIERI, 1961).

Technical data.

Two types of instruments were used, the Askania Gf6 balance (1955-1958) and the Askania Gfz torsion-magnetometer (1959), with a reading accuracy of 2 γ or better. The scale factors were periodically checked with a calibrated Helmoltz coil and the observed values were always corrected for diurnal variation, recorded with a semi-mobile station and also by the Magnetic observatory of S. Vittorino (L'Aquila).

A first order net has been connected to S. Vittorino absolute station in order to have for the survey the same reference value as for the magnetic survey of Puglia.

From the 28 base stations of this first order net, 665 detail stations were measured checking each of them for normality by measuring at least three points; observations in these points has been averaged to avoid as possible erroneous values due to way local magnetic rocks.

Closure errors have been always small and the mean difference deduced from the 71 stations re-occupied in the detail net is of only 4 γ .

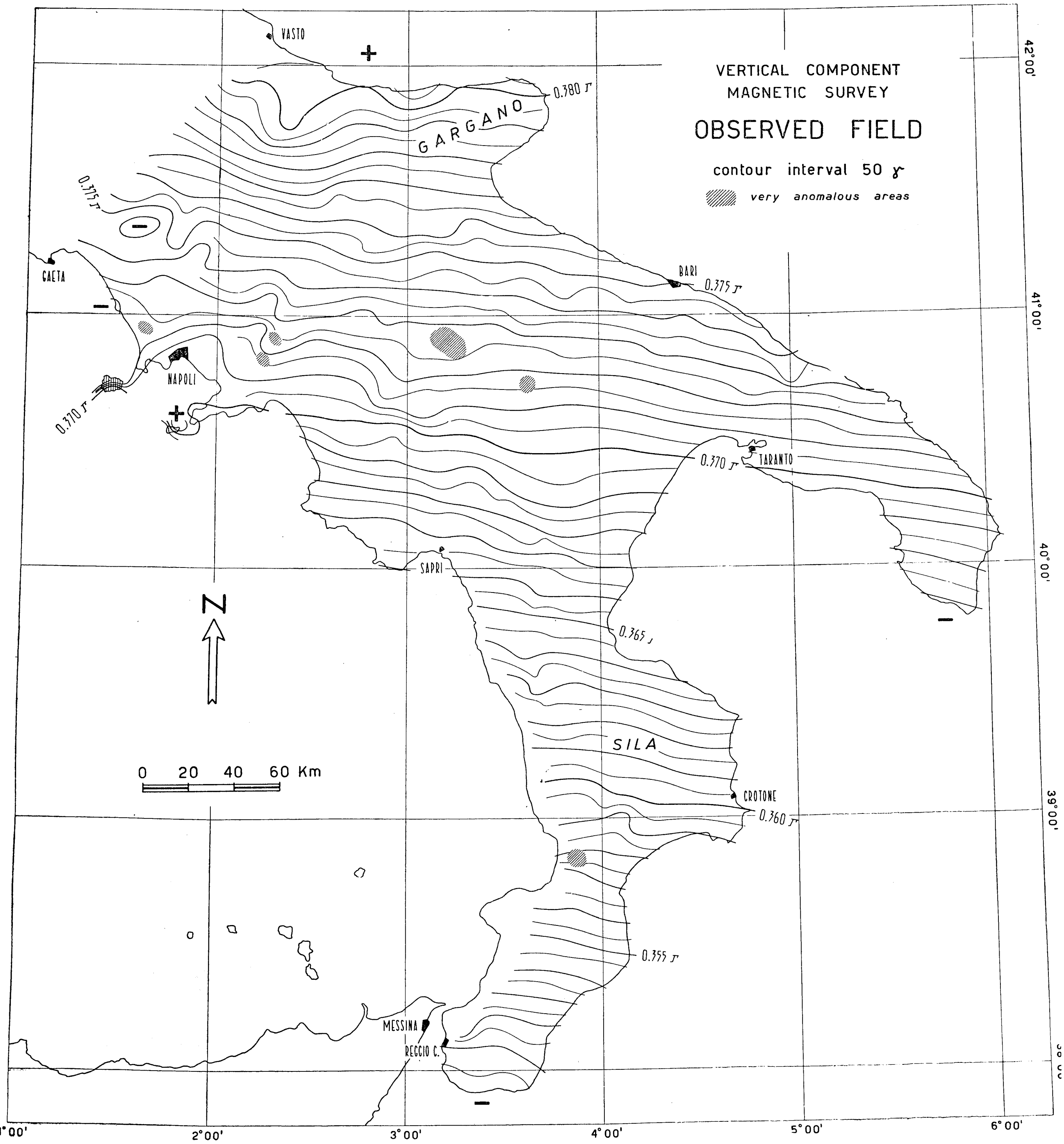
The map in figure 2 shows the distribution of the vertical intensity in the surveyed area. With a residuating procedure like that indicated by Griffin (1949) and after a further modification introduced in order to avoid excessive dipendencies from the high total, we obtain the residual map of figure 3.

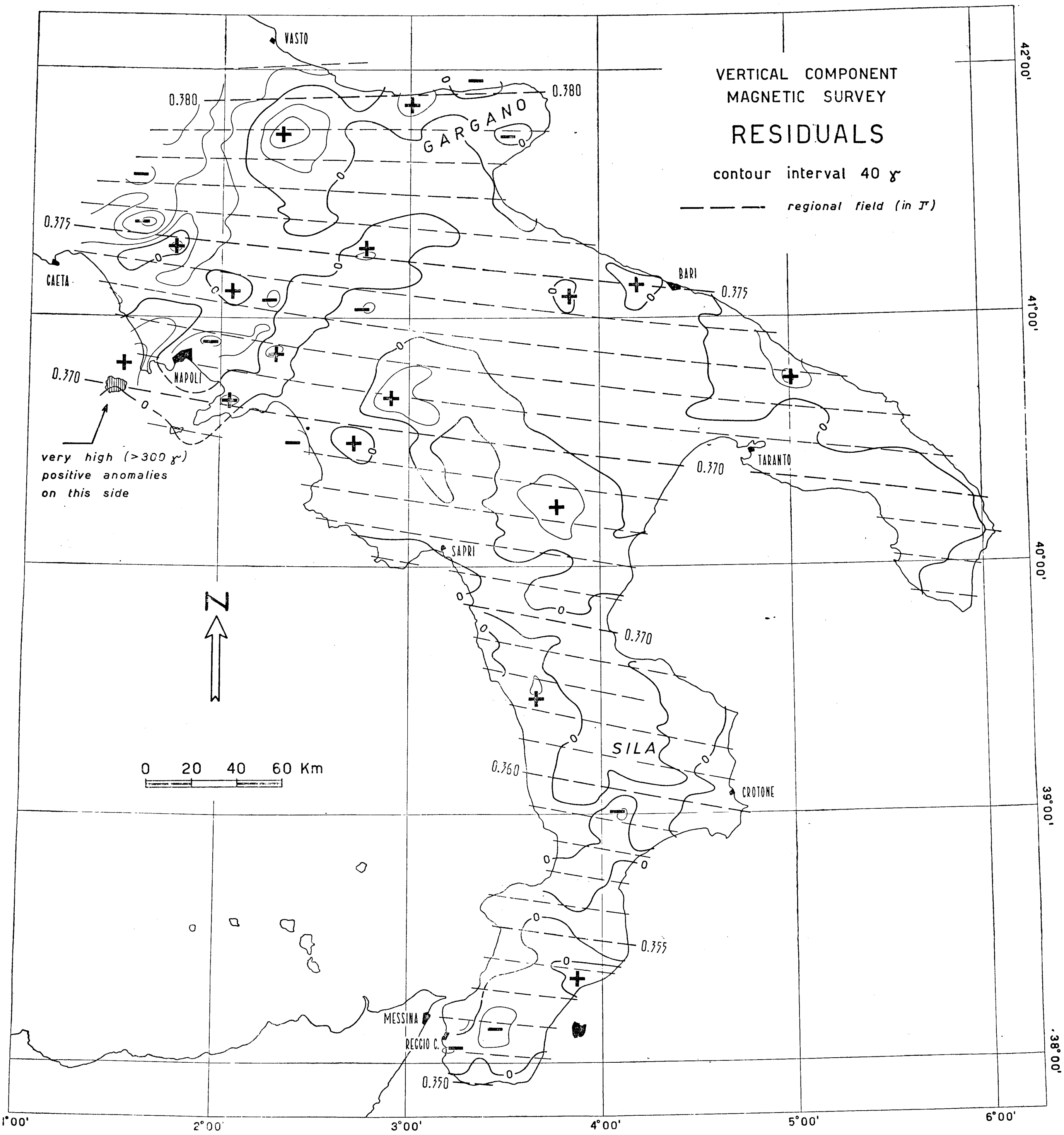
The goodness of this residual map is proved by the equilibrium reached in areal distribution of positive and negative anomalies, which confirms that a good degree of indipendence from local factor has been reached.

Obviously the normal field so obtained is provisional because only with the total survey of the italian peninsula a better and more general normal field may be calculated.

Results.

The interpretations of a magnetic map is somewhat more difficult than for a gravity one : magnetic susceptibility of rocks is variable within greater limits, same types of rocks can have very different susceptibilities, and permanent magnetism can be present.


VERTICAL COMPONENT
MAGNETIC SURVEY
OBSERVED FIELD
contour interval 50 γ
very anomalous areas
VASTO
GARGANO
0.380 γ
0.375 γ
GAETA
NAPOLI
0.370 γ
BARI
0.375 γ
TARANTO
0.370 γ
SAPRI
0.365 γ
SILA
CROTONE
0.360 γ
0.355 γ
MESSINA
REGGIO C.
N
0 20 40 60 Km
42°00'
41°00'
40°00'
39°00'
1°00'
2°00'
3°00'
4°00'
5°00'
6°00'


VERTICAL COMPONENT
MAGNETIC SURVEY
RESIDUALS
contour interval 40 γ
regional field (in Γ)
VASTO
GARGANO
0.380
0.380
0.375
GAETA
BARI
0.375
NAPOLI
0.370
very high (>300 γ) positive anomalies on this side
TARANTO
0.370
SAPRI
0.370
SILA
0.360
CROTONE
0.355
MESSINA
REGGIO C.
0.350
0 20 40 60 Km
42°00'
41°00'
40°00'
39°00'
38°00'
1°00'
2°00'
3°00'
4°00'
5°00'
6°00'

As to the first point, we refer immediately to an example : the granites in the Sila Region ($39^o 2$ N 4^oE) give a negative magnetic anomaly. We can't therefore follow the crystalline on the basis of the magnetic anomalies, as for instance AGOCS and TERRY (1959) did.

We see also that the magnetic anomalies are not very strong (more than + 100 γ only in the regions to the south of Vasto and around Naples) : therefore, they are probably not caused by basalts or other igneous rock with very high magnetic susceptibility.

In general, we see also that the features of the magnetic anomalies follow the general tectonic lines in this region : which are characterized by longitudinal trends (in the Peninsula sense) and by tranversal ones (about perpendicular to them).

In this sense, we can say that the big positive magnetic anomaly to the west of the Lucania sedimentary basin is real; but, it is not corresponding to a positive gravity anomaly : situated on a negative one, it could be thought as caused for instance by material of greater magnetic susceptibility dispersed in the olystostromic strata covering the basin (see for instance Beneo, 1959).

Indeed, southern Italy is geologically divided into three longitudinal sectors. The two lateral ones, Apennine and Gargano-Murge sector, are both characterized by exposures of calcareous dolomitic rocks ranging from Triassic to Miocene in age. The central sector is characterized by a techtonic sink involving these same rocks, and filled with clastic sediments of flysch facies of Upper Miocene age and partly, of Pliocene age.

The flysch mass, which sometimes reaches great thickness, probably originated through the rapid and sometimes graded redeposition, by turbidity currents, of older rocks and their fossils. This mass contains intercalated olistostroma which inglobe rocks of variable age and dimension.

A very interesting transverse tectonic structure is probably indicated by the position anomaly going from Capri to the southern edge of the Gargano : it corresponds probably to a very big fault system.

To the same origine is probably due the positive anomaly in the NW edge of the Gargano (Punta delle Pietre Nere; see COTECCHIA and CANITANO 1954.)

The magnetic positive anomalies corresponding to positive gravity ones are only that on the SE of Bari, and on the NE of the Gargano. For both, the surface geology can't give any possible explication.

The same can be said for the big magnetic anomaly to the south of Vasto : it has no strong correspondance on the gravity map, and could be explained inferring the presence of igneous material into the depths.

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