

PROCEEDING OF MARINE GEOPHYSICAL MAPPING OF AEGEAN SEA

Pavlakis, P.* , Makris, J.** and Alexandrie, M.*

* National Centre for Marine Research, 16604 Hellenikon-Athens, Greece

** Institute of Geophysics, University of Hamburg, West-Germany

A B S T R A C T

During the period 1986-1989 the National Centre for Marine Research (Athens) with the cooperation of the Institute of Geophysics (Hamburg) carried out a systematic and detailed Bathymetric, Gravity and Magnetic survey at the entire area of Aegean sea. Although in the past, other institutes have contributed in the geophysical mapping of the area, the resulted considerably more detailed maps of the present survey, offer new possibilities in the geophysical investigation of this particularly complex tectonically area.

ΕΞΕΛΙΞΕΙΣ ΣΤΗΝ ΘΑΛΑΣΣΙΑ ΓΕΩΦΥΣΙΚΗ ΔΙΑΣΚΟΠΗΣΗ ΤΟΥ ΑΙΓΑΙΟΥ

Παυλάκης, Π., Μακρής, Ι. και Αλεξανδρή, Μ.

Π Ε Ρ Ι Λ Η Ψ Η

Κατά τη διάρκεια των ετών 1986-89 το Εθνικό Κέντρο Θαλασσίων Ερευνών (Αθήνα) και το Ινστιτούτο Γεωφυσικής του Πανεπιστημίου του Αμβούργου εκτέλεσαν συστηματικές και λεπτομερείς μετρήσεις βυθομετρίας, βαρύτητας και μαγνητισμού στην θαλάσσια περιοχή του Αιγαίου. Παρά το γεγονός ότι στο παρελθόν και άλλοι φορείς έχουν συνεισφέρει στην γεωφυσική χαρτογράφηση της περιοχής, οι σημαντικά λεπτομερέστεροι χάρτες που προέκυψαν από την παρούσα διασκόπηση, προσφέρουν νέες δυνατότητες στην γεωφυσική μελέτη της εξαιρετικά σύνθετης τεκτονικά περιοχής.

INTRODUCTION

Several well known geophysical features render the Aegean sea area as one of the most interesting in Europe. More specifically these features can be summarized as following (Morelli et all 1975). The area presents the highest seismicity in Europe, so indicating the presence of a very active tectonic stress field. The volcanism is widely spread connected with faults and energy released from tectonic activity at various depths. The heat flow is generally high in the Aegean area. The gravity field is strongly anomalous, thus indicating the presence of unbalanced masses. The magnetic field presents also strong anomalies connected with magmatic bodies, only partly known at the surface.

All the above justify a series of geophysical surveys done at the area in the past.

Cassinis (1941) on board the Italian submarine "Des Geneys" was the first who measured the great difference in gravity between the Aegean sea and Ionian sea area. That first attempt was followed by the British scientists (Cooper et al., 1952), on board the submarine "HMS Talend". The development of the sea surface Gravity meter led to more extended surveys at the area. Most important among them, are those of the Cambridge University with the R/V "HMS OWEN" and "HMS Discovery", the Lamont Doherty Geological Observatory with the R/V "Conrad" and the Woods Hole Oceanographic Institute with the R/V "Chain".

In 1964 Fleischer presents a first simple free air Gravity map of the Eastern Mediterranean including a part of the Aegean sea area. This effort of rather reconnaissance character, was followed by more systematic survey by the institute "Saclant ASW Research Centre" (NATO) and "Osservatorio Geofisico Sperimentale" (Italy) with the research vessels "Aragonese" (1961-64), "Maria Paolina" (1964-65) and "Bannock" (1965). Furthermore during the period 1968-71 the "Istituto Osservatorio Geofisico Sperimentale" continues the geophysical survey to the entire Mediterranean area including the Aegean Sea. At the same time Cambridge University continues its own geophysical survey at the area with the R/V "Shackleton".

In 1977 the Italian researchers (Morelli et al., 1975) construct a reconnaissance map of the free air gravity anomaly of the entire Aegean sea. The dominant features of the Aegean sea gravity field came to light, as a distribution of relatively short wave length anomalies mainly positive with an increase in absolute values southwards.

Except the above cruises, combined with gravity surveys, magnetic surveys at the Aegean sea area took place firstly during the period 1957-58 from the air, by the U.S Naval Oceanographic Office, in the frame of a general survey of the entire Mediterranean area, leading to the construction of preliminary maps of local anomalies (Vogt and Higgs, 1969). Consequently the same organization supported (U.S.N.O.O 1967) marine magnetic survey at the area by the Texas Instruments Inc. By those efforts it appears that the Aegean sea area is characterized by the presence of series of high amplitude local magnetic anomalies striking NNE-SSW in the Southern, N-S in the central and NE-SW in the Northern Aegean sea.

PRESENT SURVEY BY THE NATIONAL CENTRE FOR MARINE RESEARCH (NCMR)

Although the above surveys led to important conclusions and discussions about the dominant tectonic and geodynamic mechanisms that deform the Aegean area, the detailed investigation of their particular critical sides are still poor as far as gravity and magnetic data are concerned. That was mainly due to the fact that the above surveys mostly took place at the area, as part of general surveys of the entire Mediterranean area. Hence they resulted to rather rare sampling of the area and poor resolution of the observed anomalies. Therefore the necessity of a more detailed gravity and magnetic survey of the Aegean sea area was

always in present.

In 1985 the NCMR decided to resurvey the entire Aegean sea and construct a new series of detailed Gravity, Magnetic and Morphological maps of the area. This effort was supported by national funds, in the frame of a general oceanographic program titled "National program of Hellenic open seas". The project was technically supported, as far as the gravity equipment was concerned, by the Institute of Geophysics of the University of Hamburg. In addition the above Institute contributed to the survey, with one oceanographic cruise (26/3/86-18/4/86), with the German R/V "SONNE" at the area of the central Cretan sea.

The project was lasted between 1986-89 and seven research cruises took place for this purpose with the R/V "AEGAIOS" during the following periods: 19/7/86-26/7/86, 2/10/86-10/10/86, 20/1/87-17/2/87 (S.Aegean-Cretan Sea), 10/11/87-18/12/87 (S.Aegean-Myrtoos Sea), 2/11/88-16/12/88 (S.Aegean-Karpathos Sea), 10/10/89-2/11/89 (North Aegean), 27/11/89-21/12/89 (Central Aegean).

The magnetic measurements were acquired using a towed marine proton magnetometer, while the gravity field was measured using an air/sea gyro-stabilised platform type, gravity meter. For the bathymetric survey a narrow beam echosounder was used.

The navigation was supported mainly by GPS receiver combined with Loran-C, to cover the blank period of GPS. Digital recording systems, designed for all the receivers were used to record the data every 10 sec for post acquisition processing. Further details on the instruments used and on the criteria followed in the reductions are published in Pavlakis (1990) and Pavlakis (1992).

Using the cross points on the tie lines, we estimated a standard deviation for the gravity measurements ± 1.39 mgal and ± 12.6 nT for the magnetic measurements. Furthermore the mean value of the deviation of the gravity measurements was estimated to be 0.2 mgal indicating a rather random character. On the contrary the mean value of the deviation of the magnetic measurements found to be -2.3 nT, indicating a rather systematic character. This fact was attributed to the different periods of the data acquisition in relation to the incompleteness of the IGRF-75 formula used for the reduction (Corrado et al., 1977).

MAP PRESENTATION

The tracks of the survey lines are presented on the map of Fig.1. For the purpose of this paper a data set of every 4 min sampling has been selected.

The free air map (Fig.2) although its scale is not permitting a presentation to the last detail, shows clearly the laterally variable disturbed isostatic character of the Aegean plate.

Using the detailed bathymetric map (Fig.3) which was produced by this survey, as well as digitized heights of the surrounding lands, we produce a complete Bouguer anomaly for the area (Fig.4), assuming a mean density 2.67 gr/cm^3 for reduction.

The map of the total magnetic field, presented on Fig.5 shows that high amplitude magnetic anomalies, mostly arranged in chain-shaped arrays, are mainly concentrated in the Northern and

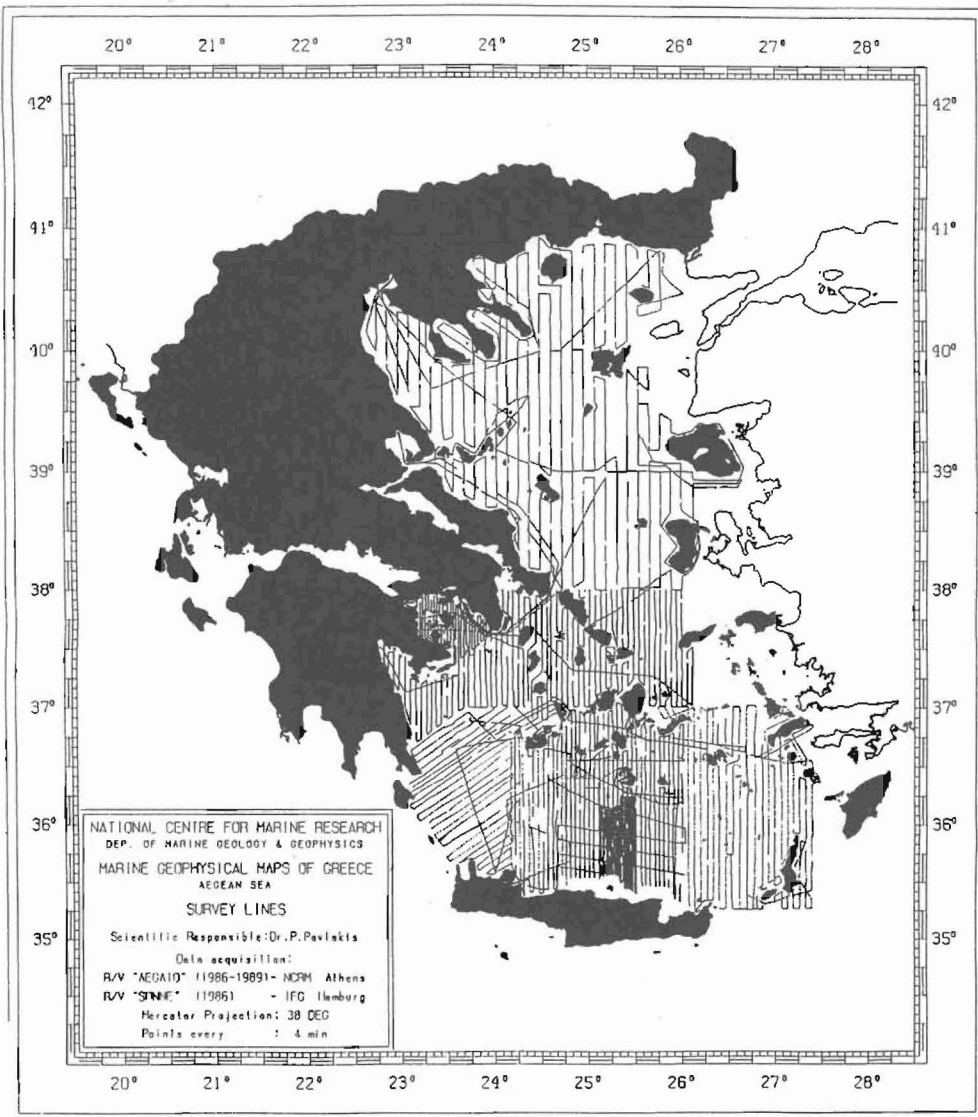


Fig.1. Vessel tracks over which the measurements were made during the period 1986-89.

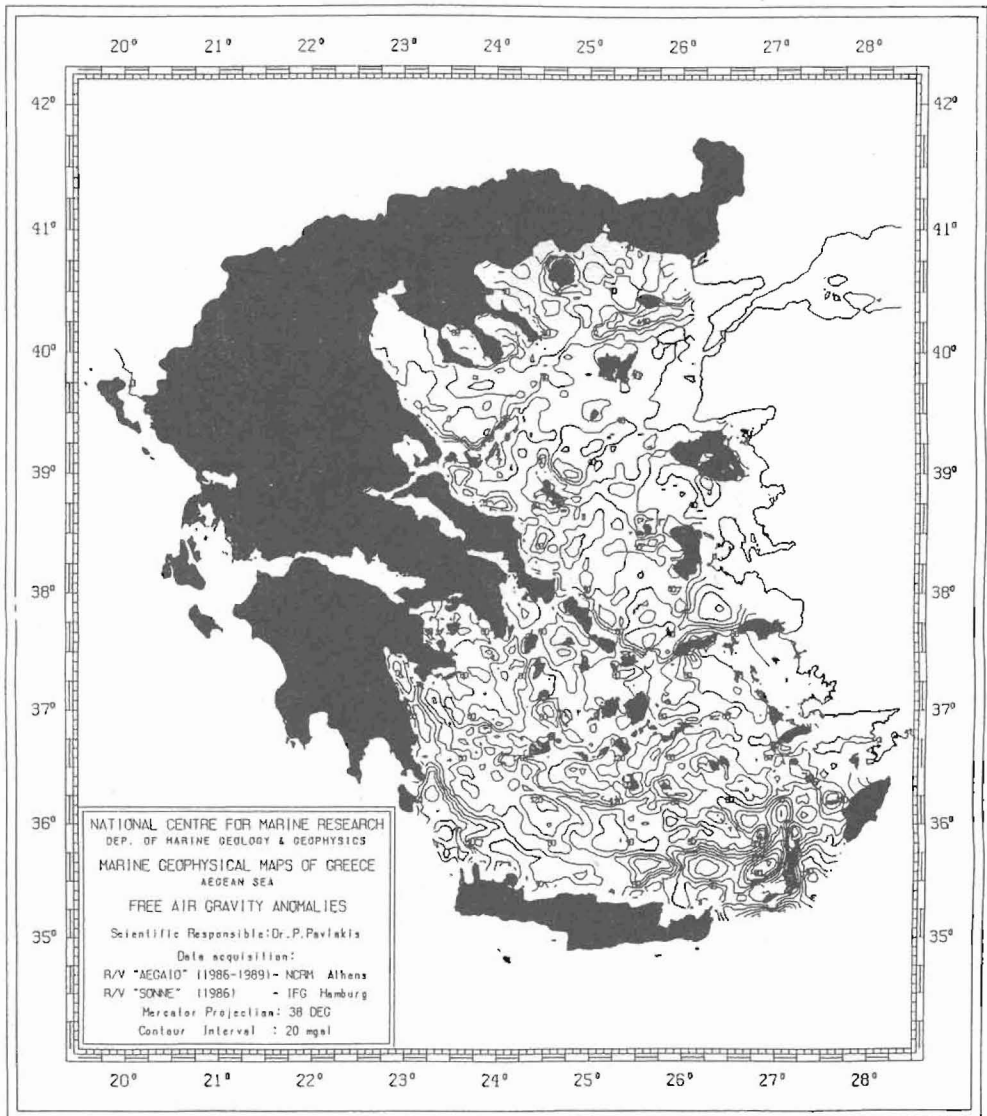


Fig.2. Free air gravity anomaly of Aegean sea.

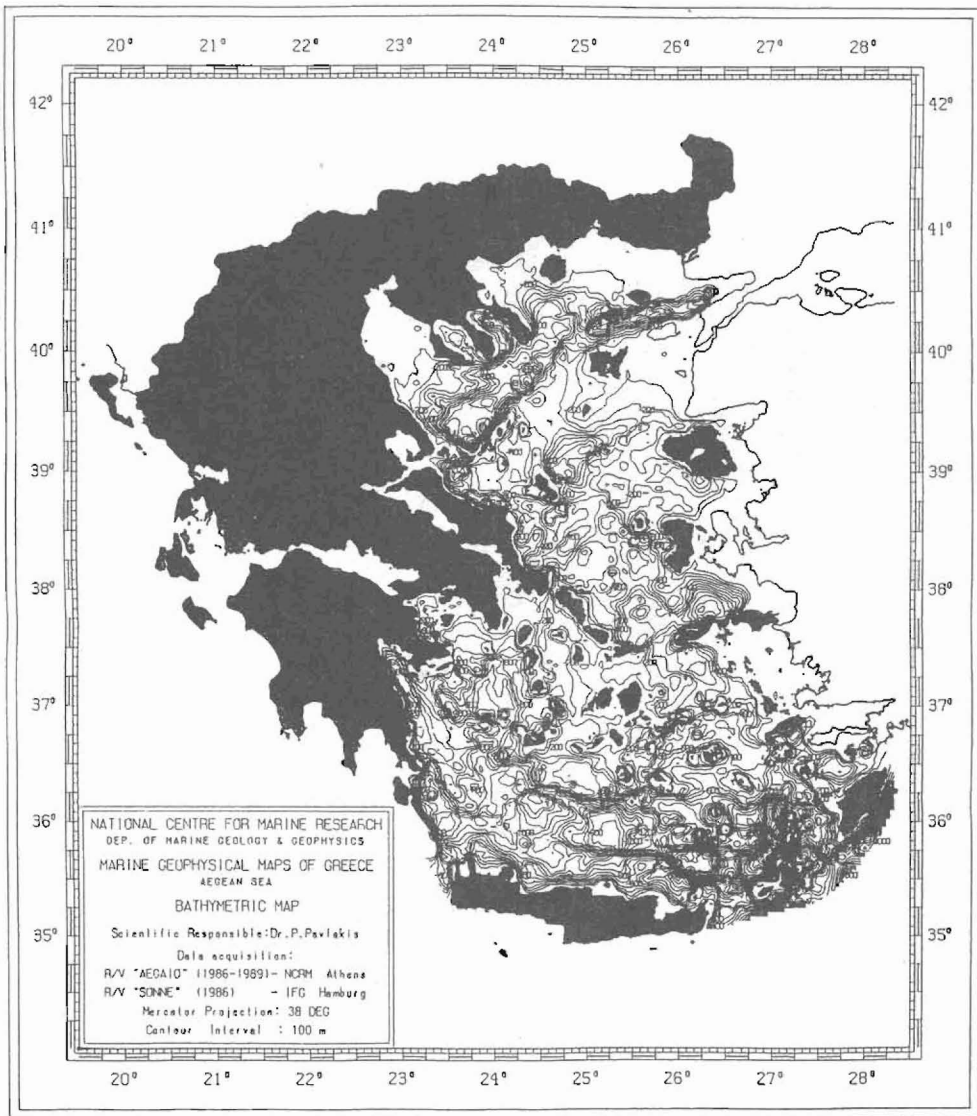


Fig.3. Bathymetry of Aegean sea.

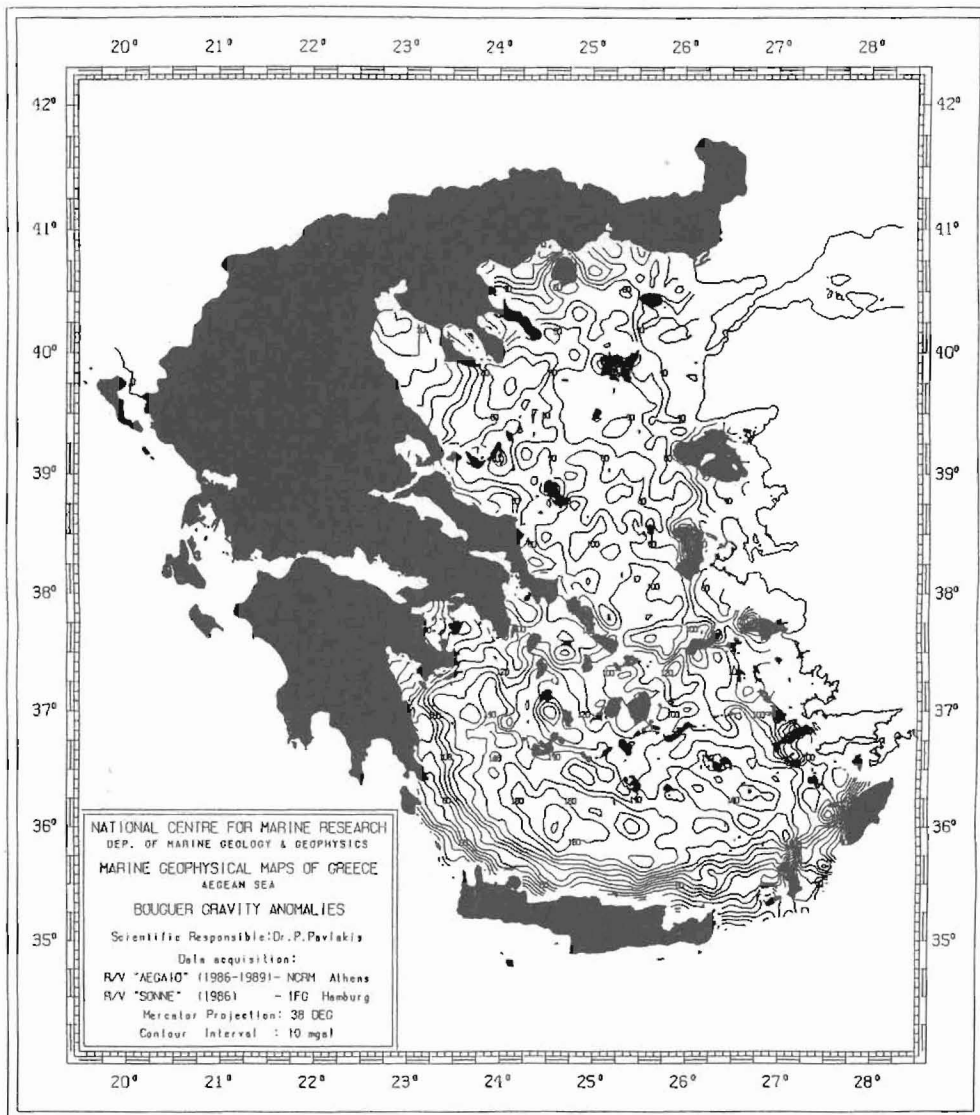


Fig.4. Complete Bouguer anomaly of Aegean sea.

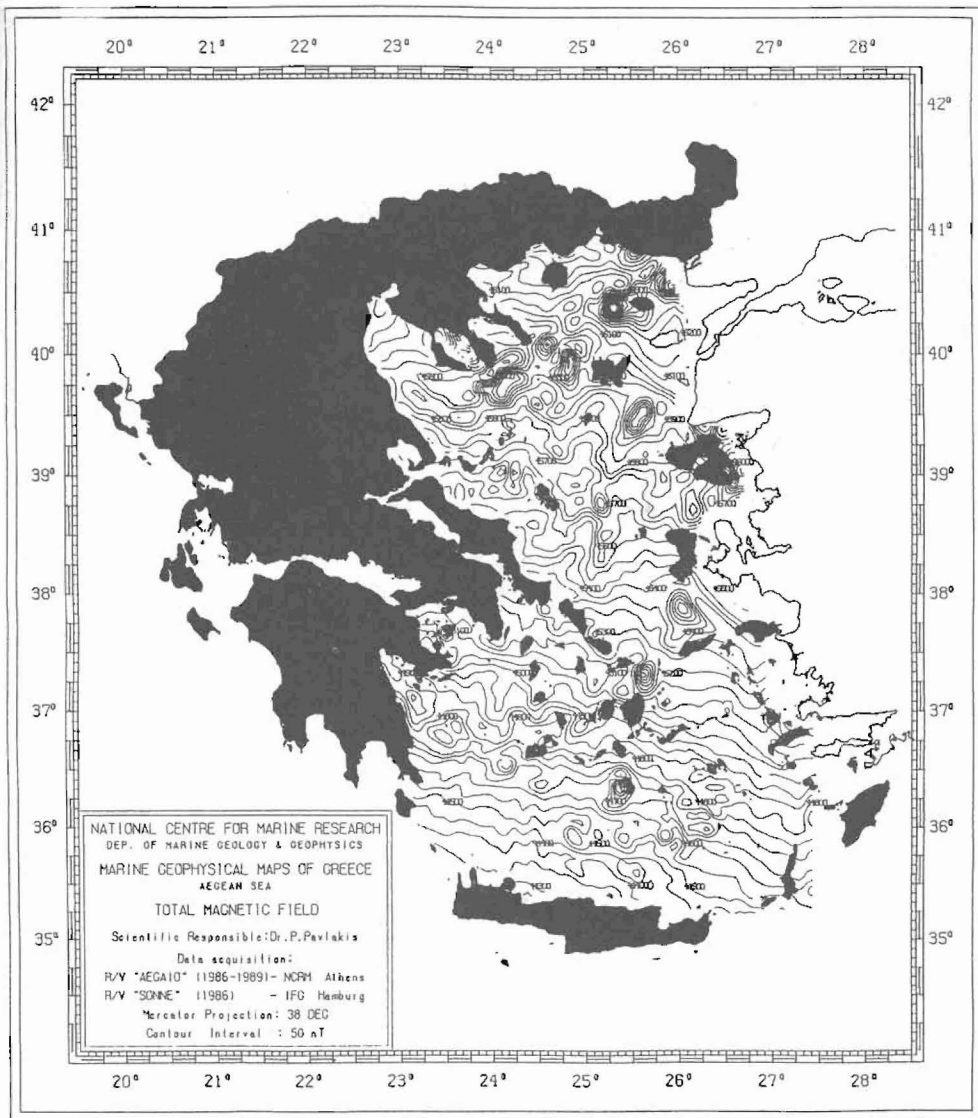


Fig.5. Total magnetic field of Aegean sea.

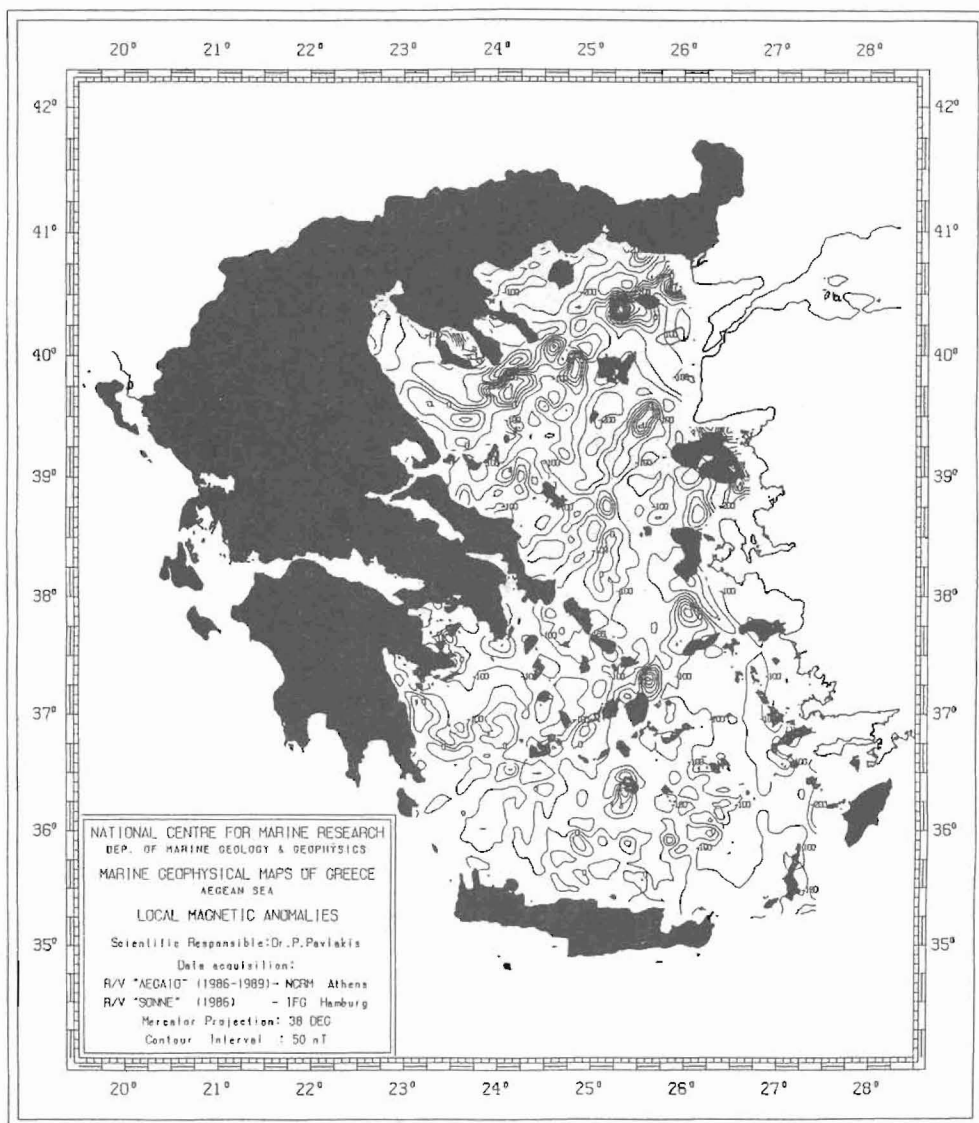


Fig.6. Local magnetic field of Aegean sea.

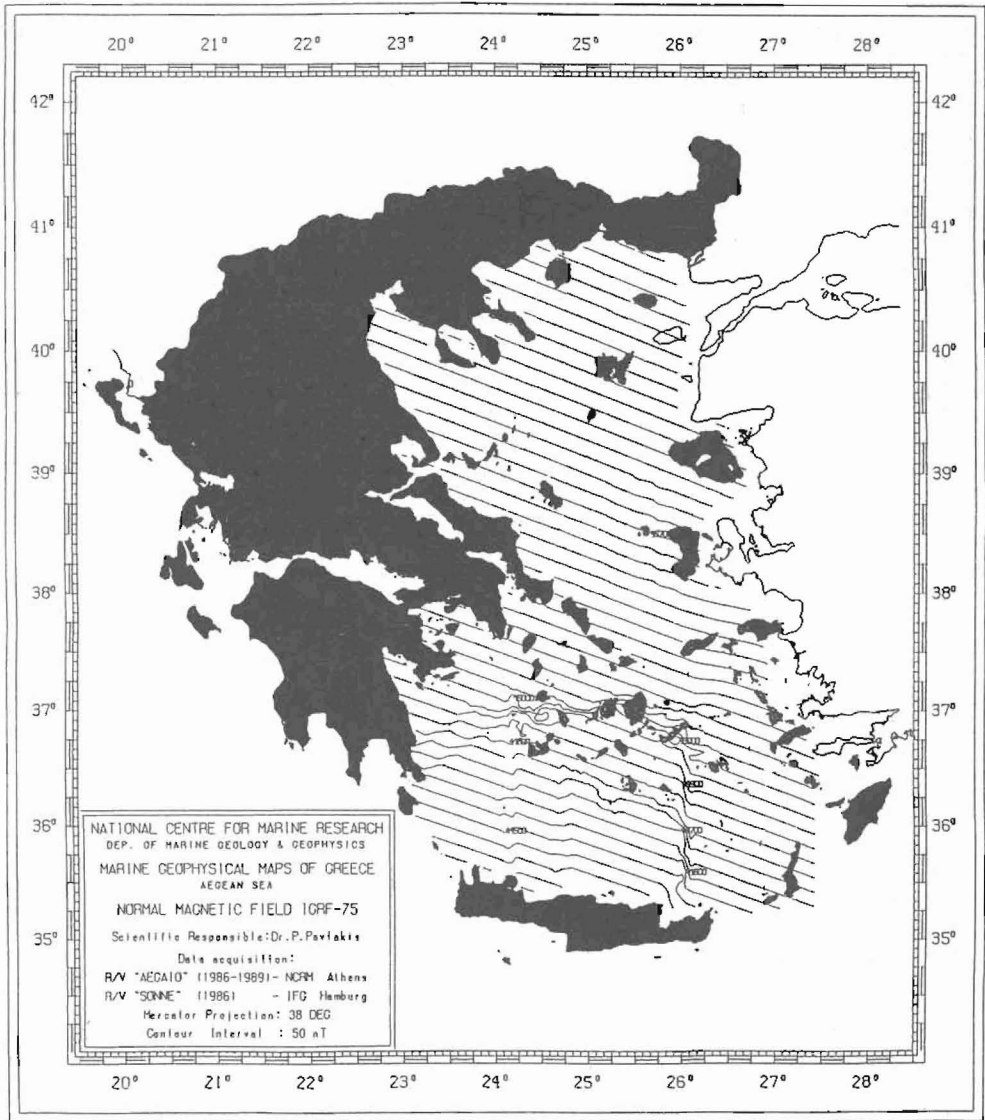


Fig.7. Normal magnetic field (IGRF-75) of Aegean sea.

Southern part of the area. More over it is worth to note their rather circular arrangement in the southern part, while stripes of rather undisturbed field are clearly observed. Analogous scenery is presented on the map of the residual magnetic anomaly field (Fig.6) produced by the subtraction of the normal field using the formula IGRF 75 (IAGA 1976), (Fig.7). The disturbances of the normal field which appeared on the map are due to the different periods of the several survey cruises that took place at the area.

ACKNOWLEDGEMENTS

The above survey could not have been successfully carried out without the cooperation of many people, impossible to acknowledge individually. To all associated with this project we extend our gratitude. However we wish to thank in particular, the President and the Board of Directors of the NCMR, as well as the captain and the crew of the "R/V AEGAIOS", while we are indebted to the coordinator of the "National program of the Hellenic open seas", Dr. C. Anagnostou for his will to support the above effort. Finally the technical support of our German colleagues Dr K.H. Toed and Mr R. Egloff is gratefully acknowledged.

REFERENCES

- Cassinis, G., (1941). La crociera gravimetrica del R. Sommergibile "Des Genes", anno 1935: R. acc. d'Italia Rend. Fis., f.12, s. VII, v.11.
- Cooper, R.I.B., Harrison, J.C and Willmore, P.L., (1952). Gravity measurements in the Eastern Mediterranean. Phil. Trans. A, 244, 533-559.
- Corrado, G., Pinna, E., Rapolla, A., (1977). The magnetic field of Italy: description and analysis of the new T, Z and H maps between 40°N and 44°N, Boll. Geof. Teor. e Appl., vol. XX, 75:140-156.
- Fleischer, V., (1964). Schwerestörungen im ostlichen Mittelmeer nach Messungen mit einem Askania-Seegravimeter. Deutsche Hydrogr. Zeit., 17, 153-164.
- IAGA Division 1 study group, (1976). International Geomagnetic reference field 1975, EOS Trans. Am. Geophys. Union 57:120-121.
- Morelli, C., Pisani, M. and Gantar, C., (1975). Geophysical studies in the Aegean sea and in the eastern Mediterranean. Boll. Geof. Teor. Appl., 18, 127-168.
- Παυλάκης, Π., (1990). Συλλογή και επεξεργασία μετρήσεων βαρυμετρίας, μαγνητομετρίας, βυθομετρίας Νοτίου Αιγαίου. Τεχνική Εκθεση Α' Ε.Κ.Θ.Ε, 1, 41.
- Παυλάκης, Π., (1992). Νότιο Αιγαίο - Θαλάσσια γεωφυσική διασκόπηση και στοχαστική-ντετερμινιστική προσέγγιση της τεκτονικής-γεωδυναμικής - γεωθερμικής δομής του. Διδακτορική διατριβή. Πανεπιστήμιο Αθηνών 1992.
- U.S. Naval Oceanographic Office, (1967). Marine geophysical survey program 1965-1967. North Atlantic Ocean, Norwegian Sea and Mediterranean Sea area 6, vol.5 Geology and

Geophysics, Texas Instr. Inc. Contr. No N62306-1687.
Vogt, P.G., and Higgs, R.H., 1969. An aeromagnetic survey of the
Eastern Mediterranean Sea and its interpretation. Earth and
Planetary Sci. Lett., 5, 439-448.