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HYDROGRAPHIC CHARACTERISTICS AND CIRCULATION OF THE WATERS IN THE EASTERN MEDITERRANEAN.

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ABSTRACT

Classical observations carried out during March 1977 have been analysed to explain the variability of the water masses and of the surface circulation occurring in the Eastern Mediterranean Sea. Three water masses were identified: (1) The near-surface water mass of Atlantic origin between 0-150 m depth, (2) The intermediate water mass between 200-600 m and (3) The deep water mass between 800-3000 m.

The water characteristics at the surface, 50 m and 100 m levels are approximately the same. The outstanding features of the surface layer salinity in the Levantine sea is the presence of a wide area coverd with salinity higher than 39.00‰. The Levantine intermediate water, characterized by a secondary maximum salinity, forms in the central, the northern and the south-eastern parts of the Levantine basin where the winter convection reaches a depth of maximum salinity. The water temperature and salinity slightly decrease with increasing depth to reach 13.60°C and 38.70‰ near the bottom respectively.

INTRODUCTION

In spite of the numerous investigations made by many authors in the Eastern Mediterranean, we think that more detailed studies are needed to shed more lights on and to understand the variability of the hydrographic and dynamic structures.

Classical observations carried out during March 1977 have been analysed in order to explain the different water masses and of the surface circulation in the Eastern Mediterranean Sea.

The region under study extends between 23 to 35°E, and from north African coast, in the south, to 36°N latitude.

MATERIALS AND METHODS

The data used in this study were collected by the Russian R/V Vasily Golovnin during the period 3-20 March 1977. Forty seven hydrographic

stations were taken during this period. Fig. (1), illustrates the area of investigation and the locations of the hydrographic stations.

RESULTS AND DISCUSSION

Horizontal Distribution of the Hydrographic Parameters

During March 1977, the surface water temperature varies between 14.72 and 17.42°C decreasing northward. The lowest values of the water temperature were observed in the northwestern part of the Levantine sea, while the maximum values were in the eastern part of the investigated area (Fig. 2-a).

The water characteristics at the surface, 50 m and 100 m levels are approximately the same. The horizontal distribution of temperature at the surface, 50 m and 100 m indicate that a water body of low temperature (15.0-15.5°C) moves in the southwestern direction. Isotherm of 16.0 C

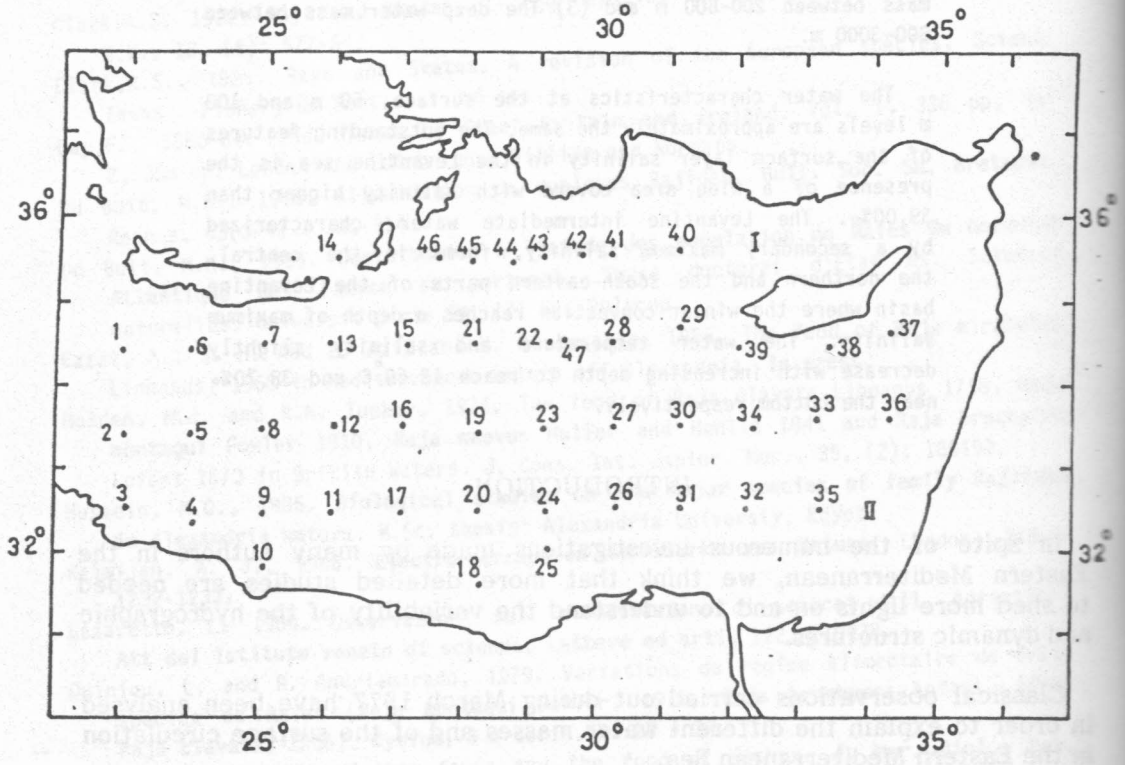

Fig. (1)
Area of investigation and the locations of the hydrographic stations.

is observed at the surface, 50 m and 100 m levels, and it moves from the west to the east (Fig. 2-a,b and 3-a). At 200 m level, low temperature water body (15.0°C) is also observed (Fig. 3-b). Meantime, water of temperature range 15.5-16.0°C moves northward. Fig. (3-b), indicates that, at 200 m depth there is a water of temperature 15.5°C moves from the south Aegean sea to the Eastern Mediterranean basin.

During March 1977, the lowest salinity values (38.50-38.80 ‰) were observed at the west of the investigated area. The outstanding features of salinity distribution at the surface layer, (Fig. 4), is the presence of a wide area covered with salinity higher than 39.00 ‰. This area is mostly found in the central and southeastern parts of the sea. On the other hand, the low saline waters existed near the western part of north African coast. In the central part of the Levantine sea a cyclonic gyre, at the surface, could be distinguished. This water has a salinity range of 39.00-39.05‰ (Fig. 4-a). At 200 m level (Fig. 5-a) a water of salinity 39.00 ‰ moves southward from the north of the Levantine sea. Also there is a water body of salinity 39.05 ‰ moves from the southern Aegean sea to the Eastern basin of the Mediterranean Sea.

Vertical Distribution of the Hydrographic Parameters

Two vertical sections parallel to the northern and southern coasts of the Eastern Mediterranean basin (Fig. 1) were taken in order to study the vertical distribution of the water temperature, salinity and density ( ).

At section (I), the distribution of the hydrographic characteristics, indicate that, the upper layer (150-200 m) is approximately homogenous. The water temperature of this surface layer varies between 15.0 and 16.0°C. Below this layer the temperature decreases with increasing depth from 15.0 to 13.6°C at 1000 m depth (Fig. 6-a). Thermal stratification was observed below the upper layer to the depth of 1000 m. The temperature of the water below the level of 1500 m is between 13.59 and 13.67°C.

Salinity of the upper layer ranges between 39.00 and 39.10 ‰. The homogeneity in the water temperature and salinity of this layer is obviously observed at stations 44 and 45, due to the strong winter convection which occurrs in this time of the year. This winter convection reaches there the layer of maximum salinity and consequently the subsurface layer of maximum salinity disappeared (Fig. 6-b). Below this layer the salinity decreases with increasing depth to reach 38.75 ‰ at 1000 m. Salinity of the water below that level is between 38.69 and 38.74 ‰.

The distribution of the isopycnals (Fig. 6-c), indicates that, the values vary from 28.94 to 29.03 at the surface and increase to reach its maximum value (29.20) at 1000 m level.

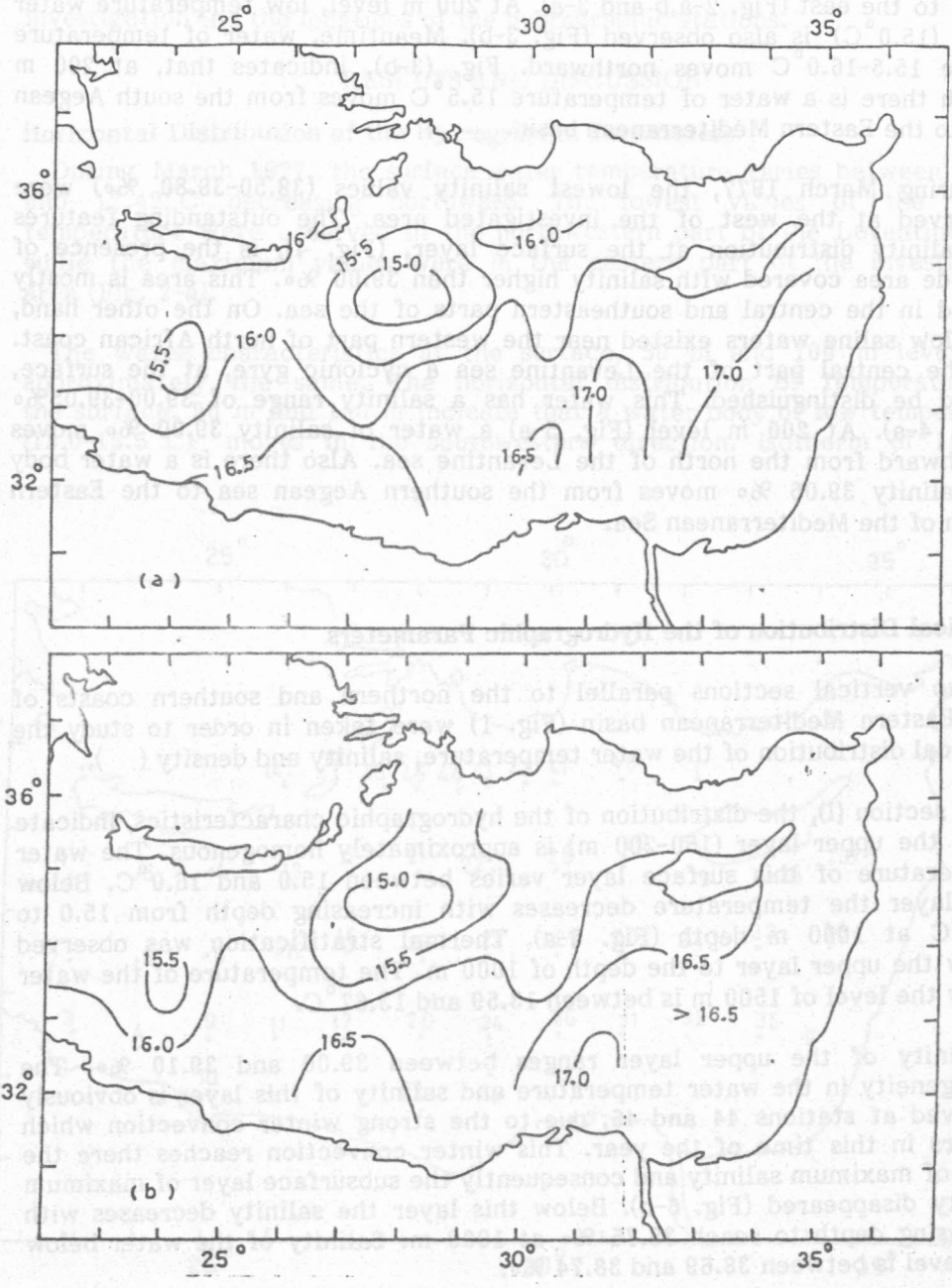

Fig. (2)
Horizontal distribution of water temperature at (a) surface and (b) 50 m levels during March 1977.

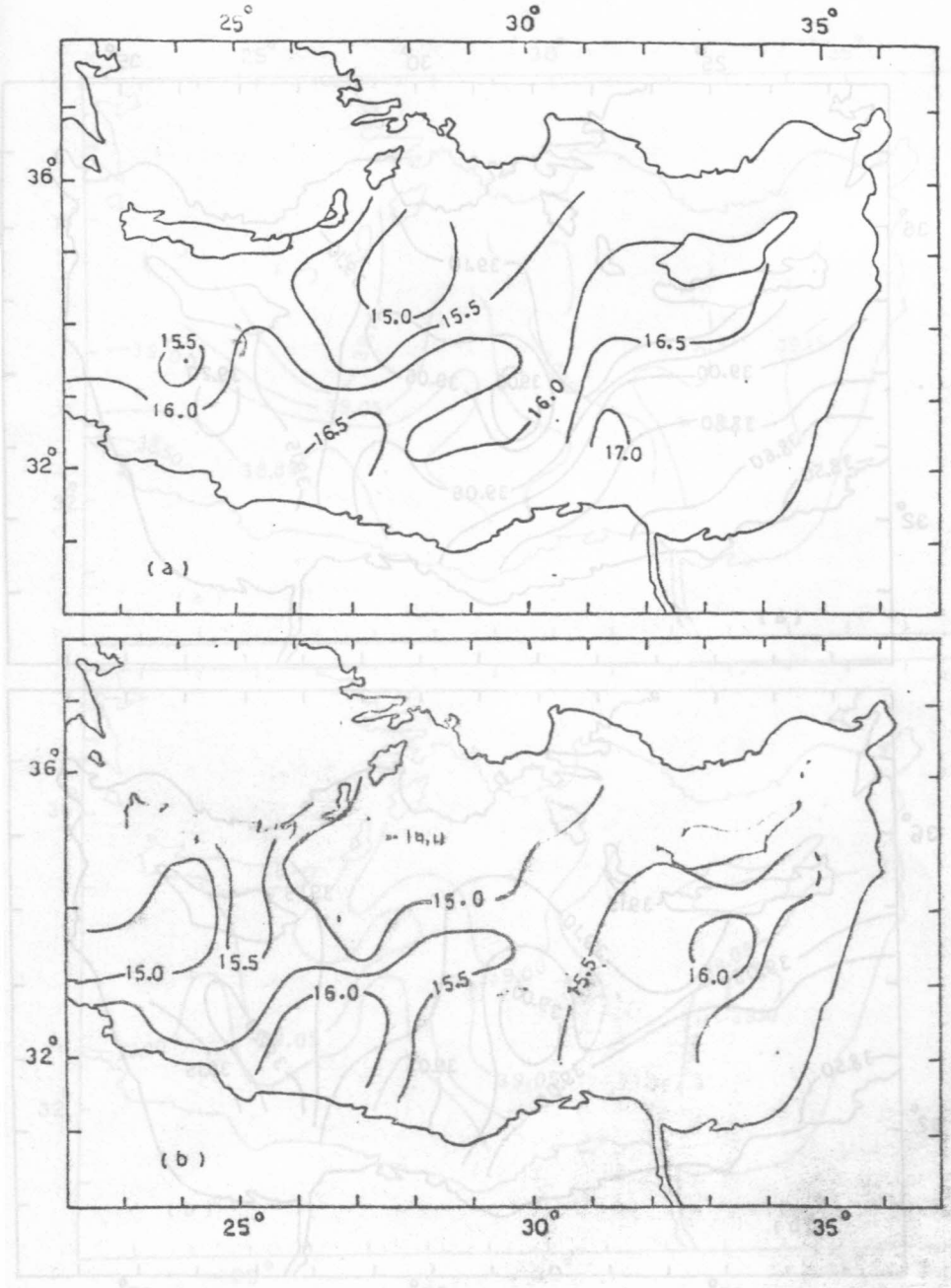

Fig. (3)
Horizontal distribution of water temperature at (a) 100 m and (b) 200 m levels during March 1977.

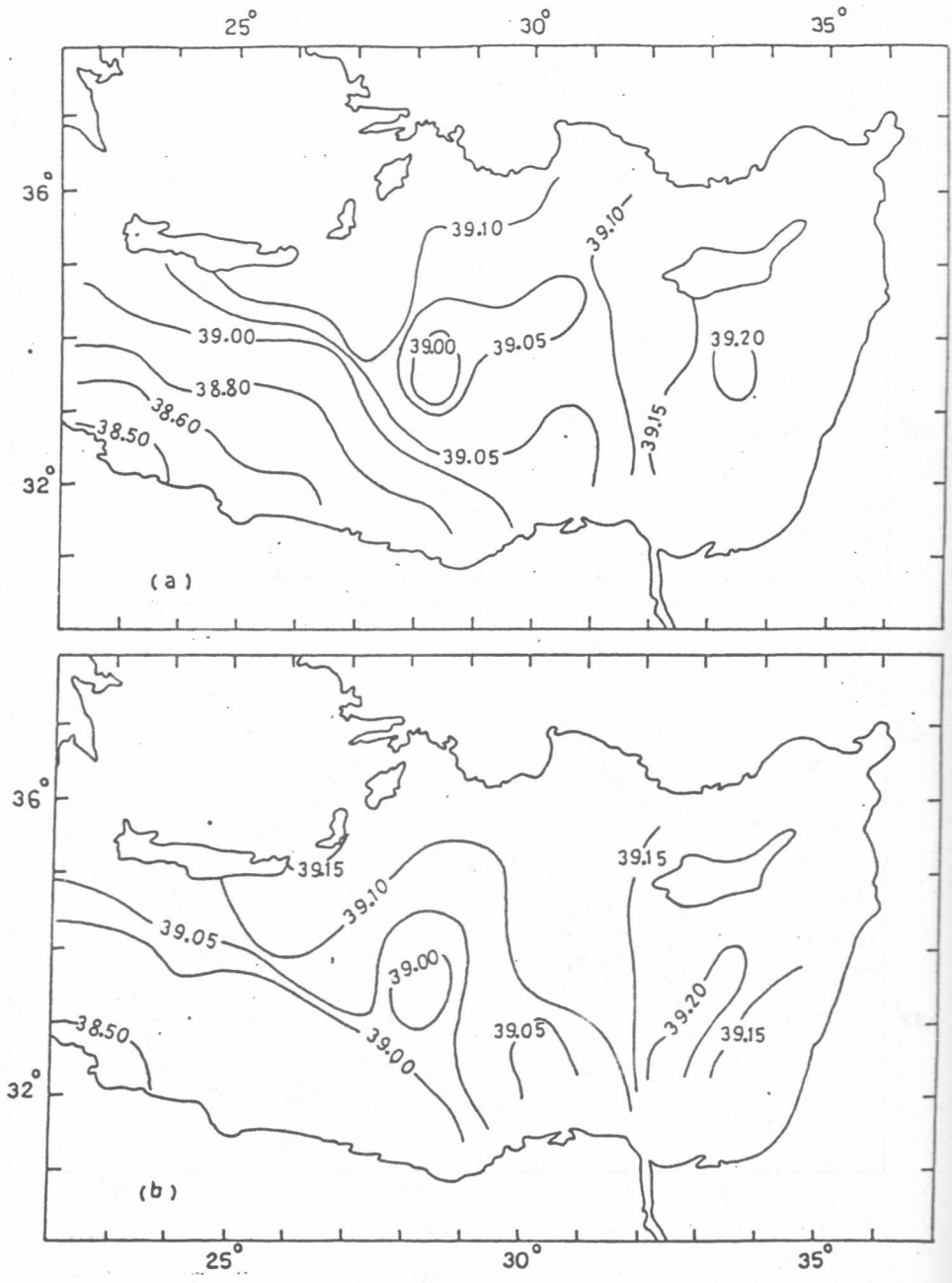

Fig. (4)
Horizontal distribution of salinity at (a) surface and
(b) 50 m level during March 1977.

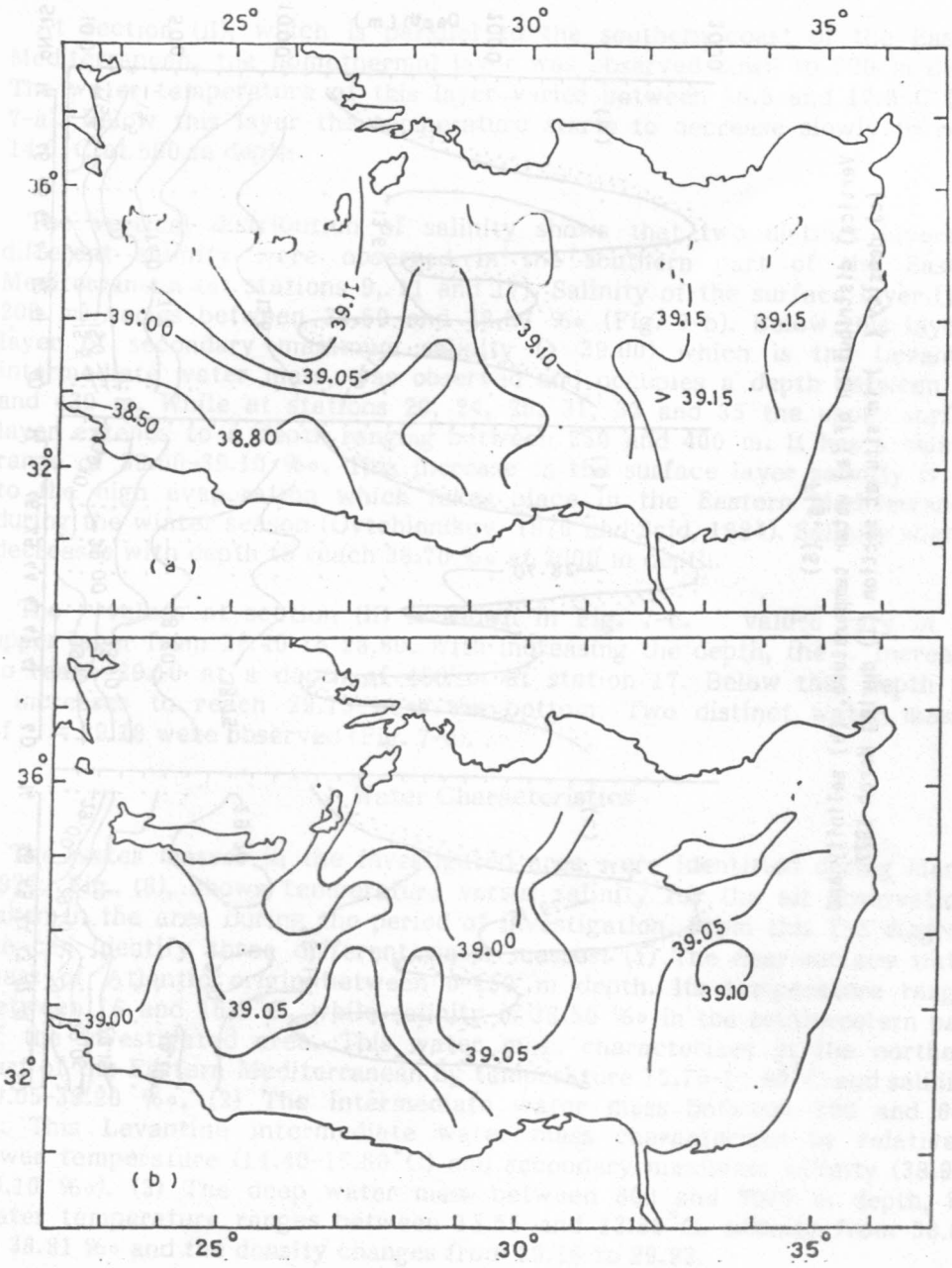

Fig. (5)
Hroizontal distribution of salinity at (a) 100 m and
(b) 200 m levels during March 1977.

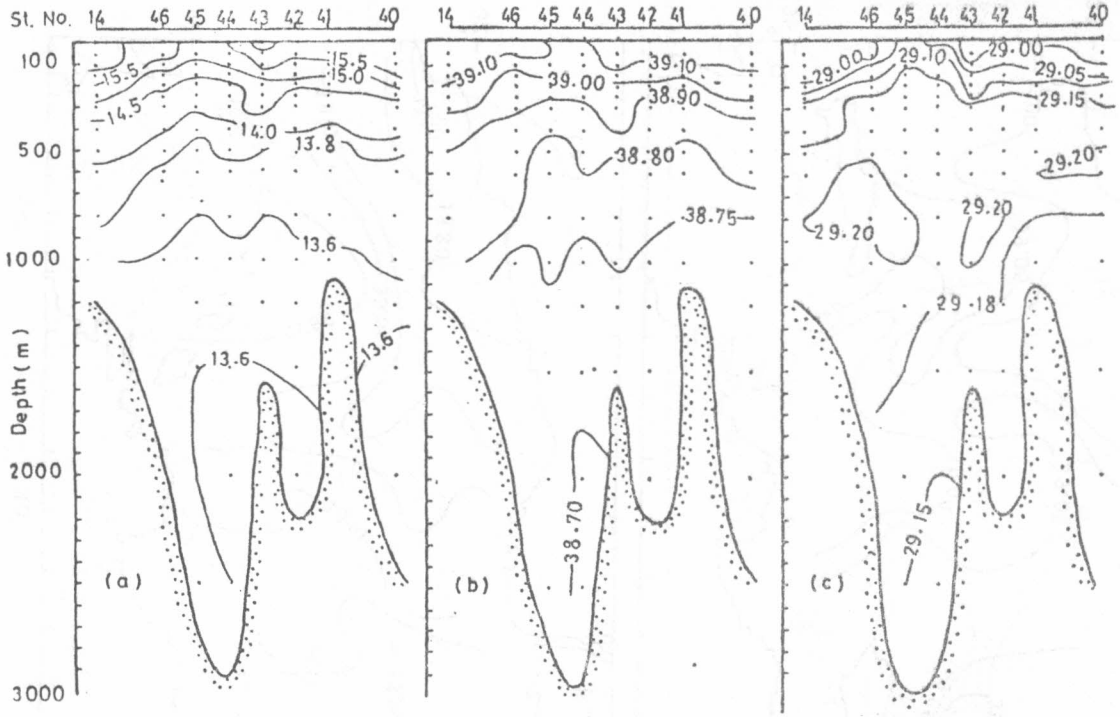

Fig. (6)
Vertical distribution of (a) water temperature, (b) salinity and (c) density ( ) in situ at section (I) during March 1977.

At section (II), which is parallel to the southern coast of the Eastern Mediterranean, the homothermal layer was observed down to 200 m depth. The water temperature of this layer varies between 16.5 and 17.0°C (Fig. 7-a). Below this layer the temperature starts to decrease slowly to reach 14.0°C at 600 m depth.

The vertical distribution of salinity shows that two distinct layers of different salinity were observed in the southern part of the Eastern Mediterranean (at stations 9, 11 and 17). Salinity of the surface layer (180-200 m) varies between 38.50 and 38.80 ‰ (Fig. 7-b). Below this layer a layer of secondary maximum salinity (> 39.00) which is the Levantine intermediate water mass, was observed and occupies a depth between 180 and 430 m. While at stations 20, 24, 26, 31, 32 and 35 the upper surface layer extends to a depth ranging between 250 and 400 m. It has a salinity range of 39.00-39.10 ‰. This increase in the surface layer salinity is due to the high evaporation which takes place in the Eastern Mediterranean during the winter season (Ovtchinnikov, 1976 and Said, 1984). Salinity slightly decreases with depth to reach 38.70 ‰ at 2000 m depth.

The values at section (II) is shown in Fig. 7-c. values vary in the upper layer from 28.40 to 28.80. With increasing the depth, the increases to reach 29.10 at a depth of 480 m at station 17. Below that depth the increases to reach 29.15 near the bottom. Two distinct water masses of = 29.18 were observed (Fig. 7-c).

Water Characteristics

The water masses in the investigated area were identified during March 1977. Fig. (8), shows temperature versus salinity for the all observations taken in the area during the period of investigation. From this T-S diagram we can identify three different water masses: (1) The near-surface water mass of Atlantic origin between 0-150 m depth. Its temperature ranges between 16 and 16,5°C, while salinity is 38.50 ‰ in the southwestern part of the investigated area. This water mass characterizes in the northern part of the Eastern Mediterranean by temperature 15.75-17.00°C and salinity 39.05-39.20 ‰. (2) The intermediate water mass between 200 and 600 m. This Levantine intermediate water mass characterizes by relatively lower temperature (14.40-15.60°C) and secondary maximum salinity (38.95-39.10 ‰). (3) The deep water mass between 800 and 3000 m depth, its water temperature ranges between 13.55 and 13.80°C, salinity from 38.69 to 38.81 ‰ and the density changes from 29.16 to 29.23.

The Levantine intermediate Water Mass

Wust (1960 - 1961) pointed out that along the coasts of Asia Minor, the temperature drops in February to values between 12.5 and 15.5°C. At the same time the surface salinity reaches its maximum of about 39.10 ‰.

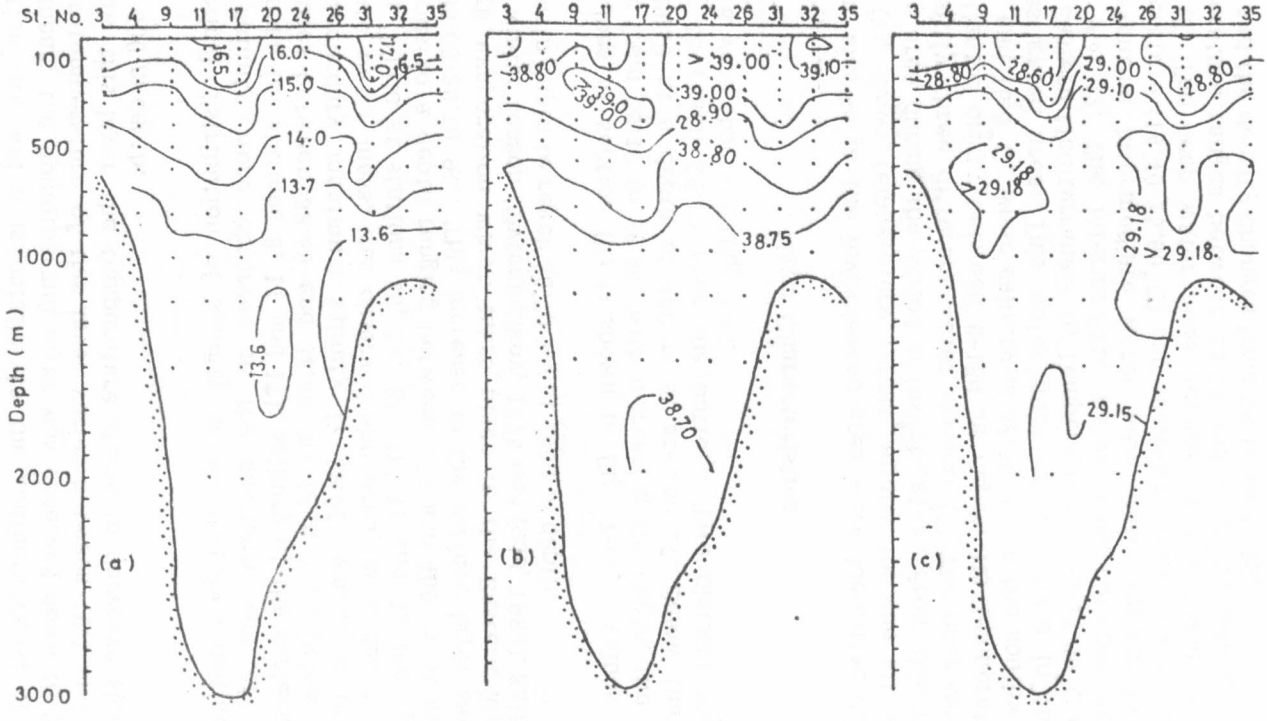

Fig. (7)
Vertical distribution of (a) water temperature, (b) salinity and (c) density ( ) in situ at section (II) during March 1977.

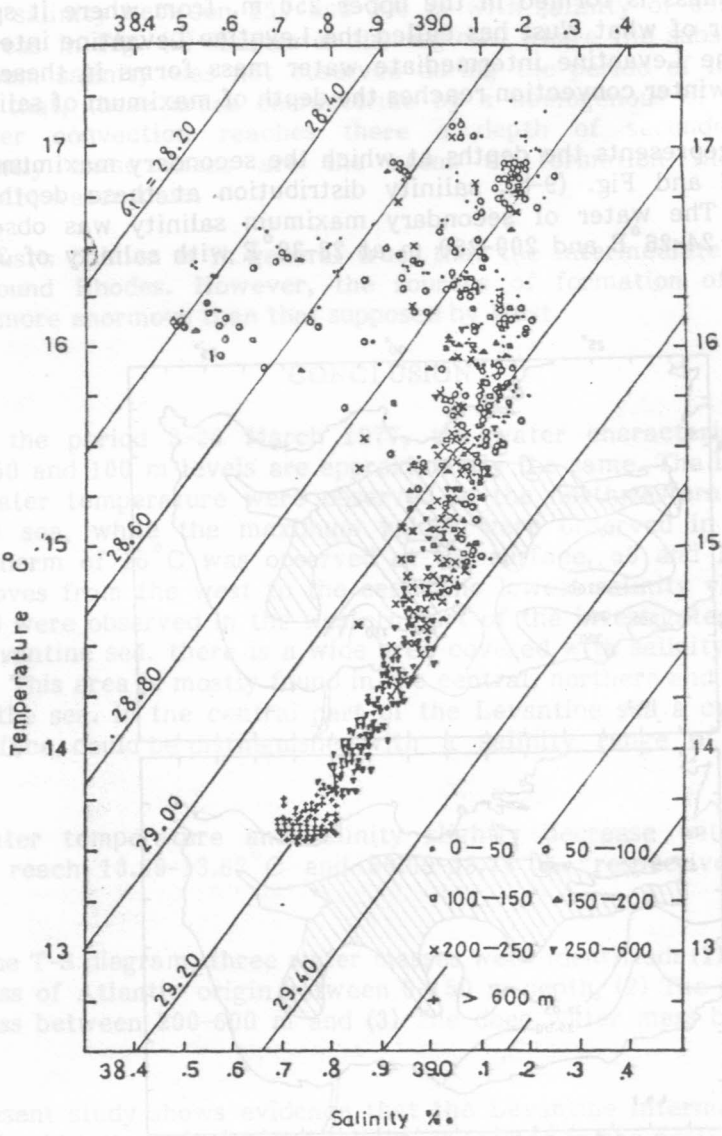

Fig. (8)
Temperature versus salinity for all observations taken in the investigated area during March 1977.

As a result of the influence of low temperature and high salinity, a relatively dense surface water is formed on both sides of Rhodes. This homogeneous large water mass is formed in the upper 250 m, from where it spreads in the core layer of what Wust has called the Levntine Levantine intermediate water. i.e. the Levantine intermediate water mass forms in these regions, at which the winter convection reaches the depth of maximum of salinity.

Fig. (9-a), represents the depths at which the secondary maximum salinity was observed and Fig. (9-b), salinity distribution at these depths during March 1977. The water of secondary maximum salinity was observed at 150 at about 24-26°E and 200-250 m at 28-30°E with salinity of 39.05 ‰

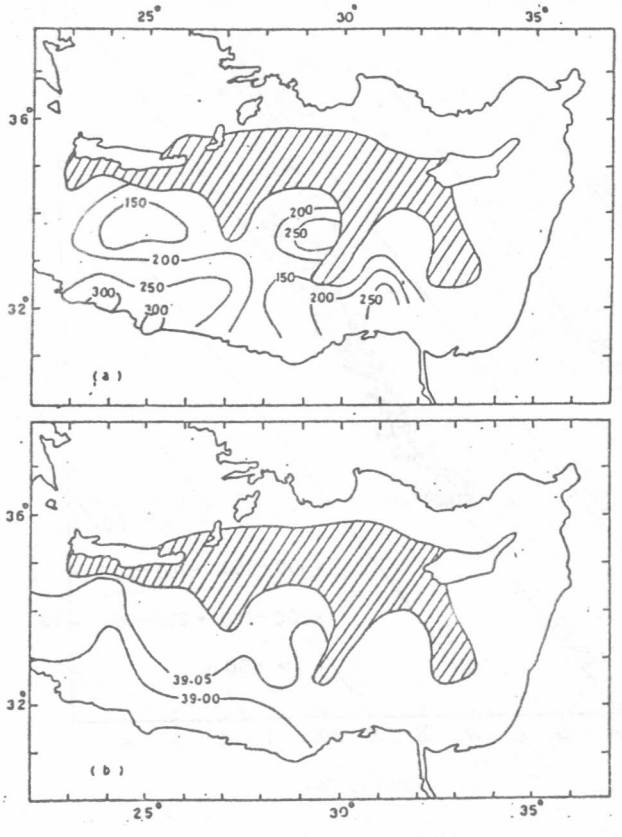

Fig. (9)
(a) The depths of the water of maximum salinity,
(b) Salinity distribution at the depths of maximum salinity during March 1977.
Regions, where the subsurface layer of maximum salinity was not observed during the period of investigation.

(Fig. 9-b). In the southern part of the investigated area, the depth of maximum salinity between 150 and 300 m with salinity of 39.00 ‰. The hashed areas in Fig. (9) illustrates the regions, where the subsurface layer of maximum salinity was not observed during the period of investigation. It means that, these areas characterize by a homogenous of salinity. i.e. the winter convection reaches there a depth of secondary salinity. Consequently these areas are the areas of formation the Levantine intermediate water mass.

Thus Wust's opinion is in general true, that the intermediate water mass forms around Rhodes. However, the sources of formation of this water mass are more enormous than that supposed by Wust.

CONCLUSION

During the period 3-20 March 1977, the water characteristics at the surface, 50 and 100 m levels are approximately the same. The lowest values of the water temperature were observed in the northwestern part of the Levantine sea, while the maximum values were observed in the eastern part. Isotherm of 16°C was observed at the surface, 50 and 100 m levels and it moves from the west to the east. The lowest salinity vlaues (38.50-38.80 ‰) were observed in the western part of the investigated area, while in the Levantine sea, there is a wide area covered with salinity higher than 39.00 ‰. This area is mostly found in the central, northern and southeastern parts of the sea. In the central part of the Levantine sea a cyclonic gyre, at the surface, could be distinguished with a salinity range of 39.00-39.05 ‰.

The water temperature and salinity slightly decrease with increasing depth to reach 13.59-13.67°C and 38.69-38.74 ‰ respectively near the bottom.

From the T-S diagram, three water masses were identified: (1) The surface water mass of Atlantic origin between 0-150 m depth, (2) The intermediate water mass between 200-600 m and (3) The deep water mass between 800-3000 m.

The present study shows evidence that the Levantine intermediate water characterized by the maximum of salinity is formed in the north, the central and southeastern Levantine basin during winter. Part of the Levantine intermediate water flows over the strait of Sicially sill and expands in the Western Basin where it plays a major role in forming deep water in the West Mediterranean (Unesco Reports, 1984).

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