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NEW GEOSTROPHIC STUDIES ON CURRENTS IN THE CENTRAL PART OF THE RED SEA.

BY

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ABSTRACT

Some geostrophic studies were done across a transverse section between latitude 21° and 22 N in the Red Sea during May 1981,where the relative current velocities were computed. This work is a comparison of that done before along nearly the same section in May 1978. In the first upper 50 meters layer, the calculated currents show a northward flow along the Eastern Arabian Coast of the Sea with an average velocity of about 0.27m.s^{-1} giving a northward volume transport of about 1.27x10^{6}m^{3}.s^{-1}.along the Arabian Coast. In the same layer another southward flow of average velocity 0.39 m.s^{-1} was observed along the African Coast giving rise to southward volume transport of 1.98 x 10^{6} m^{3}. s^{-1}. Below this layer and down to 400 meters depth another southward flow of velocity of 0.098 m.s^{-1} was observed along the Eastern Arabian side of the Sea, giving a southward volume transport of 3.22x10^{6} m^{3}.s^{-1}.

Another northward flow of average velocity of 0.101 m.s^{-1} was observed along the western side, its volume transport was about 3.58x10^{6}m ^{3}.s^{-1} . Our results were supported by Thompson (1939a, b), Gerges & Soliman (1987) and Maillard & Soliman (1986) . These results are also more compatible with the general accepted circulation in the Red Sea during this period. The present work shows a different picture from that reached by Sultan and Ahmad (1990) in the form of complete difference in the flow direction along the Arabian and African Coasts.

INTRUDUCTION

The study of the surface flow and its variability in the Red Sea, is one of the desirable field of research since there is no enough work was done about it. The surface flow in the Red Sea, in most of time and in many places, coincides well with the wind regime,but north of latitude 20° N, the surface flow was to the north northwest direction, only in winter, i.e. against the wind direction (Barlow, 1934). Thompson (1939 a) emphasized that the shifting wind field over the Red Sea has the greatest influence on its circulation. Neumann & McGill (1962) suggested that evaporation is the major factor affecting the circulation specially in early summer. Phillips (1966) developed a theoretical model of convection flow restricted to early summer, he speculates, that convecting effects may dominate as the wind is weaker and therefore less influencing the circulation pattern in the Red Sea. Morcos (1970) stated that " The currents of the Red Sea are weaker at the times of the change of the monsoons, April, May and October, where at this time there is a little or no flow through the Strait of Bab El - Mandab. Except during the transitional months,the currents in the southern Red Sea are always greater than that in the Northern Red Sea". Maillard (1971) analyzed the lateral and longitudinal hydrographic stucture of the Red Sea during February 1963, based on a geostrophic interpretation of hydrographic data, and concluded that the circulation at that time consisted of series of large eddies, causing strong cross currents. During summer season, in the northern part, a northward flow exists along the Arabian Coast and a southward flow exists along the African Coast (Gerges and Soliman, 1987). Sultan and Ahmad, (1990) showed that, the computation of the geostrophic currents in the Red Sea along a lateral transverse during early summer gives a northward drift along the western side and a southward one along the eastern side.

DATA COLLECTION AND METHODOLOGY

Within the frame work of the oceanographic survey of the Saudi Sudanese Commission (SSC) for the Exploration of the Red Sea Resources,during May 1981, between latitudes 21° N, and 22° N, some hydrographic parameters, as the water temperature, water salinty,and direct current measurements were collected. Here we are dealing with some of these data collected along a transverse section crossing the Red Sea in the mentioned latiude. Figure (1) shows the position of the section and stations under considerations in May 1981.

The results of the analysis of the data collected in May 1981 were compared with that collected along nearly the same section in May 1978.

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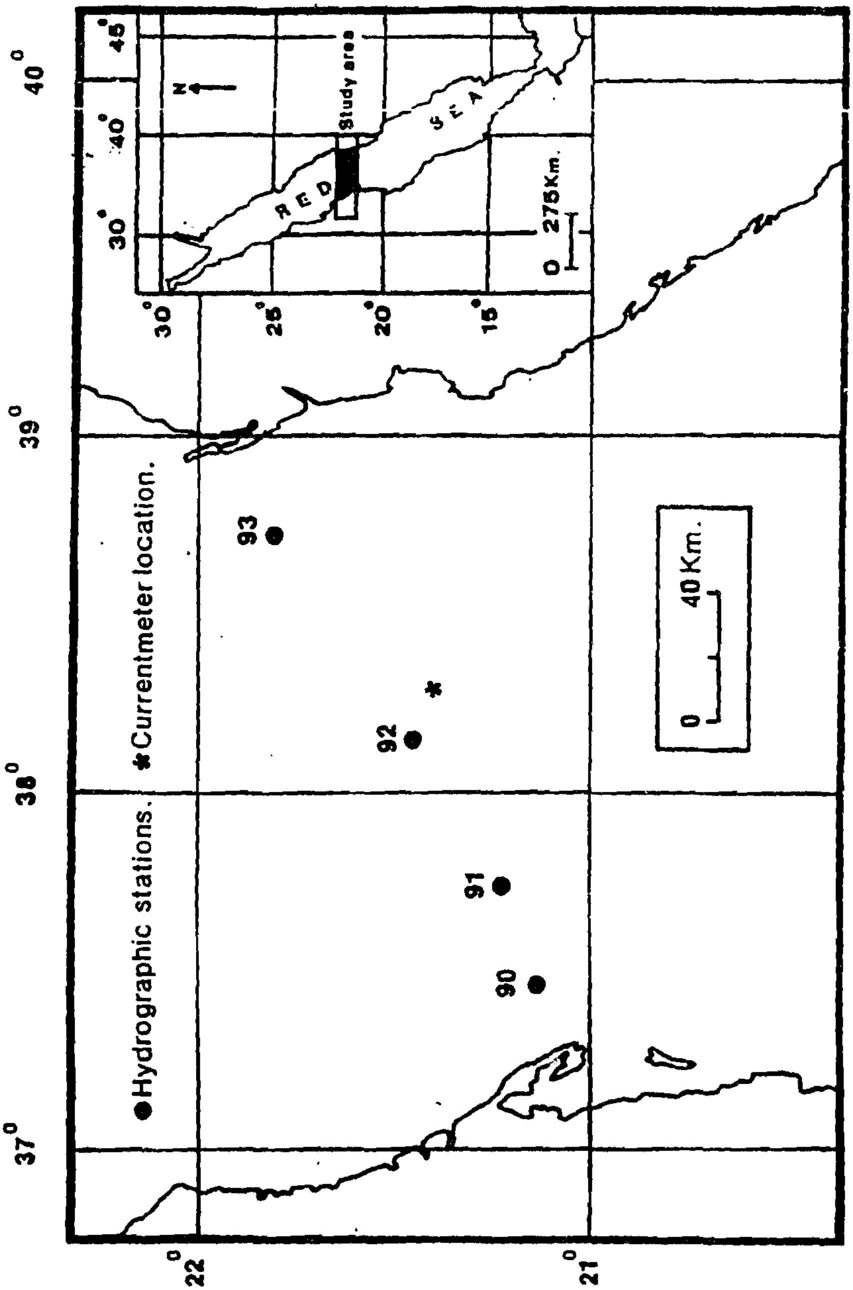

Figure 1: Map of the Red Sea showing hydrographic stations & currentmeter location.

According to many authors, the seasonal variations of the Red Sea water below 250 m depth are very small (Morcos, 1970 ; Morcos & Soliman, 1974; Patzert, 1972 and Sultan & Ahmad, 1990), due to the small density difference (0.02 kg/m^3). Concerning the question of reference level,Morcos & Soliman (1974) used depth of the intermadiate minimum oxygen layer, 300 m, as a reference level, Maillard (1974) considered 300 meter depth as a reference level, and Ahmad & sultan (1991) calculated the geopotential anomalies relative to 250 m depth.

If the reference level is located at greater depths (no motion layer)and using the International Equation Of State for Sea Water (1980) (EOS 80) , the accuracy of dynamic method will be achieved, accordingly the reference level can be safely taken at 400 meter depth.

The relative velocities at each depth was calculated from the equation :

$$V.rel. = \frac{1}{L \times 2w \sin \phi} (\triangle D_B - \triangle D_A) \ m.s^{-1}$$

$$\triangle D = \int_{P_1}^{P_2} \delta \, dP$$

where,

L: distance between stations in meters,
w : angular velocity of the earth's rotation = 7.29×10^{-5} S^{-1} ,
ϕ : average latitudes of stations pairs,
$\triangle$: the integrals of the specific volume anomalies expressed in m^2/S^2

The computed currents data were checked with the direct current measurement collected during the same period of hydrographic data collection (May 1981) in a reference mooring station at: 21° 24' N , 38 ° 15' E. Figure (1).

RESULTS AND DISCUSSION

Figures 2 through 5 show the vertical distribution of temperature, salinity, density and the computed geostrophic velocities for the collected data in May 1981.Temperature section reflects a higher water temperature at the middle of the section extending to 400 meter depth which is surrounded by lower temperature from both sides . This figure makes us to propose that sinking of warm water occurs in the upper surface layer of the middle of the section which attributed to the increase of salinity or density (Figures 3 and 4).

The vertical section of the computed current velocities from the surface down to 400 dbars are shown in figure 5. In the surface layer (50 meter thick) the currents indicate well two opposite flows one toward the reader i.e. towards the south (to the left of the figure), and the other away from the reader i.e. towards the north (to the right of the figure), i.e. the circulation pattern in this area indicates two layers system of opposite direction. Along the eastern Arabian Coast, a northward flow exist within the upper 50 meter layer with relative speed of 0.27 $m.s^{-1}$. In the lower layer down to 400 dbars depth a southward flow exist with a speed of 0.098 $m.s^{-1}$. These two flows give rise to a volume transport of about 1.27 x 10^6 $m^3.\ s^{-1}$ in the upper 50 meters layer to the northward direction, and 3.22 x 10^6 $m^3.\ s^{-1}$ to the south in the lower layer down to 400 meters depth. Along the western African Coast and in the same upper 50 meter layer, a southward flow exists with relative speed of 0.39$m.\ s^{-1}$. In the lower layer down to 400 meter depth a north ward flow exists with a speed of 0.101 $m.\ s^{-1}$. These two flows give rise to a volume transport of 1.98 x 10^6 $m^3.\ s^{-1}$ in the upper 50 meter depth in the southward direction, and of 3.58 x 10^6 $m^3.\ s^{-1}$ to the north.The direct current measurements confirm the presence of the two layers system (figures 1and 7).The values of the computed speed are little bit less than that of the direct measurements as the dynamic method gives only the horizontal components.

Figure (6) shows a cyclonic gyre, where sinking of the surface water at the center or upwelling of the deeper one at the bounderies may be accompanied with.

The present work shows a differnt picture of that reached by Sultan and Ahmad (1990) in the form of complete difference in the flow direction along the Arabian and African coasts. They mentioned that in the west of the Red Sea there exists a northward flow with mean velocity of 7.7 $cm.\ s^{-1}$. and in the east a southward flow of mean speed of 14.0 $cm.\ s^{-1}$. This gives rise to a north transport of 1.9 x 10^6 $m^3.\ s^{-1}$ and a south one of 2.1 x 10^6 $m^3.\ s^{-1}$.

The stick diagram (Figure 8)of the residual velocity of Sultan and Ahmad (1990) supports the results of the present study.

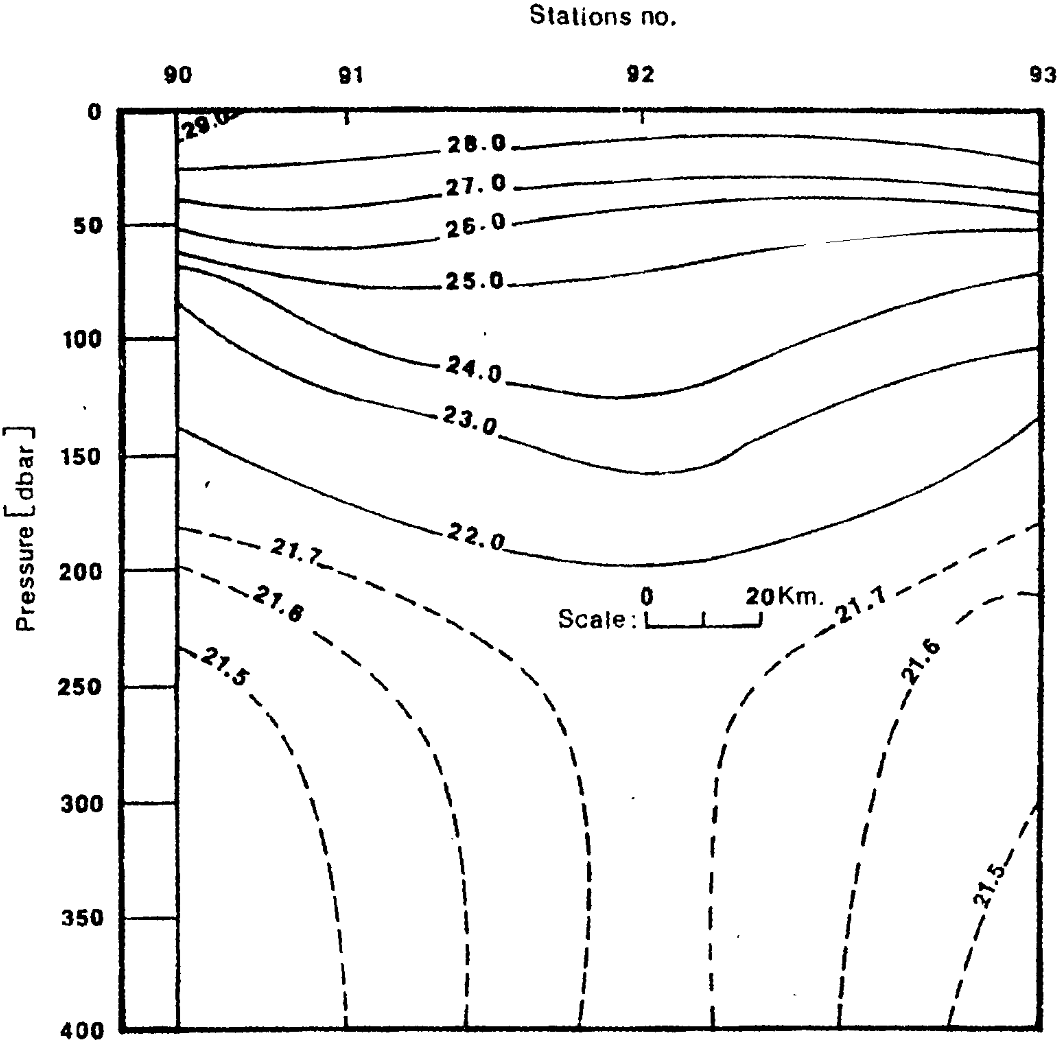

Figure 2: Vertical structure of temperature (°C).

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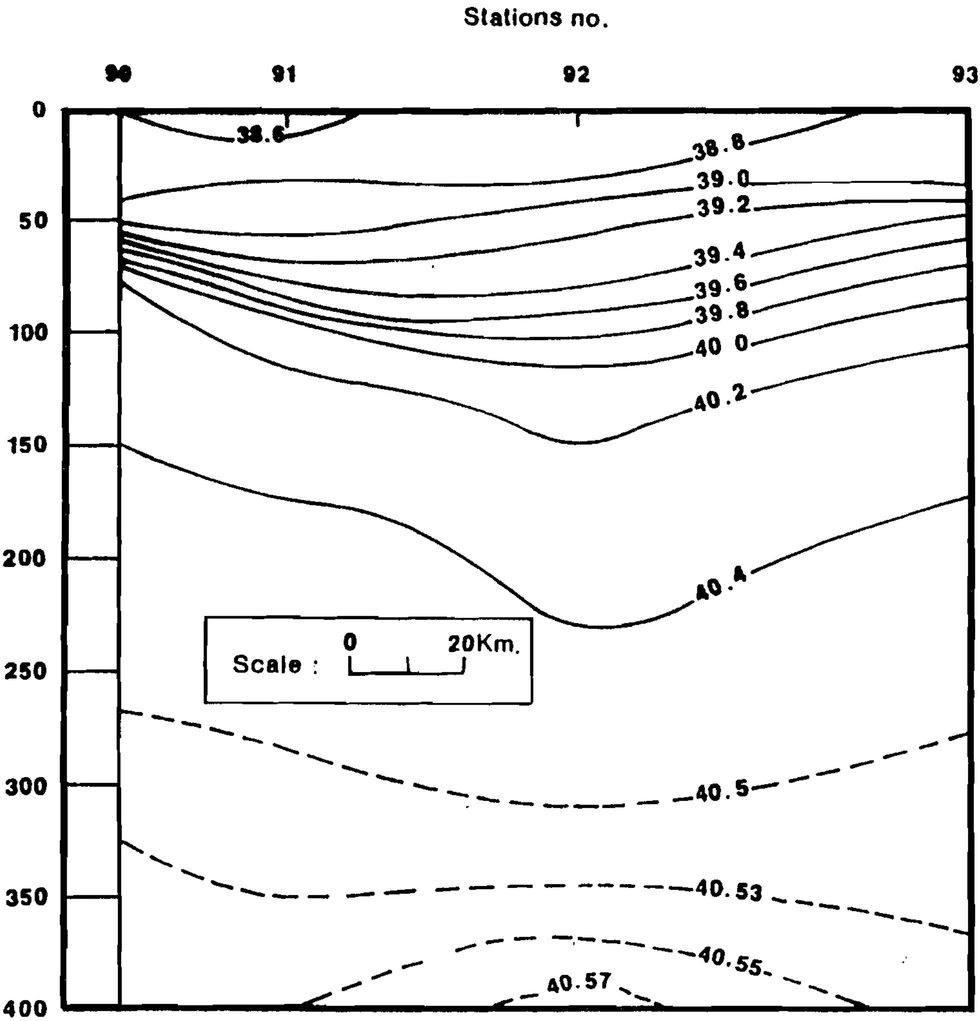

Figure 3: Vertical structure of salinity.

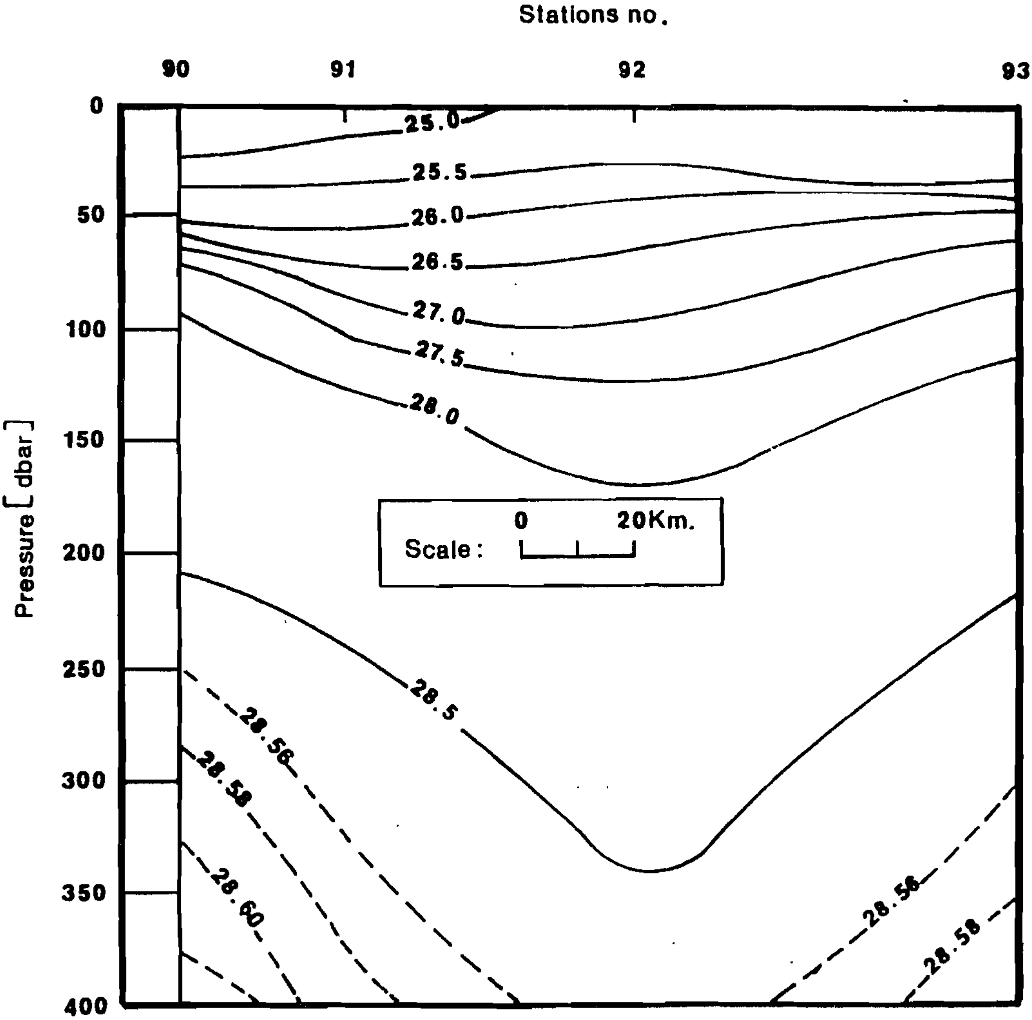

Figure 4: Vertical structure of sigma-t.

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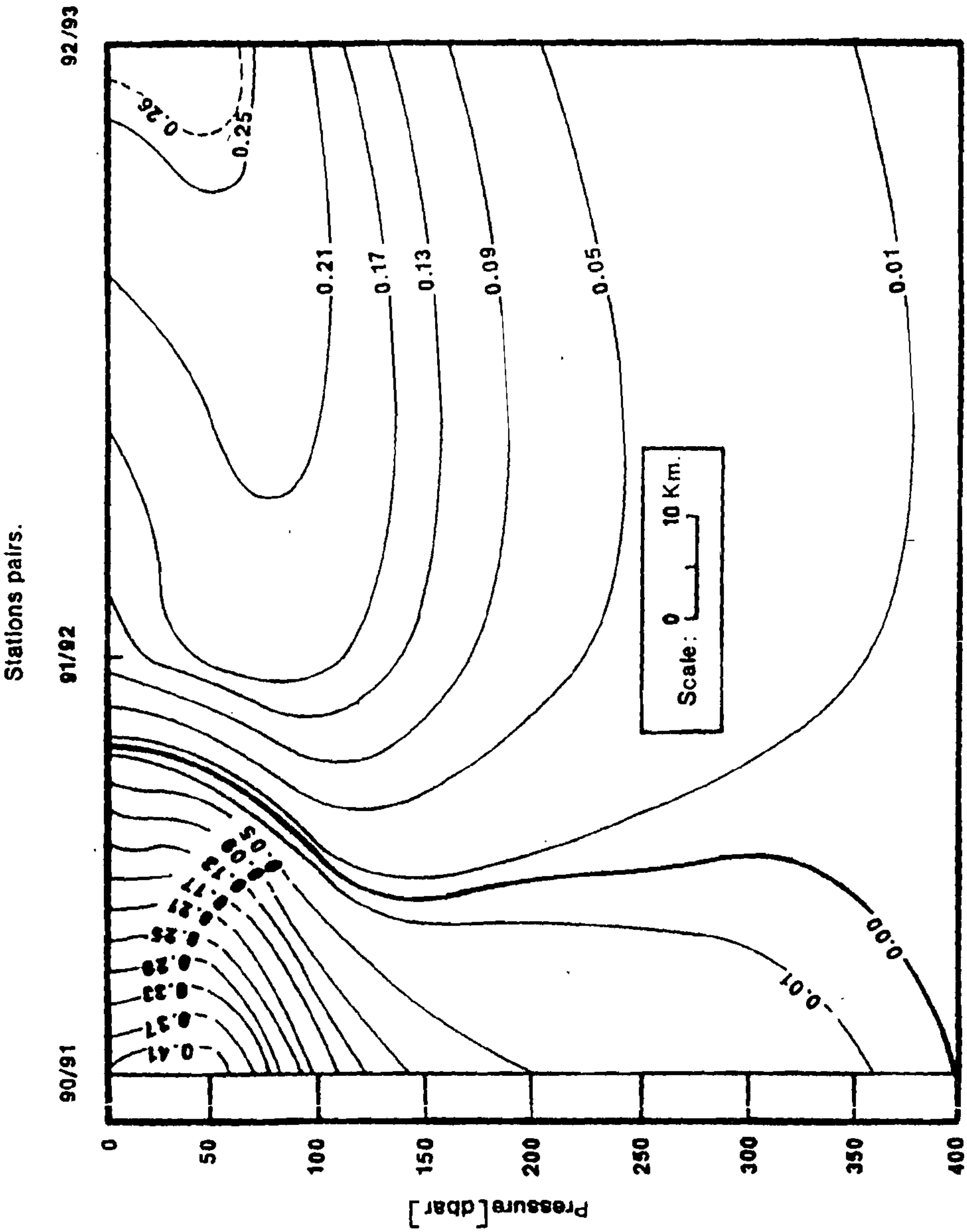

Figure 5: Vertical structure of the relative velocities (m.S.$^{-1}$).

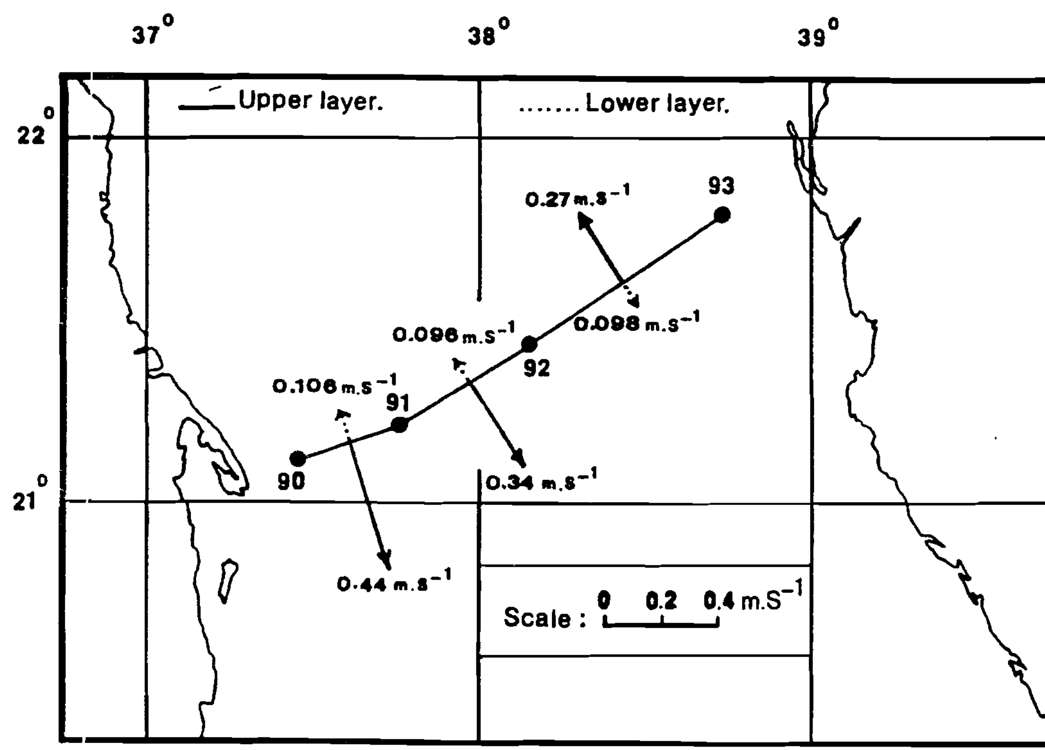

Figure 6: Geostrophic current speed & direction in the upper & lower layers.

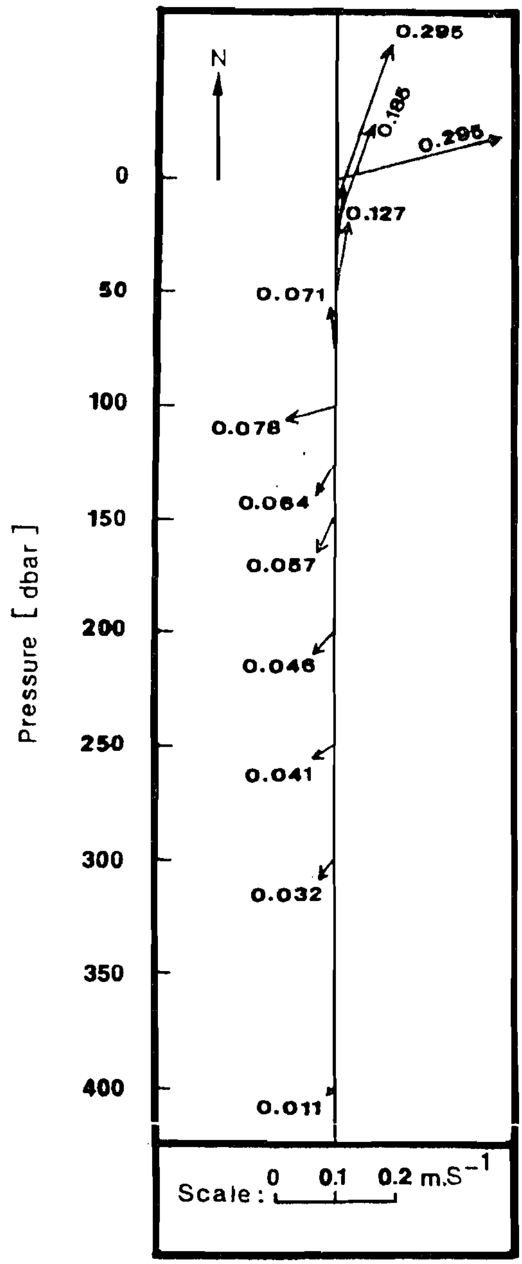

Figure 7: Profile of direct current measurement.

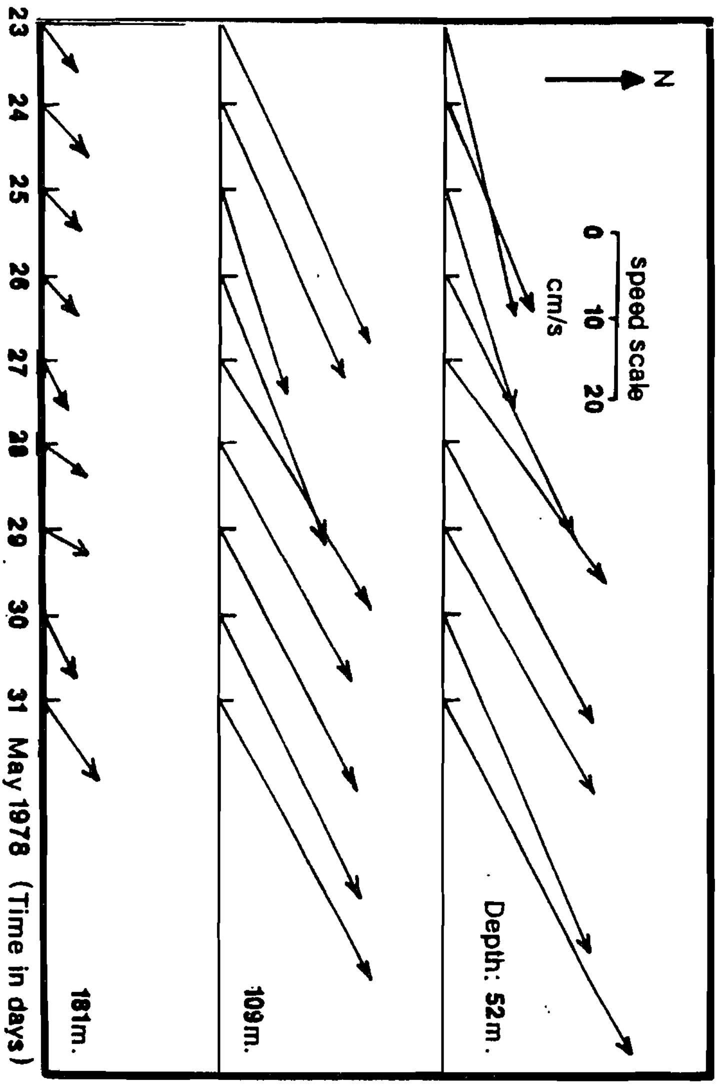

Figure 8: Stick diagram of Sultan, S. & Ahmed, F. (1990) showing the E-NE direction of the direct current measurement.

SUMMARY AND CONCLUSION

During May 1981 the work on the area between latitudes 21° Nand 22° N in the Red Sea Indicated two currents system in the upper 50 meters layer. These two currents are in opposite direction, one northward along the Arabian Coast and the other is southward along the African Coast. Another two opposite currents were observed under the upper 50 meter layer and down to 400 meters depth of reverse directions. The direct current measurements confirms the presence of these currents system. The present work showed a different picture of that reached by Sultan and Ahmad (1990).

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