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Influence of a Seamount on the Circulation of the Upper Layers in the Ocean shown on the Example of the Great Meteor-Seamount.

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1. Introduction

During the "Atlantic Seamount Cruises" of R.V. "Meteor" in 1967 the physical oceanography group investigated the influence of a seamount on the stratification and the circulation of the upper layers of a deep-sea area in the subtropical Northatlantic. The main working field was the region of the Great Meteor-Seamount (30° N, 28° W), which steeply rises from a depth of more than 4 500 m to a depth of less than 300 m. The top of the seamount is formed by a flat and elliptically shaped plateau with a maximum diameter of 30 nm.

2. Observational results

By means of a frequently used bathythermograph it was possible to cover the area on top and around the seamount with a dense grid of temperature-depth profiles. It was found that the depths of the isotherms in the layers between 150 m and 280 m were on the average 60 - 80 m higher in the area above the seamount, than in the area around it. Thus the isothermal surfaces showed a dome-like structure. The temperature observed in the bottom layer of the plateau was found to be

0.5 - 1.0° C lower than in the corresponding level over deep-water. From simultaneous temperature records within and outside the range of the plateau it was possible to prove that the observed variations in the depths of the different isotherms (60 - 80 m) were really due to spatial and not to time dependent causes. The latter (mainly with tidal periods) would only give vertical deviations of 30 - 40 meters for an individual isotherm.

Three chains of three current-meters each were anchored for several weeks near the edge of the plateau. Simultaneously two chains of six current-meters each were moored outside the range of the seamount. This made it possible to investigate the spatial and time dependent variations of the currents.

The time dependence of the observed currents was completely tidal. The currents are of a mixed type, the current vector rotating to the right in the layers between 0 and 300 m. Surface and internal tides were apparent. The observed vertical distribution of the tides above the plateau clearly showed a strong frictional influence. This was not found from the records in deep-water. The amplitudes of the tidal currents in 150 m differed from 14 cm/s in the area within the plateau to 5 cm/s in the area outside.

The computation of the residual currents led to the following results: In the surface layer the direction and the speeds of 3 - 12 cm/s were related to the wind. In the 300 m level the directions of the residual currents at the edge of the plateau were parallel to the elliptical depth contours of the seamount, following them in a clockwise rotation with speeds of 3 - 5 cm/s. In the level between the surface and 300 m the residual currents (3 - 8 cm/s) were directed either according to the wind, or to the bottom contours, or by both in varying degrees. The residual currents over the deep-water (8 - 10 cm/s in 150 m) were mainly directed towards the seamount.

Simultaneous records of temperature and current direction and speed in a depth of 150 m above the plateau gave a good correlation between the amplitude of the tidal current and the deviation of the actual temperature from its total mean value. During spring-tide the observed temperatures were below the mean value, during neap-tide the corresponding temperatures were above.

3. A possible explanation of the observations

From the spatial distribution of temperatures (and accordingly of density as it could be calculated from the temperature values by use of the well defined TS-relation in the area of the seamount) and from the spatial distribution of the residual currents in the bottom layer it follows, that in the region of the plateau of the Great Meteor-Seamount a cum sole rotating system is developed in depths between 150 and 300 m. The speed of rotation decreases from the bottom (3 - 5 cm/s) to 150 m (~1 cm/s). A dynamical comption led to speeds of rotation, which completely agreed with the observed ones.

There are mainly two working models for a possible explanation of the observed circulation:

a. According to the theory of lee-waves a positive horizontal divergence of a flow over a submerged ridge gives rise to a gain of anticyclonic vorticity above the ridge.

b. The amplification of the tidal wave due to a decrease in depth (4 500 - 300 m) and the corresponding increase of the influence of bottom friction causes intensive vertical mixing. This leads to horizontal density gradients and corresponding gradient currents.

The first model does not fit the observations. In this case the speed of the residual currents would lave to be increased on top of the seamount in comparison to the surrounding area, Another objection is the fact, that the streamlines of the observed circulation system form a closed path, which should not be the case if the first model is assumed. Besides this the absolute speeds of the residual currents in the area of the Great Meteor-Seamount as well as the spatial magnitude of the submerged body are too low for the formation of the pronounced anticyclonic circulation. The only fact which supports this model is the cold water observed on the plateau, especially near the edge of the plateau. This indicates a certain upwelling and overflow of the surrounding water masses, but it takes place with a very low speed.

The second model can explain the observed circulation system without any restrictions if a certain amount of cold water is advected to the level of the plateau. Then the strong amplification of the tidal motion will cause high values of the vertical exchange coefficients as it could be calculated from the observed decrease of the amplitudes of the tidal currents with depth.

Thus as a working hypotheses it is stated that the observed anticyclonic system is caused by mixing processes on top of the Great Meteor-Seamount. This concept will be used for further detailed investigations.