

Deep & Bottom Water Characteristics in the Owen Fracture Zone, Western Arabian Sea

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Hydrochemical studies at a station ($10^{\circ}34.1'N$, $56^{\circ}31.7'E$) in the Owen Fracture Zone reveal an active movement of bottom water as ~ 75 m thick, cold, low-salinity layer. Silicate profile exhibits a broad maximum coinciding with a salinity maximum at about 3 km depth in conformity with earlier results. Within the benthic layer, an increase in AOU is observed associated with minor increases in nutrients, presumably due to the oxidation of particulate organic matter sinking from the surface layer.

Spreading of Antarctic bottom water into the deep basins of the Indian Ocean has been studied¹⁻⁶. As in other oceans, the densest bottom waters are restricted to the Antarctic basins (Atlantic-Indian basin and south Indian basin) due to dynamic and topographical factors, and only the lighter water masses, formed by mixing of Antarctic bottom water with overlying circumpolar water, extend to the northern basins of the Indian ocean⁶. The complex ridge system in the region appears to divide the abyssal flow into 3 components, associated with 3 western-boundary currents, and the western basins are penetrated by bottom waters derived from the Indian-Atlantic basin³. Fractures in the southwest Indian Ridge allow the entry of a mixture of circumpolar water and the Antarctic bottom water originating in the Weddell Sea into the Madagascar basin from the Crozet basin². It then spreads into the Mascarene and Somali basins as a western-boundary current^{2,3,5}. The same current is believed to extend into the Arabian basin through the Owen Fracture Zone in the Carlsberg Ridge; such penetration is evident from the low bottom-water potential temperature lobes extending into the interior of the Arabian basin from the fracture zone^{5,6}. However, the sill depth at the Owen Fracture Zone is not accurately known, and the abyssal flow through deep saddles has not been studied in detail so far. In the present communication, characteristics of deep and bottom waters in the fracture zone, which provide additional information on the bottom water movement into the Arabian basin are presented.

The study is based on observations made during a cruise of *R V Sagar Kanya* in June 1983. Only one hydrographic station could be occupied; it was located ($10^{\circ}34.1'N$, $56^{\circ}31.7'E$) in a deep channel, 7-10 miles wide and characterized by rather uniform depths, northeast of the Error Seamount. TPN Nansen and PVC Niskin samplers (5 l) equipped with reversing

thermometers, were used for collecting samples with standard hydrocast. The samplers were fixed at 25 m intervals to achieve closer water sampling in the layer within 100 m from the bottom and the lowermost sampler was guided to within ~ 5 m from the seafloor with the help of a hydrographic pinger. The analytical procedures have been described elsewhere⁷.

Variations in potential temperature with depth show that the potential temperatures observed in the benthic layer are significantly lower than expected from the trend in the overlying water column. The potential temperature (θ) decreased from $1.553^{\circ}C$ at 3157 m to $1.097^{\circ}C$ at 4646 m [$0.0306^{\circ}C \cdot (100 \text{ m})^{-1}$], and then more steeply in the benthic layer to $1.039^{\circ}C$ at 4746 m [$0.058 \cdot (100 \text{ m})^{-1}$]. A sharp fall in salinity is also observed in the benthic layer with the values decreasing from 34.736×10^{-3} at 4646 m to 34.710×10^{-3} at 4746 m depth. This causes a sharp change in $\theta - S$ profile between 4646 and 4671 m (Fig. 1). The potential-temperature data are consistent with the observations of Kolla *et al.*⁵, but the near-bottom salinity value observed here (34.71×10^{-3}) is slightly lower than expected ($\sim 34.72 \times 10^{-3}$) from the map of Mantyla and Reid⁶. This is presumably due to a closer sampling to the bottom in the present study than achieved by earlier workers. The low temperatures and salinities observed in the benthic layer, distinguishing it from the overlying water column, provide an evidence for an intense flow of bottom water through the deep channel northeast of the Error Seamount where the station is located. Judging from the shape of $\theta - S$ profile, the abyssal flow appears to be most vigorous in a layer about 75 m thick hugging the bottom. The silicate content of the benthic layer ($137 \mu M.l^{-1}$) is in agreement with the observations of Mantyla and Reid⁶. The silicate profile exhibits a maximum ($141 \mu M.l^{-1}$) coinciding with a weakly-developed salinity maximum at about 3 km depth

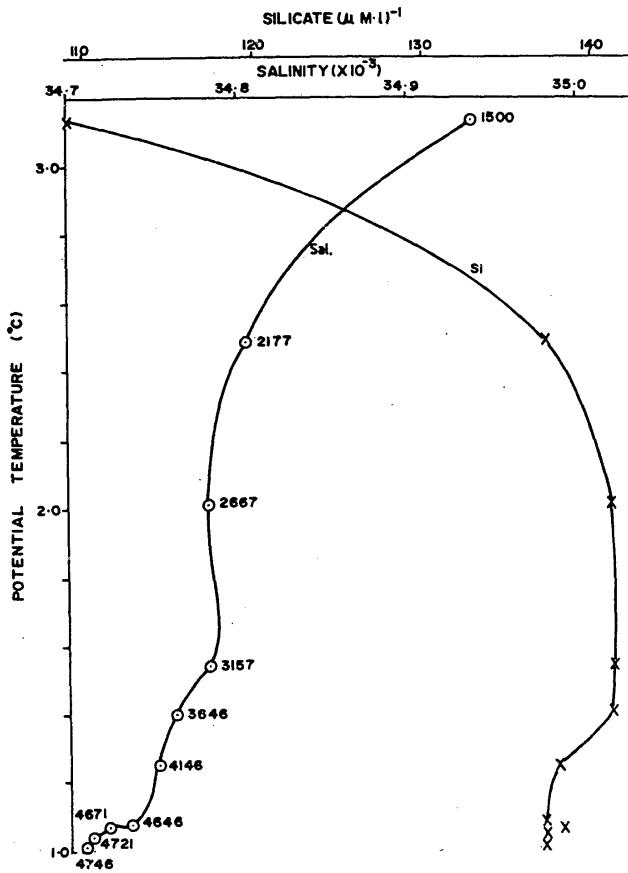


Fig. 1—Potential temperature-salinity and potential temperature-silicate profiles for the deep and bottom waters

(Fig.1). This is in conformity with the results of Edmond *et al.*⁸ and suggests southerly flow at these depths of water enriched with silicate as a result of solution of diatomaceous sediments at the seafloor in the Arabian Sea.

Variations in the apparent oxygen utilization (AOU), NO₃-N and PO₄-P with potential temperature in deep and bottom waters are presented in Fig.2. All properties decrease with potential temperature down to a depth of about 4670 m and increase slightly thereafter to the bottom. The increase in AOI is much more pronounced than the corresponding increases in nutrients, although the near-bottom nitrate and phosphate concentrations remain significantly above the values expected from the trends in the overlying layers. Edmond *et al.*⁸ and Broecker *et al.*⁹ have observed similar but more pronounced increases in nutrients and alkalinity and a decrease in dissolved oxygen at 3 GEOSECS stations, one located in the Arabian Sea (13°N; 64°30'E) and the other 2 in the Bay of Bengal (8°30'N; 86°E and 12°30'N; 84°30'E). The features are attributed to the oxidation of organic matter at the deep seafloor, transported down from the surface, presumably as fecal pellets. In the Arabian basin and the Bengal Fan, however, the contact times

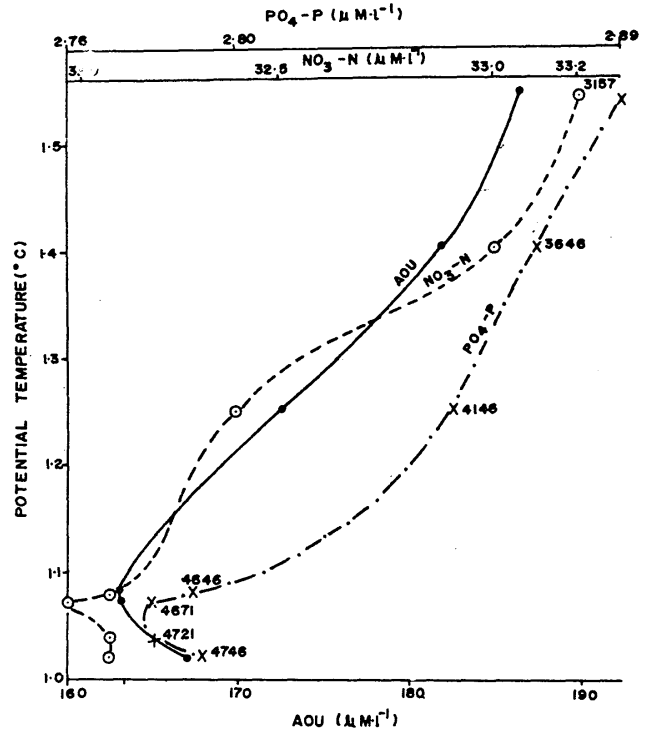


Fig. 2—Plots of nitrate-nitrogen, phosphate-phosphorus and apparent oxygen utilization (AOI) versus potential temperature for the deep and bottom waters

of bottom water with the sediments are expected to be much longer than in the Owen Fracture Zone where active movement of bottom water occurs. That the near-bottom anomalies could still be discernible in the latter area probably reflects the large flux of particulate organic matter reaching the deep sea floor. These features seem to be characteristic of the north Indian Ocean, presumably caused by high surface productivity and incomplete oxidation of organic matter in the water column.

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