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NOTE

Abyssal eddy in the southwest Atlantic

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Abstract—A subsurface anticyclonic eddy has been observed in the southwestern Atlantic (46°S, 53°30′W) between 2800 and 4800 m. Within this feature is a nearly homogeneous core, composed of water identical to the bottom water of the Falkland Plateau, about 700 km to the southeast. It is suggested the abyssal eddy is a product of interaction between circulation and local topography, with subsequent isopycnal spreading into the Argentine Basin.

INTRODUCTION

IN THE past few years, numerous observations of subsurface eddies have been reported, particularly in the heavily sampled North Atlantic (MCWILLIAMS, 1985). An abyssal eddy has been detected in the Argentine Basin at 46°S, 53°30′W (Fig. 1). The 77 km

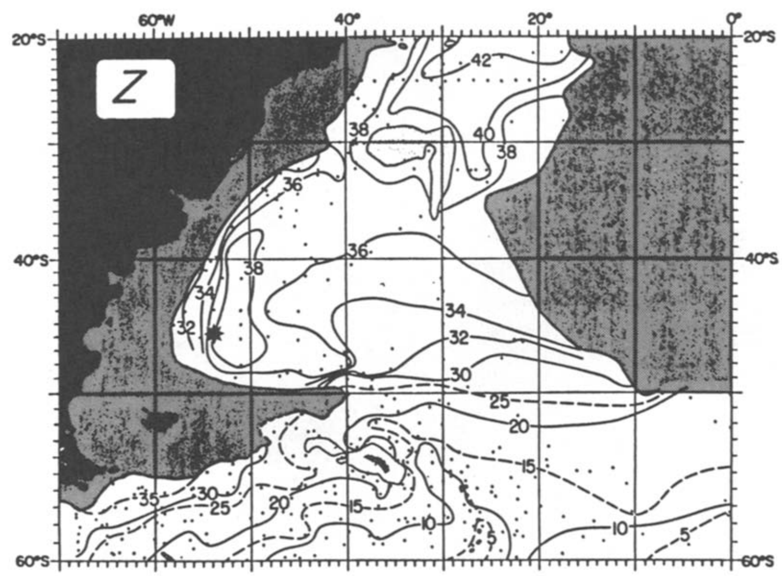

Fig. 1. Depth of σ_4 = 46.00 density surface after Fig. 19 of REID *et al.* (1977). The star marks the location of the abyssal eddy. Hydrographic data listed in Table 1 show continuation of the σ_4 = 46.00 surface over the saddle of the Falkland Plateau.

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(maximum diameter) eddy is revealed by a distortion of isopycnals at Sta. 84 (CTD-O_2/ Rosette hydrographic data from *Atlantis* II 107–3; Guerrero *et al.*, 1982) from 2800 to 4800 m (Fig. 2) associated with a nearly homogeneous lense of water between 3200 and 4200 m (Fig. 3). It is situated within the benthic thermocline (Broecker *et al.*, 1976) just below the deep oxygen minimum of Circumpolar Deep Water (CDW) but above the Weddell Deep Water (Reid *et al.*, 1977).

Geostrophic calculations relative to the oxygen minimum, at σ_4 = 45.9, indicate anticyclonic flow with a maximum velocity of 8 cm s^{-1} about the perimeter at 3800 m. The hydrographic properties within the core of the abyssal eddy at 3800 m are given in

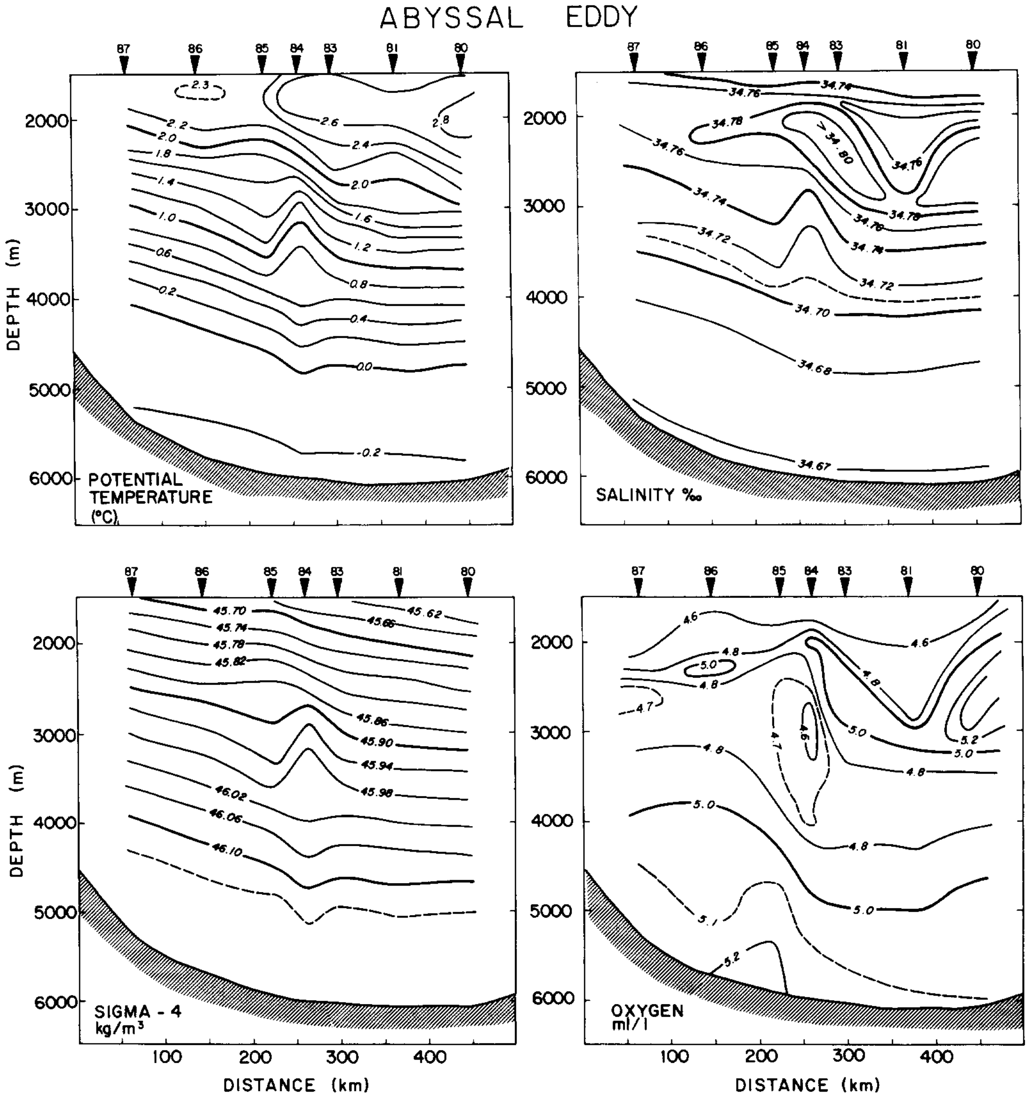

Fig. 2. Sections of potential temperature (°C), salinity (‰), density (σ_4) and oxygen (ml l^{-1}) along 46°S from 51 to 56°W. the abyssal eddy falls between Stas 83 and 85; *Atlantic* II 107-3 Hydrographic Data; Guerrero *et al.* (1982).

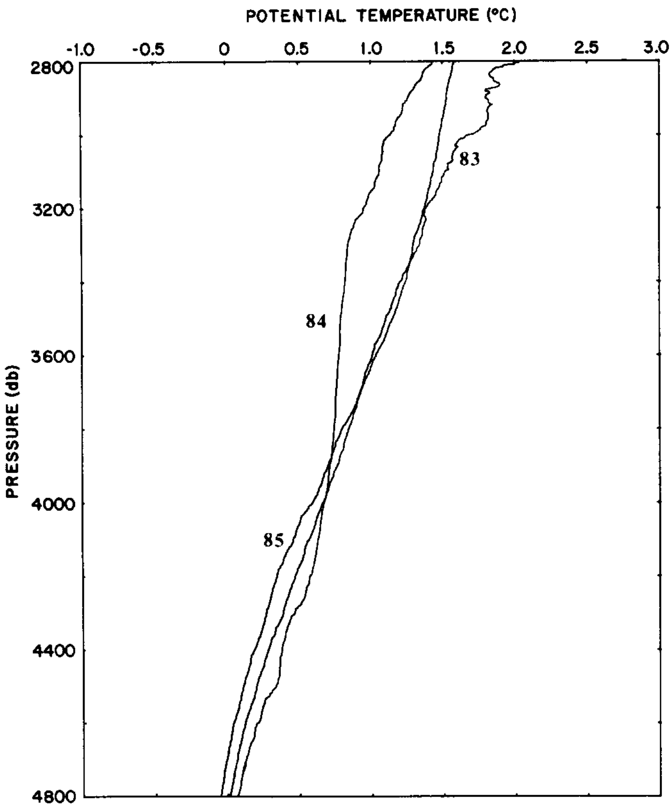

Fig. 3. Potential temperature (°C) vs pressure (db) for Stas 83, 84 and 85. Station 84 represents a profile through the abyssal eddy.

Table 1. Comparison of Stas 83, 84 and 85 in θ–S space (Fig. 4) reveals no gross anomalies of the lense. Given the above characteristics, this feature may be classified as a Submesoscale Coherant Vortex (McWilliams, 1985).

The water within the homogeneous core of the abyssal eddy is similar to the water within the benthic boundary layer on the saddle of the Falkland Plateau between the Falkland Islands and the Maurice Ewing Bank. The abyssal eddy characteristics are within 0.01°C; 0.01‰; 0.1 ml/1, and has the same σ_4 value as the average bottom water measured at three hydrographic stations (194, 321, and 182) on the saddle of the plateau (Table 1).

Since the eddy core is homogeneous and composed of water with characteristics similar to that in contact with the Falkland Plateau 700 km to the southeast, it is possible that the generating mechanism is associated with the interaction of circulation and local topography. Armi (1978) found homogeneous layers in the North Atlantic interior that were formed by the interaction of 10–30 cm s^{-1} currents with the New England Seamount Chain and then transported downstream along isopycnals. Armi and D'Asaro (1980), in a further study of benthic boundary layer mixing, showed that density surfaces which intersect rough or sloping terrain are likely to contain numerous detached mixed layers.

Table 1. *Hydrographic stations*

Station	Latitude (S)	Longitude (W)	Bottom depth (m)	Sample depth (m)	θ (°C)	S (‰)	O_2 (ml l^{-1})	σ_4	Source
84	46° 00′	53° 30′	5998	3800	0.74	34.71	4.71	46.01	*Atlantis* II 107–3; 12/10/79–1/10/80, GUERRERO *et al.* (1982).
194	49° 43′	47° 17′	2363	2355	0.74	34.71	4.95	46.01	*Islas Orcadas* 16; 4/5/78–5/21/78, HUBER *et al.* (1981).
321	50° 30′	48° 59′	2755	2736	0.82	34.72	4.72	46.00	*Conrad* 18–01; 2/2/75–3/12/75.
182	52° 17′	48° 58′	2913	2843	0.71	34.71	4.81	46.01	*Atlantis* II 107–10; 8/6/80–9/4/80. PIOLA *et al.* (1981).

Bottom photographs (Fig. 5)

Station	Latitude (S)	Longitude (W)	Bottom depth (m)	Description	Source
102	49° 37′	47° 36′	2615	*Tetrachaelasma southwardi* Newman & Ross (filter feeders clinging to edge of escarpment on the northern side of Falkland Plateau)	*Conrad* 15–05; 2/19/72
30	50° 57′	49° 11′	2730	Sand ripples — central saddle of Plateau	*Vema* 18; 3/24/62
72	52° 11′	48° 50′	2532	Clean swept pavement, ice rafted detritus and manganese nodules — southern edge of Plateau	*Conrad* 15–04; 1/9/72

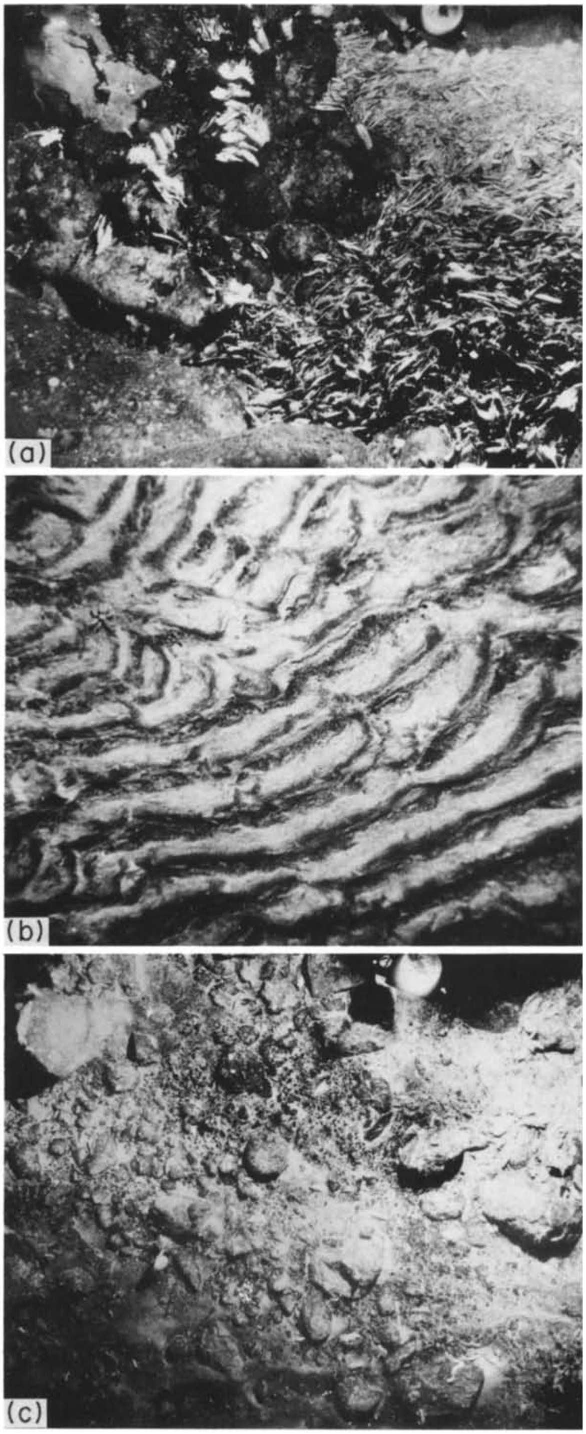

Fig. 5a–c. The three bottom photographs of the Falkland Plateau were taken with a Ewing-Thorndike deep-sea camera, 2.1 m from the bottom. The field of view is approximately 1.5 × 2.0 m, with a 7.5 cm diameter compass for scale. An individual description of each plate is provided in Table 1.

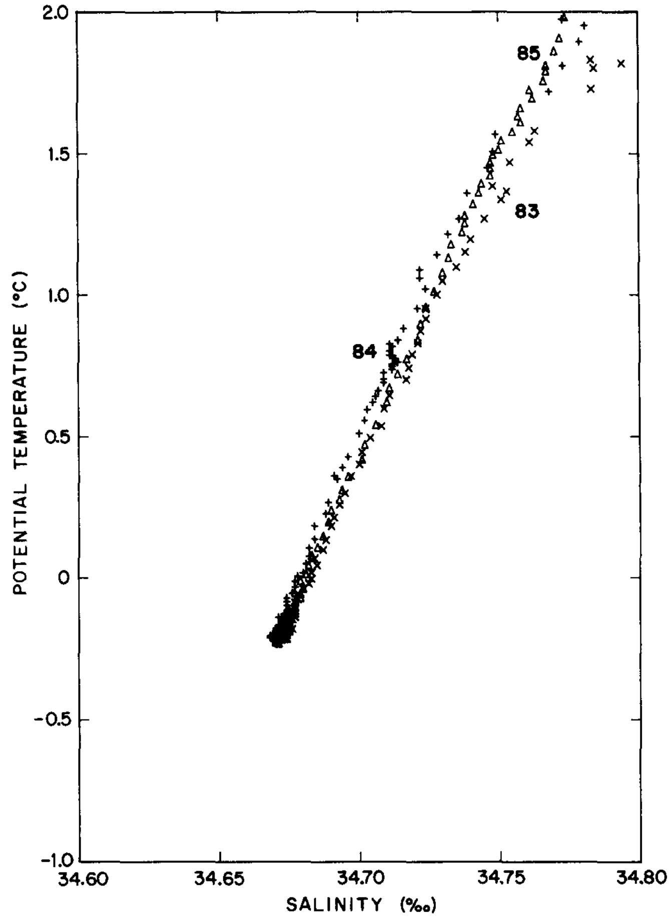

Fig. 4. θ–S diagram for Stas 83, 84 and 85 at 50 m intervals.

The Antarctic Circumpolar Current traverses meridionally across the Plateau (Gordon *et al.*, 1978; Whitworth and Ward-Divins, personal communication). Northward flow is indicated by abundant ice-rafted detritus (IRD) and diatomaceous ooze within plateau sediments (Harris and Sliter, 1977). Water mass properties determine that the benthic boundary layer on the plateau consists of CDW flowing from the Drake Passage over the Falkland Plateau into the Argentine Basin (Reid *et al.*, 1977; Whitworth and Ward-Divins, personal communication). Reid *et al.* (1977; their Fig. 11) and Georgi (1981a; his Fig. 13) both suggested cyclonic abyssal flow in the basin north of the Plateau.

It is hypothesized that the abyssal eddy observed in the Argentine Basin is a product of the benthic boundary layer over the Falkland Plateau saddle. The eddy is then advected isopycnally along the $\sigma_4 = 46.00$ density surface to its location within the northward flow of the cyclonic gyre (Fig. 1). The abyssal eddy, if it continues to move along this surface, would intercept the ocean floor near 10°N (Reid and Lynn, 1971; their Fig. 3a). The farther from its origin, the more anomalous the eddy characteristics would become relative to its surroundings.

No direct current measurements are available on the Plateau; however evidence for flow–topography interaction is given by GEORGI (1981b). He found enhanced benthic fine structure in two hydrographic stations near 50°S, 47°W and variable turbulence in the vicinity of the Plateau.

Geologic evidence of high velocity bottom currents in this area is given by three bottom photographs (Fig. 5) taken near each of the hydrographic sites on the Plateau (Table 1). Figure 5a, located at the edge of the escarpment near Sta. 194, shows *Tetrachaelasma southwardi* Newman & Ross attached to pillow basalts (B. HECKER, personal communication). These filter feeders require a strong current environment for their survival. Figure 5b, located in saddle center, shows 20 cm wavelength sediment ripples. Core top analysis of DSDP (Deep-Sea Drilling Project) sites from legs 36 and 71 in the area indicate this to be medium grain sand (BORNHOLD, 1980; CAMERON, 1977), implying bottom current velocities of 20–50 cm s^{-1} (R. FLOOD, personal communication). An earlier study of Plateau piston cores by EWING *et al.* (1971) states that, "The coarseness of the Pleistocene and recent sediments recovered at the tops of the cores indicates strong currents have been inhibiting normal pelagic deposition since the Pliocene." Figure 5c is from the south side of the Plateau next to Sta. 182 and shows clean swept pavement, IRD and manganese nodules, again indicative of an active, high current erosional environment (HARRIS and SLITER, 1977).

CONCLUSION

Within the benthic thermocline at 46°S between 53 and 54°W is a lense of homogeneous water 77 km in diameter which distorts the isopycnals from 2800 to 4800 m, forming an anticyclonic abyssal eddy. The properties within the core of the abyssal eddy are the same as those observed within the benthic layer over the saddle of the Falkland Plateau, some 700 km to the southeast. It is proposed that the abyssal eddy is a product of benthic boundary layer mixing and current–topography interaction (ARMI and D'ASARO, 1980; MCWILLIAMS, 1985). The flow pattern and strength of bottom currents over the Falkland Plateau associated with the σ_4 = 46.00 density surface are sufficient to support the detached benthic boundary layer hypothesis and subsequent isopycnal flow into the Argentine Basin. As the abyssal eddy spreads isopycnally northward away from its origin, the θ–S core characteristics would become increasingly anomalous relative to its surroundings. If it continues to move northward, it would intercept the sea floor near 10°N.

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