fugal force on plasma near the equatorial plane will create a Jovian ring current and lead to interchange motions. Finally, the incidence of plasma on the surface of Io may account for its unusual optical properties^{3,4}.

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Detection of a Deep Boundary Current in the Western South Pacific

FROM the distribution of salinity, temperature, oxygen and radio-carbon observed in the deep oceans (deeper than 2,000 m) of the world, it seems that all the deep water in both the North and South Pacific comes from other oceans, entering the Pacific from the south. The Tasman Sea is closed to the north at depths greater than 3,000 m, so that any deep current reaching into the North Pacific must lie east of New Zealand. The simple linear geostrophic theory of the abyssal circulation proposed by Stommel and Arons^{1,2} requires that the source water, "after passing south of New Zealand, flows northward into the Pacific Ocean as a narrow western boundary current along the Tonga-Kermadec Trench". It seems surprising that the source water should move in such a narrow current when it has the full width of the South Pacific within which it might flow, but the dynamics demands weak, southward geostrophic flow over most of the width of the South Pacific, and permits northward flow only in a higher-order boundary current. We are not at all certain that such simple dynamics do prevail, and the data have so far been insufficient to reveal the existence or non-existence of this current.

Between March 10 and August 2, 1967, we made two long oceanographic sections (Scorpio Expedition) across the South Pacific between Australia and Chile on 43° 15' S. and 28° 15' S., with 78 and 100 hydrographic stations, respectively. In the deep water, temperatures were measured with Kahl reversing thermometers of range -2° to 60° C on which temperature could be read to ±0.001° C. Salinities were measured on a University of Washington conductivity bridge ('Paquette' model) with precision ±0.002‰. The work was done aboard the USNS Eltanin, the research vessel of the US Antarctic Research Program.

The sections were made partly to fill a great void in the world coverage of oceanographic data, and partly in the belief that with closely spaced, highly precise observations, features not discernible in the sparse older data³ would be disclosed. Chief among these was the expectation that some evidence of the postulated deep western boundary current would be found along the eastern side of New Zealand and the Tonga-Kermadec Ridge—kinematical,

through advection of properties such as temperature, salinity and oxygen; and dynamical, through an intensification of the field of horizontal density gradient. No attempt was made to make direct measurements of the velocity field such as those by Swallow and Worthington⁴ in a similar current in the North Atlantic.

The evidence for the current on the salinity profile at 28° 15' S. consists of a salinity maximum layer with highest values (greater than 34.730‰) compressed within 70 km of the eastern slope of the Tonga-Kermadec Ridge, between the depths of 3,000 and 4,000 m. A somewhat thicker (between 2,500 and 4,400 m) and much broader (extending 1,300 km to the east) tongue is delineated by the 34.720‰ contour. Further eastward the salinity at these depths falls to 34.690‰ and increases monotonically with depth. The deep salinity maximum is probably the last distinct evidence of the North Atlantic component of this water's origin—the extremum being continuously traceable all the way from the Atlantic sector of the Antarctic to the Pacific sector. It seems, however, that the current is not as wide as might be inferred from the 34.720‰ salinity contour, but is essentially confined to the short distance of 70 km adjacent to the Ridge, because the intense horizontal gradient of temperature (and density) is confined to this narrow region. The 1.10° C isotherm drops from 4,000 m, where it intersects the eastern slope of the Ridge, to 4,600 m, 70 km to the east. A similar slope—downward towards the east—occurs above these levels, but the amplitude of drop diminishes with decreasing depth; thus at 2.00° C the downward drop had diminished to a change from 2,550 m to 2,650 m. At 3.00° C the slope is the other way.

The current, as computed geostrophically, thus appears to be 70 km wide, to be confined between depths of 2,500 m and 4,500 m (there is always some uncertainty in assigning depths of no motion), and to transport an amount of water northward amounting to 8 to 12 × 10⁶ m³/s, which compares with 12–15 × 10⁶ m³/s as estimated in a steady stage budget of heat, mass, salt and radiocarbon⁵.

There was no such intensification of the current observed on the 43° 15' S. section; the zone of sloping isotherms is about 500 km wide (though the vertical displacements are about the same as at 28° 15' S.), and the tongue of salinity greater than 34.730‰ extends 1,100 km east of the New Zealand slope. This is presumably caused both by the fact that at this latitude the current is still in transition from the zonal current that feeds it from the south and has not travelled a sufficient distance in latitude to be influenced by the change in Coriolis parameter; and to the fact that the western boundary at this latitude has an extremely gentle and prolonged slope.

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