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Subaerial Volcanic Rocks of the Willaumez-Manus Rise, Papua New Guinea: A Key to the Origin of the Rise?

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Expanded Abstract

An asymmetrical rise, 450 km long, on the Bismarck Sea floor extends between Manus Island and Willaumez Peninsula on the north central coast of New Britain (Figure 1). Northeast of the steeper flank of the rise is the Manus Basin, 2500 m deep, which is deeper and apparently younger than the New Guinea Basin southwest of the rise. The Willaumez-Manus Rise is coincident with a Bouguer gravity trough; Willcox (1977) calculated its crust to be 21-25 km thick, in contrast to values of mainly 19-21 km for the two adjacent basins.

The Bismarck sea floor is thought to be a marginal basin (e.g. Karig, 1973). An anomalous feature, however, is the pronounced east-west zone of earthquakes that extends across the sea, and cuts the Willaumez-Manus Rise. The earthquake zone has been regarded as a left-lateral strike-slip plate boundary (e.g. Johnson and Molnar, 1972), but the rise is not obviously displaced by the boundary, and more recent studies have shown that sea-floor spreading is probably taking place along parts of the earthquake zone, particularly in the Manus Basin (Connelly, 1975, 1976; Taylor, 1975).

Quaternary volcanic rocks form the islands in the St Andrew Strait area and the Witu islands at the northwestern and southeastern ends of the rise, respectively. Two possibilities for the origin of the rise may be discussed with regard to the compositions of these volcanic rocks. One possibility is that the rise is the trace of a mantle melting spot. Basaltic rocks on one of the St Andrew Strait islands have compositions similar in many respects to those of oceanic islands, but the most abundant rock type in the area is alkali-rich rhyolite which appears to be the product of partial melting of basaltic crust, implying high geothermal gradients (Johnson et al., 1978). Although St Andrew Strait may overlie an intra-plate melting spot, the Willaumez-Manus Rise is unlikely to represent its trace across the Bismarck Sea floor. There is, for example, no evidence along the rise crest for a chain of volcanoes that are progressively younger northwestwards; and if the Manus Basin is younger than the New Guinea Basin the presence of a melting-spot trace at the southwestern margin of the Manus Basin would be highly coincidental.

Many basaltic rocks in the Witu Islands are petrologically similar to the rocks that are found in marginal basins formed by back-arc sea-floor spreading (Johnson and Arculus, 1978). If these rocks are representative of the submarine volcanic rocks that may exist elsewhere along the rise crest,

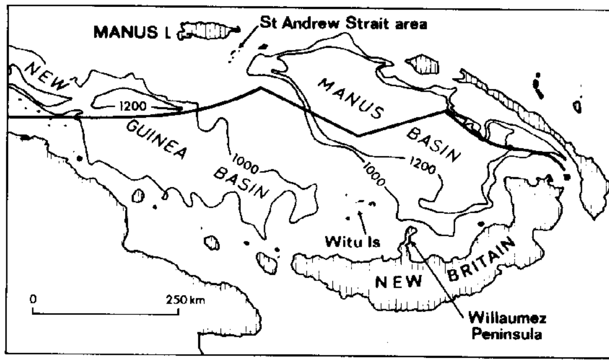

FIGURE 1

Bismarck Sea locality map. Isobaths (fathoms) from Mammerickx *et al.* (1971). Thick east-west zig-zag line represents approximate trend of earthquake zone.

then the rise may be an extinct spreading axis. But this interpretation is also unlikely, because, together with andesites, dacites, and rhyolites, the basalts of the Witu Islands are consistent with progressive changes in chemical composition of rocks from New Britain volcanoes, and these changes are apparently related to different depths to the Benioff Zone that dips northwards beneath the New Britain island arc (Johnson, 1977). Volcanism in the Witu Islands may therefore be dependent upon mantle upwelling above a downgoing slab rather than at a spreading axis. Moreover, a spreading-axis interpretation does not account for the apparent difference in age between the two basins, or for the asymmetry of the rise, and fracture zones orthogonal to the postulated spreading axis have not been identified.

The Willaumuz-Manus Rise does not seem to be primarily a volcanic feature. Its origin is more likely to be tectonic — perhaps uplift of old lithosphere at the edge of the New Guinea Basin near its contact

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with hotter and younger lithosphere beneath the Manus Basin (Johnson et al., in prep.).

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A Convergent Subduction Model for the Solomon Islands

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Abstract

Some of the data from seismic studies, gravity, and the distribution of Quaternary surfaces and deposits in the Solomon Islands are consistent with convergent subduction at the margin of the Pacific and Australian — Solomon Sea Plates, that is, the convergent Benioff Zones meet at considerable depth and are overlain by a small wedge-shaped plate composed of lithosphere. Such convergent subduction probably occurred in the Solomons during much of Late Oligocene through Quaternary time.

Introduction

Seismic studies of the New Guinea — Solomons region (Johnson and Molnar, 1972; Curtis, 1973a; Denham, 1975) suggest the presence of 'platelets' in Melanesia; Curtis (1973b) suggested, tentatively, that the Solomon Islands forms a 'platelet' which is bounded by trenches (Figure 1). The Solomon Islands archipelago is a double chain of islands and is lensoid in plan, about 1,000 km long and 350 km wide at its maximum width. Considered as an island arc it differs from the normal case and in this paper I propose an alternative model.

The standard model for island arcs has one plate plunging beneath another that bears a volcanic arc near its margin (Isacks, Oliver and Sykes, 1968); possible variations from this simple model have been considered by Karig (1974). Karig's (1970) theory that island arcs could split to form extensional areas behind the volcanic arc has been popular as has the notion of the flipping of subduction zones. The latter notion has been proposed for the Solomons (Karig and Mammerickx, 1972; Halunen and Von Herzen, 1973). Hackman (1973) proposed anticlockwise rotation of two degrees every million years for Guadalcanal during the Cainozoic (misprinted as clockwise — B.D. Hackman, pers. comm. 1977) and a similar theory modeled on Carey's (1958) rhombochasm model has been proposed for the Solomons (Taylor, 1976). Recently, Coleman (1975, 1976) and Coleman and Packham (1976) made a passing suggestion that the Solomon Islands may have formed, initially, as volcanic accumulations along fracture zones and leaky transform faults within the Pacific Plate. Certainly, to match the features of the Solomon Islands to a simple model is difficult (Coleman, 1976).

Solomon Islands features consistent with convergent subduction

In this paper I propose that the Solomon Islands owe their identity to convergent subduction, that is, to two active Benioff zones that dipped towards each other, meeting at considerable depth, during much of Late Oligocene through Quaternary time.

The archipelago is bounded by trenches of which the southern one is about 6 km deep, discontinuous, and seismically active; the northern one is about 4 km deep and largely aseismic (Figure 2). The major islands of each of the two chains invariably show evidence of fairly youthful uplift or are tilted towards The Slot. For example, Plio-Pleistocene limestone on Choiseul is tilted to the south or southwest (Coleman, 1962) and limestone of western New Georgia is tilted to the north (Pudsey-Dawson, 1960a, 1960b). The northern coast of Guadalcanal has many raised terraces which indicates rapid Late Quaternary uplift (Hackman, 1973) and, inland,

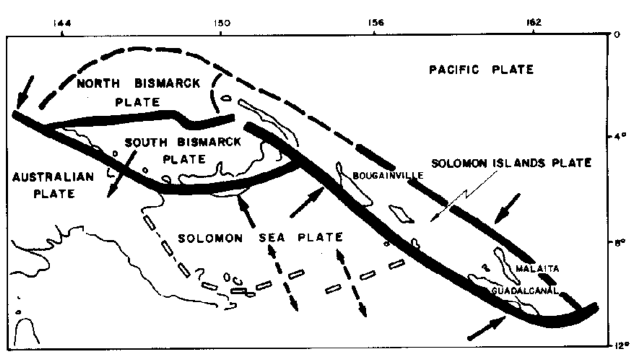

FIGURE 1

Plates in the Solomon Islands area — largely after Denham (1975) and Curtis (1973a).