mainly tholeiitic basalts and andesites, but rare dacites are also present, rhyolites appear to be atsent. The chemical compositions of the rocks change along the arc — i.e., in a direction parallel to the strike of a postulated subducted lithospheric slab. These changes can be explained by identifying Late Cainozoic poles of rotation in the northwestern part of mainland Papua New Guinea, and by postulating eastwardly increasing rates of plate convergence.

An eastern volcanic arc is associated with the boundary between the South Bismarck and Solomon Sea plates. The rocks are mainly andesites, but also include tholeiitic basalts and dacites; rhyolites are present, but rare. The volcanoes are arranged in an unusual zig-zag pattern, and the compositions of the volcanic rocks change with increasing depths to the northward dipping New Britain Benioff zone — i.e., in a direction at right angles to the strike of the Benioff zone, and to the axis of the New Britain submarine trench. The existence of a thrust slice in the northwestern corner of the Solomon Sea is postulated to account for the distribution pattern of the eastern-arc volcanoes.

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LINEATIONS IN THE BISMARCK SEA

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The Bismarck Sea is a complex tectonic region lying in a zone of interaction between the Pacific and Australian Plates. Several small crustal plates have been outlined in the region. Although the Bismarck Sea has a crustal thickness of about 20 km it appears to be oceanic in origin.

Data from some 10 000 n.mi.of traversing in the Bismarck Sea has thrown some light on the understanding of the structure and evolution of the area. Oceanic basement occupies the northern two thirds of the Bismarck Sea region while the southern third appears to be primarily of andesitic composition. Minor northeast magnetic trends underlie major east-west trends associated with volcanic ridges. These minor trends appear to have arisen from sea floor spreading. Preliminary interpretation indicates the anomalies are possibly of Oligocene age.

A simple but speculative evolution consistent with most of the facts can be put forward.

a) The Bismarck Sea region formed during the **Oligocene** on the southern limb of a spreading ridge. The ridge is now possibly situated between Manus Island and the PNG margin.

Until this time the Northern New Guinea Arc, New Britain Arc and the West Melanesian Arc formed a continuous island arc to the south.

b) About **early Miocene** the Northern New Guinea Arc collided with the Australian plate. Subduction ceased along the island arc and a shear zone was formed along the southern boundary of the West Melanesian Arc to release stress.

c) Between the **early Miocene to early Pliocene** the West Melanesian Arc moved 1000 km northwest along shear zone (rate about 7 cm/yr). Shearing could explain the absence of volcanism during this period, the formation of tensional features in the eastern Bismarck Sea, and the 'arc type' volcanics of Oligocene/Miocene age on the northeast of the West Melanesian Arc.

d) Post Pliocene saw the readjustment of plate boundaries and resumption of subduction under New Britain. The left-lateral Bismarck Sea fault was formed to accommodate movement originally along the West Melanesian Arc. A zone of andesitic volcanism from eastern New Britain to the Schouten Islands formed by subduction of the Australian plate to the north and northeast.

HELWIG-HALL CONCEPTS OF OROGENIC MODE AND UNDERTHRUSTING MODE

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A few years ago, the fact that thick piles of undeformed sediments occur in some trenches, caused several geologists to doubt the reality of subduction. However, in 1971, Oxburgh and Turcotte published the results of a study on the origin of paired metamorphic belts and concluded that in a convergent plate boundary periods of active subduction must episodically alternate with periods of cessation of movements along the subduction zone.

Several geologists in Australia (Packham, 1973: Packham and Leitch, 1974; Leitch, 1974; Rod, 1974) reached the same conclusion during their investigations of the origin of the Tasman orogenic belt and of the emplacement of ultramafic rocks. Convincing evidence was produced that during such brief periods when the leading edge of the continental crust was strongly compressed and deformed, there was also a very substantial uplift.

Helwig and Hall (1974) analysed the structural phenomena caused by plate convergence along a plate boundary and proposed a model whereby the plate convergence at a subduction zone operates in two distinct but not exclusive modes.

Firstly, in the orogenic mode, the continental edge is coupled to the oceanic lithosphere. The trench contains undeformed sediments and most of the plate convergence is expressed by thrusting along the imbricate wedges and other intense deformation in the upper (continental) plate, up to 200 km from the trench axis.

Secondly, when the continental edge is uncoupled from the oceanic lithosphere, most of the plate convergence is accomodated by movements along the Benioff zone. This is the underthrusting mode which produces more or less continuous accretion of trench sediments.

As stressed by Helwig and Hall, all transitions between the two modes can be envisaged. Thus the paradox of continuous plate motion and episodic orogeny finds an elegant explanation.

When applied to an analysis of the evolution of the old orogenic belts in the Southwest Pacific area, the concept of bimodal behaviour of subduction zones proposed by Helwig and Hall is of great importance. Combined with a study of the structural deformations accompanying the Chilean and

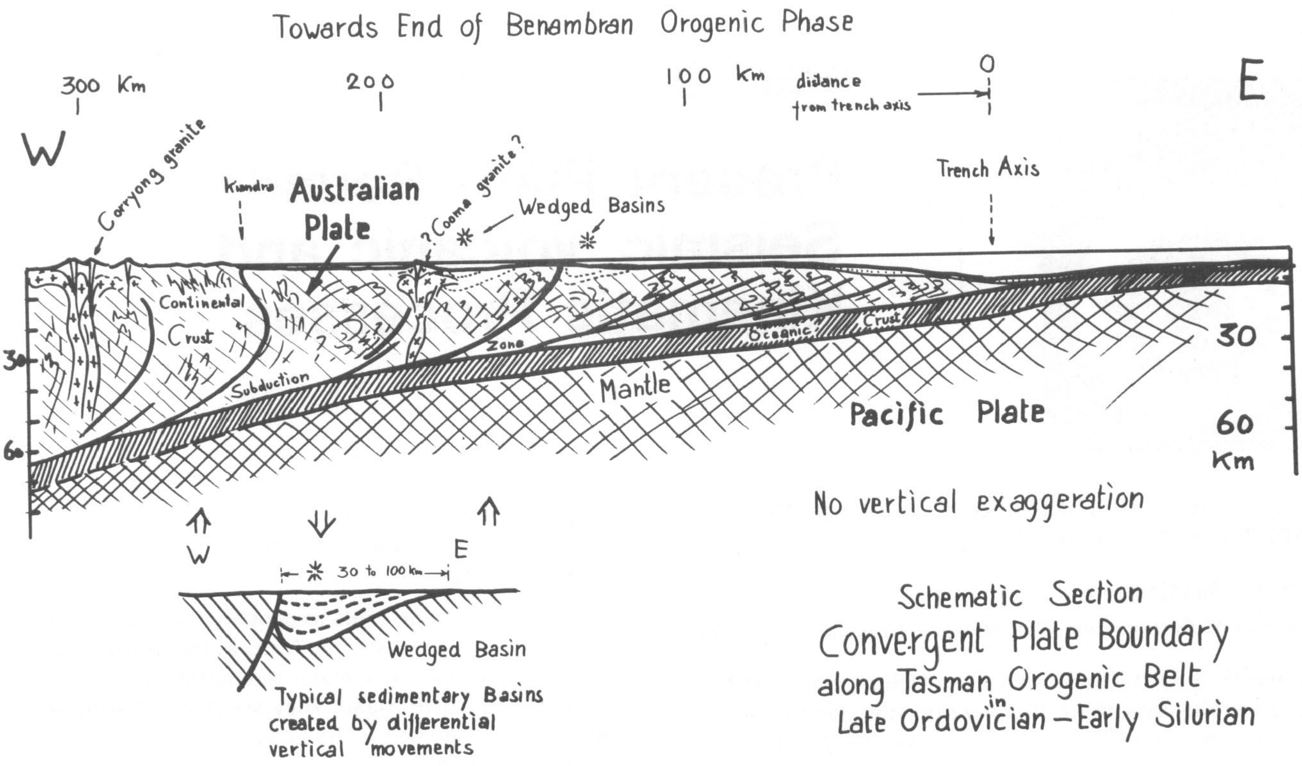

Figure 1
Schematic section through leading edge of Australian Plate at end of Benambran Orogeny.

Alaskan earthquakes of 1960/64 (Plafker, 1972). all the sediment-filled, elongate basins and troughs trending more or less parallel to the grain of the Tasman orogenic belt - so characteristic for the area - find an easy explanation. They are the old, asymmetric "central valleys" produced by the orogenic mode of plate convergence (Fig. 1). The back side (towards the continent) of the trough or basin is bound by a major thrust fault and on the front side (oceanwards) the sediments are in transgressive contact with the basement. An outstanding modern example of such a wedged basin is the Central Valley of Chile.

The history of the Tasman orogenic belt confirms Helwig's and Hall's view that the "entire orogenic belt is the expression of plate convergence".

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