correlation with general seismic activity, which can be taken as the symptom of actual convergent movement at the plate boundaries, indicates that the striking **general** increase in volcanic activity is not simply the result of a surge in plate convergence. The role of a creep contribution in such convergence is unknown.

DISTRIBUTION OF UNDERTHRUST LITHOSPERIC SLABS AND FOCAL MECHANISMS – PAPUA NEW GUINEA AND SOLOMON ISLANDS REGION

David Denham

Bureau of Mineral Resources, Canberra, A.C.T.

Studies of the spatial distribution of shallow earthquakes define the present day plate boundaries. In the Papua New Guinea and Solomon Islands region (PNGS) these are well determined and indicate a mozaic of several small plates each moving relatively to the other (see fig. 1). Some of the boundaries are zones of plate convergence where lithospheric material is being thrust (or sinks) deep into the mantle. These regions are indicated by earthquakes occurring at depths greater than 100 km.

In the PNGS region there appears to be three main zones where the lithosphere is being underthrust.

1. **The Mainland of New Guinea.** Here the situation is similar to a continent/continent collision zone where earth-

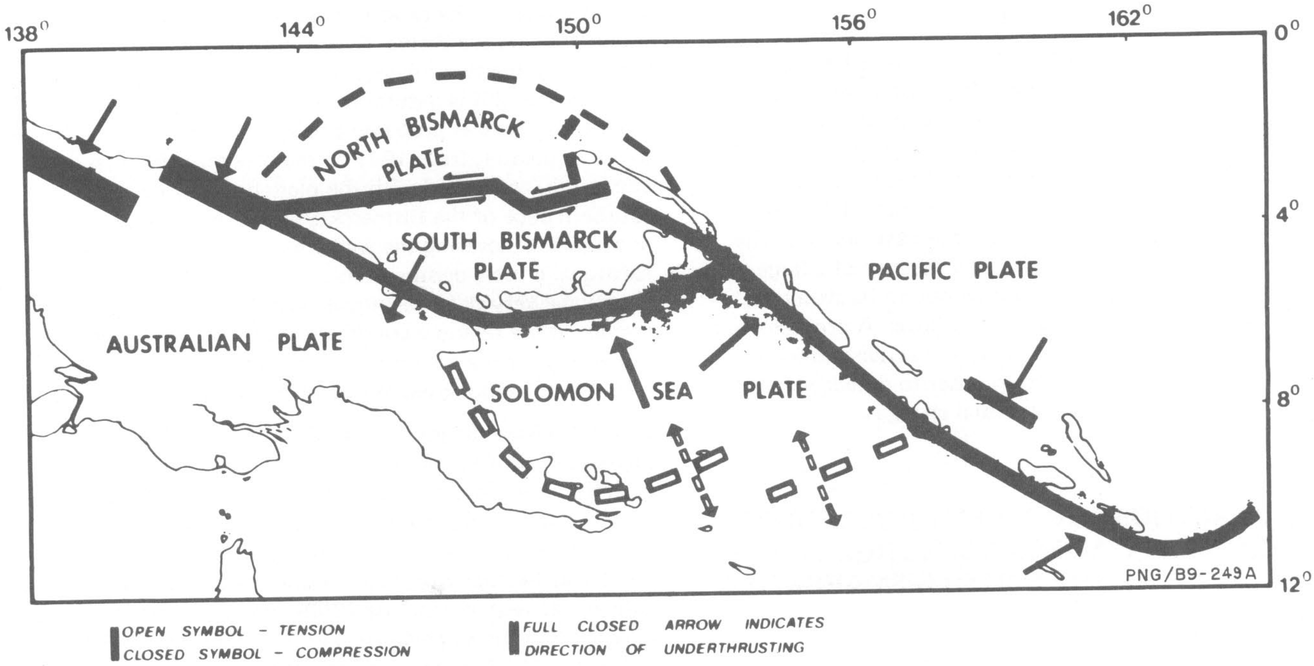


Figure 1. Locations of plate boundaries in the Papua New Guinea/ Solomon Island region.

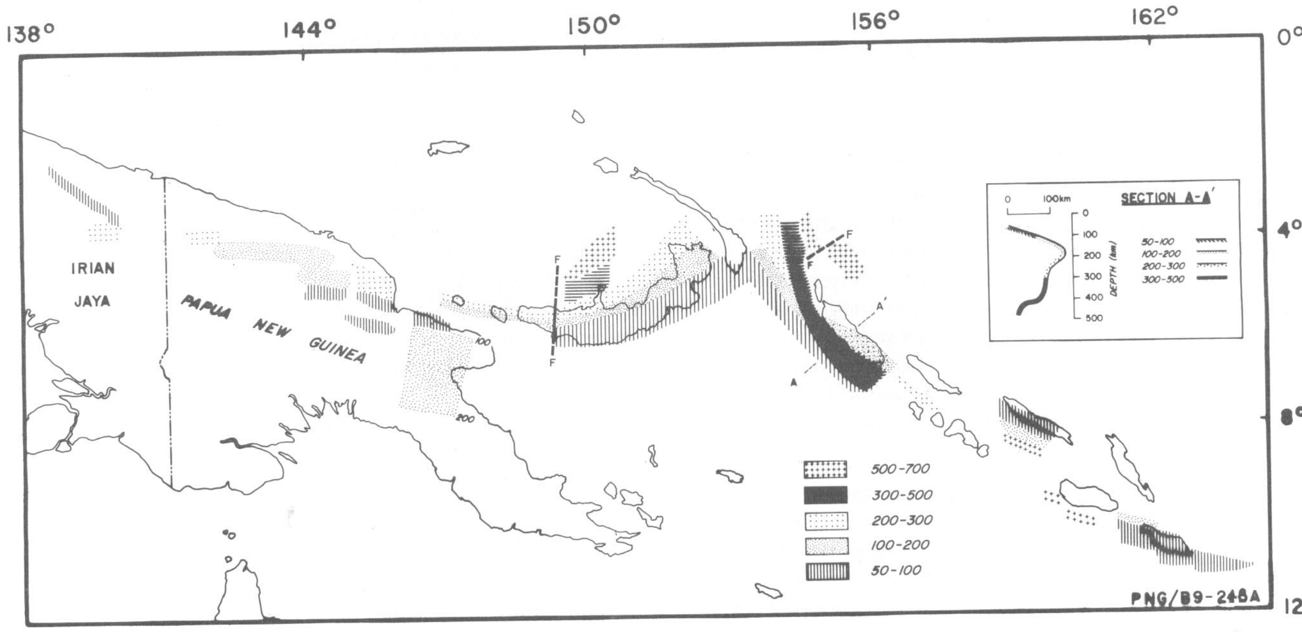


Figure 2. Location of underthrust lithosphere. F_ _ _ _ F represent major discontinuities at depth. Section A_ . . . . A' portrays the complications beneath Bougainville Island.

quakes do not take place deeper than 200 km. The absence of very deep earthquakes indicates that the rate of subduction is low, because the slabs are being assimilated into the mantle at comparatively shallow depths and also that a large part of the crustal compression results in mountain building. The stress directions from the focal mechanisms do not produce a recognizable pattern and are indicative of the complicated tectonic situation in this region.

2. **The northern boundaries of the Solomon Sea.** This region represents an island arc environment of rapid underthrusting (~10cm/yr) where earthquakes take place down to 600 km. The lithospheric slabs appear to be continuous except beneath Bougainville Island where the slab changes its strike below 400 km.

3. **The Solomon Islands Arc, south of Bougainville Island.** The situation here is very complex involving current underthrusting of the Australian Plate beneath San Cristobal Island, deep remnants of lithospheric slabs beneath the central part of the island chain, and underthrusting of the Pacific Plate beneath Santa Isabel Island.

The earthquake evidence supports significant recent changes in the zones of underthrusting beneath the Solomon Chain but suggests that the New Britain Arc has only changed its position slightly, if at all, in the last 6 m.y.

Fig. 2 shows the main zones of underthrusting.

SUBDUCTION-ZONE VORTICES

J. F. Harper

Department of Mathematics and Institute of Geophysics

Victoria University of Wellington, New Zealand

Introduction

Sinking slabs of lithosphere must push the asthenosphere if they pull the plates. The resulting flow in the asthenosphere then goes rapidly round the ends of a slab, pulling the lithosphere with it. The motion can be analyzed with the help of Hele-Shaw's mathematical analogy between viscous flow in a thin layer of fluid and classical two-dimensional irrotational flow.

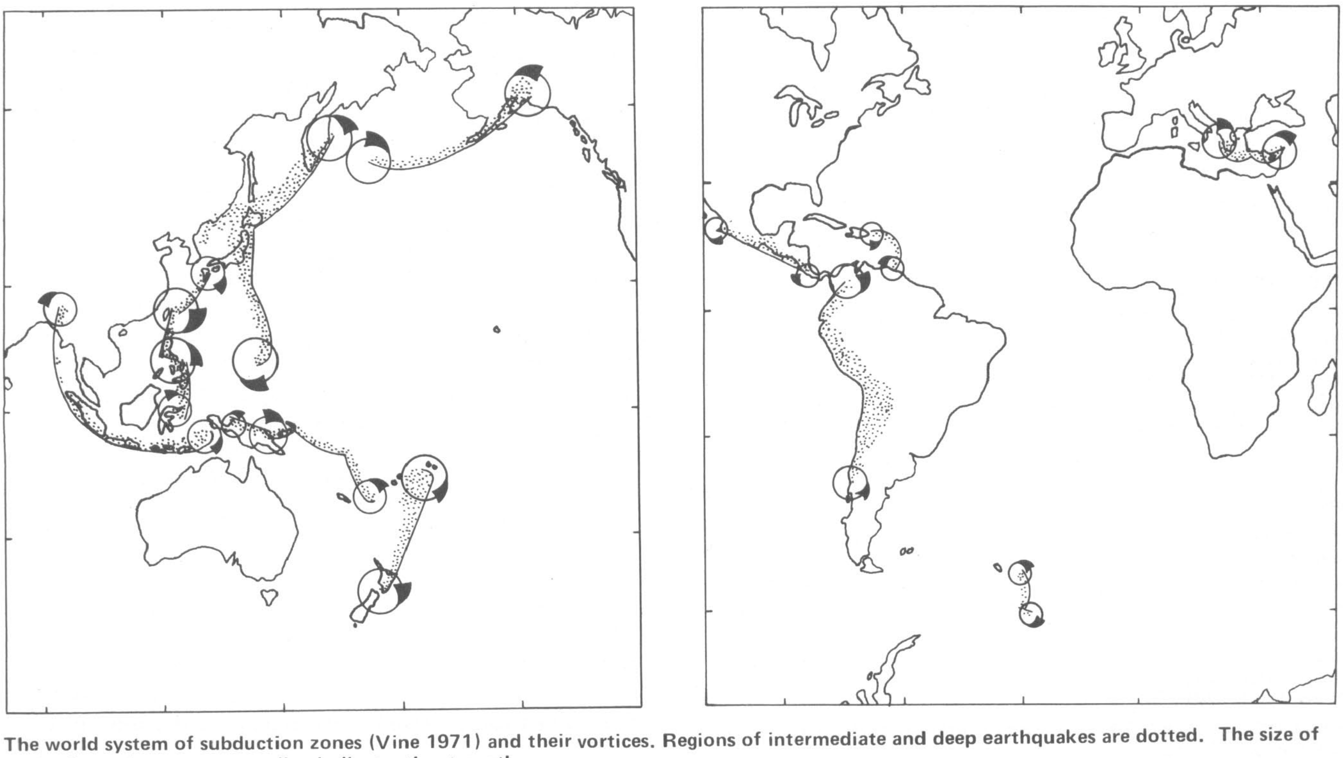
Theory

The relative motions of all the major plates can be calculated surprisingly well (Harper, 1975) on the Orowan-Elsasser-Lliboutry hypotheses that the plates are pulled across a viscous asthenosphere by their dense sinking leading edges, and that they tend to slide down the flanks of mid-ocean ridge systems. The thinness of young lithosphere must be allowed for, otherwise small plates would go too fast (McKenzie, 1969).

Let us explore some more consequences of the above hypotheses by considering the asthenosphere as a Hele-Shaw cell (see Prandtl, 1952) of constant vertical thickness δ which is much smaller than any horizontal dimension of interest. If the dynamic viscosity has the constant value η, then the horizontal velocity $\underset{\sim}{u}$ averaged over the depth of the asthenosphere obeys

$$\underset{\sim}{u} - \tfrac{1}{2}\underset{\sim}{U} = -(\delta^2/12\eta)\nabla p = \nabla\phi \quad ,$$

where $\underset{\sim}{U}$ is the velocity of the plate on top relative to the deep mantle, ϕ is the velocity potential, and p is the pressure modified by subtracting out the hydrostatic term. Wherever we can ignore mass transfer between lithosphere and asthenosphere, i.e. anywhere far from a plate boundary, we find that $\nabla^2\phi = 0$. This flow is irrotational, with its velocity potent-



The world system of subduction zones (Vine 1971) and their vortices. Regions of intermediate and deep earthquakes are dotted. The size of each schematic vortex streamline indicates the strength.