Geological Evolution of New Hebrides and Loyalty Areas

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Geophysical data obtained during recent years in the area surrounding New Caledonia, Loyalty and New Hebrides Islands provide additional data on the main structural features and on the geodynamics of this area during the last 50 million years.

This area, located in the vicinity of the present boundary between the Indian and Pacific lithospheric plates, contains several geological structures which are characteristic of either active or fossil island arcs. We propose three different island arcs.

The New Hebrides island arc, which was active about 2 to 5 m.y. ago, is due to the present subduction of the Indian plate under the Pacific one.

The Loyalty Islands constitute a second volcanic island arc. This structure presents characteristics of a fossil arc which would have been due to an ancient subduction zone located in the western part of the Loyalty Basin with the fossil Benioff zone dipping towards the east. An obduction occurred at late Eocene and/or early Oligocene.

Finally, very recent data in the central part of New Hebrides indicate a submarine structure which may be interpreted as a fossil island arc transverse to the present arc of New Hebrides in front of Espiritu Santo island. The period of activity of this arc appears to be from about early Miocene to early Pliocene. Its extension towards the east, in the Pacific plate, is difficult to establish, while towards the west it is represented by a strike slip fault, the d'Entrecasteaux Fracture.

Both fossil arcs present different morphologies which we explain by different genesis, due to unequal constraints on the movements of, or differences in the rigidity of the crust.

MAGNETIC AND GRAVITY MODELLING IN THE BISMARCK SEA

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A marine geophysical survey of the Bismarck Sea was made by the BMR in 1970 and magnetic gravity and seismic reflection records were made along north south traverses at a spacing of between 40 and 50 kms.

The geology of the land areas surrounding the Bismarck Sea indicates that they all originated as island arc type structures and that activity along these arcs ranges in age from Upper Cretaceous to Recent. Most of the arcs have been reactivated several times. Water depth in the sea is about 2000m but with two fairly extensive rises over which the water shallows to 100m. Sediment distribution shows a general thickening towards land with a sediment free region in the centre and depths of up to 2 kms of sediment at the edges.

The sediment free area is an elongate east west zone of recent extrusion some 80 kms wide and the topography of this region is uniform in the east but more rugged and with some areas of sediment in the west. The Bismarck Sea Seismic Lineament a zone of shallow earthquakes coincides with the area of recent extrusion. Earthquake focal mechanism solutions along the lineament indicate that it is a major left lateral strike slip fault.

Magnetic trends in the Sea generally strike east west but are not pronounced except the eastern area of recent extrusions and along the coast of mainland New Guinea. Bouguer gravity values are very uniform except for lows over the two rises.

Two dimensional magnetic and gravity modelling was undertaken along five north south traverses comprising a total of 1800 kms. The models were used in combination with topographic and sedimentary features to delineate the main tectonic provinces.

The sea, while having a rather thicker crust than most other seas behind trenches, nonetheless appears to have originated by extension in a similar manner to them. The extension has occurred in a north south direction and is episodic rather than continuous. It is occurring at present across the centre of the sea but is most regular in the eastern half where an extension rate of 8 cms/year is indicated. The extension in the east is being accommodated along an extensive series of NW trending faults which extend from the Gazelle Peninsula to west of New Hanover.

Other tectonic features are the ridge between New Ireland and Manus Island which appears to be of similar age to these islands and to have formed at least in part by compression. The area of deep sediments and thick continental crust east of Madang which must have affinities with the Adelbert and Finisterre Ranges and the broad rise parallel to the New Guinea Coast which appears to have been formed by diapiric action.

STRUCTURE OF THE LOYALTY BASIN

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Seismic reflection, bathymetric and magnetic profiles across the Loyalty Basin and Ridge show the geological or sedimentary Loyalty Basin to be a restricted feature within the morphological basin. The basin contains a thick accumulation of sediment which in the centre exceeds a two-way reflection time of 4 sec., and thickens northwards. Three main sedimentary formations are recognised which rest on a basement which is correlated with the layer of about 5.9 km /sec velocity of the seismic refraction profile of Shor *et al.* (1971). The axes of sedimentation of these main sedimentary units and the respective areas of provenance vary between the different formations, with both the New Caledonia and Loyalty Ridges acting as important source areas at various time through the depositional history, giving three main phases of morphological and sedimentological history prior to the present time. Although only pelagic sedimentation is currently taking place within the Loyalty Basin, the large thickness of sediment within the basin implies a considerable amount of terrigenous and volcanoclastic sedimentation

during earlier deposition.

Since the sedimentary formations within the basin do not appear to have been seriously deformed during the major orogenic phase associated with the emplacement of peridolites on New Caledonia in the Upper Eocene, deposition within the basin has occurred since the beginning of the Oligocene. A major unconformity surface which represents an old erosional platform which occurs at the western margin of the basin, implies major subsidence of the platform and basin of about 200 m. This appears to have occurred post Oligocene, possibly in the Miocene or Pliocene.

The Loyalty Ridge, which has acted as an important source of sediment during earlier phases of deposition within the basin and must have been in existence prior to the Oligocene, models magnetically as an essentially uniformly magnetised ridge of intermediate to basic composition. Since basaltic material from the ridge has been dated as 10 m.y. old, the ridge is either one of essentially basaltic composition which has suffered a number of phases of volcanic activity, or it represents the old andesitic island arc related to the previous Benioff Zone of the inferred ancient New Caledonia Trench, which again has suffered subsequent phases of basaltic volcanicity probably related to major tensional block faulting during its subsequent history. The latter interpretation is preferred.