The above evidence is taken to indicate a compressive regime for the central as well as for the better known northern part of the Macquarie Ridge Complex. That subduction in the central region of the Complex is not well developed is indicated by the lack of earthquake activity at intermediate and greater depths and the lack of island arc volcanics in the region.

It is not immediately clear whether the Pacific or Indian plate is being subducted in the central part of the Complex. The structure of the Macquarie Ridge Complex is similar to that observed in the western part of the Bowers Ridge Complex described by Kienle (1971). This structure, however, grades into what appears to be a typical island arc structure along the Bowers Ridge and this is apparently due to loading by island arc volcanics landwards from the previously existing morphological ridge. This would suggest that the morphological ridges associated with subduction zones include the effect of initial uplift and crusted thickening under compressive forces. The evolution of a mature subduction zone from a structure similar to that of the Macquarie Ridge complex could then be as depicted in Figure 1. This suggests that in the case of an incipient plate-plate subduction zone, that plate on the opposite side of the trench to morphological ridge will be subducted. It would follow then that, for example, the Emerald Basin rocks will be subducted at the Macquarie Trench if the present structural regime continues for a long period.

The above model further suggests that sea-floor lavas are more likely to be found closer to the trench than island arc volcanics in continent building by orogeny and this may add a further criterion for ascertaining the polarity of fossil subduction zones.

### References


HAYES, D.E., and TALWANI, M., 1962: Geophysical investigation of the Macquarie Ridge Complex. *In* Hayes, D.E. (Ed.) *Antarctic Oceanology II: The Australian New Zealand Sector,* Antarctic Res. Ser. A.G.U., Washington, D.C. 19: 125-145.

JOHNSON, T., and MOLNAR, P., 1972: Focal mechanisms and plate tectonics of the Southwest Pacific. *Jnl. Geophys. Res.* 77 (26): 5000-5032.

KIENLE, J., 1971: Gravity and magnetic measurement over Bowers Ridge and Shirshov Ridge, Bering Sea. *Jnl. Geophys. Res.* 76 (29): 7138-7153.

WILLIAMSON, P., and JOHNSON, B.C., 1974: Crustal structure of the central region of the Macquarie Ridge from gravity studies. *Marine Geophys. Res.* 2(2): 127-132.

WILLIAMSON, P., 1974: The structure and evolution of the Macquarie Island Region and its Relation to Ocean Crust. Unpubl. Ph.D. Thesis, University of NSW.


## MOTION ALONG THE NEW ZEALAND ALPINE FAULT AND A MODEL FOR THE FORMATION OF THE SOUTHERN ALPS


### D.A. Christoffel

*Physics Department Victoria University of Wellington, New Zealand.*


Analysis of marine geophysical data by Falconer, Geddes and Christoffel shows that the present position of the pole of rotation for motion between the Pacific and Indian Plates differs from the average pole for the past 10 million years.

The pattern of volcanic activity for the North Island and geochemical data for the Alpine Fault indicate that a more or less abrupt change occurred about 3 million years ago. A significant thrust component should now exist along the line of the Alpine Fault.

A model, assuming that the lithosphere beneath the Southern Alps deforms by plastic flow has been developed. It can account for the formation of the Southern Alps and appears to be compatible with current geological and geodynamic observations.

## NEW ZEALAND 60 M.Y. AGO


### H.W. Wellman

*Geology Department, Victoria University of Wellington, New Zealand.*


Rigid plate theory has been highly successful in explaining the origin of the oceans, but far less so in explaining the twisted rock belts of the continents. The New Zealand region is the smallest of the continents, and its rocks have a fairly simple twist, which is well mapped and has been termed a recurved arc. Can New Zealand be straightened out while keeping the ocean floor rigid? The following is a preliminary attempt.

The reconstruction is for 60 m.y. ago, and is based on oceanic magnetic anomaly 24 (A24), and the Stokes Magnetic Anomaly (SMA). A24 is now in two well separated parts: the central anomaly for the Tasman Sea; and to the south of Campbell Plateau. In the reconstruction it is assumed that the two parts were originally parallel, but not necessarily collinear, and that SMA had the form of a circular arc with unknown radius. It is further assumed that the length of SMA has been conserved. SMA is well defined within the New Zealand land area, and magnetic anomalies in the eastern part of the Campbell Plateau are assumed to represent its south-eastern off-shore extension. Within the New Zealand land area SMA is parallel to the belts of pre-upper Cretaceous rocks.

SMA is dextrally displaced by 500 km by the Alpine Fault, and is here assumed to be dextrally displaced by about 200 km by an inferred fault here named the AC Fault (Auckland Island – Chatham Island Fault). The recurved arc of New Zealand is defined by the bend in the anomaly, the bend increasing towards the Alpine Fault, and being in the direction expected for dextral drag.

Fig. 1 shows the present position of SMA, and its inferred position relative to the northern part of the New Zealand region 60 m.y. ago. The amount of rotation is about 75°, and the shiftpole is shown by a star. If the two parts of A24 had been collinear the shiftpole would lie on the bisector of the angle between the two parts of the anomaly. The difference is less than the errors of construction, and a collinear relation is probable.

In the reconstruction first the dextral displacement of SMA at the Alpine and AC faults was taken out; second the recurved arc was straightened. In Fig. 2 the parallel rock belts, and the 3 km bathymetric contour have been bent in conformity with the straightening. Also shown on Fig. 2 is the 60 m.y. coastline determined from the boundary between marine and freshwater strata; the position of the 100 m.y. old basic intrusives and volcanics; and the position of the

Hawk Crag Breccia (distinctive red-weathered fan-glomerate) about 130 m.y. old.

The main feature of the reconstruction is the angle between SMA and its parallel feature (the pre-upper Cretaceous rock belts) and A24 and its parallel features (the Hawk Crag Breccia, and the 100 m.y. old igneous rocks). The discovery of the same angle between the two sets of features in Lesser Antarctica would support the reconstruction.


**Figure 1**
**Map of NZ on conical projection with 10° grid, and standard parallels at 30° and 60°. A24 = Oceanic Magnetic Anomaly 24; SMA = Stokes Magnetic Anomaly; Abcd = inferred position of SMA 60 m.y.ago, north-west side assumed fixed; star = cumulative shiftpole for 60 m.y.; NZSZ = New Zealand Shear Zone India Pacific Plate Boundary.**

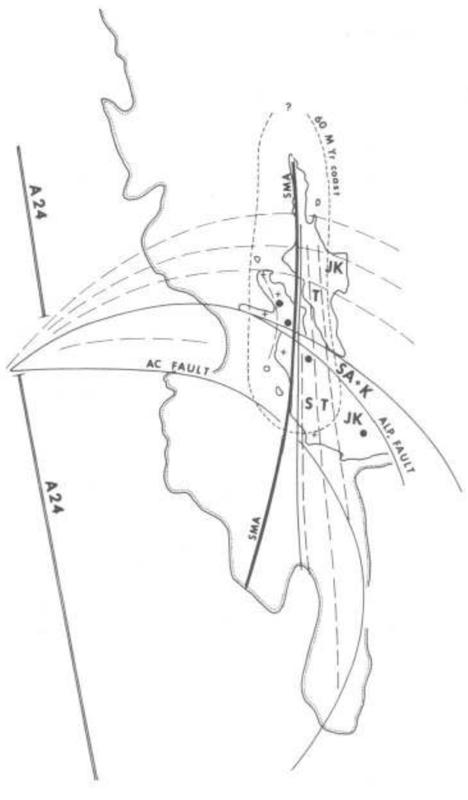


**Figure 2**
**Map of NZ 60 m.y. ago based on Figure 1.**
**Rock belts left to right: O = Ordovician; SMA = Rotoroa igneous complex; Synclinal symbol = Marginal Syncline; S = schist; T = Triassic; JK = Jurassic and Cretaceous.**
**Other rocks; crosses = Hawk Crag Breccia; dots = 100 m.y. old basic igneous intrusives and volcanics.**
**SA + K = Gap to represent Southern Alps and Kaikoura Mountains.**

## MESOZOIC-MIDDLE TERTIARY TECTONIC DEVELOPMENT OF NORTHERN NEW ZEALAND

### Evan C. Leitch

*Department of Geology and Geophysics*, The University of Sydney*

Northland, that part of New Zealand north of the city of Auckland, is formed in large part from sedimentary rocks belonging to three successive sedimentary associations each of which is accompanied by distinctive igneous rocks. Deposition of the two earlier associations was terminated by brief but widespread periods of deformation at about 90 m.y. and 25 m.y. before present. Deposition in the youngest association ended some 15 m.y. ago, but no clear relationship between this event and deformation has been demonstrated. A brief outline of the rocks that formed during each depositional interval is outlined below and an attempt is made to construct a coherent tectonic history of Northland.

### Interval 1 (prior to 90 m.y. before present)

A major break in the depositional record in Northland occurs between pre-Late Cretaceous rocks and younger strata. This break is a prominent metamorphic and structural discontinuity, a manifestation of the Rangitata Orogeny. South of 35°S latitude the older rocks are indurated sandstone and siltstone and accompanying limestone, chert and basalt, from which Permian and Jurassic fossils are known. Further north Jurassic and Early Cretaceous basalt and rhyolite contain intercalations of chert, siltstone, and sandstone, and are associated with a gabbro-periodotite mass, the Kerr Pluton (Leitch, 1970).

The close association of this pluton with the Jurassic Whangakea Volcanics is of special interest. Within the pluton serpentinised ultramafic rocks are overlain by interlayered gabbro and peridotite, and then gabbro which in its upper part is intruded by a swarm of basic dykes. Although the pluton is structurally disturbed the rock sequence is similar to that in many ophiolite complexes. Whangakea Volcanics are faulted against the pluton; they constitute massive and pillowed basaltic flows, dolerite dykes and sills together with minor breccia, chert and limestone. Close to the pluton the rocks are extensively altered and a 'spilitic' mineralogy is present, but further away alteration is less intense.

### Interval 2 (90-25 m.y. b.p.)

Both the structure and depositional history of the Late Cretaceous – Late Oligocene sedimentary rocks of Northland are imperfectly understood. Two contrasting views have been promulgated; one suggests these rocks constitute a largely autochthonous dominantly shallow marine sequence laid down adjacent to a landmass of subdued topography, the other envisages that they are allochthonous and include

* Marine Studies Centre, Contribution No. G44