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Interpretation of Magnetic Anomalies Across the Campbell Plateau, South of New Zealand

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Abstract

Magnetic anomalies over the Campbell Plateau show up a linear belt of positive anomalies extending for 900 km with an approximate east-west trend. This belt is identified as part of the Stokes Magnetic Anomaly System which extends throughout New Zealand and is associated with rocks of the New Zealand Geosyncline. The system defines a trans-current fault with a dextral displacement of 330 km which can be traced from the SW tip of the Campbell Plateau to the Bounty Trough in the north. Restoration of this Campbell Fault requires the Bounty Trough to be a rift feature, probably associated with Indian-Pacific plates' movements during the Miocene or Oligocene. The extension of this boundary may have been a subduction zone running from the NE tip of the Campbell Plateau past the North Cape of New Zealand to the Norfolk Ridge, along what is now the southern margin of the South Fiji Basin.

Introduction

The most prominent single geophysical feature of the continental crust of New Zealand is a series of linear magnetic anomalies. This has been called the Stokes Magnetic Anomaly System (Wellman, 1973; Hatherton, 1975). Davey and Christoffel (1978) have recently constructed a magnetic anomaly contour map of the Campbell Plateau. This shows that the system also extends across the northern part of the Campbell Plateau for 900 km (Figure 1). A discontinuity in the Anomaly System occurs approximately 150 km eastward of the Southland Coast, and marks an offset of 330 km. Adding this to the well-documented 460 km offset along the Alpine Fault (Wellman, 1964), this gives a total offset on faults of 790 km. It still remains to determine, (a) the period over which the Campbell Fault was active and (b) the nature of the extension of the Fault to the north and south of its presently recognized extremities.

Possible extensions of the Campbell Fault

A well-marked magnetic anomaly discontinuity runs from the southwestern tip of the Campbell Plateau southward to the Pacific-Antarctic Fracture zone (Christoffel and Falconer, 1972). The Campbell Fault runs into it and can thus be extended southward, along a well marked discontinuity, toward the Pacific-Antarctic Ridge.

To the north of the Campbell Fault, the situation is not so clear. There is no apparent structural discontinuity in the Chatham Rise (Austin *et al.*, 1973) making it unlikely that the fault passes through it. It could thus either skirt the southeastern end of the Rise or terminate at the Bounty Trough. In the former case, it would be necessary for the trace to continue eastwards. In the latter case, the fault could terminate with the Bounty Trough remaining as an extinct region of spreading. An interesting extension could well be to a subduction zone, now also extinct, running from the northern edge of the Chatham Rise to the north of North Cape and perhaps even to the Norfolk Ridge. It would have followed the present southern boundary of the South Fiji Basin (Ballance, 1976). Davey (1974) has identified Miocene andesite volcanic centres along the Northland Coast. They could have been the volcanic arc associated with this subduction zone. A spreading centre has not yet been identified in the Bounty Trough. However, the well-marked boundary of identified Cretaceous magnetic anomalies follows the line of the Campbell Slope, NE of Antipodes Is. (Christoffel and Falconer, 1972) at about the region where a boundary for a Bounty Trough spreading centre would be expected. The Bounty Trough, with a depth of 2-4 km, is also sufficiently deep to identify it as having oceanic crust but not deep enough to associate it with the ocean basin of Late Cretaceous age to the east.

Age of the Campbell Fault

Little evidence exists to establish the age. It is unlikely to have been active at the same time as the Alpine Fault zone. At the other extreme, it is likely to post-date the rifting with Western Antarctica (84 m.y.) although it could have been concurrent with this rifting. The strike of the Campbell Fault is approximately along a small circle concentric with that of the Alpine Fault, and this makes it most likely to have been part of the boundary between the Indian and Pacific plates. The Indian plate started moving from Antarctica approximately 50 m.y. ago, setting an upper limit for the age of the fault.

Active volcanism occurred in the Chatham Islands both during the Late Eocene-Early Oligocene (35-40 m.y.) and also in the Late Miocene-Pliocene (2-6 m.y.) (Grindley *et al.*, 1977). It is tempting to associate the rifting and the proposed subduction zone with one of the above volcanic episodes — most likely the 35-40 m.y. period. However, unless Chatham Is. was at that time part of the Bounty Trough rift, there is not necessarily an association between basalt volcanism and subduction. We have insufficient magnetic data from the Bounty Trough to recognise the magnetic anomalies that are present.

Reconstruction

Assuming relative plate movements along the Campbell Fault were much the same as at present in this region (20-40 mm/yr) the movements would have lasted for the order of 10 m.y., some time during the mid-Miocene to Eocene (15-45 m.y.). The Campbell Fault extended from the triple junction at the Pacific-Antarctic Ridge to the Bounty Trough, which would appear as an extensional feature. In reconstructing the Campbell Plateau with Western Antarctica, Falconer (1974) showed that a significantly better fit results from closing up the Bounty Trough.

Restoring the movement, first on the Alpine Fault (460 km) and then on the Campbell Fault (330 km), shows that the continuation of the plate boundary was most likely to have

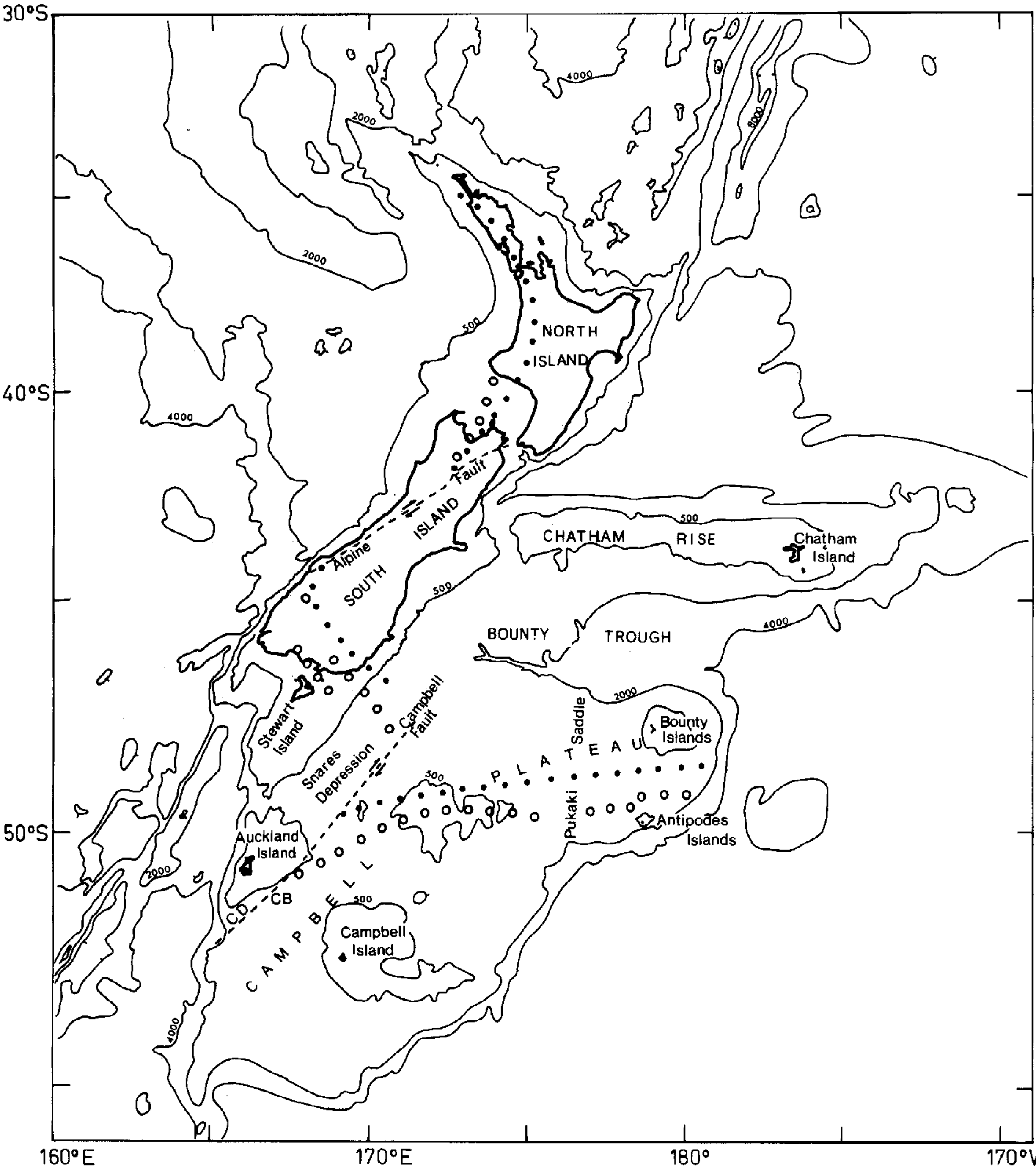

FIGURE 1

Location of the Stokes Magnetic Anomaly System and the Campbell Magnetic Anomaly System. The solid circles mark anomalies associated with the boundary between the main sedimentary facies of the New Zealand Syncline (The Junction Anomaly of Hatherton). The open circles mark less continuous but larger amplitude anomalies associated with intermediate and basic volcanics of late Palaeozoic-early Mesozoic. The Alpine Fault and the newly identified Campbell Fault shown dashed.

been a subduction zone extending westward from the Chatham Rise to beyond the northern tip of the North Island. The reconstruction is shown in Figure 2. This predicts that NW-SE trending magnetic anomalies of Miocene-Oligocene age will be present in the Bounty Trough. Over the same time, a subduction zone, extending from the Campbell Plateau possibly as far as the Norfolk Ridge, subducted over 350 km of ocean floor. A stringent test of this reconstruction is the identification of a spreading centre with associated magnetic anomalies within the present Bounty Trough. This is being pursued.

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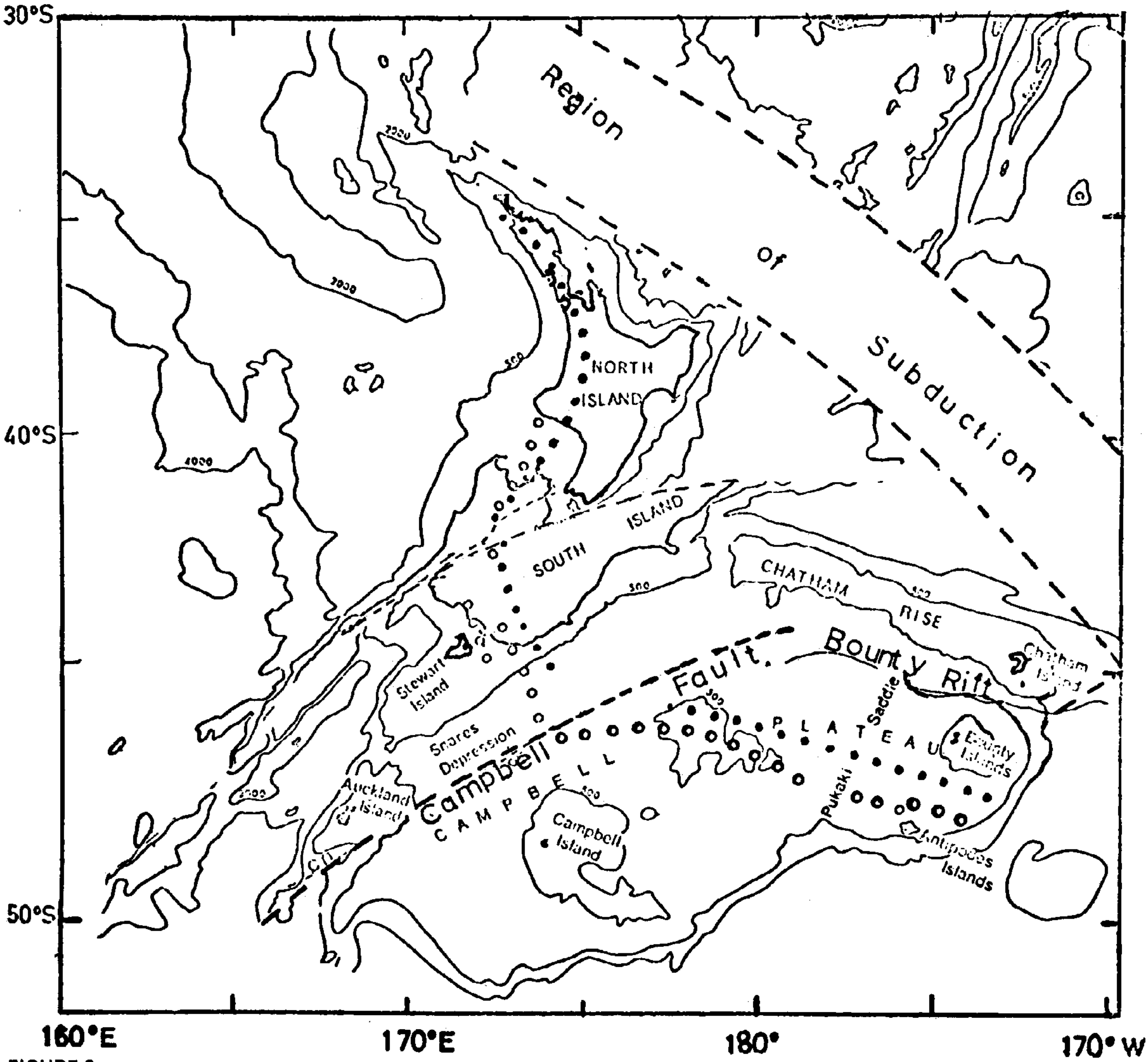

FIGURE 2

Reconstruction of the New Zealand continent by restoring 460 km of movement along the Alpine Fault and 330 km on the Campbell Fault. The Bounty Trough is closed up along the 2,000 m contour. The postulated marginal subduction from northeast Chatham Rise to North Cape is shown clear. The offsets are deduced from the Stokes Magnetic Anomaly System, but possible bending not restored.