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Late Cretaceous to mid Eocene plate boundaries in the southwest Pacific

Kara J. Matthews, R. Dietmar Müller, Joanne Whittaker, Nicolas Flament, and Maria Seton
EarthByte Group, School of Geosciences, The University of Sydney, Sydney, Australia (kara.matthews@sydney.edu.au)

The late Cretaceous to mid Eocene history of the southwest and southernmost Pacific has been subject to starkly contrasting interpretations, ranging from relative tectonic quiescence with the Lord Howe Rise (LHR) being part of the Pacific plate to a dynamic subduction setting. In the first scenario the Tasman Sea would have formed as a consequence of divergence between the Pacific and Australian plates, whereas in the second scenario it would have formed as a marginal basin associated with subduction. The first scenario is supported by a number of arguments, including a lack of evidence for deformation and tectonic activity in New Zealand during this period and a geodynamic modelling inference, namely that the bend in the Hawaiian-Emperor chain can be better reproduced if the LHR is part of the Pacific plate. The second scenario is supported by regional plate kinematic models reconciling a variety of observations including back-arc basin formation and destruction through time and the history of arc-continent collisions. The primary problem with the first scenario is the use of a plate circuit that leaves relative motion between East and West Antarctica unconstrained, leading to an improbable history of periodic compression and extension. The main problem with the alternative scenario is a lack of sampled late Cretaceous volcanic arc rocks east of the LHR. We analysed available geological and geophysical data to constrain the locations of and movements along the plate boundaries in the southwest and southern Pacific from the late Cretaceous to mid Eocene, and assessed how Pacific plate motion is best quantified during this period. Geological and geophysical evidence suggests that a plate boundary separated the Pacific plate from the LHR. The distribution of lower mantle slab material that is imaged by seismic tomography beneath New Zealand is best explained if subduction occurred to the east of the LHR during the entire late Cretaceous to mid Eocene period. Rocks from ophiolitic nappes in the North Island of New Zealand, New Caledonia and Papua New Guinea show evidence of having formed in a back-arc basin during this period, consistent with a subduction zone near the LHR. Although New Zealand is commonly viewed as tectonically quiescent at this time, deformation at several locations to the east and west of the present-day Alpine Fault suggests that a plate boundary cut through Zealandia during Tasman Sea opening. As the LHR was not attached to the Pacific plate and subduction occurred to the east and north of the LHR we suggest that Pacific plate motion is best quantified using a plate circuit through East and West Antarctica, avoiding this zone of southwest Pacific subduction. Future work should focus on better constraining the location of and motion along the late Cretaceous-mid Eocene plate boundary through New Zealand to enable the use of a plate circuit via Australia.