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TERRANES OF THE PACIFIC MARGIN OF AUSTRALIA AND ANTARCTICA — THEIR DEVELOPMENT BY SLOW SPREADING AND STRIKE-SLIP

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The Australian Precambrian craton passes eastwards to the very wide Kanmantoo and Lachlan orogens or terranes which are broadly Late Precambrian to Devonian in age. Those terranes can be correlated with the Ross and Borchgrevink terranes to the east of the Antarctic craton.

Tectonic models of the last 30 years have assumed that the orogens were 'one-sided', that is that they formed between the craton and the paleo-Pacific Ocean. Consciously or unconsciously the models were tied to the concept of permanency of the Pacific; and they have not worked. The models have invoked also one or more subduction zones within the orogens, or to the east of them, but neither accretionary wedges nor subduction-related volcanic arcs have been recognised with certainty, and they may not exist. This situation has been puzzling for most recent workers and bewildering for some. Indeed Coney has concluded that the Lachlan Orogenic Zone is unique and not satisfactorily explained by any existing tectonic model.

"Convergent models" and "one-sided models" have not worked, and in this paper we propose that the set of four Early Paleozoic terranes formed between two cratons which very slowly extended and separated in the time interval between the latest Precambrian and the Devonian.

The first move towards this hypothesis was probably made by Korsch and Wellman in a description of New Zealand geology. They proposed that the eastern craton was South America. At about the same time other workers were trying to recognise the conjugate craton that had rifted away from the western side of the North American craton in the Late Proterozoic. Bell and Jefferson in 1987 made the daring but reasonable suggestion that there is a connection between Late Proterozoic sediments in western Canada and eastern Australia. Then Moores in 1991 produced the even more dramatic 'SWEAT hypothesis' that the North American craton margin could be matched with the Precambrian craton edge in eastern Australia and East Antarctica (Transantarctic Mountains). This idea has been expounded by Dalziel and has been developed also by Hoffman based on the slender evidence of correlation of rocks of Grenville age found in North America and Antarctica.

In our opinion, which is based on our collective experience in Australia and Antarctica, no absolutely convincing correlations or piercing lines have yet been established between South America or North America on the one hand and Australo-Antarctica on the other. We do accept however that Australo-Antarctica was bordered by another continent, but because we do not know whether it was North or South America we term it Tasmantis. (This is a temporary resurrection of a very old name, the significance of which was discussed by David, 1950).

The traditional tectonic concepts for the Lachlan Zone have attributed folding to named compressional orogenies or events, such as the Delamerian, Ross, Benambran, Tabberabberan, Borchgrevink and Kanimblan orogenies. It is important to note, however, that not only faulting but also intense folding can occur in an extensional setting, as demonstrated long ago by S.W. Carey. We can therefore challenge the compressional mind-set with the alternative concept that the Lachlan Zone, and its Antarctic equivalent, formed in a region dominated until the Devonian by slow spreading extension and separation between two Precambrian cratons.

The first interval of extension was between the latest Proterozoic and Early Ordovician, and produced the Kanmantoo Orogen alongside the Precambrian craton and above a crustal fault detachment that might have been east-dipping. If that is correct the Kanmantoo Orogen was an upper-plate feature. Similarly, the Ross Orogen was produced beside the Antarctic craton, possibly as a lower-plate feature as suggested by the presence of high-grade metamorphics.

This initial stretching and partial separation formed a passive margin that became a huge Cambrian carbonate platform extending from the

Shackleton Mountains in Antarctica to northern Australia. The length of the passive margin was similar to the length of South America, and to the length of western North America as shown by Dalziel. The thinned continental crust to the east of the shelf sank to form deeper waters that received the quartzose turbidites of the Kanmantoo and Ross orogens or terranes. They ended eastwards at the complex Bowers terrane in Antarctica, and the Grampians terrane in Australia.

In the late Cambrian and Ordovician there were more episodes of separation further east on one or several crustal detachment faults that probably dipped gently westwards. This stretching formed the Lachlan terrane or super-terrane of moderately deep water along the **western** side of Tasmantis and in it, on the thinned upper-plate Precambrian basement, a sheet of mainly Ordovician muds, quartzose sands and cherts was deposited. In this time interval Tasmantis was also moving north relative to Australia-Antarctica and the intervening area on the **southern** side of Tasmantis became the Borchgrevink terrane which received quartzose turbidites similar to those in the Lachlan terrane.

Following its thinning, and a time-dealy for conductive heating, the Precambrian crust under the Kanmantoo and Lachlan terranes became abnormally hot, and the resultant magmas rose as granitoid plutons. These were intruded mainly during the Late Cambrian and Early Ordovician in the Kanmantoo-Ross terrane, and during the Silurian and early Devonian in the Lachlan and Borchgrevink terranes.

Those who work on the chemistry of the granites demand the existence of a concealed Precambrian basement under the widespread turbidite cover. Our new slow-spreading model admits or provides the required Precambrian basement and means that tectonicists now have a picture agreeing with the hard chemical data, and that is a real advance. We are pleased to acknowledge that the advance was driven by the inescapable data gathered by the "granite college" over a period of more than 30 years.

In the Silurian and Devonian the Lachlan terrane also developed internal depositional basins separated by highs. Rickard and Wyborn had independently developed concepts that the ridges were related to the diapiric rise of the granites and related volcanics. Those concepts can also be reconciled with the new tectonic model.

In the Middle Devonian and early Late Devonian there were major unconformities in the Lachlan terrane, and indeed throughout Australia.

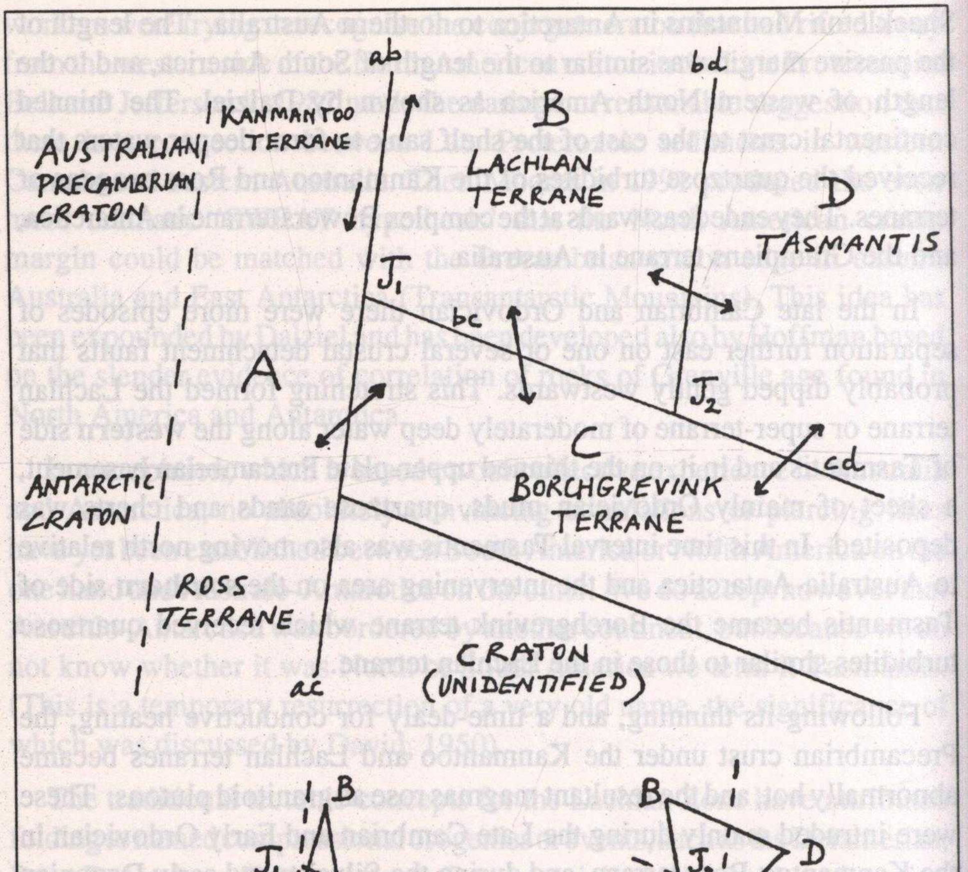

Fig. 1. The arrangement of plates A, B, C and D in Australo-Antarctica in the Early Ordovician is shown schematically in the upper diagram. The arrows show the sense and direction of the relative motions between them. Lower-case letters are used for plate boundaries. Note that all boundaries are extensional with a strike-slip component. The lower diagrams are velocity vector and stability diagrams for the plates around the triple junctions J_1 and J_2. A plate in the upper diagram can have arrows on it in three different directions because they do not show absolute motions but the relative motions between adjoining plates. (McKenzie & Morgan, 1969). The relative motions could have been different at times other than Early Ordovician. Upper and lower plates are not shown because the dip directions on plate boundaries are not yet known.

This might mean that stretching of the Precambrian crust between Tasmantis and Australo-Antarctica had been succeeded by the opening of a new ocean east of present-day Australia, and north of West Antarctica. In other words the South Pacific Ocean was born in the Middle Devonian and subduction had started at its western margin causing compression in the Lachlan Orogenic Zone, and possibly some thrusting by reversal of movement on older extension faults.

Tasmantis became either South America or North America after the opening of the South Pacific. On the southwest margin of the Pacific in Australia and Antarctica there was left behind a collage of Early Paleozoic terranes about 700 km wide. They had formed by slow spreading over a period of about 220 million years, which represents an average rate of about 3 mm yr^{1}. They were indeed an unusual tectonic system.

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