A geodynamic history of Australia's western margin

I.C.W. Fitzsimons

Tectonics SRC, Dept. of Applied Geology, Curtin University, GPO Box U1987, Perth WA 6845, Australia (email: ianf@lithos.curtin.edu.au, phone: +61 8 9266 2455, fax: +61 8 9266 3153)

Abstract

The western margin of Australia has a prolonged history of tectonic activity stretching back at least 1000 million years. North-south structures along this margin were associated with two episodes of Neoproterozoic strike-slip movement that led to the progressive accretion of exotic terranes to the West Australian craton. The second of these events involved sinistral movement driven by the oblique collision of India with Australia, but the nature of an earlier episode of continent-scale dextral strike slip is poorly understood. The strike-slip structures developed during these events were reactivated as normal faults during the Mesozoic opening of the Indian Ocean. Rocks exposed along Australia's western margin illustrate the complexity of real orogenic belts and the importance of pre-existing structure in controlling the location and orientational framework of later tectonism. They also show the difficulties involved in reconstructing the history of Precambrian orogens, where there is no direct evidence for the direction, magnitude, and cause of tectonic displacements.

Introduction

Australia's western margin is dominated by the Phanerozoic Perth and Carnarvon sedimentary basins, which record the birth of the Indian Ocean and are bounded to the east by the Darling Fault, which preserves evidence for 9 km of normal displacement. This is, however, only the most recent event to have shaped an area that has been a site of repeated tectonism for the last 1000 Myr.

The Pinjarra Orogen

The Darling Fault reactivated a major north-south zone of Precambrian tectonism called the Pinjarra Orogen (Fig. 1), which truncates the Archaean Yilgarn Craton, and the Palaeo- to Mesoproterozoic Capricorn and Albany-Fraser orogens. The Pinjarra Orogen comprises three blocks of gneissic basement: the Northampton and Mullingarra complexes dominated by metasedimentary rocks and the Leeuwin Complex dominated by granitic gneiss. All of these record evidence for tectonic activity at 1100–1000 Ma, 780–680 Ma, and 570–530 Ma. Protolith sediments in the Northampton and Mullingarra complexes were eroded from a mountain range produced by tectonic activity in the Albany-Fraser Orogen. They were deposited south of the these mountains, where they were deformed and metamorphosed at 1080 Ma, within 50 Myr of their deposition. This event buried the sediments to depths of 20 km, and coeval 1090 Ma granite plutons in the Leeuwin Complex have trace-element concentrations consistent with continental collision. The Yilgarn Craton, Capricorn Orogen and Albany-Fraser Orogen were truncated along their present-day western margins sometime after 1000 Ma, perhaps along a pre-existing terrane boundary in the Yilgarn Craton, and the Northampton and Mullingarra complexes were then translated 750–1000 km northwards by dextral strike-slip until they were accreted onto the northwest Yilgarn Craton at about 750 Ma. This dextral wrench movement is recorded by mylonite along the western edge of the Yilgarn Craton and by dolerite dykes and brittle-ductile shears in the Northampton Complex. Felsic magmatism at 780–680 Ma in the Leeuwin Complex may also reflect this accretion event.

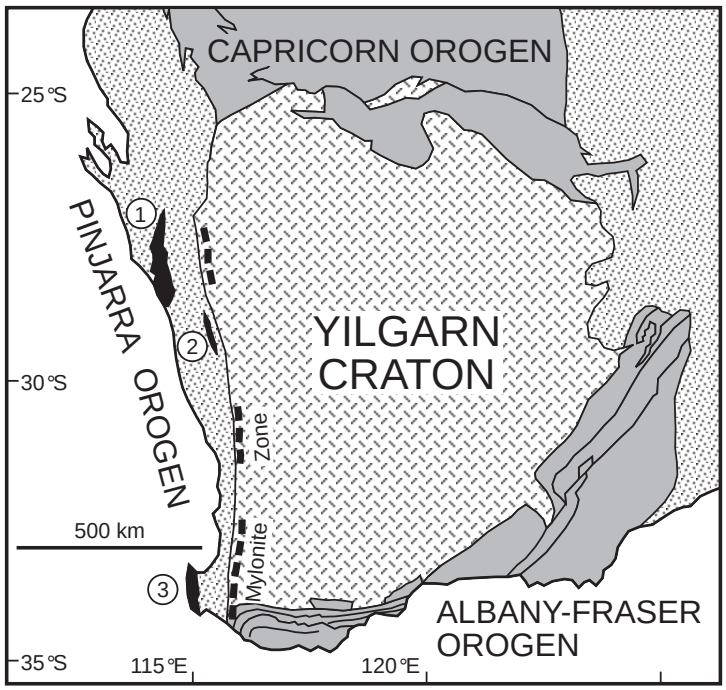

Figure 1. Geology of SW Australia. Black areas are the Northampton (1), Mullingarra (2) and Leeuwin (3) complexes. Phanerozoic sedimentary cover marked in a stippled pattern.

North-south trending 550 Ma sinistral mylonite at the western edge of the Yilgarn Craton has largely obliterated the evidence for early dextral strike-slip and has deformed the western Albany-Fraser orogen into a regional drag fold. Although minor sinistral SSE-NNW shear zones displace dolerite dykes in the Northampton Complex, this later phase of ductile deformation was focused to the west of the Northampton and Mullingarra complexes, which remained attached to the Yilgarn Craton. In contrast, it is likely that the Leeuwin Complex was translated southwards to its present position during the 550 Ma event. This accretion was synchronous with the emplacement of 570–530 Ma granitic plutons in the Leeuwin Complex, which all have penetrative fabrics consistent with sinistral transcurrent deformation, and was driven by the oblique collision of India with the western Australian margin during the final assembly of Gondwana.

Conclusions

Metamorphic rocks along the Pinjarra Orogen have previously been interpreted in terms of continental collision between Australia and India at 1080 Ma, but a variety of data indicates that these metamorphic rocks are not *in situ* and that they were transported to their present locations during two episodes of continent-scale strike slip tectonics sometime after they were metamorphosed. There is a tendency to treat all Precambrian orogenic belts as simple orthogonal collision zones between two rigid blocks, but ancient orogens will exhibit the same variety of tectonic processes as modern-day examples. However, their interpretation is hindered by sporadic exposure, erosion of the upper crustal levels that may best preserve kinematic information, and subduction of the oceanic crust that can record relative plate movements. They may also have undergone multiple tectonic cycles that can only be resolved after exhaustive geochronology, and major structures may only record the most recent tectonic movements. These problems are all relevant to the western margin of Australia, where a particularly long-lived tectonic boundary has been repeatedly reactivated for at least the last 1000 million years, suggesting that the Darling Fault is only the latest incarnation of a fundamental and deep-rooted crustal structure.