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Book Review

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West Gondwana: Pre-Cenozoic Correlations Across the South Atlantic Region

Edited by R.J. Pankhurst, R.A.J. Trouw, B.B. de Brito Neves & M.J. de Wit
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Everyone recognizes the South Atlantic's significance in global tectonics. Popular science writing uses it compellingly to introduce the notion of a mobile Earth surface. Du Toit's depiction, in 1937, of the closed South Atlantic was the scientific pinup for Wegener's continental displacement theory, as Bullard's follow-up of 1965 came to be for plate tectonics. Bullard's reconstruction has even crossed over into the cultural mainstream, and was reproduced on the cover of a 2000 dance music CD, appropriately entitled *Tectonics*. All this because the coastlines of western Africa and eastern South America so closely resemble one another that no specialist knowledge of geology or geophysics is required to appreciate that they were once nearly congruent.

A lot is made of the fact that we are by no means the first to appreciate this much, and that in doing so we can trace a scientific lineage back over four centuries to the likes of Ortelius and Bacon. *West Gondwana: Pre Cenozoic Correlations across the South Atlantic Region* demonstrates that in spite this pedigree, there is much for Earth scientists still to learn in this region. The book comprises a collection of twenty papers examining geological correlations between the former continental neighbours. What makes this particular publication special is that by its size it can do so, for the first time in one place, from both sides of the South Atlantic Ocean, presenting new and previously unpublished knowledge alongside existing data and models that are spread throughout the international, regional, and proprietary literature.

An introductory pair of papers sets the scene well for newcomers like me. In the first, De Wit *et al*. provide a historical overview, and an entirely necessary word of warning about the approaching terminological blizzard of blocks, shields, cratons, platforms, orogenic and mobile belts, massifs, terrains, terranes, domains, provinces, microcontinents, microplates, shear zones, orogenies, sutures, and 'events'. The book later covers the Neoproterozoic to Ordovician Araçuaí-West Congo orogen, where this warning came into its own as I realized that the enclosing São-Francisco and Congo cratons, which must have moved with respect to each other during the orogeny, are frequently shown as continuous in pre-Jurassic reconstructions. The second introductory paper meets the necessity in any book that touches on Proterozoic palaeogeography for a section on palaeomagnetic models. In it, Pisarevsky *et al*. review just what it is that these models can, and cannot, tell us about West Gondwana within Rodinia, itself a cauldron of conflicting opinions. The emphasis on uncertainties, with both high- and low-latitude Neoproterozoic–Cambrian palaeogeographies apparently only to be chosen between on the basis of how many mantle plumes one prefers to invoke for breaking up Rodinia, is sober and entirely justified.

In line with the pre-Cenozoic tag in its title, West Gondwana's Phanerozoic history is represented in the volume. Milani & De Wit present an interesting comparison of the geology and subsidence patterns of the enormous Paraná and Cape-Karoo basins, emphasising both similarities and differences. Mohriak *et al*. focus on large offshore salt basins in the central Southern Atlantic, presenting some fine seismic reflection data - their locations made suitably imprecise - in the process. But the bulk of the book appropriately concentrates on the Proterozoic and older rocks that are so widespread along the South Atlantic margins. Neoproterozoic diamictites are recorded in several of the papers, and Pazos *et al*. concentrate on correlating them across West Gondwana and with global events. The focus on West Gondwana assembly in many of the other papers, however, is probably the book's strongest selling point, making it a good companion to the Society's 2003 Special Publication number 206, on East Gondwana.

This focus begins with a comparison of Proterozoic sedimentary basins on the São Francisco and Congo cratons (Pedreira & De Waele), which is followed by five fascinating papers concentrating on north-east Brazil and its western and central African neighbours (Arthaud *et al*., Van Schmus *et al*., Dos Santos *et al*., Dada, and Klein & Moura). In the latter paper, we see evidence linking the São Luís craton and flanking Gurupi Belt to the much larger West Africa craton and flanking Trans-Saharan deformation. Elsewhere, we learn of shared Late Palaeoproterozoic and Neoproterozoic histories that culminated in collision and shearing between the São Luís/West Africa and São Francisco/Congo cratons, producing the paired Borborema Province and Central African Fold Belt. Within these are identified prominent linear and potentially precisely-correlatable features: for example the Transbrazilian and Kandi/4°50 lineaments, or the Pernambuco shear zone and Adamawa Fault.

Pedrosa-Soares *et al*. take a detailed look at the Neoproterozoic Araçuaí-West Congo orogen, an embayment of Pan-African–Brasiliano shortening and subduction within the >2 Ga São Francisco/Congo craton. Further into the book we encounter the Ribeira Belt, the more southerly reaches of the same collision, in papers by Heilbron *et al*. and Schmitt *et al*., and the collision is shown to have evolved through multiple phases. As well as this, the emphasis is on the

differential partitioning of its asymmetrical Neoproterozoic-Cambrian products on the Mesozoic continental margins of South America and Africa. Basei *et al*. also study the Ribeira Belt, using analyses of detrital zircons, but by comparison with the more southerly Dom Feliciano Belt and African Gariep, Rocha and Damara belts. In doing so, they bring further cratons - the Paranapanema and Rio de la Plata in South America and the Kalahari in Africa - into the story of West Gondwana assembly.

Moving into the interior of South America, a provenance study based on zircon and quartzite analyses (Moura *et al*.) concludes the possible presence of an amalgamated continent including the Paranapanema and Goiás massifs between the Amazonian and São Francisco cratons during the collisional assembly of West Gondwana and, with another paper by Paixão *et al*., adds to earlier suggestions that the South American Araguaia and West African Rokelide belts may have been involved in the same later Pan-African collision. Underlining the complex history of the Brazilian interior, Valeriano *et al*. highlight the earlier (640–610 Ma) collisional evolution of the Brasília belt south of, and almost contiguous with, the Araguaia Belt, in a paper that also brings sharply into focus the complexity and longevity of the Pan-African/Brasiliano collisional epoch, with its interpretations of subduction zones and volcanic arcs modifying and colliding with the western passive margin of the São Francisco craton. For me, the paper presented the region as West Gondwana in microcosm, drawing its focus out in reference to later collisions with the Amazonian, West African and Kalahari cratons.

In a switch of focus to African rocks, Gray *et al*. highlight the Damara Belt, which strikes at an unusually high angle to the later South Atlantic margin. As any self-respecting Pan-African feature, the Damara Belt experienced several phases of deformation, culminating in the Cambrian collision of the Kalahari/Antarctic and Congo/São Francisco/Rio de la Plata cratons of southern and northern Gondwana. The paper places itself attractively in context with a set of quantitative reconstruction figures, which both raised as well as answered questions in my mind. On the one hand, I saw the assembly of Africa proceeding comfortingly at what seemed a plate tectonically reasonable pace, and to read clearly how the Damara orogeny might fit into the picture of Gondwana amalgamation by collision of northern and southern parts perhaps as much as from eastern and western ones. On the other, I wondered why the Paranapanema craton, or massif, or block, did not feature in the reconstructions, and remain perplexed as to the apparently zero rate of motion of the 100 million year active plate boundary in the Congo/São Francisco cratonic bridge in their figures 8 & 9.

One of the aspirations of the volume, voiced in its introduction, is that improved understanding of correlations should help to improve reconstruction of the Jurassic total fit in West Gondwana. Van Schmus *et al*. are critical of the current value of some of these correlations, whereas in the book's final paper De Wit *et al*. identify ten features that might most precisely be correlated, presenting them on a foldout map. Despite De Wit *et al.'s* acknowledgement of recent improvements to total fit reconstructions achieved by marine geophysical work, throughout the book there is a continuing preference for the results of palaeomagnetic reconstructions, which are inevitably of lower resolution. This preference is entirely reasonable when the focus is to be on plate kinematics in Proterozoic supercontinent amalgamation, as no better constraints exist, but for as long as high-resolution Jurassic reconstructions are attempted using low-resolution starting points like this, correlatable onshore features of any age will remain largely an irrelevance. A further hurdle, highlighted by Schmitt *et al*., is the requirement for marine geophysical expertise when correlating across submerged shelves that can be as wide as 250 km. Precambrian geologists and marine geophysicists clearly still have work to do to learn from each other.

The text, figures and tables are reproduced in the Geological Society's usual style, with only occasional omissions and problems. My copy contained a loose leaf printed with an amended figure; the printed page repeats another figure from earlier in the same paper. There are some instances where I think the use of colour could have added a lot to the utility of the figures; I struggled to follow the complicated pattern fills and shading schemes in some of the geological maps. I also would have liked to see at least some of Mohriak *et al.'s* seismic sections at a larger scale.

This of course should not detract from the overall impact of the volume, which I think goes a long way to uniting what would have been two geographically separate, but unjustifiably separated, streams of thought in the minds of many geologists. Personally, in addition to what I have already learnt from it, I look forward to using the volume much more in fleshing out what had been rather sketchy knowledge dating back to an undergraduate cartography exercise that had all but faded from my memory. In comparison to my more recent experience, after starting to discover West Gondwana from the point of view of this book I have nothing but the utmost regard for geological work of this kind, which seems to me require intricate juggling of multiple competing interpretations of a protracted series of events placed in a palaeomagnetic reference context that is itself subject to multiple competing interpretations. Congratulations are due to those who are brave enough to manage it.

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