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Tight Reassembly of Gondwana Exposes Phanerozoic Shears in Africa as Global Tectonic Players

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Abstract

Aeromagnetic surveys help reveal the geometry of Precambrian terranes through extending the mapping of structures and lithologies from well-exposed areas into areas of younger cover. Continent-wide aeromagnetic compilations therefore help extend geological mapping beyond the scale of a single country and, in turn, help link regional geology with processes of global tectonics. In Africa, India and related smaller fragments of Gondwana, the margins of Precambrian crustal blocks that have escaped (or successfully resisted) fracture or extension in Phanerozoic time can often be identified from their aeromagnetic expression. We differentiate between these rigid pieces of Precambrian crust and the intervening lithosphere that has been subjected to deformation (usually a combination of extension and strike-slip) in one or more of three rifting episodes affecting Africa during the Phanerozoic: Karoo, Early Cretaceous and (post-) Miocene. Modest relative movements between adjacent fragments in the African mosaic, commensurate with the observed rifting and transcurrent faulting, lead to small adjustments in the position of sub-Saharan Africa with respect to North Africa and Arabia. The tight reassembly of Precambrian sub-Saharan Africa with Madagascar, India, Sri Lanka and Antarctica (see animation in http://kartoweb.itc.nl/gondwana) can then be extended north between NW India and Somalia once the Early Cretaceous movements in North Africa have been undone. The Seychelles and smaller continental fragments that stayed with India may be accommodated north of Madagascar. The reassembly includes an attempt to undo strike-slip on the Southern Trans-Africa Shear System. This cryptic tectonic transcontinental corridor, which first formed as a Pan-African shear belt 700–500 Ma, also displays demonstrable dextral *and* sinistral movement between 300 and 200 Ma, not only evident in the alignment of the unsuccessful Karoo rifts now mapped from Tanzania to Namibia but also having an effect on many of the eventually successful rifts between Africa-Arabia and East Gondwana. We postulate its continuation into the Tethys Ocean as a major transform or megashear, allowing minor independence of movements between West Gondwana (partnered across the Tethys Ocean with Europe) and East Gondwana (partnered with Asia), Europe and Asia being independent before the ~250 Ma consolidation of the Urals suture. The relative importance of primary driving forces, such as subduction 'pull', and 'jostling' forces experienced between adjacent rigid fragments could be related to plate size, the larger plates being relatively closely-coupled to the convecting mantle in the global scheme while the smaller ones may experience a preponderance of 'jostling' forces from their rigid neighbours.

Key words: Africa, Gondwana, Phanerozoic plate tectonics, aeromagnetics, global shears.

The Approach to Model-building

This paper attempts to summarize a broad view of Phanerozoic tectonics across Africa and its Gondwana neighbours. In this case, the viewpoint was a desire to capitalize on the ability of aeromagnetic survey coverage to track structures and lithologies in igneous and metamorphic basement rocks even where (as happens in large areas of Precambrian terrain, not only in Africa) cover and weathering obscures the bedrock from direct surface observation (Fig. 1a; Sahu, 2001). While aeromagnetic interpretation is never unambiguous, magnetic anomaly mapping makes up in objectivity and uniformity of coverage what it lacks in geological certainty, and can be calibrated against geological observations wherever possible (Reeves, 1999). While serious gaps still exist elsewhere, reconnaissance aeromagnetic coverage of eastern and southern Africa is virtually complete (Fig. 1b; Barritt, 1993; Jelsma et al., 2003), a region defined to the west and north by the paucity of even reconnaissance coverage in Angola, DR Congo, Sudan and Ethiopia.