The post-Gondwana development of East Africa's coastline with emphasis on the development of the Rovuma Basin

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Africa formed a central part of the Gondwana Supercontinent (Figure 1) that was created by end-Precambrian-Ordovician (c. 560-480 Ma) orogenesis in a number of collisional orogenic belts. Within the African part of Gondwana the (Pan-African) orogens form an intersecting array of linear belts including the major N-S East Africa-Antarctica Orogenic Belt (EAAOB) that forms the crystalline basement throughout present-day coastal East Africa, from Egypt to Mozambique. In early Palaeozoic times the EAAOB will have formed a major mountain belt. Uplift and extension of Gondwana during lower Palaeozoic times created a number of wholly intra-cratonic Karoo rift-basins (Figure 2) that locally follow pre-existing structural weaknesses in the crystalline basement, including the trans-Africa shear system (STASS) that actually bisected the whole of Gondwana (Figure 1). The rift-basins are infilled by Carboniferous-early Permian periglacial sediments, Permian coal measures and Permo-Triassic red beds. The N-S EAAOB mountain belt formed a source region for the sediments (west-directed currents are recorded in the rift-basins of Mozambique and Zimbabwe) and will have formed the western shoulder of the Karoo rift-basin now concealed beneath younger sediments in the Mozambique Channel to the west of the Davie Fracture Zone. The Karoo sediments are locally overlain by Jurassic (c. 182 Ma) lavas (predominantly flood basalts). Smaller Triassic to early Jurassic half-grabens discordant to the Karoo rift-basins are filled with up to 2.5 km of predominantly continental sediments with intercalations of marine sediments (including the N'Gapa and Rio Mecole formations of coastal northern Mozambique).

Measurable break-up of Gondwana was initiated in the mid-Jurassic (about 167 million years ago), when East Gondwana, comprising Antarctica, Australia, India and Madagascar, began dextral strike-slip against Africa creating the Somali, Mozambique, and Weddell proto-oceans (Figure 2). Early and intermittent Tethyan marine incursions off East Africa and NW Madagascar created a salt basin in the Somali proto-ocean (Reeves, 2009 and references therein). Sedimentary sequences in the Rovuma Basin of coastal parts of southern Tanzania and northern Mozambique record the Mesozoic and Cainozoic development of East Africa's coast (Key *et al*., 2008 and references therein). Sedimentation started in a south-facing marine gulf fed by rivers that flowed with increasing energy off the rising and eroding continental landmass of eastern Africa. Basal sediments of the Pemba Formation were deposited on the western side of the gulf. During the Barremian (135 to 125 Ma) an open sea passage formed all along what is now the eastern coast of Africa. Macomia Formation sediments were deposited inland of Africa's new coast-line with Pemba Formation sedimentation continuing offshore. Vertical uplift of the western landmass was at least in part controlled by north-northwest to south-southeast faults. However, a number of east-northeast to west-southwest trending transfer faults have been identified in the offshore part of the Rovuma Basin. These brittle fractures are parallel to the Lurio Belt, which is a major Pan African ductile shear zone in Precambrian basement south of Pemba and it is possible that some of the offshore transfer faults represent reactivated basement shear zones. Stabilization of the East Africa continental margin occurred at about 125 Ma with the demise of the active mid-ocean ridge east of the Davie Fracture Zone and Madagascar becoming part of the Africa plate. From mid-Cretaceous (c. 93 Ma) separation of India from eastern Madagascar got under way, opening the Mascarene Basin and leaving the east coast of Africa as a truly passive margin. The Late Cretaceous was typified by a widespread transgression in eastern Africa with uniform marls/clays (including the Mifume Formation) deposited along the whole continental margin and prograding onto the continental slope. The greatest accumulation of sediments occurred during Cretaceous times with about 3000

m of sediment recorded in the Pemba Formation (c.155 - 100 Ma), ~500m in the Macomia Formation (c.125 - 100 Ma) and up to about 810m in the Mifume Formation (c.100 - 65 Ma). Subsequent reduced sedimentation rates during early Cenozoic times coincide with an order of magnitude reduction in erosion of Africa's interior. Shallow water carbonate sediments (of the Alto Jingone and Quissanga formations) were deposited during the Paleocene and Eocene with a reefal facies along the outer edge of the shelf. There were periods of relatively low sea levels to create low-stand submarine fans. The Quissanga Formation is made up of shallow water coastal sediments. Although active vertical faulting accompanied sedimentation throughout the Cenozoic, the relative thinness of the Paleocene and Eocene sediments in the Rovuma Basin suggests that this was a period with very little vertical (fault or isostatic) crustal movement and with a reduction in sediment supply from the African mainland.

Delta progradation followed rift initiation in the East African Rift System at c. 35 Ma that has continued intermittently to the present day, mostly with deposition of marine and deltaic sediments (of the Mikindani and possibly Chinda formations). Uplift/doming of Africa in the Oligocene, prior to the formation of the East African Rift, initiated the Rovuma River Delta System and the associated marine regression. A Miocene transgression led to shallow water marine sedimentation during progradation of the delta (contemporaneous with rift-related onshore sedimentation in the East African Rift System). The present day outcrop of the Miocene sediments on the mainland of northeastern Mozambique is due to uplift of much of southern Africa since the Quaternary.

Although the eastern coastline of Africa is regarded as a passive margin, it is clear from the preserved sedimentary record in the onshore part of the Rovuma Basin, that faulting, mostly with vertical displacement, has remained a major control on sedimentation. The present coastline of northern Mozambique remains fault controlled with intermittent movement on north to south trending faults resulting in earthquakes.

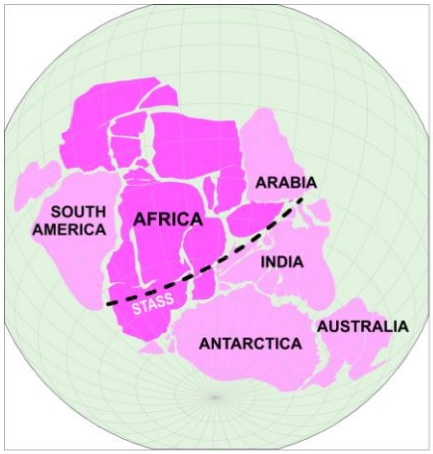

Figure 1. Gondwana reassembled as about 50 rigid Precambrian fragments at 250 Ma in the model CR09madC. The fragments that make up the present-day Africa are shaded darker. The Southern Trans-Africa shear System (STASS) that bisected Gondwana during Karoo times is indicated.

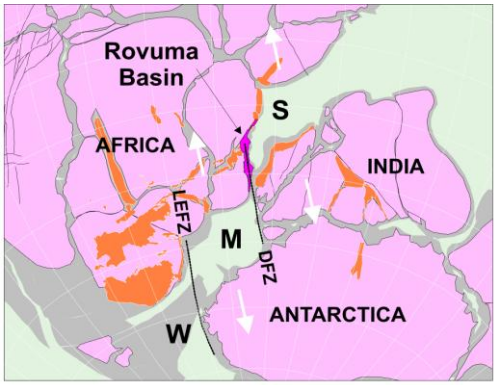

Figure 2. 145 Ma, Jurassic-Cretaceous boundary time, model CR09madC. East Gondwana moves south with respect to Africa creating the Somalia (S), Mozambique (M) and Weddell (W) proto-ceans offset by the Davie Fracture Zone (DFZ) and the Lebombo-Explora Fracture Zone (LEFZ). Precambrian continental crust shown in pink. Karoo sediment-filled rifts and basins shown in orange.

References

Key, RM, Smith, R A, Smelror, M, Powell, J H, Thorsnes, T, Njange, F, Sæther, O.M and Zandamela, E B. 2008. Revised lithostratigraphy of the Mesozoic-Cenozoic succession of the onshore Rovuma Basin, northern coastal Mozambique. South African Journal of Geology, 111, 89-108.

Reeves, C.V., 2009. Re-examining the evidence from plate-tectonics for the initiation of Africa's passive margins. Proceedings GSH/PESGB Africa Meeting, London, Sept 2009.