The southern South Atlantic Ocean in the context of a holistic Gondwana dispersal model

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***Figure 1**. The Bouvet plume and early separation between East and West Gondwana, 170 Ma.*

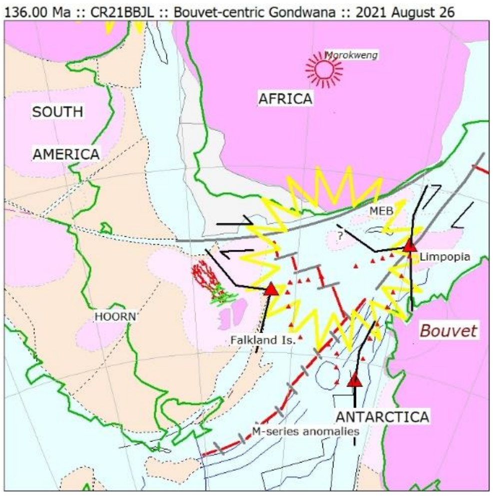

***Figure 2A**. 136 Ma: MEB still part of Africa plate.*

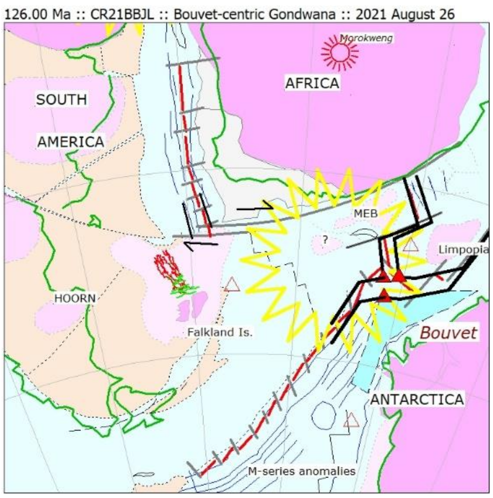

***Figure 2B.** 126 Ma: New TJ; MEB has joined Hoorn.*

Global tectonics within Gondwana is not so much about continents moving as about oceans – or at least their mid-ocean ridges – staying in the same place. A constellation of plume locations, fixed with respect to the earth's rotation axis, appears to influence strongly the location of the mid-ocean ridges of the oceans that now separate the Gondwana continents. The Bouvet plume is not only central to this dispersal process but also the first to have become active (c 184 Ma, Toarcian) with the Karoo-Ferrar events (Fig. 1).

The evolution of a mid-ocean ridge linking Bouvet to the Tristan plume over a distance of about 2400 km - essentially the southern half of the South Atlantic – is not simple but has perhaps been overly obscured by confusing ideas. Until about 165 Ma (Callovian) Gondwana still existed as just two large fragments, East and West. At about this time, a large part of Patagonia (call it Hoorn) became a third fragment and started to move west with dextral strike-slip along the Agulhas FZ where it was in contact with Africa. The first triple junction was between Hoorn, Antarctica and the Maurice Ewing Bank (MEB) that remained (largely) attached to Africa for another 30 myr. The triple junction remained stable while almost 900 km of extension occurred between MEB and the Malvinas plateau surrounding the Falkland Is. There was an almost equal amount of dextral strike-slip within southern South America (Fig. 2A) with only modest rift extension in the proto-southern South Atlantic and that only after about 140 Ma.

A rejuvenation of the Bouvet plume, contemporaneous with the first outbreak of the Tristan and Kerguelen plumes, caused a reorganisation of the triple junction off southern Africa in the interval 135-129 Ma (Valanginian-Hauterivian boundary now placed at 132.6 Ma, GTS2020). From a situation with MEB (as part of Africa) and Limpopia (as part of Antarctica) closely adjacent (Fig 2A), the MEB started following Hoorn along the Agulhas FZ while Limpopia left Antarctica and became fixed to Africa as the southern tip of the Mozambique Rise, where it is today. The new triple junction was between Limpopia (now part of Africa), MEB (now part of Hoorn) and Antarctica (Fig. 2B). The triple point is clearly preserved in the ocean off Antarctica.

True ocean growth had started in the southern South Atlantic Ocean, north of the Falklands-Agulhas FZ (FAFZ), during the period of triple junction reorganisation, evidenced by the presence of M-series magnetic anomalies there. Remarkably, the transform offset of 1200 km, initiated in this mid-ocean ridge as the Agulhas FZ, was to persist there until about 50 Ma (Eocene).

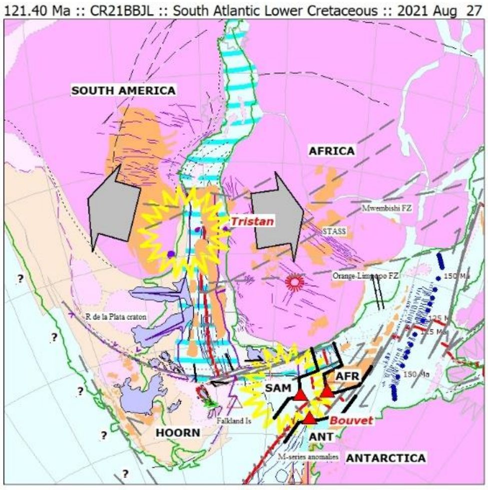

Figure 3A. *121.4 Ma, M0, begin Aptian.*

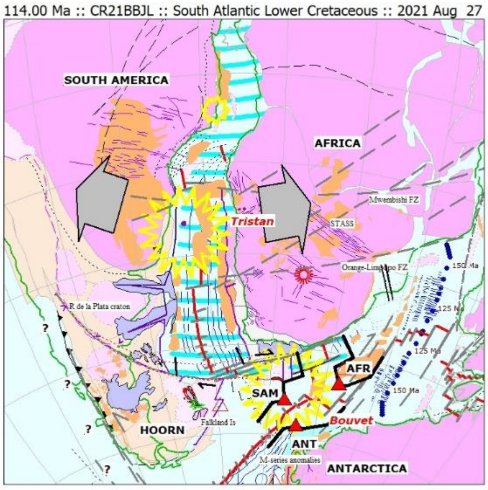

Figure 3B. *114 Ma, end Aptian*.

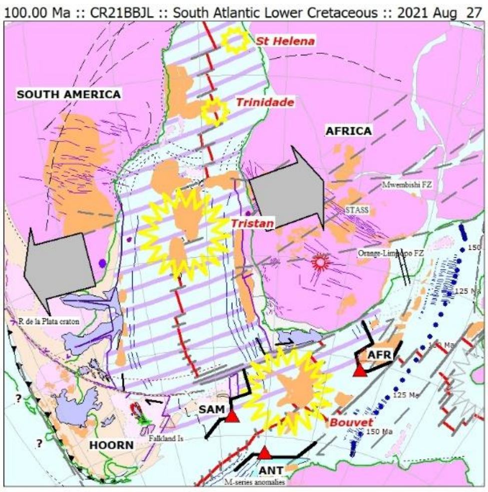

Figure 3C. *100 Ma, begin Cenomanian.*

The views shown in figure 3 are from model CR21BBJL which is also used in an animation for the interval 165-100 Ma that may be viewed and downloaded at:
www.reeves.nl/upload/ReevesAnimationLondon2021.gif

Continental separation south of the Tristan plume head was possible earlier than to its north since neither Africa nor South America was strictly rigid early in the Cretaceous. In Africa there is substantial evidence for a coast-to-coast Mwembishi FZ crossing Africa, moving dextrally by 70-80 km at about 130 Ma (Reeves, 2019) and a similar movement is also possible on an 'Orange-Limpopo FZ' sub-parallel to it (Fig. 3A). Both features are evident in offshore seismic surveys in South Africa and Namibia and the Mwembishi FZ links NE to the demise of the mid-ocean ridge between Africa and Madagascar and to what later became the Owen FZ.

On the South America side, the SW extrapolations of the known Permian-Triassic (Karoo) age strike-slip movements crossing the whole of Gondwana (STASS) are conceivable into Patagonia and southern Brazil (Fig. 3A). Cretaceous re-activation of (some of) these faults as scissor-like rifts (Salado and Colorado) is used in our model to add the extra length (about 150 km) to the South America margin that is evident in present-day geometry.

Scissor-like rigid opening of the South Atlantic north of Tristan, about a point near the Gulf of Guinea (Fig. 3B), gave way to coast-normal spreading at about 113 Ma (Aptian-Albian boundary, 113.2 Ma). This second rotation pole persisted until at least the end of the Cretaceous Quiet Zone (83.64 Ma, Campanian). This 30 myr period saw the development of the Walvis Ridge and Rio Grande Rise as products of Tristan plume activity at the mid-ocean ridge (Reeves and Souza, 2021) while a further outbreak of the Bouvet plume created the Agulhas Plateau at about 100 Ma (end Albian, Fig. 3C).

Southern Africa has tracked steadily NE, away from the Bouvet plume head, since the events described here for the Early Cretaceous. Even now the SW tip of the continent is displaced from it by no more than 2500 km. By contrast, the South America margin has moved almost 5000 km to the west in the same reference frame.

Related earlier work:

Reeves, C.V., 2019. The creation of the African margins and the Mesozoic demise of Gondwana. Abstract, PESGB Africa meeting, London, October 2019.

Reeves, C.V. & Souza, P., 2021. The lost 'continents' of the South Atlantic Ocean. Poster, Netherlands Earth Science Congress, April 2021.