

THE OPENING OF THE SOUTH ATLANTIC

How one ocean has opened

Seen from an African perspective

Thick piles of sedimentary rock accumulate on the "passive" or "Atlantic-type" margins of oceans of this kind. Data are generally too incomplete for establishing what has happened.

Speculations and models abound. Many are helpful but recognizing the assumptions involved and assessing the utility of the methods applied in constructing the models is a personal responsibility.

Caveat Emptor (Let the buyer beware)

HOW TIGHTLY CAN OCEANS BE CLOSED ?

Classic studies from the north side of the Bay of Biscay, where there is very little post-rift sediment, showed listric normal faults and flow of the continental crust at depth. Both accommodated extension.

The transition between continent (ca.35 km continental crust) and ocean-floor (ca.10 km basaltic crust) showed a ca.150 km wide transitional region. The conjugate shore transition zone is likely to have been narrower.

Too many terms are used e.g.:" **rifted and thinned continental Crust**", "stretched continental crust"
"Transitional crust" and "proto-oceanic crust". Some see two or more varieties of crust.

- (1) MOST SOUTH ATLANTIC INTRA-CONTINENTAL RIFTS WERE INITIATED 140 Ma +/- 5 (mid-Berriasian). (IN K-pippe)**
- (2) THEY EVOLVED AS INTRA-CONTINENTAL RIFTS TILL ca. 125 Ma (Late Barremian) WHEN OCEAN FLOOR BEGAN TO FORM.**
- (3) WHAT IS NOW THE TRISTAN PLUME ERUPTED AT ca 133 Ma (Hauterivian) TO FORM PARANA (S. AMERICA) AND ETENDEKA (Africa) LARGE IGNEOUS PROVINCES.**
- (4) OCEAN FLOOR BEGAN TO FORM ALL THE WAY FROM DURBAN TO THE DEMERARA RISE (at 125 +/- 3 Ma within BARREMIAN times.) M 9 130 Ma? M8: 129, M2:124 Ma).**
- (5) EVAPORITES WERE DEPOSITED ON OCEAN FLOOR (UNDER AIR) NORTH OF THE TRISTAN PLUME TRACK AND IN NEARBY CONTINENTAL MARGIN RIFTS AT 112 Ma (Late Aptian).**
- (6) RIFT SHOULDERS WERE ERODED BY ca. 90 Ma.**
- (7) SUBSEQUENT TECTONIC PERTURBATIONS AND THE ELEVATION OF ERODABLE AREAS IN SOUTH AMERICA HAVE BEEN DOMINATED BY EVENTS IN THE ANDES.**
- (8) FOR AFRICA THE SANTONIAN (C.84 Ma) AND AFRICA ARREST EVENTS (30 Ma) HAVE BEEN TECTONIC DRIVERS SINCE THE TRISTAN HOT SPOT TRACK WAS BREACHED**

Rifted and thinned continent with listric faults. 150-200 km wide

Offshore ANGOLA

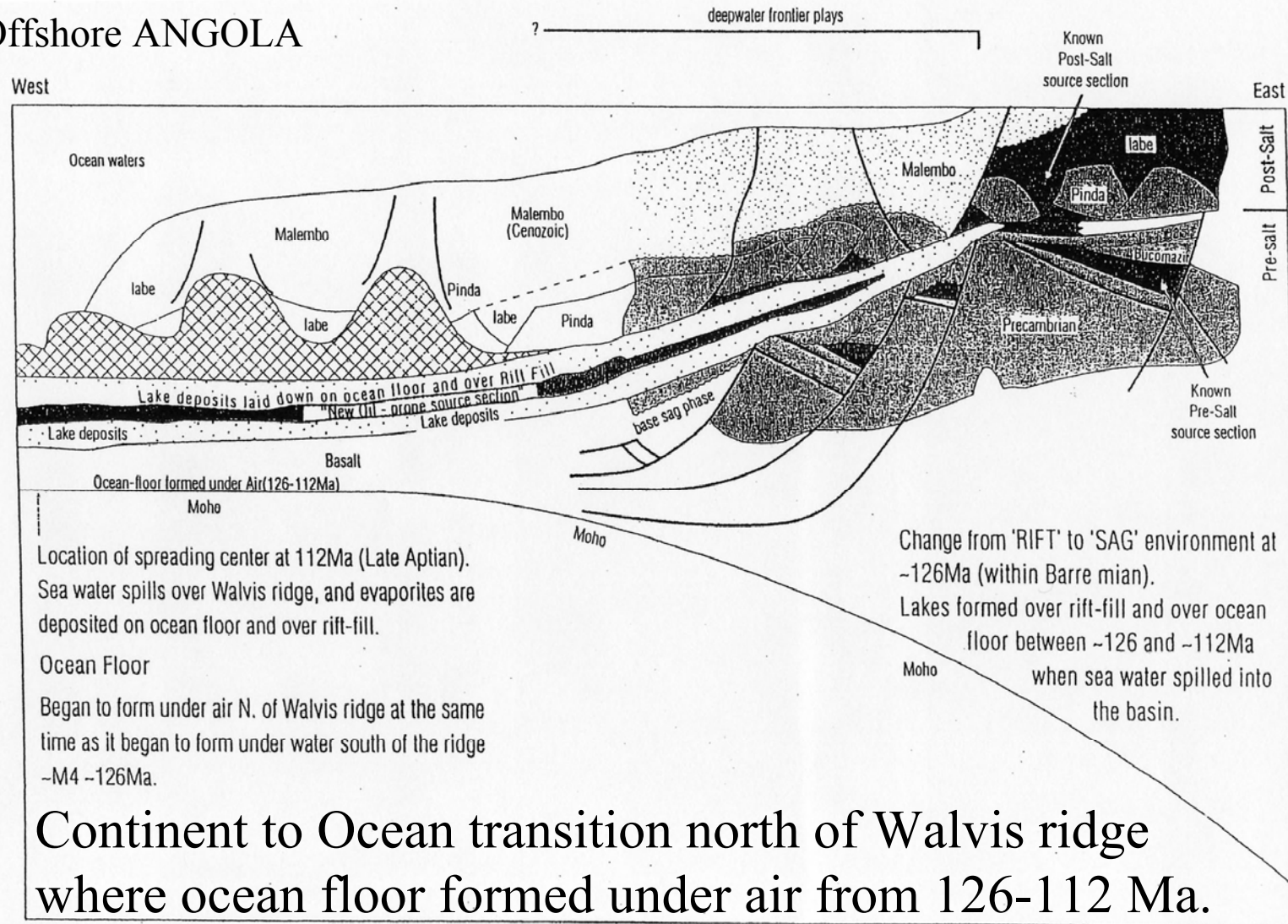


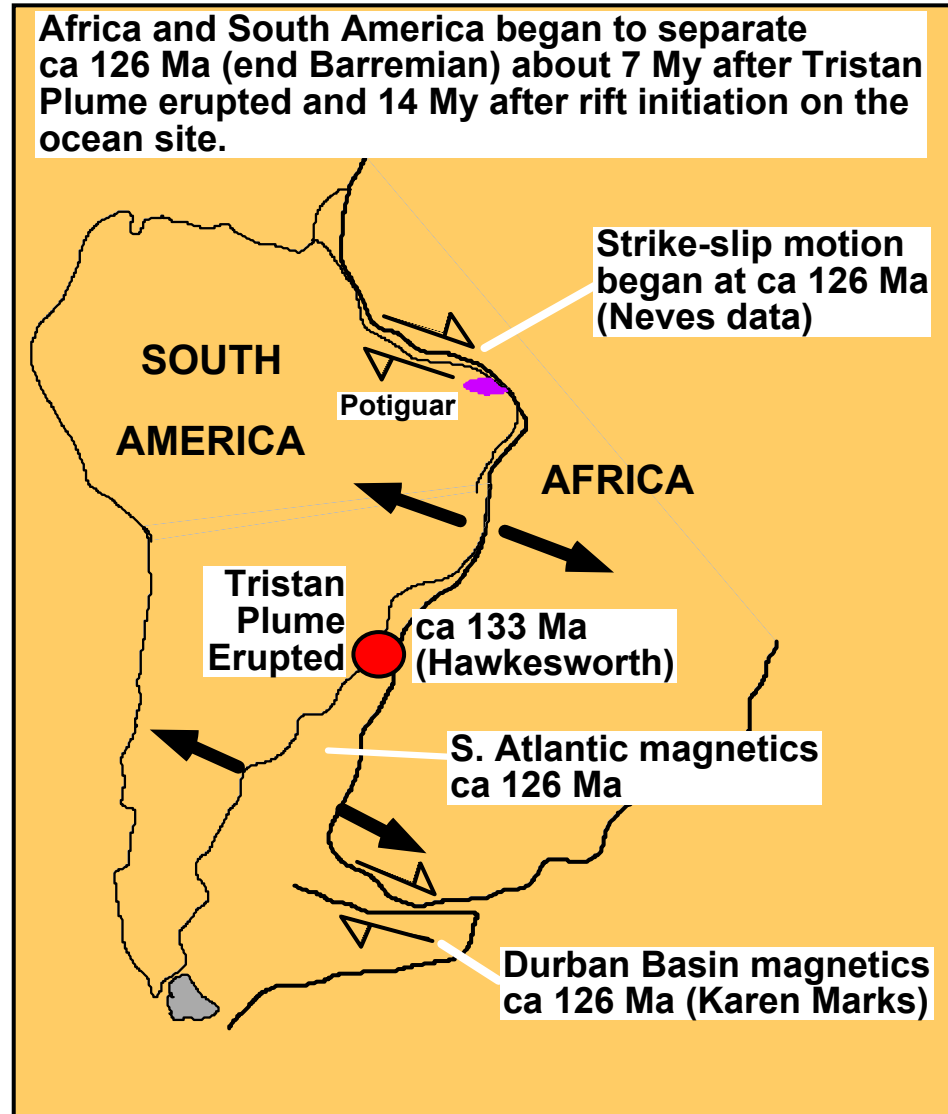
Fig 5 of Cameron et al (1999) extended to the West.

Sea water then spilled in to form a 1M sq.km area of evaporites.

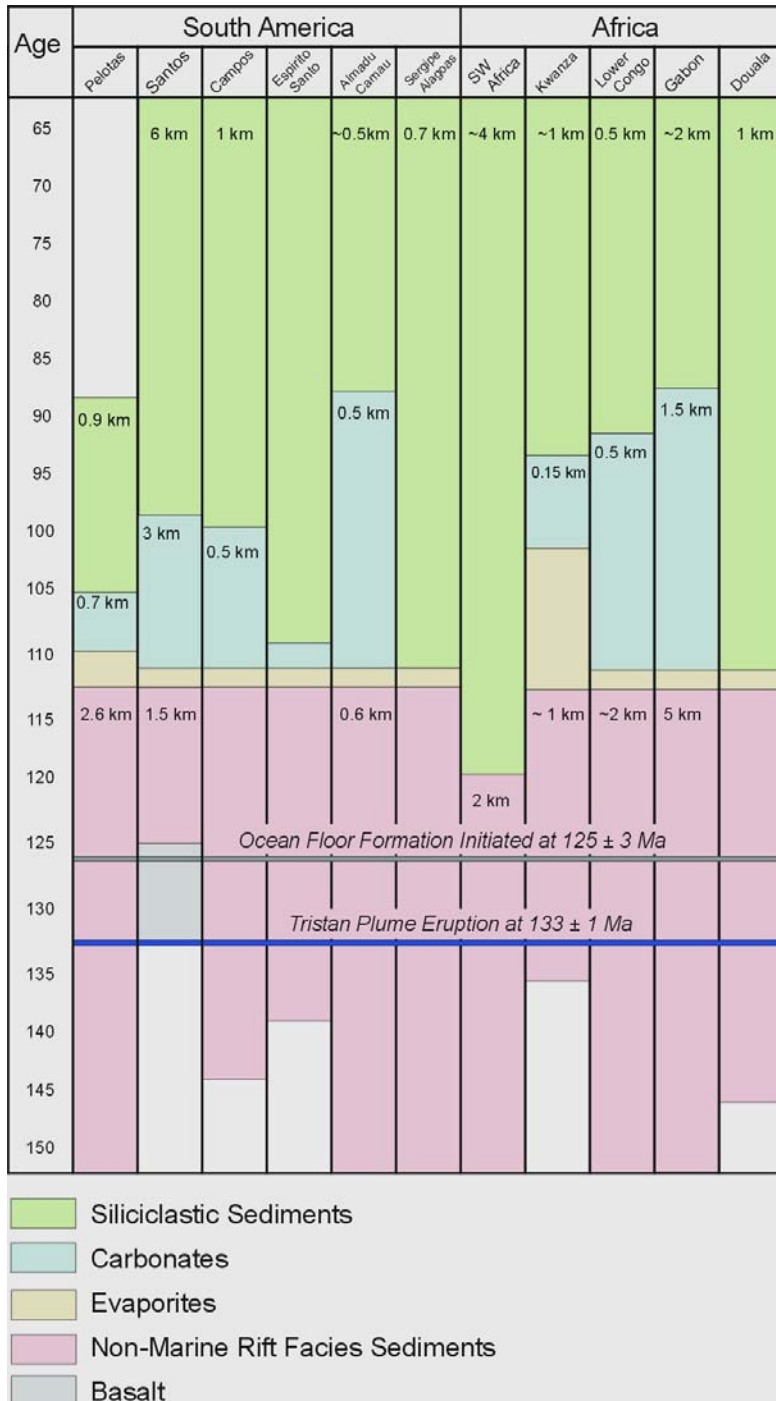
BEST :From Durban to Guinea Nose the start of Ocean formation was between 131 and 124 Ma (128 +/- 4 Ma) Burke et al. 2003 Macmillan 2003 Fig.5, Tikku & Marks, Neves 1989

OLDEST SOUTH ATLANTIC OCEAN FLOOR:

- M11 (131Ma ?)
Off Durban
 - *M4 (126 Ma ?)
Off Namibia
- 3 anomalies strike obliquely into the shore between the Cape and the Walvis Ridge.
- *Oldest Marine faunas Ca.126 Ma.
 - *Subaerial ocean floor formed north of the Walvis ridge: No Magnetic anomalies and No marine faunas



How long do escarpments at the continental margin last?



Coward *et al.* (Ed Purdy's strat columns 1998) showed:

South Atlantic rifts formed 145 ± 5 Ma.

Rift deposition (pink) persisted in rifts and on ocean floor, under air, till sea water spilled in to form evaporites at 112 Ma (Late Aptian)

After evaporites were deposited, carbonate deposition (blue) followed ending at 20-40 My after ocean floor began to form. This was the "Rift shoulder duration time".

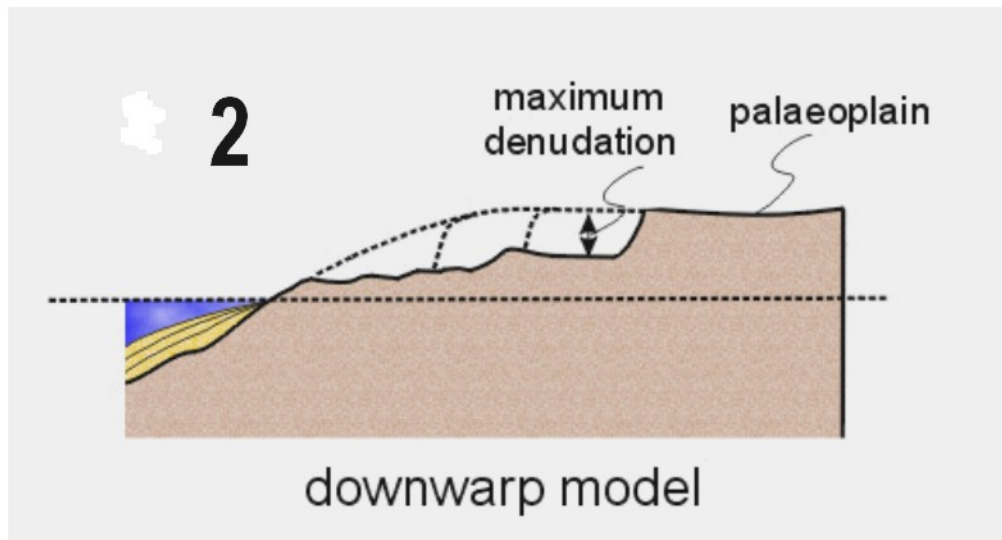
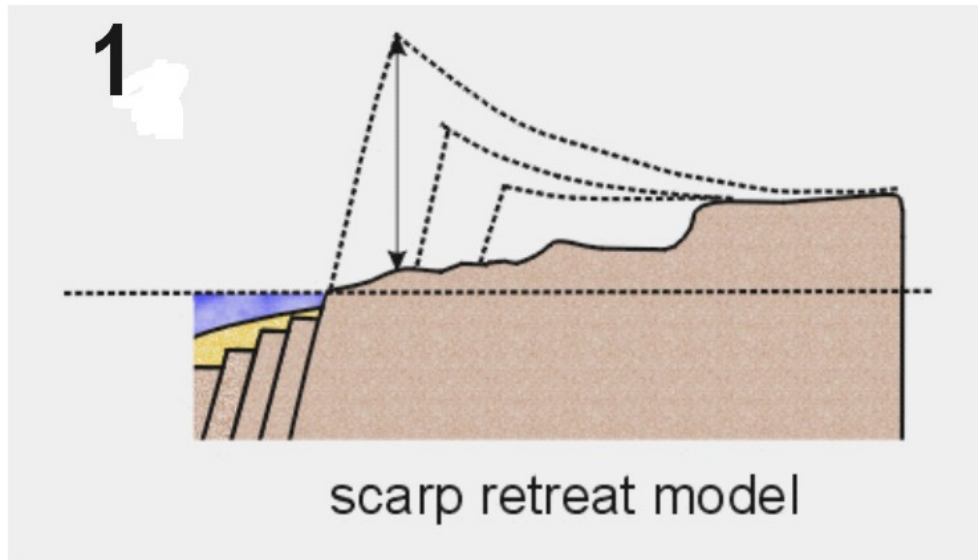
Rift shoulders had been eroded by the time silici-clastic deposition (green) began at 105-90 Ma.

No Long-lived escarpments

Conclusion: Escarpments lasted a few tens of millions of years.

Pelotas (on crest of Rio Grande Rise) and SW Africa (S.of Walvis) are different

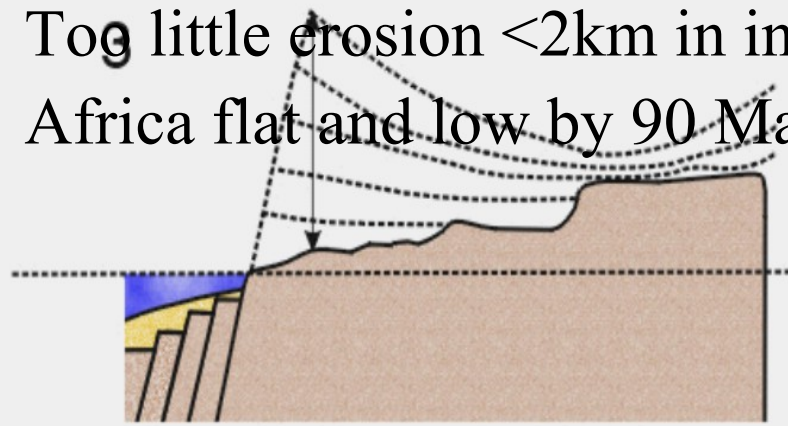
Mod. from Gallagher *et al.*, 1998, AREPS



- (1) AFT reset near coast while shoulders eroded (? 5km)(180-140 and 130-80 Ma)
- Too little erosion (<2km) in interior to reset AFT
- Interior eroded and Africa low by 90 Ma
- (2) Swell initiated at 30 Ma. Erosion mostly outboard of newly formed Great Escarpment
- Too little erosion (<2km) to reset AFT

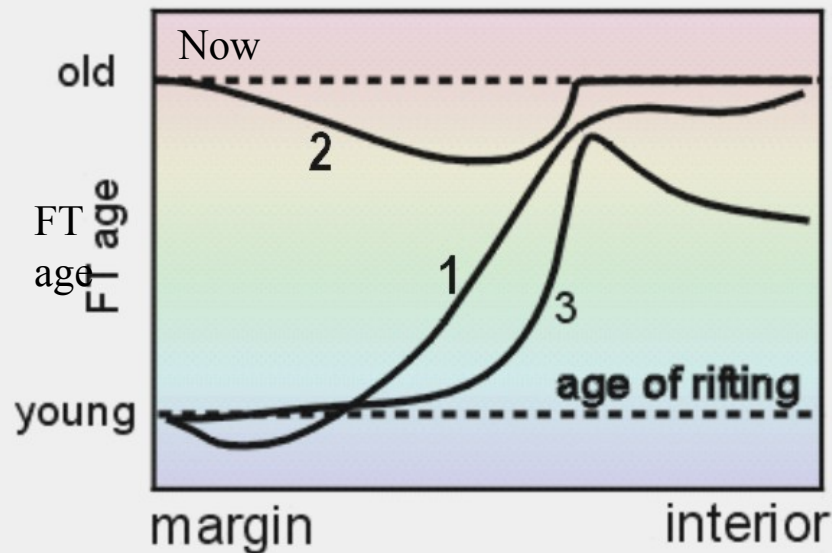
AI special (b of scarp retreat. FT reset near coast when shoulder eroded

- Too little erosion <2km in interior to reset FT
- Africa flat and low by 90 Ma.



pinned divide model

In this model (1) Scarp stays fixed for > 100 My because virtually no rain falls on the crest. (2) Rivers draining inward have farther to travel and are less steep than rivers going directly to coast.



Fission track predictions For 3 models. Model 2 applies to swell forming Process (active only since 30 Ma). A Model 1 and a later model 2 event work for Africa and for all other rifted margins with a near coast escarpment.

Great
Scarps
are
products
of
erosion
during
the past
30 My

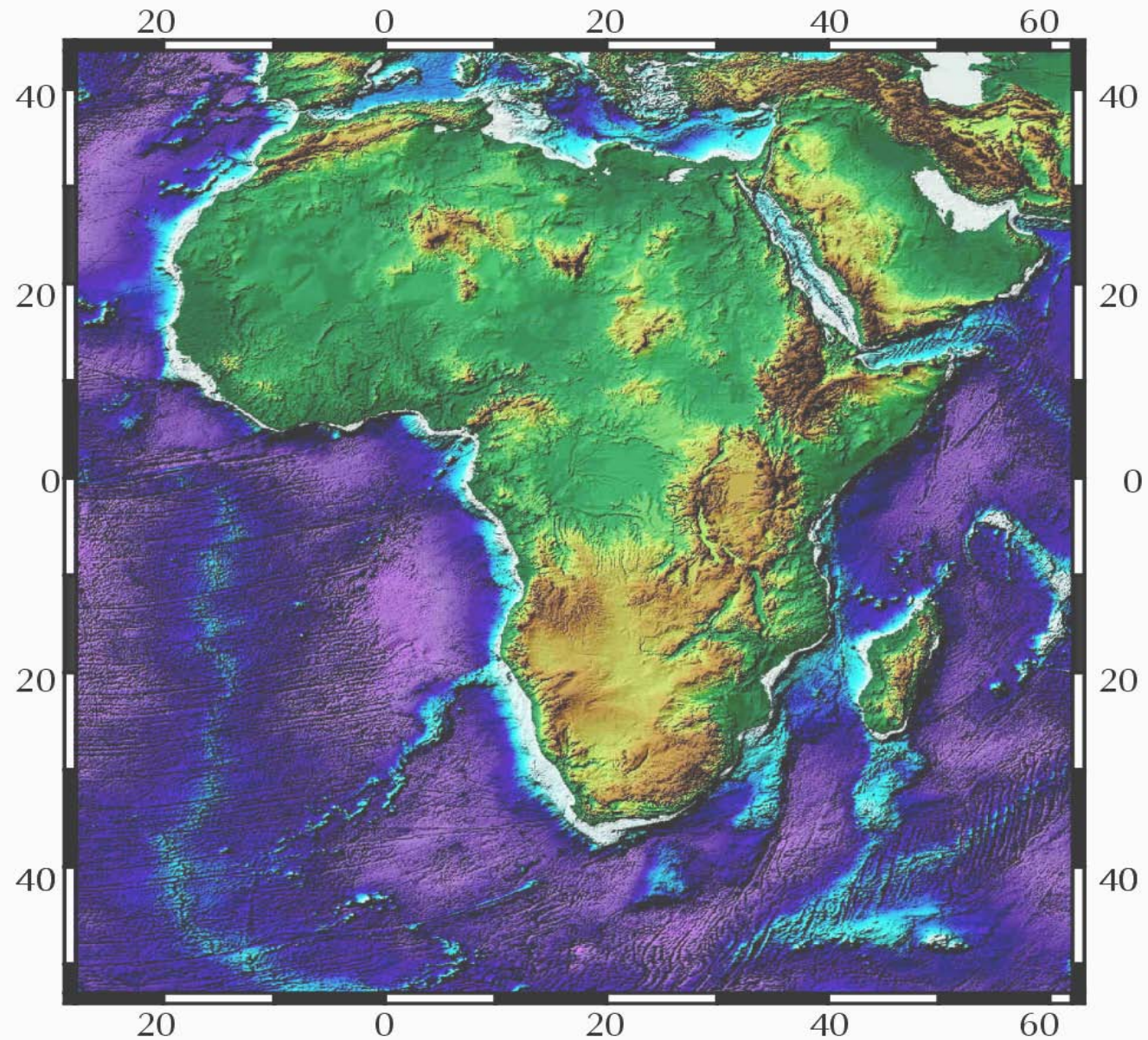
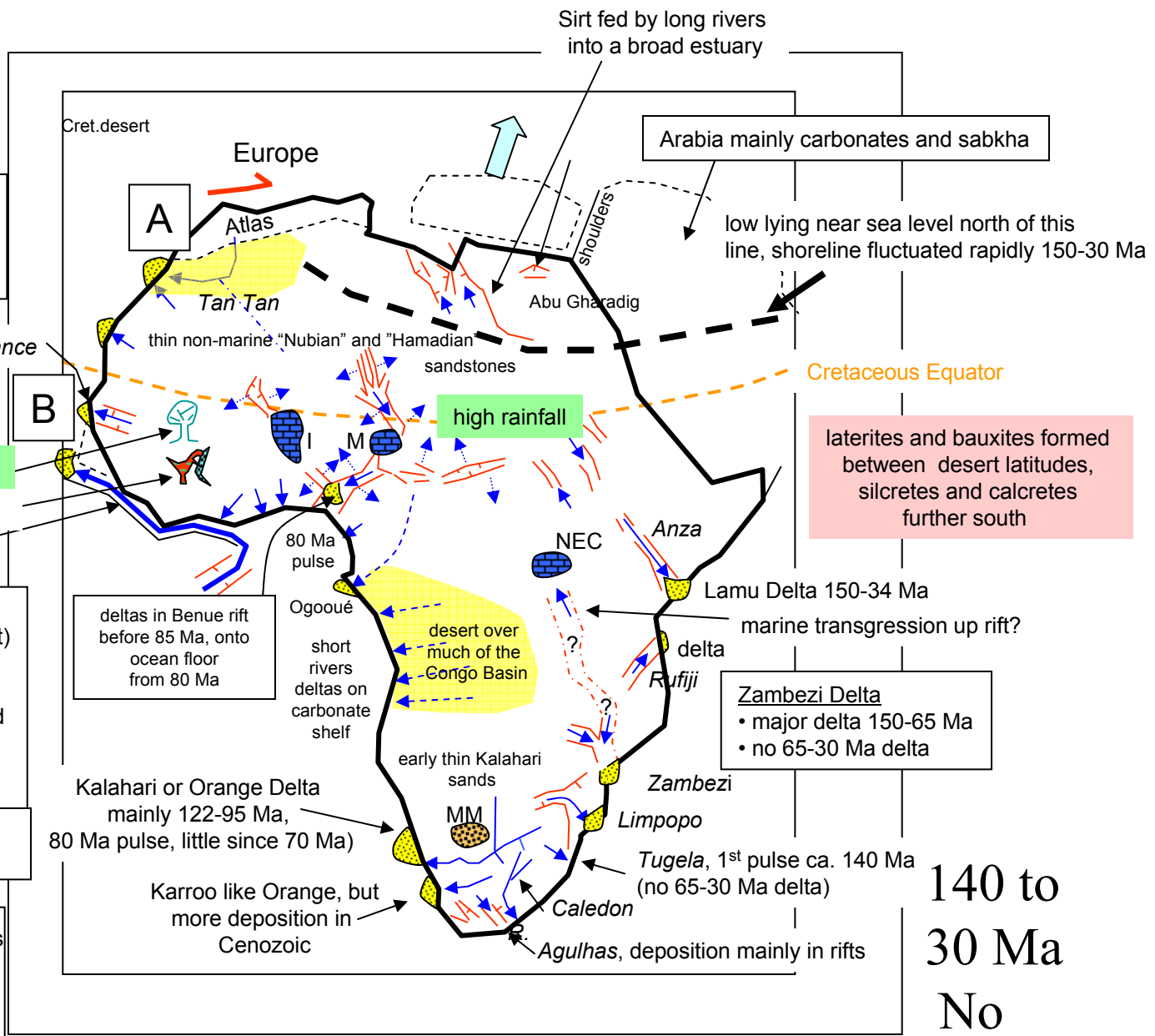
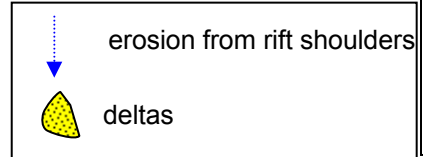


Image courtesy of NOAA and USGS.

Bulge from A to B
 a) ocean floor from 180 Ma
 b) carbonate shelf 180-125 Ma
 c) deltas 135-65 Ma

Interior marine transgressions
 a) I (Lullemeden Basin, Gao rift) five between 100 and 50 Ma
 b) M (Benue and Maidugari Basins) five between 100 and 50 Ma
 c) NEC (North East Congo) only late Cretaceous.

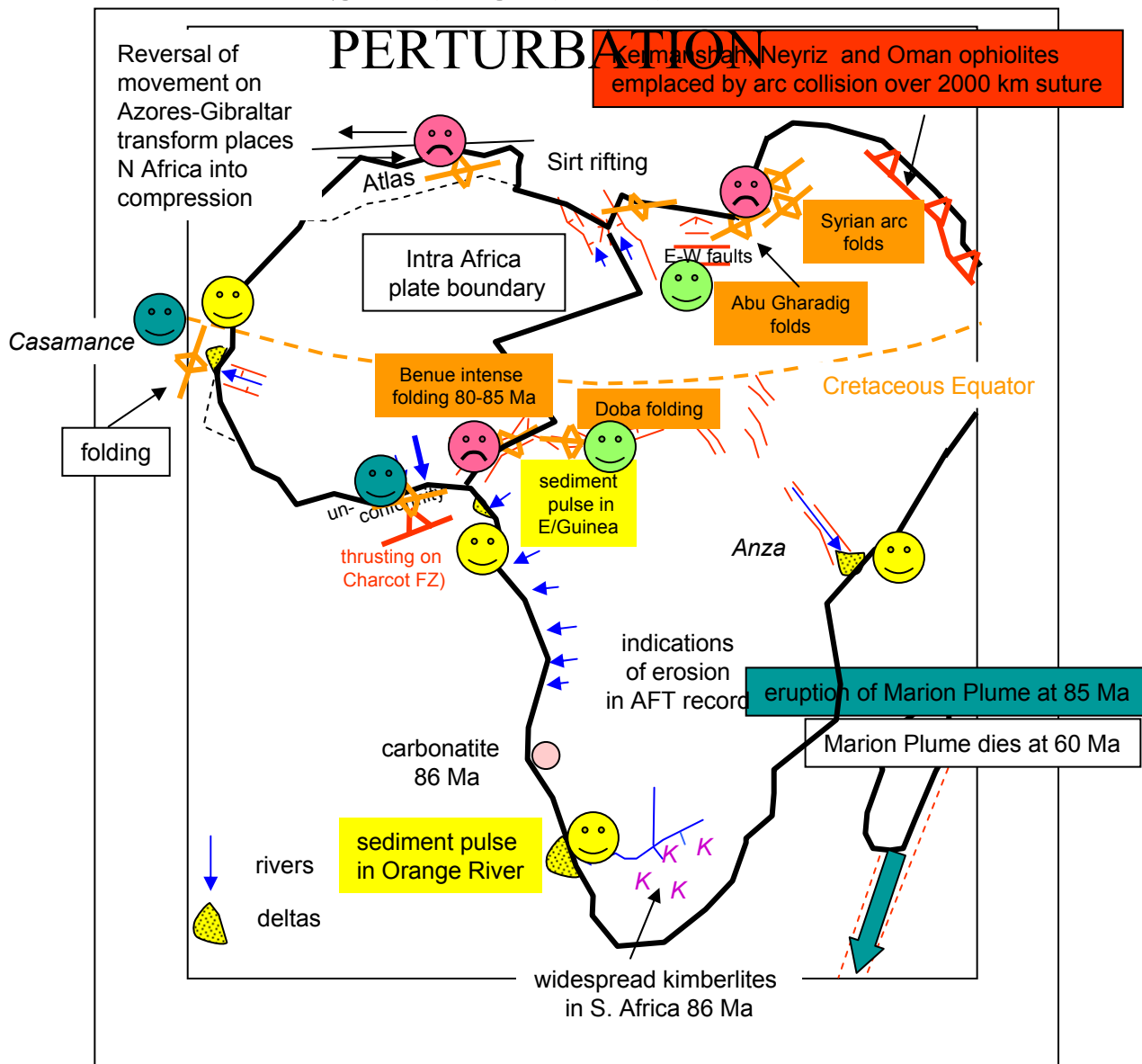
MM (Mahura Muthla)
 land plants in river gravels






140 to
 30 Ma
 No
 83 Ma
 Events

SANTONIAN

PERTURBATION



-  Santonian 84-80 Ma Structures Formed and Producing Dark green prospects
-  Yellow Sediment pulse. Rio Muni
-  Structures Breached. Folding too intense