AFRICAN PLATE PLUME TRACKS

Now you see them! Now you don’t

Map largely based on Morgan 1971 which linked active hotspot volcanoes to as few as one igneous rock along track. For example: Sierra Leone norite (200 Ma) was linked to Ascension(which has no track). More up-to-date ages and bathymetry from satellite altimetry show this practise is unjustified

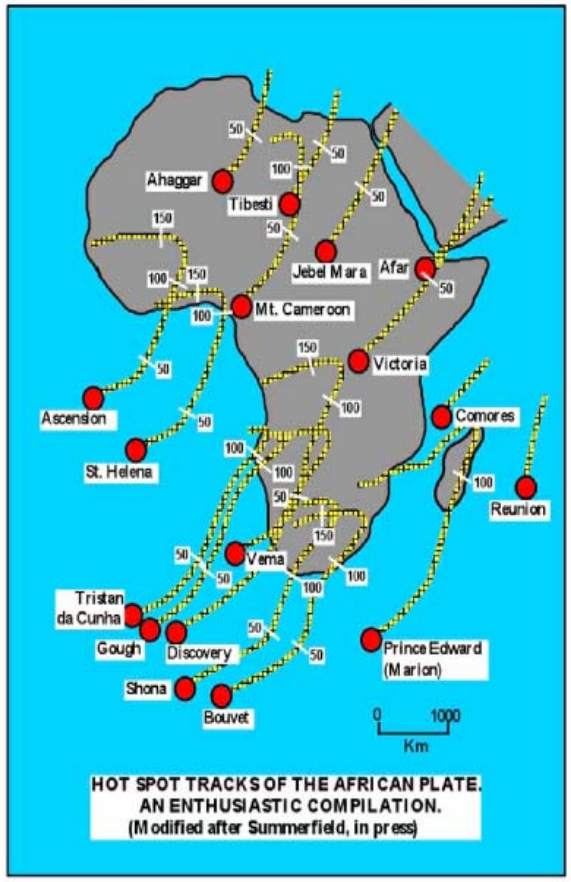

Figure 10 A compilation of hot-spot tracks for the African Plate based on the results of the present study. Only Tristan and Gough, shown here as two separate tracks from a source at the Etendeka basalt outcrop, meet the criteria used here. It is possible that there is a track between southern Ethiopia and Lokitipi representing the interval ~40 to ~30 Ma and that other tracks on the oceanic part of the plate such as that of the Sierra Leone rise (Schilling *et al.*, 1994) may become well enough established to meet the criteria used here at some time in the future.

Image courtesy of The Geological Society of South Africa.

Reunion is now known to be trackless

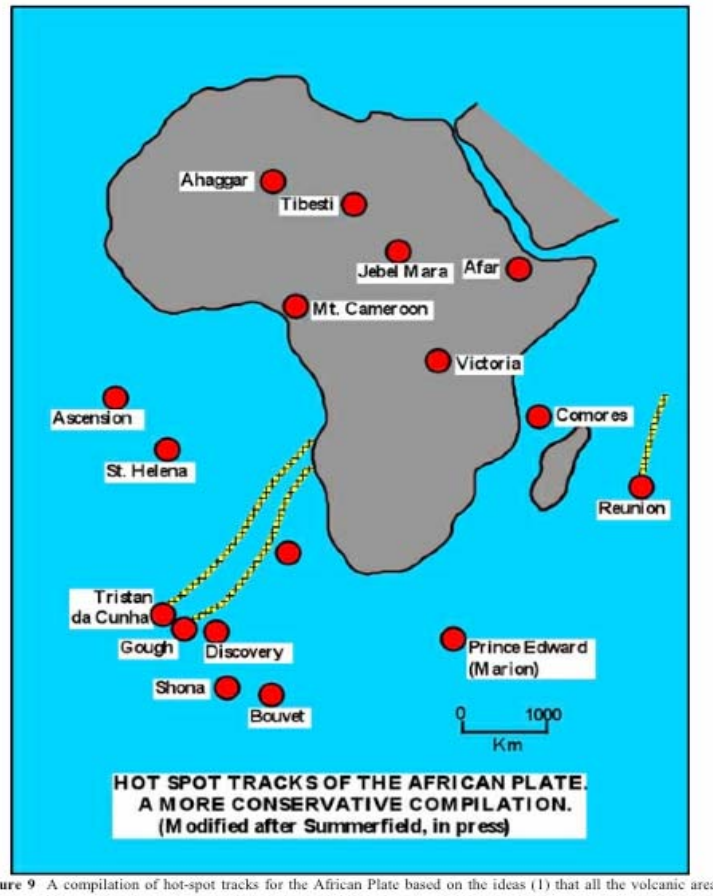

Figure 9 A compilation of hot-spot tracks for the African Plate based on the ideas (1) that all the volcanic areas represented by small open circles are generated by underlying plumes which have existed for more than 150 My, and (2) that the plumes have remained fixed with respect to one another throughout that 150 My. Based on a map in Summerfield (1996).

121

Image courtesy of The Geological Society of South Africa.

Tristan, (shown here as a pair of tracks) is the only active hotspot volcano with an established track. For all the rest activity is within a 300 km area and ages are < 30 My.

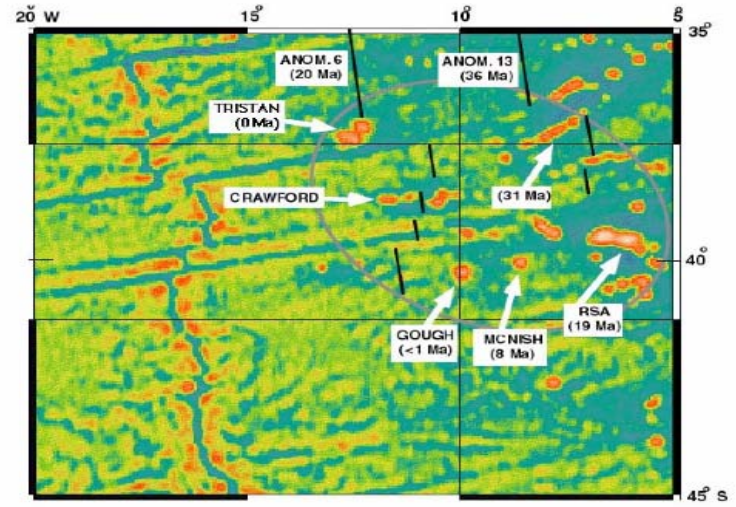

Figure 11 The South Atlantic spreading center to the west, and the present site of hot-spot volcanism located over the Tristan and Gough or Walvis Ridge mantle plume. The young volcanic islands of Tristan and Gough, as well as three dated seamounts all less than 31 Ma, lie within an elliptical area which straddles ocean floor generated at 30 Ma (O'Connor & le Roex, 1992). The underlying plume is interpreted as having remained fixed with respect to the African Plate for the past ~30 My, while the South Atlantic spreading center has migrated westward for a distance of about 650 km. Map is based on satellite altimetry from Sandwell *et al.* (1994).

123

Tristan hotspot activity within a 500km x 200km ellipse centered 800 km East of ridge axis over past 31 My

The S.Atlantic spreading center axis has moved west at ca.25 mm/yr with respect to the Tristan hot spot in 31 My

Image courtesy of The Geological Society of South Africa.

Ocean floor that has formed since 30 Ma around Africa to show location of Tristan

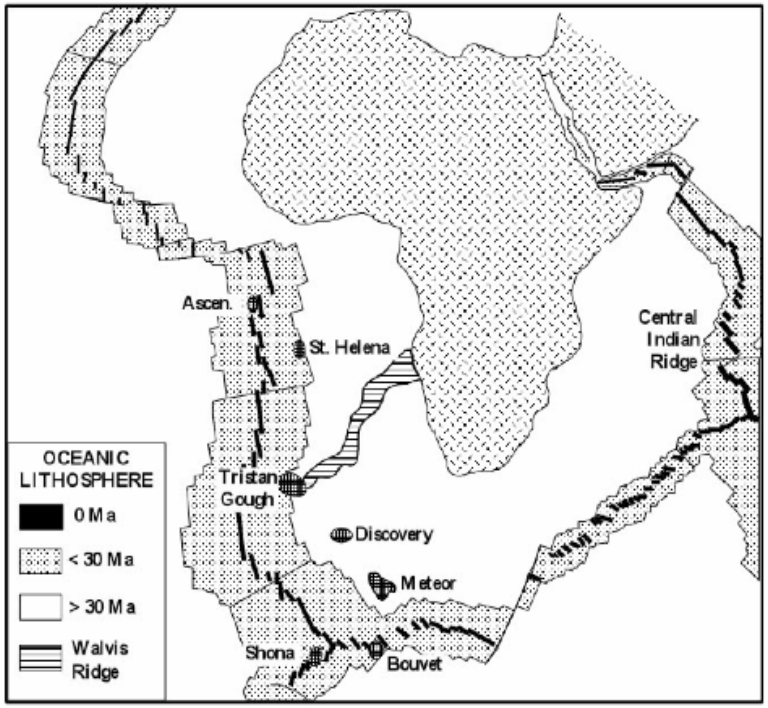

Figure 18 African and conjugate plates showing the distribution of ocean floor formed in the past 30 My. During that interval, the African Plate has not moved with respect to its underlying plume population. St. Helena, Tristan and Gough, Discovery and Meteor form part of the stationary plume population. Ascension, Shona and Bouvet, which lie on oceanic lithosphere generated within the past 30 My on the South American and Antarctic Plates, are new young hot spots. Their compositions are all likely to be similar to that of Ascension which is dominated by the HIMU and MORB sources (Hart *et al.*, 1992).

Tristan hot-spot track

Etendeka on land (134 Ma)

to Tristan (30 Ma to 0 Ma).

Wispiness of young track shows supply of energy and rock (?) from deep mantle has declined with time. ^{3} He is now low

No mappable ridge jumps (they are all on the S. American side)

Rate of propagation

has been uniform.

Plume has stayed on spreading center

till 30 Ma

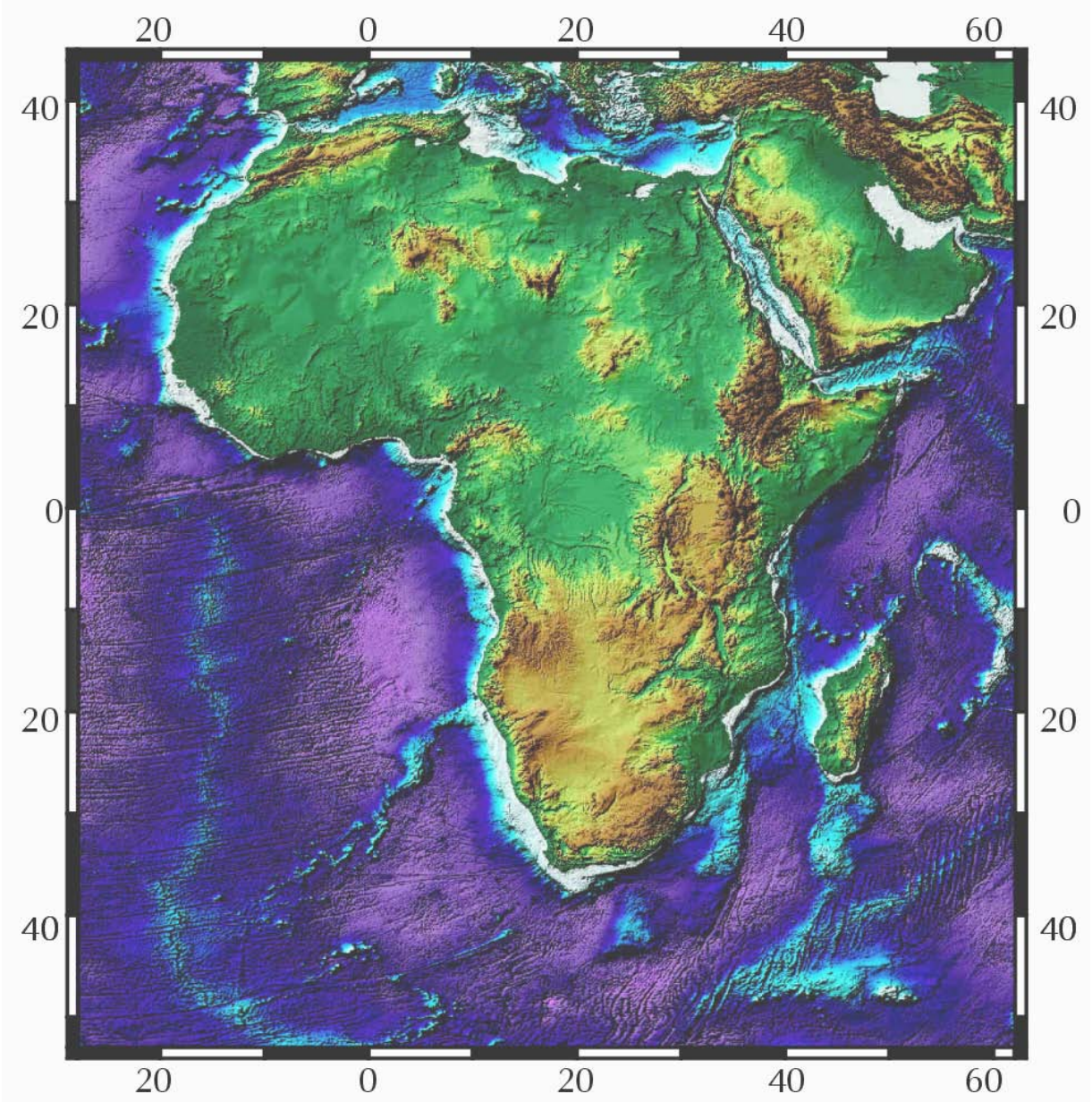

Image courtesy of NOAA and USGS.

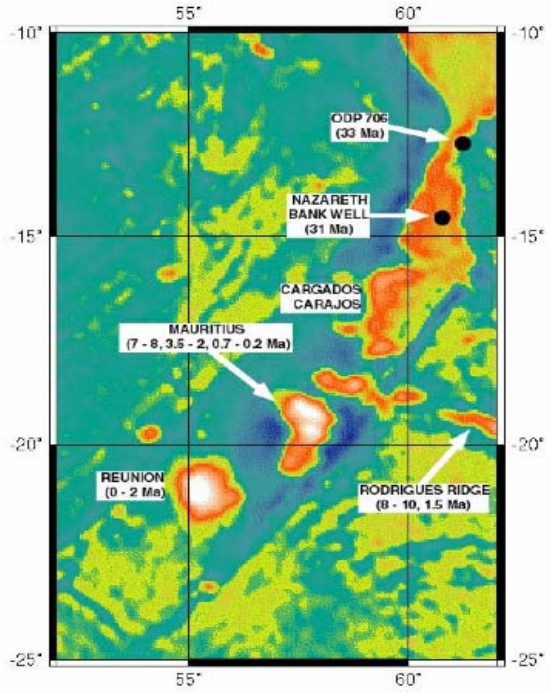

Figure 12 Map based on satellite altimetry showing the positions of the islands of Réunion and Mauritius as well as the Rodrigues Ridge and the carbonate covered Nazareth bank. The bank to the north of Nazareth bank is the Saya de Malha bank and that to the south is the Cargados Carajos bank. Réunion is a very young island yielding isotopic ages no older than 2 My. Only if the plume source beneath Réunion has moved independently of the rest of the sub-African plume population for a distance of more than 700 km between 31 Ma and 2 Ma can Réunion be a product of the plume whose products were encountered at the bottom of ODP hole 706 and the Nazareth bank well. Because I feel uncomfortable about one plume out of a population of about forty careening off independently on its own, I prefer the hypothesis that the plume that made the basaltic substrata of the Saya de Malha, Nazareth and Cargados Carajos banks, which was the Deccan trap source plume, died at about 30 Ma when the African Plate came to rest. Mauritius, Rodrigues Ridge, Rodrigues island (which is just off the map to the east) and Réunion are four separate members of the youthful population of African hot spots each of which is underlain by its own discrete young plume.

124

Reunion not Deccan

Image courtesy of The Geological Society of South Africa.

Deccan plume hotspot track died at Nazareth bank/CC 31 Ma.
Reunion, Mauritius and Rodrigues ridge volcanics are typical African plate style hotspot products showing no progression in age.
Background green bathymetry is from Early Cenozoic fracture zones unrelated to hotspot volcanism.

DOES THE PATTERN OF IGNEOUS ACTIVITY ON THE AFRICAN PLATE TELL MUCH ABOUT THE MANTLE CONVECTION PATTERN BELOW ?

DEEP: AT CMB LIPS COME ONLY FROM EDGES OF LLVPS

AT SHALLOW DEPTHS: THERE ARE A LOT OF CLUES BUT THE MESSAGE HAS HARDLY BEGUN TO BE READ

Location of Afar plume on the edge of the African LLVP

A large fraction of the shear wave velocity variatic
CMB is concentrated close to the edges of the tw
Velocity Provinces (LLVPS of Lay 2005) .
Plumes generating and hotspots have risen from
CMB at those edges.

No volcanoes on cratons.

There are swells
but
lithosphere is too thick
for base
(even
where
elevated
under a swell) to cross
basalt solidus

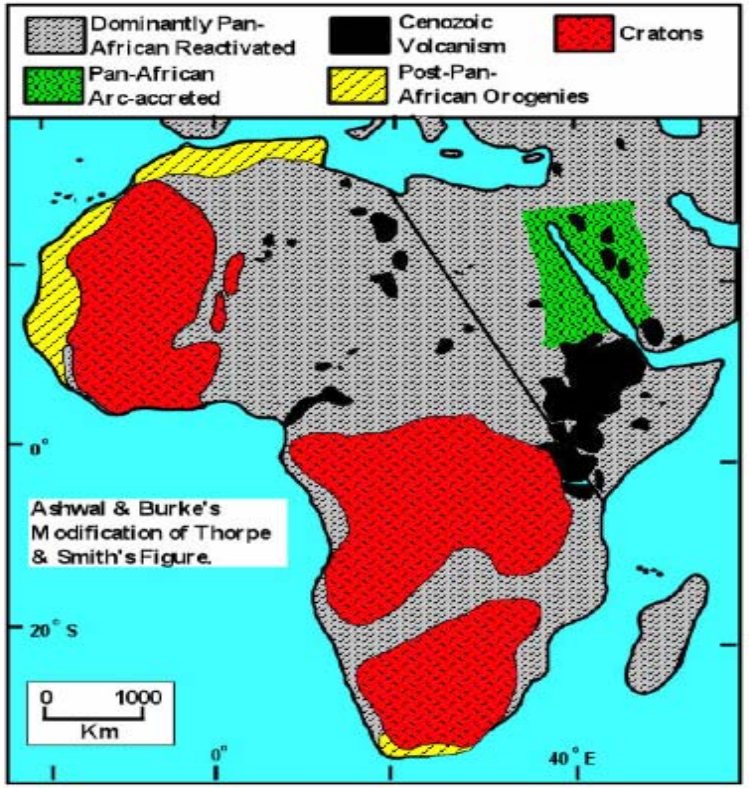

Figure 21 Map illustrating that the 30 Ma and younger volcanic areas of Africa are strongly concentrated in areas involved in Pan-African tectonism. This sketch does not adequately show that in the northern third of the western rift of the East African Rift System volcanism occurs in areas of older cratonic rock. Redrawn from Ashwal & Burke (1989) who based their map largely on Thorpe & Smith (1974).

Image courtesy of The Geological Society of South Africa.

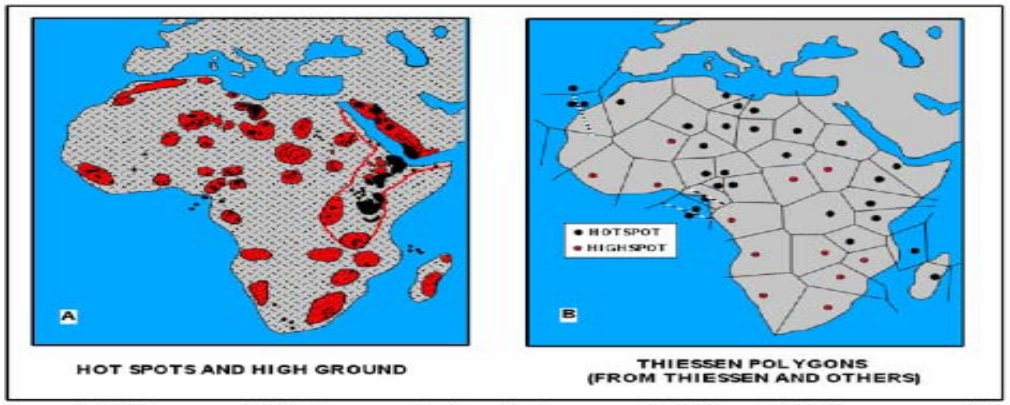

Figure 23 R. Thiessen *et al.* (1979) constructed polygons in the manner of A. Thiessen (1911) in an attempt to look for regularity in the separation of hot spots and high spots (crests of swells without volcanic rocks) on the African continent.

An attempt to see if crests of swells are regularly spaced

Image courtesy of The Geological Society of South Africa.

Thiessen's spacing results for

Hotspots And Highspots

A possibly Relevant Model Richter & Parsons (1975)

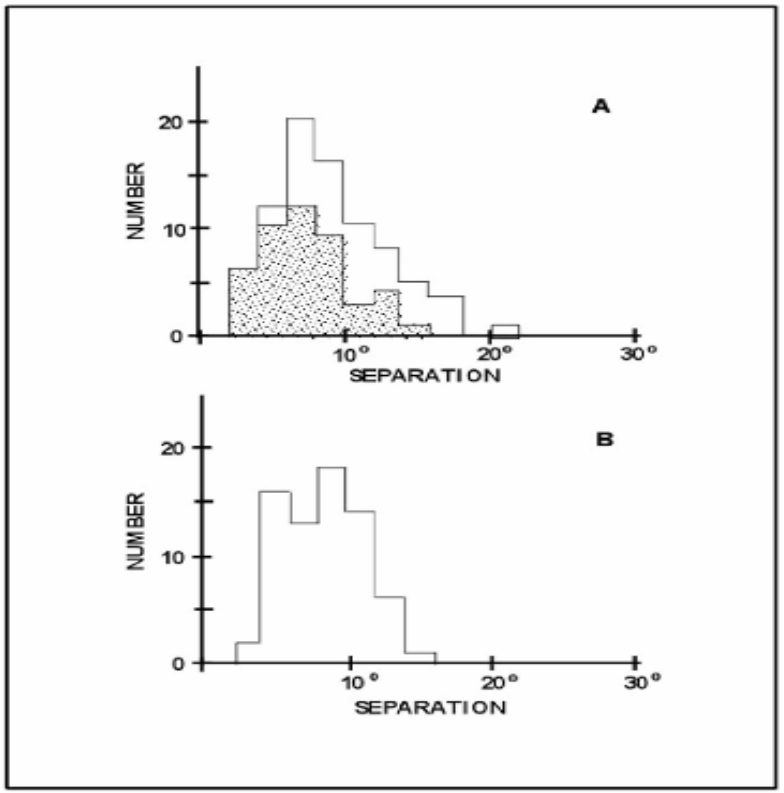

Figure 24 **(A)** Histograms generated by R. Thiessen *et al.* (1979) showing the separation of hot spots (open columns) and high spots (stippled columns) on the African continent. Separation is shown in units of degrees of arc or ~111 km. **(B)** For comparison, the separation of rising plumes in the mechanical model of Richter & Parsons (1975) is shown scaled to a 500 km thick convecting layer. Assuming an average of ~150 km for the thickness of the lithosphere, this value corresponds roughly to the depth from the surface to the base of the transition zone.

137

Image courtesy of The Geological Society of South Africa.

Intermittent igneous activity in small areas (~ 300 km diameter) shows that the African plate has not moved with respect to the underlying mantle convection pattern for ca.30 My. Four of many areas selected.Sites of rising plumes discerned ?

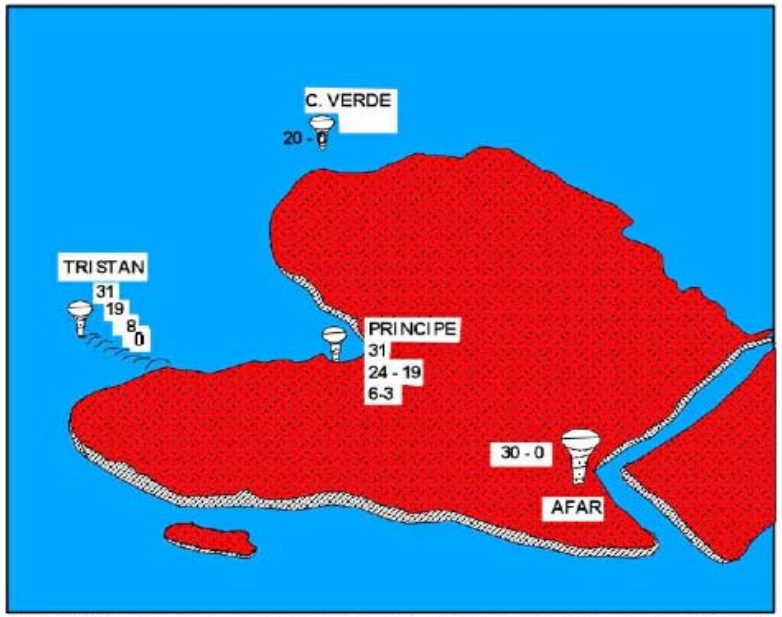

Figure 7 Oblique view of Africa showing it as screwed down. Episodic volcanic activity at the same place has been recorded for several areas on the African Plate through the past 20 to 30 My. This I interpret as showing: (1) that the African Plate has not moved with respect to underlying plumes which are the source of that volcanism, and (2) that those plumes have not moved with respect to each other over that interval.

119

Image courtesy of The Geological Society of South Africa.

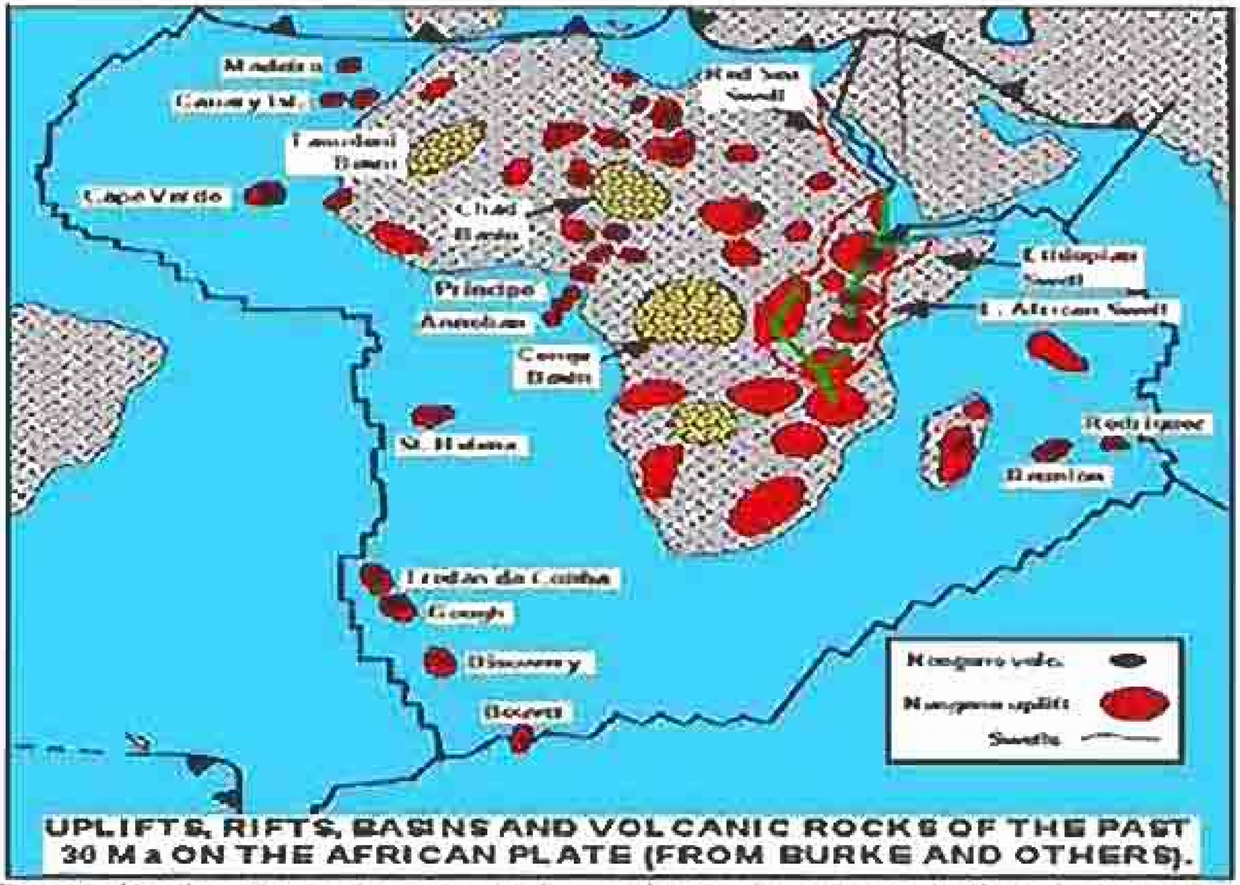

Figure 6. Map illustrating the distribution of volcanic rocks erupted over the past 30 Ma on the African Plate. Swells are enclosed by dashed lines. Note that much but by no means all of the volcanic activity occupies the crests of topographic or basement swells. The locations of four interior basins bounded by swells are indicated. From a figure drawn by Bill Kidd (figure 6.2.1) in *Basaltic Volcanism on the Terrestrial Planets* (1981).

THE CAMEROON LINE

A SET OF 10 SMALL(d~ 100 km)
VOLCANO-CAPPED SWELLS
HALF ON CONTINENT AND
HALF ON OCEAN FLOOR

Cameroon Line

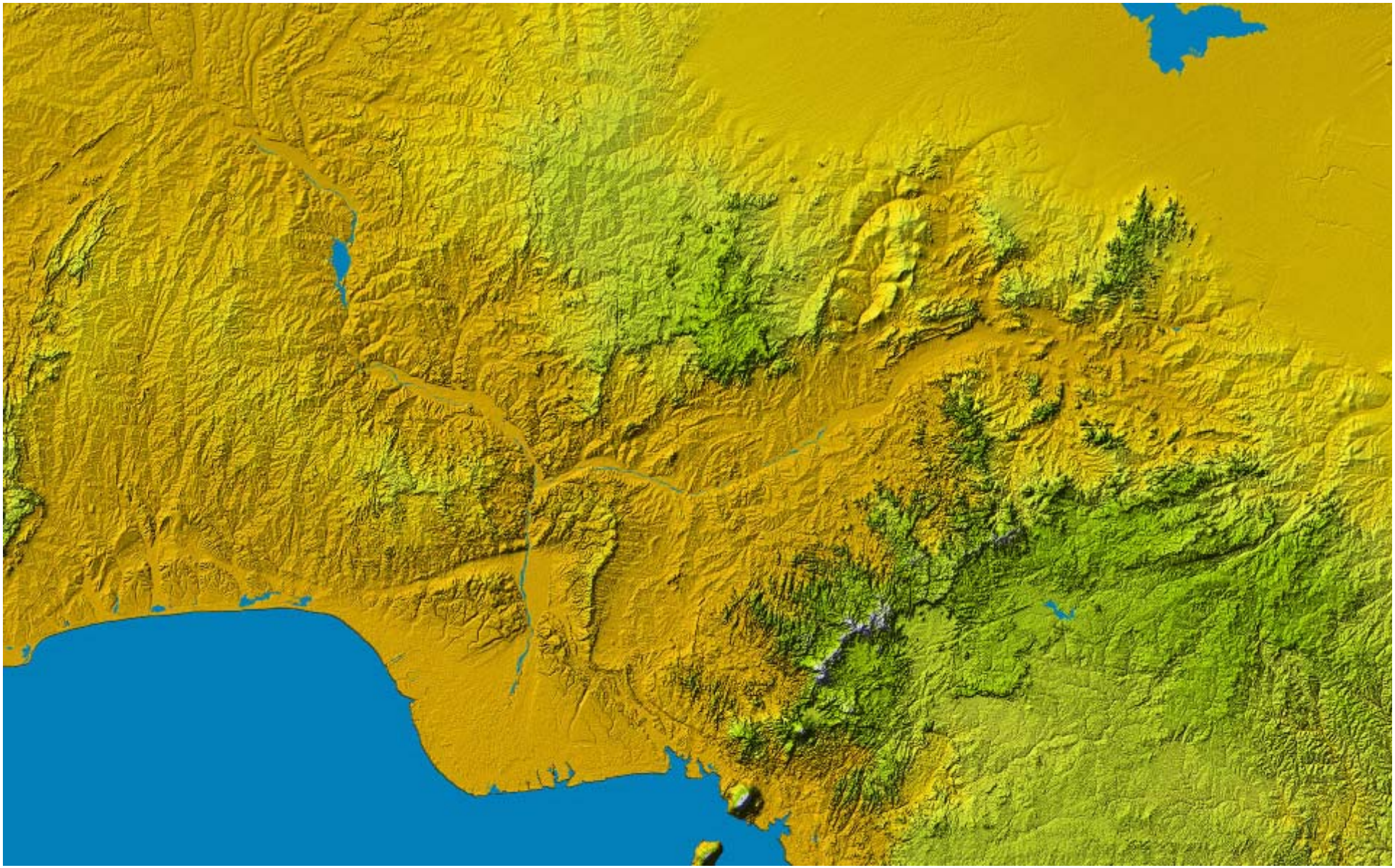

Image courtesy of NOAA and USGS.