

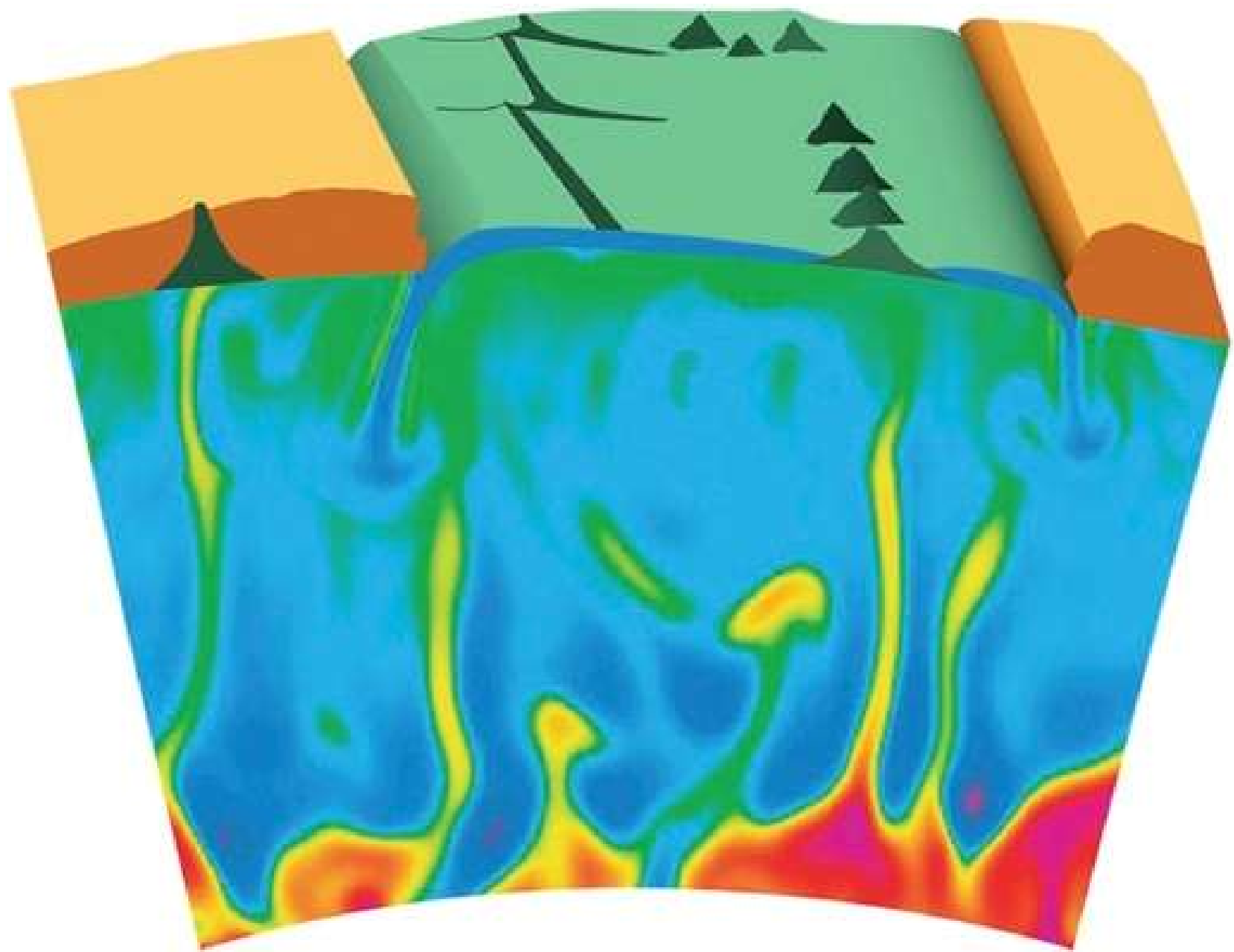
MANTLE PLUMES: FABLE FACT OR FICTION?

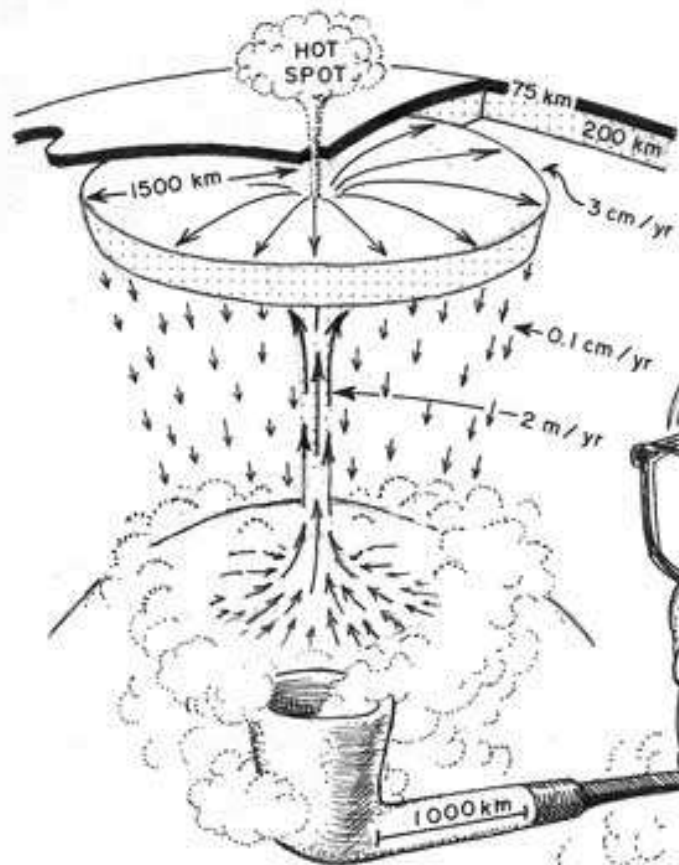
Andy Moore & Tom Blenkinsop
& Roger Key & Wolfgang Maier

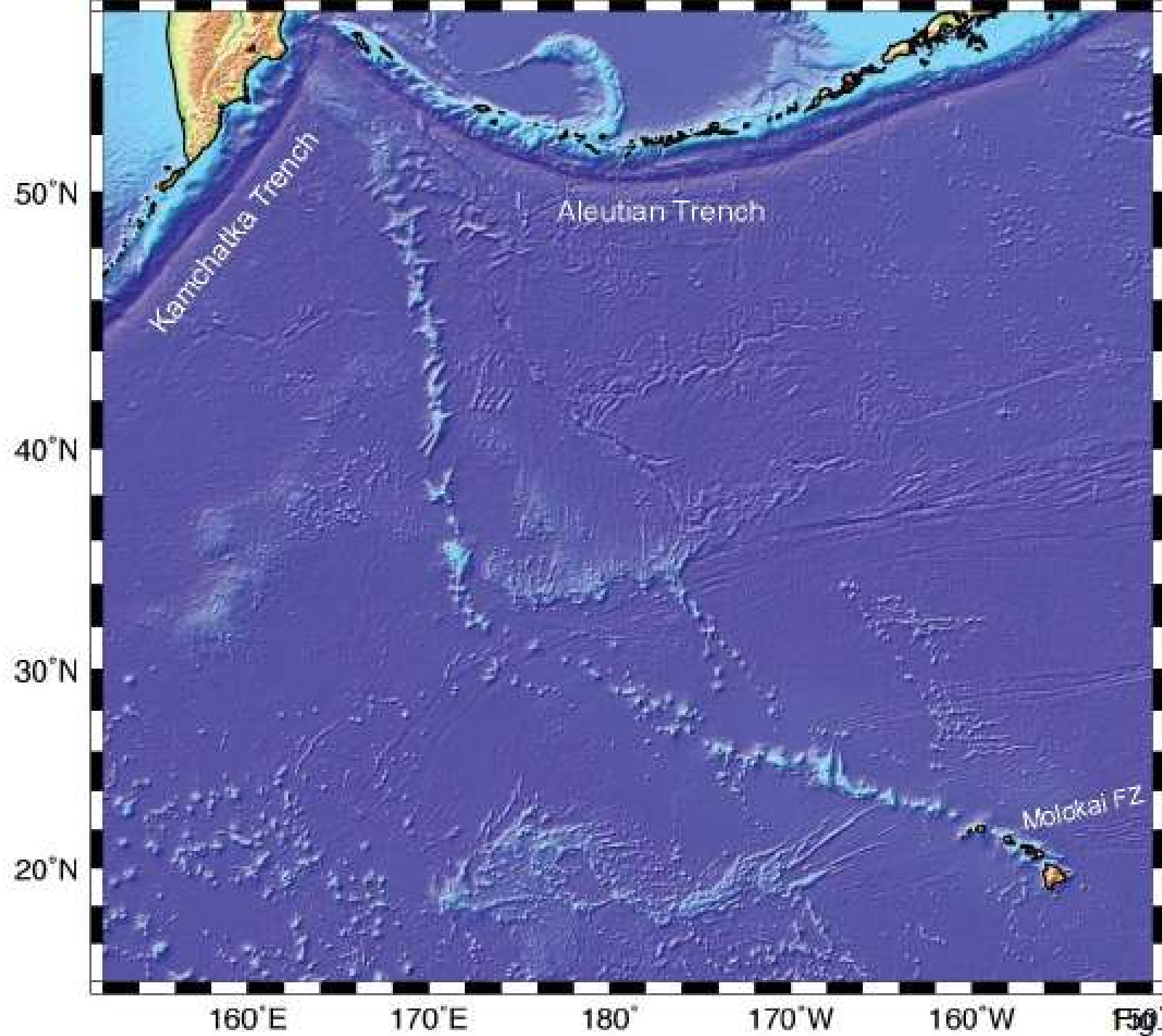
PLUME MODEL



Hot
Relative
Velocities







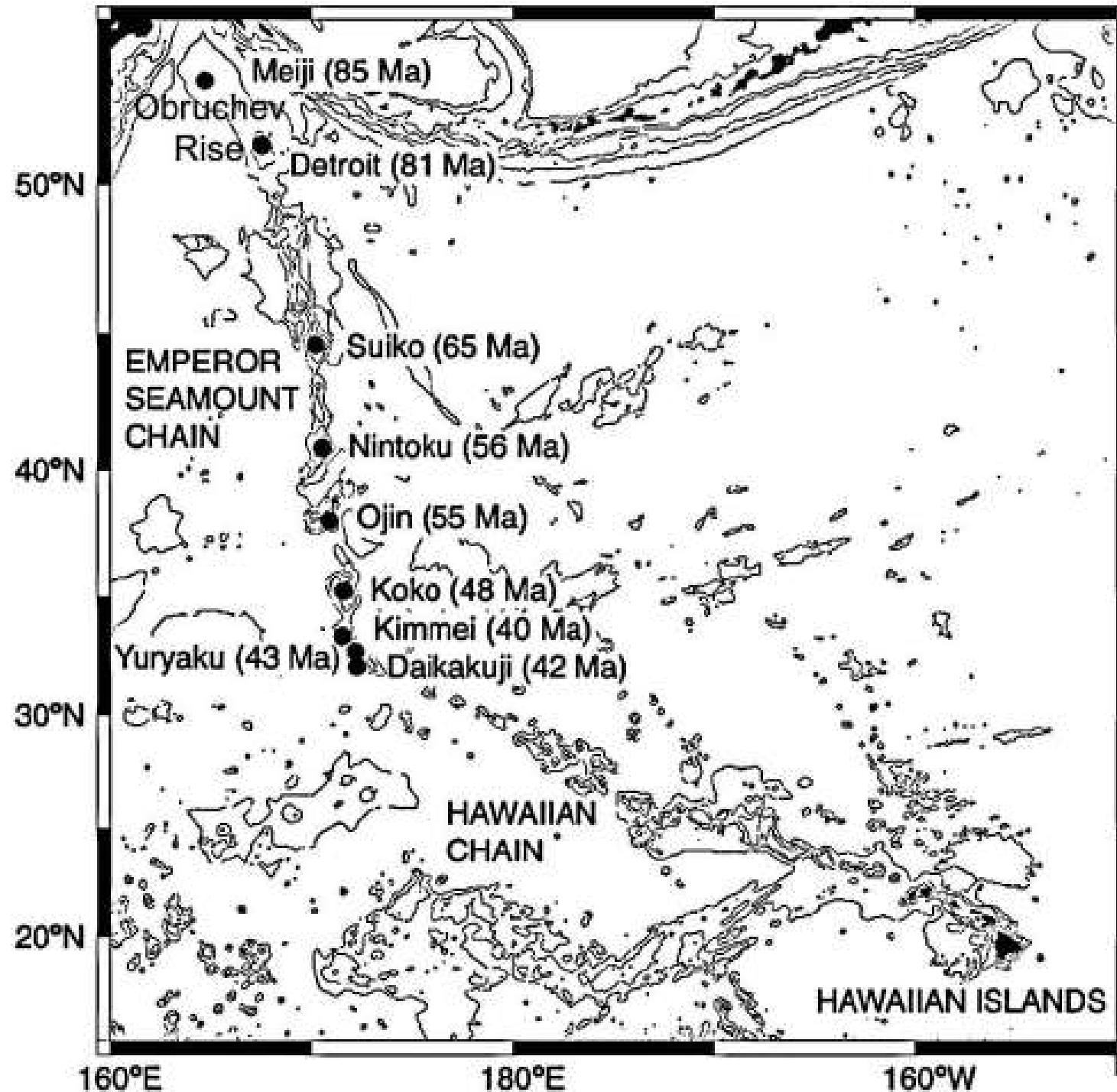


Fig. 2.13

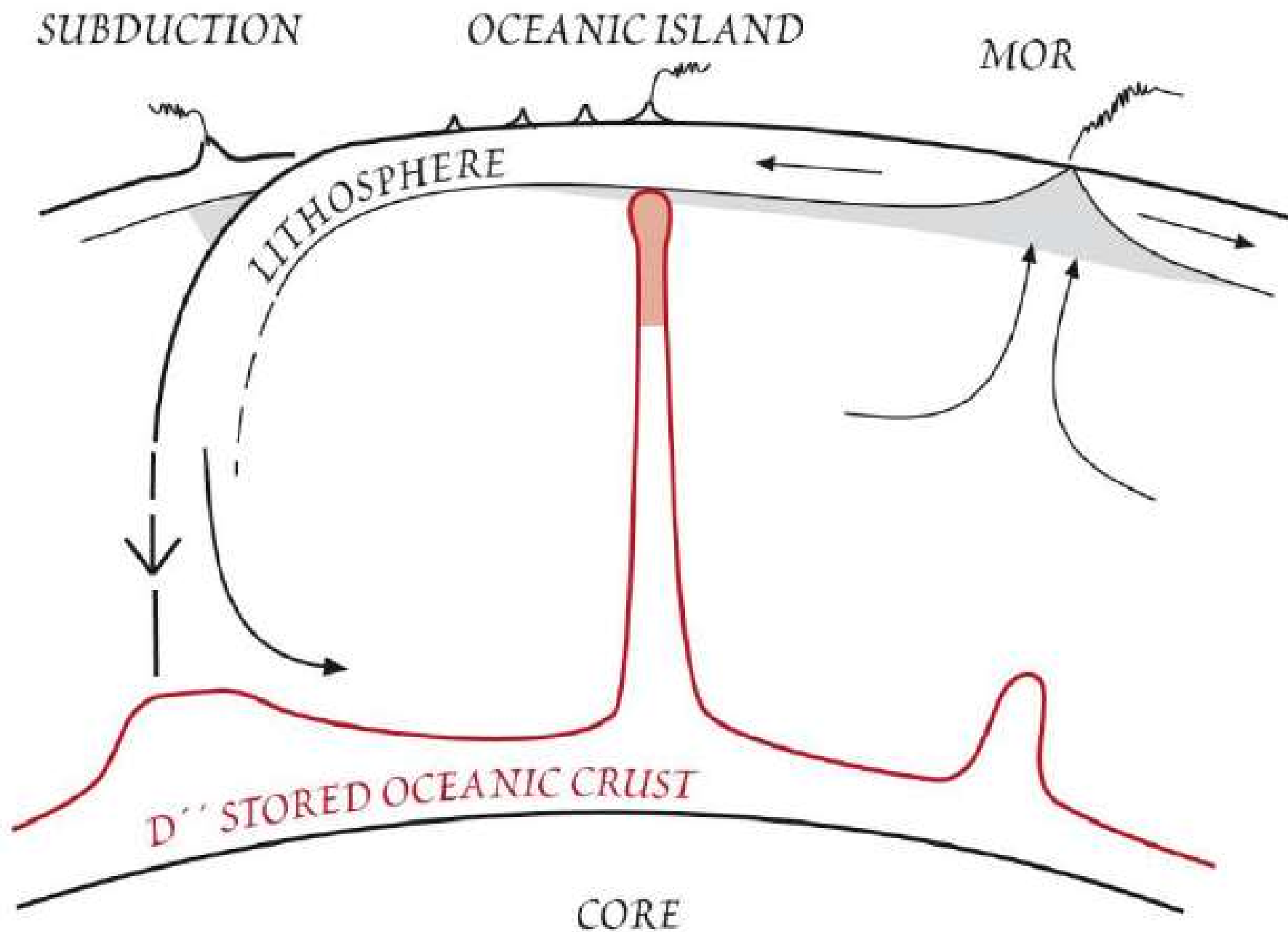


Fig. 7.13

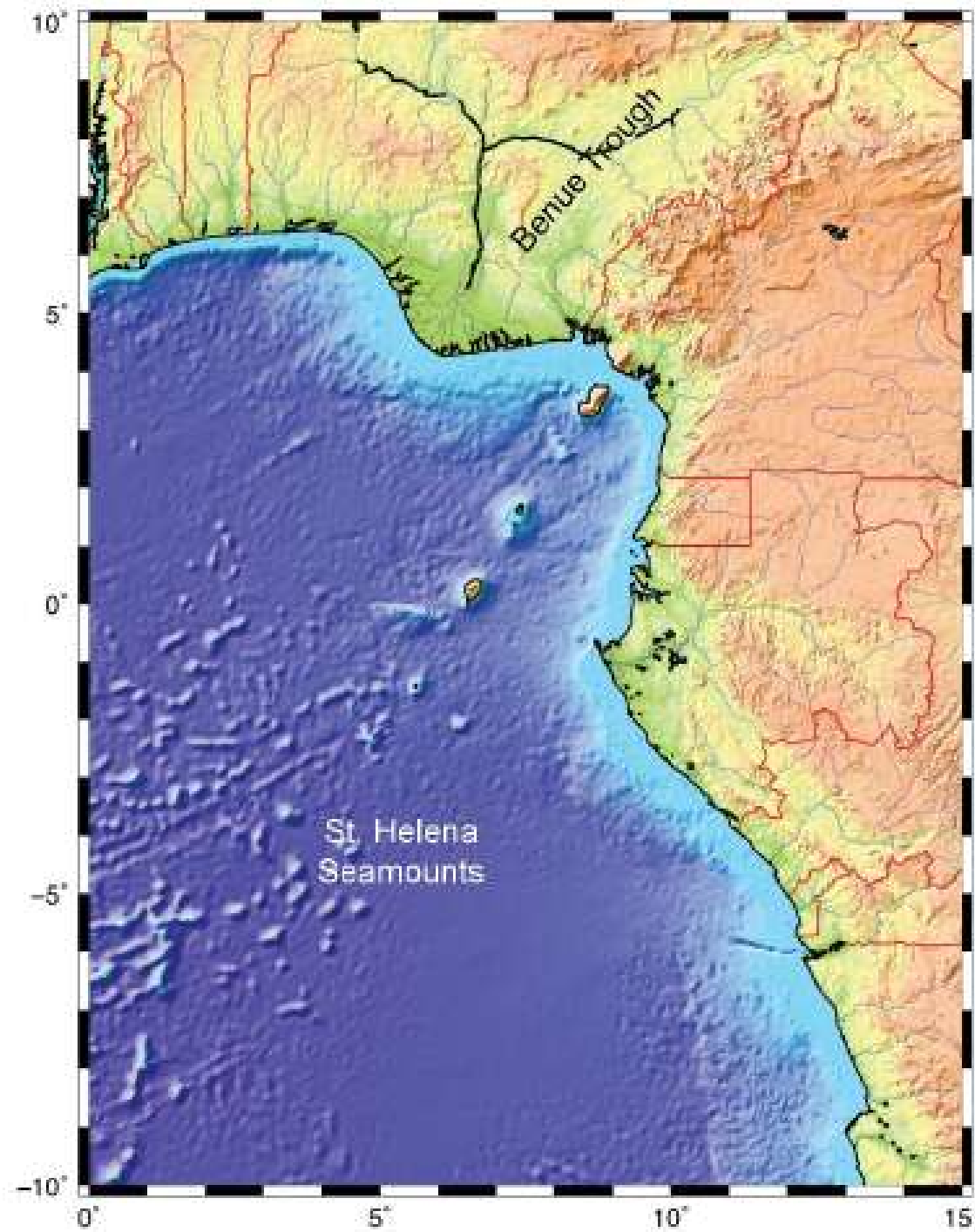
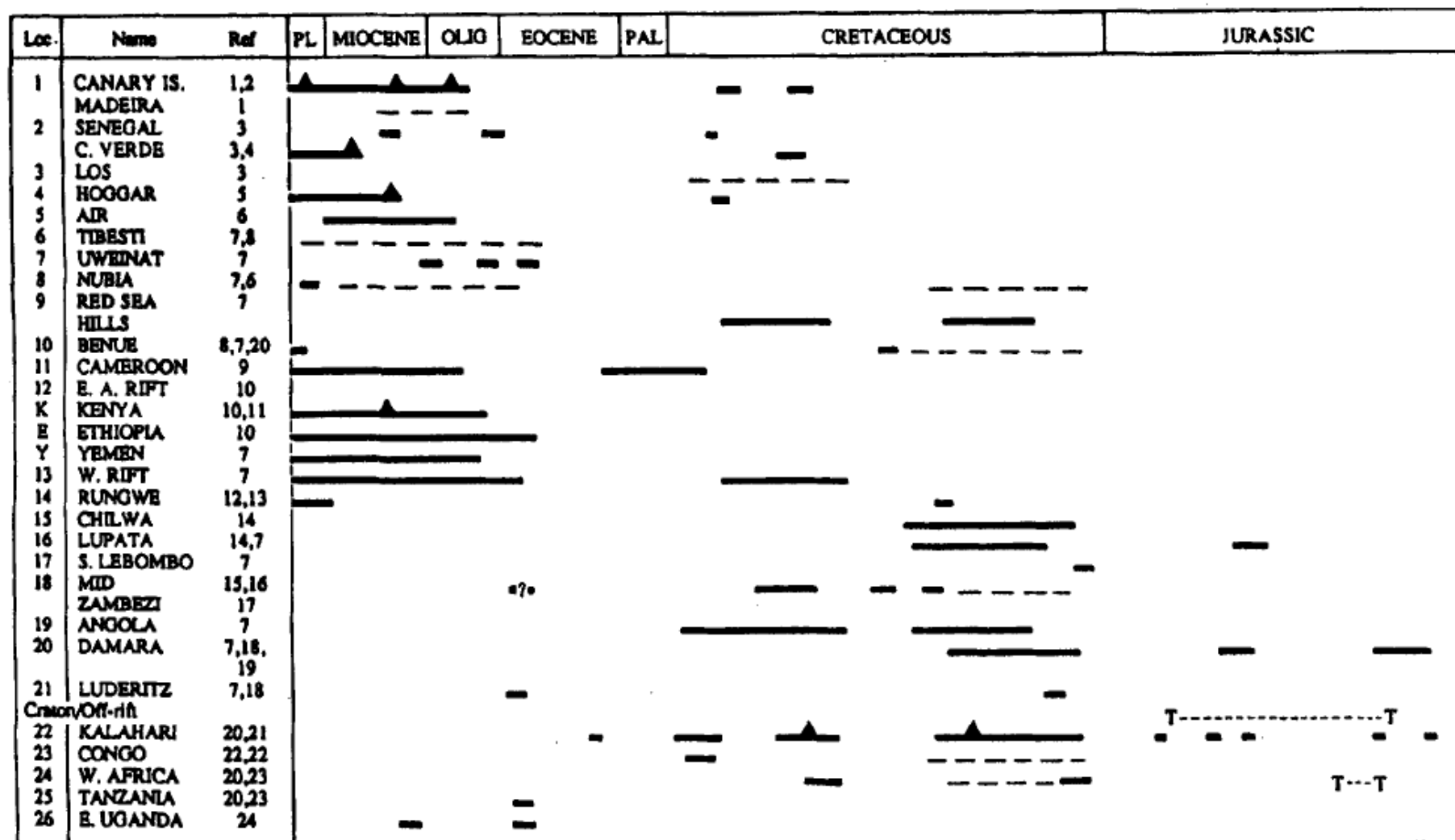
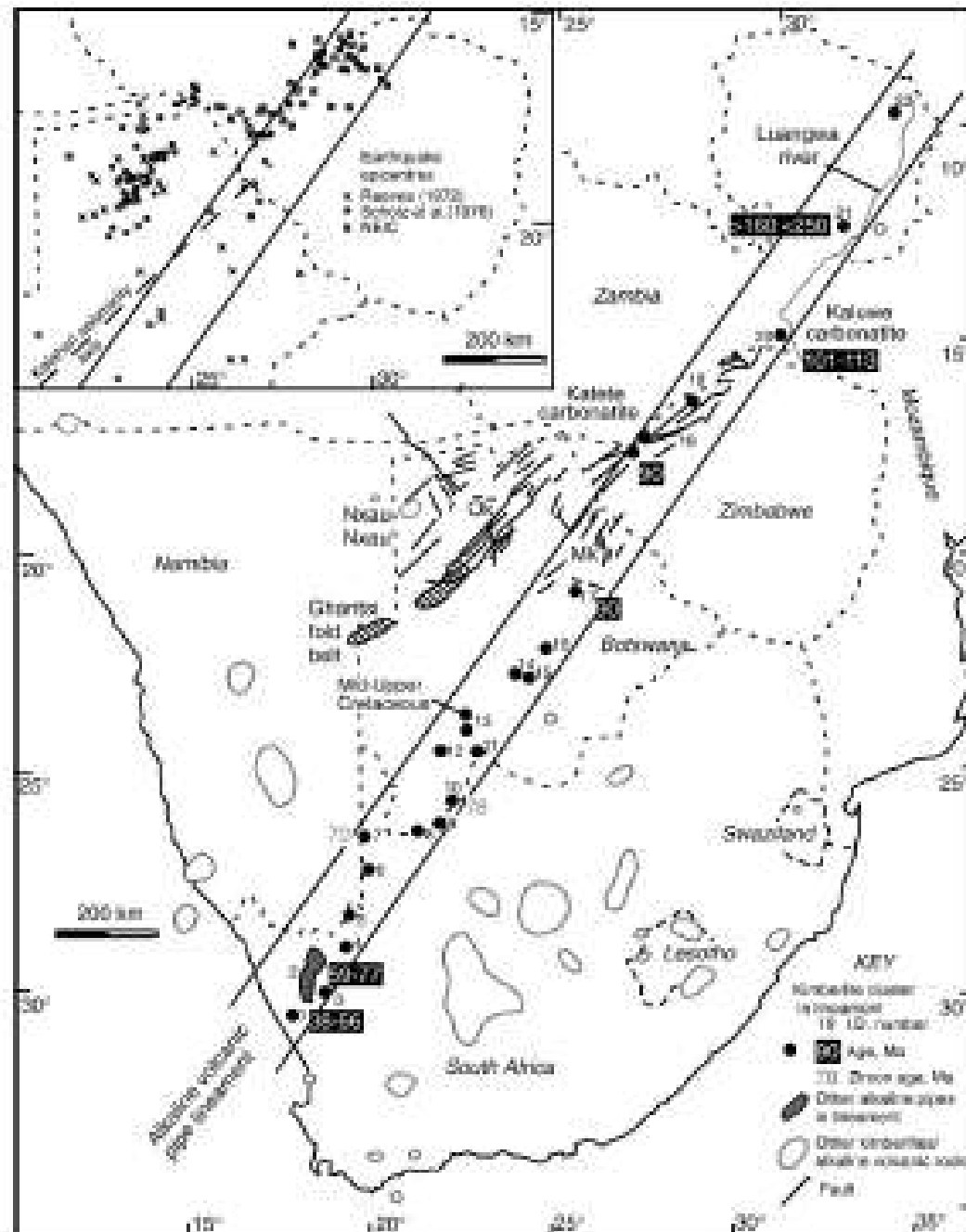


Fig. 2.11

EPISODIC ALKALINE MAGMATISM IN AFRICA

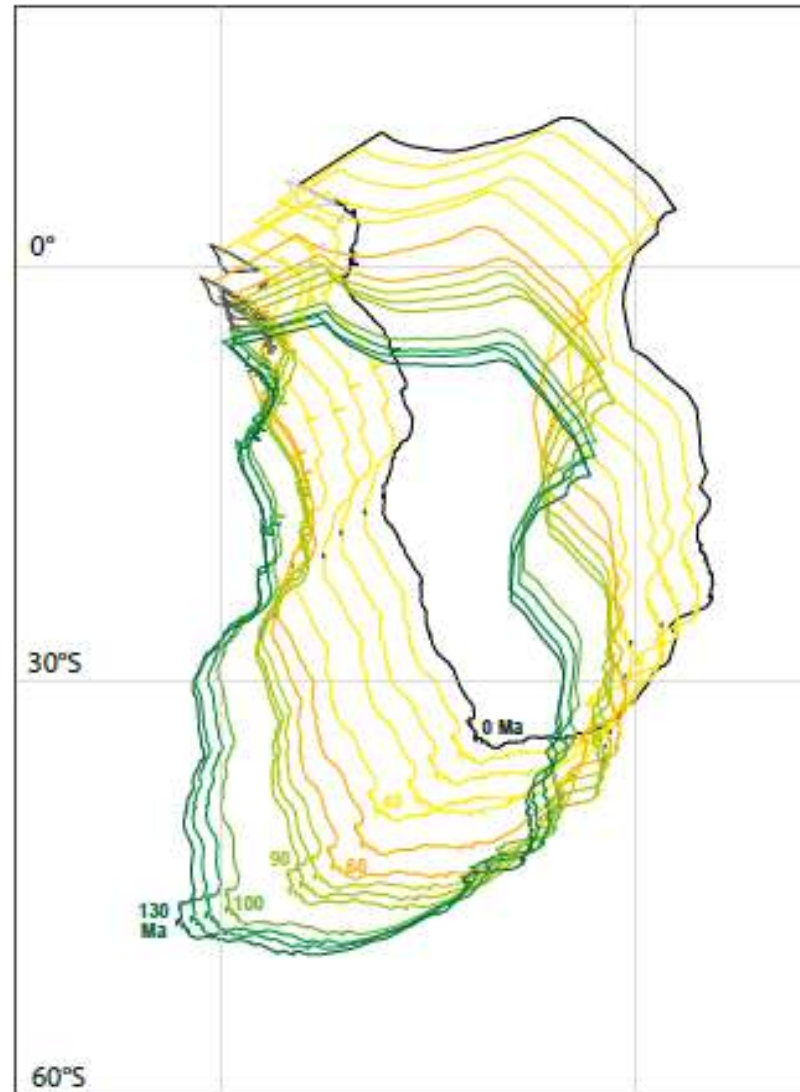
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SOUTHERN AFRICA HORIZONTAL MOVEMENT

(GPlates data)



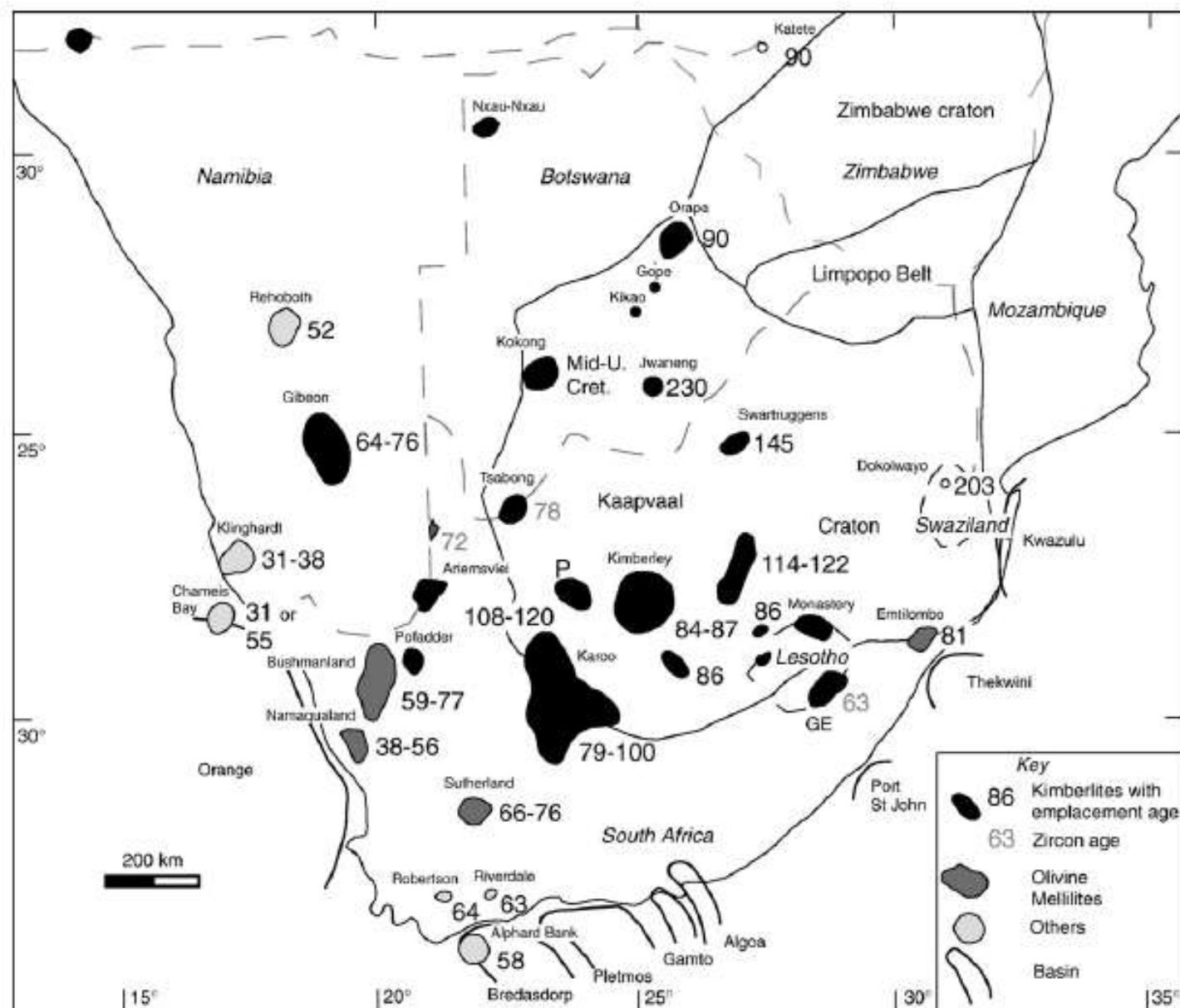
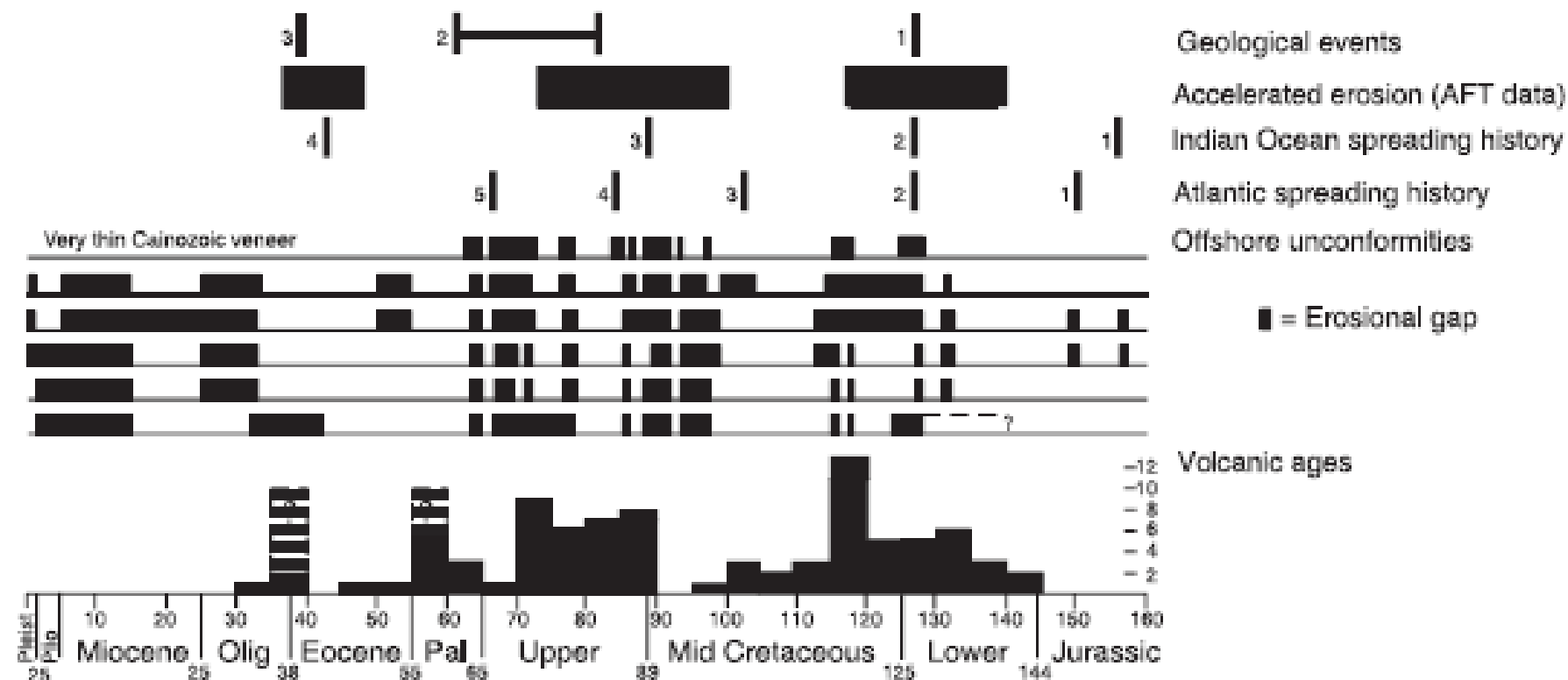
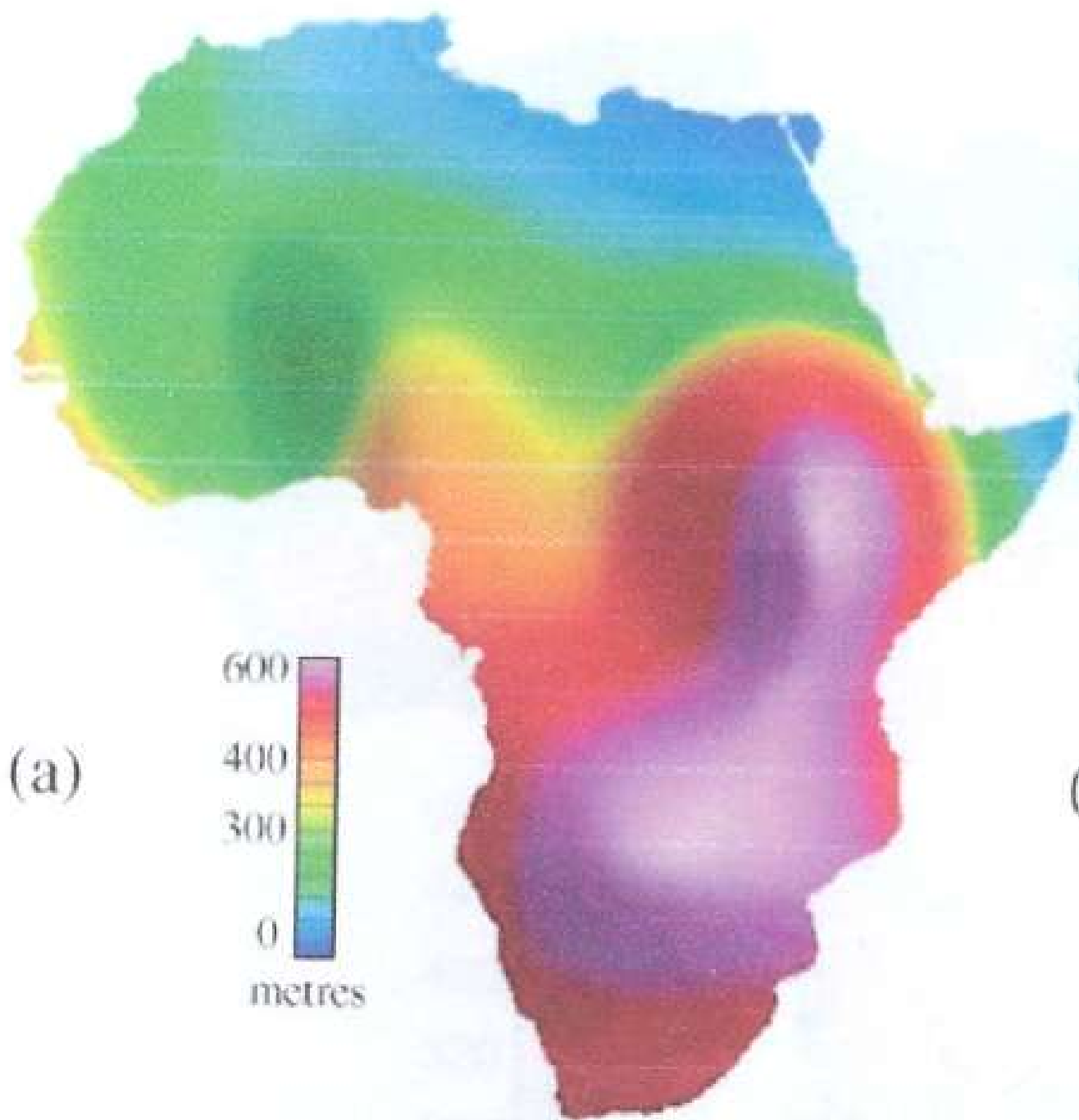
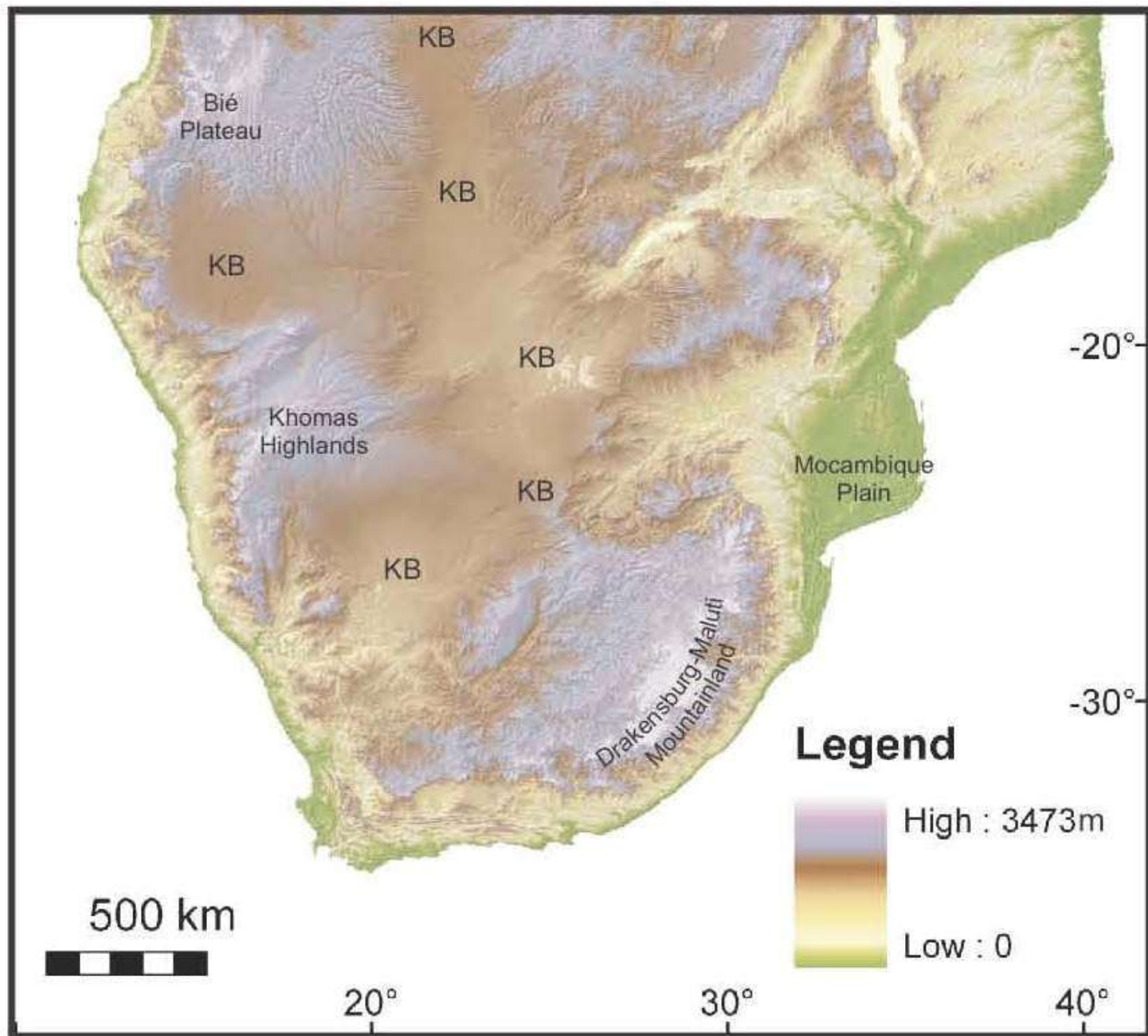


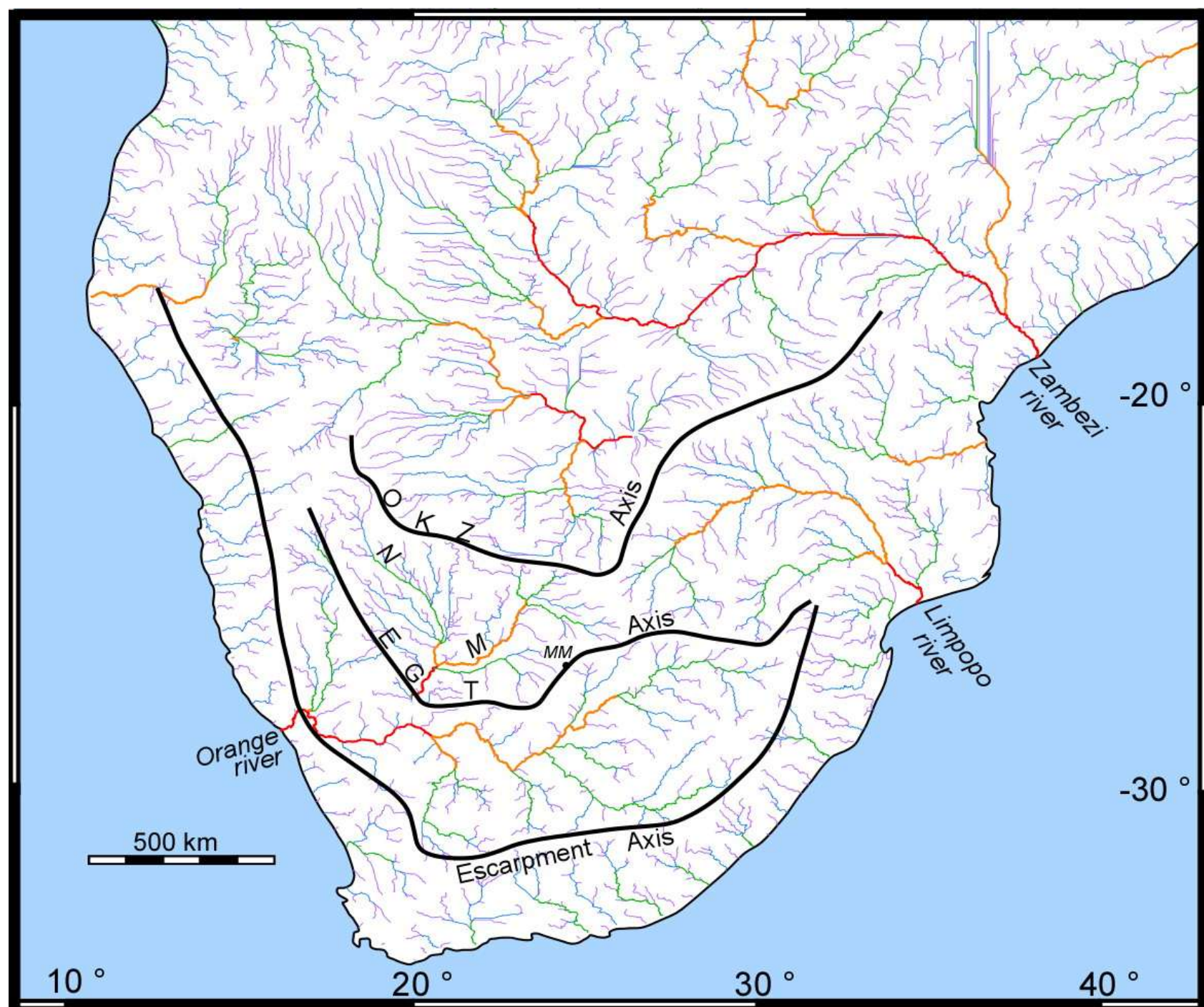
Fig. 3. Distribution, and representative ages of alkaline volcanic pipes in southern Africa. While zircon ages have been included where other data are unavailable, these only provide an upper limit on the timing of emplacement, as discussed in the text.



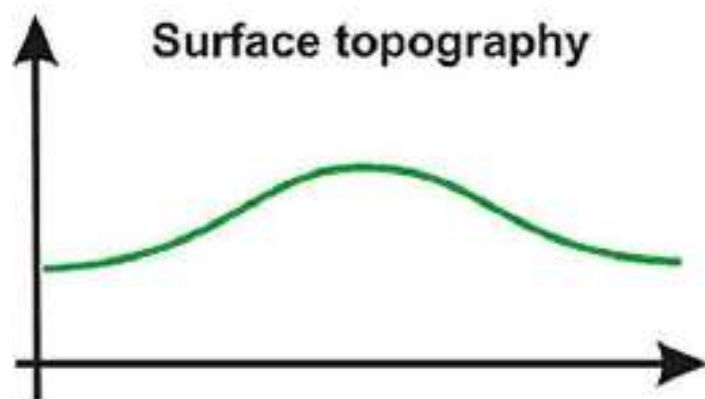








a) Newtonian plume and
a mono-layer
Newtonian lithosphere



b) Non-Newtonian plume and
a multi-layer
brittle-elastic-ductile lithosphere

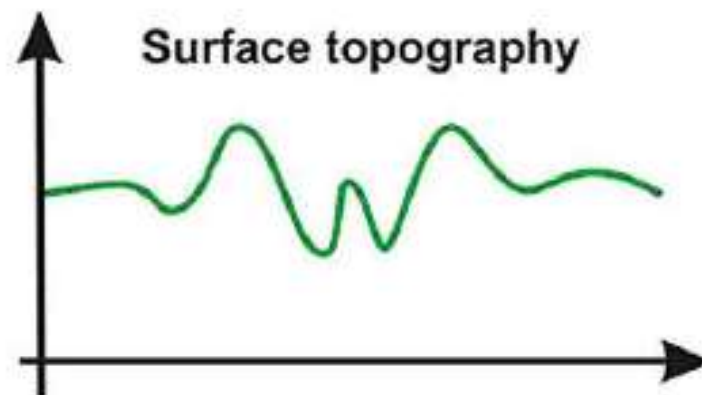
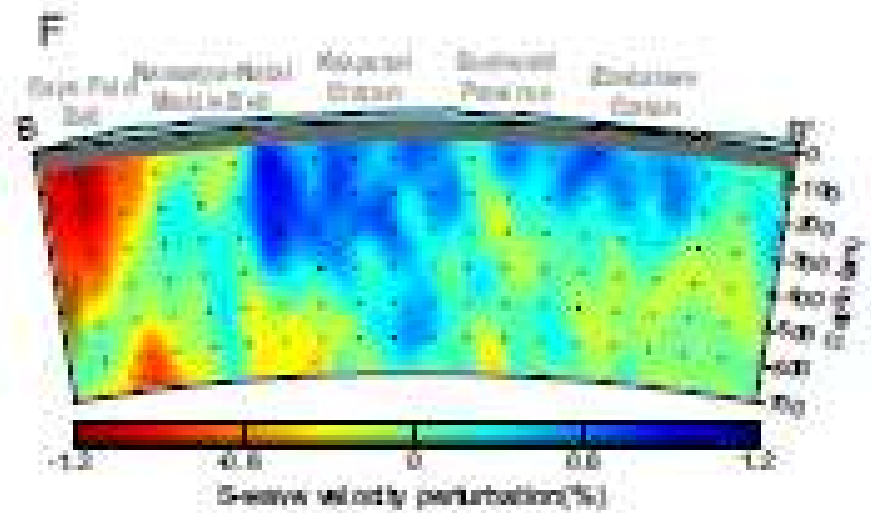
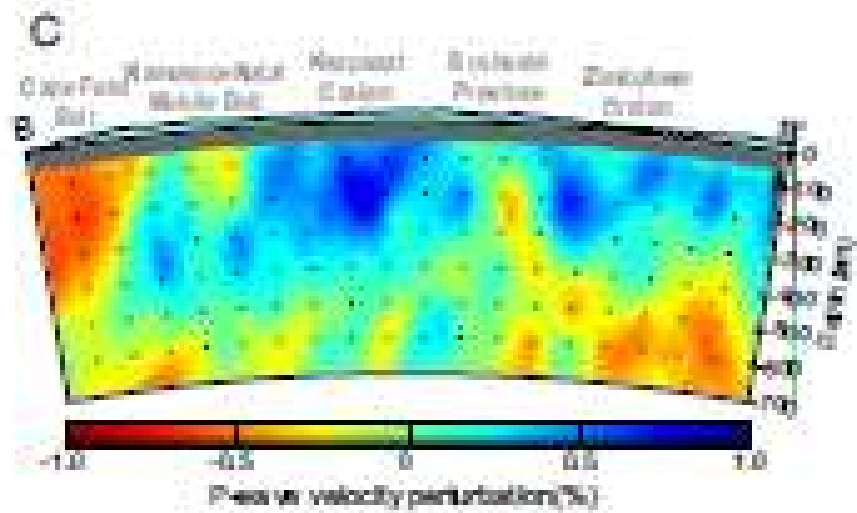


Fig. 2.24



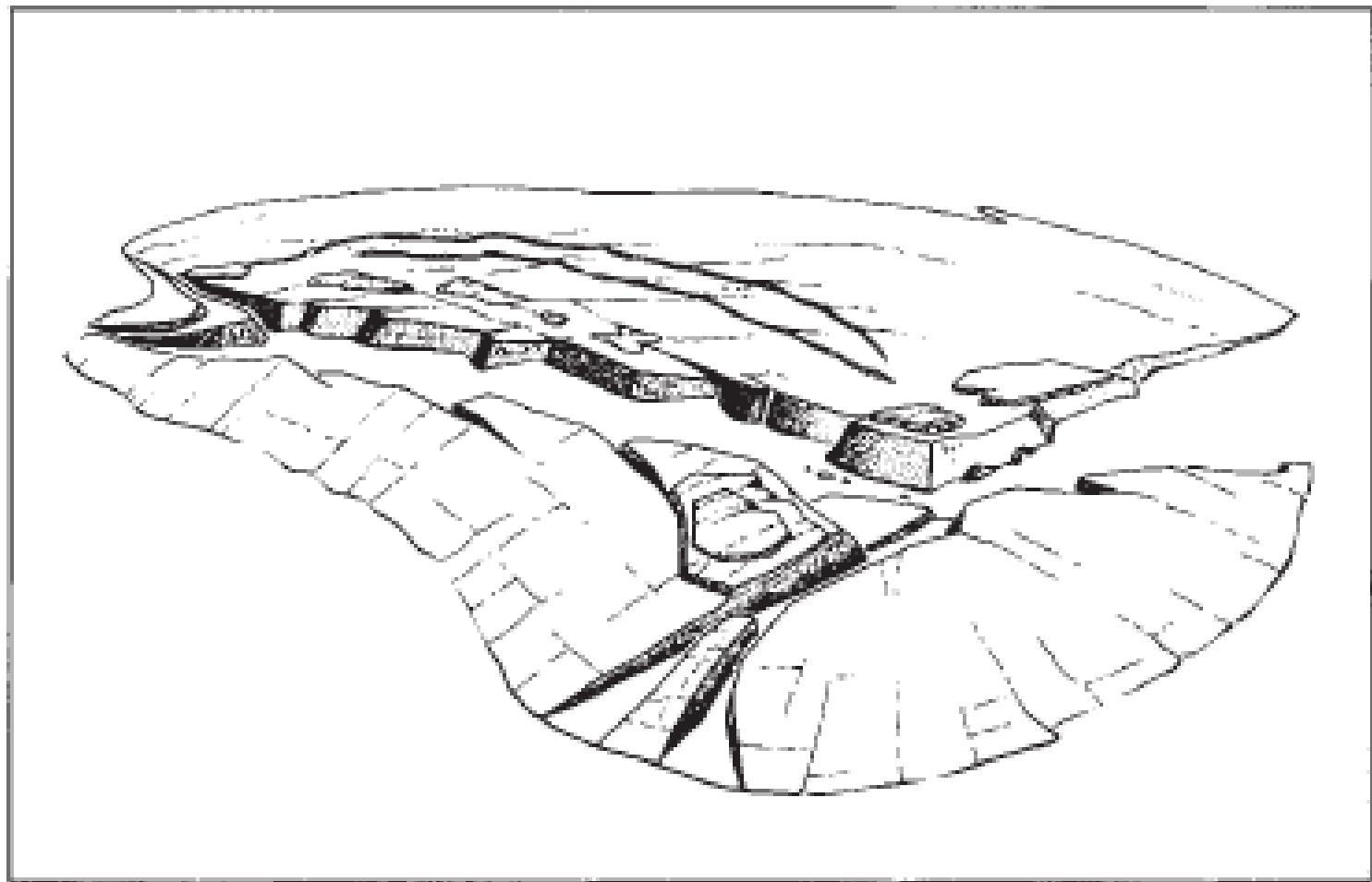


FIG. 1 The Afro-Arabian dome, redrawn from ref. 5. The view is from the south with Africa in the foreground, separated from Arabia by the Red Sea (left) and the Gulf of Aden. The Ethiopian rift system cuts the African side of the dome in the foreground. If the drawing is turned upside down a remarkable similarity is observed between the African side and the morphology of peninsular India (Fig. 2), with the Ethiopian rift playing the part of the Narmada and Tapti rifts.

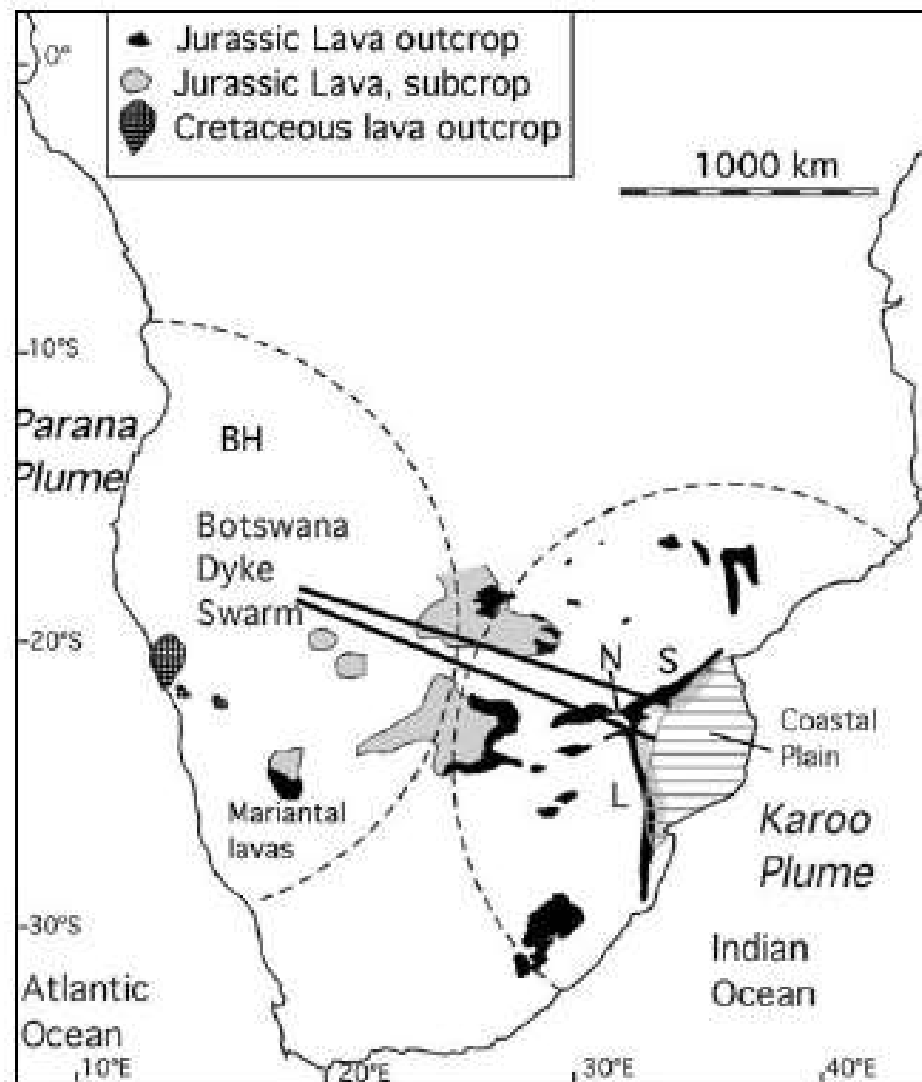


Figure 2. Location of outcrops and sub-outcrops of Karoo and Cretaceous lavas in southern Africa, and of the Botswana dyke swarm. Dashed lines show inferred extents of the Karoo and Paraná plume heads (White and McKenzie, 1989; Cox, 1989). L = Lebombo monocline; S = Sabi monocline; N = Nuanetsi; BH - Bié highlands.

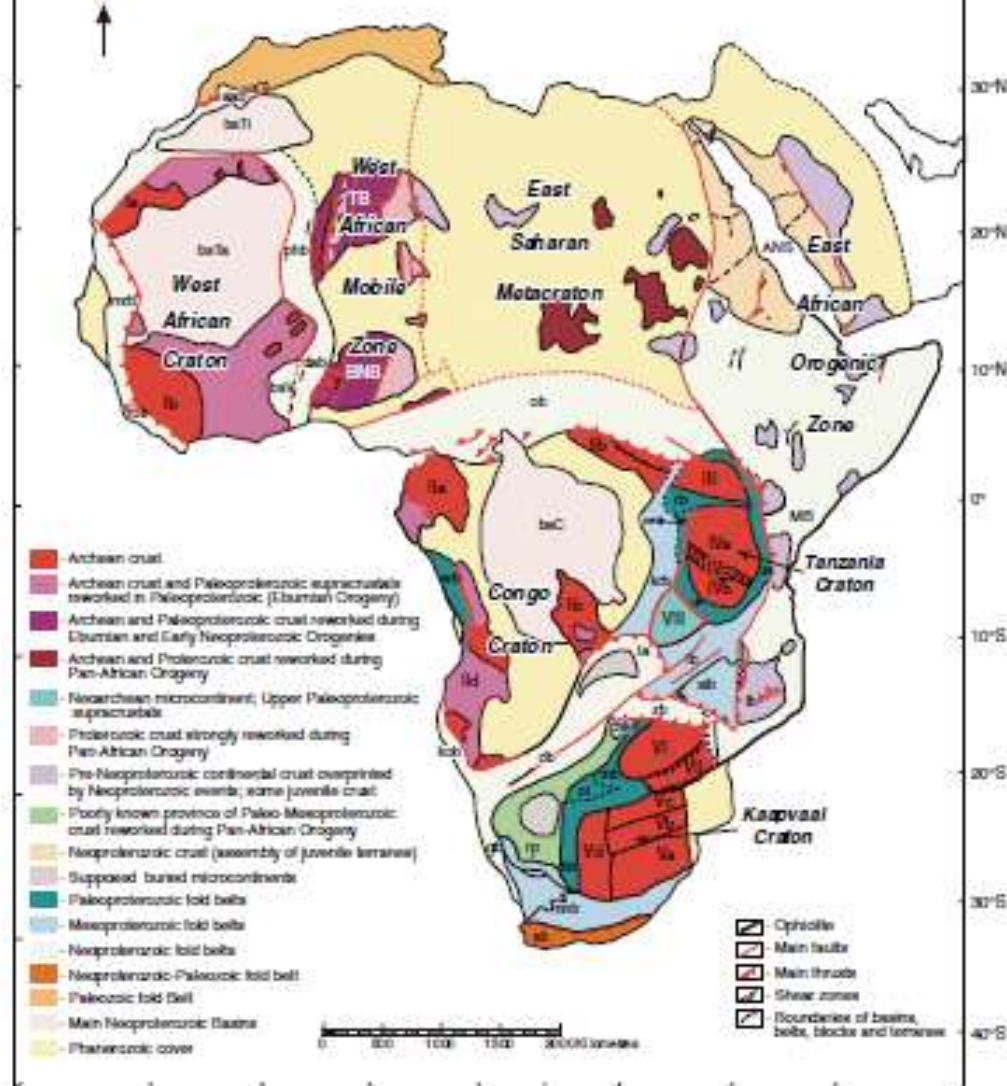
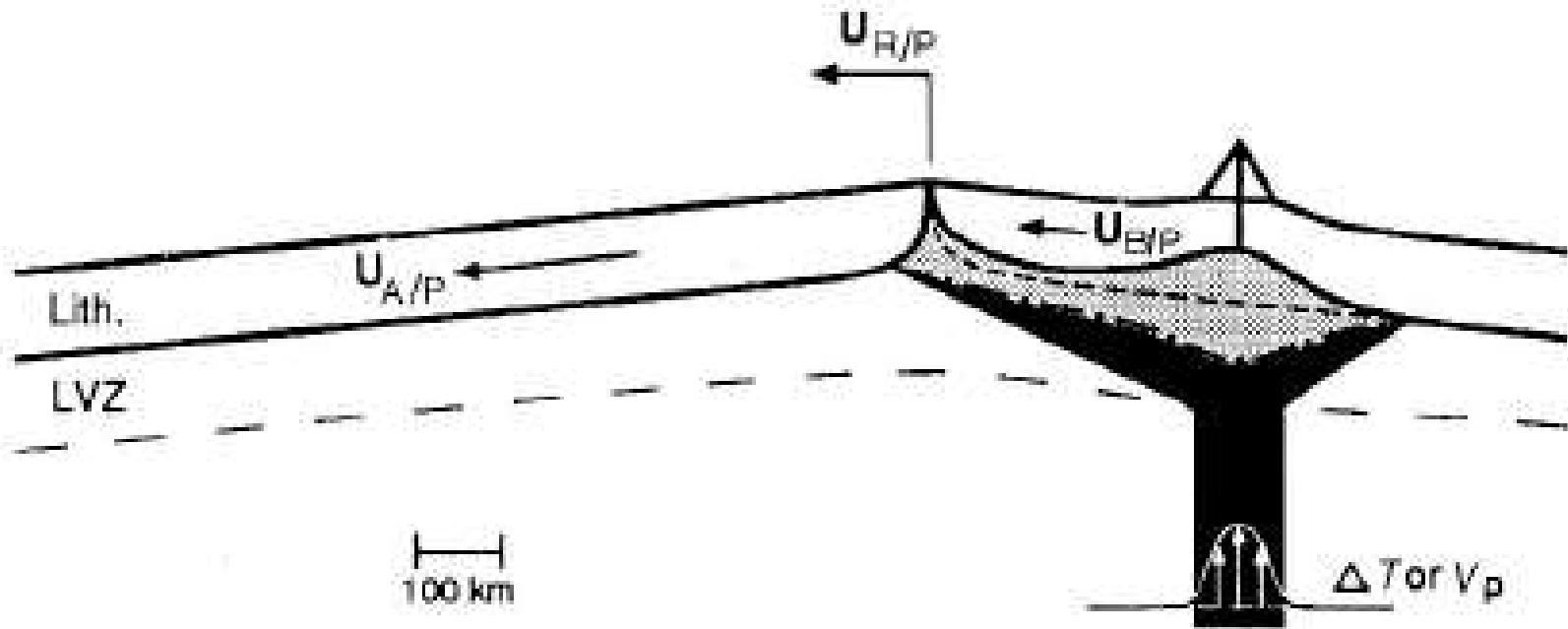


Figure 1. Map of the bedrock geology of Africa, outlining the major subdivisions of the crust discussed in the text. **Cratons and Microcontinents:** West African Craton (Ia—Reguibat Shield; Ib—Man-Léon Shield); Congo Craton (IIa—Gabon-Kamerun Shield; IIb—Boma-Kibali Shield; IIc—Kasai Shield; IId—Angolan Shield); Ugandan Craton—III; Tanzanian Craton (IVa—Northern Terrane; IVb—Southern Terrane; IVc—Dodoma Zone); Kaapvaal Craton (Va—Southern Terrane; Vb—Central Terrane; Vc—Petersburg Terrane; Vd—Western Terrane); Zimbabwe Craton—VI; Limpopo Block—VII; Bangweilo Block—VIII. **West African Mobile Zone:** TB—Tuareg Block; BNB—Benin-Nigerian Block. **East African Orogenic Zone:** ANS—Arabian-Nubian Shield; MB—Mozambique Orogenic Belt. **Fold Belts:** Paleoproterozoic Belts: ub—Ubandian; us—Usugaran; ru—Ruwendary; kh—Khibi; ok—Okwa Inlier; mb—Magondi; wb—West Central African; nek—North-Eastern Kibaran. **Paleo-Mesoproterozoic Provinces:** rp—Rehoboth. **Mesoproterozoic Belts:** krb—Kibaran; th—Irumide; sb—Southern Irumide; ch—Chomo-Kolomo; nnb—Namaqua-Natal. **Neoproterozoic Belts:** zb—Zambesi; la—Lufilian arc; db—Damaru; kb—Kaoko; gh—Gariep; ob—Ouhanguiides; aab—Anti-Atlas; phb—Pharusian; dab—Dahomeyan; rob—Rockellides; mrb—Mauritanides; lb—Lurio; sb—Saldania. **Neoproterozoic Basins:** bsC—Congo; bsTa—Taoudeni; bsTi—Tindouf; bsV—Volta.

Maybe a channelled plume would
help?!!
(Schilling, 1991 – Nature)



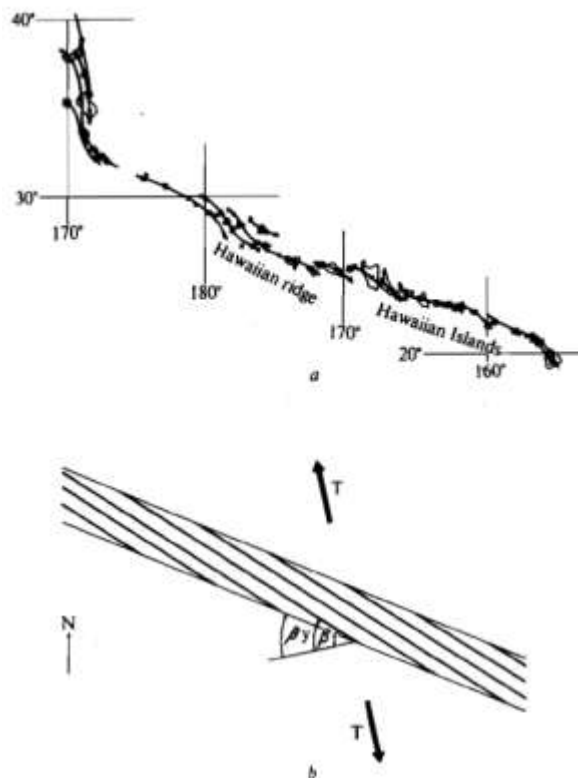


Fig. 1 a, Structure of the Hawaiian Islands after Jackson *et al.*¹². Apparent shield volcanoes (x) seem to lie along en-echelon fractures (—). b, Predicted pattern of plastic yielding at an angle $\beta_y = 35^\circ$ and brittle fractures at an angle $\beta_f = 45^\circ$ due to a tensional stress shown by the vectors T.

tensional stresses that seem to be responsible for the Hawaiian Islands?

Thermal Stresses

The lithosphere is created in the vicinity of an ocean ridge by the cooling of mantle rock. As the lithosphere convects away from the ridge further cooling takes place and its thickness increases. The lower boundary of the lithosphere can be defined as the isotherm T_y ; at temperatures less than T_y , there are no significant deformations of the mantle rock on geological time scales at stresses below the yield stress.

An elastic plate which is cooled non-uniformly is subject to thermal stresses. We consider a lithosphere which is

cooling as it moves away from an ocean ridge. We take the direction parallel to the ridge axis to be the y direction, the direction perpendicular to the ridge axis to be the x direction, and the normal to the surface to be the z direction as shown in Fig. 2. We assume that deformation in the y direction is zero so that the thermal stress is given by¹⁶

$$(\sigma_{yy})_{th} = \alpha E (T_y - T_0) \quad (1)$$

where α is the coefficient of thermal expansion, E is Young's modulus, and T_0 is the temperature to which the plate is cooled. The resultant stress is a tension parallel to the ridge

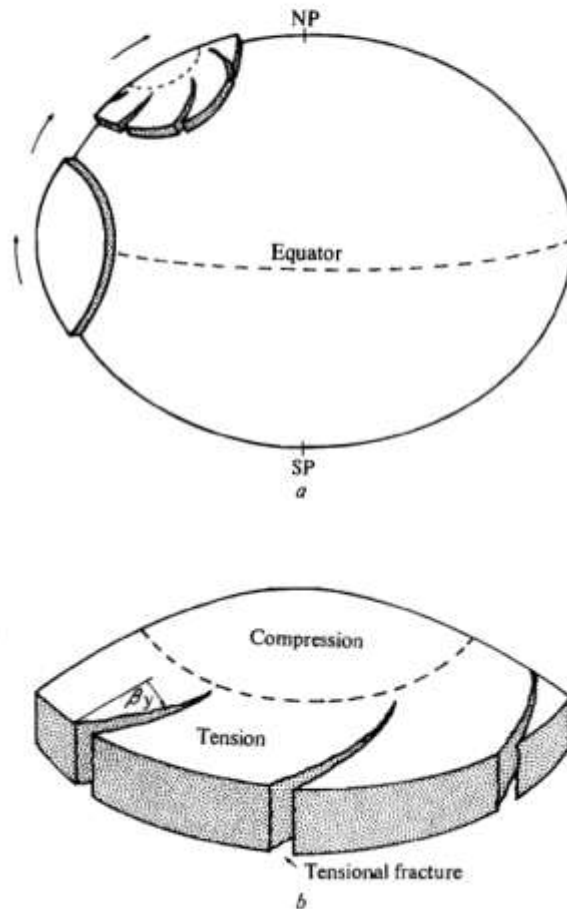
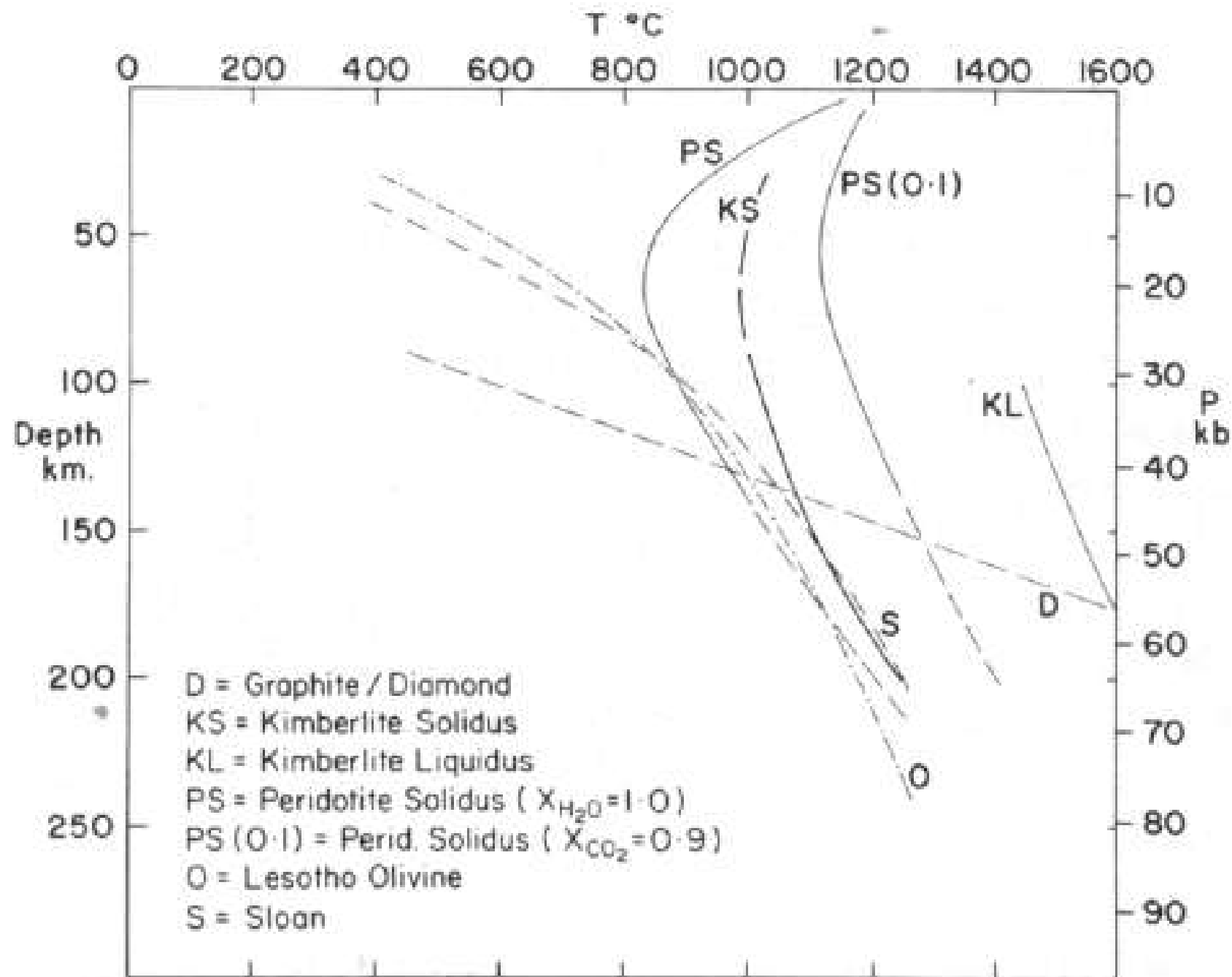


Fig. 3 Illustration of fractures due to non-spherical plate tectonics. a, Movement of a plate northwards from the equator showing edge fractures due to an increase in radii of curvature. b, Distribution of stresses and fractures due to an increase in radii of curvature in a circular plate.





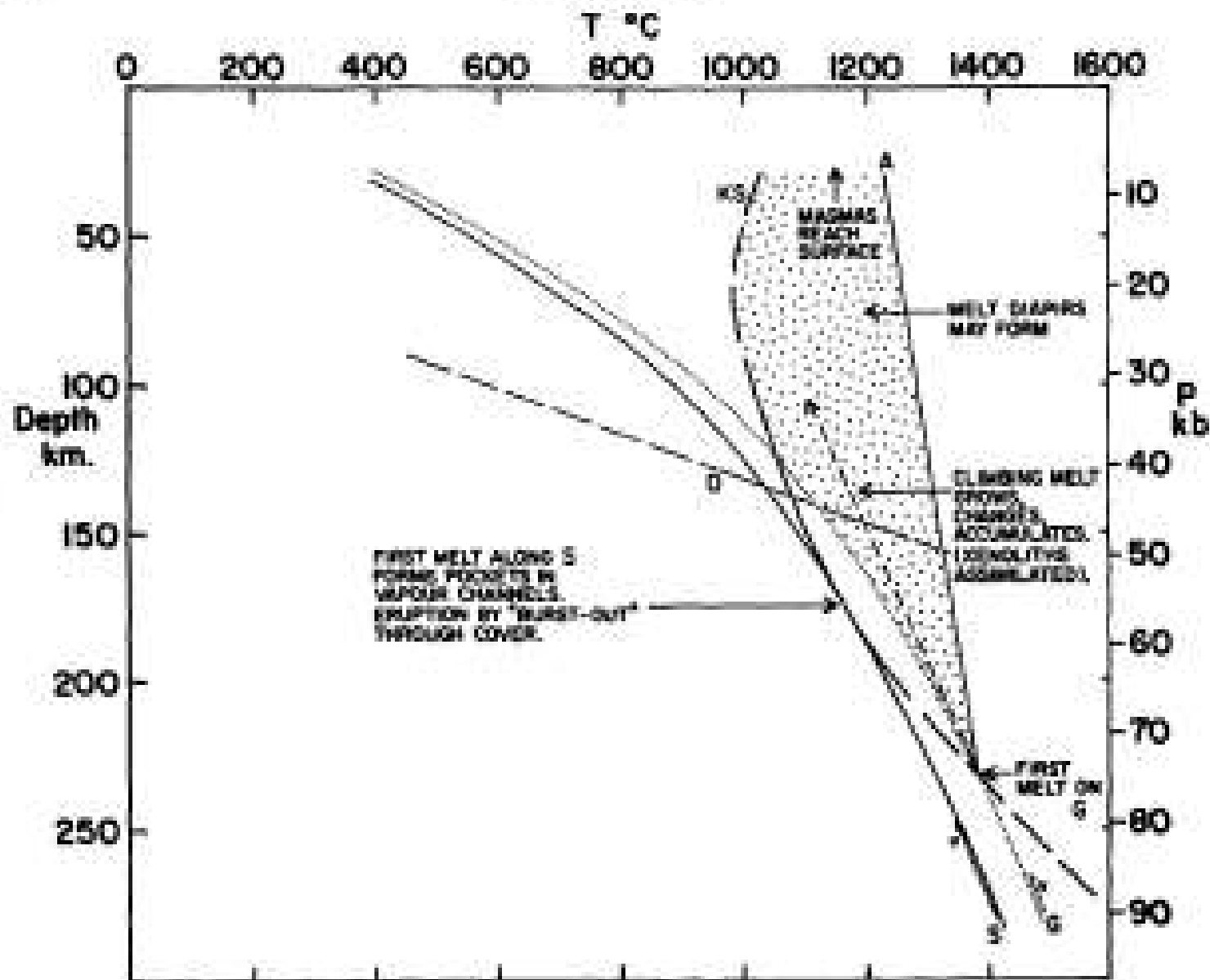


FIG. 5. To show the contrasting types of magmatism that would result from volatile (V) uptake through two lithosphere segments with different geothermal gradients S and G. A is the melt adiabat. Discussion in text.

SO
MANTLE PLUMES:
FACT, FABLE OR
FICTION?

THANK YOU

PLATES vs PLUMES

A Geological Controversy

GILLIAN R. FOULGER



 WILEY-BLACKWELL

