Exhumation and Uplift History of Namibia's Atlantic Margin*

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Abstract

Published thermochronology data from Namibia have been interpreted as revealing widespread exhumation beginning in the Early Cretaceous (~130 Ma), with ~5 km of section removed from coastal locations since that time, decreasing inland to ~1 km. This is difficult to reconcile with geological constraints, such as the presence of the Early Cretaceous Etendeka volcanics, which show that many of the sampled locations must have been near surface in the Early Cretaceous. Preservation of the early Jurassic Kalkrand volcanics also argues against erosion of thick basement sections. We have obtained AFTA data from outcropping basement rocks collected with reference to key landscape elements, in order to provide a more integrated interpretation. Results show three key cooling episodes, which are also recognised in adjacent regions. Samples between the coast and the Fish River cooled below ~110°C around 110-100 Ma. Cooling at this time is recognised along the West African Margin from the Orange River to Equatorial Guinea, where it is clearly associated with a decrease in heat flow, and a similar origin is inferred for this cooling episode along the Namibian margin. Samples inland of the Fish River cooled below ~110°C around 65 to 60 Ma, while samples towards the coast also show cooling at this time but from lower temperatures, 80 to 100°C. We interpret this episode as the onset of exhumation across the region. This interpretation is more consistent with evidence from landscape studies and sediment supply within the Orange River drainage system, as well as evidence for Early Cenozoic exhumation from AFTA in offshore wells. Regional exhumation during the Early Cenozoic has major implications for hydrocarbon prospectivity, including potential disruption of accumulations and reservoir occurrence.

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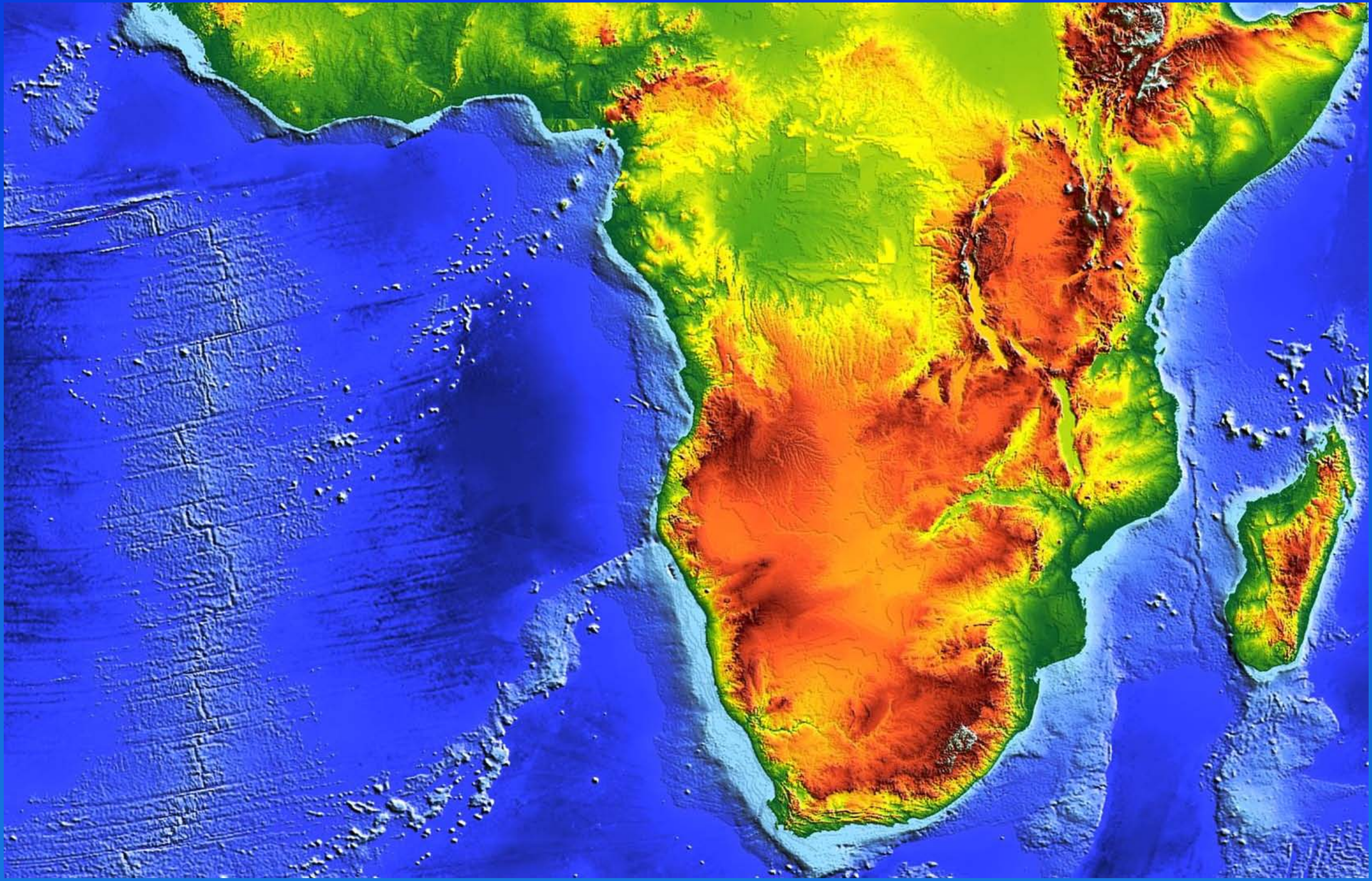
Cape Town, 26th-29th October 2008

African Energy Global Impact

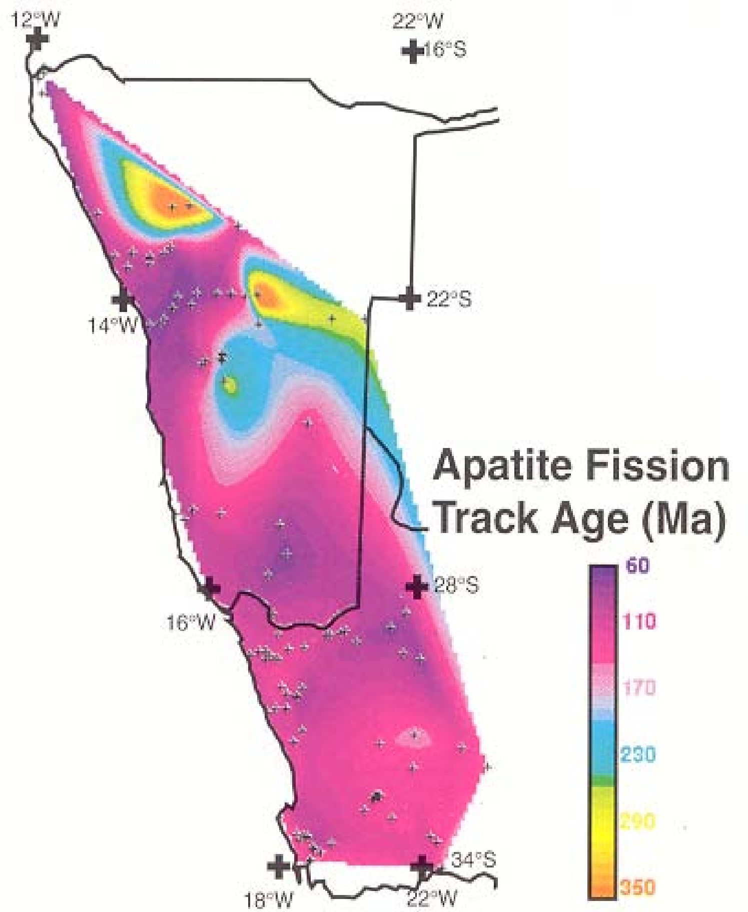
Talk outline

- Current ideas
- Some geological constraints
  - Offshore
  - Onshore
- New data acquisition
- Alternative ideas

Location



Fission track ages from SW Africa



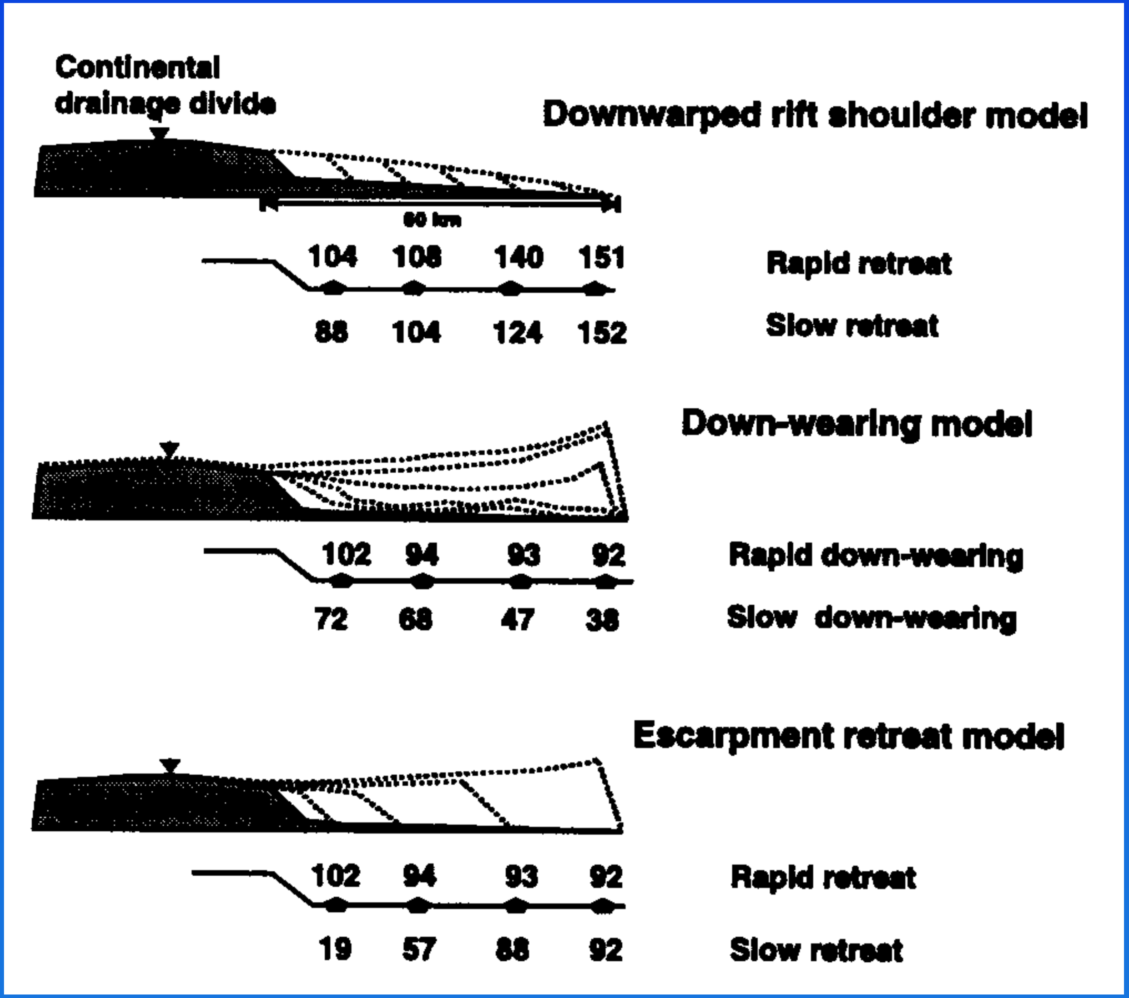
Brown and Gallagher, 1999

Fission track ages around 100 Ma in coastal locations have conventionally been interpreted as representing the effects of exhumation associated with rifting, with no contribution from elevated heat flow.

Data from the University of Melbourne fission track research group

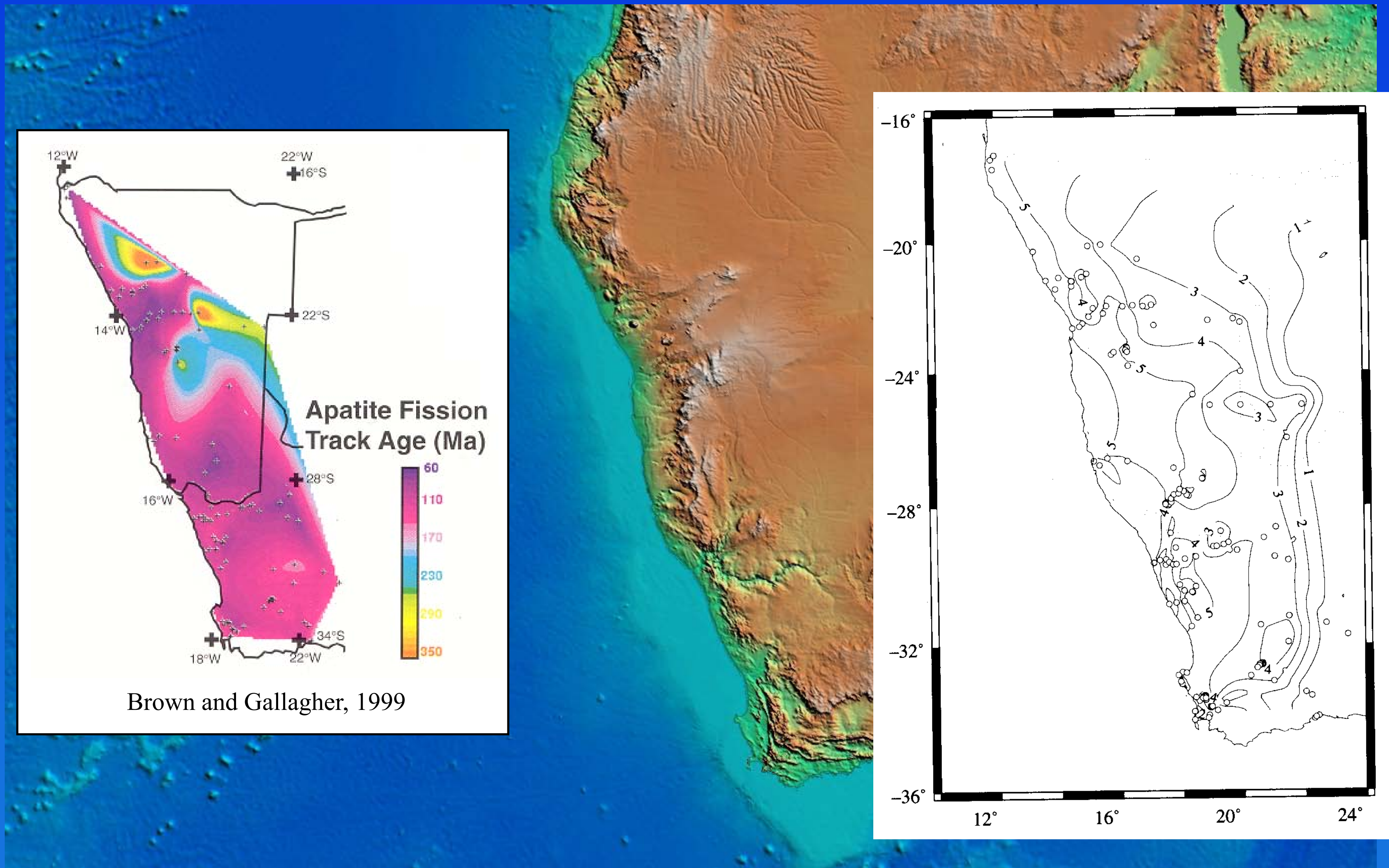
Models for evolution of rifted margins:

Denudation associated with rifting is commonly assumed to be restricted to margins, with discussion presented in terms of 3 options:



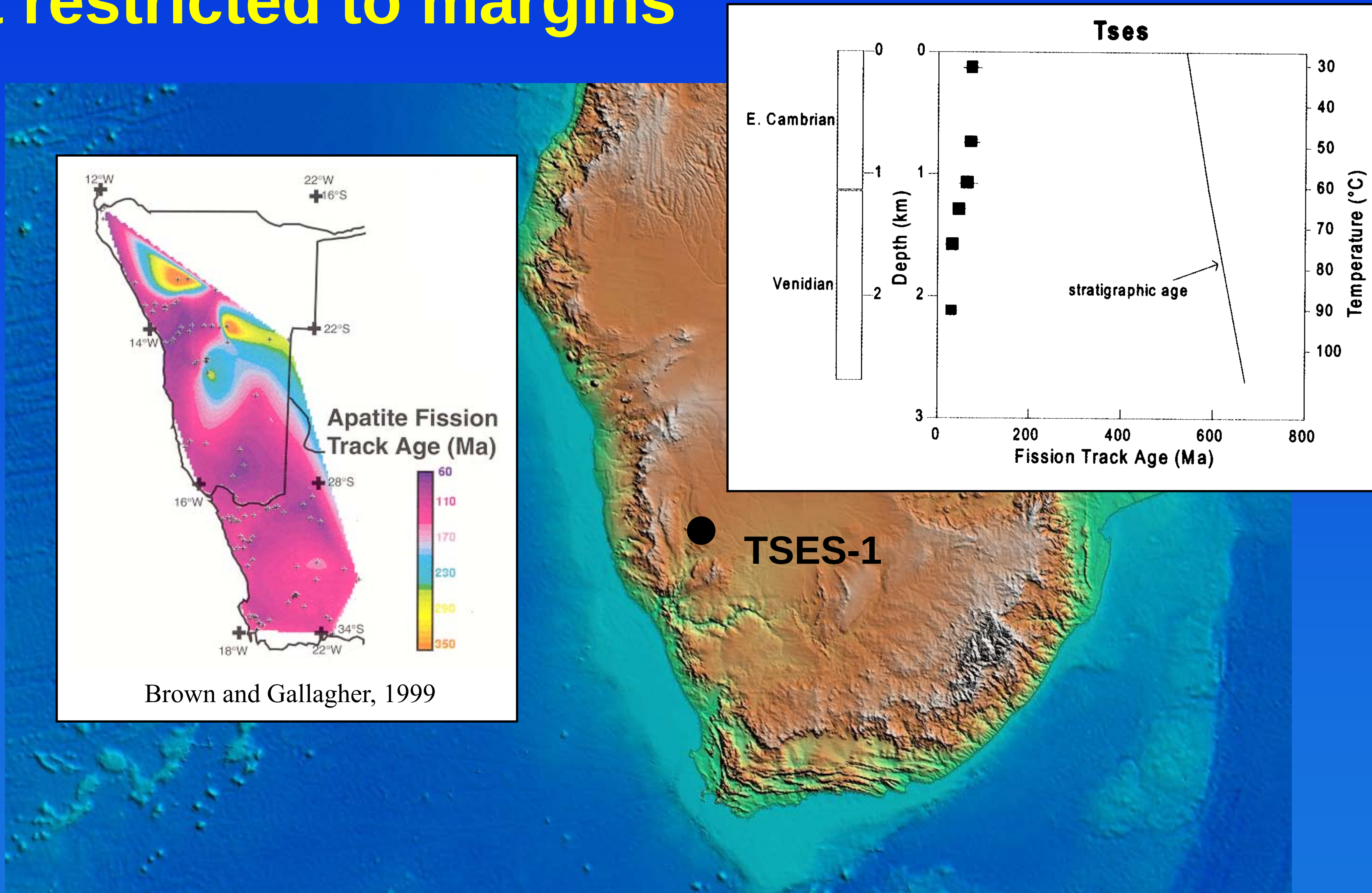
From Persano et al. Earth and Planetary Science Letters, 200 (2002), 79-90.

Interpretation of apatite FT ages from SW Africa

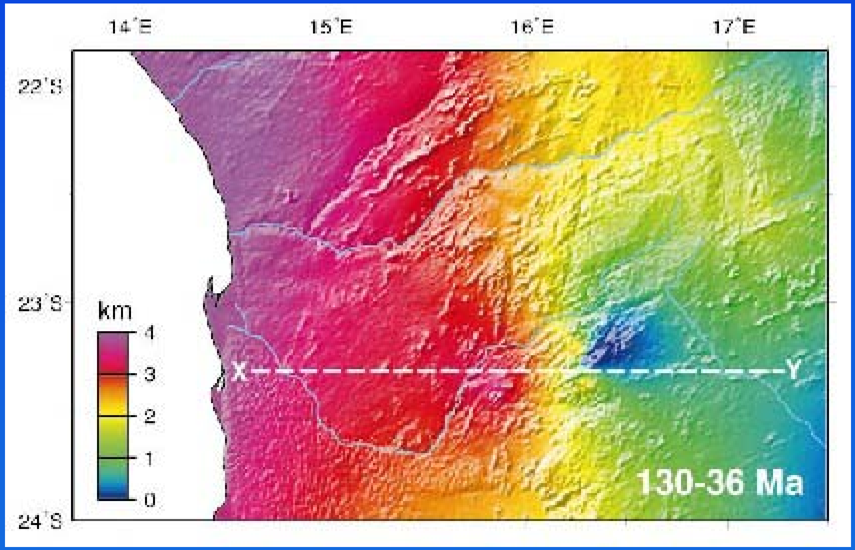


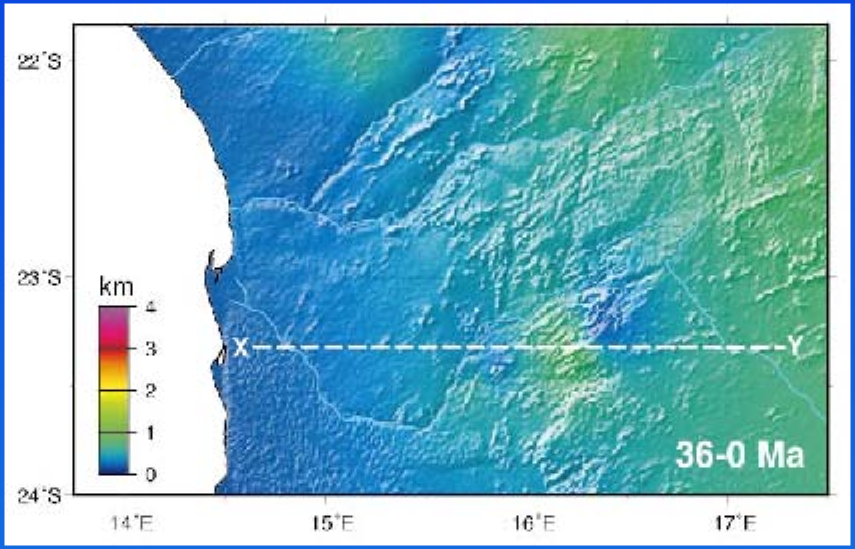
Brown and Gallagher, 1999

BUT: “rift-related” paleo-thermal effects are not restricted to margins



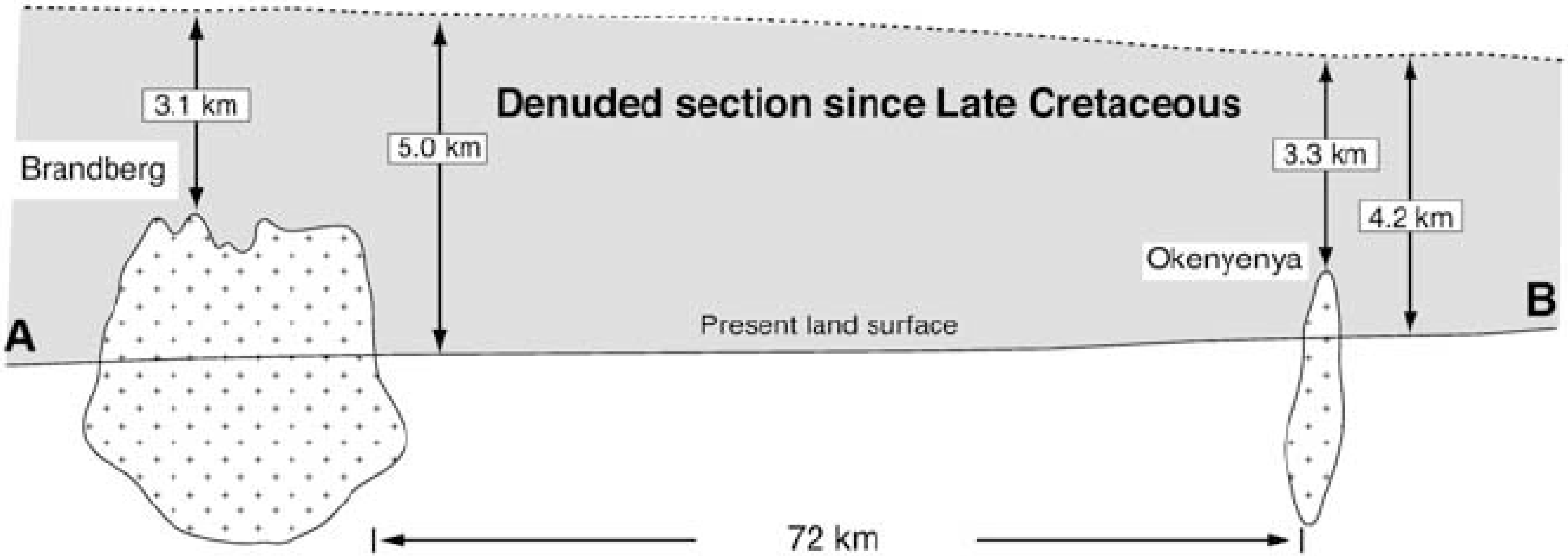
4 km of section missing on the coast near Walvis Bay?





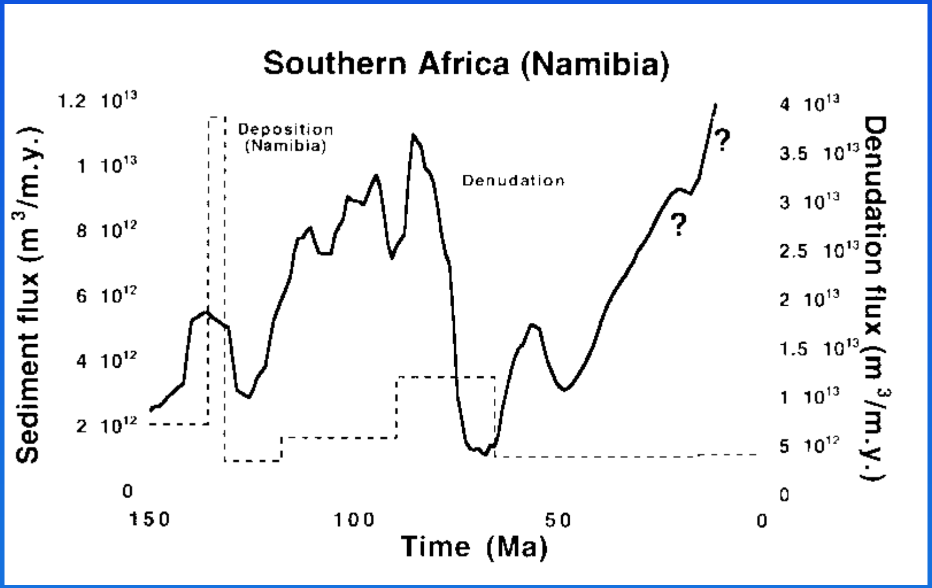
Cockburn et al. 2000 Earth and Planetary Science Letters 179 () 429-435

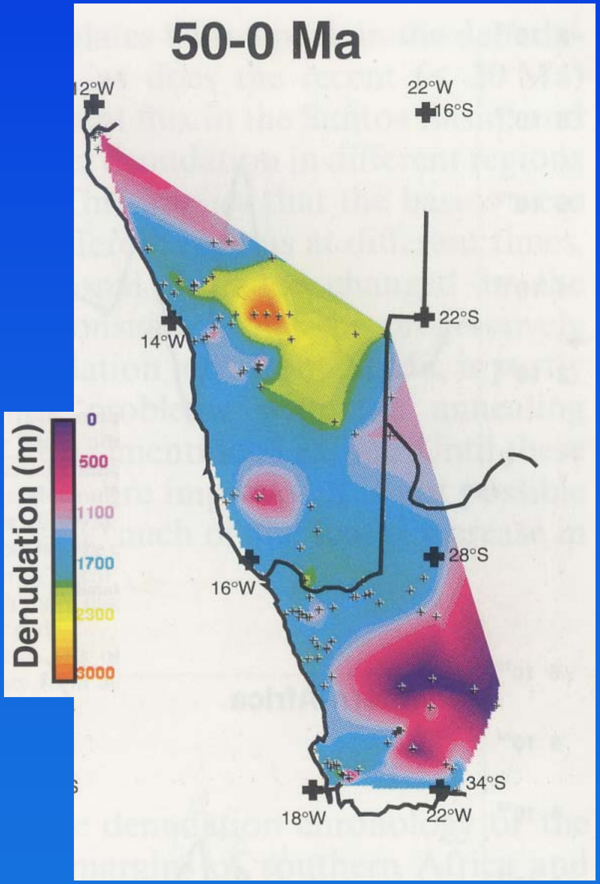
2-5 km of material removed?



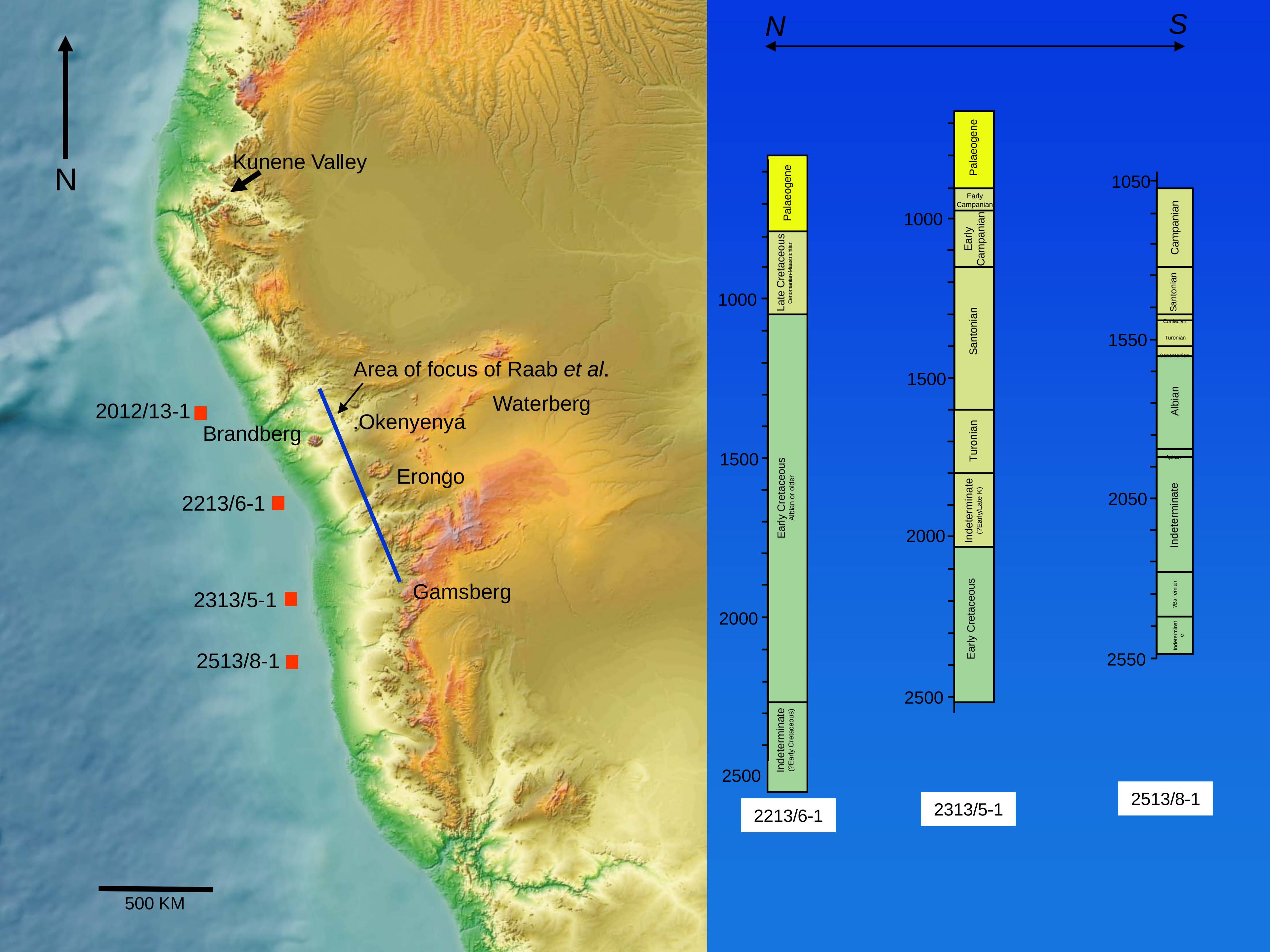
Raab *et al*., 2005, Tectonics, 24

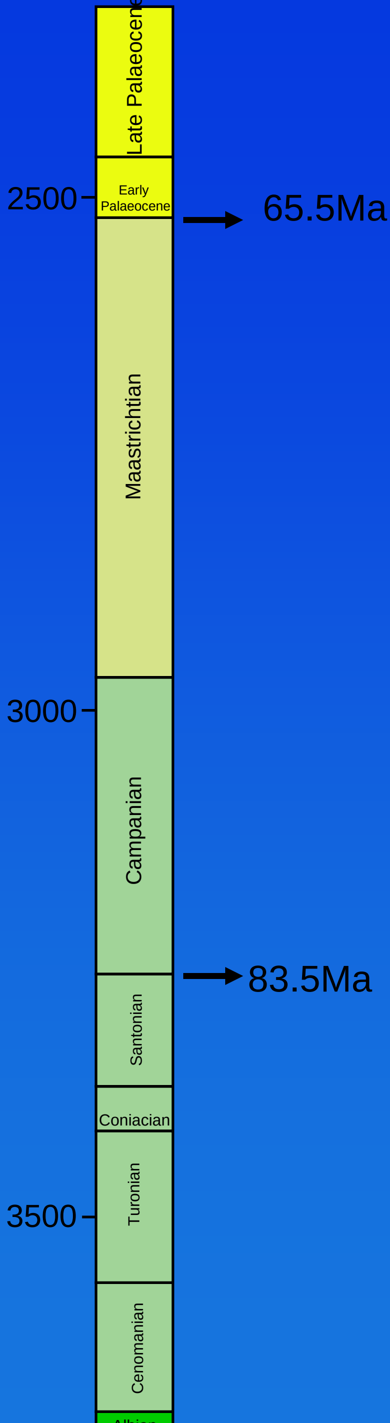
Post 50 Ma increase in denudation?

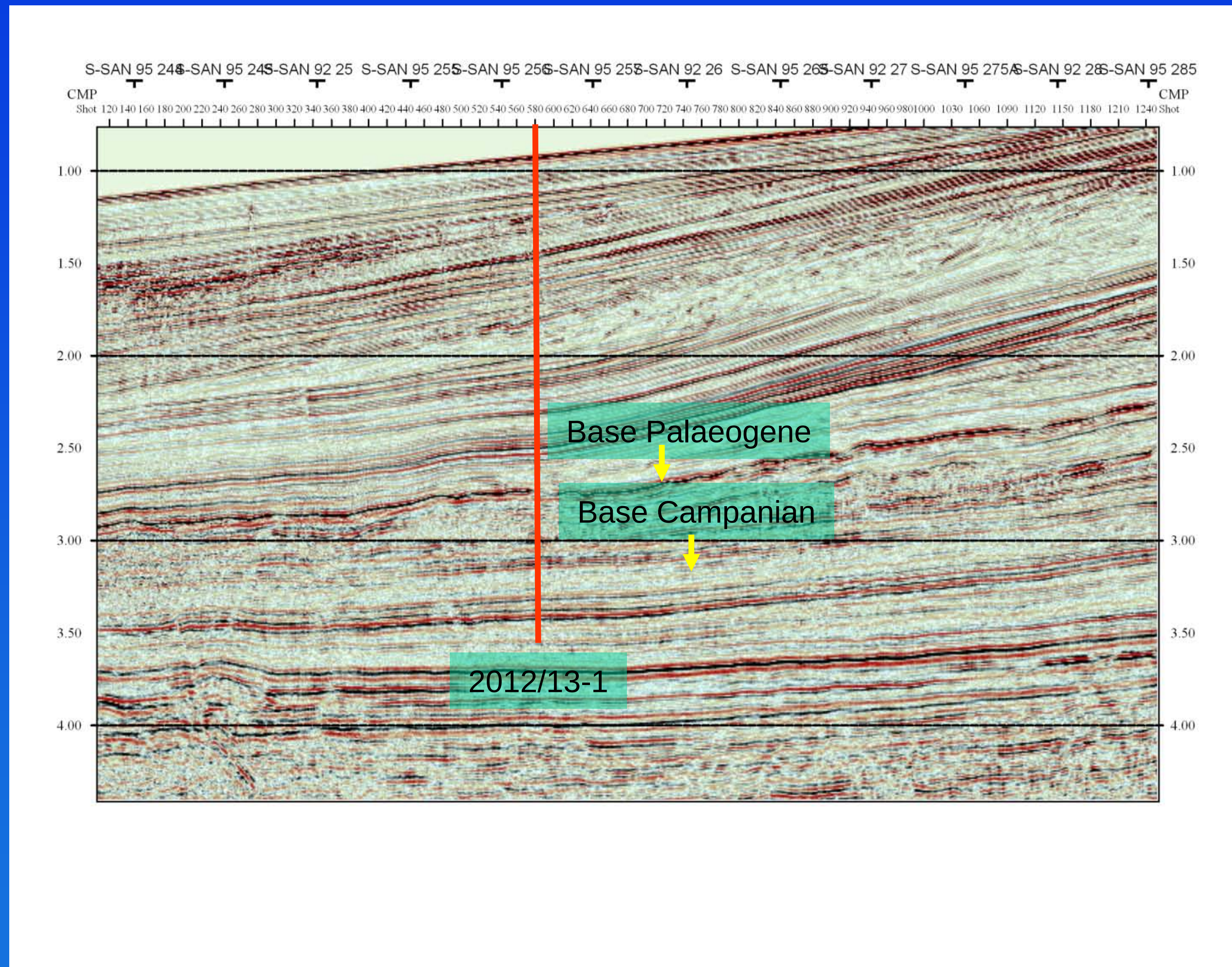




Gallagher and Brown ,1999


N
Kunene Valley
Area of focus of Raab et al.
2012/13-1
Brandberg
.Okenyenya
Waterberg
Erongo
2213/6-1
2313/5-1
Gamsberg
2513/8-1
500 KM
N
S
Palaeogene
Late Cretaceous
Cenomanian-Maastrichtian
1000
Early Cretaceous
Albian or older
1500
2000
Indeterminate
(?Early Cretaceous)
2500
2213/6-1
Palaeogene
Early Campanian
1000
Early Campanian
Santonian
1500
Turonian
Indeterminate
(?Early/Late K)
2000
Early Cretaceous
2500
2313/5-1
1050
Campanian
Santonian
Coniacian
Turonian
1550
Cenomanian
Albian
Aptian
2050
Indeterminate
?Barremian
Indeterminate
2550
2513/8-1


Late Palaeocene
2500
Early Palaeocene
65.5Ma
Maastrichtian
3000
Campanian
83.5Ma
Santonian
Coniacian
3500
Turonian
Cenomanian
Albian


S-SAN 92 25
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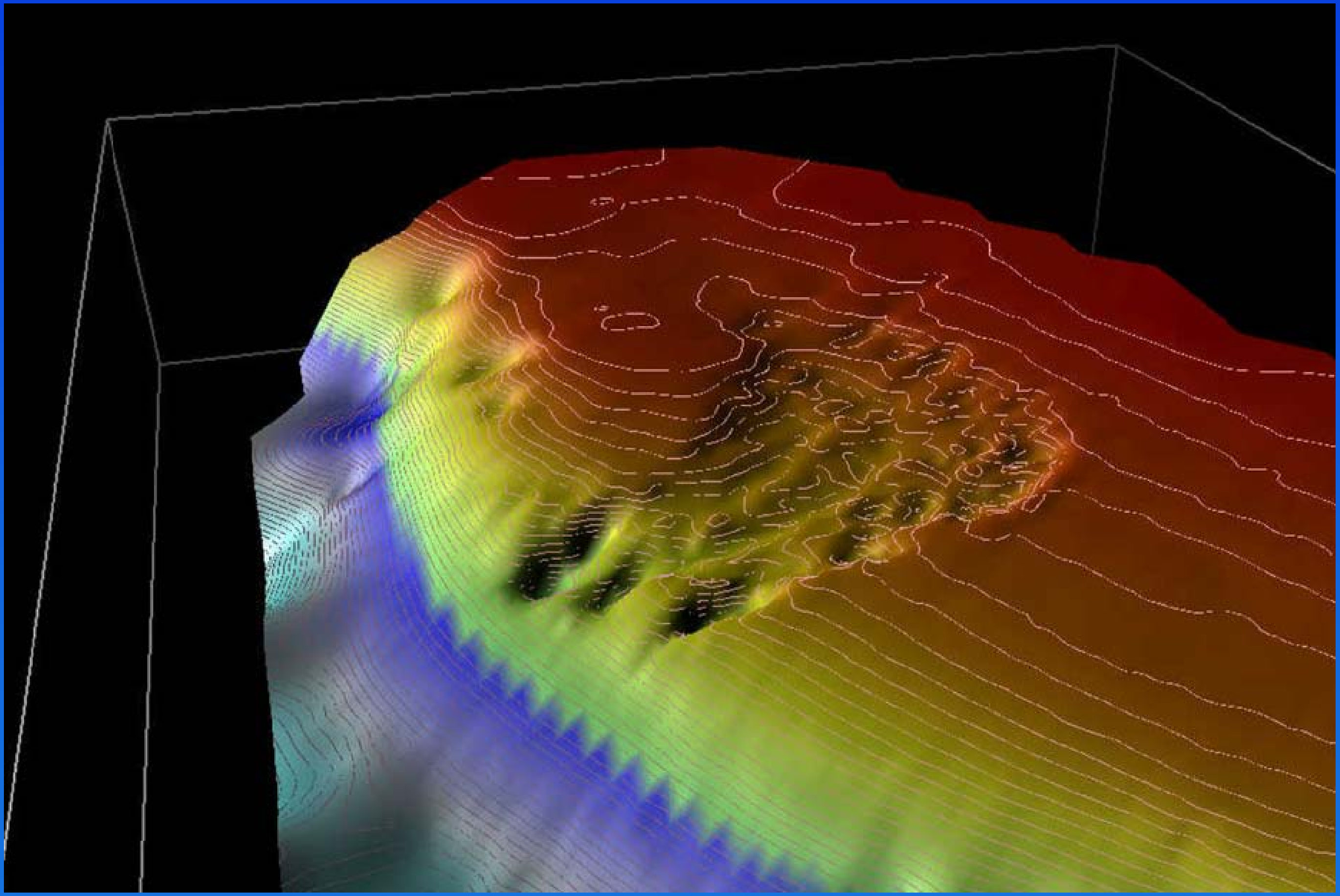
CMP
Shot
1.00
1.50
2.00
2.50
3.00
3.50
4.00
Base Palaeogene
Base Campanian
2012/13-1

A caution - Contourites



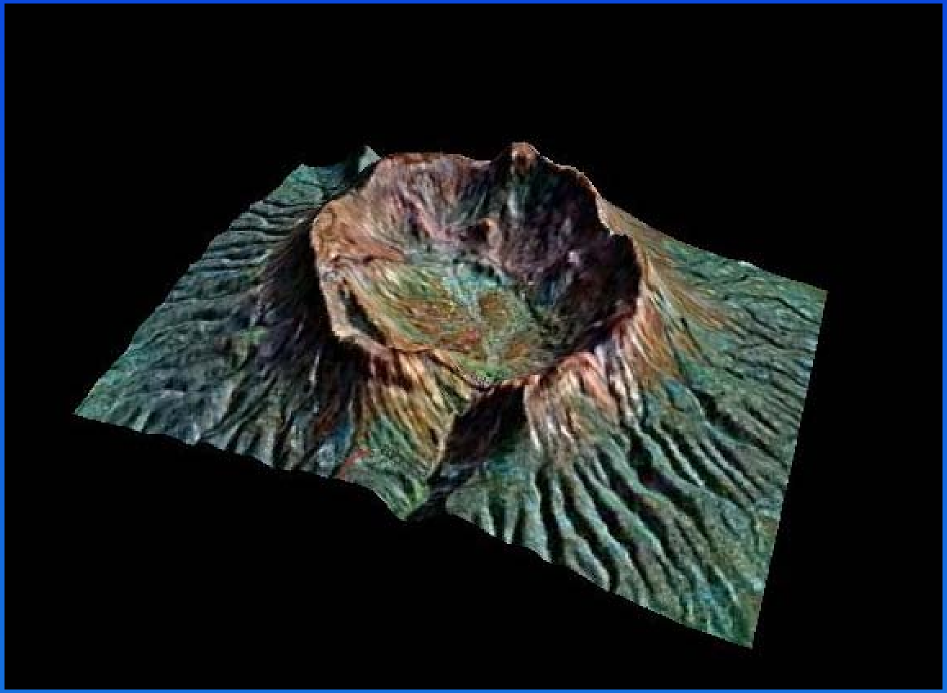
Hopkins, 2007, Fig. 6.7

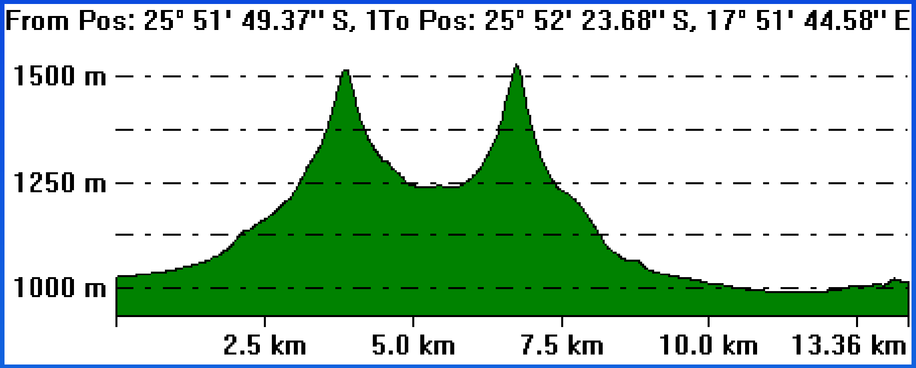
Kalkrand lavas near Schlip

Gamsberg

- Escarpment edge
- 2 Ga basement
- Capped by aeolian sands of Mesozoic age

Brukkaros and kimberlites



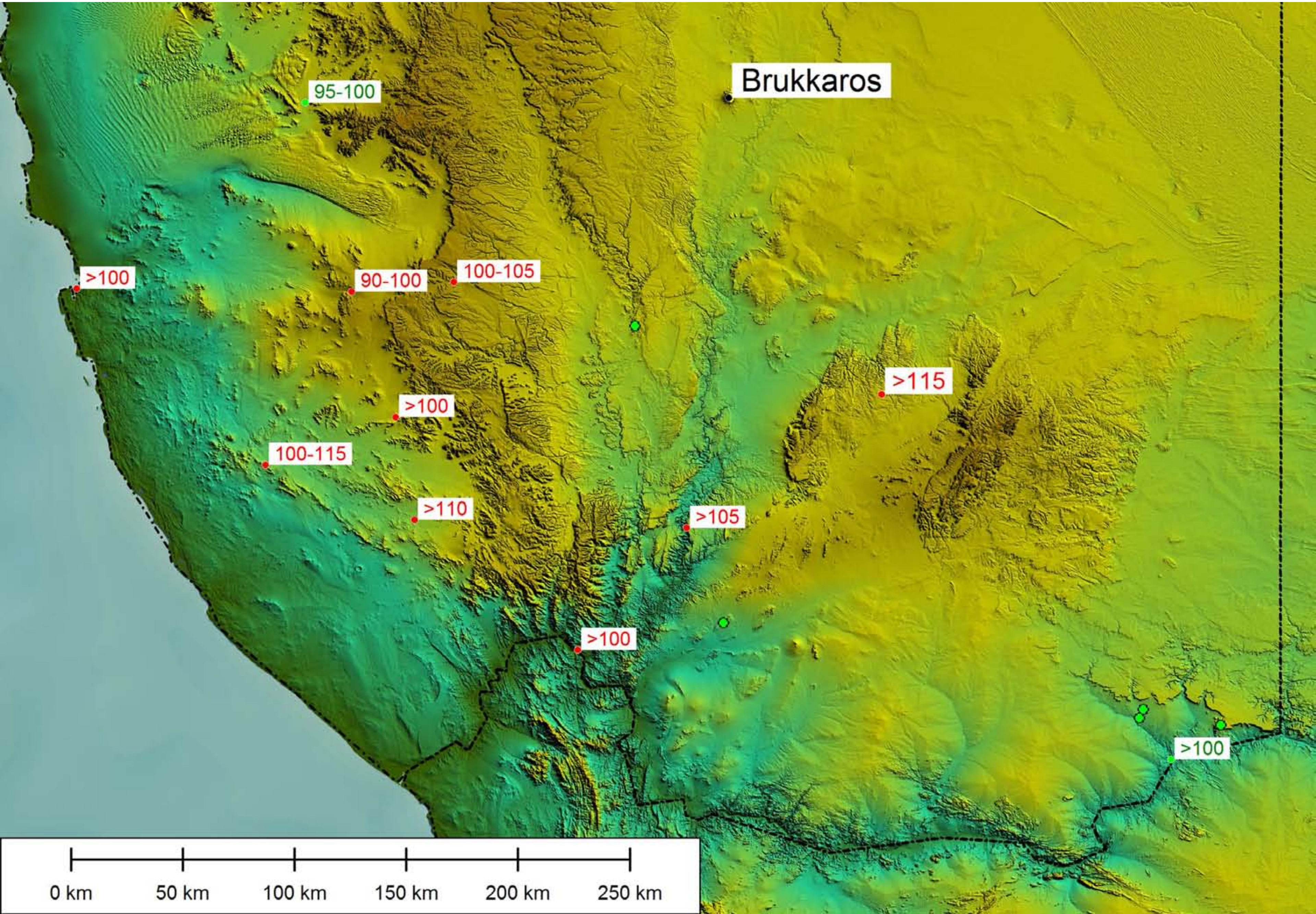


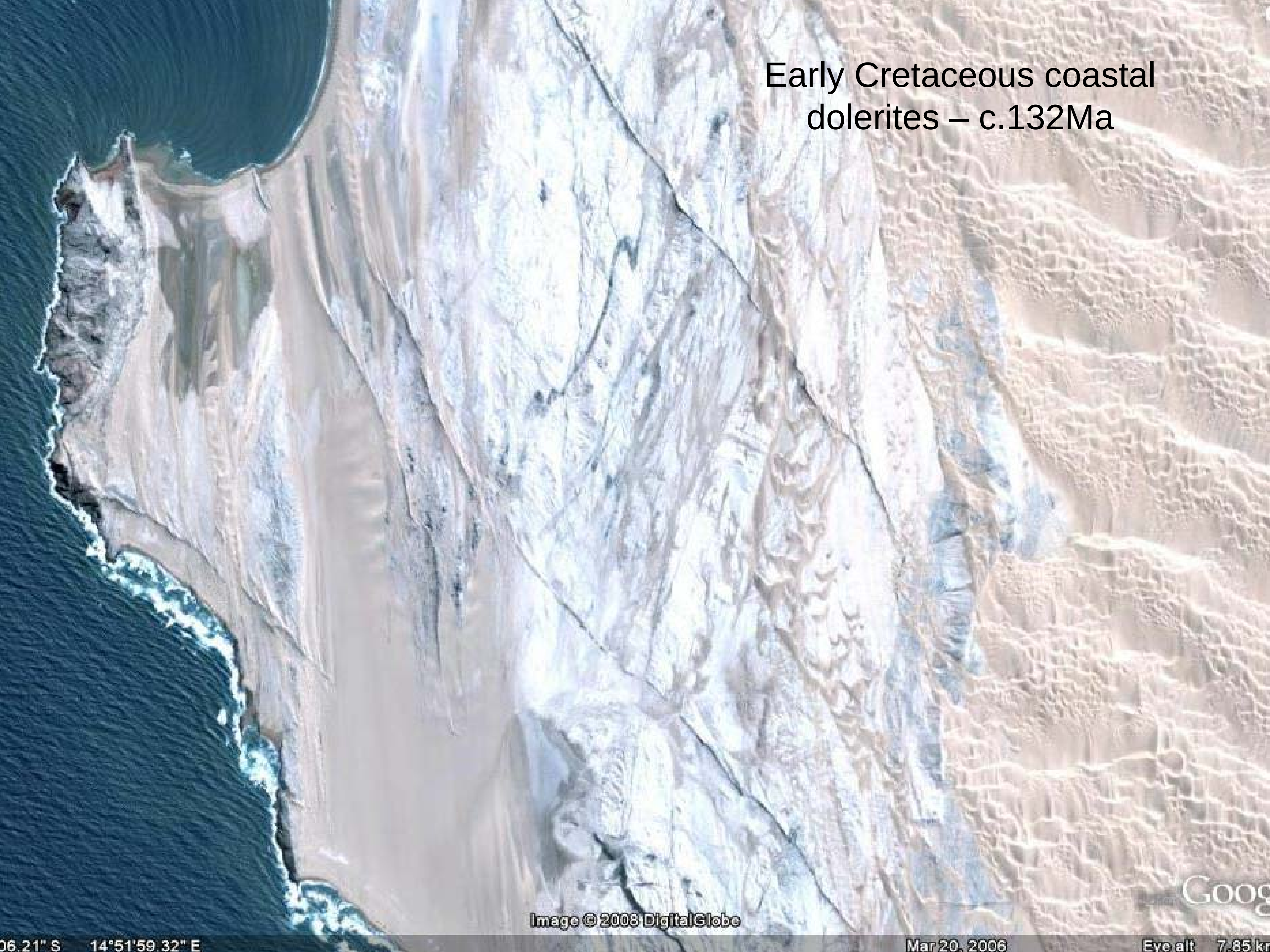
- Lorenz *et al*., 2000a&b, 400-500m material removed from Brukkaros and top of kimberlites
- Kangnas Kimberlite – crater facies preserved

Orange River – by 40Ma had already excavated its valley

Early-mid Cretaceous palaeotemperatures

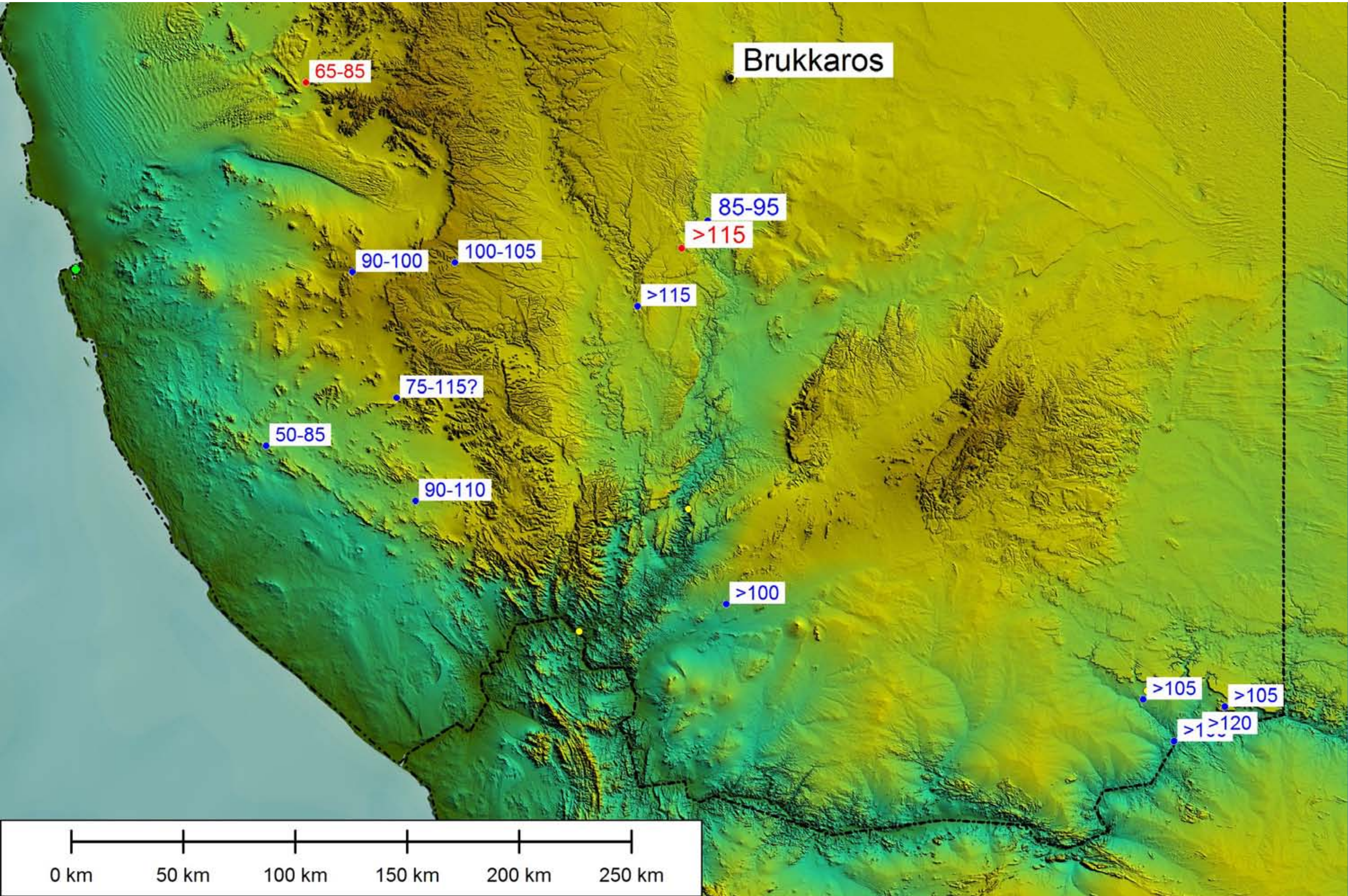
Mid Cretaceous palaeotemperatures



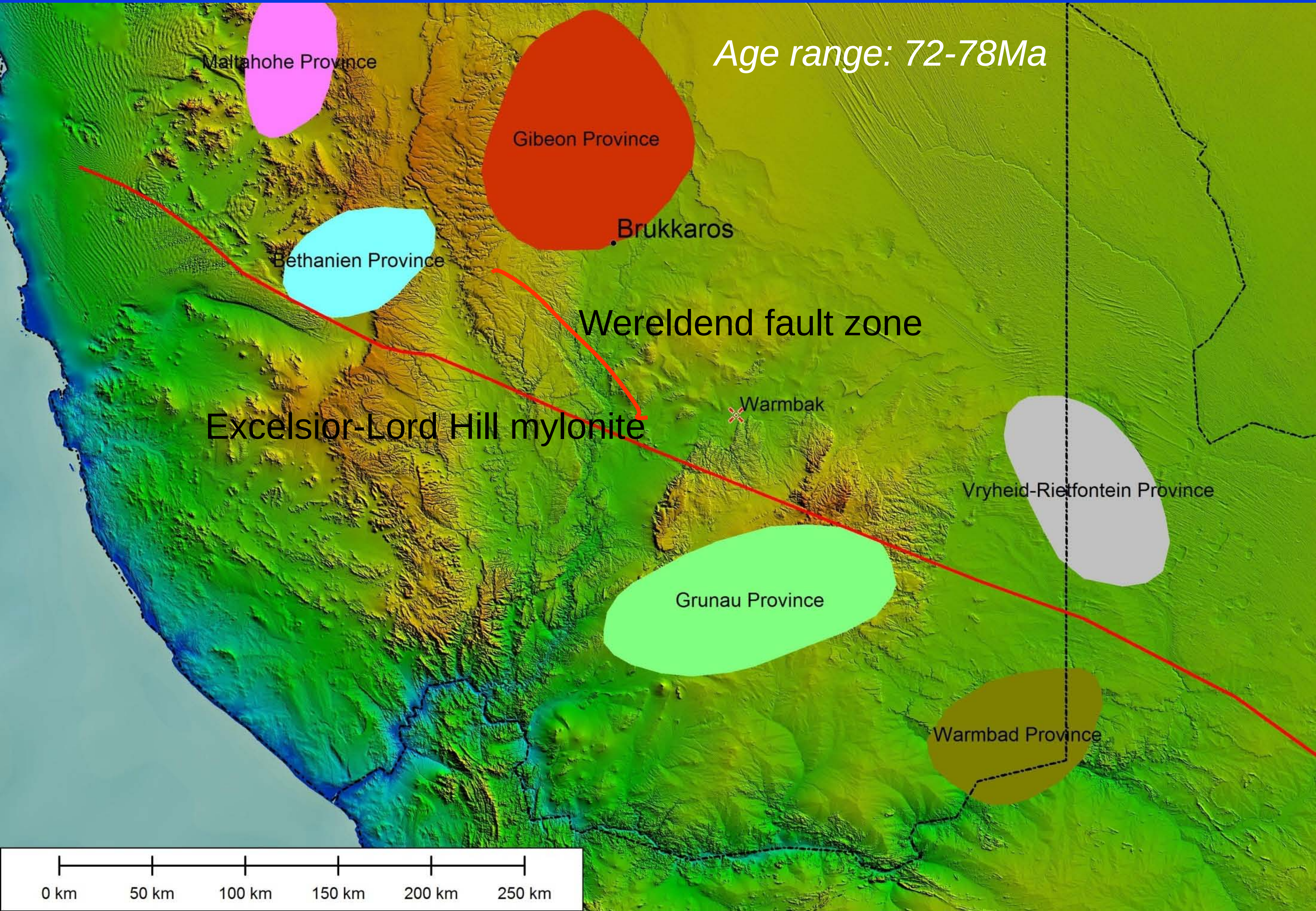

Early Cretaceous coastal
dolerites – c.132Ma
Image © 2008 DigitalGlobe
14°51'59.32" E
Mar 20, 2006
Eye alt

Early Cenozoic palaeotemperatures (65-55 Ma)?

Late Cretaceous palaeotemperatures (80-75 Ma)

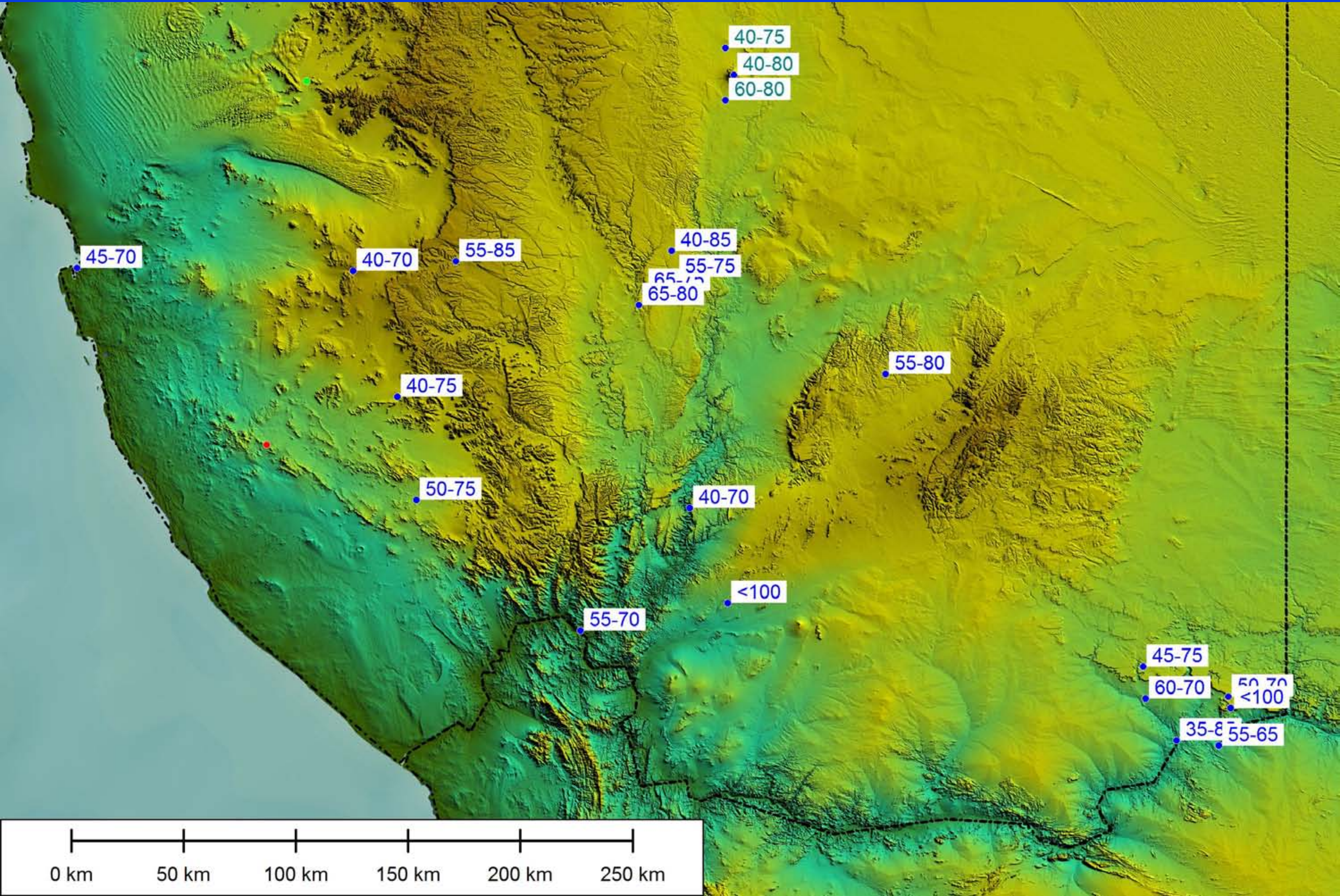


Kimberlite provinces

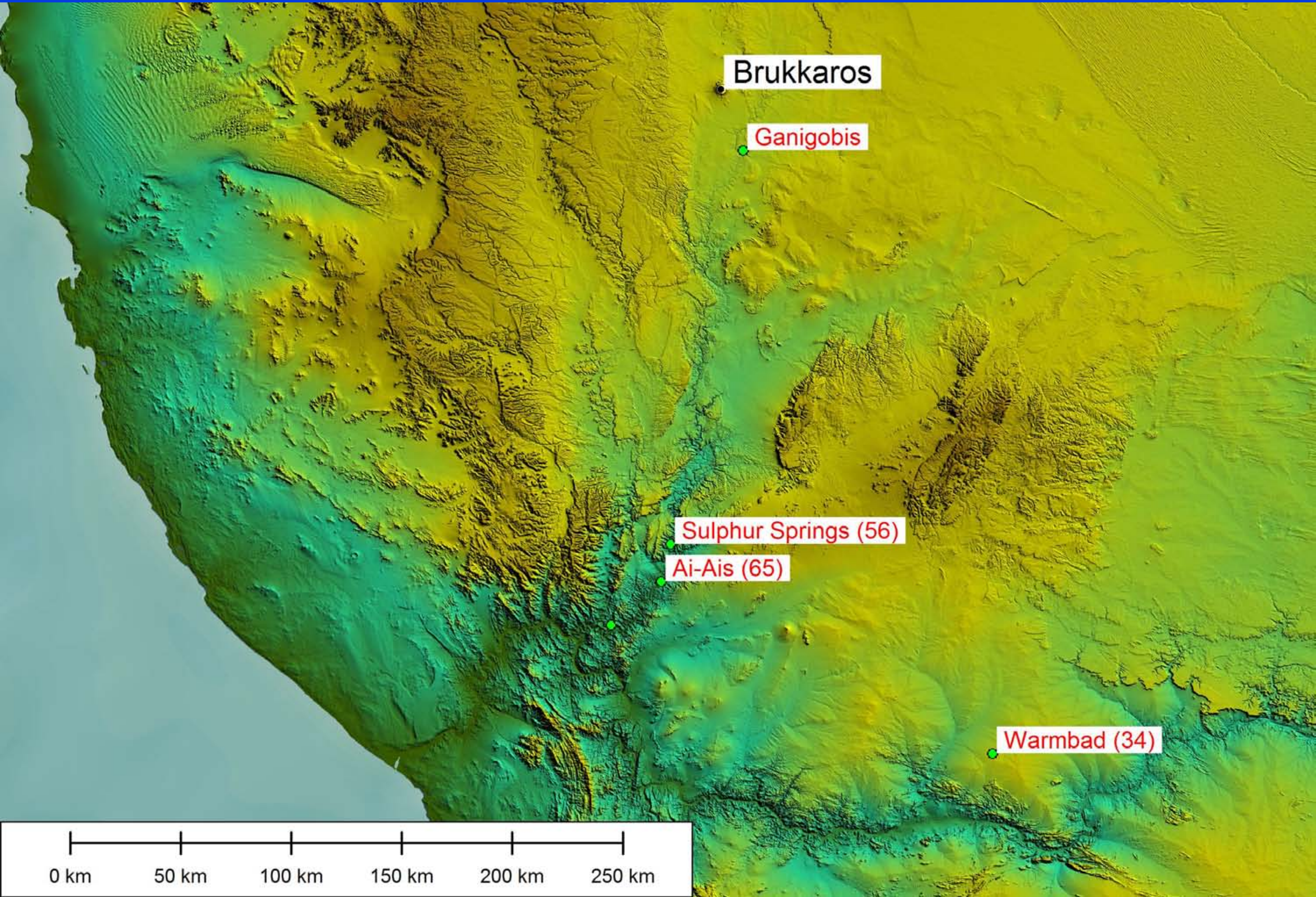


Late Cenozoic palaeotemperatures

(15-0 Ma)



Thermal springs?



Summary

- Geological observations don't match interpretations of AFT data and we need alternatives to denudation
- ~105 Ma
  - may be due to thermal cooling and erosion after break-up at 132 Ma
- 80-75 Ma
  - thermal effects of kimberlite intrusion at 72-78 Ma
- 15-0 Ma
  - Not well constrained but consider thermal springs
- Need further integration of offshore-onshore

The end! But a start of new ideas?

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NAMCOR

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