POLYPHASE INVERSION OF AN INTRAPLATE RIFT-BOUNDING FAULT— THE WATERBERG THRUST IN NAMIBIA

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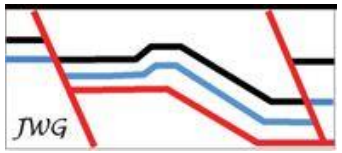
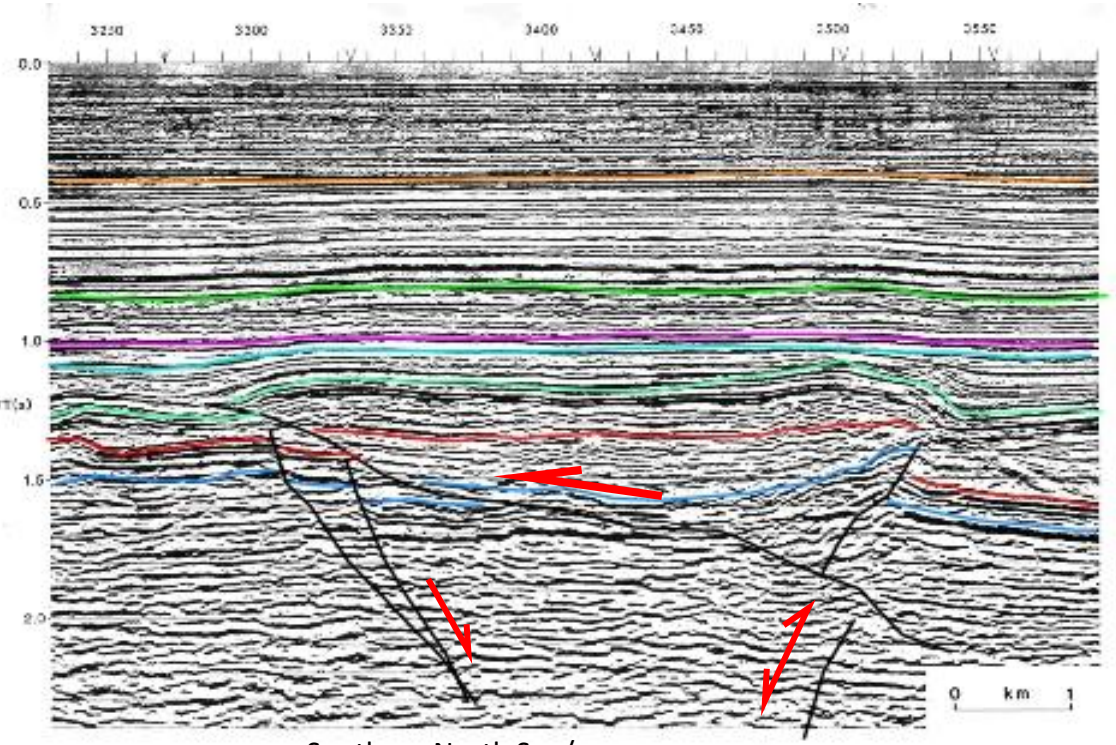


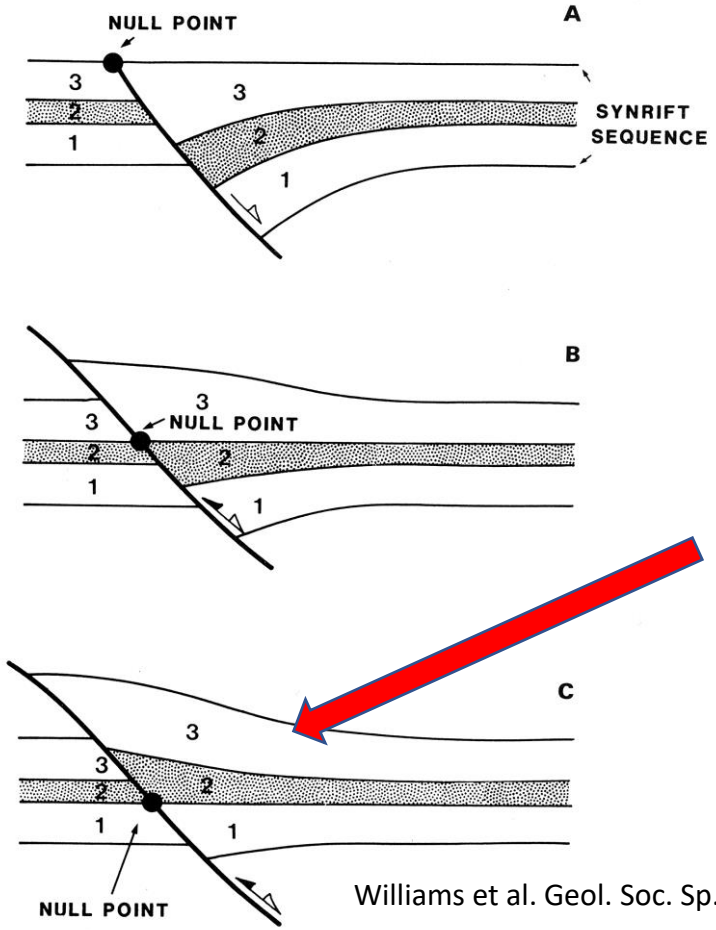
INVERSION

CORE CONCEPTS

- EXTENSION OVERPRINTED BY CONTRACTION
- NORMAL FAULT DISPLACEMENT REVERSED, SOMETIMES IN COMPLEX WAYS

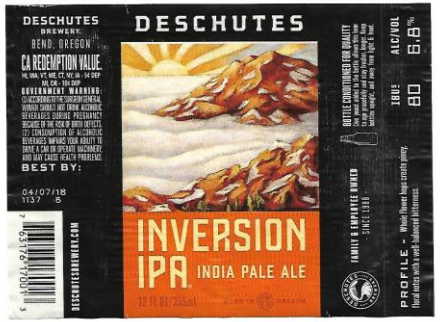


Southern North Sea/
re-interpreted from Badley et al. Geol. Soc. Sp. Publ. 44(1989)



Williams et al. Geol. Soc. Sp. Publ. 44 1989)

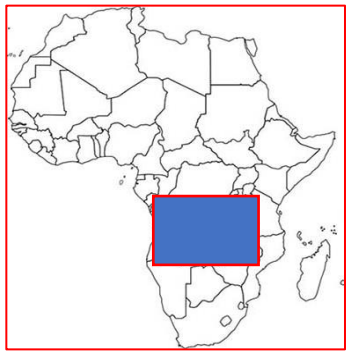
Often recognized by thickening of sedimentary growth section in hanging wall of thrust

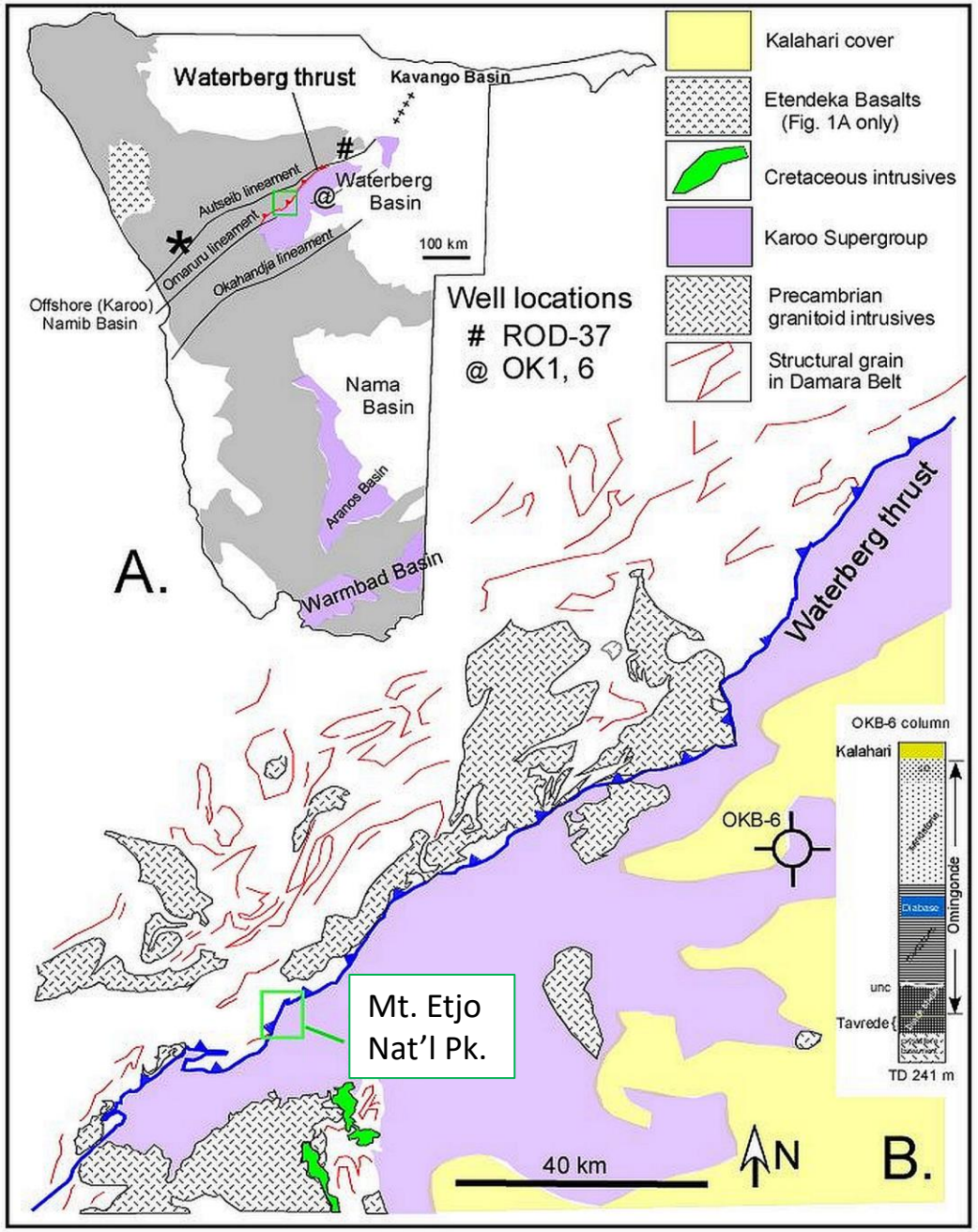


Implies a reversal of shear stress on fault planes,
and thus often taken to infer two separate tectonic events

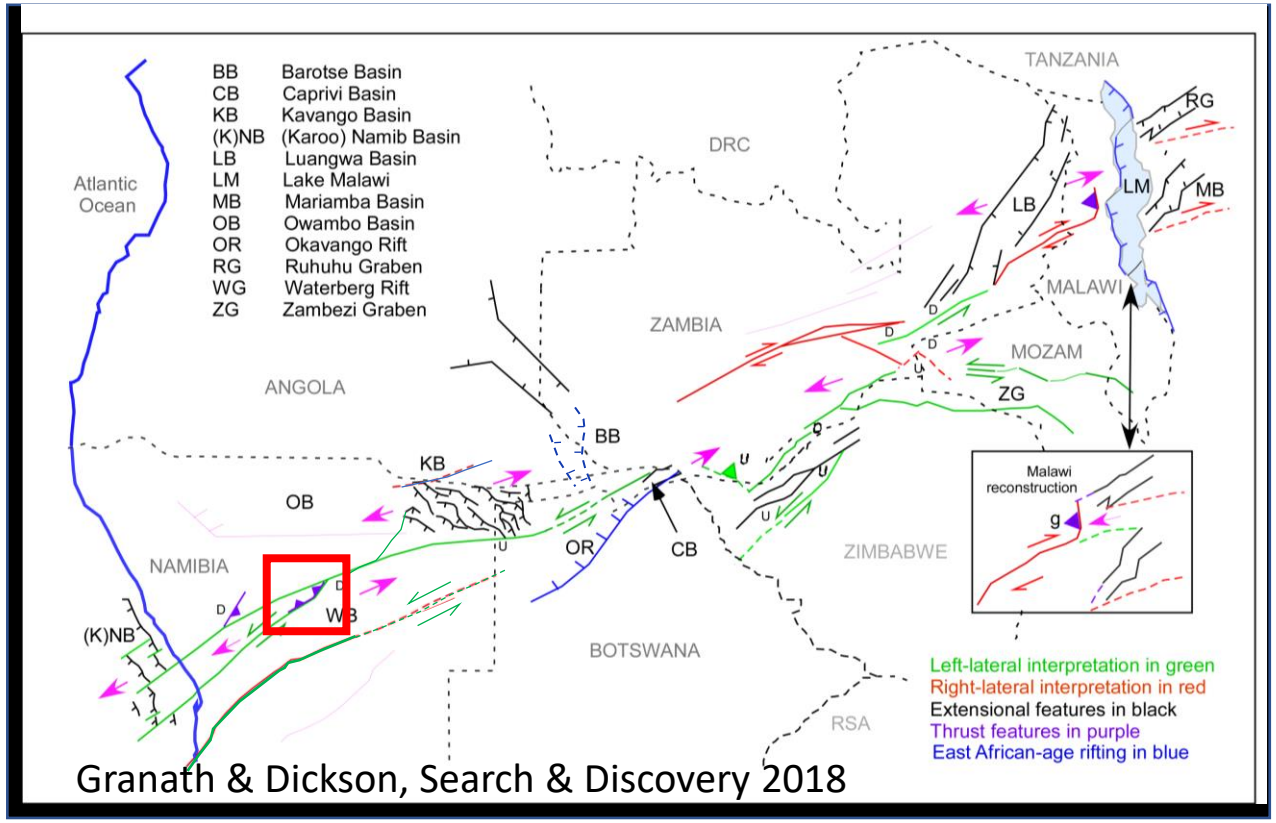
Study area

‘Karoo’ (Permo-Triassic) Rift and Shear System across Southern Africa





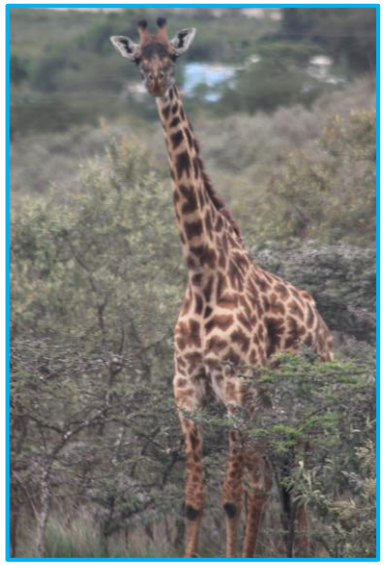
Granath et al., J. Struc. Geology 2022

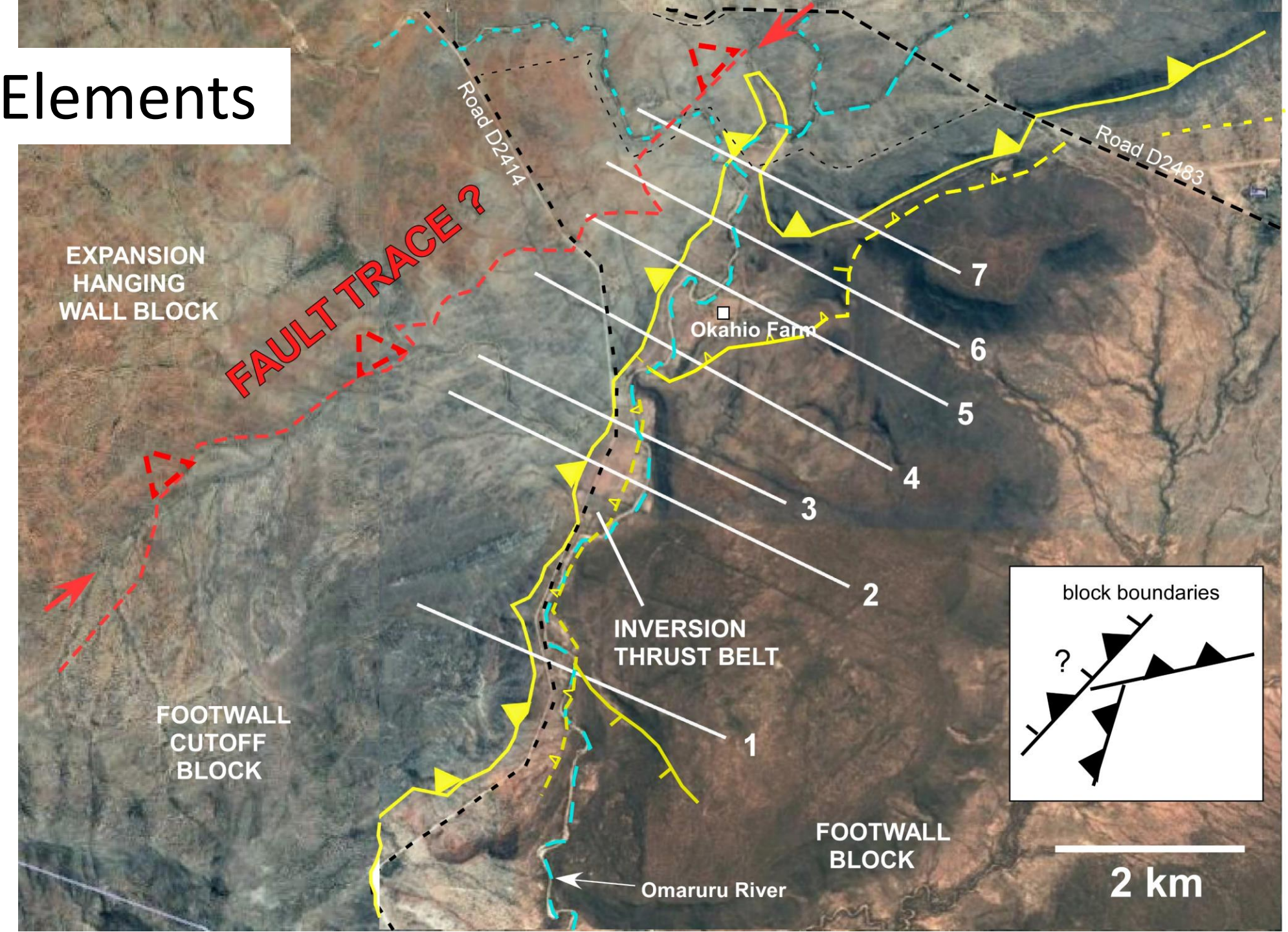


Granath & Dickson, Search & Discovery 2018

Structural Elements

Google Earth image with
-Cross sections in white
-Thrust traces in yellow

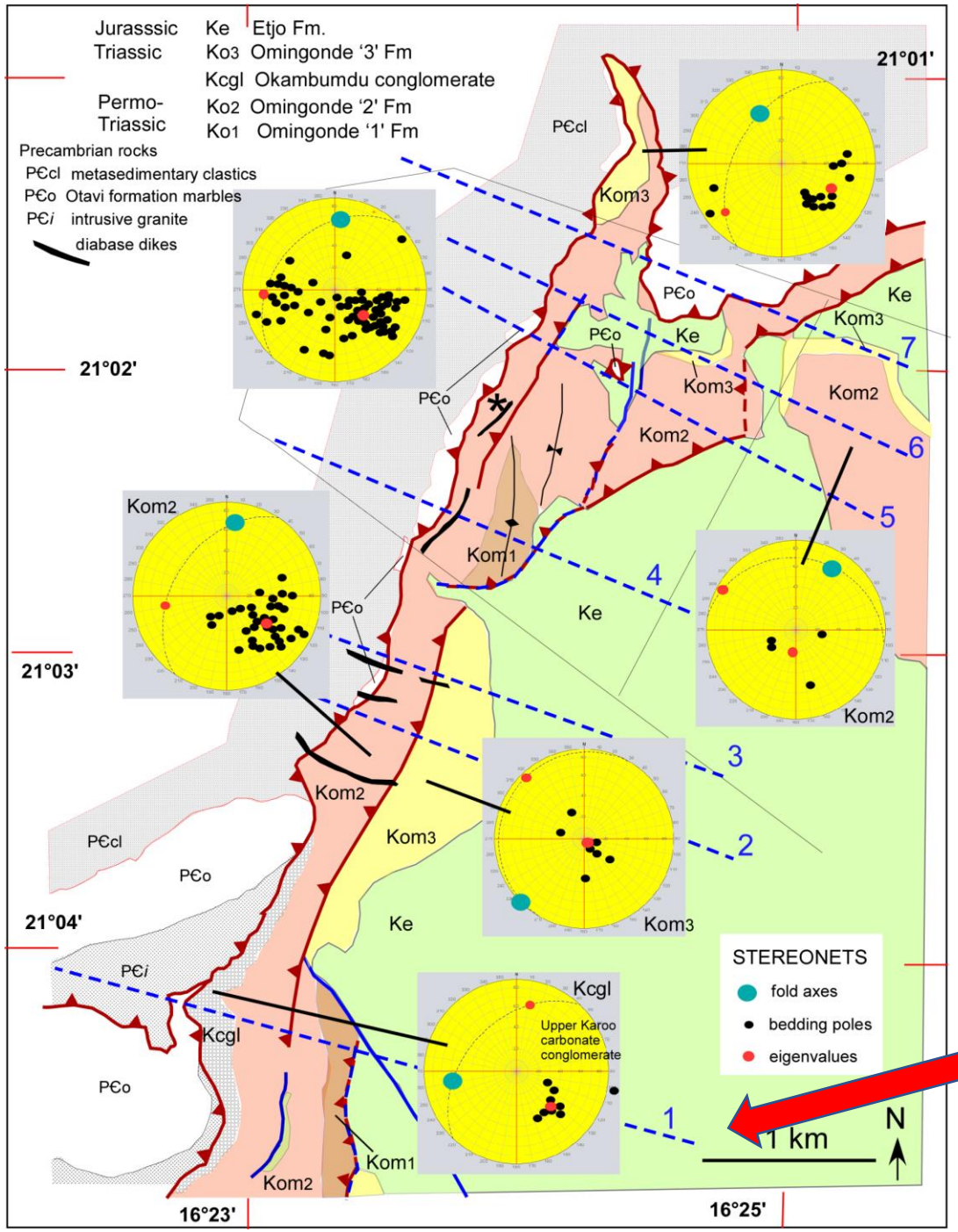


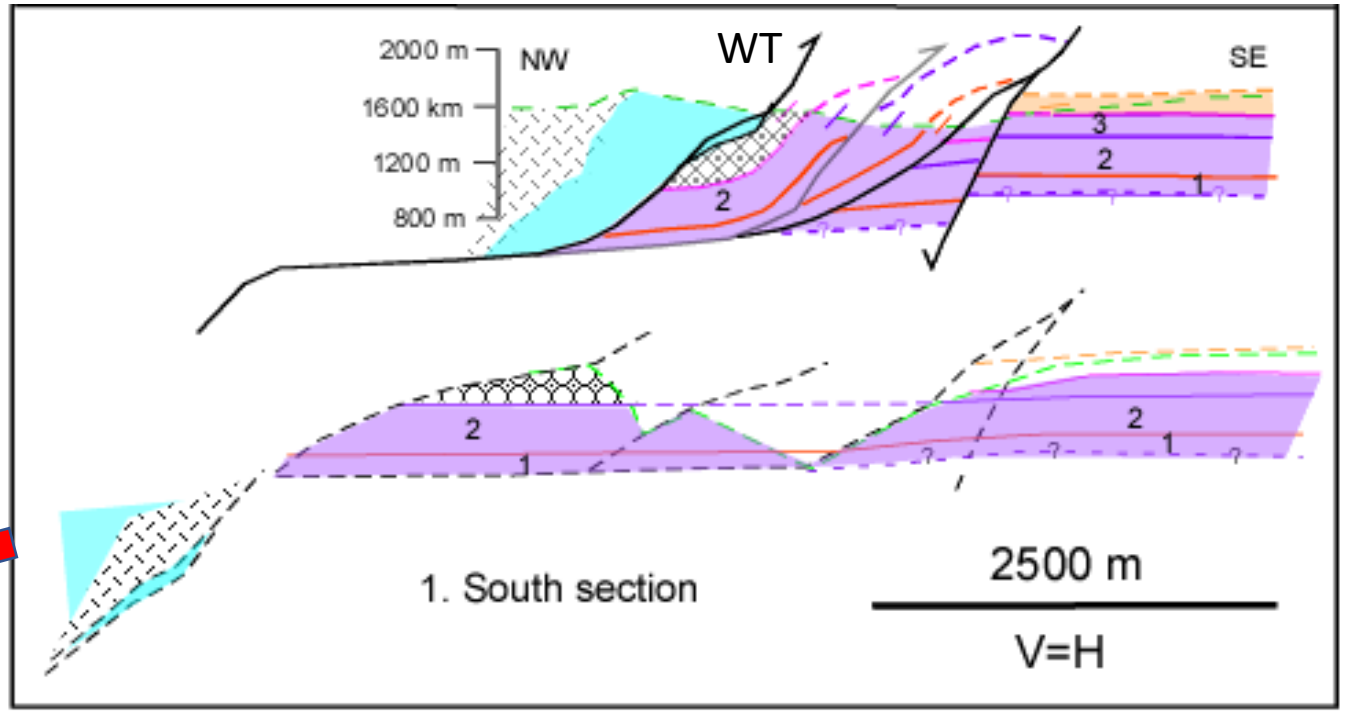


Mapping and structural analysis

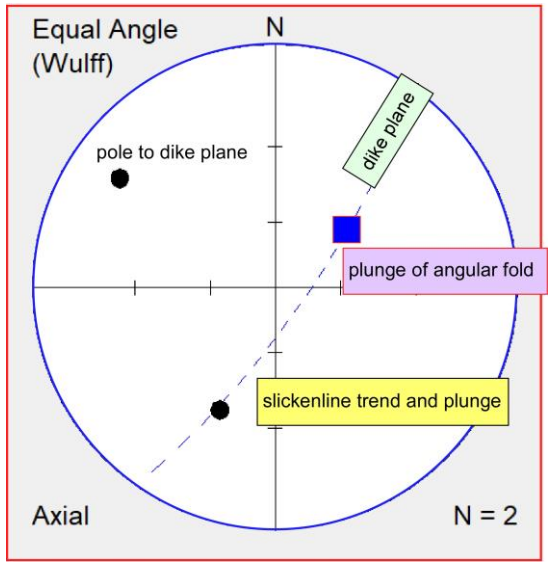
Important evidence

- Contractional mesoscale structures
- Progressively deformed unconformities within Karoo
- Shear parallel to SW plunging directions
- Basement detritus shed into footwall during deformation



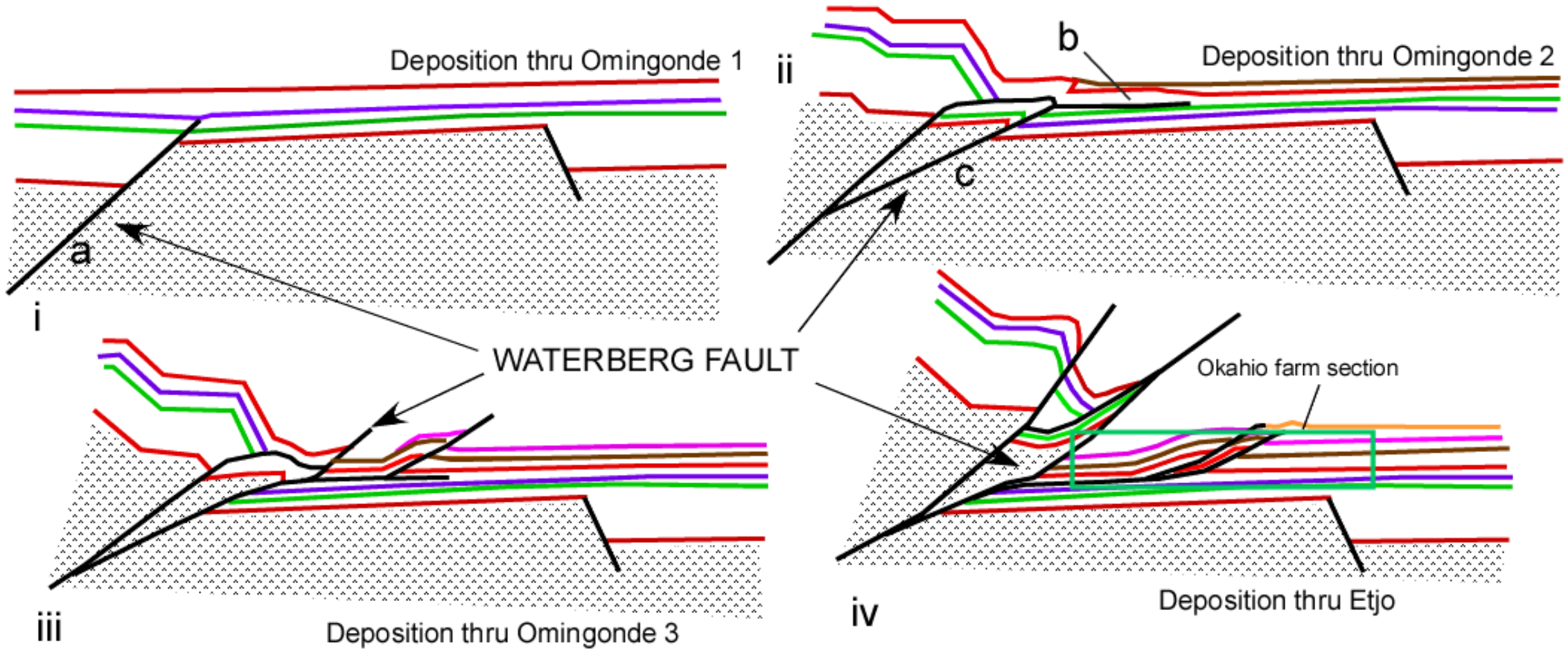


Mesoscale structures



KINEMATICS OF FOOTWALL CUTOFF

Forward model of evolution from normal fault to inversion with footwall cutoff



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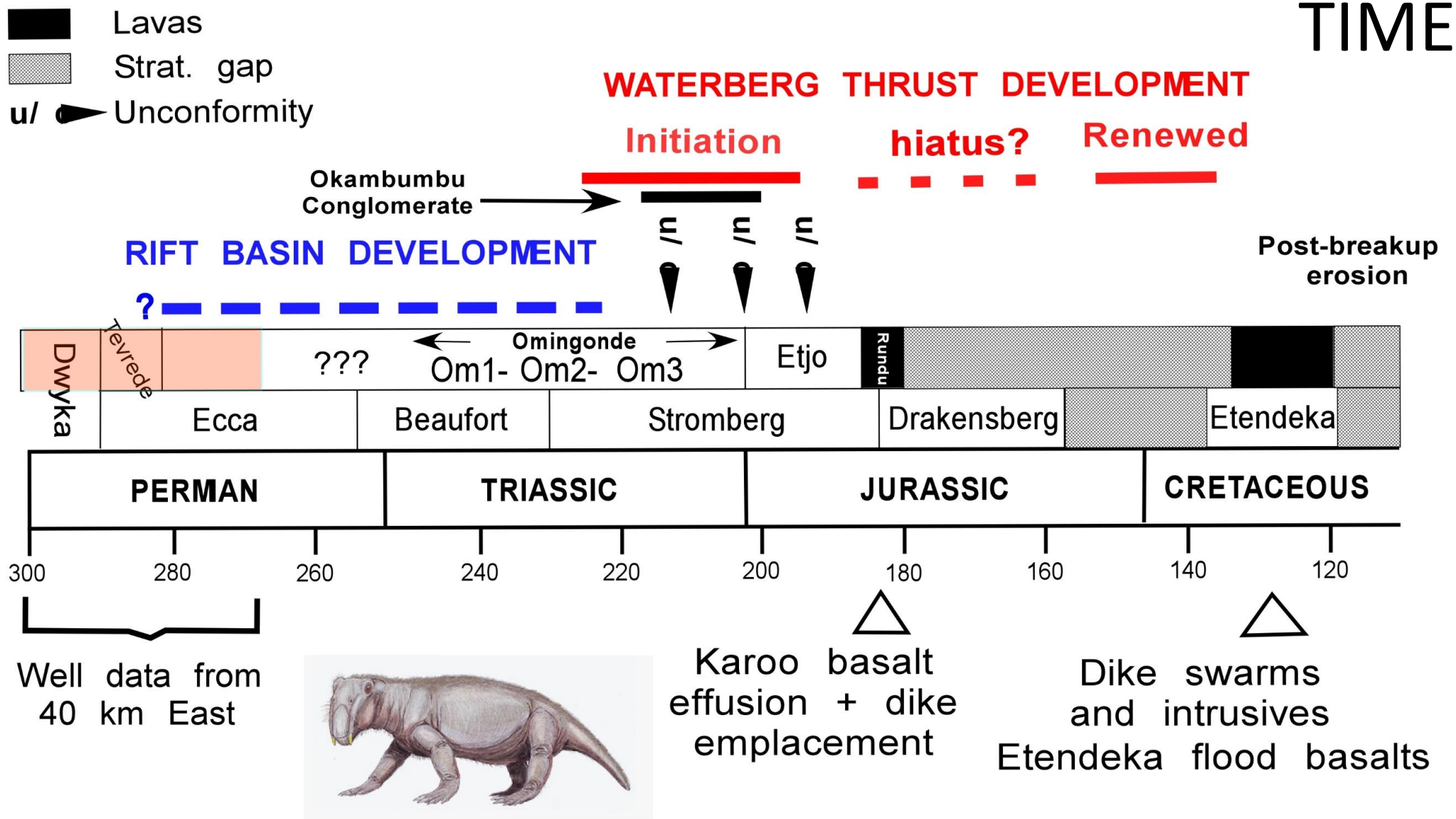
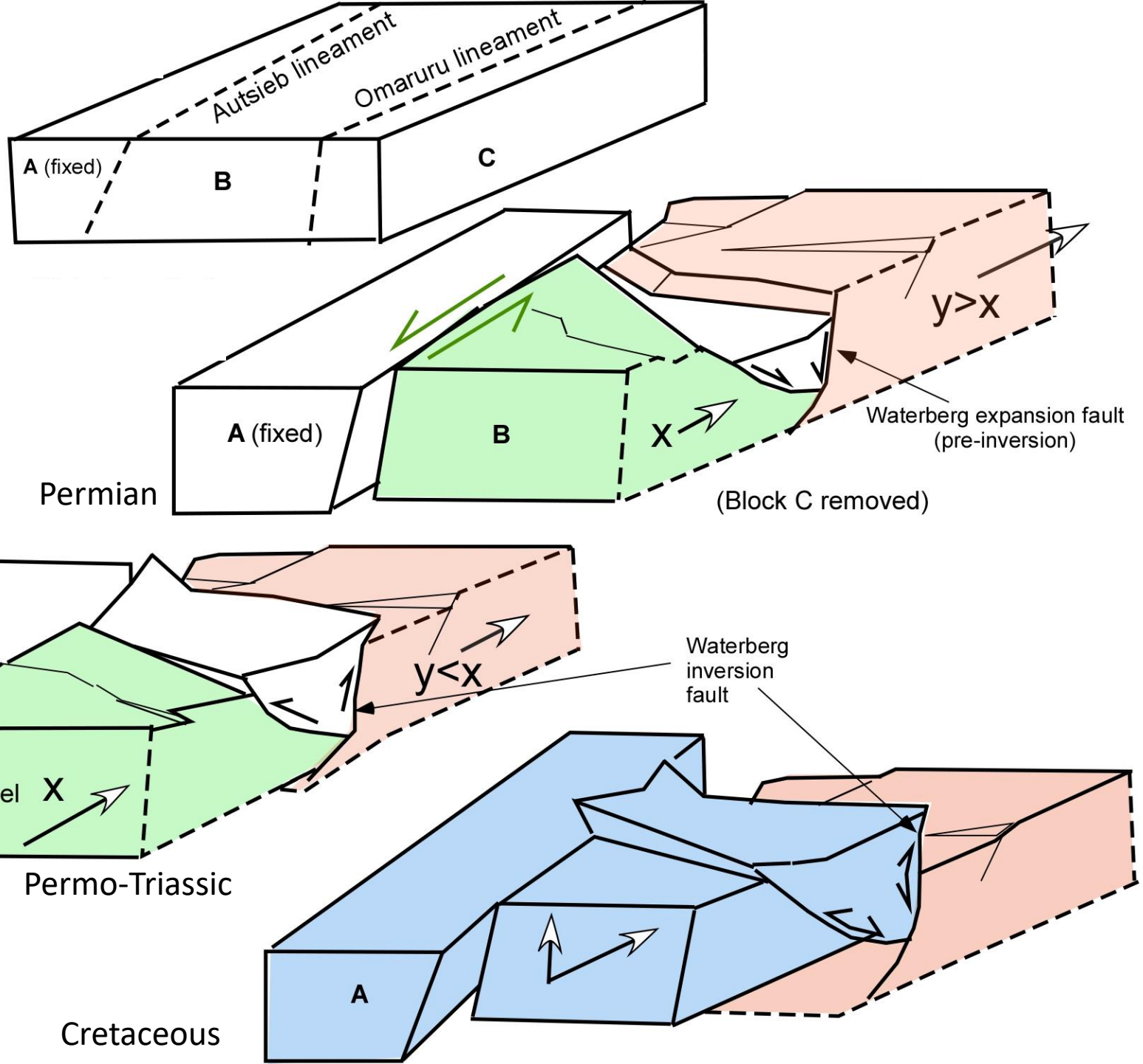
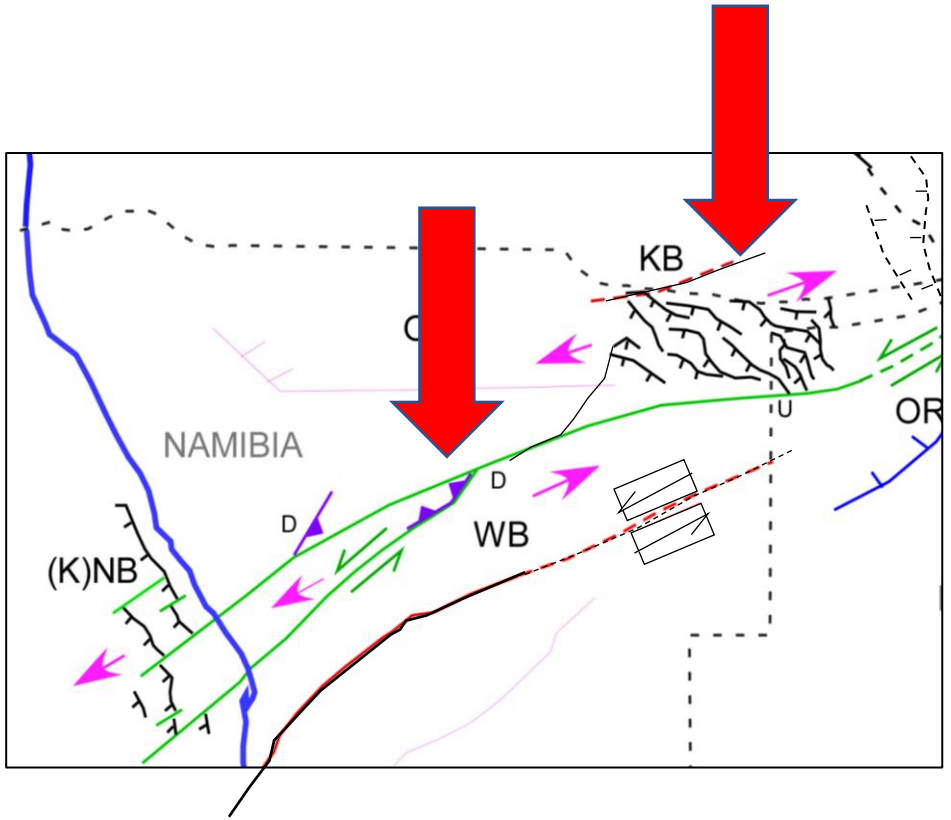
TIMELINE


Lavas
Strat. gap
u/ Unconformity
WATERBERG THRUST DEVELOPMENT
Initiation
hiatus?
Renewed
Okambumbu Conglomerate
RIFT BASIN DEVELOPMENT
?
u/
u/
u/
Post-breakup erosion
Dwyka
Tevrede
???
Omingonde
Om1- Om2- Om3
Etjo
Rundu
Ecca
Beaufort
Stromberg
Drakensberg
Etendeka
PERMAN
TRIASSIC
JURASSIC
CRETACEOUS
300
280
260
240
220
200
180
160
140
120
Well data from 40 km East
Karoo basalt effusion + dike emplacement
Dike swarms and intrusives Etendeka flood basalts
Palynology
Triassic dicynodonts & Jurassic sauropods
Apatite fission track & radiometric dates

Synthesis


Autsieb lineament
Omaruru lineament
A (fixed)
B
C
Extensional development
Permian
A (fixed)
B
X
y>x
Waterberg expansion fault
(pre-inversion)
(Block C removed)
"Syn-kinematic inversion"
A (fixed)
B vel X
y<x
Waterberg
inversion
fault
Permo-Triassic
"Allo-kinematic inversion"
A
Cretaceous

Regional parallel



Neighboring basin tectonics based on 2D reflection seismic network

Simultaneous normal faulting and inversion in the neighboring Kavango Basin, as is evident in seismic data, argues for an internal driver to inversion (‘syn-kinematic’) and against an external, ‘allo-kinematic’ driver.

Conclusions

Thank you!

- Inversion can be a multi-phase phenomenon; there are other examples of this elsewhere in the world
- In Namibia it is synchronous with its own extensional features in a basin that contains a Permo-Triassic rift-related Karoo Supergroup
- We interpret this to mean it relates to differential motion between blocks in its own rift system >>> the syn-kinematic phase
- In the case of Waterberg, early inversion was overprinted by a second phase driven by the regional uplift of the western continental margin in the Cretaceous >>> the allo-kinematic phase

Acknowledgments

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- Reconnaissance Energy Africa, LLC, for release of the results of palynological work in the Waterberg Basin