Agulhas Plateau and Mozambique Ridge: Two LIPs and their effect on oceanic circulation

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The gateway south of South Africa

- southern African continental margin represents a crucial gateway within the oceanic circulation system
- exchange of warm and cold water masses maintain global conveyor belt
- Agulhas Current AC, Antarctic Intermediate Water AAIW, North Atlantic Deep Water NADW, and Antarctic Bottom Water AABW meet and flow in opposing directions
- paths of oceanic currents are strongly influenced by seafloor topography
- => tectonic evolution is of major importance to understand the evolution of the current systems and the Greenhouse-Icehouse transition

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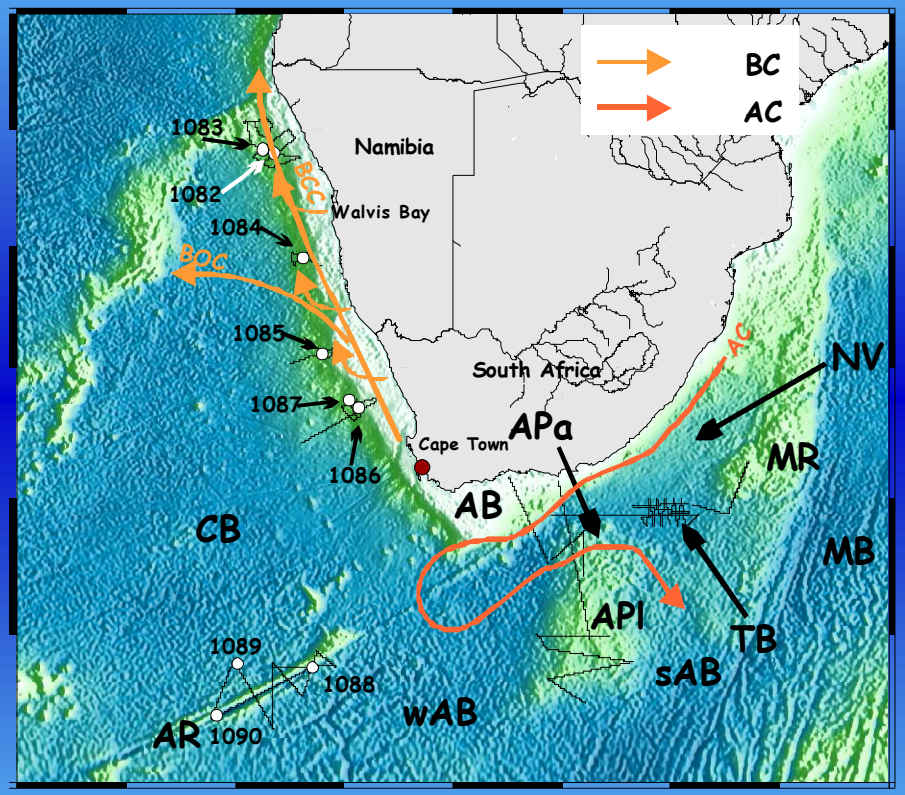
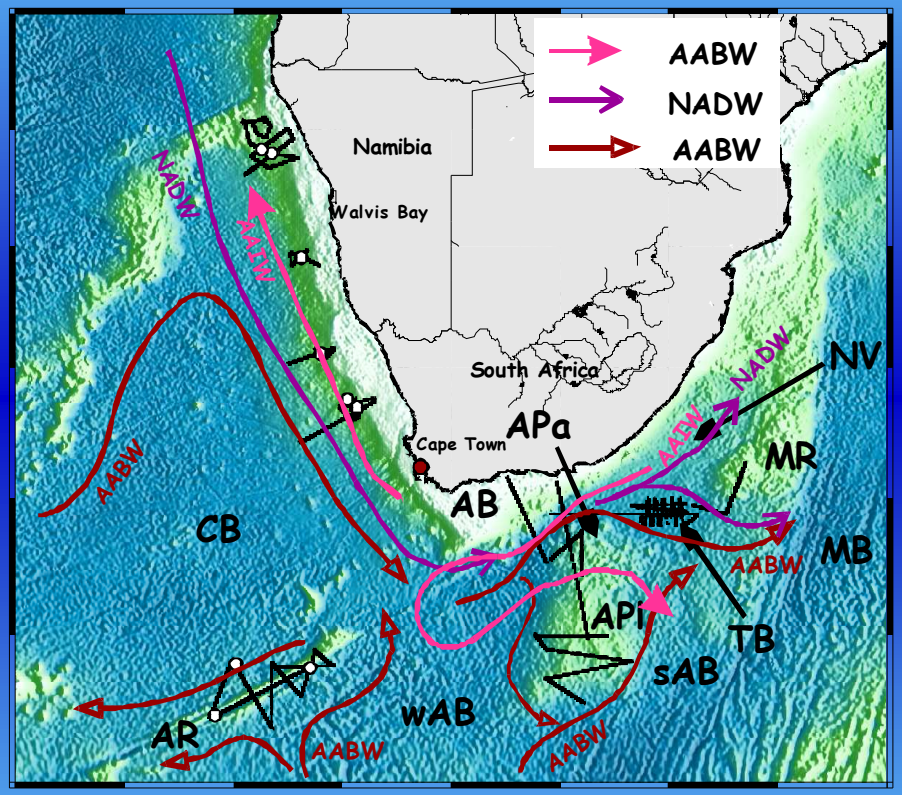
surface circulation



deep and bottom circulation



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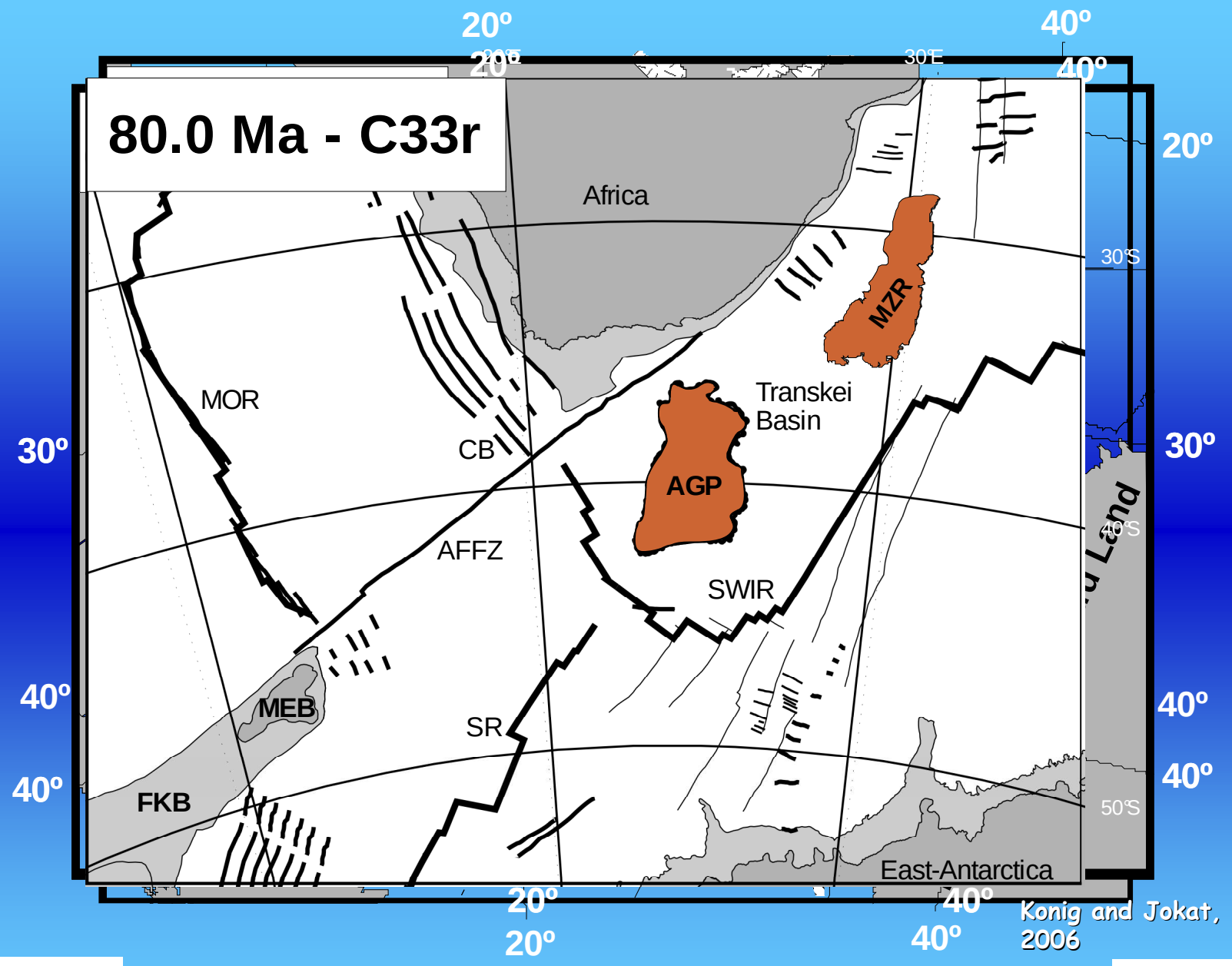
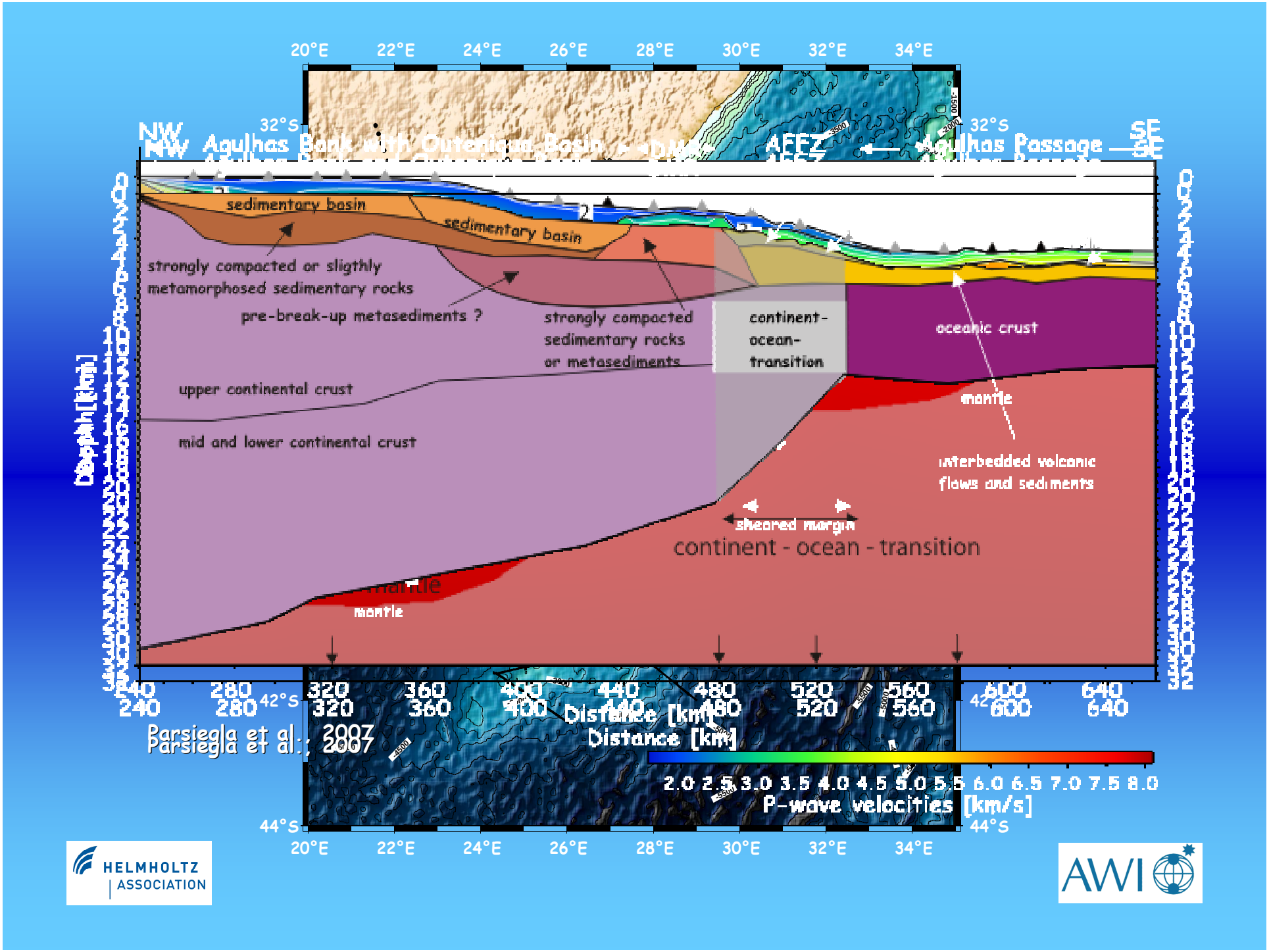
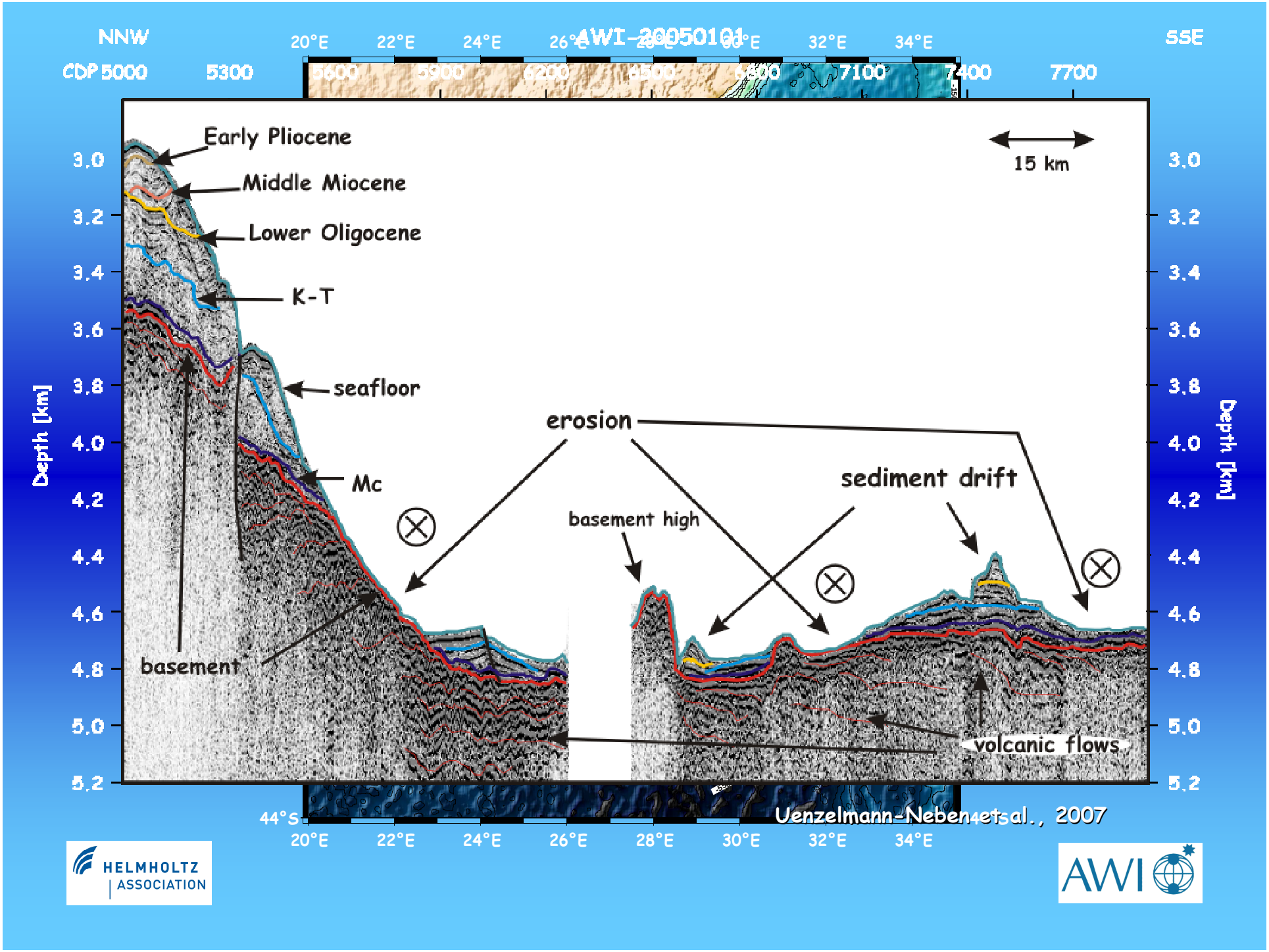

80.0 Ma - C33r
Africa
MZR
Transkei
Basin
AGP
MOR
CB
AFFZ
SWIR
SR
MEB
FKB
East-Antarctica
Konig and Jokat,
2006
20°
40°
30°
30°E
30°S
50°S


20°E
22°E
24°E
26°E
28°E
30°E
32°E
34°E
32°S
42°S
44°S
NW
SE
Agulhas Bank with Outeniqua Basin
AFEZ
Agulhas Passage
sedimentary basin
sedimentary basin
strongly compacted or sligthly metamorphosed sedimentary rocks
pre-break-up metasediments ?
strongly compacted sedimentary rocks or metasediments
continent-ocean-transition
oceanic crust
upper continental crust
mid and lower continental crust
mantle
interbedded volcanic flows and sediments
sheared margin
continent - ocean - transition
mantle
Depth [km]
Distance [km]
Parsiegla et al.; 2007
2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0
P-wave velocities [km/s]


NNW
SSE
AWI-20050101
CDP 5000
5300
5600
5900
6200
6500
6800
7100
7400
7700
20°E
22°E
24°E
26°E
28°E
30°E
32°E
34°E
Early Pliocene
Middle Miocene
Lower Oligocene
K-T
seafloor
Mc
basement
erosion
basement high
sediment drift
volcanic flows
15 km
Depth [km]
3.0
3.2
3.4
3.6
3.8
4.0
4.2
4.4
4.6
4.8
5.0
5.2
44°S
Uenzelmann-Neben et al., 2007
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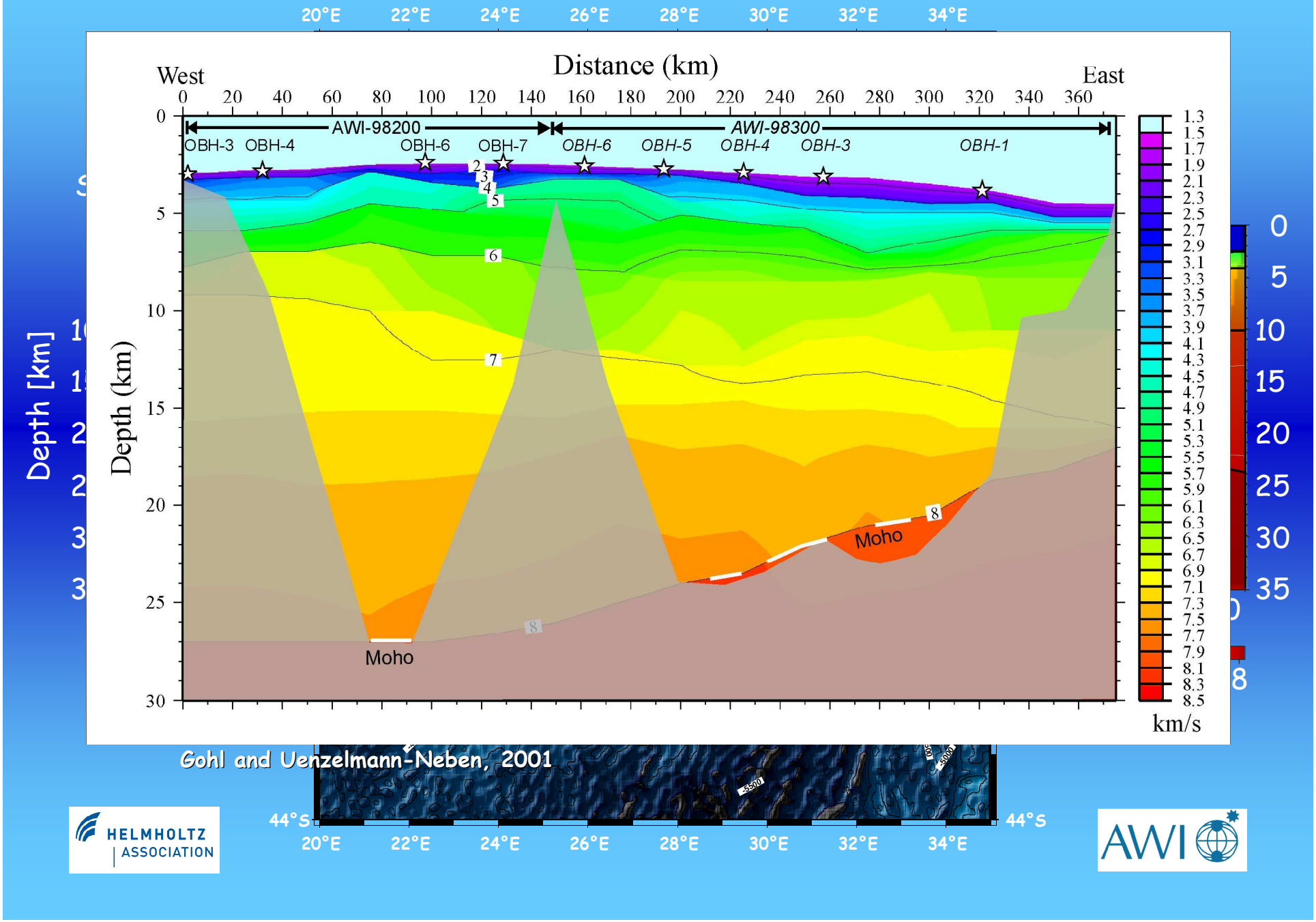
20°E
22°E
24°E
26°E
28°E
30°E
32°E
34°E
West
Distance (km)
East
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
360
AWI-98200
AWI-98300
OBH-3
OBH-4
OBH-6
OBH-7
OBH-6
OBH-5
OBH-4
OBH-3
OBH-1
Depth (km)
Moho
Moho
km/s
1.3
1.5
1.7
1.9
2.1
2.3
2.5
2.7
2.9
3.1
3.3
3.5
3.7
3.9
4.1
4.3
4.5
4.7
4.9
5.1
5.3
5.5
5.7
5.9
6.1
6.3
6.5
6.7
6.9
7.1
7.3
7.5
7.7
7.9
8.1
8.3
8.5
Depth [km]
0
5
10
15
20
25
30
35
Gohl and Uenzelmann-Neben, 2001
44°S
44°S
20°E
22°E
24°E
26°E
28°E
30°E
32°E
34°E
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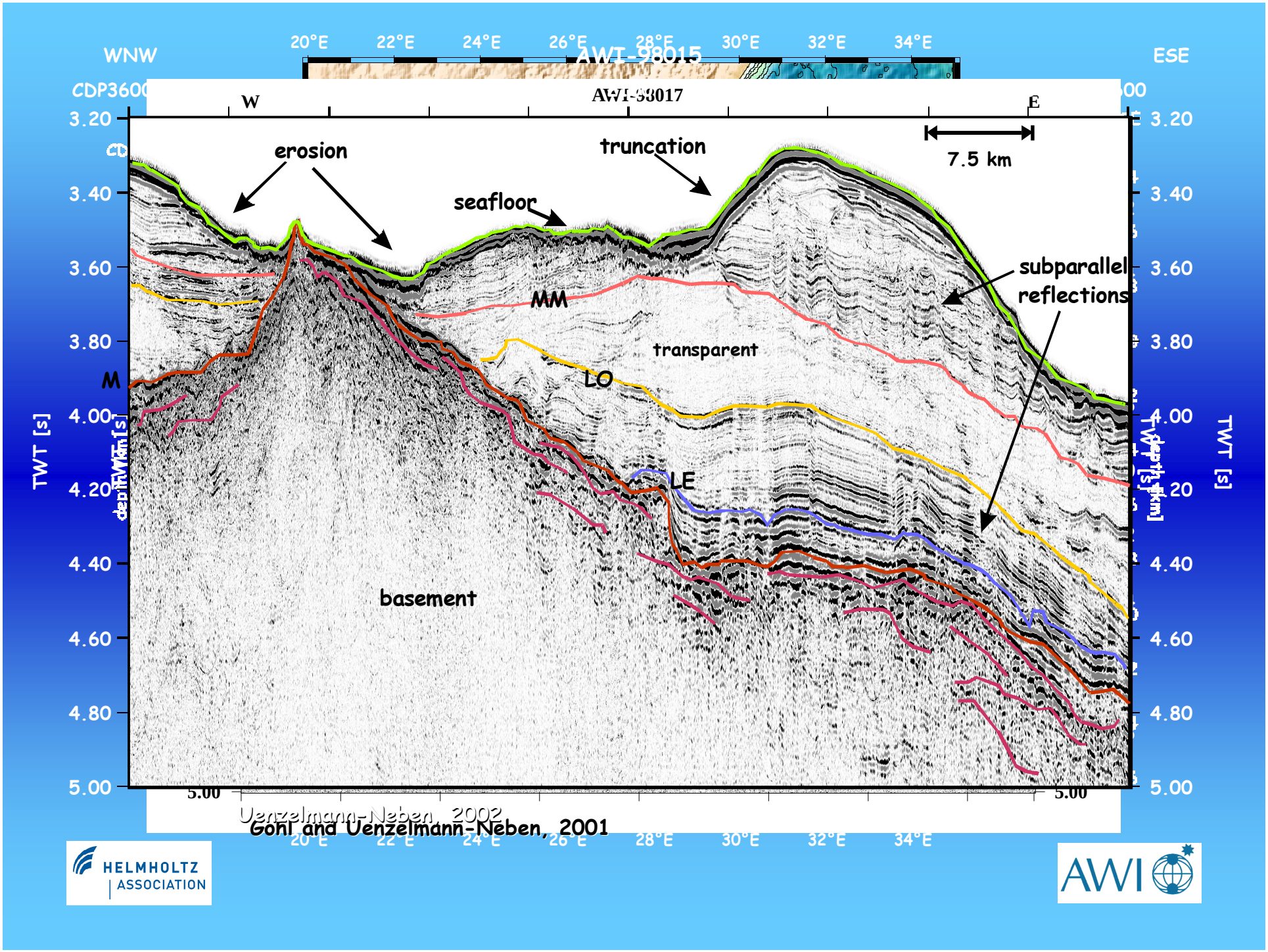
WNW
ESE
AWI-98015
AWI-98017
W
E
CDP3600
20°E
22°E
24°E
26°E
28°E
30°E
32°E
34°E
3.20
3.40
3.60
3.80
4.00
4.20
4.40
4.60
4.80
5.00
TWT [s]
erosion
truncation
seafloor
7.5 km
subparallel
reflections
MM
transparent
LO
LE
basement
M
Uenzelmann-Neben, 2002
Gohl and Uenzelmann-Neben, 2001
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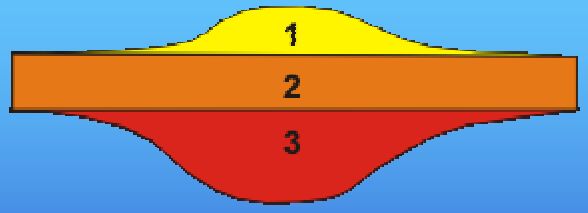
A

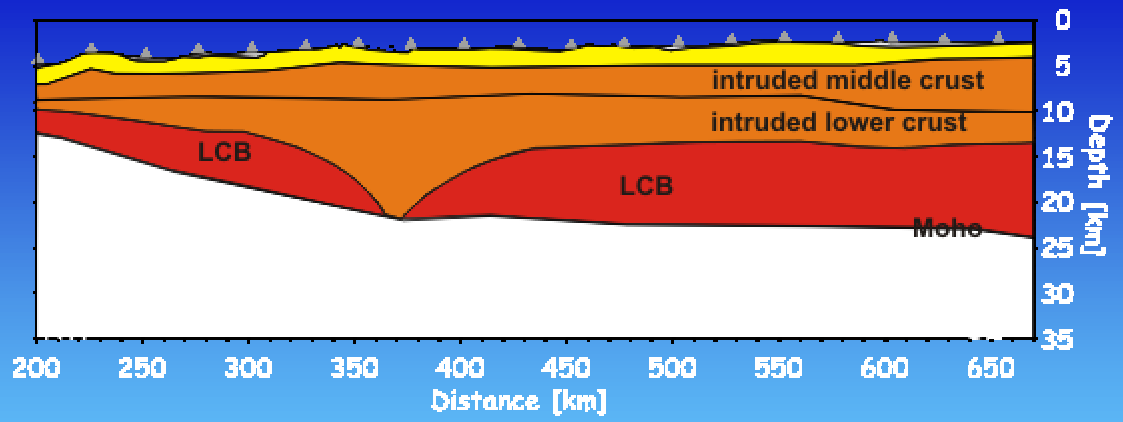
B



1: extruded upper crust
2: intruded crust
3: lower crustal body

4.1 * 10^6 km^3 with 10 % extrusive material

C



Parsiegla et al., 2008

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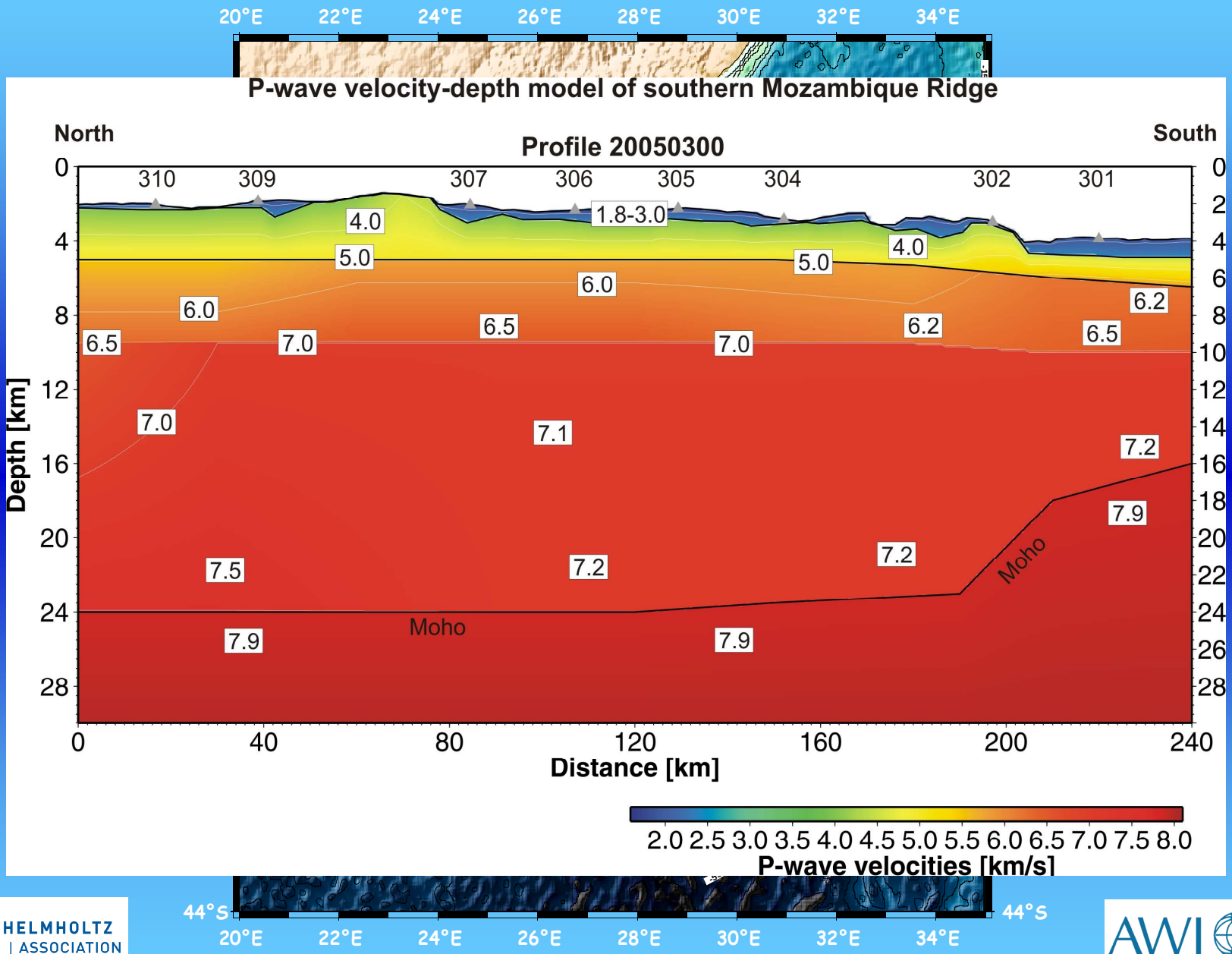
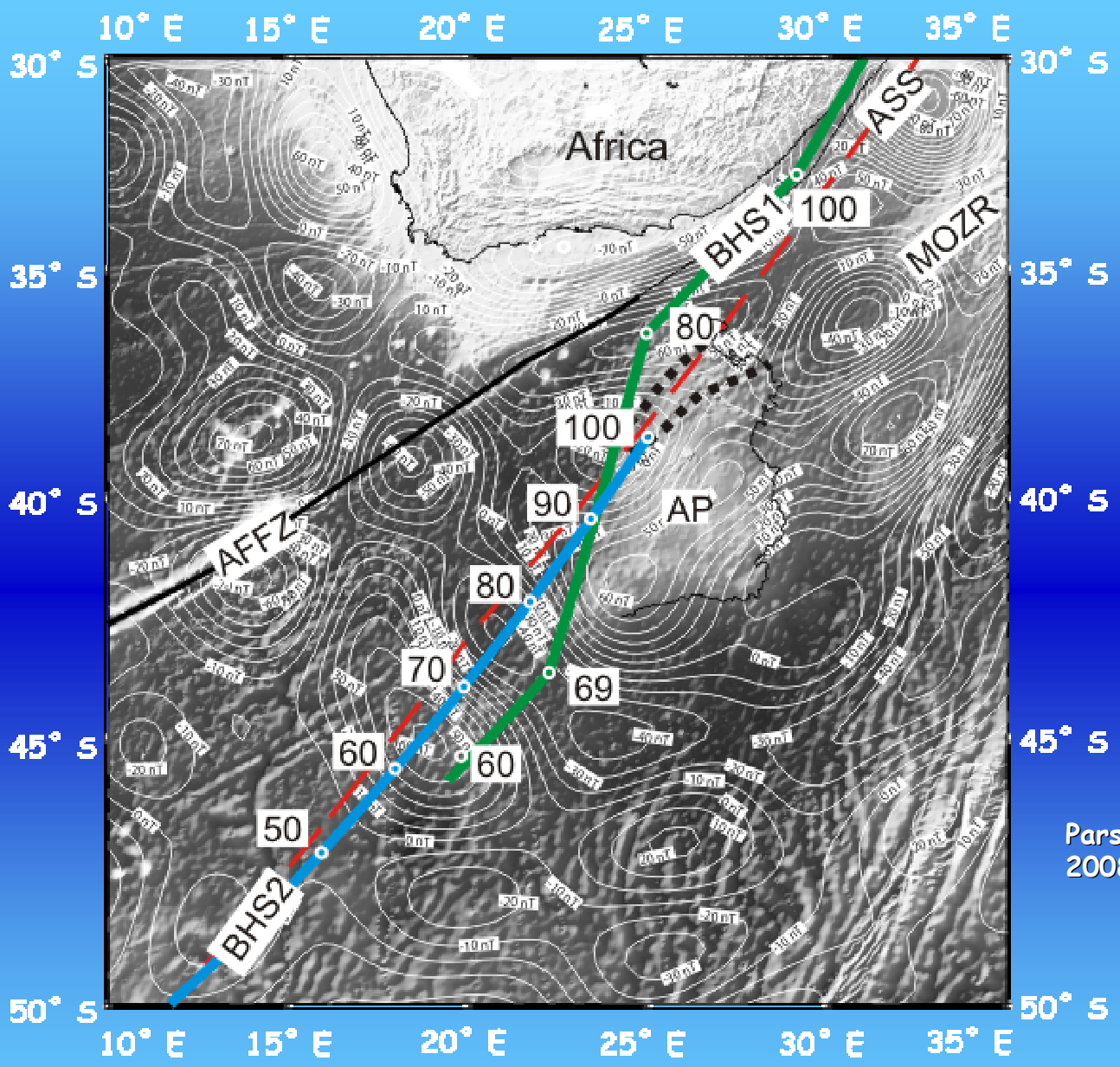

20°E 22°E 24°E 26°E 28°E 30°E 32°E 34°E
P-wave velocity-depth model of southern Mozambique Ridge
North
South
Profile 20050300
310 309 307 306 305 304 302 301
4.0
1.8-3.0
5.0
6.0
6.5
7.0
7.1
7.2
7.5
7.9
Moho
Depth [km]
Distance [km]
2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0 7.5 8.0
P-wave velocities [km/s]
44°S
20°E 22°E 24°E 26°E 28°E 30°E 32°E 34°E



Parsiegla et al., 2008

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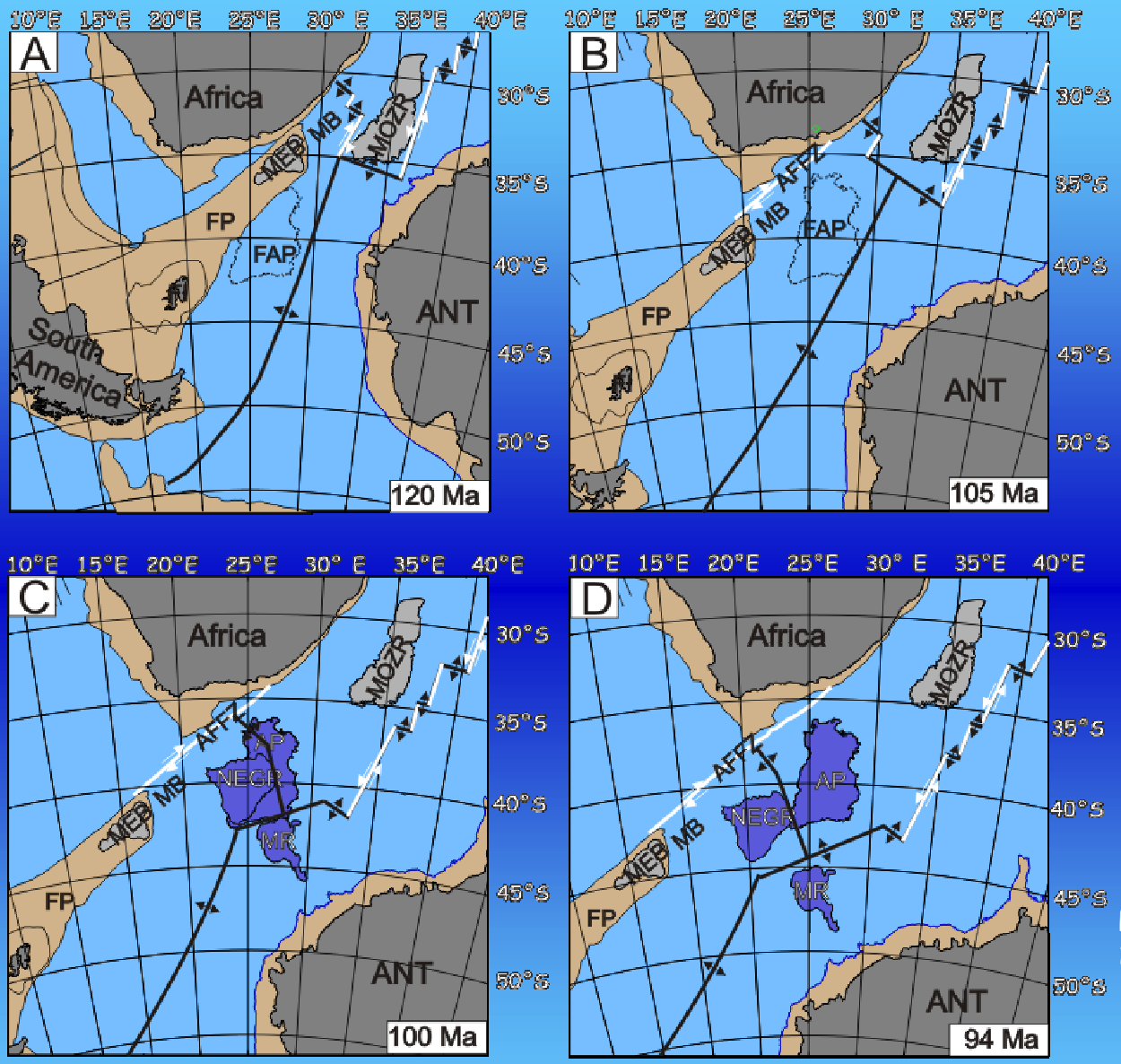

Parsiegla et al., 2008

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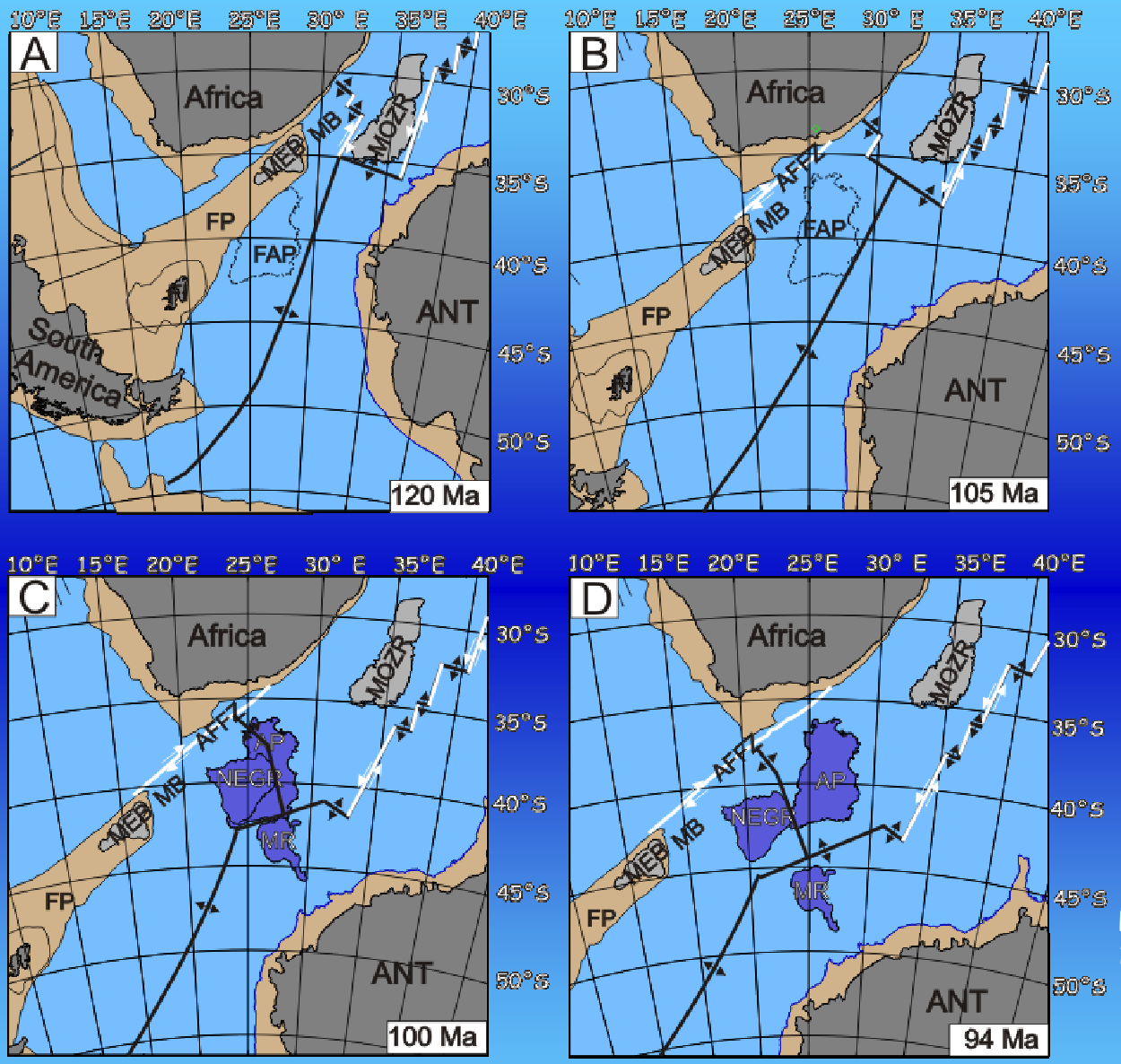

Parsiegla et al., 2008

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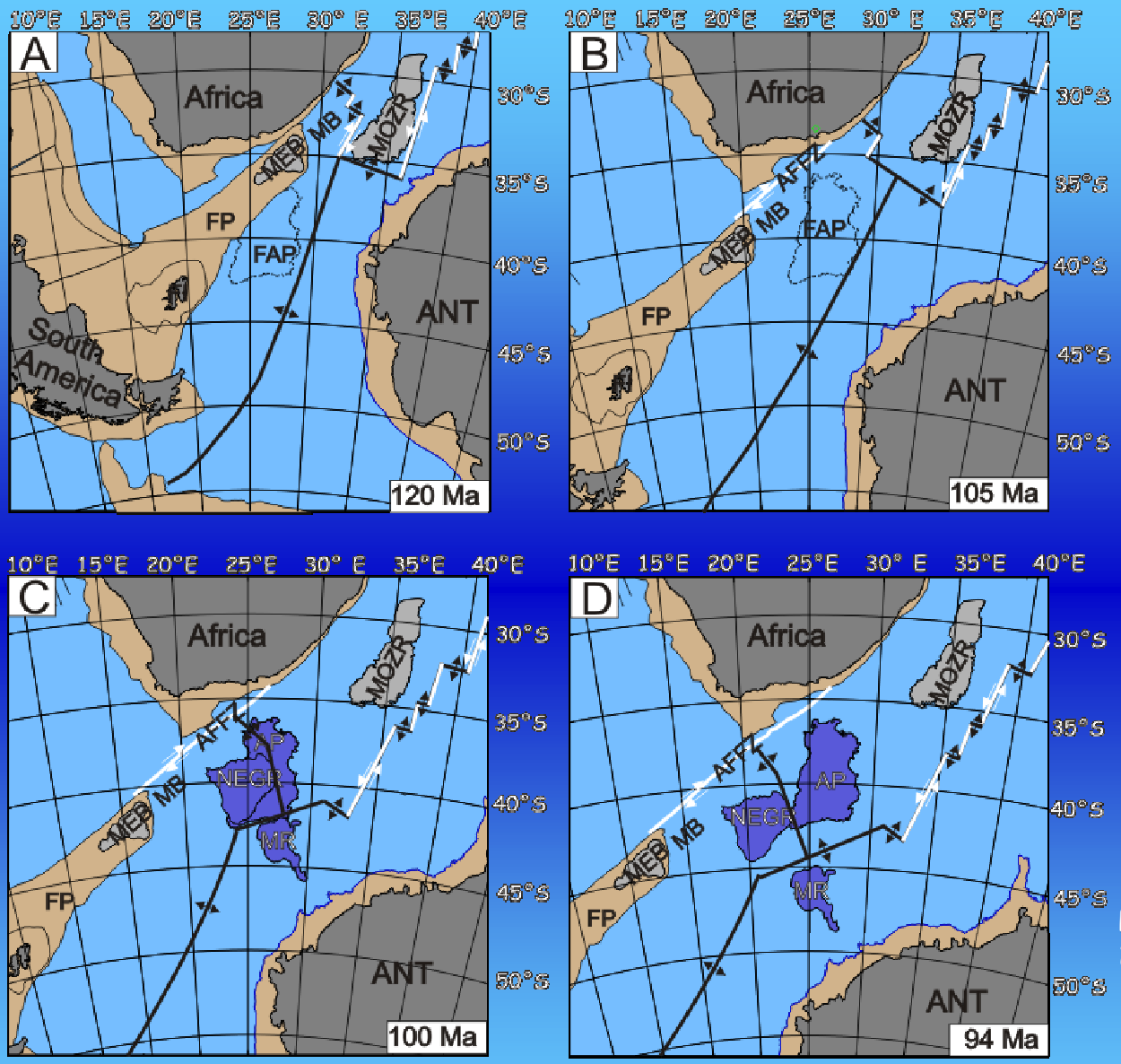

Parsiegla et al., 2008

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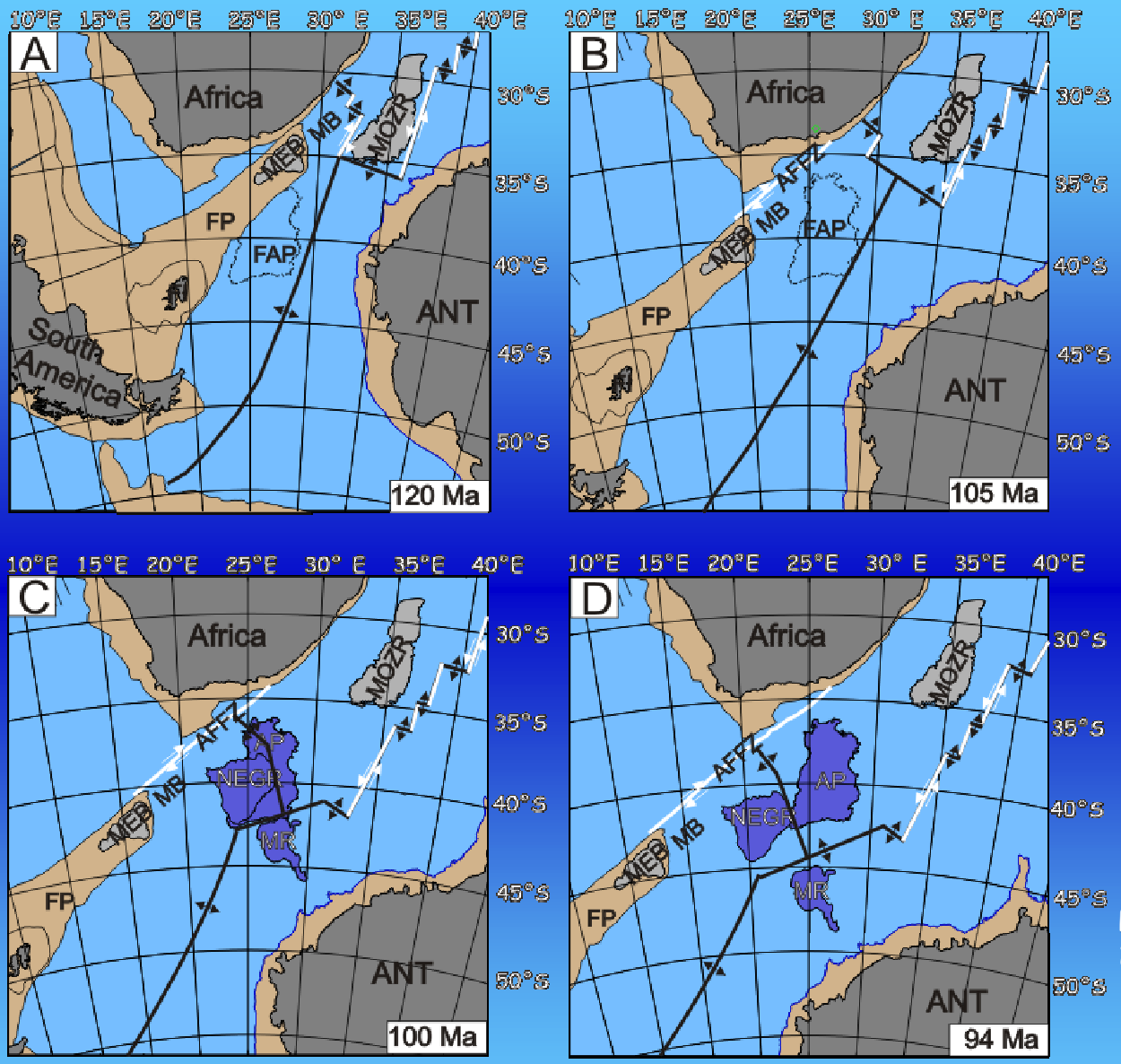

Parsiegla et al., 2008

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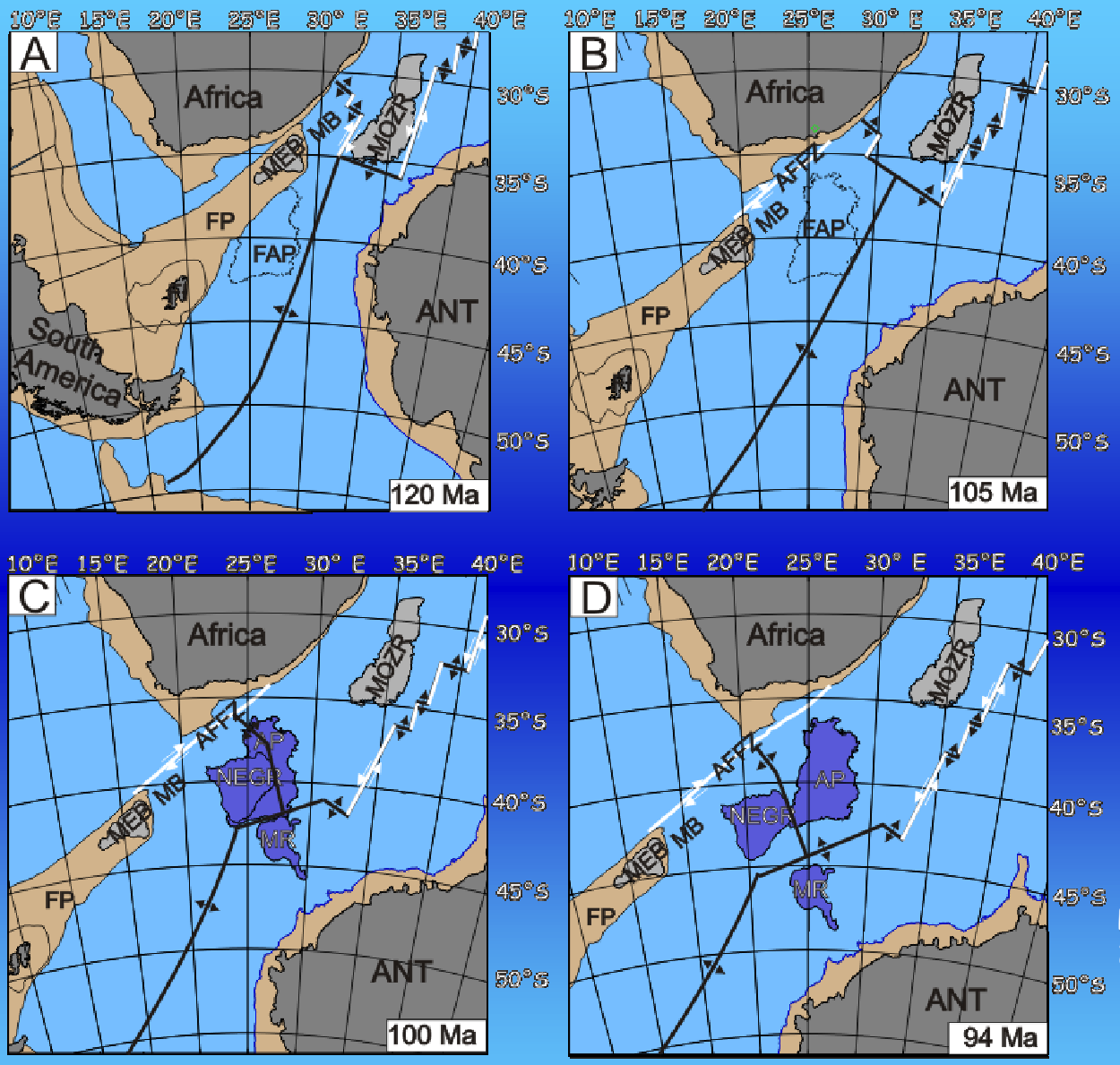

Parsiegla et al., 2008

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Results

- Agulhas Plateau and Mozambique Ridge are interpreted as Large Igneous Provinces
- Agulhas Plateau was formed as part of a larger LIP consisting of AP, NEGR, and MR
- Agulhas Plateau was formed between 100 and 90 Ma, Mozambique Ridge probably earlier but exact age is unclear
- plate tectonic reconstructions allow only a constricted flow in ocean basins, but no inter-ocean exchange before 100 Ma
- effect of those bathymetric structures on the currents' paths is documented in sediment drifts

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Open questions

- basement petrology and geochemical composition and hence origin of Agulhas Plateau and Mozambique Ridge
- age of the basement and timing of lava flows relative to the separation of Africa and Antarctica
- age and composition of lava flows within the framework of worldwide LIP occurrence and excessive volcanism
- age and composition of sediments on Agulhas Plateau and Mozambique Ridge as an indication for the earliest occurrence for modern type circulation
- the effect of those bathymetric structures on the paths of AABW, NADW, AAIW, and AC

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