The lithospheric structure of Northern Africa from seismological constrained gravity inversion

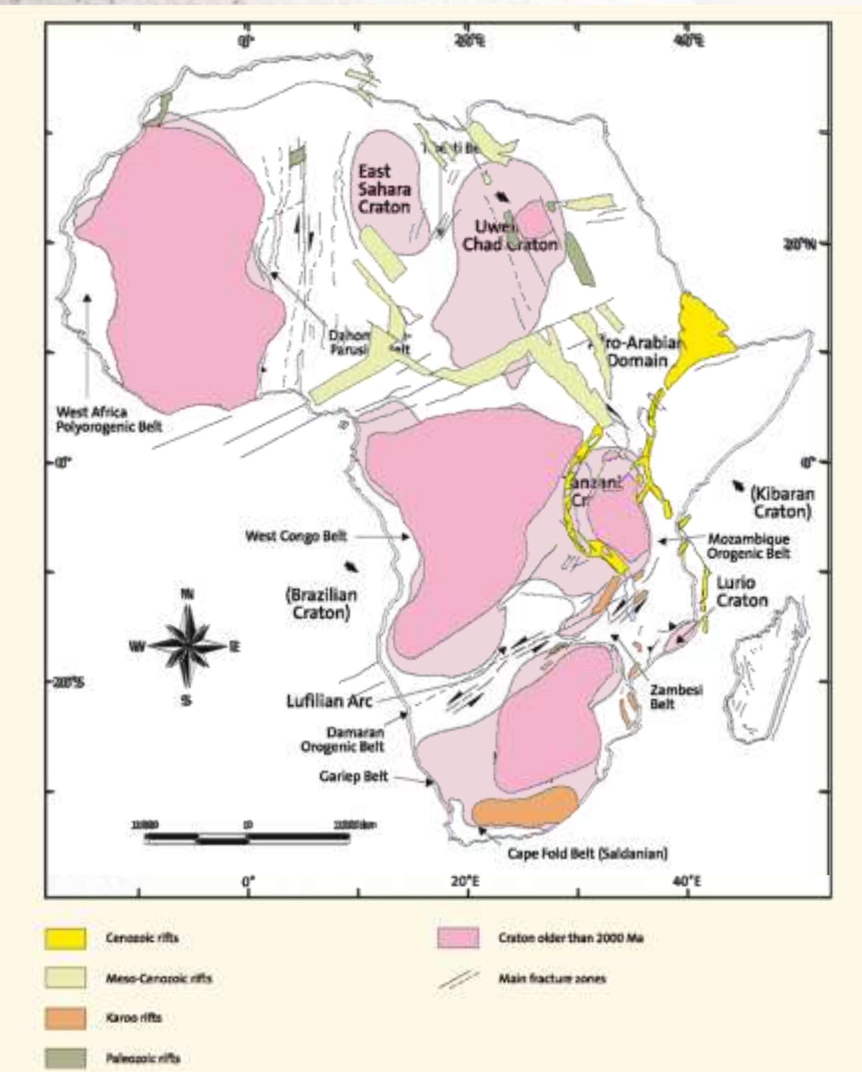
Jörg Ebbing (NGU), Albert Eyike (NGU, U Douala), Stewart Fishwick (U Leicester), Sue J. Webb (WITS), Stephanie C. Werner (PGP Oslo), Carla Braitenberg (U Trieste)

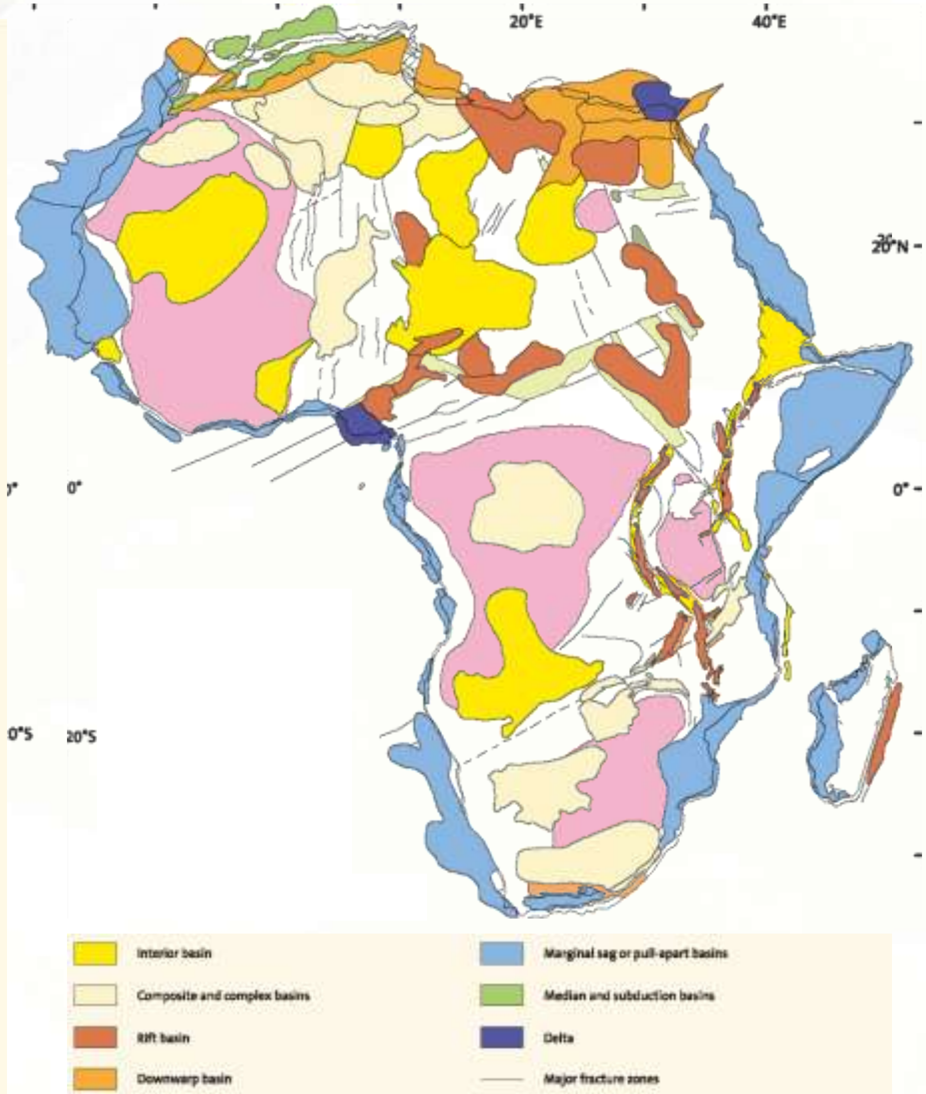
Out of Africa
Johannesburg
November, 16th 2009

StatoilHydro

NGU
Norges geologiske undersøkelse
Geological Survey of Norway

Lithospheric structure to understand tectonic history and basin evolution in Northern Africa

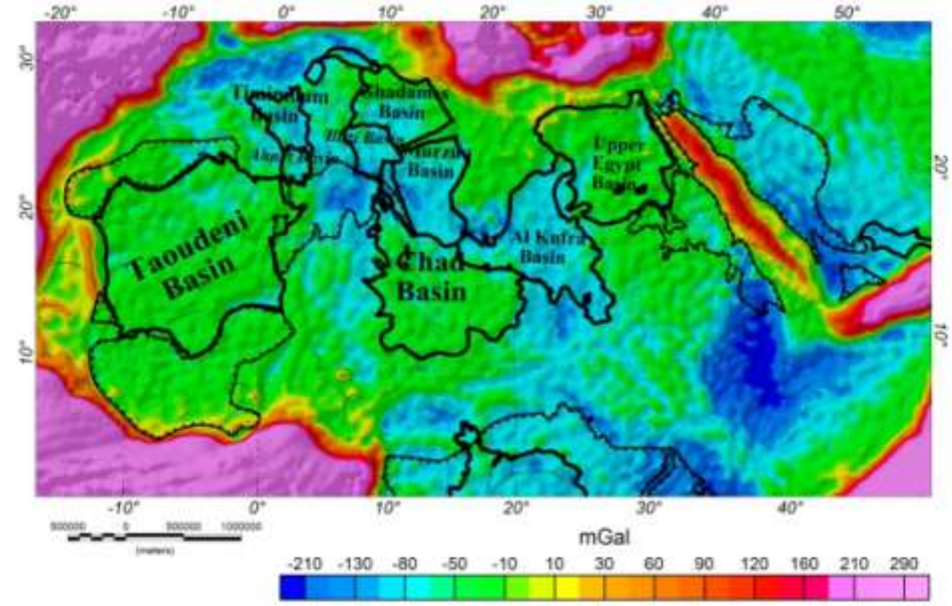




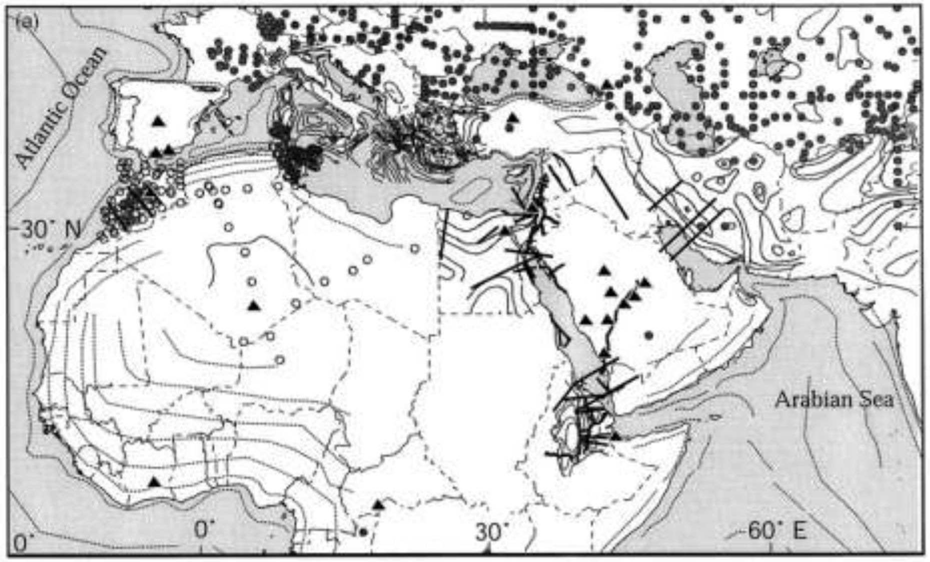
Figures from Geological Atlas of Africa, 2nd edition, Schlüter 2008

Available information about the lithospheric structure of Northern Africa

Bouguer anomaly (EGM-08)



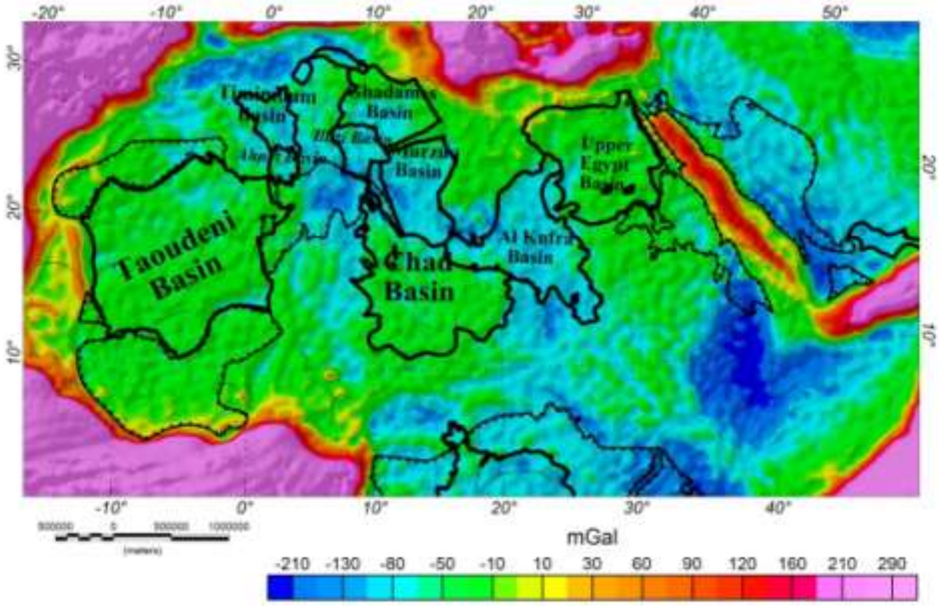
Crustal thickness



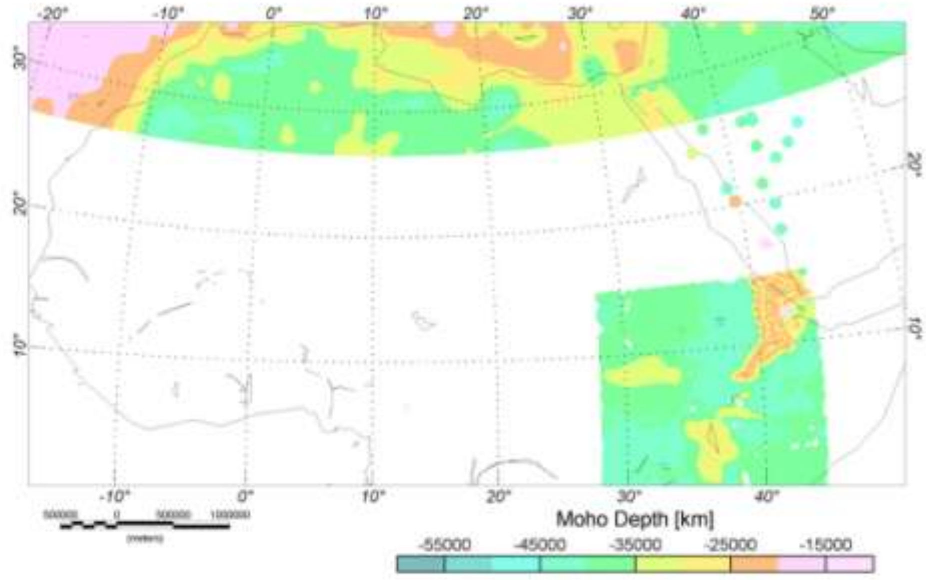
Seber et al. 2001

Available information about the lithospheric structure of Northern Africa

Bouguer anomaly (EGM-08)

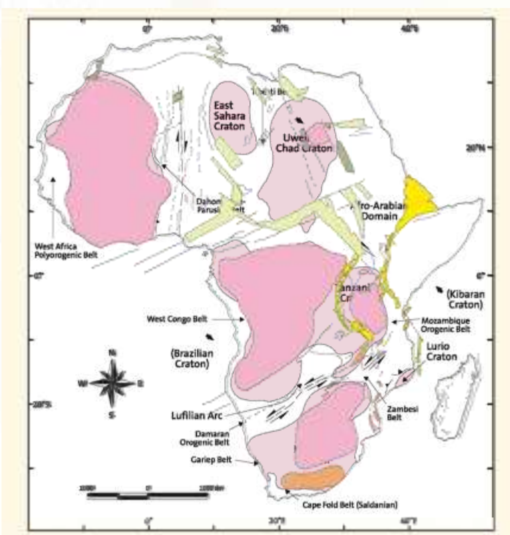


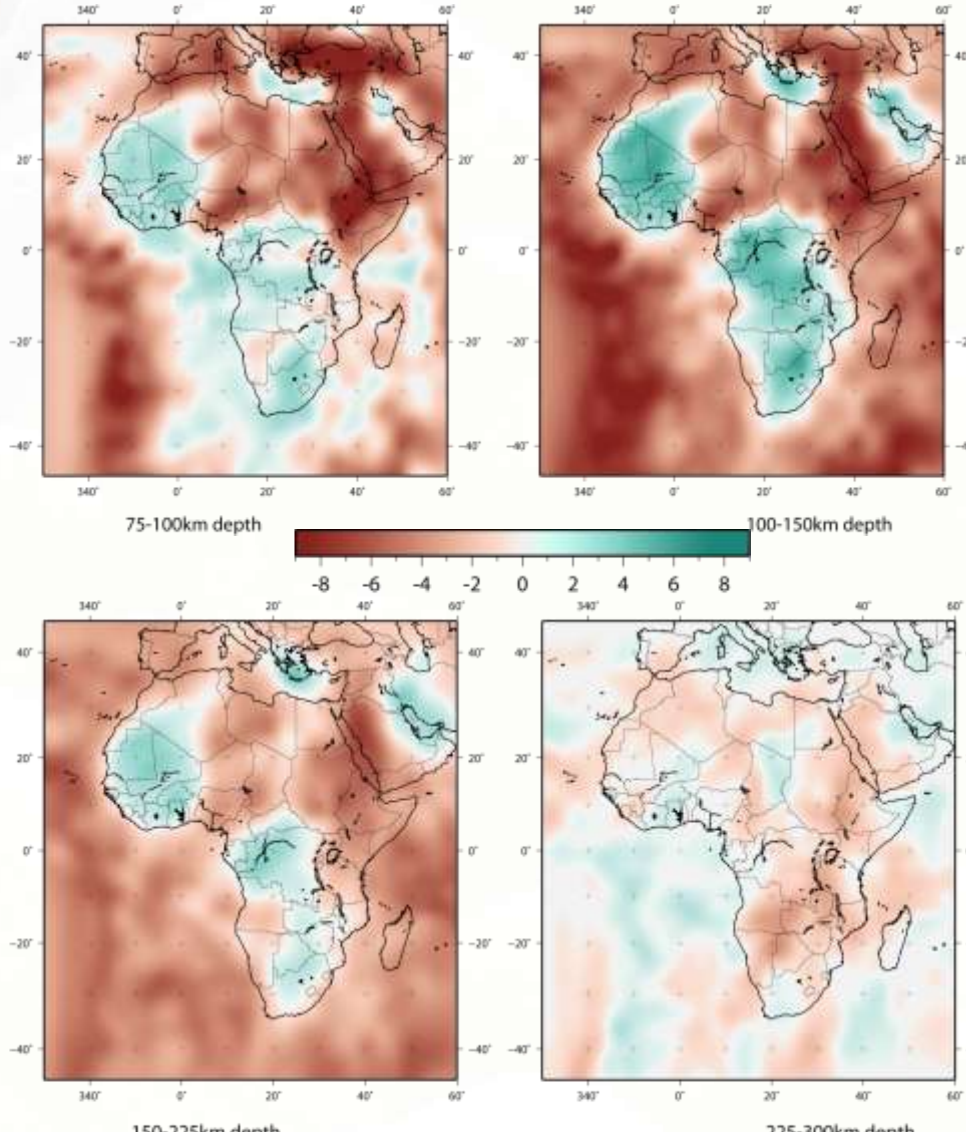
Crustal thickness



Moho depth for northern Africa based on Grad et al. (2008), Al-Damegh (2005) and Woldetinsae (2005).

Mantle velocity anomalies (Fishwick 2008)





Possible ways to estimate crustal thickness in Northern Africa

1. Gravity inversion (see Poster)

2. **Seismological constrained gravity inversion**
   - **Applying conversions between mantle velocity anomalies and density anomalies**

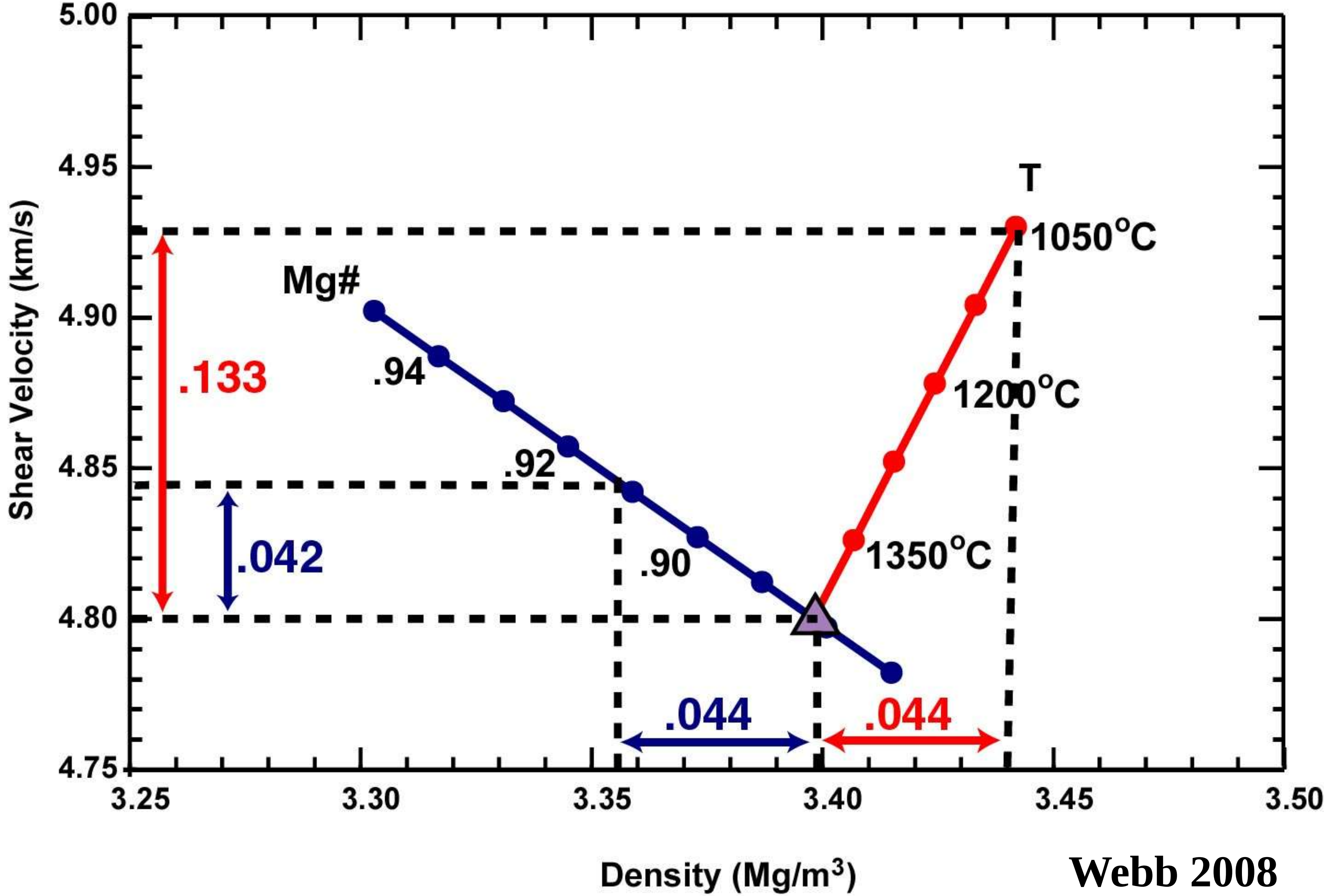
3. Isostatic inversion (see Poster)

Density vs. seismic velocity

- Generally assumed that temperature is the main control on velocity – density relationship (increase temperature, decrease density)

- Testing hypothesis (Jordan, 1975) that craton keel is low density, but high seismic velocity due to increase in Mg#

(Webb 2008)



5.00
4.95
4.90
4.85
4.80
4.75
Shear Velocity (km/s)
3.25
3.30
3.35
3.40
3.45
3.50
Density (Mg/m3)
T
1050°C
1200°C
1350°C
Mg#
.94
.92
.90
.133
.042
.044
.044

Webb 2008

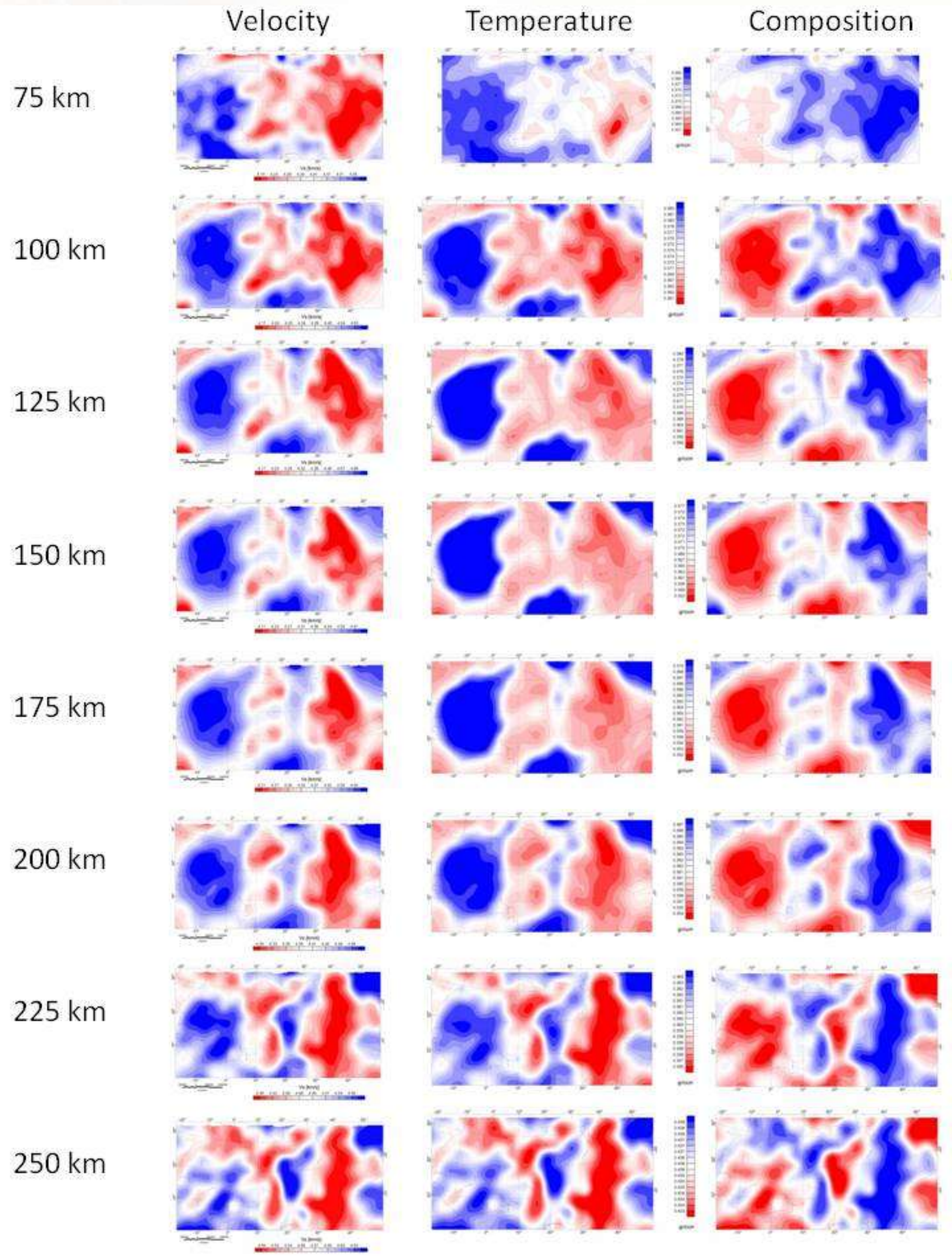
S-velocities from tomographic model (Fishwick 2008) and converted densities

Mean velocities and densities (PREM) for the different depth intervals – used to convert density variations to absolute densities

Temperature: positive velocity-density relation

Composition negative velocity-density relation

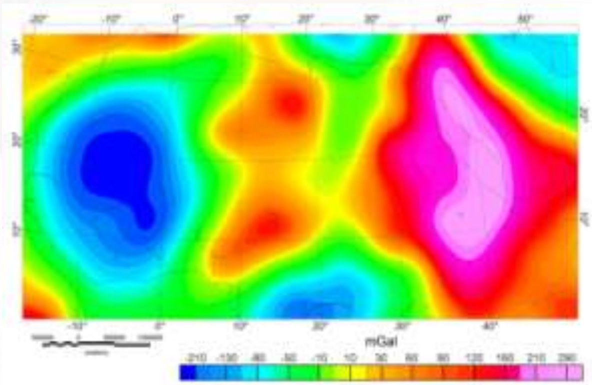
Depth	Vs [km/s]	Density [kg/m^3]
75	4.3780876	3374.71
100	4.40040043	3372.53
125	4.41063499	3369.82
150	4.39772939	3367.10
175	4.39088571	3362.03
200	4.42046938	3360.77
225	4.48829708	3359.50
250	4.56818894	3435.78

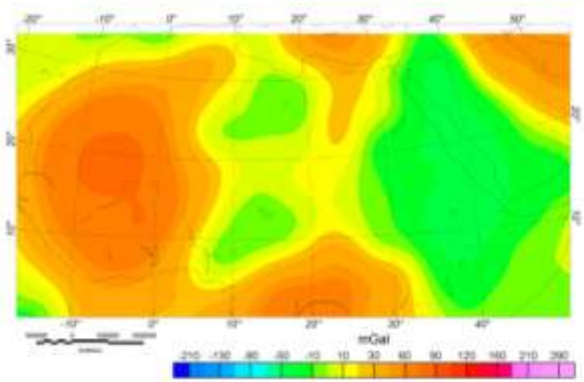


Mantle density distribution

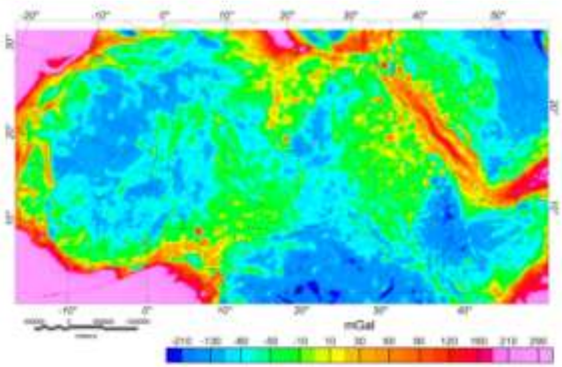
Temperature | Composition

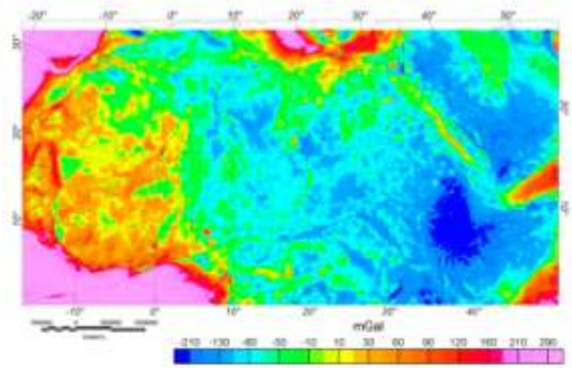
Gravity effect





Gravity residual



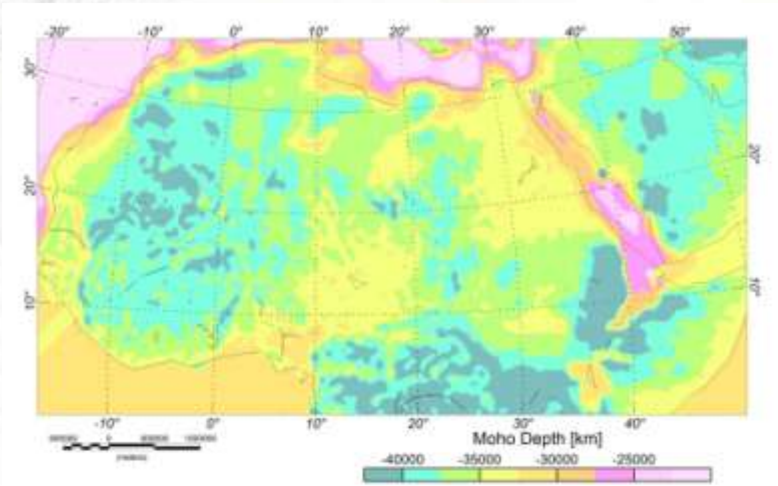


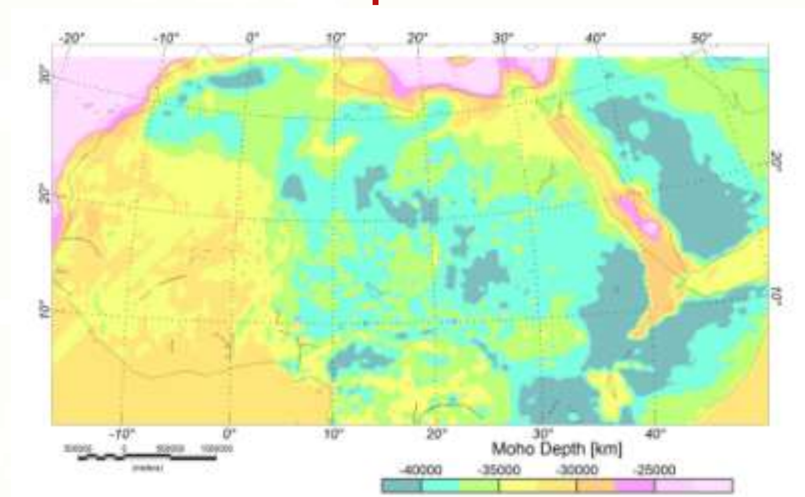
Inverted Moho depth

with density increase in crust, corrected mantle gravity and constraints from Moho compilations

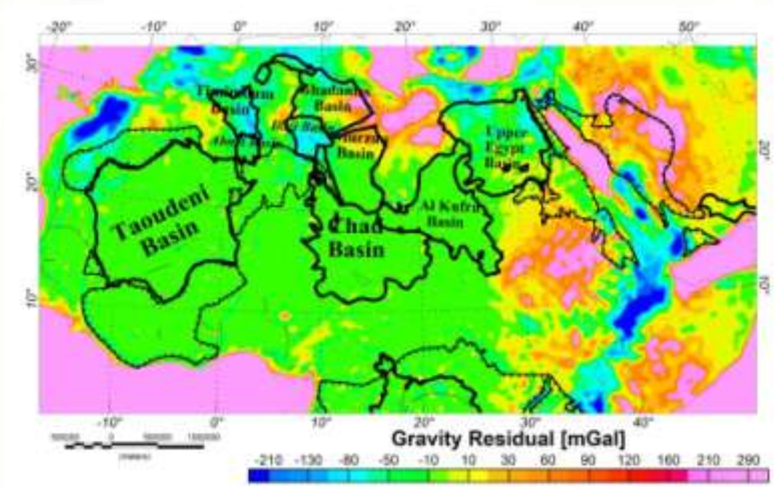
Temperature | Composition

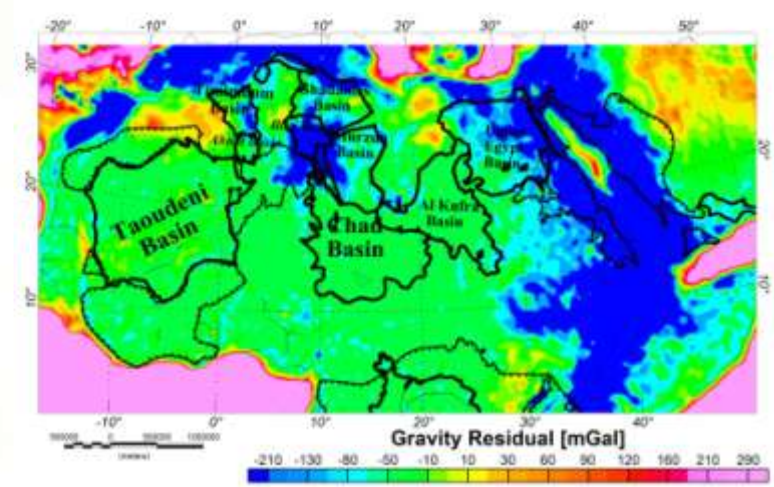
Moho depth



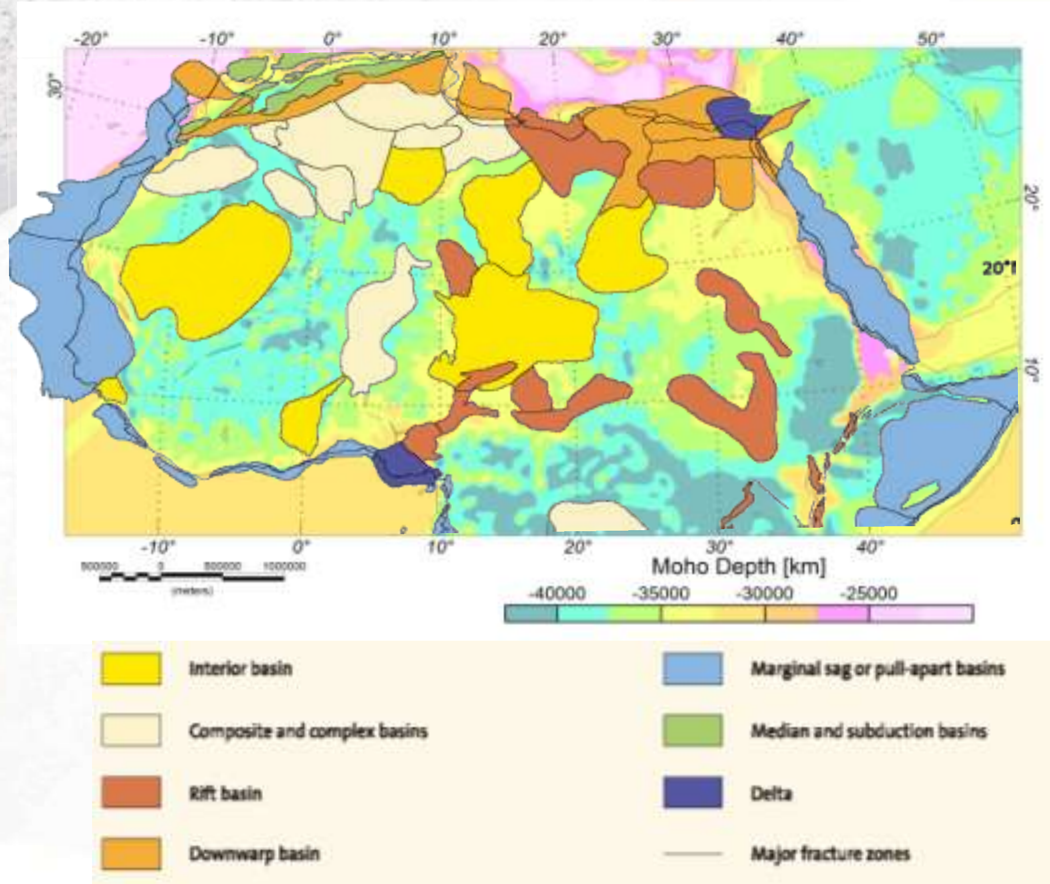


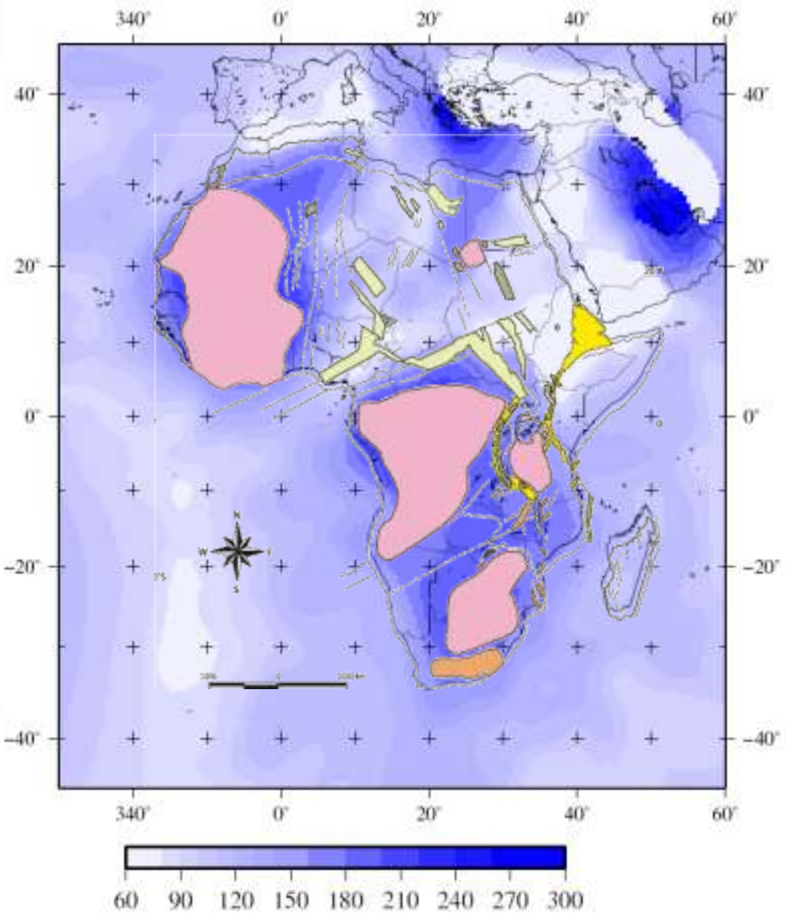
Gravity residual



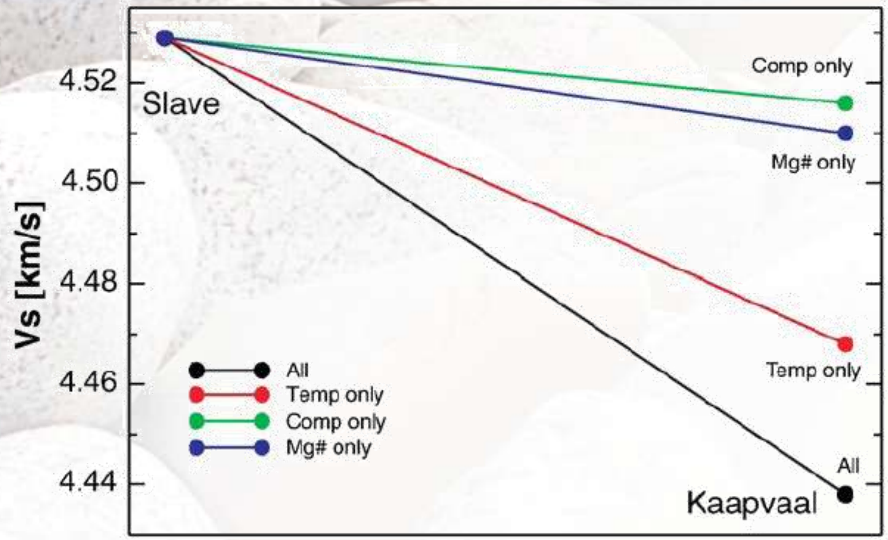


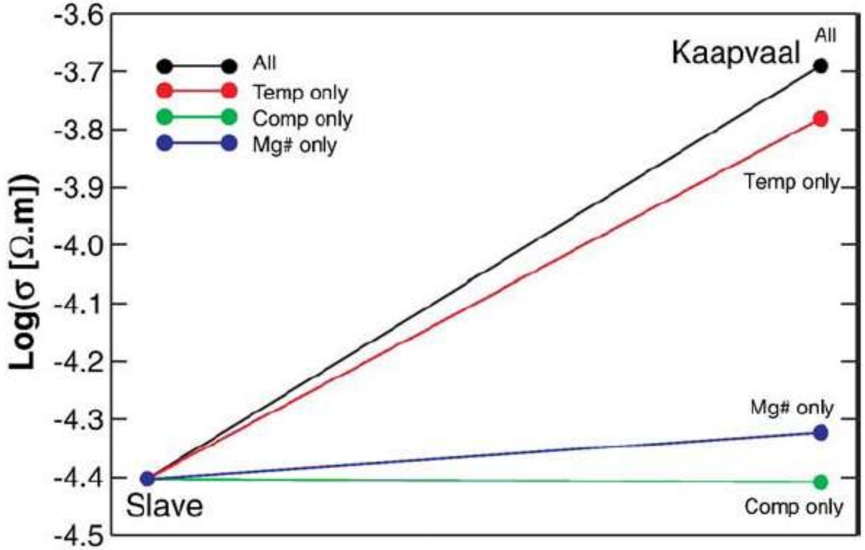
Temperature model
Comparison to tectonic elements



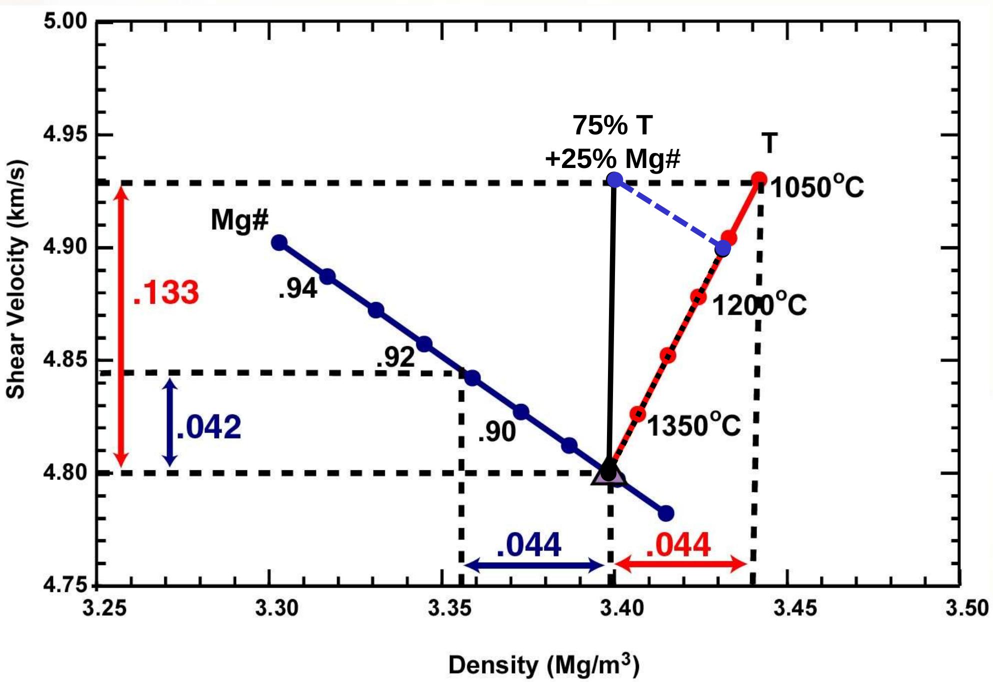


Variations of shear wave velocity and electric conductivity at 150 km depth





Jones et al. 2009



Conclusions

- Information on Moho depth for North Africa is sparse, but must be used to constrain inversion
- Bouguer anomaly alone is not good indicator of crustal thickness
- For large scale gravity modeling it is important to consider the full thickness of the crust as well as contributions from the lithospheric mantle as these contributions are of similar wavelength and will be difficult to separate
- New Moho map enhances differences between West African Craton and Northeast Africa, but is it realistic?
- Temperature vs. Compostion remains a challenge to understand
- Refined lithospheric structure can be achieved by using
  - sediment thickness
  - geoid undulations and magnetic anomalies