UNIVERSITÀ DEGLI STUDI DI TRIESTE

ISTITUTO NAZIONALE DI OCEANOGRAFIA E DI GEOFISICA SPERIMENTALE

18th International Symposium on Geodynamics and Earth Tides

Intelligent Earth system sensing, scientific enquiry and discovery

Trieste (Italy), 5 - 9 June 2016

Trieste University Campus

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Organizers

Carla Braitenberg (General Chair)
University of Trieste

Giuliana Rossi (Co-Chair)
OGS (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale) - Trieste

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LithoFLEX

Control of high velocity lithosphere roots on crustal and lithosphere density variations

Carla Braitenberg and Patrizia Mariani

GNGTS- Stazione Marittima- Trieste

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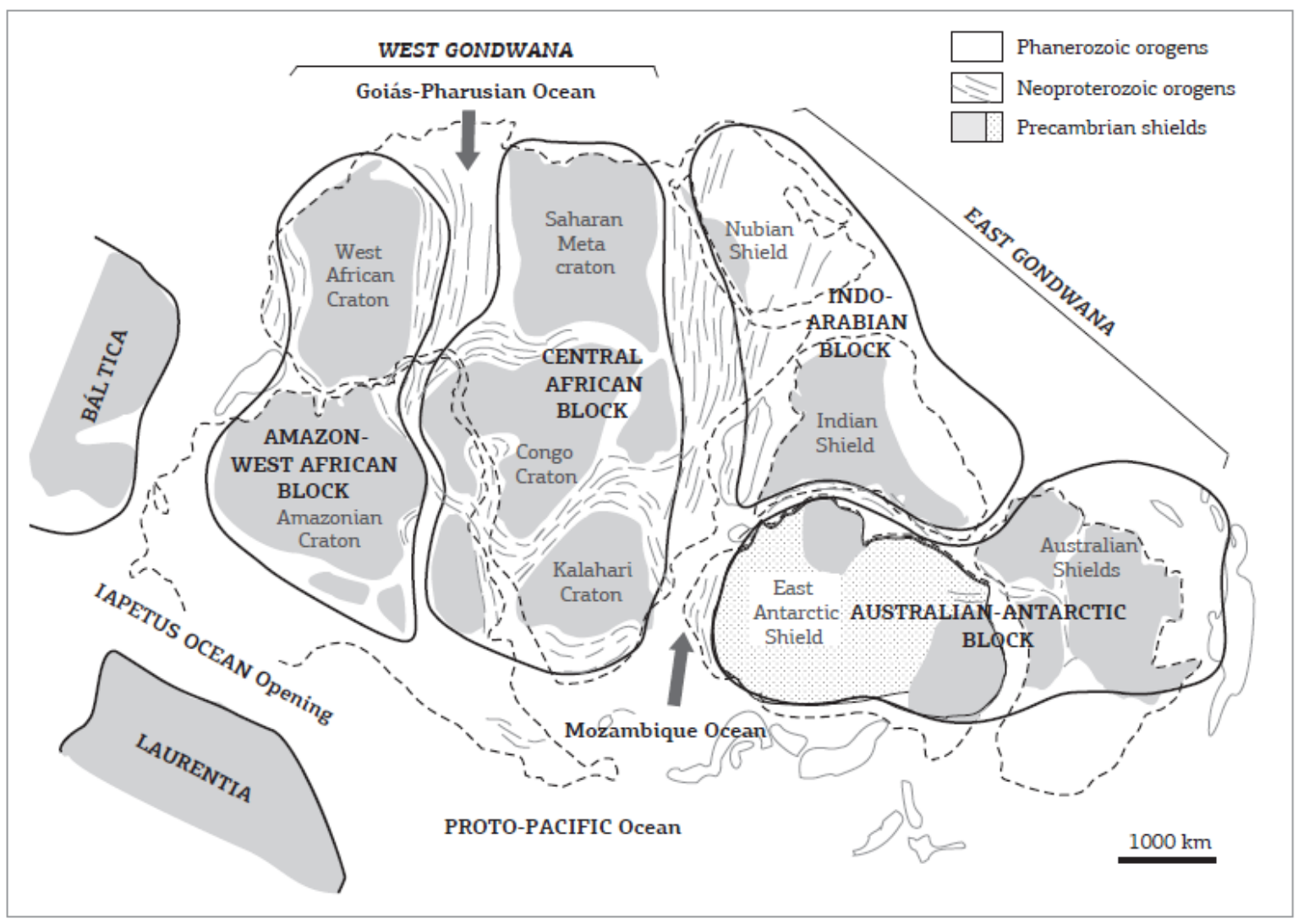
Department of Mathematics and Geosciences,

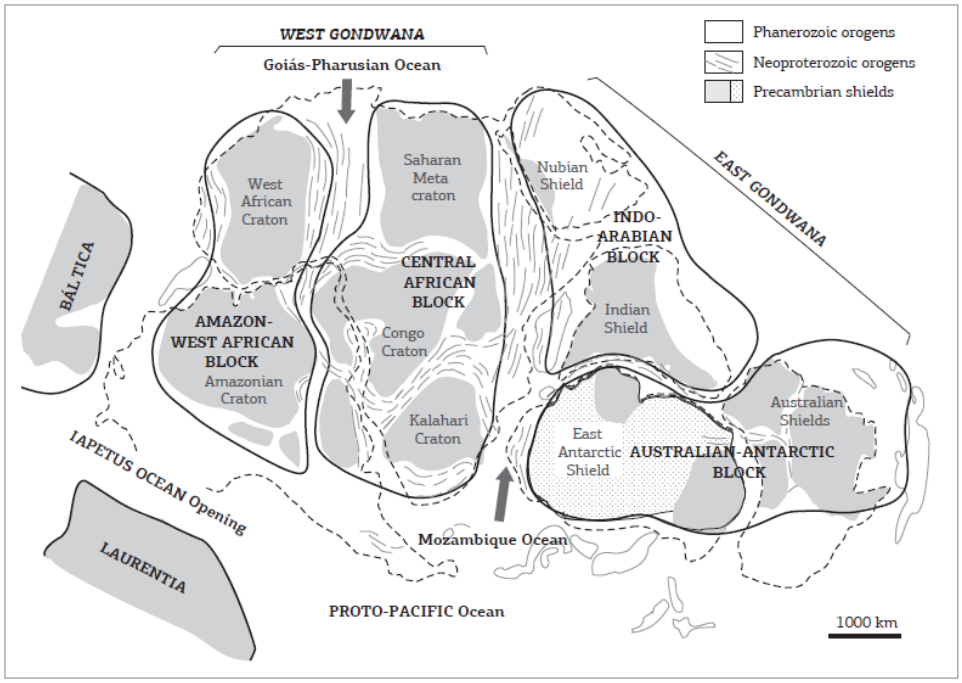
University of Trieste (Italy)

Gondwana constituents



Cordani et al., 2013.

Topic



- geophysical characterization of cratons and fold belts
- physical reason of tectonic activity outside cratons
- Lithospheric craton root definition

Contents

1) Investigate causal relationship between deep lithospheric structures and surface geology
2) Data used: GOCE gravity field and seismic tomography model
3) Gondwana reconstructions of mantle tomography and GOCE gravity as analysis tool

Data and tools

- GOCE gravity – TIM R5 (rel. 2014 based on Pail et al 2011)
- Global topo-reduction available in SH (rel. 2015, based on Hirt et al., 2012)
- Seismic tomography of the mantle (Simmons et al., 2012).
- Already demonstrated:
- Resolution and precision of GOCE adequate to define geologic lineaments (Alvarez et al.,2014 Tectonophysics; Braitenberg et al., 2014 IAG Symposia; 2015 J. Applied Geoinformatics)

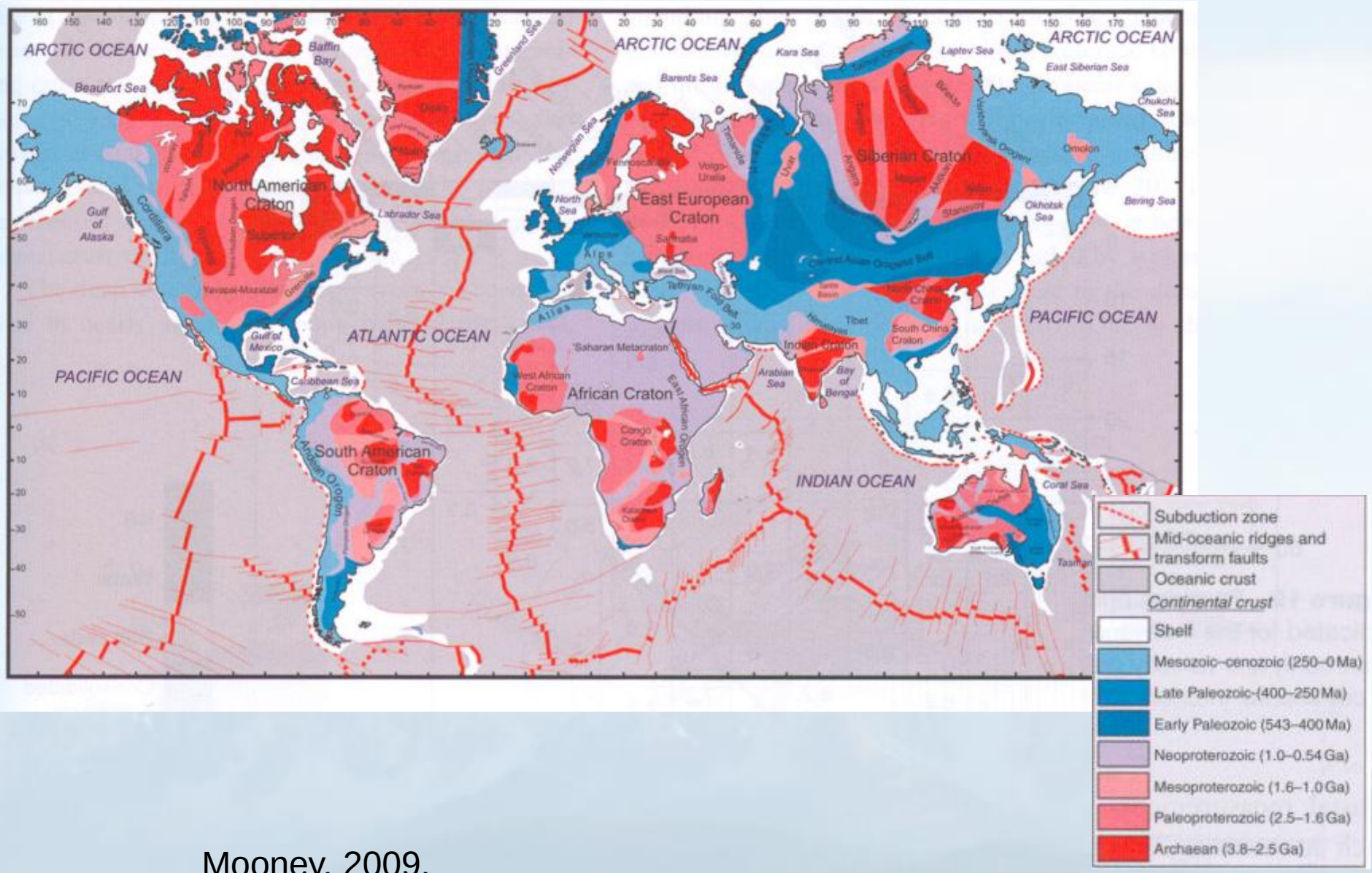
Crust densification and gravity highs

- Biunivocal relation between crustal densification and positive gravity anomaly

Crustal scale geodynamic event lead to increased density: Magmatism Metamorphism

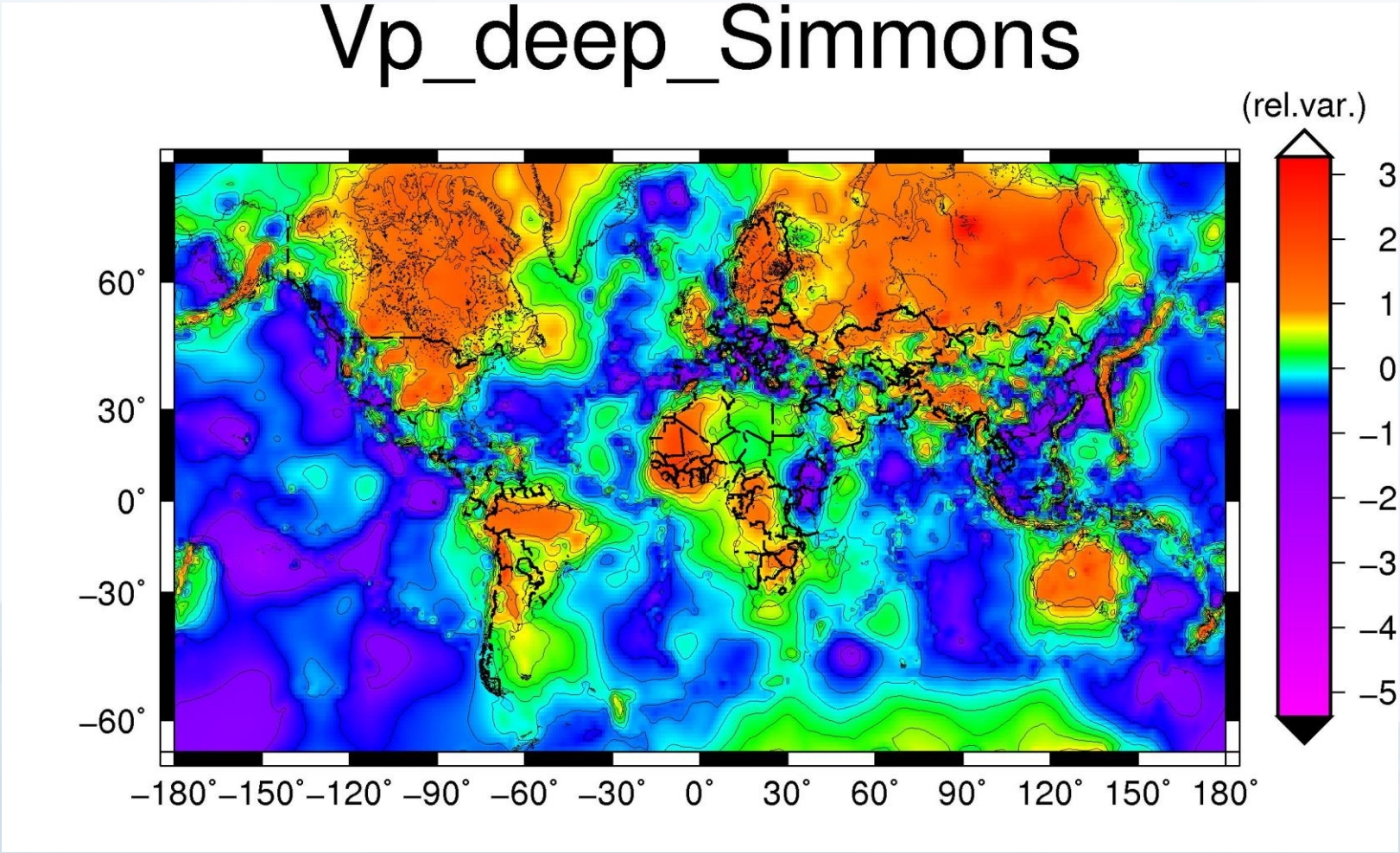
Crustal scale positive gravity anomaly observed

Basement age of the continental crust

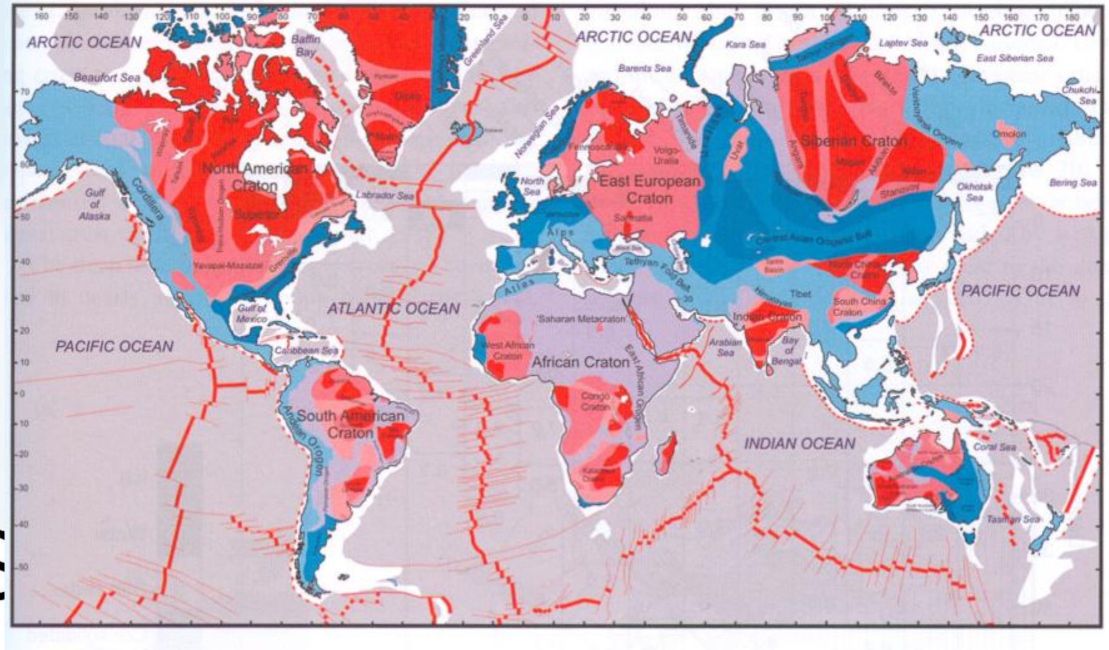


Mooney, 2009.

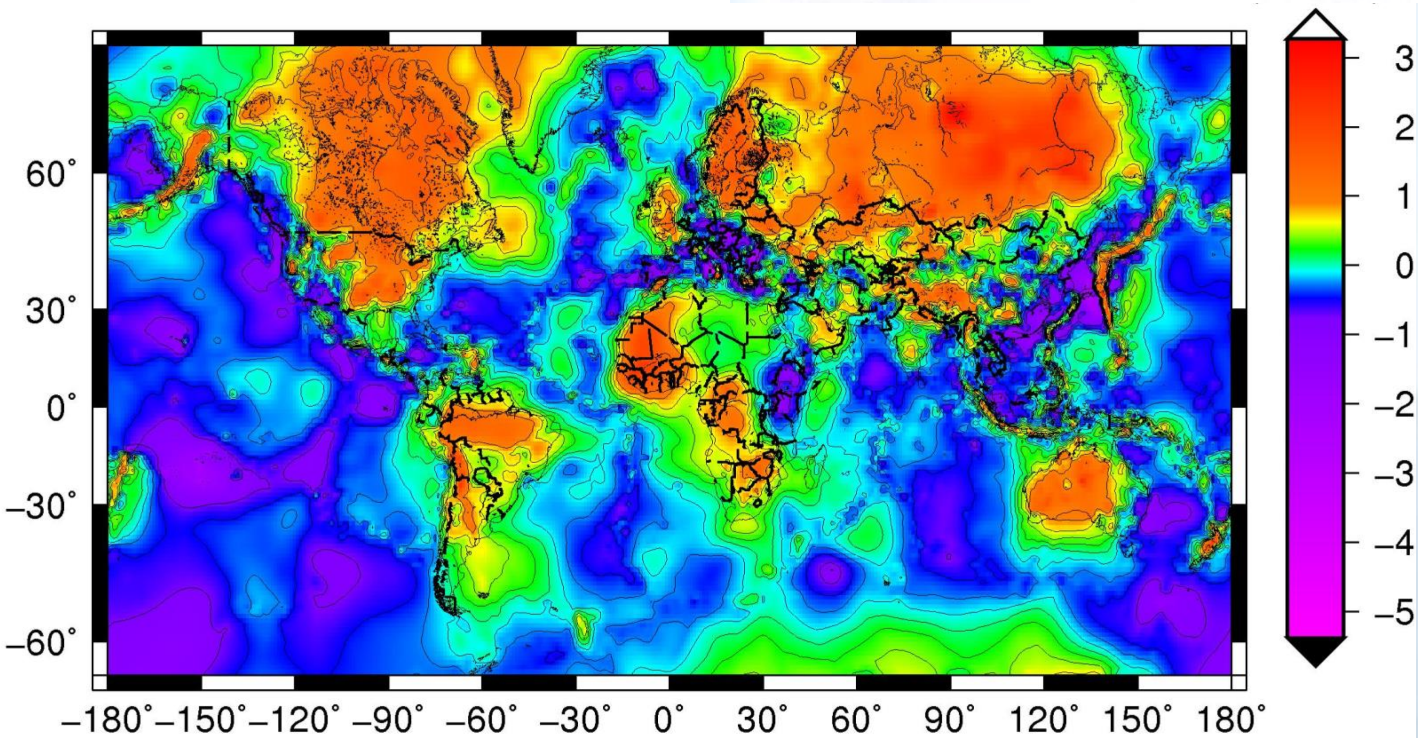
Increased velocity
stacked and averaged layers 185km-355km



Vp_deep_S



ARCTIC OCEAN
ARCTIC OCEAN
ARCTIC OCEAN
Beaufort Sea
Baffin Bay
Greenland Sea
Barents Sea
Kara Sea
Laptev Sea
East Siberian Sea
Chukchi Sea
North American Craton
Cordillera
Gulf of Alaska
Labrador Sea
Norwegian Sea
North Sea
East European Craton
Alps
Siberian Craton
Okhotsk Sea
Bering Sea
Central Asian Orogenic Belt
Tibet
North China Craton
South China Craton
PACIFIC OCEAN
PACIFIC OCEAN
ATLANTIC OCEAN
Gulf of Mexico
Caribbean Sea
Saharan Metacraton
West African Craton
African Craton
Congo Craton
East African Orogen
Arabian Sea
Bay of Bengal
Indian Craton
South American Craton
Andean Orogen
INDIAN OCEAN
Coral Sea
Tasman Sea



60˚
30˚
0˚
–30˚
–60˚
–180˚ –150˚ –120˚ –90˚ –60˚ –30˚ 0˚ 30˚ 60˚ 90˚ 120˚ 150˚ 180˚
3
2
1
0
–1
–2
–3
–4
–5

Hypothesis testing

- Gravity from GOCE has been demonstrated to distinguish crustal scale events that produced magmatic alteration or metamorphism
- Cratons stable, least effected by events

-> gravity and gradient should positively correlate with craton outlines

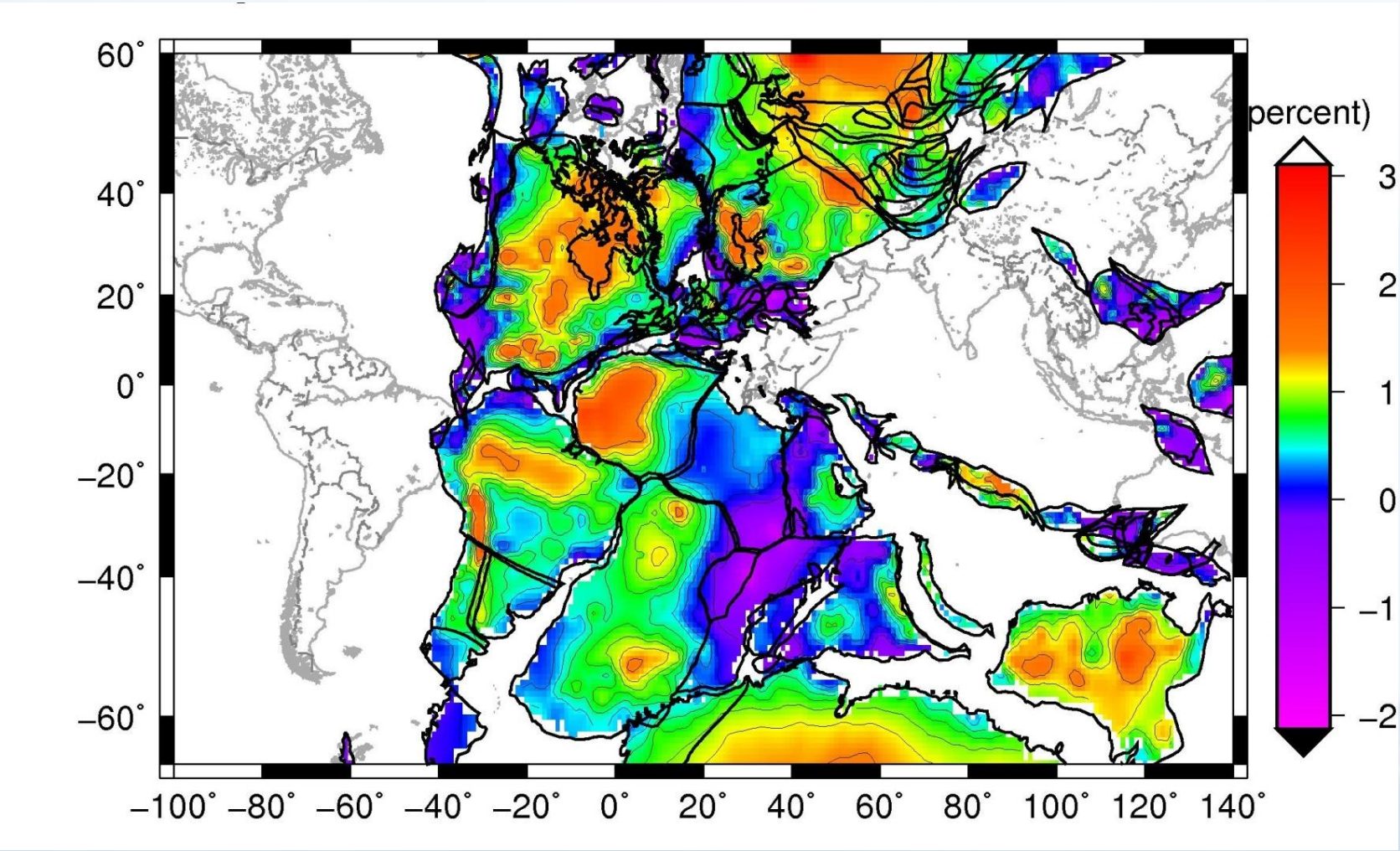
-> gravity should anticorrelate with mantle velocities

-> gravity should be subdued over cratons

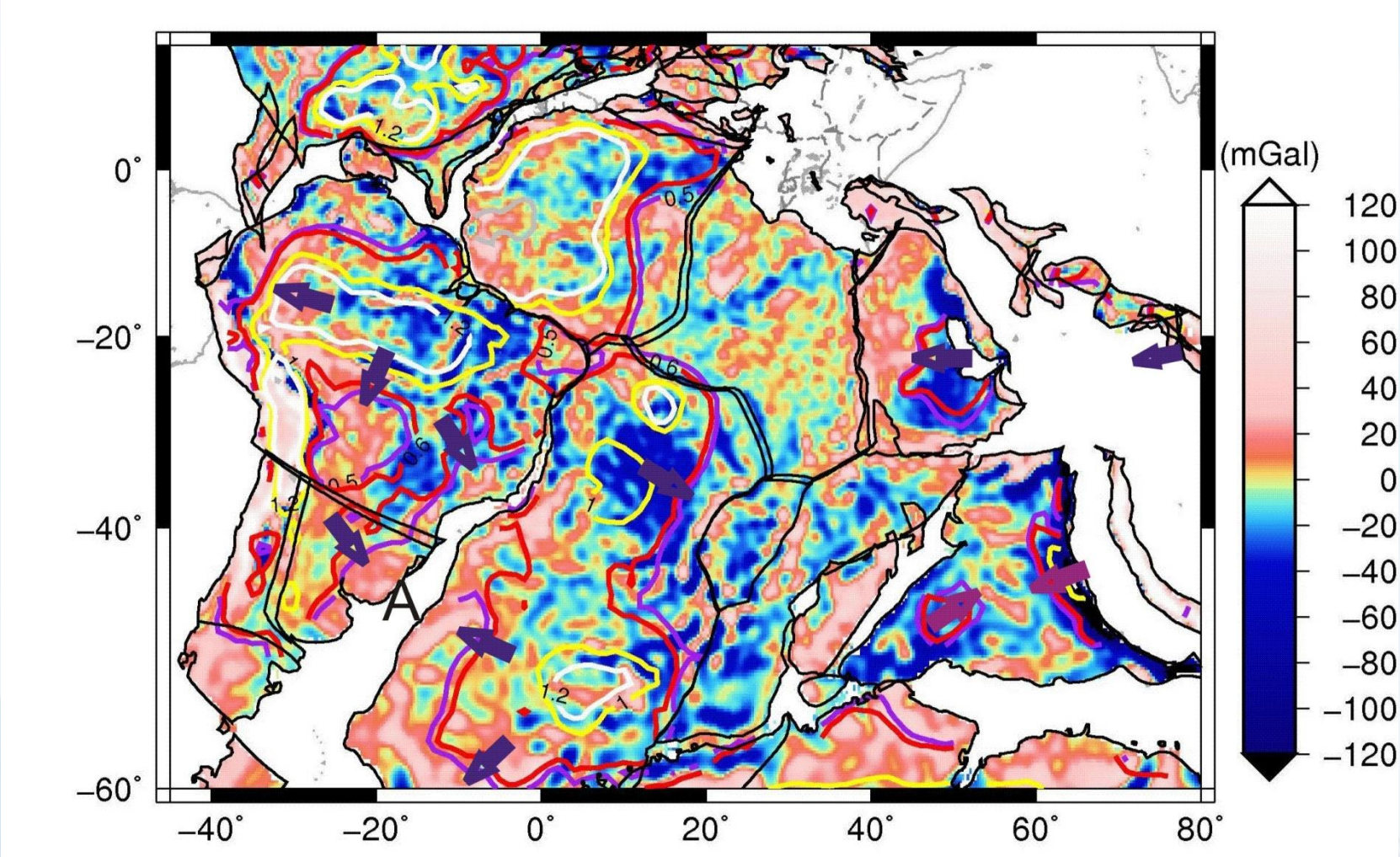
Gondwana reconstruction

- Assemble cratonic units to form Gondwana
- Rotations based on paleomagnetic observations on continent, ocean spreading reconstructions
- We refer to models of Torsvik et al., 2009
- Hypothesis: continental fragments can be rotated together with mantle to a depth of 350 km. This is certainly valid for cratons.
- Rotate gravity field and seismic tomography models

Gondwana assemblement
Vp variations averaged 185 to 355km depth

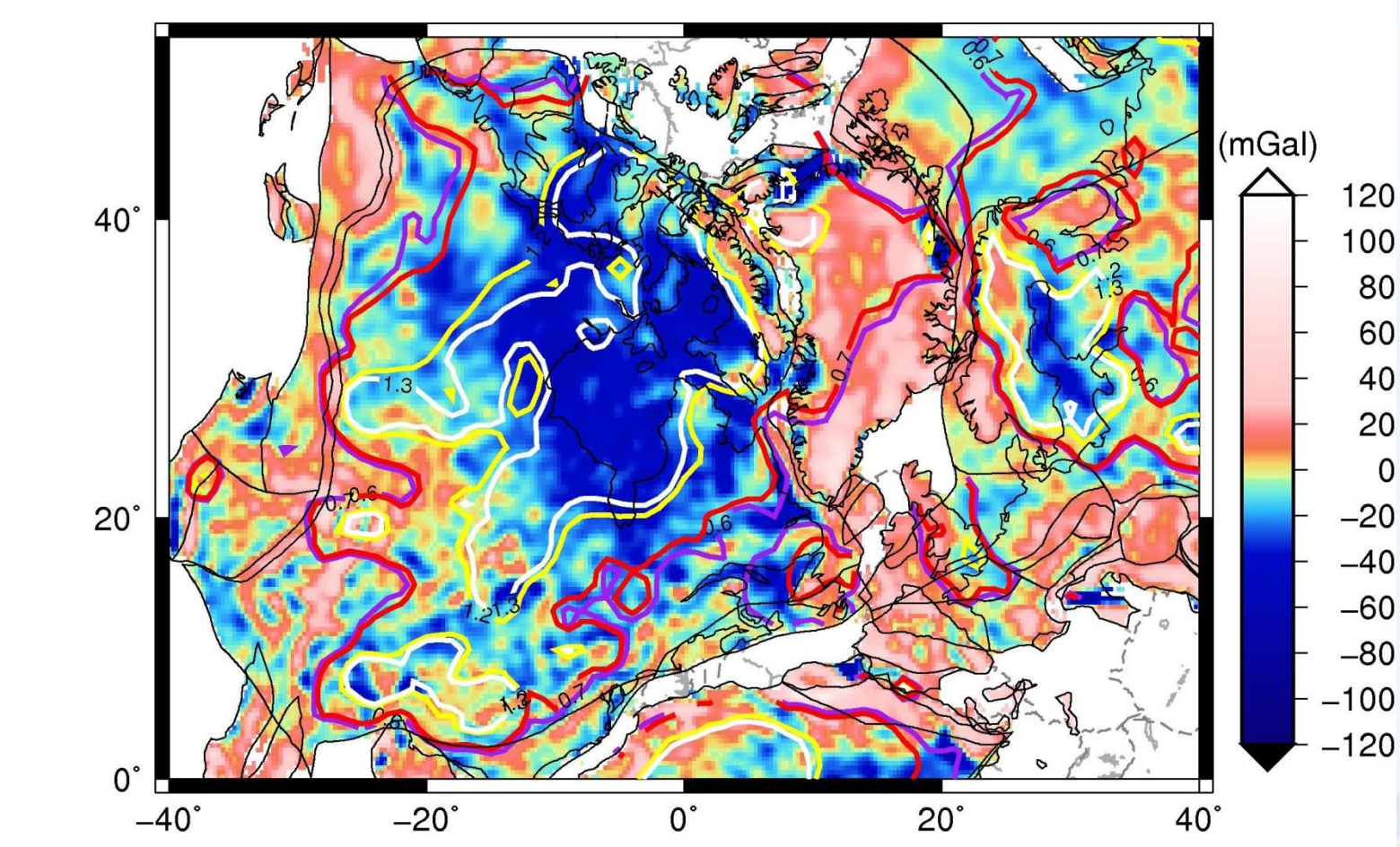


GOCE FA residual with Vp 185 to 355km depth



Isolines: 0.5 P, 0.6 R, 1.0 Y, 1.2 W, 2.0 Gr % average variation Vp

GOCE FA Res variations with deep Vp anomalies



Isolines: 0.9 P, 1.0 R, 1.2 Y, 1.3 W, 1.6 Gr, % average variation Vp

Results

- Cratons defined from rock age maps correlate to increased velocity up to 355 km or more.
- Inside of cratons downscale gravity values largely.
- Border of high velocity root coincides with increased gravity
  - SAM-AFR conjugate passive margins with magmatism or underplating

Implications for large scale geologic features

- Border of high velocity lithosphere roots appear as gravity highs due to metamorphic events and magmatism
- Cratons have little large scale positive gravity lineaments due to stability through Earth history
- Exception: event that is older than craton consolidation.

Conclusion

- Expected correlation found: partially the positive gravity variations correlate with outlines of deep lithosphere roots
- Cratons have generally low gravity
- Possible cause: mantle flow- cratonic roots disturbance
- Could demonstrate conditioning of mantle flow and tectonics through cratonic root.

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