EGU General Assembly 2020

Abstract EGU2020-5000

Online | 4–8 May 2020

Lithosphere thermo-chemical heterogeneity in the European-North Atlantic region, Greenland and Anatolia

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Artemieva, Earth-Science Reviews 2019a (European TLAB)
Artemieva, Earth-Science Reviews 2019b (Greenland TLAB)
Shulgin & Artemieva, JGR 2019 (Mantle density, Europe, Greenland, North Atlantics)
Artemieva & Shulgin, Tectonics, 2019 (Anatolian TLAB)

This online presentation is based on 4 papers published in 2019 with selected highlights presented below.

- Artemieva I.M., 2019. The lithosphere structure of the European continent from thermal isostasy. Earth-Science Reviews, 188, 454-468.
- Artemieva I.M., 2019. Lithosphere thermal thickness and geothermal heat flux in Greenland from a new thermal isostasy method. Earth-Science Reviews, 188, 469-481.
- Artemieva, I. M., & Shulgin, A. (2019). Geodynamics of Anatolia: Lithosphere thermal structure and thickness. Tectonics, 38. https://doi.org/10.1029/2019TC005594
- Shulgin, A., & Artemieva, I. M. (2019). Thermochemical heterogeneity and density of continental and oceanic upper mantle in the European-North Atlantic region. J. Geophys. Research: Solid Earth, 124. https://doi.org/10.1029/2018JB017025 (open access)

OCEANS:

Mantle heterogeneity in North Atlantics?

Iceland plume?

... Azores?

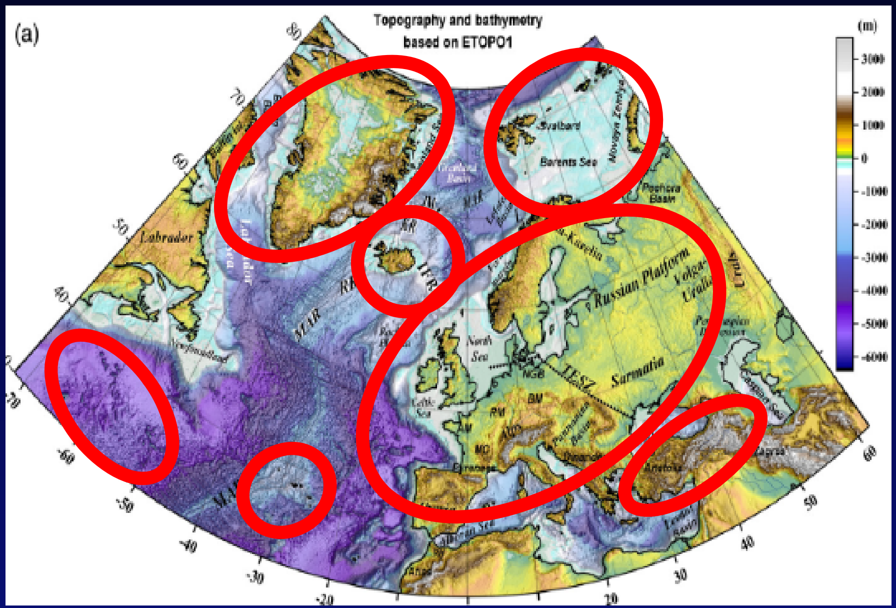
CONTINENTS:

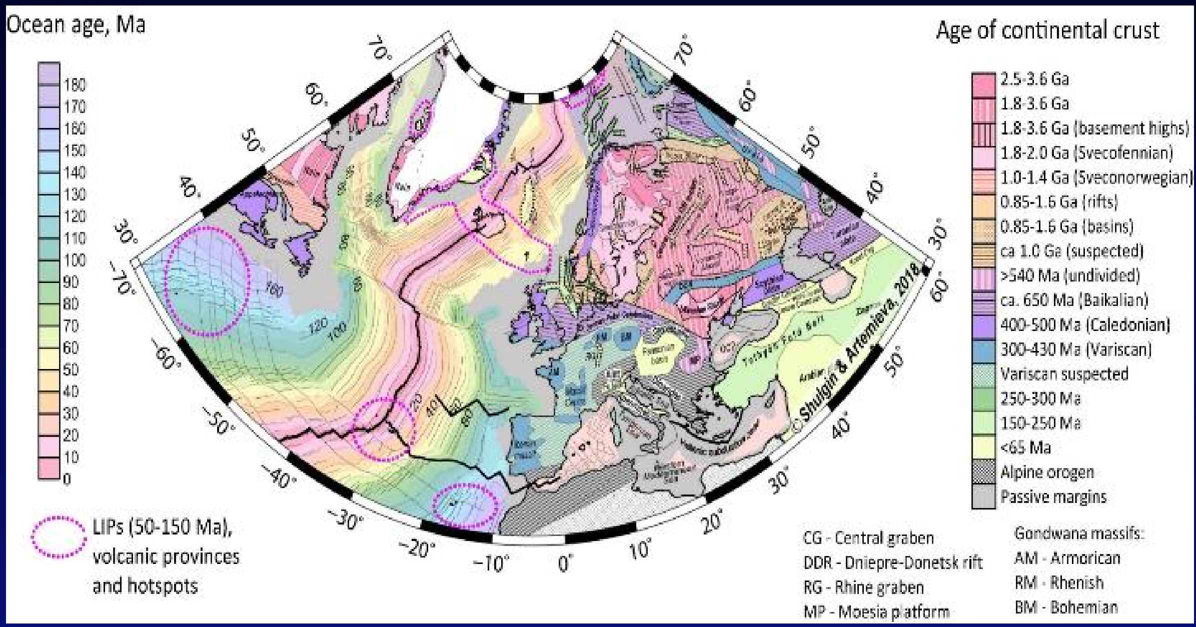
Lithosphere structure in Greenland?

.... at the Barents Shelf?

.... in Anatolia?

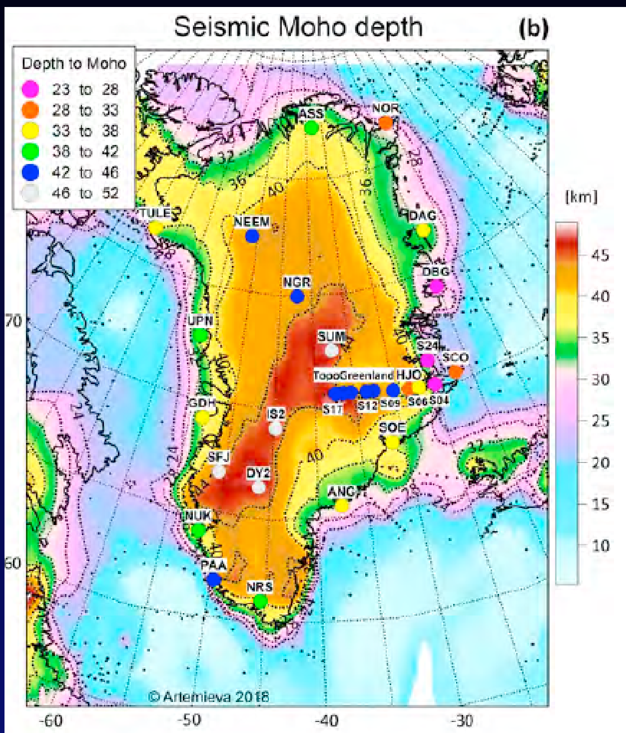
Lithosphere heterogeneity in Europe?





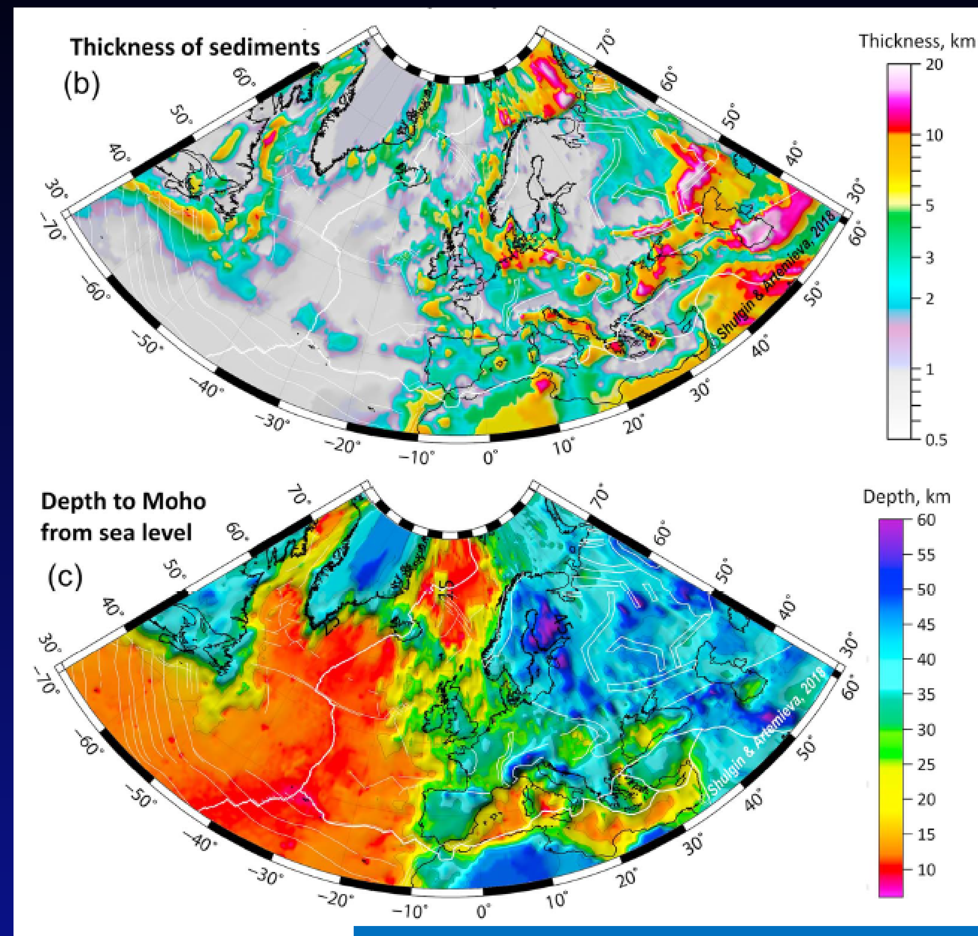
Artemieva & Thybo, 2013

The present studies are constrained by regional crustal models:



Artemieva, ESR, 2019b (compilation)

Based on updated EUNAseis model (Artemieva & Thybo, 2013)



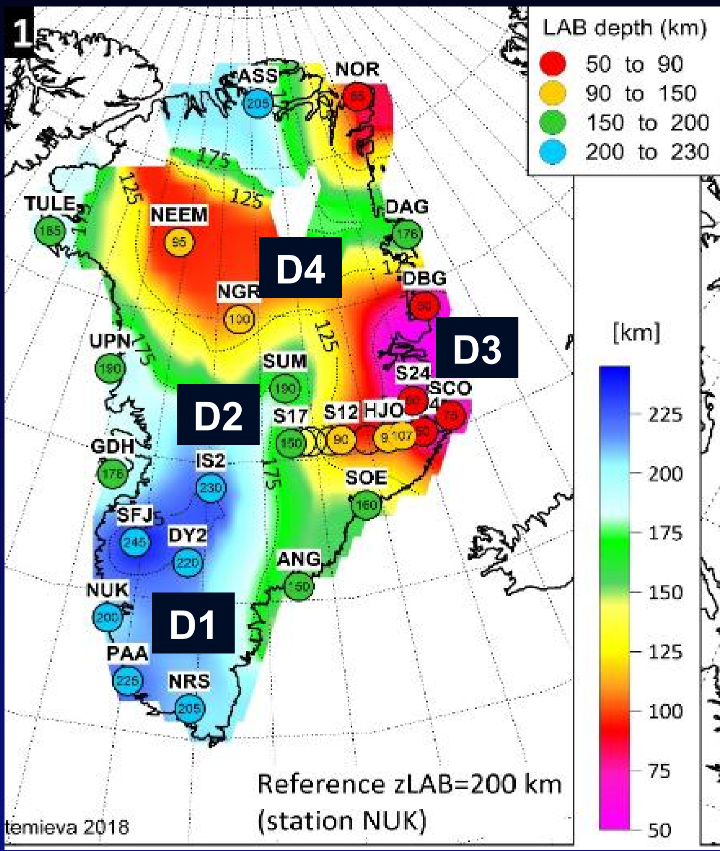
Artemieva & Shulgin, EGU2020-5000 on-line

Results:

Lithosphere thermal structure in Greenland

Lithosphere thermal structure in Greenland

Thermal LAB



Artemieva, ESR, 2019b

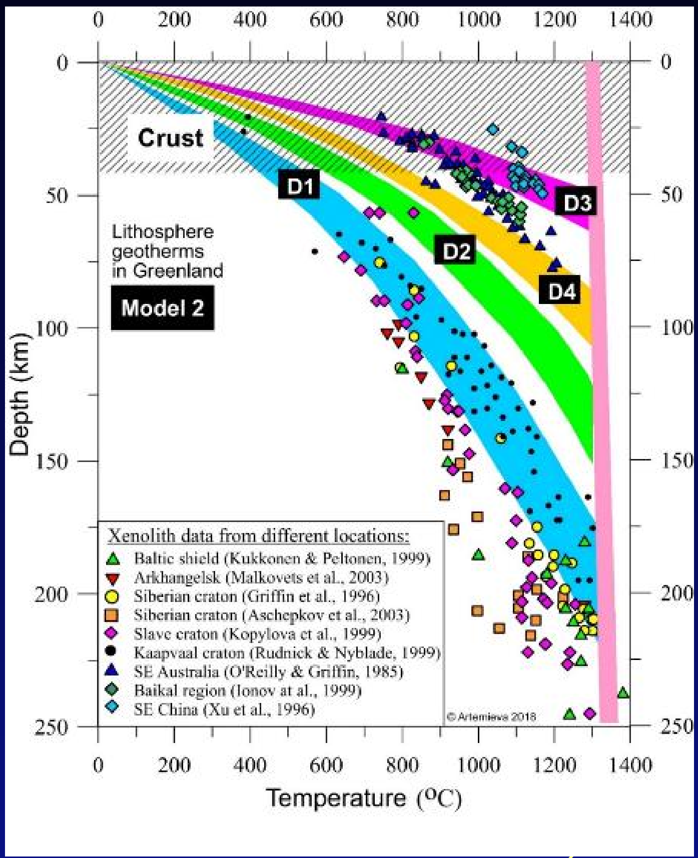
D1:
Typical Archean craton, LAB ~ 200 km

D2:
Typical Pt lithosphere, LAB ~ 150 km

D3:
Hot, LAB ~ Moho

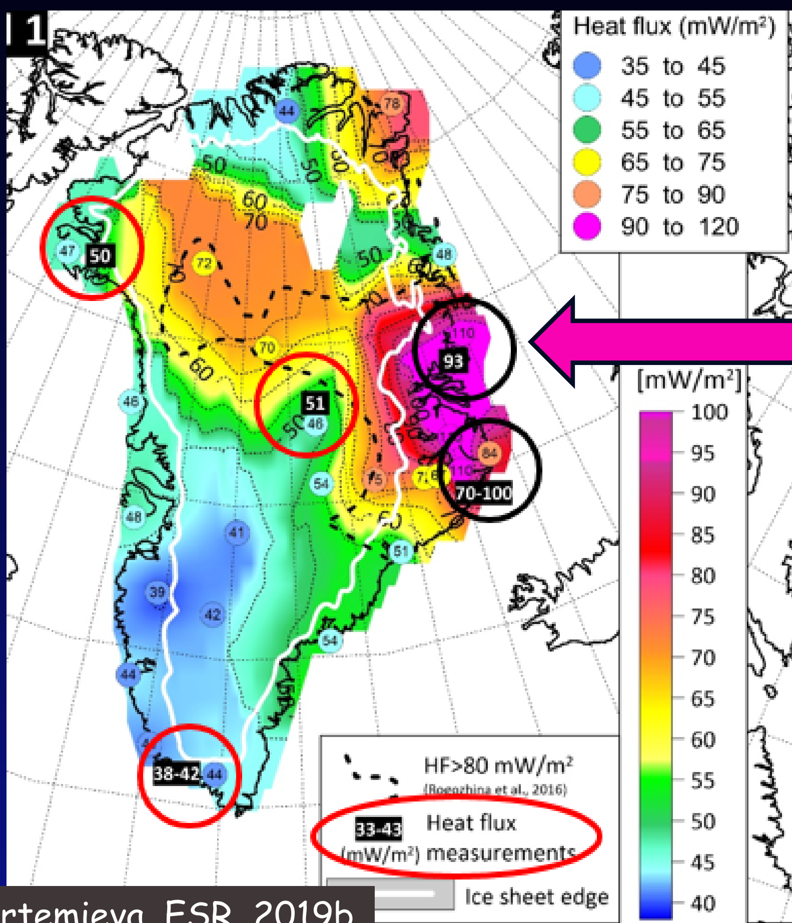
D4:
Anomalous belt, Iceland hotspot track?

Geotherms



Artemieva & Shulgin, EGU2020-5000 on-line

Greenland: Predicted heat flux



Artemieva, ESR, 2019b

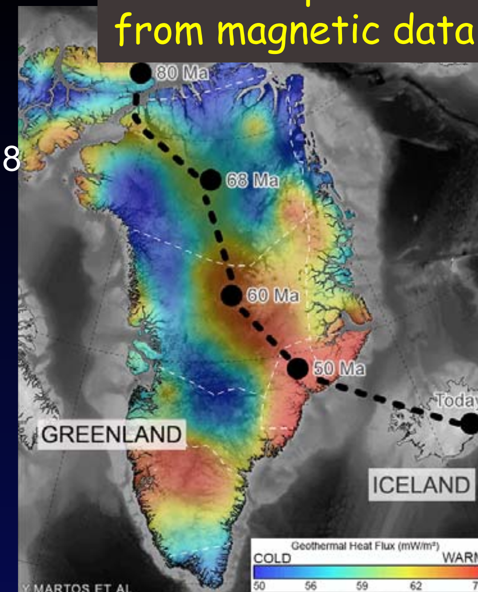
Agrees with measurements, where exist

Requires advective heat flux component in E. Greenland

Iceland hotspot track?

Heat flux predicted from magnetic data

Martos et al 2018



Iceland hotspot track

Torsvik et al, 2015

Artemieva & Shulgin, EGU2020-5000 on-line

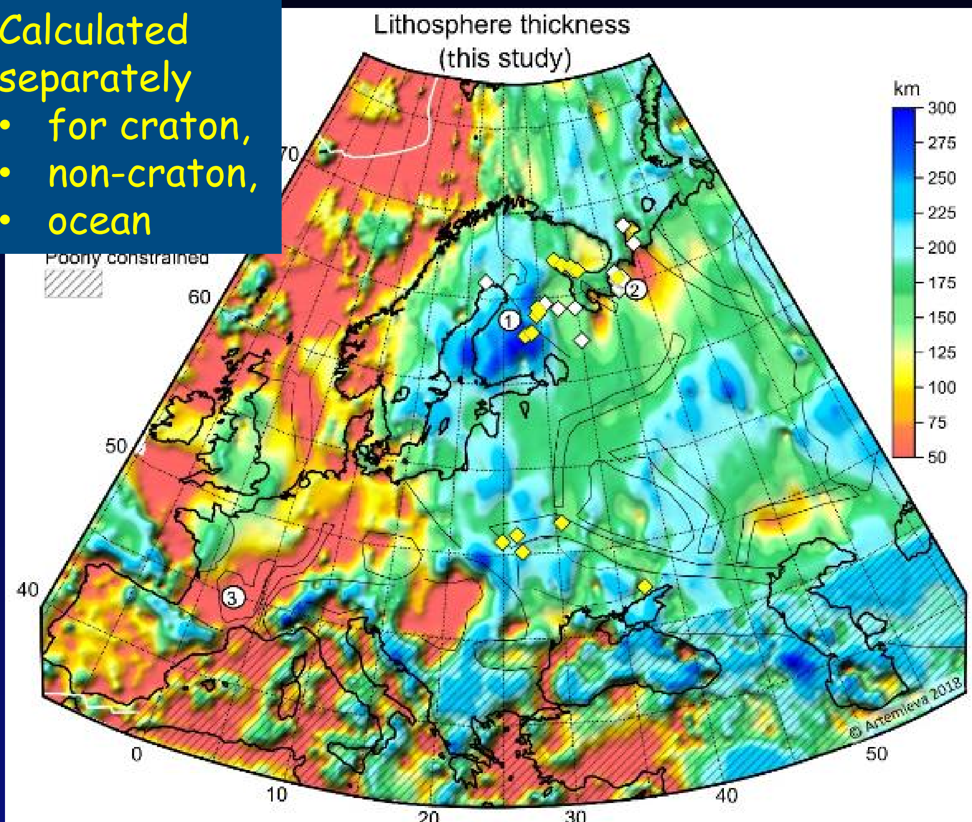
Results:

Lithosphere thermal structure in Europe

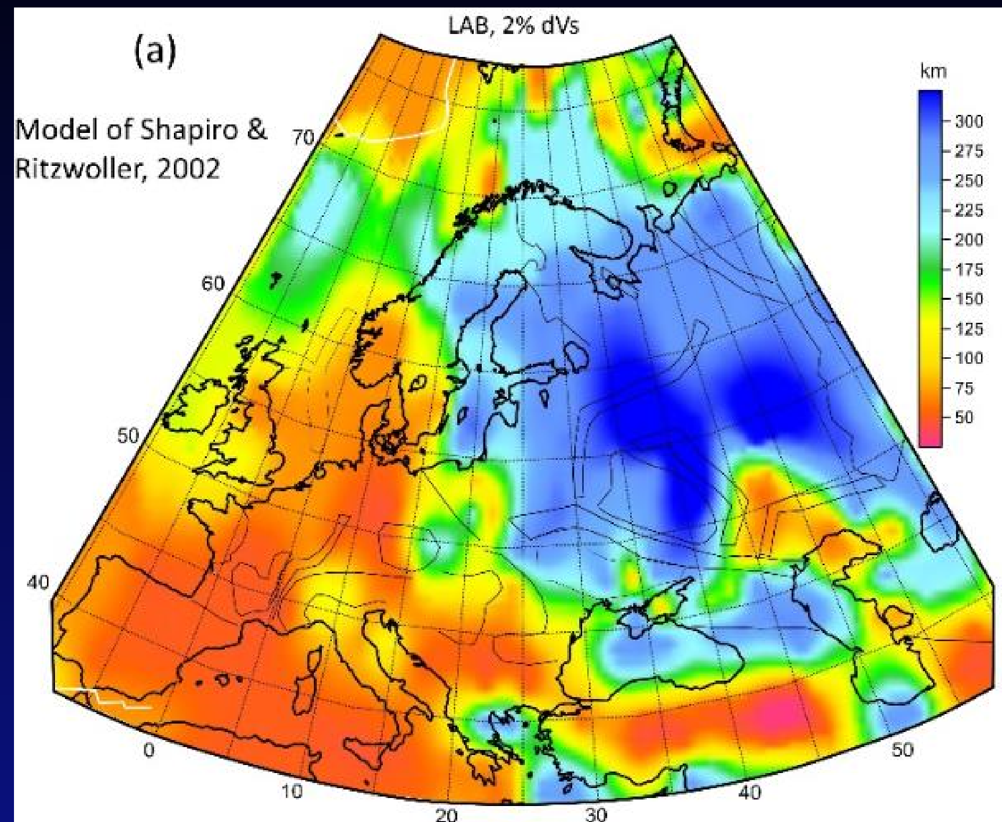
European lithosphere:

Thermal LAB vs Seismic LAB

Calculated separately
- for craton,
- non-craton,
- ocean

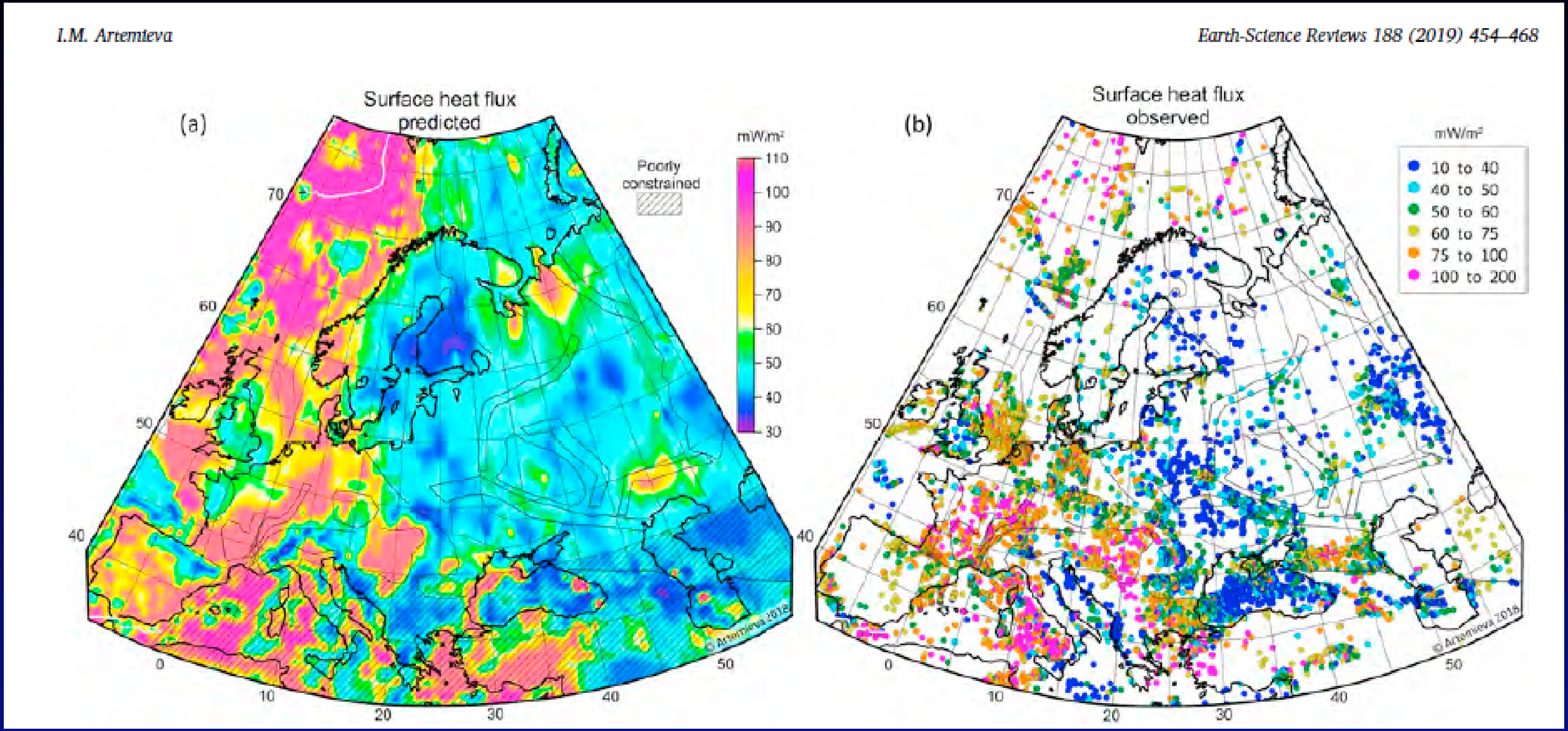


Artemieva, ESR, 2019a



Rayleigh wave model, Shapiro & Ritzwoller 2002

Model verification: predictions vs data



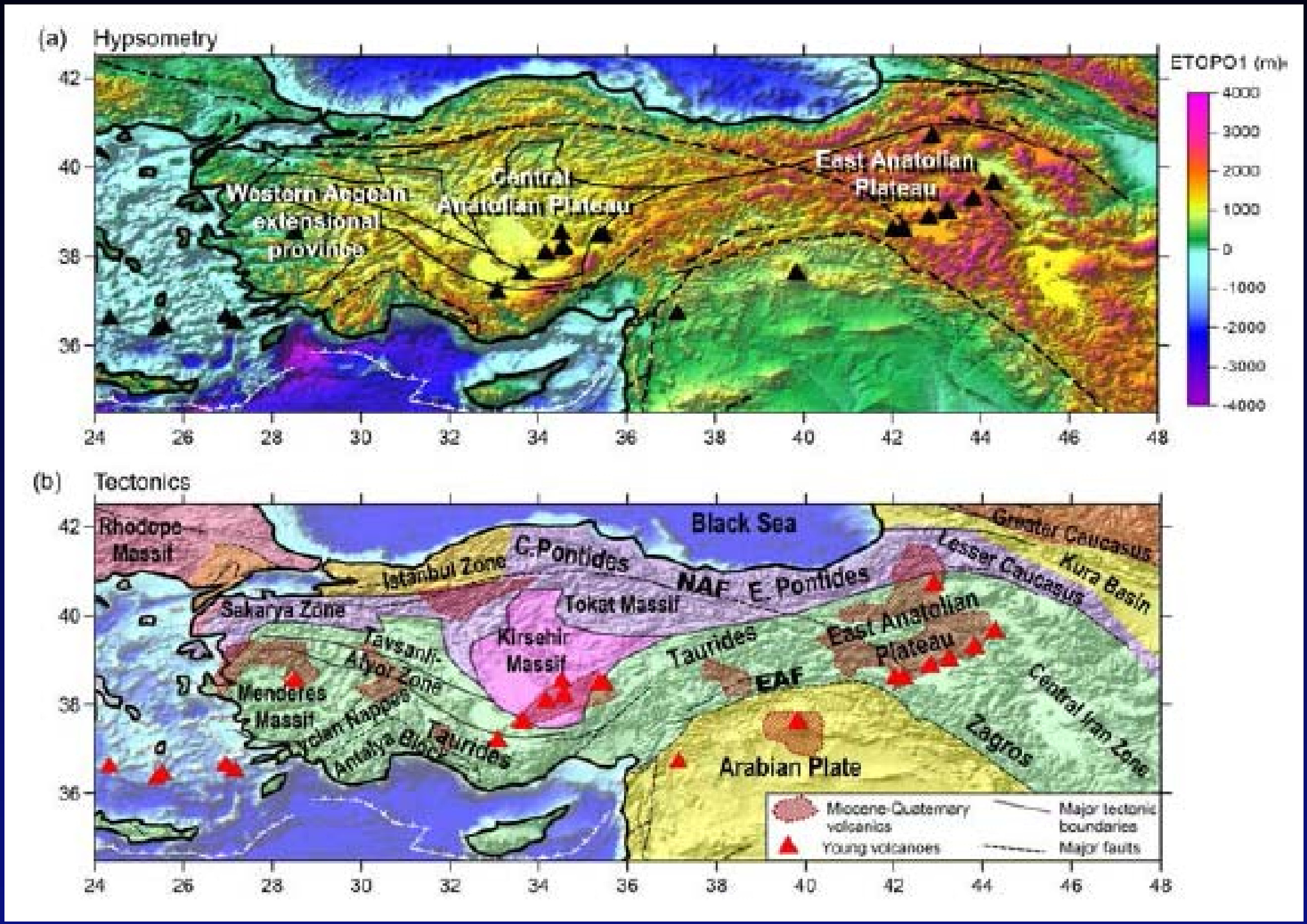
Artemieva, ESR, 2019a

Artemieva & Shulgin, EGU2020-5000 on-line

Results:

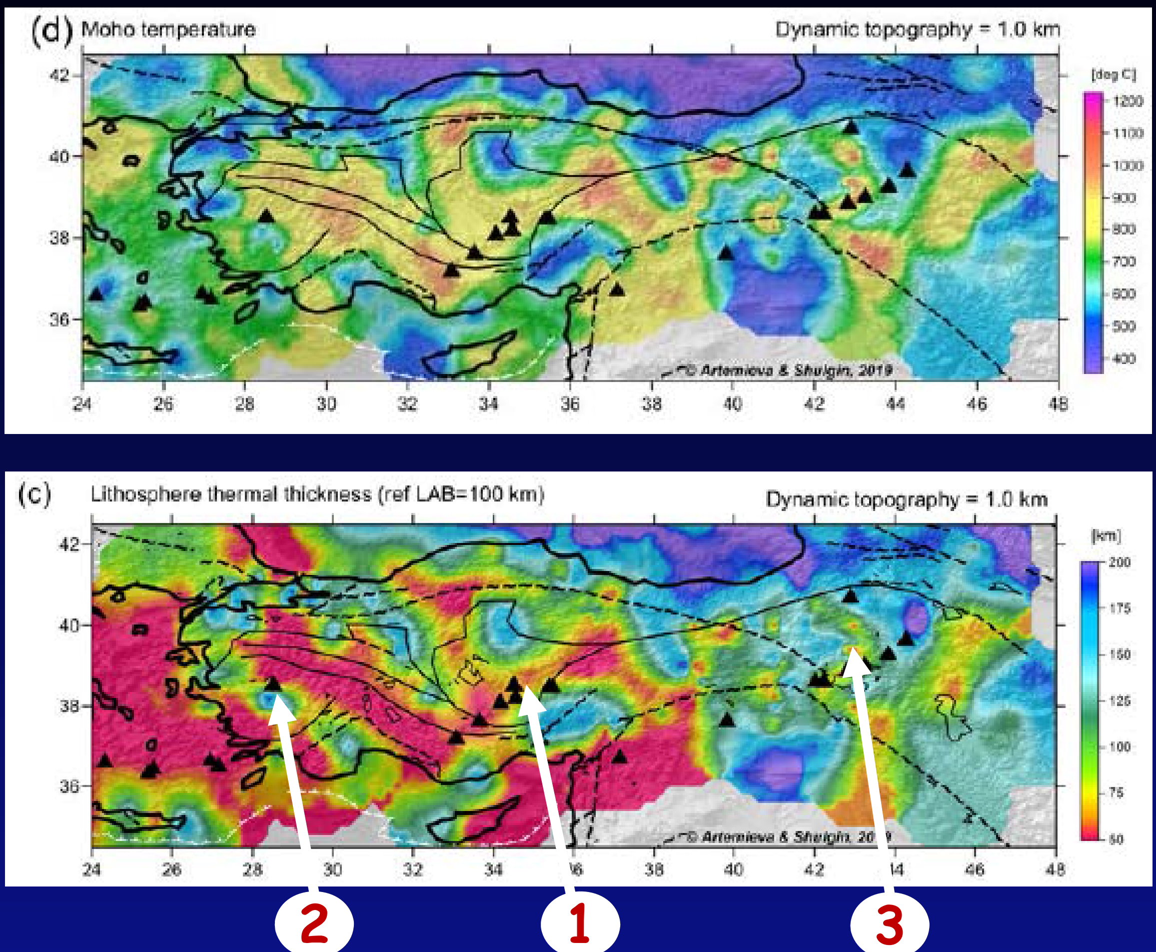
Lithosphere thermal structure in Anatolia

Anatolia: enigmatic tectonics



Artemieva & Shulgin, Tectonics 2019

Lithosphere geotherms and LAB in Anatolia



1. Lithosphere fragmentation by subduction systems of different ages creates the patchy pattern of lithosphere thermal anomalies in Anatolia

2. Thin (50–75 km) lithosphere of the Menderes Massif, controlled by the Hellenic subduction, includes a block with a 150 km thick lithosphere

3. Thick (80–140 km) lithosphere of the East Anatolian Plateau includes continental fragments and teared Neo-Tethyan slab(s)

Artemieva & Shulgin, Tectonics 2019

Artemieva & Shulgin, EGU2020-5000 on-line

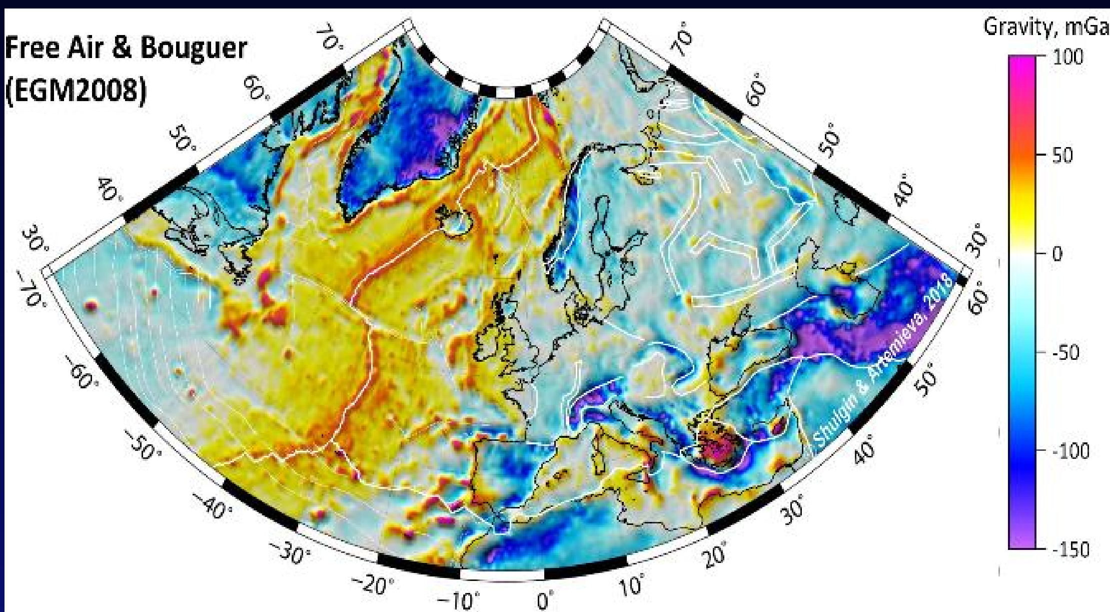
Results:

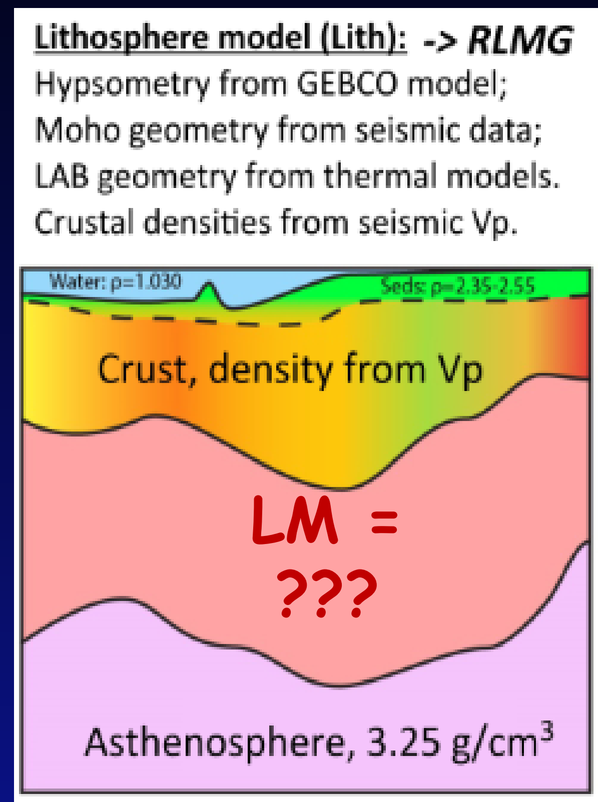
Mantle density structure in the European-North Atlantics region

LM = Lithosphere mantle
LAB = lithosphere-asthenosphere boundary
SPT = standard P-T conditions (P=1 atm, T=20 oC)

Europe + N. Atlantics: Mantle density

(3D tesseroid gravity modeling)

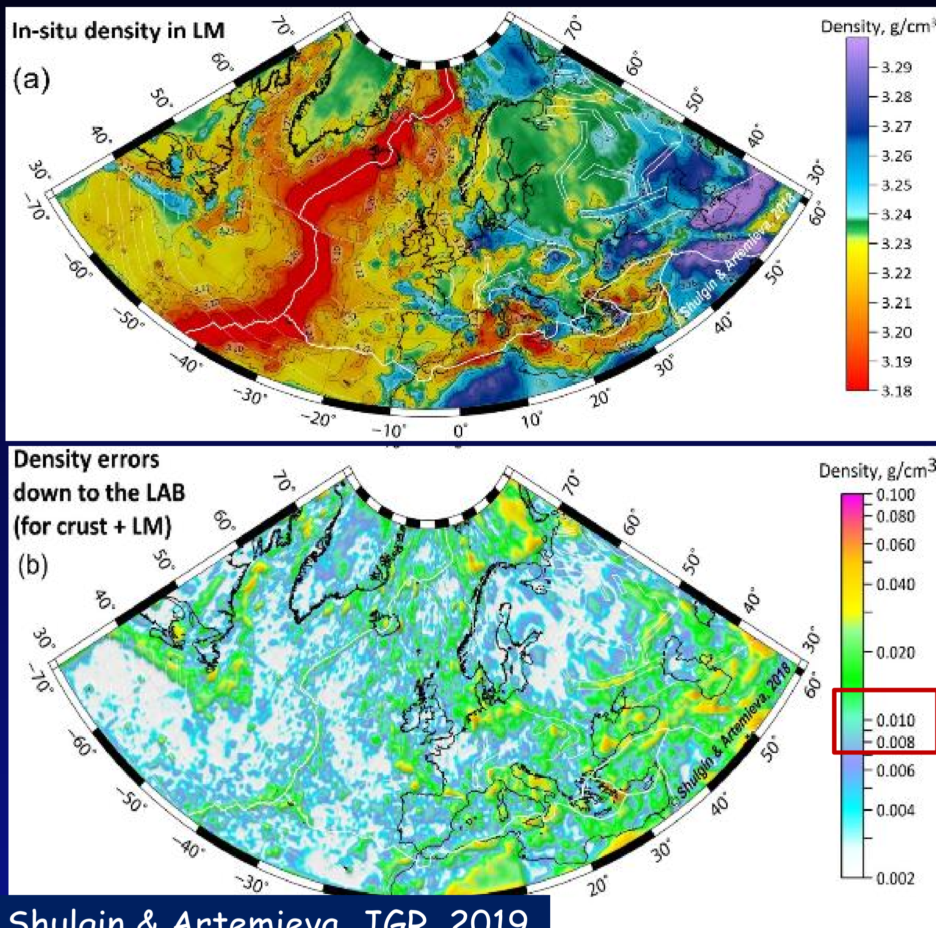




Shulgin & Artemieva, JGR, 2019

Artemieva & Shulgin, EGU2020-5000 on-line

Europe + N. Atlantics: Mantle density
(3D tesseroid gravity modeling)



Shulgin & Artemieva, JGR, 2019

<u>In situ LM density:</u>
Assume that all mantle gravity anomalies are in the LM (between the Moho and LAB)

Adopt thermal LAB:
- TC1 for continental part;
- HSC (age) for oceanic part

<u>Density errors:</u>
1. Calculated the misfit between the observed free air and free air predicted from our lithosphere density model
2. Converted the misfit to density error

Artemieva & Shulgin, EGU2020-5000 on-line

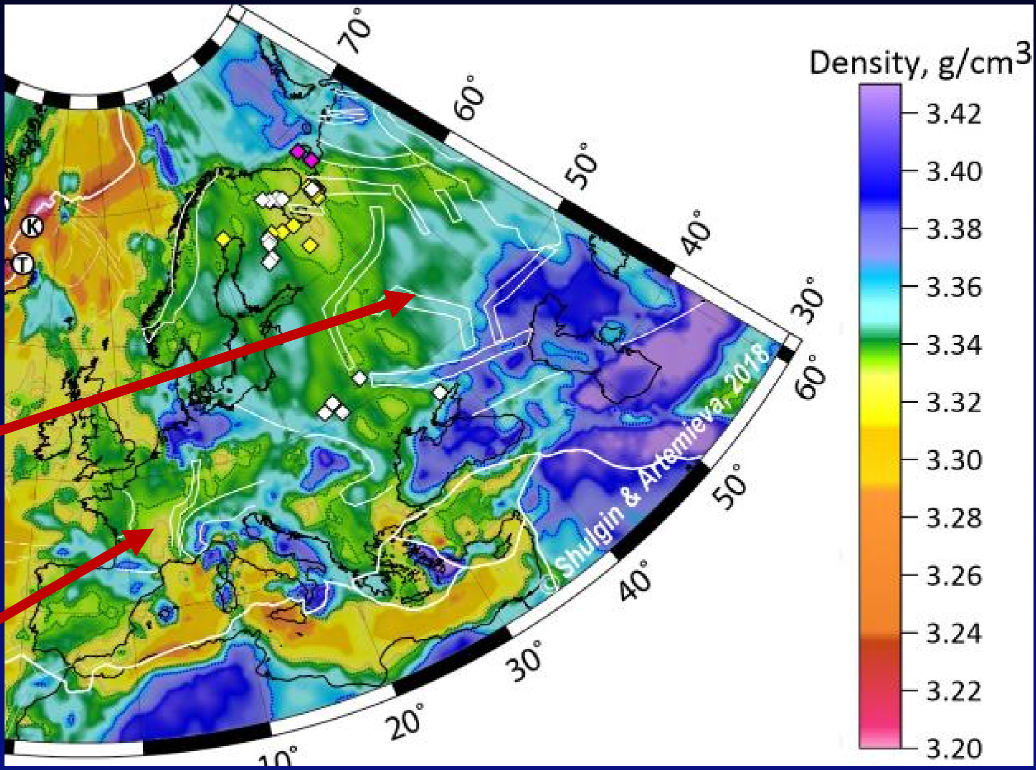
Continental LM: SPT density

No sharp density change across the Trans-European suture zone

TESZ is associated with a high density body in the shallow mantle - a paleoslab associated with the closure of the Tornquist Ocean ?

No age dependence of LM density; strong chemical reworking of the cratonic LM.

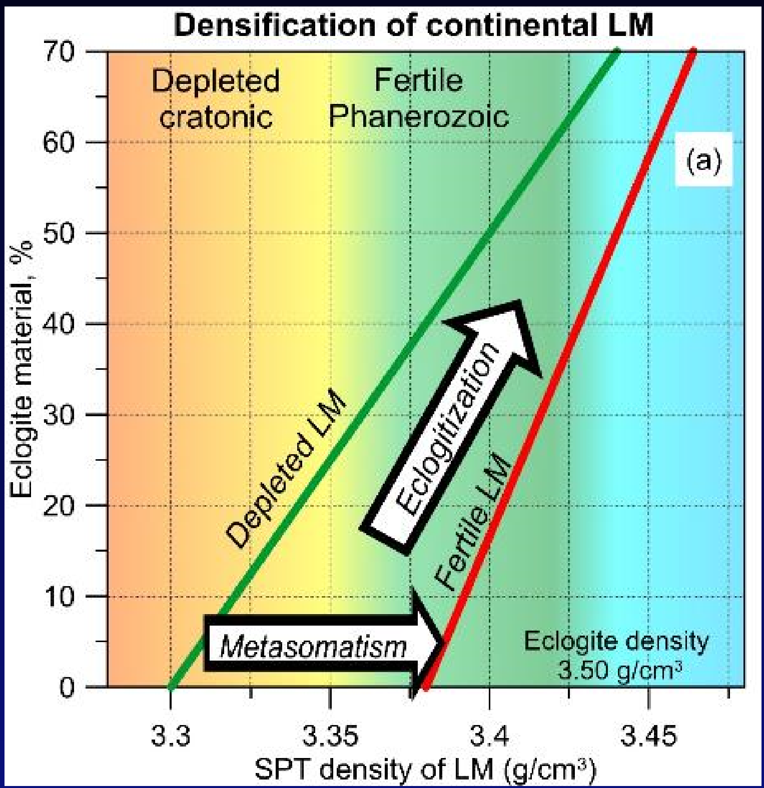
Cratonic fragments entrapped within the W. European mantle



Shulgin & Artemieva, JGR, 2019

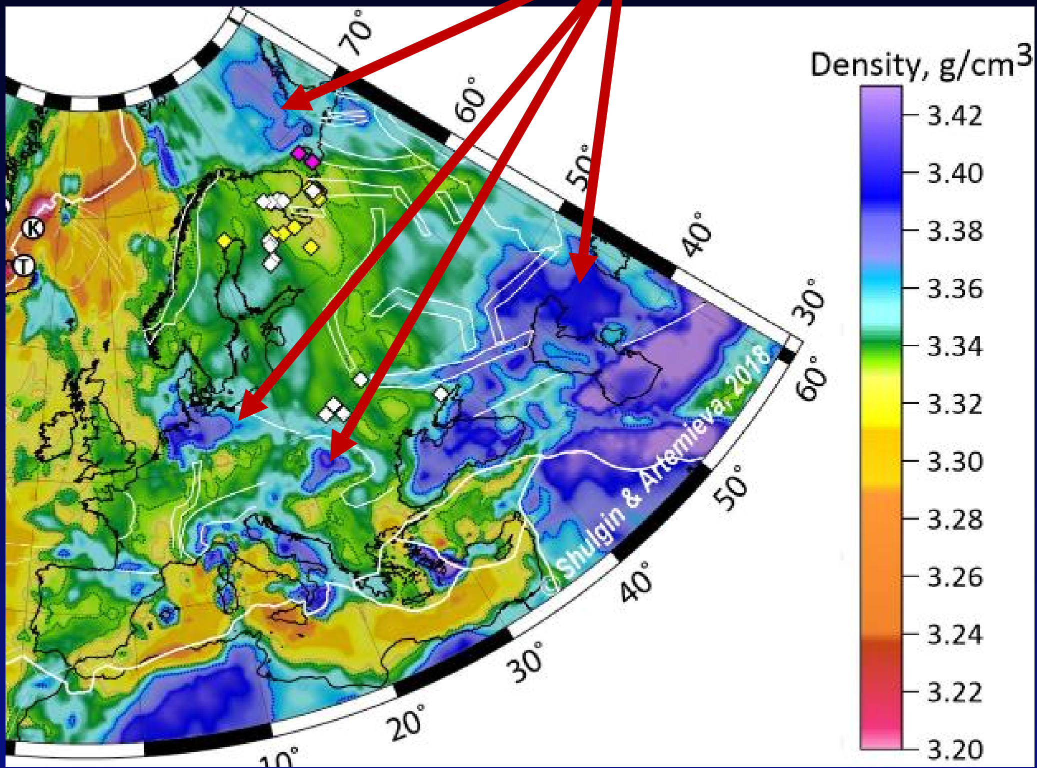
Artemieva & Shulgin, EGU2020-5000 on-line

Continental LM: SPT density & basins



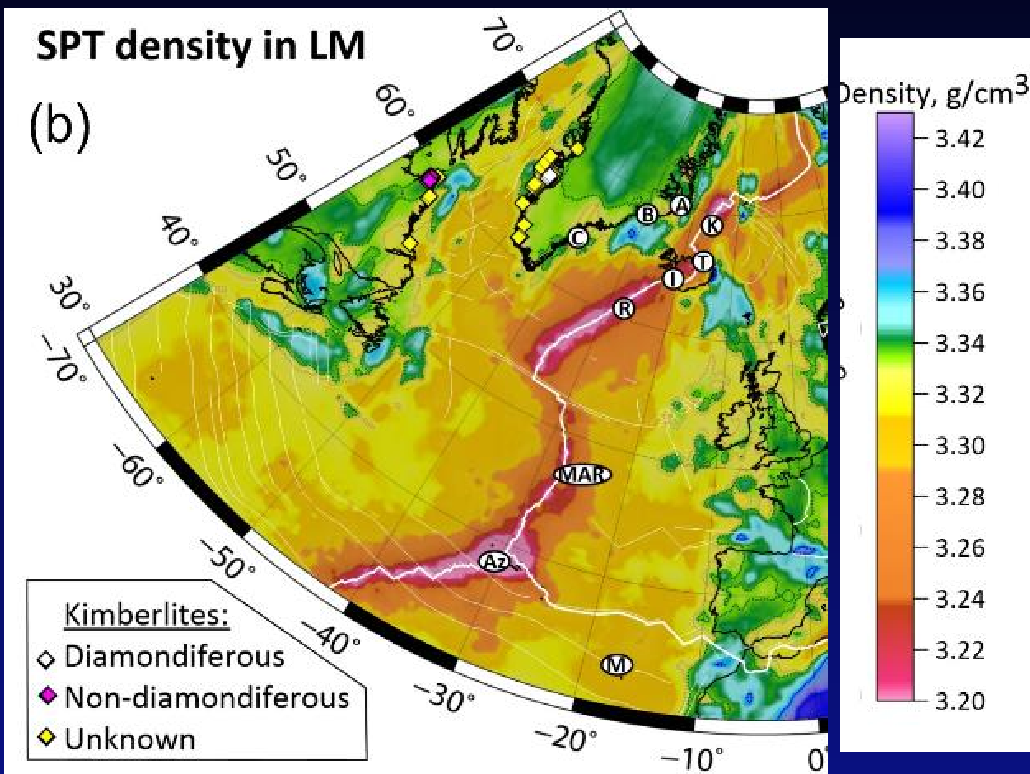
Shulgin & Artemieva, JGR, 2019

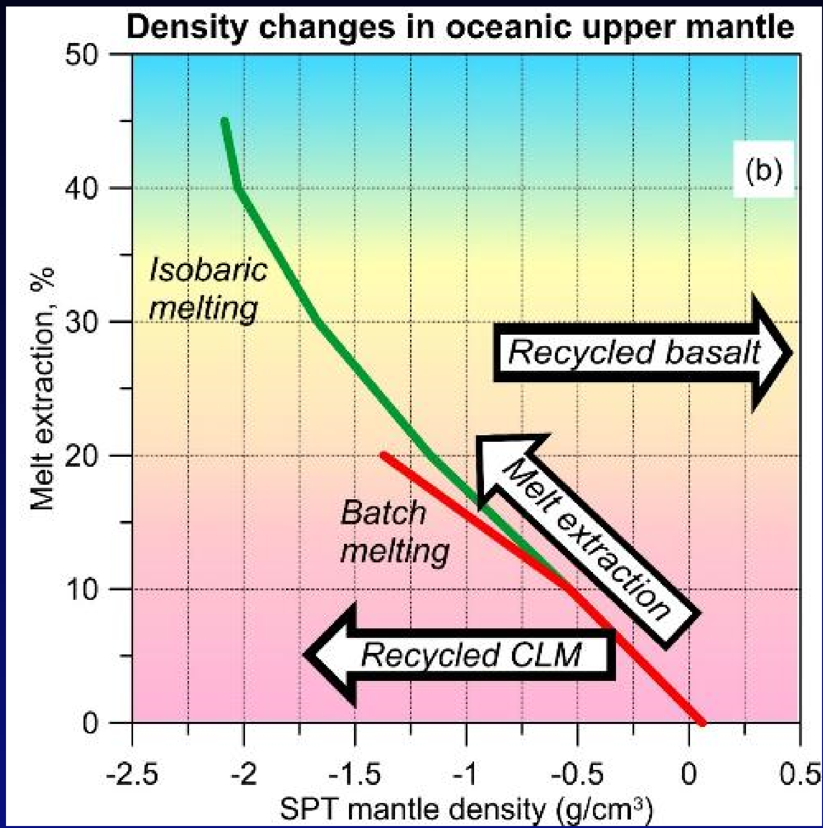
Superdeep basins (>15 km) require 10-20% of eclogite in LM



Artemieva & Shulgin, EGU2020-5000 on-line

Oceanic mantle: chemical heterogeneity

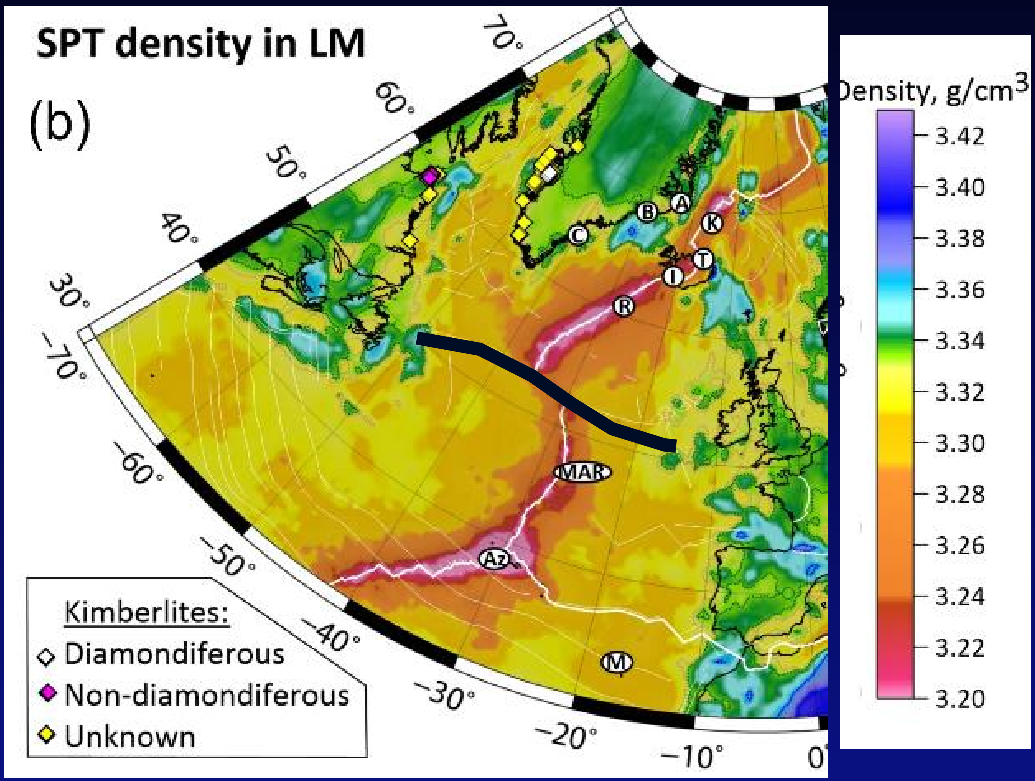




Shulgin & Artemieva, JGR, 2019

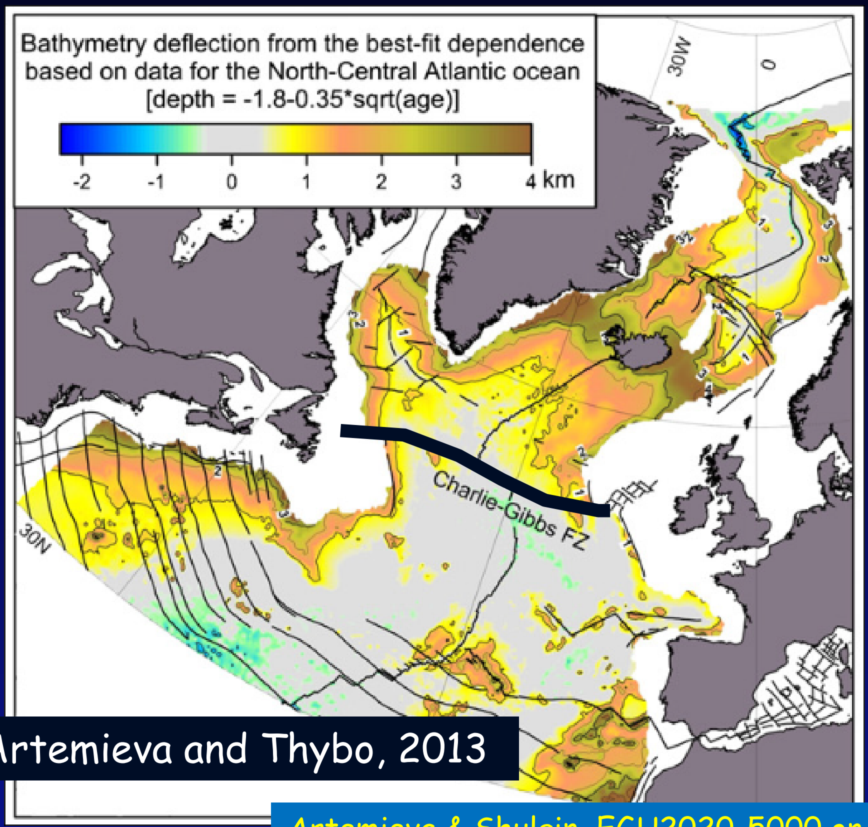
Artemieva & Shulgin, EGU2020-5000 on-line

Oceanic mantle: thermal heterogeneity



Shulgin & Artemieva, JGR, 2019

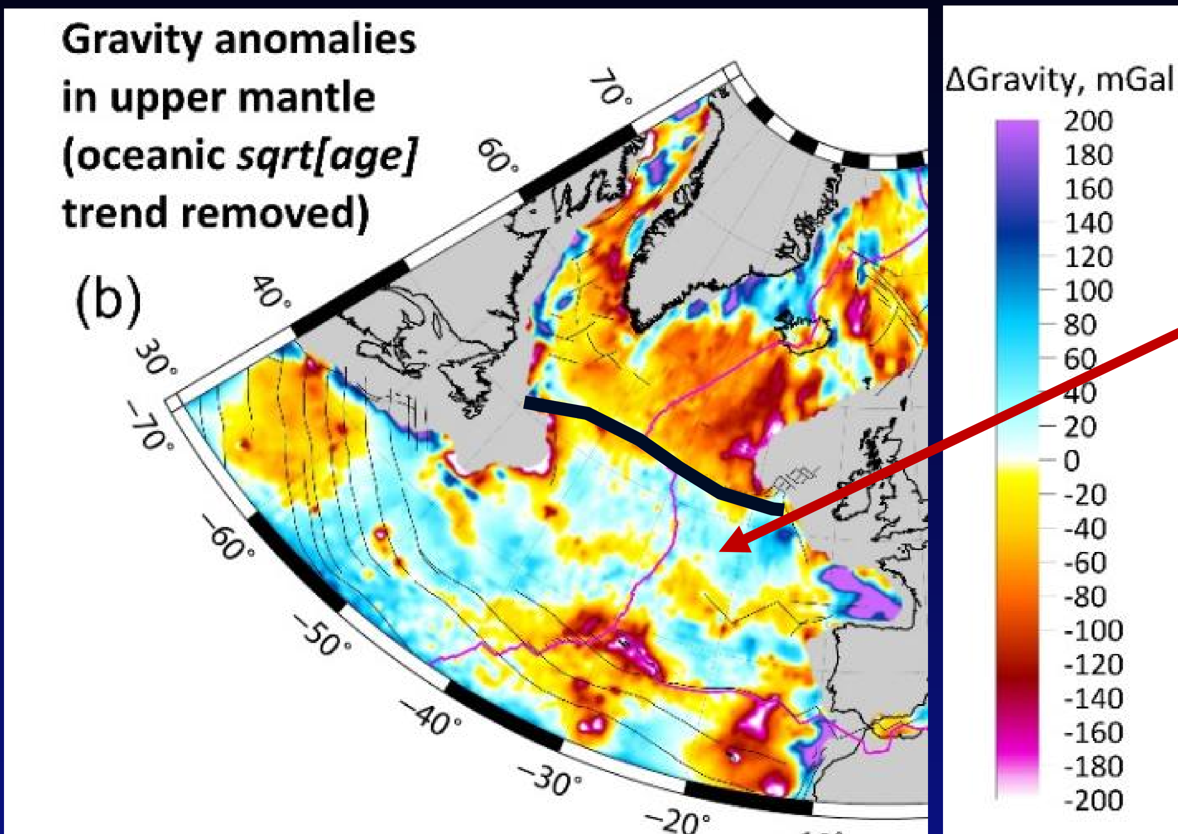
Anomalous bathymetry: deviation from SQRT(age)



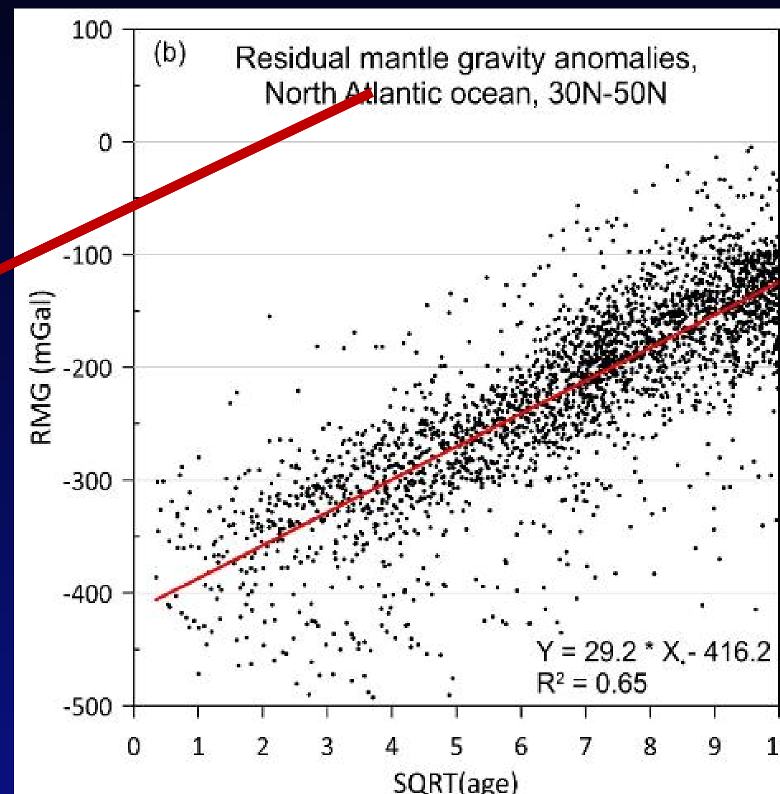
Artemieva and Thybo, 2013

Artemieva & Shulgin, EGU2020-5000 on-line

Oceanic mantle: deviation from sqrt(age)



Residual anomalies = gravity effect of the crust is excluded)

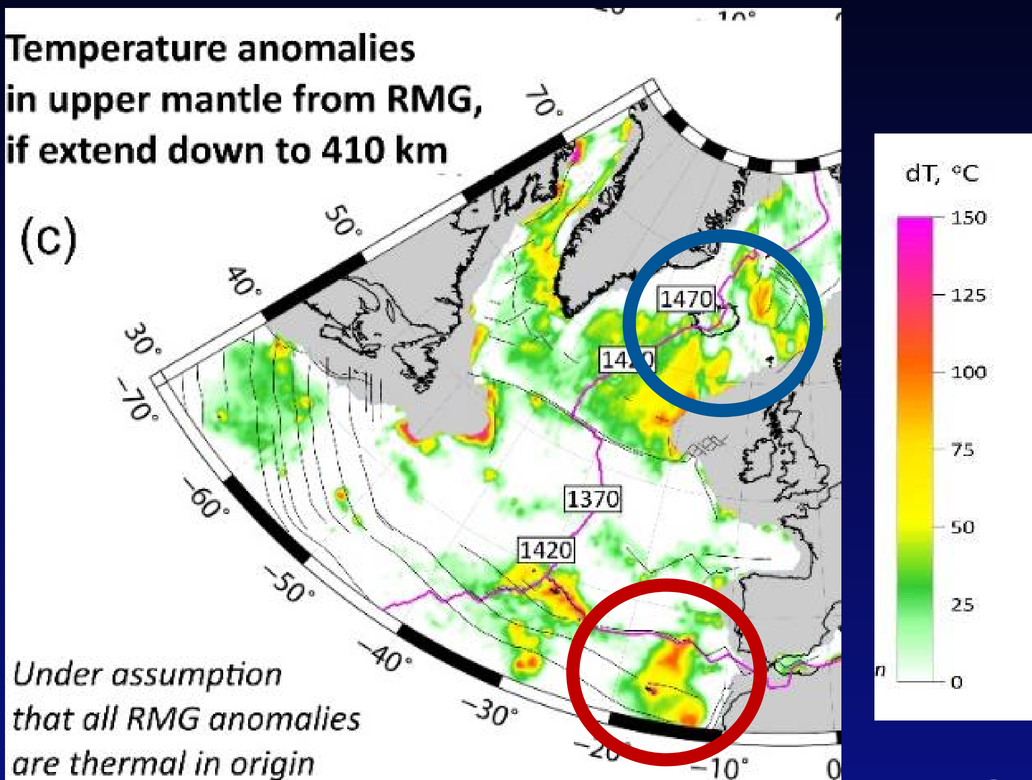


Shulgin & Artemieva, JGR, 2019

Artemieva & Shulgin, EGU2020-5000 on-line

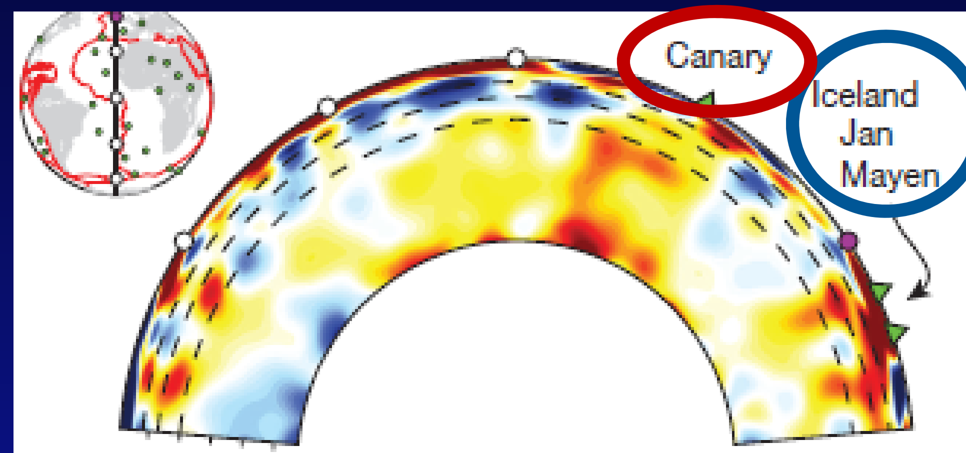
How strong is T-anomaly below hotspots ?

Ignore chemical heterogeneity;
assume all mantle density anomalies are caused by T alone



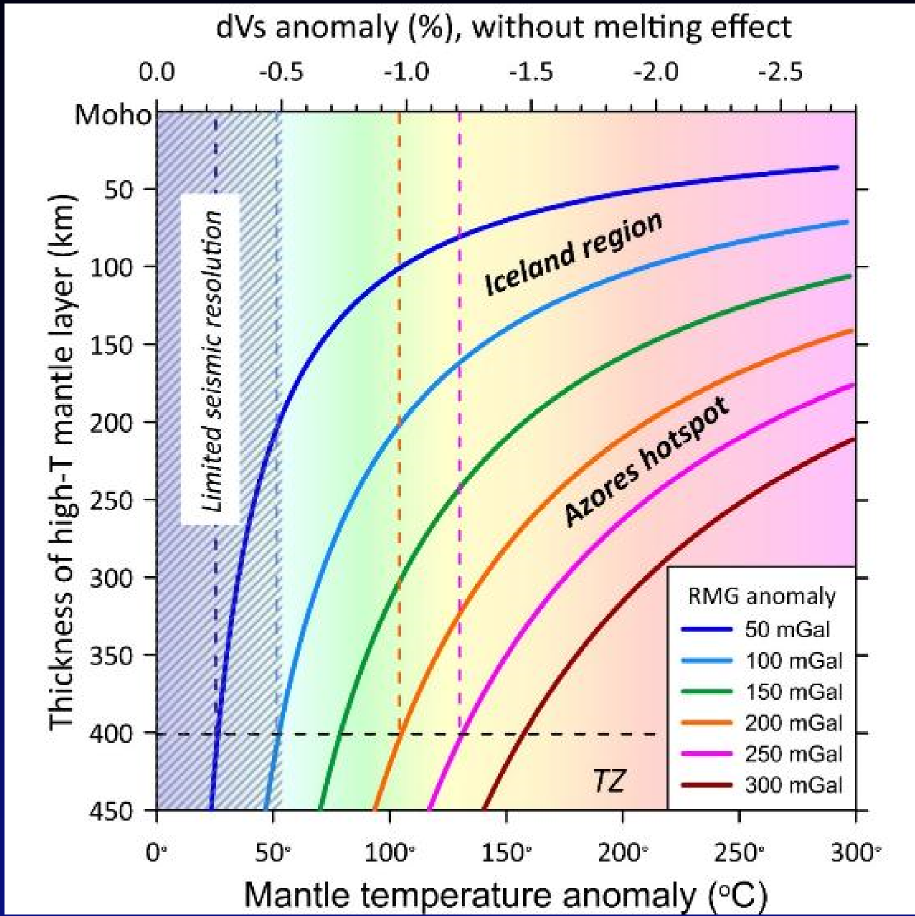
Shulgin & Artemieva, JGR, 2019

Can mantle T anomaly below Iceland and the Azores be seen in seismic data?



French & Romanowicz, 2015

How strong is T-anomaly below hotspots ?



Shulgin & Artemieva, JGR, 2019

Interplay of the layer thickness and the amplitude of T anomaly:

Mantle gravity anomaly ~ [thickness of anomalous layer]*d(rho)

Iceland & Bermudas:

If T anomaly is ~100-150 °C (seismically detectable), seismic LVZ should be only 100-150 km thick

Azores & Canary:

T anomaly is seismically detectable even if extends down to TZ

Conclusions

Greenland:

- typical cratonic lithosphere (150-200 km thick) in southern part;
- belt of thinned lithosphere across central Greenland – the Iceland hotspot track?
- anomalously hot mantle beneath E. Greenland

Europe:

- no difference in mantle density across the TESZ -> strong reworking of the EEC;
- superdeep basins require 10-20% of eclogite in LM

Anatolia:

- patchy lithosphere thermal anomalies due to lithosphere fragmentation by paleo-subductions;
- continental fragments and teared Neo-Tethyan slabs control high topography of East Anatolia

North Atlantics:

- "Normal" ocean mantle only south of the Charlie-Gibbs FZ;
- Strong thermal and compositional heterogeneity with continental fragments

Iceland:

- Thermal anomaly is either shallow or weak, and at the limit of seismic detection;
- Can be obscured by continental fragments within oceanic mantle.

Azores and Canary: Strong thermal anomaly