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From Core to Crust: Towards an Integrated Vision of Earth's Interior

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Seismic structure of the Iceland hotspot: Main features and mysteries

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Seismic structure of the Iceland hotspot: Main features and mysteries

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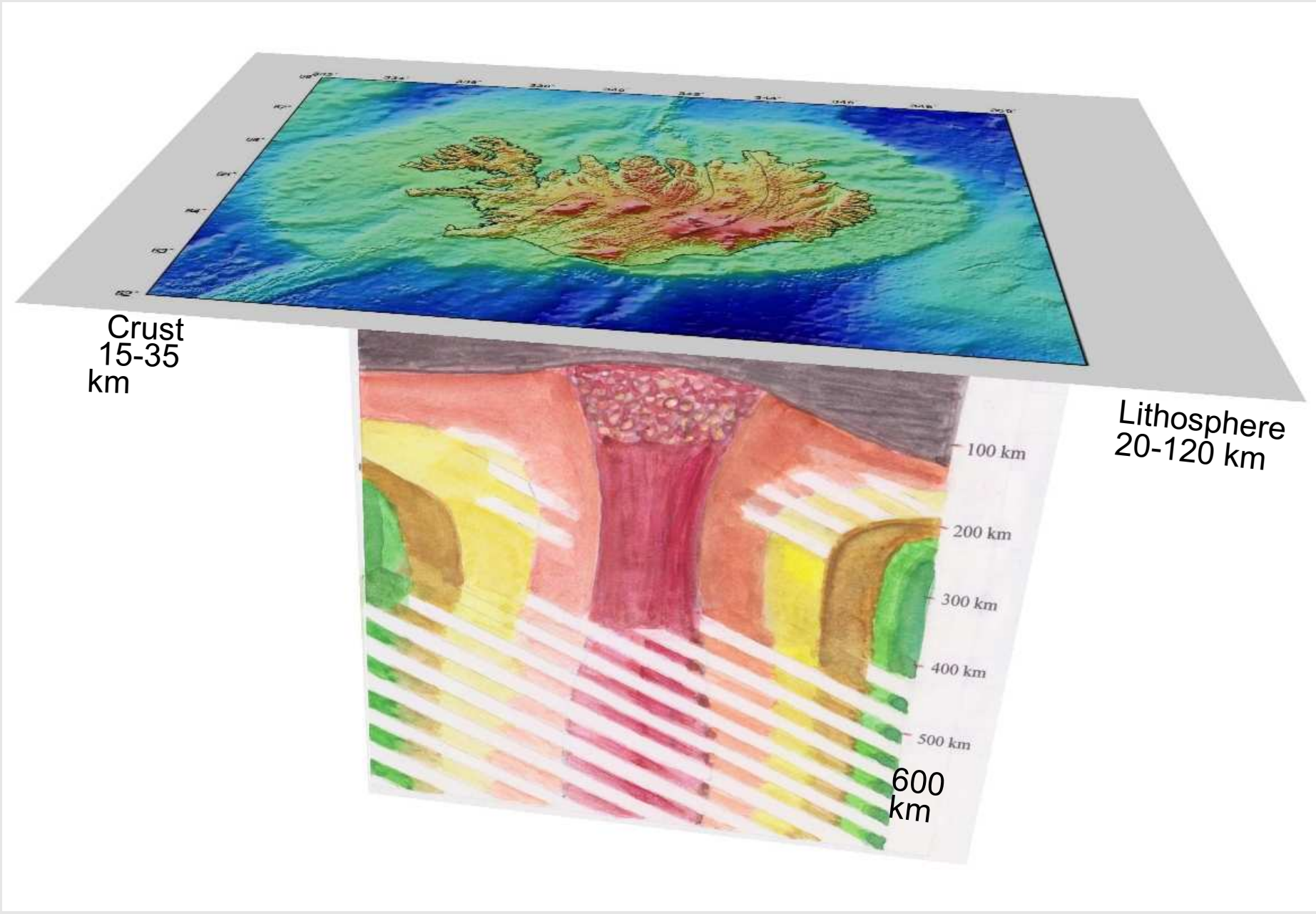
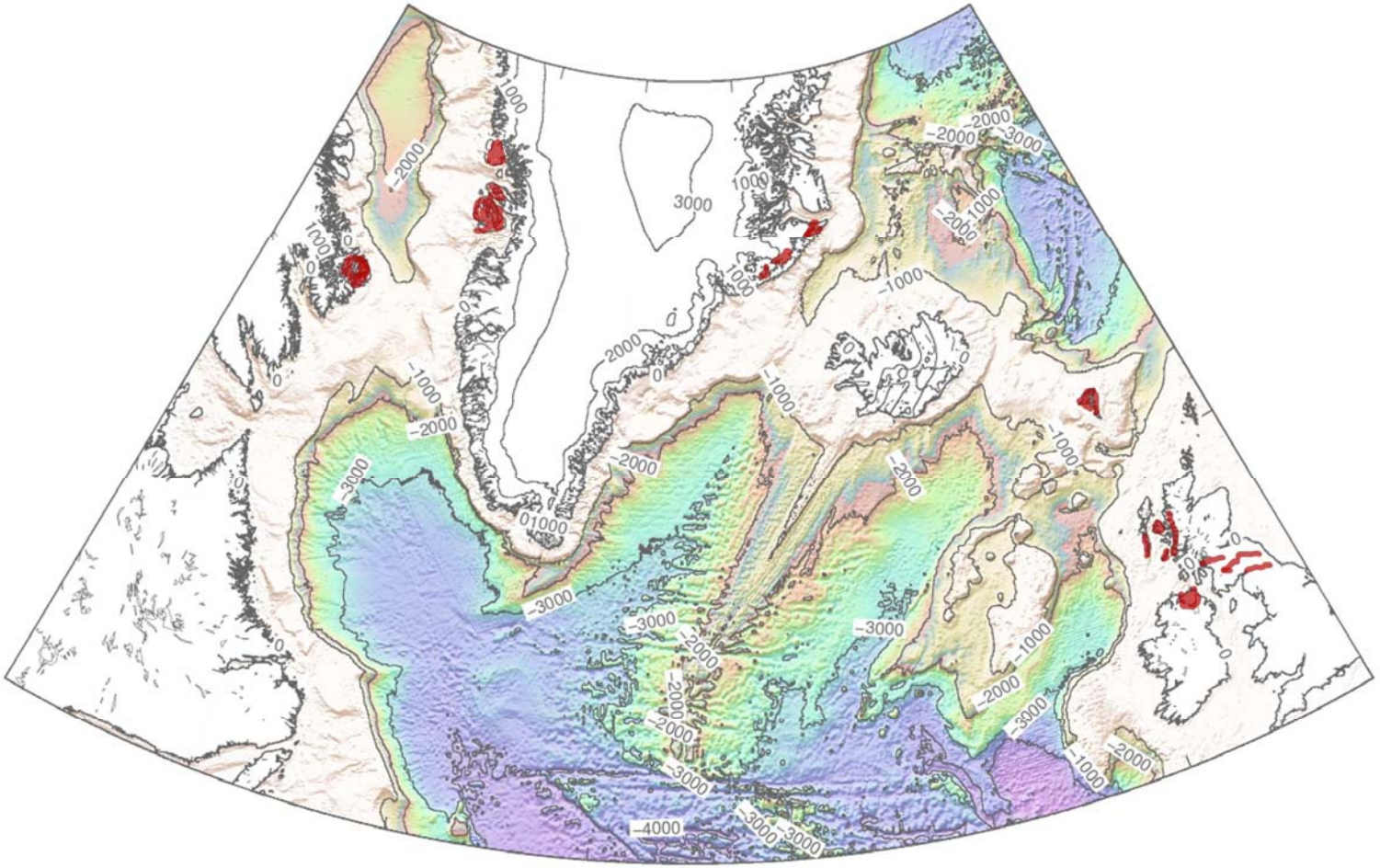
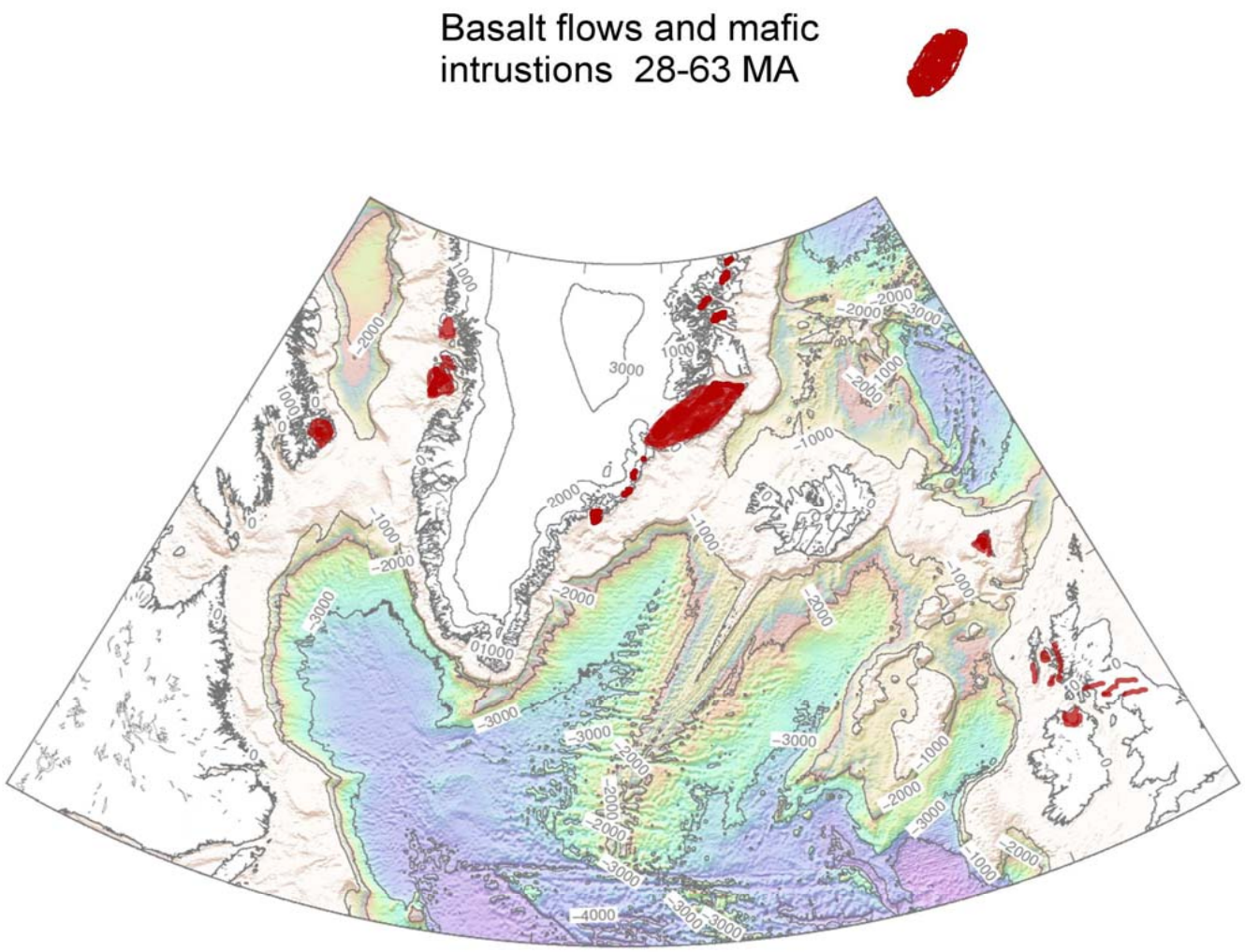
University of Iceland



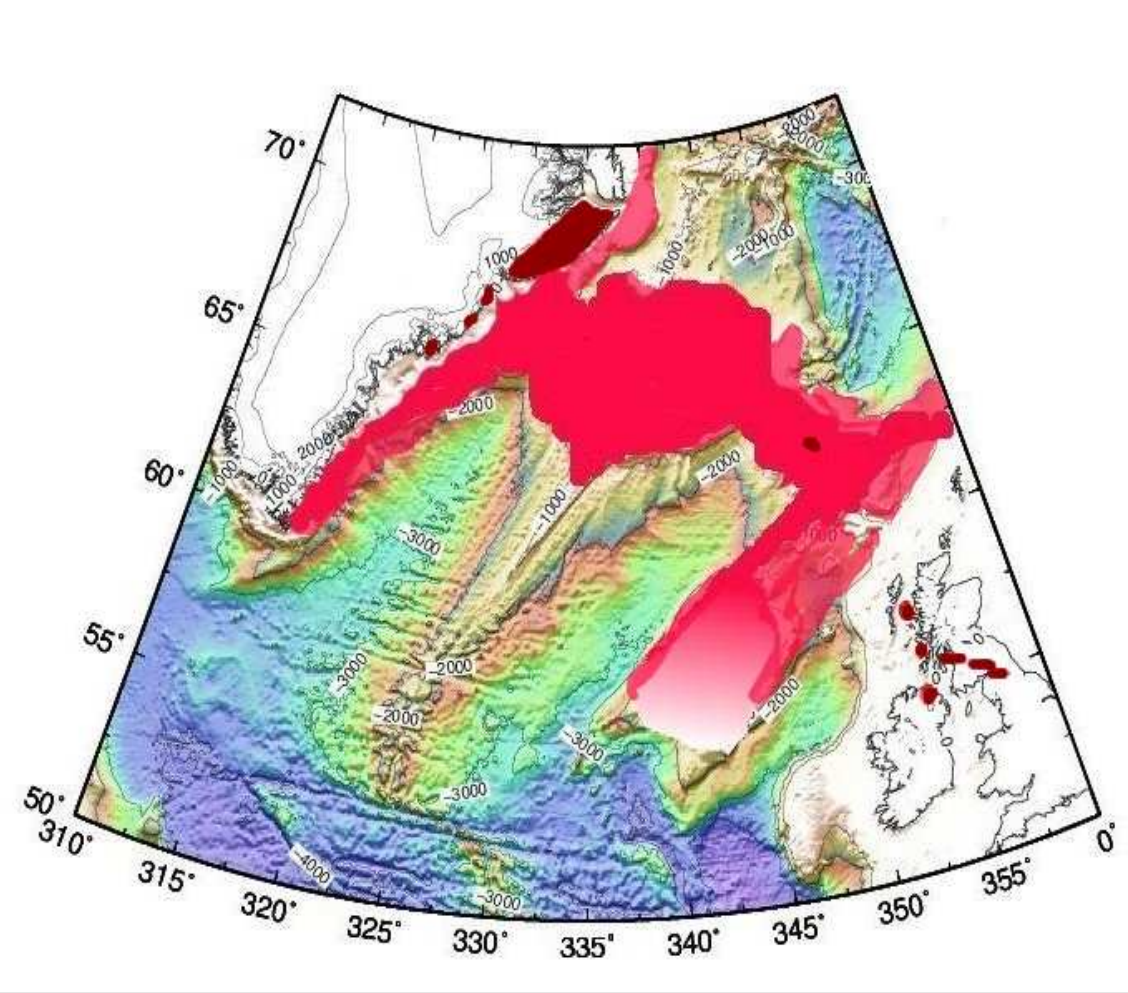
Early Tertiary Basalts:
59-63 MA




Basalt flows and mafic
intrustions 28-63 MA

Melt Anomaly

North Atlantic Large Igneous Province



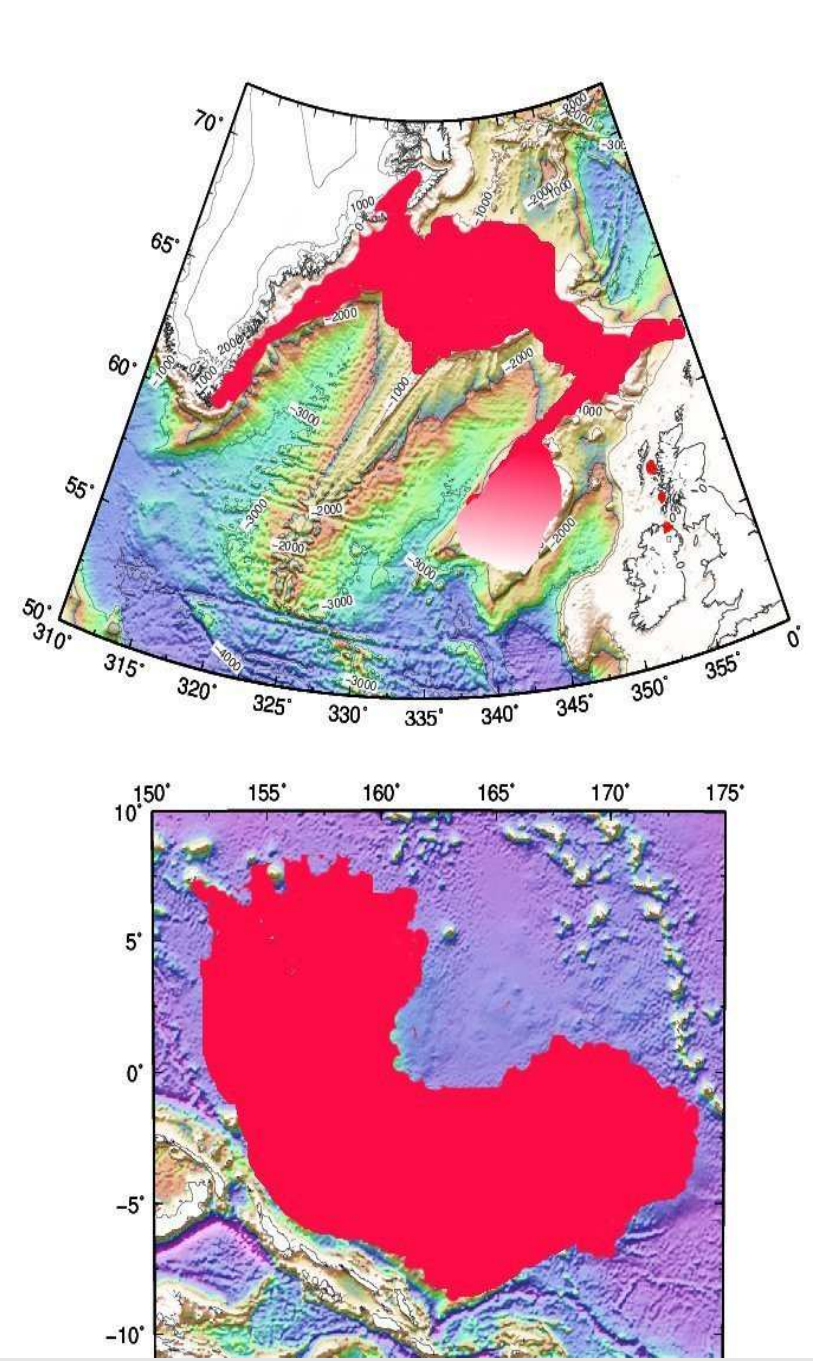
Modified from Saunders et al., 1997

Iceland hotspot is part of the North Atlantic Igneous Province (NAIP)

NAIP: 1.3 million km^2

Iceland and shelf ~1/3 of NAIP

NAIP active since 63 Ma



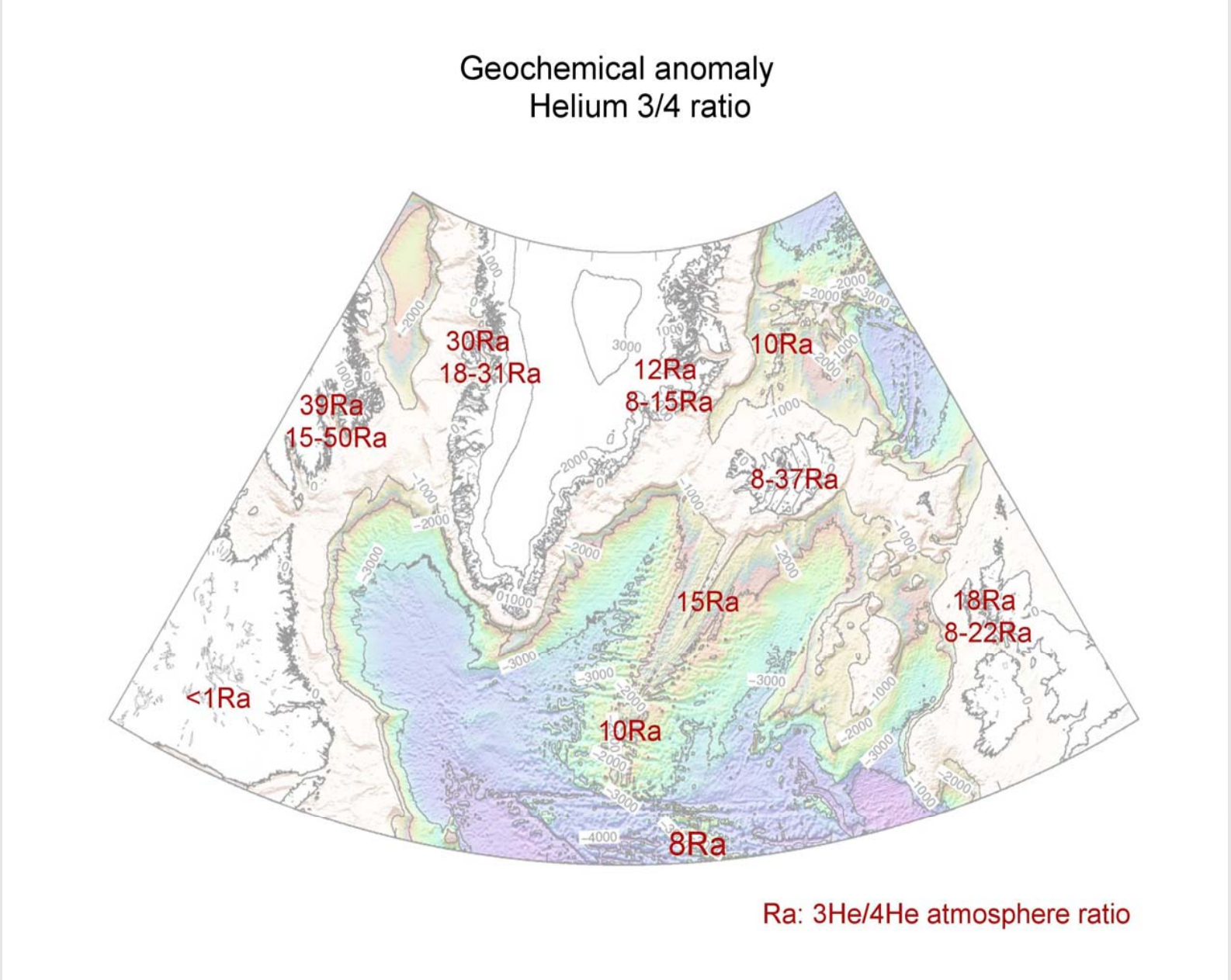
Large Igneous Provinces

North Atlantic Igneous Province

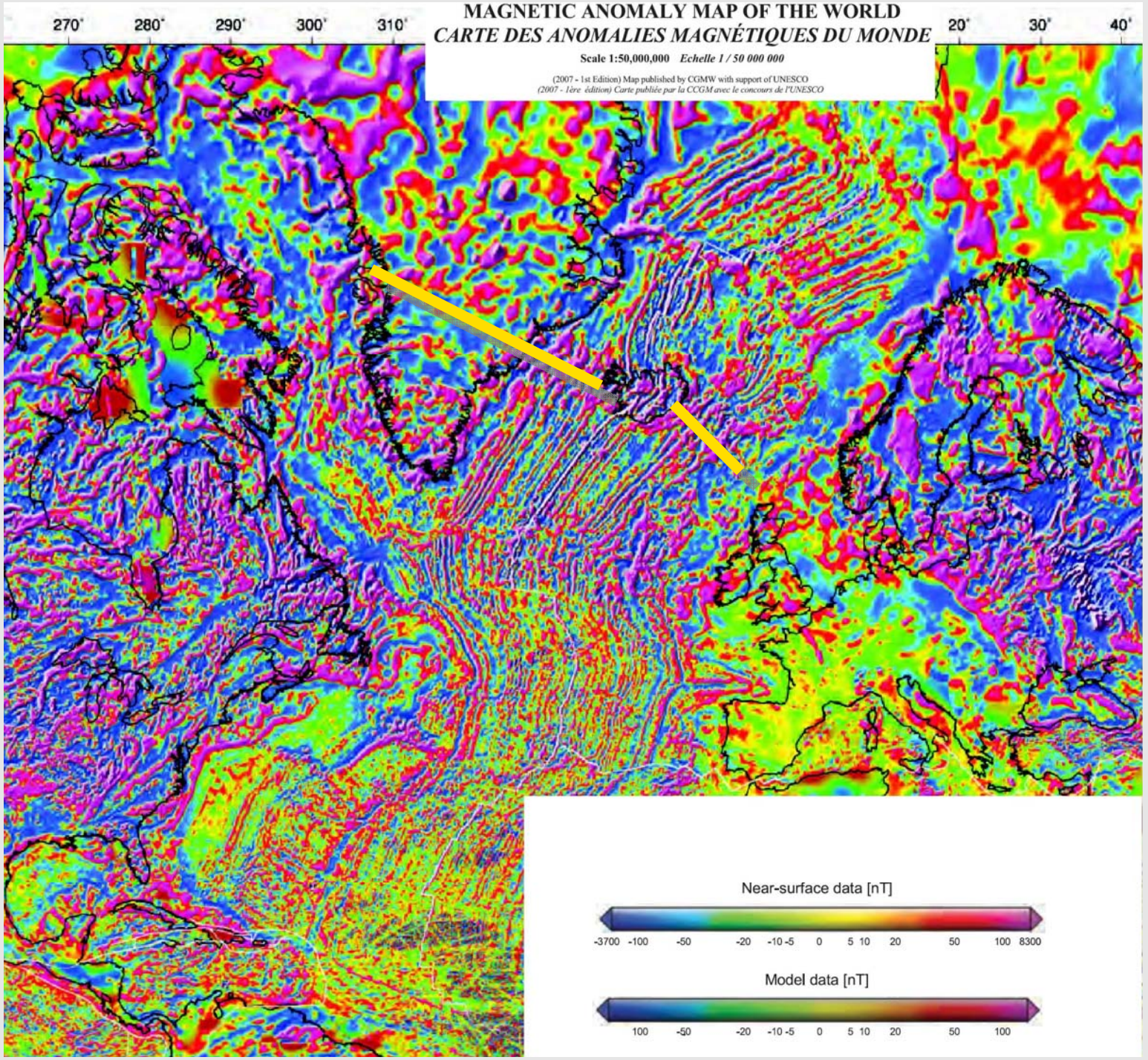
1.3 million km^2

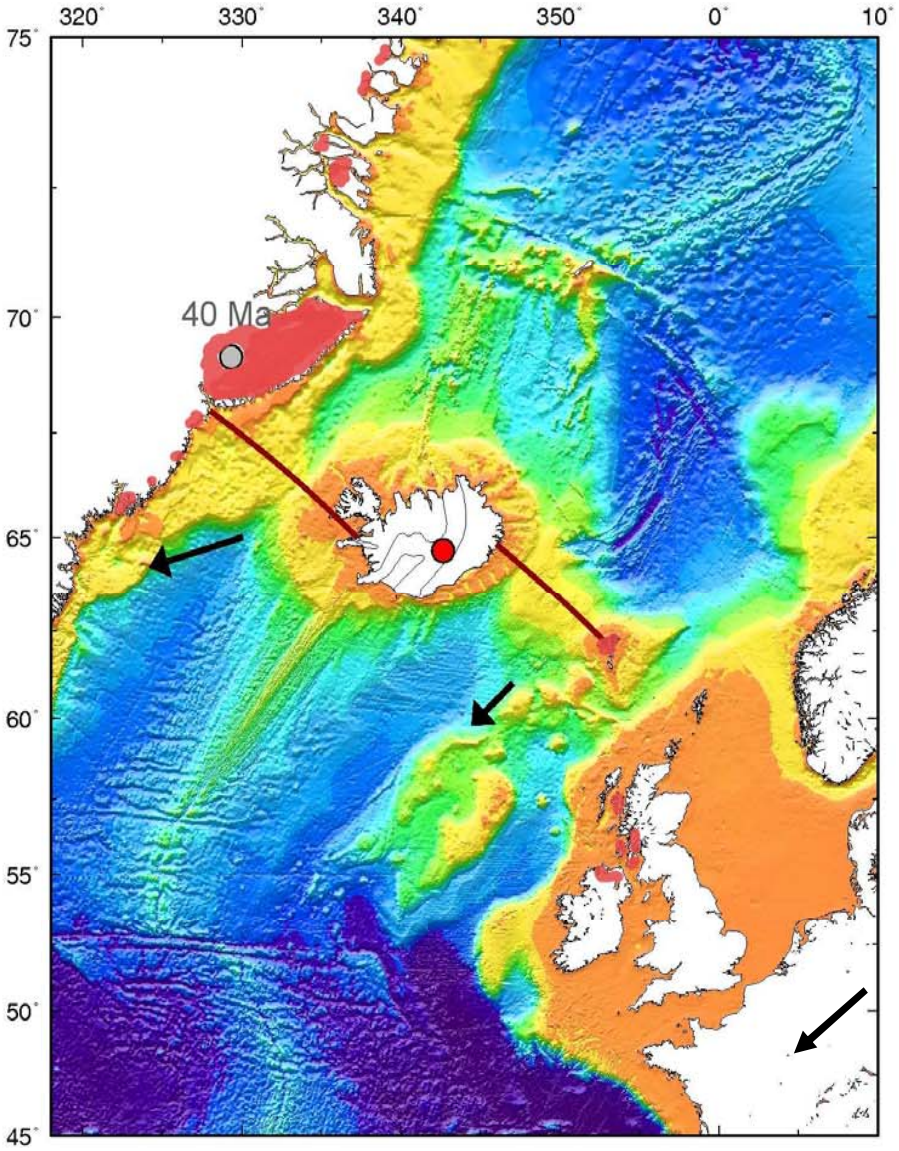
Ontong Java Plateau

2.0 million km^2



many many authors


MAGNETIC ANOMALY MAP OF THE WORLD
CARTE DES ANOMALIES MAGNÉTIQUES DU MONDE
Scale 1:50,000,000 Echelle 1 / 50 000 000
(2007 - 1st Edition) Map published by CGMW with support of UNESCO
(2007 - 1ère édition) Carte publiée par la CCGM avec le concours de l'UNESCO
270° 280° 290° 300° 310°
20° 30° 40°
Near-surface data [nT]
-3700 -100 -50 -20 -10 -5 0 5 10 20 50 100 8300
Model data [nT]
100 -50 -20 -10 -5 0 5 10 20 50 100



Lawver & Mueller 1994

Wolfe et al. 1997

HS3-Nuvel1A

Gripp & Gordon 2002

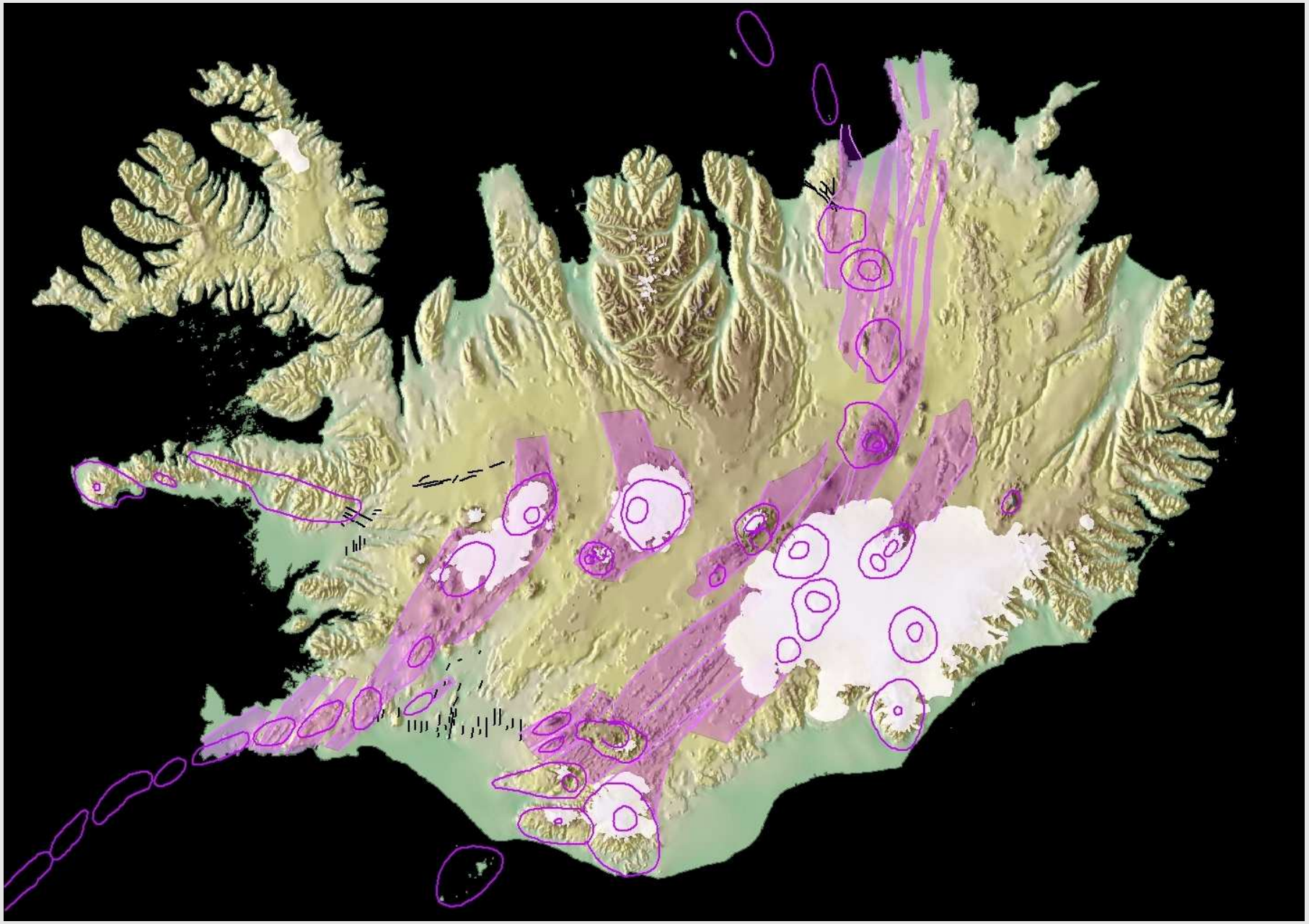
The North Atlantic hotspot is a melt and geochemical anomaly, now centered in Iceland.

It goes 63 Ma back in time seen in West Greenland, Baffin Island and the British Islands Igneous Province.
Effects currently the Mid-Atlantic Ridge between 52°N to 70°N+, more to the south.

The hotspot tracks have irregularities or are rather wide.

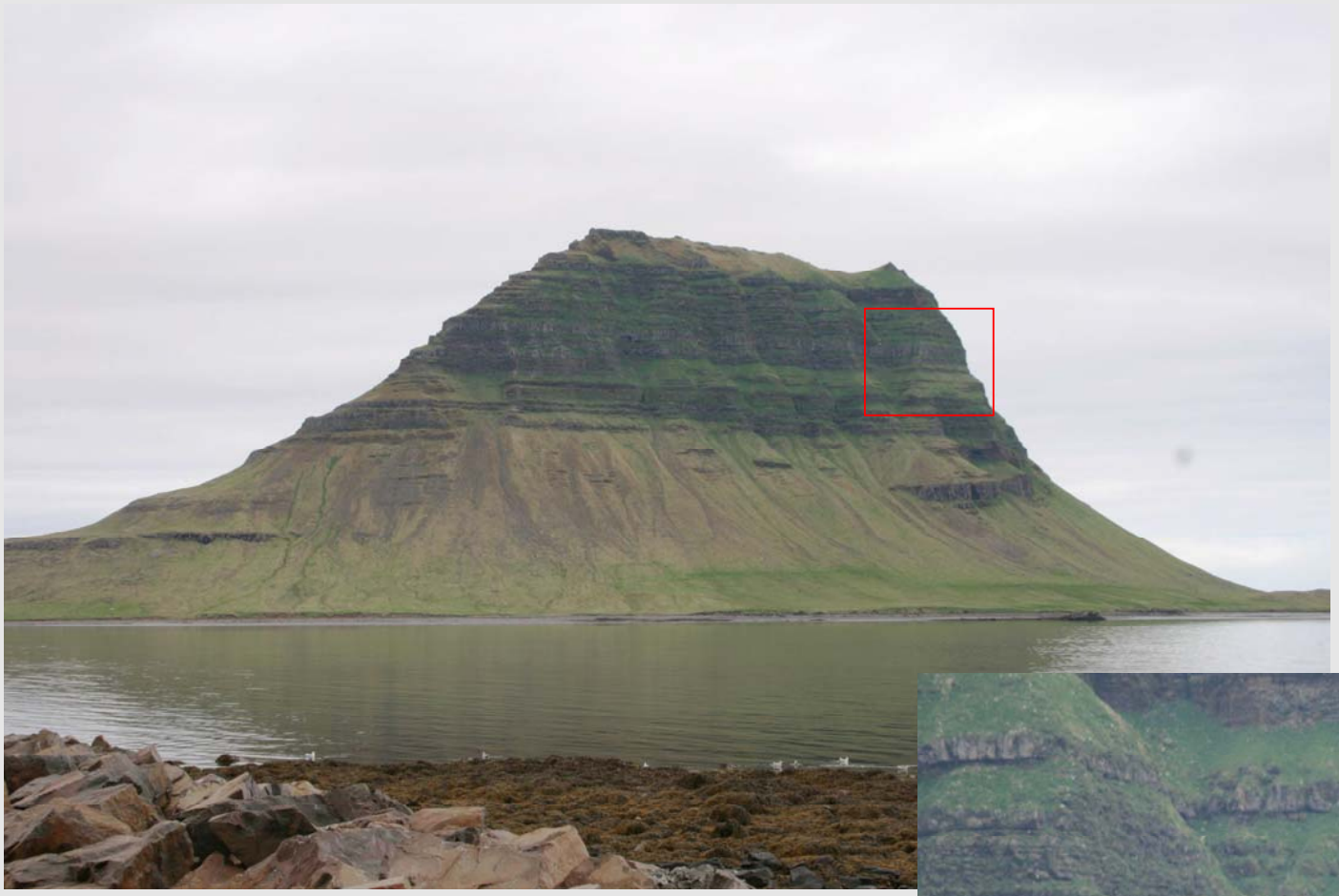
The Iceland hotspot is not a fixed point in absolute reference frame with Passific hotspots.

The Eurasian plate has southward drift and the North American plate a northward drift relative to the Iceland hotspot.

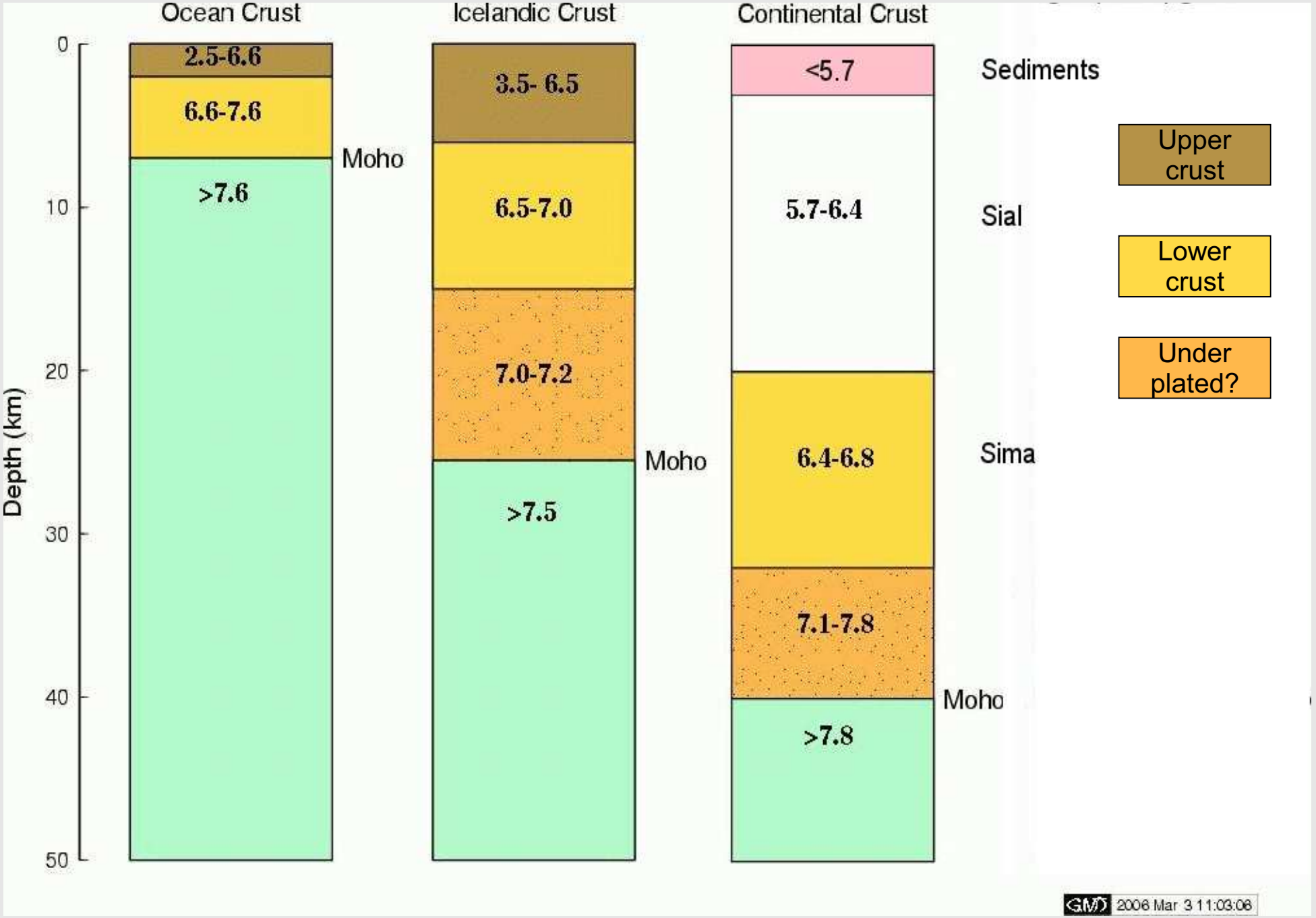


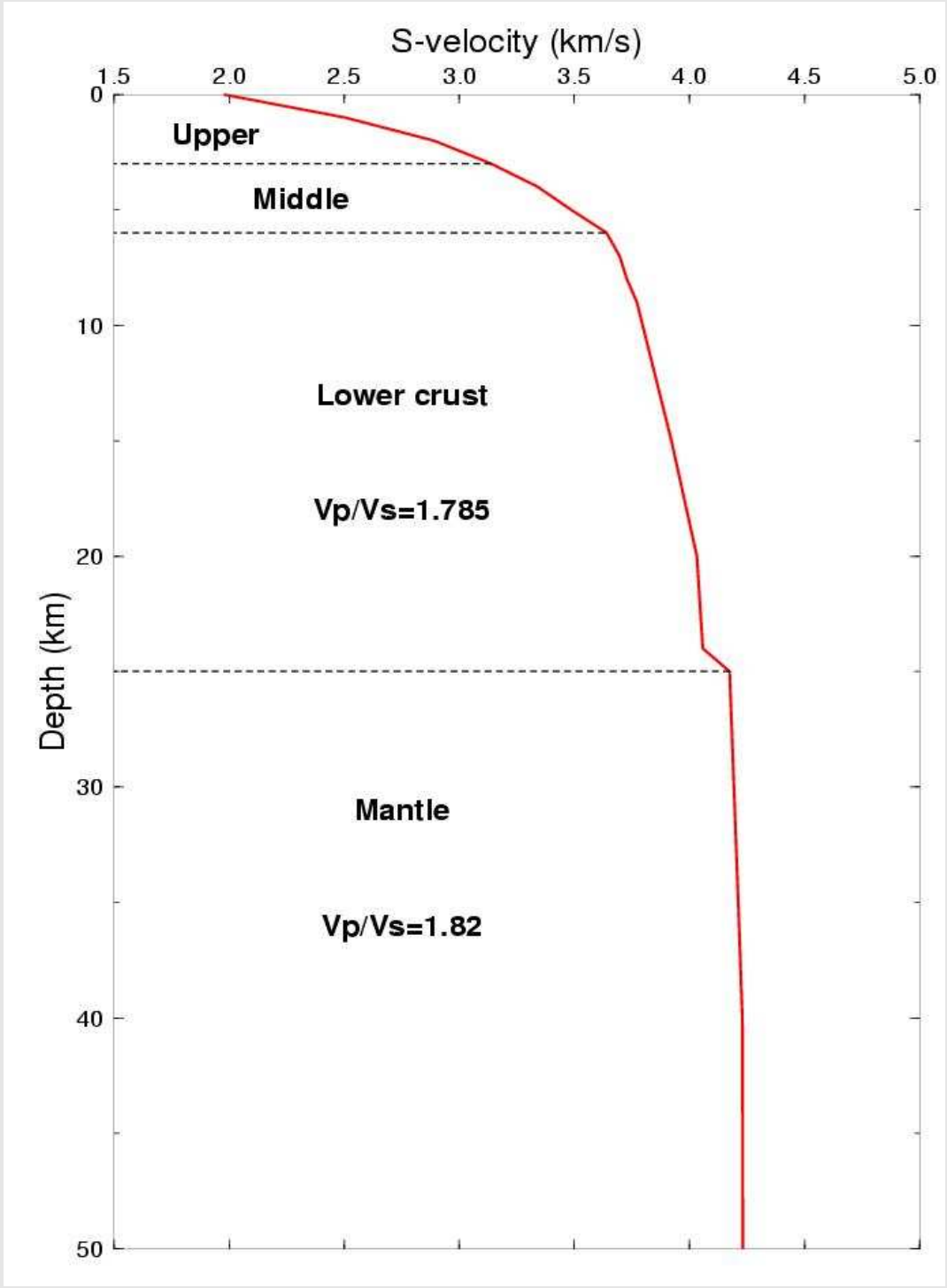
From Amy Clifton

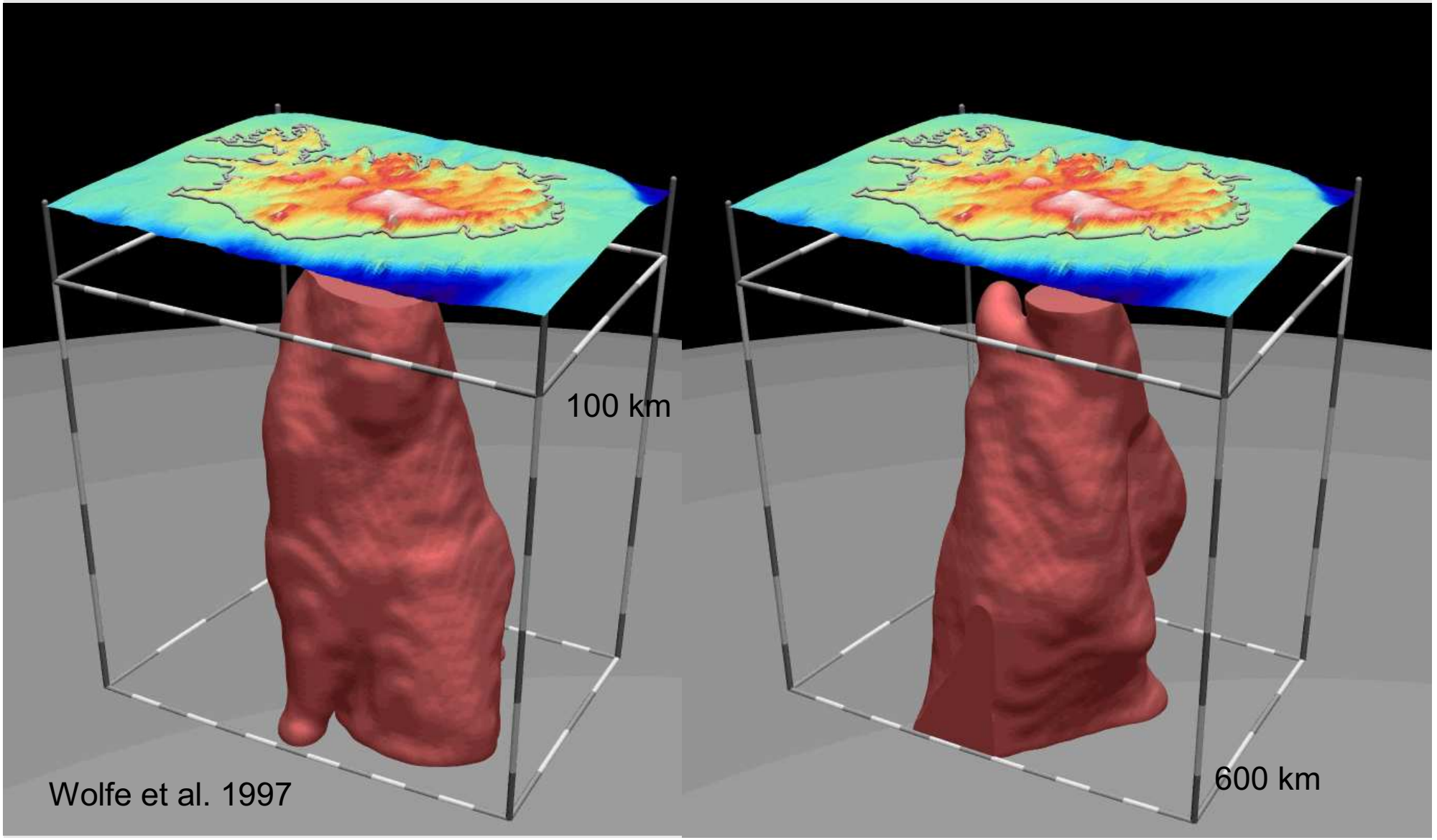
Krafla Fires 1975-1984

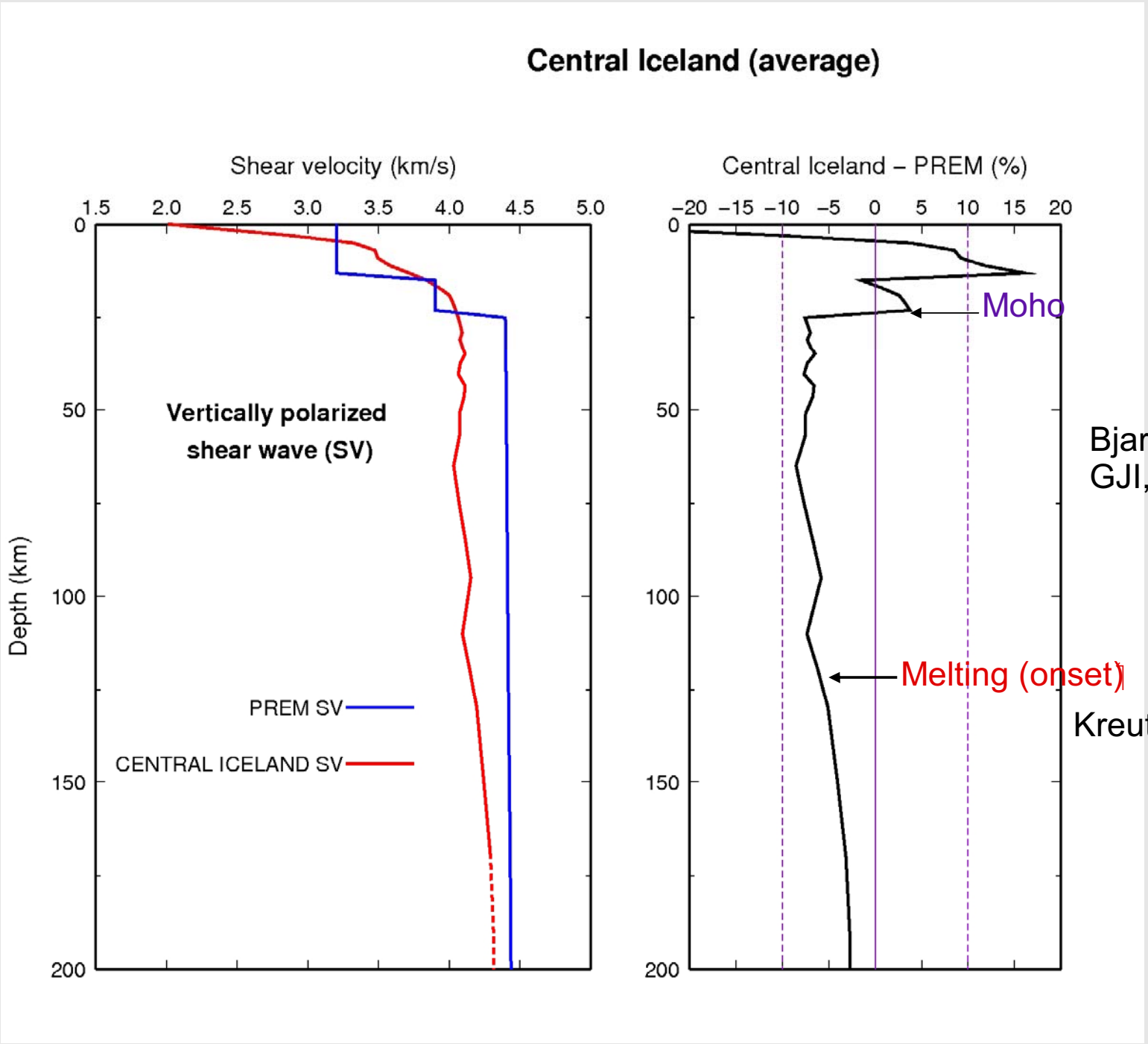


Kistufell, Grundarfjörður, 11. June, 2009


Ocean Crust
Icelandic Crust
Continental Crust
Depth (km)
0
10
20
30
40
50
2.5-6.6
6.6-7.6
>7.6
Moho
3.5- 6.5
6.5-7.0
7.0-7.2
>7.5
Moho
<5.7
5.7-6.4
6.4-6.8
7.1-7.8
>7.8
Moho
Sediments
Sial
Sima
Upper crust
Lower crust
Under plated?
GMT 2006 Mar 3 11:03:08


S-velocity (km/s)
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
0
10
20
30
40
50
Depth (km)
Upper
Middle
Lower crust
Vp/Vs=1.785
Mantle
Vp/Vs=1.82


Shear-wave anomaly
4%
Compressional-wave anomaly
2%
100 km
600 km
Wolfe et al. 1997

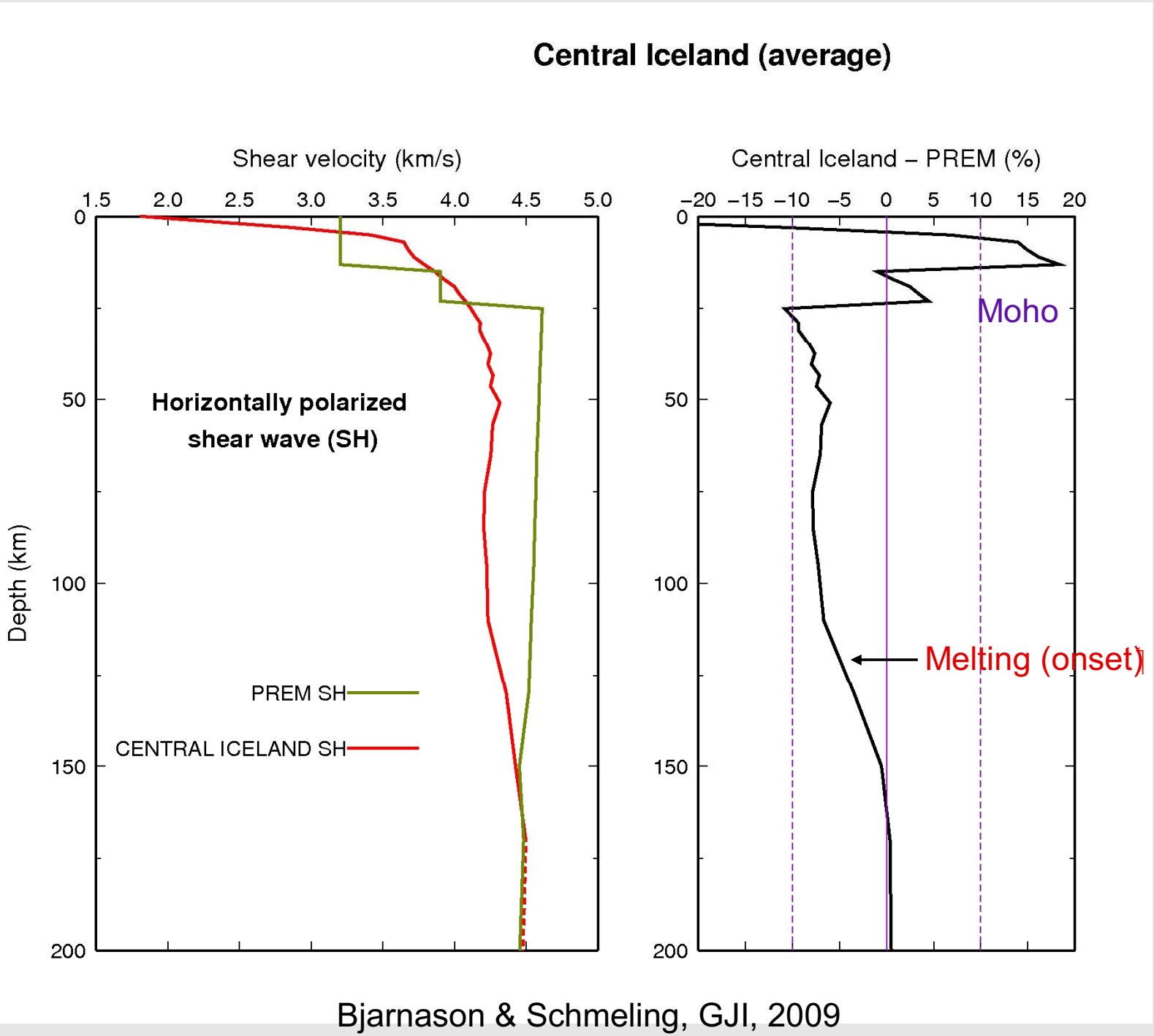


Φ=2-3%
T=1400±50℃

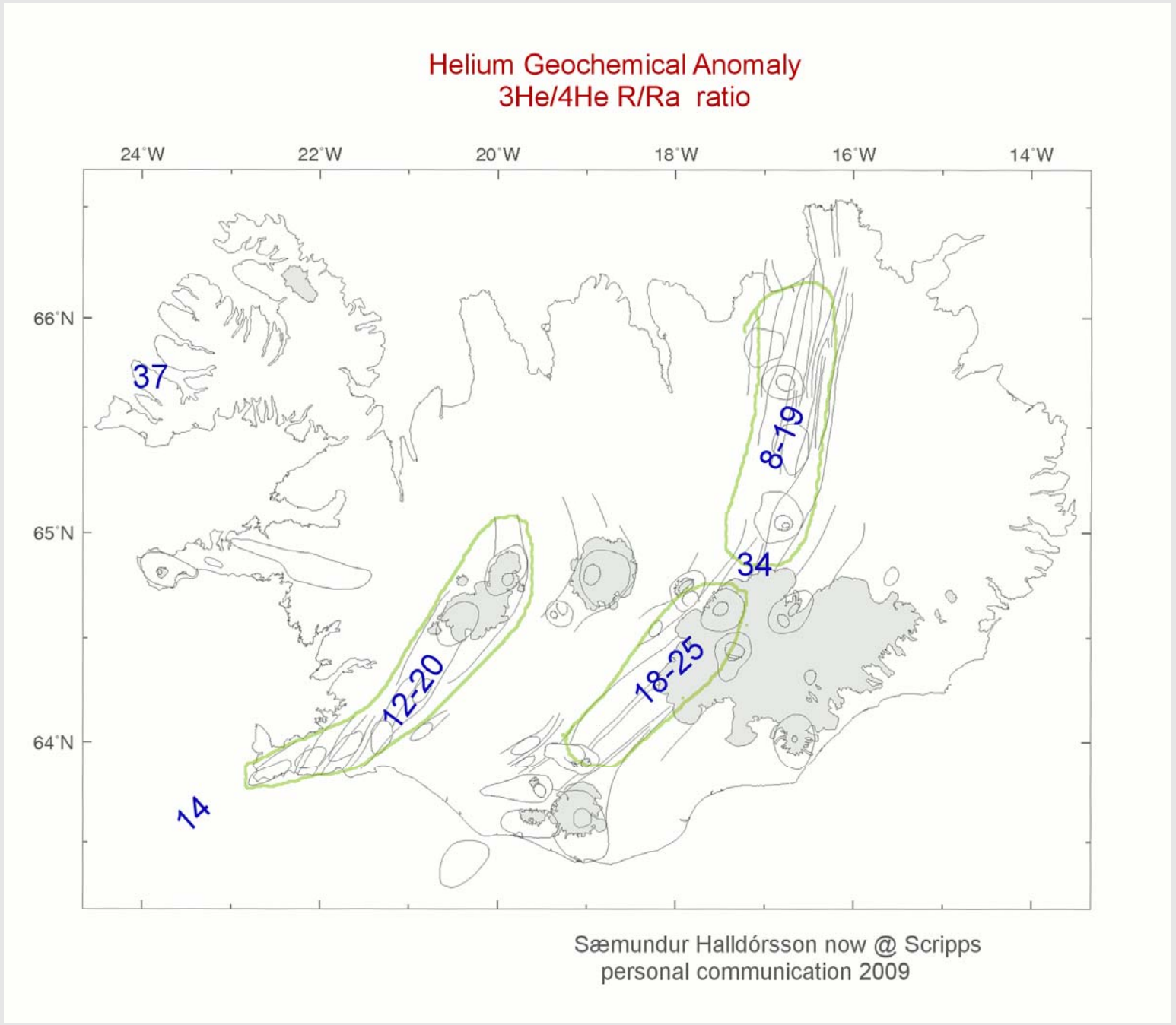
Bjarnason & Schmeling
GJI, 2009

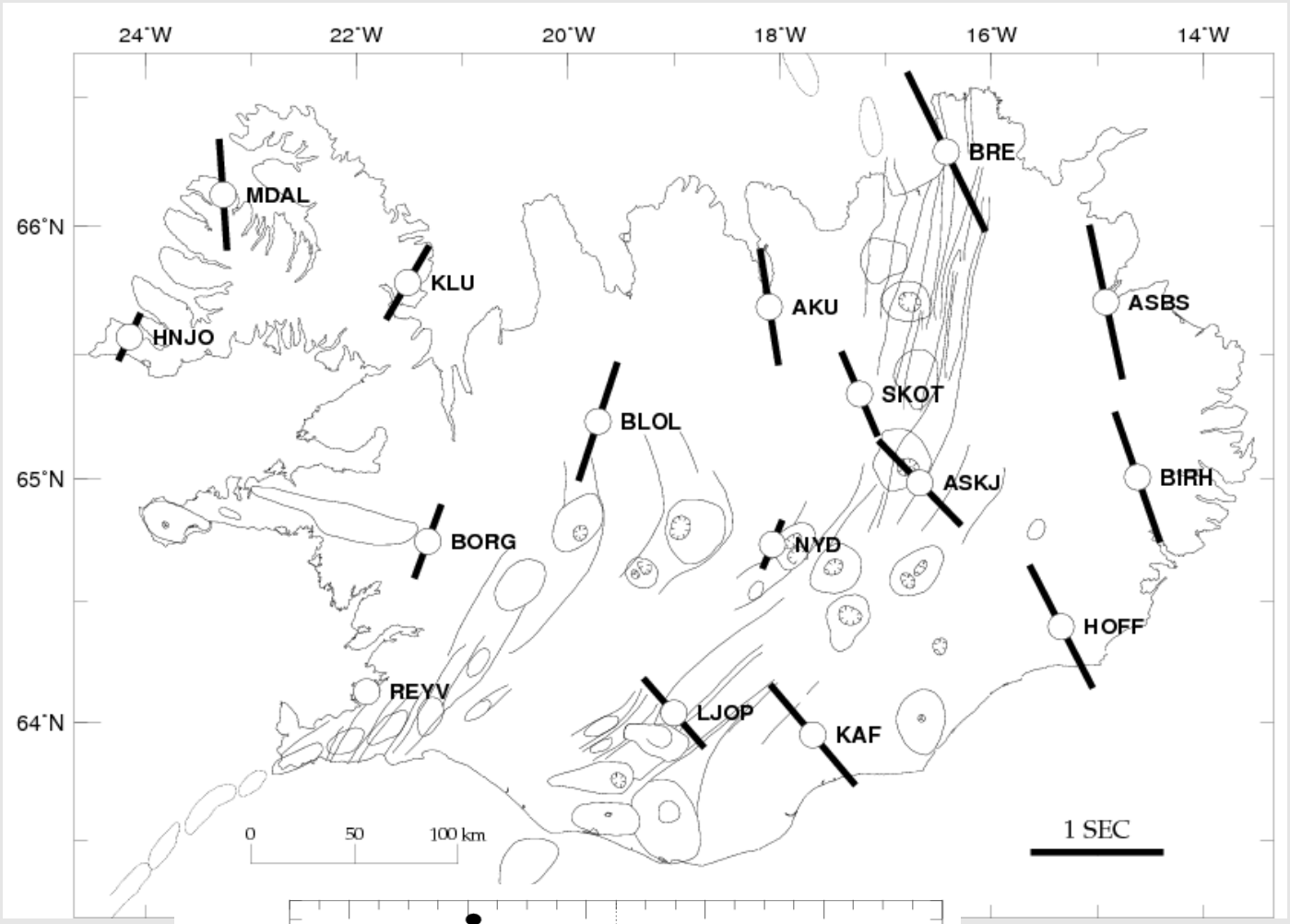
Φ=1%
ΔT=135ºK

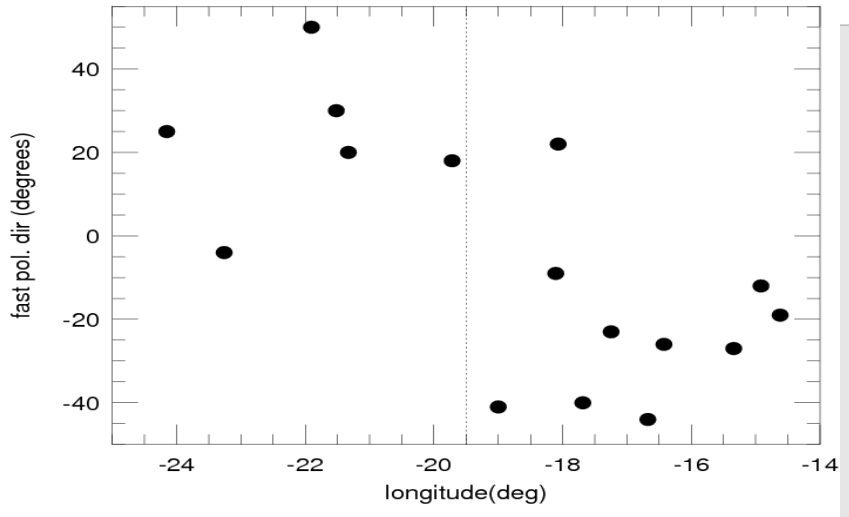
Kreutzmann etal 2004



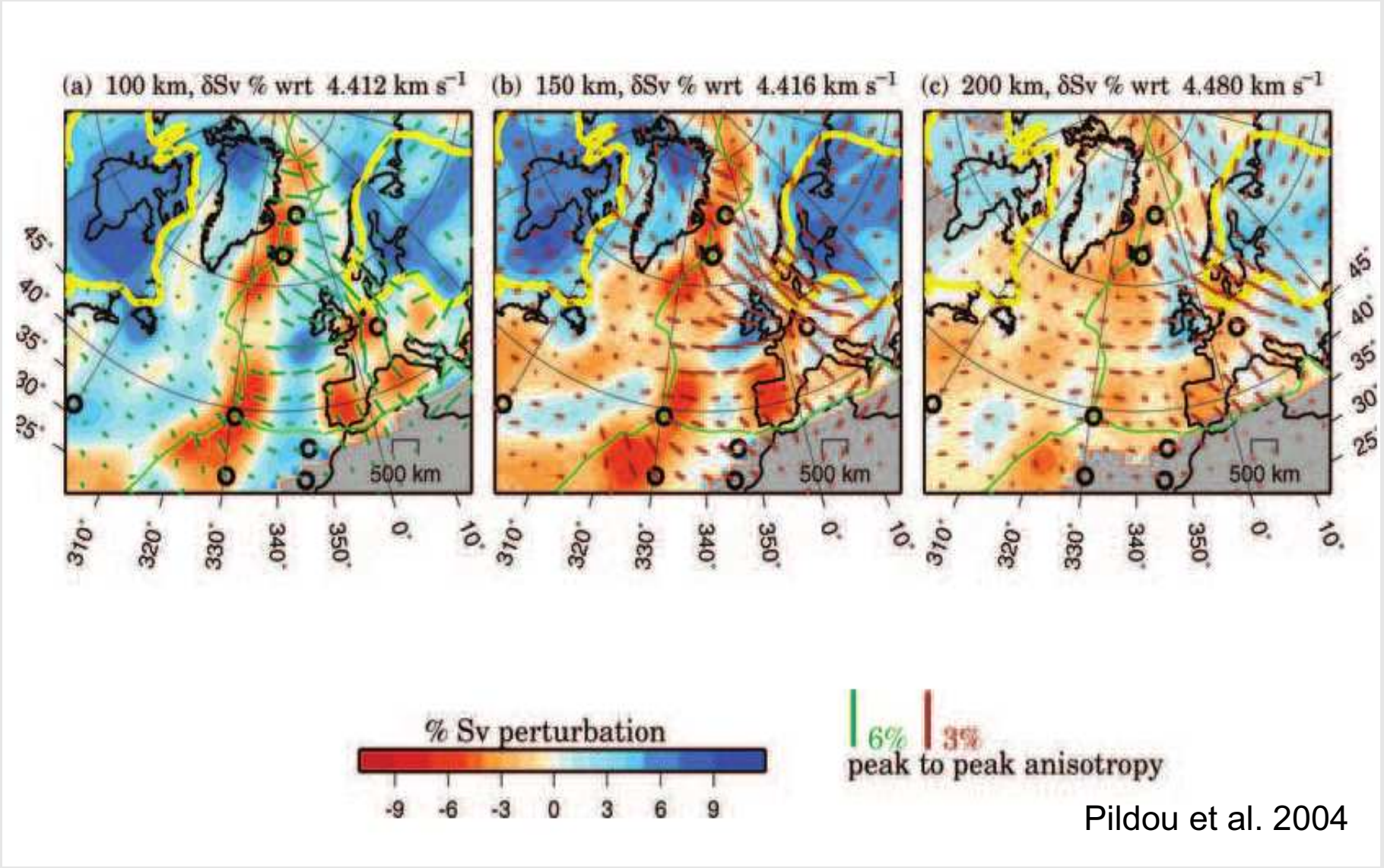
Bjarnason & Schmeling, GJI, 2009


Helium Geochemical Anomaly
3He/4He R/Ra ratio
24°W
22°W
20°W
18°W
16°W
14°W
66°N
65°N
64°N
37
8-19
34
12-20
18-25
14
Sæmundur Halldórsson now @ Scripps
personal communication 2009

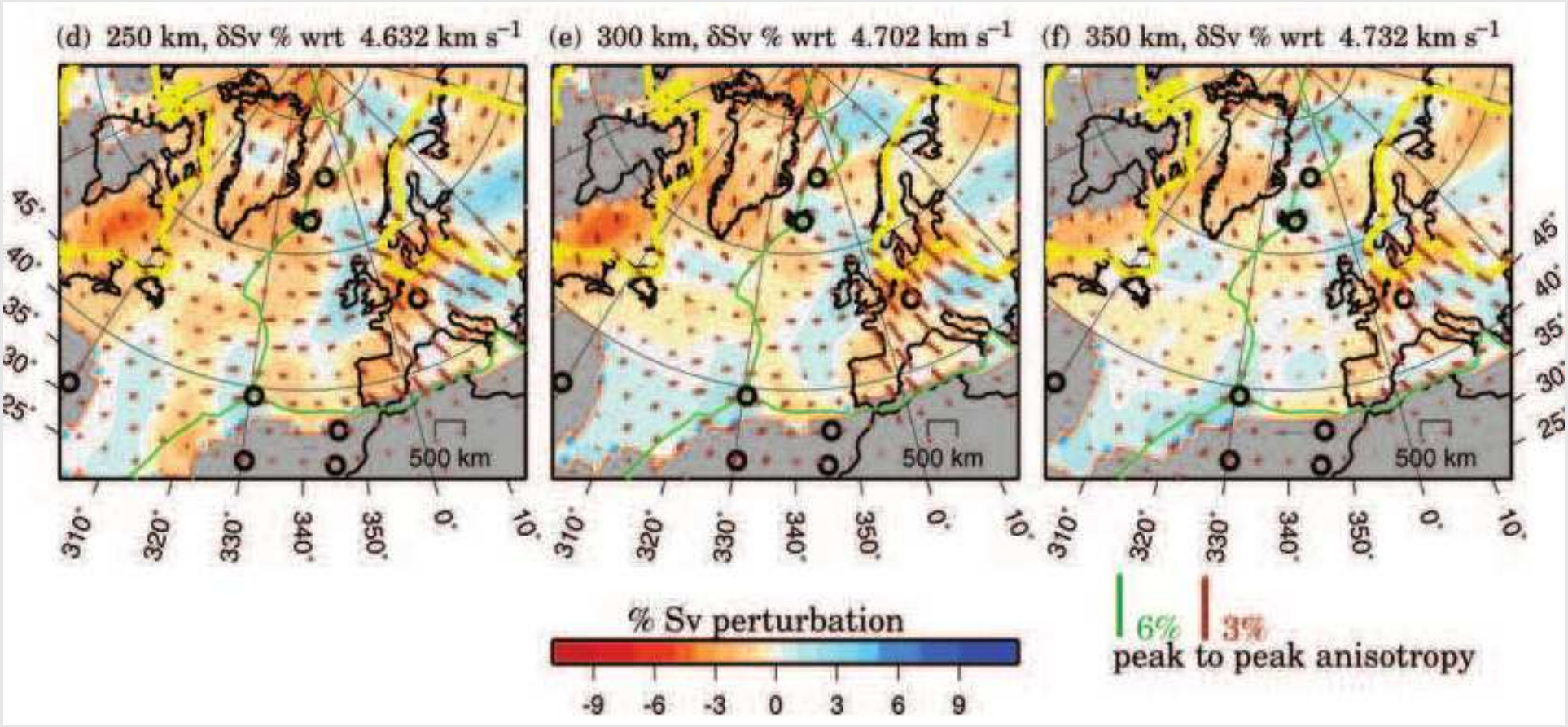




Bjarnason et al.
JGR, 2002



Pildou et al. 2004



Pildou et al. 2004

Ucisik et al. (2005) get median 19° fast directin in E-Greenland

The mantle low velocity zone (MLVZ) under Iceland is the source (ultimume or interim) of the hotspot.

The melting zone has been modeled in the top 100 km of the mantle,
With V_{SH} < 5-10% lower and V_{SV} < 5.5-8.5% than PREM.
Highest partial melt in the shallowest mantle.

There is some gradient of higher 3He/4He-ratio along the volcanic zones towards the center of the hotspot, but the highest values are found in older basalt. Geothermal waters show the same 3He/4He patern as the rocks.

Is the sharp (100 km) change of azimuthal anisotropy across the plate boundaries in Iceland reflecting a much wider spread dissimilar anisotropic patterns under the NA-plate and the EA-plate, or is melt masking a hotspot radial flow mantle flow direction.