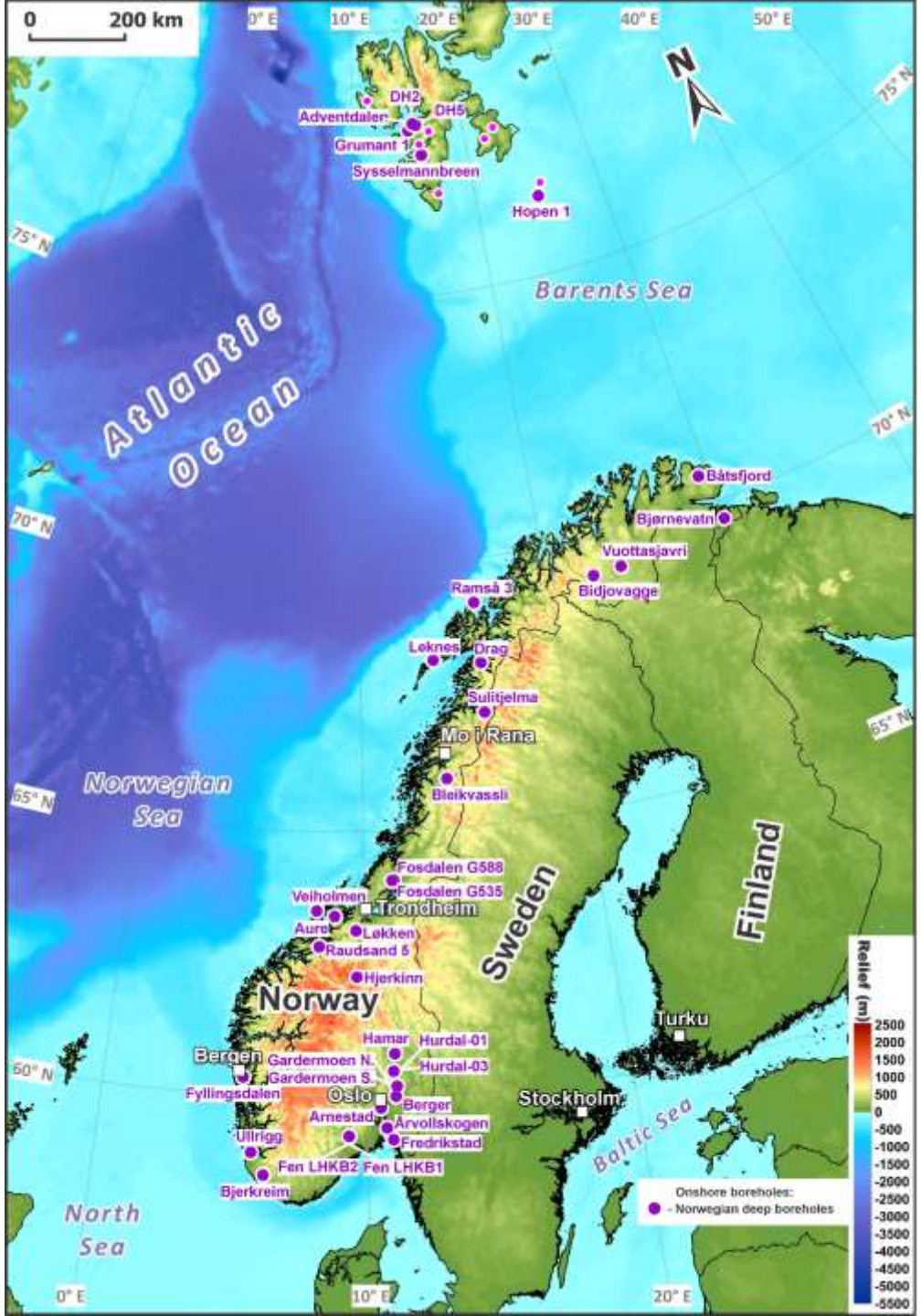
Major factors controlling the deep geothermal potential of the North and the Norwegian seas

GEOLOGICAL SURVEY OF NORWAY
- NGU -

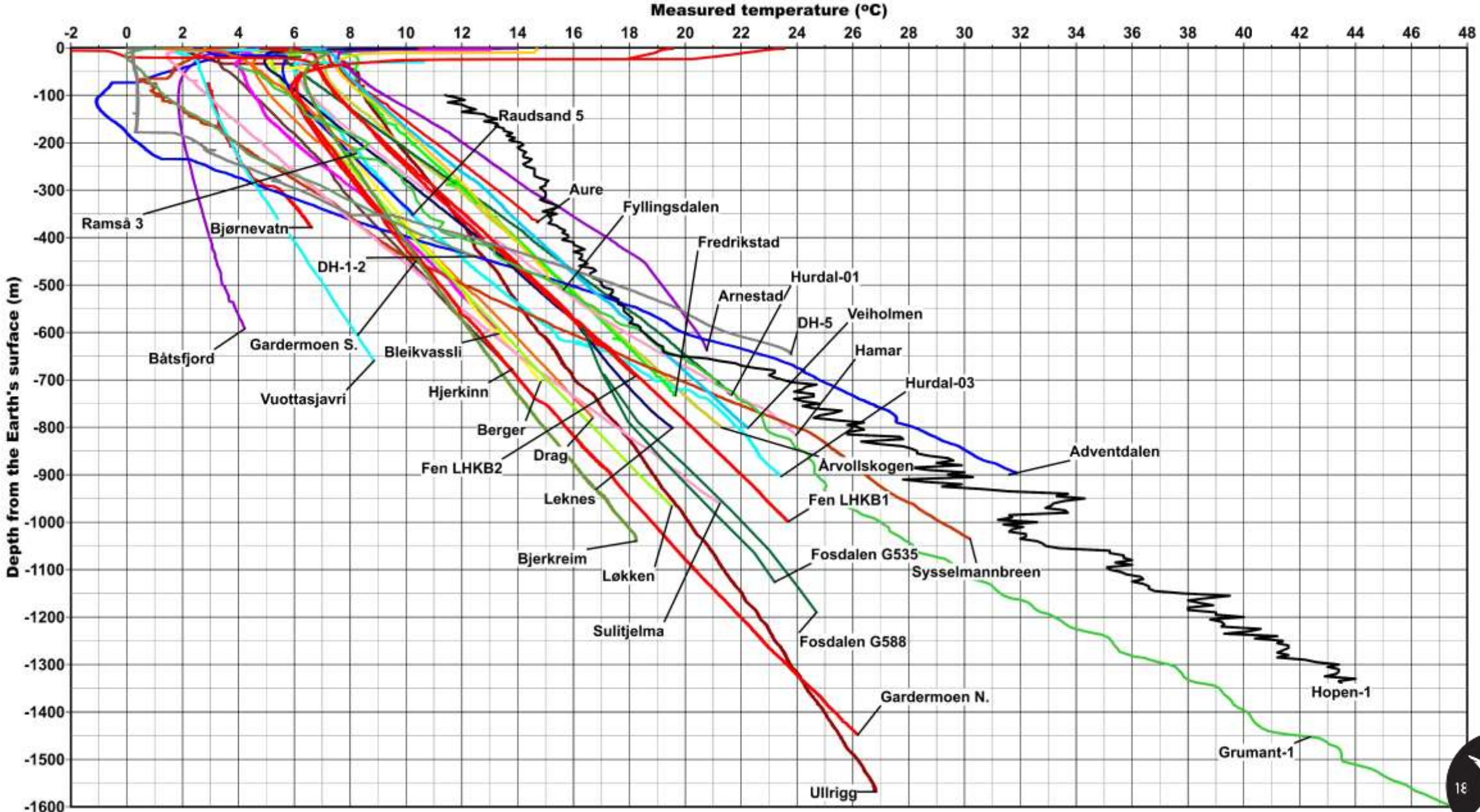
Yuriy Maystrenko

Reginal-scale overview

Deep boreholes onshore



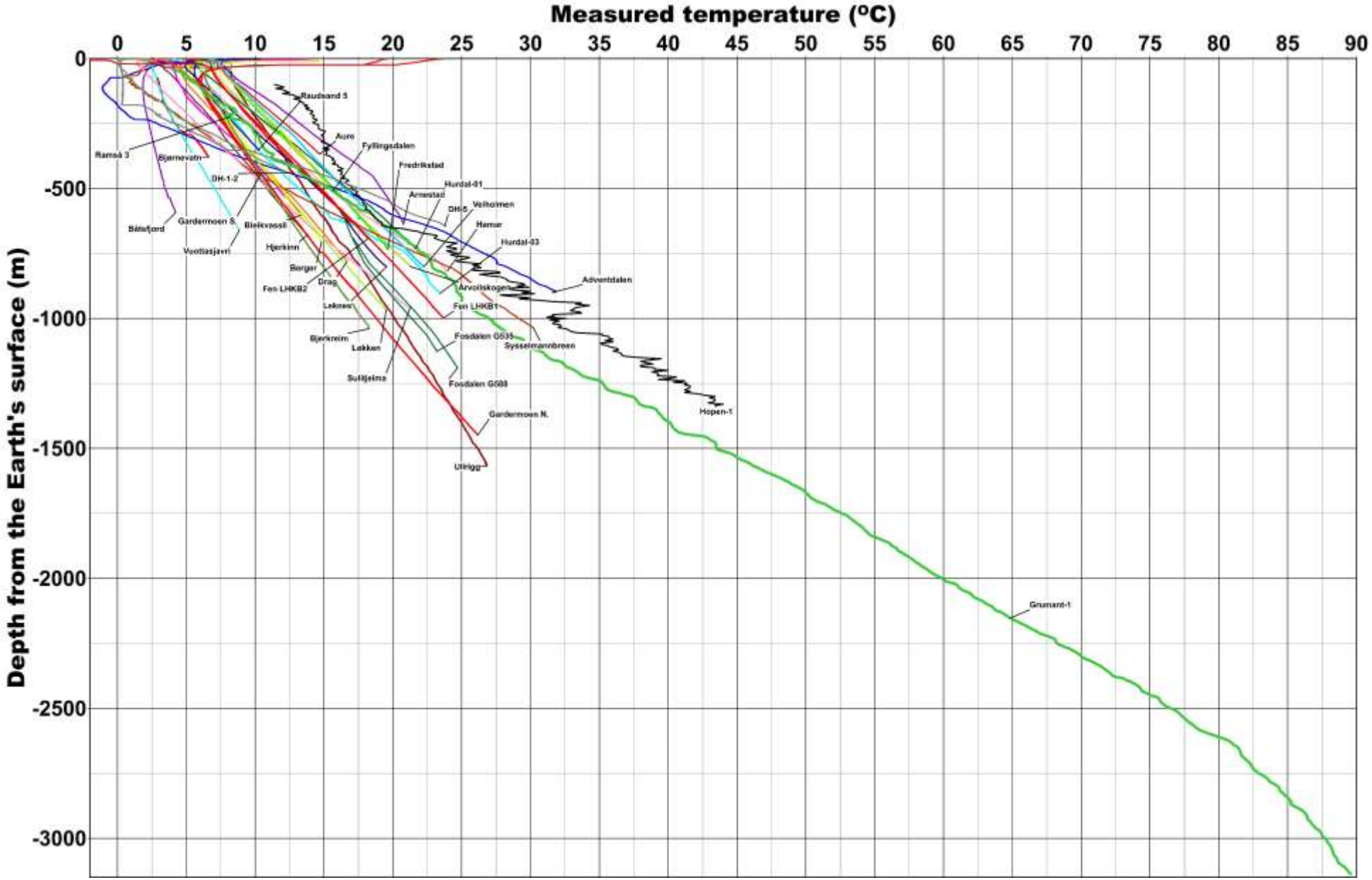
Borehole data



NGU data and data from Senger et al. (2023)

Deep Norwegian boreholes onshore

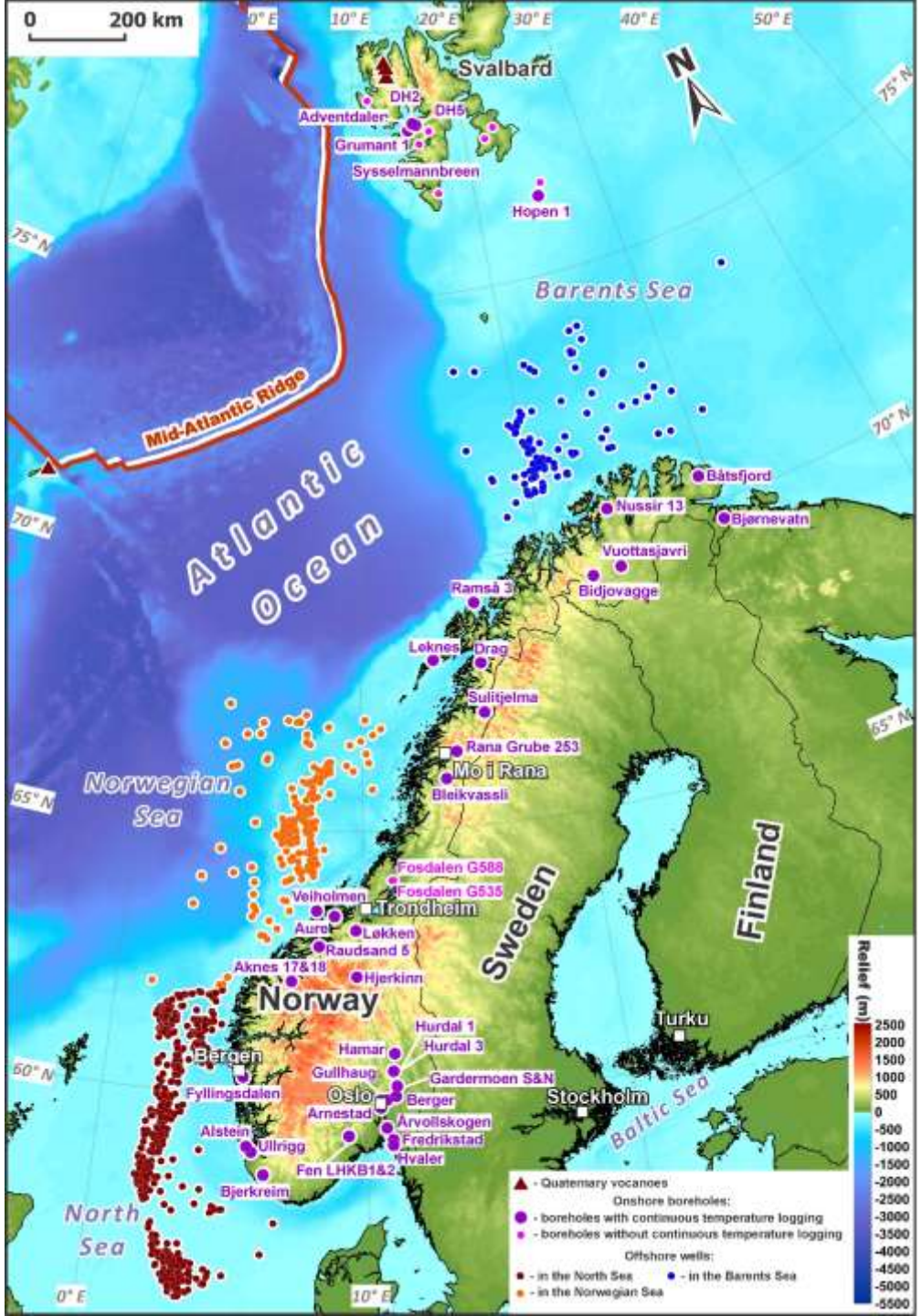
Borehole data



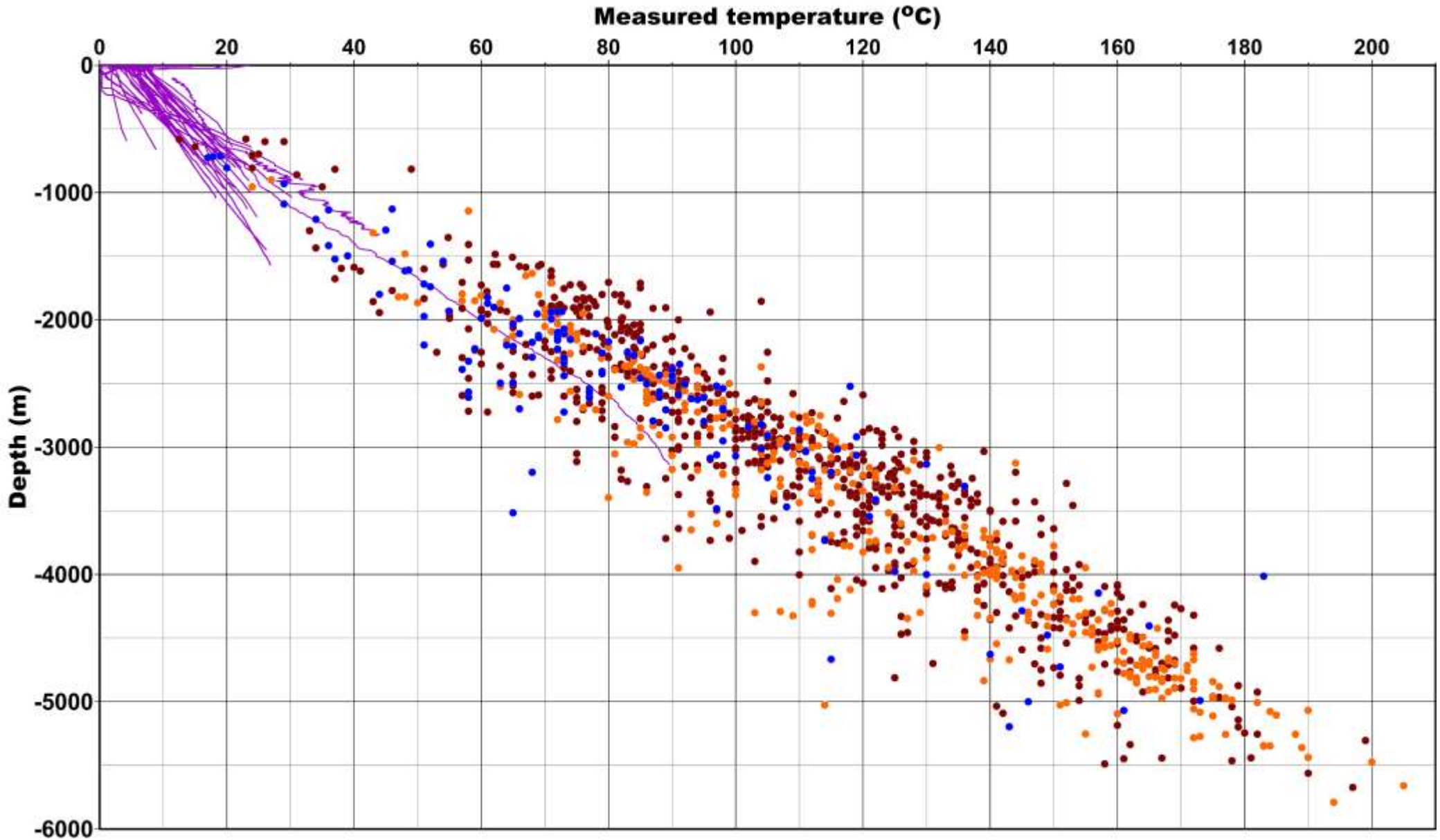
NGU data and data from Senger et al. (2023)

Deep Norwegian boreholes onshore

Deep boreholes offshore



Borehole data

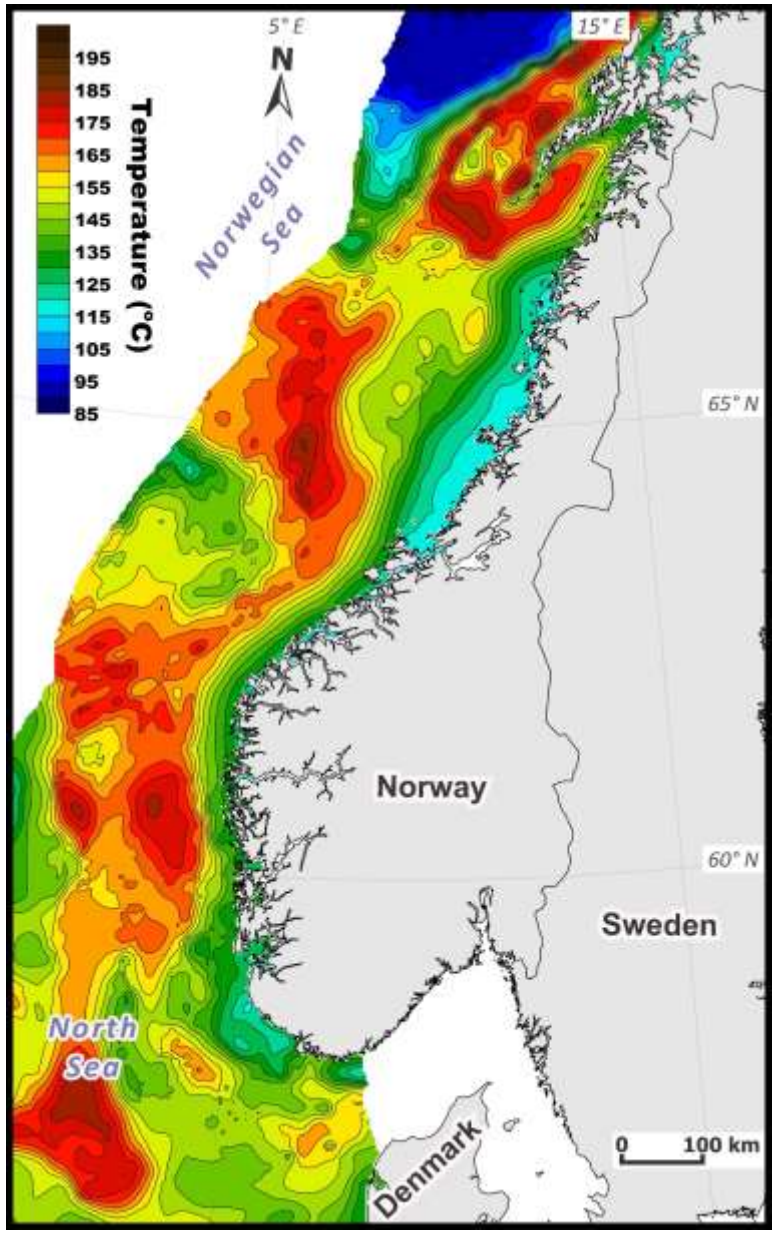


NGU data and data from Senger et al. (2023) and NPD (2023)

Deep thermal pattern offshore

Deep thermal pattern

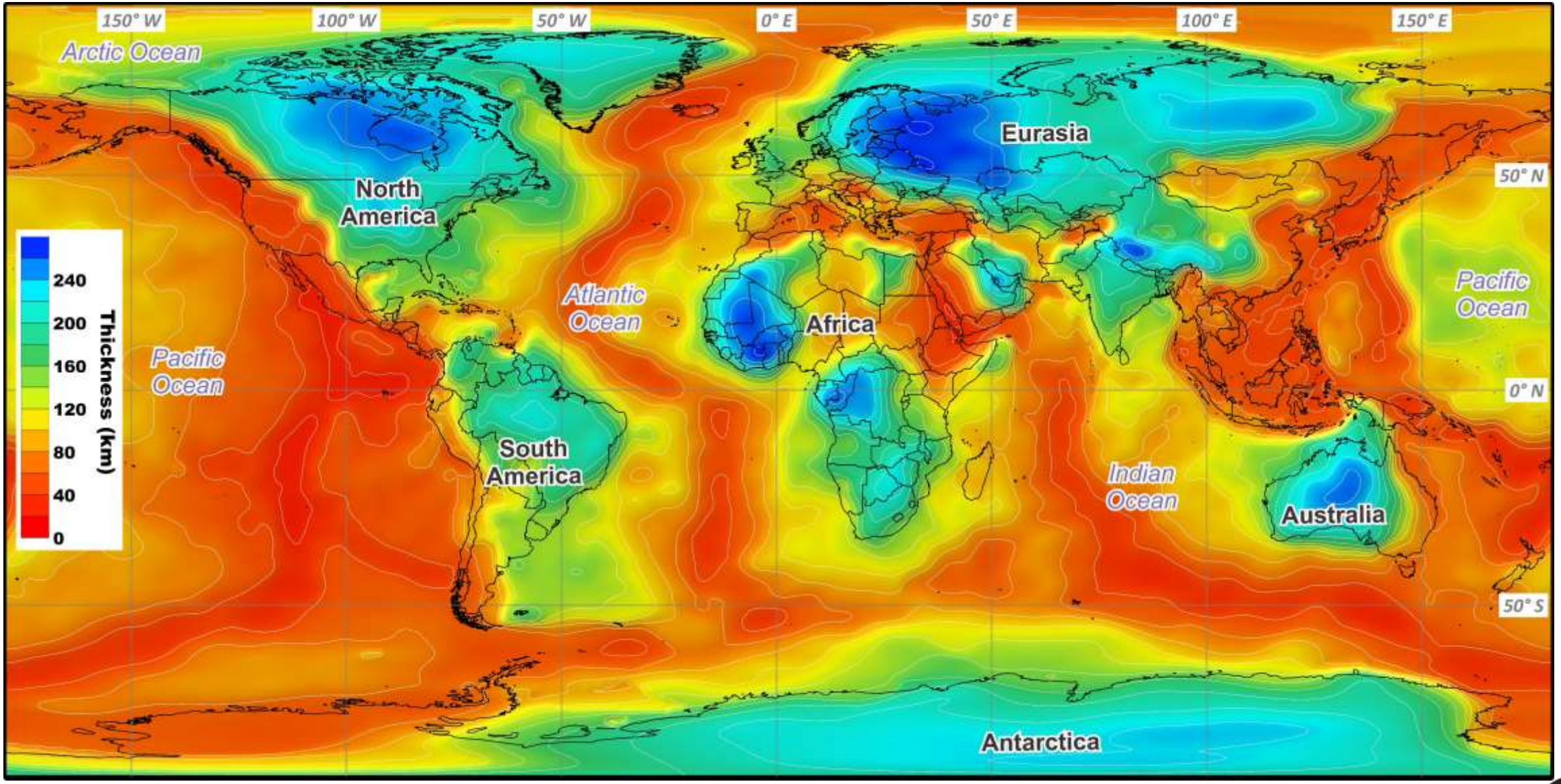
after Maystrenko et al. (2018, 2022)



Modelled temperature at a depth of 5 km

Controlling factors

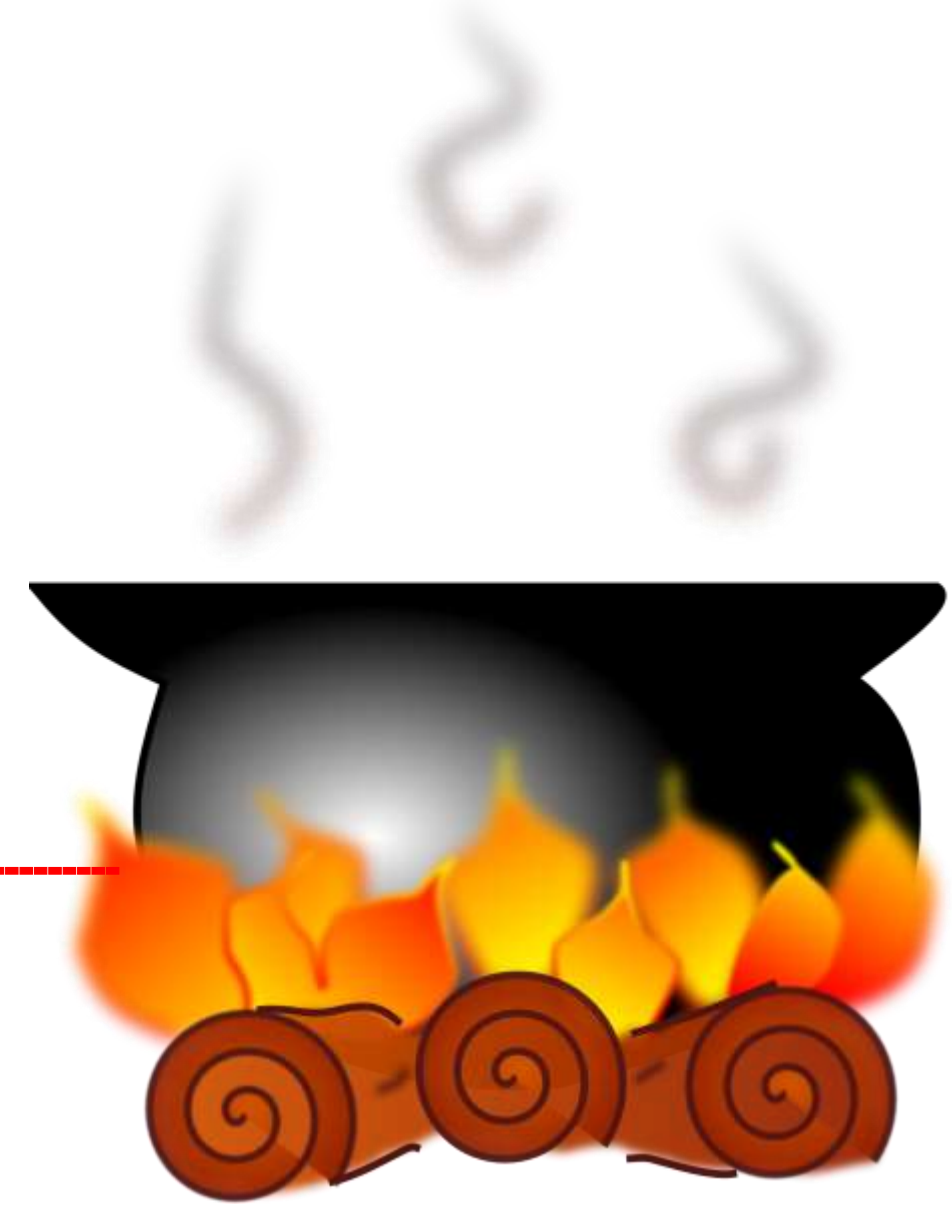
Major heat source



after Steinberger and Becker (2018)

Thickness of the lithosphere

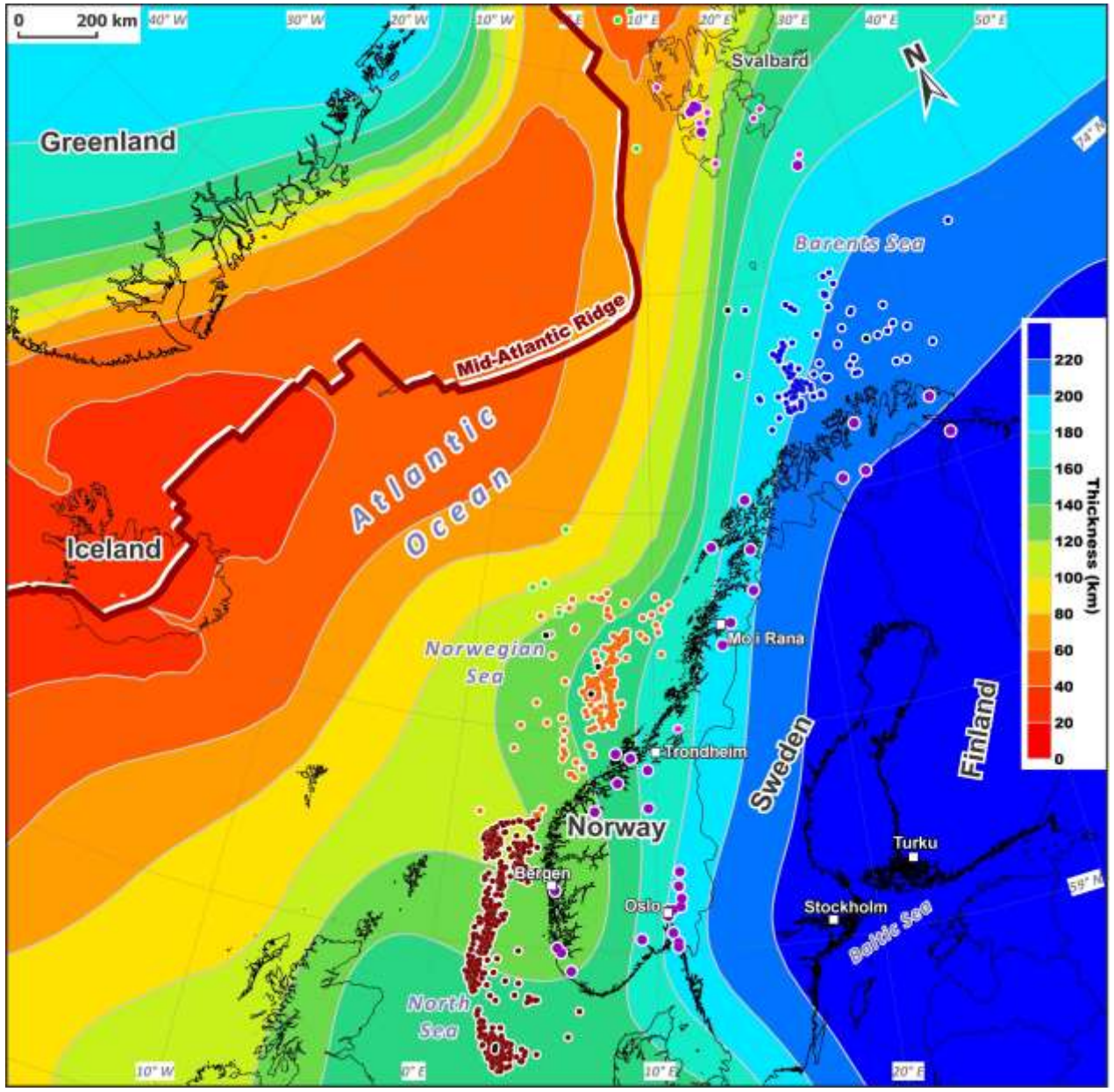
Major heat source



Internal heat of the Earth

Major heat source

Thickness of the lithosphere controls heat transfer from the deep Earth's interior at the regional scale

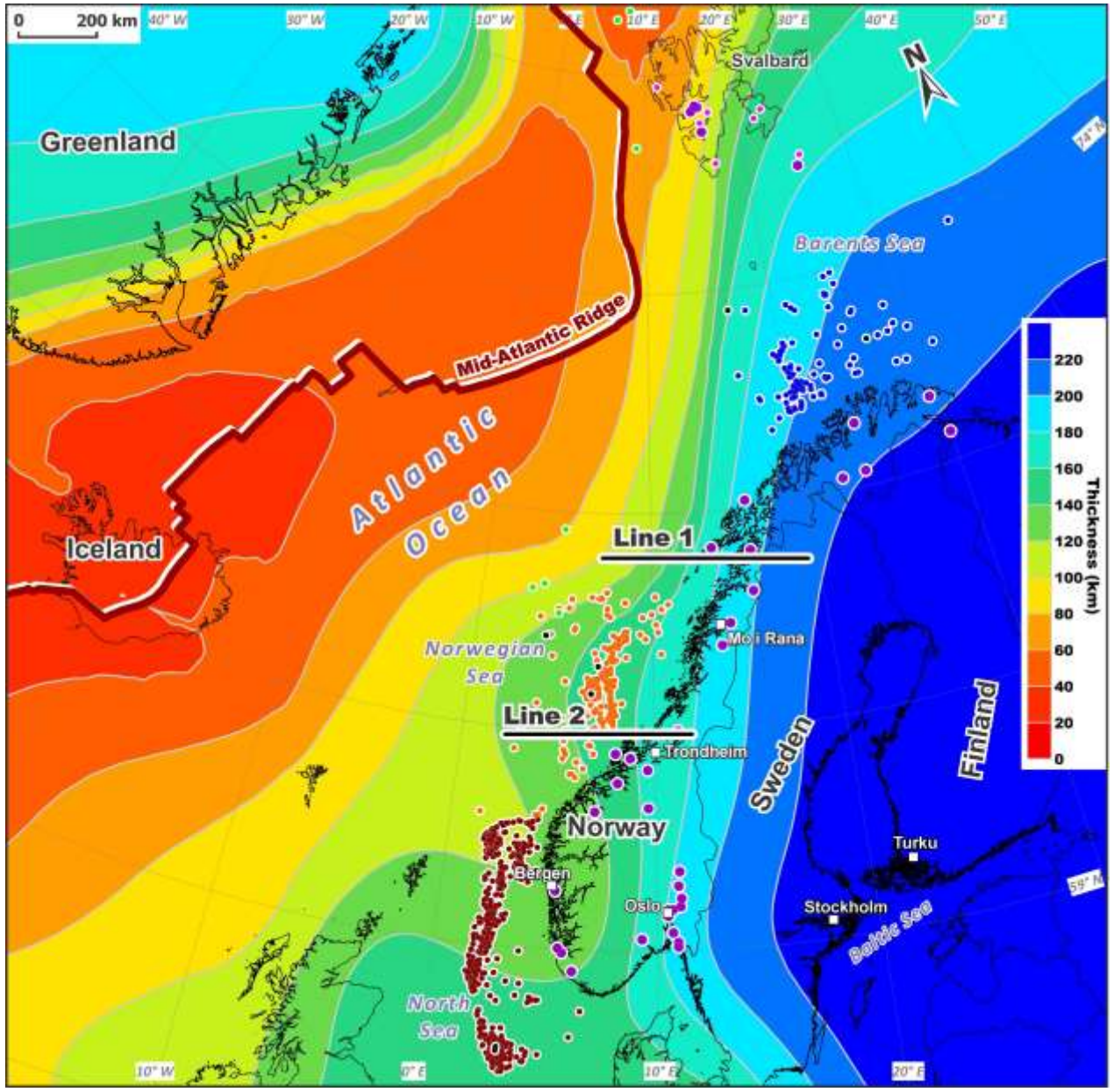


Thickness of the lithosphere

Lithosphere from Steinberger and Becker (2018)

Major heat source

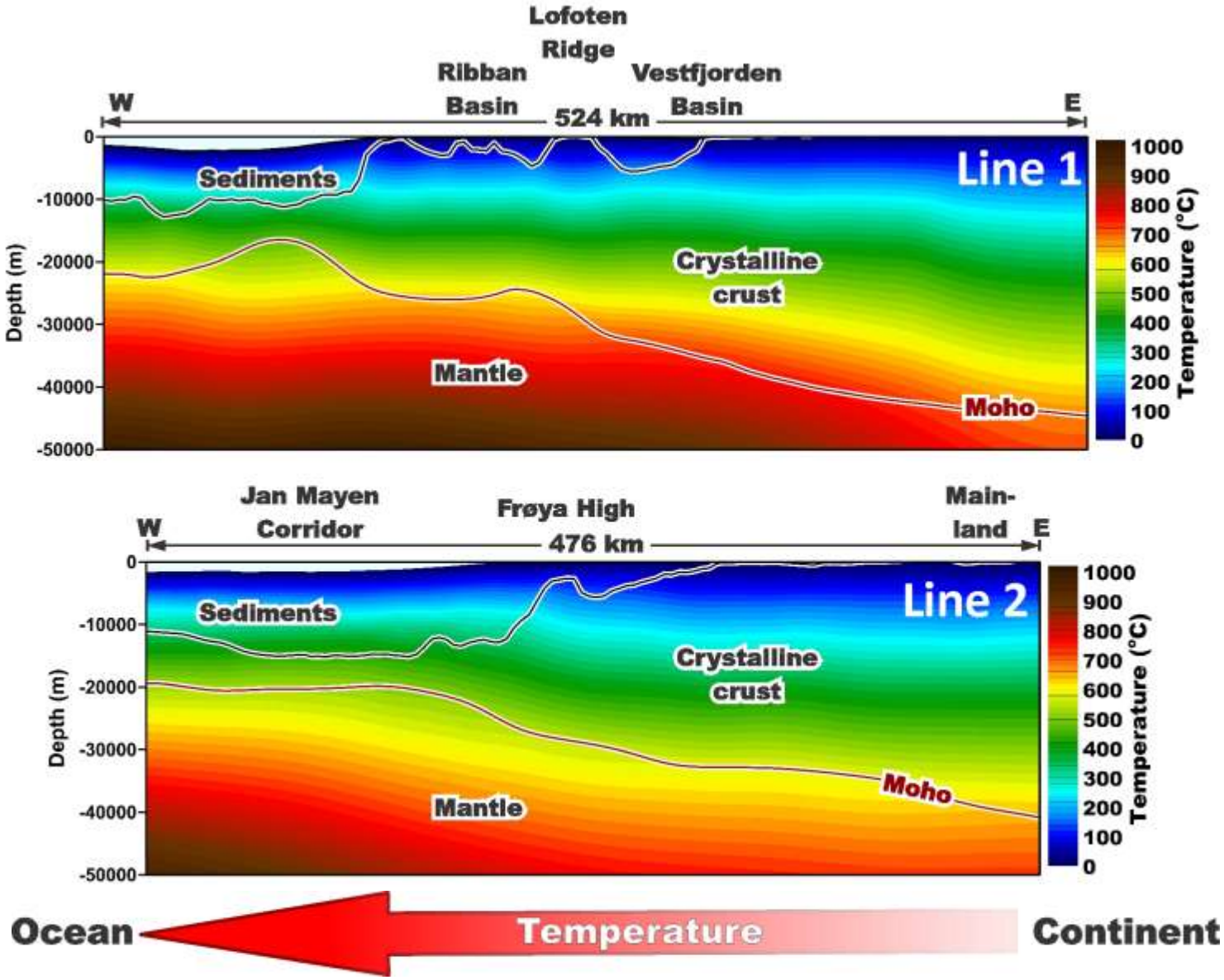
Thickness of the lithosphere controls heat transfer from the deep Earth's interior at the regional scale



Thickness of the lithosphere

Lithosphere from Steinberger and Becker (2018)

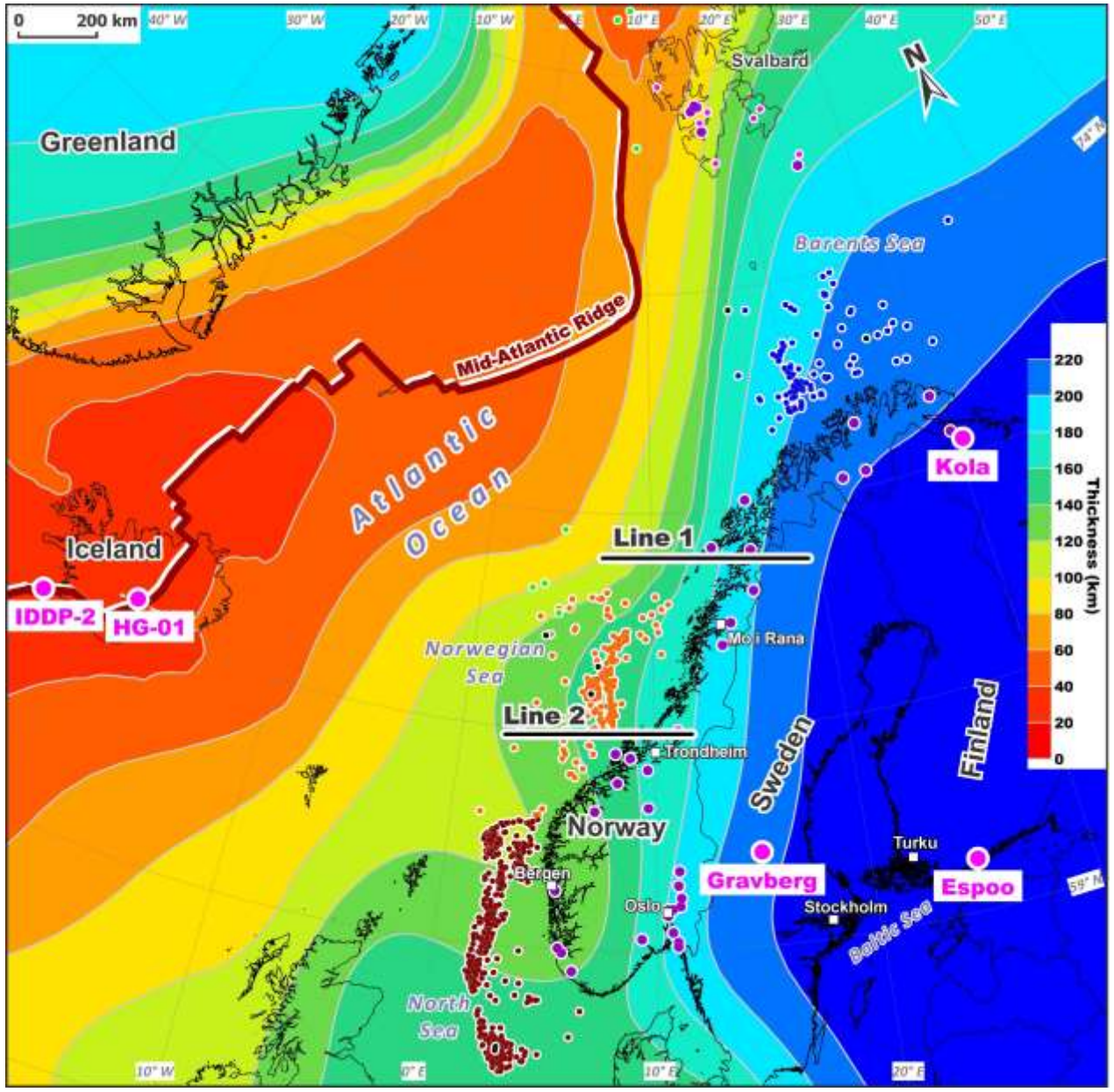
Major heat source



after Maystrenko et al. (2017, 2018)

Major heat source

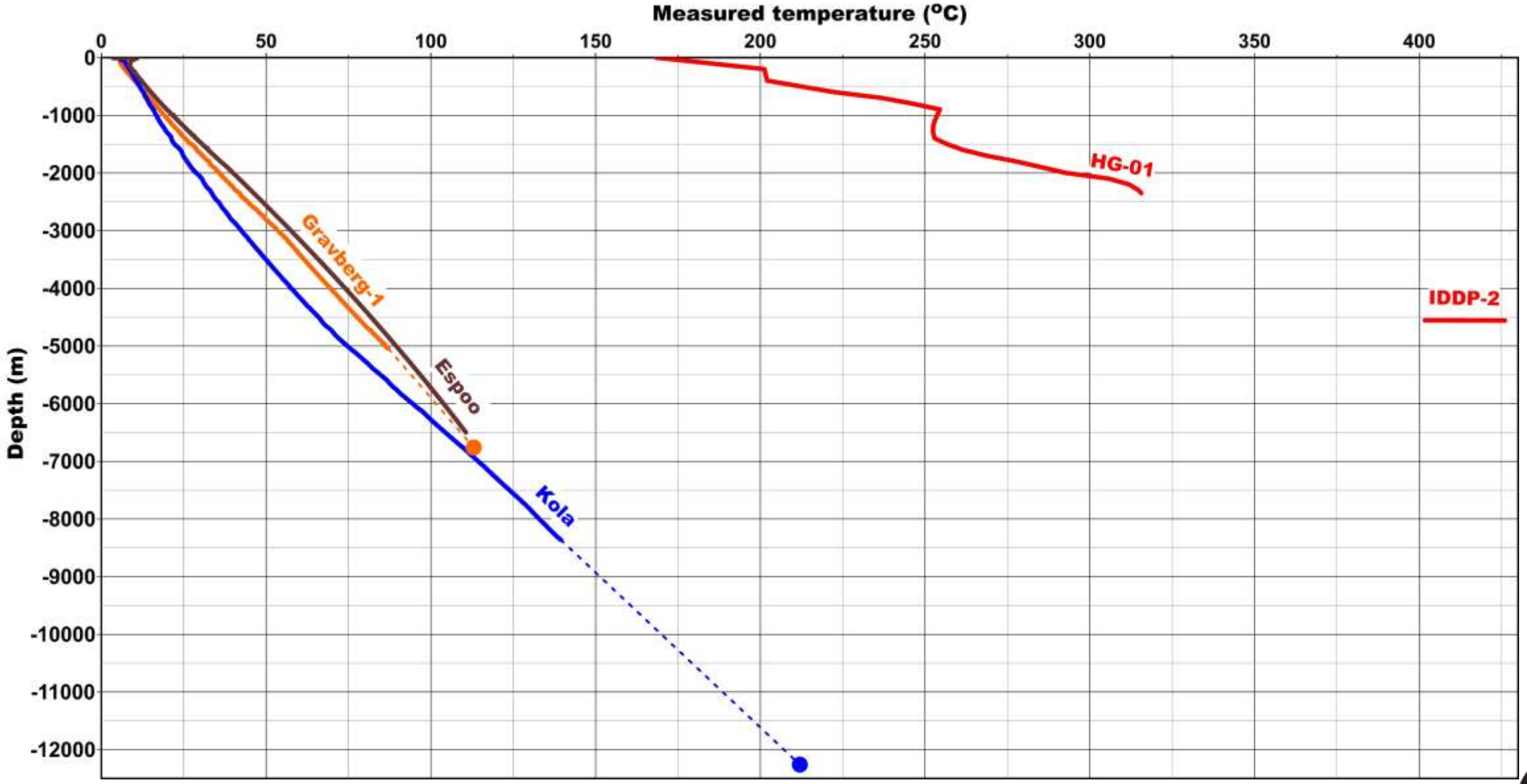
Base of the lithosphere controls heat transfer from the deep Earth's interior at the regional scale



Thickness of the lithosphere

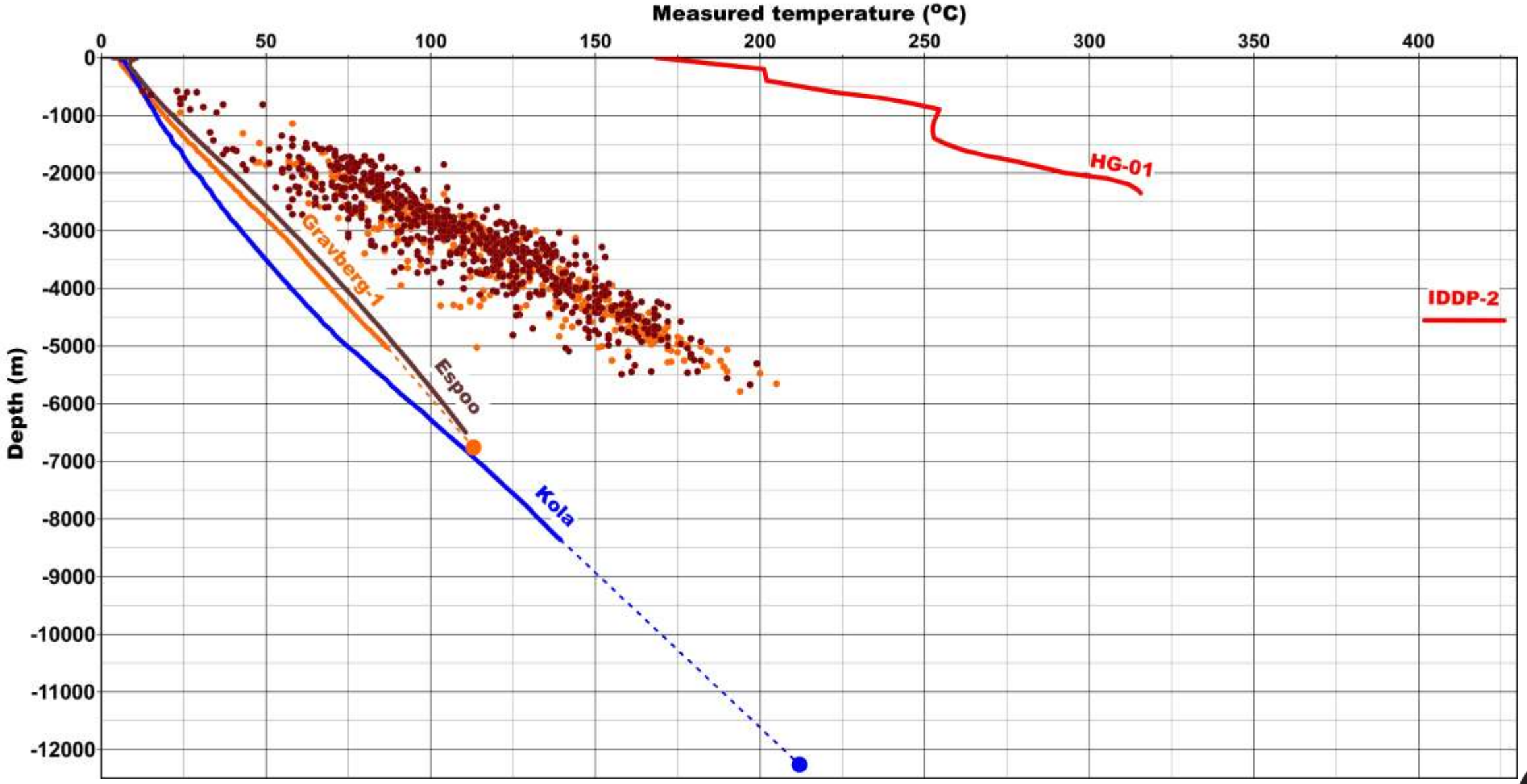
Lithosphere from Steinberger and Becker (2018)

Superdeep boreholes



after Popov et al. (1999), Seifu (2004), Balling (2013),
Friðleifsson et al. (2020), Heikkinen et al. (2021), Kukkonen & Pentti (2021)

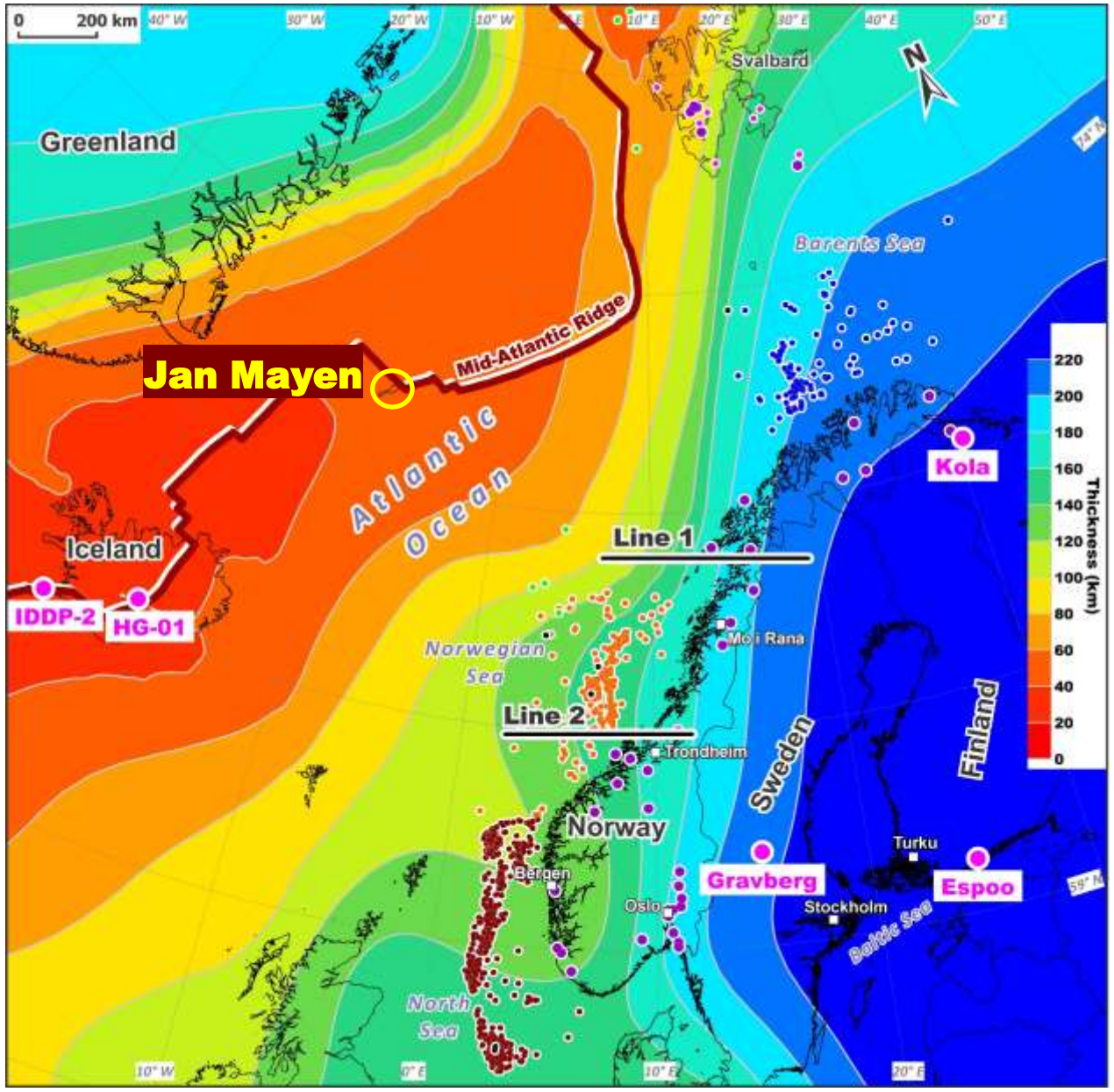
Superdeep boreholes



after Popov et al. (1999), Seifu (2004), Balling (2013),
Friðleifsson et al. (2020), Heikkinen et al. (2021), Kukkonen & Pentti (2021), NPD (2023)

Major heat source

Base of the lithosphere controls heat transfer from the deep Earth's interior at the regional scale



Thickness of the lithosphere

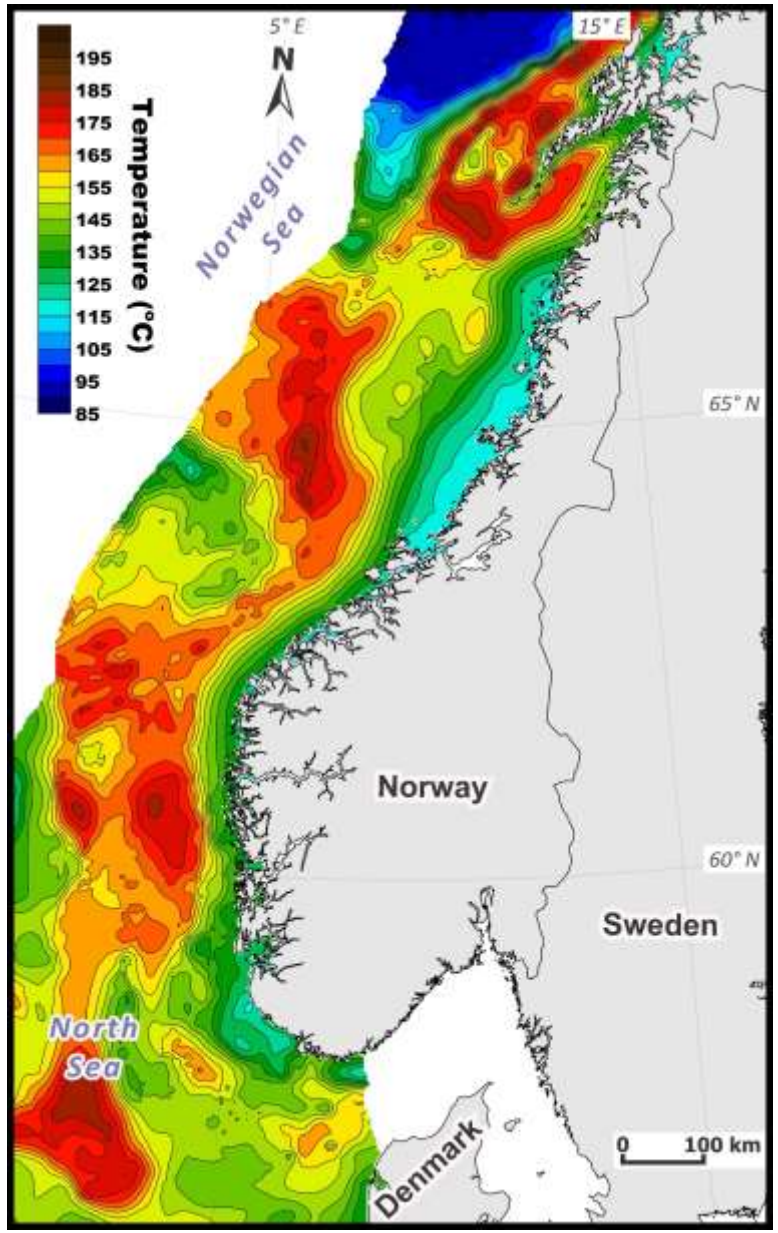
Lithosphere from Steinberger and Becker (2018)

Controlling factors

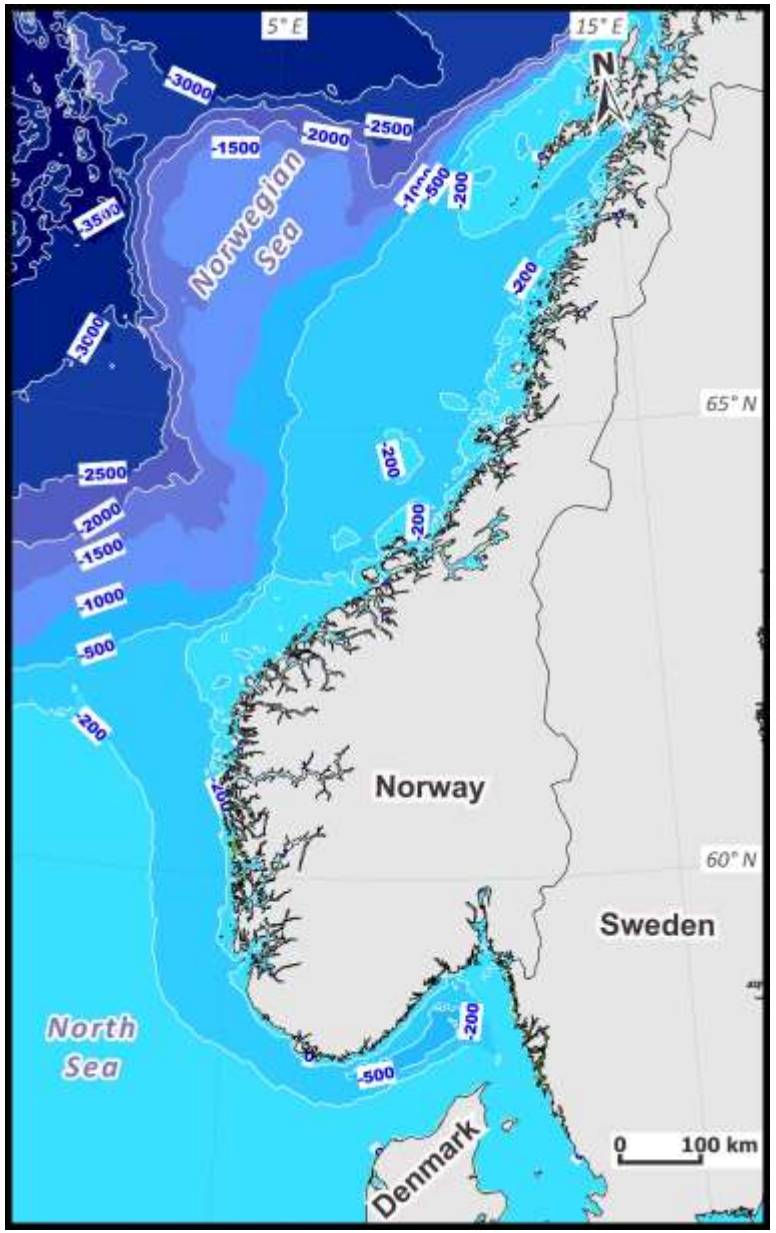
1. **Thickness of the lithosphere**

Controlling factors

after Maystrenko et al. (2018, 2022)



Modelled temperature at a depth of 5 km



Bathymetry

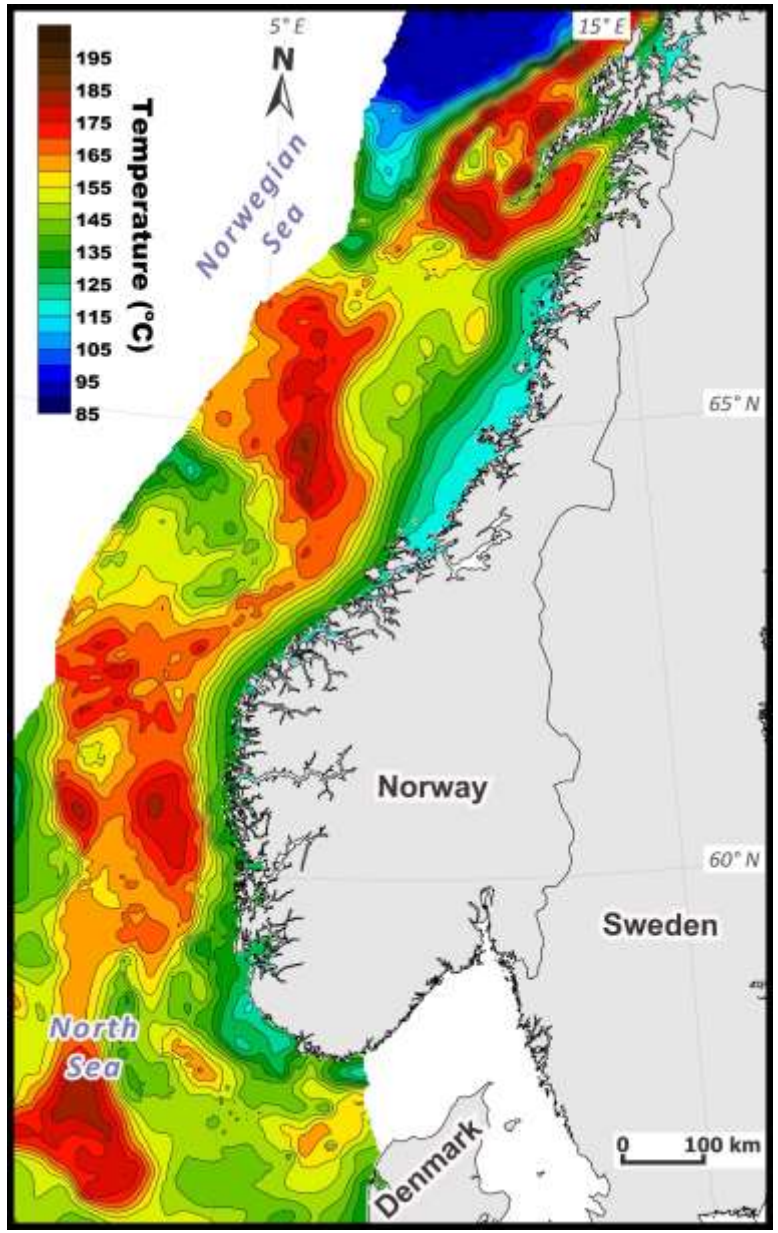
from the Norwegian Mapping Authority

Controlling factors

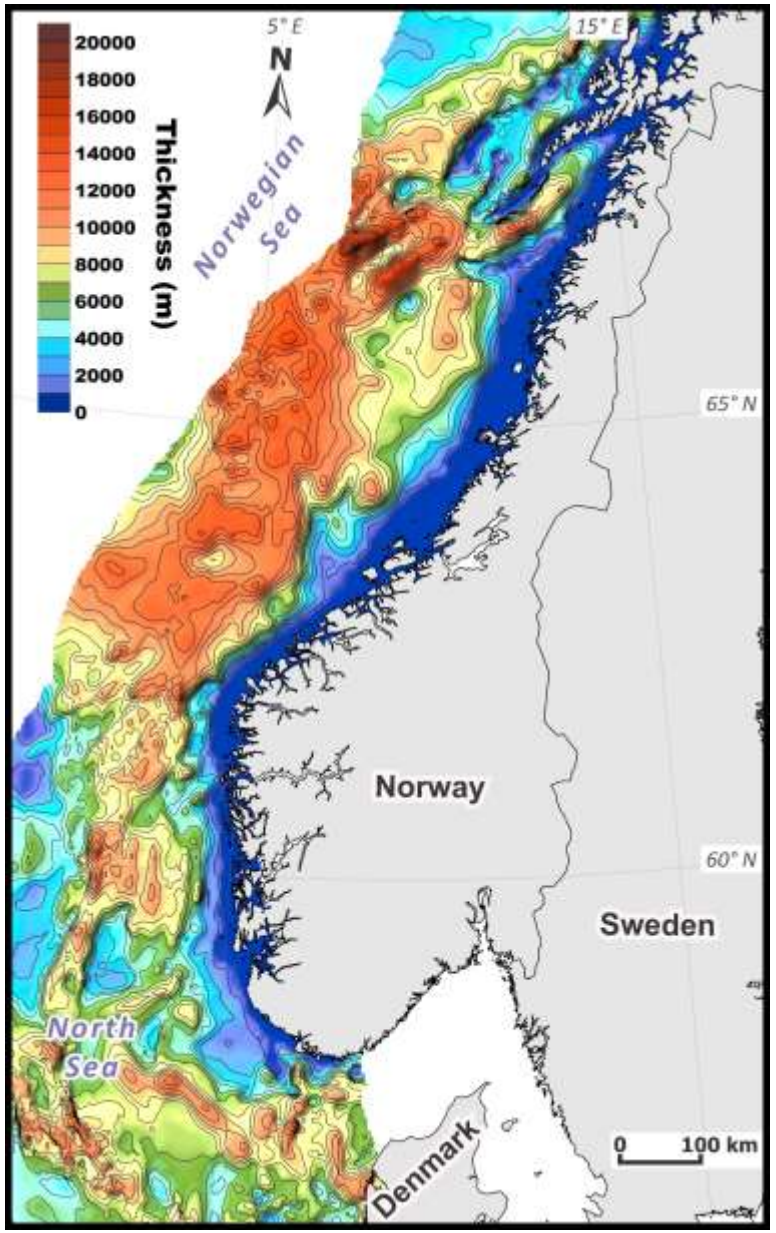
1. Thickness of the lithosphere
2. Bathymetry

Controlling factors

after Maystrenko et al. (2018, 2022)



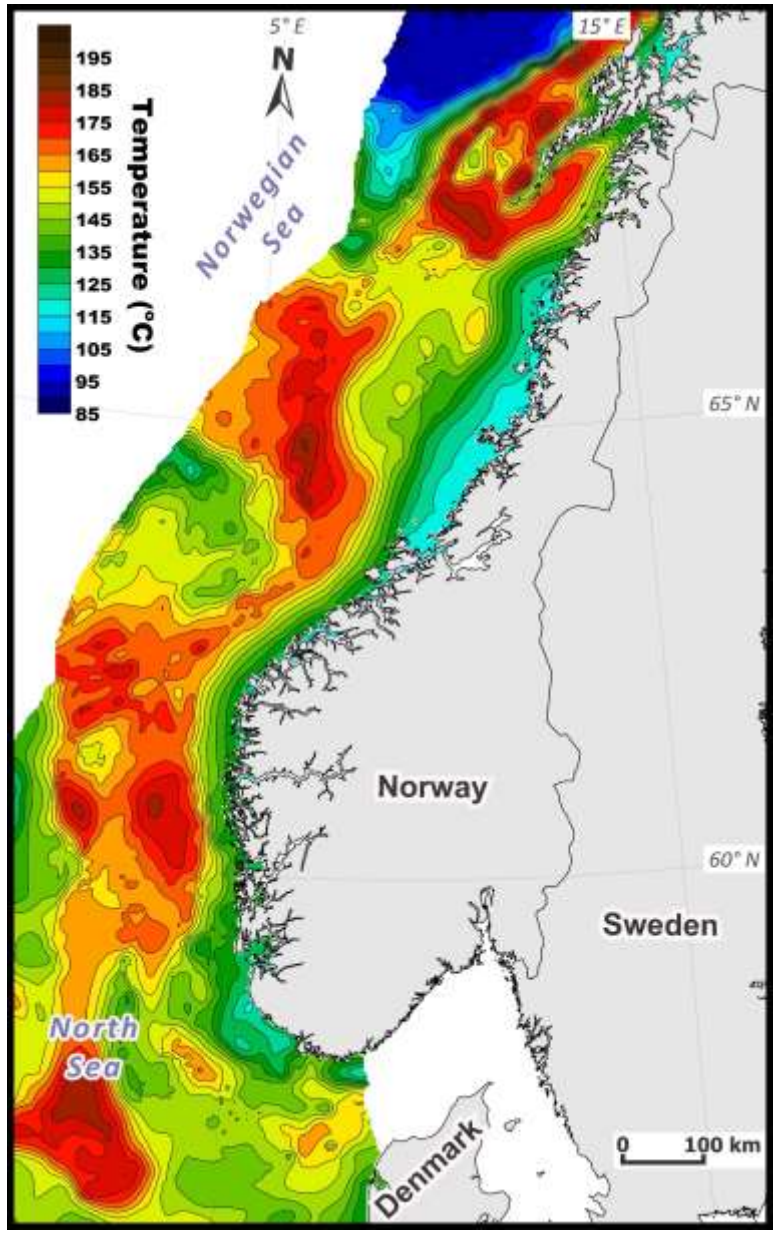
Temperature at a depth of 5 km



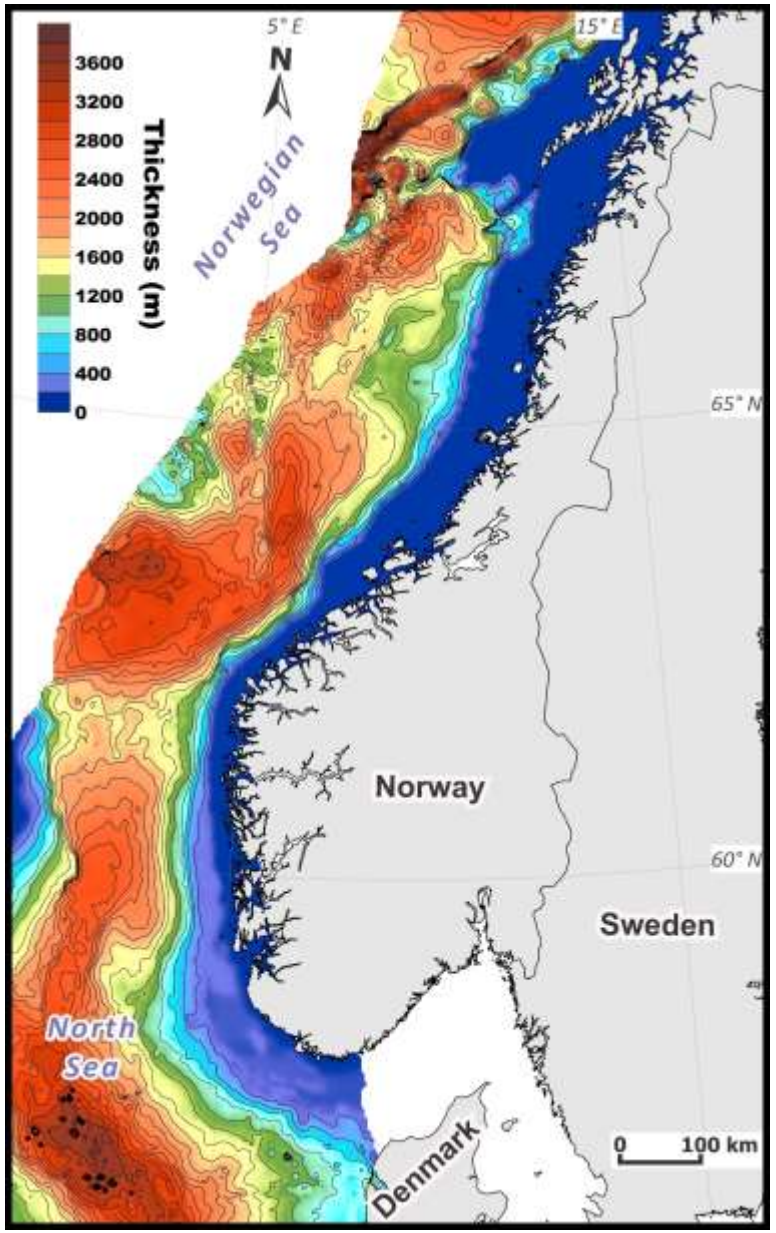
Total thickness of the sedimentary cover

Deep thermal pattern

after Maystrenko et al. (2018, 2022)



Temperature at a depth of 5 km

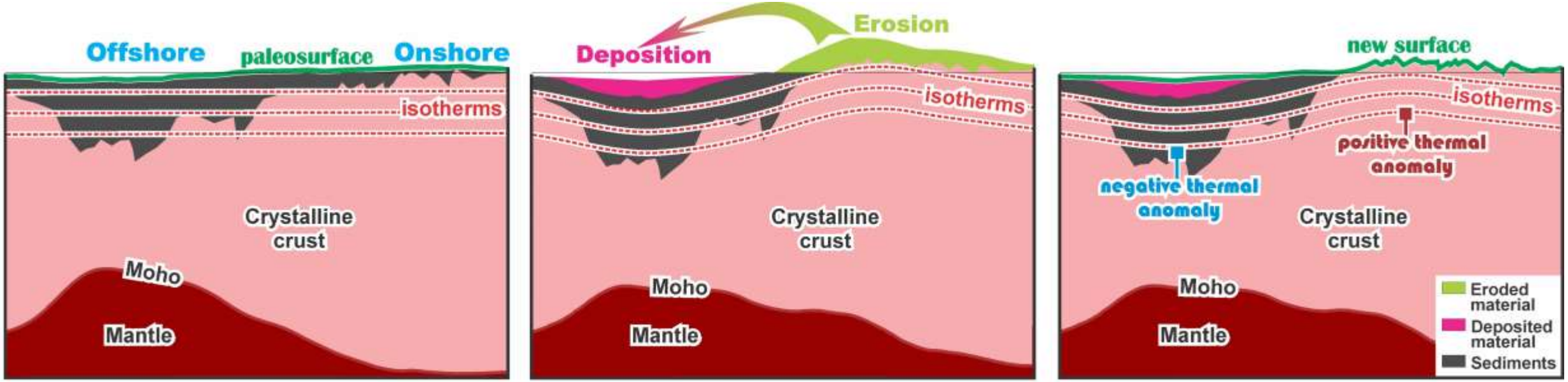


Thickness of the Cenozoic sediments

Controlling factors

1. Thickness of the lithosphere
2. Bathymetry
3. Blanketing effect of sediments

Erosion and deposition



Before erosion and deposition

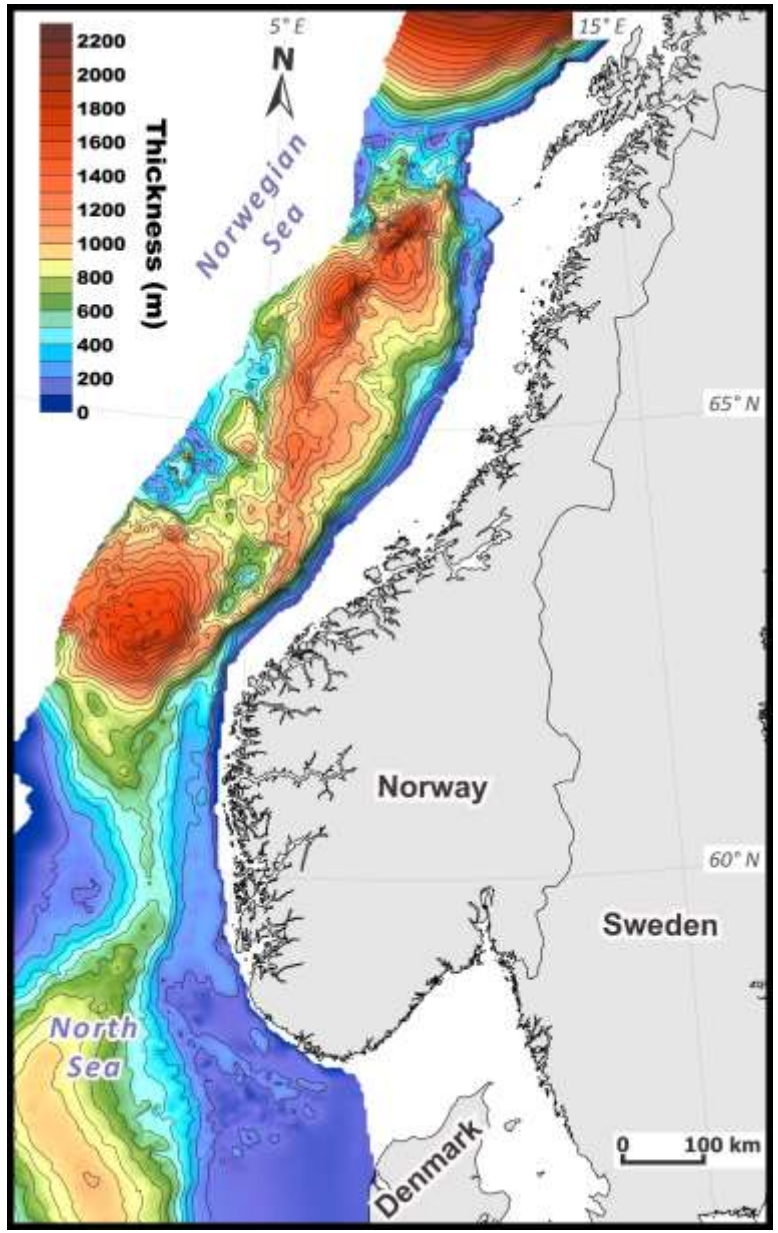
During erosion and deposition

After erosion and deposition

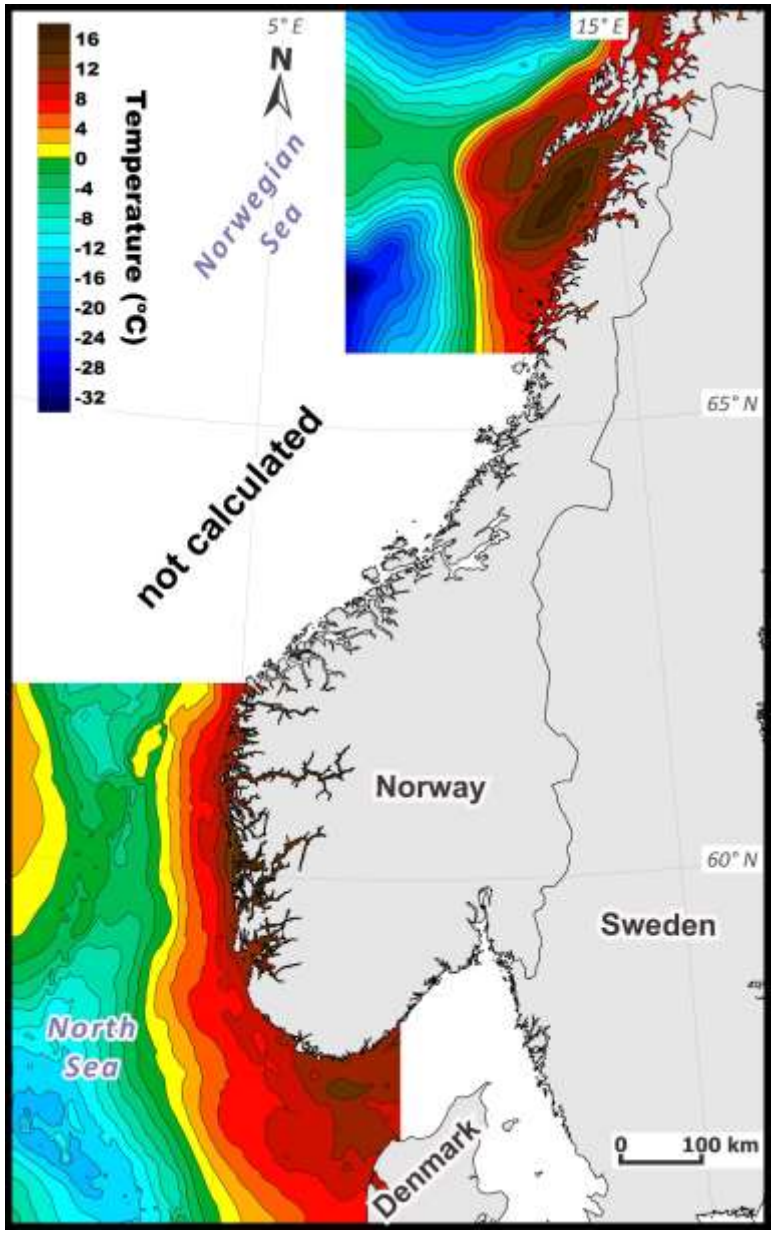
Thermal anomalies due to erosion and deposition

Erosion and deposition

after Fiedler & Faleide (1996), Rise et al. (2005), Eidvin et al. (2007), Hjelstuen et al. (2007), Dowdeswell et al. (2010), Rise et al. (2010), Laberg et al. (2012), Ottesen et al. (2012, 2014, 2018), Batchelor et al. (2017)



Thickness of the Quaternary



Thermal anomalies at a depth of 5 km

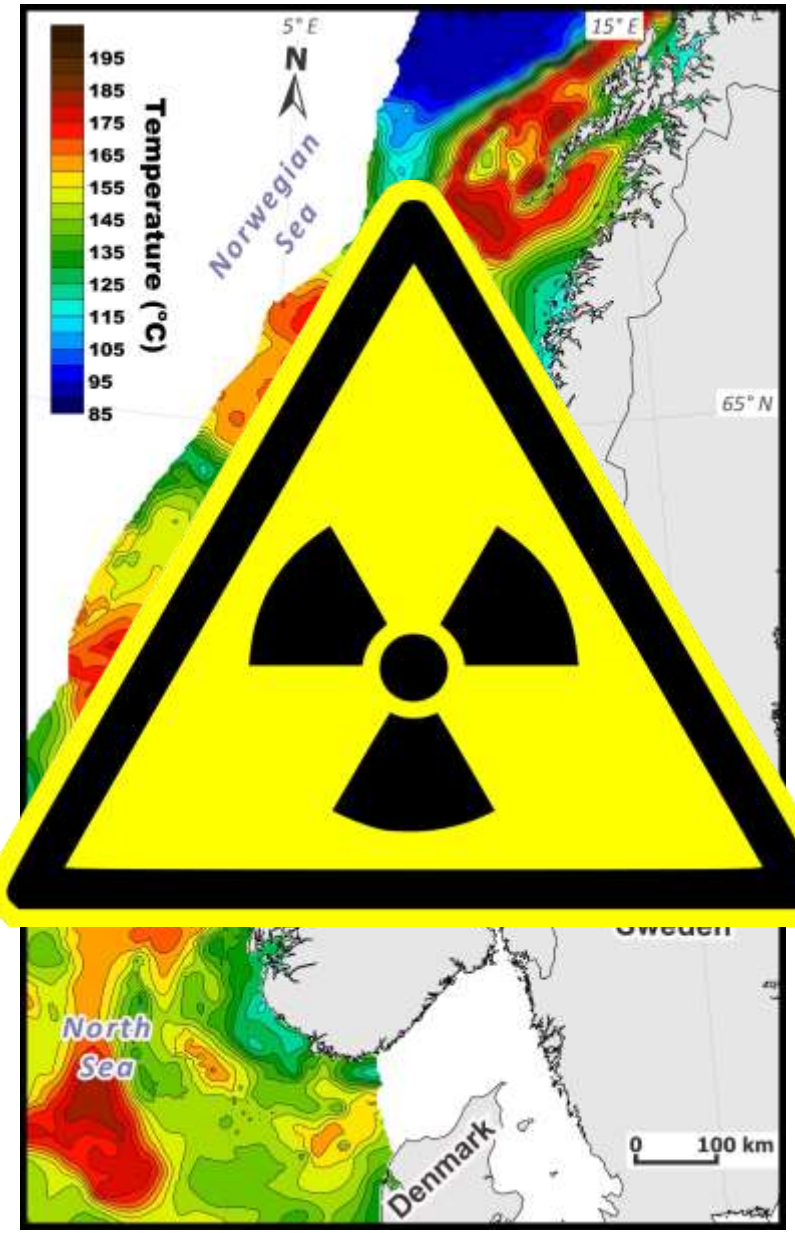
after Maystrenko et al. (2018, 2022)

Controlling factors

1. Thickness of the lithosphere
2. Bathymetry
3. Thickness of sediments
4. Erosion and deposition vs. thermal equilibrium

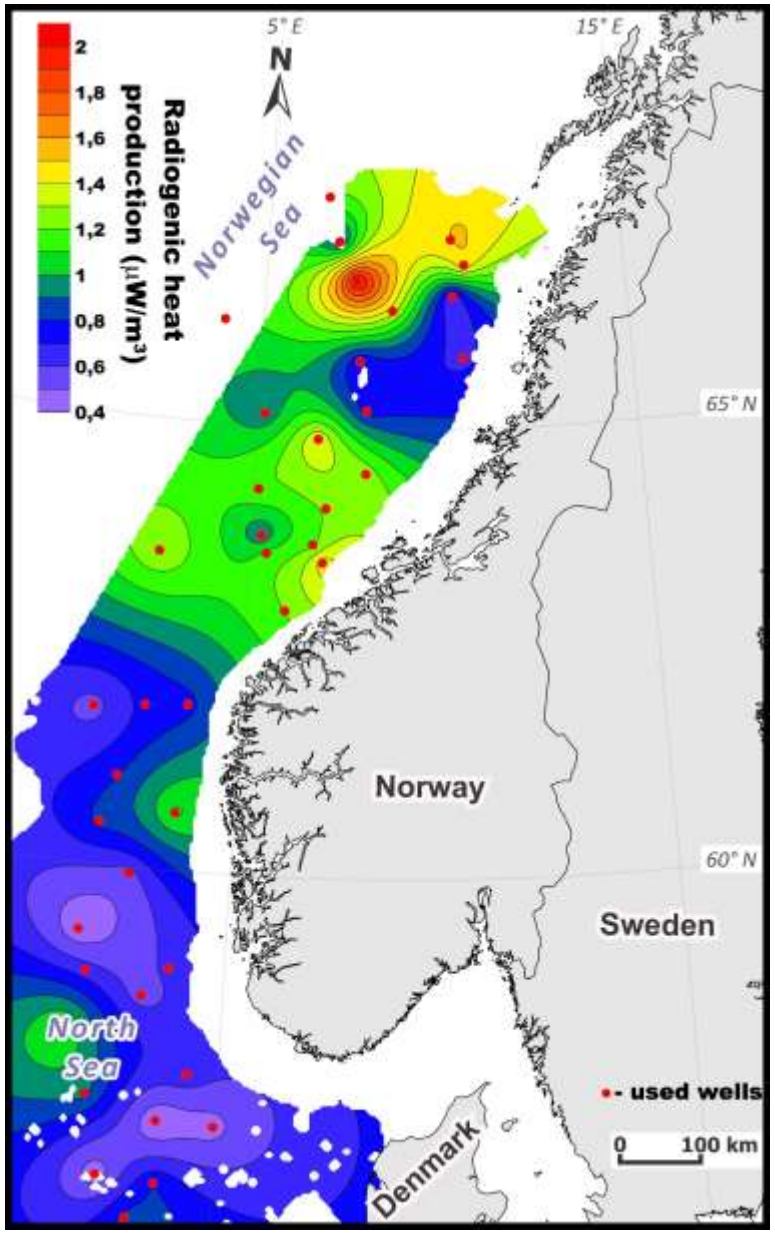
Deep thermal pattern

after Maystrenko et al. (2018, 2022)

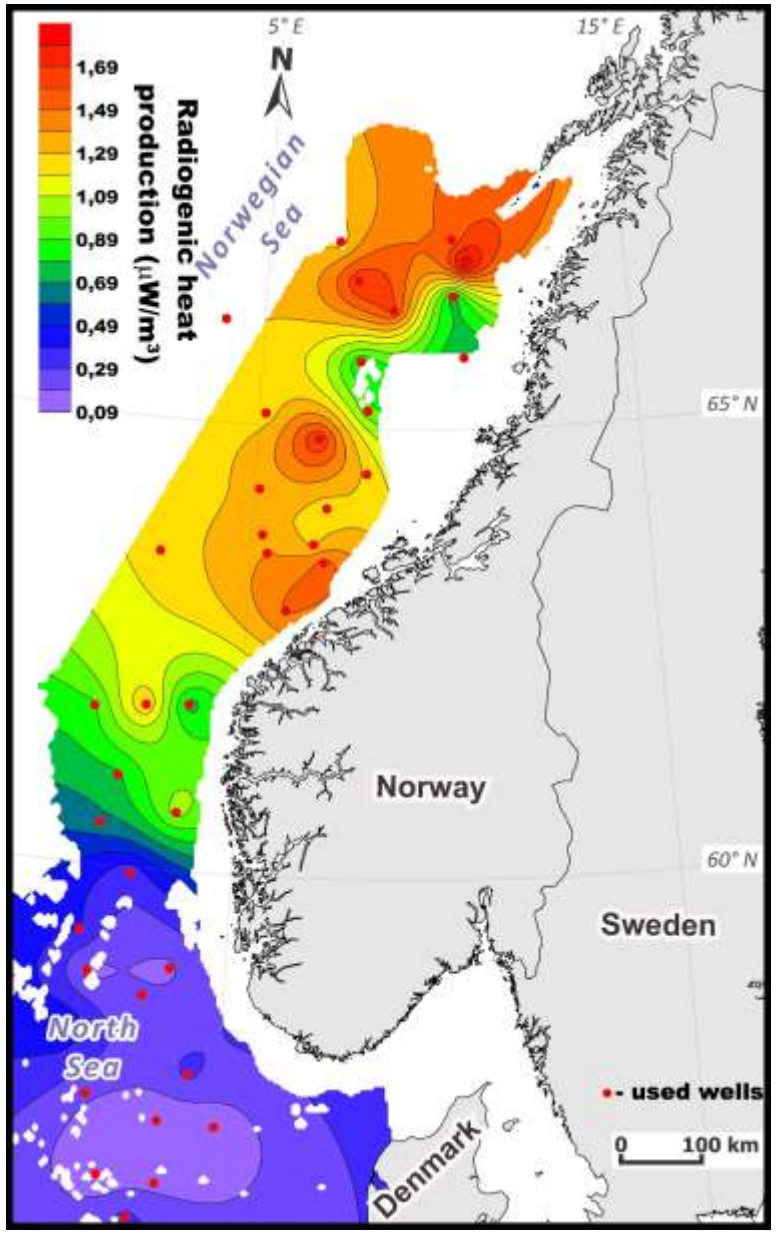


Modelled temperature at a depth of 5 km

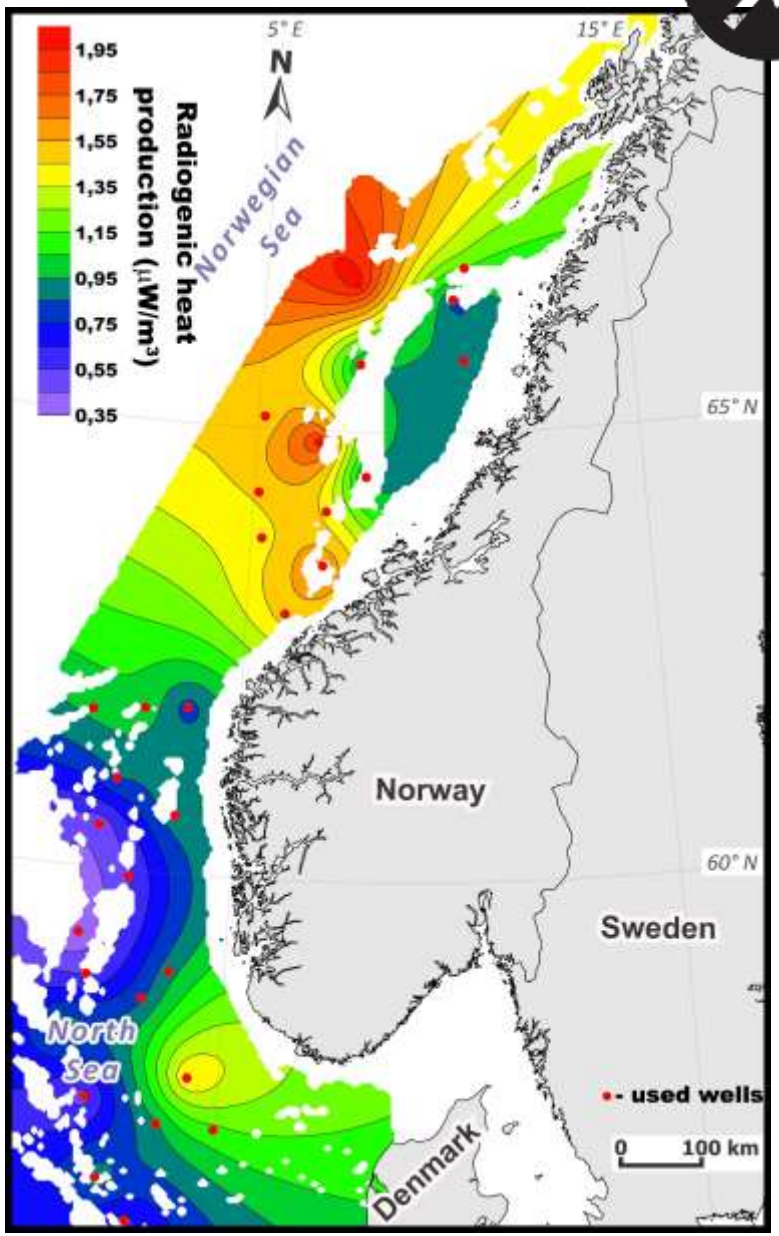
Radiogenic heat production



Rogaland Group



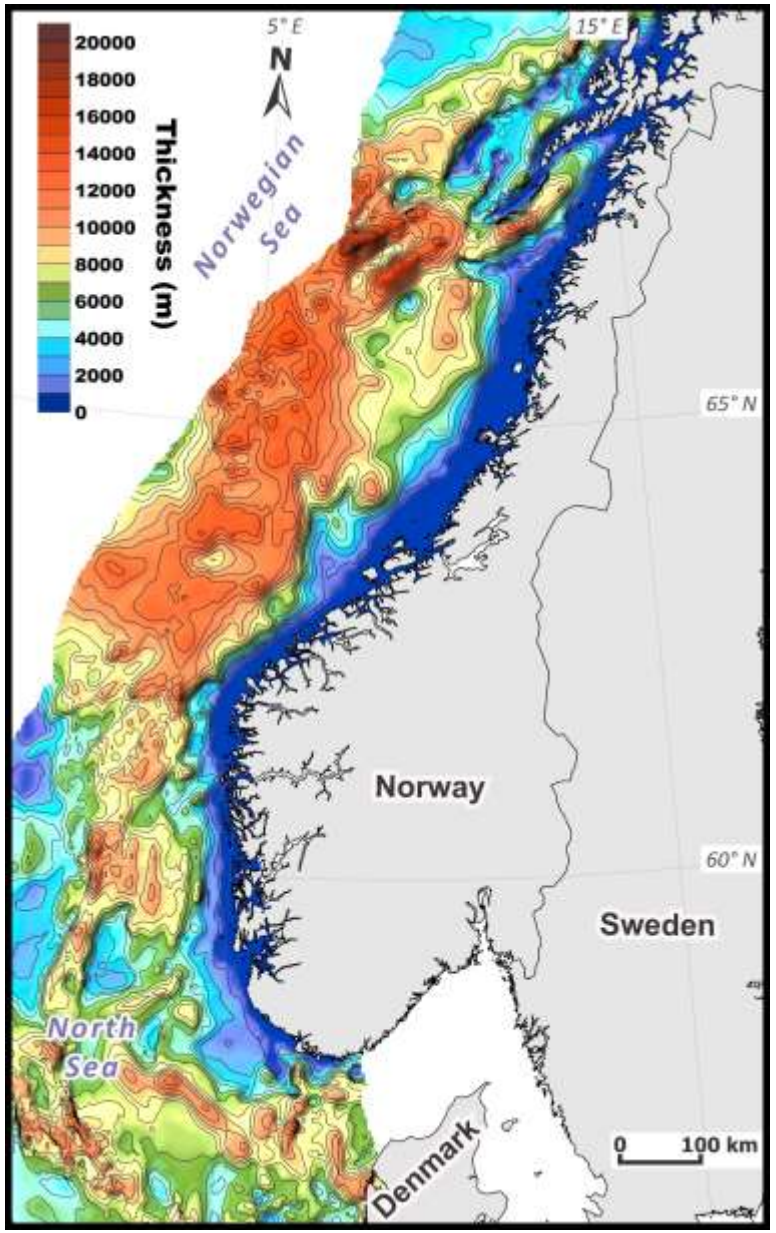
Shetland Group



Cromer Knoll Group

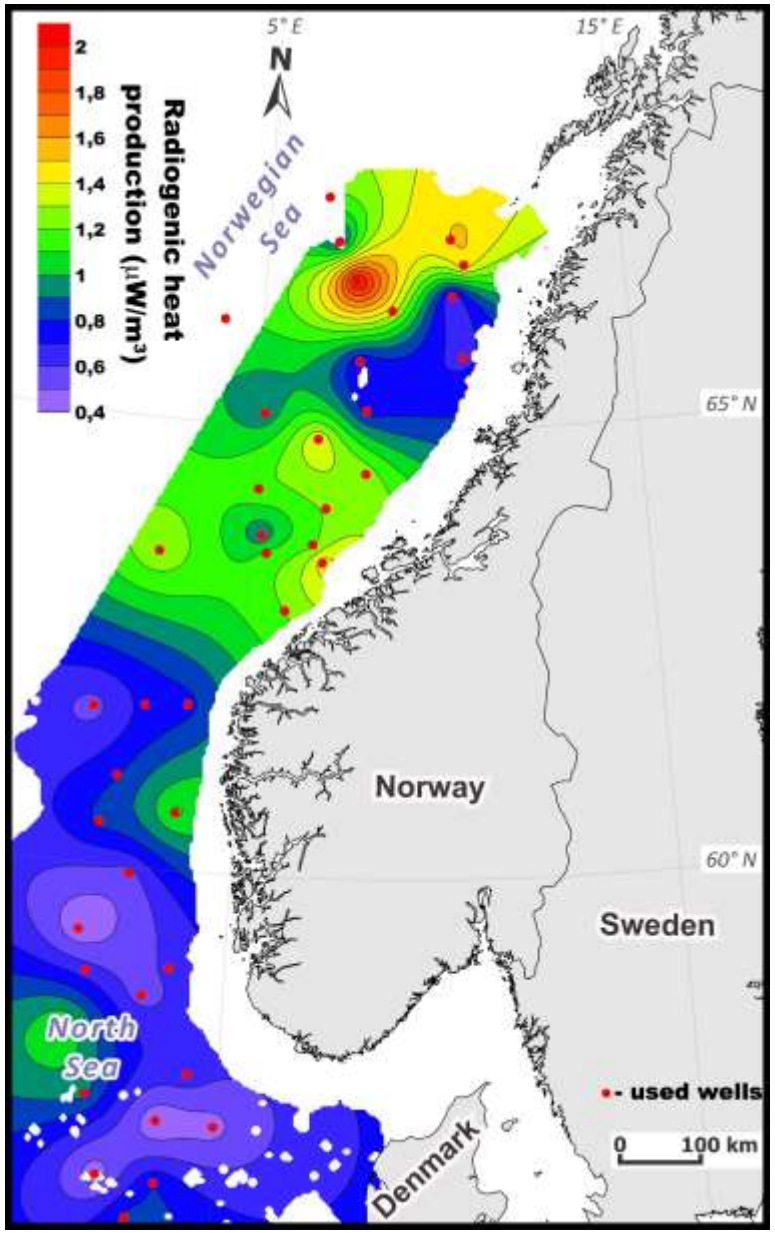
Sedimentation pattern

after Maystrenko et al. (2018, 2022)

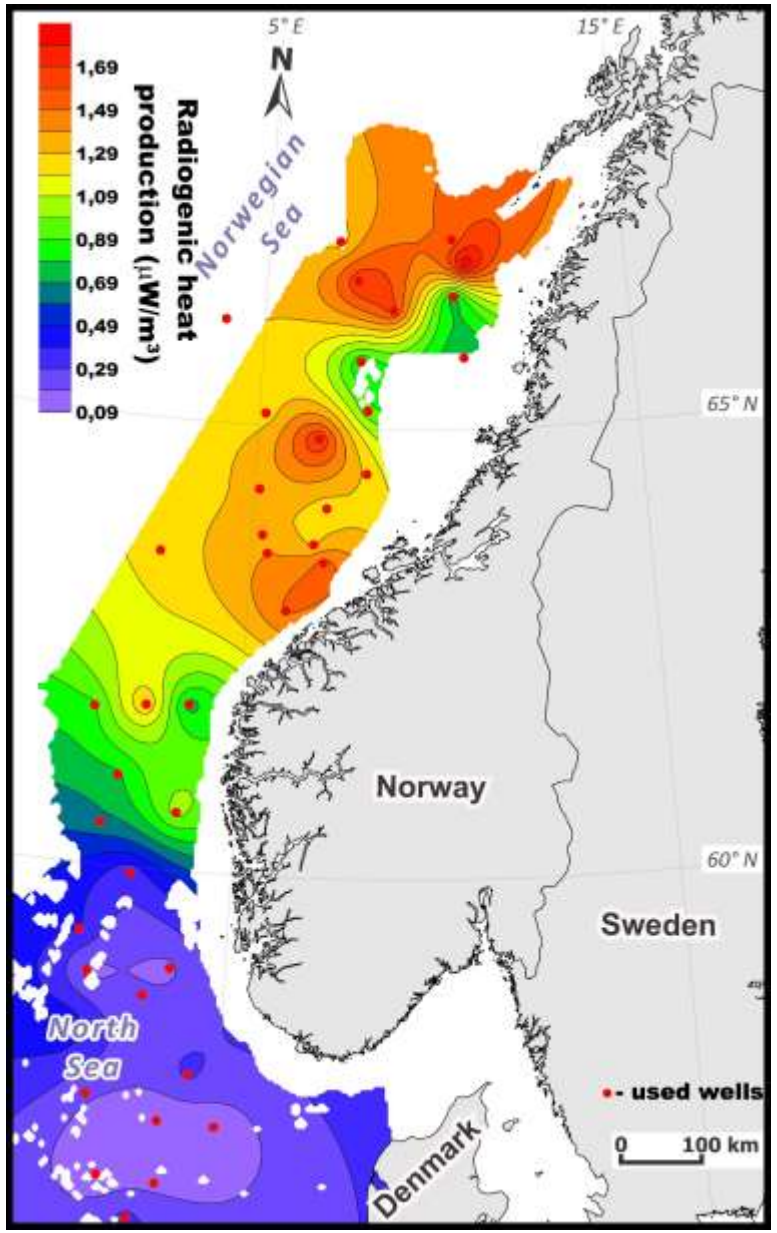


Total thickness of the sedimentary cover

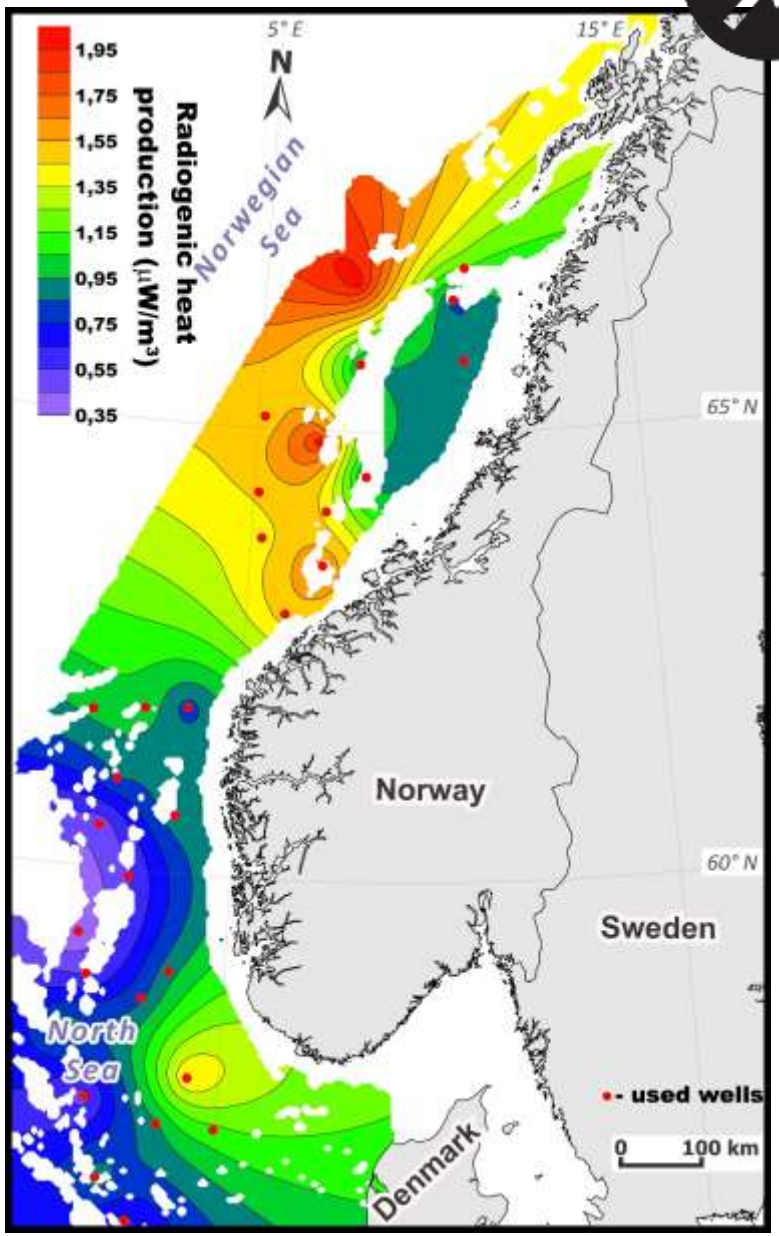
Radiogenic heat production



Rogaland Group



Shetland Group

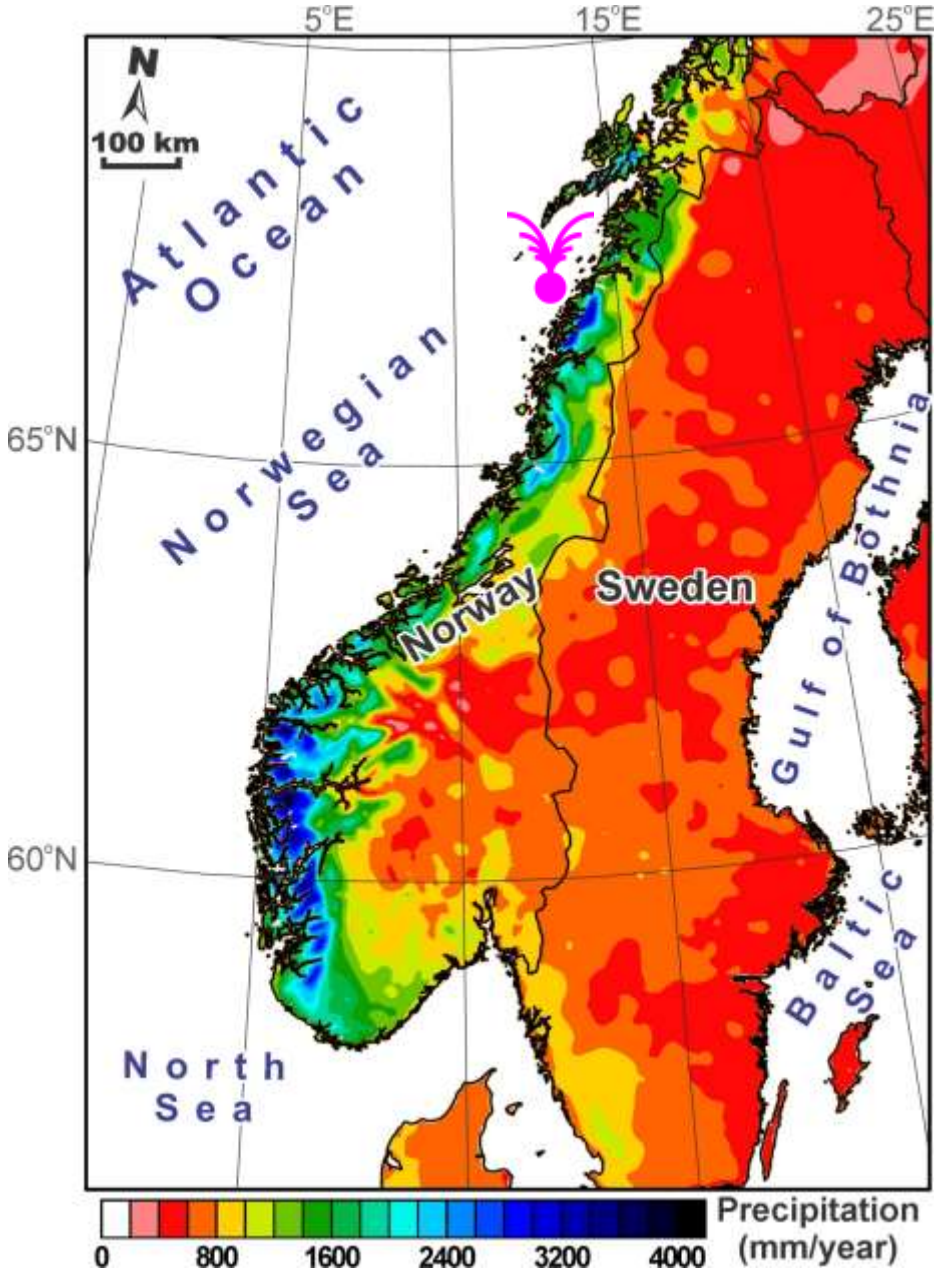


Cromer Knoll Group

Controlling factors

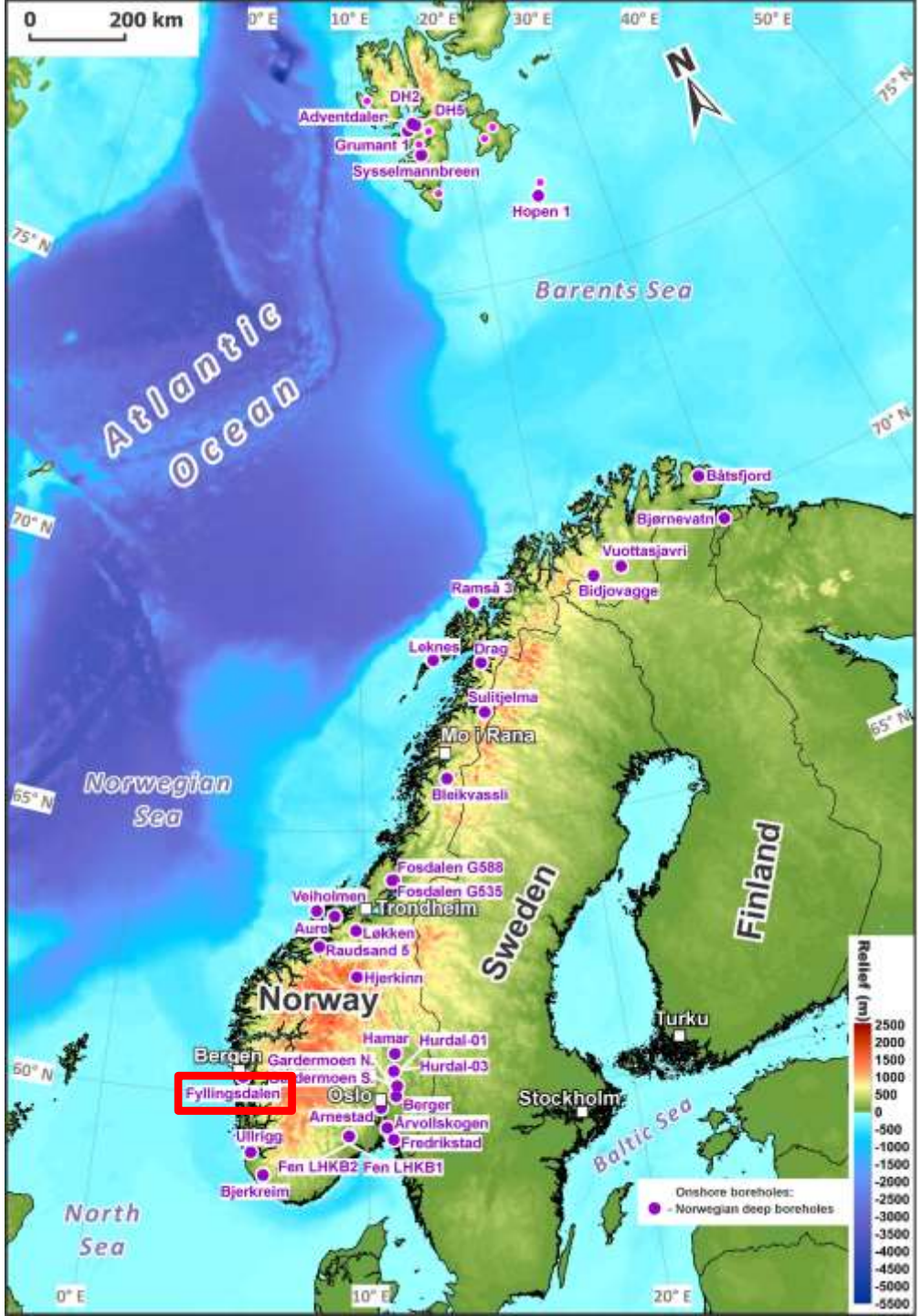
1. Thickness of the lithosphere
2. Bathymetry
3. Thickness of sediments
4. Erosion and deposition vs. thermal equilibrium
5. Radiogenic heat production

Groundwater flow

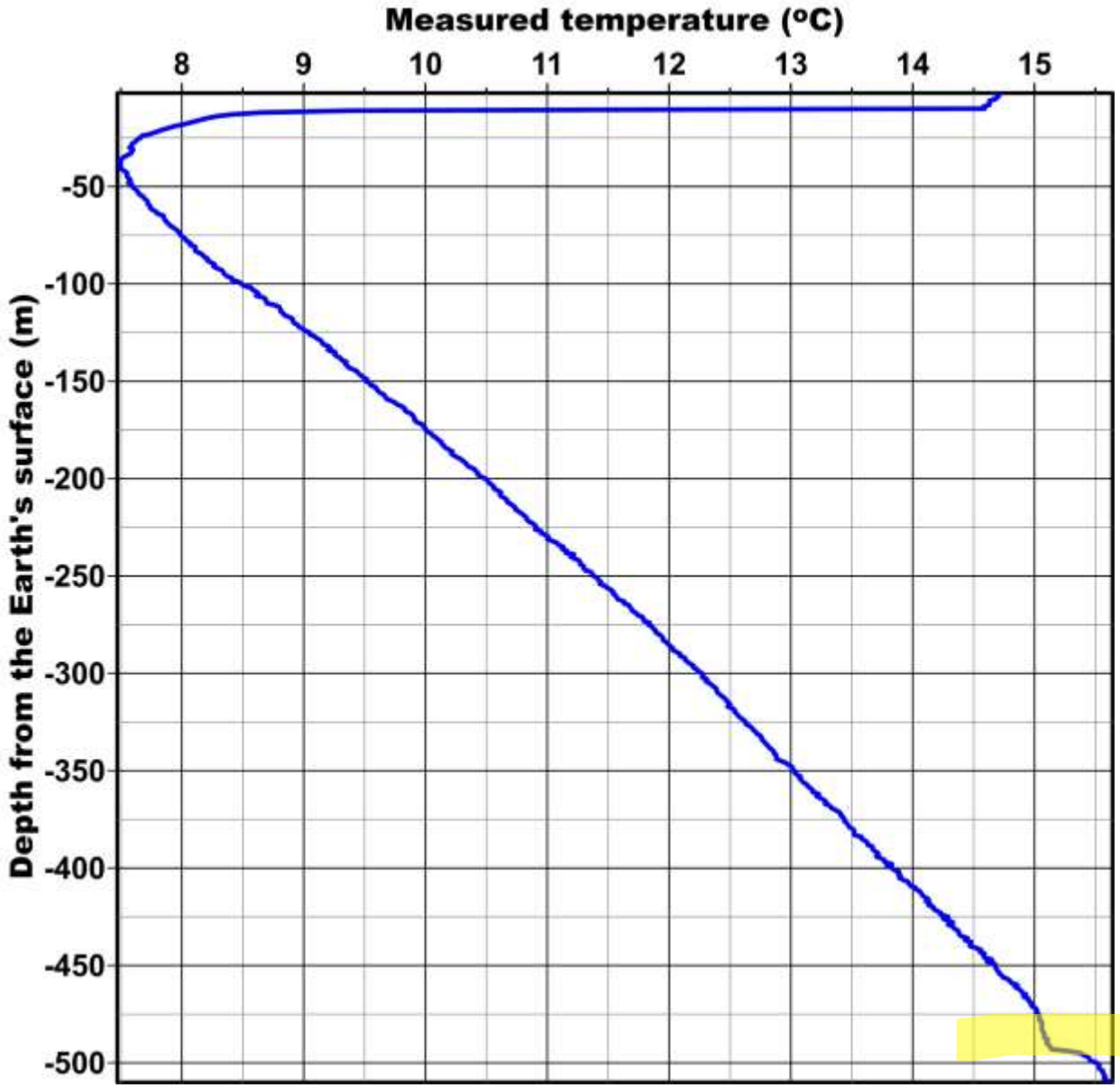


Precipitation is according to NMI (2013), SMHI (2017) and Tveito et al. (1997)

Deep boreholes onshore

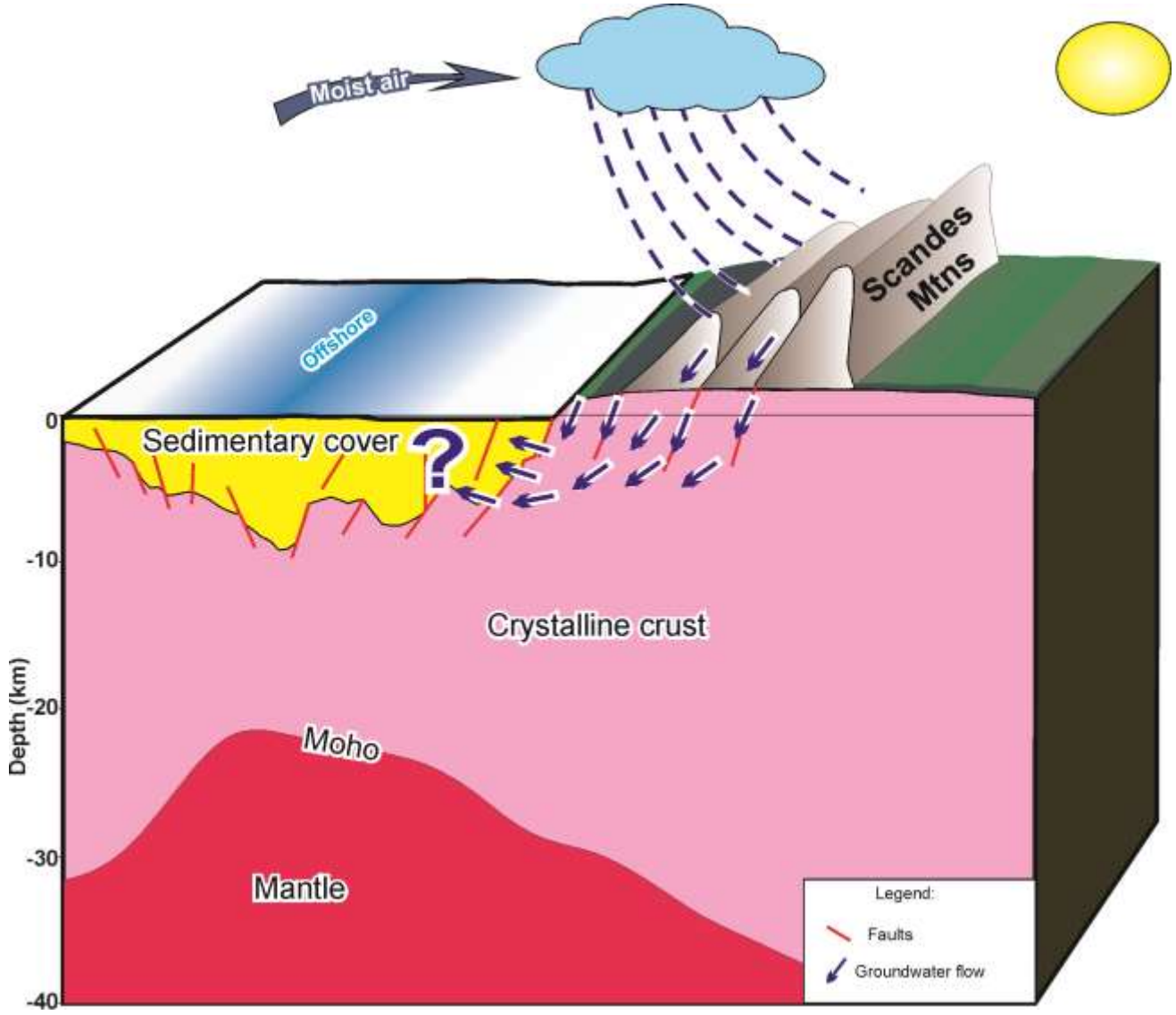


Groundwater flow



The Fyllingsdalen borehole near Bergen

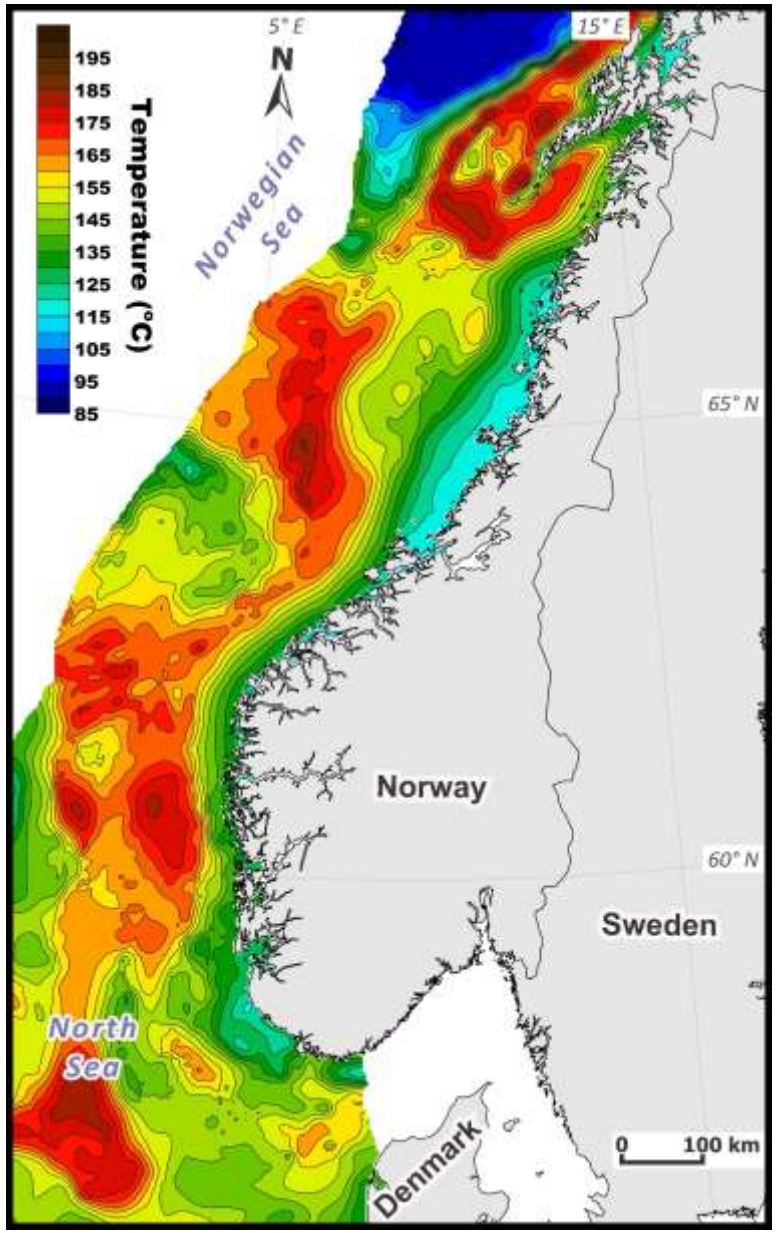
Groundwater flow



Groundwater flow

Deep thermal pattern

after Maystrenko et al. (2018, 2022)

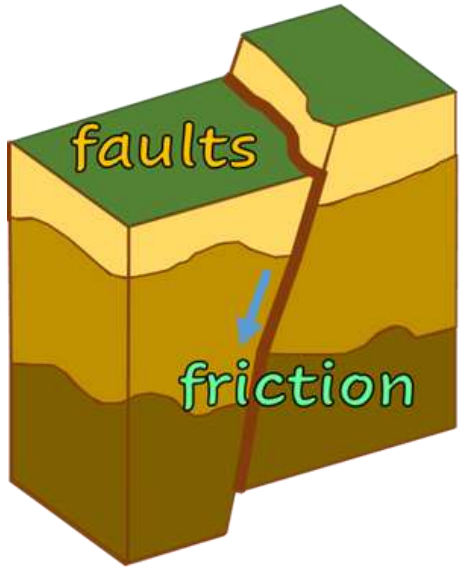


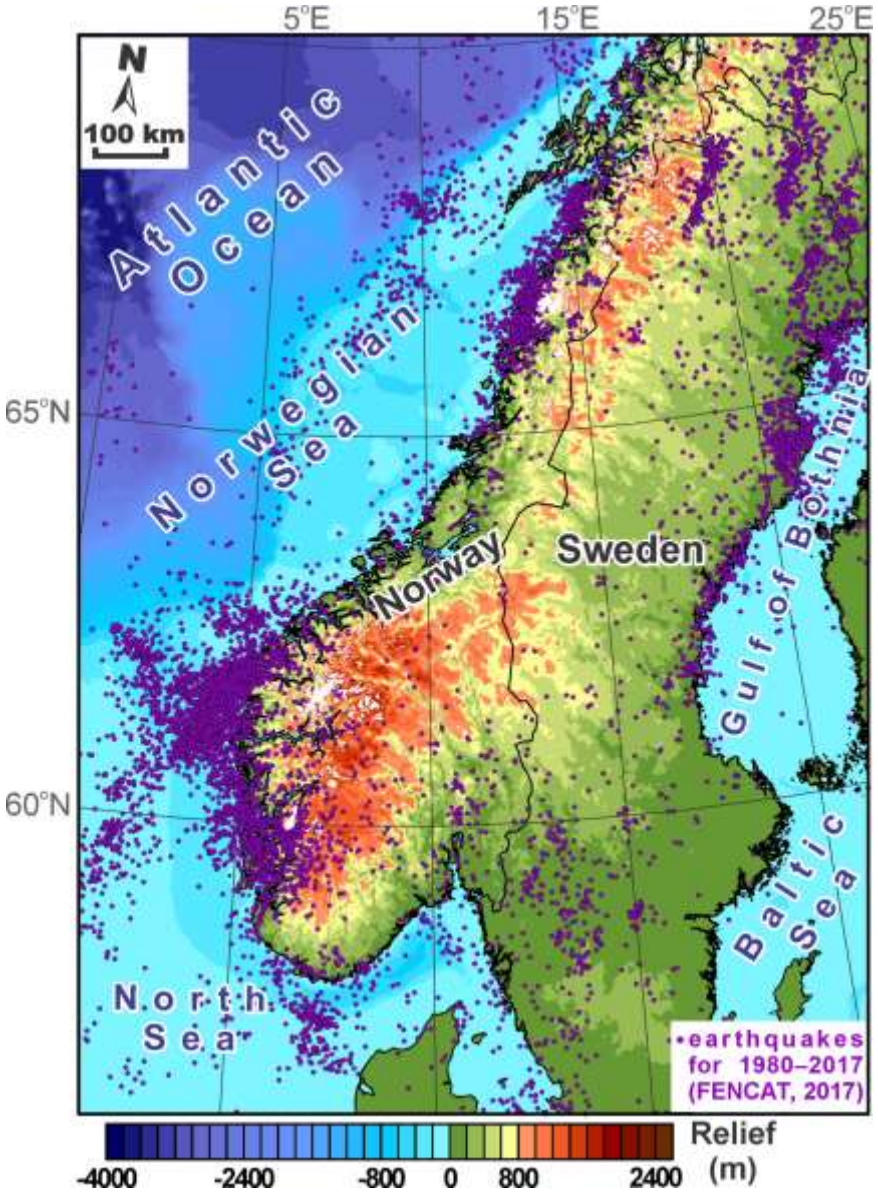
Temperature at depth of 5 km

Controlling factors

1. Thickness of the lithosphere
2. Bathymetry
3. Thickness of sediments
4. Erosion and deposition vs. thermal equilibrium
5. Radiogenic heat production
6. Regional-scale groundwater flow disturbs the conductive heat transfer

Seismicity

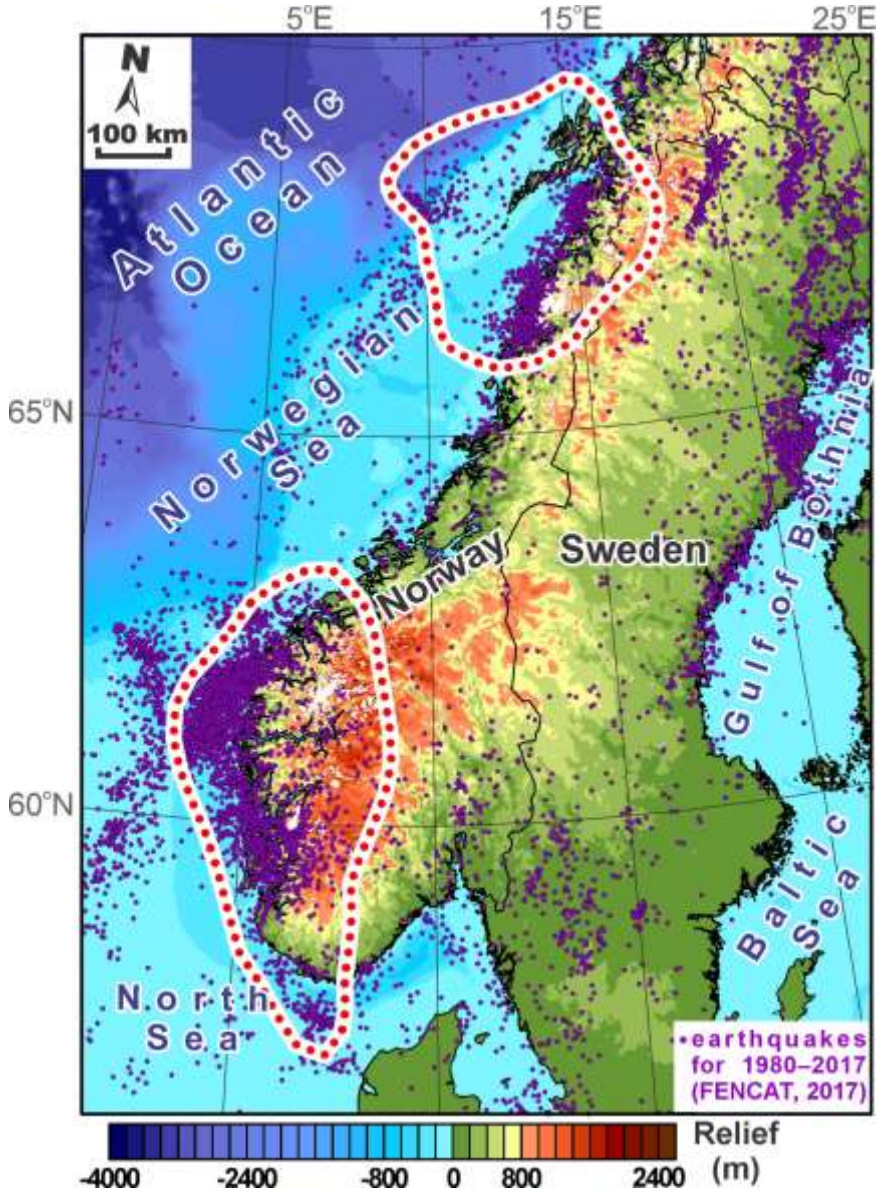

faults
friction


5°E
15°E
25°E
N
100 km
65°N
60°N
Atlantic Ocean
Norwegian Sea
Norway
Sweden
Gulf of Bothnia
Baltic Sea
North Sea
•earthquakes for 1980–2017 (FENCAT, 2017)
-4000
-2400
-800
0
800
2400
Relief (m)

Controlling factors

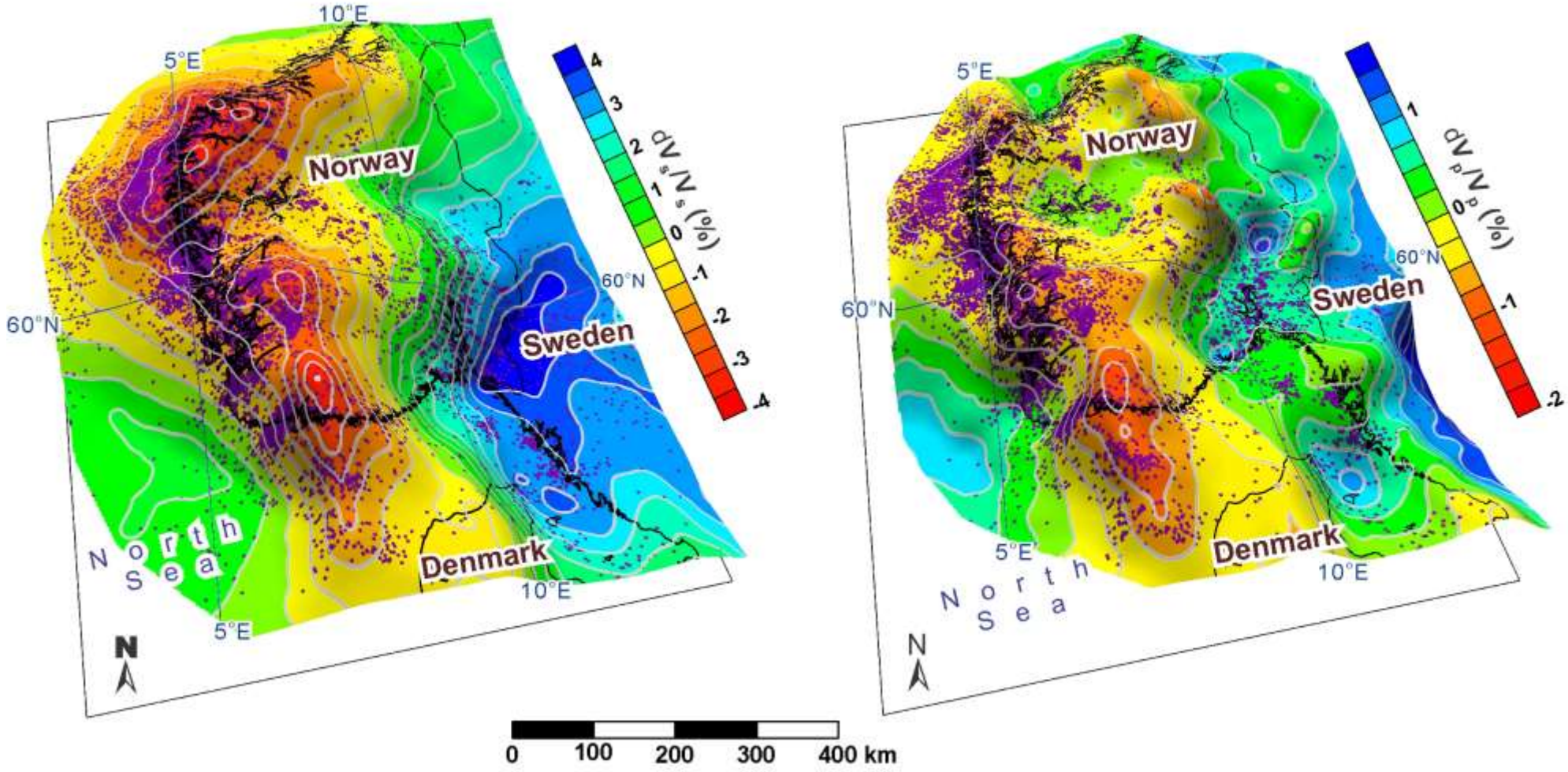
1. Thickness of the lithosphere
2. Bathymetry
3. Thickness of sediments
4. Erosion and deposition vs. thermal equilibrium
5. Radiogenic heat production
6. Regional-scale groundwater flow disturbs the conductive heat transfer
7. Friction-related heat due to seismicity

Deep mantle anomalies



Deep mantle anomalies

Mantle velocity anomalies at a depth of 50 km
after Kolstrup et al. (2015)



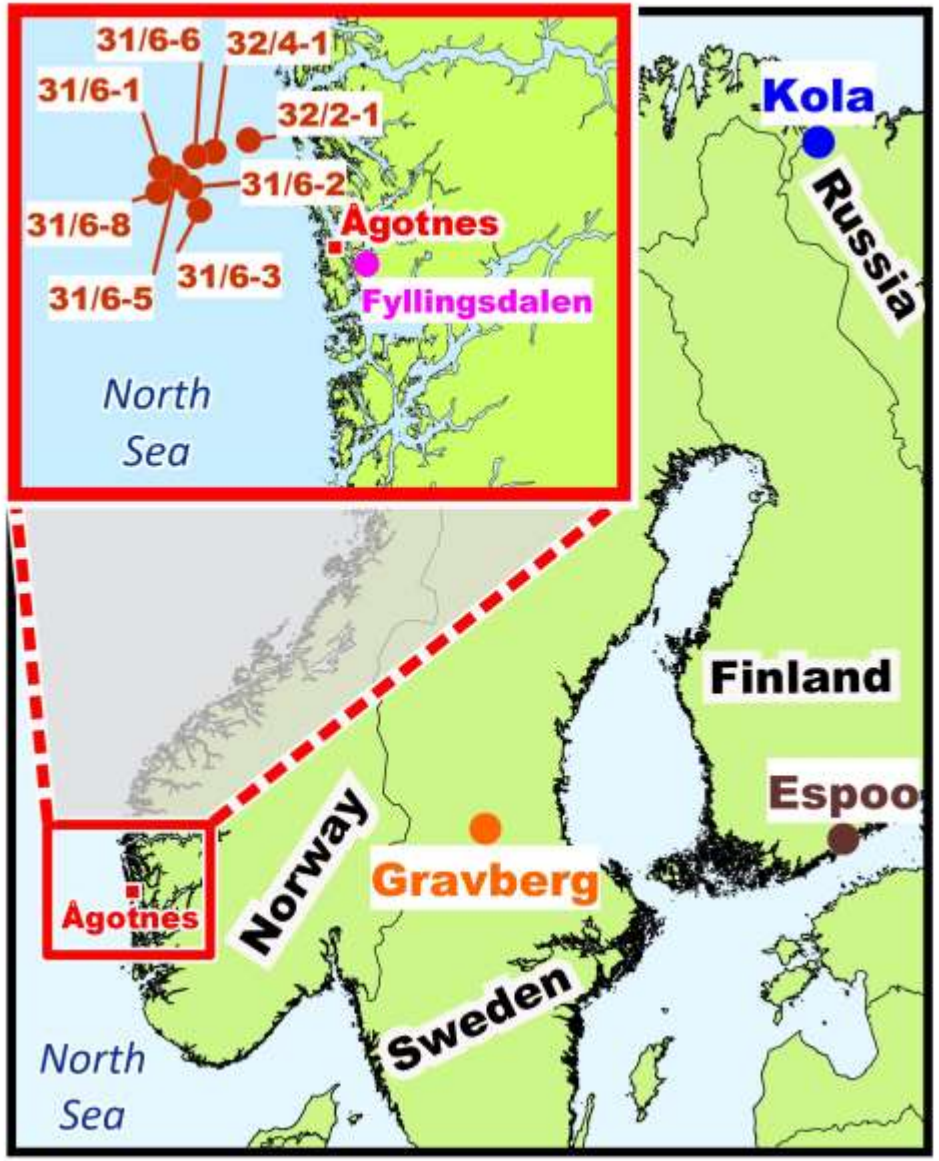
Western Norway

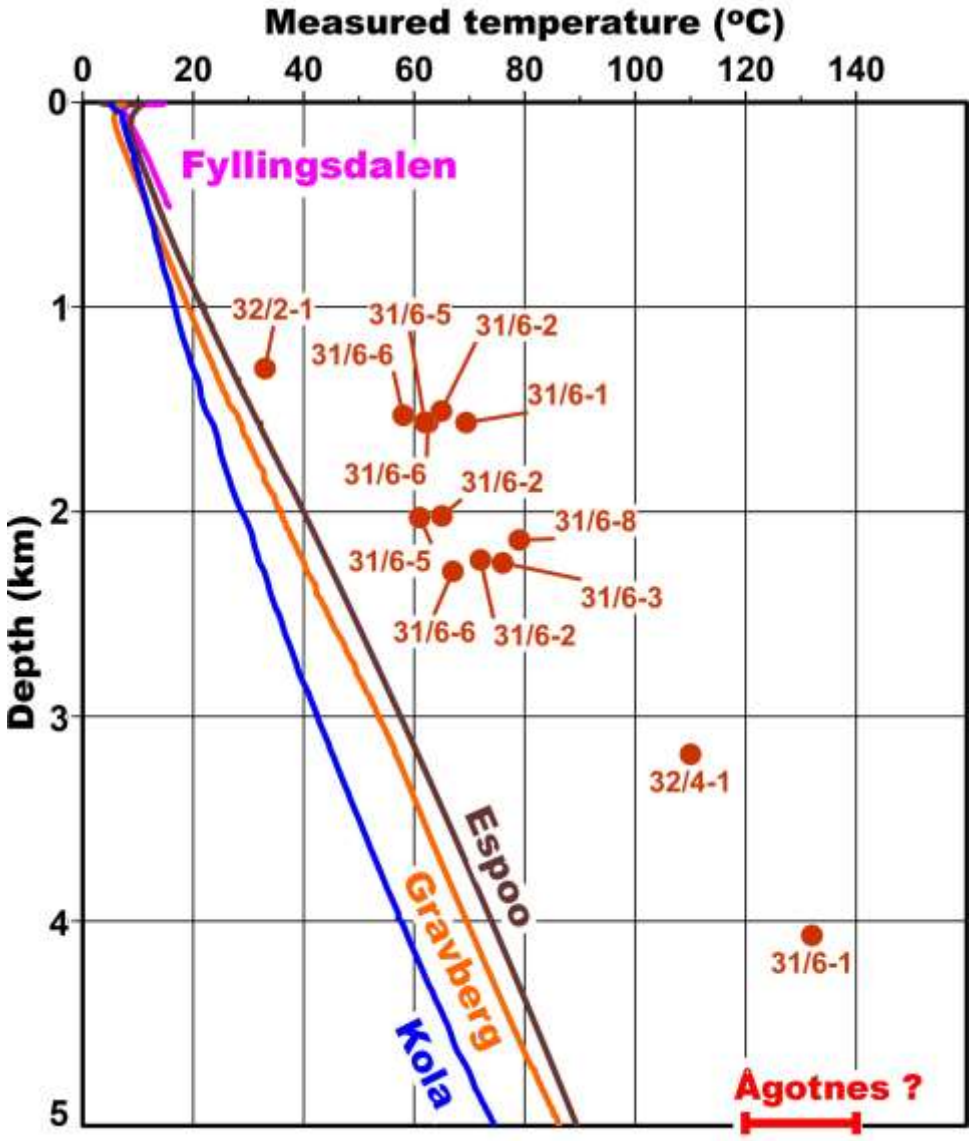
Controlling factors

1. Thickness of the lithosphere
2. Bathymetry
3. Thickness of sediments
4. Erosion and deposition vs. thermal equilibrium
5. Radiogenic heat production
6. Regional-scale groundwater flow disturbs the conductive heat transfer
7. Friction-related heat due to seismicity
8. High-temperature upper-mantle anomalies add heat to the crust

The Norwegian continental shelf is characterized by relatively high temperatures which are controlled by a combination of several factors

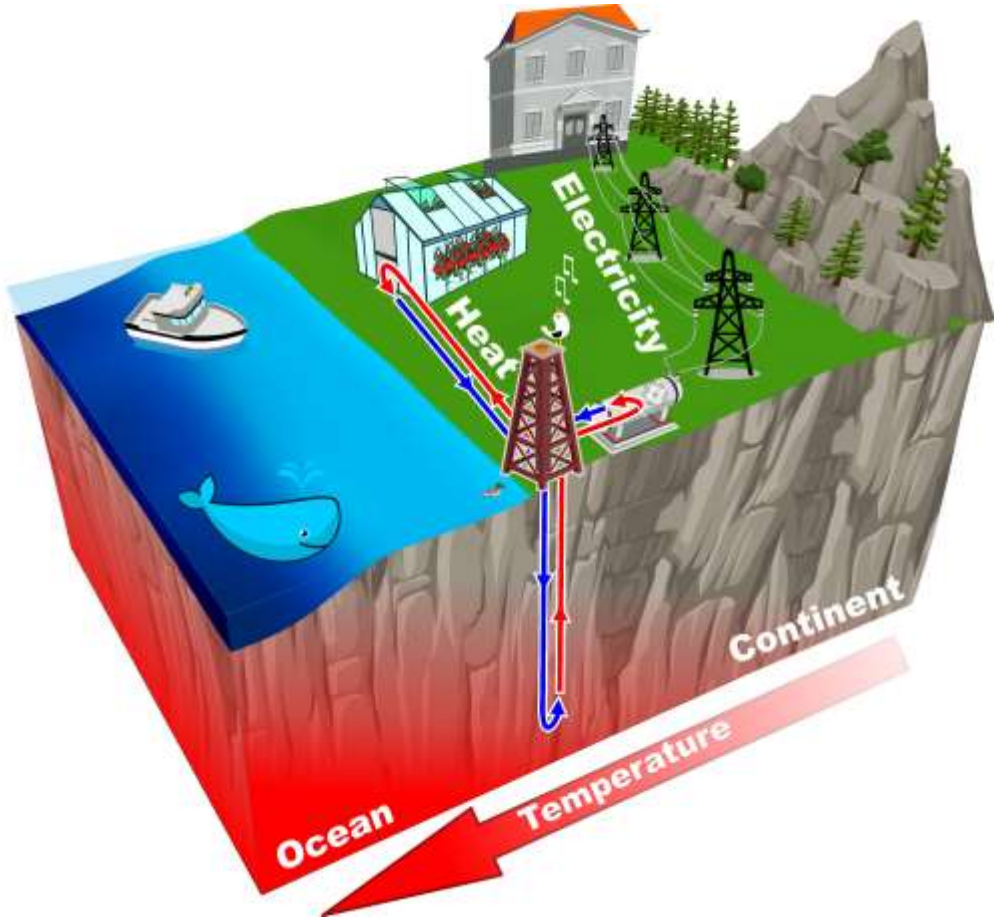
Ågotnes deep geothermal project

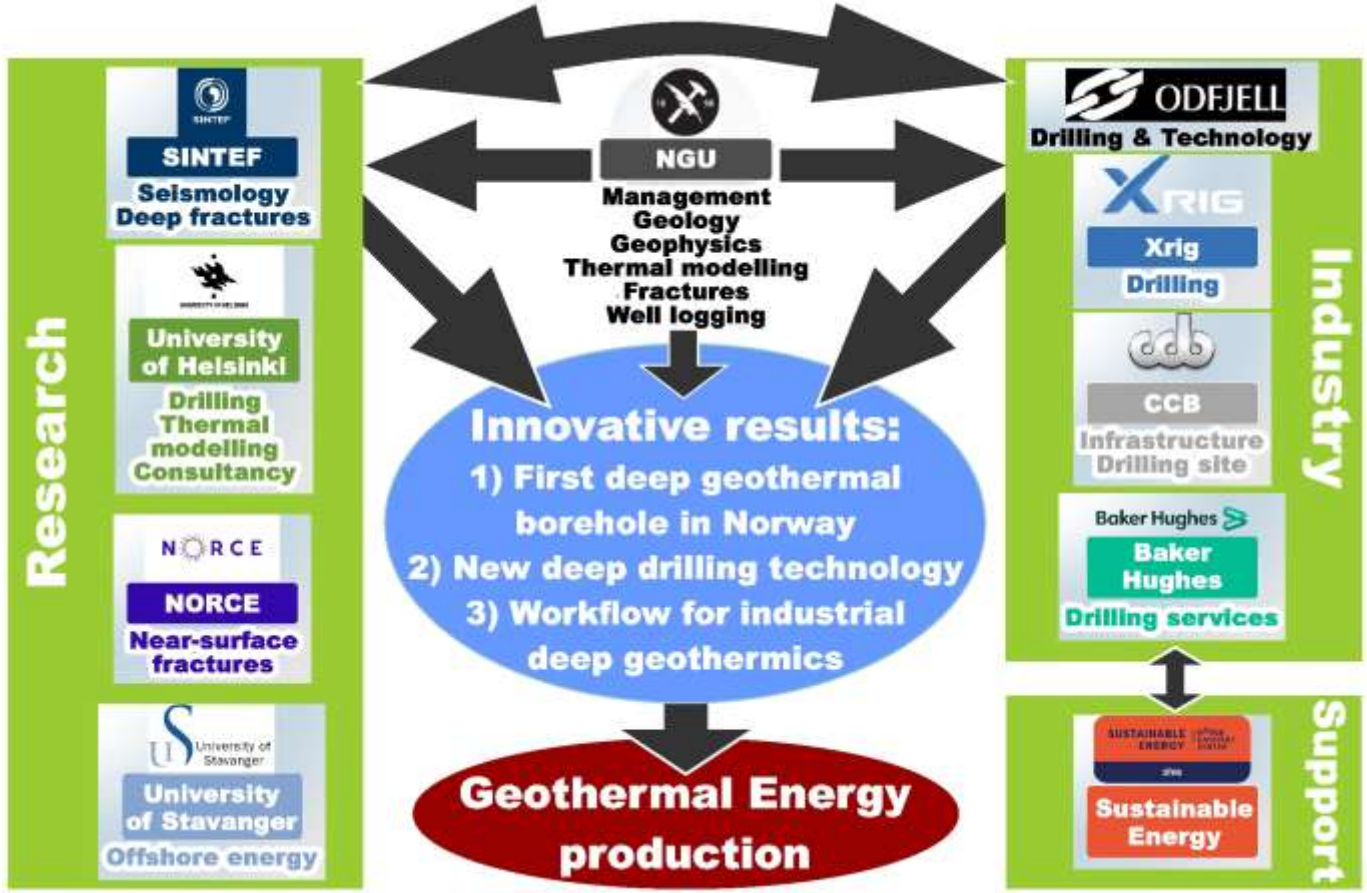




NGU data and data from Popov et al. (1999), Balling (2013), Heikkinen et al. (2021), Kukkonen & Pentti (2021), NPD (2023)

Ågotnes deep geothermal project





Near-coastal region of Western Norway is a promising region at the transition from the mainland to the offshore areas

Thank you for your attention