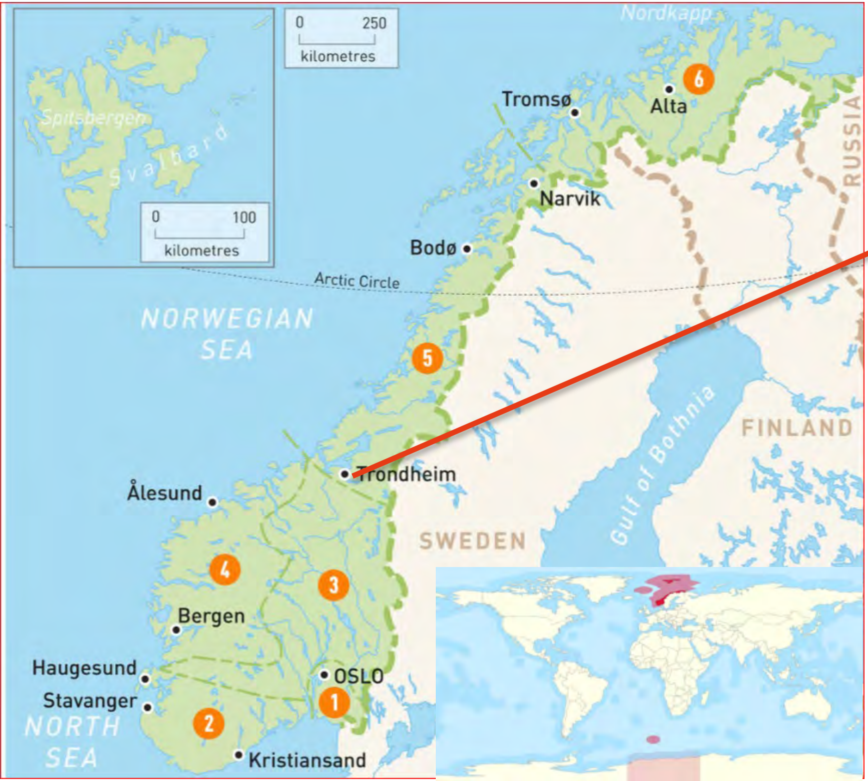
GEOLOGICAL SURVEY OF NORWAY

- NGU -

AN OVERVIEW OF POTENTIAL FIELD DATABASES AND STUDIES AT THE GEOLOGICAL SURVEY OF NORWAY

Aziz Nasuti & Geophysical team at NGU

The Geological Survey of Norway (NGU)



NGU was established in**1858** (166 yrs.)

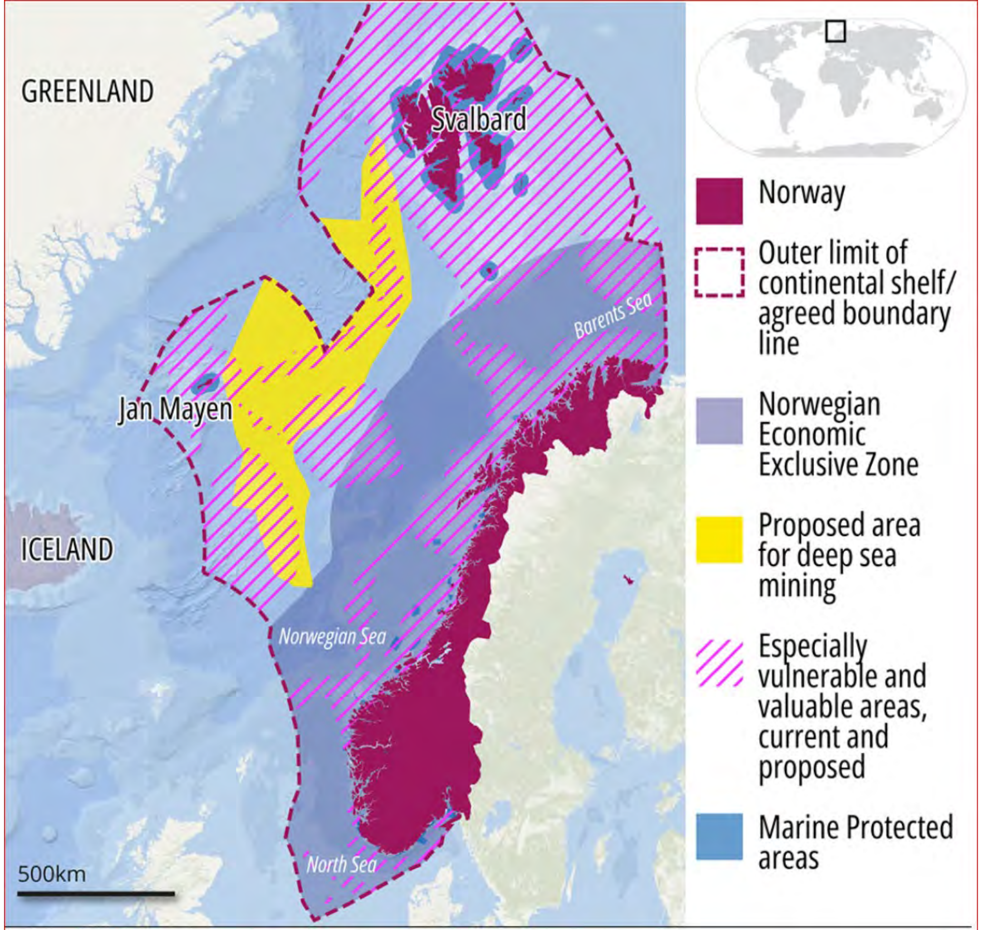
1. NGU collects, processes, and shares knowledge about bedrock, mineral resources, deposits, and groundwater.
2. Key areas include the Arctic, Antarctica, Svalbard, and the continental shelf.
3. NGU's motto is "Geology for the Society."
4. NGU provides maps and geological information in national databases.

•Geological Mapping
- Solid Earth Geology
- Quaternary Geology
- Marine Geology
- Geochemistry and Hydrogeology
- Geohazard and Earth Observation

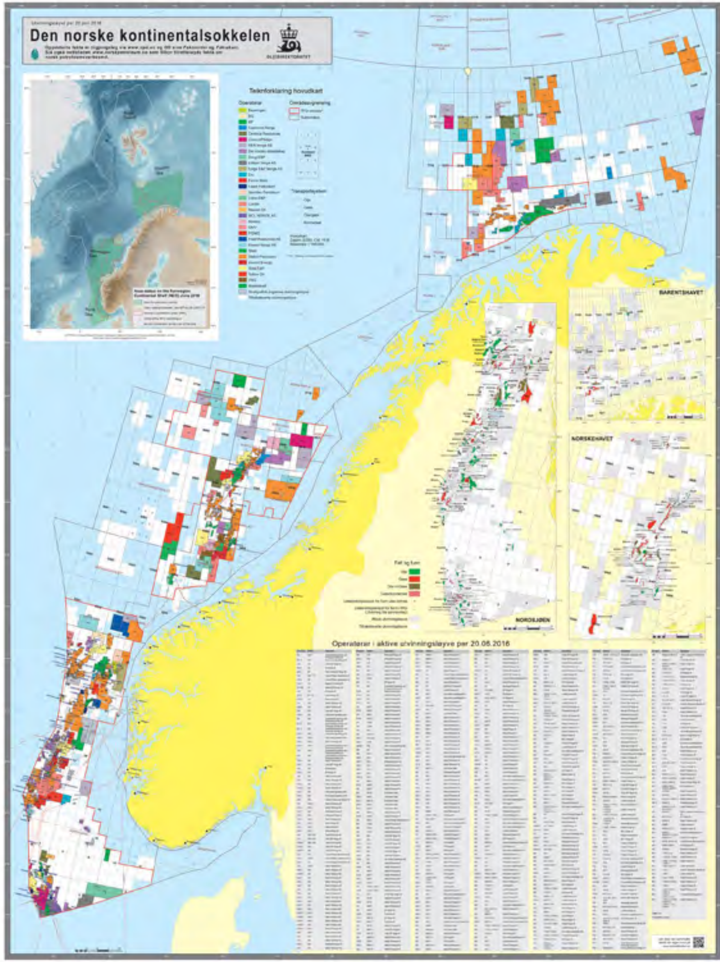
•Geological Resources and Environment
- **Geophysics**
- Natural Construction Materials
- Mineral resources
- NGU Laboratory

200 employees

Geophysics at NGU



Sources: Norwegian Petroleum Directorate; NLOD; Institute of Marine Research; WDPA



NGU Geophysical databases

1- Ground Geophysics

1- Gravity & Magnetics

2- Electrical method (DC resistivity and IP)

3- Electromagnetics (VLF, EM, MT, GPR)

4- Seismics (Refraction and reflection)

5- Borehole logging

2- Airborne Geophysics

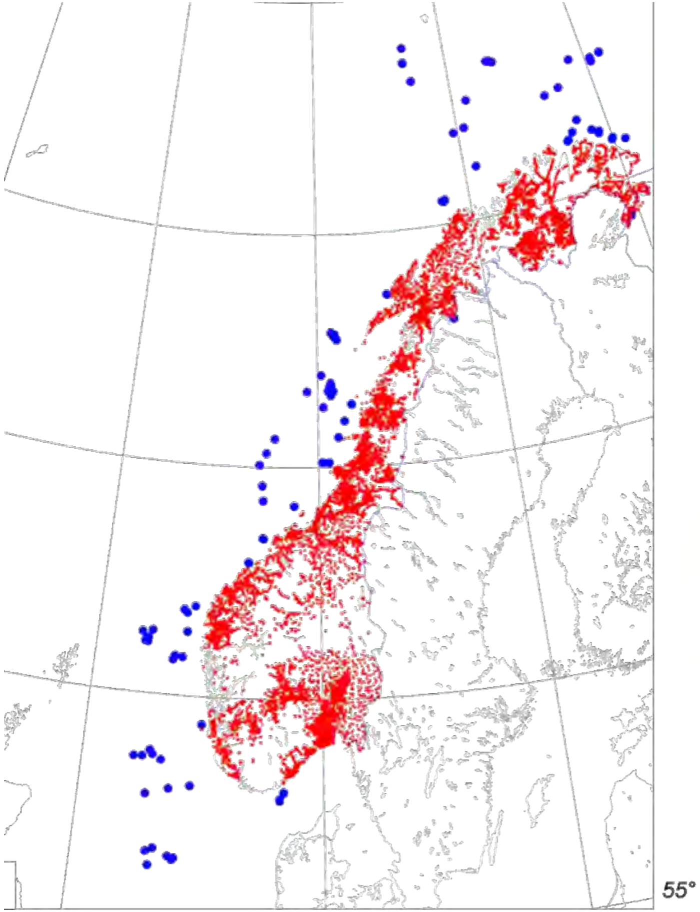
1- Aeromagnetics

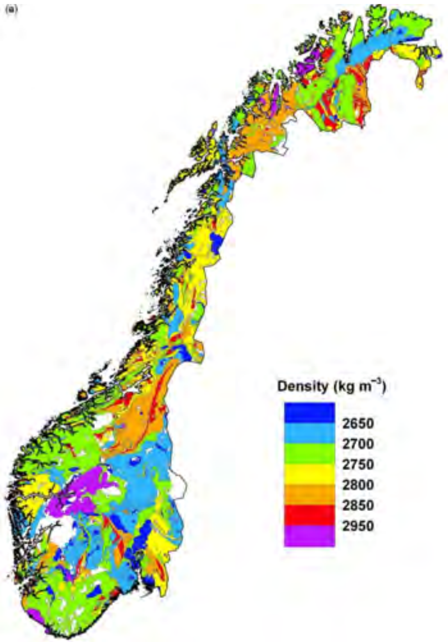
2- EM and VLF

3- Aerogravity

4- Radiometry

Ground geophysical database





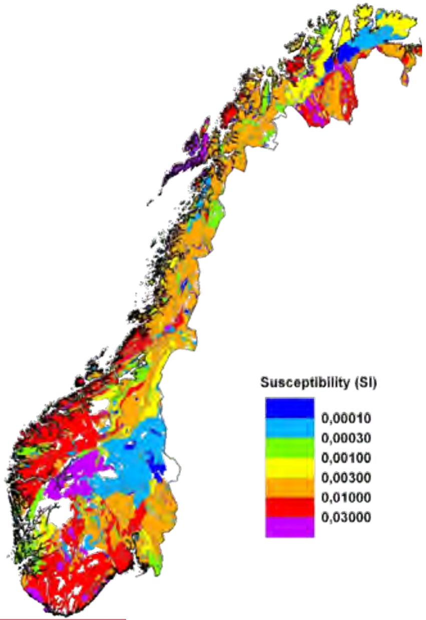


Table 2. Magnetic properties of basement rocks from the coastal part of mainland Norway

Rock type	Location	No.	Susceptibility	*Q*-value	NRM Dec./Inc.	Reference
Greenstone	Alta-Kautokeino, Finnmark	698	0.003	0.21		Olesen *et al.* (1990)
Gabbro	Seiland, Finnmark	78	0.019	0.71		Olesen *et al.* (1990)
Gneiss	Senja and Kvaløya, Troms	500	0.005	0.59		Olesen *et al.* (1997*b*)
Gneiss	Vesterålen, granulite facies	153	0.021	0.27	2/81 (n = 11)	Olesen *et al.* (1991)
Gneiss	Vesterålen, amphibolite facies	98	0.001	2.0		Olesen *et al.* (1991)
Gneiss	Roan, Fosen Peninsula	66	0.023	0.25	348/74 (n = 10)	Skilbrei *et al.* (1991)
Gabbro	Smøla	11	0.020			Sindre (1977)
Norite	Tellnes, Rogaland	191	0.037	7.3	293/ − 64 (n = 32)	McEnroe *et al.* (1996)

Olesen et al. 2010

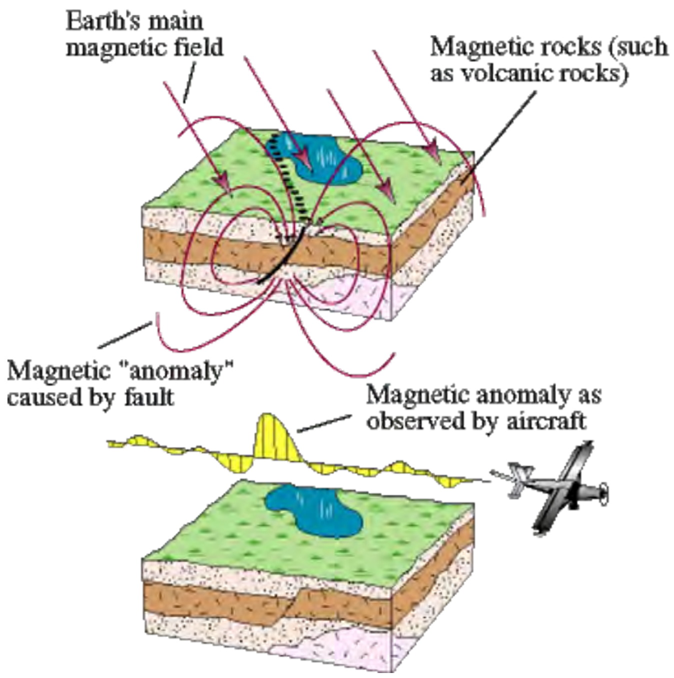
Airborne databases

1- The history of airborne geophysics at NGU

2- Type of data (methods)

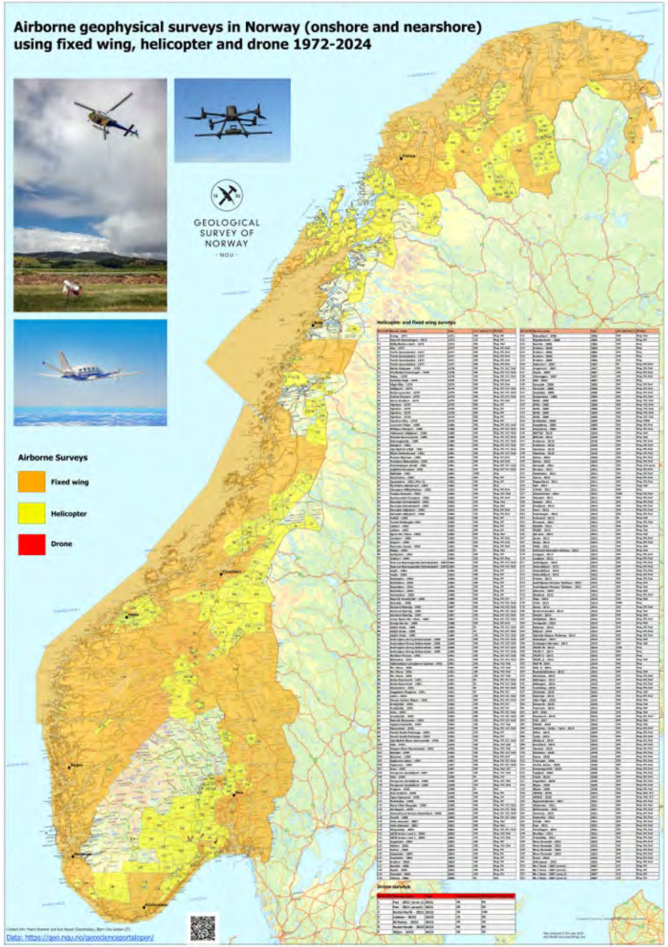
- Coverage maps
- Resolution
- Quality

3- How to find datasets



After Michael F. Diggles (2005)

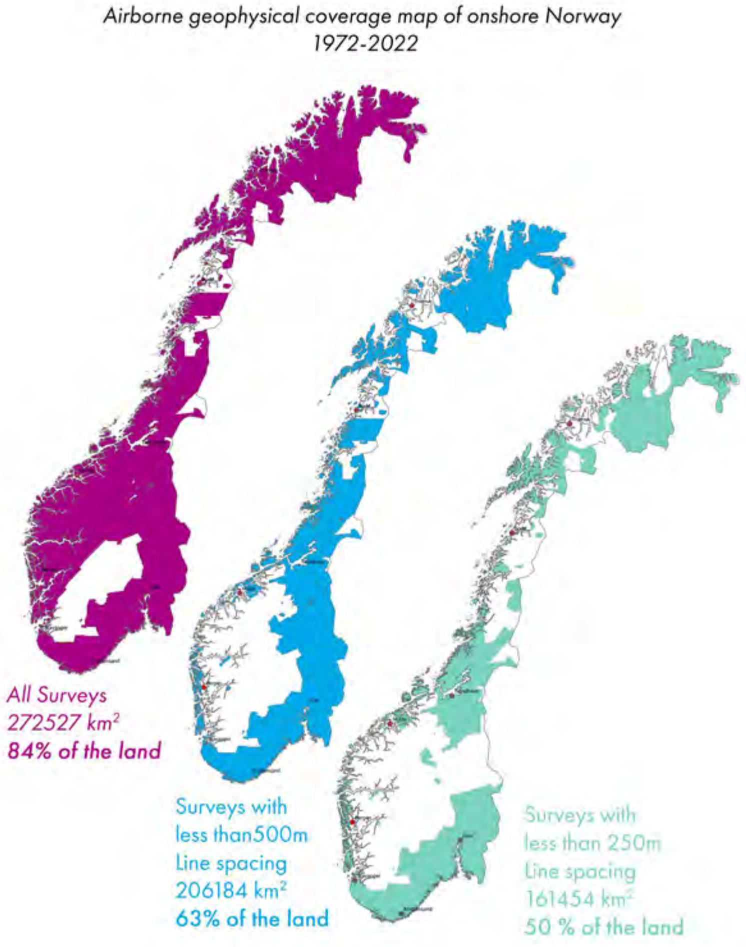
60 years of airborne surveying at NGU



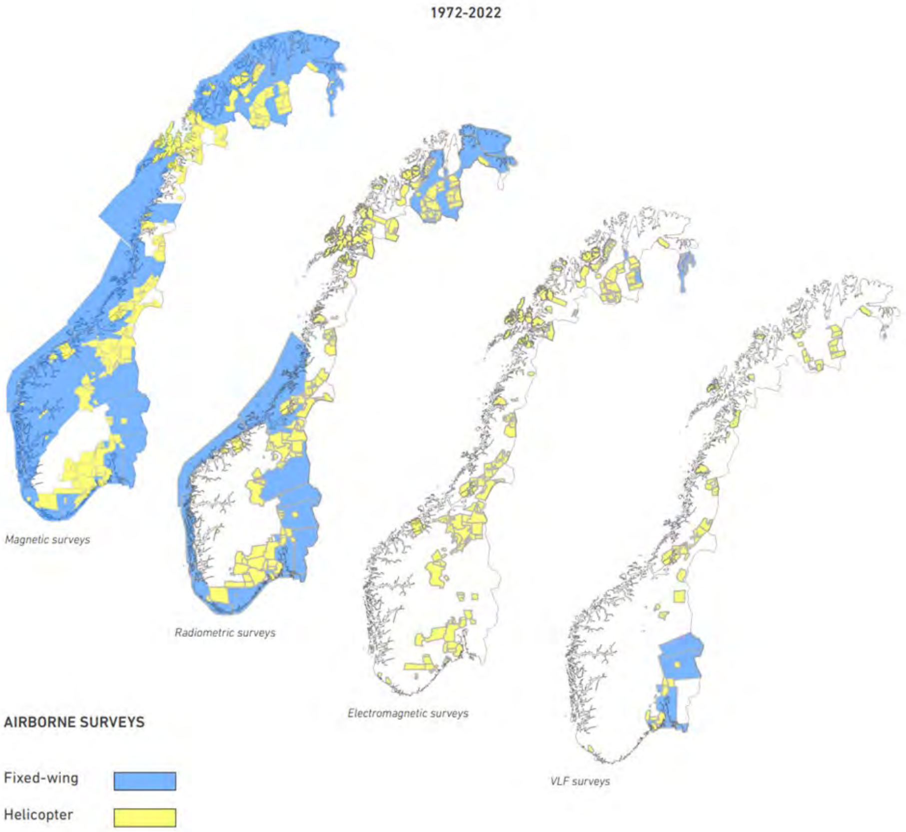
233 Surveys

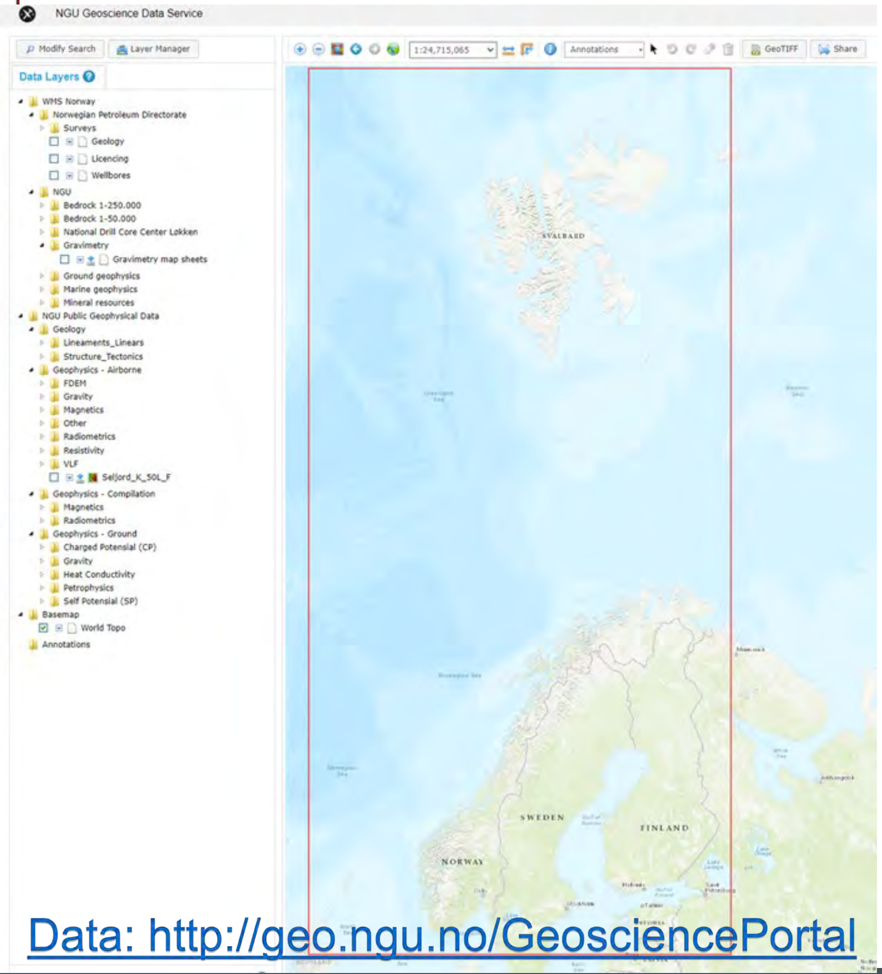
Line Spacing
100-1000 m

Flight height
30-300



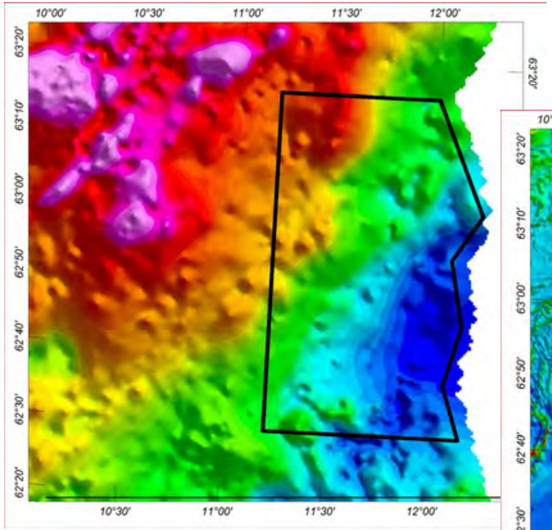
AIRBORNE GEOPHYSICAL SURVEYS IN NORWAY (ONSHORE AND NEARSHORE)





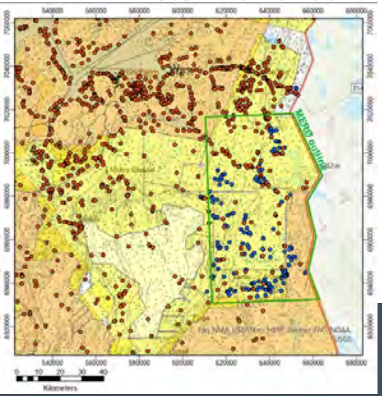
Data: http://geo.ngu.no/GeosciencePortal

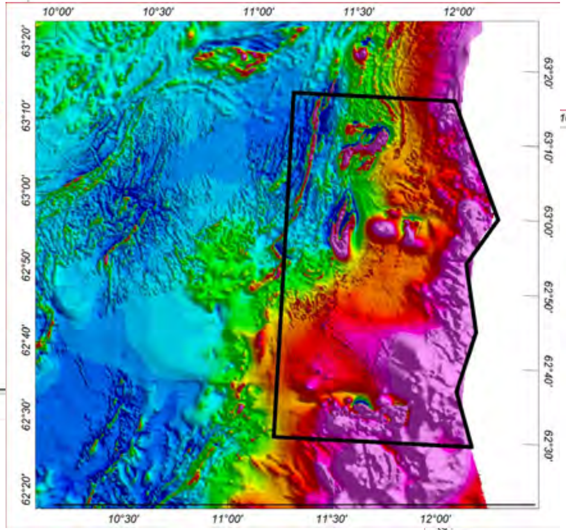
Multidisciplinary onshore Geophysical datasets



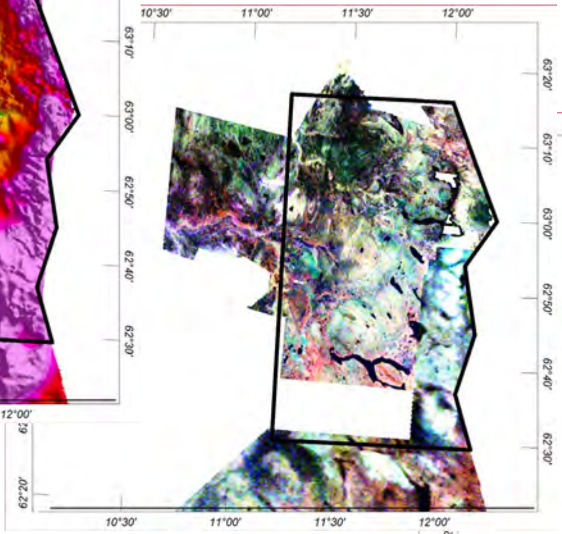
Gravity anomaly

Airborne surveys, gravimetry and petrophysics

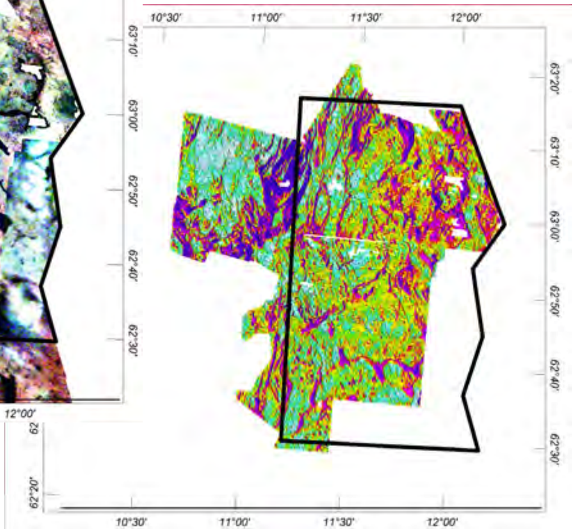




Magnetic anomaly



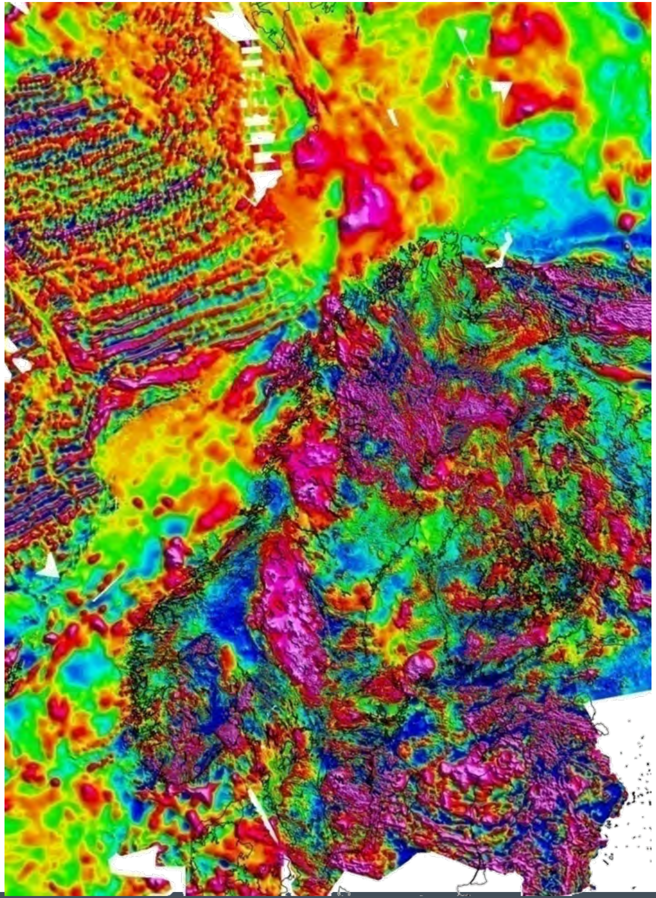
Radiometric data



Electromagnetic data

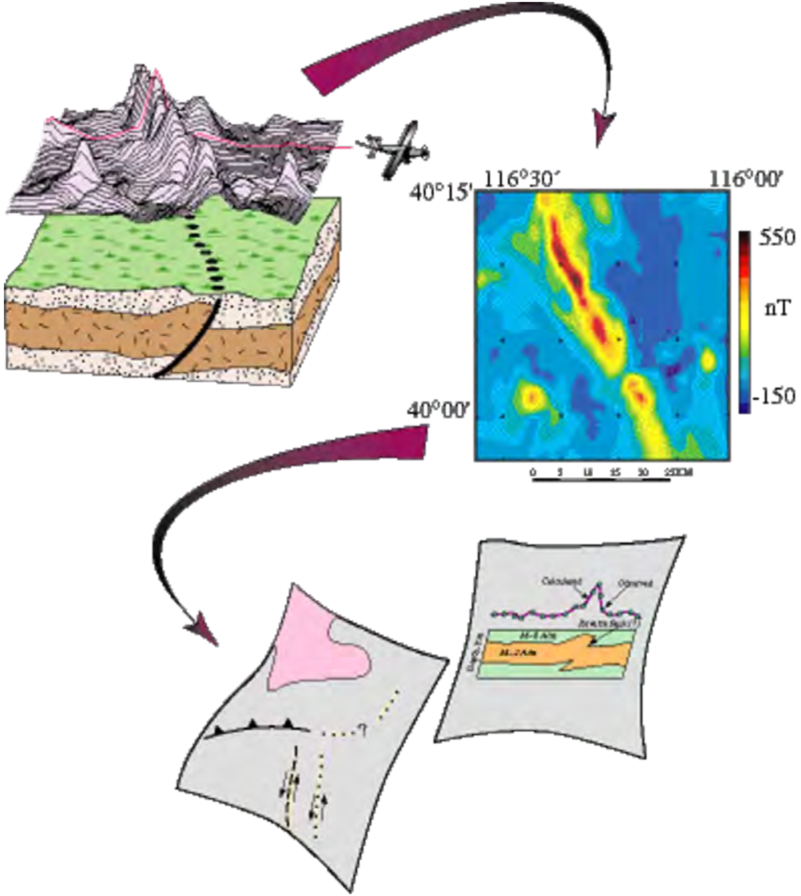
Data: https://geo.ngu.no/geoscienceportalopen/search

Offshore geophysical data



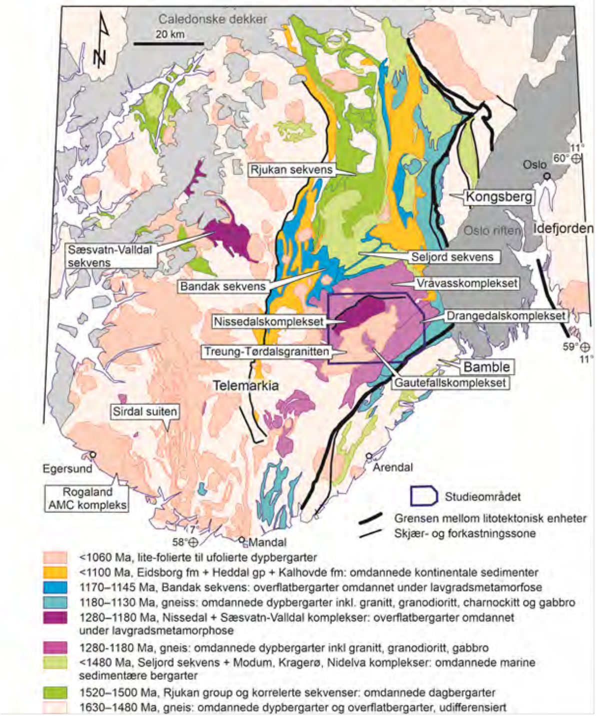
Line spacing 250 – 7500 m

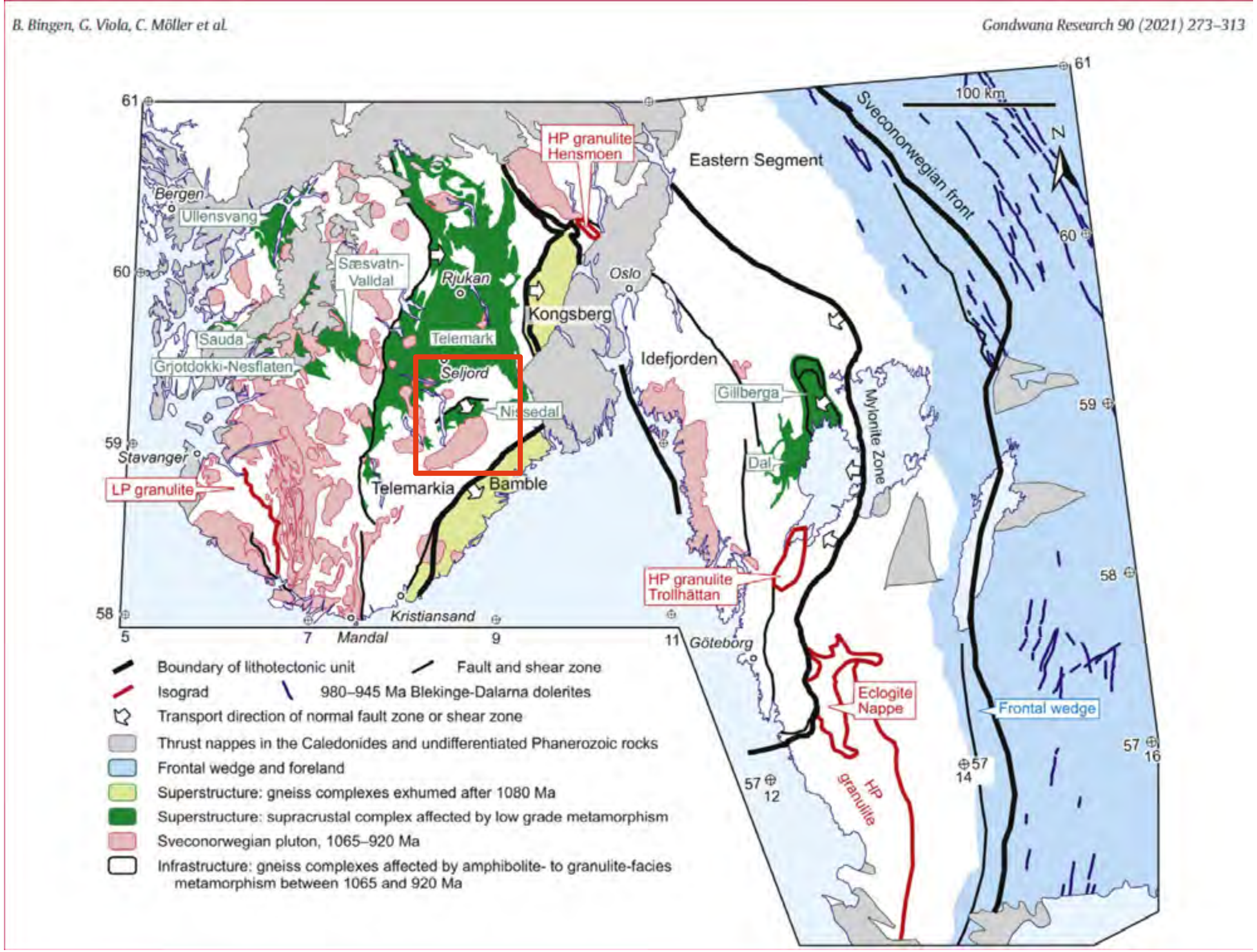
Case studies using Potential field dataset to map geology and modelling the underground



CASE 1

Nissedal complex
South Norway





DATA

1- Geological surface samples

2- Geophysics

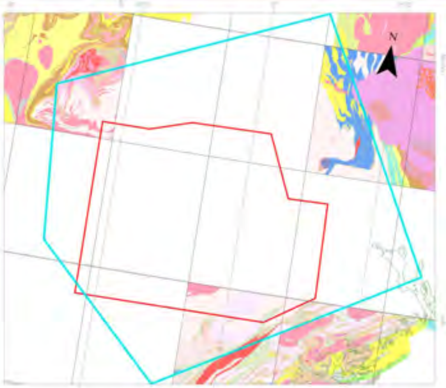
- Airborne
  - Magnetic data
  - Elelectromagnetic data
  - Radiometric data
- Ground data → gravity data

Survey name	Survey year	Collected data types	Used instruments	Average flying height, line spacing and direction (azimuth)	Reference
Bamble	2005	HEM, Magnetic Radiometry	Hummingbird Cs-2 and GR-820	60 m, 100 m, 246°	Mogaard, 2006
Nissedal	2011	HEM, Magnetic Radiometry	Hummingbird Cs-2 and RSX-5	80 m, 200 m, 90°	Ofstad and Baranwal, 2016
Kviteseid	2012	Magnetic Radiometry	Cs-3 and RSX-5	50 m, 100 m, 210°	Baranwal et al., 2012
Kviteseid-Notodden-Ullefos	2013	Magnetic Radiometry	Cs-3 and RSX-5	80 m, 200 m, 140°	Stampolidis et al., 2014
Drangedal	2014	Magnetic Radiometry	Cs-3 and RSX-5	80 m, 200 m, 155°	Stampolidis & Ofstad, 2014
Telemark	2015	Magnetic Radiometry	Cs-3 and RSX-5	80 m, 200 m, 90°	Stampolidis & Ofstad, 2015
BITE	2020	HEM, Magnetic Radiometry	Hummingbird Cs-2 and RSX-5	87 m, 200 m, 90°	Ofstad & Tassis, 2021
Vegårshei	2020	HEM, Magnetic Radiometry	Hummingbird Cs-2 and RSX-5	87 m, 200 m, 90°	Ofstad & Tassis, 2021

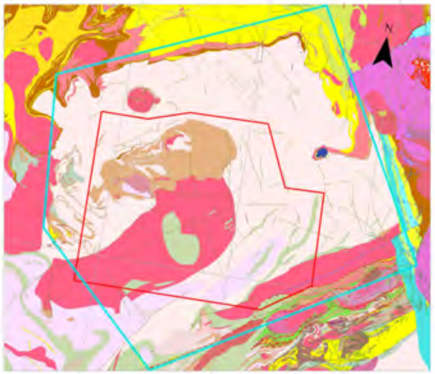
3- Petrophysics

4- Geochronology data

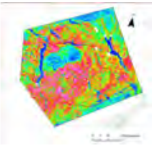
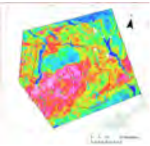
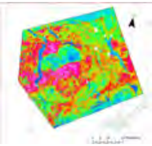
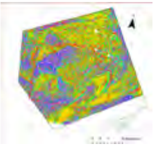
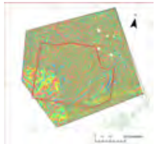
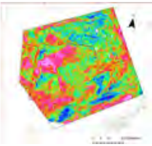
What did we have?

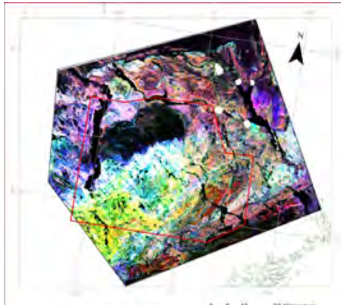


1:50.000 map sheets

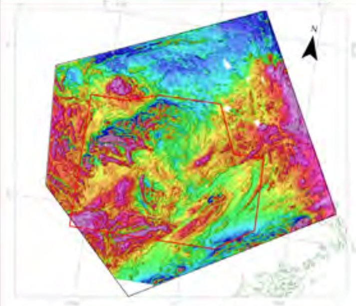


1:250.000 Harmonised map

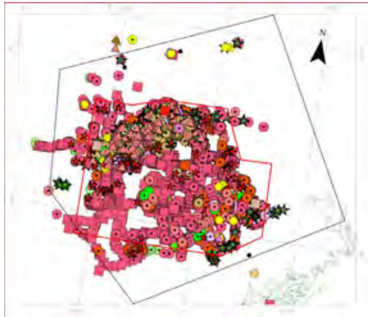









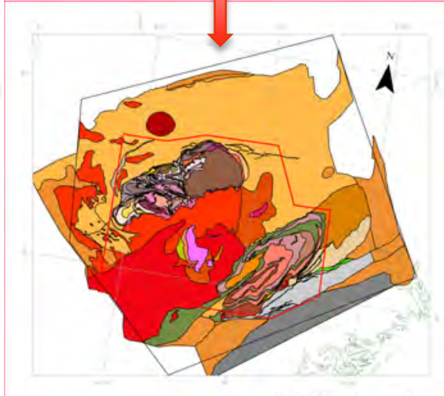
Radiometric ternary map



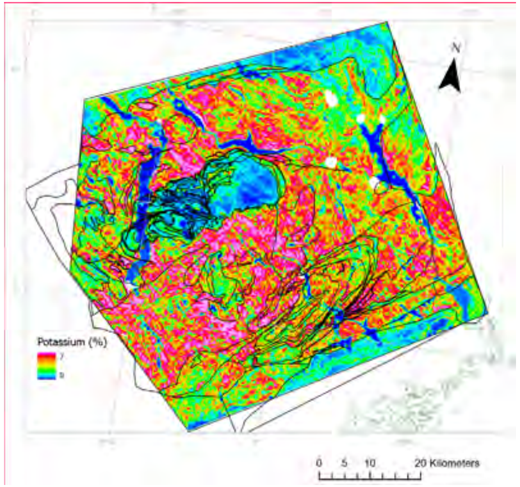
Magnetic anomaly

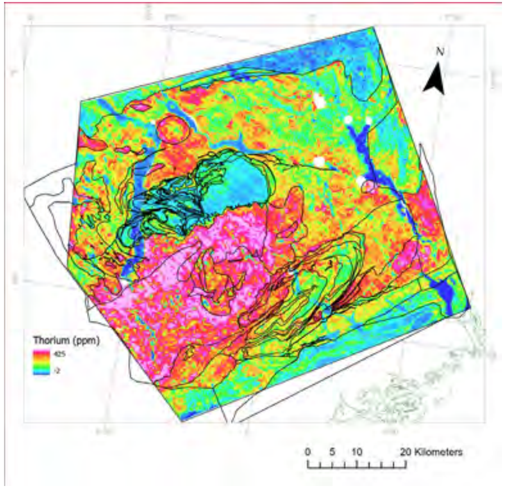


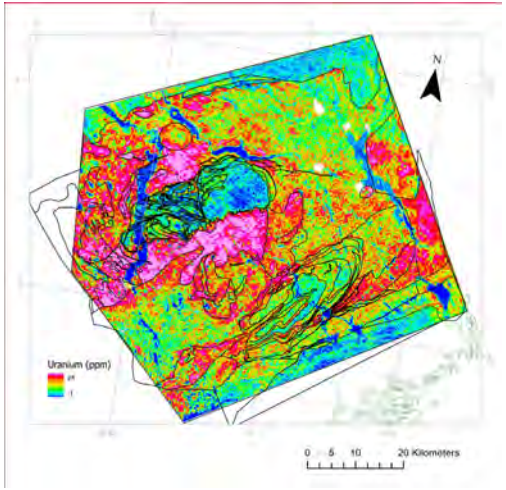
Fieldwork and sample analysis



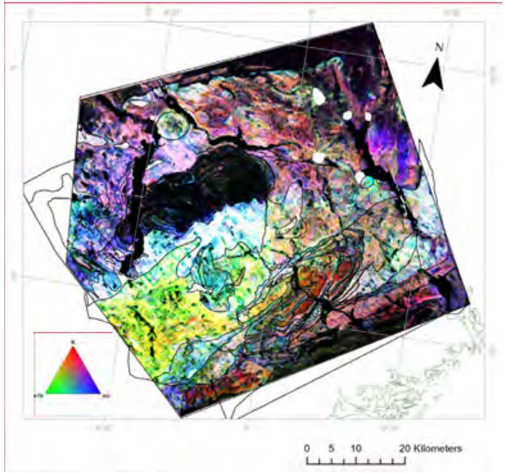
What do we have now


N
Potassium (%)
0 5 10 20 Kilometers

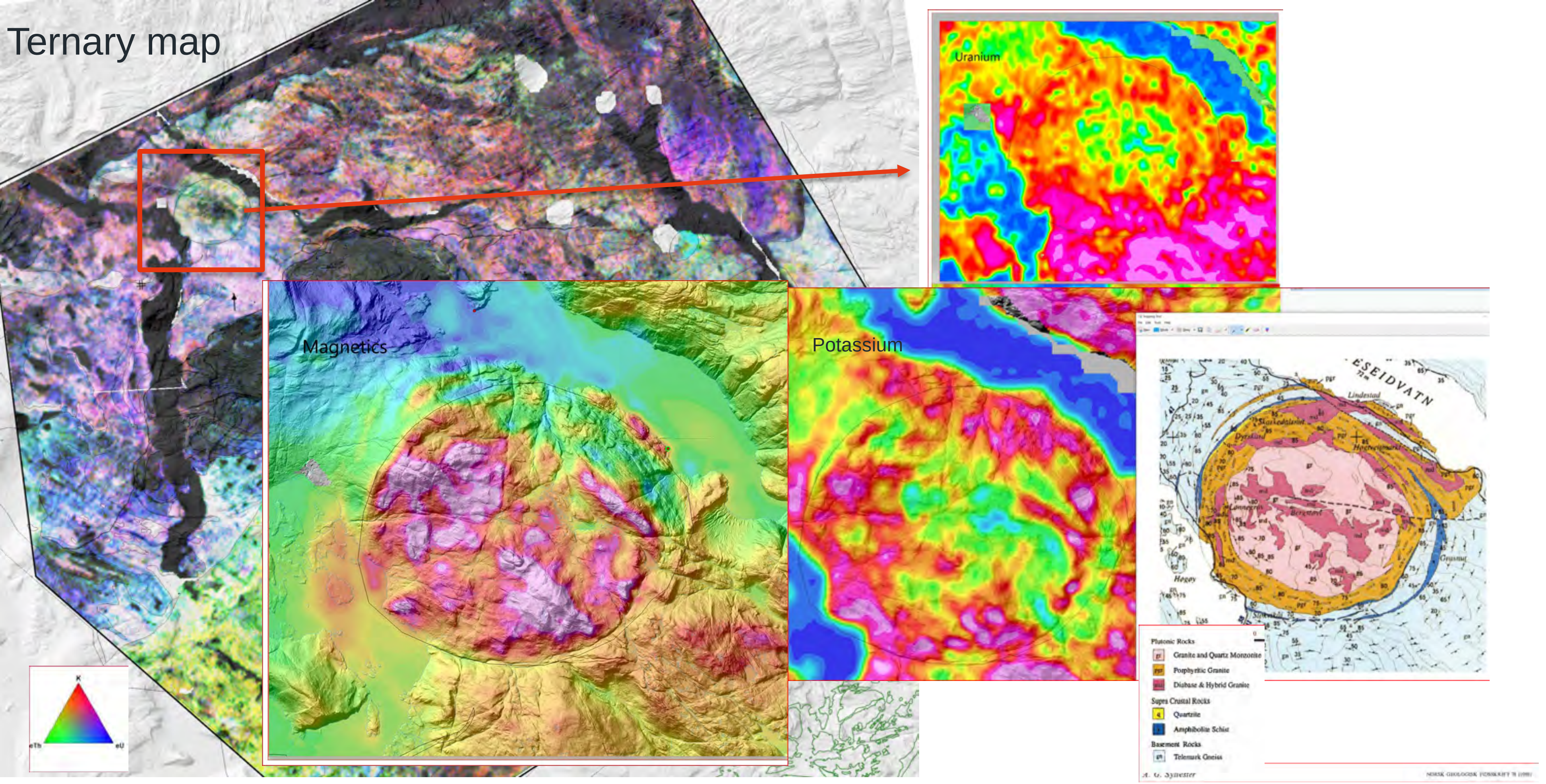

N
Thorium (ppm)
0 5 10 20 Kilometers


N
Uranium (ppm)
0 5 10 20 Kilometers

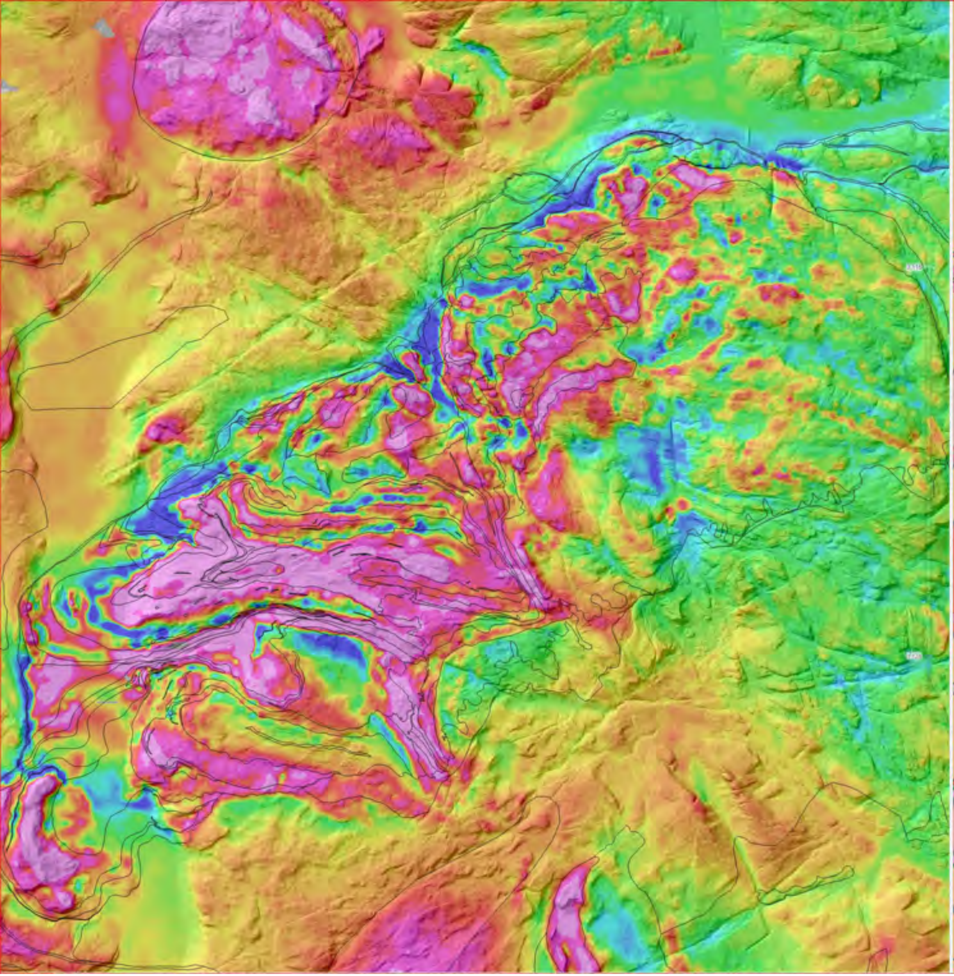
Radiometry

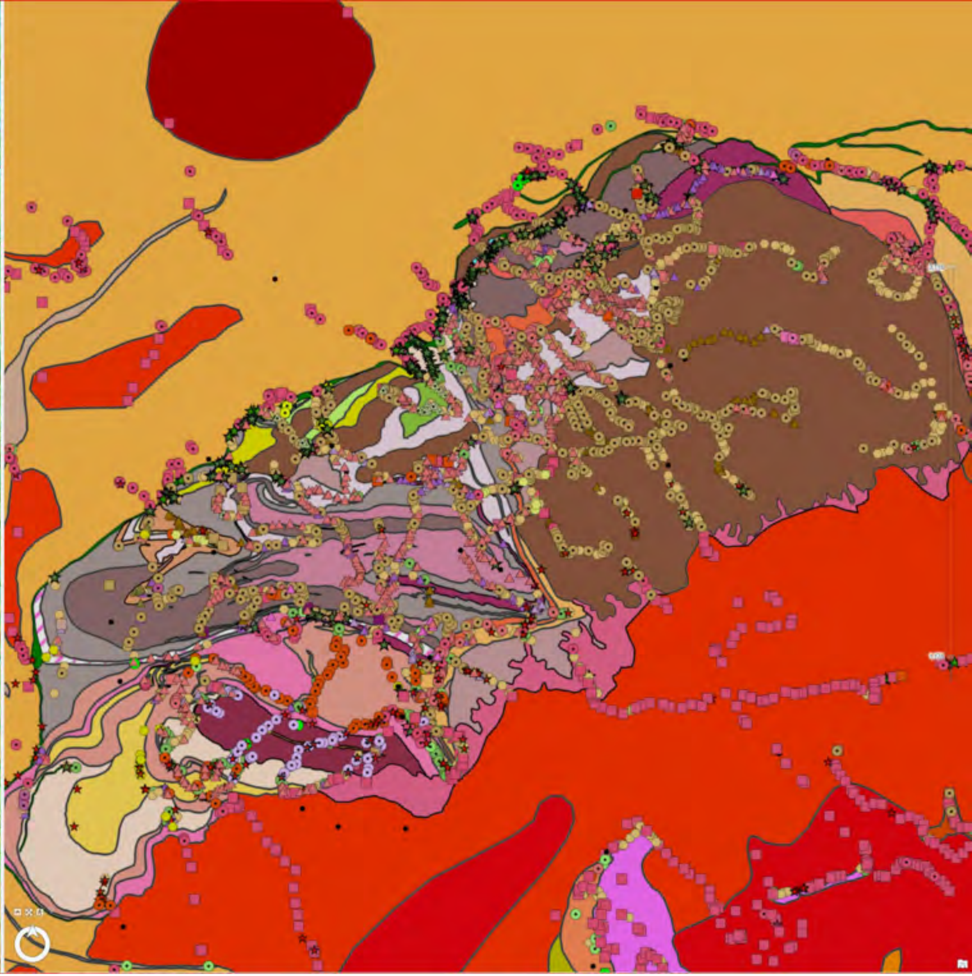

N
0 5 10 20 Kilometers

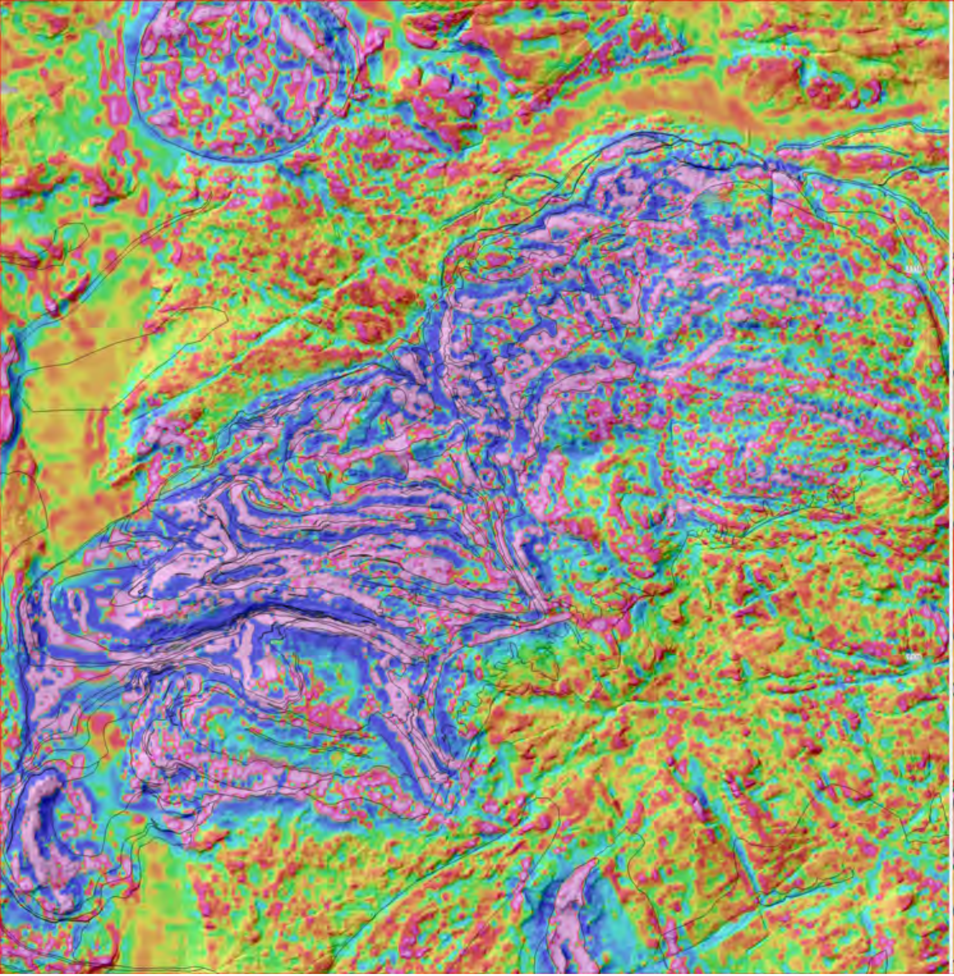
Ternary map

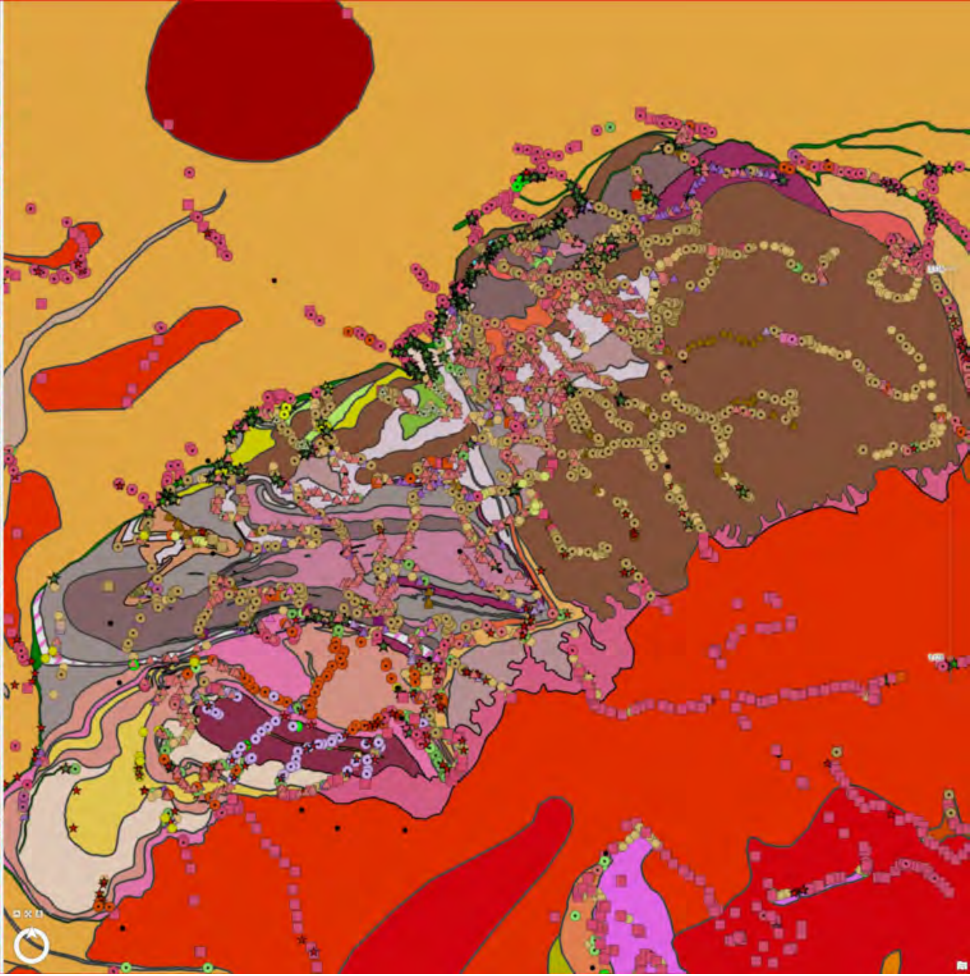


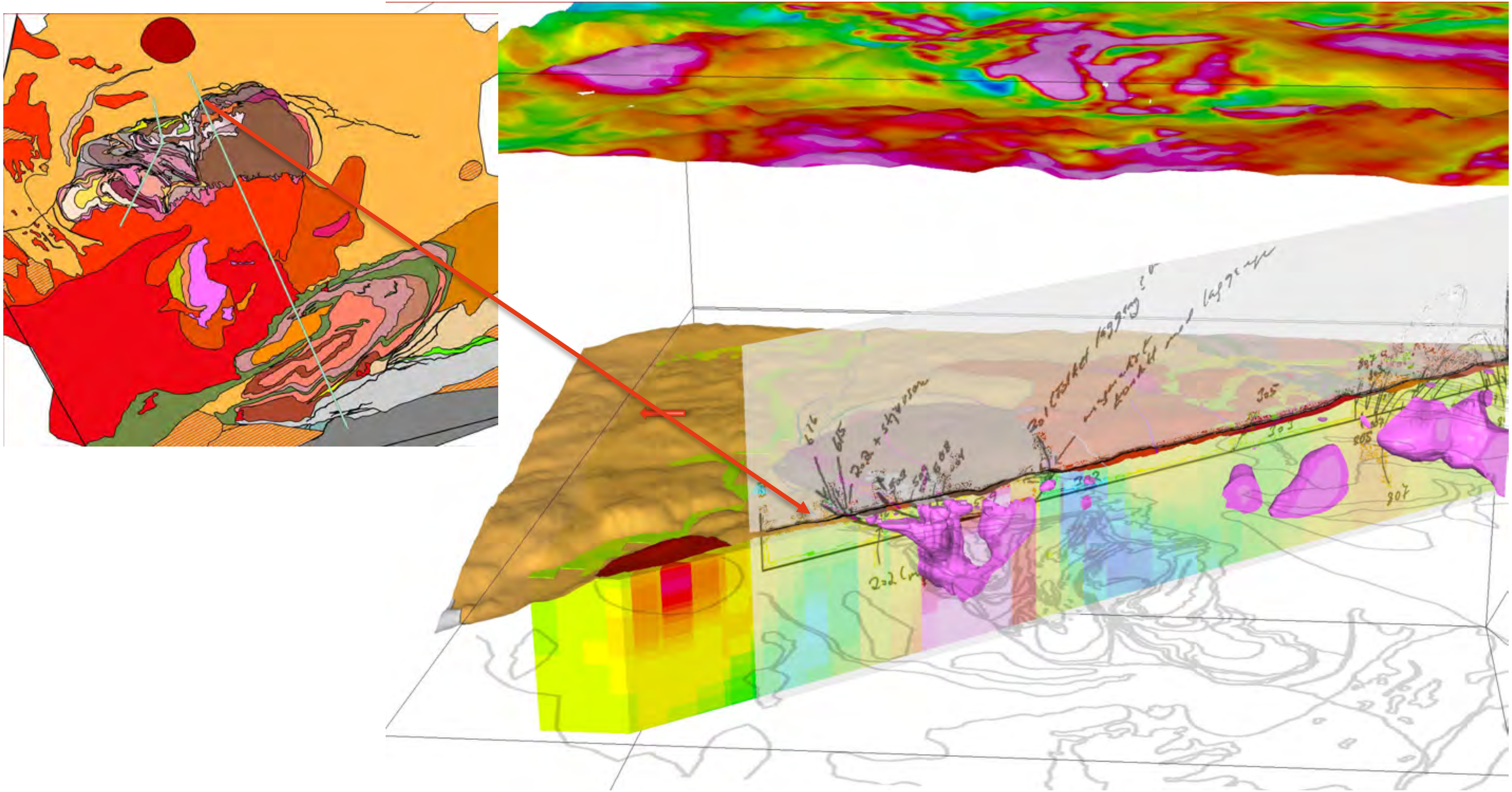
Uranium
Magnetics
Potassium
K
eTh
eU
ESEIDVATN
Plutonic Rocks
Granite and Quartz Monzonite
Porphyritic Granite
Diabase & Hybrid Granite
Supra Crustal Rocks
Quartzite
Amphibolite Schist
Basement Rocks
Telemark Gneiss
A. G. Sylvester



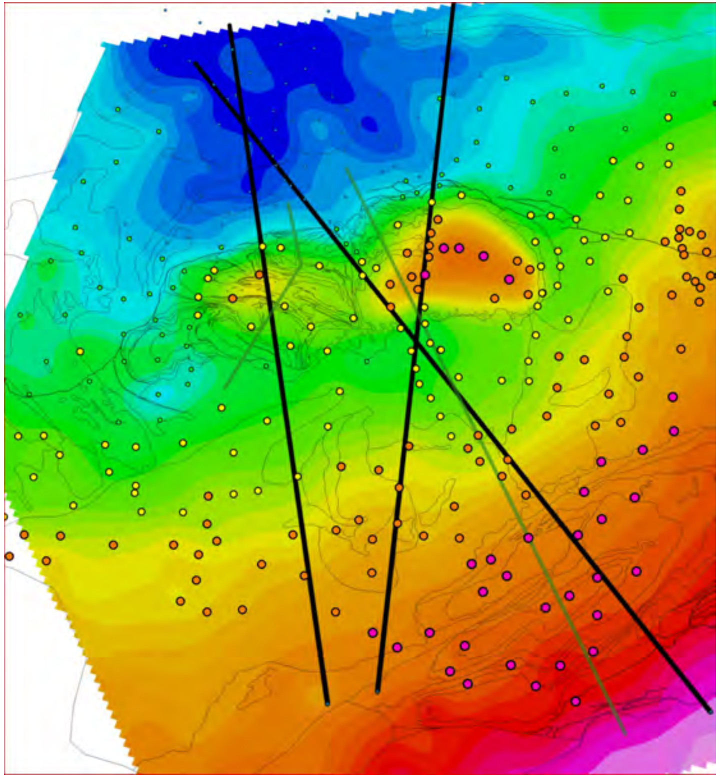


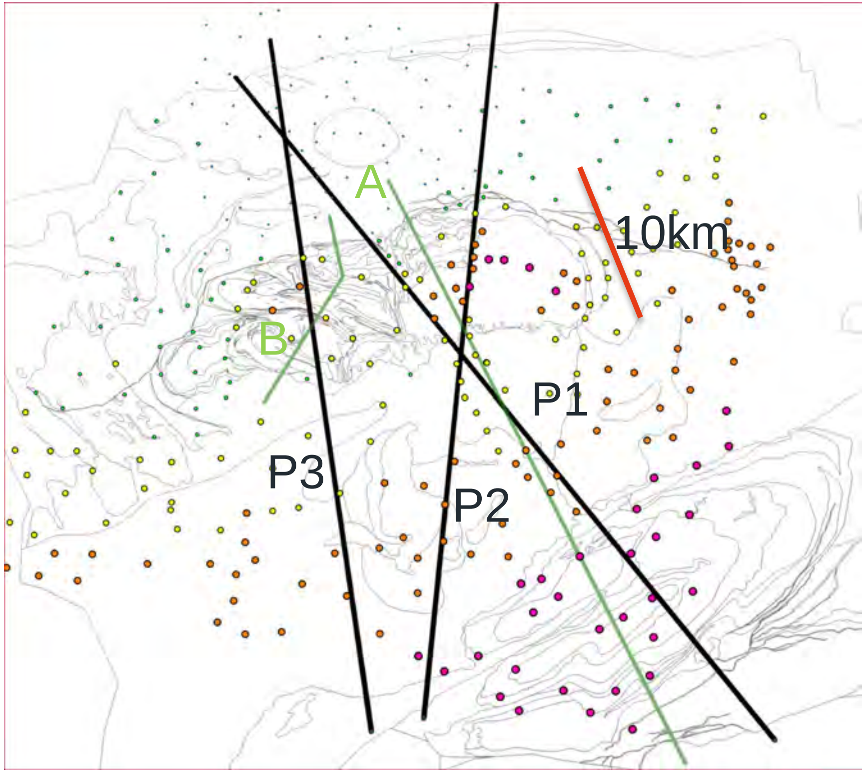






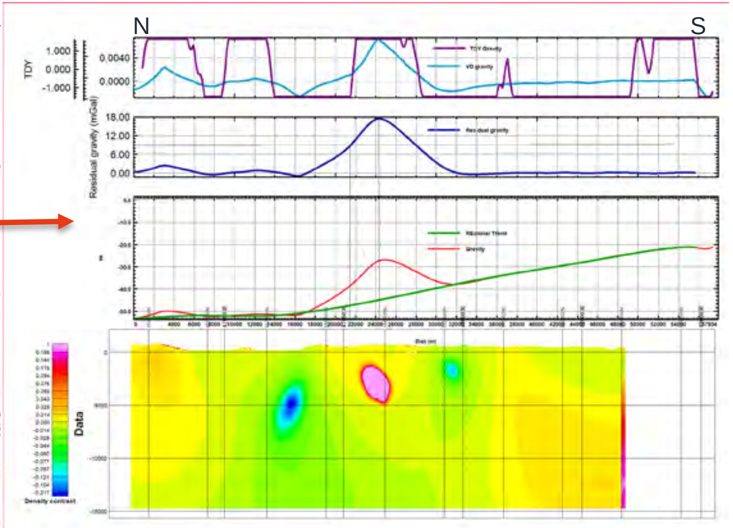
What about depth?

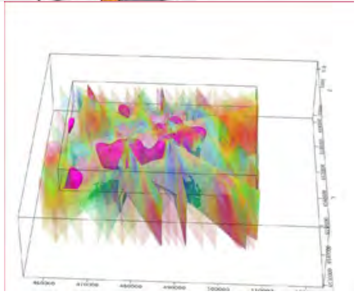


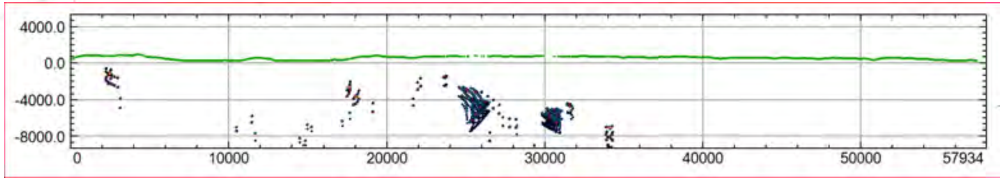


What about depth?

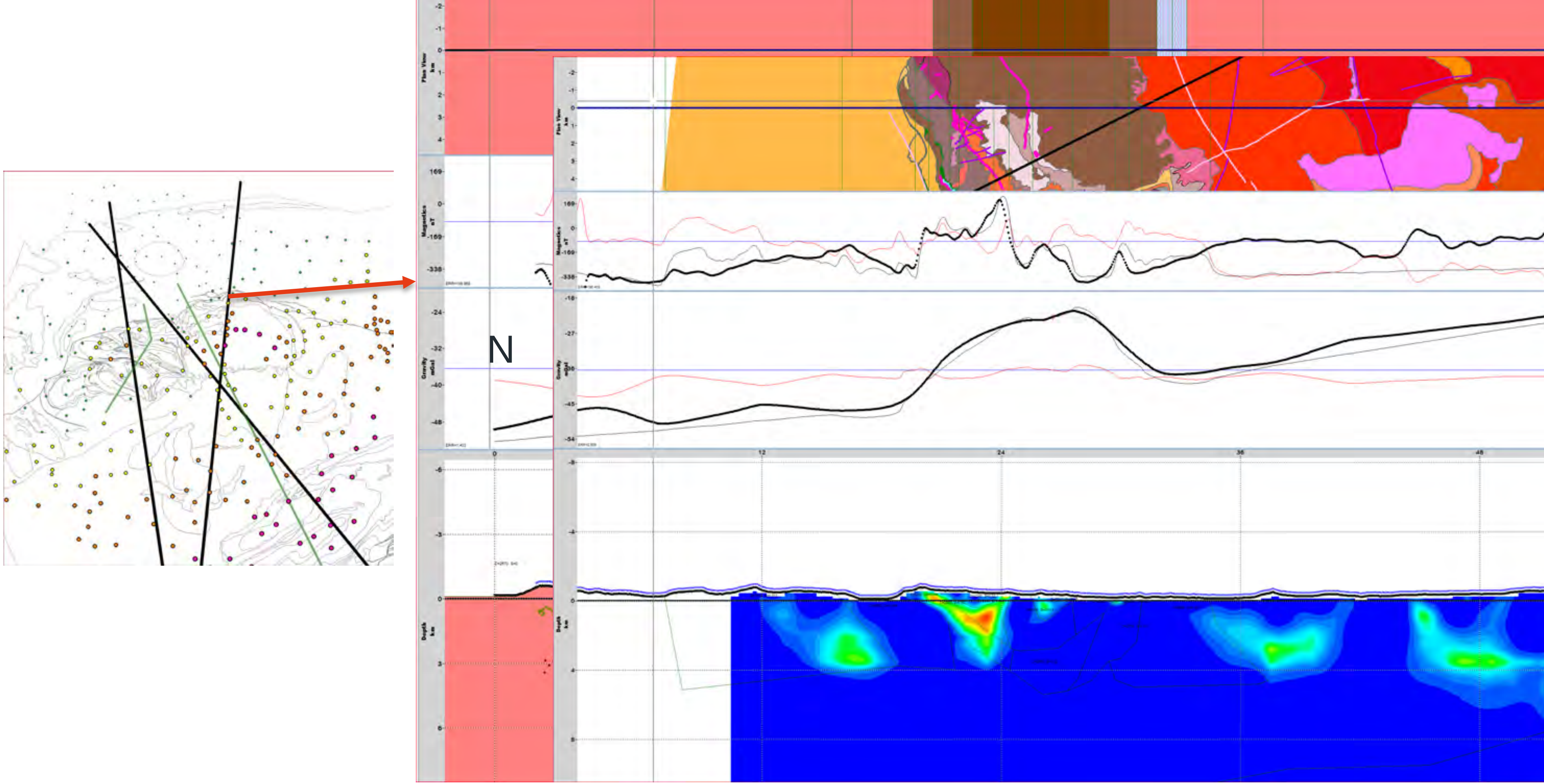
Density contrast 0.05-1 g/cm^3

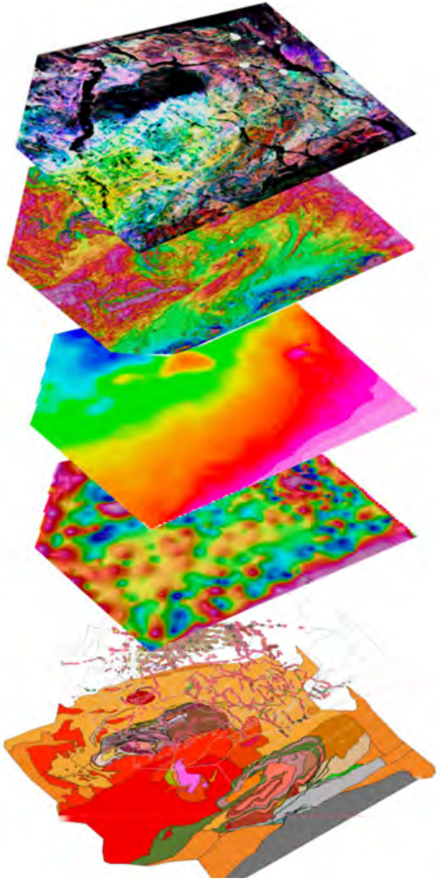




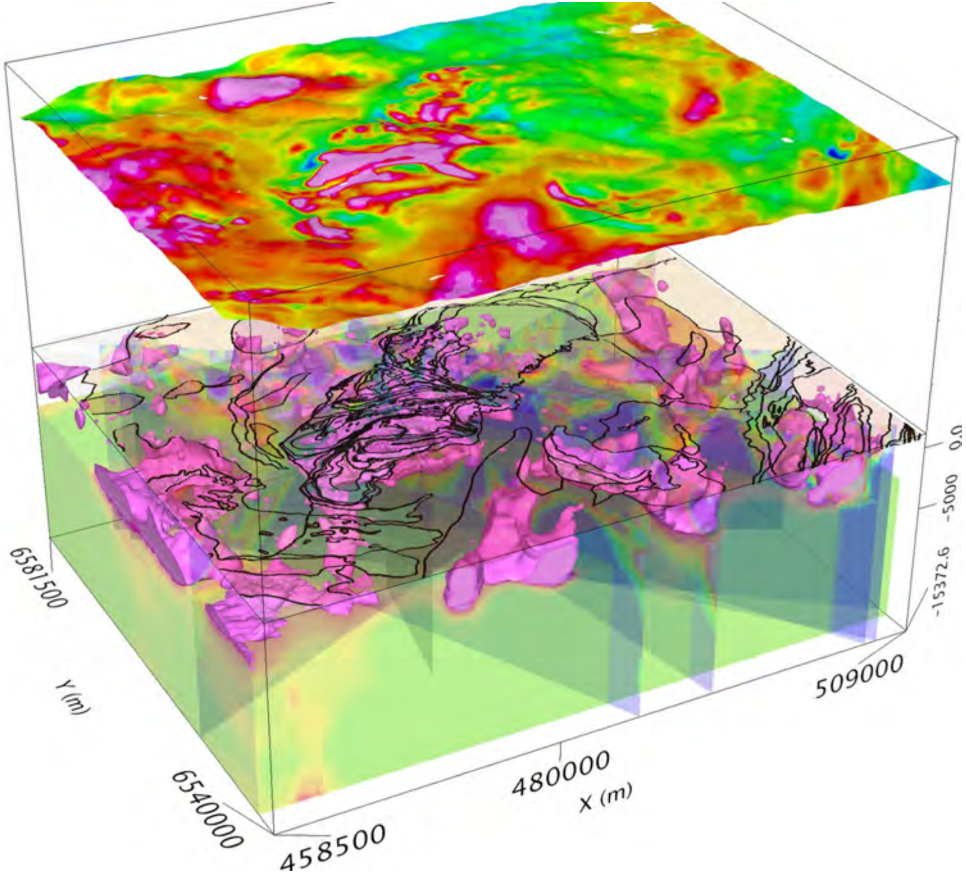


Werner deconvolution depth solutions


N
0
12
24
36
48



Surface Geology



Depth Model

NORWEGIAN JOURNAL OF GEOLOGY
https://dx.doi.org/10.17850/njg101-3-4

GEOLOGICAL SOCIETY OF NORWAY

CASE 2

Integrated 3D geophysical and geological modelling of the Kautokeino Greenstone Belt in Finnmark, northern Norway

Aziz Nasuti[1], Odleiv Olesen[1], Yuriy Maystrenko[1], Alexandros Stampolidis[2], Vikas C. Baranwal[1]

[1]Geological Survey of Norway, P.O.Box 6315 Torgarden, 7491 Trondheim, Norway
[2]Geophysical Laboratory, Aristotle University of Thessaloniki, GR 540 06, Thessaloniki, Greece.

E-mail corresponding author (Aziz Nasuti): aziz.nasuti@ngu.no

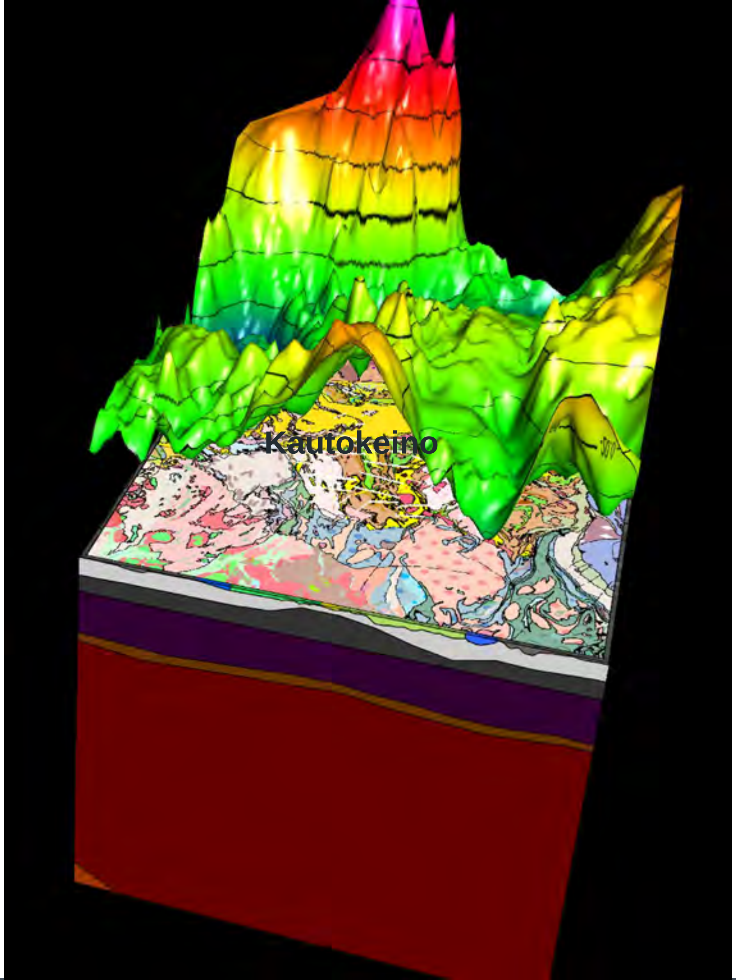
Keywords:
- *Kautokeino Greenstone Belt*
- *Finnmark*
- *3D geophysical modelling*
- *Gravity and magnetic data*
- *Northern Norway*

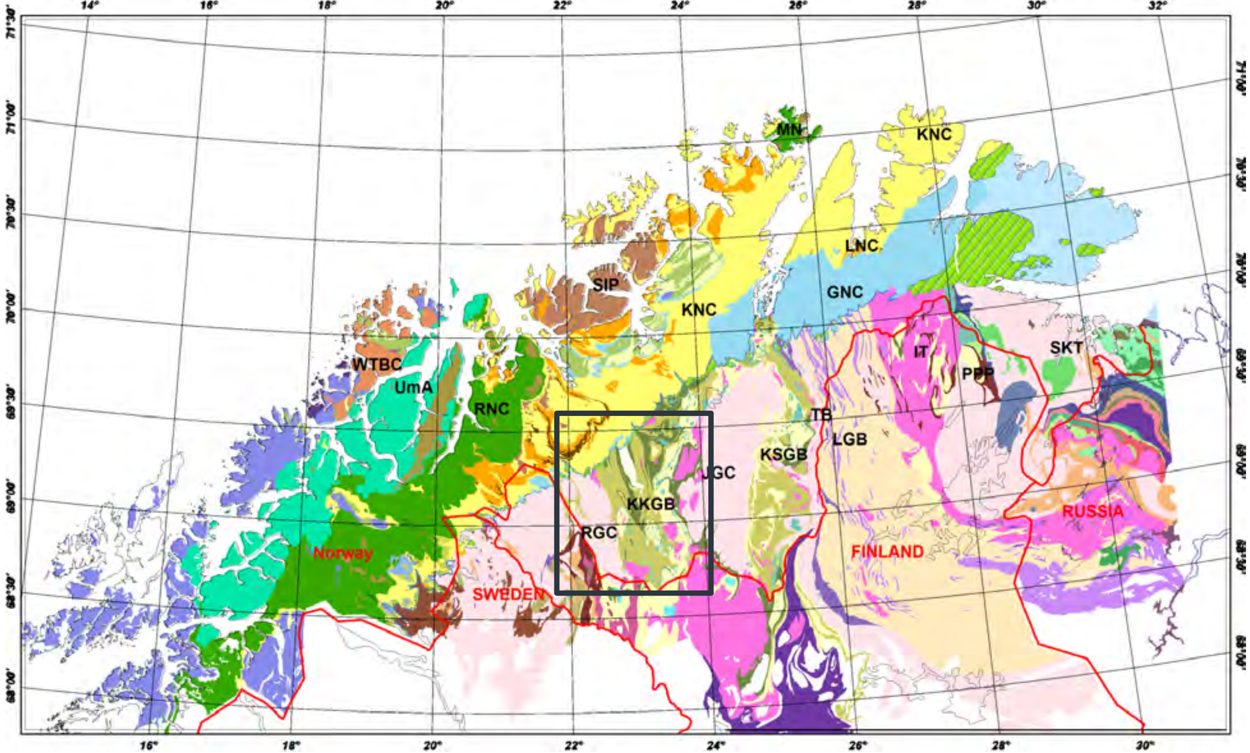
Received:
23. April 2021

Accepted:
5. October 2021

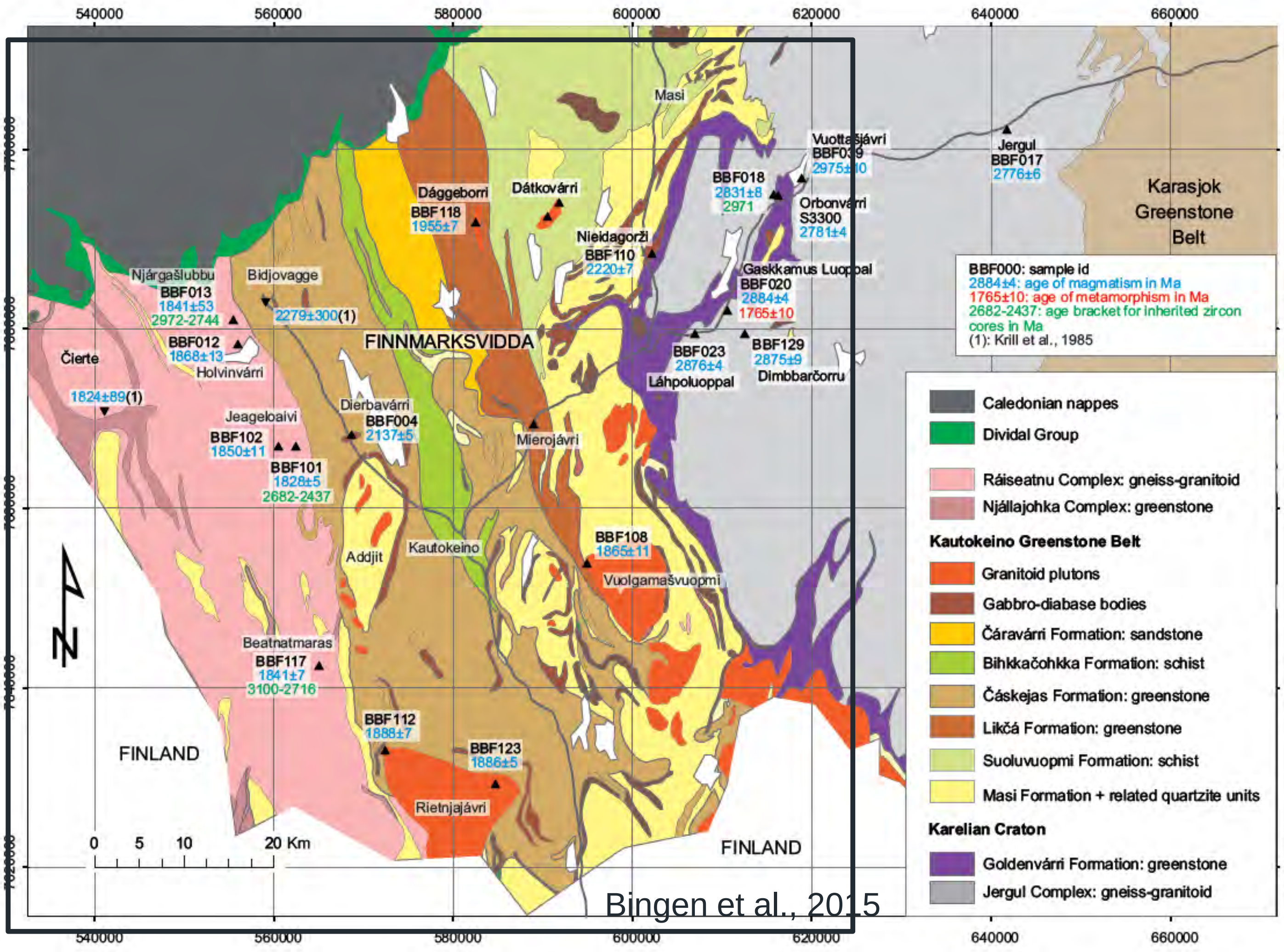
Published online:
12. January 2022

A new 3D crustal-scale model has been created for the Kautokeino Greenstone Belt (KKGB) in northern Norway based on 3D density modelling and aeromagnetic data, integrated with qualitative interpretation of geophysical and geological data. Detailed geophysical analyses and their integration with an existing petrophysical database allowed us to identify and interconnect shallow and deeper structures throughout the study area. To have better control on the regional tectonic setting of the KKGB, the model area has been extended to include the northern part of Finland and Sweden. The new 3D density model reveals that the KKGB is broader than supposed previously. The 3D analysis indicates that the belt reaches depths of approximately 5–6 km and is emplaced as a highly deformed structure between the Archaean Jergul Gneiss Complex (JGC) to the east and the Rommaeno Gneiss Complex (RoGC) in Finland to the west. The Ráiseatnu Gneiss Complex (RaGC) in the western part of the KKGB is characterised by a dominant NNW–SSE magnetic trend that is sub-parallel to the main trend of the KKGB. Moreover, the RaGC is similar to the KKGB in terms of the presence of a large number of sub-parallel magnetic anomalies. This gneiss complex shows mostly short-wavelength anomalies and some circular anomalies that differ from the more subdued and irregular anomaly pattern of the JGC and RoGC. In the new 3D model, the RaGC is assumed to constitute a migmatised part of the Kautokeino Greenstone Belt. At a large scale, this Proterozoic greenstone belt has some similarities to Archaean counterparts, where most of the deformation is caused by gravitational tectonics. This study shows that careful integration of geological and geophysical data can strongly improve the 3D understanding of the complex, poorly exposed, Precambrian terranes of the Finn-marksvidda region in Norway.

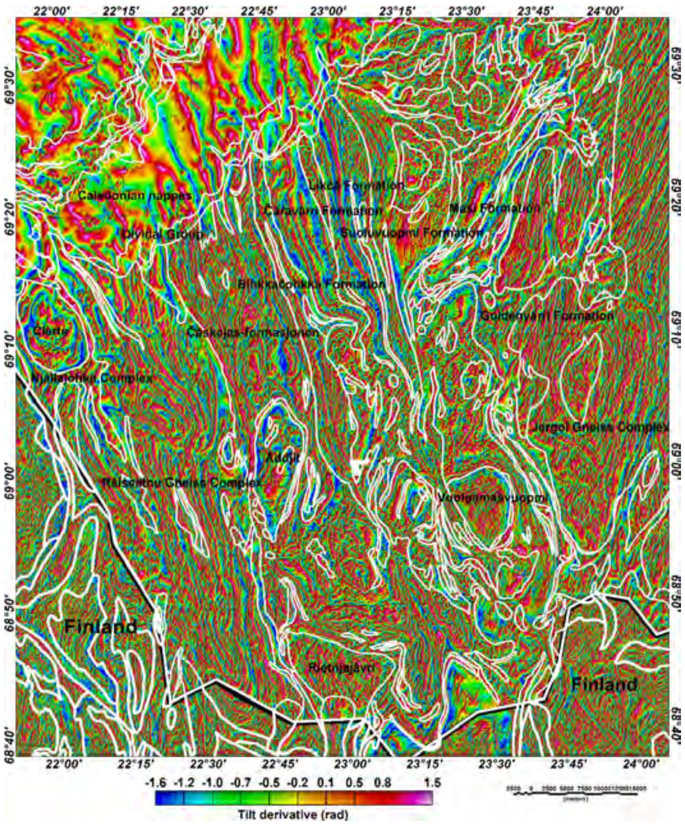


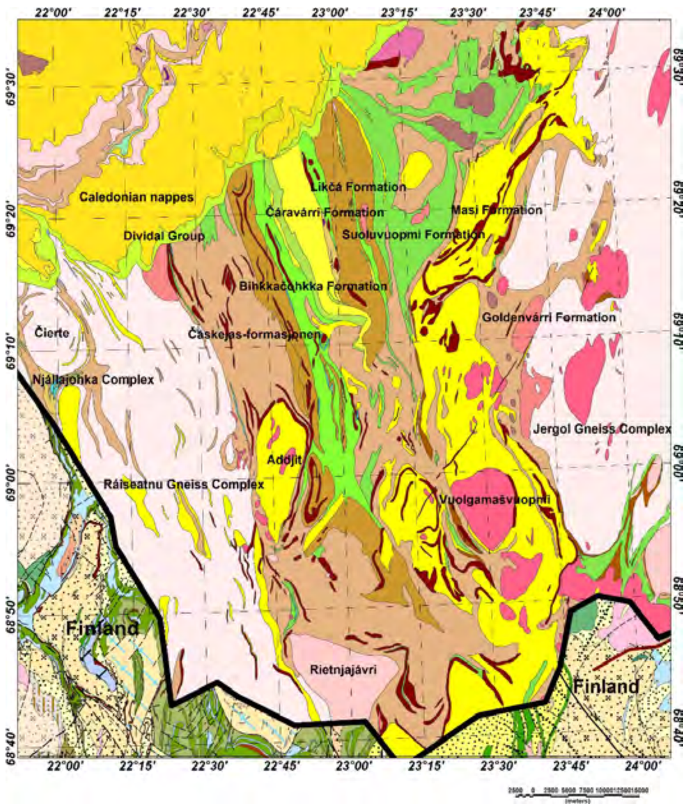


GNC: Gaissa Nappe Complex ; IT: Inari Terrane; KKGB: Kautokeino Greenstone Belt ; KNC: Kalak Nappe Complex ; KSGB: Karasjok Greenstone Belt; LGB: Lapland Granulite Belt; MN: Magerøy Nappe; LNC: Laksefjord Nappe Complex ; PPP: Polmak-Pasvik-Pechenga greenstone belt RGC:Ráiseatnu Gneiss Complex ; RNC: Reisa Nappe Complex ; SIB: Seiland Igneous Province ; SKT: Sørvaranger-Kola Terrane UmA: Uppermost Allochthon ; WTBC: West Troms Basement Complex



Bingen et al., 2015


22°00' 22°15' 22°30' 22°45' 23°00' 23°15' 23°30' 23°45' 24°00'
69°30' 69°20' 69°10' 69°00' 68°50' 68°40'
Caledonian nappes
Dividal Group
Likčá Formation
Čáravárri Formation
Masi Formation
Suoluvuopmi Formation
Bihkkačohkka Formation
Goldenvárri Formation
Čierte
Čáskejas-formasjonen
Njállajohka Complex
Jergol Gneiss Complex
Addjit
Ráiseatnu Gneiss Complex
Vuolgamašvuopmi
Finland
Rietnjajávri
Finland
-1.6 -1.2 -1.0 -0.7 -0.5 -0.2 0.1 0.5 0.8 1.5
Tilt derivative (rad)


22°00' 22°15' 22°30' 22°45' 23°00' 23°15' 23°30' 23°45' 24°00'
69°30' 69°20' 69°10' 69°00' 68°50' 68°40'
Caledonian nappes
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Likčá Formation
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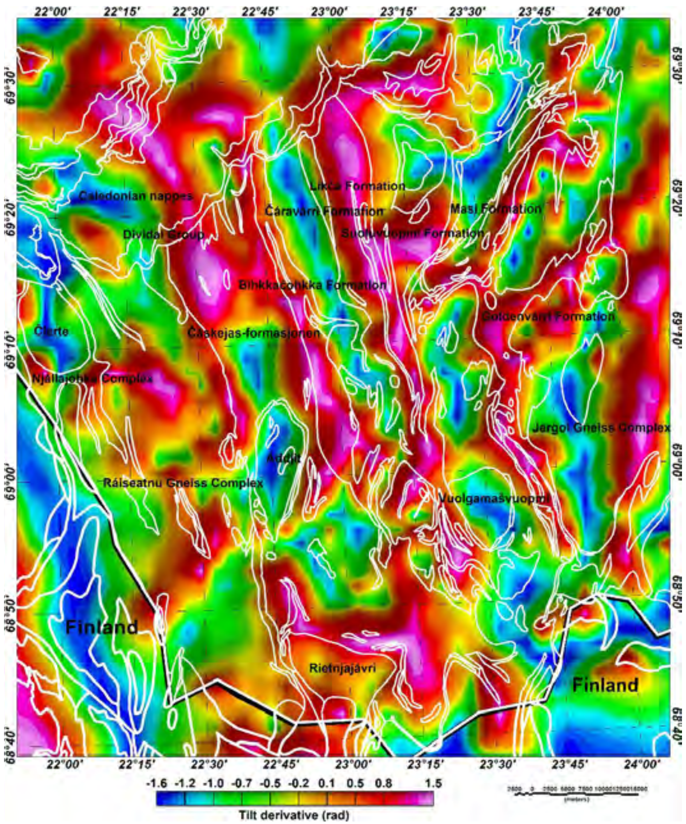
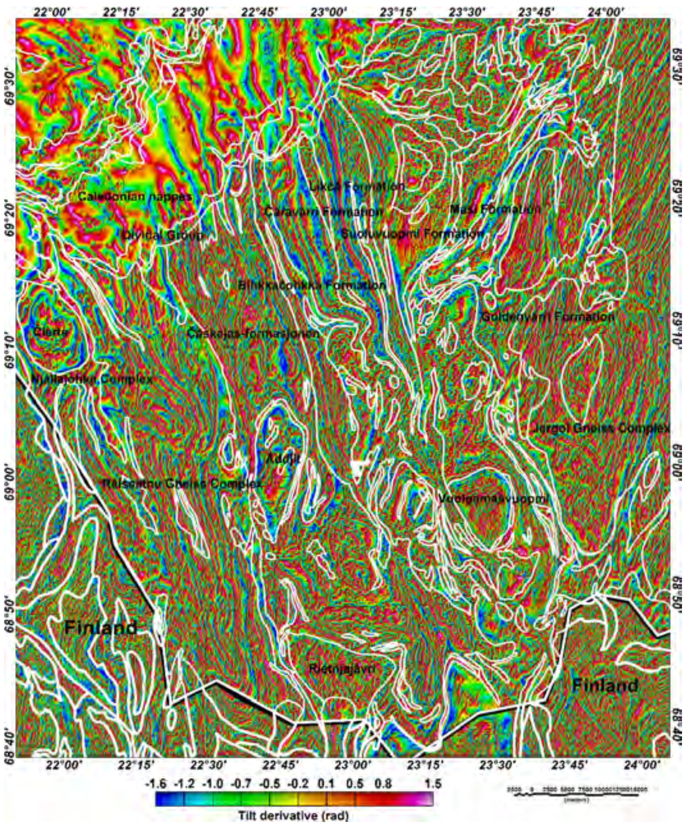
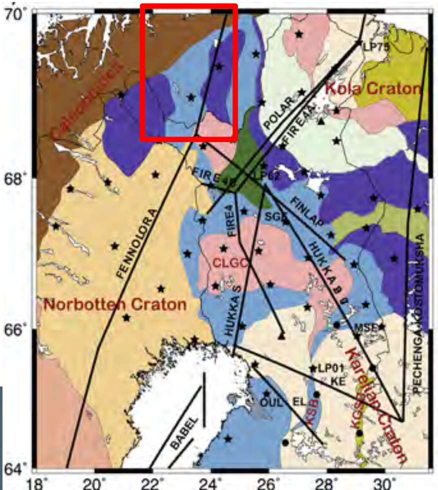
Vuolgamašvuopmi
Finland
Rietnjajávri
Finland



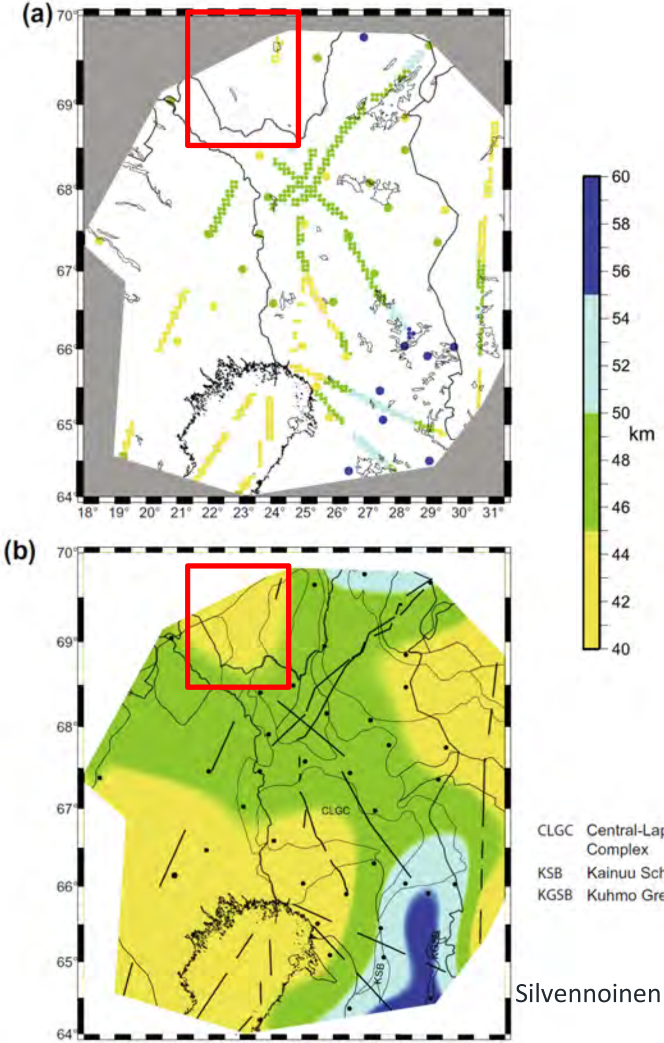
Gravity



Magnetic



★ POLENET/LAPNET broad-band station
▲ POLENET/LAPNET short period station
● SVEKALAPKO broadband station with PRF included into this study from Kozlovskaya et al. (2008)

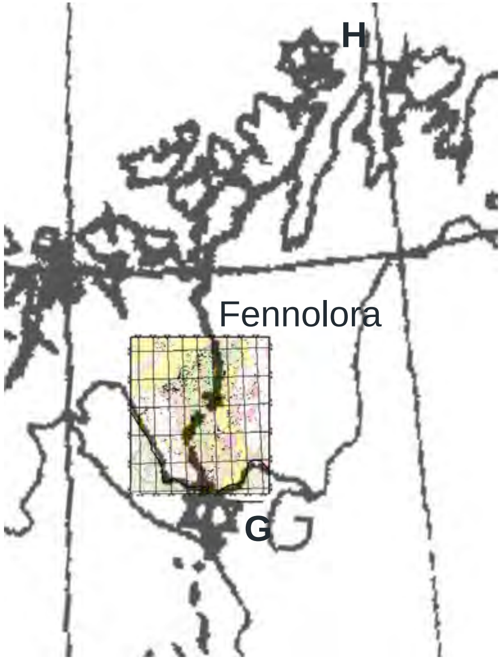


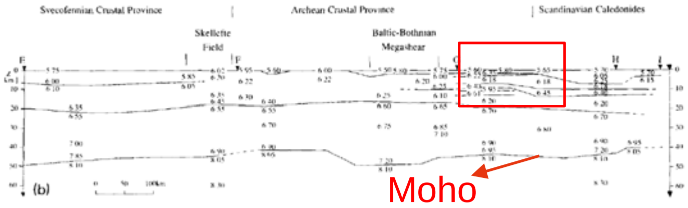
CLGC Central-Lapland Granitoid Complex

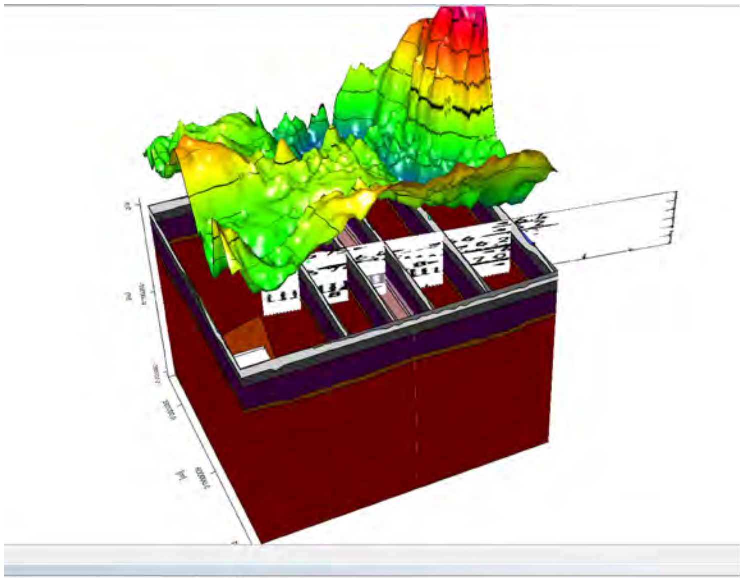
KSB Kainuu Schist Belt

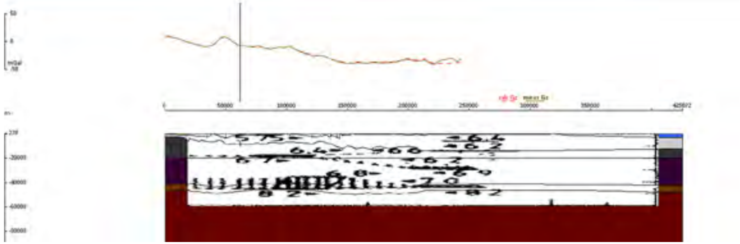
KGSB Kuhmo Greenstone Belt

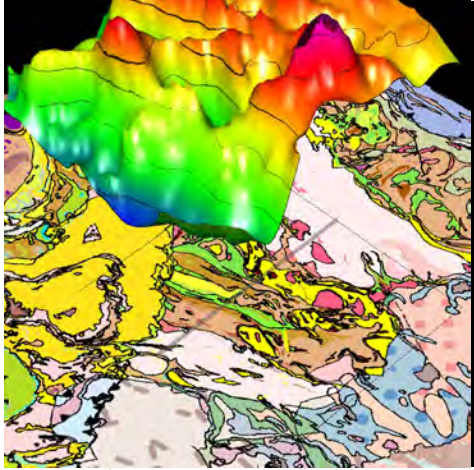
Silvennoinen et al., 2014

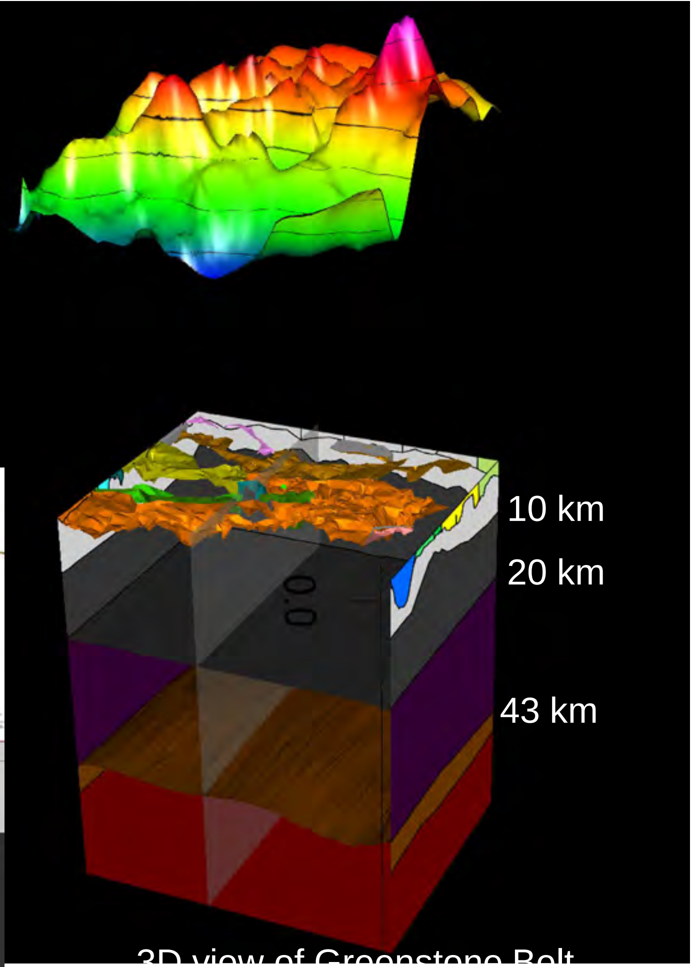

H
Fennolora
G


Svecofennian Crustal Province
Archean Crustal Province
Scandinavian Caledonides
Skellefte Field
Baltic-Bothnian Megashear
(b)
Moho

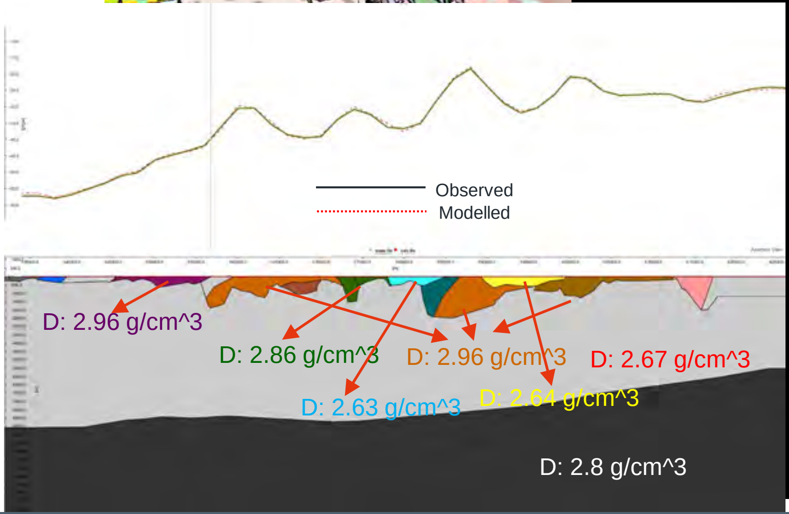






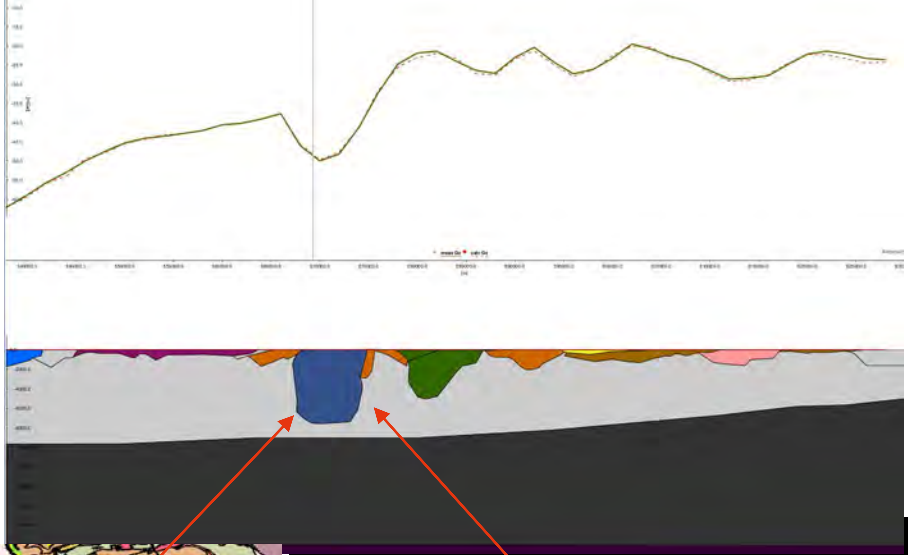


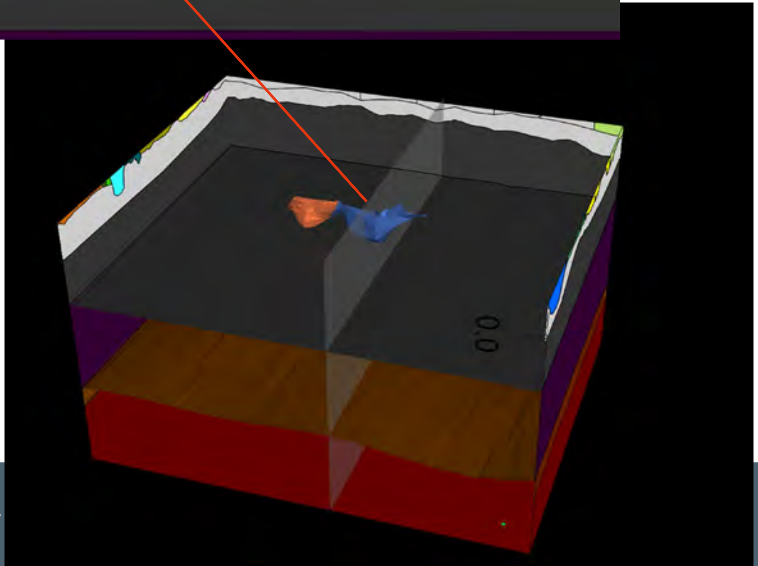
10 km
20 km
43 km
0.0
3D view of Greenstone Belt

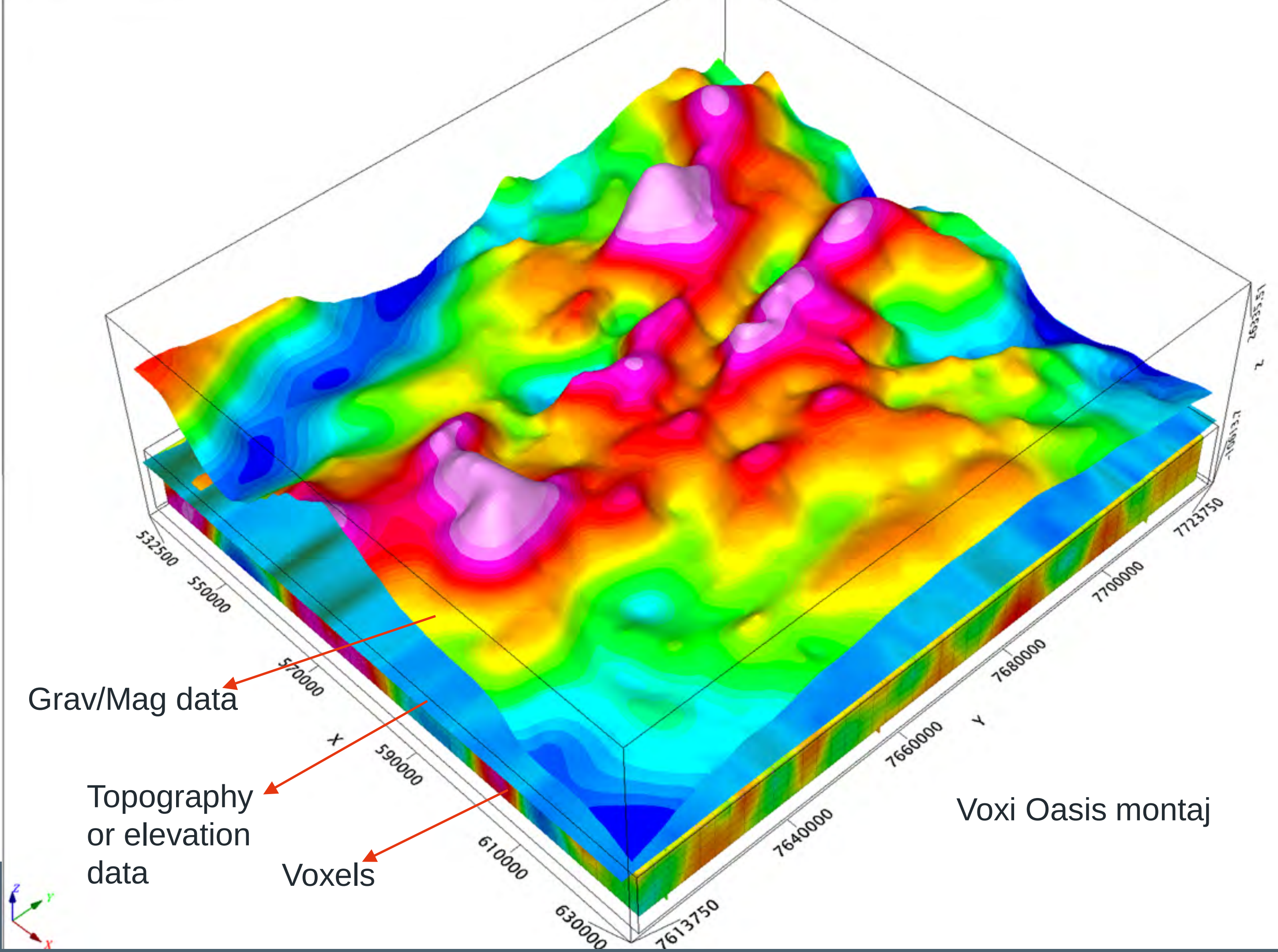


Observed
Modelled
D: 2.96 g/cm^3
D: 2.86 g/cm^3
D: 2.96 g/cm^3
D: 2.67 g/cm^3
D: 2.63 g/cm^3
D: 2.64 g/cm^3
D: 2.8 g/cm^3

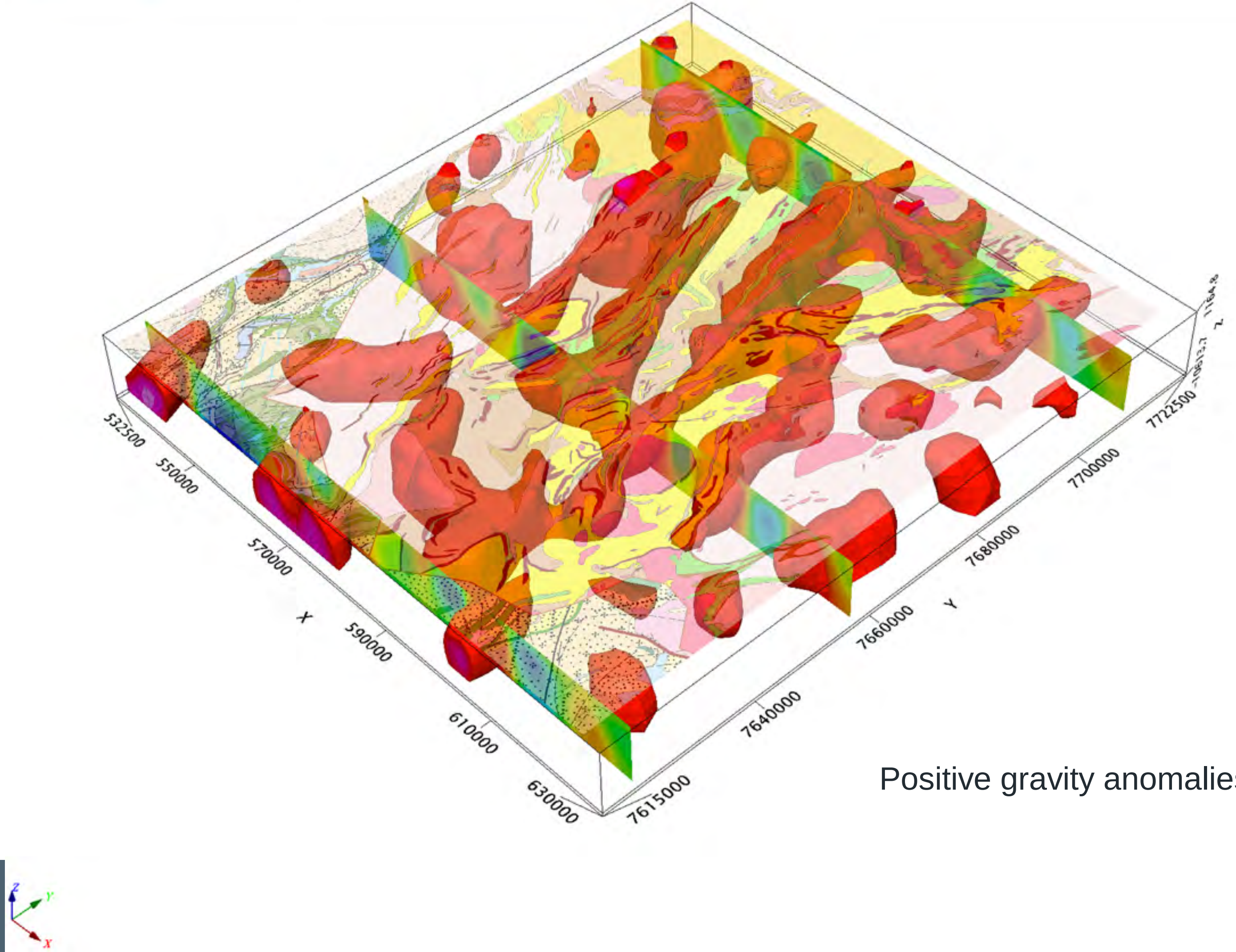
Addijt Formation



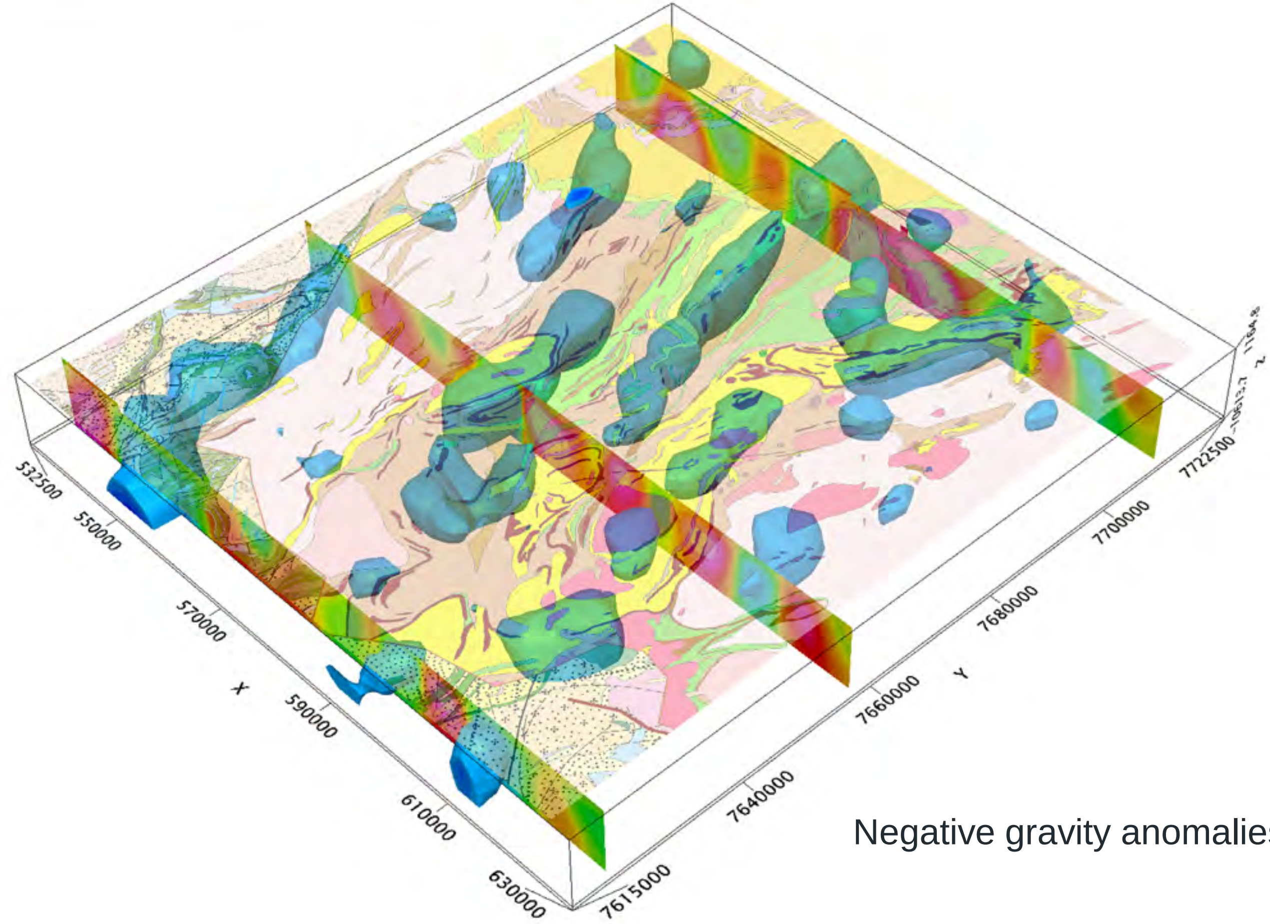




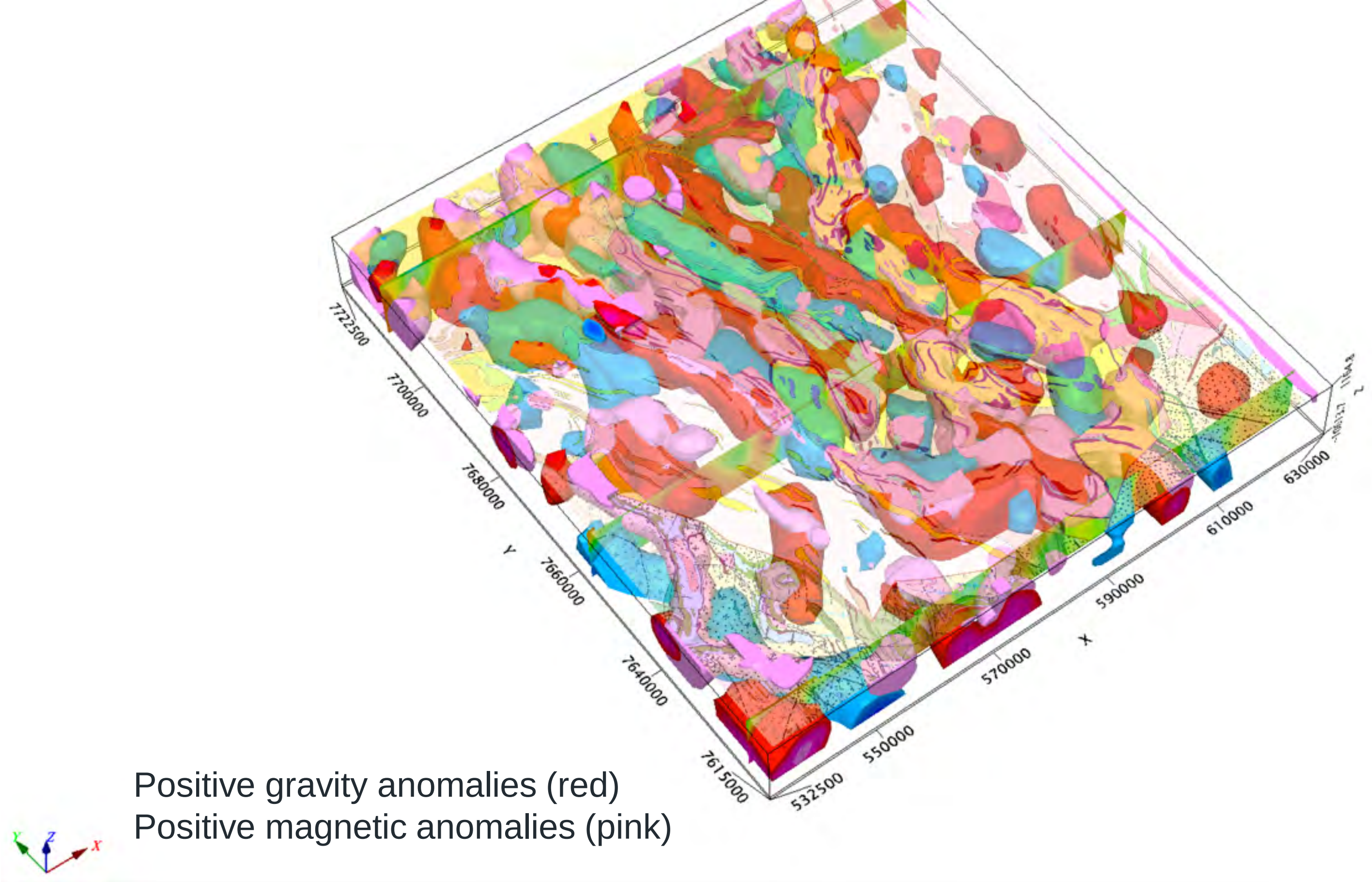
Grav/Mag data
Topography or elevation data
Voxels
Voxi Oasis montaj
532500
550000
570000
590000
610000
630000
X
7613750
7640000
7660000
7680000
7700000
7723750
Y



Positive gravity anomalies



Negative gravity anomalies



Positive gravity anomalies (red)
Positive magnetic anomalies (pink)

3D density modelling

CASE 3

NEONOR2

AGU PUBLICATIONS

JGR

Journal of Geophysical Research: Solid Earth

RESEARCH ARTICLE

10.1002/2016JB013443

Deep structure of the Lofoten-Vesterålen segment of the Mid-Norwegian continental margin and adjacent areas derived from 3-D density modeling

Y. P. Maystrenko[1], O. Olesen[1], L. Gernigon[1], and S. Gradmann[1]

[1]Geological Survey of Norway (NGU), Trondheim, Norway

Key Points:

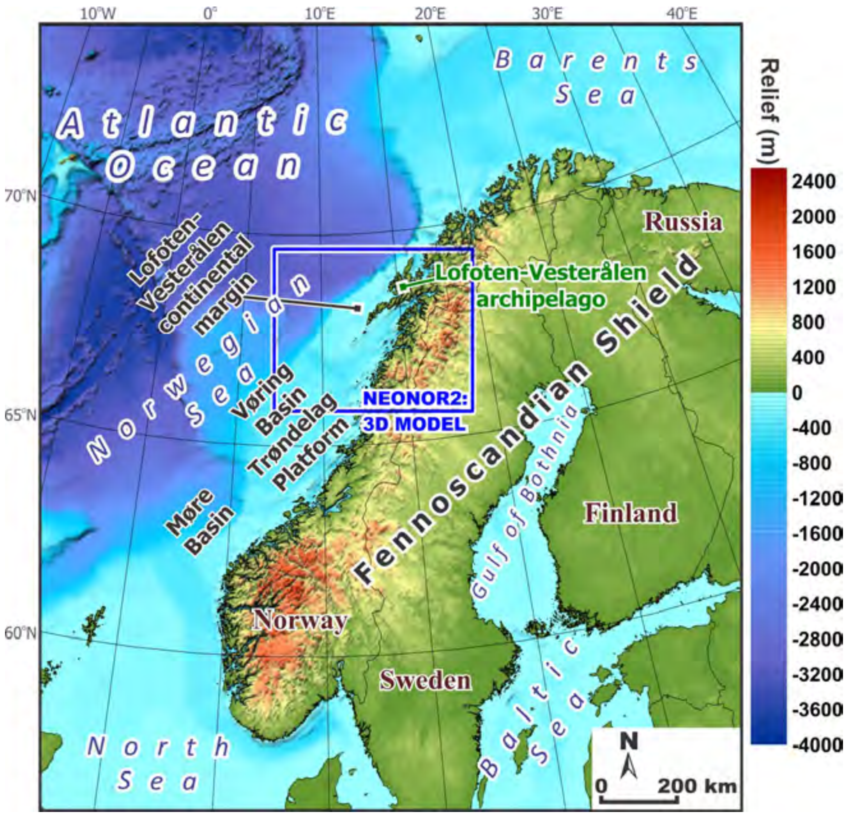
- Three-dimensional structural/density lithosphere-scale model
- Thick sedimentary succession within the Røst Basin
- Low-density mantle beneath the Lofoten-Vesterålen continental margin

Correspondence to:
Y. P. Maystrenko,
yuriy.maystrenko@ngu.no

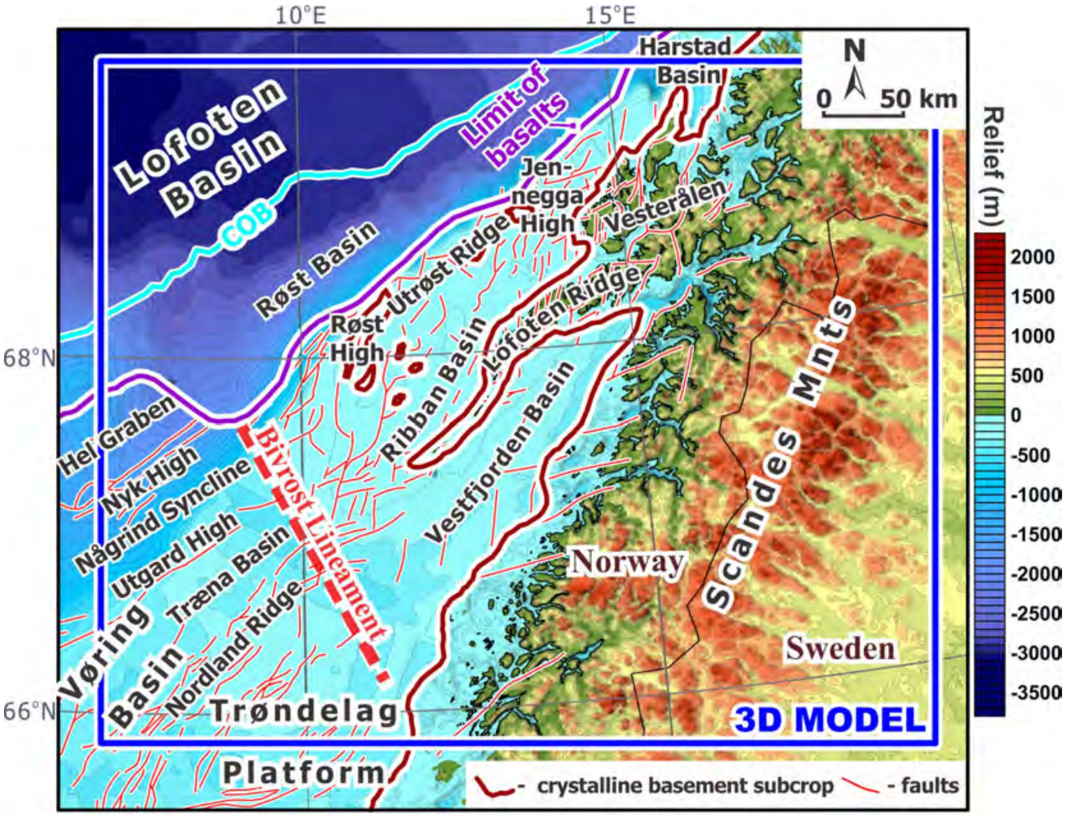
Citation:
Maystrenko, Y. P., O. Olesen, L. Gernigon, and S. Gradmann (2017), Deep structure of the Lofoten-Vesterålen segment of the Mid-Norwegian continental margin and adjacent areas derived from 3-D density modeling, *J. Geophys. Res. Solid Earth*, *122*, 1402–1433, doi:10.1002/2016JB013443.

Received 4 AUG 2016
Accepted 28 DEC 2016
Accepted article online 30 DEC 2016
Published online 3 FEB 2017

Abstract To understand the major structural features of the sedimentary cover and crystalline crust of the Lofoten-Vesterålen margin and the northern part of the Vøring segment of the Mid-Norwegian continental margin, a lithosphere-scale 3-D structural model has been constructed. This model extends from the exposed crystalline rocks of the Fennoscandian Shield in the east to the Cenozoic oceanic domain of the Norwegian-Greenland Sea in the west, covering the Vestfjorden, Ribban, and Røst Basins and the northern parts of the Vøring Basin and Trøndelag Platform. All available published and/or released data have been used to set the initial 3-D model which has been validated by means of 3-D density forward modeling to obtain a gravity-consistent 3-D structural/density model. Results from the 3-D density modeling reveal that relatively thick sedimentary rocks are present in the distal Røst Basin below the lava flows. The presence of a low-density more than 20 km thick granitic body has been modeled within the middle-upper crystalline crust beneath the eastern part of the Vestfjorden Basin and the adjacent mainland. Moreover, the results of the 3-D density modeling indicate the presence of an atypical low-density lithospheric mantle beneath a large part of the Lofoten-Vesterålen margin which is required to fit the regional component of the modeled gravity with the observed one. The pronounced crustal feature within the model area is the Bivrost Lineament that appears to be the deeply seated lithosphere-scale boundary that delineates clearly the Lofoten-Vesterålen segment from the Vøring margin showing contrasting densities and crustal thicknesses.

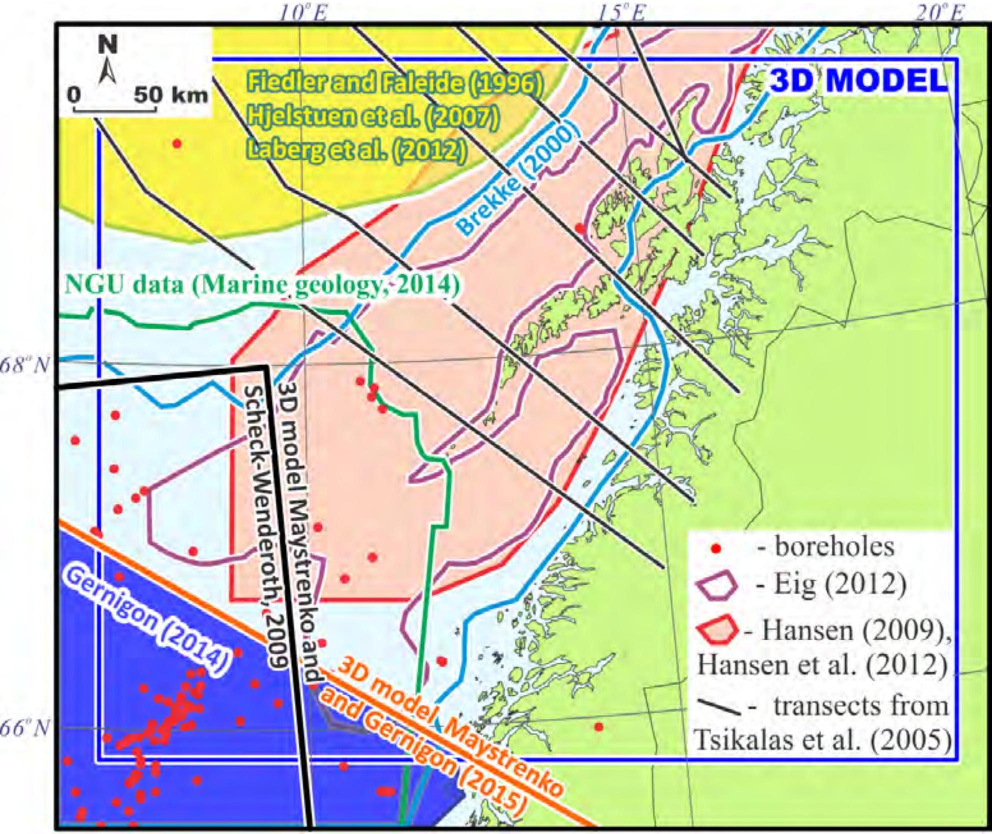


Study area: tectonic settings

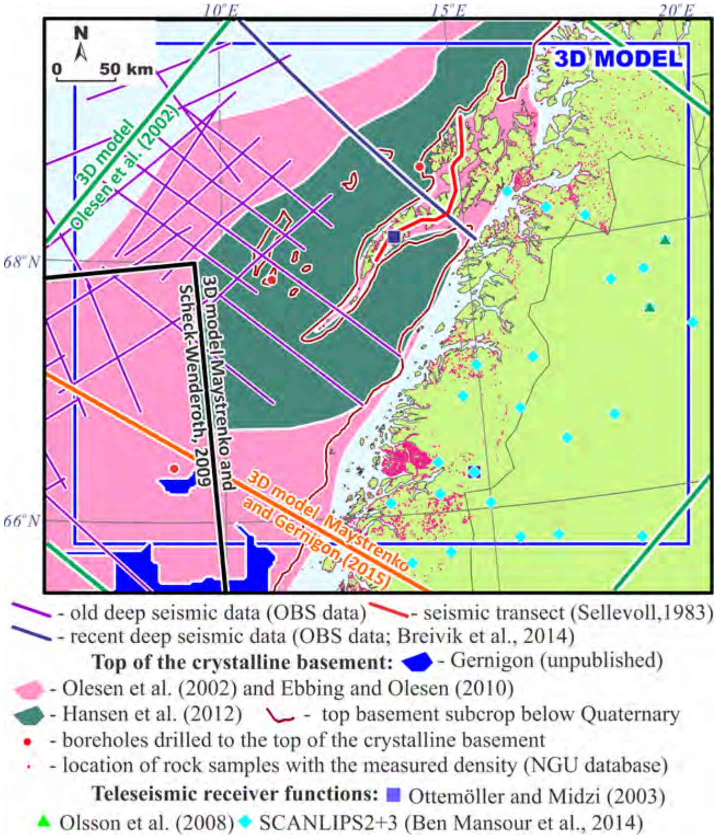


(COB – continent-ocean boundary)

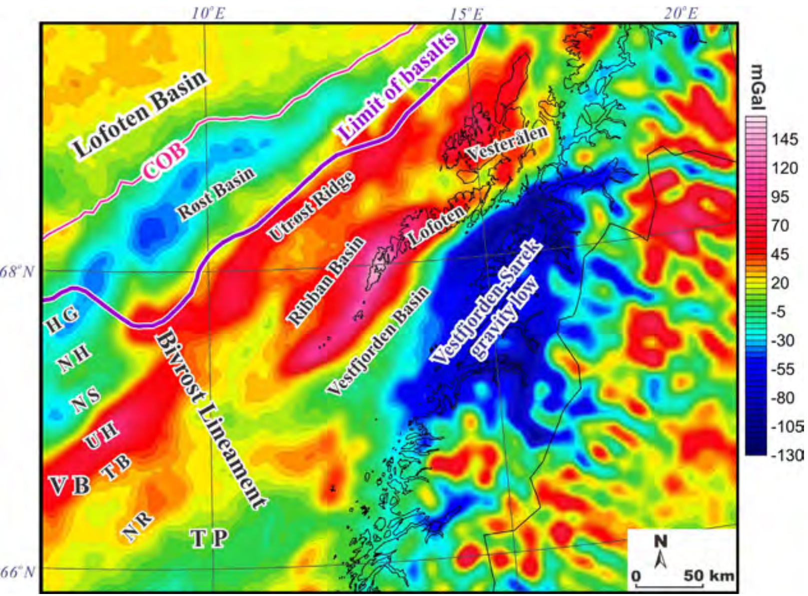
Datasets for sediments



Datasets for crystalline crust

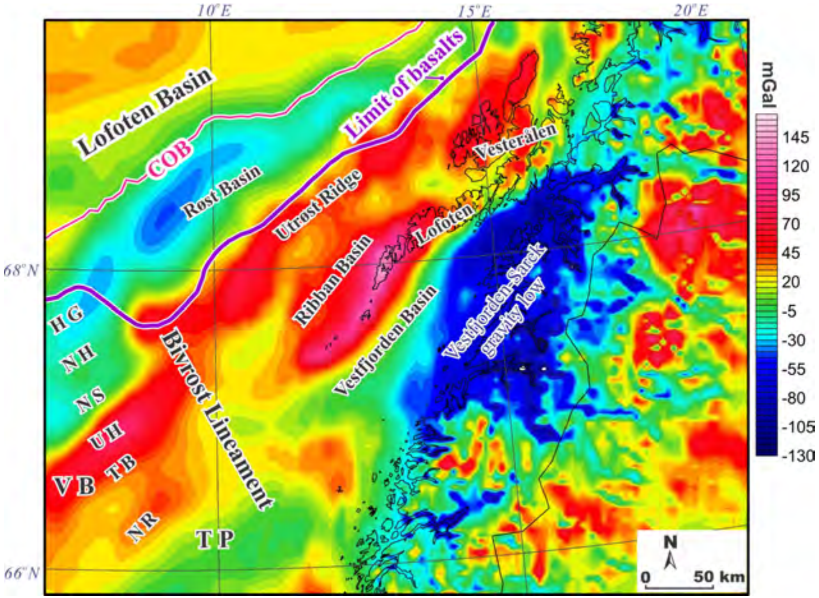


Observed Gravity field



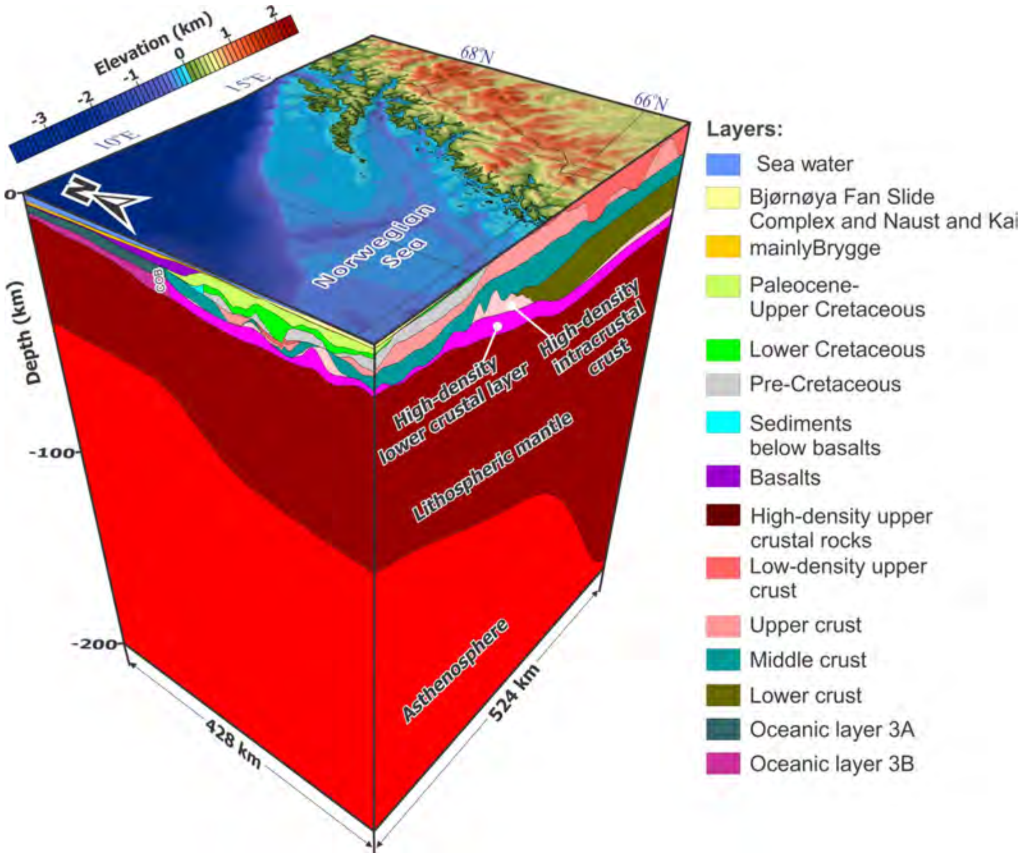
Observed gravity field
Free-Air gravity anomalies (Andersen et al., 2013)

Modelled Gravity field



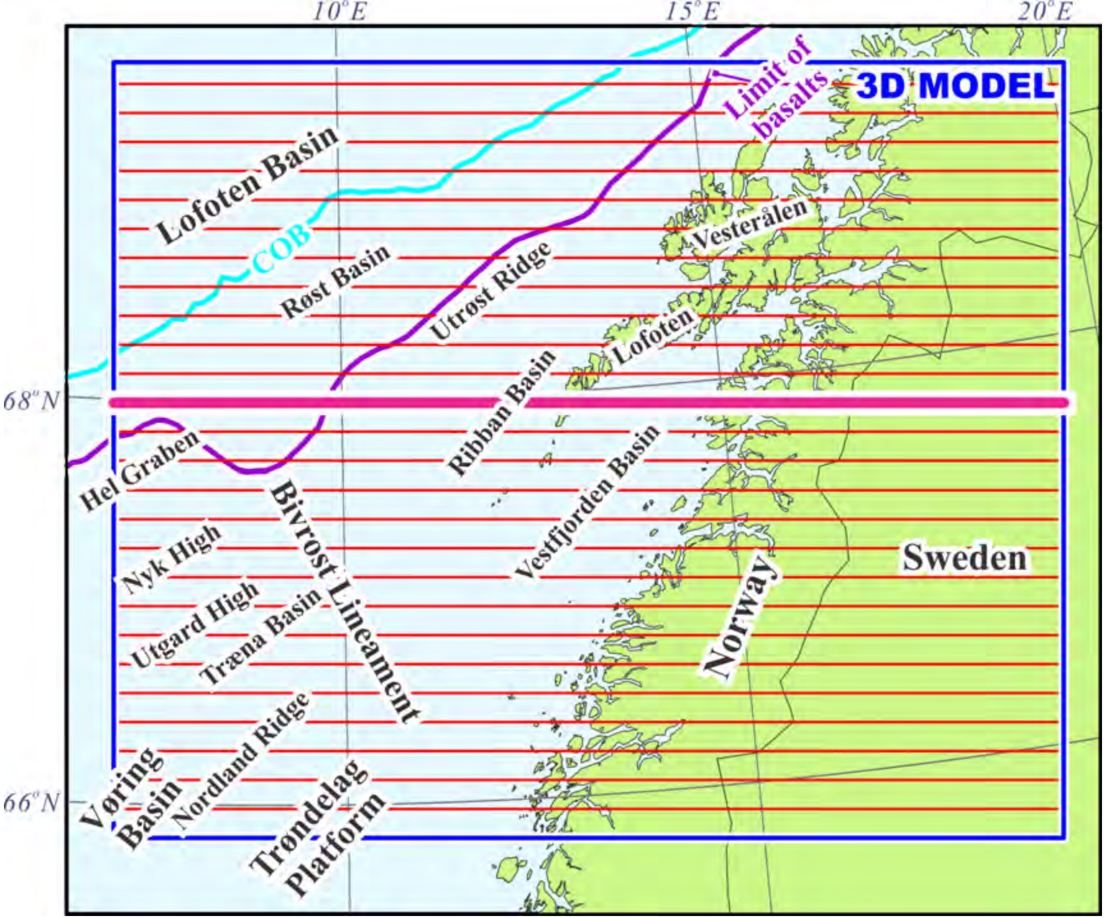
Calculated gravity field Modelled gravity response of the 3D density/structural model

3D density/structural model

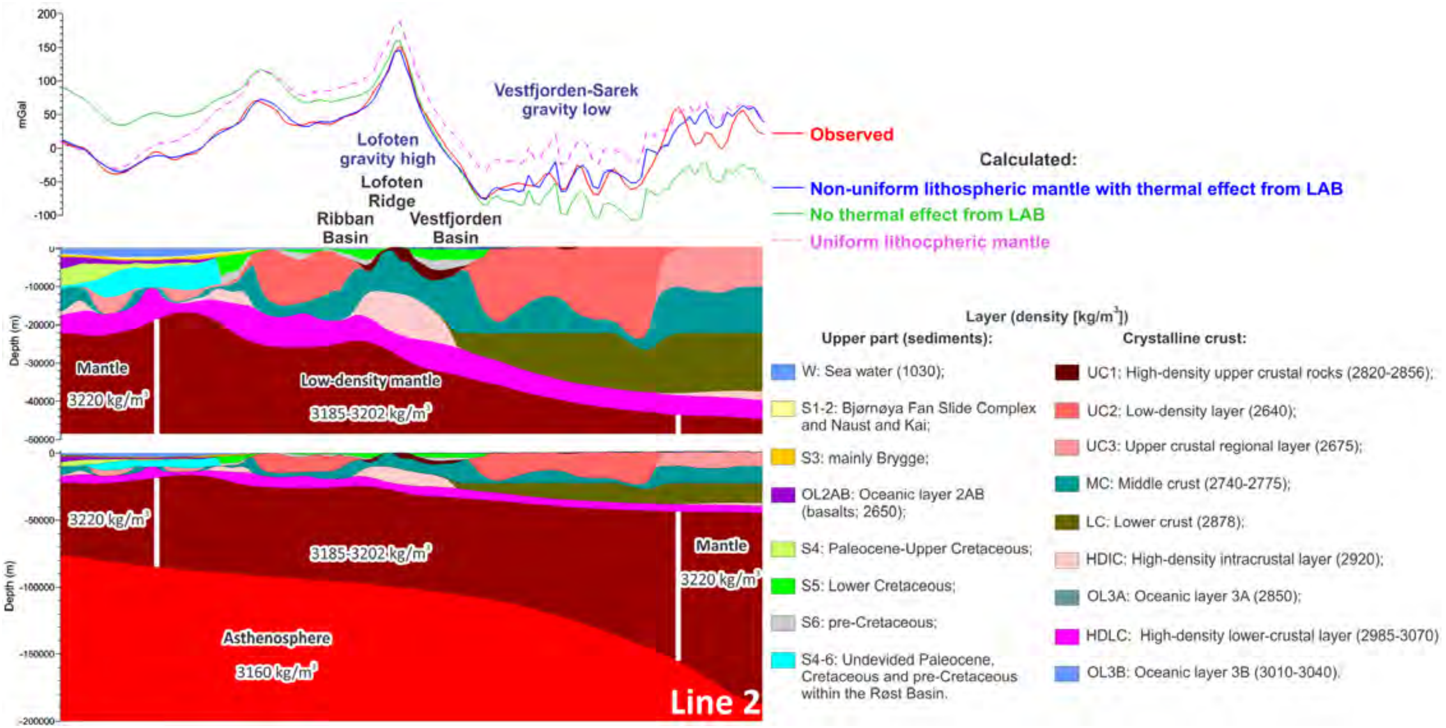


2D vertical slices

Location of the selected vertical slices

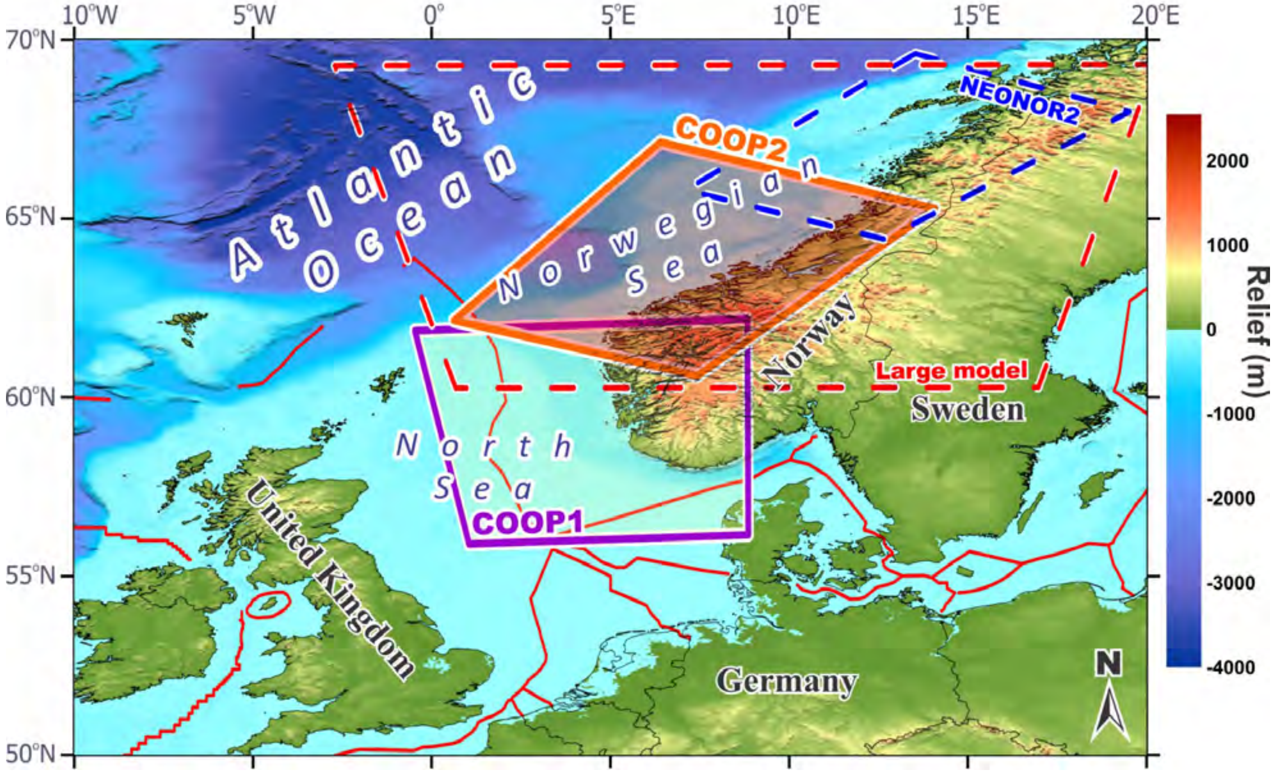


2D vertical slices



Vertical slice trough the middle part of the 3D density model

Crustal Onshore-Offshore Projects



Northwestern Europe **(bathymetry and topography from IOC, IHO, BODC 2003)**

Geophysical Journal International

Geophys. J. Int. (2018) **212,** 1696–1721 doi: 10.1093/gji/ggx491
Advance Access publication 2017 November 14
GJI Geodynamics and tectonics

Deep structure of the Mid-Norwegian continental margin (the Vøring and Møre basins) according to 3-D density and magnetic modelling

Yuriy Petrovich Maystrenko, Laurent Gernigon, Aziz Nasuti and Odleiv Olesen

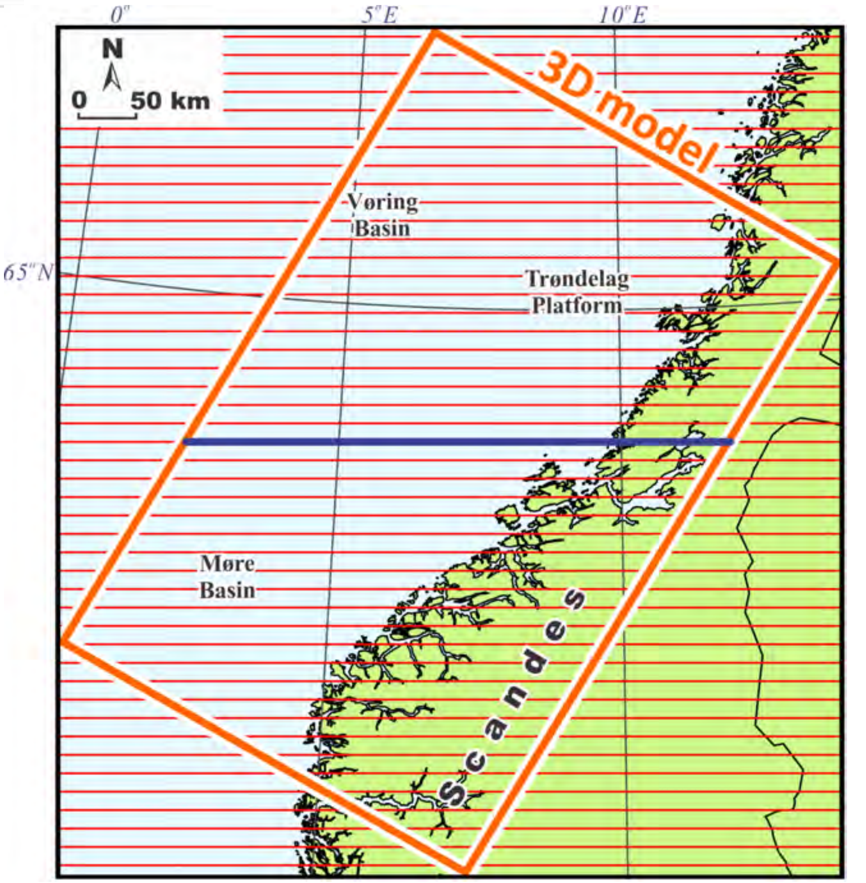
Geological Survey of Norway, Leiv Eirikssons vei 39, 7040 Trondheim, Norway. E-mail: yuriy.maystrenko@ngu.no

Accepted 2017 November 13. Received 2017 November 8; in original form 2017 February 10

SUMMARY

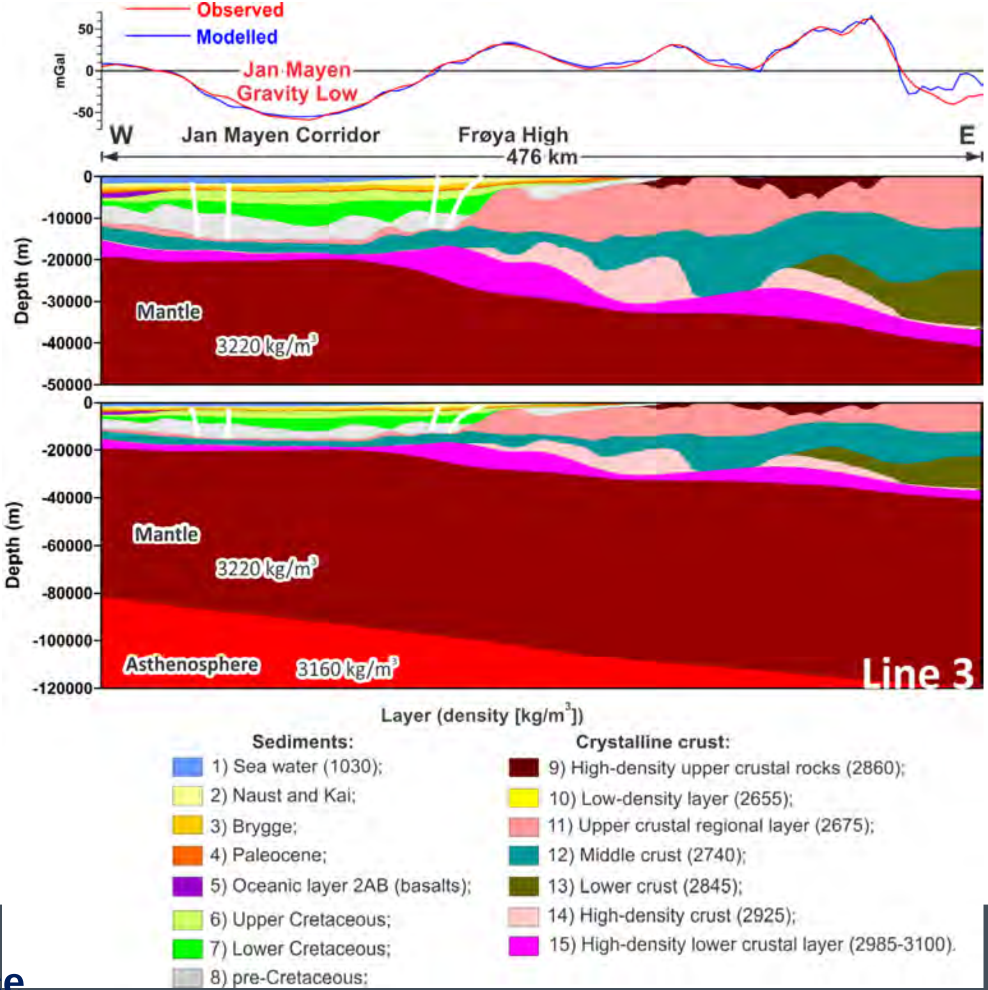
A lithosphere-scale 3-D density/magnetic structural model of the Møre and Vøring segments of the Mid-Norwegian continental margin and the adjacent areas of the Norwegian mainland has been constructed by using both published, publically available data sets and confidential data, validated by the 3-D density and magnetic modelling. The obtained Moho topography clearly correlates with the major tectonic units of the study area where a deep Moho corresponds to the base of the Precambrian continental crust and the shallower one is located in close proximity to the younger oceanic lithospheric domain. The 3-D density modelling agrees with previous studies which indicate the presence of a high-density/high-velocity lower-crustal layer beneath the Mid-Norwegian continental margin. The broad Jan Mayen Corridor gravity low is partially related to the decreasing density of the sedimentary layers within the Jan Mayen Corridor and also has to be considered in relation to a possible low-density composition-and/or temperature-related zone in the lithospheric mantle. According to the results of the 3-D magnetic modelling, the absence of a strong magnetic anomaly over the Utgard High indicates that the uplifted crystalline rocks are not so magnetic there, supporting a suggestion that the entire crystalline crust has a low magnetization beneath the greater part of the Vøring Basin and the northern part of the Møre Basin. On the contrary, the crystalline crust is much more magnetic beneath the Trøndelag Platform, the southern part of the Møre Basin and within the mainland, reaching a culmination at the Frøya High where the most intensive magnetic anomaly is observed within the study area.

Key words: Composition and structure of the continental crust; Gravity anomalies and Earth structure; Europe; Magnetic anomalies: modelling and interpretation; Numerical modelling; Continental margins: divergent.



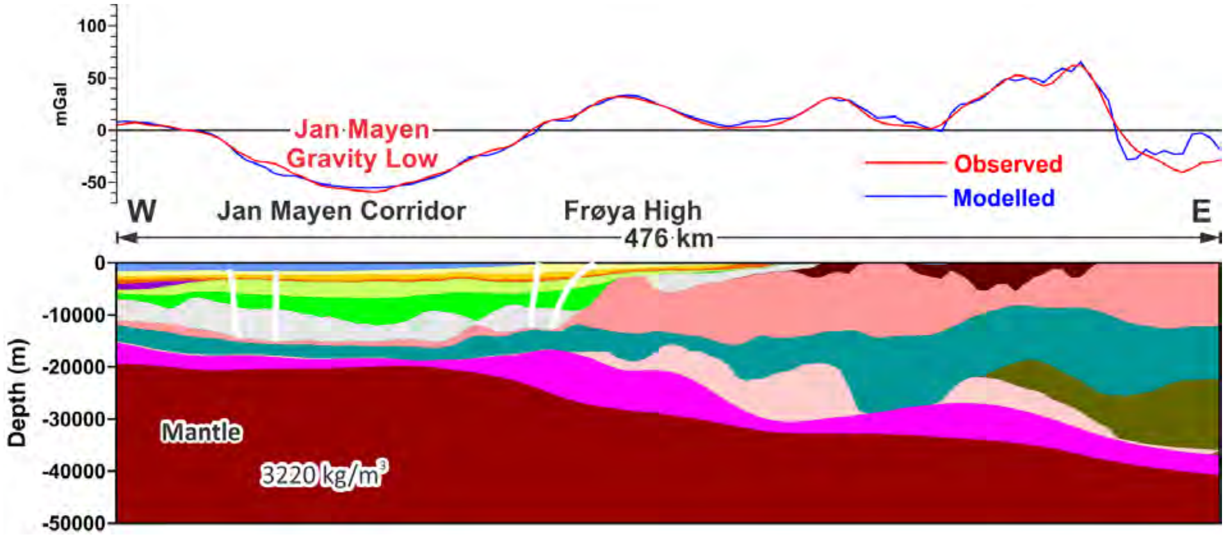
Location of the 2D vertical slices through the 3D density model

2D vertical slices



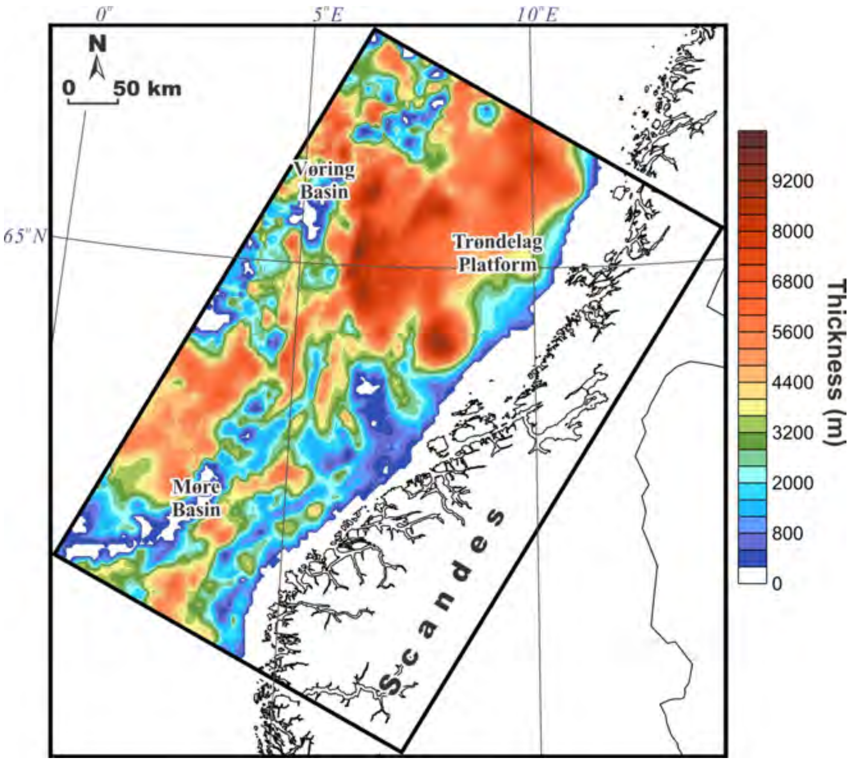
Selected vertical slice

2D vertical slices

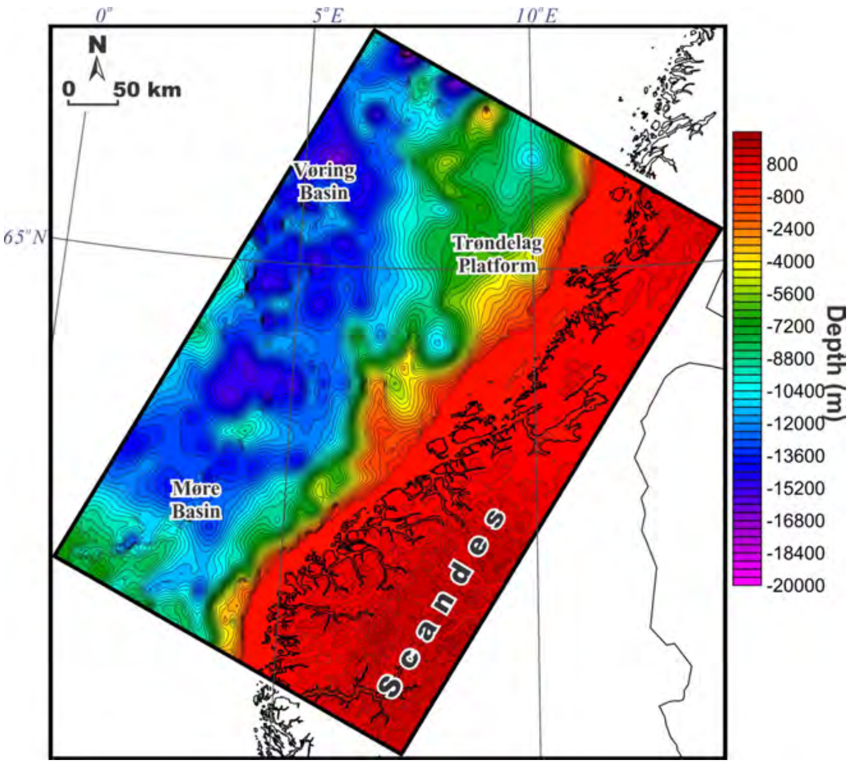


Gravity effect of the oceanic domain

Sediments: thickness map

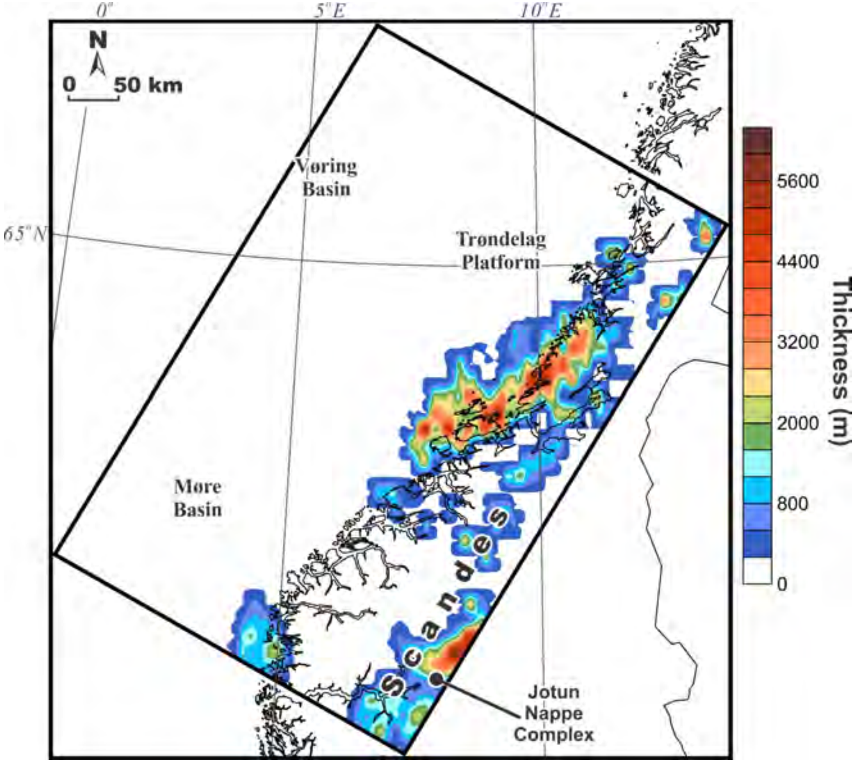


Top of the crystalline crust



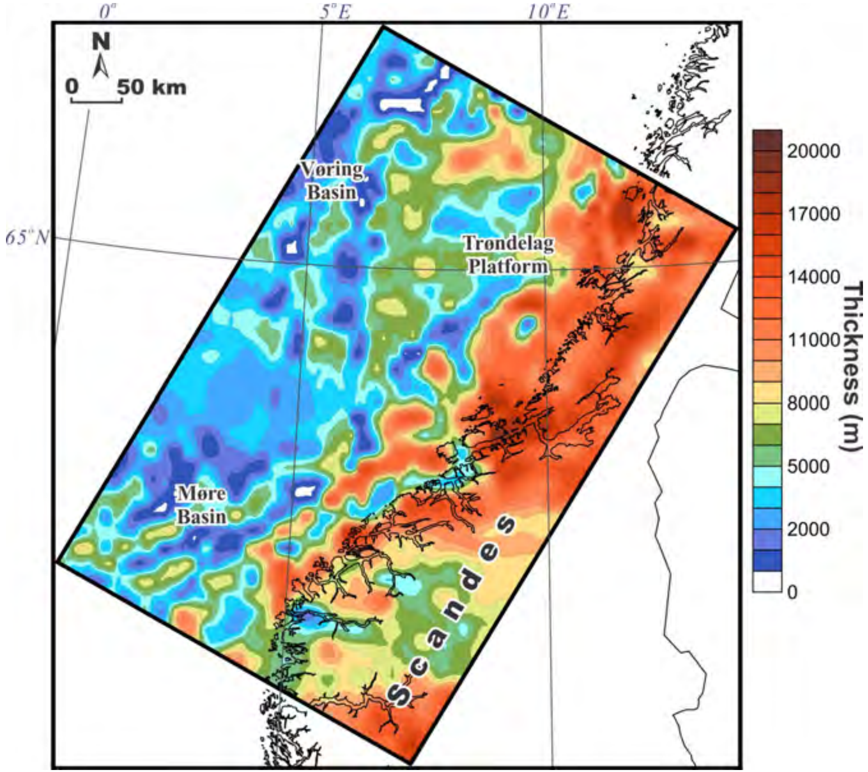
Pre-Createaceous (Jurassic, Triassic and older sediments)

Crystalline crust: thickness map



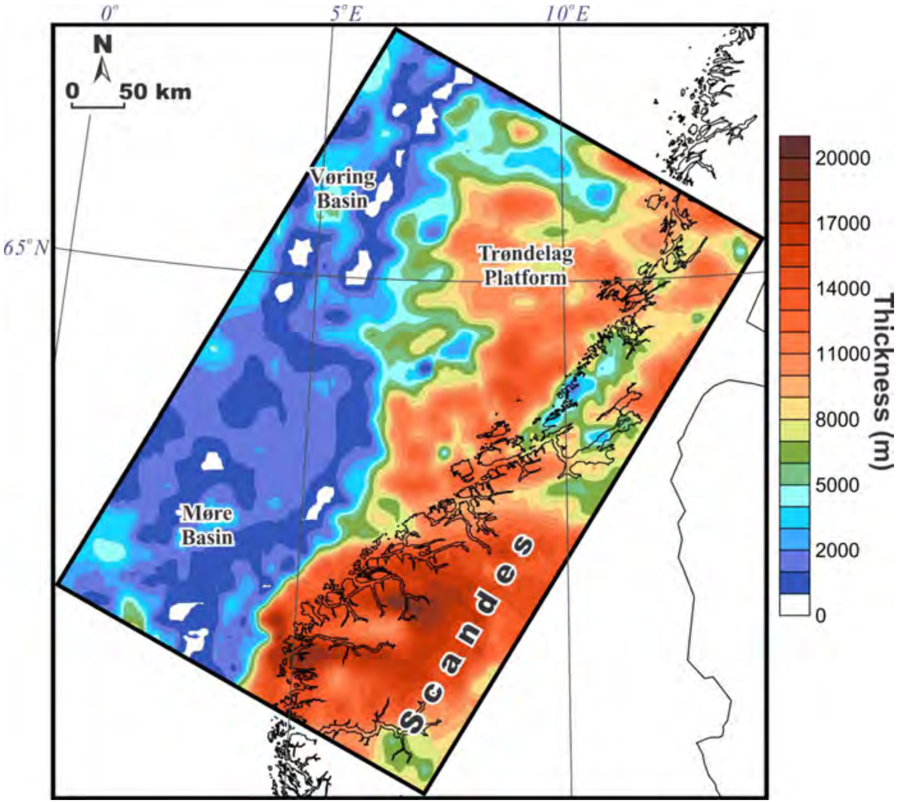
Upper crustal high-density crystalline rocks (2860 kg/m^3)

Crystalline crust: thickness map



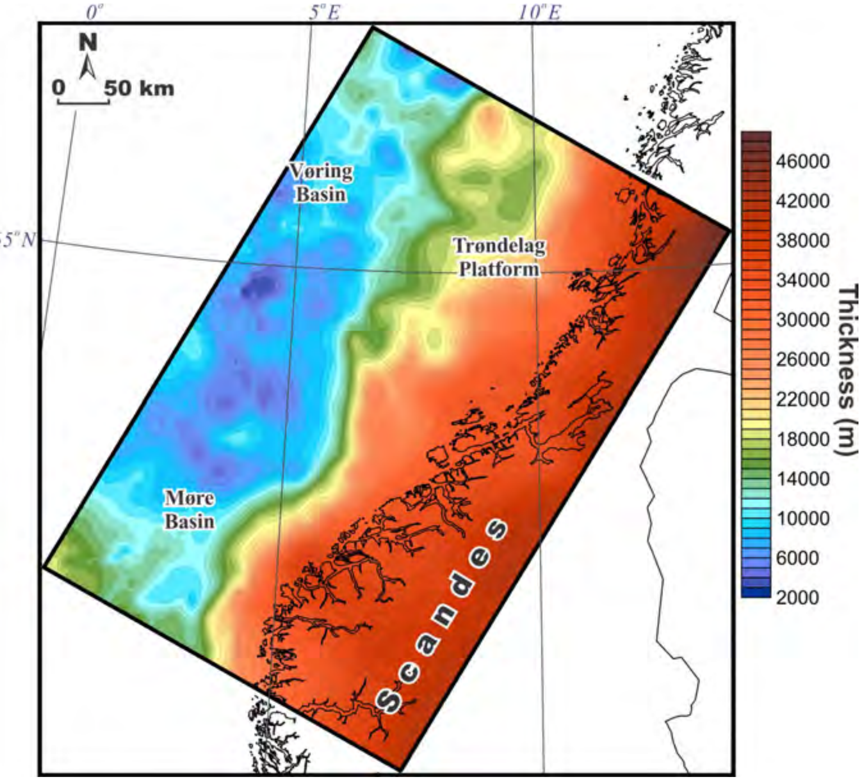
Middle crust (2740 kg/m^3)

Crystalline crust: thickness map



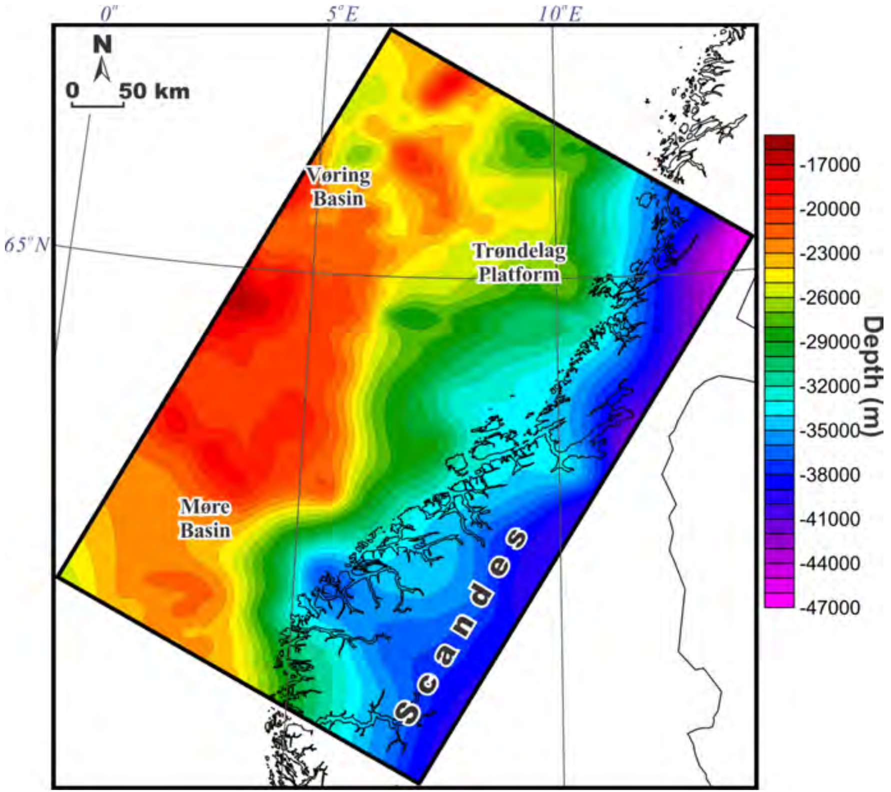
Regional upper crustal layer (2675 kg/m^3)

Crystalline crust: thickness map



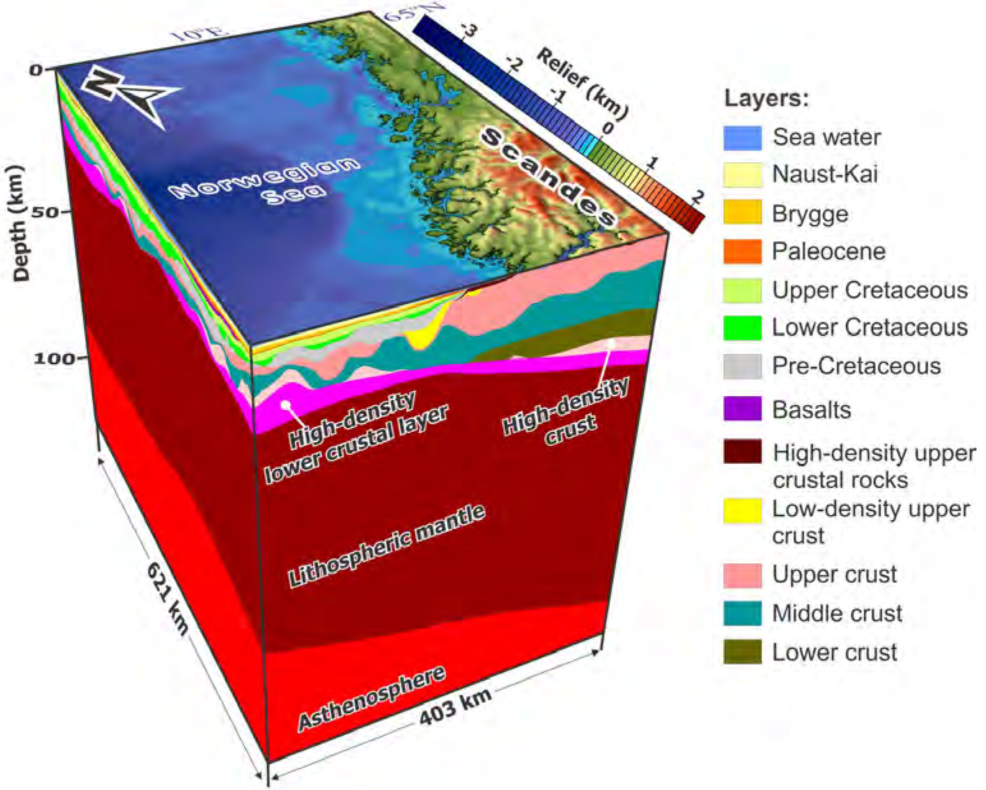
Thickness of the whole crystalline crust

Base of the crust



Moho topography

3D density/structural model



NORWEGIAN JOURNAL OF GEOLOGY Vol 97 Nr. 3
https://dx.doi.org/10.17850/njg97-3-01

GEOLOGICAL SOCIETY OF NORWAY

Deep structure of the northern North Sea and southwestern Norway based on 3D density and magnetic modelling

Yuriy Petrovich Maystrenko[1], Odleiv Olesen[1], Jörg Ebbing [2], Aziz Nasuti[1]

[1]*Geological Survey of Norway, P.O. Box 6315 Torgard, 7491 Trondheim, Norway.*
[2]*Department of Geosciences, Christian–Albrechts–Universität Kiel, Otto–Hahn–Platz 1, 24118 Kiel, Germany.*

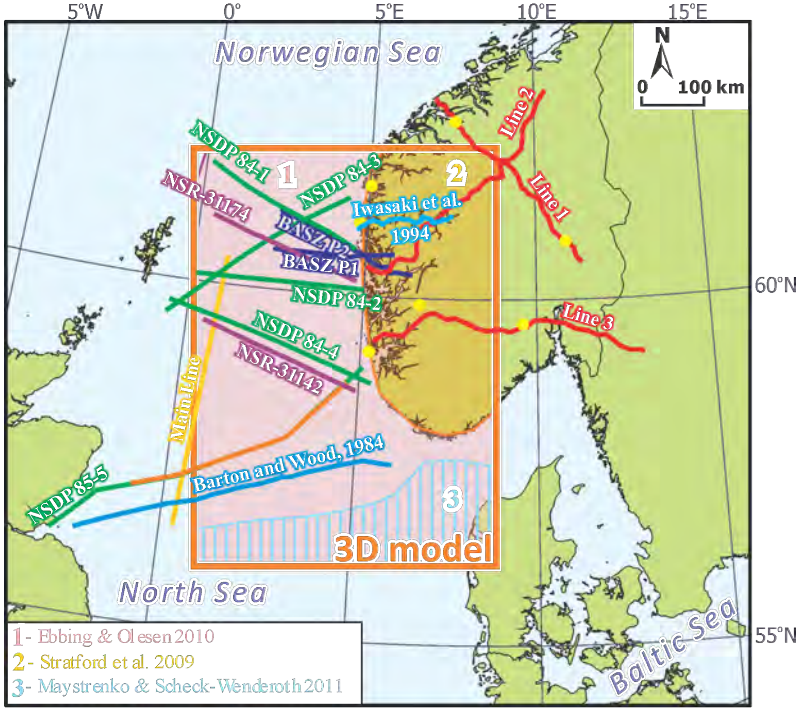
E-mail corresponding author (Yuriy Petrovich Maystrenko): yuriy.maystrenko@ngu.no

The deep structure of the northern North Sea and the adjacent Norwegian mainland has been analysed by integrating all available structural data in combination with 3D density and magnetic modelling into a lithosphere-scale 3D structural model. The modelled configurations of the sedimentary cover and crystalline crust are consistent with the long-wavelength components of the observed gravity and magnetic fields over the study area. The first-order configurations of the top of the crystalline basement and the Moho topography have been obtained. According to the 3D density modelling, the low-density upper-crustal block beneath the Horda Platform has been shown to indicate a possible presence of metasedimentary and/or fractured granitic rocks. Possible remnants of island arc chains within the central part of the North Sea between the Laurentian and Baltican crustal domains are supported by the modelling. Moreover, based on the results of the 3D magnetic modelling, the 3D density/structural model has been differentiated into smaller crustal blocks with different magnetic properties, implying that these magnetically derived crustal blocks most likely differ lithologically from the rest of the initial density-based larger layers. Within the mainland, most of the crustal blocks with increased magnetic susceptibility are related to granitic and/or granodioritic rocks which are well mapped at the surface according to geological data. A prominent middle–upper crustal magmatic intrusion has been modelled within the northern part of the Norwegian–Danish Basin. The local magnetic pattern supports a possible Permian age for this intrusion, whereas the regional magnetic pattern and known geology from the mainland indicate a Sveconorwegian origin as a more viable alternative. At the mantle level, a low-density lithospheric mantle has been modelled beneath NW Norway and adjacent offshore areas, reflecting the likely presence of an upper-mantle low-velocity zone there.

Keywords: 3D modelling, gravity and magnetic fields, density, continental shelf, Viking Graben, Horda Platform

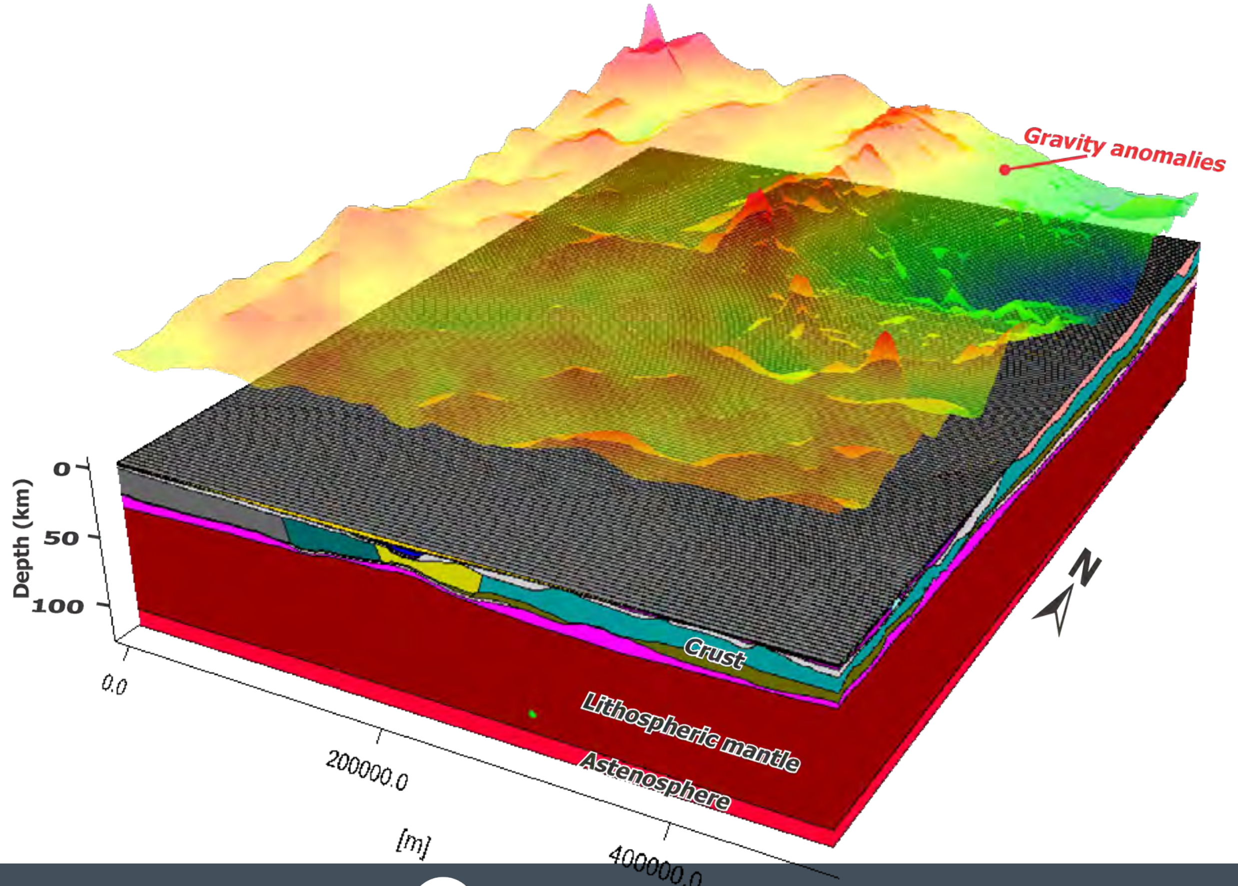
Received 10. February 2017 / Accepted 10. July 2017 / Published online 24. October 2017

Deep part: Moho and crystalline crust



Datasets used for the internal structure of the crystalline crust

3D gravity modelling: Input 3D model

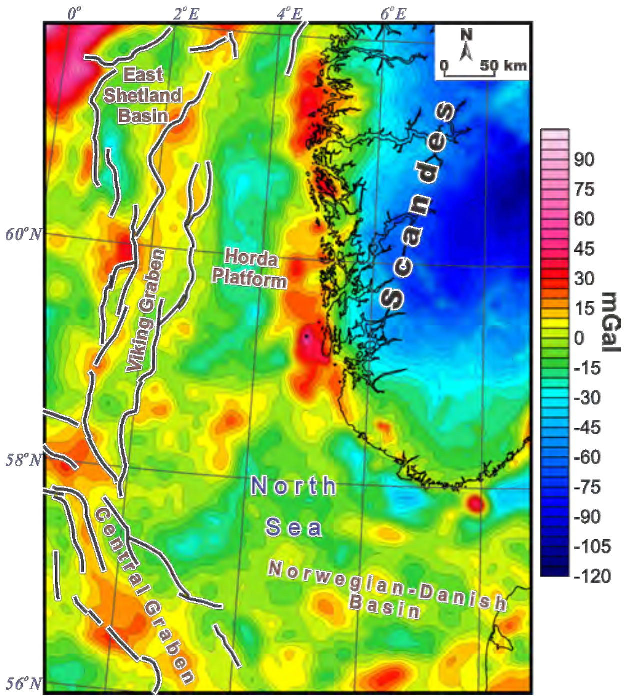


IGMAS+

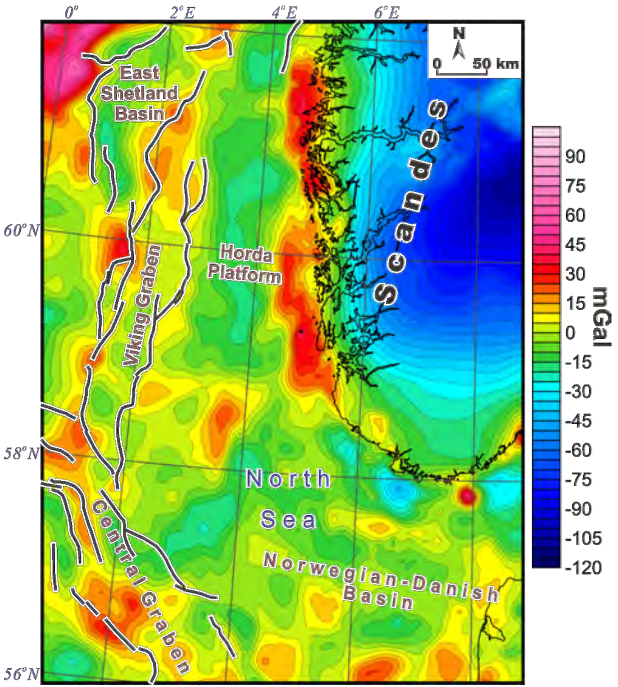
Deep structure:

3D density and magnetic modelling

Gravity anomaly map

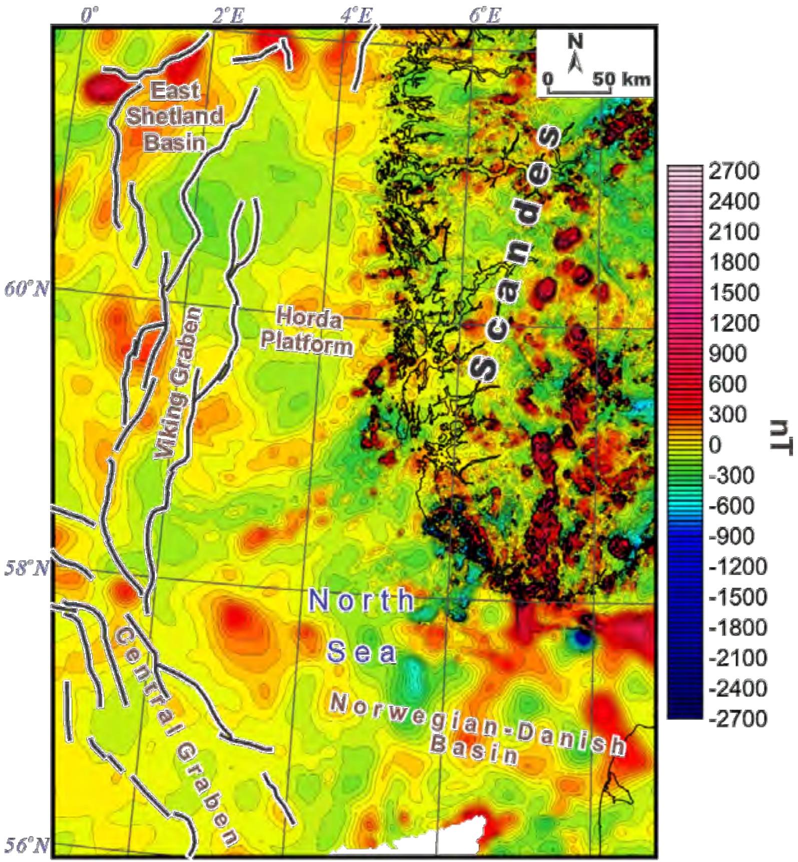


Modelled Gravity anomaly map

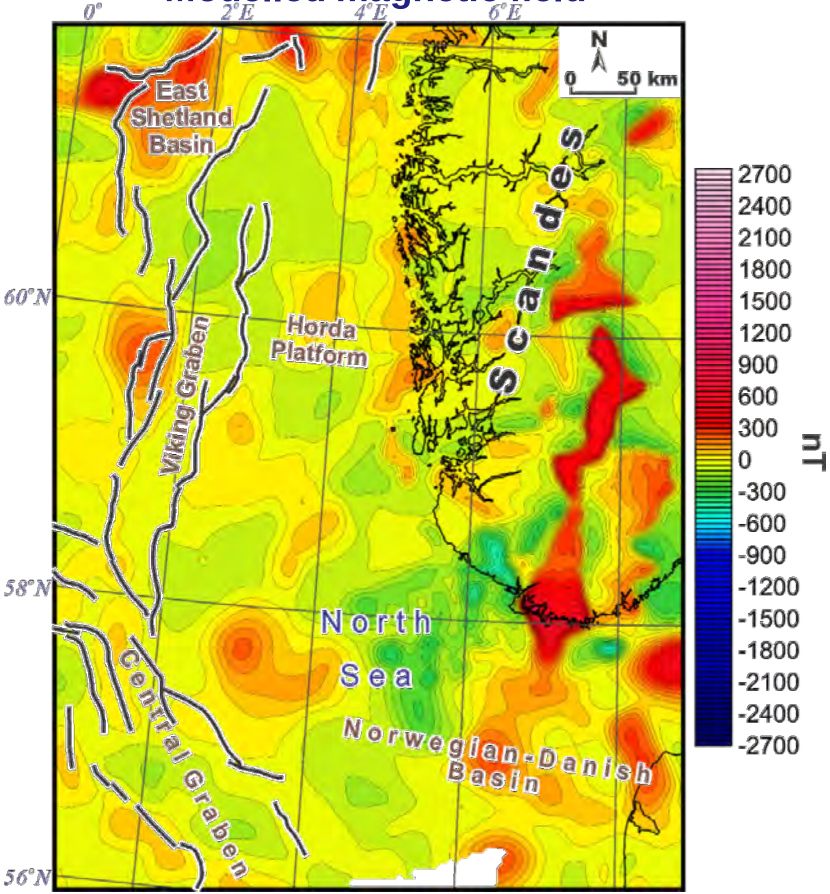


Bouguer gravity anomalies onshore and Free-Air anomalies offshore (data from Olesen et al., 2010 and Andersen et al., 2010)

Observed magnetic anomaly map



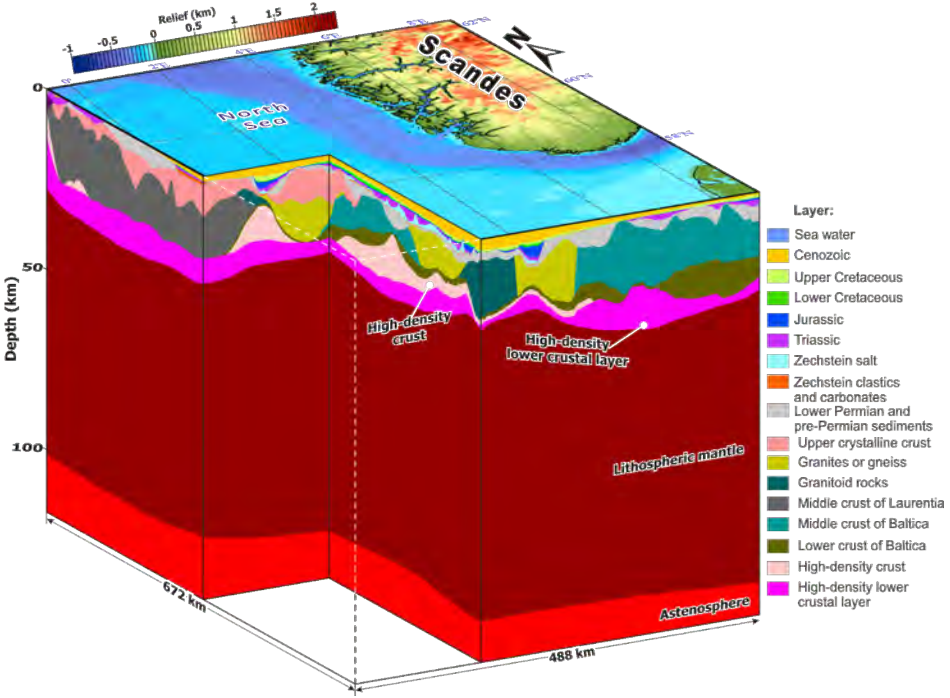
Modelled magnetic field



Observed magnetic field (compiled by Nasuti et al., 2013)

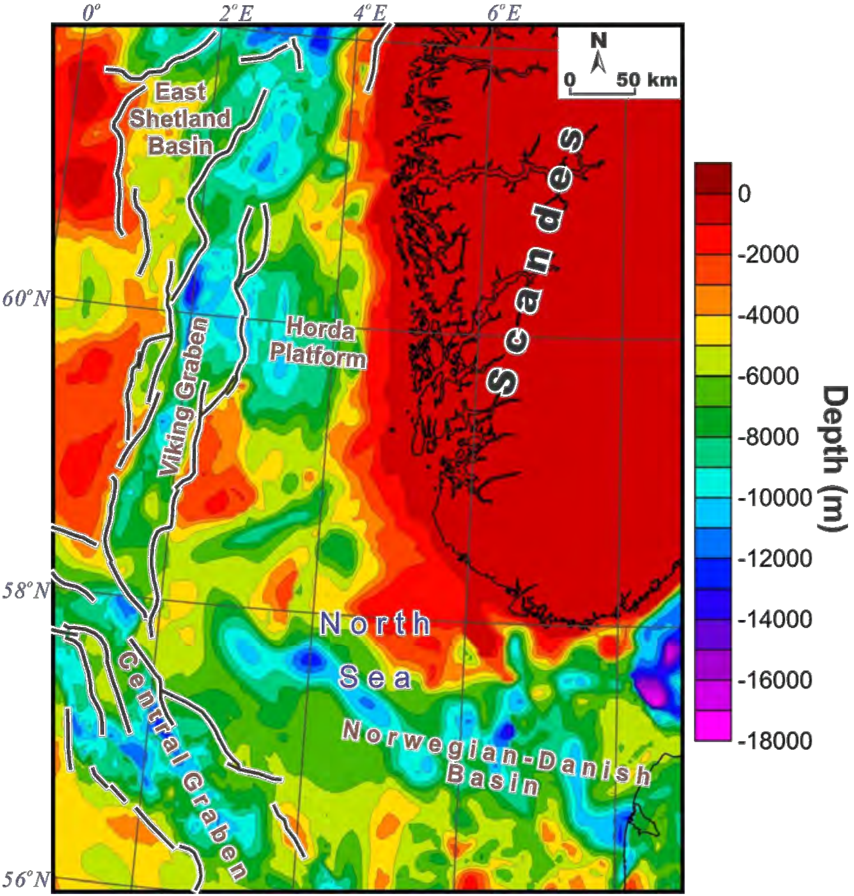
3D structural model

4 times vertically exaggerated

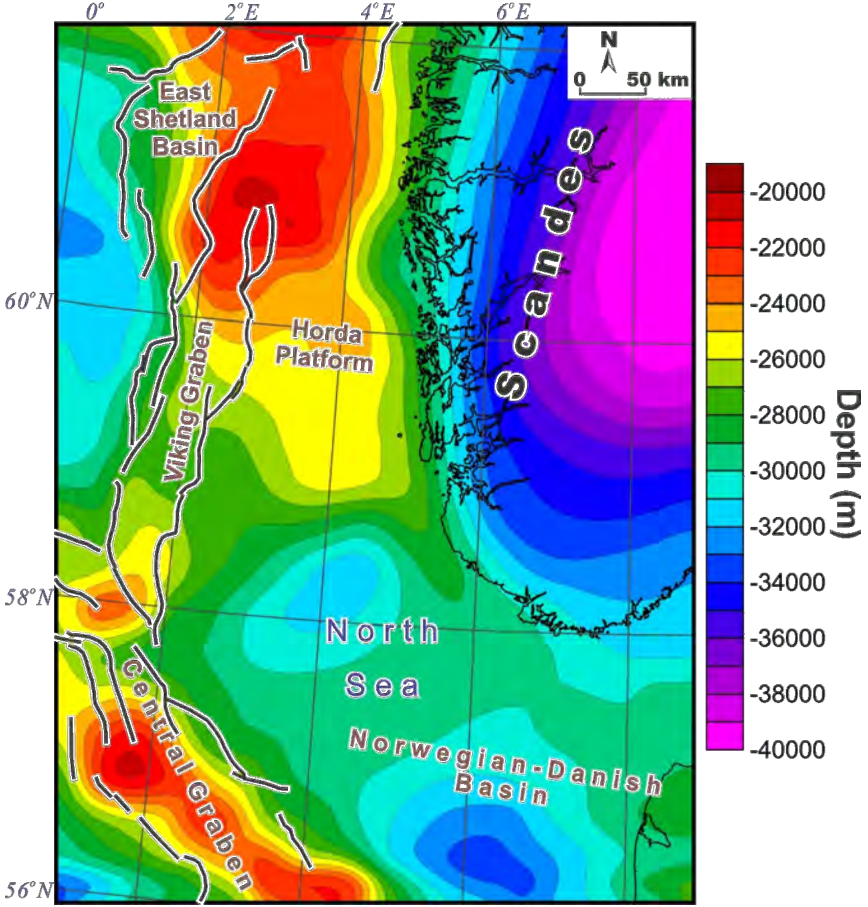


Lithosphere-scale 3D model of the northern North Sea and adjacent areas of the continent (Maystrenko et al., 2013)

Upper part: crystalline basement



Moho

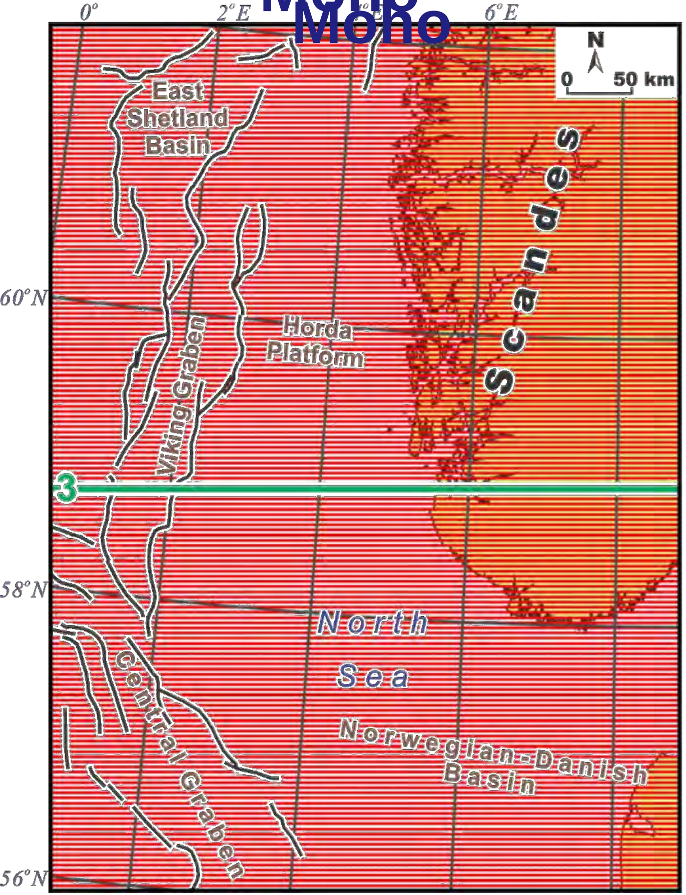


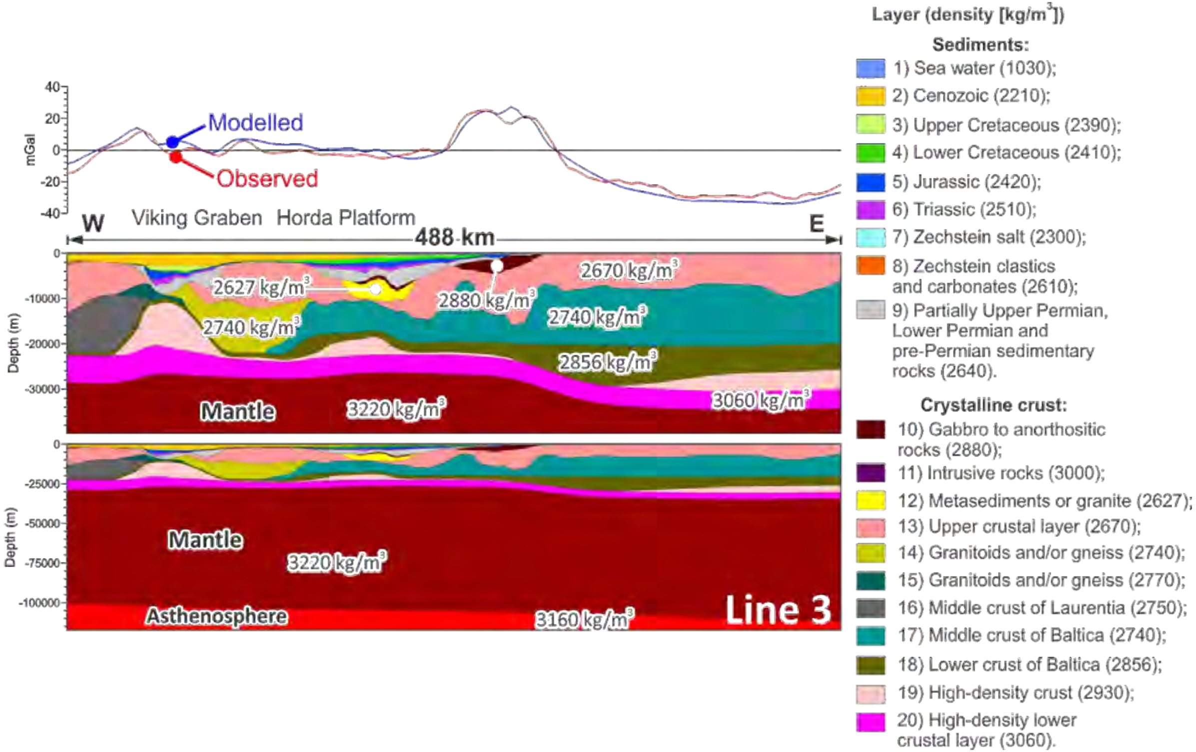
(after Christiansson et al. 2000; Olesen et al. 2007; Ebbing & Olesen 2010; Maystrenko & Scheck-Wenderoth 2012, Ebbing & Osmundsen 2012, Lassen

Structural map of depth to the top of the crystalline basement

2D vertical slices: magnetic modelling

Moho
Moho





Vertical slice 3

Crustal fragmentation, magmatism, and the diachronous opening of the Norwegian-Greenland Sea

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Crustal fragmentation, magmatism, and the diachronous opening of the Norwegian-Greenland Sea

Gernigon L.[a,*], Franke D.[b], Geoffroy L.[c], Schiffer C.[d,e], Foulger G.R.[e], Stoker M.[f]

[a] Geological Survey of Norway (NGU), Trondheim, Norway
[b] Federal Institute for Geosciences and Natural Resources (BGR), Hannover, Germany
[c] Institut Universitaire Européen de la Mer (IUEM), Plouzané, France
[d] Uppsala University, Uppsala, Sweden
[e] Dept. Earth Sciences, Durham University, Science Laboratories, South Road, Durham DH1 3LE, UK
[f] Australian School of Petroleum, University of Adelaide, Adelaide, SA 5005, Australia

ABSTRACT

The Norwegian-Greenland Sea (NGS) in the NE Atlantic comprises diverse tectonic regimes and structural features including sub-oceanic basins of different ages, microcontinents and conjugate volcanic passive margins, between the Greenland-Iceland-Faroe Ridge in the south and the Arctic Ocean in the north. We summarize the tectonic evolution of the area and highlight the complexity of the conjugate volcanic and rifted margins up to lithospheric rupture in the NGS. The highly magmatic breakup in the NGS was diachronous and initiated as isolated and segmented seafloor spreading centres. The early seafloor spreading system, initiating in the Early Eocene, gradually developed into atypical propagating systems with subsequent breakup(s) following a step-by-step thinning and rupture of the lithosphere. Newly-formed spreading axes propagated initially towards local Euler poles, died out, migrated or jumped laterally, changed their propagating orientation or eventually bifurcated. With the Palaeocene onset of volcanic rifting, breakup-related intrusions may have localized deformation and guided the final axis of breakup along distal regions already affected by pre-magmatic Late Cretaceous-Palaeocene and older extensional phases. The final line of lithospheric breakup may have been controlled by highly oblique extension, associated plate shearing and/or melt intrusions before and during Seaward Dipping Reflectors (SDRs) formation. The Inner SDRs and accompanying volcanics formed preferentially either on thick continental ribbons and/or moderately thinned continental crust. The segmented and diachronic evolution of the NGS spreading activity is also reflected by a time delay of 1–2 Myrs expected between the emplacement of the SDRs imaged at the Møre and Vøring margins. This complex evolution was followed by several prominent changes in spreading kinematics, the first occurring in the Middle Eocene at 47 Ma–magnetic chron C21r. Inheritance and magmatism likely influenced the complex rift reorganization resulting in the final dislocation of the Jan Mayen Microplate Complex from Greenland, in the Late Oligocene/Early Miocene.

Case study 4

Geological setting: from Caledonides to sea-floor spreading

Neo.
Paleo.
Cretaceous
Jurassic
Triassic
Permian
Carbon.
Devonian

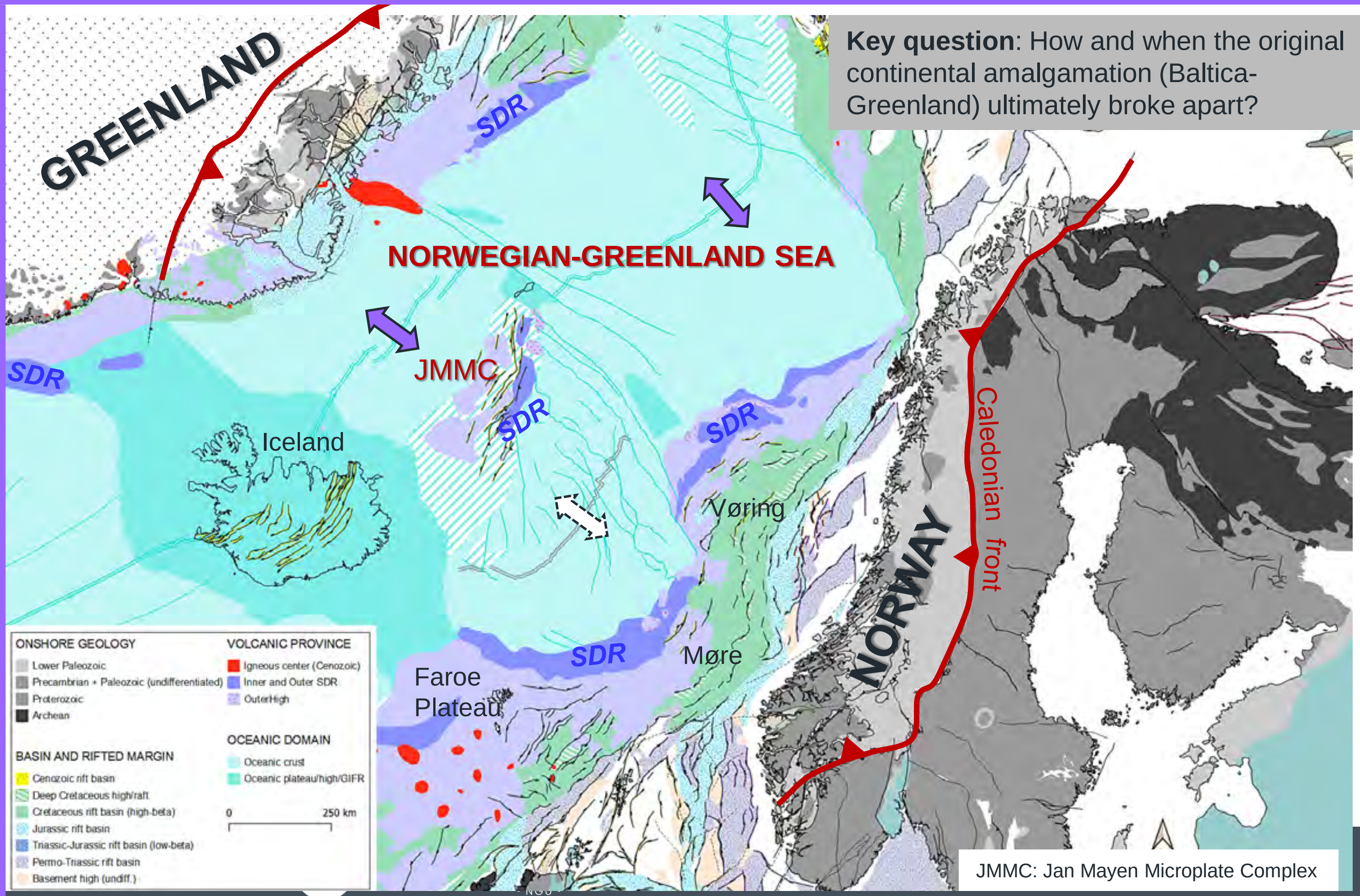
JMMC

breakup

~300 My of episodic rift events

Caledonides

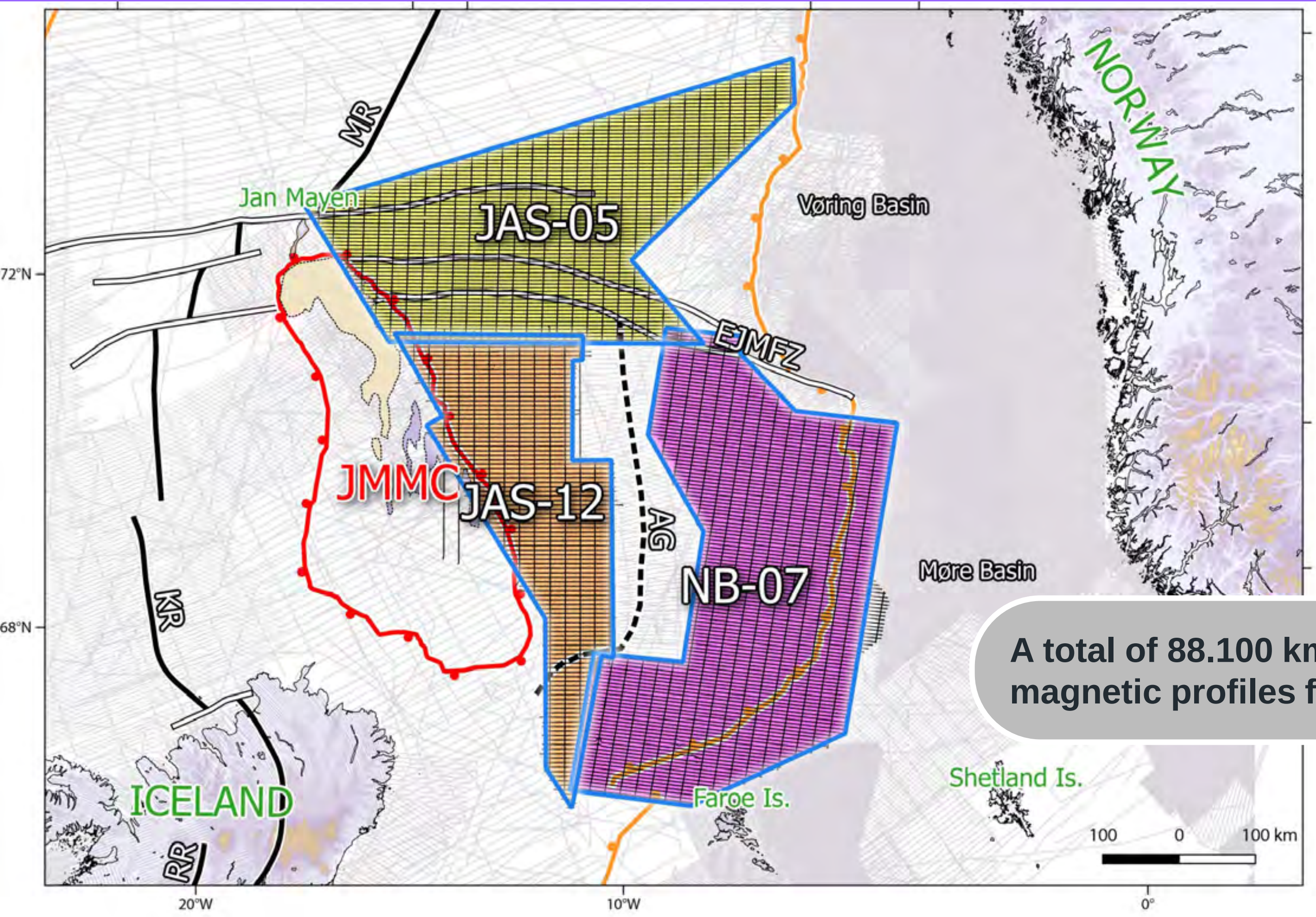
Key question: How and when the original continental amalgamation (Baltica-Greenland) ultimately broke apart?



JMMC: Jan Mayen Microplate Complex

Volcanism after Berndt et al., 2001 and Geissler et al., 2017

Norwegian-Greenland Sea: New aeromagnetic data



Line/tie-line spacing: 6/20 km

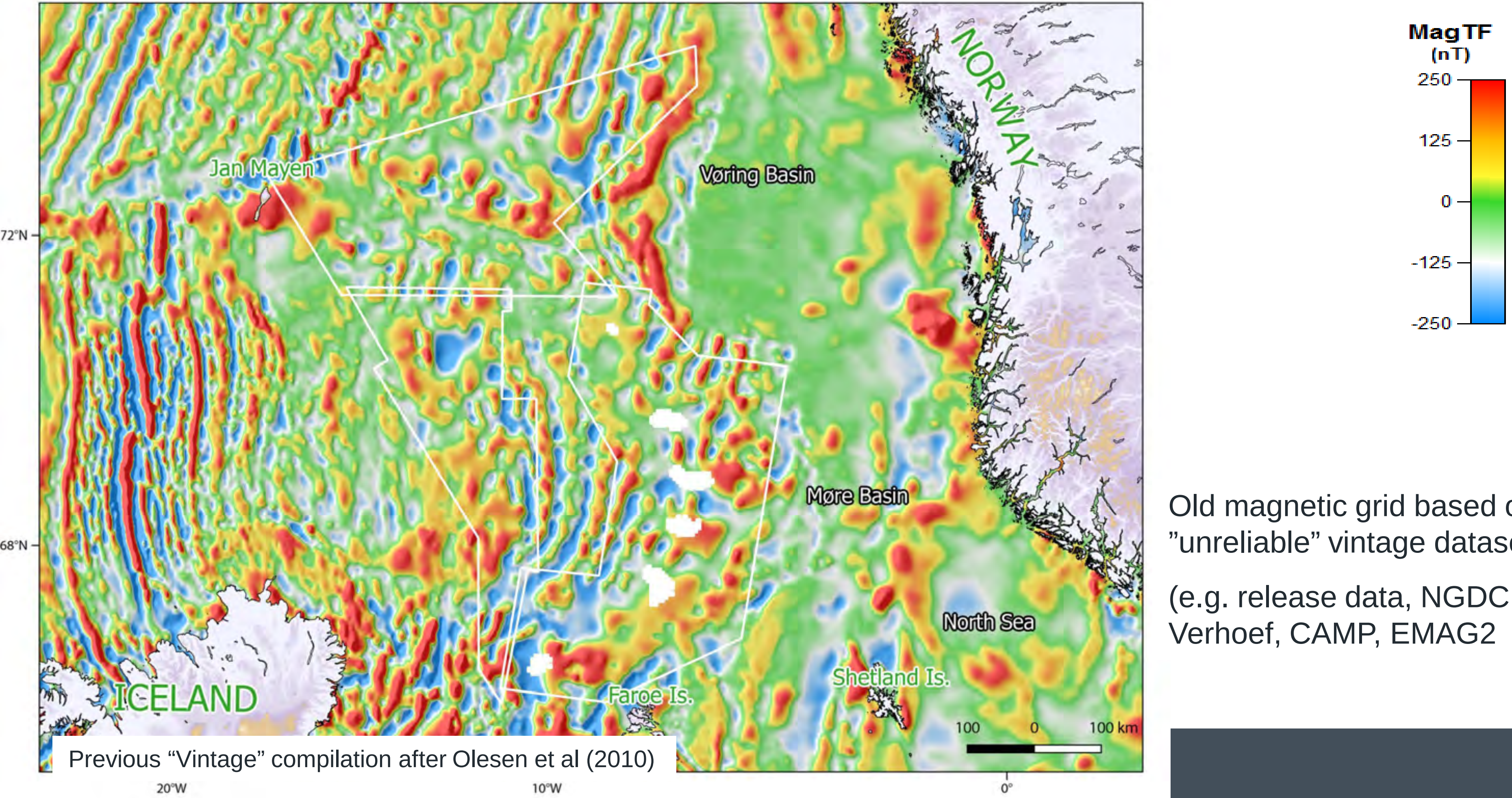
Sensor elevation: 230 m

Area coverage: 80.000 km²

Total flying distance: 17.600 km

A total of 88.100 km of new HR/HQ magnetic profiles from COB to COB

Comparison with vintage aeromagnetic data

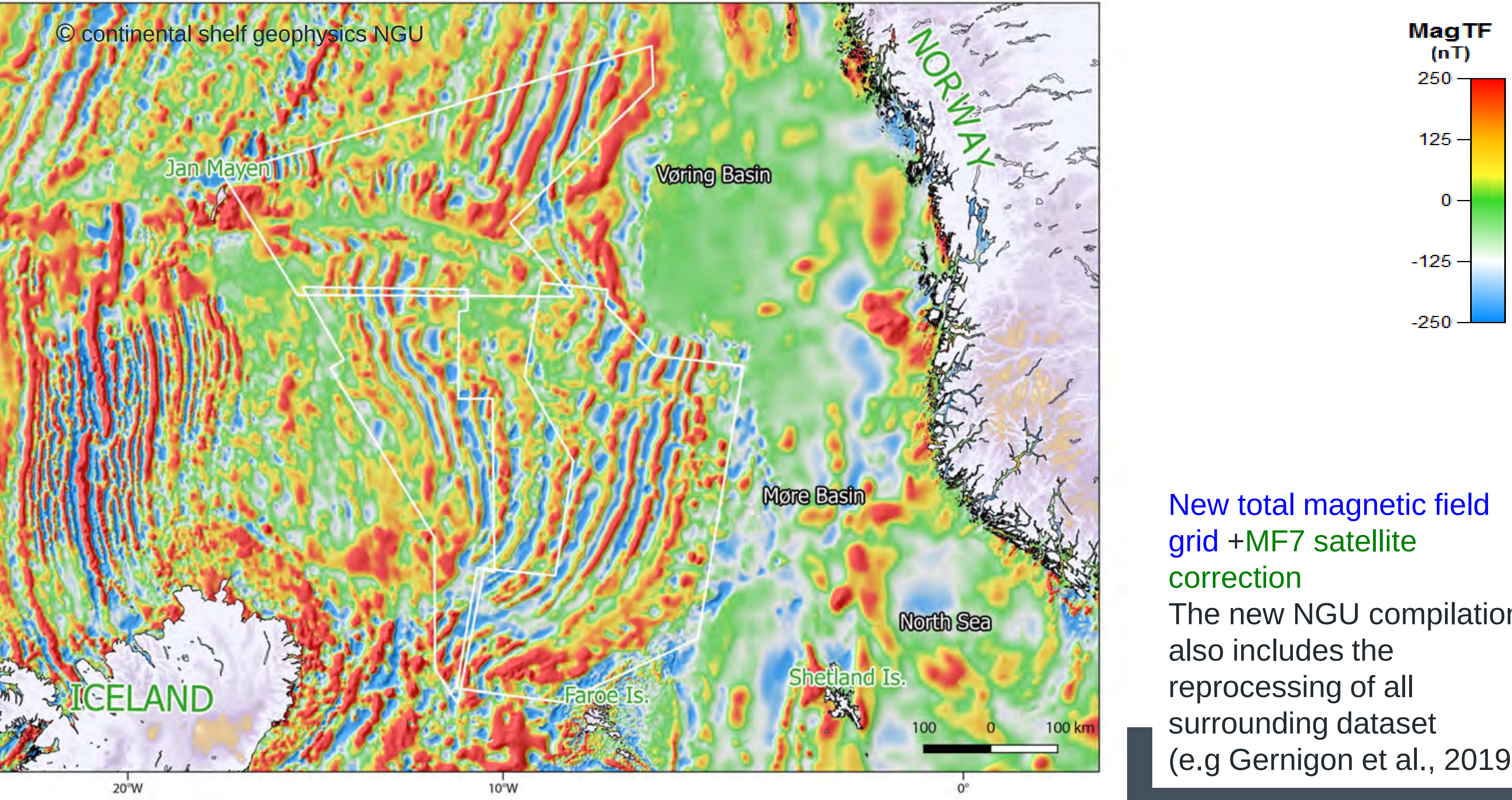


Previous "Vintage" compilation after Olesen et al (2010)

Old magnetic grid based on "unreliable" vintage dataset

(e.g. release data, NGDC, Verhoef, CAMP, EMAG2

Up-to-date aeromagnetic compilation 2019



New total magnetic field grid +MF7 satellite correction

The new NGU compilation also includes the reprocessing of all surrounding dataset (e.g Gernigon et al., 2019)

Pre-drift configuration: What's happened before the SDR emplacement ?

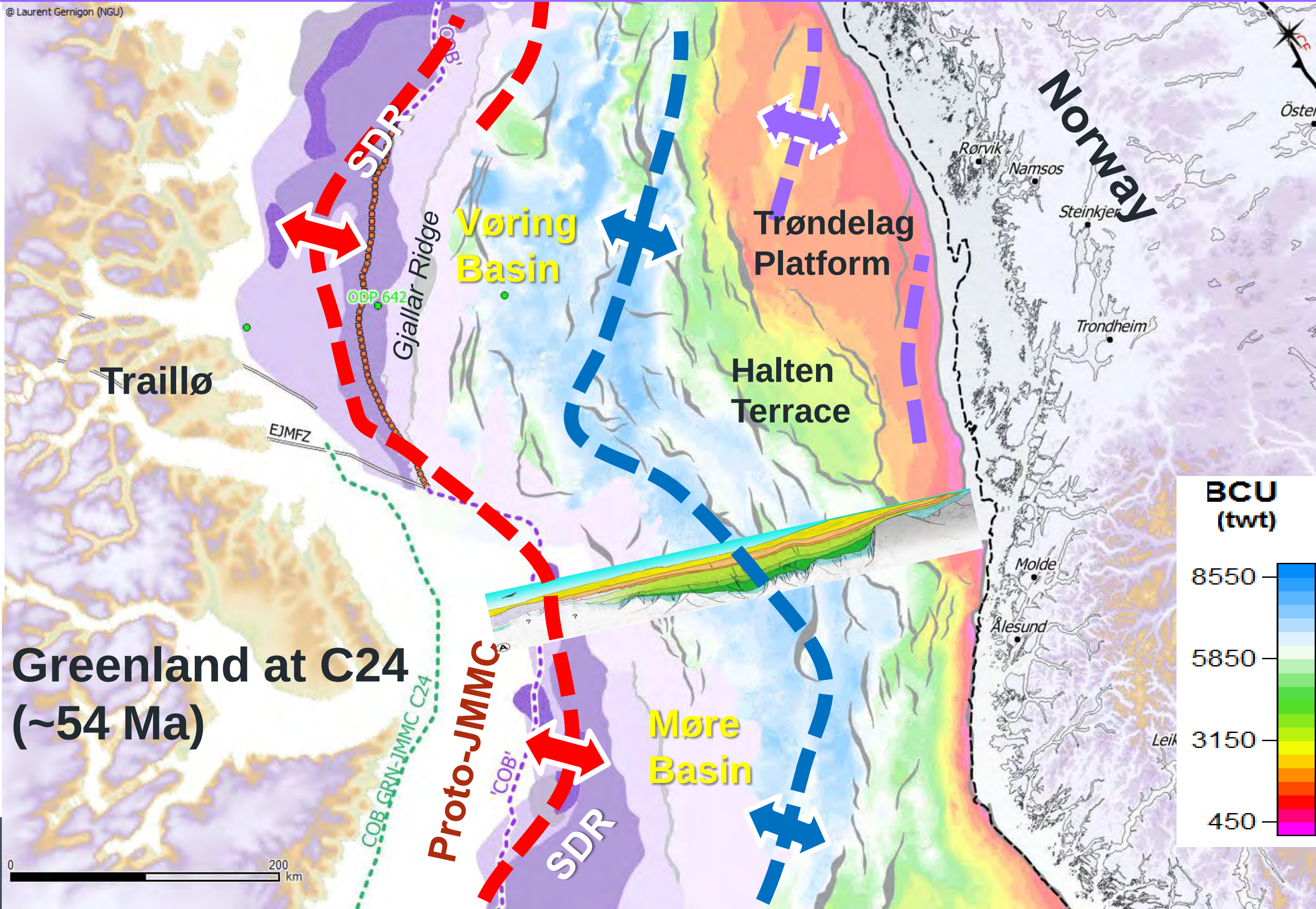
The Base Cretaceous Unconformity (BCU) illustrates the pre-drift configuration of the rift system between Norway and Greenland.

In Late Cretaceous, a new phase of stretching and thinning focused in the western flank of the Late Jurassic-Early Cretaceous inner rift system

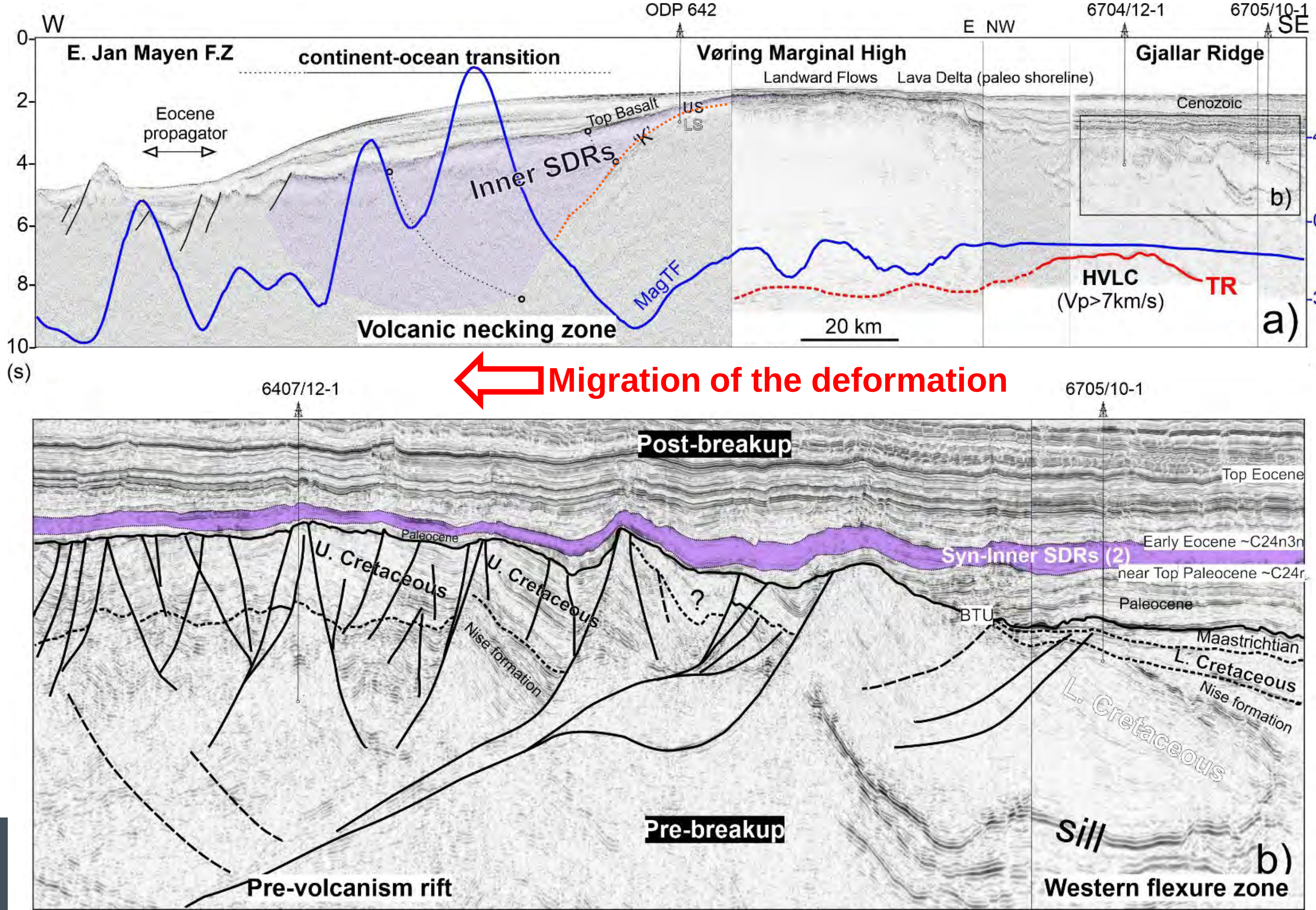
Permo-Trias rift axis

Late Jurassic-Early Cretaceous rift axis

Late Cretaceous-Paleocene rift axis



Volcanic margin formation: lessons from the outer Vøring basin



Syn-rift phase

Show a hiatus between Late Maastrichtian/Early Paleocene (~BTU Unc)

Tilt and faulting during Campanian-Maastrichtian

Minor faulting during mid/Late Paleocene -> migration of the deformation

Syn-magmatic phase

US: Upper series: transitional E-MORB Type
Age: around 56-54 Ma (Sinton et al., 1998) (C24r)

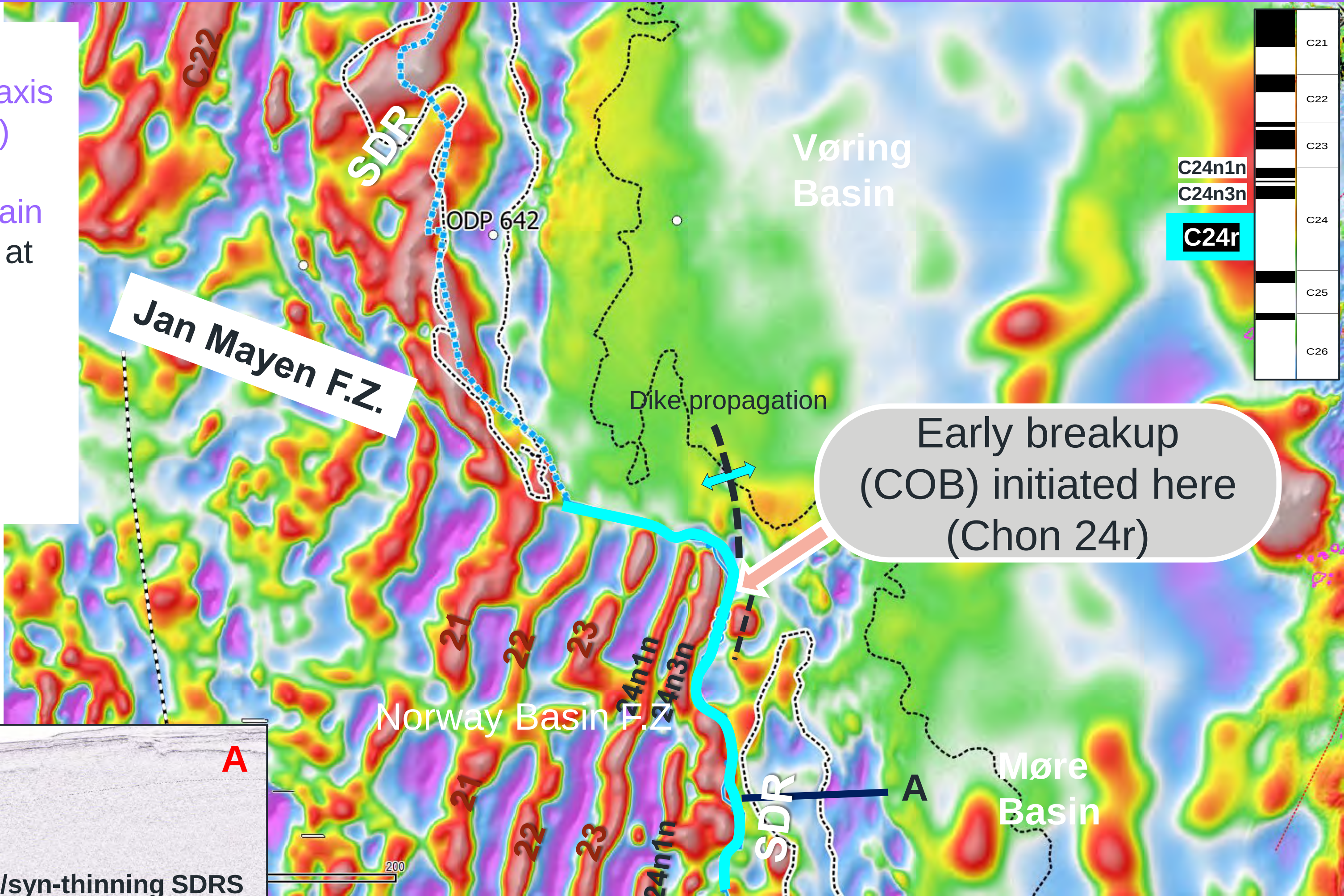
"K"

LS: Lower series: rhyolite, ignimbrite, andesite, dacite
Age: 57.8 Ma (close to C25n/C24r, Abdelmalak et al., 2016)

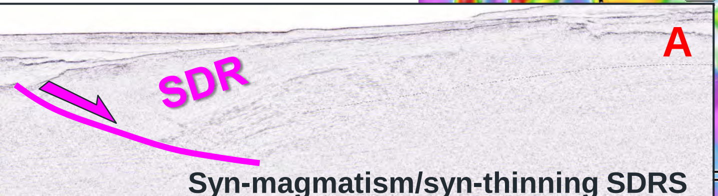
Volcanic margins: what about timing and segmentation?

Extinct spreading ridge axis around C25? (~57.5 Ma) (interpreted as an embryonic oceanic domain before ultimate breakup at ~C24r (~54Ma)

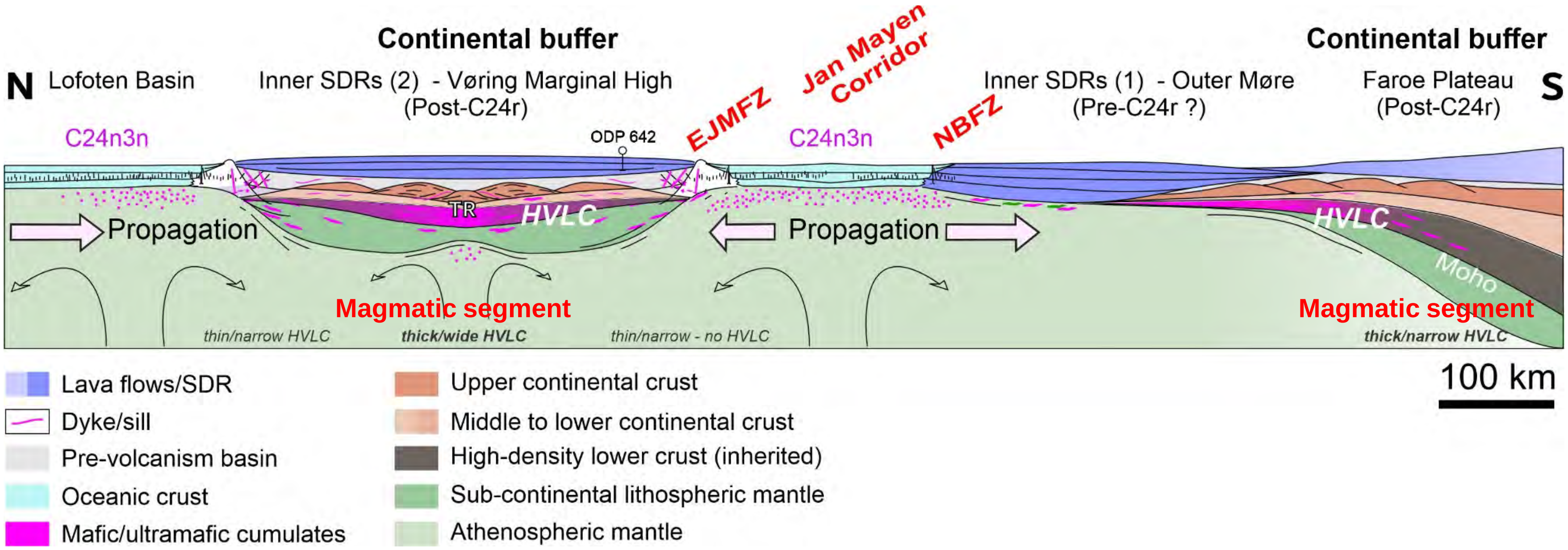
In the outer More, some Inner SDR observed on seismic formed before C24r-C24n1n



COB



Diachronous opening model of the Norwegian Greenland Sea

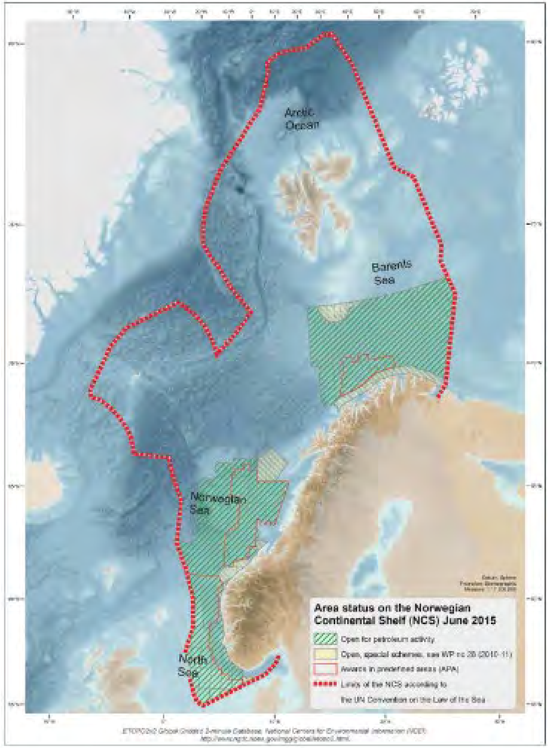


Conceptual model of volcanic margin segmentation (from North to South) during the punctiform initiation of breakup around C24n3n (Early Ypresian ~53.98 Ma)

The model considers the volcanic margins to be diachronic. The breakup and early opening of the Norwegian-Greenland Sea were not instantaneous but propagated in different directions.

Atlas of Geophysics of Norway (GON)

Current Project



NGU and partners will within the frame of the GONA Project provide comprehensive and state of the art geophysical compilations and interpretations.

High-resolution geophysical data are particularly useful for detailed mapping of bedrock lithologies and structures such as volcanics, igneous bodies, Moho and top basement, fault systems, deep weathering, thermal modelling, uplift, subsidence and onshore-offshore basement structures. The deliverables will include 3D crustal, thermal and rock stress modelling

KEY RESEARCH TOPICS related to our using potential field data Includes:

Mapping surface geology (bedrock, faults, folds,…)

Modelling underground (in 2D and 3D)

Modelling of geological structures in all scales.

- Evolution of volcanic rifted margins, volcano-stratigraphy,
- microcontinent formation (Jan Mayen) – Plate reconstruction
- Lithospheric rupture, oceanic accretion (Norwegian-Greenland Sea)
- Sedimentary basin analysis, modelling, salt tectonics
- Basement characterisation, inheritance, Onshore-offshore correlation