# Central East Greenland Conjugate Margin of the Jan Mayen Microcontinent

## Database, Structural and Stratigraphical Mapping Project

Anett Blischke
Ögmundur Erlendsson

Prepared for Orkustofnun

ÍSOR-2018/024

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Report Project no.:
15-0187
14-0172

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Key page

| Report no. | Date | Distribution |
|---|---|---|
| ÍSOR-2018/024 | April 2018 | ☐ Open ☒ Closed for 2 years |

| Report name / Main and subheadings | Number of copies |
|---|---|
| Central East Greenland – Conjugate Margin of the Jan Mayen Microcontinent. Database, Structural and Stratigraphic Mapping Project. | 3 |
| | **Number of pages** |
| | 95 + 2 maps |
| **Authors** | **Project manager** |
| Anett Blischke and Ögmundur Erlendsson | Anett Blischke |
| **Classification of report** | **Project no.** |
| Confidential | 14-0172, 15-0187 |

Prepared for

Orkustofnun (OS)

Cooperators

GEUS (Geological Survey of Denmark and Greenland)


Abstract

The following report presents the results of the comprehensive mapping project in regards to the Central East Greenland area in direct comparison with its conjugate margin area of the Jan Mayen microcontinent (JMMC). A margin area that includes the Jameson Land Basin, Scoresby Sund, Blosseville Kyst, Liverpool Land High and basin areas. The project included the compilation of a 2D seismic reflection and refraction database in combination with geophysical potential field, geological surface map and offshore borehole data. Key deliverables were the structural framework, stratigraphic distribution and igneous domain mapping. The in detailed mapped structural elements and igneous domains resulted in a time phased breakup model that links directly to the westernmost extend of the JMMC and breakup margin. A model that resulted in a new view of the margin area, as a much more complex transition from its Central East Greenland continental domain across a complex volcanic margin that connects to the JMMC area. The structural trends for the JMMC area is in-line to the Northeast Atlantic trends at break up time. These include two implied parallel oriented rift basins that straddle the microcontinent´s area. Thus, subdividing the JMMC into a northern and southern domain of narrow rift basins that are separated by a possibly Caledonian to Palaeozoic high across the main Jan Mayen ridge area. Major linking fracture zones in between the two conjugate areas were reconstructed offshore the central Blosseville Kyst. Zones that tie directly into the south-western igneous domain of the JMMC and the potential Scoresby Sund potential transfer system that links directly into the central part of the Jan Mayen Ridge area. The microcontinents northernmost extend is formed by the complex fracture zone system of the Jan Mayen fracture zone since pre-breakup times.



| Key words | ISBN-number |
|---|---|
| Jameson Land Basin, East Greenland, Jan Mayen microcontinent, Exploration, crustal structures, 2D seismic reflection, database, Permo-Triassic, Jurassic stratigraphy, Blosseville Kyst, Tertiary plateau basalts, Orkustofnun, ÍSOR | |
| | **Project manager's signature** |
| | |
| | **Reviewed by** |
| | Tobias Björn Weisenberger |

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# 1 Introduction

This project report compiles the data- and interpretation work conducted on the central East Greenland margin, including the Jameson Land Basin (JMLB), Blosseville Kyst (BK), Scoresby Sund (SD), Liverpool Land High (LH), and Liverpool Land Basin (LLB) areas (Figure 1) in cooperation between Iceland GeoSurvey (ÍSOR) and the Geological Survey of Denmark and Greenland (GEUS). The main task for this project was the interpretation of the 2D multi-channel seismic reflection data (2D MCS) in combination with geophysical potential field data, and the geological map of Central East Greenland area. As a basis to build a structural and stratigraphic understanding of the mapped region in direct comparison to the Jan Mayen microcontinent (JMMC) as its conjugate margin. Funding was provided through the Icelandic Hydrocarbon Research Fund (HCRF) for the mapping project "Seismic Investigation of the Central East Greenland Margin, structural tie and sediment fairway analysis to the western margin of the Jan Mayen Micro-continent", and through the participation in the NORDMIN project "Crustal Structure and Mineral Deposit Systems: 3D-modelling of base metal mineralization in Jameson Land Basin (JMLB) area and nickel mineralization in Disko-Nuussuaq", also referred to as CRUSMID-3D (Blischke and Erlendsson, 2014).

## 1.1 Project setup and outline

All technical project related tasks were finalised during an original scheduled time period from October 2015 to 2017. A deadline extension was permitted to April 2018 by the National Energy Authority (Table 1) due to time lack of finishing the reporting and several overlapping projects. Our goal is to understand the pre- to post-rift stratigraphic and tectonic setting of the Eastern Greenland margin in comparison to the Jan Mayen microcontinent (JMMC). The project is subdivided into three stages with the emphasis on different structural developed areas and by their stratigraphic age in reference to the central Northeast Atlantic breakup timing (Figure 1):

- **Stage (a)** Comparing the Palaeozoic and Mesozoic JMLB and Scoresby Sund pre-breakup sections to the JMMC.
- **Stage (b)** Compare the pre-breakup and breakup igneous regions of the Blosseville Kyst to the JMMC western igneous margin that are part of the North Atlantic igneous province.
- **Stage (c)** Compare the East Greenland Oligocene-Miocene breakup margin to the western extend of the JMMC.

All sub-regions (BK, JMLB, JMMC, LLH and LLB) were tied to a comprehensive interpretation that enables a comparison to the mapping results of the JMMC area (Blischke et al., 2016; Blischke and Erlendsson, 2016). The project is built on previous mapping results on a regional mapping scale (e.g. Larsen et al., 1989, 2013; Henriksen, 2008; Hopper et al., 2014; Guarnieri et al., 2017). Thus far, such a data and interpretation study has not been conducted at this level of detail for this region. The comparison of seismic refraction, chrons geomagnetic reversal data (Gaina et al., 2017), and existing onshore interpretations of the BK area to the southern conjugate margin of the JMMC were a specific focus of this study. The JMMC project database and data tie-in comprises of a detailed regional reconstruction at breakup time using seismic refraction data as the data control for the tie-in to the pre-Cenozoic stratigraphic section (Blischke et al., 2016, 2018).

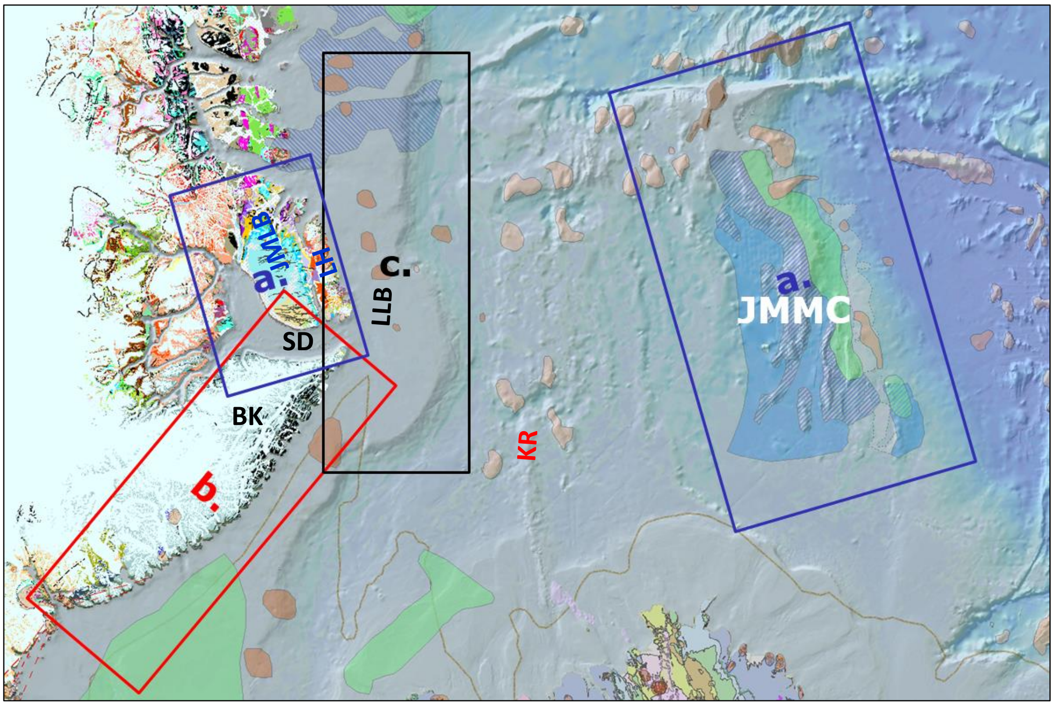



**Figure 1.** *East Greenland – JMMC project stage area overview, BK – Blosseville Kyst, JMLB – Jameson Land Basin, JMMC – Jan Mayen microcontinent, KR – Kolbeinsey Ridge, LH – Liverpool Land High, LLB – Liverpool Land Basin, and SD – Scoresby Sund on base map (Blischke and Erlendsson, 2016).*

The northern and central JMLB represent the initial phase of the project of **Stage (a)** to obtain a good calibration of the subsurface datasets to the known onshore geology, seismic reflection and refraction datasets (Bengaard and Henriksen, 1986; Pedersen et al., 2013) (Table 2). This was followed by mapping the southern extend of JMLB and Scoresby Sund offshore seismic data interpretations. This data was correlated with a higher degree of uncertainty, as the seismic reflection data grid has no direct tie-in control and is an interpolation from the north-eastern part of the JMLB across profiles and regional dip datasets. Structural top surface isochron maps have been produced for the Caledonian basement, and the Permian, Triassic, Jurassic and Cretaceous-Cenozoic stratigraphic periods. Stratigraphic thickness isopach maps have been generated for the Palaeozoic (post-Caledonian Devonian-Carboniferous), Permo-Triassic and Jurassic to Cenozoic stratigraphic periods.

Composite line profiles were compiled based on onshore mapping results and offshore seismic reflection data interpretations for the BK during project ***Stage (b)*** (Figure 2; Table 2). The aim of that work was to better visualize the offshore extend of the BK basaltic formation that on-laps onto the southernmost extend of the JMLB, in comparison to the plateau basalt formation mapped across the JMMC that lies discordant across the pre-breakup structures. The transition from the Liverpool Land high across the Liverpool Land basin area to the domain of the Kolbeinsey Ridge area was concluded within the last project ***Stage (c)***. Only one offshore borehole and chrons geomagnetic reversal mapping gave some data control in regards to the geological time tie estimates. Mapping of this area was a key point to understand the transition from an extensional rift basin to a wide volcanic margin and transition during the final breakup of the microcontinent from the Central East Greenland coast during the latest Oligocene to earliest Miocene.

**Table 1.** *Project timeline and task list that were finalized (purple – task; green – sub-task; red – milestones; orange - meeting). The project deadline was extended to April 2018, which was accepted by the National Energy Authority (NEA).*

***Jameson Land Basin – East Greenland*** *8.3.2018*

| Project Stage | Project Item |
|---|---|
| **Stage 1. Expand existing database (Petrel & GIS) and first path interpretation.** | ***Database expansion*** |
| | a. 2D multi-channel reflection seismic database complation |
| | b. Reference database and implimentation (refraction seismic, age data, surface correlation charts) |
| | ***First path interpretation:*** |
| | a. JMMC project dB tie-in (regional reconstruction at breakup time, refraction seismic data tie in to the pre-Cenozoic section, find best analogue section for comparison with JMLB) |
| | b. Southern Jameson Land Basin & Scoresby Sund (isochron & isopach maps for Permian, Triassic, Jurassic & Cretaceous) |
| | c. Blosseville Kyst (3 composite line compilations to show the Blossevile Kyst basaltic formation on lapping onto the Jameson Land Basin area, tie in of the interpretations by Engkilde & Surlyk (2003), chronologic sequence of main basalt sequences) |
| | d. Liverpool Land Basin - offshore (map main structures, basement high blocks, Cenozoic sediment fan, identify main COB limits, igneous complexes) |
| | ***Interpretation compilations and summaries*** |
| | a. Summary map of main fault zones and structural elements (outcrop / sub-crop maps: seafloor or surface; pre-breakup (Base Tertiary); Base Mesozoic & Caledonian basement) |
| | b. Summary map of main fairway directions, based on isochron mapping |
| | ***Project update meeting*** |
| | ***Status report and presentation*** |
| **Stage 2. Project area interpretation tie in to the JMMC.** | ***Seismic facies definition - Scoresby Sund area*** |
| | ***Direct comparison with seismic data of the JMMC:*** |
| | a. Southern Jameson Land Basin & Scoresby Sund |
| | b. Blosseville Kyst |
| | c. Liverpool Land Basin – offshore |
| | ***Estimates of basalt thickness and tie to available geo-chronologic data*** |
| | a. Basalt thickness estimates (Blosseville Kyst vs. JMMC) |
| | b. Implement chronologic model in section view. (Final reconstruction profiles from the JMLB to JMMC) |
| | c. Interpretation compilations, summaries and documentation |
| | ***Project update meeting(s)*** |
| | ***Reporting and / or presentation*** |

## 1.2 The NordMin CRUSMID-3D project

The CRUSMID-3D project´s original goal was the understanding and definition of the relationship between the tectonic setting, large-scale intrusive systems and connected hydrothermal fluid-bearing mineralization for the JMLB and the Disko areas in East and West Greenland.

The project resulted in a structural model of the pre- and post-breakup geodynamic evolution and the potential relationships between crustal structure and mineralized systems was product (Blischke and Erlendsson, 2016).

The Iceland GeoSurvey has been involved in work package 3 (WP3), which includes the structural 3D modelling of the project. The main deliverable of the project during the second phase (2015–2016) was in the interpretation of the sub-surface structural settings for the project area. The resulting data compilation consists of geological and structural data, the analysis of magnetic and gravity data, and especially the tie of the seismic lines to the onshore geology map data, which in parallel assisted the conjugate margin-mapping project set out through the HCRF.

# 2 Database, methods and mapping input considerations

A 2D seismic reflection and refraction database (2D-MCS) was compiled in combination with bathymetry, regional gravity, magnetic, onshore cross section profiles and surface geological mapping data along the central East Greenland coast. The main focus areas of the project were the JMLB area, SD, BK, LH and LLB areas (on- and offshore) (Table 2 and Appendix 1).

All datasets were imported into the project database using ArcGIS 10.5.1 for Desktop (ESRI) and the Schlumberger´s (http://www.software.slb.com/) data interpretation tool PETREL 2014.01. Both systems were used to tie-in 2D subsurface observations with regional geophysical grid data, such as bathymetry, gravity and magnetic anomaly data. The entire project database is converted into the WGS84 projection system at UTM Zone 28 North.

The final aim was to construct a 3D structural area model to enable the generation of isopach thickness maps for true-vertical thickness differences in TWT (ms) for the main sequences. These maps are used in order to assess the paleo-thickness distribution of sediments in between major hiatus events. The resulting maps lead to a better understanding of locating basin depositional centres, main deposition trend directions and paleo-topography. The results of this model will be shown and discussed in chapter 5.

## 2.1 2D multi-channel seismic reflection data

2D seismic reflection and seismic refraction database have been compiled in combination with onshore geological maps and cross section profiles. Together with elevation/bathymetry, gravity and magnetic potential field data along the central East Greenland coast (Tables 2 and 3). The complete and available 2D seismic reflection data base covers the onshore and offshore areas for the JMLB, SD, LH, LLB, and BK (Figures 2 and 3).

The 2D seismic reflection database was made available for this project by GEUS and Federal Institute for Geosciences and Natural Resources in Hannover (BGR) geophysical databases, containing seismic data acquired in the perid of 1975 to 1989. The database covers the area of

JMLB, SD and offshore LLB and BK areas (Figure 2). Research surveys by BGR were carried out in 1975–1976 within the framework of the BGR program "Geoscientific studies in the North Atantic" whereas serveral seismic reflection lines were aquired along the central East Greenland margin. From 1980 to 1982 the Geological Survey of Greenland (GGU) acquired 8400 km of 2D seismic reflection data in the Scorsby Sund and along the Jameson Land and Blosseville Kyst margins (Table 3). Atlantic Richfield Company (ARCO) conducted detailed exploration work Jameson Land in the 1970s and 1980s. ARCO acquired about 1,800 km of 2D seismic reflection data in five surveys from 1986–1989 over the JMLB (Table 3 and Figure 2).

Some problems due to incomplete data information were encountered in preparing the seismic reflection data for interpretation. Before the 2D-MCS data was imported, several data checks had to be performed in order to generate a uniform dataset that include consistent line navigations data, the SEGY file consistency, static shifts, duplicate data points, and tie to the bathymetry or topography grids (Blischke and Erlendsson, 2016).

**Table 2.** *List of the 2D MCS data surveys made available by GEUS, seismic refraction data, cross-section profiles, geological data information, magnetic-, gravity- and bathymetry grid data.*

| Year | Survey ID | Conducted by | Country | Data repository | Data types |
|---|---|---|---|---|---|
| 1975 | BGR1975 | Bundesanstalt Für Geowissenschaften Und Rohstoffe (BGR) | Germany | GEUS | BGR data owner, 2D Seismic reflection, SEGY, deep, offshore |
| 1976 | BGR1976 | Bundesanstalt Für Geowissenschaften Und Rohstoffe (BGR) | Germany | GEUS | BGR data owner, 2D Seismic reflection, SEGY, deep, offshore |
| 1980 | GGU1980 | Geological Survey Of Greenland (GGU) | Denmark | GEUS | GGU data owner, 2D Seismic reflection, SEGY, deep, offshore |
| 1981 | GGU1981 | Geological Survey Of Greenland (GGU) | Denmark | GEUS | GGU data owner, 2D Seismic reflection, SEGY, deep, offshore |
| 1982 | GGU1982 | Geological Survey Of Greenland (GGU) | Denmark | GEUS | GGU data owner, 2D Seismic reflection, SEGY, deep, offshore, PGS reprocessed GGU1982 data in 2010-11 in partnership with Spectrum. |
| 1984 | Scoresby Sund | GEUS | Denmark | GEUS | Geological Map of Greenland, Sheet 12 (Bengaard and Henriksen, 1986; Pedersen et al., 2013) |
| 1986 | ARC1986V | Geophysical Service Incorporated | Denmark | GEUS | ARCO data owner, 2D Seismic reflection, SEGY, deep, onshore |
| 1987 | ARC1987D | Geophysical Service Incorporated | Denmark | GEUS | ARCO data owner, 2D Seismic reflection, SEGY, deep, onshore |
| 1988 | ARC1988D | Western Geophysical Co. | Denmark | GEUS | ARCO data owner, 2D Seismic reflection, SEGY, deep, onshore |
| 1988 | ARK88-P3 | IFG; GEOMAR; AWI | Germany | AWI | Seismic refraction data (Weigel et al., 1995) |
| 1989 | ARC1988V | Western Geophysical Co. | Denmark | GEUS | ARCO data owner, 2D Seismic reflection, SEGY, deep, onshore |
| 1989 | ARC1989D | Western Geophysical Co. | Denmark | GEUS | ARCO data owner, 2D Seismic reflection, SEGY, deep, onshore |
| 1989 | | GGU | Denmark | GGU | Onshore cross section profiles (Larsen et al., 1989) |
| 1990 | AWI 90539 | Alfred Wegener Institute (AWI) | Germany | AWI | Seismic refraction data (Fechner and Jokat, 1996) |
| 1990 | AWI 90544 | AWI | Germany | AWI | Seismic refraction data (Fechner and Jokat, 1996) |
| 1990 | AWI 90320 | AWI | Germany | AWI | Seismic refraction data (Fechner and Jokat, 1996) |
| 1990 | AWI 90300 | AWI | Germany | AWI | Seismic refraction data (Fechner and Jokat, 1996; Schmidt-Aursch and Jokat, 2005) |
| 1994 | AWI 94400 | AWI | Germany | AWI | Seismic refraction data (Fechner and Jokat, 1996; Schmidt-Aursch and Jokat, 2005) |
| 1995 | ODP 162 - 987 | IODP and Lamont-Doherty Earth Observatory | U.S.A. | ODP-TAMU | Site 987 (East Greenland Margin) coring and wireline logging |
| 1995 | ODP 162-987 | IODP and Lamont-Doherty Earth Observatory | U.S.A. | ODP-TAMU | Site 987 (East Greenland Margin) coring and wireline logging (Party, S. S. (Year), Site 987, paper presented at *Proceedings of the Ocean Drilling Program, Initial reports.*, TX (Ocean Drilling Program) |
| 2009 | ETOPO1 | NOAA | U.S.A. | National geophysical data center | ETOPO1 Global Relief Model, Bathymetry (Amante and Eakins, 2009) |
| 2010 | DTU 2010 | DTU-Space, EAPRS lab., NGA | Denmark | Danish National Space Center | Global Gravity Field Model (Andersen et al., 2010) |
| 2011 | CAMP-GM | CAMP-GM group | Norway | CEED University of Oslo | Magnetic anomaly grid (Gaina et al., 2011) north of 60N |

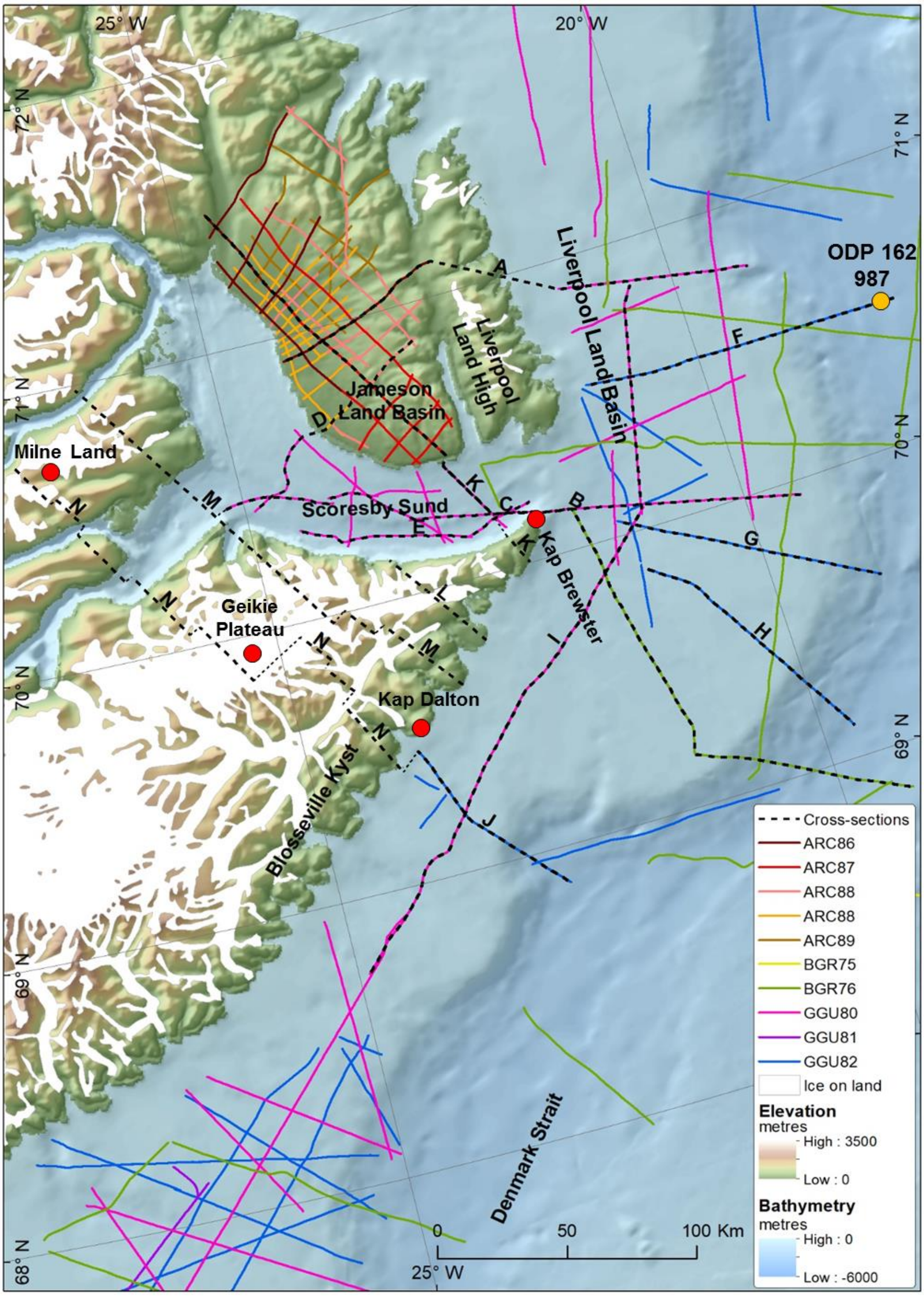



**Figure 2.** *Location of the prepared and loaded 2D-MCS data surveys, regional cross-sections, and key control sites across the Jameson Land Basin, Blosseville Kyst, Liverpool Land High and Liverpool Land Basin areas. The onshore cross section K, L, M, and N profiles are based on over 130 mesured traverses.*

**Table 3.** *2D multichannel seismic data acquisition parameters.*

| Survey ID | Total length of lines | Streamer length | Number channels | Source type | Sample rate | Shot Interval | Record length |
|---|---|---|---|---|---|---|---|
| ARC1986V | 331 km | | | | | | |
| ARC1987D | 357 km | | | | | | |
| ARC1988D | 398 km | | | | | | |
| ARC1988V | 401 km | | | | | | |
| ARC1989D | 308 km | | | | | | |
| GGU1980 | 2.651 km | 3.000 m | 60 | Maxipulse | 4 ms | 25/50 m | |
| GGU1981 | 2.398 km | 2.400 m | 48 | Airgun | 4 ms | 25/50 m | |
| GGU1982 | 2.821 km | 3.000 m | 60 | Airgun | 4 ms | 25/50 m | |
| BGR1975 | 2.815 km | 2.400 m | 48 | Airgun | 4 ms | 50 m | 10.000 ms |
| BGR1976 | 8.909 km | 2.400 m | 48 | Airgun | 4 ms | 50 m | 6.000 ms |

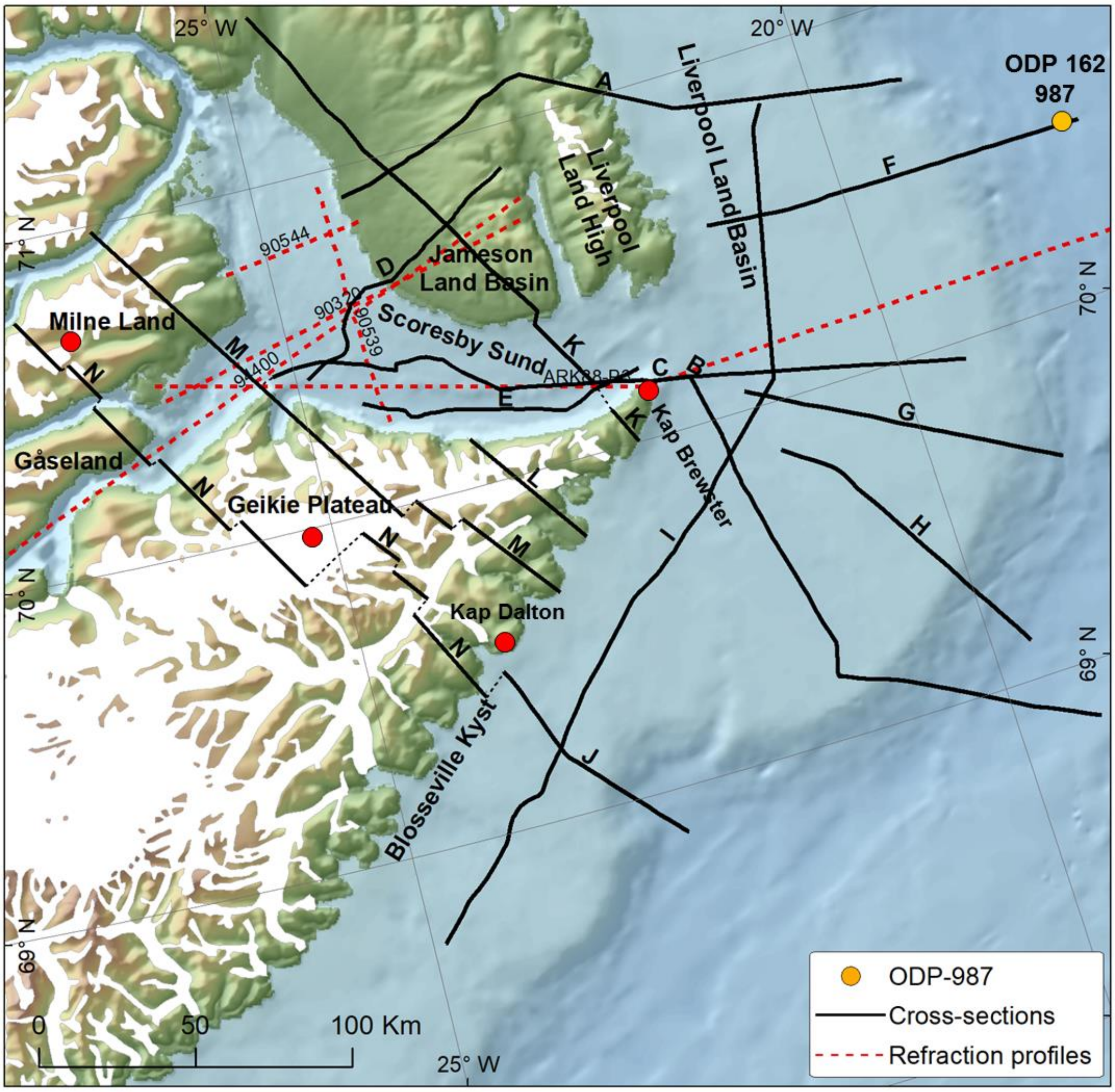



**Figure 3.** *Location of the prepared and loaded seismic refraction data surveys, regional cross-sections, and key control sites across the Jameson Land Basin, Blosseville Kyst, Liverpool Land High, and Liverpool Land Basin areas. Detailed interpretations of cross sections K, L, M, N are modified after Larsen et al. (1989) extends through the Milne Land, Gåseland, Geikie Plateau and Blosseville Kyst basalts.*

## 2.2 Offshore borehole data control

The composite borehole site 987 of Ocean Drilling Program (ODP) Leg 162 represents our only offshore borehole control. The boreholes were drilled at a water depth of 1671 m outside the mouth of Scoresby Sund and the Liverpool Land basin domain (Figures 2–4 and Appendix 2). In August 1995, five holes were drilled at Site 987 with a maximum penetration of 859.4 m. Site 987 is located close to magnetic anomaly 5 on the oceanic crust (~10–11 Ma; Vogt, 1986; Gaina et al., 2016).

This borehole enables the tie of the youngest stratigraphy and the Pliocene to Miocene boundary to the seismic reflection line GGU1982-12 ("F" Appendix 5), and is the only direct well control for the area. The borehole did not reach the oceanic crustal basement and is inferred by the seismic reflection data to be only a few meters below the base of the drill hole (Jansen et al., 1996; Channell et al., 1999; Butt et al., 2001).

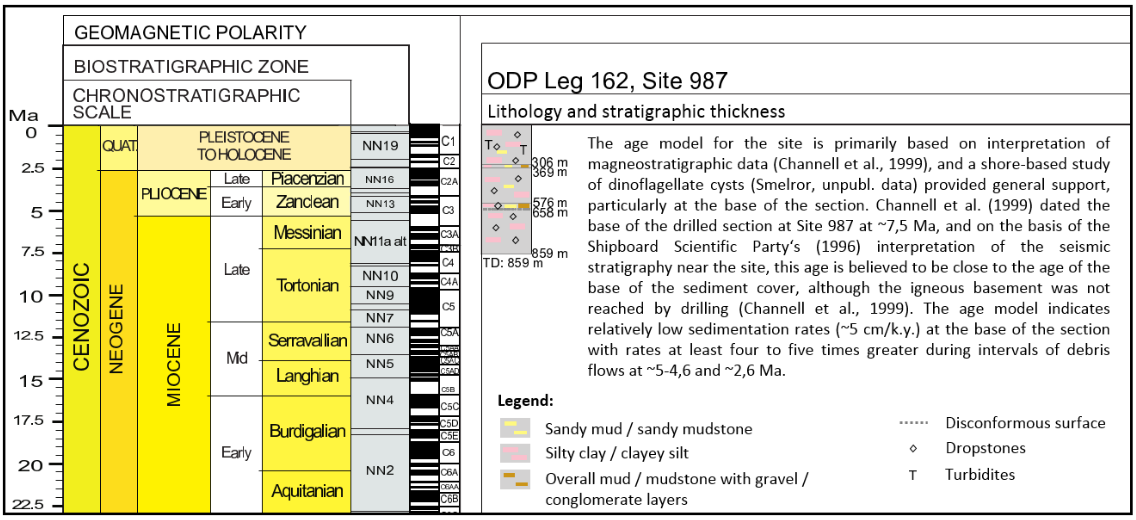



**Figure 4.** *ODP-162 borehole 987 data control (Shipboard Scientific Party, 1996), Liverpool Land Basin.*

## 2.3 Existing onshore data and stratigraphic section controls

Onshore cross section profiles from Larsen et al. (1989) extends through Milne Land, Gåseland, Geikie Plateau and Blosseville Kyst. Over 520 km of profiles were measured that are distributed over 130 traverses (Larsen et al., 1989). Several onshore cross section profiles (K, L, M and N) were modified after Larsen et al. (1989) (Figures 2 and 2, and Appendix 5). These 11 sections extend through the Milne Land, Gåseland, Geikie Plateau and Blosseville Kyst. These sections are based on outcrop profiles that were measured and interpreted at over 130 locations (Larsen et al., 1989).

Of specific interest was the onshore outcrop record of the pre-breakup stratigraphy that was found at Kap Brewster for the Blosseville Kyst area (Soper et al., 1976; Nøhr-Hansen and Piasecki, 2002) (Figures 2 and 3). The exposed Paleocene dark mudstone formation of the Kap Brewster location are older than 56 Ma and at the base of the plateau basalts. They contain reworked Cretaceous dinoflagellate cysts that indicate an age range between the Danian to early Selandian (Nøhr-Hansen and Piasecki, 2002).

Nøhr-Hansen (2003) and Larsen et al. (2013) reported that the landwards flows (Planke et al., 2000) of the plateau basalts overlie Lower Paleocene sediments at Kap Brewster and Kap Dalton (Figures 2 and 3, and sections B, C, N and J in Appendix 5). This corresponds to a distinct unconformity boundary, representing a regional marker that most likely also covered the JMMC area in the Paleocene, as this location represents the closest conjugate segment to the central JMMC by reconstructing the areas to 55 Ma (Gaina et al., 2009, 2017; Blischke and Erlendsson, 2016).

Further to the west, the Milne Land Formation (Figures 2 and 3) (56.36+0.25 Ma) of the main plateau basalts discordantly overlies Precambrian gneiss (Storey et al., 2007), marking the breakup unconformity for the north Blosseville Kyst and Scoresby Sund region.

### 2.3.1 Surface data and seismic reflection data tie-in

Detailed, digital geological surface map data of the central East Greenland areas have been included in the database (Bengaard and Henriksen, 1986; Pedersen et al., 2013; Hopper et al., 2014) (Figure 5). This map provided the opportunity to acquire a direct tie to the 2D-MCS data for the JMLB and into the Scoresby Sund area. This composite database was then used to corrleated the main known formation sequences for the JMLB area (Figures 2–5) from their onshore exposures to the sub-surface seismic reflection data records along the northwestern edge of the JMLB. Structural trends were provided by GEUS (2015), and are based on a field mapping campaign in 2015 (Brethes et al., 2018). Previously published results on structural trends and their timing were included for comparison as well (Seidler et al., 2004; Guarnieri et al., 2017).

The onshore mapping and structural trends analysis work by Seidler et al. (2004) has been helpful for calibrating the seismic unconformity boundaries for the post-Caledonian section, specifically the example of the mappable low angle unconformity between the Carboniferous and the Permo-Triassic section (Figure 6). The previously mapped regional trends by Seidler et al. (2004) in Figure 7 and GEUS (2015) in Figure 5 were compare with mappable trends of the JMLB basement top surface. Similarities and differences are then described in the results section.

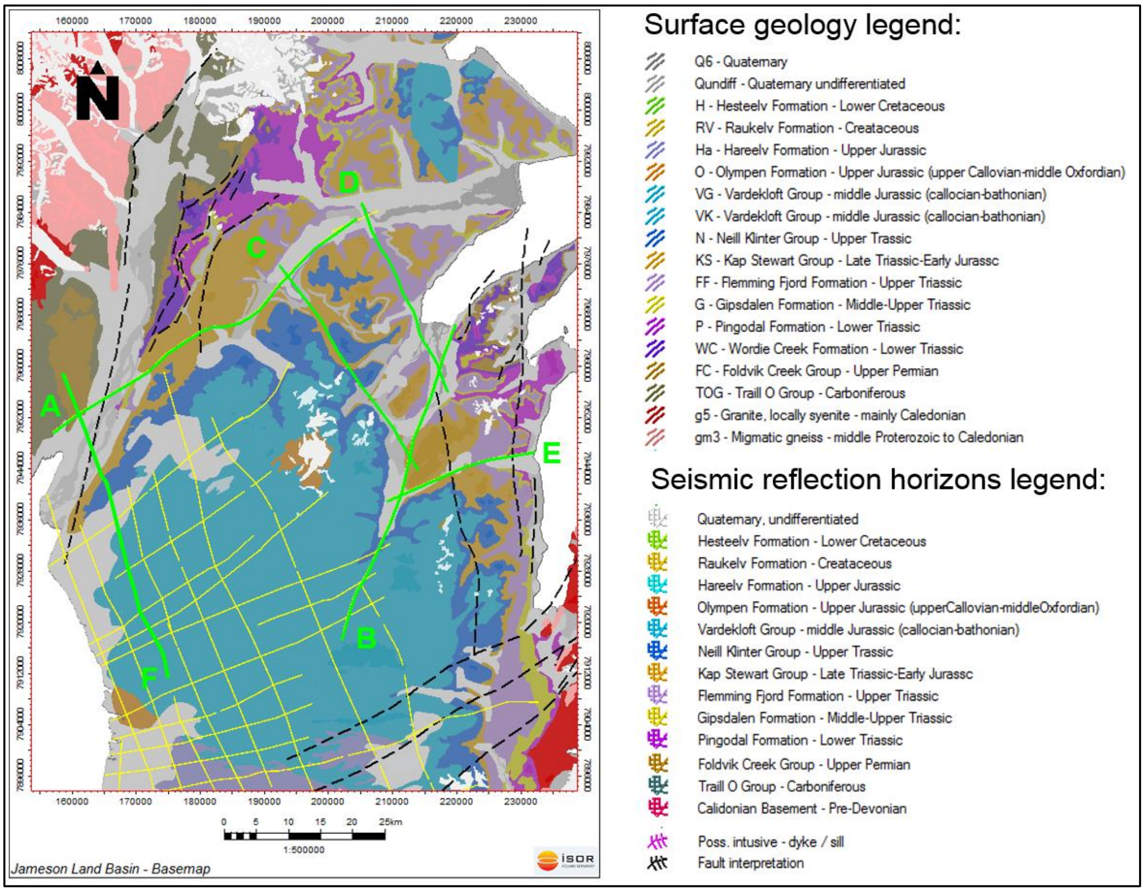



**Figure 5.** *Geological surface map and tie seismic reflection horizons of the northeast-central Jameson Land Basin area. Displayed are the seismic reflection data grid (yellow lines), key tie lines of the northeast area, the main structural surface trends (black dashed lines) observed by GEUS in 2015 and interpreted section profiles (green) that will be reviewed in chapter 5. The legend for seismic reflection horizons and interpreted features to the right correlate to the onshore geology maps record Pedersen et al., 2013.*

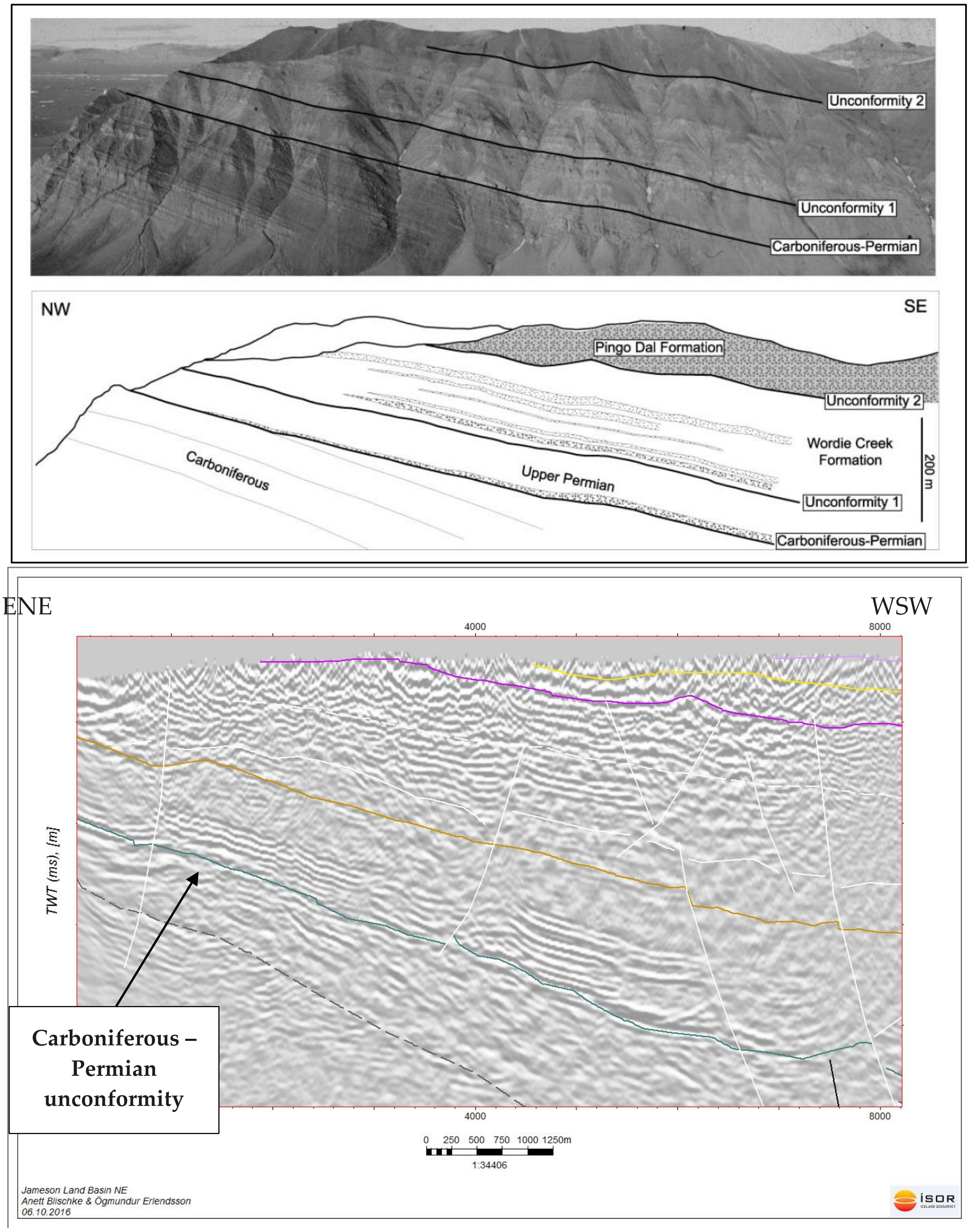



**Figure 6.** *Permian angular unconformity record for outcrop (top image) location at the Mestersvig sub-basin at the Griesbachian-Dienerian angular unconformity (image second from the top) (Seidler et al., 2004), north of the JMLB and for the north-eastern end of seismic reflection data profile E in comparison, see location in Figure 5 (bottom image).*

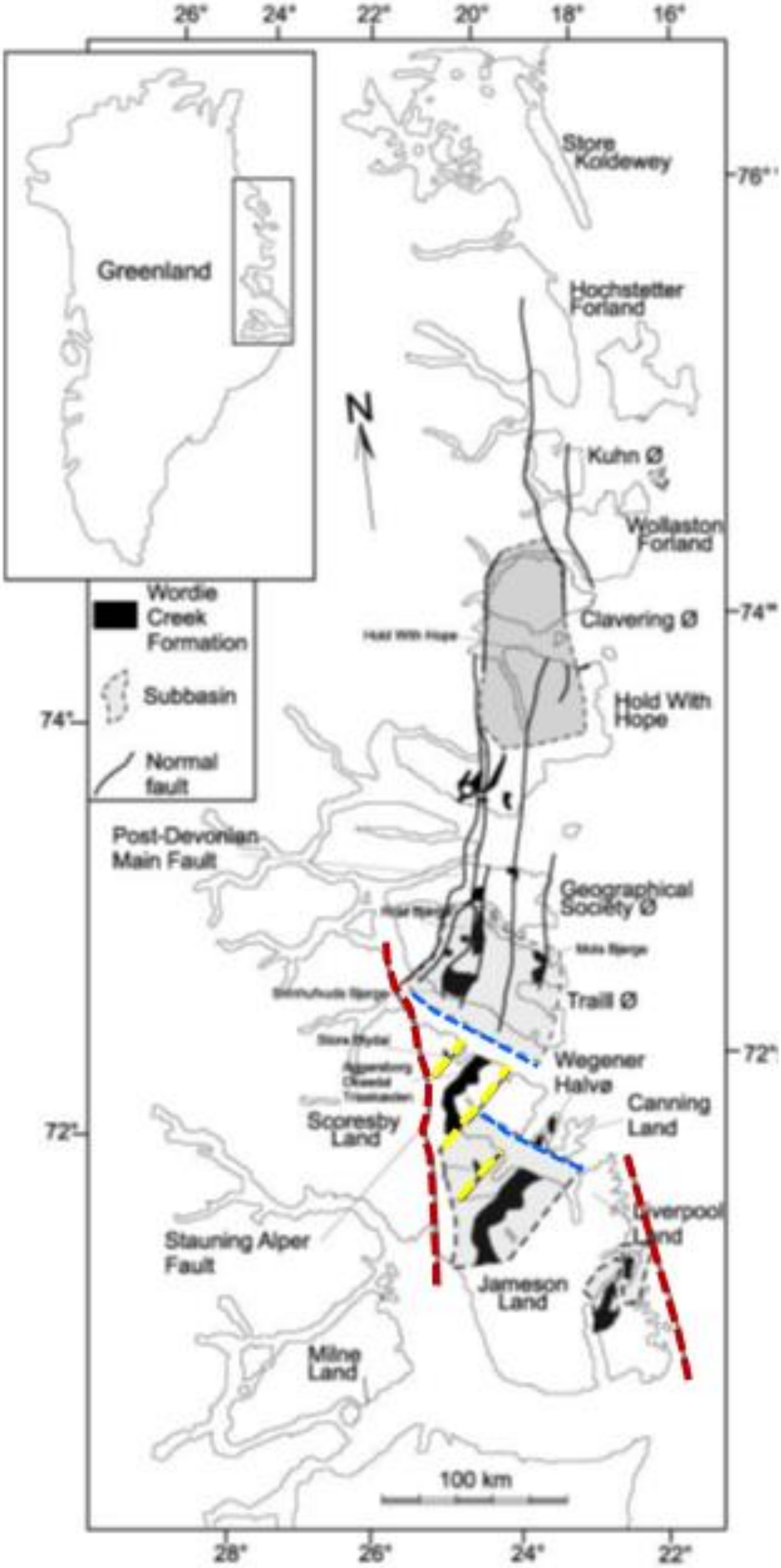



**Figure 7.** *Major fault trends along the East Greenland coast displayed with outcrops and sub-basins of the Wordie Creek Formation (Lower Triassic) by Seidler et al. (2004). Additional legend dashed lines: red - post-Caledonian rift system trend; yellow - Permo-Triassic rifting trend; blue - NW-SE basin boundary elements.*

## 2.4 Seismic refraction velocity data comparison and tie-in

Five seismic refraction profiles from the Scoresby Sund area were tied into the Petrel project database, by tying profile location and depth values of each model profile line. Then the main velocity layers were digitized to be able to compare velocity sequences/layers to the seismic reflection profiles in the region that were in two-way travel time (TWT). Bathymetry-, magnetic-, gravity- and geology map datasets were additionally included to the seismic refraction profiles (Figures 8 and 9) to make sure that the modelled velocity features line up with observed features on the other datasets.

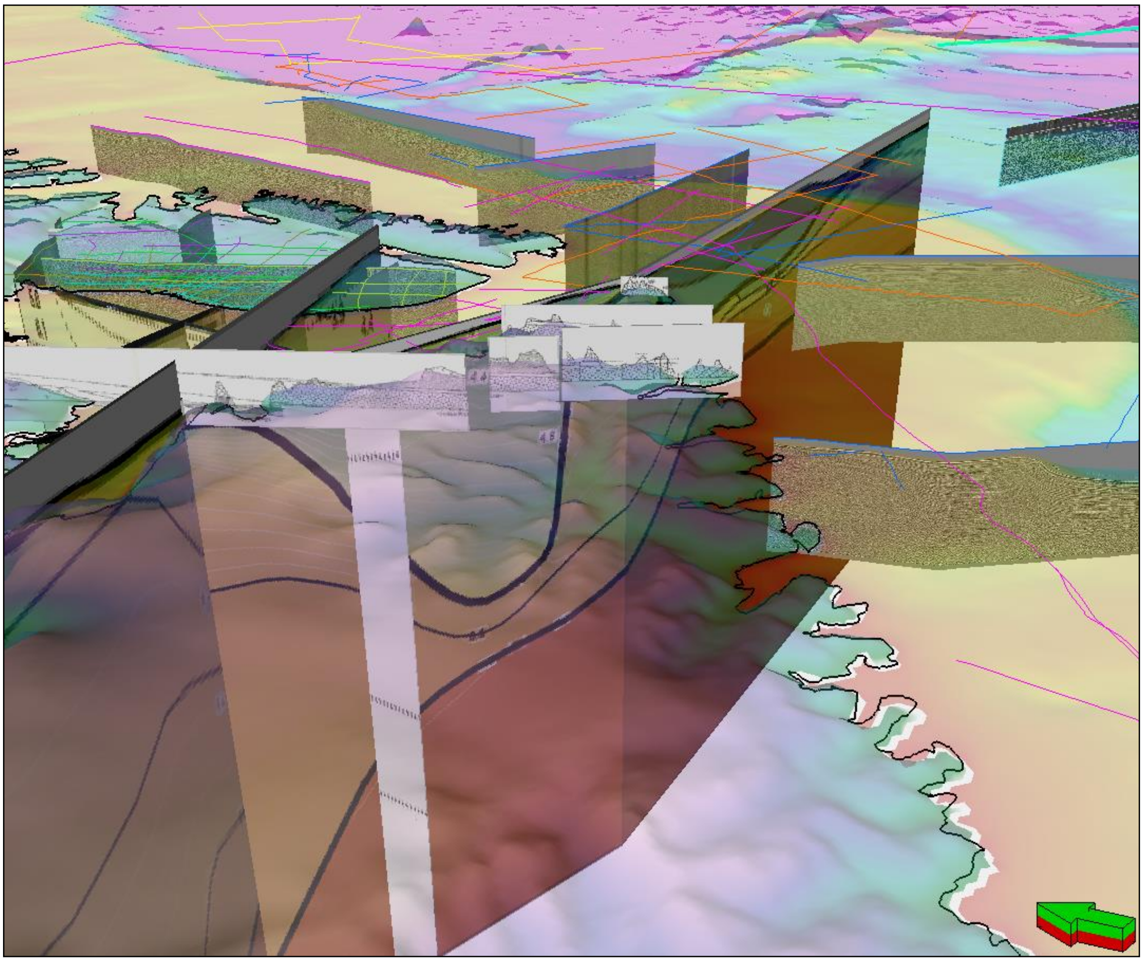


**Figure 8.** *Data tie-in example display within a 3D workspace in Petrel.*

The depth scale for all velocity models are in kilometre and the seismic reflection data is given in TWT. The different scales required prior a depth conversion from km to TWT for the velocity models to be able to compare them to the reflection data.

The first seismic refraction surveys in the Jameson Land region were acquired in 1988 by the German reacerch vessel Polarstern, in connection with oil exploration activities (Mandler and Jokat, 1998). The main objective was to investigate the crustal structure of the old Greenland continent and the adjacent young oceanic crust formed by the active Kolbeinsey spreading ridge. Based on that study two further expeditions were planned in 1990 and 1994 by the

Alfred Wegner Institute for Polar and Marine Research (AWI) to continue the research in the Scoresby Sund area. Six seismic refraction profiles were acquired in the region, yielding a much more detailed information about the velocity structure and the overall crustal thickness of the East Greenland Caledonides (Mandler and Jokat, 1998; Schmidt-Aursch and Jokat, 2005).

The crustal structure of the central East Greenland margin is controlled by the Caledonian fold belt that consists of pre-Devonian and mostly Precambrian rock formations (Henriksen, 2008). The forming of the JMLB as a narrow rift basin was initiated during the Caledonian orogeny and the oldest sedimentary rocks deposited in the basin are of Devonian age. The basin is bounded by several major fault trends that developed during the Palaeozoic rift extension, and during the Permo-Triassic to Jurassic extensional phases of pre-opening rifting phases in the Northeast Atlantic (Schmidt-Aursch and Jokat, 2005). Jameson Land is an example of an asymmetric, half-graben shaped sedimentary basin with an N-S striking axis. During the opening of the North Atlantic in Tertiary times, the area investigated a significant crustal thinning, which was associated with the production of large amounts of flood basalts. Flood basalt outcrops unconformably overlie Caledonian along the south-western edge of the JMLB (Larsen et al., 1989).

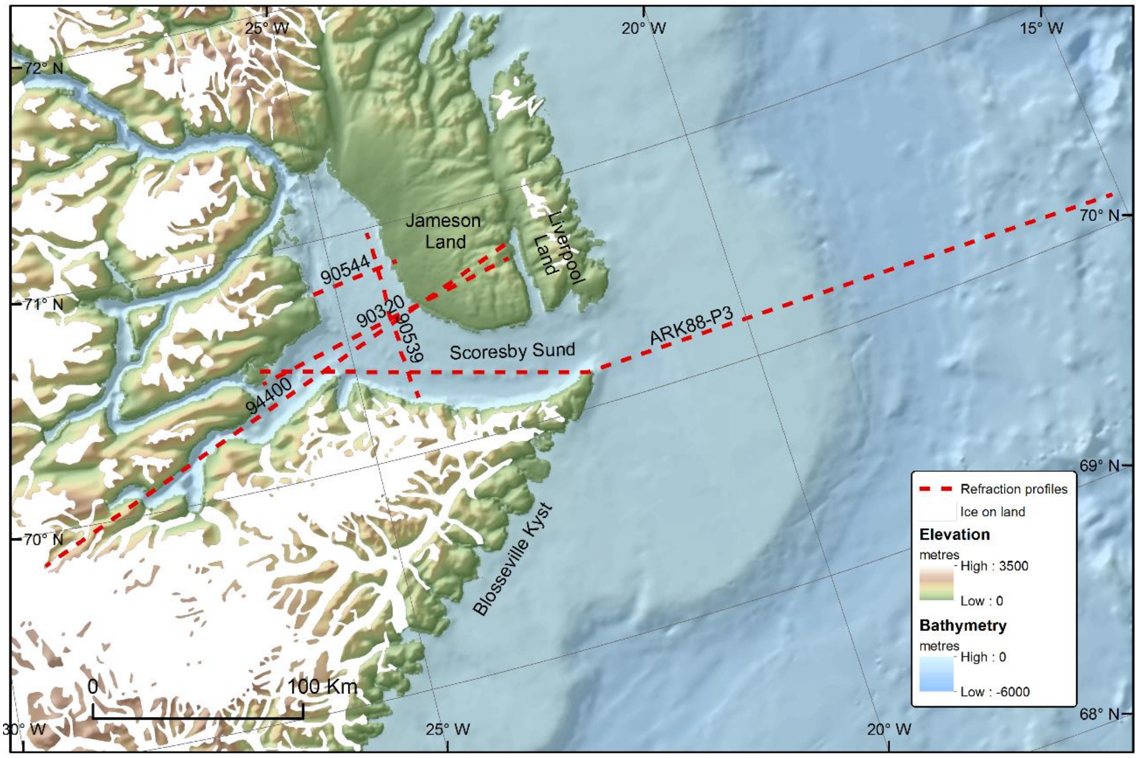
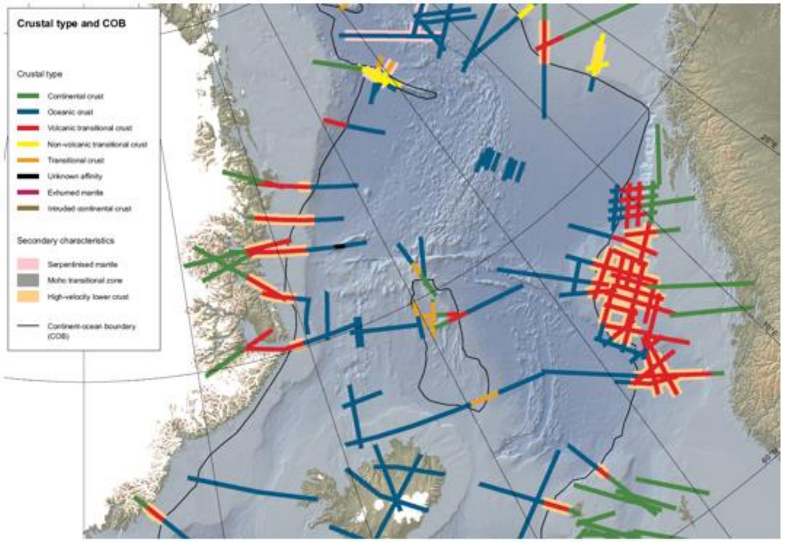



**Figure 9.** *Map showing the location of the refraction profiles in the Scoresby Sund. Profile number 1 (red) – AWI 90539; Profile number 2 (turquoise) – AWI 90544; Profile number 3 (dark blue) – AWI 90320; Profile number 4 (purple) – AWI 90300, 90310 and 94400; Profile number 5 (pink) – ARK88-P3 (Weigel et al., 1995; Fechner and Jokat, 1996; Schmidt-Aursch and Jokat, 2005).*

| Seismic intervals | OBS Model *Kodaira et al., 1998* | | OBS Model *Kandilarov et al., 2012* | Velocity data used for time-depth conversion | Estimated stratigraphic thickness across JMMC | Estimated stratigraphic thickness OBS model Fig. 4 intersection |
|---|---|---|---|---|---|---|
| | P-wave model layer | $V_P$ (km/s) | $V_P$ (km/s) | $V_P$ (km/s) | Thickness ranges (km) | TST estimate (km) |
| Seabed | Water depth | | - | 1.49 | 0 - 3.2 | 0.95 |
| Plio-Pleistocene | Cenozoic sediments | 2.0 - 3.5 | 1.7 - 2.2 | 1.8 | 0.1 - 1.1 | 0.06 |
| Late Oligocene – early-Miocene | | | | 2.0 | 0 - 1.05 | 0.09 |
| Early Oligocene | | | 2.2 - 3.2 | 2.3 | 0 - 2.05 | 0.29 |
| Late Eocene | | | | | | |
| Mid-Eocene | | | | 3.0 | 0 - 2.84 | 0.65 |
| Basalts – early Eocene | Basalt (SDR) | 4.0 - 5.0 | 3.2 - 4.1 | 4.0 | 0 - 6 | 1.48 |
| Early-mid Paleocene<br>Poss. Mesozoic | Poss. Lower Paleocene - Mesozoic | 3.9 - 4.7 | 3.9 - 5.0 | 4.4 | 0 - 4.5 | 2.25 |
| Poss. Paleozoic | Poss. Paleozoic | 5.0 - 5.3 | 5.0 - 5.5 | 5.2 | 0 - 4 | 3.82 |
| *Estimated stratigrahic and igneous section thickness above Caledonian basement:* | | | | | | 8,64 |
| Poss. Caledonian Basement | Cont. upper crust | 5.5 - 6.7 | 5.5 - 6.5 | 5.6 | 0 - 15 | 2,79 |
| Cont. Lower crust – subbasalt | Cont. lower crust | 6.7 - 6.8 | 6.5 - 7.2 | 6.8 | 0 - 10 | 2,96 |
| *Estimated stratigrahic , igneous section, and crustal stratigraphic thickness:* | | | | | | 14.4 |



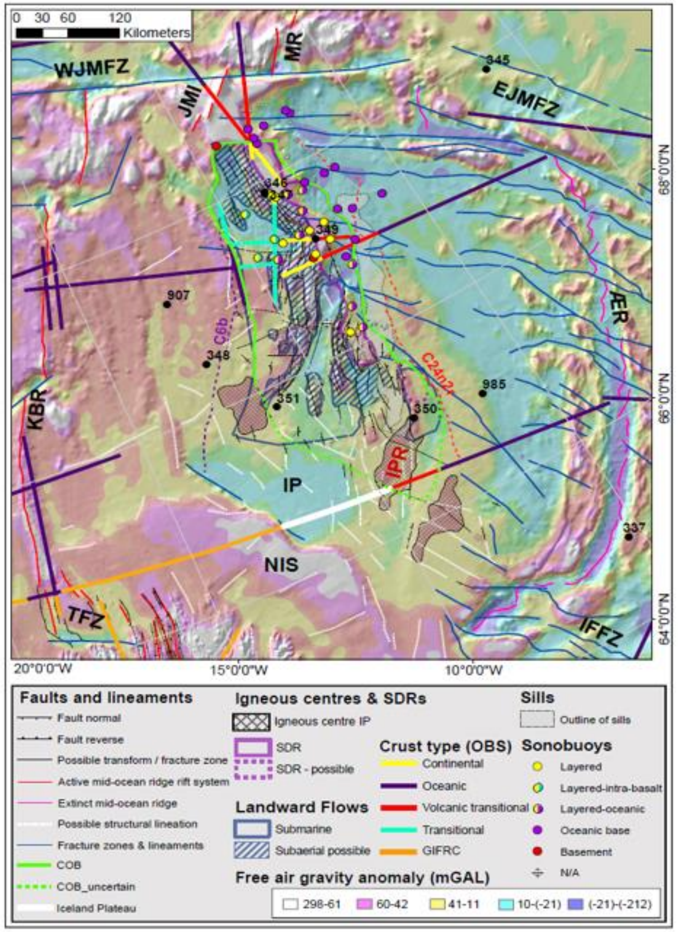




**Figure 10.** *Refraction seismic data tie in to the pre-Cenozoic stratigraphy for the JMMC (Hopper et al., 2014; Blischke et al., 2016).*

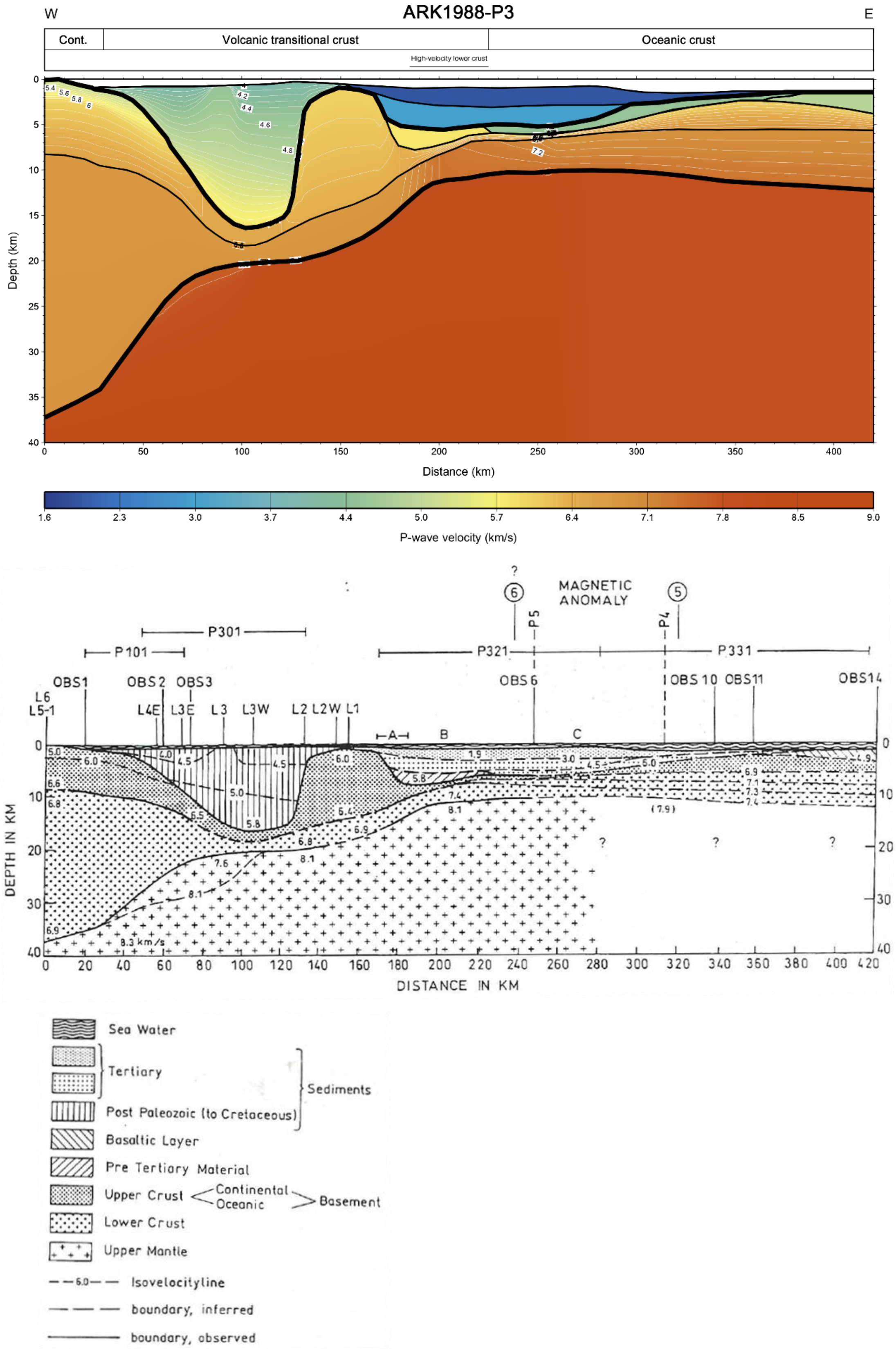



**Figure 11.** *ARK1988-P3 velocity model extending from Scoresby Sund in the west and continues towards the Kolbeinsey in the east. The upper version of the model is from the NAGTEC – Atlas (Funck et al., 2014 modified after Weigel et al., 1995). While the lower model is the original version, from Weigel et al. (1995).*

Profile ARK1988-P3 is characterised by more than 35 km thick continental crust at the western part of Scoresby Sund (Figures 9, 10 and 11). Towards east, the crust thins out to less than 10 km thickness. The crustal thinning is associated with a major inner sedimentary basin that is about 15 km deep and 80 km wide. This basin is believed to be the southward continuation of the main JMLB (Weigel et al., 1995).

During the late Cretaceous and early Tertiary periods, the JMLB was intruded by magmatic sills and partly covered by flood basalt (Larsen and Marcussen, 1992; Hald and Tegner, 2000). East of the basin, a basement high block of the Liverpool Land shows a crustal thickness of about 15–20 km (Weigel et al., 1995; Funck et al., 2014) (Figure 11). The Liverpool Land Escarpment at the eastern limit of the horst marks the transition to a 50 km wide and 5–8 km deep sedimentary basin that opens towards the oceanic basin. The oldest part of the oceanic crust on ARK 1988 P-3 has a thickness of 5 km and it thickens towards the Kolbeinsey Ridge (see Figure 11).

Fechner and Jokat (1996) suggest six main seismic velocity sequence/layers in their seismic refraction studies of the western JMLB (Table 4). The three top layers are interpreted as sedimentary rocks with velocities ranging from 3.9 to 5.5 km/s. The uppermost layer with the velocity of 3.9 km/s is interpreted as the Upper Jurassic and younger sediments, mainly composed of marine sediments. The layer number two has a velocity of 4.4 km/s. This layer is interpreted to be part of Permian to Jurassic sediments representing the deposits of the major transgression and consist of marine sediments only. Layer three has a rather high velocity of 5.5 km/s that indicates a large degree of compaction or possibly due to intrusive rocks that were emplaced at a later stage. This layer is made of sedimentary rocks that are mainly a continental origin and syn-sedimentary volcanics. Layer four has a velocity of 6.1–6.5 km/s and is interpreted as crystalline upper crust. The thickness of this layer varies from 13–22 km and most likely consists of Caledonian rocks. Layer five is interpreted as the lower crust with velocities of 7.0 km/s and the average thickness is 5–6 km.

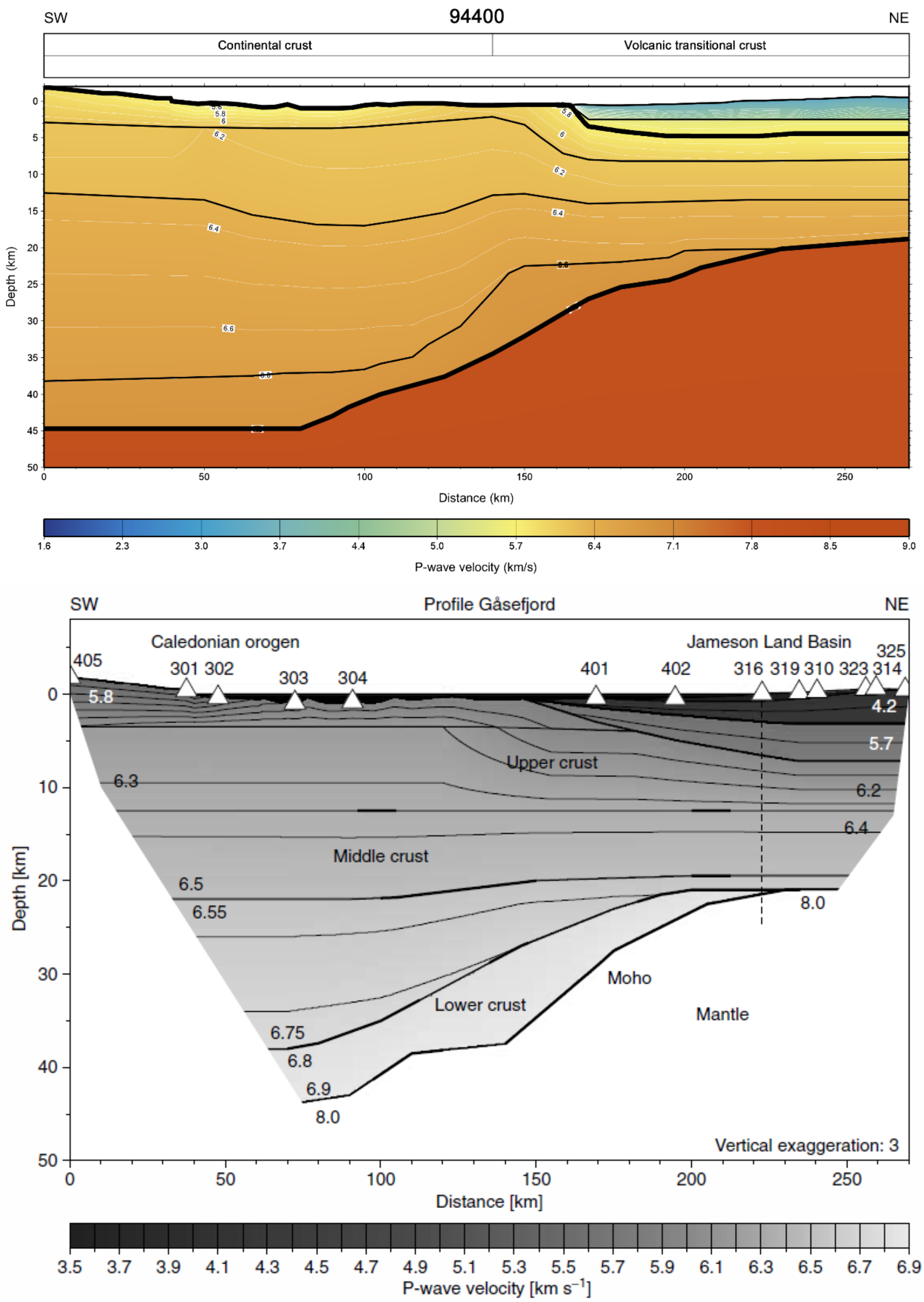



**Figure 12.** *P-wave velocity model for the southwest-northeast trending Gasefjord profile is a compilation of three profiles acquired in 1990 (AWI-90300, 90310) and 1994 (AWI-94400) (Fechner and Jokat, 1996; Schmidt-Aursch and Jokat, 2005). According to this model, the sedimentary basin is estimated to be about 10 km deep. The depth of Moho ranges from 44 km below the Caledonian belt to 21 km at the eastern end of the profile beneath JMLB.*

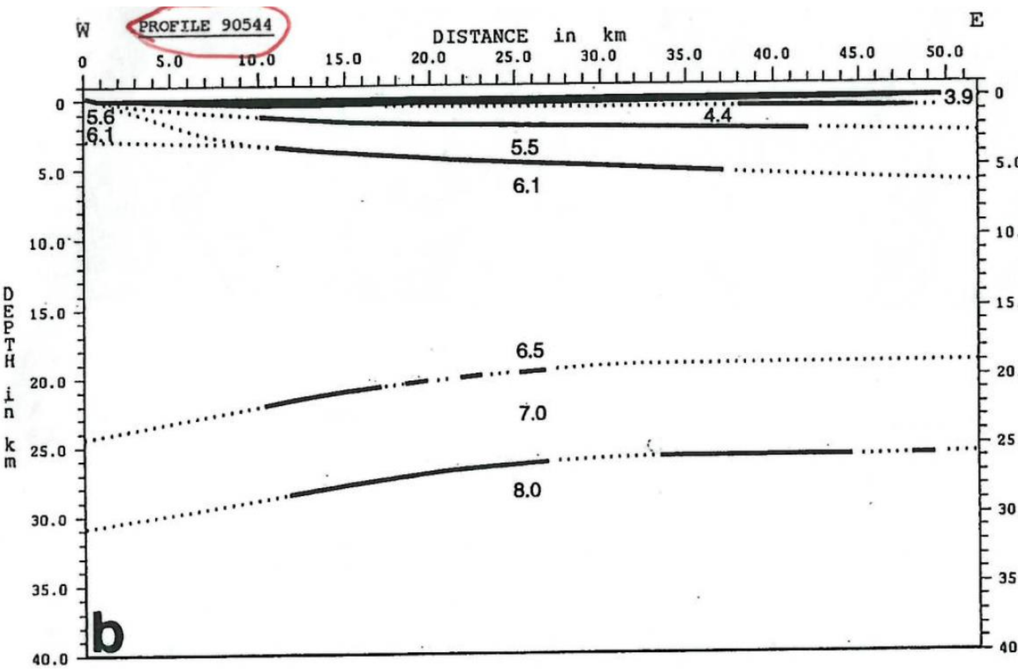



**Figure 13.** *Velocity model of profile AWI90544 (Fechner and Jokat, 1996). The bold lines in the model mark confirmed interfaces and the dotted lines indicate estimated layer boundaries. The profile is about 50 km long trending W-E. The total depth of Moho ranges from 30.8 km (+-1km) below the east coast of Milne Land and shallows to 25.7 km (+-1km) below the west coast of Jameson Land.*

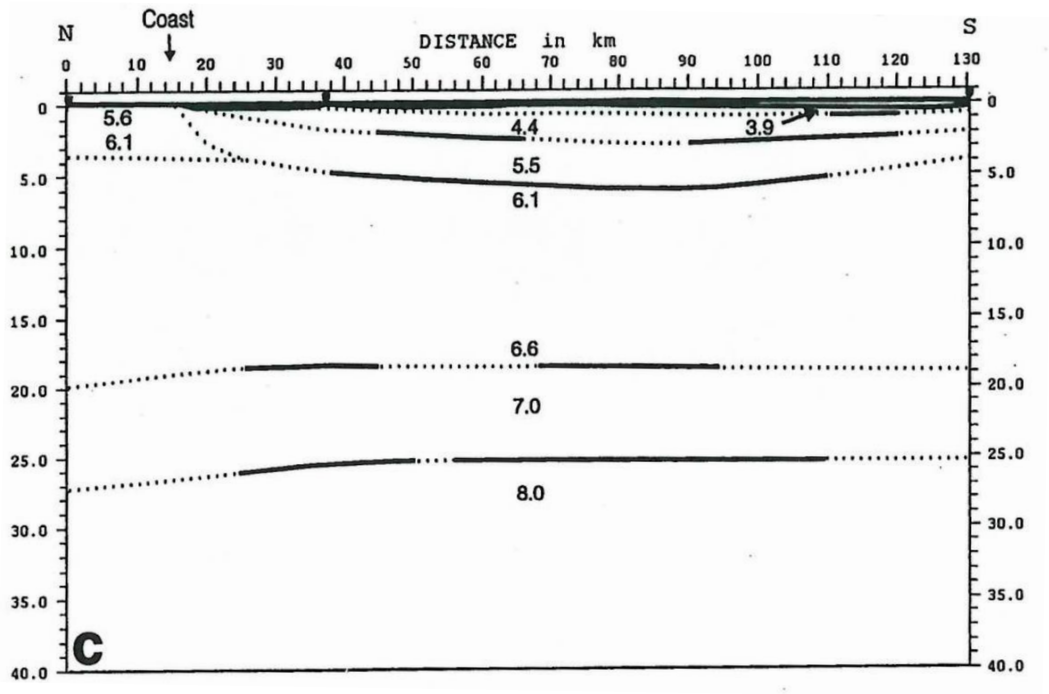



**Figure 14.** *Velocity model of profile AWI90539 trends N-S with a total length of 84 km. The Moho boundary is modelled at a depth of about 26 km and deepens slightly towards north (Fechner and Jokat, 1996).*

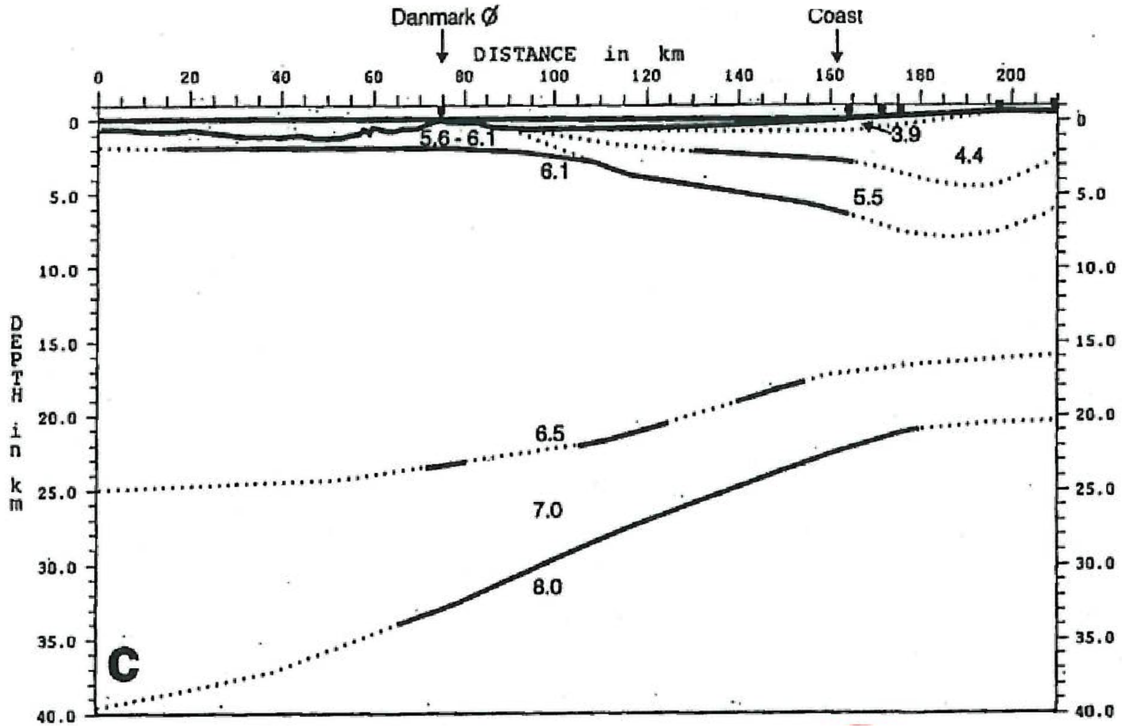



**Figure 15.** *The AWI90320 profile is about 200 km long and reveals the crustal structure in a W-E detection. Extending from Fønfjord, along the Danmark Ø and to the Jameson Land. The profile shows confirmed interfaces as bold lines, recorded by six REFTEK stations onshore (Fechner and Jokat, 1996).*

**Table 4.** *Velocities, thickness and layer interpretations (Fechner and Jokat, 1996).*

| $v_p$, km/s | $v_p/v_s$ | Thickness, km | Interpretation |
|---|---|---|---|
| 3.9 (±0.1) | 1.73* | 0–0.8 (±0.1) | Upper Jurassic (mainly marine sediments) |
| 4.4 (±0.1) | 1.73 (±0.10) | 0–5 (±0.2) | Permian to middle Jurassic (marine sediments) |
| 5.5 (±0.1) | 1.73 (±0.10) | 0–4 (±0.2) | Devonian (continental sediments and synsedimentary volcanics) |
| 6.1–6.5 (±0.1) | 1.72 (±0.08) | 13–22 (±1.0)† | upper crystalline crust |
| 7.0 (±0.2) | 1.85–1.90* | 5–6 (±1.0)† | lower crust |
| 8.0 (±0.2) | | | upper mantle |

*: The $v_p/v_s$ ratio is derived from ray tracing.
†: Thickness in the Hall Bredning area.

# 3 Regional correlation panels

In total eleven regional geo-seismic cross-section were compiled to show the main correlation of the stratigraphy and structural elements across the complex western conjugate margin of the JMMC (Figure 16).

**Cross-section A** is a composite section of the onshore Jameson Land, Liverpool Land High and the offshore Liverpool Land basin, showing the main structural and stratigraphic settings (Appendix 5). The JMLB is about 100 km wide (east–west) and up to 5 s TWT deep. It contains a presumed Carboniferous–middle Permian non-marine sediments rift succession strata of about 1–2 s TWT vertical thickness, which is overlain by marine Upper Permian–Jurassic strata of about 4.0 s TWT vertical thickness that are highly affected by sill intrusive complexes. The Liverpool Land High (LLH) area represents the crystalline basement, mainly Caledonian and pre-Caledonian strata. The Liverpool Land Basin contains an eastward prograding Paleogene to Quaternary sedimentary succession, ranging from 0–3 s TWT vertical thickness. That succession is underlain by possible block of pre-opening strata (older than 56 Ma) and possible pre-breakup basalt formations, which is presumed to be equivalent to the Blosseville Kyst formations. The final Late Oligocene to Early Miocene breakup phase can be seen in form of SDR's and the formation of rough regular oceanic crust that is covered by the prograding sediment wedge.

**Cross-section B** is the composite section of the onshore JMLB, Scoresby Sund and the offshore Liverpool Land basin, showing the main structural and stratigraphic settings (Appendix 5). The JMLB is part of N-S elongated Palaeozoic-Mesozoic basin (Surlyk, 1990; Anais et al., 2018). A 180 km long NW-SE striking profile is included in this cross-section across the main JMLB, which clearly extends into the Scoresby Sund area. The basin fill starts with a series of non-marine clastic rift sediments of Late Devonian to Early Permian age (Hamann et al., 2005; Guarnieri et al., 2017). The Upper Permian to Upper Cretaceous post rift succession is dominated by marine deposits, up to 5 s TWT deep. At the mouth of Scoresby Sund fjord, a Caledonian horst seems to define, the eastern extend of the Jameson Land strata, where the Triassic strata is getting thinner but the Jurassic section thicker towards the horst.

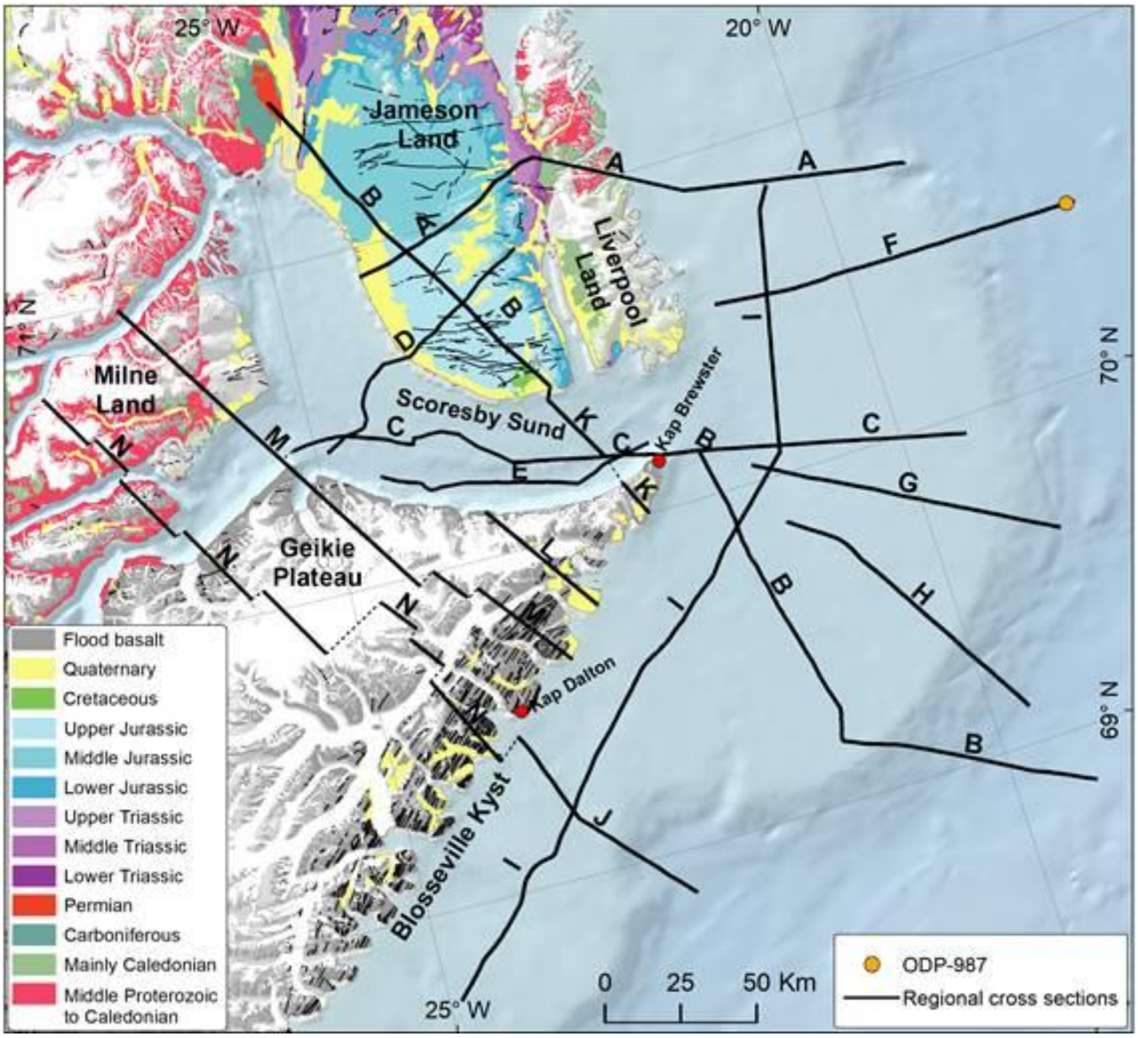



**Figure 16.** *Location map of regional correlation panels of Appendix 5.*

Large sill intrusive features can be seen throughout the pre-Jurassic strata centred within the deepest part of the basin, whereas shallower and smaller scale intrusive signatures were observed within the Scoresby Sund area for the pre-Cenozoic stratigraphic section. These different sill intrusive signatures at different depth levels may have been in relation with the opening of the North Atlantic Ocean, or pre-opening and older igneous activities. Extrusive igneous activity and formations are recorded in outcrops (Larsen et al., 1989) with more than 2 km thick volcanic series that are still preserved along the Blosseville Kyst, and the subsurface seismic reflection data throughout the area south and east of the JMLB. A section of possible pre-breakup plateau basalt, equivalent to the Blosseville Kyst Formation, is mapped to extend over 150 km offshore the Liverpool Land High and the Blosseville Kyst areas. This basalt series covers the Caledonian horst and the possible pre-opening Liverpool Land Basin strata.

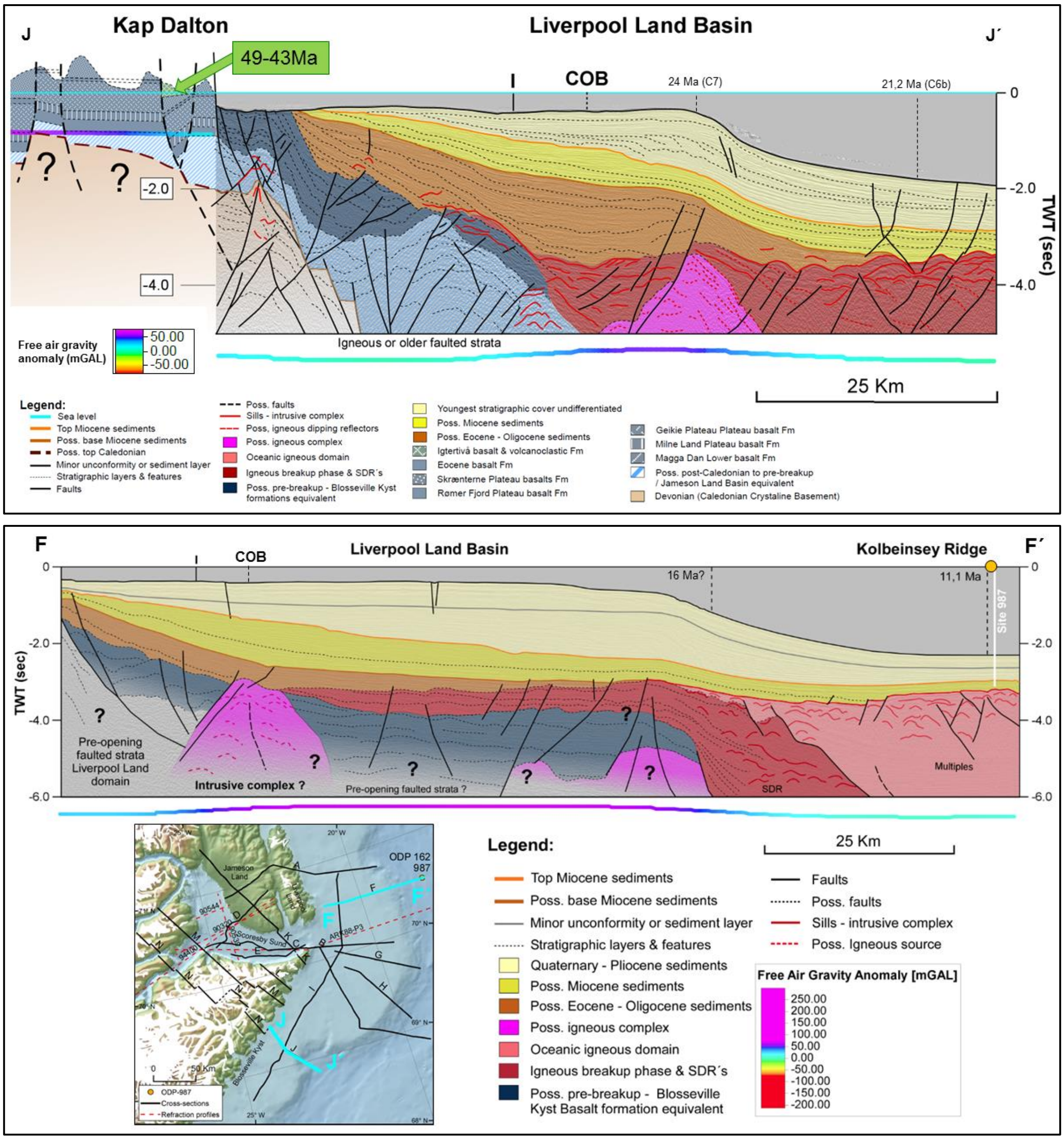



**Figure 17.** *Key regional correlation panel and tie-in section to the southwest igneous province of the JMMC.*

The younger stratigraphic cover contains an eastward prograding Paleogene to Quaternary sedimentary succession (up to 3 s TWT thick), which also covers the igneous breakup extrusive and intrusive formations, seaward dipping reflector (SDR) (Mutter et al., 1982), and regular oceanic igneous crust of the Kolbeinsey Ridge system.

**Cross-sections C and E** show the main structural and stratigraphic settings of the Mesozoic formations within the Scoresby Sund area (Appendix 5). Cross-section C is a composite section of the Scoresby Sund and offshore Liverpool Land basin. The Scoresby Sund strata consist mainly of Triassic and Jurassic formations with a combined vertical thickness estimate of up to 5 s TWT. Notably less intrusive activity was observed within the Mesozoic strata of the Scoresby Sund area than in the deepest part of the JMLB. At the mouth of Scoresby Sund fjord, a Caledonian horst structure defines, the eastern extend of the Mesozoic strata. The Liverpool

Land Basin is located east of that horst structure, which is covered most likely by the Blosseville Kyst equivalent extrusive formations, and further eastward by a up to 3 s TWT thick prograding Upper Paleogene to Quaternary sedimentary succession. Faulted blocks of most likely BK-basalt equivalent and pre-opening strata can be seen below this prograding sediment succession. The sediment succession is getting progressively younger into the Neogene further east, covering the igneous formation equivalent of the second breakup phase that formed the Kolbeinsey Ridge system.

**Cross-section D** is a composite SW-NE striking section of the Scoresby Sund and JMLB, showing the main structural and stratigraphic settings of the basin Mesozoic formations (Appendix 5). The JMLB strata extends into the Scoresby Sund and contains mainly of Triassic and Jurassic formations with a vertical thickness up to 5 s TWT into the deepest section of the Jameson Land rift basin. Intrusive features are observed primarily within the Triassic strata as sill but occur across the Mesozoic strata within the Scoresby Sund area close to main fault zones. The topography of the JMLB represents an erosional surface due to several uplift events and an estimated erosion of more than 2 km (Mathiesen et al., 1994).

**Cross-sections F, G and H** show the complex igneous breakup margin with its structural and volcano-stratigraphic segmentation from the possible pre-breakup flood basalt sequences thought to be identical to the onshore Blosseville Kyst basalt formations (Appendix 5). Actual thickness estimates of these flat lying basalt formations are greatest along the Blosseville Kyst coast, reaching up to 2 km (Larsen et al., 1989). This flood basalt formation forms the base of the Liverpool Land Basin sections and are heavily faulted with steeply dipping seismic reflection signatures. These steeply dipping faults and formations can also be observed along the Blosseville Kyst coast (Figure 16). Both intrusive and extrusive complexes are interpreted along these sections, as a record for the great volcanic activity in the area since the beginning of the North Atlantic breakup around 56 Ma to the final separation of the JMMC domain and the forming of the Kolbeinsey Ridge between 24 Ma – 16 Ma (e.g. Gaina et al., 2009, 2017; Gernigon et al., 2015; Blischke et al., 2016). These are mapped as the possible flood basalt formations equivalent to Blosseville Kyst basalt series, the overlying basalt formation of the final breakup phase and forming of a distinct edge of SDR formations, and the on-lapping oceanic crustal domain of the Kolbeinsey Ridge. Large intrusive complexes are located close to fault and fracture zones within this “stacked” and vertically accreted igneous margin, which either relate to the final breakup phase around 24 Ma ago (Gaina et al., 2009, 2017), or they are related to subsequent rifting events between 24 Ma and 14.6 Ma (Figure 18).

The igneous sequences are covered by approximately 3 s TWT vertical thick Eocene to Quaternary sedimentary sequences, of which clear prograding sediment successions are visible from the Miocene onwards. The only available offshore borehole control of site 987 of ODP leg 162 (Figure 4) is located at the eastern edge of cross-section F (GGU82-12) on the north-eastern flank of the Scoresby Sund Fan (Figure 17) and enables the tie of the youngest stratigraphic section and the Pliocene to Miocene boundaries to the seismic reflection data interpretation grid. The borehole did not reach the oceanic crustal basement and is inferred by the seismic reflection data to be only a few meters below the base of the drill hole (Jansen et al., 1996; Channell et al., 1999; Butt et al., 2001), and is located close to magnetic anomaly 5 oceanic crust (~10–11 Ma; Vogt, 1986; Gaina et al., 2017).

**Cross-section I** is a composite section along the coast of Blosseville Kyst and Liverpool Land High. The Neogene to Quaternary section is up to 3 s TWT thick. Example of both intrusive and extrusive complexes are well visible on this section. Over a 100 km long intruded igneous domain offshore the Blosseville Kyst that overlies the possible pre-breakup plateau basalt formation. These features appear to be extruded at slightly later phase than the main post-breakup plateau basalt formations (62–55.7 Ma), probably related to the breakup and first spreading during the Eocene period. The estimated Oligocene strata apparently onlaps discordant across the igneous domain structures. At the northern end of this section is more likely an intrusive feature that crosses section F. This mounded structure must have occurred earlier than the possibly igneous and extrusive igneous complex at the southern end of line. The central part of cross-section, east of the Scoresby Sund area, is a good example for an extrusive feature that onlaps onto older stratigraphic successions.

**Cross-sections K, L, M, N and J** show the general structure of the basalt succession from the Milne Land, Scoresby Sund and Blosseville Kyst areas (Figures 16 and 17, and Appendix 5). Five basalt formations of regional extent were established by Larsen et al. (1989) and are often referred to as plateau basalts. The successions are referred to as the Magga Dan basalt formation, the Milne Land-, Geikie-, Romer Fjord- and the Skrænterne plateau basalt formations. One younger formation, the Igtertivå basalt formation is only preserved as down-faulted fragments at Kap Dalton (Larsen et al., 1989) (Figure 17). The basalt formations are mainly flat lying with a regional dip 0.5–1° to the SE (Larsen et al., 1989). The estimated vertical thickness of the preserved basalt formations is around 2 km along the Blosseville Kyst coast, decreases inland to about 1.5 km in the Gåsefjord area, and to 300–800 m across the Gåseland and Milne Land areas (Larsen et al., 1989) (Figure 16). Onshore geologic mapping along the Blosseville Kyst coast shows an over 200 km long swarm along the coast and fault parallel NE-SW with striking basalt dyke intrusions. Further inland are ENE-WSW trending dyke intrusions mapped across the Milne Land, Gåseland and south of Gåsefjord areas.

They dominantly rest on the Caledonian basement that is exposed at surface to the north-west of the sections, while their base drops below sea level to the east and is not clearly exposed at surface, besides the Paleocene pre-breakup stratigraphic control that was found at the Kap Brewster location (Soper et al., 1976; Nøhr-Hansen and Piasecki, 2002) (Figure 16). The seismic reflection data interpretation of section N-J shows the unconformity between the plateau basalt succession and the post-Caledonian to pre-breakup sections that are most likely equivalent to the JMLB strata (Figure 17 and Appendix 5).

# 4 Igneous domains and features

Successions of the pre-breakup and breakup formations of the North Atlantic Igneous Province can be followed as thick flood basalt formation, also referred to as plateau basalts, with coast parallel dyke swarms and sill intrusions along the Blosseville Kyst margin (Larsen et al., 1989) (Figure 16).

These plateau basalt formations formed prior to continental breakup during Paleocene and have been dated from 62–55.7 Ma (Storey et al., 2007). A series of onshore intrusive complexes within in the area are dated within a time ranging from 40 to 55 Ma. This relative large time span corresponds to the onset time of continental breakup and first seafloor spreading along the Reykjanes mid-oceanic rift system further south of the study area (Tegner et al., 2008) and younger igneous activity along the central East Greenland margin. The interpreted seismic reflection data indicate that the basin strata is highly affected by sill intrusions, however the frequency of sill intrusions is much lesser in the southern part of the basin, within the Scoresby Sund area (Figure 18 and cross-sections A-E and K in Appendix 5). The sill intrusions were mapped in the depth range between 1 to 5 s TWT. They are emplaced within the Carboniferous to Cretaceous formations. Still, the sill intrusions are primarily located within the Triassic formations, within the central and deepest part of the JMLB. The intrusions can be seen throughout the Post-Caledonian strata within the Scoresby Sund area, parallel to the strong magnetic anomaly that strikes parallel to the Scoresby Sund area and mapped faults zones (Figure 18).

Several intrusive and extrusive igneous features were interpreted coast parallel to the offshore areas of the Liverpool Land High and Blosseville Kyst that correlate with strong positive and negative magnetic anomaly signatures (Figures 17 and 18, and Appendix 5). Due to the lack of borehole control it is difficult to determine if these igneous features are intrusive our extrusive features. The interpretations are based on seismic reflection pattern interpretations of sudden changes of layered and regular reflectors to irregular and chaotic reflector areas that are emplaced within or discordantly overlay an evenly layered sequence.

On cross-sections F, B and I are igneous complexes interpreted with a mounted like structure that are covered by possible pre-breakup flood basalt formation. Both complexes could be intruded into the plateau basalt equivalent formation, or possible be one of the sources for these thick basalt formations. These igneous complex features line up with negative polarity of the magnetic anomalies data (Figures 17 and 18). Along cross-section I are well visible different types of intrusive and extrusive complexes. Where a 100 km long igneous domain towards the southern end of the section appears to onlap onto the plateau basalt equivalent formation. With its deeper section to have been intruded along a major fault and fracture zone and lava flow like features along the top section of that igneous complex, which as well correlates to a positive magnetic anomaly feature (Figures 17 and 18, and Appendices 1 and 5).

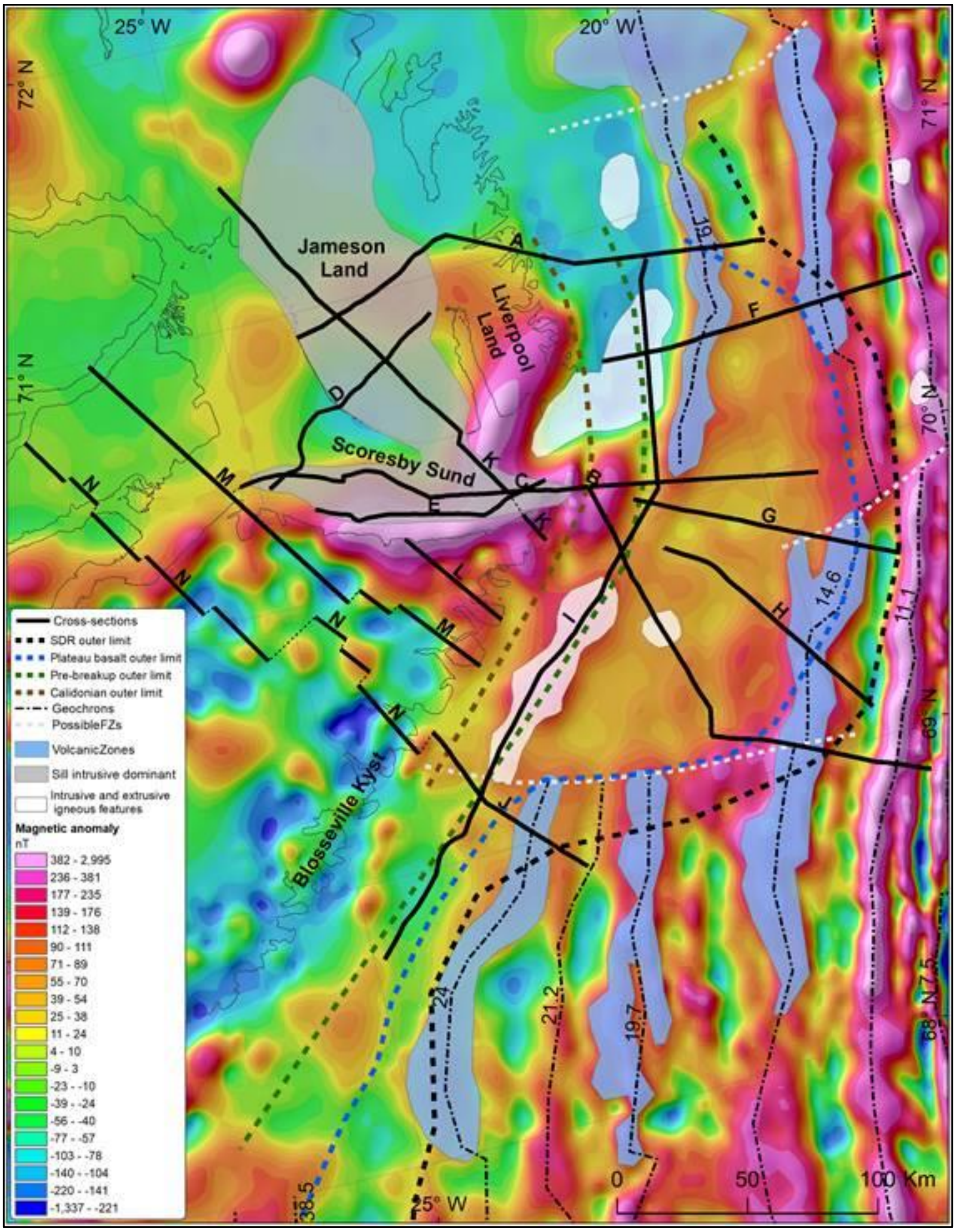



**Figure 18.** *Main outlines and borders of igneous domains and features, locations of regional geo-seismic cross-sections overlain on the magnetic anomalies data map (Gaina et al., 2011).*

The northern end of that section shows a more likely intrusive feature that crosses section F and correlates to a negative magnetic anomaly feature of the Liverpool Land High and must have occurred earlier than the possibly igneous and extrusive igneous complex at the line´s southern end. The central part of cross-section I, east of the Scoresby Sund area, is a good example for an extrusive feature that onlaps onto older sequence.

The interpreted pre-breakup plateau basalt formation extends more than 100 km offshore the coast of the Liverpool Land high and the Blosseville Kyst, and are assumed to be the down-faulted section and equivalent of the plateau basalt formation of the Blosseville Kyst area. This plateau basalt formation is observed to have a rather strong and smooth top reflector with slightly landward dipping reflectors on the seismic reflection profiles. These flood basalts are possible mainly composed of subaerial and/or some shallow submarine lavas. Along the central part of Blosseville Kyst is the outer limit of the interpreted flood basalts extended about 50 km offshore the coast. Along the outer limit of the plateau basalt formation, we have mapped a package of SDR´s (with reflection that dip seaward). SDR´s are common features on volcanic rifted margins and it represent a dipping flood basalt sequences associated with breakup and early seafloor spreading. They are interpreted to be a subaerial to shallow marine lava flow features.

# 5 Tectonostratigraphic framework of the JMLB region

A 3D JMLB grid model was created based on all seismic reflection and refraction line data (Figure 2). Structural trends and styles that were mapped onshore were considered and tied in for the entire project area and projected for the offshore areas within the JMLB and Scoresby Sund areas (Figures 7, 19, 20 and 21, and Appendix 3 and 4) (Pedersen et al., 2013; Guarnieri et al., , 2017), Brethes et al., 2018). The area with the highest data overlap to start tying the seismic reflection data to the surface geology, was the north-western and north-easternmost extend of the JMLB area (Figure 5). From that area, several key seismic reflection lines were tied to the onshore geological records (Figures 22 and 23).

The underlain magnetic anomaly data grid was compared to the mapped profile data and indicates parallel trends for the Mesozoic to Cenozoic rifting and breakup events and incudes high velocity seismic refraction data observations within the Scoresby Sund area and northernmost extend of the Blosseville Kyst areas (Appendix 1; see sections B and C in Appendix 5).

Five distinct trends can be seen based on the data compilations and interpretations for the mapped and modelled area (Figures 19 and 20):

(1) White dashed lines correspond to the original N-S Caledonian trend and basement faults.

(2) The NE-SE striking yellow dashed lines correspond to the Permo-Triassic rifting stage and possibly reactivated fault trend.

(3) The WNW-ESE striking blue dashed subsurface fault observations and black solid lines of the surface fault trends are primarily associated with the mid- to southern area of the JMLB and effected the strata primarily through the Upper Triassic.

(4) The NW-SE trending red dashed faults possibly correspond to reactivated Carboniferous fault trends by Mesozoic – Cenozoic rifting and dyke intrusive rock formations.

(5) The EEN-WWS striking green dashed trends corresponds to Mesozoic – Cenozoic breakup transform fracture shear zone that primarily is active within the area of the Scoresby Sund.

## 5.1 Onshore review of the northeast area of the Jameson Land Basin

The general structural interpretation shows a narrow, NNE-SSW post-Caledonian, coast parallel rift basin (Figure 7, 19 and 20) that has been overprinted by a Permo-Triassic rifting event and changed the sub-basin axis trends to NE-SW (yellow trend on Figure 20) (Seidler et al., 2004). Rifting continued during the Jurassic and Cretaceous period (Henriksen, 2008; Henriksen et al., 2009). Tertiary intrusive sections, e.g. thick sills (Larsen, 1990; Larsen and Marcussen, 1992; Hald and Tegner, 2000) intruded into the Palaeozoic- and Mesozoic sediment sections mostly along fault planes during the breakup of the Northeast Atlantic region. Today´s topography represents the erosional surface and the result of the Cenozoic uplift history, and the erosion of approximately 2–3 km (Mathiesen et al., 1994; Bonow et al., 2016).

### 5.1.1 Devonian - Carboniferous

The Devonian and pre-Devonian structures are characterised by regional steep dipping sequences, and folded sections (Appendix 4) that can also be seen in the seismic reflection record (Figures 22 and 23). Rift starting during Devonian epoch. First initial post-Caledonian deposition filled the basin during a time of block faulting and continues rifting during the Early and Late Carboniferous (Surlyk, 1990, 2003; Stemmerik et al., 1993). Up to 3000 m of fluvial and lacustrine sediments were deposited in active half-graben structures (Henriksen et al., 2009) onto the Caledonian basement (Figures 22 and 23, which forms a distinct unconformity (seismic reflection horizon "Caledonian Basement – pre-Devonian" Figures 5 and 22–27). A major hiatus marks the time period between the Devonian-Carboniferous early rifting sequences and the earliest Permian, when deposition ceased that was caused by a regional Early Permian uplift period (Henriksen et al., 2009).

### 5.1.2 Permo-Triassic

During the Permo-Triassic period, the basin´s alignment direction changed to NE-SW, prompting a basin and highs area of NE-SW striking sub-basins and half graben areas. These sub-basins and half-grabens were in-filled by on-lapping sediments onto basin shoulders accompanied by normal faulting within a complex wrench fault system (Figures 7 and 20–27 (Seidler et al., 2004). During Late Permian and throughout the Mesozoic, the basin was controlled by thermal subsidence and localized wrench faulting and subsidence due to the starting rift phases between Greenland and Scandinavia (Henriksen et al., 2009).

The stratigraphic sequences of the basin consist mostly of alluvial fan conglomerates to marginal marine carbonates and evaporate formations in the lower part, and carbonate platform to basin shale deposits in the upper part (Henriksen et al., 2009). During the Latest Permian to Triassic time periods, marine sandstones and shale deposits dominated the area, regressing to alluvial conglomerates and lacustrine dolomite, gypsum and shale deposits during the remainder of the Triassic epoch (Clemmensen, 1980a, b).

### 5.1.3 Jurassic - Cretaceous

The rifting and block faulting processes continued throughout the Mesozoic, specifically the Late Jurassic and Cretaceous time periods (Surlyk 1990, 2003; Stemmerik et al., 1993). This can be seen on seismic reflection line data as shallower extension fault systems and basin infill sequences (Figures 22–27).

The latest Triassic to earliest Jurassic sequence consist of a major lacustrine basin deposits (Dam and Surlyk, 1993, 1998), which also includes the Lower Jurassic oil-prone, lacustrine shale deposits (Dam and Christiansen, 1990). In the Middle and Late Jurassic, the depositional environment changes to shallow marine and primarily sandstone deposition in the northern half, and deeper marine environment with predominantly shale deposits in the southern part of the basin, belonging to a large deltaic system during that period.

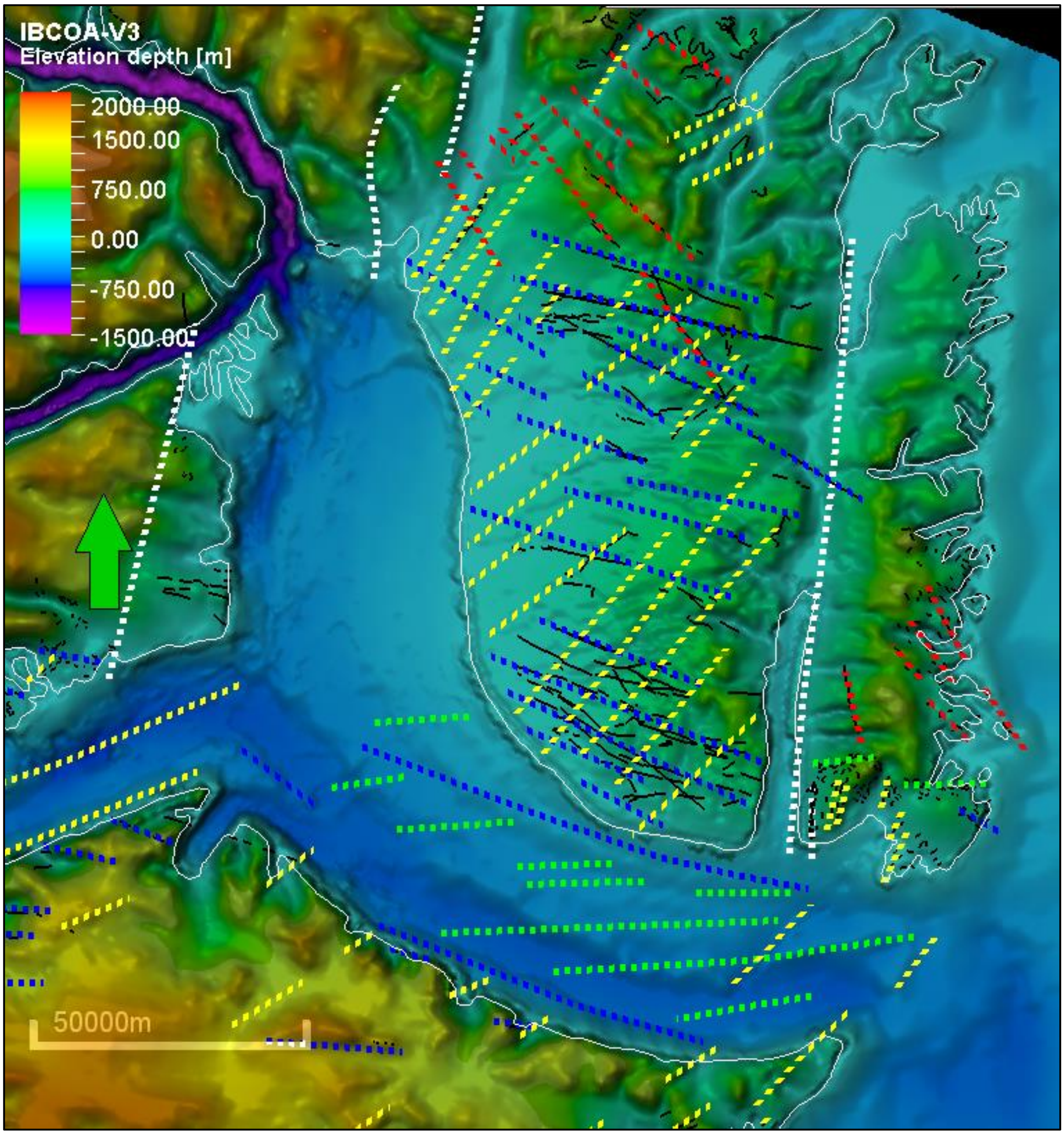



**Figure 19.** *Topographic map grid surface for the onshore JMLB area, regional surface (black) and subsurface (white - Caledonian, blue - Mesozoic, red and green – Mesozoic to Cenozoic, and yellow - Cenozoic) structural trends that effected the basin its basement structures (Jakobsson et al., 2012; Pedersen et al., 2013, Guarnieri et al., 2017; Brethes et al., 2018) at different geological times.*

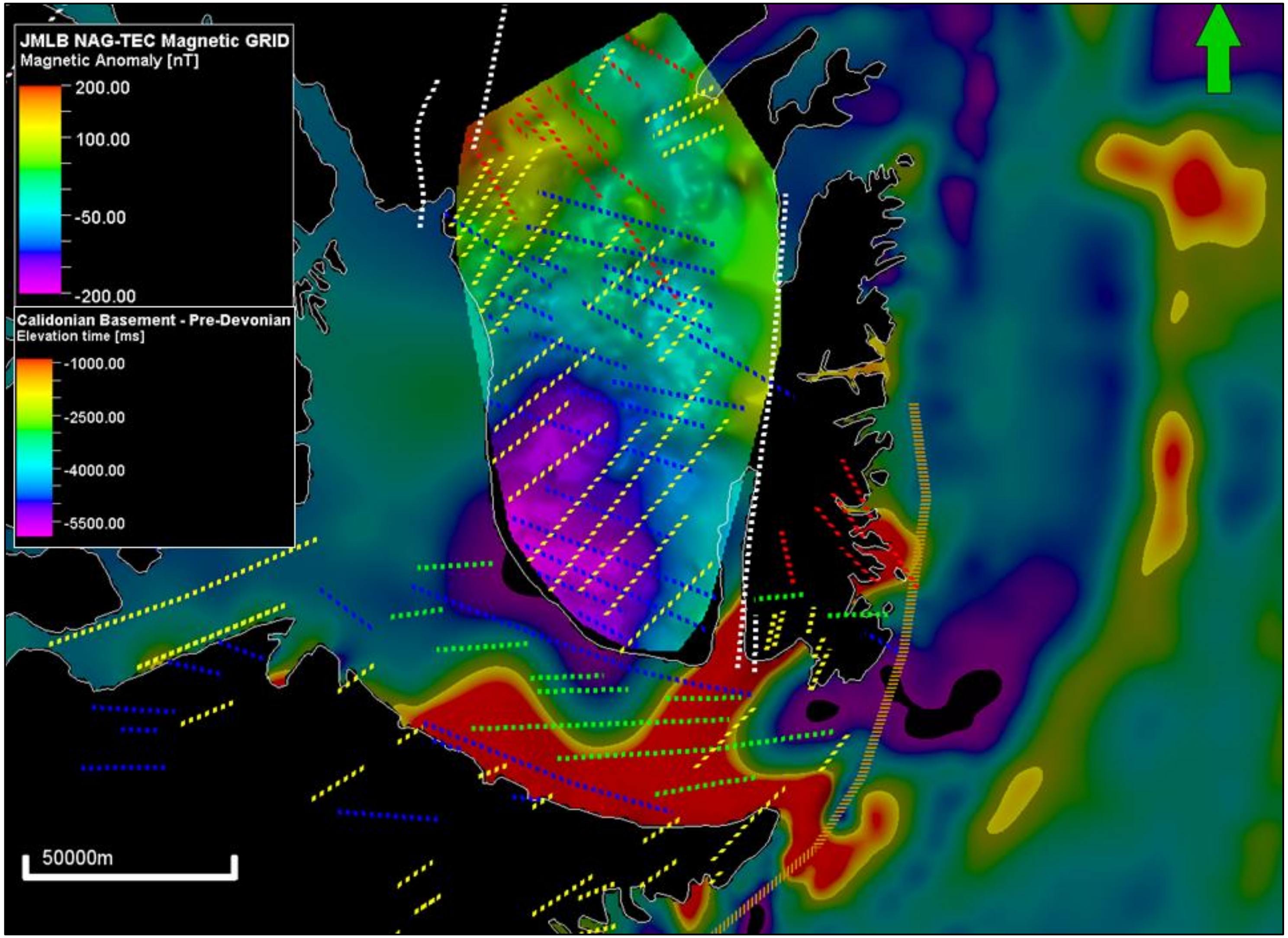



**Figure 20.** *Caledonian basement top marker grid surface for the onshore JMLB area, regional subsurface structural trends that effected the basin´s structures (dashed coloured lines for different trends), and the underlying magnetic anomalies map (Gaina et al., 2011). Marked with a light brown dotted line represents the Caledonian main boundary fault. Magnetic anomaly highs (red) and lows (purple) most likely relate to deep-seated intrusive formations.*

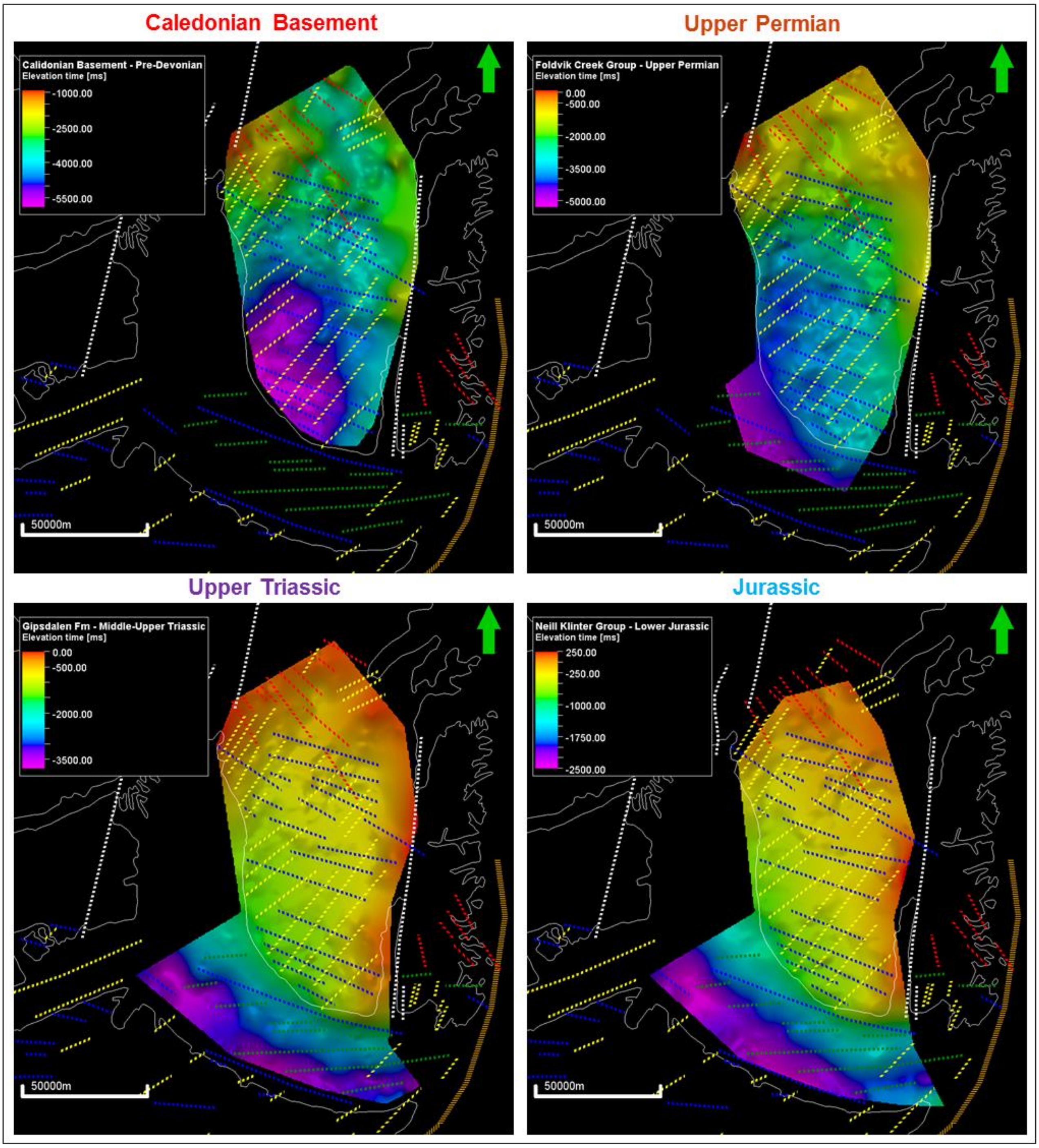



**Figure 21.** *Isochron – top structure maps for the main mapped intervals. The structural trends overlay (Figures 19 or 20) is based on the basin basement map, for comparison if these trends are seen consistently throughout the area. Apparent deepest basin centres shift from the central JMLB to the Scoresby Sund area from the post-Caledonian to Jurassic.*

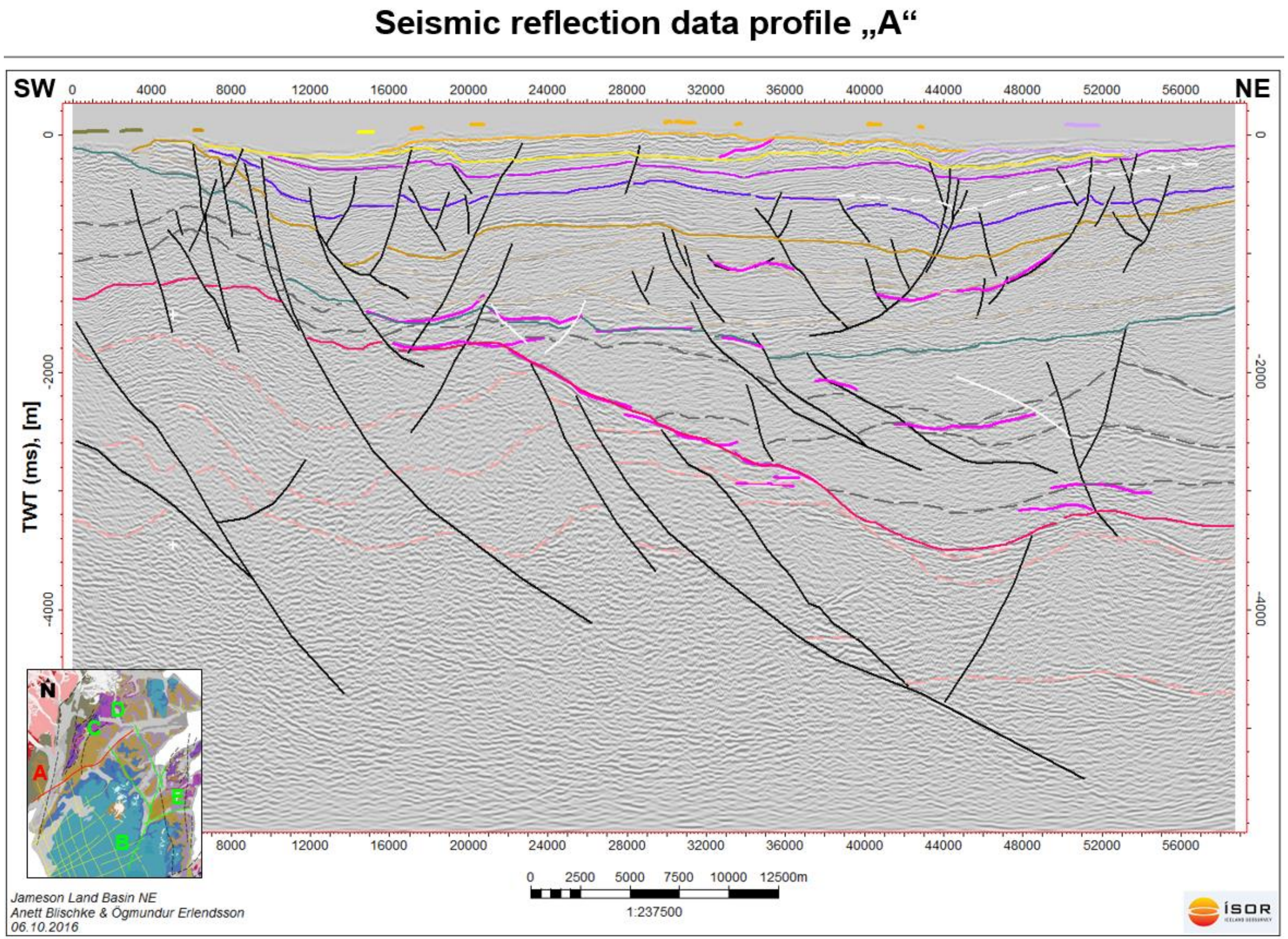



**Figure 22.** *Key seismic reflection line "A" that has been tied to onshore outcrops of Carboniferous, Permian and Triassic sequences. Legend see Figure 5.*

# Seismic reflection data profile „F“

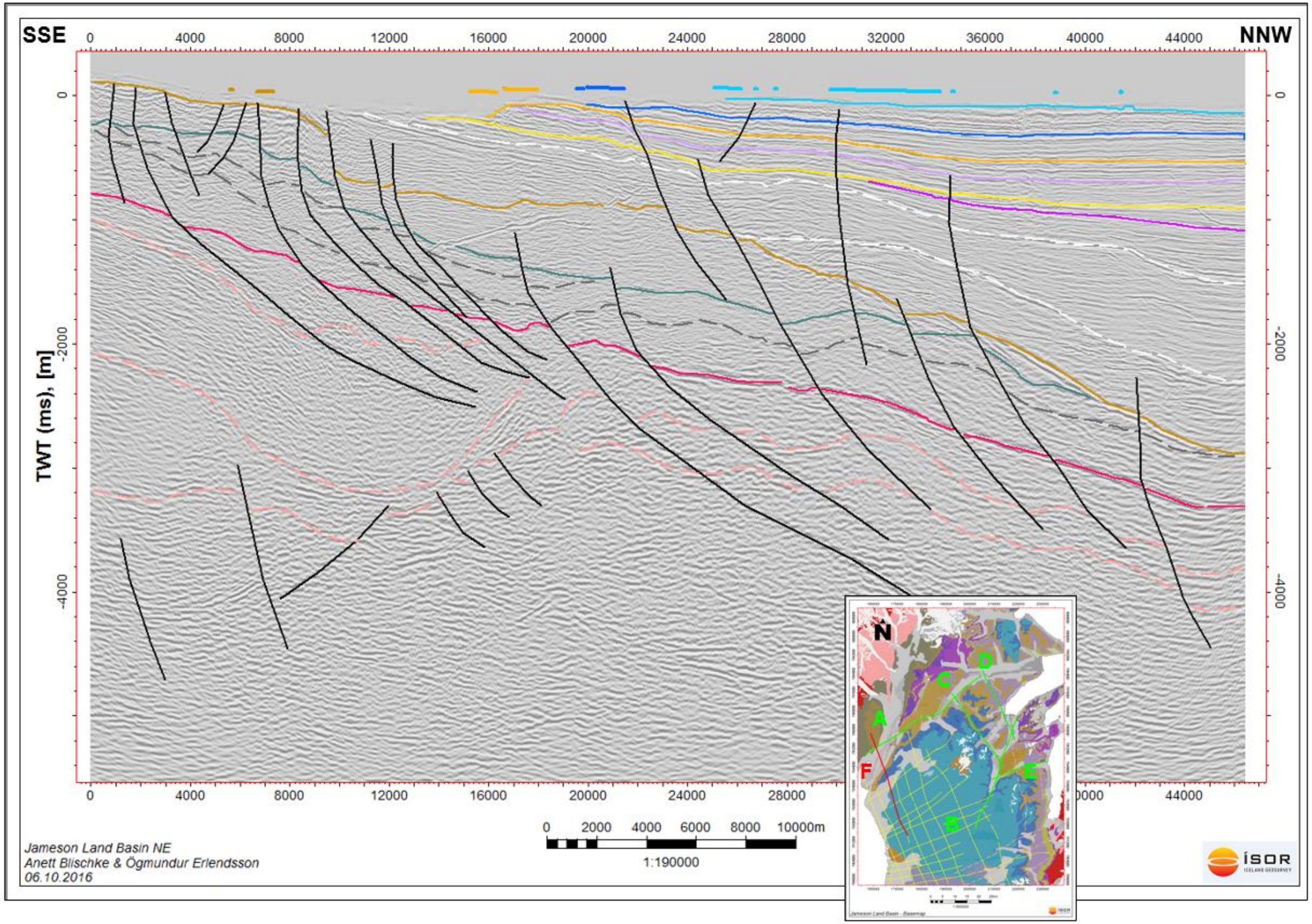



**Figure 23.** *Key seismic reflection line "F" that has been tied to onshore outcrops of Carboniferous, Permian and Triassic sequences. Legend see Figure 5.*

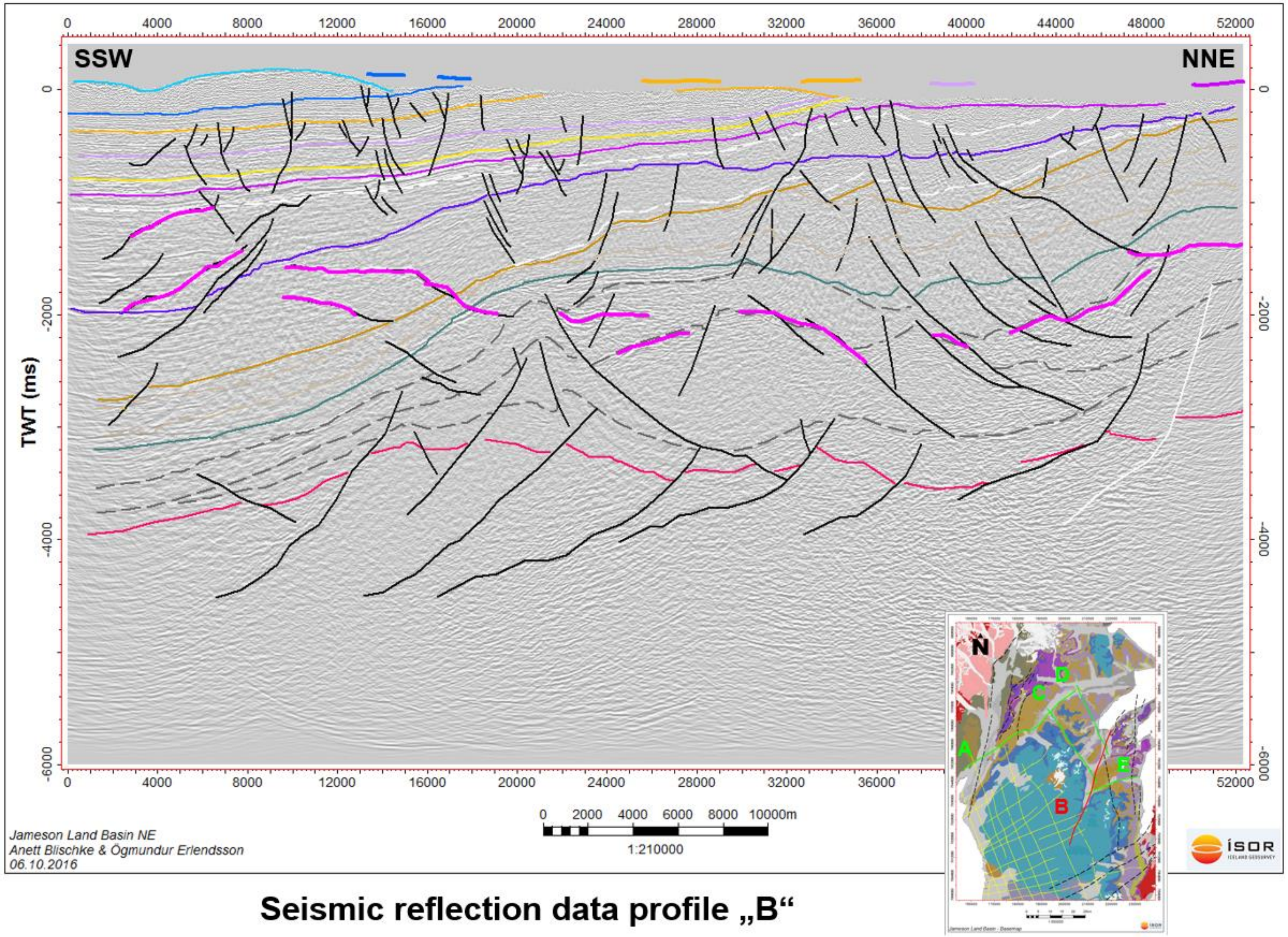



**Figure 24.** *Northeast JMLB seismic reflection line "B" that has been tied to onshore outcrops of Carboniferous, Permian and Triassic sequences. Shortening and structural reversal of the initial central Devonian – Carboniferous rift basin. Legend see Figure 5.*

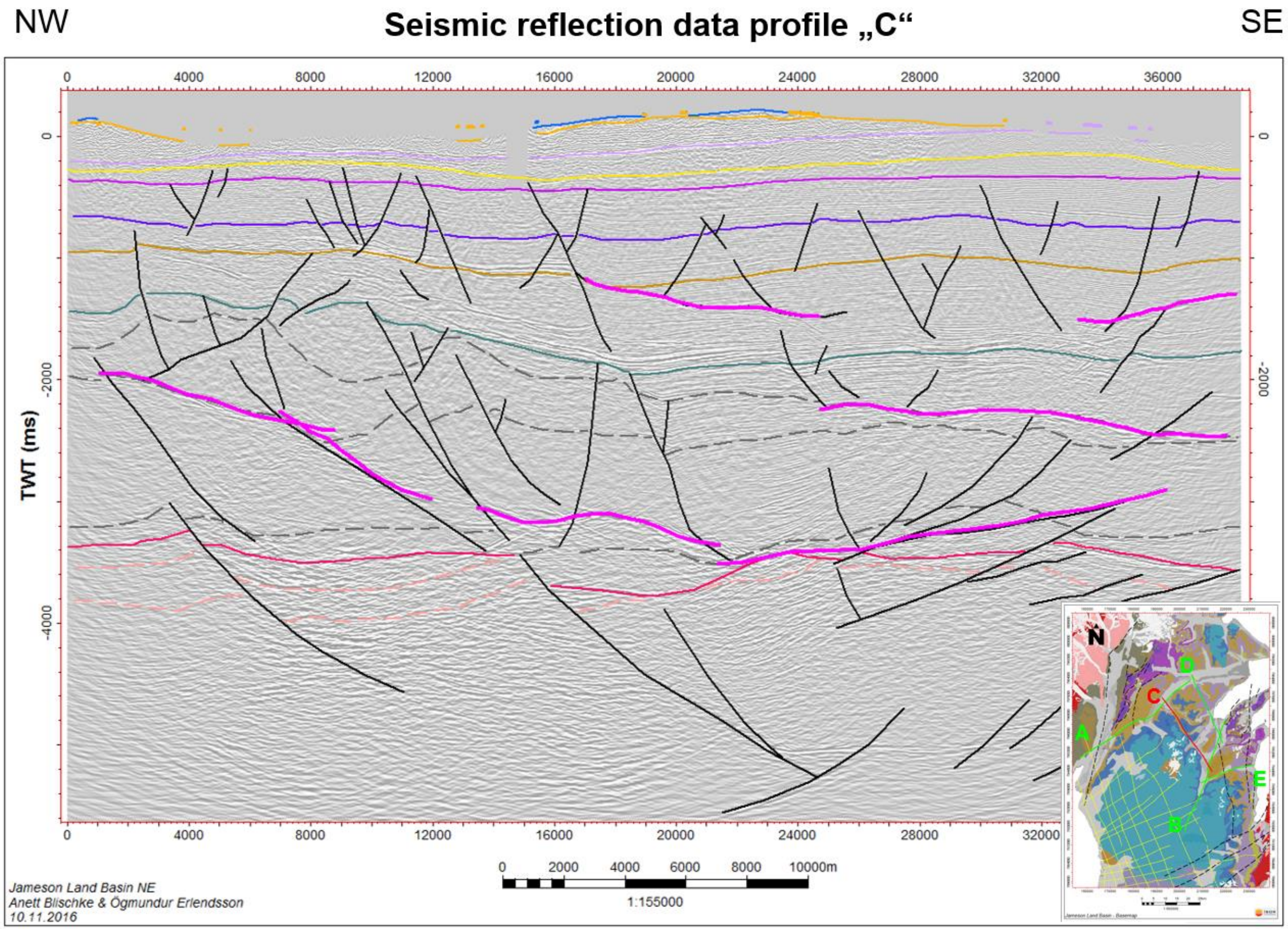



**Figure 25.** *Northeast JMLB seismic reflection line "C" that has been tied to onshore outcrops of Carboniferous, Permian and Triassic sequences. Legend see Figure 5.*

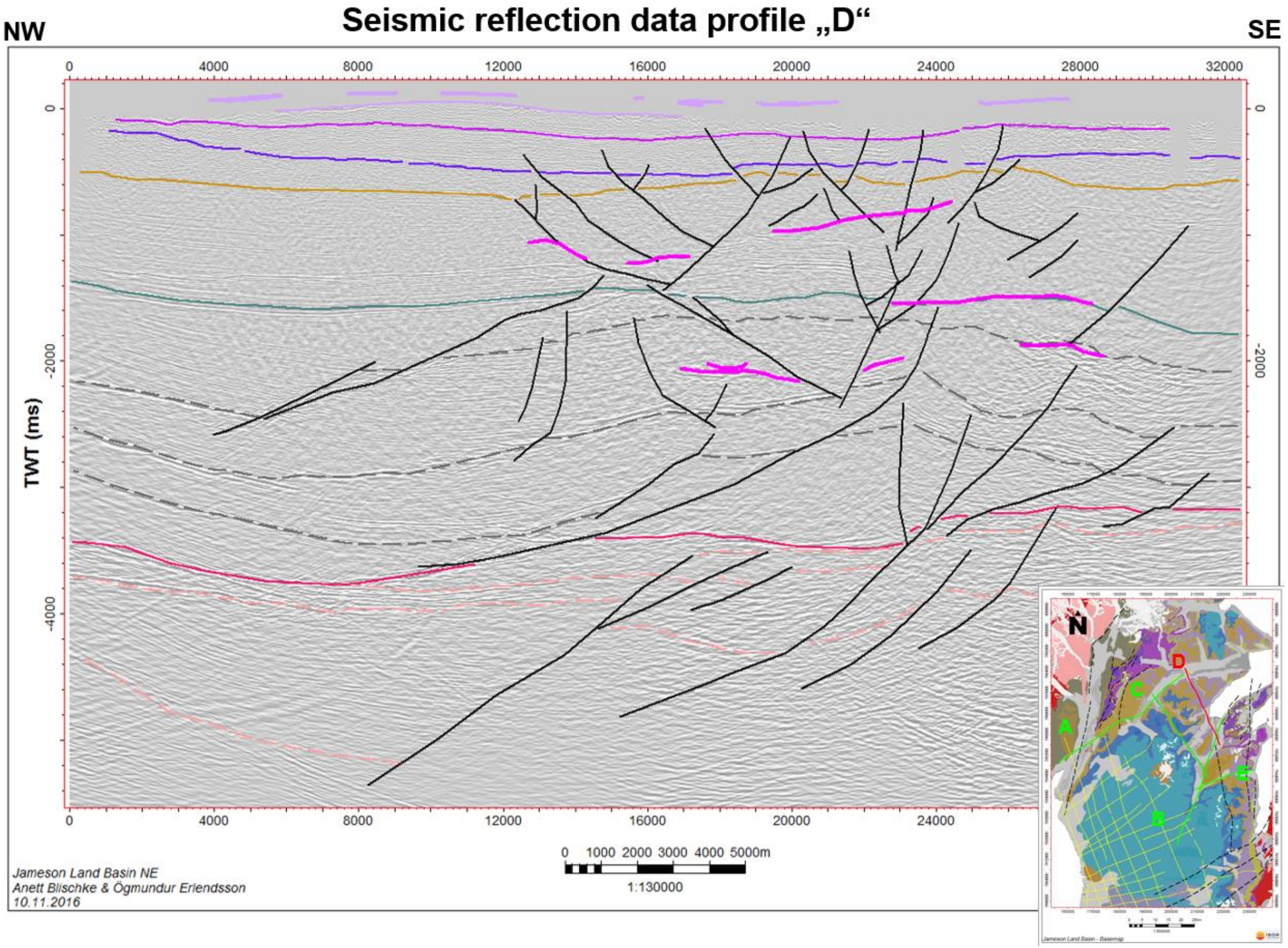



**Figure 26.** *Northeast JMLB seismic reflection line "D" that has been tied to onshore outcrops of Carboniferous, Permian and Triassic sequences. Legend see Figure 5.*

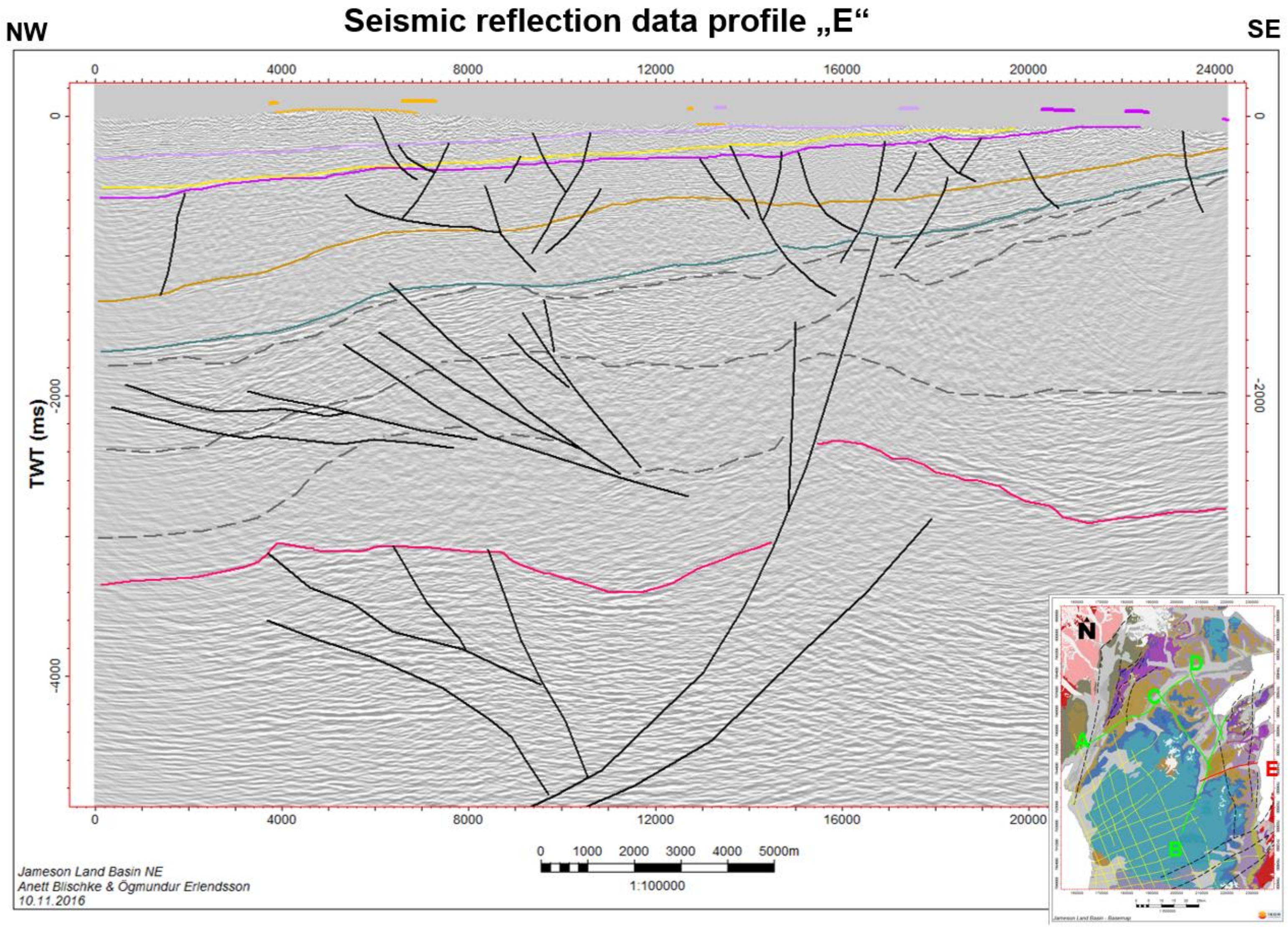



**Figure 27.** *Northeast JMLB seismic reflection line "E" that has been tied to onshore outcrops of Carboniferous, Permian and Triassic sequences. Legend see Figure 5.*

## 5.2 The Jameson Land Basin structural model

The at the north-western JMLB surface exposed N-S Caledonian structural basin trend, the NW-SE striking trend of Permo-Triassic rift basins, and the NE-SW striking rift basin trend of the Jurassic rifting events were confirmed with certainty by Seidler et al. (2004), Guarnieri et al. (2017) and Brethes et al. (2018) (Figure 7).

The line tie correlation of JMLB´s regional grid in comparison with the surface geology and fault observations has been concluded. The timing of the rift system with a special focus along the northern- and north-eastern extends of the basin has been subdivided into three main systems visible on formation section characteristics and the fault pattern mapped (Figure 28). The main structural phase observations can be subdivided into (1) Caledonian – Carboniferous period with large north-south striking half-grabens and wrench fault structures; (2) the Permo-Triassic period with flower type structures that have been located within the NE area of the basin and a NE-SW basin axis trends and a NW-SE rift basin boundary trend; and (3) the Jurassic-Cenozoic period where older Mesozoic structures were re-activating Permo-Triassic structures with moderate subsidence and infilling strata.

The generate structural 3D JMLB model (Figure 29; Appendix 3) is the basis of a set of isopach map (TVS, ms) for the intervals of the Permian, Triassic, Jurassic and Cretaceous-Cenozoic that indicate the possible paleo-geographic distribution of basins and highs across the onshore JMLB area during those intervals (Figures 30 and 31). These maps and the 3D structural model indicate that the JMLB opened in the northern part originally during the Devonian to Carboniferous, post-Caledonian phase, and later in the southern part during the Permo-Triassic phase. These sequences were slightly folded within the northern extend of the basin and show an overall shortening of the basin´s horizontal extend that was probably caused during a later tectonic and structural movement phase, see Figure 24. Such shortening can specifically be seen in regards to the Carboniferous to basin basement growth-fault graben section. That structure was slightly pushed up / reversed by later Permo-Triassic wrench / strike slip faulting. This re-focused the main sediment transport from north to south, an observation that is based on the isopach map (Figure 31).

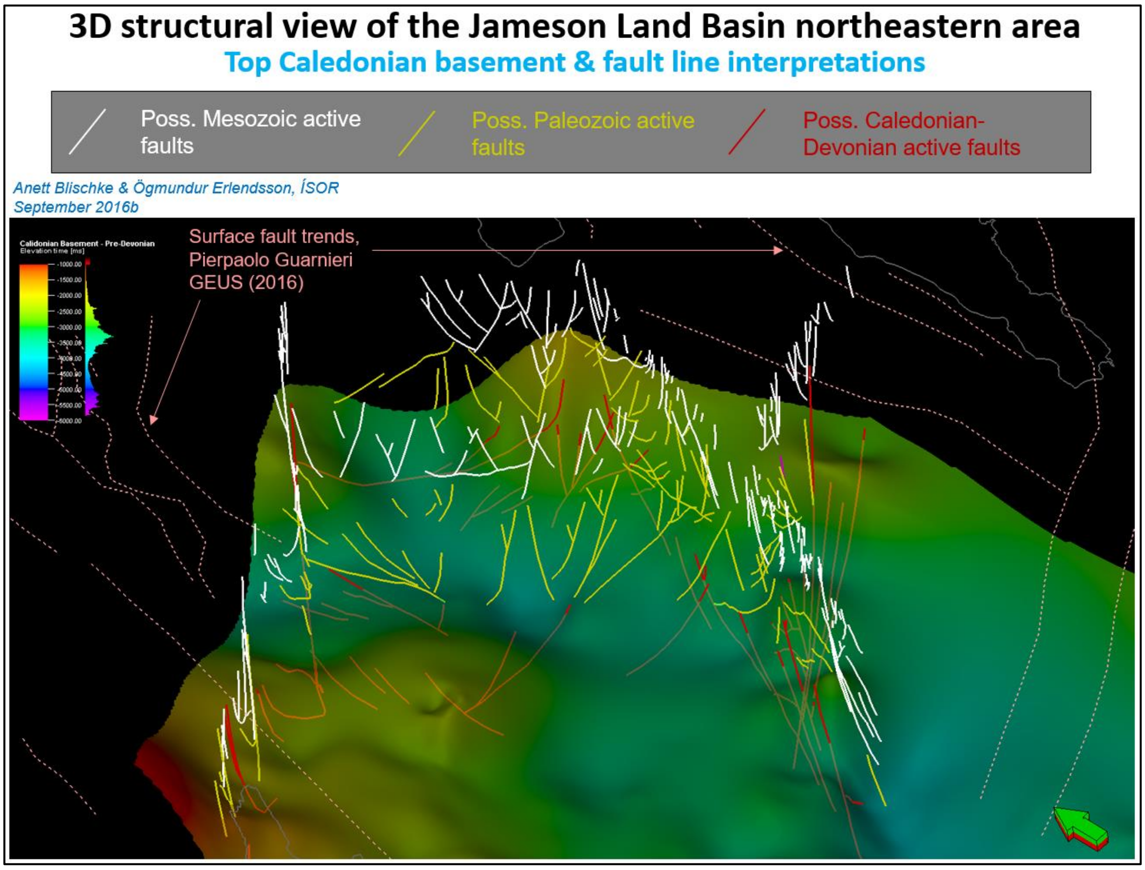



**Figure 28.** *The northern JMLB extend along strike of the Mesozoic basin axis and the top basement (see Figure 5) seismic horizon structural surface and the three dominating fault pattern distribution for the Devonian post-Caledonian fault system (red), the Palaeozoic rifting faults (wrench and normal faulting in light green), and the youngest Mesozoic fault trend (white).*

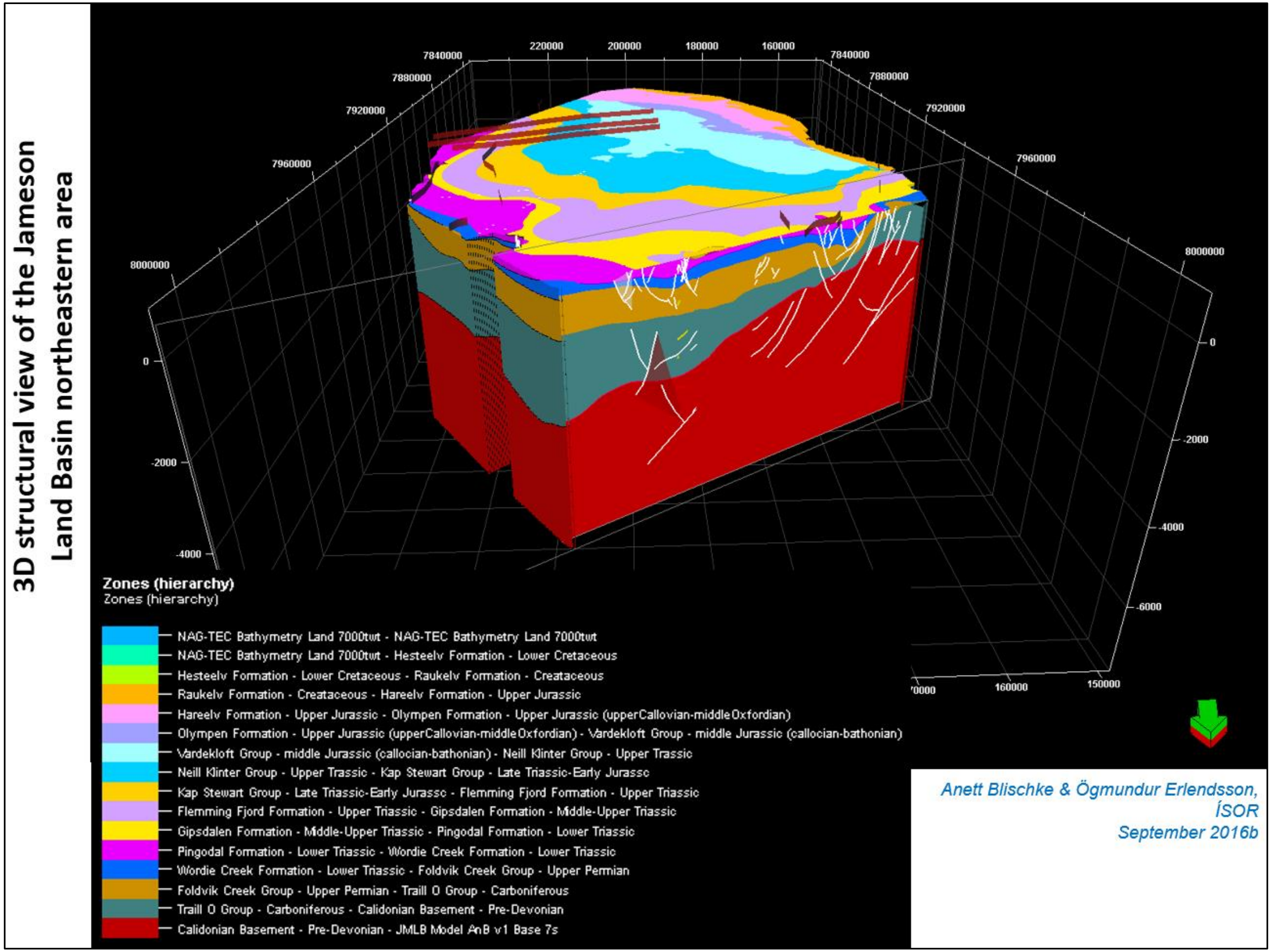



**Figure 29.** *3D structural and sequence model of the JMLB along the north-eastern extend. In addition is a horizontal section is displaying the sub-crop map of the Jurassic to Later Triassic basin indicating a shift of depo-centre towards the south-southwest along the western main boundary fault system.*

## 5.3 The Jameson Land Basin sequence section distribution

The pre- breakup reconstructions suggest that the JMLB can be projected south towards the Blosseville Kyst area and probably crossed over the central part of the still attached JMMC region (see white dashed line projection polygon on Figure 30), based on the isopach mapping of the basin´s Jurassic to Cretaceous and younger sediment thickness trends (Figure 31). This interpretation was quality check by compiled set of isopach maps for the JMLB area (Figure 30) and regional cross-section compilations, e.g. line "J-N" in Appendix 5 that give clear indications if the basin continued and/or deepened towards the south. The set of isopach thickness maps was generated for true-vertical thickness differences in TWT (ms) for the main sequences to assess the paleo-thickness distribution of sediments in between major hiatus events (Figure 31). The sequences were subdivided into:

(1) ***Jurassic*** (topography- Neill Klinter Group - Upper Triassic)
(2) ***Triassic*** (Neill Klinter Group - Upper Triassic – Foldvik Creek Group - Upper Permian)
(3) ***Permian*** (Foldvik Creek Group - Upper Permian – Traill O Group - Carboniferous)
(4) ***Palaeozoic – post-Caledonian*** (Traill O Group – Carboniferous – Post-Caledonian Palaeozoic)

Overlays of the structural grain map (Figure 20) were used to assess if the basin sediment lows fit into the structural trend pattern at the time.

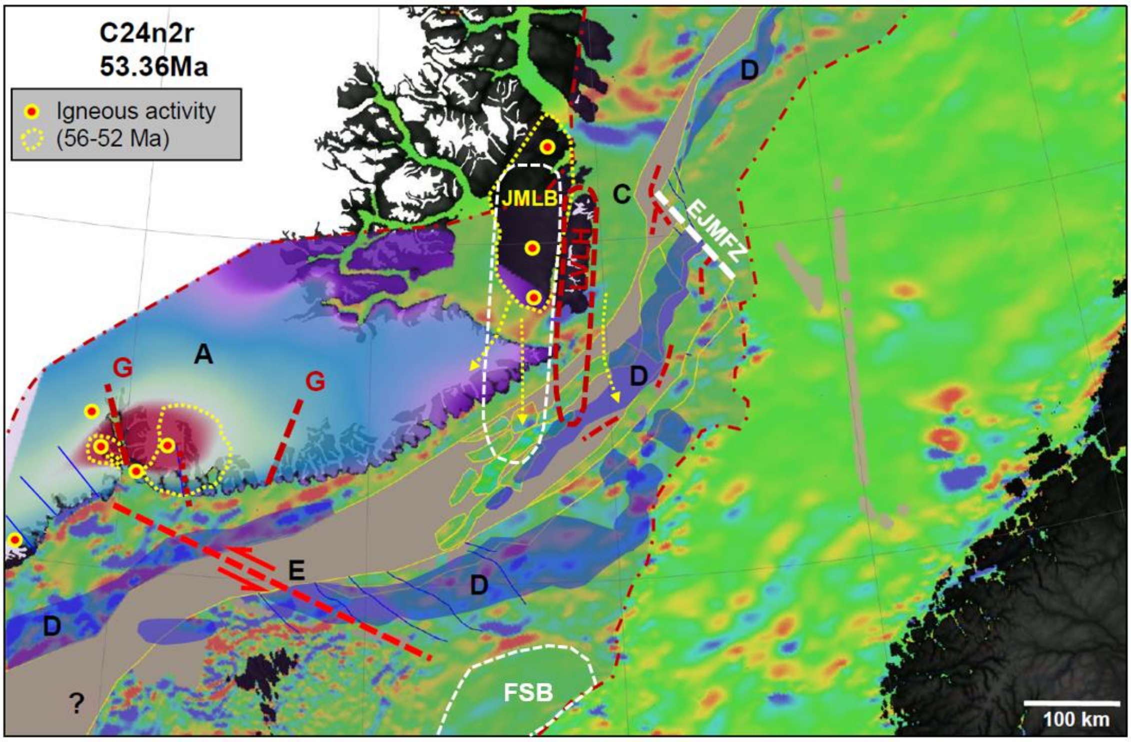



**Figure 30.** *Regional reconstruction of the central Northeast Atlantic area (Blischke et al., 2016). The overall trend of the Jurassic basin is north-south with a deepening trend due south for the southern JMLB area and potential depositional directions due SSW to SSE (Figure 31).*

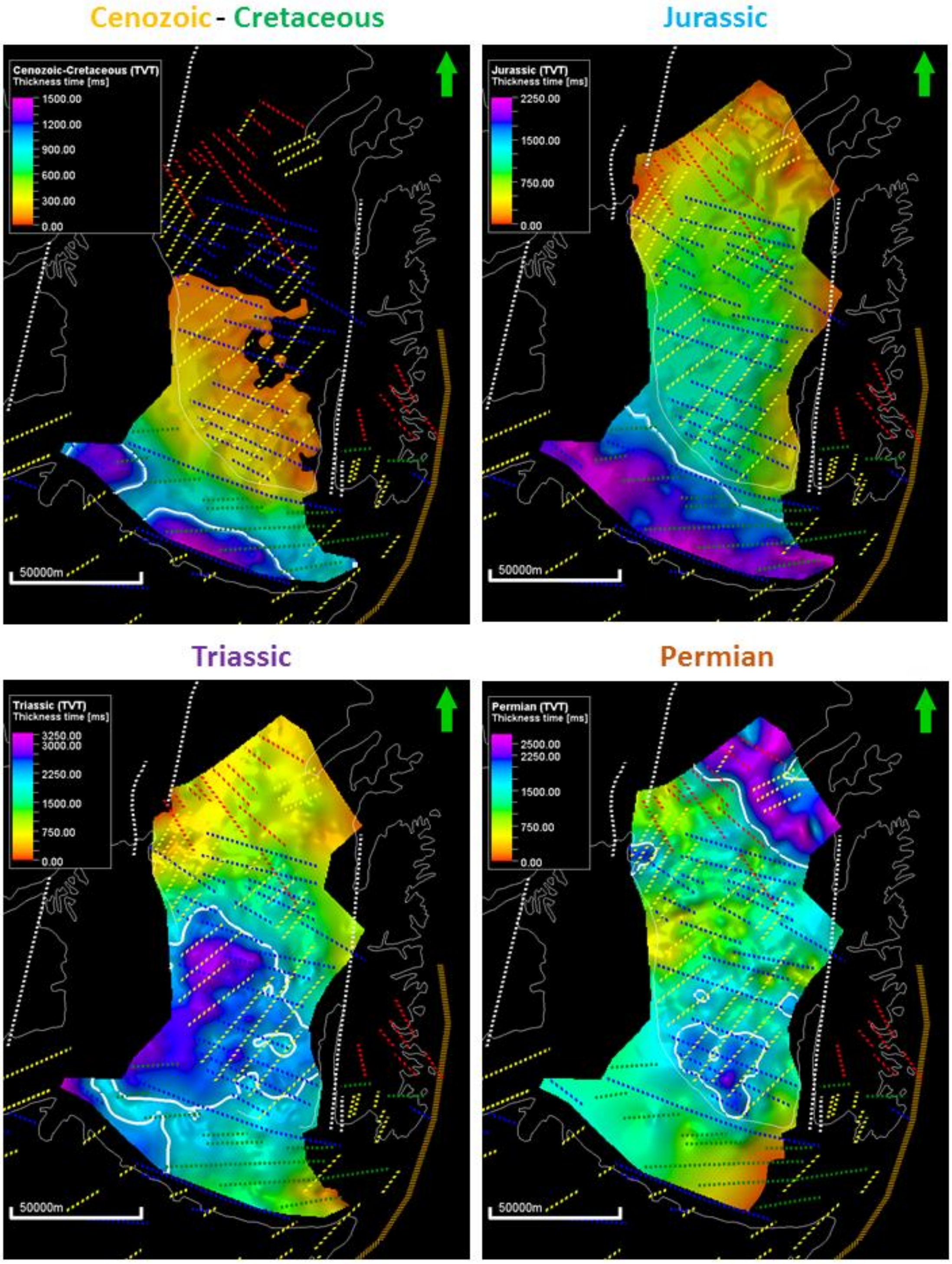



**Figure 31.** *Interval isopach thickness maps in true vertical TWT (ms) estimates for the main sequences for the JMLB. Overlays are the structural grain map based on the basin´s basement topography, and main sequence basin depocentres marked with a solid white line that show a shift of basin development and subsidence from the NE to the JMLB centre to the Scoresby Sund area.*

This appears to correlate with the NW-SE trend that aligns with a fair to good certainty with the Permian, Triassic and Jurassic basin fills for the southern extend of the JMLB. Possible paleo-geographic highs are marked as dashed white line, where sediments appear to be thinnest.

# 6 Structural and igneous complex ties of the conjugate margins at breakup and post- breakup time

The basic framework of the JMLB structural and igneous trends, the JMMC area and its eastern and southern conjugate margins were reconstructed to the initial breakup time position around 56–55 Ma and the final breakup of the JMMC domain from the central East Greenland margin and the forming of the Kolbeinsey Ridge system. These two reconstructions include primarily main fault and fracture zones, known and possible igneous complexes, domains and rift segments, and initial interpreted and by other research suggested breakup focal points for the area (Figures 30–36) (Doubrovine et al., 2012; Hopper et al., 2014; Nasuti and Olesen, 2014; Blischke et al., 2016; Gaina et al., 2017; Geissler et al., 2017; Blischke et al., 2018).

## 6.1 Pre-breakup setting around 56–55 Ma

The main structural fault and fracture orientation of the JMMC domain indicate a series of smaller segmented rift basins, which are oriented NW-SE with internal normal faulting of NE-SW and the continuation of the Liverpool Land High domain across the central and northern part of the JMMC (Figures 30, 32 and 33) (Blischke et al., 2016; 2018). The high basement block area is reflected within the JMMC seismic reflection data record as well with an apparent thinning of the post Caledonian strata due north and a rapidly increasing stratigraphic thickness of estimated Palaeozoic and Mesozoic cover towards the south of the Liverpool Land interpolation (Figures 30, 32 and 33) (Blischke and Erlendsson, 2016).

The vertical stratigraphic thickness estimates align in between the two regions for the time interval, just before the initial breakup of the Northeast Atlantic. It was possible to align the two mapped regions parallel to the pre-breakup rift situation for the structural trends of the Jurassic to Cretaceous-Cenozoic pre-breakup rifting patterns. Thus, aligning the Jameson Land Basin with the central and southern extend of the JMMC and possibly onwards to the Fugloy Ridge High and Faroe-Shetland Basin, and the Liverpool Land High area with the central segments of the JMMC (Figures 30–33). The Jan Mayen Northern Ridge segment however, aligns in a NNW-SSE trend direction with the Liverpool Land Basin and the north western-most margin of the Møre margin (Figure 32).

The projection in between the Blosseville Kyst area and the Iceland Plateau area can only be speculated, as the pre-breakup strata is covered onshore with plateau basalt that are also continuing offshore based on the seismic reflection data record, and is only exposed inland at the Milne Land location (Figures 16 and 17, and Appendix 5). No data is available across the Iceland Plateau region to confirm pre-breakup sequences. However, it is assumed that the southern region of the Blosseville Kyst area is primarily a high terrain of Precambrian gneiss and Caledonian overlain by a north to south thinning post-Caledonian and pre-volcanic stratigraphic sections.

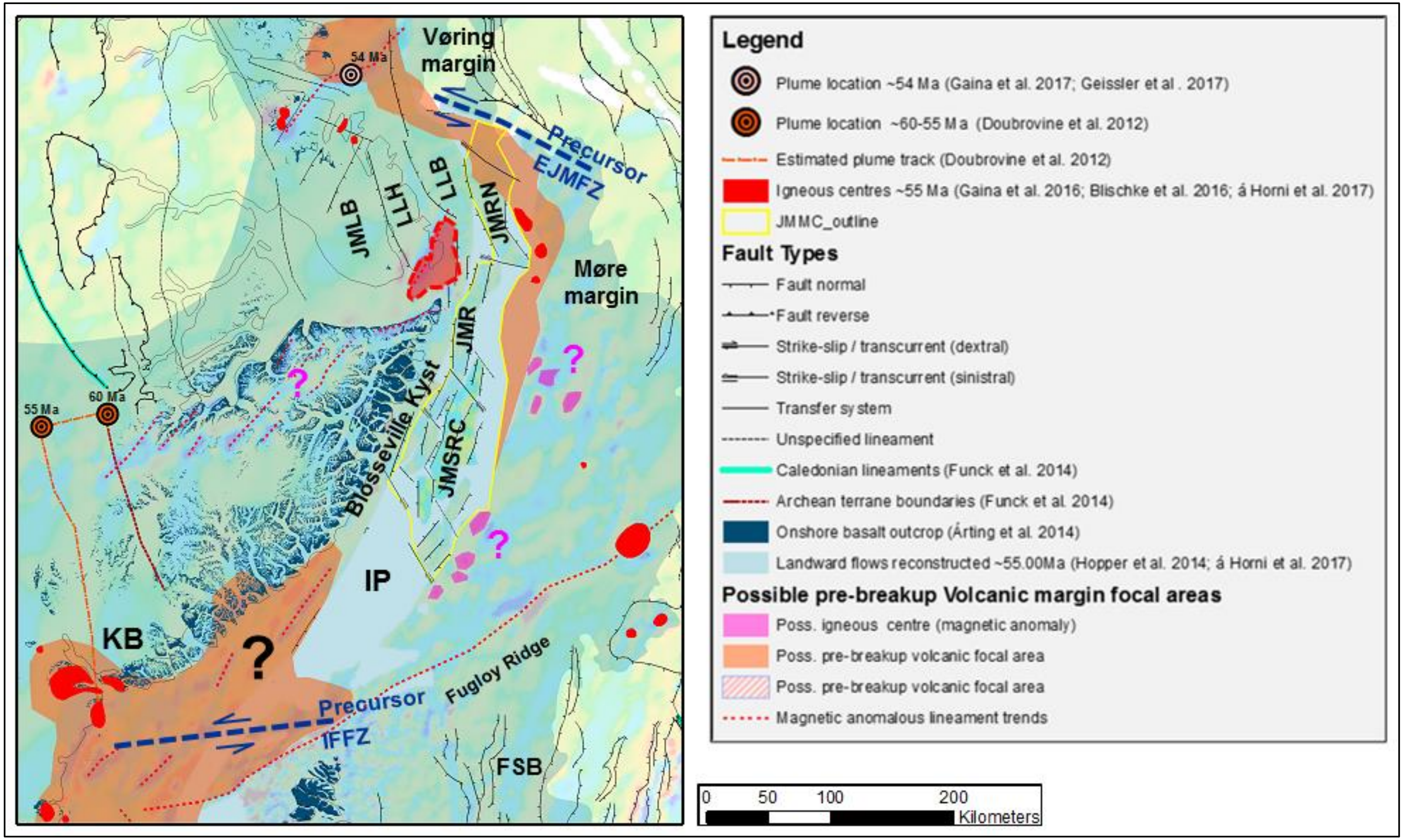



**Figure 32.** *JMMC and central East Greenland – possible separation scenario and data compilation at around 56–55 Ma and location of main igneous source centers (Hopper et al., 2014; Blischke et al., 2018). Potential field and feature data: Nasuti and Olesen (2014); Project seismic reflection database permissions from GEUS and BGR. The abbreviations are EJMFZ – East Jan Mayen Fracture Zone, FSB – Faroe-Shetland Basin, IFFZ – Iceland Faroe Islands Fracture Zone, IP – Iceland Plateau, JMLB – Jameson Land Basin, JMR – Jan Mayen central ridge, JMRN – Jan Mayen Northern Ridge, JMSCR – Jan Mayen Southern Ridges, KB - Kangerlussuaq Basin, LLH – Liverpool Land High, LLB – Liverpool Land Basin.*

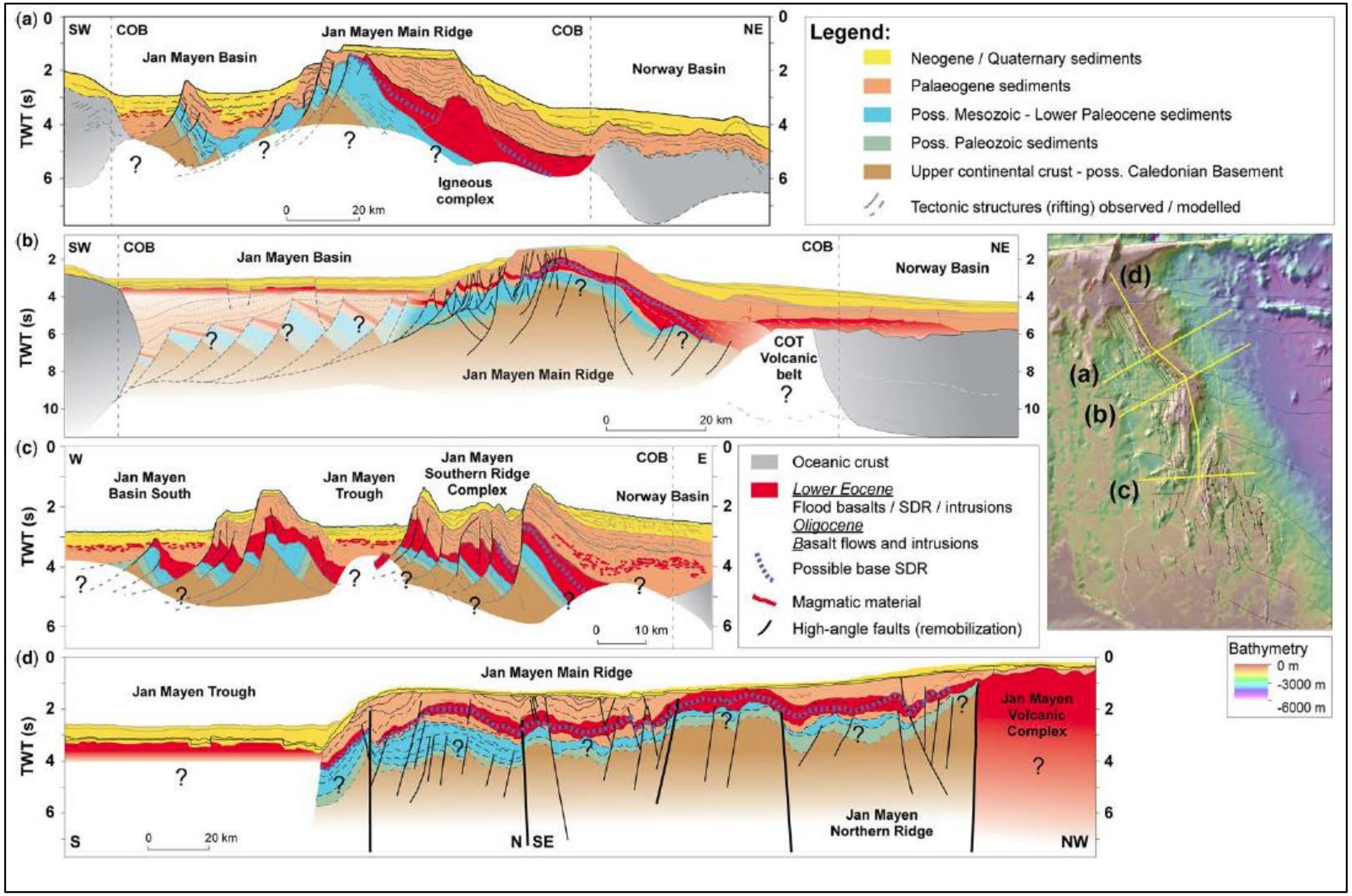



**Figure 33.** *JMMC tectonostratigraphic type sections that are based on seismic reflection and refraction data interpretations, tied to shallow borehole data only (Blischke and Erlendsson, 2016). Possible Palaeozoic–Mesozoic formations of the JMMC are inferred from the structural and stratigraphic setting in comparison to the East Greenland analogue areas (Hamann et al., 2005). Seismic velocity models from refraction data are consistent with interpretation. Modified from Peron-Pinvidic et al. (2012a, b) and Blischke et al. (2014). The volcanic margin is clear (see the sections in a–c) along the eastern flank of the microcontinent. The magmatic anomaly poor western margin that was formed during the second breakup (d) appears as a sharp boundary along the western margin of the microcontinent.*

An opposite trend of increase in stratigraphic thickness can be seen in onshore and offshore formation records of volcanic extrusive emplacement of pre-breakup flood basalt and volcanoclastic formations of the North Atlantic Igneous Province (NAIP) that extend down to the Faroe Island region across the area of the Iceland Plateau (IP) and the southern extends of the JMMC. The estimated compiled stratigraphic thickness is up to 6–7 km of igneous section and possibly relate to one of the igneous focal areas close to the southern extend of the Blosseville Kyst prior to breakup (Figure 32 and Appendix 5) (Larsen et al., 1989; Storey et al., 2007; Larsen et al., 2013). The Faroe Islands are believed to be covered by primarily landward basalt flows (Passey and Jolley, 2009; Passey and Hitchen, 2011; Árting, 2014), as the direct conjugate to the Kangerlussuaq Basin area, located at the southernmost extent of the Blosseville Kyst.

### 6.1.1 The possible pre-breakup stratigraphic records of the JMMC

Where the JMMC intersects the seismic refraction profile data (Figure 10) (Kodaira et al., 1998; Brandsdóttir et al., 2015; Kandilarov et al., 2012; Hopper et al., 2014; Blischke et al., 2016), the pre-breakup sedimentary section is approximately 6 km thick, which is defined as the interval between the flood basalts and possible acoustic / continental basement. The velocity model indicates that this interval is characterised by velocities of 3.9–5.3 km (Kodaira et al., 1998). This compares very well with the Palaeozoic–Mesozoic sequences with seismic velocities range estimates between 3.5 and 5.5 km of the JMLB (Table 4) (Fechner and Jokat 1996).

Specifically the north-south structural segmentation and changes in stratigraphic thickness of the JMMC (Figure 33) is similar in structural character to the JMLB. The JMLB is 3–5 s deep at its centre and contains up to 12–16 km of pre-breakup sedimentary sequences (Henriksen, 2008) with multiple unconformities, complex faulting patterns, and deep intrusive events (Blischke et al., 2016).

There is a striking similarity of seismic refraction velocity data analysis of the mapped pre-breakup stratigraphic intervals for both areas, the JMMC and the JMLB. Furthermore are the similarities in structural alignment leading to a valid comparison of the JMLB strata with the mapped sequences across the JMMC, despite the lack of borehole or seafloor sample confirmation.

## 6.2 The central East Greenland Igneous province and Iceland Plateau – 55–33 Ma

Seismic reflection features and structural build-up of the JMMC compare directly the central East Greenland coast, with the plateau basalts overlie Lower Paleocene sediments at Kap Brewster and Kap Dalton, where the erosional horizon interpreted as the equivalent to a distinct breakup unconformity (Nøhr-Hansen, 2003; Larsen et al., 2013). This unconformity is also visible on the regional cross-section lines of the Blosseville coast and the Liverpool Land Basin (Appendix 5) and do project well across the central JMMC (Figure 33) (Blischke et al., 2016).

Initial breakup related basaltic layers that are related to Early-Mid Eocene flood basalts, SDRs and igneous centres can be seen along the eastern flank along the JMMC (Blischke et al., 2016). These SDR sequences are interpreted as landward flows by their flat and clearly marked acoustic seismic reflector characteristics (Mutter et al., 1982; Planke et al., 2000). A large section of these breakup related westerly landward directed flood basalt flows were truncated by the main Late Oligocene – Earl Miocene unconformity (Blischke et al., 2016). Based on the observation it can be suggested that the inland continuation of this erosional high terrain can be found close to the central East Greenland margin. That conclusion is substantiated as younger age extrusive formations are reported along the Kap Dalton area (Figure 17; "N-J" in Appendix 5) (Larsen et al., 2013). Along the Blosseville Kyst area, the lower Igtertiva Formation (ca. 49–44 Ma) coincides with the beginning of rift transfer away from the eastern margin of the JMMC and the Ægir mid-oceanic ridge along the southern margin of the JMMC, the Iceland Plateau Rifts (Figure 34) (Larsen et al., 2013; Blischke et al., 2016). A borehole and seismic reflection interpretation data recorded Mid-Eocene unconformity (ca. 44–40 Ma) is observed across the JMMC, which appeared to have truncated the Blosseville Kyst area as well. This rift transfer processes may have been accompanied by emplacement of igneous complexes and sill intrusions primarily into the Lower Eocene strata along the northern and south-eastern flanks of the JMMC, in turn contributed to some thermal uplift along the conjugate margin area. Increased magmatism most probably coincided with volcanism within the Greenland–Iceland–Faroe Ridge Complex region and the area of the Iceland Plateau, reaching into the extending corridor in between the central East Greenland coast and the western margin of the JMMC (Figure 34).

Sills and dyke intrusive formations have been emplaced primarily within the Lower Eocene sediment succession, these appear to coincide with the Mid-Eocene increased igneous activity. Similar activity is also observed along the East Greenland coast (Larsen et al., 2013). A clear separation of a gravity and magnetic data "opaque" area is visible in between the East Greenland continental domain to the oceanic crustal domain of the Kolbeinsey ridge system. This can be seen on offshore seismic reflection interpretations (Appendix 5) or potential field data compilations (Figure 35).

Igneous features of intrusive and extrusive formations can be seen on offshore seismic reflection and magnetic anomalies data (Figure 35; Appendix 5). These anomalies have different polarities, which suggest that these events took place at different times during the forming of an igneous terrain in between the two conjugate margins. This igneous terrain was intersected by younger rifting events from the south along a possible fracture zone that intersects with the south-westernmost edge of the JMMC at the time period 22–21 Ma (Figures 34 and 35). This observation is based on the magnetic anomalies chrons model projection by Gaina et al. (2017) and adds to the complexity of this area.

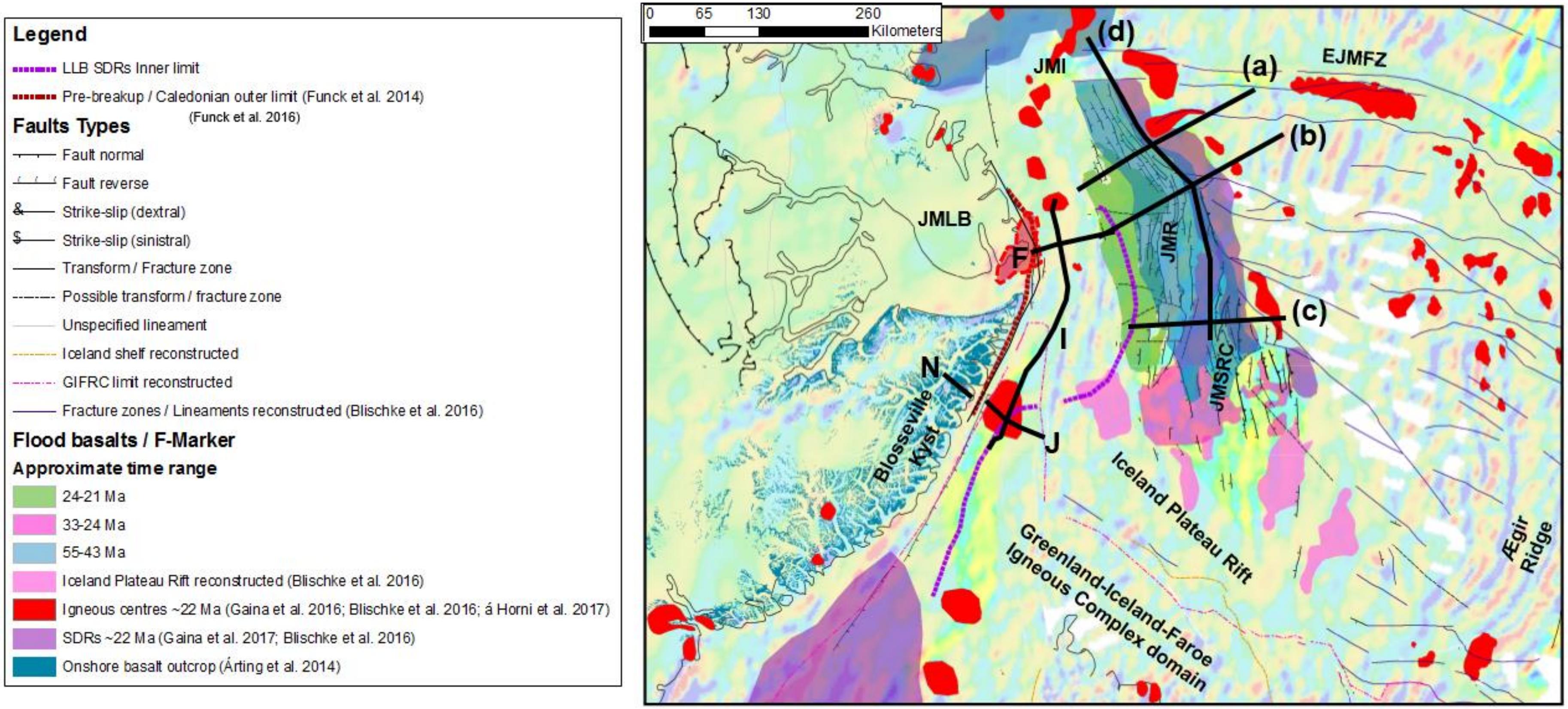



**Figure 34.** *Reconstruction summary at 22–21 Ma prior to full breakup and igneous domains (Blischke et al., 2018). Cross-section annotations refer to the regional sections in Appendix 5 and Figure 33.*

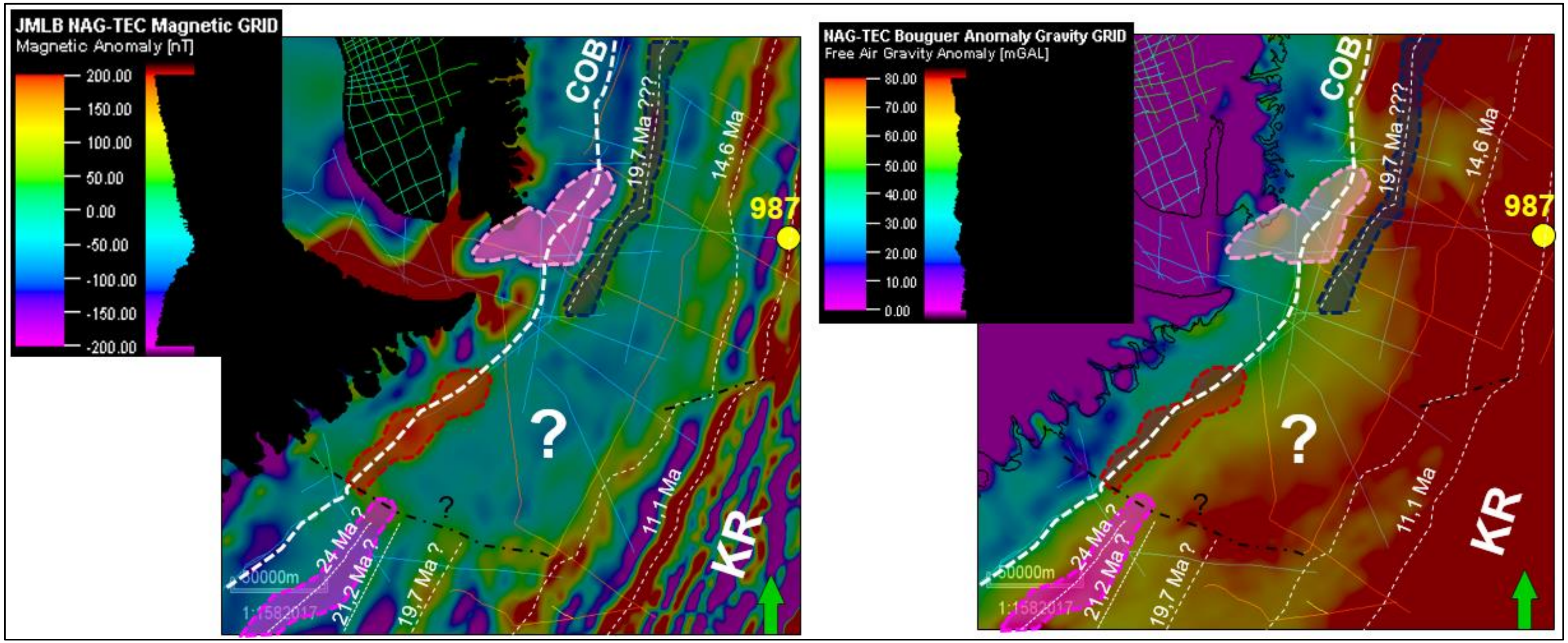



**Figure 35.** *Kinematic model and igneous centre breakup features along the East Greenland conjugate margin (Gaina et al., 2017; Blischke et al., 2018). Igneous features marked in pink, red and dark blue are corresponding to the regional cross-sections in Appendix 5. Potential field data: Haase and Ebbing, 2014; Nasuti and Olesen, 2014; Hopper et al., 2014; project seismic reflection database permissions from GEUS and BGR.*

## 6.3 The final breakup of JMMC and forming of the Kolbeinsey Ridge system; 33 Ma and younger

The complex igneous domain from the Iceland Plateau area along the western margin of the JMMC indicated a gradual rift propagation that was accompanied by rapid extension of the microcontinents western flank areas and forming of listric fault and rotated fault block patterns (Figure 33) (Blischke et al., 2016). Similarly, are steep flank faults visible along the East Greenland continental margin, based on seismic reflection data record (Appendix 5), implying an over-stretched area in between the two conjugate margins. The previous sections described the forming of a wide igneous affected region, approximately in between 49–33 Ma since the initial breakup at about 55 Ma (Figure 36).

The youngest regionally extensive igneous event along the JMMC western margin has been interpreted on seismic reflection and refraction data and is referred to as the ‘F-Reflector’ (Figure 36) (Gunnarsson et al., 1989; Blischke et al., 2016). This igneous formation is interpreted as shallow-marine landwards flows emplaced during chrons C13–C6b (33–21.56 Ma) (Blischke et al., 2016), possibly sourced from fissure-type volcanic complexes south and west of the microcontinent. On the seismic reflection data, we can see a small lava delta that is located on the south-western extent of the JMMC and suggesting a south to north – southwest to northeast flow direction (Blischke et al., 2016). This implies the main source direction to lie within the Iceland Plateau domain.

Similar features and most likely landward flows that overlay the older igneous margin and pre-breakup strata, can be observed looking across the central East Greenland igneous margin. A distinct breakup margin can be seen landward from the first set of SDRs along the magnetic and gravity “opaque” area with intersected rifting events from the north and south, and possible fracture zones that are accompanied by intrusive to extrusive features (Figures 17 and 35, and Appendix 1; or Appendix 5). The south-western extend of the JMMC, also referred to as the “Jan Mayen western igneous province” (JMWIP) (Figure 36), links directly to the fracture zone and igneous complex that crosses line “J” in Figure 17 and Appendix 5.

Along the southern edge of the central east Greenland igneous domain and the JMWIP newly formed oceanic crust formed as a pre-curser of the Kolbeinsey mid-oceanic that formed a long wedge in between the two conjugate margins around 22–21 Ma, which is confirmed by borehole data along the western margin of the JMMC (Figure 36) (Blischke et al., 2016). After the Kolbeinsey mid-oceanic ridge had completely separated the JMMC from East Greenland igneous margin between 21–14 Ma (Figures 35 and 36; offshore regional cross-sections in Appendix 5), regular oceanic anomalies patterns can be observed.

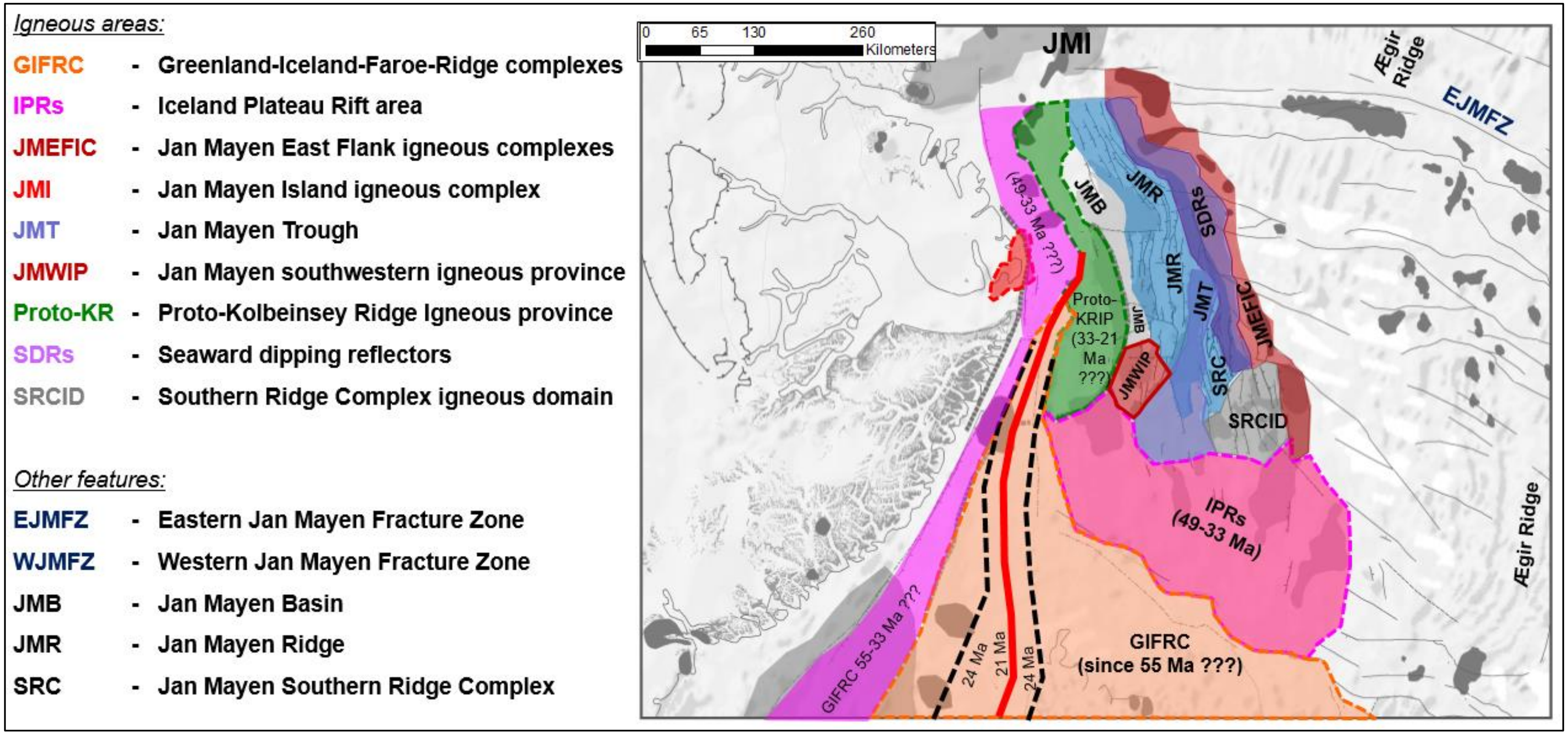



**Figure 36.** *Summary on central Northeast Atlantic igneous domains (~22–21 Ma) (Blischke et al., 2018).*

# 7 Conclusion

This study summarises the completed tectonostratigraphic, structural and igneous framework mapping project of the Central East Greenland area with the Jameson Land Basin, Blosseville Kyst, Scoresby Sund, Liverpool Land High, and Liverpool Land Basin areas in direct comparison to the Jan Mayen microcontinent region, as its direct conjugate margin.

This comprehensive interpretation of geological- and geophysical data have resulted in a new view of the margin areas, as a much more complex transition from its central East Greenland continental domain across a highly complex volcanic margin that connects to the Jan Mayen microcontinent area.

This study includes the implementation of onshore and offshore data sets and interpretations, combining seismic reflection and refraction data with offshore borehole and onshore outcrop observations datasets. The structural mapping and compilation of vertical stratigraphic thickness maps of the Palaeozoic and Mesozoic (post-Caledonian) stratigraphic sections that are based on a 3D model volume, indicates a similar structural trend for the JMMC area in comparison prior to the Northeast Atlantic break up time. However, the Jameson Land basin, Liverpool Land High and Basin mapping result imply that there were two parallel oriented rift basins that straddle the microcontinent´s area, subdividing the JMMC into a northern and southern domain of narrow rift basins that are separated by a possibly Caledonian to Palaeozoic high across the main Jan Mayen ridge area.

The comparison of potential linking fracture zones in between the two areas that were reconstructed using chrons magnetic reversal interpretations in GPlates, have added certainty to the reconstruction and breakup terrain segmentation model. The primary linking structural elements are located offshore the central Blosseville Kyst that tie directly into the south-western igneous domain of the JMMC, the Scoresby Sund potential transfer system, and the complex system of the Jan Mayen fracture zone. The potential Scoresby Sund transfer system links directly into the central part of the Jan Mayen Ridge area. The Jan Mayen fracture zone limits the microcontinent to the north from initial breakup time to the fully establishment of the Kolbeinsey Ridge.

The detailed structural elements and igneous domain mapping resulted in a time phased breakup model that links directly to the westernmost extend of the Jan Mayen microcontinent and breakup margin. The igneous phases were subdivided into pre-breakup 56–55 Ma, breakup phase 55–49 Ma, rift transfer phase 49–33 Ma, final breakup phase 33–21 Ma, and establishing of the Kolbeinsey mid-oceanic rift system 21–14 Ma.

## Acknowledgements

This work is in part tied into a PhD project at the University of Iceland, the National Energy Authority of Iceland (Orkustofnun), and the Iceland GeoSurvey, with data permissions provided by Spectrum ASA, TGS; the University of Oslo (UiO), the Norwegian Petroleum Directorate (NPD), the Federal Institute for Geosciences and Natural Resources (BGR), and GEUS (Geological Survey of Denmark and Greenland). We would like to thank especially Pierpaolo Guarnieri, Lotte M. Larsen, John R. Hopper of the Geological Survey of Denmark and Greenland, and Bryndís Brandsdóttir at the University of Iceland for their valuable advice and help with data permissions.

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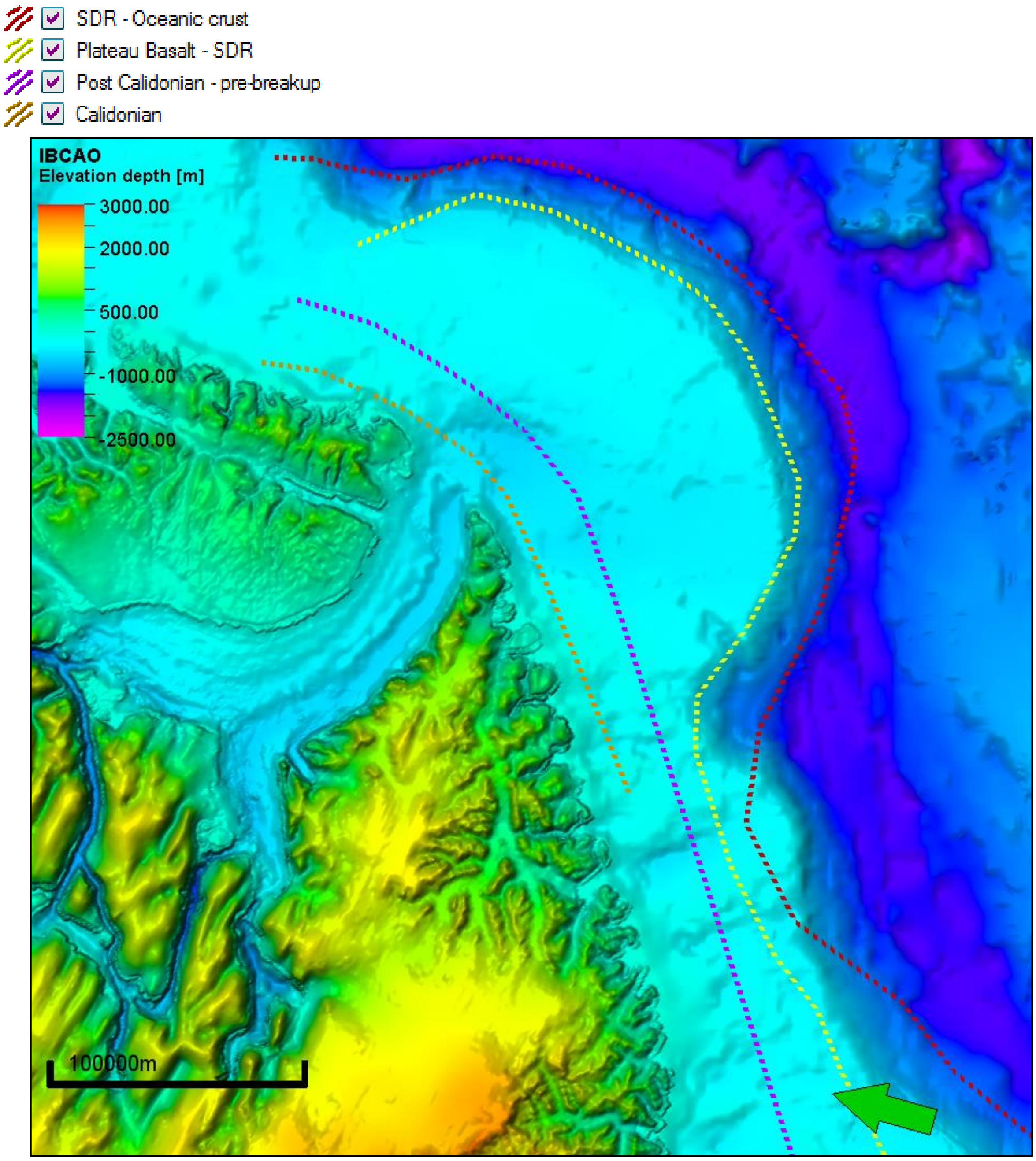
# Appendix 1: Mapped central East Greenland shelf section outlines on potential field data

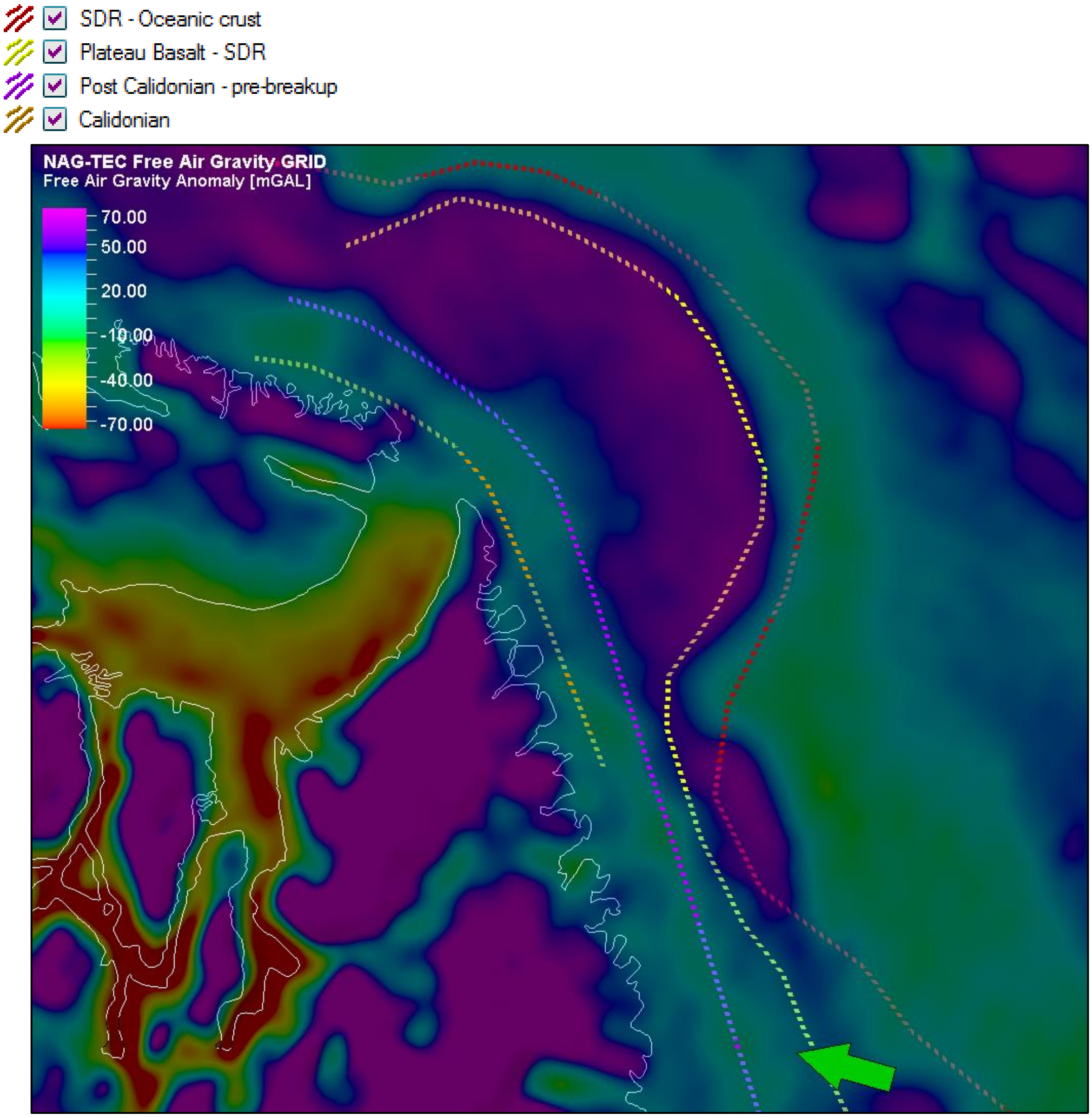
## Bathymetry and topography

ETOPO1 Global Relief Model, Bathymetry (Amante and Eakins, 2009)



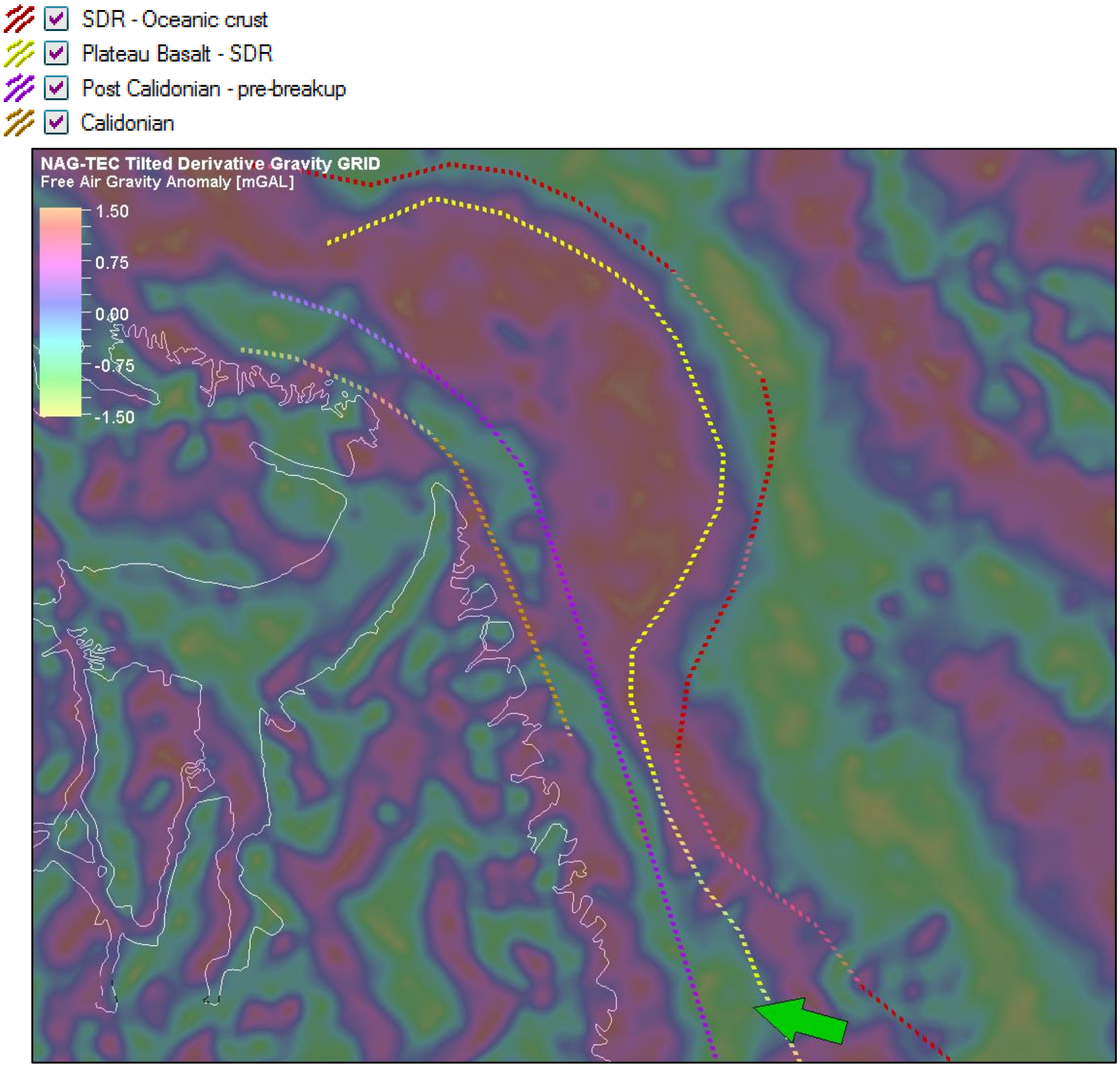
## Free air gravity anomalies map

(DTU - Global Gravity Field Model (Andersen et al., 2010))



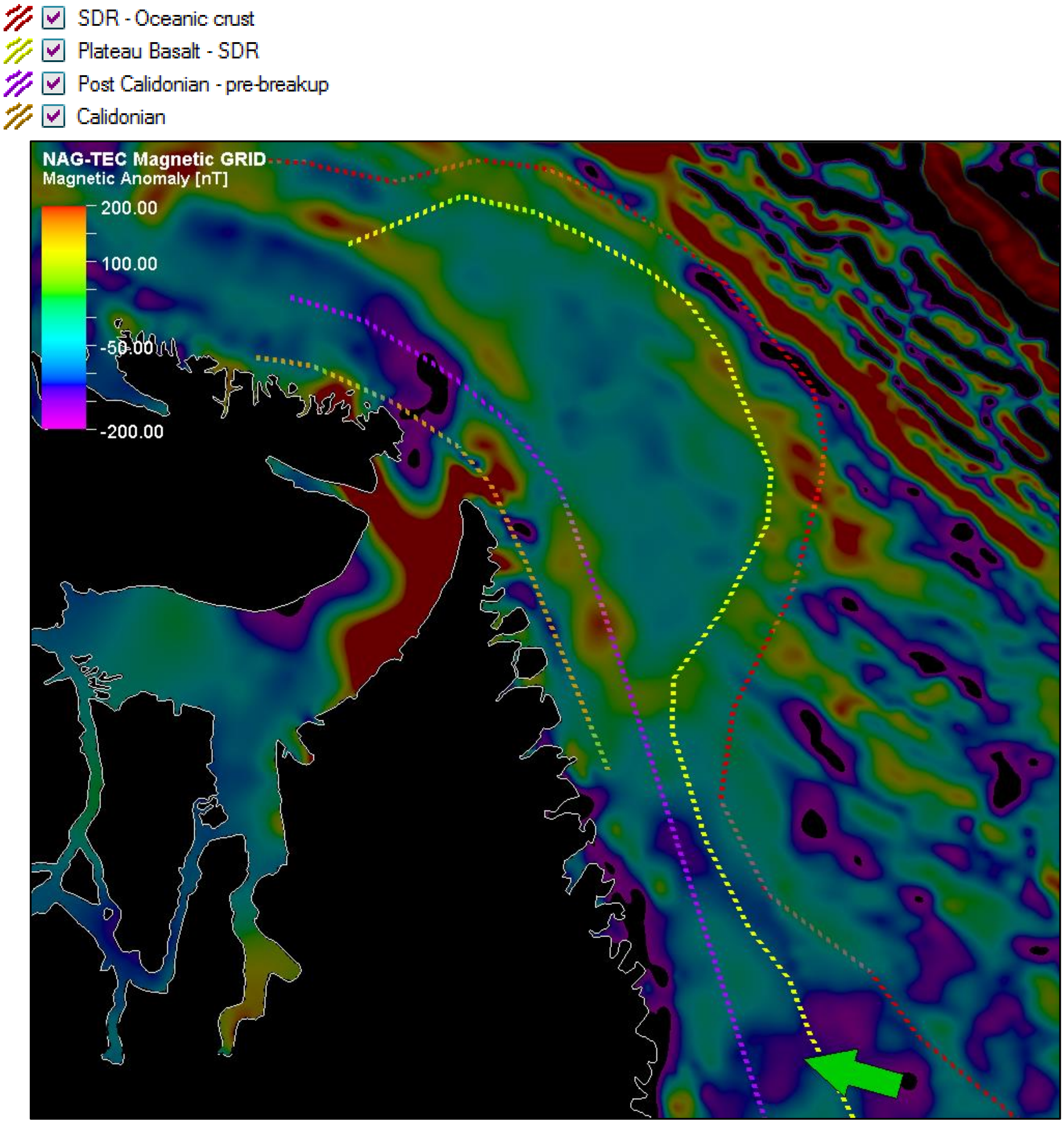
# Gravity tilt-derivative map

(Hopper et al., 2014)



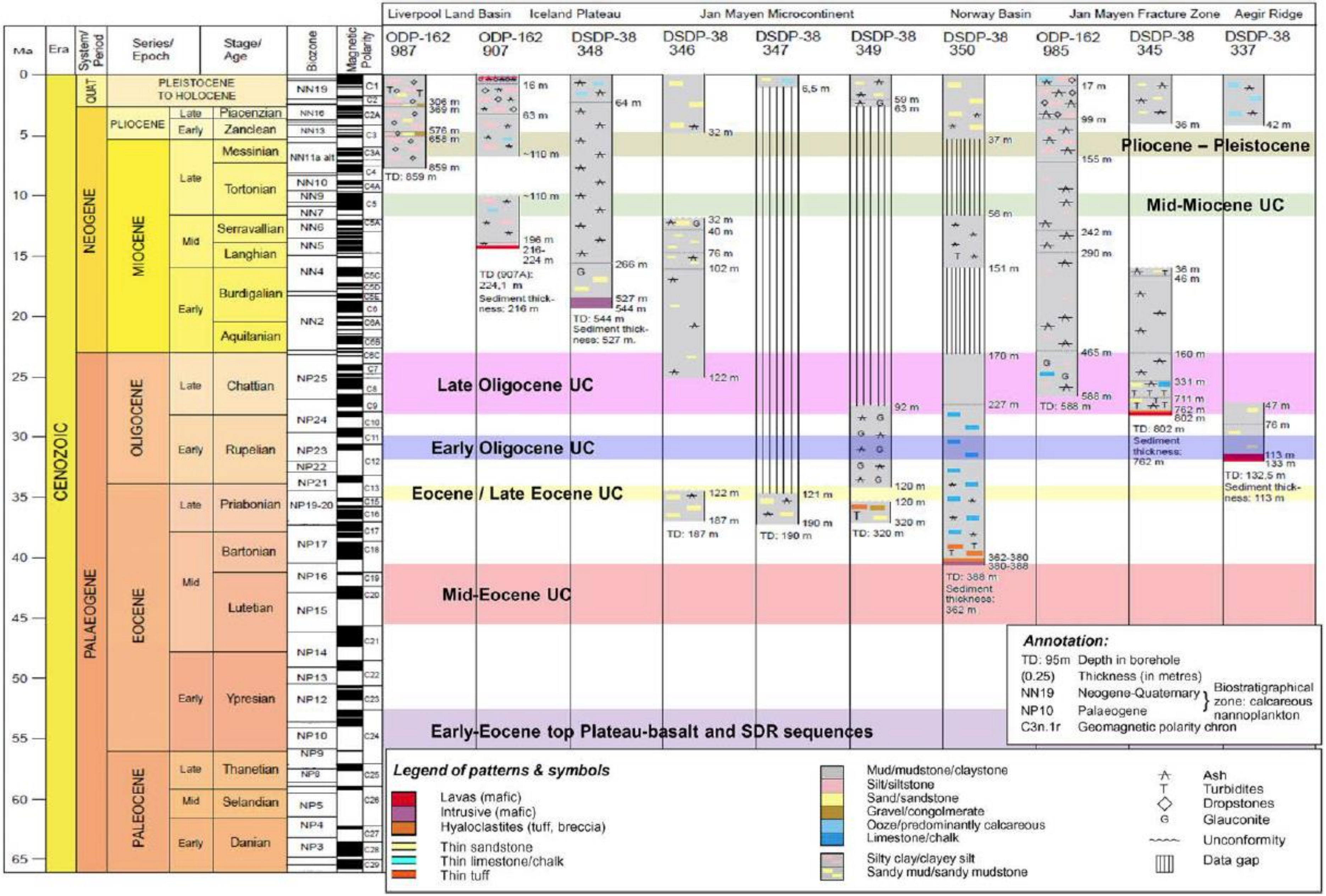
# Magnetic anomalies map

(Magnetic anomaly grid (Gaina et al., 2011) north of 60°N)



## Appendix 2: Offshore borehole correlation chart for the central Northeast Atlantic.

The JMMC stratigraphic summary chart. (Blischke et al., 2016), partly based on DSDP and ODP boreholes (Talwani et al., 1976a,b; Manum and Schrader, 1976; Manum et al., 1976a,b; Raschka et al., 1976; Nilsen et al., 1978; Thiede et al., 1995; Jansen et al., 1996; Channell et al., 1999a, b; Butt et al., 2001). This is used to tie the known shallow Cenozoic stratigraphy and unconformities to the seismic reflection data for the central Northeast Atlantic region. The Pliocene–Pleistocene correlation marker is based on sedimentary core records (Talwani et al., 1976a, b).



Ma
Era
System/ Period
Series/ Epoch
Stage/ Age
Biozone
Magnetic Polarity
CENOZOIC
QUAT
NEOGENE
PALAEOGENE
PLEISTOCENE TO HOLOCENE
PLIOCENE
MIOCENE
OLIGOCENE
EOCENE
PALEOCENE
Piacenzian
Zanclean
Messinian
Tortonian
Serravallian
Langhian
Burdigalian
Aquitanian
Chattian
Rupelian
Priabonian
Bartonian
Lutetian
Ypresian
Thanetian
Selandian
Danian
Liverpool Land Basin
Iceland Plateau
Jan Mayen Microcontinent
Norway Basin
Jan Mayen Fracture Zone
Aegir Ridge
ODP-162 987
ODP-162 907
DSDP-38 348
DSDP-38 346
DSDP-38 347
DSDP-38 349
DSDP-38 350
ODP-162 985
DSDP-38 345
DSDP-38 337
Pliocene – Pleistocene
Mid-Miocene UC
Late Oligocene UC
Early Oligocene UC
Eocene / Late Eocene UC
Mid-Eocene UC
Early-Eocene top Plateau-basalt and SDR sequences
Legend of patterns & symbols
Lavas (mafic)
Intrusive (mafic)
Hyaloclastites (tuff, breccia)
Thin sandstone
Thin limestone/chalk
Thin tuff
Mud/mudstone/claystone
Silt/siltstone
Sand/sandstone
Gravel/congolmerate
Ooze/predominantly calcareous
Limestone/chalk
Silty clay/clayey silt
Sandy mud/sandy mudstone
Ash
Turbidites
Dropstones
Glauconite
Unconformity
Data gap
Annotation:
TD: 95m Depth in borehole
(0.25) Thickness (in metres)
NN19 Neogene-Quaternary
NP10 Palaeogene
Biostratigraphical zone: calcareous nannoplankton
C3n.1r Geomagnetic polarity chron

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Manum, S.B., Raschka, H., Eckhardt, F.J., Schrader, H., Talwani, M. & Udintsev, G. (1976b). Site 337 initial reports of the Deep Sea Drilling Project. In: Talwani, M., Udintsev, G. et al. (eds) *Initial Reports of the Deep Sea Drilling Project, Volume 38.* United States Government Printing Office, Washington, DC, 117–150,

Raschka, H., Eckhardt, F.J. & Manum, S.B. (1976). Site 348. In: Talwani, M. & Udintsev, G. (eds) *Initial Reports of the Deep Sea Drilling Project, Volume 38.* United States Government Printing Office, Washington, DC, 595–654.

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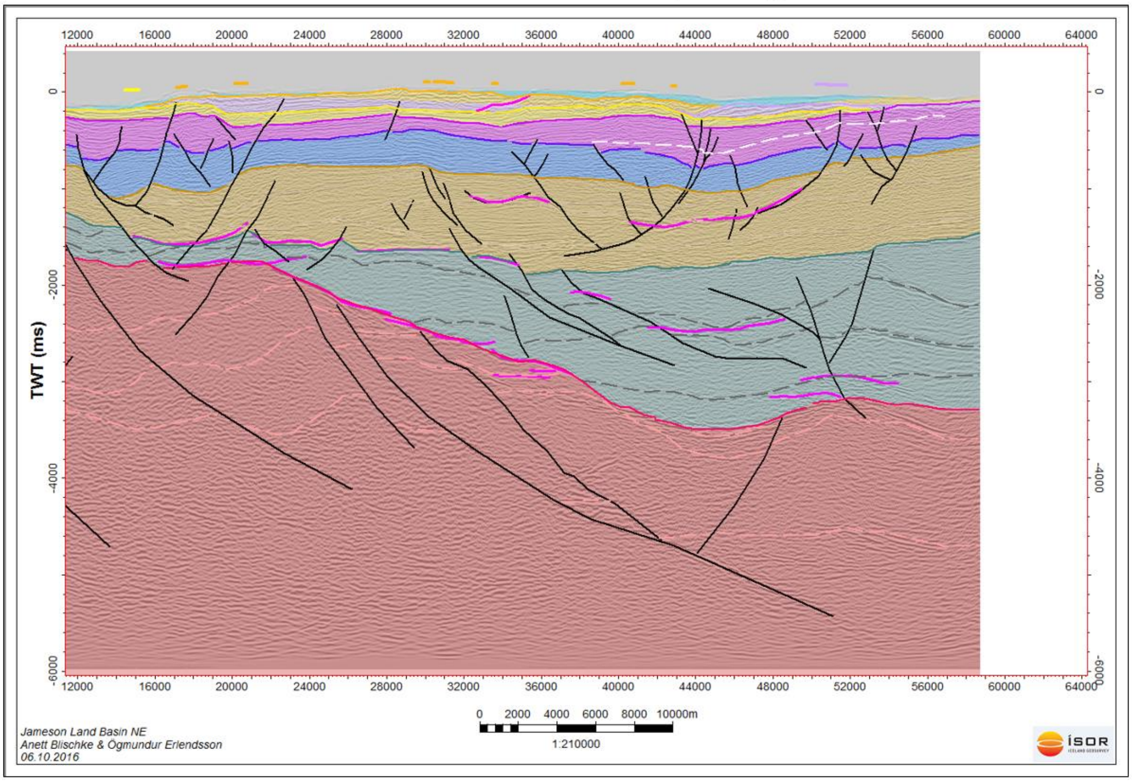
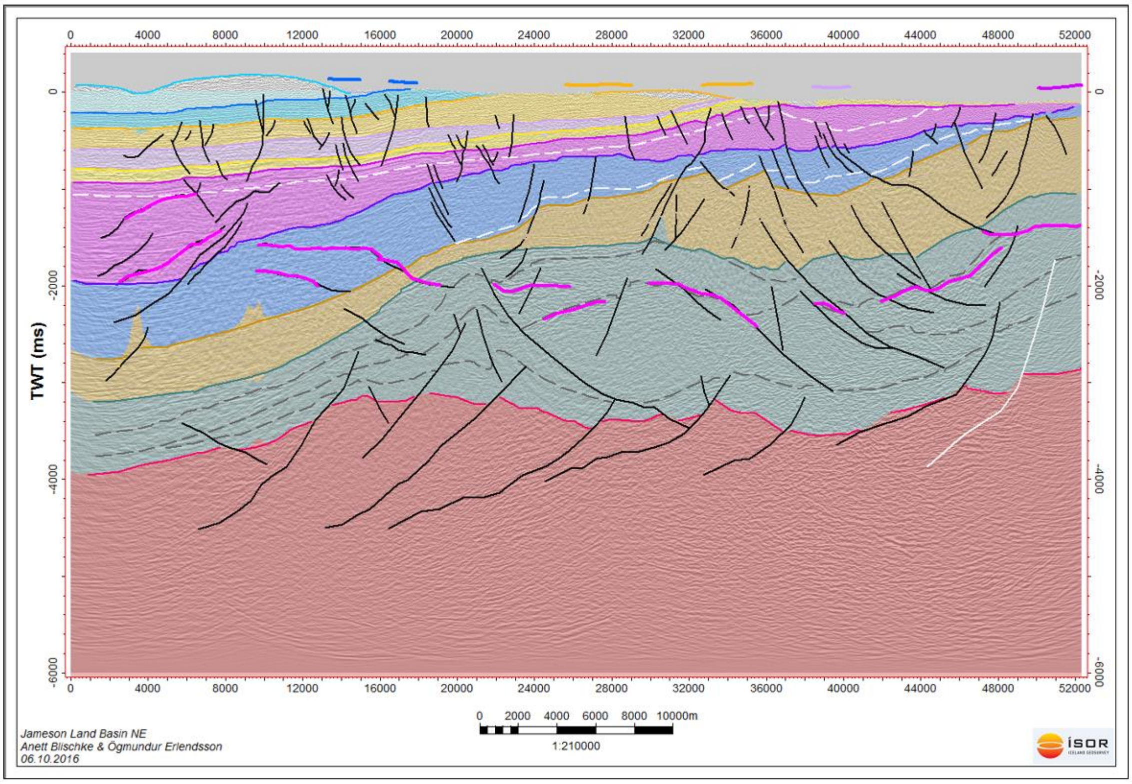
Butt, F.A., Elverhoi, A., Forsberg, C.F. & Solheim, A. (2001). An evolution of the Scoresby Sund Fan, central East Greenland – evidence from ODP Site 987. *Norsk Geologisk Tidsskrift*, 81, 3–15.

# Appendix 3: Northeast JMLB structural seismic reflection sections within 3D structural model

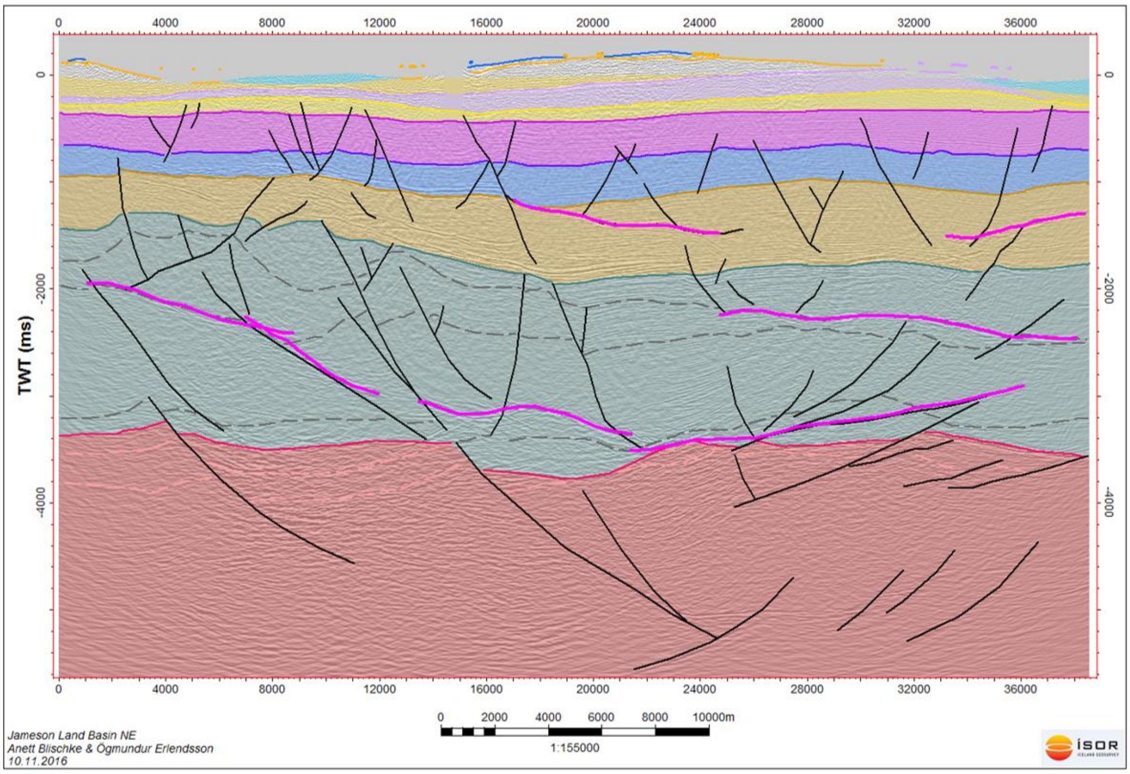
Seismic reflection data profile „A“



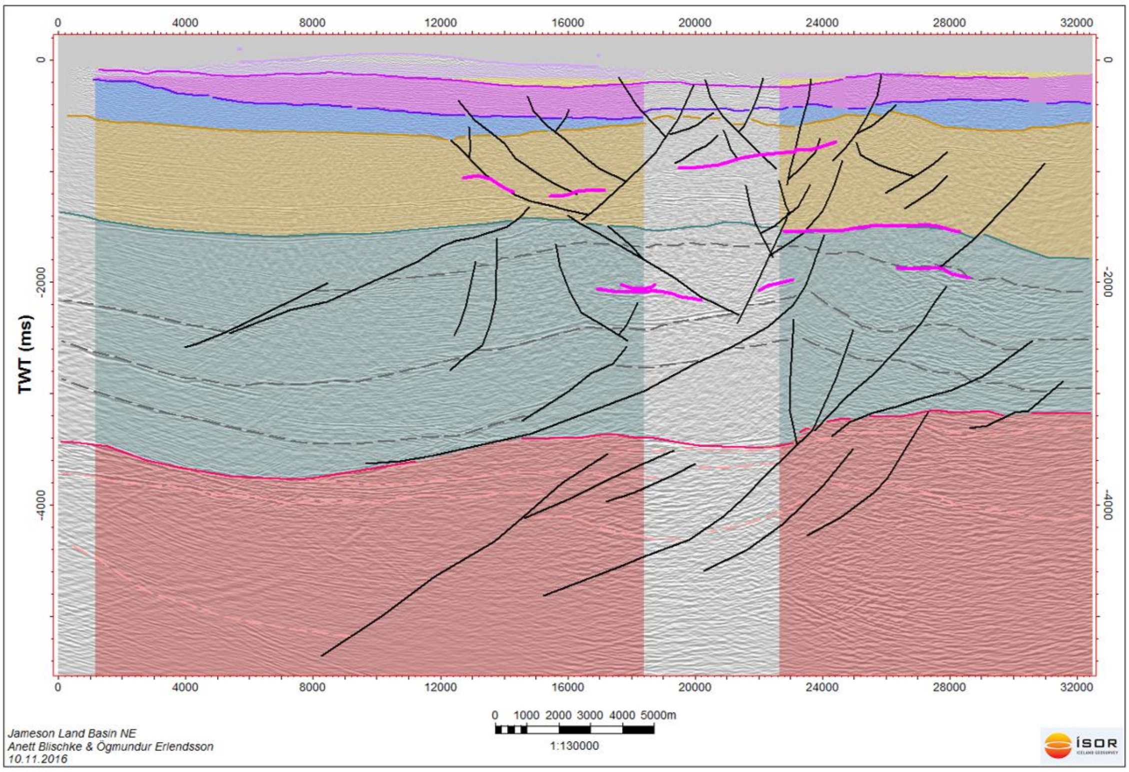

Seismic reflection data profile „B“



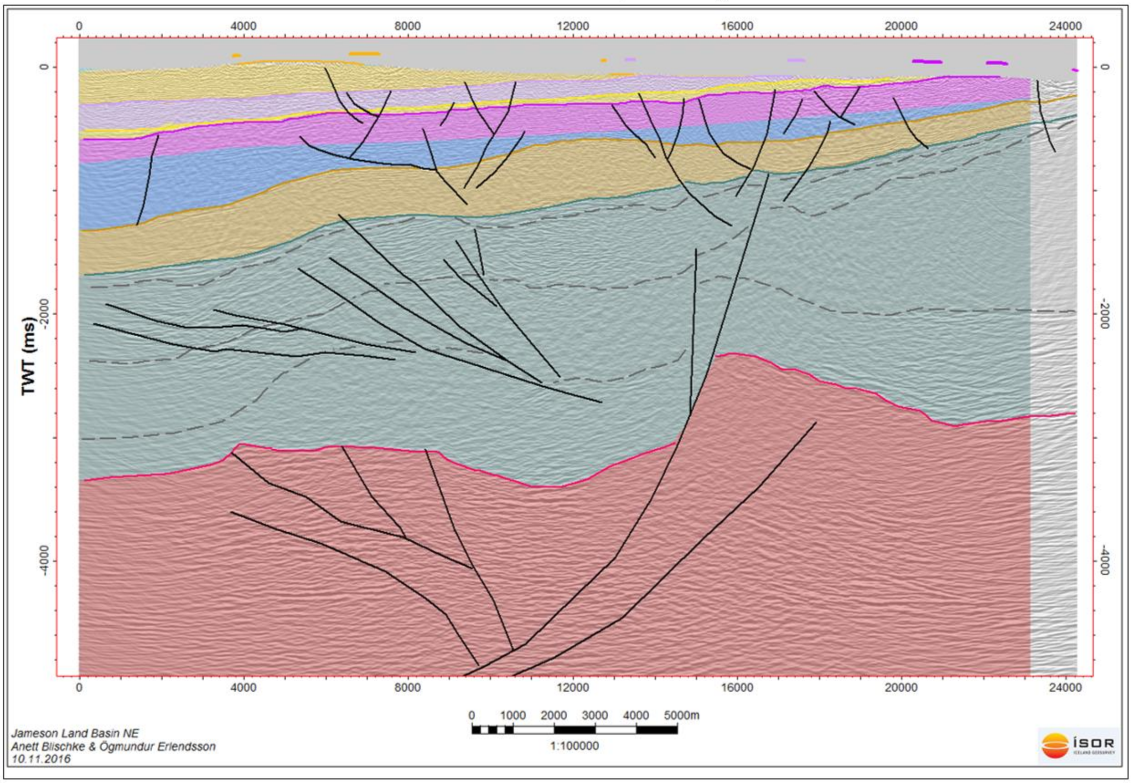
## Seismic reflection data profile „C“



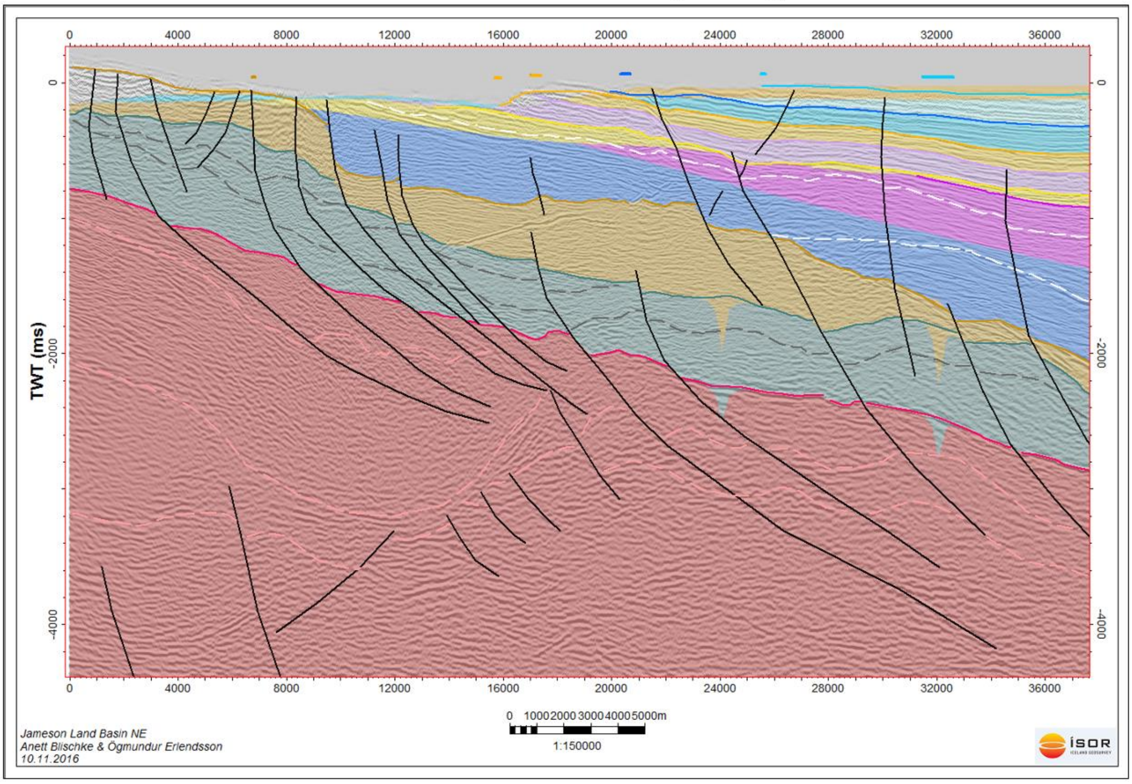

## Seismic reflection data profile „D“



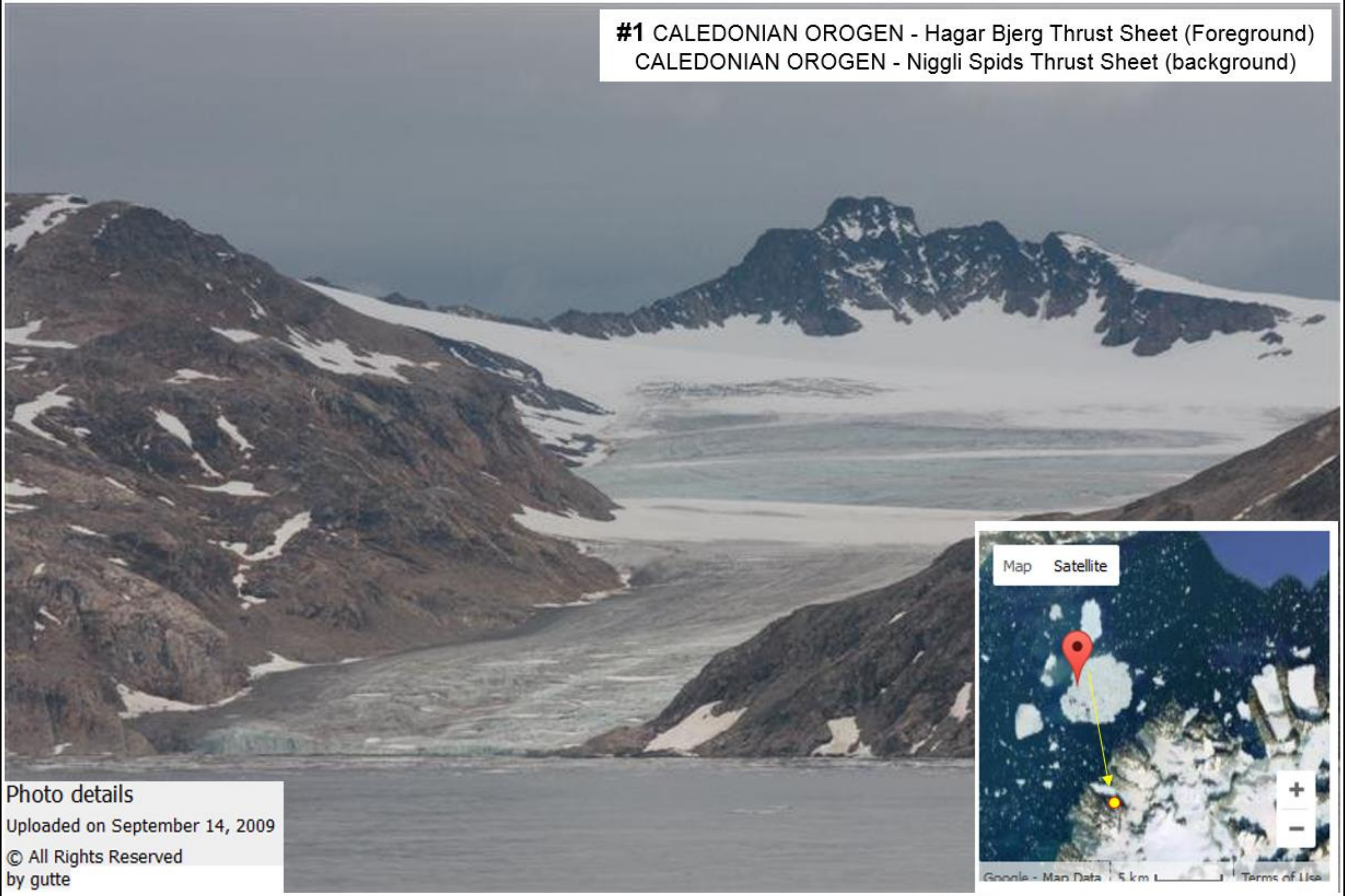
## Seismic reflection data profile „E“



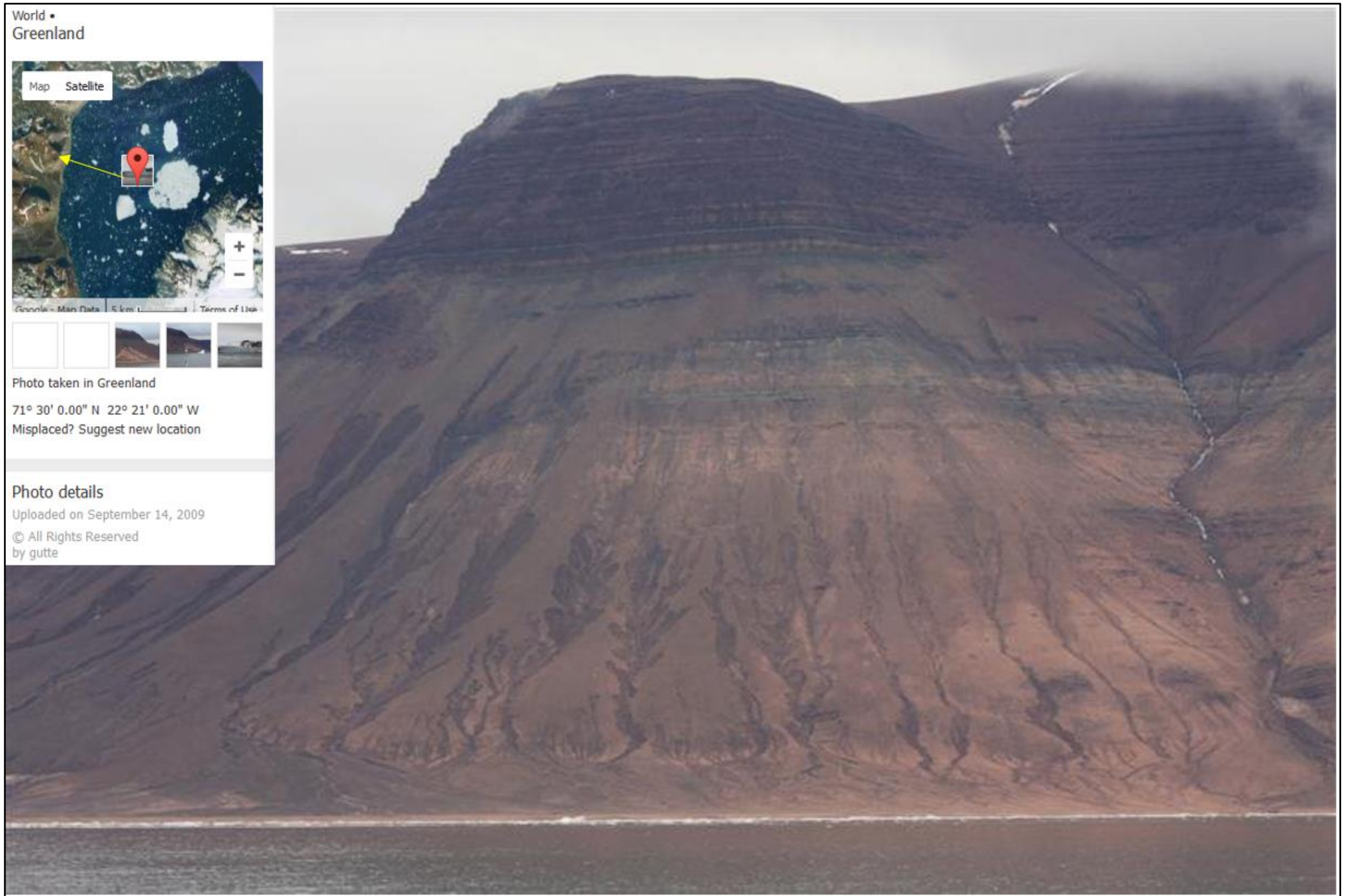

## Seismic reflection data profile „F“



# Appendix 4: Onshore geology sites analogues

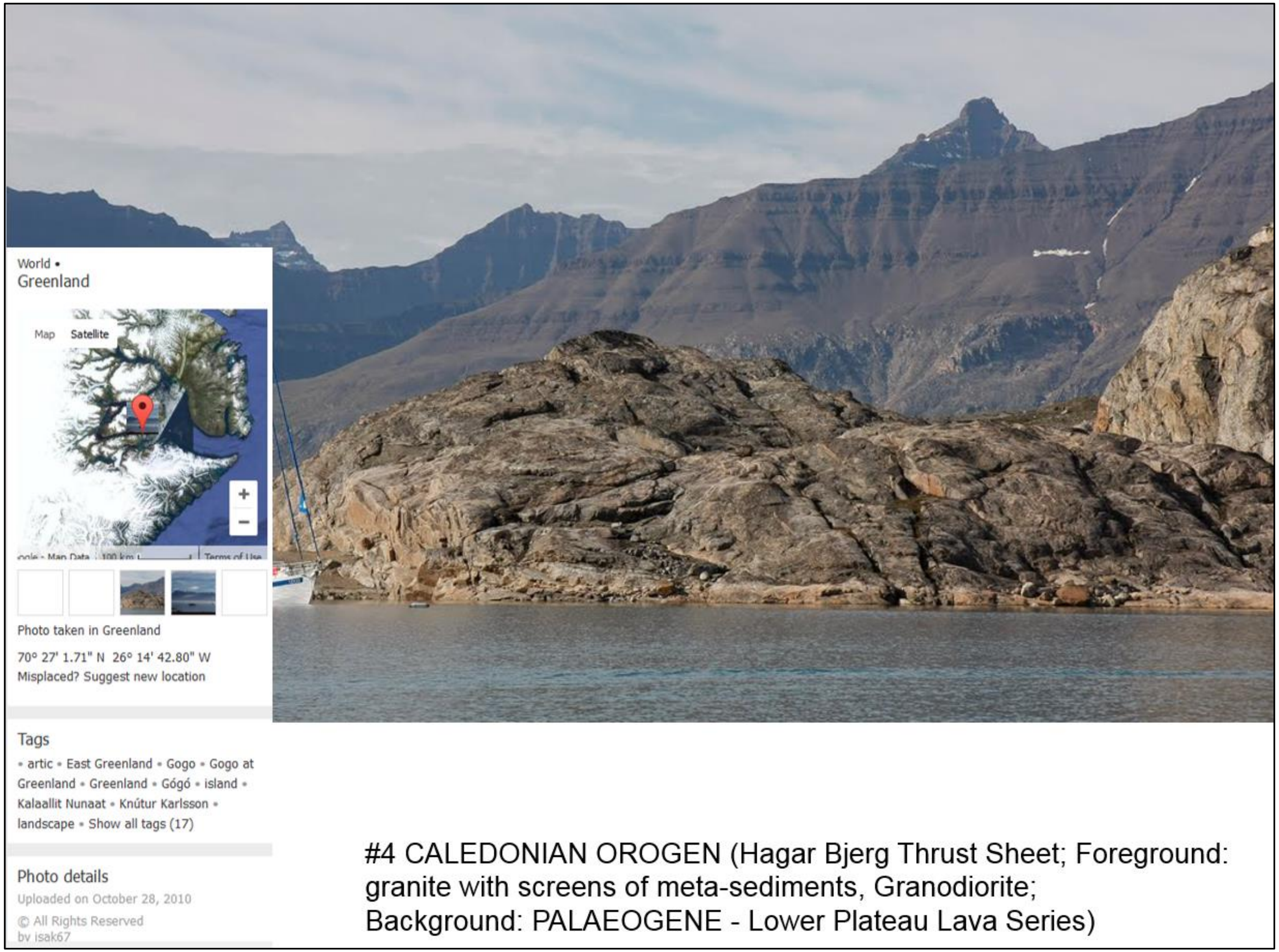



Basement; north-end of Liverpool Land High
„Carlsbergfjord“




#2 TRIASSIC; Pingodal Fm. => Gipsdalen Fm. ?


#3 CALEDONIAN OROGEN (Hagar Bjerg Thrust Sheet; granite with screens of meta-sediments, Granodiorite

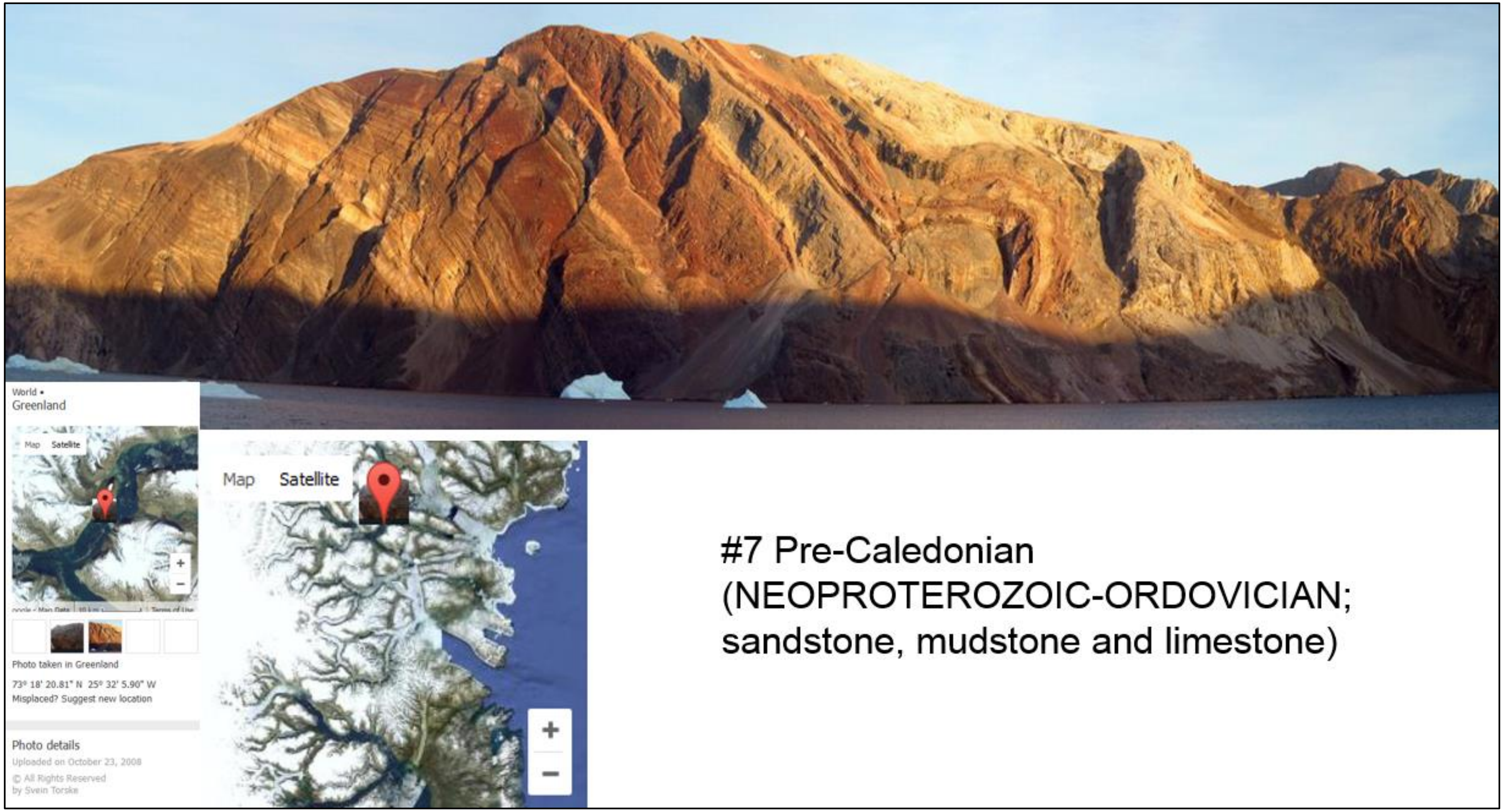



#4 CALEDONIAN OROGEN (Hagar Bjerg Thrust Sheet; Foreground: granite with screens of meta-sediments, Granodiorite; Background: PALAEOGENE - Lower Plateau Lava Series)

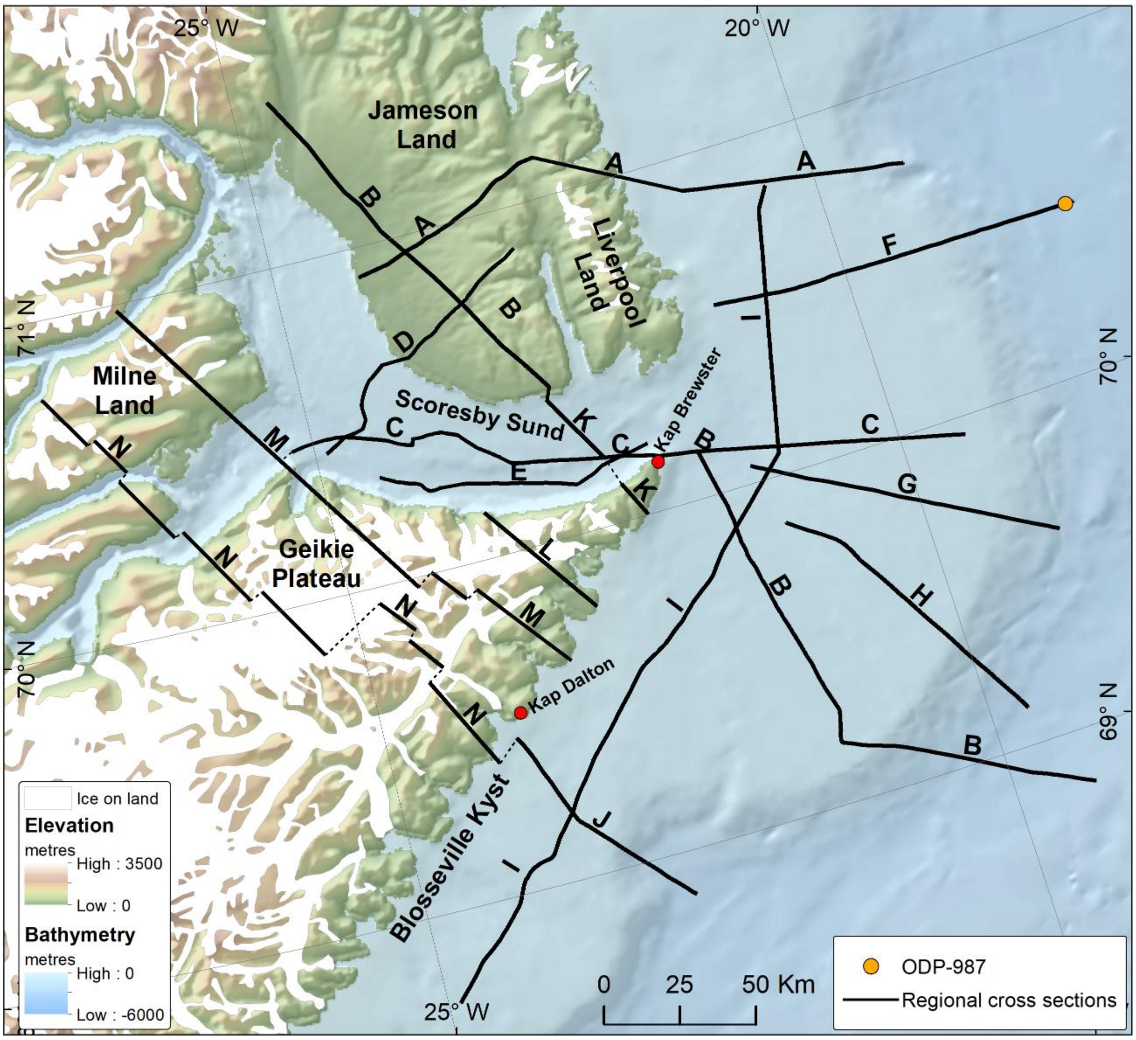
#5 Pre-Caledonian (CAMBRO - ORDOVICIAN; Sandstone, siltstone, limestone and dolomite)

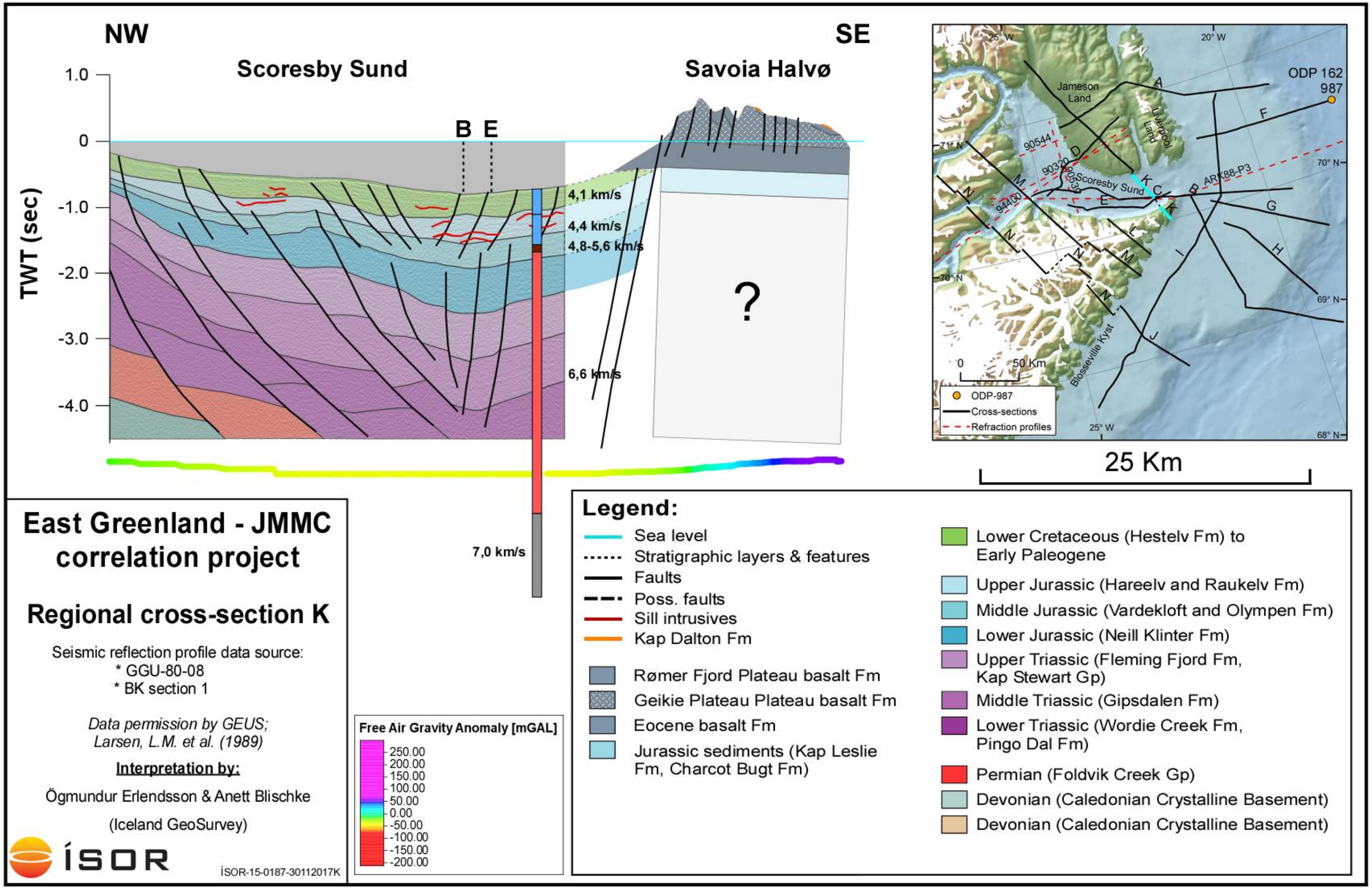


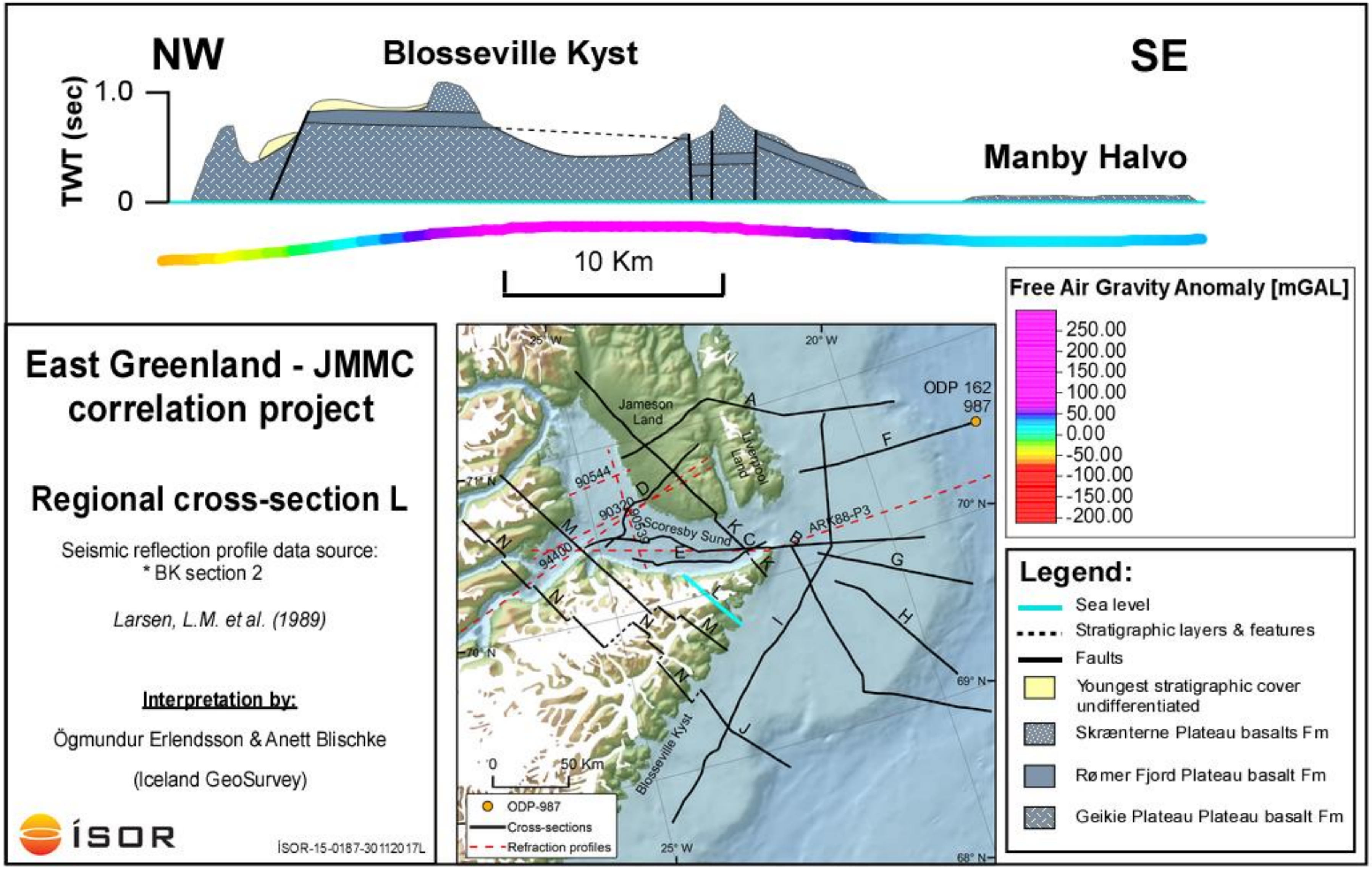
#6 Pre-Caledonian (Ella-Ø; Cambrian, Ordovician-Devonian sandstone, mudstone and limestone)

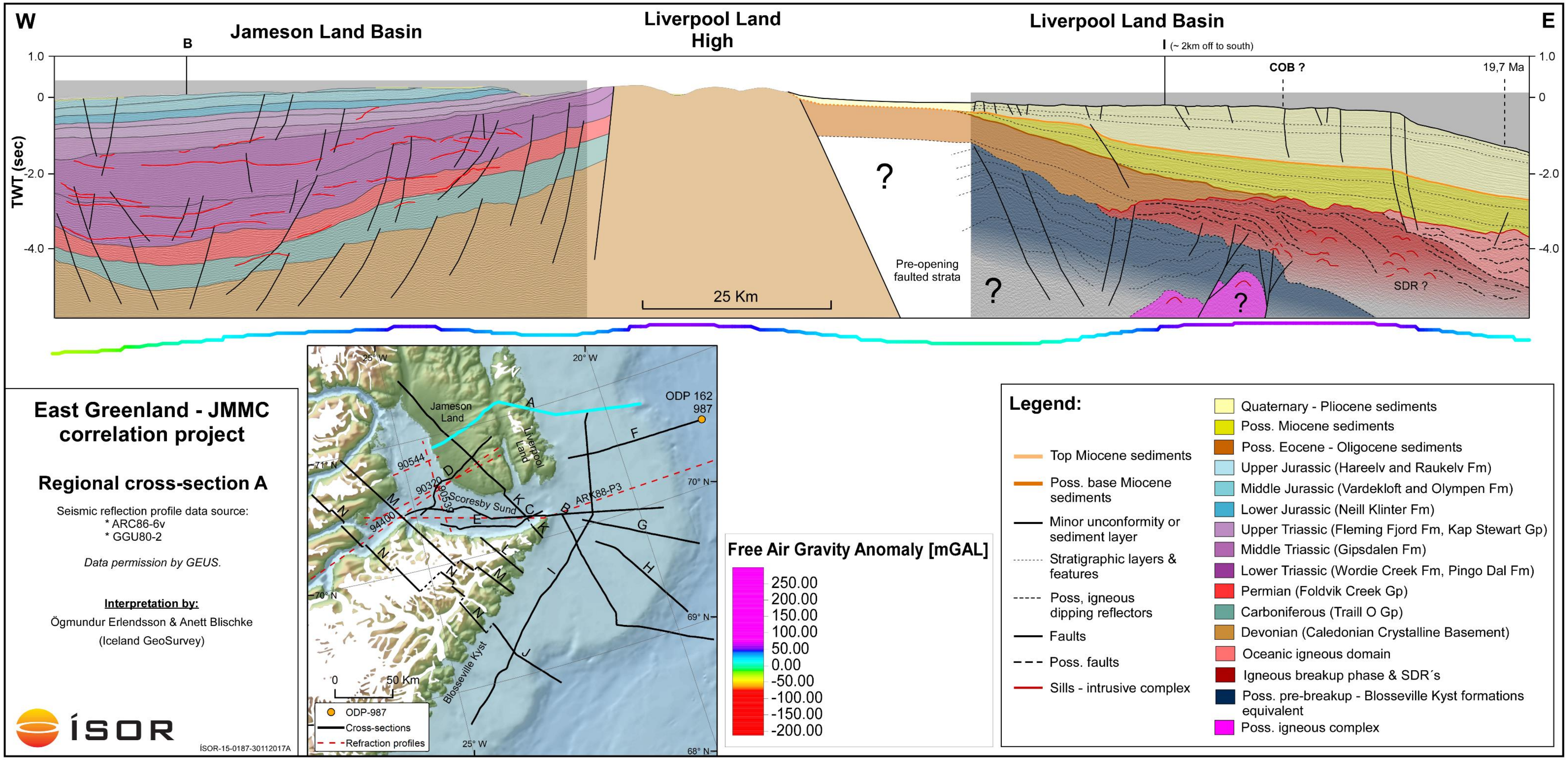

World •
Greenland
Map Satellite
Photo taken in Greenland
73º 18' 20.81" N 25º 32' 5.90" W
Misplaced? Suggest new location
Photo details
Uploaded on October 23, 2008
© All Rights Reserved
by Svein Torske
Map Satellite
#7 Pre-Caledonian
(NEOPROTEROZOIC-ORDOVICIAN;
sandstone, mudstone and limestone)

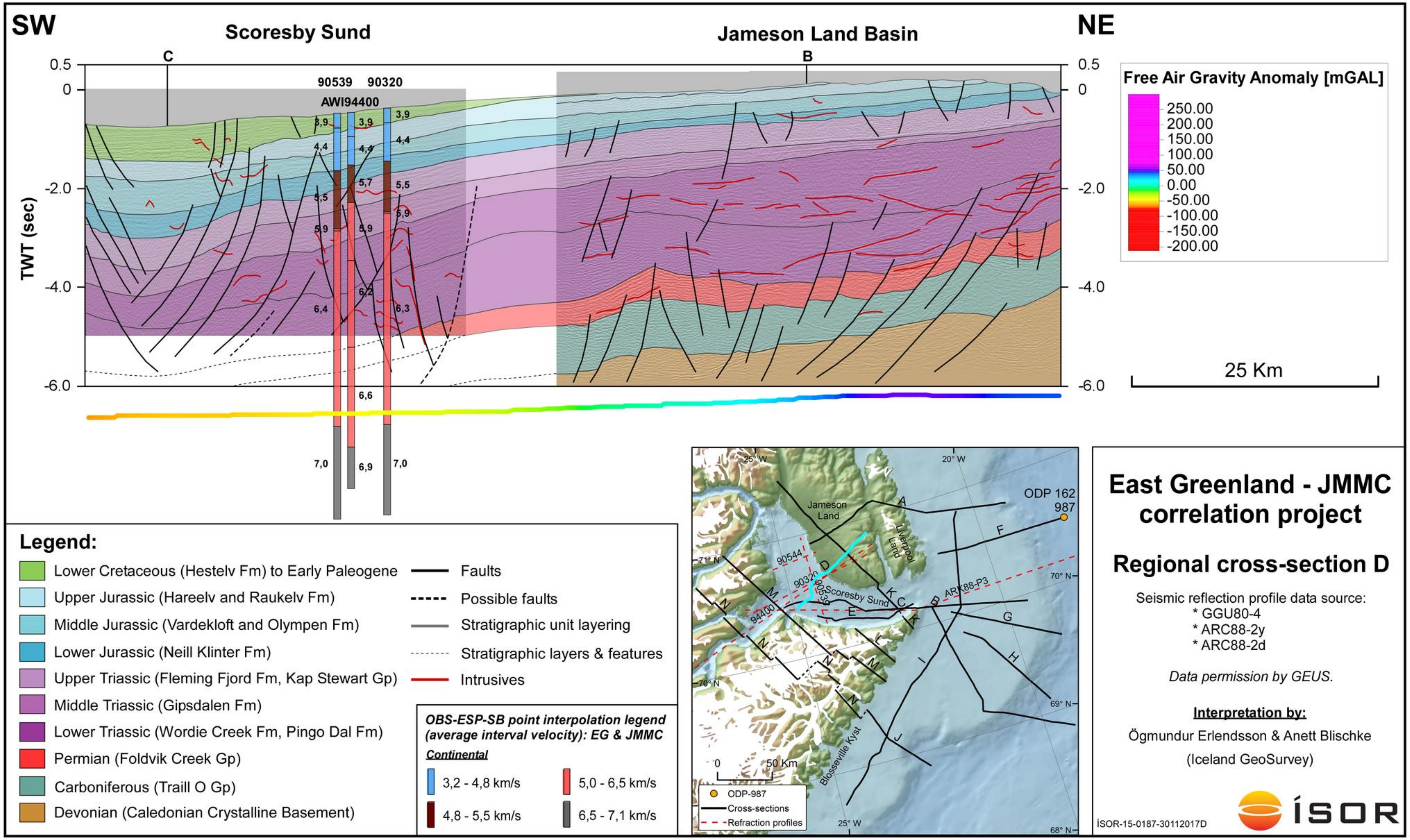
# Appendix 5: Jameson Land Basin – Liverpool Land high / -basin, and Blosseville Kyst regional correlation panels

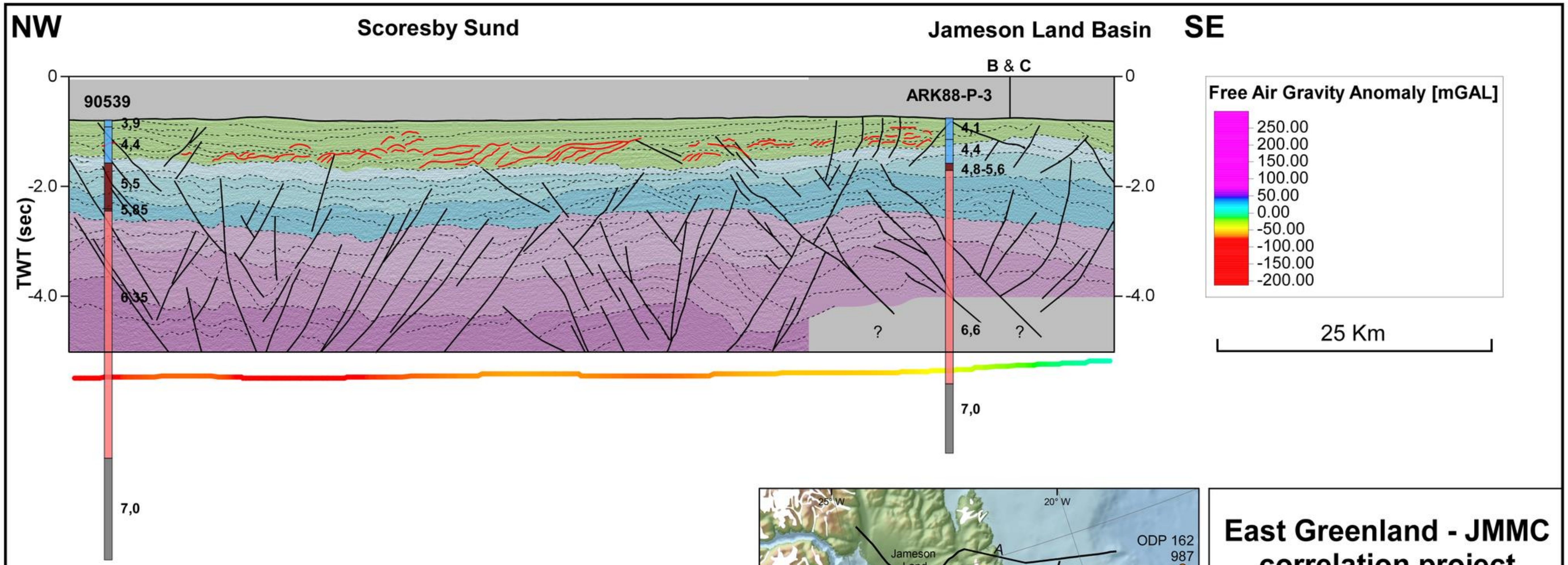



NW
SE
Scoresby Sund
Savoia Halvø
TWT (sec)
1.0
0
-1.0
-2.0
-3.0
-4.0
B E
4,1 km/s
4,4 km/s
4,8-5,6 km/s
6,6 km/s
7,0 km/s
?
25° W
20° W
ODP 162
987
Jameson Land
Liverpool Land
90544
90320
90539
94400
Scoresby Sund
ARK88-P3
71° N
70° N
69° N
68° N
0
50 Km
Blosseville Kyst
ODP-987
Cross-sections
Refraction profiles
25 Km
Legend:
Sea level
Stratigraphic layers & features
Faults
Poss. faults
Sill intrusives
Kap Dalton Fm
Rømer Fjord Plateau basalt Fm
Geikie Plateau Plateau basalt Fm
Eocene basalt Fm
Jurassic sediments (Kap Leslie Fm, Charcot Bugt Fm)
Lower Cretaceous (Hestelv Fm) to Early Paleogene
Upper Jurassic (Hareelv and Raukelv Fm)
Middle Jurassic (Vardekloft and Olympen Fm)
Lower Jurassic (Neill Klinter Fm)
Upper Triassic (Fleming Fjord Fm, Kap Stewart Gp)
Middle Triassic (Gipsdalen Fm)
Lower Triassic (Wordie Creek Fm, Pingo Dal Fm)
Permian (Foldvik Creek Gp)
Devonian (Caledonian Crystalline Basement)
Devonian (Caledonian Crystalline Basement)
Free Air Gravity Anomaly [mGAL]
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
East Greenland - JMMC correlation project
Regional cross-section K
Seismic reflection profile data source:
* GGU-80-08
* BK section 1
Data permission by GEUS; Larsen, L.M. et al. (1989)
Interpretation by:
Ögmundur Erlendsson & Anett Blischke
(Iceland GeoSurvey)
ÍSOR
ÍSOR-15-0187-30112017K


NW
Blosseville Kyst
SE
TWT (sec)
1.0
0
Manby Halvo
10 Km
Free Air Gravity Anomaly [mGAL]
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
East Greenland - JMMC correlation project
Regional cross-section L
Seismic reflection profile data source:
* BK section 2
Larsen, L.M. et al. (1989)
Interpretation by:
Ögmundur Erlendsson & Anett Blischke
(Iceland GeoSurvey)
ÍSOR
ÍSOR-15-0187-30112017L
Jameson Land
Liverpool Land
Scoresby Sund
Blosseville Kyst
ODP 162
987
ARK88-P3
90544
90320
94400
25° W
20° W
71° N
70° N
70° N
69° N
68° N
0
50 Km
ODP-987
Cross-sections
Refraction profiles
Legend:
Sea level
Stratigraphic layers & features
Faults
Youngest stratigraphic cover undifferentiated
Skrænterne Plateau basalts Fm
Rømer Fjord Plateau basalt Fm
Geikie Plateau Plateau basalt Fm


W
Jameson Land Basin
Liverpool Land High
Liverpool Land Basin
E
B
I (~ 2km off to south)
COB ?
19,7 Ma
TWT (sec)
1.0
0
-2.0
-4.0
?
Pre-opening faulted strata
SDR ?
25 Km
East Greenland - JMMC correlation project
Regional cross-section A
Seismic reflection profile data source:
* ARC86-6v
* GGU80-2
Data permission by GEUS.
Interpretation by:
Ögmundur Erlendsson & Anett Blischke
(Iceland GeoSurvey)
ÍSOR
ÍSOR-15-0187-30112017A
Jameson Land
Liverpool Land
Scoresby Sund
Blosseville Kyst
ODP 162 987
90544
90320
94400
ARK88-P3
25° W
20° W
71° N
70° N
69° N
68° N
0
50 Km
ODP-987
Cross-sections
Refraction profiles
Free Air Gravity Anomaly [mGAL]
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
Legend:
Top Miocene sediments
Poss. base Miocene sediments
Minor unconformity or sediment layer
Stratigraphic layers & features
Poss, igneous dipping reflectors
Faults
Poss. faults
Sills - intrusive complex
Quaternary - Pliocene sediments
Poss. Miocene sediments
Poss. Eocene - Oligocene sediments
Upper Jurassic (Hareelv and Raukelv Fm)
Middle Jurassic (Vardekloft and Olympen Fm)
Lower Jurassic (Neill Klinter Fm)
Upper Triassic (Fleming Fjord Fm, Kap Stewart Gp)
Middle Triassic (Gipsdalen Fm)
Lower Triassic (Wordie Creek Fm, Pingo Dal Fm)
Permian (Foldvik Creek Gp)
Carboniferous (Traill O Gp)
Devonian (Caledonian Crystalline Basement)
Oceanic igneous domain
Igneous breakup phase & SDR´s
Poss. pre-breakup - Blosseville Kyst formations equivalent
Poss. igneous complex


SW
Scoresby Sund
Jameson Land Basin
NE
C
B
90539 90320
AWI94400
TWT (sec)
0.5
0
-2.0
-4.0
-6.0
3,9
4,4
5,5
5,7
5,9
6,2
6,4
6,3
6,6
7,0
6,9
Free Air Gravity Anomaly [mGAL]
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
25 Km
Legend:
Lower Cretaceous (Hestelv Fm) to Early Paleogene
Upper Jurassic (Hareelv and Raukelv Fm)
Middle Jurassic (Vardekloft and Olympen Fm)
Lower Jurassic (Neill Klinter Fm)
Upper Triassic (Fleming Fjord Fm, Kap Stewart Gp)
Middle Triassic (Gipsdalen Fm)
Lower Triassic (Wordie Creek Fm, Pingo Dal Fm)
Permian (Foldvik Creek Gp)
Carboniferous (Traill O Gp)
Devonian (Caledonian Crystalline Basement)
Faults
Possible faults
Stratigraphic unit layering
Stratigraphic layers & features
Intrusives
OBS-ESP-SB point interpolation legend (average interval velocity): EG & JMMC
Continental
3,2 - 4,8 km/s
5,0 - 6,5 km/s
4,8 - 5,5 km/s
6,5 - 7,1 km/s
25° W
20° W
Jameson Land
Liverpool Land
ODP 162 987
71° N
70° N
69° N
68° N
90544
90320
90539
94400
Scoresby Sund
ARK88-P3
Blosseville Kyst
A
B
C
D
E
F
G
H
I
J
K
L
M
N
0 50 Km
ODP-987
Cross-sections
Refraction profiles
East Greenland - JMMC correlation project
Regional cross-section D
Seismic reflection profile data source:
* GGU80-4
* ARC88-2y
* ARC88-2d
Data permission by GEUS.
Interpretation by:
Ögmundur Erlendsson & Anett Blischke
(Iceland GeoSurvey)
ÍSOR-15-0187-30112017D
ÍSOR




**Legend:**

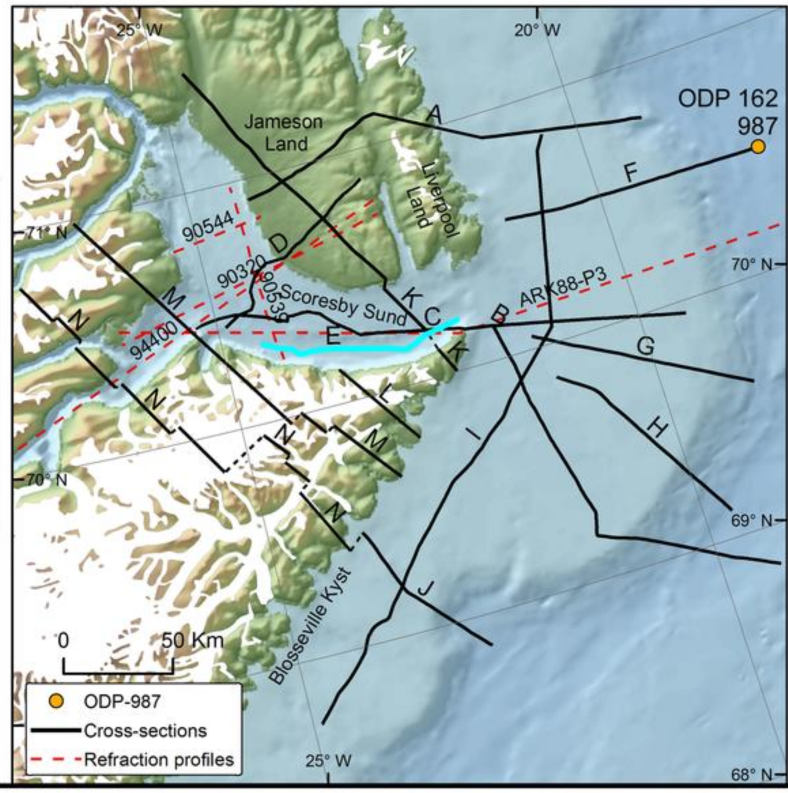
- Lower Cretaceous (Hestelv Fm) to Early Paleogene
- Upper Jurassic (Hareelv and Raukelv Fm)
- Middle Jurassic (Vardekloft and Olympen Fm)
- Lower Jurassic (Neill Klinter Fm)
- Upper Triassic (Fleming Fjord Fm, Kap Stewart Gp)
- Middle Triassic (Gipsdalen Fm)
- Lower Triassic (Wordie Creek Fm, Pingo Dal Fm)
- Permian (Foldvik Creek Gp)
- Carboniferous (Traill O Gp)
- Devonian (Caledonian Crystalline Basement)

- Faults
- Possible faults
- Stratigraphic layers & features
- Intrusives & poss. extrusives

***OBS-ESP-SB point interpolation legend (average interval velocity): EG & JMMC***

***Continental***

| | |
|---|---|
| 3,2 - 4,8 km/s | 5,0 - 6,5 km/s |
| 4,8 - 5,5 km/s | 6,5 - 7,1 km/s |




# East Greenland - JMMC correlation project

## Regional cross-section E

Seismic reflection profile data source:
* GGU80-6
* GGU80-9

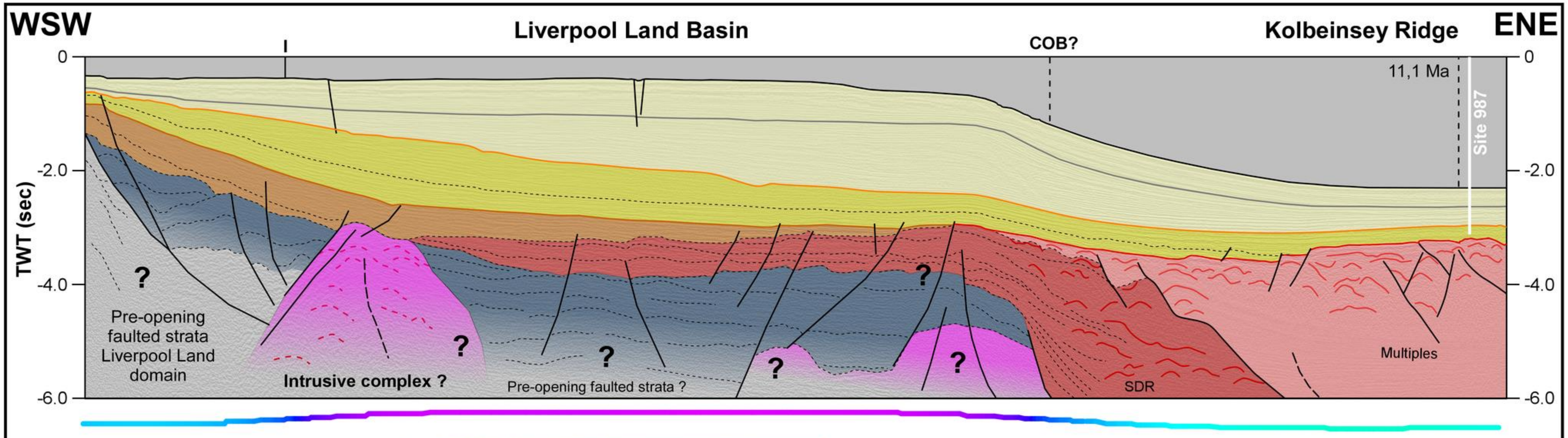
*Data permission by GEUS.*


**Interpretation by:**

Anett Blischke & Ögmundur Erlendsson

(Iceland GeoSurvey)


ÍSOR-15-0187-30112017E




## East Greenland - JMMC correlation project

## Regional cross-section F

Seismic reflection profile data source:
* GGU80-12

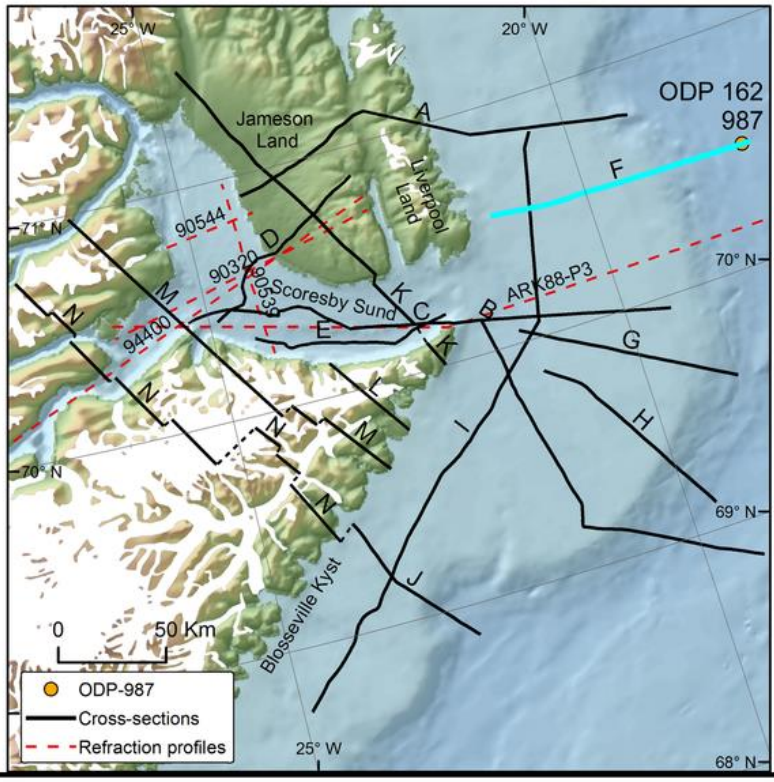
*Data permission by GEUS.*

**Interpretation by:**

Ögmundur Erlendsson & Anett Blischke
(Iceland GeoSurvey)

ÍSOR

ÍSOR-15-0187-31112017F



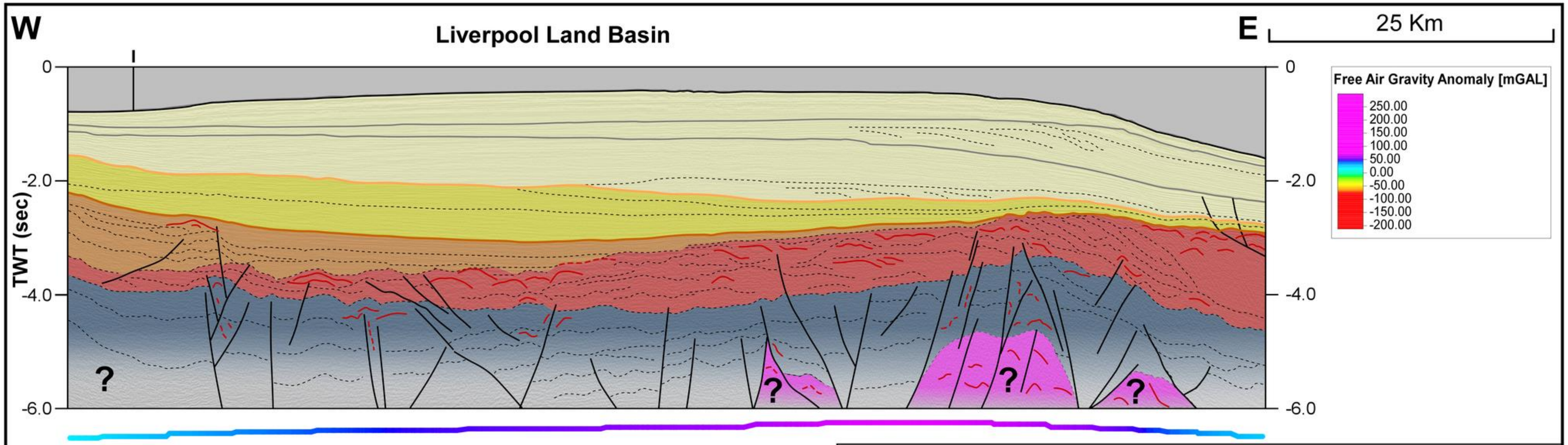

**Legend:**

25 Km

- Top Miocene sediments
- Poss. base Miocene sediments
- Minor unconformity or sediment layer
- Stratigraphic layers & features
- Quaternary - Pliocene sediments
- Poss. Miocene sediments
- Poss. Eocene - Oligocene sediments
- Poss. igneous complex
- Oceanic igneous domain
- Igneous breakup phase & SDR´s
- Poss. pre-breakup - Blosseville Kyst Basalt formation equivalent
- Faults
- Poss. faults
- Sills - intrusive complex
- Poss. Igneous source

**Free Air Gravity Anomaly [mGAL]**

250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00




# East Greenland - JMMC correlation project

## Regional cross-section G

Seismic reflection profile data source:
* GGU82-22

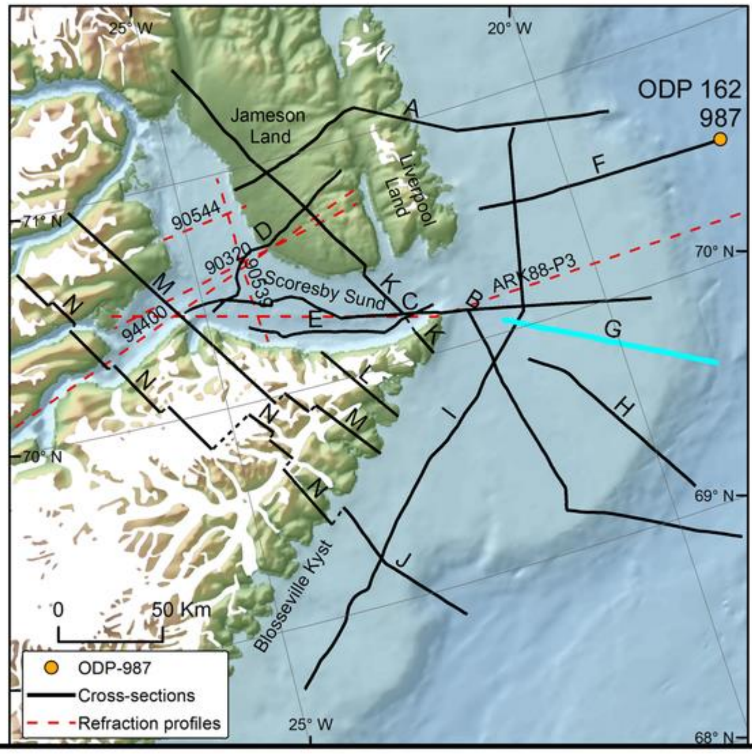
*Data permission by GEUS.*

**Interpretation by:**

Anett Blischke & Ögmundur Erlendsson
(Iceland GeoSurvey)

ÍSOR

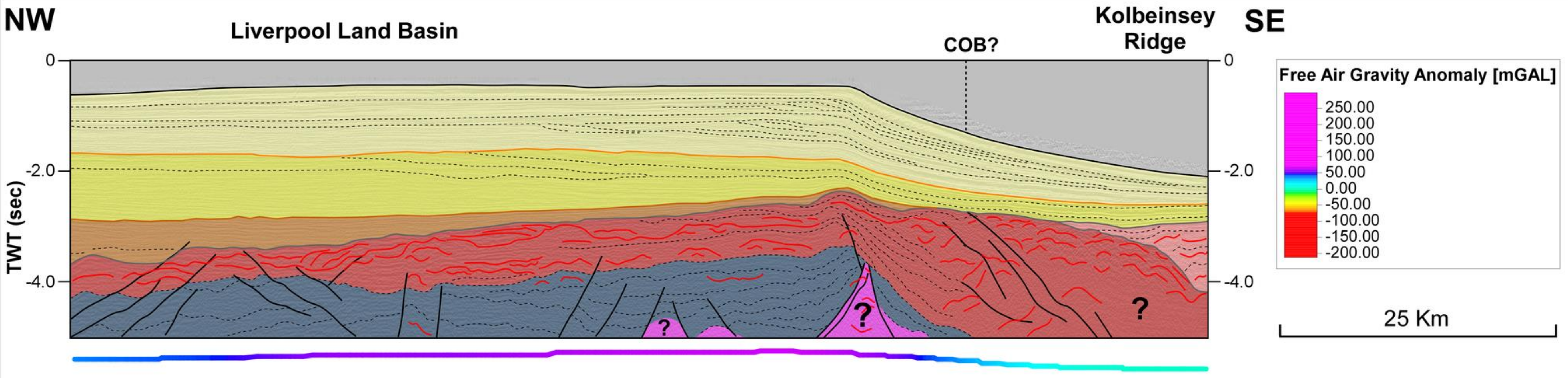
ÍSOR-15-0187-30112017G




**Legend:**

- Top Miocene sediments
- Poss. base Miocene sediments
- Minor unconformity or sediment layer
- Stratigraphic layers & features
- Faults
- Poss. faults
- Sills - intrusive complex
- Poss. Igneous source

- Quaternary - Pliocene sediments
- Poss. Miocene sediments
- Poss. Eocene - Oligocene sediments
- Poss. igneous complex
- Igneous breakup phase & SDR´s
- Poss. pre-breakup - Blosseville Kyst formations equivalent




# East Greenland - JMMC correlation project

## Regional cross-section H

Seismic reflection profile data source:
* GGU82-26

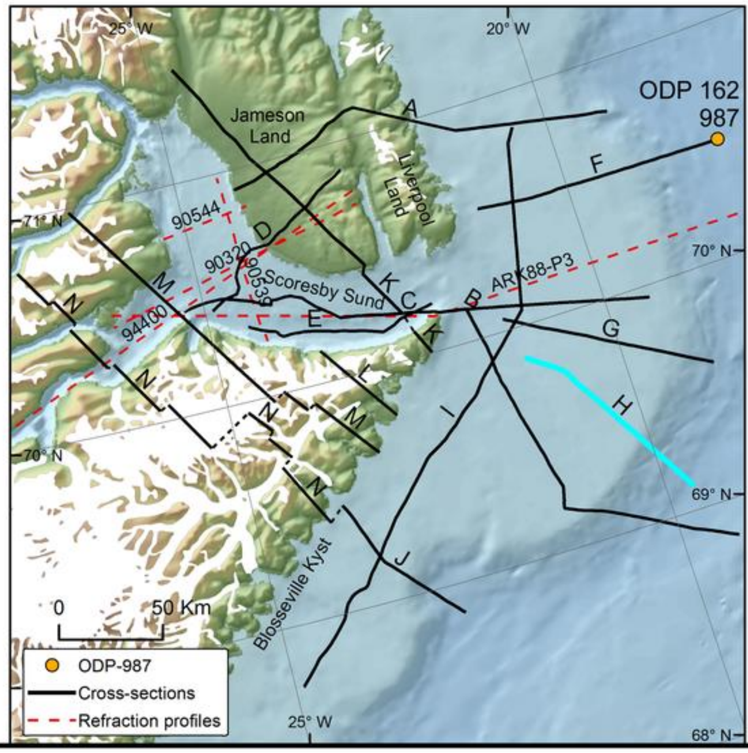
*Data permission by GEUS.*

**Interpretation by:**

Anett Blischke & Ögmundur Erlendsson
(Iceland GeoSurvey)

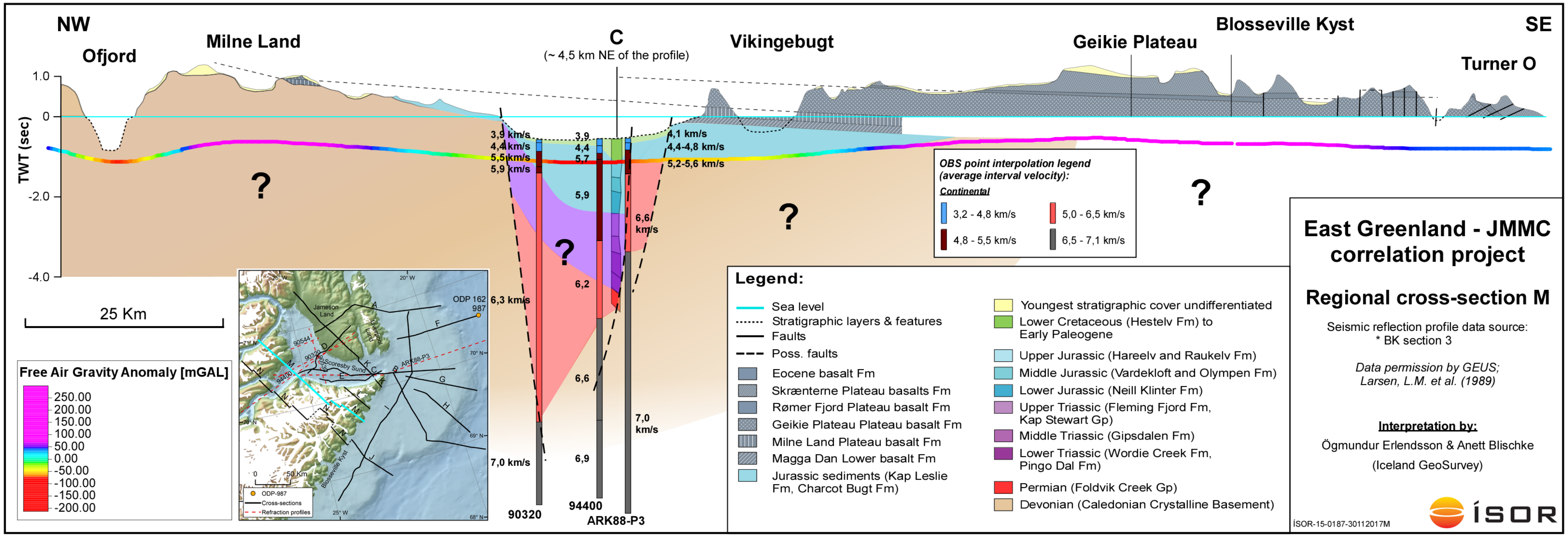
ÍSOR

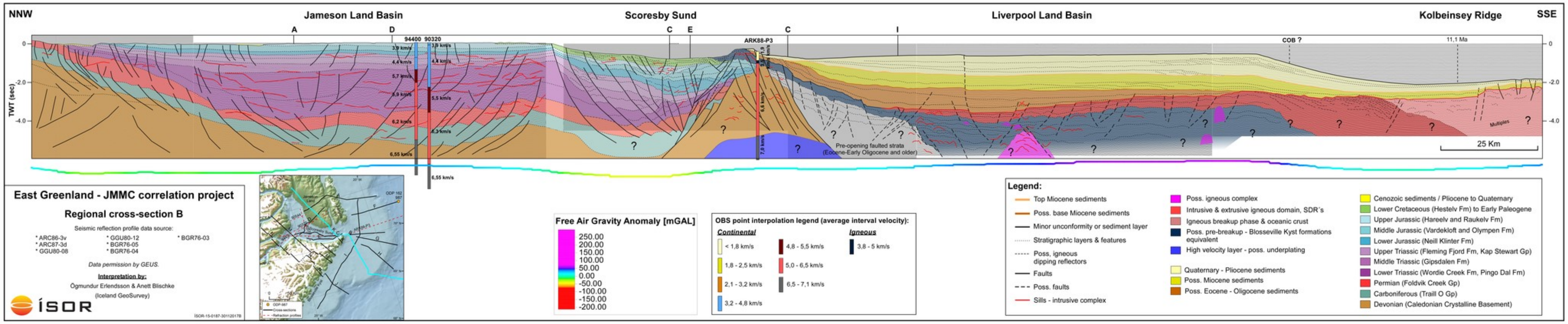
ÍSOR-15-0187-30112017H

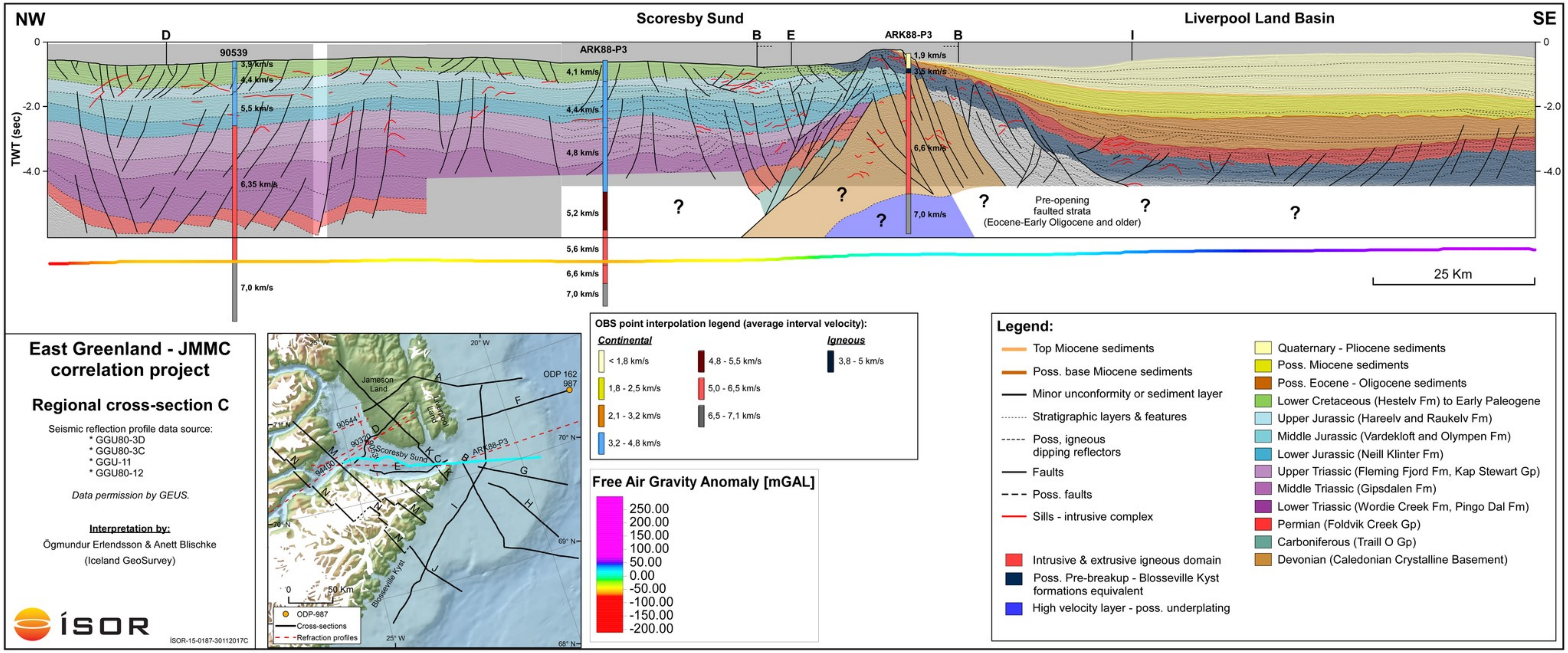


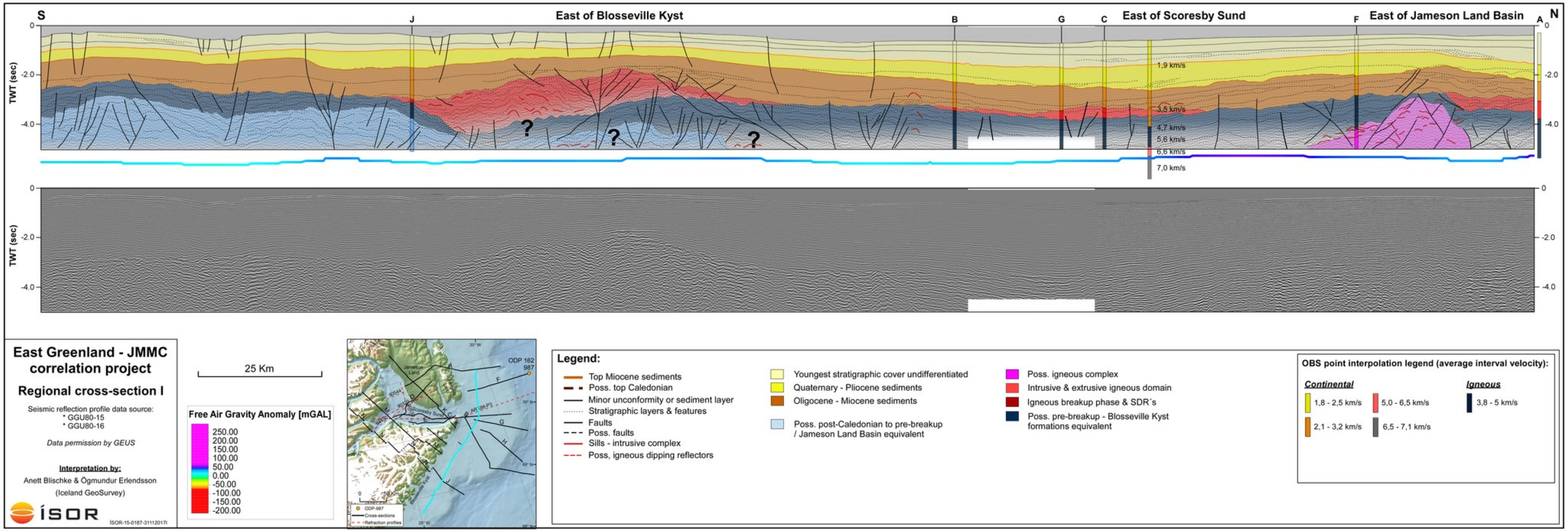

## Legend:

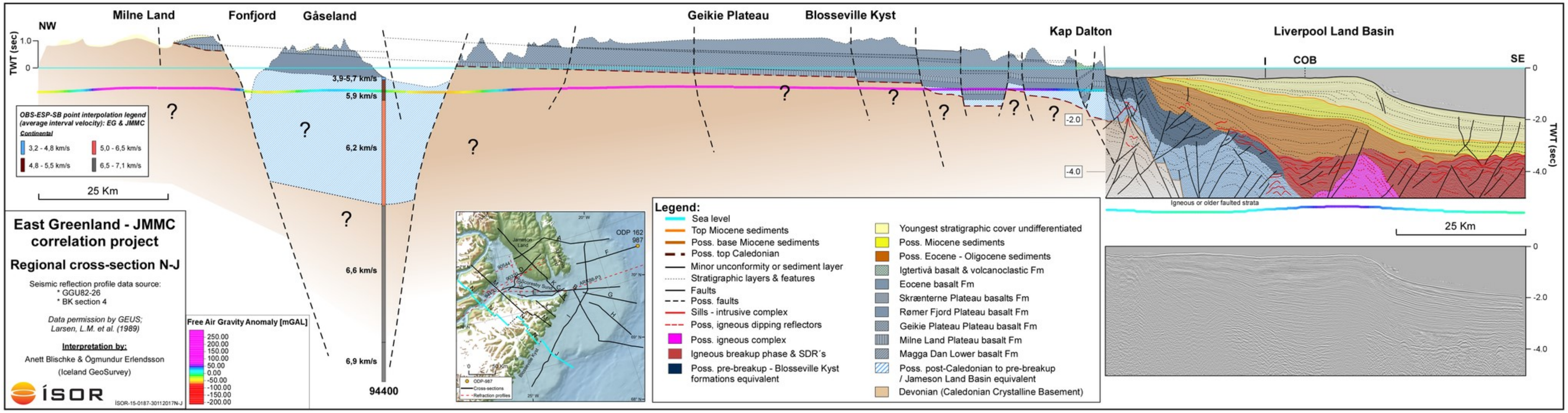
- Top Miocene sediments
- Poss. base Miocene sediments
- Minor unconformity or sediment layer
- Stratigraphic layers & features
- Faults
- Poss. faults
- Sills - intrusive
- Quaternary - Pliocene sediments
- Poss. Miocene sediments
- Poss. Oligocene sediments
- Oceanic igneous domain
- Igneous breakup phase & SDR´s
- Poss. pre-breakup - Blosseville Kyst Basalt formation equivalent
- Poss. igneous complex


NW
Ofjord
Milne Land
C
(~ 4,5 km NE of the profile)
Vikingebugt
Geikie Plateau
Blosseville Kyst
SE
Turner O
TWT (sec)
1.0
0
-2.0
-4.0
3,9 km/s
4,4 km/s
5,5 km/s
5,9 km/s
3,9
4,4
5,7
5,9
6,6/ km/s
6,2
6,6
6,9
7,0 km/s
4,1 km/s
4,4-4,8 km/s
5,2-5,6 km/s
6,3 km/s
7,0 km/s
90320
94400
ARK88-P3
25 Km
Free Air Gravity Anomaly [mGAL]
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
ODP 162 987
OBS point interpolation legend (average interval velocity):
Continental
3,2 - 4,8 km/s
5,0 - 6,5 km/s
4,8 - 5,5 km/s
6,5 - 7,1 km/s
Legend:
Sea level
Stratigraphic layers & features
Faults
Poss. faults
Eocene basalt Fm
Skrænterne Plateau basalts Fm
Rømer Fjord Plateau basalt Fm
Geikie Plateau Plateau basalt Fm
Milne Land Plateau basalt Fm
Magga Dan Lower basalt Fm
Jurassic sediments (Kap Leslie Fm, Charcot Bugt Fm)
Youngest stratigraphic cover undifferentiated
Lower Cretaceous (Hestelv Fm) to Early Paleogene
Upper Jurassic (Hareelv and Raukelv Fm)
Middle Jurassic (Vardekloft and Olympen Fm)
Lower Jurassic (Neill Klinter Fm)
Upper Triassic (Fleming Fjord Fm, Kap Stewart Gp)
Middle Triassic (Gipsdalen Fm)
Lower Triassic (Wordie Creek Fm, Pingo Dal Fm)
Permian (Foldvik Creek Gp)
Devonian (Caledonian Crystalline Basement)
East Greenland - JMMC correlation project
Regional cross-section M
Seismic reflection profile data source:
* BK section 3
Data permission by GEUS; Larsen, L.M. et al. (1989)
Interpretation by:
Ögmundur Erlendsson & Anett Blischke
(Iceland GeoSurvey)
ÍSOR-15-0187-30112017M
ÍSOR


NNW
Jameson Land Basin
Scoresby Sund
Liverpool Land Basin
Kolbeinsey Ridge
SSE
TWT (sec)
ARK88-P3
COB ?
Pre-opening faulted strata (Eocene-Early Oligocene and older)
25 Km
East Greenland - JMMC correlation project
Regional cross-section B
Seismic reflection profile data source:
Data permission by GEUS.
Interpretation by:
Ögmundur Erlendsson & Anett Blischke
(Iceland GeoSurvey)
ÍSOR
Free Air Gravity Anomaly [mGAL]
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
OBS point interpolation legend (average interval velocity):
Continental
Igneous
Legend:
Top Miocene sediments
Poss. base Miocene sediments
Minor unconformity or sediment layer
Stratigraphic layers & features
Poss. igneous dipping reflectors
Faults
Poss. faults
Sills - intrusive complex
Poss. igneous complex
Intrusive & extrusive igneous domain, SDR's
Igneous breakup phase & oceanic crust
Poss. pre-breakup - Blosseville Kyst formations equivalent
High velocity layer - poss. underplating
Quaternary - Pliocene sediments
Poss. Miocene sediments
Poss. Eocene - Oligocene sediments
Cenozoic sediments / Pliocene to Quaternary
Lower Cretaceous (Hestelv Fm) to Early Paleogene
Upper Jurassic (Hareelv and Raukelv Fm)
Middle Jurassic (Vardekloft and Olympen Fm)
Lower Jurassic (Neill Klinter Fm)
Upper Triassic (Fleming Fjord Fm, Kap Stewart Gp)
Middle Triassic (Gipsdalen Fm)
Lower Triassic (Wordie Creek Fm, Pingo Dal Fm)
Permian (Foldvik Creek Gp)
Carboniferous (Traill O Gp)
Devonian (Caledonian Crystalline Basement)


NW
Scoresby Sund
Liverpool Land Basin
SE
D
B
E
ARK88-P3
B
I
90539
ARK88-P3
TWT (sec)
0
-2.0
-4.0
3,9 km/s
4,4 km/s
5,5 km/s
6,35 km/s
7,0 km/s
4,1 km/s
4,4 km/s
4,8 km/s
5,2 km/s
5,6 km/s
6,6 km/s
7,0 km/s
1,9 km/s
3,5 km/s
6,6 km/s
7,0 km/s
Pre-opening faulted strata (Eocene-Early Oligocene and older)
25 Km
East Greenland - JMMC correlation project
Regional cross-section C
Seismic reflection profile data source:
* GGU80-3D
* GGU80-3C
* GGU-11
* GGU80-12
Data permission by GEUS.
Interpretation by:
Ögmundur Erlendsson & Anett Blischke
(Iceland GeoSurvey)
ÍSOR
ÍSOR-15-0187-30112017C
Jameson Land
Liverpool Land
Scoresby Sund
Blosseville Kyst
ODP 162 987
20° W
25° W
70° N
69° N
68° N
0
50 Km
ODP-987
Cross-sections
Refraction profiles
OBS point interpolation legend (average interval velocity):
Continental
< 1,8 km/s
1,8 - 2,5 km/s
2,1 - 3,2 km/s
3,2 - 4,8 km/s
4,8 - 5,5 km/s
5,0 - 6,5 km/s
6,5 - 7,1 km/s
Igneous
3,8 - 5 km/s
Free Air Gravity Anomaly [mGAL]
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
Legend:
Top Miocene sediments
Poss. base Miocene sediments
Minor unconformity or sediment layer
Stratigraphic layers & features
Poss. igneous dipping reflectors
Faults
Poss. faults
Sills - intrusive complex
Intrusive & extrusive igneous domain
Poss. Pre-breakup - Blosseville Kyst formations equivalent
High velocity layer - poss. underplating
Quaternary - Pliocene sediments
Poss. Miocene sediments
Poss. Eocene - Oligocene sediments
Lower Cretaceous (Hestelv Fm) to Early Paleogene
Upper Jurassic (Hareelv and Raukelv Fm)
Middle Jurassic (Vardekloft and Olympen Fm)
Lower Jurassic (Neill Klinter Fm)
Upper Triassic (Fleming Fjord Fm, Kap Stewart Gp)
Middle Triassic (Gipsdalen Fm)
Lower Triassic (Wordie Creek Fm, Pingo Dal Fm)
Permian (Foldvik Creek Gp)
Carboniferous (Traill O Gp)
Devonian (Caledonian Crystalline Basement)


S
J
East of Blosseville Kyst
B
G
C
East of Scoresby Sund
F
East of Jameson Land Basin
A
N
TWT (sec)
1,9 km/s
3,5 km/s
4,7 km/s
5,6 km/s
6,6 km/s
7,0 km/s
East Greenland - JMMC correlation project
Regional cross-section I
Seismic reflection profile data source:
* GGU80-15
* GGU80-16
Data permission by GEUS
Interpretation by:
Anett Blischke & Ögmundur Erlendsson
(Iceland GeoSurvey)
ÍSOR
ÍSOR-15-0187-31112017I
25 Km
Free Air Gravity Anomaly [mGAL]
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
ODP 162
987
Legend:
Top Miocene sediments
Poss. top Caledonian
Minor unconformity or sediment layer
Stratigraphic layers & features
Faults
Poss. faults
Sills - intrusive complex
Poss. igneous dipping reflectors
Youngest stratigraphic cover undifferentiated
Quaternary - Pliocene sediments
Oligocene - Miocene sediments
Poss. post-Caledonian to pre-breakup / Jameson Land Basin equivalent
Poss. igneous complex
Intrusive & extrusive igneous domain
Igneous breakup phase & SDR´s
Poss. pre-breakup - Blosseville Kyst formations equivalent
OBS point interpolation legend (average interval velocity):
Continental
1,8 - 2,5 km/s
5,0 - 6,5 km/s
2,1 - 3,2 km/s
6,5 - 7,1 km/s
Igneous
3,8 - 5 km/s


NW
Milne Land
Fonfjord
Gåseland
Geikie Plateau
Blosseville Kyst
Kap Dalton
Liverpool Land Basin
COB
SE
TWT (sec)
3,9-5,7 km/s
5,9 km/s
6,2 km/s
6,6 km/s
6,9 km/s
94400
OBS-ESP-SB point interpolation legend (average interval velocity): EG & JMMC
Continental
3,2 - 4,8 km/s
5,0 - 6,5 km/s
4,8 - 5,5 km/s
6,5 - 7,1 km/s
25 Km
Igneous or older faulted strata
East Greenland - JMMC correlation project
Regional cross-section N-J
Seismic reflection profile data source:
* GGU82-26
* BK section 4
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Larsen, L.M. et al. (1989)
Interpretation by:
Anett Blischke & Ögmundur Erlendsson
(Iceland GeoSurvey)
ÍSOR
ÍSOR-15-0187-30112017N-J
Free Air Gravity Anomaly [mGAL]
250.00
200.00
150.00
100.00
50.00
0.00
-50.00
-100.00
-150.00
-200.00
ODP 162
987
Legend:
Sea level
Top Miocene sediments
Poss. base Miocene sediments
Poss. top Caledonian
Minor unconformity or sediment layer
Stratigraphic layers & features
Faults
Poss. faults
Sills - intrusive complex
Poss. igneous dipping reflectors
Poss. igneous complex
Igneous breakup phase & SDR´s
Poss. pre-breakup - Blosseville Kyst formations equivalent
Youngest stratigraphic cover undifferentiated
Poss. Miocene sediments
Poss. Eocene - Oligocene sediments
Igtertivâ basalt & volcanoclastic Fm
Eocene basalt Fm
Skrænterne Plateau basalts Fm
Rømer Fjord Plateau basalt Fm
Geikie Plateau Plateau basalt Fm
Milne Land Plateau basalt Fm
Magga Dan Lower basalt Fm
Poss. post-Caledonian to pre-breakup / Jameson Land Basin equivalent
Devonian (Caledonian Crystalline Basement)