The Jan Mayen microcontinent: an update of its architecture, structural development and role during the transition from the Ægir Ridge to the mid-oceanic Kolbeinsey Ridge

A. BLISCHKE1*, C. GAINA2, J. R. HOPPER3, G. PÉRON-PINVIDIC4, B. BRANDSDÓTTIR5, P. GUARNIERI1, Ø. ERLENDSSON6 & K. GUNNARSSON6

1Iceland GeoSurvey, Branch at Akureyri, Rangárvöllum, 602 Akureyri, Iceland
2Centre for Earth Evolution and Dynamics, University of Oslo, Sem Sælænds vei 24, PO Box 1048, Blindern, NO-0316 Oslo, Norway
3Geological Survey of Denmark and Greenland, Øster Voldgade 10, DK 1350 Copenhagen, Denmark
4Geological Survey of Norway, Postboks 6315 Sluppen, Trondheim 7491, Norway
5Institute of Earth Science, Science Institute, University of Iceland, Askja, Sturlugata 7, 101 Reykjavík, Iceland
6Iceland GeoSurvey, Grensásvegi 9, 108 Reykjavík, Iceland
*Correspondence: Anett.Blischke@isor.is

Abstract: We present a revised tectonostratigraphy of the Jan Mayen microcontinent (JMMC) and its southern extent, with the focus on its relationship to the Greenland–Iceland–Faroe Ridge area and the Faroe–Iceland Fracture Zone. The microcontinent’s Cenozoic evolution consists of six main phases corresponding to regional stratigraphic unconformities. Emplacement of Early Eocene plateau basalts at pre-break-up time (56–55 Ma), preceded the continental break-up (55 Ma) and the formation of seawards-dipping reflectors (SDRs) along the eastern and SE flanks of the JMMC. Simultaneously with SDR formation, orthogonal seafloor spreading initiated along the Ægir Ridge (Norway Basin) during the Early Eocene (C24n2r, 53.36 Ma to C22n, 49.3 Ma).

Changes in plate motions at C21n (47.33 Ma) led to oblique seafloor spreading offset by transform faults and uplift along the microcontinent’s southern flank. At C13n (33.2 Ma), spreading rates along the Ægir Ridge started to decrease, first south and then in the north. This was probably complemented by intra-continental extension within the JMMC, as indicated by the opening of the Jan Mayen Basin – a series of small pull-apart basins along the microcontinent’s NW flank. JMMC was completely isolated when the mid-oceanic Kolbeinsey Ridge became fully established and the Ægir Ridge was abandoned between C7 and C6b (24–21.56 Ma).

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The Jan Mayen microcontinent (JMMC) is a structural entity encompassing the Jan Mayen Ridge and the surrounding area, including the Jan Mayen Basin, the Jan Mayen Basin South, the Jan Mayen Trough and the Southern Ridge Complex (SRC) (Fig. 1; Table 1). The JMMC is bordered to the north by the east and west segments of the Jan Mayen Fracture Zone and the volcanic complex of Jan Mayen Island (Svellingen & Pedersen 2003). To the south, it is bordered by the NE coastal shelf of Iceland, to the east by the Norwegian Basin and to the west by the Kolbeinsey Ridge. Early descriptions of the JMMC considered only the Jan Mayen Ridge (Vogt et al. 1970; Talwani et al. 1976a), a steep-flanked bathymetric horst structure with water depths varying between 200 and 2500 m that extends south from Jan Mayen Island. However, based on modern datasets, it is now accepted that the microcontinent is much larger than this and encompasses a number distinct, structurally controlled tectonic features that were formed by a succession of tectonic and volcanic events (e.g. Scott et al. 2005; Gaina et al. 2009; Peron-Pinvidic et al. 2012a, b; Gernigon et al. 2012). In total, the JMMC is 400–450 km long, and varies in width from 100 km in the north to 310 km in the south.
Fig. 1. Overview map (a) of the study area with the location of structural elements identified on potential field data. Structural elements map (b) for the JMMC study with mapped faults, fractures zones and lineaments based on this study and modified after Peron-Pinvidic et al. (2012a) and Gernigon et al. (2015) (for label keys, see Table 1). The background image is shaded bathymetry (IBCAO 3.0: Jakobsson et al. 2012; Amante & Eakins 2009).
Table 1. Explanation of structural element abbreviations and label key, modified after Gunnarsson et al. (1989), Jóhannesson (2011), Hjartarson & Sæmundsson (2014), Hopper et al. (2014) and Magnúsdóttir et al. (2015)

| Abbreviation and label key |
|-----------------------------|
| **General features:**       |
| COB | Continent–ocean boundary | JMMC | Jan Mayen microcontinent | IB | Iceland Basin |
| SDR | Seawards-dipping reflector | BR | Buðli Ridge |
| **Mid-oceanic ridges:**     |
| AER | Ægir mid-oceanic ridge | EFBN | Jan Mayen East Flank Basins North | GIFRC | Faroe–Iceland–Greenland Ridge Complex |
| MR | Mohr’s mid-oceanic ridge | EFBS | Jan Mayen East Flank Basins South | GIR | Greenland–Iceland Ridge |
| KBR | Kolbeinsey mid-oceanic ridge | HC/JMWIP | Hakarena Channel/Jan Mayen West Igneous Province South | HFR | Húnaflói Riff |
| RR | Reykjanes mid-oceanic ridge | JMT/HT | Jan Mayen Trough/Herssund Trough |
| JMI | Jan Mayen Island System | JMB | Jan Mayen Basin |
| **Transfer systems and fracture zones:** |
| EJMFZ | East Jan Mayen Fracture Zone | JMRN | Jan Mayen Ridge North |
| IFFZ | Iceland–Faroe Fracture Zone | Lyr | Lyngvi Ridge |
| MIRFTS | Mid-Iceland Rift Transfer System | SFB/JMBS | Sørlahryggur Flank Basin/Jan Mayen Basin South | MØMA | Møre Marginal High |
| SISZ | South Iceland Seismic Zone | SHR | Sørlahryggur Ridge | MØMB | Møre Basin |
| TFZ | Tjörnes Fracture Zone | WIPN | Jan Mayen West Igneous Province North | VØMA | Vøring Marginal High |
| WJMFZ | West Jan Mayen Fracture Zone | SRC | Jan Mayen microcontinent–Southern Ridge Complex (SRC) – continental crust |
| **Central East Greenland Margin:** |
| BK | Blosseville Kyst | FR | Fáfnir Ridge | FYR | Fugloy Ridge |
| JMLB | Jameson Land Basin | OR | Otur Ridge | FP | Faroe Platform |
| KD | Kap Dalton outcrop site | SRCTC | Jan Mayen microcontinent–Southern Ridge Complex – transitional crust | FSB | Faroe–Shetland Basin |
| KB | Kap Brewster outcrop site | DR | Drevik Ridge |
| KgB | Kangerlussuaq Basin | LR | Langabrunn Ridge |
| LVPL | Liverpool Land High | ORS | Otur Ridge southern spur | |
| ML Fm | Milne Land Formation outcrop site | TR | Treitel Ridge |
| SD | Scoresby Sund | |
| TØ | Trail Ø | NIS | North Iceland Shelf |
| IP | Iceland Plateau |
| IPR | Iceland Plateau Rift | | |
The microcontinent is bounded on all sides by oceanic crust, although its southern limit remains poorly constrained. This is due, in part, to sparse data coverage south of 68° N (Fig. 2), but also to the occurrence of numerous intrusive and extrusive volcanic rocks that limit seismic imaging of the underlying features. Previous interpretations of the continent–ocean transition (COT) along the JMMC margins were mainly based on magnetic and/or gravity data (e.g. Vogt et al. 1970; Talwani & Eldholm 1977; Åkermoen 1989; Doré et al. 1999; Lundin & Doré 2002; Rey et al. 2003; Gaina et al. 2009; Gernigon et al. 2012) and seismic reflection data (Gunnarsson et al. 1989; Scott et al. 2005; Peron-Pinvidic et al. 2012a, b). Breivik et al. (2012) considered crustal velocity information from wide-angle data with potential field data to derive the location of the COT.

The purpose of this paper is to establish a detailed tectonic and stratigraphic framework for the JMMC based on a new regional database of geological and geophysical data. The analysis includes interpretation of new seismic reflection data, as well as recent geological findings, from on- and offshore central East Greenland (e.g. Larsen et al. 2013; Guarnieri 2015). This study has been facilitated by the interpretation of recently acquired commercial seismic reflection data that were made available for the project, together with older seismic reflection and refraction data collected offshore Iceland since the early 1970s (Fig. 2). Revised 39Ar–40Ar dates of East Greenland basalt samples (e.g. Tegner et al. 2008; Larsen et al. 2013), and an improved coverage of magnetic data and interpretations (CAMP-GM: Gaina et al. 2011; Gernigon et al. 2015), are also considered. Pre- and post-break-up sedimentary strata and igneous complexes, together with volcanostratigraphic seismic characterization, have been revisited, together with a reassessment of the seawards-dipping reflector sequences (SDRs), igneous complexes, sill and dyke intrusions, and hydrothermal vent complexes.

The JMMC margins are compared to the conjugate margins: the central East Greenland margin and the Møre margin off Norway (Blystad et al. 1995). The western JMMC margin is linked to central East Greenland, where the Palaeozoic–Mesozoic Jameson Land Basin is located (JMLB: Henriksen 2008) (Fig. 1). The segmentation and extent of the southern area of the JMMC and its link to the oblique opening of the Norway Basin are also considered. Finally, the question of how the igneous
Fig. 2. (b) seabed sampling sites (NEA, National Energy Authority, Iceland; NPD, Norwegian Petroleum Directorate (2013); Spectrum ASA; TGS; SFS seafloor samples; VBPR, Volcanic Basin Petroleum Research AS).
events along the southern half of the JMMC are related to the Blosseville Kyst, the Iceland–Faroe Fracture Zone system that forms the NE limit of the Greenland–Iceland–Faroe Ridge Complex (GIFRC) (Árting 2014), and the Iceland Plateau (Fig. 1; Table 1) is addressed. The new interpretation has been used to model the detailed kinematics of the JMMC from pre-break-up time to the present day.

Geological setting of the central NE Atlantic

Several distinct rifting episodes and the subsequent break-up of the supercontinent Pangea led to the formation of a series of segmented rifted margins along the North Atlantic Ocean (Ziegler 1988). Extensional episodes are recognized from Devonian and Carboniferous times, initiated by the collapse of the Caledonian mountain belt (e.g. Andersen & Jamtveit 1990). Devonian onshore rift basins along East Greenland (Henriksen 2008) and SW Norway (Osmundsen & Andersen 1994, 2001; Osmundsen et al. 2002) are well documented, including their complex relationship to large-scale transtensional tectonics (Osmundsen & Andersen 2001). These basins are interpreted to extend in the central and northern part of the NE Atlantic during the Carboniferous, and were not affected by the Variscan Orogeny (Hopper et al. 2014), which occurred at the same time and influenced the NE and SE regions of the NE Atlantic, the North Sea and northern Europe (Pharaoh et al. 2010). During the Permian and Triassic periods, the entire NE Atlantic region was subjected to extension (e.g. Doré et al. 1999; Brekke 2000). At that time, a first rifting phase led to minor rotational block faulting and westwards tilted half-graben along East Greenland (Seidler 2000), forming terrestrial to shallow marine basins that discordantly covered the old Devonian–Carboniferous basin (Stemmerik 2000). The entire NE Atlantic system went through two major rifting phases during the Late Jurassic and a major Cretaceous rifting phase from the late Early Cretaceous (Aptian–Albian) to Late Cretaceous (Lundin & Doré 1997, 2011; Stoker et al. 2016), leading to significant crustal thinning in the central parts of the corridor and forming deep basins. The Cretaceous rifting phase may have included a hyperextension (Peron-Pinvidic et al. 2013), resulting in exhumation of deep crust and possibly mantle, as suggested by Osmundsen et al. (2002) or Osmundsen & Ebbing (2008).

During Late Paleocene and pre-break-up time, early volcanism associated with the North Atlantic igneous province occurred. Regionally extensive landwards flows consisting of subaerial and submarine lava flows onto adjacent elevated margins were emplaced during this time (Horni et al. 2016). Infilling of pre-existing basin areas formed escarpments and hyaloclastite deltas (Planke et al. 2000; Horni et al. 2016). Intense magmatism occurred at this time just SW of the JMMC, close to the Kangerlussuaq Basin and the southern extent of the Blosseville Kyst (e.g. Tegner et al. 2008; Brooks 2011). Magmatic rocks formed during the Early Eocene (56 – 55 Ma), in association with final rupture of the lithosphere and the onset of seafloor spreading of the NE Atlantic (e.g. Talwani & Eldholm 1977). The resulting North Atlantic continental margins contain SDR sequences observed on seismic reflection data (Hinz 1981). The break-up process was also accompanied by the emplacement of sill and dyke complexes into the margin flank areas. Oceanic crust was first formed in the Norwegian Basin at the end of chron C25 or the beginning of C24r (c. 55 Ma) forming the Ægir mid-oceanic ridge (e.g. Talwani & Eldholm 1977; Gaiña et al. 2009).

The JMMC structure and stratigraphy observed between its eastern and western margins is profoundly segmented. A first-order boundary within the microcontinent is between the Jan Mayen Ridge and the SRC. Updated datasets suggest that the JMMC internal segmentation is probably related to the complex multistage seafloor spreading processes on both sides of the microcontinent.

Published plate tectonic reconstructions indicate a westwards migration of the plate boundary from the Norwegian Basin towards the Kolbeinsey mid-oceanic ridge (Nunns 1983a, b; Nunns et al. 1983; Lundin & Doré 2005; Doré et al. 2008; Gaiña et al. 2009), suggesting a gradual separation of the microcontinent from East Greenland during the Early Miocene (Talwani & Eldholm 1977; Gunnarsen et al. 1989). Larsen et al. (2013) suggested that early rifting between the JMMC and East Greenland coast may have occurred from 49 to 44 Ma, with a direction semi-parallel to the Ægir mid-oceanic ridge system. This event generated increased igneous activity and structural deformation along the NE extent of the Blosseville Kyst (Fig. 1).
Fig. 4. Type section showing sedimentary basins below the Cenozoic succession and the seismic refraction velocity interval interpretation intersection (a) (Table 3). The SDR sequence (purple) is interpreted to overlie a thick basalt sequence (blue) that is likely to be equivalent to the plateau basalts exposed on East Greenland. The east–west line is courtesy of Spectrum ASA, and the north–south line is courtesy of NPD.
Data overview and methods

Geophysical datasets consist of magnetic and gravity anomaly compilations (Haase & Ebbing 2014; Nasuti & Olesen 2014) and from seafloor samples retrieved by the Deep Sea Drilling Program (DSDP) and Ocean Drilling Program (ODP) boreholes (legs 38, 151 and 162) (Eldholm & Windish 1974; Talwani & Udintsev 1976; Eldholm et al. 1987, 1989) and from seismic reflection data (Johansen et al. 1988; Olafsson & Gunnarsson 1989; Kodaira et al. 1998; Brandsdóttir et al. 2015). Eight shallow Ocean Drilling Program (ODP) and Deep Sea Drilling Program (DSDP) boreholes (legs 38, 346, 348, 349) and from seafloor samples retrieved by the DSDP Leg 38 (sites 346, 348, 349 and 350) and from seafloor samples retrieved by the NPD in 2011, 2012 and 2013 (Fig. 2b; Table 2) provide key constraints for tying it to the seismic reflection data along the central part of the JMMC (Fig. 3). This permits mapping of unconformities and post-basalt stratigraphy across the JMMC (Figs 4, 5 & 6). Some uncertainties in local stratigraphic correlations still exist, notably along the collapsed western flank of the JMMC and between the dislocated southern ridges. The sub-basalt sequences are only visible in the central area of the JMMC and around DSDP Leg 38 site 349. Seismic reflection data in vicinity of this drill site has been interpreted as possible Mesozoic and Palaeozoic strata based on comparisons to the Jameson Land Basin (Blischke et al. 2014a).

In addition to the well ties, onshore and offshore stratigraphic relationships along the western conjugate margin (Blosseville Kyst in East Greenland) provide information on the basalt stratigraphy that can be used for interpreting volcanic horizons on the seismic reflection dataset. This will be discussed in detail in the following section on ‘Stratigraphic setting’.

Base ment tie on reflection data using velocity interpretations

Significant uncertainty surrounds the full extent of the JMMC, primarily to the south but also to the east and west. Of particular focus here is the southern extent of the JMMC towards the Icelandand Shelf (Fig. 1). Talwani & Eldholm (1977) and Brandsdóttir et al. (2015) suggested that the JMMC terminates south of the SRC (Fig. 5). However, other studies propose severely stretched and fragmented continental crust and/or exhumed altered mantle for the southernmost part of the JMMC (Gaina et al. 2009; Breivik et al. 2012; Peron-Pinvidic et al. 2012a; Gernigon et al. 2015; Torsvik et al. 2015). Sparse data in combination with the inherent non-uniqueness of geophysical modelling and interpretation makes this particularly challenging. To better constrain this region, the 2D seismic reflection dataset was analysed in combination with the available seismic refraction data and crustal velocity models, as well as available well control along the ridges. This enabled an interpretation of the nature of acoustic basement and different crustal type domains (Figs 4 & 5).

Seismic refraction velocity model. Three ocean-bottom seismometer (OBS) experiments have been carried out for the larger JMMC area (Fig. 2; Table 2). The JMKR-95 survey included east–west- and SW–NE- orientated profiles (Kodaira et al. 1998), with profile JMKR95-L4 crossing the Jan Mayen Ridge just south of DSDP borehole...
Leg 38 site 349. Line 8 of the OBS2000 survey lies 30 km south of that same borehole, crossing the SW end of the JMMC and the NW end of the EJMFZ (Mjelde et al. 2002, 2007; Breivik et al. 2012). The southern extent of the JMMC onto the Iceland Plateau was investigated as part of the KRISE survey in 2000 (Brandsdóttir et al. 2015) (L7 on Fig. 2b). A third survey in 2006 focused on the northern region of the JMMC, consisting of a NW–SE (L1) and a north–south profile (L2) across Jan Mayen Island (Kandilarov et al. 2012). Refraction data from all these surveys were used to constrain the southern extent of the JMMC.

Sonobuoys deployed during a 1985 seismic reflection survey provide velocity information for the upper layers of the microcontinent (Olafsson & Gunnarsson 1989). Based on these, we were able to better constrain the igneous crust of the JMMC, especially the area within the SDR sequences. Each sonobuoy location was assigned to a velocity-profile domain and incorporated into the volcanic facies map (Table 2; Fig. 5). Distinct velocity-profile domains are defined: layered, layered-intra-basalt, layered-oceanic, oceanic basement and basement of the microcontinent. The layered domain corresponds to velocity layers within the range 1.7–3.2 km s\(^{-1}\), which are interpreted as post-breakup sediments; velocity layers between 3.9 and 5.5 km s\(^{-1}\) across the crest area of the JMMC, and distinct velocity interval breaks, are, however, most likely to correspond to pre-break-up sedimentary sections that correlate directly to seismic refraction data. The layered-intra-basalt domain corresponds to 270–470 m-thick basaltic layers (4–5 km s\(^{-1}\)) within the post-break-up sedimentary section (1.8–2.5 km s\(^{-1}\)) of the Jan Mayen Basin. A distinct velocity domain within the SDR area of the eastern flank is termed the layered-oceanic domain. The oceanic basement domain is characterized by thin low-velocity sediment layers (<2.5 km s\(^{-1}\)) on top of a high-velocity layer (4–5 km s\(^{-1}\)) that gradually and smoothly increases towards the base (5–6 km s\(^{-1}\)). These oceanic basement velocity domains were also compared to seismic refraction data interpretations (Breivik et al. 2012). One velocity profile at the crest of the JMMC is inferred to represent continental crust, as an abrupt velocity layer increase to 5.5 km s\(^{-1}\) was recorded below the thin post-break-up sediment cover (1.9–2.2 km s\(^{-1}\)).

Seismic velocities derived from wide-angle data were used as a basis for the depth and stratigraphic thickness estimations across the JMMC (Figs 4, 5, 6 & 7; Table 3). Relatively high-velocity values (4.4–5.6 km s\(^{-1}\)) have been assigned to the deeper layers above the acoustic basement where reflectivity is observed and interpreted as older pre-Cenozoic sedimentary sequences. This is similar to what is observed along the conjugate Norwegian Shelf, where the Mesozoic–Palaeozoic sections are usually interpreted to range between 4 and 5.5 km s\(^{-1}\) (Mjelde et al. 2008, 2009).

### Stratigraphic setting

The following subsections summarize the interpretations of the Palaeozoic–Cenozoic succession over the JMMC. The total thickness of interpreted sediments is variable across the area and may reach up to 18 km along the eastern flank of the JMMC. The microcontinent contains several major unconformities and related structures that are linked to the complex tectonomagmatic processes on both sides.

A type section was constructed to provide a framework for mapping unconformity horizons and stratigraphic geometries along the JMMC (Figs 4 & 8). The section is based on bathymetric, borehole and seismic refraction data, combined with a dense grid of seismic reflection data. The section is orientated north–south along the strike of the Lyngvi Ridge, a central and stable block of the JMMC (Fig. 4, LYR in Fig. 8; Table 1).

The presence of Palaeogene volcanic rocks on the JMMC makes it difficult to interpret older strata below on seismic sections. Some local uncertainties in stratigraphic correlations still exist, notably along the microcontinent’s collapsed western flank and between the dislocated southern ridges. Sub-basalt sequences are only visible within the central area of the microcontinent in the vicinity of DSDP Leg 38 site 349, where seismic reflection and refraction data have been compared to the Mesozoic and Palaeozoic strata of the Jameson Land Basin area of the East Greenland margin.

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**Fig. 5.** Volcanic facies map based on the interpretation of seismic reflection and refraction data and information from wells, in addition to free-air gravity anomaly data (DTU2010: Andersen 2010). Refraction information includes velocity profile interpretations of wide-angle data and crustal-type interpretations (modified after Funck et al. 2014), as well as sonobuoy velocity profile interpretations (Olafsson & Gunnarsson 1989). Magnetic anomalies C6b and C24n2r are from Gernigon et al. (2015), showing the onset of oceanic seafloor spreading east and west of the JMMC. The extent of landwards flows labelled ‘subaerial possible’ refers to the pre-break-up plateau basalt extent over the area. The areas labelled ‘submarine’ areas are interpreted primarily by mapping the F-reflector (Gunnarsson et al. 1989) and are inferred as being related to the second break-up phase during Late Oligocene.
| A | Year       | Survey ID        | Survey lead | Country | Platform name          | Data repository | Data types                                                                 |
|---|------------|------------------|-------------|---------|------------------------|----------------|-----------------------------------------------------------------------------|
| X | 1957       | NAVO V2304/V2703 | USA         | Aeromagnetic | NGDC                   | Bathymetry; magnetics; gravity; 2D multichannel reflection seismic (2D MCS) |
| X | 1961–1971  | V2304/V2703      | USA         | Aeromagnetic | Explora                | Boreholes       |
| X | 1961–1971  | V2703/V2803      | L-DGO       | USA      | Vema/Conrad            |                |
| X | 1973       | V3010            | L-DGO       | Norway   | Vema/Conrad            |                |
| X | 1974       | DSDP Leg 38      | DSDP        | France   | Jean Charcot           | Ifermer         |
| X | 1975       | CEPAN-75         | CNEXO       | France   | Jean Charcot           | Ifermer         |
| X | 1975       | CEPAN-75         | CNEXO       | France   | Jean Charcot           | Ifermer         |
| X | 1975       | CEPAN-75         | CNEXO       | France   | Jean Charcot           | Ifermer         |
| X | 1975       | BGR-75           | BGR         | Norway   | Longva                 | BGR             |
| X | 1976       | BGR-76           | BGR         | Germany  | Explora                | BGR             |
| X | 1976       | CGG-76           | NPD/CGG     | Norway   |                       | 2D MCS          |
| X | 1977       | IOS-77           | UD/IOS      | England  | Shackleton             | NGDC             |
| X | 1978       | RC2114           | L-DGO       | USA      | Robert Conrad          | MGDS            |
| X | 1978       | WGC-78           | USA         | Norway   | Karen Bravo            | Western-Geco    |
| X | 1979       | J-79             | NPD         | Norway   | GECO alpha             | NPD             |
| X | 1980       | PAH/SGC          | USSR        | Academichurchotov |                       | Seafloor sampling |
| X | 1983       | NGT33/RC2412     | L-DGO/BGR   | USA/Germany | Prospekt/Conrad        | 2D MCS and single-channel reflection seismic (2D SCS) |
| X | 1983       | RC2412           | L-DEO       | Norway   | Robert D. Conrad       | 2D MCS          |
| X | 1984       | Artik II/5       | UHH         | Germany  | Polarstern             | NPD             |
| X | 1985       | JM-85            | NPD/NEA     | Norway   | Malene Østervold       | Bathymetry; magnetics; free air gravity; Bouguer gravity; magnetic; 2D MCS |
| X | 1985       | ODPE Leg 104     | ODP         | Norway   | JOIDES Resolution      | 2D MCS          |
| X | 1986       | UiO-86           | UiO         | Norway   | Håkon Mosby            | NPD             |
| X | 1987       | ESP               | IFP         | France   |                       | ESP; velocity; gravity |
| X | 1988       | JM-88            | NPD/NEA     | Norway   | Håkon Mosby            | 2D MCS          |
| X | 2000       | KRISE 2000       | Uib         | Norway   | Håkon Mosby            | 2D MCS          |
| X | 2001       | IS-MJR-01         | InSeis      | Norway   | Polar Princess         | 2D MCS          |
| X | 2002       | ICE-02           | TGS-Nopec   | Iceland  | Zephyr I               | 2D MCS          |
| X | 2003       | EW0307           | L-DEO       | USA      | Maurice Ewing          | 2D MCS; gravity; bathymetry cores |
| X | 2005       | JAS-05           | NGU/NPD     | Norway   | Pipa Navajo            | 2D MCS; gravity; magnetics |
| X | 2006       | OBS JM-06        | Uib/Geornar | Norway/Germany | G. O. SARS            | 2D MCS          |
| X | 2008       | WL-MJR-08        | Wavefield InSeis | Norway   | Malene Østervold       | 2D MCS          |
| X | 2008       | AS-14-2008       | HAFRO/NEA   | Iceland  | Arni Fridriksson       | Multibeam       |
| X | 2009       | JM-85-88         | Spectrum    | Norway   | Re-processing          | 2D MCS          |
| X | 2009       | SAR-ICE-2009     | NEA         | Norway   | ENVISAT satellite      | Satellite Synthetic Aperture Radar (SAR) |
| X | 2010       | AII-2010         | HAFRO/NEA/NPD | Iceland  | Arni Fridriksson       | Multibeam; seafloor sampling |
| X | 2010       | B11-2008         | HAFRO/NEA   | Iceland  | Arni Fridriksson       | Bentic survey   |
| X | 2011       | NPD-11           | NPD/Uib     | Norway   | Harrier Explorer       | 2D MCS; seafloor sampling |
| X | 2011       | JMRS11           | VPBR/TGS    | Norway   | TGS                    | Seafloor sampling |
| X | 2012       | NPD-12           | NPD/Uib     | Norway   | Nordic Explorer        | 2D MCS; seafloor sampling |
| X | 2012       | JAS-12           | NGU/NPD/NEA | Norway   | Piper Chieftain        | Aeromagnetic    |
The Palaeozoic

Sub-basalt structures and inferred velocities along the JMMC (Fig. 4) are comparable to the Upper Palaeozoic–Lower Mesozoic rocks of the Jameson Land Basin and Traill Ø (Fig. 1a) areas onshore East Greenland, as well as of the Møre and Vøring basins offshore Norway (e.g. Surlyk et al. 1973; Surlyk & Nøe-Nygård 2001; Brekke et al. 1999; Osmundsen et al. 2002; Surlyk 2003; Henriksen 2008; Faleide et al. 2010). The inferred Palaeozoic section on the JMMC is thinner and more condensed in comparison to the East Greenland and Møre–mid-Norway areas. It can be inferred that the JMMC was at that time in a structurally higher position, corresponding to a shallow platform domain between the adjacent Jameson Land and Møre basins. Small sub-basins structures below the Cenozoic section are potentially linked to the region south of the Jameson Land Basin (Fig. 4). It remains uncertain whether older Palaeozoic, in particular Devonian and/or Carboniferous rocks similar to those that crop out along the NW edge of the Jameson Land Basin, underlie the northernmost part of the JMMC.

The Mesozoic

The interpreted Mesozoic–Paleocene interval of the JMMC has a velocity range of between 3.9 and 5.0 km s⁻¹ (Table 3) (Kodaira et al. 1998; Kandilarov et al. 2012). These are similar to velocities interpreted for Mesozoic sequences in the Møre Basin, where pre-Cretaceous–Lower Cretaceous sections show a range of values between 3.85 and 5.35 km s⁻¹ (Mjelde et al. 2008, 2009). Since subunits within the Mesozoic layers cannot be identified, an average value of 4.4 km s⁻¹ is used for a time-depth conversion.

Although controversial, a seafloor sample has been interpreted to contain evidence of a Jurassic oil seep (Polteau et al. 2012) (NPD 2012) (Fig. 2b). Waxy bitumen samples from Cenozoic basalts on the Faroe Islands and the Isle of Skye in Scotland have also been associated with mature source rocks (Laier et al. 1997; Laier & Nytoft 2004). The Jameson Land Basin contains deltaic and lacustrine facies of Early Jurassic age that became increasingly influenced by marine processes during Mid–Late Jurassic, including deposits of a black organic-rich mudstone of the Hareelv Formation (Surlyk 2003), which is consistent with the regional setting of the NE Atlantic (Stoker et al. 2016). Thus, a trend towards a Mesozoic marine setting in the JMMC area can be inferred from regional structural observations. That would suggest a phase of southwards and eastwards crustal thinning during the Jurassic, which, in turn, may have resulted in a general subsidence of the region and the development of marine conditions (Peron-Pinvidic et al. 2012b).

The presence of a thin, Lower Cretaceous sedimentary succession across the JMMC seems probable according to results from a structural and stratigraphic comparison with the conjugate margins and the interpretation of the local seismic refraction data (Figs 4–6). During the Cretaceous, regional extension occurred throughout much of the NE Atlantic region (Stoker et al. 2016). Thick, deep-marine, sag-type basins formed during this process, including the Danmarkshavn and Thetis basins (Lundin & Doré 1997; Doré et al. 1999; Lundin & Doré 2011), the Traill Ø–Hold with Hope area of NE Greenland, and the Norwegian Vøring and Møre basins (Brekke 2000; Osmundsen et al. 2002; Faleide et al. 2010, 2010; Peron-Pinvidic et al. 2012b). However, all of the above-mentioned basins had their main extensional to hyperextensional phase during the Mesozoic, whereas the Jameson Land Basin had a main opening phase and faulting during the Palaeozoic (Henriksen 2008). Such hyperextension cannot be seen along central Eastern Greenland or the JMMC area, and possibly formed the western shelf margin of the Vøring basin.

The Cenozoic

Cenozoic sedimentary succession. The pre-break-up Cenozoic sedimentary succession was inferred by comparing onshore geological data from East Greenland to offshore areas of Scoresby Sund and Blosseville Kyst and the seismic reflection data of the JMMC. The post-break-up successions are derived from borehole data and seismic reflection data across the microcontinent, tied to the main unconformity horizons of the post-break-up succession (Figs 3, 4, 6 & 7). Mapping thickness intervals of the Cenozoic sequence along the ridge flanks and in-between the ridge segments enabled us to indicate areas of sediment deposition due to subsidence. Depositional settings for the Cenozoic strata are constrained by borehole data interpretations and onshore analogue comparisons.

Pre-break-up Cenozoic strata. In situ Paleocene dinoflagellate cyst assemblages were found in the uppermost pre-volcanic/pre-break-up sequences at the Blosseville Kyst area (Nøhr-Hansen & Piasecki 2002) (Figs 4, 6 & 7), which is the closest conjugate segment to the JMMC. This sequence corresponds to the upper marine sections of the Ryberg Formation in the Kangerlussaqu Basin (KB on Fig. 1a) (Soper et al. 1976; Nøhr-Hansen et al. 2002), representing a regional marker that most likely also covered the JMMC area in the Paleocene. Dark mudstones of the Kap Brewster site (KB on Fig. 1a)
contain reworked Cretaceous dinoflagellate cysts, indicating an age range between the late Danian to early Selandian (Nør-Hansen et al. 2002). Analogue areas for Lower Paleocene deposits include the Hold with Hope and Wollaston Foreland formations in Northeast Greenland (Larsen et al. 1999; Nør-Hansen 2003, 2012), and the Voring and Møre basins offshore Norway (Brekke 2000; Faleide et al. 2010).

**Post-break-up Cenozoic strata.** The post-break-up Cenozoic sedimentary section is thickest along the microcontinent’s eastern flank (Figs 5, 6 & 8), but has been eroded to a large extent across the highest sections of the ridges (e.g. the Lyngvi Ridge). Based on data from DSDP Leg 38 boreholes located on the northern Jan Mayen Ridge (Talwani et al. 1976b; Talwani & Eldholm 1977), the Cenozoic succession has been subdivided into a Lower Paleocene–Lower Oligocene unit, unconformably overlain by an Upper Oligocene–Quaternary unit (Figs 6 & 7).

The stratigraphic thickness of post-break-up sediments varies from 0 to 4200 m along the eastern flank of the JMMC (Fig. 8). The Cenozoic units consist predominantly of mudstone, whereas the Lower Paleocene–Lower Oligocene unit includes thin sand and muddy sand beds, which might have been deposited by turbidity currents on the JMMC shelf edge (Figs 3 & 7). The Upper Oligocene–Miocene units probably represent erosional sediments from the JMMC highs, redeposited into the surrounding lows. This can be seen around the highs of the SRC and its small sub-basins and in the borehole records (Talwani et al. 1976b; Talwani & Eldholm 1977). Above the Mid-Upper Miocene hiatus, Pliocene–Pleistocene deep-marine sediments are present across the microcontinent (Fig. 3). These youngest sediments are cut by deep-sea current features, causing localized erosion along the ridge segments, and were affected by gravitational slumping and faulting from the steep ridge flanks.

During the Pleistocene, several glacial events removed about 1 km of the Iceland Plateau basalts (Walker 1964) and much of the JMMC. The eroded sediments were likely to have been deposited into newly formed basins within the Iceland Plateau (Figs 5 & 9b), between the Iceland shelf and the SRC.

The Cenozoic igneous sequence

The Lower Palaeogene volcanic succession probably includes two major units: the pre-break-up plateau basalt sequence; and the break-up SDR sequence along the eastern flank of the JMMC (Planke et al. 2000) (Figs 4, 6 & 7). The southern and central part of the JMMC appear to be covered by Early Eocene plateau basalts, with a layered character of distinct lava-flow events interpreted as landwards flows (Planke et al. 2000). Apparent erosional effects at the top of these formations are probably filled with Lower Eocene sediments.

The pre-break-up igneous formations. The plateau basalt equivalent section on the JMMC is subdivided into two major units and appears to increase in thickness from north to south towards the SRC (Fig. 7c). A possible base of the plateau basalts was tied to the velocity model from refraction data (Kodaira et al. 1998). From this, an igneous stratigraphic thickness of approximately 1100 m is estimated across the crest of the JMMC. There are indications that the plateau basalt sequence continues to be downfaulted towards the south (Fig. 4), implying the formation of a topographical low south of the SRC (Figs 10 & 11a). This would possibly correlate with the very thick basalt sections in the Kangerlussuaq Basin, at the southernmost extent of the Blosseville Kyst, and the NW area of the Faroe Islands Platform (FP on Fig. 1a). In these regions, the main pre-break-up to break-up phase plateau basalts are well exposed onshore. The succession is estimated to be more than 6 km thick towards the southern extent of the Blosseville Kyst and the Kangerlussuaq area (Brooks 2011), but is progressively younger and dramatically thinner to the north in Scoresby Sund and Jameson Land Basin (Larsen et al. 1999, 2014). Based on age dating of exposed dykes that have similar ages to the plateau basalts (Larsen et al. 2014), it is inferred that the plateau basalts covered the Jameson Land Basin but were subsequently eroded away. The thickness of the eroded section is estimated at 2–3 km (Mathiesen et al. 2000).

The break-up igneous formations. During break-up (54–55 Ma), a magma-rich margin formed along the eastern flank of the JMMC with thick sequences of onlapping lava flows forming SDRs (Figs 4, 5 & 7).

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**Fig. 6.** JMMC tectonostratigraphic type sections that are based on seismic reflection and refraction data interpretations, tied to shallow borehole data only. 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. (2014b). 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 break-up (d) appears as a sharp boundary along the western margin of the microcontinent.
Fig. 7. Tectonostratigraphic chart of the JMMC region based on borehole data, seismic interpretation and analogue studies (Talwani & Eldholm 1977; Åkermoen 1989; Gunnarsson et al. 1989; Rey et al. 2003; Harðarsson et al. 2008; A. BLISCHKE ET AL. 314).
These SDRs are considered to be subaerial lava flows onlapping higher terranes, stacking onto previous flows as rifting and seafloor spreading initiated along the margins (Hinz 1981; Mutter et al. 1982; Planke et al. 2000; Berndt et al. 2001). The SDRs along the eastern flank onlap westwards onto the crest of the main ridge and the SRC: they are up to 4–6 km thick at the NE end of the JMMC, thinning from north to south.

The Mid-Eocene–Neogene volcanostratigraphy

The Eocene sedimentary succession is intruded by many sills and dykes, especially along the eastern and SE flanks, coinciding with the Early–Middle Eocene time (49–44 Ma). During this period, igneous activity affected the entire southern extent of the microcontinent. The occurrence of a series of ridge jumps from east to west across the Iceland Plateau have been suggested by several authors (e.g. Gaina et al. 2009; Brandsdóttir et al. 2015) (Figs 5 & 9). The youngest substantial igneous event on the JMMC is expressed as a flat-lying, opaque reflection in seismic data, the so-called ‘F-Reflector’ (Gunnarsson et al. 1989), which covers most of the northern Jan Mayen Basin, the western margin of the JMMC (Fig. 6b, c) and much of the Jan Mayen Trough (Figs 5 & 6d). This reflection is believed to correspond to regionally extensive composite sheets of flat-lying lava flows and intrusive rocks that covered the underlying structures in very shallow and unconsolidated wet sediment possibly during the Late Oligocene (28–22 Ma) (Gunnarsson et al. 1989). This corresponds to the time of plate boundary relocation from the Ægir mid-oceanic ridge to the Kolbeinsey mid-oceanic ridge (Gaina et al. 2009). No SDR type formations are observed along the JMMC western margin. Since the complete separation from the East Greenland margin, only the northern extent of the JMMC has been affected by volcanic activity, which is related to the present-day Jan Mayen Island volcanic system.

Kinematic reconstruction of the central NE Atlantic region

A series of detailed kinematic reconstructions for the JMMC tectonic blocks and surrounding areas is presented in Figures 10 and 11. Plate reconstruction parameters for the relative motion of the JMMC and conjugate margins were calculated using an interactive fitting method using GPlates (http://www.gplates.org; Boyden et al. 2011; see also Gaina et al. this volume, in review). Rotation parameters for Greenland relative to Eurasia are based on Gaina et al. (this volume, in review). The geographical extent of the individual JMMC tectonic blocks was guided by the interpretation of Peron-Pinvidic et al. (2012a) and Gernigon et al. (2015).

The model includes six stages: (1) the pre-break-up stage ending at 56–55 Ma; (2) the break-up stage at chron C24n2r (53.36 Ma) equivalent to chron C24B of Gunnarsson et al. (1989), associated with the formation of a wide volcanic margin; (3) an early intra-JMMC rifting phase around C22n (49.3 Ma); (4) a fully established intra-JMMC rift phase and the beginning of rift transfer from east to west around C21n (47.33 Ma); (5) westwards rift transfer and the initial western JMMC margin break-up phase around C13n (33.1 Ma); and (6) the complete isolation of JMMC by establishing the Kolbeinsey mid-oceanic ridge around C6b (21.56 Ma).

Structural elements included in plate tectonic reconstructions

We combined magnetic and gravity anomaly data interpretations with other structural, geological and geophysical data for defining several distinct structural elements that constitute independent...
| 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 the JMMC | Estimated stratigraphic thickness OBS model Figure 4 intersection |
|--------------------------|----------------------------------|-----------------------------------|-----------------------------------------------|-----------------------------------------------|---------------------------------------------------------------|
| 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 | Early Oligocene                  | 2.2–3.2                           | 2.0                                           | 2.3                                          | 0–1.05                                                       | 0.09                                                          |
| Late Eocene               |                                   |                                   |                                               |                                               | 0–2.05                                                       | 0.29                                                          |
| Mid-Eocene                |                                   |                                   |                                               |                                               |                                                               |                                                               |
| Basalts–Early Eocene      | Basalt (SDR)                      | 4.0–5.0                           | 3.2–4.1                                       | 4.0                                          | 0–6                                                          | 1.48                                                          |
| Early–Mid Paleocene       | Possible Lower                    | 3.9–4.7                           | 3.9–5.0                                       | 4.4                                          | 0–4.5                                                       | 2.25                                                          |
| Possible Mesozoic         | Paleocene–Mesozoic                | 5.0–5.3                           | 5.0–5.5                                       | 5.2                                          | 0–4                                                          | 3.82                                                          |
| Possible Palaeozoic       | Possible Palaeozoic               |                                   |                                               |                                               |                                                               |                                                               |

*Estimated stratigraphic and igneous section thickness above Caledonian basement:*

- Possible Caledonian Basement: Continental upper crust 5.5–6.7 5.5–6.5 5.6 0–15 2.79
- Continental lower crust – sub-basalt: Continental lower crust 6.7–6.8 6.5–7.2 6.8 0–10 2.96

*Estimated stratigraphic, igneous section, and crustal stratigraphic thickness:*

- 14.4

Displayed are the possible stratigraphic thickness ranges across the highly variable mapped JMMC, and one specific stratigraphic thickness profile for the reflection seismic data intersection with the OBS model by Kodaira et al. (1998).
kinematic model blocks (isochrons and rotation model, see Gaining et al. this volume, in review). Interpreted fault and transfer systems are linked to stratigraphic thickness changes, mapped unconformities, age data control from borehole data and other geological information. Reconstructions include the present-day coastline for better reference (Figs 10 & 11).

We have compiled a number of structural lineaments in the JMMC area, which are based on published work, bathymetry, free-air gravity anomaly and derivatives, magnetic anomaly (Hopper et al. 2014), and seismic reflection data. These proposed structural lineaments (Fig. 1a) are based on features that can be inferred from at least two, and preferably three, different potential datasets.

We consider several observations that may give information on how the JMMC evolved during the multiphased break-up. Along the eastern margin, Palaeogene rocks dip steeply towards the Norway Basin (Fig. 6) and exhibit normal faulting associated with rapid subsidence within the northern and southern eastern-flank basin (EFBN and EFBS in Fig. 8; Table 1), in association with SDR emplacement and the early establishment of the Ægir mid-oceanic ridge system. The western margin, along the Jan Mayen Ridge, the Ægir Ridge to the Kolbeinsey Ridge became fully established along the western margin at chron C6b (22–21 Ma) (Fig. 11e).

**Pre-break-up stage ending around 56–55 Ma**

Major structural elements and subdivisions of the JMMC at pre-break-up time align fairly well with published regional trends and lineaments interpreted on the NE Atlantic continental margins (Hamann et al. 2005; Tiskalas et al. 2005, 2008; Vogt & Jung 2009; Gaining et al. 2009, 2013; Gernigon et al. 2012, 2015) (Fig. 10). Three main trends are observed (Fig. 10): (1) a north–south trend similar to the strike-slip fault systems of the Shetland Islands, which is also aligned with the Jameson Land Basin axis and the main boundary fault of the Liverpool Land High; (2) an east–west trend parallel to the strike-slip fault system proposed by Guarnieri (2015), forming the northern limit of the Faroe–Shetland region; and (3) a SE–NW trend that separates the JMMC from the Voring margin to the north and the Faroe Islands region to the south. The latter two subdivisions also form the boundaries of several gaps in the reconstructions shown by Gaining et al. (this volume, in review).

At pre-break-up time, the JMMC was most probably a 40–100 km-wide crustal fragment, with stratigraphic and crustal geometries corresponding to the conjugate central East Greenland margin (Gaining et al. 2009; Gernigon et al. 2015) (Figs 1a, 10 & 11). The JMMC was bounded to the north by the proto-Jan Mayen Fracture Zone (proto-JMFZ in Fig. 10). The northern segment of the microcontinent near the proto-JMFZ that could be mapped shows stratigraphic and structural similarities with the Scoresby Sund and Blosseville Kyst areas.

The NNE–SSE-orientated axis of the Jameson Land Basin terminates abruptly at the Blosseville Kyst (Engkilde & Surlyk 2003), with no major east–west-striking fault structures marking its southern boundary in the Scoresby Sund area. This indicates that a deep basin may continue south underneath the Blosseville Kyst. The kinematic models here suggest that the central and southern JMMC were attached to that part of East Greenland prior to break-up, with the NNE–SSE-striking Liverpool Land high lining up with all ridge areas of the microcontinent and correlates to a change in the seafloor spreading direction along the Ægir mid-oceanic ridge axis before the cessation of the mid-oceanic ridge (Gernigon et al. 2015) (Fig. 11d). This transtensional phase resulted in small-scale reverse faulting across the SRC. A second unconformity marks a major hiatus in the Late Oligocene, which corresponds to the complete cessation of the Ægir mid-oceanic ridge. The microcontinent was isolated completely, as the Kolbeinsey mid-oceanic ridge became fully established along the Scoresby Sund area.
the northern Lyngvi Ridge, the central high of the JMMC (Fig. 8).

The southern boundary is less clear, but was probably influenced by the large-scale transform system proposed by Guarnieri et al. (2015). This, in turn, was linked to the development of the Greenland–Iceland–Faroe Ridge Complex, a subdomain of the North Atlantic Igneous Province. The GIFRC forms a complex WNW–ESE-striking ridge structure that includes the Greenland–Iceland Ridge, the entire Iceland shelf and the Iceland–Faeroe Ridge.

The southernmost part of the microcontinent, where East Greenland links to the Faroe Platform and the Hatton Bank, remains far more uncertain owing to a lack of data constraints (Breivik et al. 2012; Brandsdóttir et al. 2015; Gernigon et al. 2015; Torsvik et al. 2015). Still, the stratigraphic mapping of the JMMC (event B in Fig. 7) suggests a potential link between the southern extent of the JMMC and the pre-break-up/break-up successions along the Blosseville Kyst of central East Greenland margin, the NW margin of the Faroe Platform and the northern edge of the Iceland Faroe Ridge (Figs 10 & 11a). The interpretation of seismic reflection data across the central part of the JMMC indicates two possible Early Eocene plateau basalt-equivalent sections that appear to increase in thickness from north to south (Fig. 4).

A gap in our pre-break-up reconstruction situated to the south of the JMMC is assumed to have been filled by either stretched continental crust (Torsvik et al. 2015) and/or pre-break-up formations of Palaeozoic–Early Palaeocene age, similar to those known from onshore East Greenland and the Norwegian shelf margin (Brekke 2000).

Break-up stage around C24n2r (53.36 Ma)

The break-up stage (Fig. 11a and event C in Fig. 7) is marked by large-scale extrusive volcanism leading to the formation of the plateau basalts onshore East Greenland (Storey et al. 2007a, b). The plateau basalts mapped extend from East Greenland and across the Faroe Islands area. They have an estimated thickness of more than 6 km in East Greenland (Brooks 2011 and over 7 km at the Faroe Islands (Arting 2014).

The main structural elements of the JMMC are parallel to the overall trends of the basins and highs of the surrounding regions, except for the east Jan Mayen Fracture Zone, which appears to be linked to an initial rift centre just at the NW edge of the JMMC, as proposed by Gaina et al. (2009). This coincides with the formation of SDR sequences along the eastern margin, which reach a stratigraphic thickness of 4–6 km at the northeasternmost flank (Figs 4 & 5).

Early Eocene (53.36 Ma) volcanism marks the establishment of the Ægir mid-oceanic ridge system at C24n2r (e.g. Gernigon et al. 2015), separating the mid-Norwegian Voring and Møre basins from the Central East Greenland margin. Large igneous complexes were mapped on seismic reflection data along the eastern flank of the JMMC located close to fracture/fault zones (Figs 7a, b & 9). These complexes most probably formed after the initial emplacement of SDR sequences, cutting through that sequence and the initial oceanic crust, forming a 40–80 km-wide volcanic margin (Fig. 5) as Eocene sediments onlap and fill in those features.

Initial intra-JMMC rifting phase around C22n (49.3 Ma)

The initial intra-JMMC rifting phase at chron C22n (49.3 Ma; Fig. 11b) is marked by the southwards propagation of the Ægir mid-oceanic ridge and the establishment of a continuous spreading system in the Norway Basin. The EJMFZ extends from the Mohn’s mid-oceanic ridge, which was established to the NE of the JMMC at C24 and separated the Voring margin from the NE Greenland margin. A distinct rift segment can be seen along the SE margin of the JMMC, forming the eastern extent of the Iceland Plateau, here referred to as Iceland Plateau rift I (IPR-I: Fig. 11b, c). During the Lower Eocene, thick sediment wedges formed along the central eastern and NE flank of the microcontinent (Figs 7 & 8).

An uneven north to south change in spreading rate from intermediate to slow (Gernigon et al. 2015) led to oblique spreading within the Norway Basin, initiating a V-shaped mid-oceanic ridge structure and a counterclockwise rotation of the JMMC. This resulted in extension of the entire southern half of the microcontinent and the formation of small ridge segments. This extension widened the area across the southern half of the microcontinent from the original 100 km to approximately 150 km. This also explains the crustal

Fig. 8. Post-break-up stratigraphic thickness map includes estimates from the Lower Eocene (top SDR/flood basalts) to present day. The main ridges are heavily eroded and have only a very thin sediment cover. The low areas along the east flank show a very thick stratigraphic section. The thicker stratigraphic sections along the west flank of the ridge are related to the Jan Mayen Basin, as well as to several lows between the main structural highs. The stratigraphic thinning towards the Jan Mayen Island volcanic complex to the north and towards the south, and the area of borehole 350, where the Iceland Plateau Rift is proposed. For an explanation of abbreviations, see Table 1.
thinning trend from north to south that has been observed on refraction data in the JMMC area (Kandilarov et al. 2012).

The Ægir mid-oceanic ridge system did not directly link up with the Reykjanes mid-oceanic ridge system to the south. Instead, the link to the Reykjanes mid-oceanic ridge was marked by a complex system of transforms and off-ridge volcanic systems that formed an Iceland-type oceanic crust within the proto-GIFRC (Arting 2014). In order to

Fig. 9. Structure and volcanic elements map (a) of the JMMC and the Iceland Plateau. The proposed Iceland Plateau rifts I, II and III (IPR I, IPR II and IPR III) are interpreted on seismic reflection data. Gravity and magnetic anomalies are linked to segments of older microcontinent transitional crust ‘Southern Ridge Complex transition’, pre-break-up plateau basalts segments and youngest second break-up volcanics ‘F-marker’. The Iceland Plateau rift II was described by Brandsdóttir et al. (2015) based on interpretation of seismic refraction data. The sediment wedges (sn and ss) correspond to observations on seismic reflection data (in b) and correlate to negative gravity anomalies west of the COB. Interpreted profiles.
maintain a spatial balance within the reconstruction, the areas of the Iceland Plateau and East Iceland must have been involved in this early stage of break-up, forming new basaltic crust and possibly SDR overlying older crust segments that remain as segments in-between off-mid-oceanic ridge volcanic segments (Erlendsson & Blischke 2013; Blischke et al. 2014b).

**Fig. 9.** (b) I–I′ from Brandsdóttir et al. (2015) and H–H′ across the SRC. The H–H′ profile based on TGS seismic reflection data crosses the southernmost area where the SRC is clearly observed and ties to DSDP site 350. Section H–H′ has several areas marked to explain the subdivision of the mapped structures: (1) The Dreki Ridge transfer system (possibly active from the Mid-Eocene to Oligocene with Miocene infill). (2) A graben structure that separated the Eocene ridges of the SRC. The strike of the graben is parallel to the Iceland Plateau rift II structure. (3) A sediment wedge that is closest close to the COB. This is observed along the entire eastern edge of the JMMC and helps to define the COB location. (4) Areas where deep faulting appears absent and structures are distinctly different from elsewhere. A basalt cover is indicated, possibly equivalent to the plateau basalts. (5) A typical section where the F-reflector is observed and is connected to IPR III. (6) A positive gravity anomaly that might be related to another possible rift complex, but not confirmed on seismic reflection data. A clear signature on the magnetic anomaly data (Fig. 9a) south of intersection H–H′ is observed, however. Section I–I′ shows the Iceland Plateau rift between the Langabrun Edge and the Iceland Shelf. It includes a segment of thick crust between the C6 magnetic chron just west of the youngest rift system on NE Iceland (the Eyjarfjarðar Channel/Kolbeinsey mid-oceanic ridge).

**Fully established intra-JMMC rift phase and the beginning of rift migration around C21n: 47.33 Ma**

The oblique seafloor spreading direction recorded by the Norway Basin oceanic crust caused large strike-slip/transfer fault systems that affected the eastern flank of the microcontinent (event D on
Fig. 10. Continued
Fig. 7) and subdivided the JMMC into the northern Jan Mayen Ridge and the SRC. The Ægir mid-oceanic ridge appears to terminate at the GIFRC (Fig. 11c).

A series of en echelon magnetic anomalies across the Iceland Plateau, referred to as the Iceland Plateau Rift System (Fig. 11c), is interpreted as marking the onset of a propagating rift system towards the Ægir mid-oceanic ridge (Figs 5 & 9). A NW–SE-striking fault system that links up to the Iceland–Faroe Fracture Zone and terminates the north–south fault trend of the SRC, marks the southern extent of the microcontinent. The NW–SE-striking fault system is in direct alignment with the volcanically active area of the Blosseville Kyst (F on Fig. 11c), where a major coast-parallel dyke swarm belonging to the Igtertivá Formation magmatism is thought to have been caused by a regional extensional event at 49–44 Ma (Larsen et al. 2013).

This event is also marked by a distinct unconformity, where the base consists of sediments that are dated to $49.09 \pm 0.48$ Ma and the top is formed by sediments intercalated with lava flows of the Bopladsdalen Formation, which are dated to $43.77 \pm 1.08$ Ma (Larsen et al. 2013). This Late–Middle Eocene time interval (49–44 Ma) coincides with an increase in observed sills and intrusions within the sediment stratigraphy (Fig. 8) of the JMMC area.

Fig. 10. Pre-break-up setting of the central NE Atlantic region, showing reconstructed present-day bathymetry, magnetic, gravity and crustal thickness data. Crustal thickness is based on the gravity inversion (Funck et al. 2014). The reconstruction is at pre-break-up stage ending at 56–55 Ma and is fixed to the European Plate. Features displayed are modified from data, and interpretations by Osmundsen & Andersen (2001), Torsvik et al. (2001), Foulger et al. (2005), Henriksen (2008), Gaima et al. (2009), Boyden et al. (2011), Peron-Pinvidic et al. (2012a, 2013), Gasser (2014), Hopper et al. (2014), Gernigon et al. (2015), Guarnieri (2015) and Torsvik et al. (2001, 2015). Regions marked are: BK, Blosseville Kyst; FP, Faroe Plateau; FSB, Faroe–Shetland Basin; HR, Hatton–Rockall margin and basin; JLB, Jameson Land Basin; MB, Møre Basin; NS, North Sea; VB, Vøring Basin.

Westwards rift transfer and the initial western JMMC margin break-up phase around C13n: 33.1 Ma

By chron C13n (33.2 Ma), the Norway Basin seafloor spreading had changed from slow to ultra-slow spreading (Gernigon et al. 2015), while, on
the western part of the JMMC, the proto-Kolbeinsey mid-oceanic ridge was forming. Two igneous complexes were identified on seismic reflection and gravity data, and are here referred to as the Iceland Plateau rift II and III systems (Figs 9 & 11d). Iceland Plateau rift II is located parallel to magnetic anomaly C19n (40.32 Ma) and forms the eastern shelf limit of Iceland (Brandsdóttir et al. 2015). Iceland Plateau rift III is observed on seismic reflection, gravity and magnetic anomaly data, and appears to have affected the nearby Hakarennna Channel (HC in Fig. 9). This area of the

Fig. 11. Central NE Atlantic plate reconstructions relative to the European Plate: (a) break-up stage around chron C24n2r (53.36 Ma).
microcontinent was located parallel to the offshore Blosseville Kyst region at chron C13n, and lines up with observed offshore igneous centres (Árting 2014). This is interpreted as clear evidence that the rift transition had reached the SW corner of the JMMC by chron C13n.

Fig. 11. (b) initial intra-JMMC rifting phase around chron C22n (49.3 Ma); (c) fully established seafloor spreading east of JMMC rift phase and beginning of intra-JMMC rift migration around chron C21n (47.33 Ma).
Fig. 11. (d) further westwards rift transfer and initial western JMMC margin break-up phase around chron C13n (33.1 Ma); and (e) complete isolation of the JMMC through the establishment of the Kolbeinsey mid-oceanic ridge around chron C6b (21.56 Ma). The kinematic reconstruction considers the JMMC as several independent tectonic blocks. Plate reconstruction parameters for the relative motion of the JMMC and conjugate margins were calculated using an interactive fitting method in GPlates (http://www.gplates.org; Boyden et al. 2011; see also Gaina et al. this volume, in review). The reconstructions include data interpretations for fault and transfer systems linked to stratigraphic thickness changes, mapped unconformities, age data from magnetic anomalies and borehole data. Present-day topography is included in the displays for a better reference to today’s coastline.
During this phase, the Jan Mayen Basin and Jan Mayen Trough (HT in Fig. 8; Table 1) both developed as a consequence of Middle Eocene and Late Oligocene–Early Miocene extension prior to the establishment of the Kolbeinsey mid-oceanic ridge (Peron-Pinvidic et al. 2012b). The Jan Mayen Basin was initiated as a series of small pull-apart basins along the NW flank of the JMMC (Fig. 11d, e). These small basins spatially compensated for the rapid extension occurring during this second break-up phase (Fig. 6a, b). Rotation and compression along the SE JMMC, initiated in the previous phase, probably continued until the cessation of seafloor spreading in the Norwegian Sea. This resulted in inversion structures that are also observed in the stratigraphic record in the form of the Lower Oligocene unconformity across the microcontinent’s ridges (Figs 3 & 6, event E in Fig. 7).

Extension of the SRC widened the area to about 310 km. The nature of the basement at depth still remains unconstrained, but can be interpreted in terms of highly stretched and probably very thin continental crust. This thin crust is covered by thick basalt formations emplaced since break-up. During rift transfer, the area was intersected by the Iceland Plateau rift systems that separated the stretched composite crust into segments, forming a transitional crust between continental crust and the oceanic crust of the Iceland Plateau. These basalt formations are probably Late Oligocene–Early Miocene and filled the topographical lows between the main structures along the Jan Mayen Ridge. They are indicated by the F-Marker on seismic reflection data (Figs 5 & 6).

**Complete isolation of the JMMC by establishing the Kolbeinsey mid-oceanic ridge around C6b: 21.56 Ma**

The final separation of the JMMC occurred around C6b at 21.56 Ma (e.g. Gernigon et al. 2015) (Fig. 11e), when the Kolbeinsey mid-oceanic ridge reached the JMFZ and the plate boundary in the Greenland Sea. This phase coincides with the initiation of Iceland as an insular province and the formation of the GIFRC by increased igneous activity (Harðarsson et al. 2008). The offshore area NW of Iceland, and the onshore and offshore areas of East Iceland, began to form the Icelandic Plateau basalts continuously throughout the Late Miocene (Walker 1964; Sæmundsson 1979; Thordarson & Larsen 2007).

Rift propagations have been shown to occur in a NW direction within the Iceland Plateau–GIFRC area up to the Late Miocene (7.2–5.3 Ma). At around 7 Ma, a northeastwards oceanic rift relocation occurred (Johannesson & Sæmundsson 2009) from the Húnaflói rift centre (HFR on Fig. 1) in the NW of Iceland to the NE volcanic zone. As a consequence of substantially increased volcanic activity, new land formed and the GIFRC has been documented to have been located above or close to sea level (Denk et al. 2011). Well data from the highest ridges of the JMMC show a Mid–Late Miocene hiatus with marine sedimentation continuing only from the Pliocene onwards (Fig. 3).

During the Quaternary, the JMMC has only been affected by occasional volcanic activity of the Jan Mayen Island volcanic system, located at the northern edge of the JMMC, and gravitational erosion from the escarpment areas of the steep ridge flanks. In the Pleistocene, several glacial events removed about 1 km of the Iceland Plateau basalt (Walker 1964). The opposite occurred for the area between the Iceland Shelf and the SRC, indicating that the JMMC was subsiding during this last phase, presumably due to lithospheric cooling.

**Discussion**

The central focus of this contribution is the detailed development of the Jan Mayen microcontinent and its relationship to the surrounding areas to enable a better understanding of the full extent of the continental crust and its age and history. Central goals include:

1. Establishing a detailed tectonic and stratigraphic framework for the JMMC:
   a. the pre-break-up section and the JMMC relationship to the surrounding areas, in particular the East Greenland and Norway margins;
   b. the stratigraphic and igneous record during first break-up;
   c. the stratigraphic and igneous record during mid-oceanic ridge transfer.

2. To develop a detailed kinematic model of the JMMC from pre-break-up time to the present day, in particular with respect to the second break-up phase and the formation of a microcontinent.

3. To assess the Iceland–Faroe Fracture Zone (IFFZ) and the southern extent of the JMMC, in particular the connection to the Greenland–Iceland–Faroe Ridge Complex along the IFFZ, and the Iceland Plateau.

(1a) Stratigraphic records of the pre-break-up section

Where the JMMC type section intersects the seismic refraction profile line 4 of Kodaira et al. (1998) (Fig. 4), the pre-break-up sedimentary section, defined as the interval between the basalt and acoustic basement, is approximately 6 km thick. The
velocity model indicates that this interval is characterized by velocities of 3.9–5.3 km s\(^{-1}\) (Kodaira \textit{et al.} 1998). Palaeozoic–Mesozoic sequences in the Jameson Land Basin along East Greenland also show seismic velocities in the range between 3.5 and 5.5 km s\(^{-1}\) (Fechner \\& Jokat 1996), assuming similar velocities along the central eastern flank of the microcontinent, where the pre-break sections appear thickest and may reach up to 9 km thick.

Overall, the Lyngvi Ridge seismic profile is similar in structural character to the Jameson Land Basin, which is 3–5 s deep at its centre and contains up to 12–16 km of pre-break-up sedimentary sequences (Henriksen 2008) with multiple unconformities, complex faulting patterns and deep intrusive events (Blischke \textit{et al.} 2014b).

\textit{(1b) Stratigraphic and igneous records during first break-up}

The Early Eocene flood basalts, SDRs and igneous centres along the eastern flank of the JMMC are located within an interpreted volcanic-transitional crust consisting of stretched continental crust modified by significant volcanism. The earliest clear oceanic crust produced by the Ægir mid-oceanic ridge spreading centre is indicated by the onset of regular magnetic anomalies (chron C24n2r in Fig. 5) (Gernigon \textit{et al.} 2015). The average thickness of oceanic crust in the Norway Basin is about 5.3 km ± 1 km (Breivik \\& Mjelde 2003), in contrast to the much thicker 6–10 km (Kandilarov \textit{et al.} 2012) oceanic crust close to the Jan Mayen Island volcanic complex (JMI) and the west Jan Mayen Fracture Zone (WJMFZ in Fig. 5). The crustal thickness of the central area of the microcontinent (Fig. 6b) is 15–18 km based on refraction data (JMKR-95 in Figs 2 \\& 5), whereas the continental crust under the main Jan Mayen Ridge, close to wells 346 and 347, reaches up to 20 km (Kandilarov \textit{et al.} 2012).

The break-up-related basaltic layers interpreted here along the JMMC are assumed to be correlative to the central East Greenland margin. Nøhr-Hansen (2003) and Larsen \textit{et al.} (2013) reported that the landwards flows (Planke \textit{et al.} 2000) of the plateau basalts overlie Lower Palaeocene sediments at Kap Brewster and Kap Dalton (KB and KD on Fig. 1a), and mark an erosional horizon interpreted here as equivalent to the break-up conformity of the central JMMC (Figs 3 \\& 4).

Further to the west, the Milne Land Formation (56.36 ± 0.25 Ma) of the main plateau basalts discordantly overlies Precambrian gneiss (Storey \textit{et al.} 2007b), marking the break-up unconformity for the north Blosseville Kyst and Scoresby Sund region. At break-up time (c. 55 Ma), this region was located approximately 400 km to the NE of the Faroe Island Plateau basalts.

The Faroe Islands, which have been covered by more than 7 km-thick landward basalt flows (Passey \\& Jolley 2009; Passey \\& Hitchen 2011; Årting 2014), is conjugate to the Kangerlussuaq Basin, located at the southernmost extent of the Blosseville Kyst. This plateau basalt succession has often been assumed to have had a similar stratigraphic thickness across the entire area further to the north, which would have included the proto-Jan Mayen microcontinent area. Seismic reflection data (Fig. 4; Table 3), however, indicate a thinner basaltic section of approximately 1.1–1.5 km over the central part of the JMMC. As noted earlier, the Jameson Land Basin may have been covered by thick flood basalts and 2–3 km of basalt may have been removed (Mathiesen \textit{et al.} 2000). The same may have occurred here. By inference, the flood basalts associated with SDR formation probably covered the entire JMMC and may have been continuous with the flood basalts of the Blosseville Kyst area.

\textit{(1c) Stratigraphic and igneous records during mid-oceanic ridge transfer}

Along the Blosseville Kyst area, the lower Igtertiva Formation (C22: c. 49 Ma) coincides with the beginning of rift transfer away from the Ægir mid-oceanic ridge (F in Fig. 11b), which is followed by a hiatus between the lower (C22–C21: 49–47 Ma) and the upper Igtertiva Formation (C20: c. 44 Ma) (Larsen \textit{et al.} 2014). As only the Mid-Eocene (chron C20) unconformity (Fig. 3) is observed along the eastern flank of the microcontinent, it is assumed that the area was again above sea level from 49 to 44 Ma, eroding all pre-chron C22 deposits. The rift transfer processes may have contributed to some thermal uplift along the SW and southern flanks of the microcontinent, accompanied by emplacement of igneous complexes and sill intrusions primarily into the Lower Eocene strata along the NE and SE flanks of the JMMC. This is also seen in borehole data (DSDP 38-350: Fig. 3), and on seismic reflection and refraction data (Figs 4–6).

Along the southern flank of the microcontinent, increased magmatism most probably coincided with volcanism within the Greenland–Iceland–Faroe Ridge Complex region. The Eocene sediment succession shows many intrusive sills and dykes, especially along the eastern and SE flanks. These intrusions are primarily located within the Lower Eocene sediment sequences, possibly coinciding with emplacement within the Mid-Eocene time interval (49–44 Ma). This time interval correlates well with the increased igneous activity observed along the East Greenland coast (Larsen \textit{et al.} 2014) and
may indicate a regional event, and, furthermore, may explain the major unconformity that has been observed along the JMMC in the Mid-Eocene (Figs 3, 4 & 7).

(2) The second break-up phase and the formation of a microcontinent

This second break-up phase between the western edge of the JMMC and the central East Greenland margin is most probably a magma-starved break-up due to the lack of SDR sequences and large-scale magmatic activity. A gradual rift propagation is observed beginning at chron C21 (Fig. 11c) accompanied by large-scale extension of the SRC, crustal thinning across the Iceland Plateau, and a listric normal faulting along the western flank (Fig. 5). Extension rates were probably very small, consistent with a reduced magma supply. Lundin et al. (2014) suggested that this is likely in areas near the tip of a propagating rift and eventual normal oceanic-crust accretion.

The youngest regionally extensive igneous event indicated on seismic reflection data on the JMMC (Gunnarsson et al. 1989) is referred to as the ‘F-Reflector’, and covers an area of approximately 18 400 km² along the western and SW to southern flanks of the Jan Mayen Ridge and within the Jan Mayen Trough (JMT in Fig. 5). This igneous formation is interpreted as shallow-marine landward flows emplaced during chronos C13–C6b (33–21.56 Ma), possibly sourced from fissure-type volcanic complexes south and west of the microcontinent. Small lava deltas located on the SW extent of the JMMC on seismic reflection data indicate a reduced magma supply. Lundin et al. (2014) suggested that this is likely in areas near the tip of a propagating rift and eventual normal oceanic-crust accretion.

During the second break-up event, the central East Greenland region was most probably the main sediment source, along with the Jan Mayen ridges and highs. The Jan Mayen Basin, including local low areas along the SW flank of the microcontinent, was filled with sediments sourced from the west as the microcontinent separated from the East Greenland margin (Fig. 8; Table 1). The southern area of the microcontinent towards the Iceland Plateau must have been elevated from the Mid-Oligocene, as the overall sediment stratigraphic thickness decreased from north to south and the Late Oligocene unconformity (Fig. 3) is observed on highs of the SRC (Fig. 6c).

After the Kolbeinsey mid-oceanic ridge had completely separated the microcontinent from East Greenland, the sediment supply was greatly reduced. Intra-Neogene unconformities within the oceanic sediments are observed away from the JMMC, and the occurrence of mounded onlapping sediment packages are observed on the flanks of the Jan Mayen Ridge. These attest to processes of erosion and deposition associated with deep-water bottom currents, which were common around the NE Atlantic region from the Mid-Miocene onwards (e.g. Bohrmann et al. 1990; Howe et al. 1994; Davies et al. 2001; Stoker et al. 2005). Borehole information (Talwani et al. 1976b; Talwani & Eldholm 1977) and interpretation of seismic reflection data show that these sediment sequences are very thin, deep marine, and form thick contourite deposits. Beginning in the Mid-Miocene, the sediment supply direction was from the North Iceland Shelf (NIS) area to the south. Sediment was supplied into the Ægir to Kolbeinsey rift transfer corridor of the Iceland Plateau (Fig. 5) and into the Hléssund Trough (HS in Fig. 8; Table 1), the southernmost extension of the Jan Mayen Trough.

(3) The Iceland–Faroe Fracture Zone and the southern extent of the JMMC

To understand the development of the southernmost part of the JMMC, the present-day development of the onshore areas of Iceland are considered, where complex transfer zones link the Reykjanes and Kolbeinsey mid-oceanic ridges to the main spreading axis (Sæmundsson 1974; Magnúsdóttir et al. 2015). These transfer systems result in en echelon orientated volcanic ridge segments, here referred to as flank systems (e.g. the Snæfellsmán and Óraefajökull volcanic zones: e.g. Hards et al. 1995; Prestvik et al. 2001; Einarsson 2008; Jakobsson et al. 2008). The present-day spreading axis is apparently migrating east via ridge jumps (Arting 2014). These observations serve as an analogue to understand how the left-lateral Greenland–Faroe Transfer System described by Guarnieri (2015) might have developed in time (Figs 10 & 11).

This transfer system between the Norway Basin and Kolbeinsey mid-oceanic ridge system that passes south of the JMMC and north of the Iceland–Faroe Ridge has been described previously (e.g. Vogt & Jung 2009; Gernigon et al. 2015). The interpretations of the wide-angle data along KRISE Line 7 (Brandsdóttir et al. 2015) (Figs 2 & 5), which extends from the Kolbeinsey mid-oceanic ridge to the Ægir mid-oceanic ridge, are important in this context. The western part of the profile crosses the Kolbeinsey mid-oceanic ridge and the NIS, which is part of the GIFRC. The crustal thickness ranges from 12 to 14 km near the Kolbeinsey Ridge, increasing gradually across the Iceland Shelf up to 25 km. Crustal thickness decreases abruptly down to around 8 km across the Iceland Plateau corridor and across the NIS shelf break, with a major fault escarpment dipping NE. Within the volcanic transitional area of the Iceland Plateau Rift (IPR), the crustal thickness again increases to 12 km. The oceanic crust towards the Ægir
The objective of this study was to construct a detailed tectonostratigraphic history of the Jan Mayen microcontinent with a focus on the southernmost area. This was then integrated into kinematic reconstructions of the central NE Atlantic to better understand the Cenozoic development and the implications for the pre-Cenozoic development of regional rift basins, remnants of which probably underlie the JMMC. Complex structural patterns are observed along the microcontinent’s margins, as well as the conjugate East Greenland and Norwegian margins on either side. The new model includes a description of how the southern JMMC structural elements were linked to tectonic features on the Iceland Plateau and Greenland–Iceland–Faroe Ridge Complex.

Mapping the pre- to post-break-up sedimentary strata and igneous complexes together with volcanonostratigraphic seismic characterization has facilitated a reassessment and clearer definition of the igneous v. sedimentary domains of the JMMC area throughout its break-up history. The main results include:

- Interpretation of new and vintage geophysical data suggests that a significant pre-Palaeogene stratigraphic history is preserved. However, without deep borehole data, the age of possible sedimentary successions are speculative. Nevertheless, the conjugate Jameson Land and Møre basins are considered to be direct analogue areas for the JMMC. These basins are well constrained, and contain a sedimentary succession that includes Devonian continental sediments, Permo-Triassic continental and marine sequences, Jurassic and Cretaceous shallow-to-deep-marine sequences, and Lower Paleocene alluvial to shallow-marine sediments.

- The break-up and post-break-up igneous sequences were separated into plateau basalts of probable Paleocene–Early Eocene age, seawards-dipping reflector sequences, igneous complexes, and sill and dyke intrusions along the flanks of the JMMC.

- A consistent kinematic model for the Cenozoic evolution of the JMMC and surrounding oceanic crust that consists of six main phases is proposed. The boundaries between these phases correlate to major unconformities and related structures. Important events include:

(1) A pre-break-up stage ending at 56–55 Ma and the emplacement of Lower Eocene plateau basalts across the microcontinent and the Blosseville Kyst region, with an apparent thickening of the basalt sequences to the south, possibly continuing into the Faroe–Iceland–East Greenland corridor. The structures of the JMMC are consistently orientated with major structural lineaments of the surrounding regions prior to break-up. The main trends are aligned with the Jameson Land Basin and Liverpool Land high. The JMMC probably forms the southern extension of the Jameson Land Basin.
(2) A first break-up phase that began at 55 Ma (e.g. Gaina et al. 2009) and was associated with the formation of SDR along the east flank of the JMMC, followed by the initiation of seafloor spreading in the Norwegian Basin along the Ægir Ridge in the Early Eocene (chron C24n2r 53.36 Ma) (Gaina et al. 2009; Gernigon et al. 2015).

(3) An initial intra-JMMC rifting phase around chron C22n (49.3 Ma) and the establishment of a continuous spreading system in the Norwegian Basin and forming the eastern extent of the Iceland Plateau, here referred to as Iceland Plateau rift I (IPR-I: Fig. 11b, c). Initial extension of the entire southern half of the microcontinent occurred, widening it from originally 100 km to approximately 150 km. This eventually lead to early stage break-up in the Iceland Plateau area, forming new Lower Eocene volcanic formations (volcanic breccia, intrusions and SDR sequences) along the SE flank of the Southern Ridge Complex (SRC).

(4) The initiation of the southern JMMC rift transition at chron C21n (47.33 Ma) contemporaneous with oblique seafloor spreading east of the JMMC, causing the formation of transform systems and uplift along the southern flank of the JMMC. Volcanic activity occurred along the NE margin of the Blosseville Kyst (Larsen et al. 2014).

(5) A westwards rift transfer and initial break-up along the western JMMC around chron C13n–33.1 Ma. Oblique mid-oceanic ridge relocation via a SE–NW en echelon rift system occurred from the southern extent of the microcontinent during the Early Oligocene. Significant volcanism affected the SW area of the JMMC, referred to here as the Iceland Plateau rift III, which can be linked to the Blosseville Kyst margin. Oblique extension occurred along the NW flank of the JMMC, resulting in the opening of the Jan Mayen Basin and a series of small pull-apart basins and igneous intrusions with little to no evidence of SDR formation.

(6) A second break-up phase at chron C6b (21.56 Ma) with complete cessation of seafloor spreading in the Norway Basin (Gernigon et al. 2015) and the establishment of the Kolbeinsey mid-oceanic ridge as the main mid-ocean spreading centre.

- The extension of the southern half of the JMMC has been quantified from the original 40–100 km width up to a width of 310 km during the Early Eocene. The SRC is overprinted by volcanic extrusive complexes that consist primarily of Early Eocene basalt flows, which are interpreted as being similar to the plateau basalts exposed along the Blosseville Kyst of Greenland. These are onlapped by clear and well-developed SDRs associated with the final opening of the Norwegian Basin. Multiple phases of intrusive events appear to have affected the eastern flank of the microcontinent during the Eocene and the southern part of the JMMC during the Late Eocene—Early Oligocene.

- The Iceland—Faroe Fracture Zone across the Iceland Plateau has been mapped as an en echelon transfer system from the Ægir Ridge to the Kolbeinsey Ridge. Detailed mapping of the southern extent of the JMMC supports the Gaina et al. (2009) model in which mid-oceanic ridge propagation occurred directly south of the microcontinent, beginning in the latest Early Eocene (49.3 Ma) and continuing throughout the Eocene. This formed at least three rift-flank systems on the Iceland Plateau. These rifts flanks are referred to as Iceland Plateau rift IPR-I, IPR-II and IPR-III (Brandsdóttir et al. 2015).

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