

# Linking onshore-offshore basement rock architecture and brittle faults on the submerged strandflat along the SW Barents Sea margin, using high-resolution (5 x 5 m) bathymetry data

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High-resolution bathymetry data reveal astonishingly detailed and complex morphology on the shallow offshore shelf (strandflat) along the SW Barents Sea margin, outboard Troms, northern Norway. The features are compared with, and interpreted based on, known onshore geology, including Precambrian basement structures of the West Troms Basement Complex, Caledonian thrust nappes and post-Caledonian passive-margin brittle structures. The study reveals that Precambrian basement structures commonly observed onshore, such as a generally steep gneiss foliation, steeply plunging tight to isoclinal intrafolial folds, upright macro-fold limbs, duplexes and high-strain ductile shear zones are also present on the strandflat, including possible offshore continuations of Precambrian metasupracrustal belts. The results suggest that the strandflat outboard Troms is largely composed of rocks of West Troms Basement Complex affinity. A contact with Caledonian thrust nappes is interpreted to trend NW–SE within a sound in the northern parts of the study area, where it overlaps with the Late Palaeozoic–Mesozoic Fugløya transfer zone, a possible reactivated portion of a Proterozoic–Palaeozoic basement-seated fault complex. A set of linear NNE–SSW- to ENE–WSW-trending trenches truncate the ductile fabrics and are interpreted as post-Caledonian brittle faults that formed due to multiple rifting events in the Late Palaeozoic–Mesozoic as parts of the evolution of the passive continental margin of the SW Barents Sea. Aspect analysis reveals a strong correlation between the present-day landscape and tectonic elements, which indicate a pervasive tectonic influence on the present-day coastal landscape of western Troms and the outboard strandflat.

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## Introduction

The shallow coastal portion off the coast of northern Norway comprises a distinct morphological phenomenon, the strandflat (e.g., Reusch, 1894; Nansen, 1922; Dahl, 1947; Larsen & Høltedahl, 1985; Corner, 2005; Thorsnes et al., 2009). The strandflat is typically manifested as a horizontal to gently dipping, low-relief surface consisting of exposed basement rocks. In Troms, the strandflat is largely submerged and may potentially, due to its location, be a very important source of information for onshore-offshore correlation studies. Any minor relief such as scarps, gullies, trenches, slopes, ridges, etc., visible on data covering the submerged strandflat may be the product of tectonic processes, such as foliation, folds, shear zones, faults and cleavages (cf., Thorstensen, 2011), and thus give valuable insight into the margin architecture.

In recent years, the Norwegian government has as a part of the MAREANO project, collected high-resolution (5 x 5 m) bathymetry data along the coast of Norway. The data are partly available online ([mareano.no](http://mareano.no)) and have been widely used within the geological sciences to for example map and resolve the glaciation and deglaciation history of the Norwegian shelf or to study submarine canyons and evidence for mass movement (e.g., Ottesen et al., 2005; Rise et al., 2013; Rydningen et al., 2013). For tectonic onshore-offshore studies, however, examples using bathymetry data as a correlation tool are comparatively few. This is mainly due to the military restrictions on the data, which limits the resolution to only 50 x 50 m within 12 nautical miles of the coast. This includes more or less all of the submerged strandflat along the Norwegian coast, thus making any detailed study of the strandflat difficult.

However, for the purpose of this study we have been granted access to, and permission to publish,

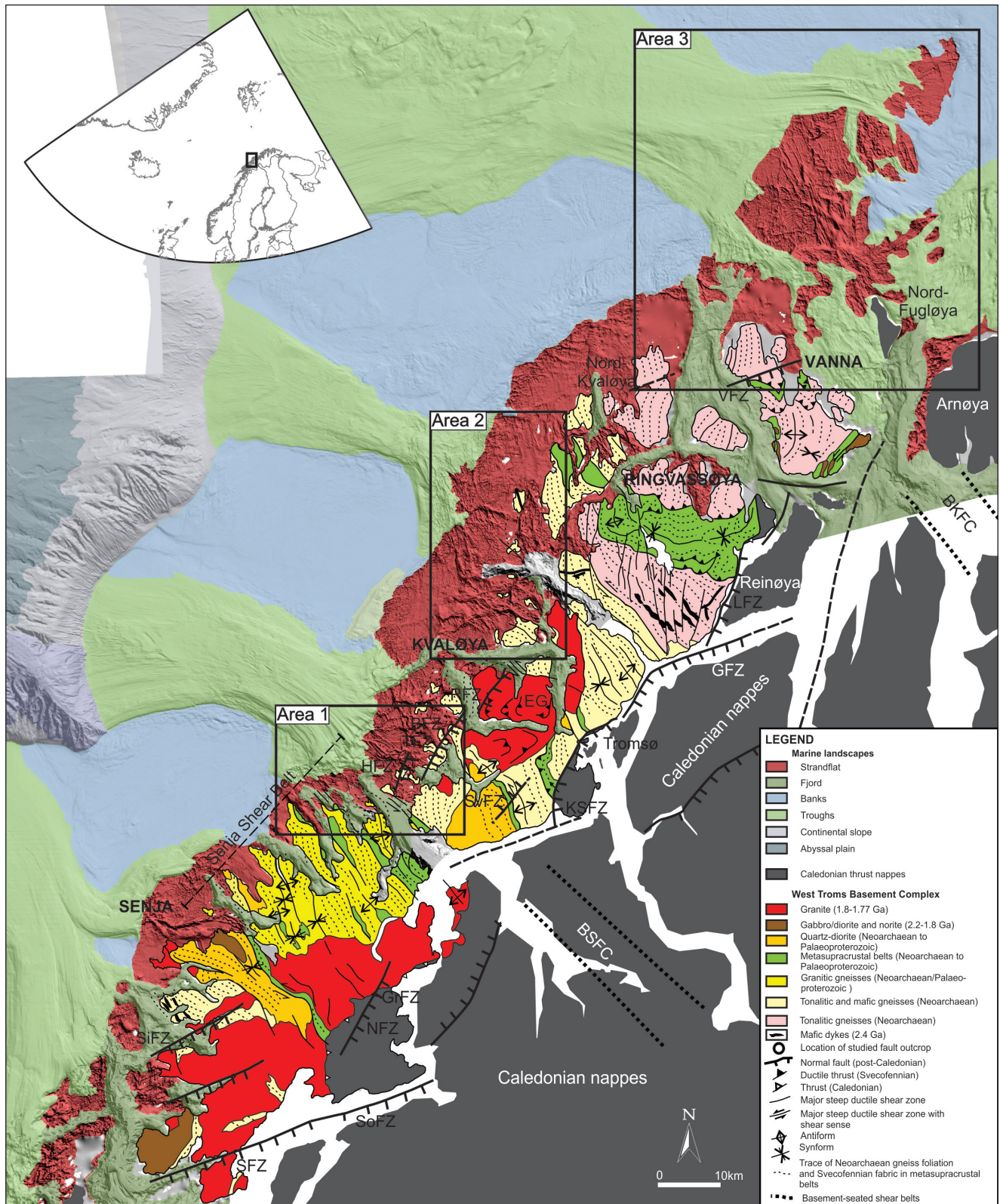


Figure 1. Detailed geological map of the West Troms Basement Complex showing the main Archaean–Palaeoproterozoic structures and post-Caledonian brittle normal faults that separate the basement horst from down-dropped Caledonian nappes to the east (after Bergh et al., 2010). Offshore, marine landscape types are given, including the lateral distribution of the strandflat (from the Mareano database). Three areas of focus of the present paper are marked. Abbreviations: BFZ=Bremneset fault zone, BKFC=Bothnian–Kvænangen Fault Complex, BSFC=Bothnian–Senja Fault Complex, EG=Ersford Granite, GFZ=Grøtsundet fault zone, GrFZ=Grasmyrskogen fault zone, HFZ=Hillesøy fault zone, KSFZ=Kvaløysletta–Straumbukta fault zone, LFZ=Langsundet fault zone, NFZ=Nybygda fault zone, RFZ=Rekvika fault zone, SFZ=Stonglandseidet fault zone, SIFZ=Sifjorden fault zone, SoFZ=Solbergfjorden fault zone, SvFZ=Skorehvatn fault zone, TFZ=Tussøya fault zone, VFZ=Vannareid–Brurøysund fault zone.



high-resolution (5 x 5 m) MAREANO data within 12 nautical miles of the coast, covering the strandflat offshore Troms (Fig. 1). The dataset is astonishingly rich in detail and may likely be used to solve many, very different, scientific problems. In this study, however, we will solely focus within a tectonic framework, using the data as a tool in the ongoing onshore-offshore correlation project in Troms and western Finnmark (Gagama, 2005; Eig, 2008; Hansen, 2009; Thorstensen, 2011; Indrevær et al., 2013, 2014). We aim to interpret and explain the strandflat morphology on the basis of known, onshore, ductile basement fabrics and brittle fault trends. The study aims to improve our understanding of the onshore and offshore SW Barents Sea margin architecture, including (i) the lateral offshore extension of the West Troms Basement Complex (WTBC), (ii) the offshore distribution of Caledonian thrust nappes and (iii) the distribution and linkage of Late Palaeozoic–Mesozoic brittle fault zones and how they relate to onshore fault complexes, such as the Vestfjorden–Vanna Fault Complex (VVFC, e.g., Olesen et al., 1997) and offshore fault complexes, such as the Troms–Finnmark Fault Complex (TFFC, e.g., Gabrielsen et al., 1990).

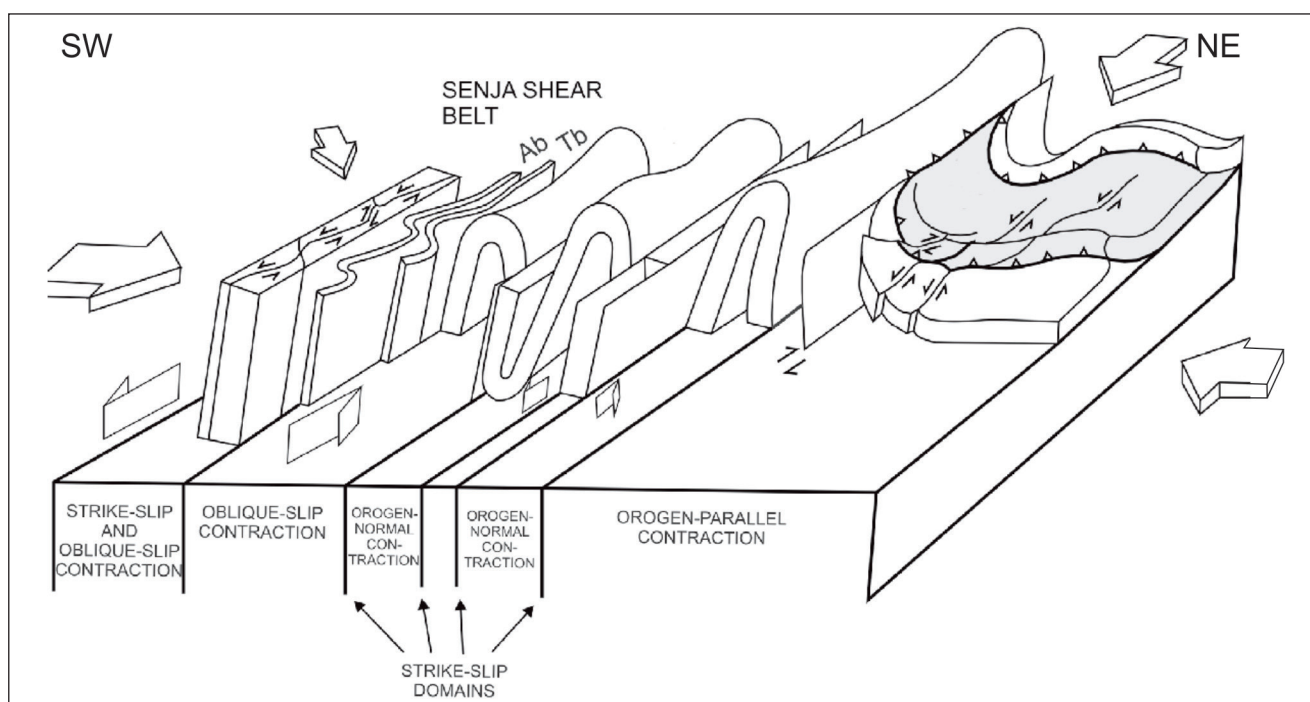
### Geological Setting

In order to interpret morphotectonic elements on the strandflat with confidence, it is crucial to have a good understanding of the onshore geology. In the following,

we provide a description of the main bedrock lithologies, the ductile and brittle fabrics onshore and the different models proposed for the formation of the strandflat.

### Precambrian structures of the West Troms Basement Complex

The outer islands of Troms constitute a major basement horst, the West Troms Basement Complex (Fig. 1). The horst is made up of a range of Meso- and Neoproterozoic (2.9–2.6 Ga) tonalitic, trondhjemitic and anorthositic gneisses (TTG-gneisses), metasediments (2.85–1.9 Ga), and felsic, mafic and ultramafic igneous rocks (2.4–1.75 Ga) (Corfu et al., 2003; Bergh et al., 2010; Myhre et al., 2011, 2013). The ductile deformation is the result of a complex tectonic history in the region, covering a large time span (Bergh et al., 2010). The host-rocks of the TTG-gneisses were tonalites metamorphosed and deformed during a Neoproterozoic orogenic event (2.69–2.56 Ga; Myhre et al., 2013), producing a main N–S-striking gneissic foliation with variable dip, intrafolial ductile shear zones and tight folds (Bergh et al., 2010). This event was followed by crustal extension and mafic dyke intrusions (2.40 Ga). The main architecture of the TTG-gneisses and metasediments was the result of a major orogenic event, the Svecofennian, in the Palaeoproterozoic (1.9–1.75 Ga), which included (Fig. 2): (i) tight to isoclinal, NW–SE-trending folds with moderate plunges and SW-dipping, mylonitic, ductile shear zones formed by NE–SW crustal shortening (D1 event), (ii) regional NW–SE-trending, open to tight upright folding of



**Figure 2.** Schematic geometric/kinematic model (not to scale) for the development of Svecofennian structures observed in the WTBC. Early-stage formation of NE-directed thrusts and a low-angle main mylonitic foliation in the metasediments was continued by orthogonal NE–SW contraction that produced upright macro-folds with steep limbs. Late-stage Svecofennian tectonism involved NE–SW orthogonal and/or oblique to orogen-parallel contraction (NW–SE) and mostly sinistral strike-slip reactivation of steep macro-fold limbs, e.g., in the Senja Shear Belt. The eastern, more flat-lying, macrofold hinges accommodated NW–SE shortening and SE-directed thrusting. From Bergh et al. (2010). Abbreviations: Ab=Astridal belt, Tb=Torsnes belt.

the mylonitic foliation (D2 event), (iii) steeply N-plunging sinistral shear folds and associated, steep, conjugate, NNW–SSE and NW–SE-trending, ductile strike-slip shear zones of regional significance (D3 event) and (iv) NE–SW-trending upright folds, SE-directed ductile thrust faults and NE–SW and ESE–WNW-trending, semi-ductile, strike-slip shear zones that formed synchronously, but orogen-parallel relative to the D3 event in the northern part of the WTBC.

The metasupracrustal belts consist of various metaconglomerates, metapsammites, mica schists and mafic to intermediate meta-volcanic rocks (Zwaan, 1989; Pedersen, 1997; Motuza et al., 2001). They dominantly trend NW–SE and some may be traced for tens of kilometres along strike, while others define folded, discontinuous inliers or dismembered enclaves that obliquely truncate the Neoarchaeal foliation in the surrounding gneisses (Bergh et al., 2010). The Svecofennian deformation of the metasupracrustal belts produced similar structures in the adjacent TTG-gneisses (cf., Armitage & Bergh, 2005).

The Senja Shear Belt (Zwaan, 1995; Bergh et al., 2010) defines a network of such metasupracrustal belts that are thought to constitute a Palaeoproterozoic terrane boundary. This more than 30 km-wide shear belt is delimited from the surrounding TTG-gneisses by the Svanfjellet metasupracrustal belt in the southwest and the Torsnes metasupracrustal belt in the northeast (Fig. 3). Internally, several separated, metasupracrustal belts and inliers, including the Astridal and Nøringen belts, are sandwiched between granitic and mafic TTG-gneisses. The widths of the belts vary along strike, and anastomosing and lens-shaped ductile shear zones can be traced into the surrounding gneisses. The dominant fabric of the Astridal belt is a mylonitic foliation aligned axial-planar to isoclinal folds (D1), which is macrofolded into upright antiforms and synforms (D2), and later folded by steeply plunging, mostly sinistral drag folds (D3) (Fig. 3; Bergh et al., 2010). Shear zones along the Astridal belt contacts to neighbouring granitic gneisses define macroscale, sinistral duplexes that are affected by a steeply plunging, sinistral macrofold in the north at Baltsfjorden (Fig. 3). The Astridal belt can be traced from Baltsfjorden along the coastline towards Nøringen (Figs. 3, 4), where narrow bands of metavolcanic and metapsammitic rocks and intercalated ultramafic lenses dominate (Pedersen, 1997). Internally, the ultramafic lenses define sinistral duplexes and comprise multiple and cross-cutting, smaller, ductile shear zones, both sinistral and dextral types (Fig. 4). The Torsnes belt on Kvaløya (Fig. 3) trends NW–SE and is folded into a macroscale, upright synform (D2) and affected by subvertical folds and sinistral strike-slip shear zones (D3). The N–S-trending foliation of the adjacent TTG-gneisses is notably bent into parallelism with the Torsnes belt. An associated subvertical macrofold (D3) in the neighbouring gneisses is present farther north, on the islands of Sommarøya and Hillesøya (Fig. 3; Thorstensen, 2011).

The overall NW–SE structural trend in the WTBC is largely parallel with the Archaean and Palaeoproterozoic orogenic belts of the Fennoscandian Shield east of the Scandinavian Caledonides, that stretch from the Kola Peninsula through Finland and Sweden into the Bothnia basin of central Sweden (Gaal & Gorbachev 1987; Hölttä et al., 2008; Lahtinen et al., 2008; Bergh et al., 2014). Despite its position as a basement outlier west of the Caledonides, the younger Caledonian overprint is generally weak within the WTBC, but is possibly manifested as arc-shaped refolding and SE-directed thrust zones (Corfu et al., 2003; Bergh et al., 2010).

#### *Caledonian nappes*

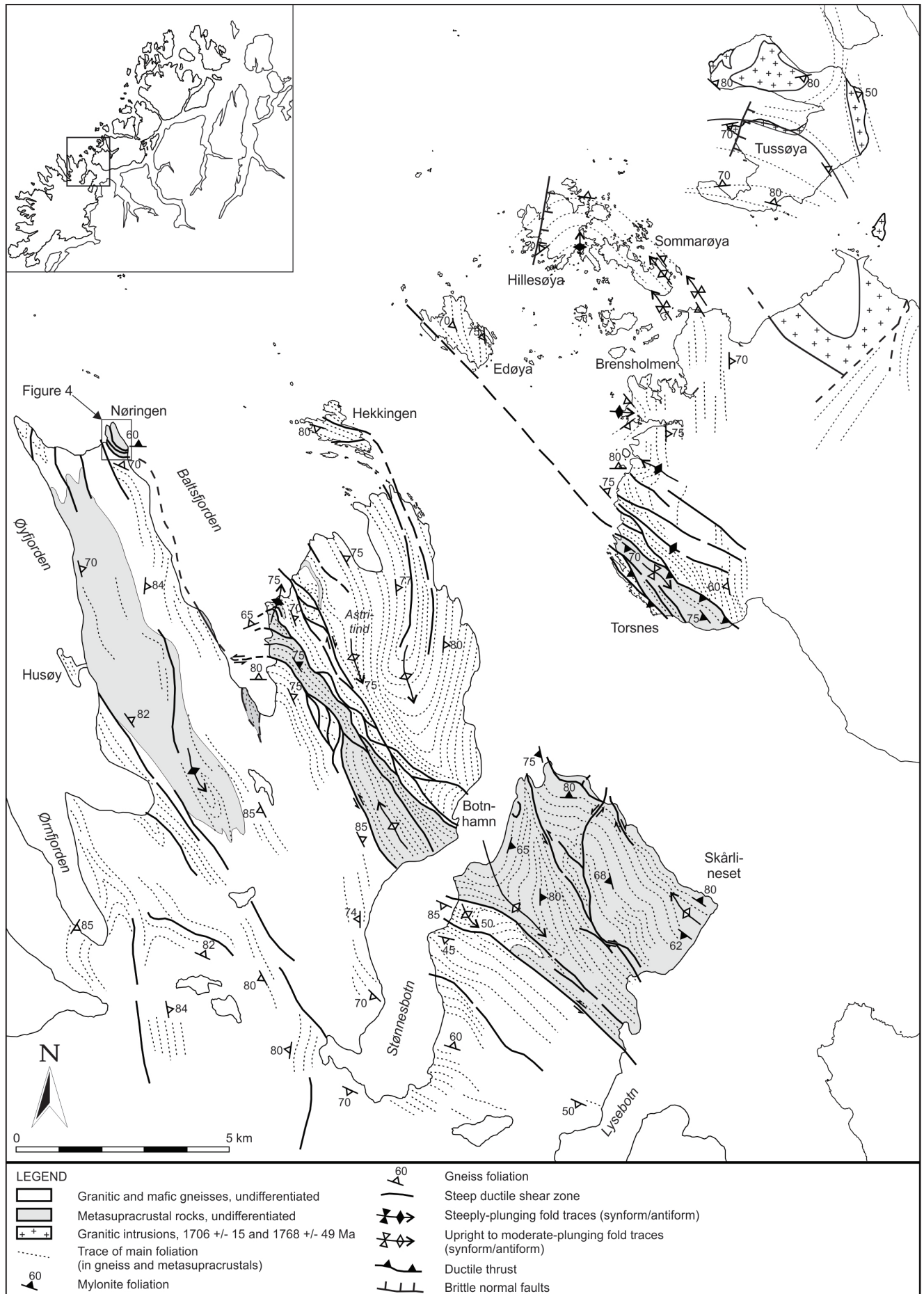
In the Mid Palaeozoic, a collision between Laurentia and Baltica led to the accretion of thrust nappes with a distinct tectonostratigraphy consisting of the Lower, Middle, Upper and Uppermost Allochthons, and their southeastward to eastward translation of up to several hundreds of kilometres as a part of the Scandian phase of the Caledonian Orogeny (e.g., Roberts & Gee, 1985; Roberts, 2003). The Caledonian rocks in northern Troms and western Finnmark are characterised by gently NW-dipping, well-foliated thrust nappes and some large-scale folds. Within the study area, the islands of Nord-Fugløy and Arnøya comprise units belonging to the Caledonian Kalak Nappe Complex (Middle Allochthon); these consist mainly of gently NW-dipping garnet-mica schists and marble units (Roberts, 1974).

#### *Post-Caledonian structures*

The Late Palaeozoic–Mesozoic rift-related activity on the west Troms margin (Figs. 1, 5) (Gabrielsen et al., 1990; Davids et al., 2013) is outlined by widespread NNE–SSW and ENE–WSW-trending, brittle normal faults that constitute at least two major fault complexes, the Vestfjorden–Vanna and the Troms–Finnmark fault complexes (Gabrielsen, 1984; Gabrielsen et al., 1990, 2002; Olesen et al., 1997; Indrevær et al., 2013), and a subsidiary NW–SE-trending transfer fracture system (cf., Indrevær et al., 2013) (Fig. 5). The onshore fault zones can be divided into the Vestfjorden–Vanna Fault Complex (VVFC), which marks the southeastern boundary of the WTBC, down-dropping the Caledonian nappes to the east in the order of 1–3 km (Forslund, 1988; Opheim & Andresen, 1989; Olesen et al., 1997), and a less prevalent, SE-dipping fault system that runs along the outer rim of the islands of the WTBC (Fig. 1) (Antonsdottir, 2006; Thorstensen, 2011; Indrevær et al., 2013) with displacements in the order of hundreds of metres or less (Indrevær et al., 2013).

*Figure 3. Tectonic map of the Senja Shear Belt in northeastern Senja and southwestern Kvaløya, illustrating the lens-shaped architecture of the Astridal and Torsnes belts. Note macro-scale folds in the adjacent tonalitic gneisses where fold hinges are rotated into parallelism with the trace of the Astridal belt. The map is modified from Nyheim et al. (1994), Pedersen (1997), Zwaan et al. (1998), Corfu et al. (2003) and Bergh et al. (2010).*





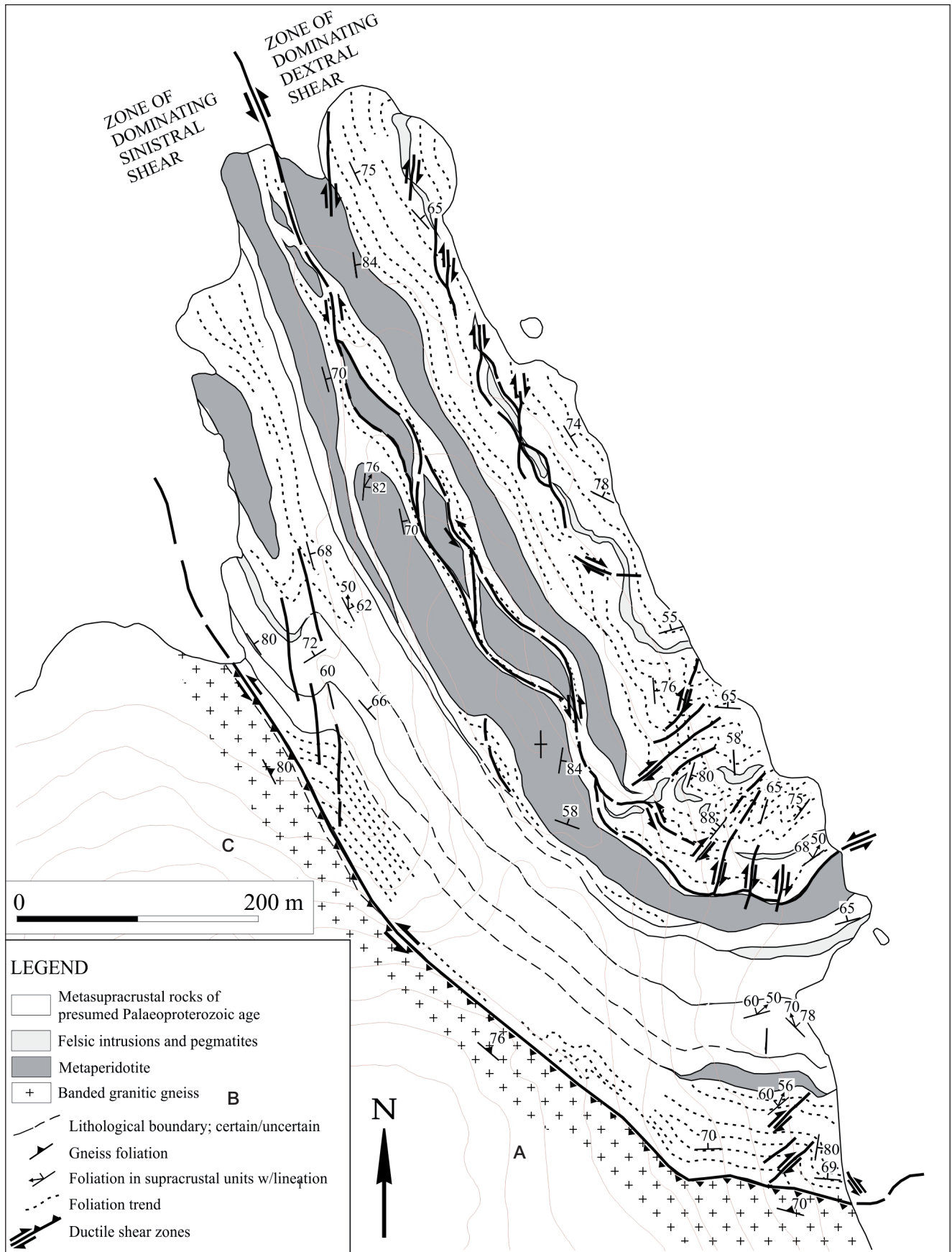


Figure 4. Detailed geological and structural map covering the metasupracrustal rocks that crop out at Nøringen. Note how metaperidotites are sinistrally duplexed. Simplified from Pedersen (1997).



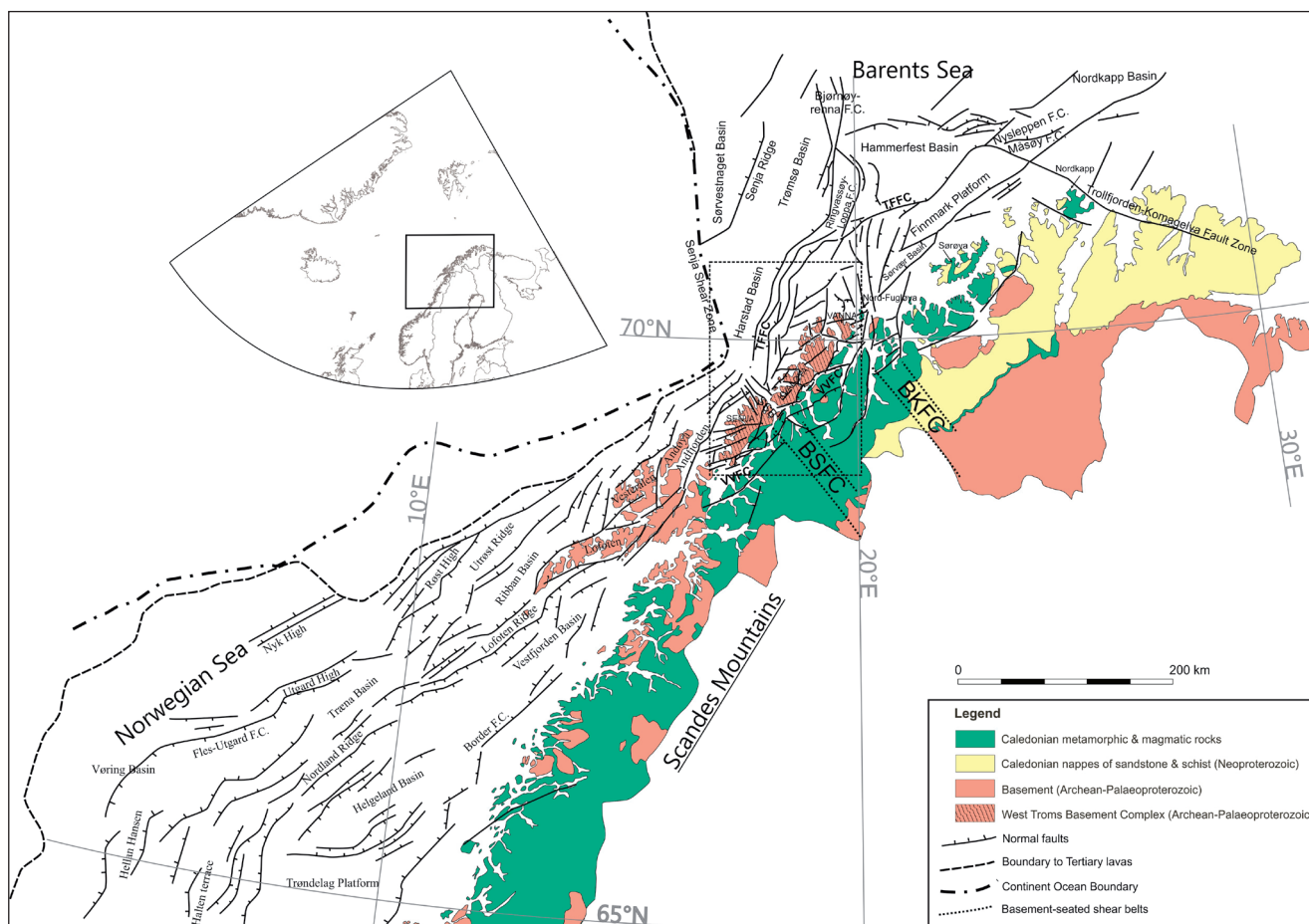


Figure 5. Regional onshore-offshore tectonic map and setting of the Lofoten-Vesterålen archipelago and the SW Barents Sea margin (after Blystad et al., 1995; Mosar et al., 2002; Bergh et al., 2007a; Faleide et al., 2008; Hansen et al., 2012; Indrevær et al., 2013). Onshore geology is from the Geological Survey of Norway. Areas of focus are outlined. Abbreviations: BKFC=Bothnian-Kvænangen Fault Complex, BSFC=Bothnian-Senja Fault Complex, TFFC=Troms-Finnmark Fault Complex, VVFC=Vestfjorden-Vanna Fault Complex.

Offshore, the Troms-Finnmark Fault Complex is the dominant, basin-bounding, fault complex and defines the northwestern limit of the WTBC, down-faulting basement rocks from 4–5 km depth on the Finnmark Platform to possibly more than ~10 km depth in the Harstad Basin (Fig. 2) (cf., Gabrielsen, 1984; Gabrielsen et al., 1990; Indrevær et al., 2013). The Troms-Finnmark and Vestfjorden-Vanna fault complexes (Fig. 5) can be traced for hundreds of kilometres along strike along the North-Norwegian continental margin, linking up major horst-bounding structural elements in the south, such as the Lofoten and Nordland Ridges, with offshore fault complexes in the north, such as the Ringvassøy-Loppa, Nysleppen and Måsøy fault complexes (c.f., Gabrielsen et al., 1990; Doré et al., 1997, 1999; Olesen et al., 1997; Indrevær et al., 2013). The margin is segmented along strike by at least two major transfer fault systems, the Senja Shear Zone and the Fugløy transfer zone, the possible continuations of the Proterozoic-Palaeozoic, Bothnian-Senja (and Senja Shear Belt) and the Bothnian-Kvænangen fault complexes, respectively (Berthelsen & Marker, 1986; Gaal & Gorbachev, 1987; Olesen et al., 1990;

Henkel, 1991; Doré et al., 1997; Olesen et al., 1997; Hölttä et al., 2008; Lahtinen et al., 2008; Indrevær et al., 2013; Bergh et al., 2014).

#### Geomorphology of the strandflat

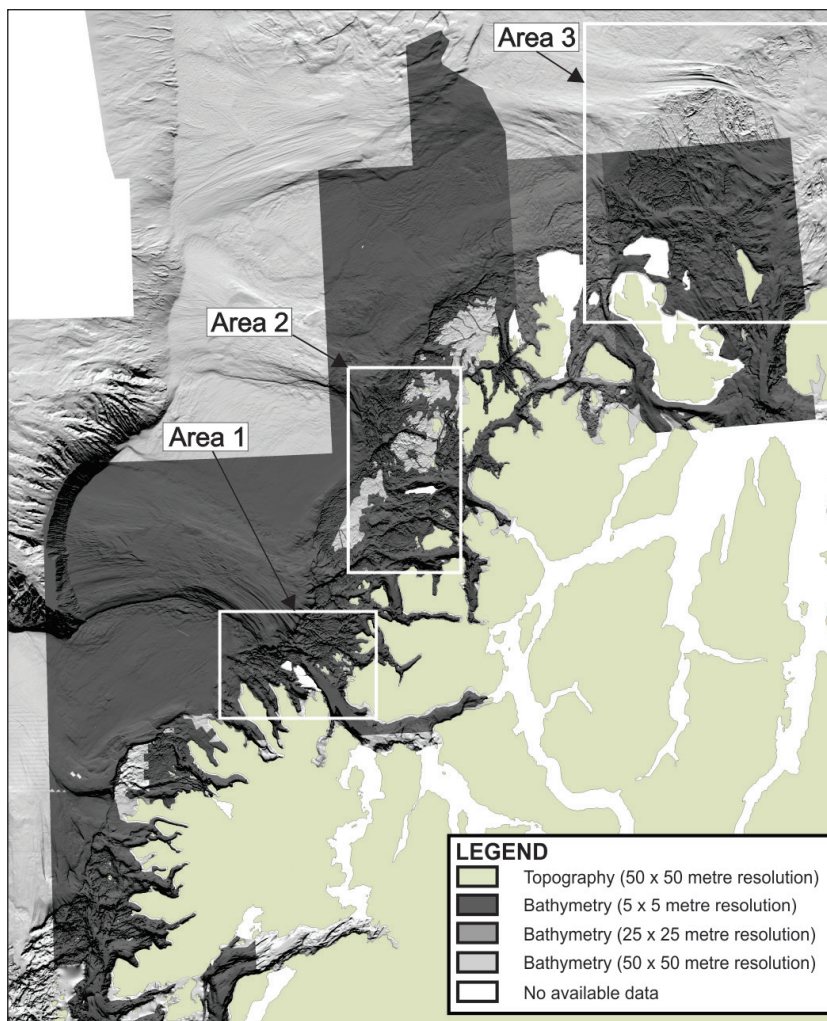
The strandflat along the Norwegian coast is manifested as a horizontal to gently dipping, low-relief surface that typically ranges in elevation from about 40 metres below sea level to a maximum of 100 metres above sea level (cf., Corner, 2005). The strandflat is composed of highly dissected bedrock commonly draped by a thin layer of Holocene sediments. It is present along large portions of the coast, from Stavanger in the south to Nordkapp in the north, and may locally reach 60 km in width. The origin of the strandflat has been widely discussed in the literature (e.g., Reusch, 1894; Nansen, 1922; Asklund, 1928; Dahl, 1947; Büdel, 1978; Larsen & Holtedahl, 1985; Olesen et al., 2013). Several models for its origin have been proposed, including one where the strandflat may represent a surface of pre-Cretaceous age that formed due to tropical weathering (Asklund, 1928; Büdel, 1978; Olesen et al., 2013). There seems, however, to be

a common consensus that the strandflat formed from a combination of frost weathering, sea-ice erosion and marine abrasion during the Quaternary (Reusch, 1894; Nansen, 1922; Dahl, 1947; Larsen & Holtedahl, 1985), most likely re-excavating a pre-Cretaceous etch plain by the removal of easily erodible weathered bedrock (cf., Olesen et al., 2013).

In western Troms and Finnmark, the strandflat is at present mainly a submarine feature, varying in width from 2 km outboard of northern parts of Senja up to 30 km north of Nord-Fugløya (Fig. 1). The strandflat is delimited in the east by the high relief, alpine landscape of the outer islands of Troms, with a topography reaching >1000 m above sea level. The western limit of the strandflat is defined by the abrupt, steeper slopes that separate the strandflat from the bankflat area, which defines the continental shelf from the strandflat towards the continental break (Corner, 2005). The bankflat outboard Troms is characterised by thick glacial deposits forming a glacially controlled morphology comprising troughs and banks (Fig. 1, cf., Rydningen et al., 2013).

## Methods and databases

The 5 x 5 m resolution dataset covers most of the strandflat off the coast of Troms (~4600 km<sup>2</sup>), from Senja in the south to Vanna in the north. Minor areas are provided with 25 x 25 m and 50 x 50 m resolution only and a few areas, especially close to shore and in regions with shallow water depths, have no data available at all (Fig. 6). The strandflat outboard Troms seems well suited for a case study like this due to (i) the wide zone of submerged strandflat along this portion of the coast, (ii) the profusion of available high-resolution bathymetry data covering the strandflat, (iii) the relatively well understood onshore basement geology of the outer islands of Troms, including both ductile and brittle deformation features (Zwaan, 1995; Corfu et al., 2003; Bergh et al., 2010; Myhre et al., 2011; Indrevær et al., 2013, 2014) and (iv) the overall margin-perpendicular, NW–SE, structural and lithological trends of the heterogeneous Precambrian bedrock (e.g., Bergh et al., 2010), thus providing an excellent framework for onshore-offshore structural analysis.



*Figure 6.* Overview of the available bathymetry data and its resolution. Note that there are several gaps in the 5 x 5 m resolution dataset covering the strandflat.



The data have been used to produce dip maps, profiles, shadow relief maps (3D-view) and aspect maps in order to highlight morphological features. The aspect maps consider only slopes that dip more than 5°, where the slope direction for each data point is calculated based on the immediately neighbouring data points (3 x 3 window). Aerial photographs have been used to map and interpret morphology on smaller islands and skerries. Geological maps from NGU and other detailed studies (Pedersen, 1997; Armitage, 2007; Bergh et al., 2010) have been used to compare and evaluate features visible on the high-resolution bathymetry data with nearby onshore basement structures.

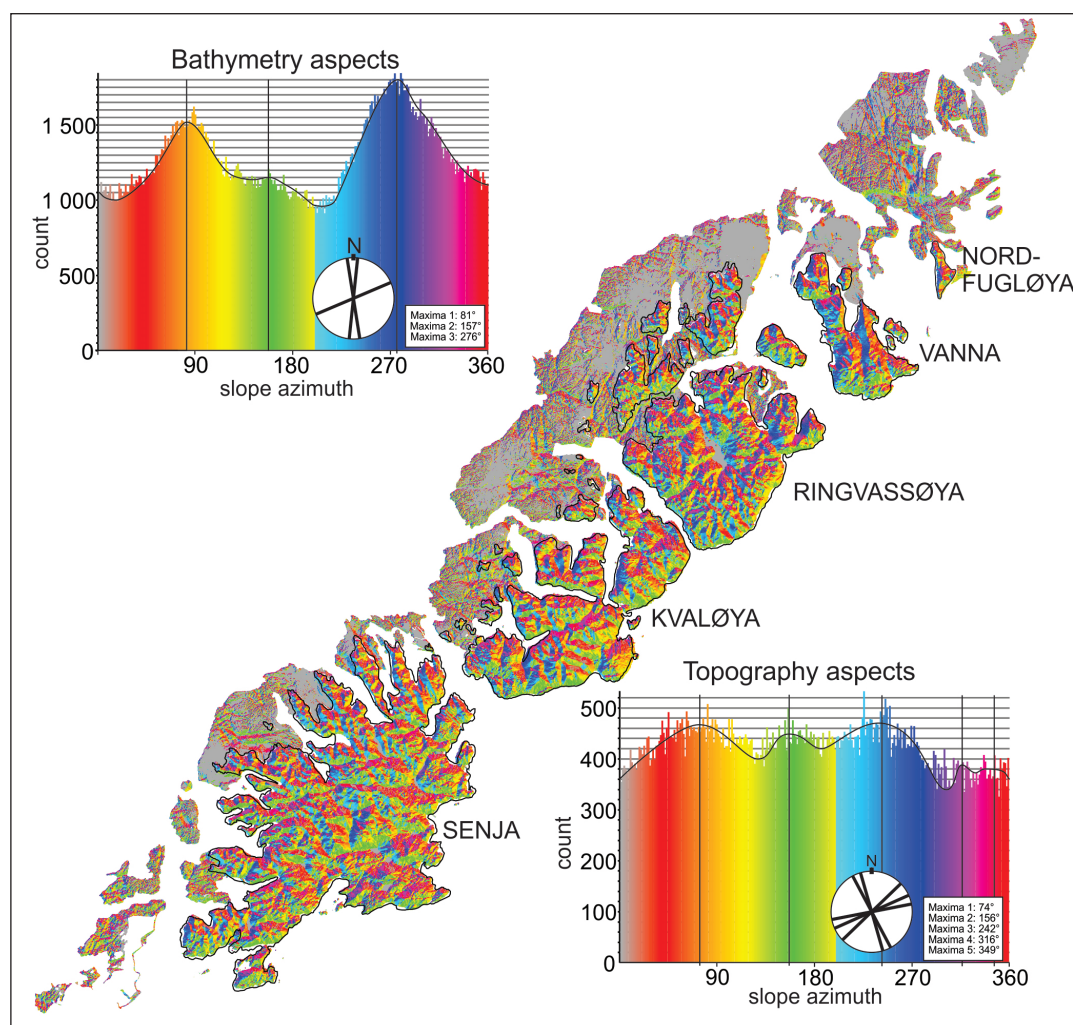
## Results

### Regional slope aspect analysis

Aspects for surface slopes dipping more than 5° covering the entire WTBC horst and the outboard subsea strandflat (Fig. 5) show that the island of Senja is dominated by

NE–SW-striking slopes, except in its northern portion where NW–SE-trending slopes are common, clearly reflected by the NW–SE-trending fjords that spatially overlap with the basement gneiss foliation and the Senja Shear Belt (Figs. 1, 7). The islands of Kvaløya and Ringvassøya are, in general, dominated by NNE–SSW to ENE–WSW-striking slopes, while the Vanna island is characterised by ~N–S-trending larger ridges (Fig. 7). The combined aspect values of all islands within the WTBC reveal that the onshore slope topography is dominated by NW–SE and NE–SW to E–W-striking slopes (Fig. 7).

The morphology of the strandflat shows, as expected, a much lower relief and slope variation than in the onshore topography, with much of the strandflat being characterised by slopes that dip less than 5°. Of steeper slopes, N–S and ENE–WSW-striking slopes dominate, including a minor maximum of slopes striking NNW–SSE (Fig. 7). The latter population of slopes is more common outboard of the northern parts of Senja and northwest of Nord-Fugløya.



**Figure 7.** Aspect analysis of slopes steeper than 5° for the outer islands of Troms and the strandflat. Bathymetry (strandflat) aspects and topography aspects are shown separately (black lines indicate a running average of the aspects). Circular insets represent simplified rose diagrams. The analysis shows that N–S and NE–SW-trending slopes are common on the strandflat, whereas NW–SE and NE–SW to E–W-trending slopes are common onshore. These orientations are the same as orientations that dominate both ductile and brittle structures onshore.

Comparing onshore and offshore aspect values reveals that slopes of very similar orientations dominate both the bathymetry and the topography, indicating that there are at least some common aspects to the controlling elements of terrain-forming processes on the strandflat and on land.

#### *Morphotectonic elements on the strandflat*

On a regional scale, the strandflat within the study area is more or less continuous along the outer coast of the WTBC, interrupted only by a few, up to 200 m-deep, ~E–W-trending trenches located at the mouths of sounds and fjords, carved out by glaciers that extended from inland and fed large glacial ice streams during previous glacial periods (Fig. 1; Vorren et al., 1983; Dahlgren et al., 2005; Rydningen et al., 2013). On a local scale, the strandflat is dissected by relatively less common trenches that define the outer boundaries of basement blocks and which internally show a lower relief variation, commonly defined by smaller, linear to curved, parallel ridges and truncating trenches.

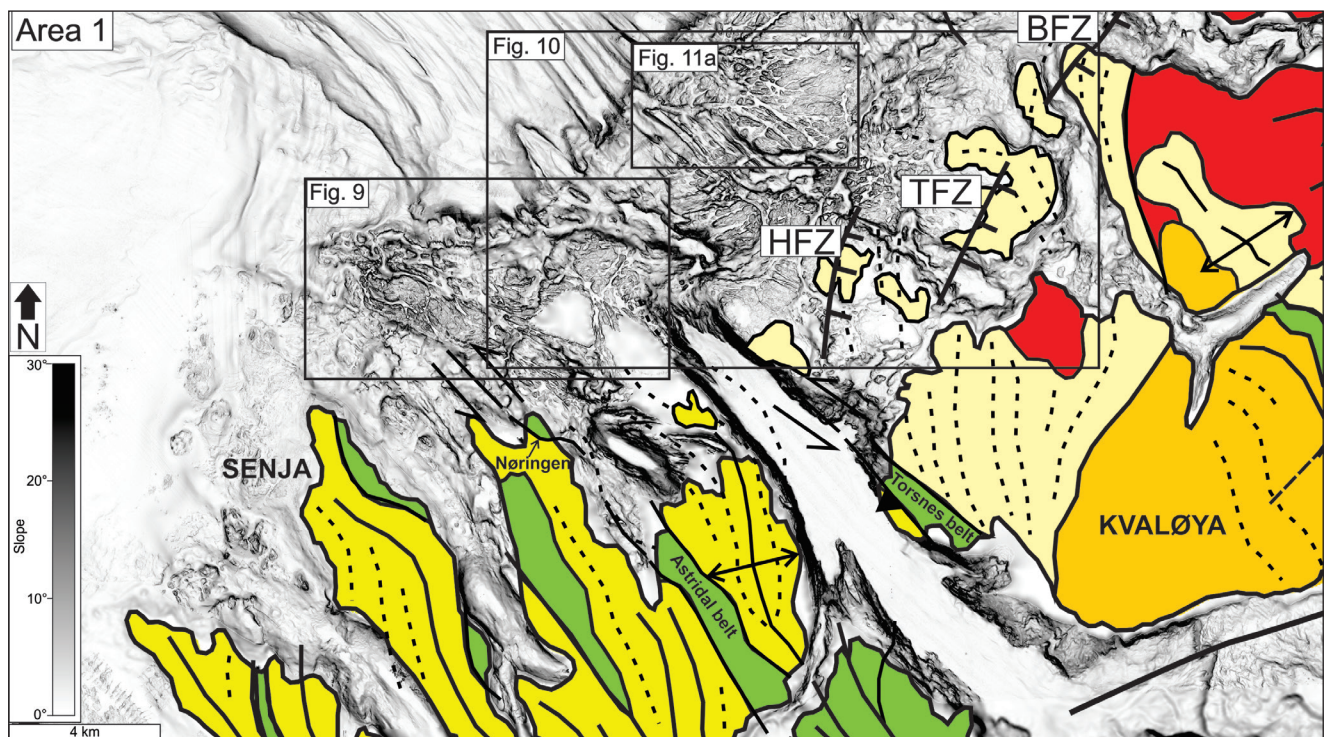
Here, we describe in detail three areas of the strandflat in western Troms and Finnmark (Fig. 1) that cover key morphotectonic elements that may be used to characterise this portion of the SW Barents Sea margin.

#### *Area 1*

##### **Local onshore geology**

Area 1 (Fig. 8) covers the northwestern parts of Senja and southwestern parts of Kvaløya. Onshore, the geology is dominated by N–S-trending, foliated, Neoarchaean TTG-gneisses, locally with intercalations of the Ersfjord granite, several NW–SE-trending, meta-supracrustal belts, including the Astridal, Nøringen and Torsnes belts, and ductile shear zones belonging to the Svecofennian Senja Shear Belt (Figs. 3, 8; Zwaan, 1995; Bergh et al., 2010).

Post-Caledonian brittle structures within Area 1 include the Bremneset, Tussøya and Hillesøya fault zones (Figs. 3, 8), which are a part of the SE-dipping fault system that runs along the outer rim of the WTBC islands. The Tussøya fault zone (Indrevær et al., 2013, 2014) defines a normal-oblique sinistral fault that dips moderately ESE and separates granitic TTG-gneisses in the footwall from banded mafic and felsic gneisses in the hanging wall. The Hillesøya fault zone (Fig. 8; Thorstensen, 2011; Indrevær et al., 2013) consists of several ENE-dipping faults that merge into a subsidiary ENE-dipping fault set. The fault zone is located on the steep northwestern limb of a subvertical macrofold on the islands of Sommarøya and Hillesøya (Thorstensen, 2011; Indrevær et al., 2013). Farther north, the Bremneset fault zone dips ESE and can be traced along the shore for c. 200 metres, cutting through migmatitic TTG-gneisses of the Kattfjord Complex (Fig. 8; Indrevær et al., 2013, 2014).



**Figure 8.** Overview of Area 1 covering the strandflat outboard of northern portions of Senja and the southeastern parts of Kvaløya. Onshore geology from Bergh et al. (2010). Figs. 9, 10 and 11a are outlined. Abbreviations: BFZ=Bremneset fault zone, HFZ=Hillesøya fault zone, TFZ=Tussøya fault zone.



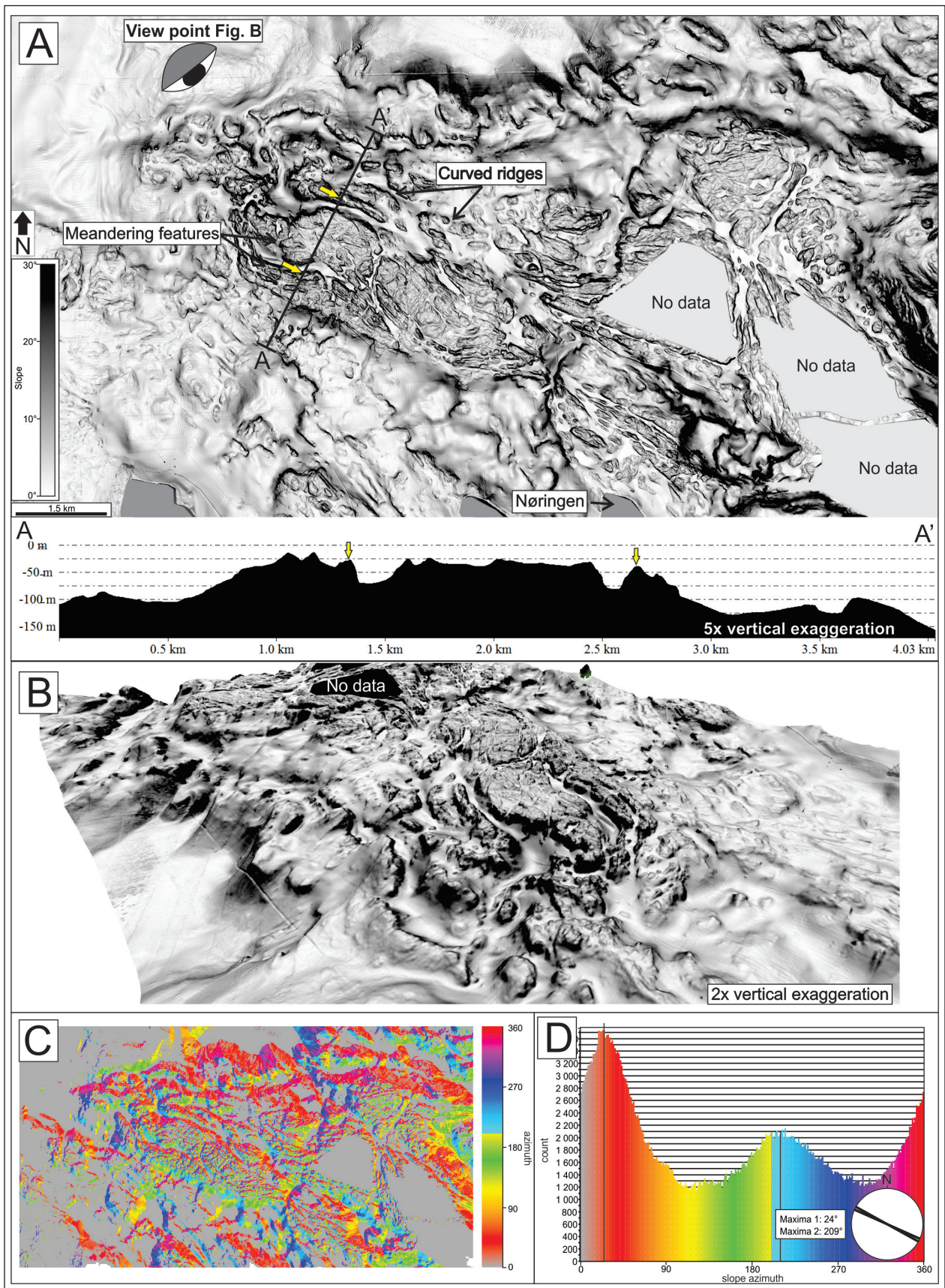


Figure 9. Detailed illustrations of the strandflat within Area 1 (see Fig. 8 for location). (A) Dip map covering the strandflat with location of cross-section given and shown below. Yellow arrows indicate points of reference. Note the NW–SE-trending meandering feature. The viewpoint for the 3D illustration is marked. (B) 3D bathymetry illustration of the subarea, which highlights the meandering nature of the seabed morphology. (C) Aspect map and (D) histogram showing the preferred dip direction for slopes steeper than 5°. The preferred strikes of slopes from the aspect analysis are shown in the small circular inset (simplified rose diagram).



### *Morphotectonic elements on the strandflat*

The strandflat northwest of Nøringen (Fig. 9), is dominated by lens-shaped, flat-topped plateaus and ridges surrounded by anastomosing, 25–50 m-deep and internally smooth depressions that have a distinct NW–SE trend (Fig. 9A, B). These anastomosing features are well displayed on the aspect map of slope directions in the area (Fig. 9C). E–W-trending parallel ridges (red aspect values) to the north truncate and/or curve into parallelism with the anastomosing NW–SE features. A few, more or less developed, NNE–SSW-trending, sub-linear trenches (blue aspect values) cut the anastomosing features and curved ridges. Aspect analysis of seabed slopes shown on the map (Fig. 9C) and slope azimuth histograms (Fig. 9D), with dips exceeding 5°, reveal that slopes trending NW–SE dominate the morphology on the seabed.

The strandflat in the northern part of Area 1 (Figs. 8, 10) shows NW–SE-trending, linear to curved, parallel ridges in the northwest that may be traced for 20 km from the Torsnes Belt in the southeast (Fig. 10). The elongated ridges are typically 1–30 m high and 100–500 m wide (Fig. 10A, cross-sections). Northwest of Edøya, these ridges curve into a macroscale z-shaped feature before continuing northwestwards. Close to the outer edge of the strandflat, these parallel ridges are obliquely truncated by an E–W-trending trench that apparently displaces the morphotectonic pattern, thus defining a boundary towards a portion of the strandflat that is characterised by rounded knobs rather than elongated ridges (Figs. 10A, 11A). Outside the zone of parallel ridges, cross-cutting trenches and a chaotic assembly of irregular, commonly rectangular depressions dominate the strandflat (Fig. 10A). The depressions have variable trends NNE–SSE to ENE–WSW and NW–SE, as illustrated by the aspect map (Fig. 10C). Aspect analysis of slopes with dips >5° shows that slopes trending NW–SE (red and blue aspect values) dominate the seabed morphology within the area (Fig. 10D). Onshore aspects (Fig. 10D; black line) show a larger variation in trends than offshore aspects, which include NE–SW trends, but reveals that slopes striking NW–SE are common also onshore.

### **Interpretation**

The anastomosing, morphotectonic feature visible northwest of Nøringen (Fig. 9) shows a similar geometry as the sinistral duplexes observed onshore in lenses of foliated granitic gneisses of the Astridal belt (Fig. 3) and ultramafic rocks in the metasupracrustal units of the Nøringen belt (Fig. 4), including an apparent sinistral displacement of the lense along a curved lineament. The anastomosing feature is therefore interpreted as a sinistrally duplexed lens (D3) (Fig. 11B). Based on the direct bathymetric link of this feature along the seabed to Nøringen (Fig. 9A), the feature is interpreted to be the offshore continuation of the Palaeoproterozoic Astridal belt, or alternatively a separate metasupracrustal inlier of the TTG-gneisses, which is a common feature within the Senja Shear Belt. The outline of this zone on the strandflat is overall similar in trend and width to the

onshore metasupracrustal belts, supporting the above interpretation. To the northeast of this zone, distributed elongated ridges and depressions are considered to reflect the exposed TTG-gneiss foliation. The gneissic foliation is transposed and/or tight to isoclinally folded and modified along the contact to the metasupracrustal belt in a similar manner as observed onshore along the Astridal belt (Fig. 3), suggesting a sinistral sense of shear (Fig. 11B).

The zone of NW–SE-trending, elongated and parallel ridges in the northern part of area 1 (Fig. 10) can be traced directly southeastward into the Torsnes metasupracrustal belt. Thus, these ridges may represent the offshore continuation of the upright macrofolded (D2) units of the Torsnes belt (Fig. 11C). This linkage is supported by the fact that metasupracrustal rocks partly step onshore on Edøya (Zwaan et al., 1998). Northwest of Edøya (Fig. 11C), the macroscale z-shaped curvature of the belt is interpreted as a subvertical macrofold (D3) formed by NW–SE-directed, sinistral ductile shearing along the boundaries of the Torsnes belt. A similar, but more localised, Svecofennian, ductile shear zone may be present on the northern limb of this macrofold, merging southeastward just east of Hillesøya (Fig. 11C). Close to the edge of the strandflat, the presumed continuation of the Torsnes belt is truncated by an E–W-trending lineament separating homogeneous rocks in the north from the well-foliated rocks in the south (Fig. 11A, C). This lineament is interpreted as either a ductile shear zone that displaced portions of the Torsnes belt, or a lithological, intrusive contact. Granitoid intrusive rocks of both Archaean and Svecofennian age are common within the TTG-gneisses (Andresen, 1980; Corfu et al., 2003) where they truncate ductile Svecofennian fabrics and shear zones (e.g., Bergh et al., 2010). Therefore, we interpret this abrupt contact to be lithological and related to some of these intrusions. This inferred granite-gneiss contact may have been tectonically reactivated during, e.g., the late-Svecofennian deformation events (Bergh et al., 2010), or alternatively during Palaeozoic–Mesozoic, brittle, normal faulting (Indrevær et al., 2013).

The linear and curved, variably trending trenches truncate many of the curved and parallel ridges and must therefore be younger (Fig. 11B, C). In general, these trenches have the same trends as known Late Palaeozoic–Mesozoic, brittle, fault zones onshore (Indrevær et al., 2013). Consequently, the linear trenches are interpreted as fault scarps, partly excavated by strandflat-forming processes. The chaotic array of rectangular to orthogonal depressions (Fig. 11C), with long axes oriented parallel to trends of brittle faults, can tentatively be interpreted as smaller basins delimited by normal faults.

In summary, Area 1 shows morphotectonic elements interpreted to be the offshore continuation of two metasupracrustal belts, the Astridal/Nøringen belt and the Torsnes belt. In addition, the inferred ductile structures are truncated by NNE–SSW and ENE–WSW-trending trenches that are interpreted as Late Palaeozoic–Mesozoic, brittle normal faults.



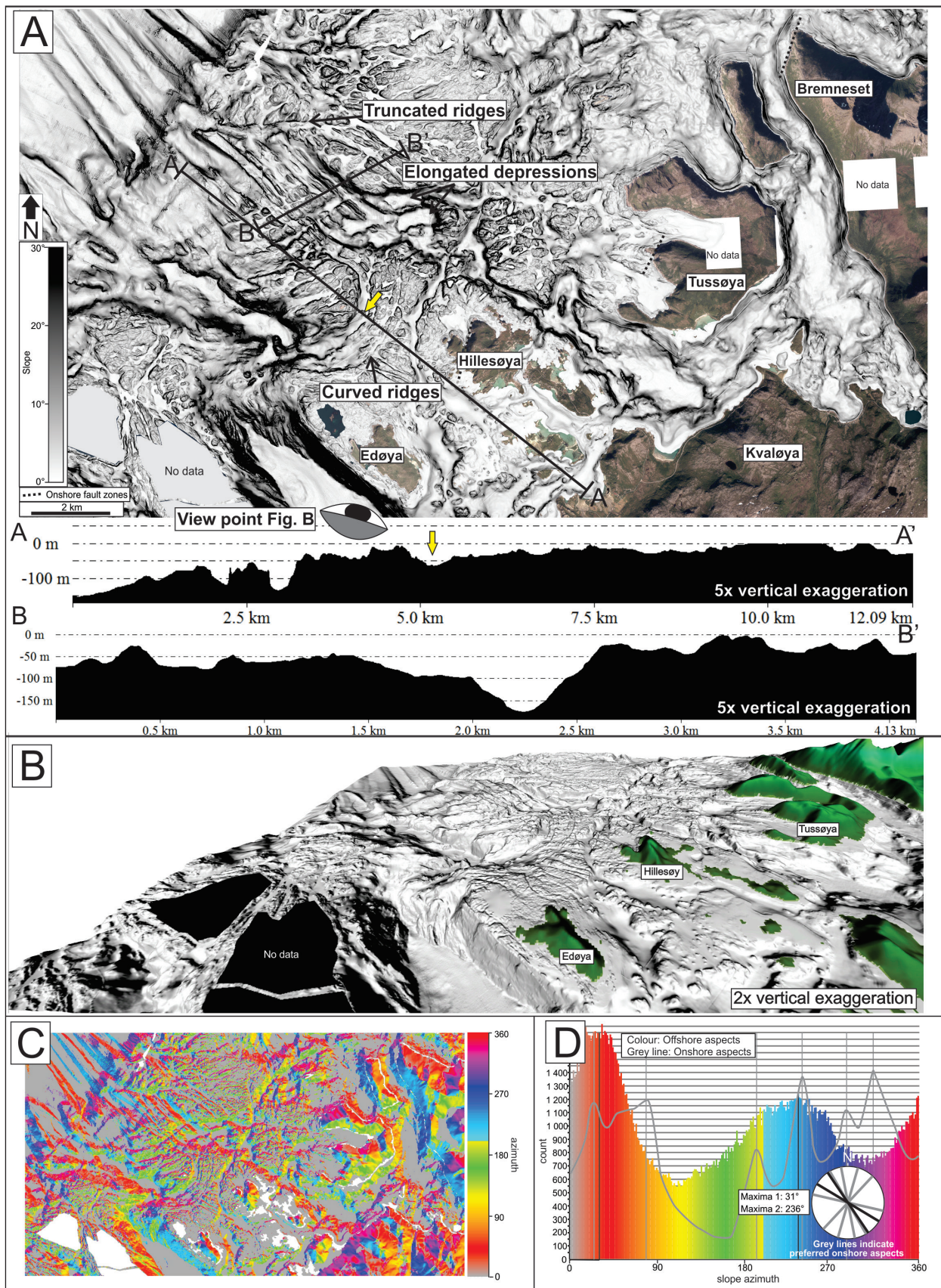
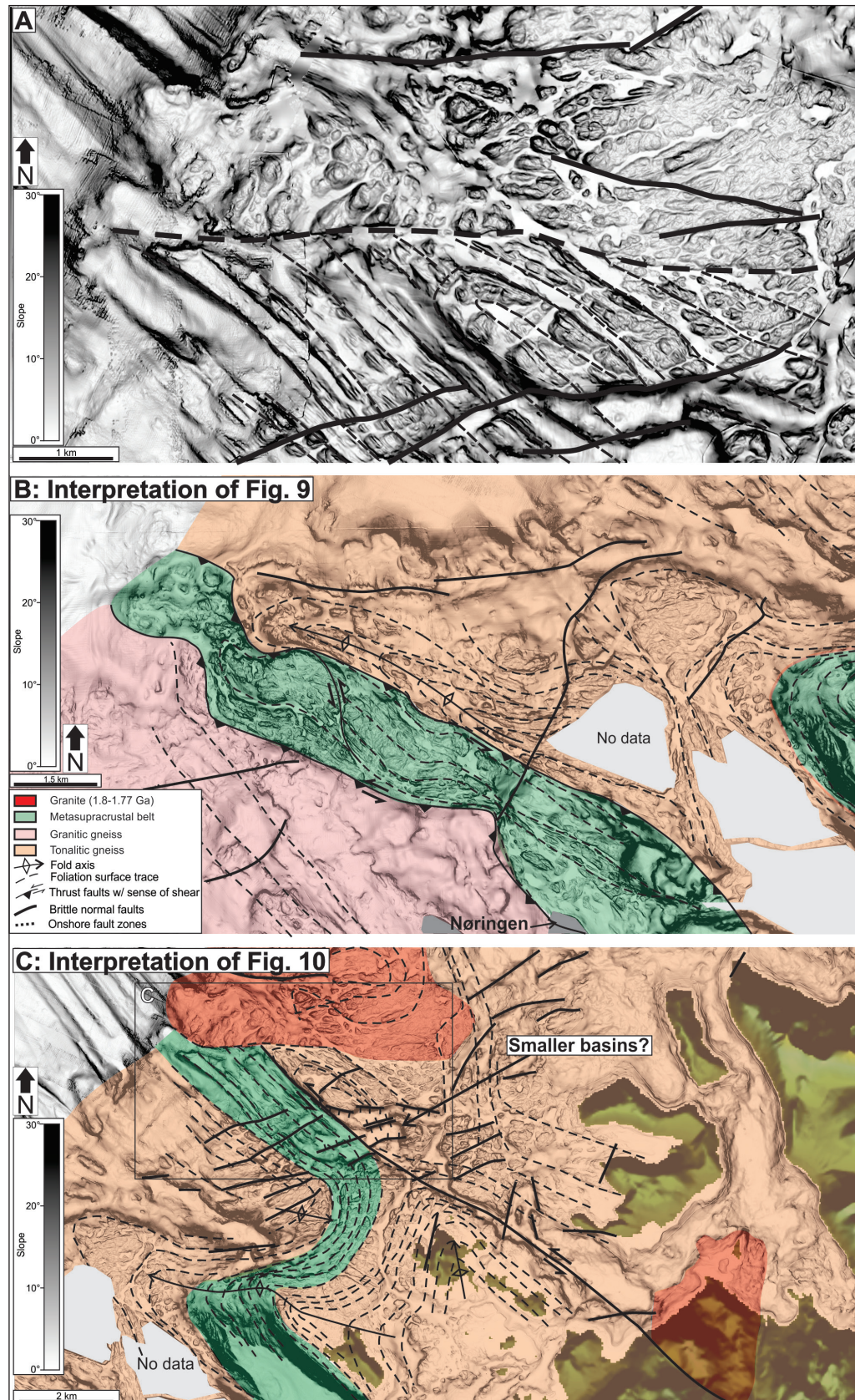


Figure 10. Detailed illustrations of the strandflat within Area 1 (see Fig. 8 for location). (A) Dip map bathymetry data covering the strandflat with onshore portions of the subarea covered by aerial photographs. Locations of cross-sections are shown and given below. Yellow arrows indicate points of reference. The viewpoint for the 3D illustration is marked. (B) 3D illustration of the subarea which highlights the continuation of the Torsnes belt with a notable rounded z-shape. (C) Aspect map and (D) histogram showing the preferred direction of dips for slopes steeper than 5°. Grey line shows the preferred aspects of the topography (not to scale along the Y-axis). The preferred strikes of slopes from the aspect analysis are shown in the small circular inset (simplified rose diagram, grey lines shows topography maxima).





**Figure 11.** Interpretative mapping of lithologies and structures covering the strandflat in Area 1 (see Fig. 8 for locations), based on correlation with known onshore structures. (A) Detailed outline of the northern portion of the offshore continuation of the Torsnes belt, which is truncated by an E-W-trending lineament, separating homogeneous and unfoliated rocks interpreted as a granitic intrusion in the north from the well-foliated rocks in the south. (B) The meandering feature visible northwest of Nøringen is interpreted as the offshore continuation of the Nøringen and Astridal belts. The belt is sinistrally duplexed (D3) and bounded by drag-folded gneiss to the north, consistent with an overall sinistral sense of shear. (C) Interpretative mapping of the northern portion of Area 1. The offshore continuation of the Torsnes belt is folded into a rounded z-shape and in the north runs parallel to a sinistral shear zone that may be traced from land.



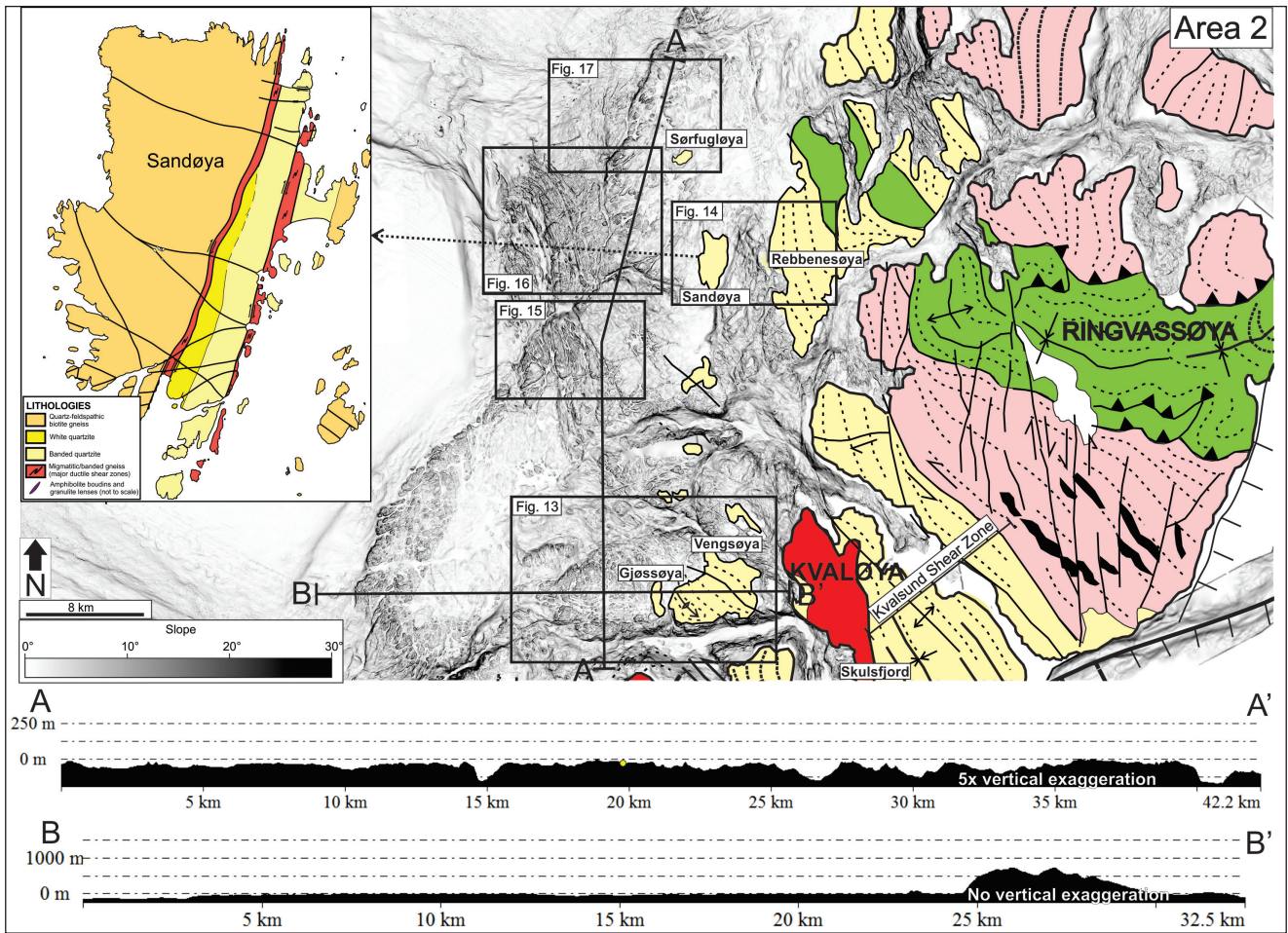


Figure 12. Overview of Area 2 covering the strandflat outboard of northern parts of Kvaløya and west of Ringvassøya, including the islands of Vengsøya, Gjøsøya, Rebbenesøya, Sandøya and Sørflugøya. Onshore geology from Bergh et al. (2010). Figs. 13–17 are outlined by boxes and the locations of two cross-sections are given and shown below. Inset: Simplified geological map of Sandøya. Note the NNE–SSW-trending quartzite layer that dominates the eastern portion of the island. From Armitage (2007).

**Area 2:**  
**Local onshore geology**

Area 2 covers the strandflat outboard of the northern parts of Kvaløya, Ringvassøya and Rebbenesøya in the central portion of the WTBC, and includes the smaller islands of Vengsøya, Gjøsøya, Sandøya and Sørflugøya (Fig. 12). The islands of Vengsøya and Gjøsøya are composed of heterogeneous TTG-gneisses and amphibolitic gneisses of the Kattfjord Complex, with intercalations of biotite schists, metapsammites, quartzites and some metavolcanic rocks (Grogan & Zwaan, 1997). On Vengsøya, the foliation is, in general, striking NW–SE and is tightly folded into a steeply plunging (D3) macrofold in the southwestern part of the island (Fig. 12; Grogan & Zwaan, 1997). On Gjøsøya, the foliation strikes NNE–SSW. Granitic intrusions are widespread both as lenses parallel to the foliation and as irregular, truncating bodies and pegmatite veins.

The islands of Ringvassøya and Rebbenesøya in the north are composed of well-foliated TTG-gneisses that have numerous intercalations of amphibolitic gneisses, and commonly cut by irregular granite intrusions (Grogan & Zwaan, 1997). The TTG-gneiss foliation on Rebbenesøya

and northern parts of Ringvassøya trends on average N–S, but is bent into a NW–SE orientation in the south, adjacent to a high-strain, migmatitic, ductile shear zone presumed to be a Neoproterozoic terrane boundary and termed the Kvalsund shear zone (Fig. 12; Myhre et al., 2013).

On the island of Sandøya, the foliation within quartz-feldspathic biotite gneisses dips steeply towards WNW (Fig. 12, inset map). A ~0.5 km-wide, foliation-parallel, quartzite layer traverses the island on its eastern side (Armitage, 2007; Gjerløw, 2008).

**Morphotectonic elements on the strandflat**

The strandflat just west of Vengsøya and Gjøsøya (Fig. 12) is characterised by a plateau surrounded by narrow, deep trenches (Fig. 13). The plateau shows an internal morphology outlined by parallel elongated ridges that trend NW–SE and curve around in a somewhat complex dome-shaped pattern (Fig. 13A, B). Minor, linear, ENE–WSW-trending trenches on the plateau truncate the curved parallel ridges. The plateau is delimited in the north by a NE–SW to ENE–WSW-trending, ~1 km wide, 50 m-deep trench and to the south by a c. 2 km-wide, ~200 m-deep, E–W-trending



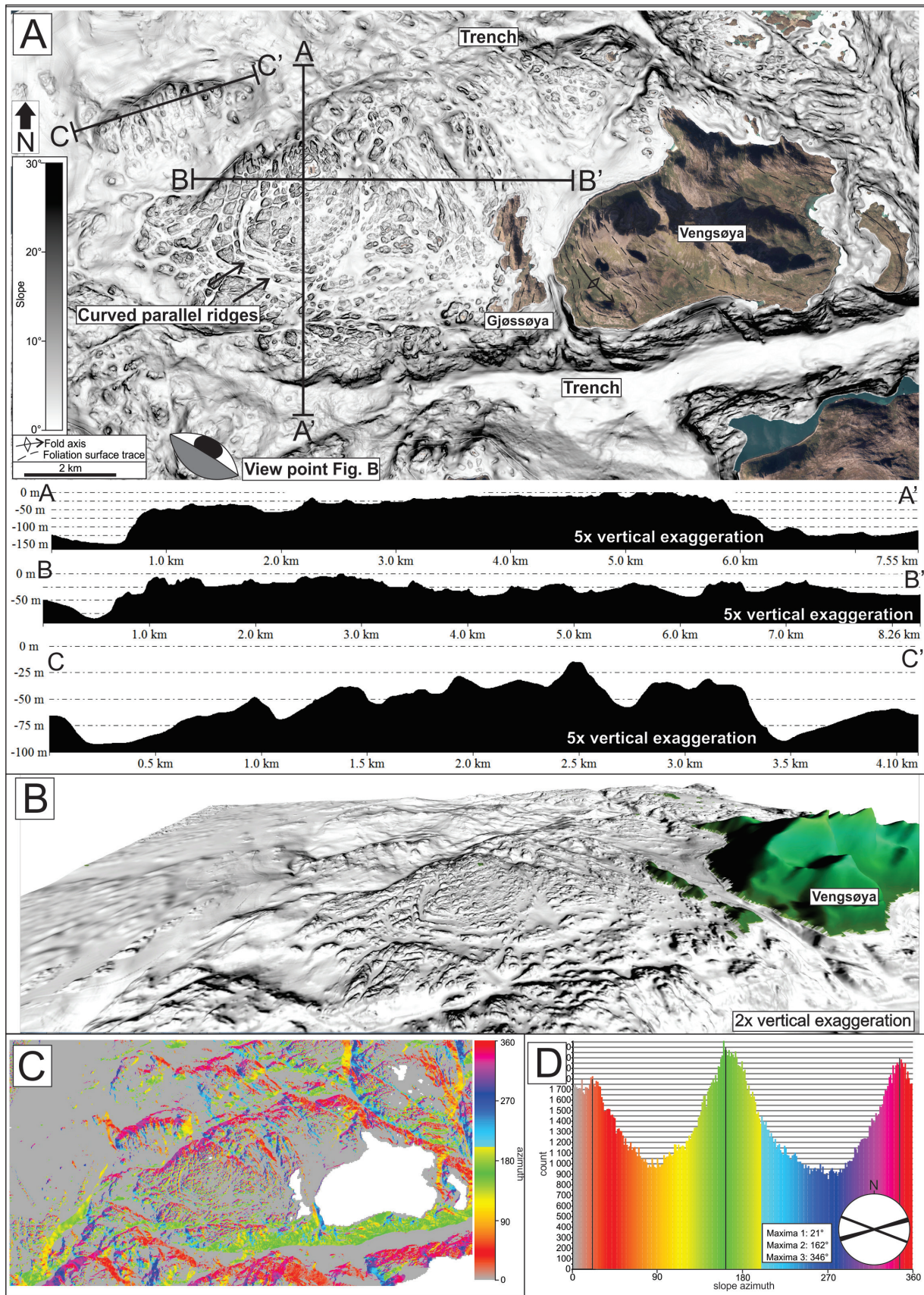


Figure 13. Detailed illustrations of the strandflat within area 2 (see Fig. 12 for location). (A) Dip map covering the strandflat with onshore portions of the subarea covered by aerial photographs. Note the curved parallel ridges characterising the basement block adjacent to Vengsøya and Gjossøya which are bounded by larger trenches. Locations of cross-sections are given and shown below. The viewpoint for the 3D illustration is marked. (B) 3D illustration of the subarea, which highlights the curved, parallel ridges. (C) Aspect map and (D) histogram showing the preferred direction of dips for slopes steeper than 5°. The preferred strikes of slopes from the aspect analysis are shown in the small circular inset (simplified rose diagram).



depression that can be traced for ~30 km eastward, merging into Skulsfjord on Kvaløya (visible as green and red slopes on the aspect map, Fig. 13C). The elongated ridges on the plateau correspond in attitude with the main TTG-gneiss foliation on the island of Vengsøya (Fig. 12), including the tight isoclinal fold that occurs in the southwestern parts of the island (also visible from aerial photographs, Fig. 13A). Aspect analysis of slopes with dips exceeding 5° reveals that slopes striking NE–SW and NW–SE (green and red aspect values) dominate the seabed morphology within the area (Fig. 13C, D), which corresponds to the orientation of the large trenches delimiting the plateau.

Within the strait between the islands of Rebbenøya and Sandøya (Fig. 12), a similar morphological pattern is observed (Fig. 14). The two islands comprise well-foliated TTG-gneisses, with foliation striking mostly N–S, but with opposite dips, i.e., steeply to the east and west, respectively (Fig. 14A, B). Aerial photographs have allowed for interpretative mapping and linkage of the basement foliation surface traces between many smaller islands and skerries (Fig. 14A). The bathymetry data between the two islands reveals a distinct curved ridge that may be traced from the eastern rim of Sandøya northeastwards until it curves into a NNW–SSE trend and proceeds southwards to match up with the foliation on Rebbenøya (Fig. 14A, B). A distinct NNE–SSW-trending trench can also be clearly observed east of Sandøya. Aspect analysis reveals that slopes striking N–S to NNE–SSW and WNW–ESE dominate the seabed morphology (Fig. 14C, D, yellow and blue aspect values). The same trends also dominate the onshore topography (Fig. 14D; grey lines).

West of Sandøya, close to the strandflat edge, a >5 km-wide zone of NNW–SSE-trending, parallel ridges is present (Fig. 12, see Figs. 15, 16 for details). The individual ridges vary from 100 to 500 m in width and 20 to 75 m in height. Within this zone, tightly curved ridges and internally anastomosing wedge-shaped lenses are observed (Fig. 15), enclosed by irregular, aligned depressions (blue and red-yellow aspect values, Fig. 15C, D). Towards the east, the area comprises well-developed parallel ridges separated by a slightly more elevated area. This ridge is mainly covered by 50 x 50 m resolution bathymetry data, but still shows a less well developed lineated morphology. The widespread red to orange and blue aspect values (Fig. 15C, D) reveal that slopes trending N–S to NNW–SSE and NE–SW dominate the seabed morphology in this subarea, which is similar to the main orientation of the zone of parallel ridges. The northern portion of this zone (Fig. 16) shows a network of irregular, variably trending trenches that truncate the parallel ridges such that the strandflat is split up into blocks of distinct geometric character. Notably, there is a marked east-west change in the elevation of the strandflat across a major escarpment, apparent on the profile (Fig. 16A). This escarpment dips steeply west and displaces the strandflat from less than c. 100 m water depth in the east to c. 250 m depth in the west. The escarpment runs northward to link up with the edge of the strandflat (Fig. 16A, B). Aspect

analysis reveals that slopes striking NNW–SSE (orange and blue aspect values, Fig. 16C, D) dominate the seabed morphology in this subarea, which reflects the flanks of the NNW–SSE-trending ridges visible on the bathymetry data.

The northernmost part of Area 2, northwest of the small island of Sørfugløya (Fig. 12), shows morphotectonic elements that are dominated by a set of linear, distinct, 200–500 m-wide steeper slopes trending N–S and NNE–SSW that link up in a system of scarps with a zigzag geometry (Fig. 17A, B). This structure defines an escarpment that separates the inner and outer portions of the strandflat, with a c. 200 m difference in elevation (Fig. 17A). Weakly developed curved ridges are visible. Aspect analysis (Fig. 17C, D) reveals that blue to purple aspect values, corresponding to the NNE–SSW-striking escarpments, dominate the seabed morphology in this region, with a minor maximum striking ENE–WSW (green aspect values).

### Interpretation

The curved, parallel ridges observed west of Vengsøya and Gjøsøya (Fig. 13) can be directly linked to the basement fabric observed onshore of these islands, and thus are interpreted to reflect the bedrock foliation. The dome-shaped and curved nature of the ridges on the strandflat suggests that the foliation is folded around a subvertical fold axis (D3), making up a tight macrofold with fold limbs trending ~NW–SE (Fig. 18A). This interpretation is supported by similar fold patterns onshore of the island of Vengsøya. The minor ENE–WSW-trending trenches that truncate the TTG-gneiss foliation, together with the larger and deeper trenches in the north and south of this portion of the strandflat, are interpreted to represent brittle faults and/or fracture systems, based on the similarity in orientation with onshore brittle normal faults (Indrevær et al., 2013).

A similar fold structure (D3) is interpreted to exist in the strait between Sandøya and Rebbenøya (Fig. 18B). The ridge that continues northward from Sandøya is interpreted to be the continuation of the metaquartzite unit mapped on Sandøya (Fig. 12, inset map), as a competent unit such as quartzite would likely manifest itself as a positive feature on the seabed (Fig. 18B). The ridge curves around and links up with the foliation onshore Rebbenøya, suggesting that this area represents a major fold hinge with a steeply N-plunging (D3) fold axis. Thus, the fold may explain the opposite dips of the foliation onshore Sandøya and Rebbenøya, due to their locations on opposite fold limbs.

The wide zone of NNW–SSE-trending parallel ridges west of Sandøya (Fig. 12) resembles that of a high-strain, ductile shear zone present within TTG-gneisses and metasupracrustal belts onshore. The internally merging ridges and wedge-shaped lenses within its southern portion (Fig. 19A) are thought to reflect intrafolial, tight to isoclinal, D1 macrofolds with transposed shear-lenses, features also commonly identified onshore in

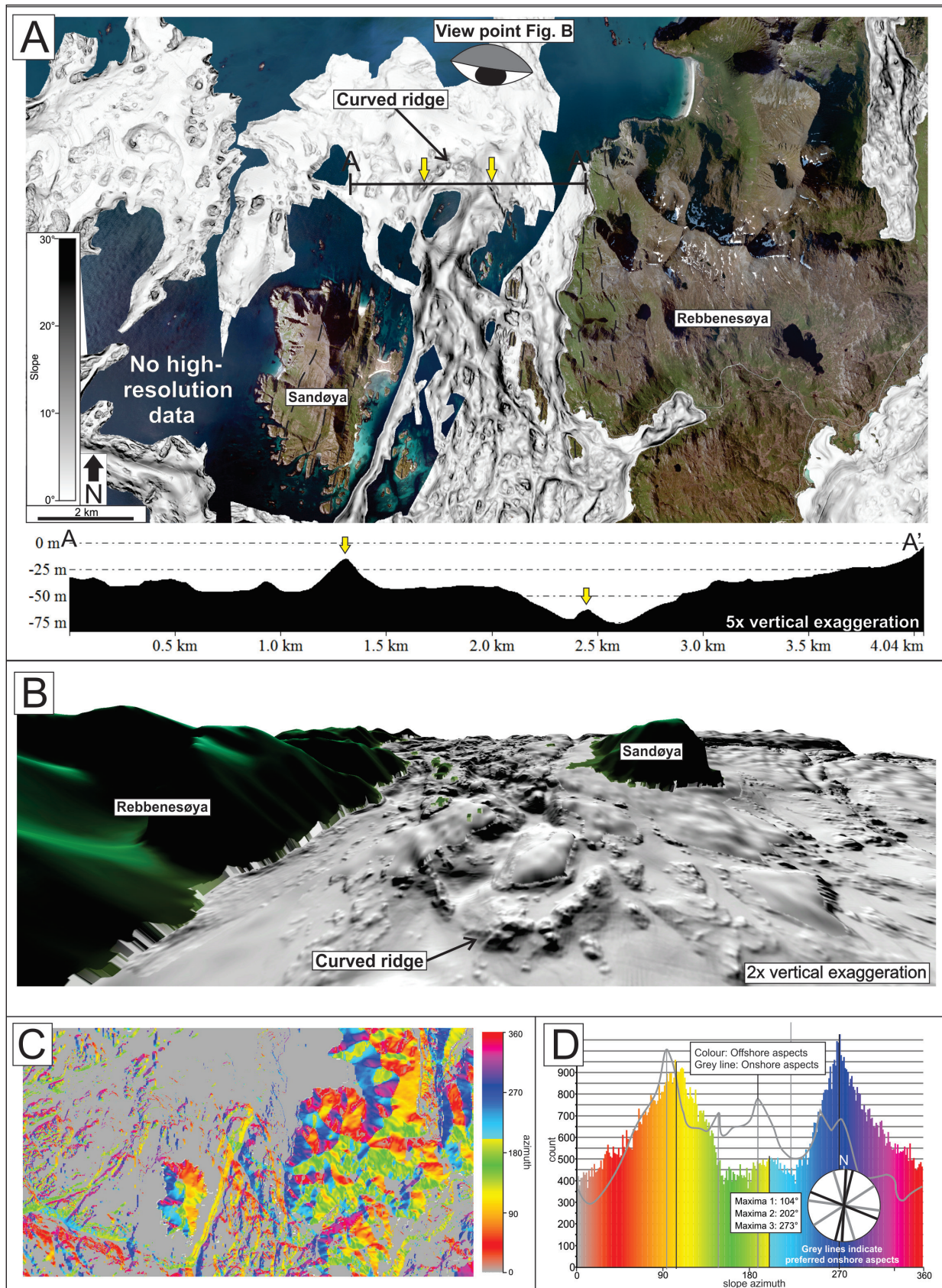


Figure 14. Various detailed illustrations of the strandflat between Rebbenesøya and Sandøya (see Fig. 12 for location). (A) Dip map covering the strandflat with onshore portions of the subarea covered by aerial photographs. Areas covered by aerial photographs of the sea surface indicate areas where no 5 x 5 m resolution bathymetry data are available. Note the curved ridge traceable northwards from Sandøya before it curves around to a SSE–NNW trend. The line A–A' shows the location of the cross-section. The viewpoint for the 3D illustration is marked. (B) 3D illustration of the subarea, which highlights the curved ridge northeast of Sandøya. (C) Aspect map and (D) histogram showing the preferred direction of dips for slopes steeper than 5°. Grey line shows the preferred aspects of the topography (not to scale along the Y-axis). The preferred strikes of slopes from the aspect analysis are shown in the small circular inset (simplified rose diagram, grey lines show topography maxima).



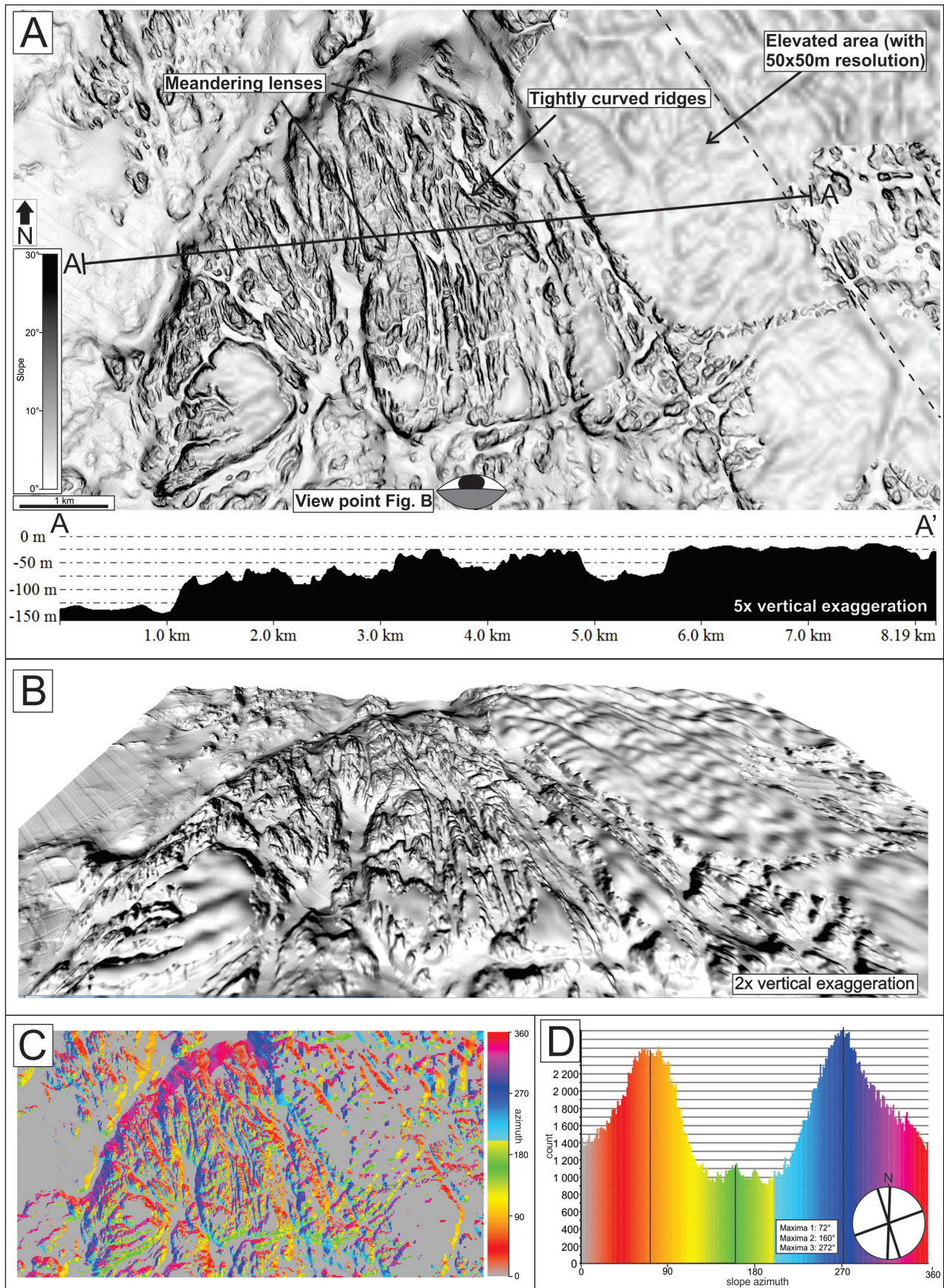


Figure 15. Detailed illustrations of the strandflat within area 2 (see Fig. 12 for location). (A) Dip map covering the strandflat with location of cross-section given and shown below. Note the internally curved, parallel ridges and meandering lenses. The viewpoint for the 3D illustration is marked. (B) 3D illustration of the subarea, which highlights the internally curved, parallel ridges. (C) Aspect map and (D) histogram showing the preferred direction of dips for slopes steeper than 5°. The preferred strikes of slopes from the aspect analysis are shown in the small circular inset (simplified rose diagram).



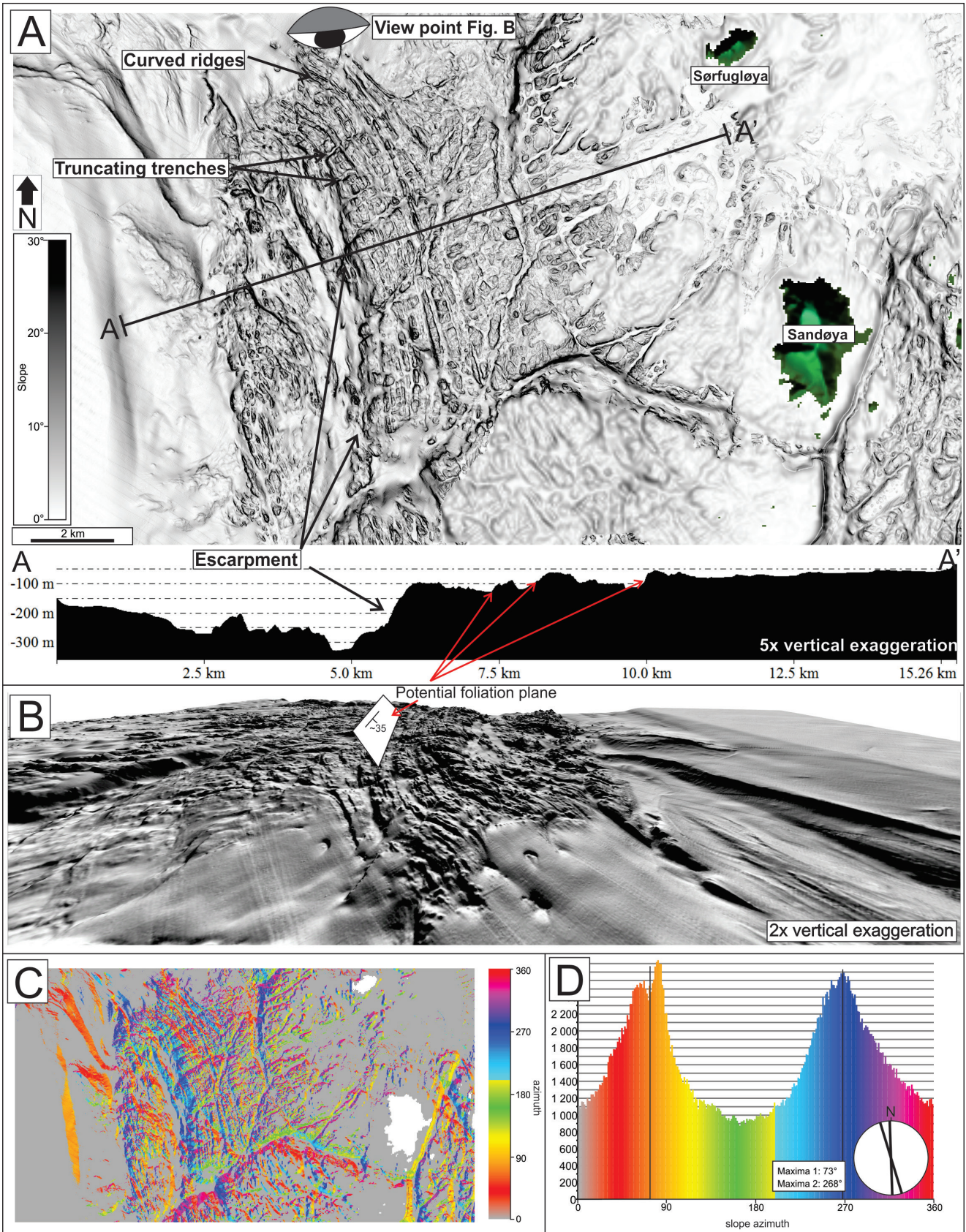


Figure 16. Illustrations of the strandflat within Area 2 (see Fig. 12 for location). (A) Dip map covering the strandflat east of Sandøya with location of the cross-section shown below. Note the NNW–SSE-trending, curved, parallel ridges and the NE–SW-trending trench in the southern portion of the subarea. The viewpoint for the the 3D illustration is marked. (B) 3D illustration of the subarea, which highlights the curved, parallel ridges. Interpretation of the dip of a major foliation surface (ductile shear zone?) is shown. (C) Aspect map and (D) histogram showing the preferred direction of dips for slopes steeper than 5°. The preferred strikes of slopes from the aspect analysis are shown in the small circular inset (simplified rose diagram).



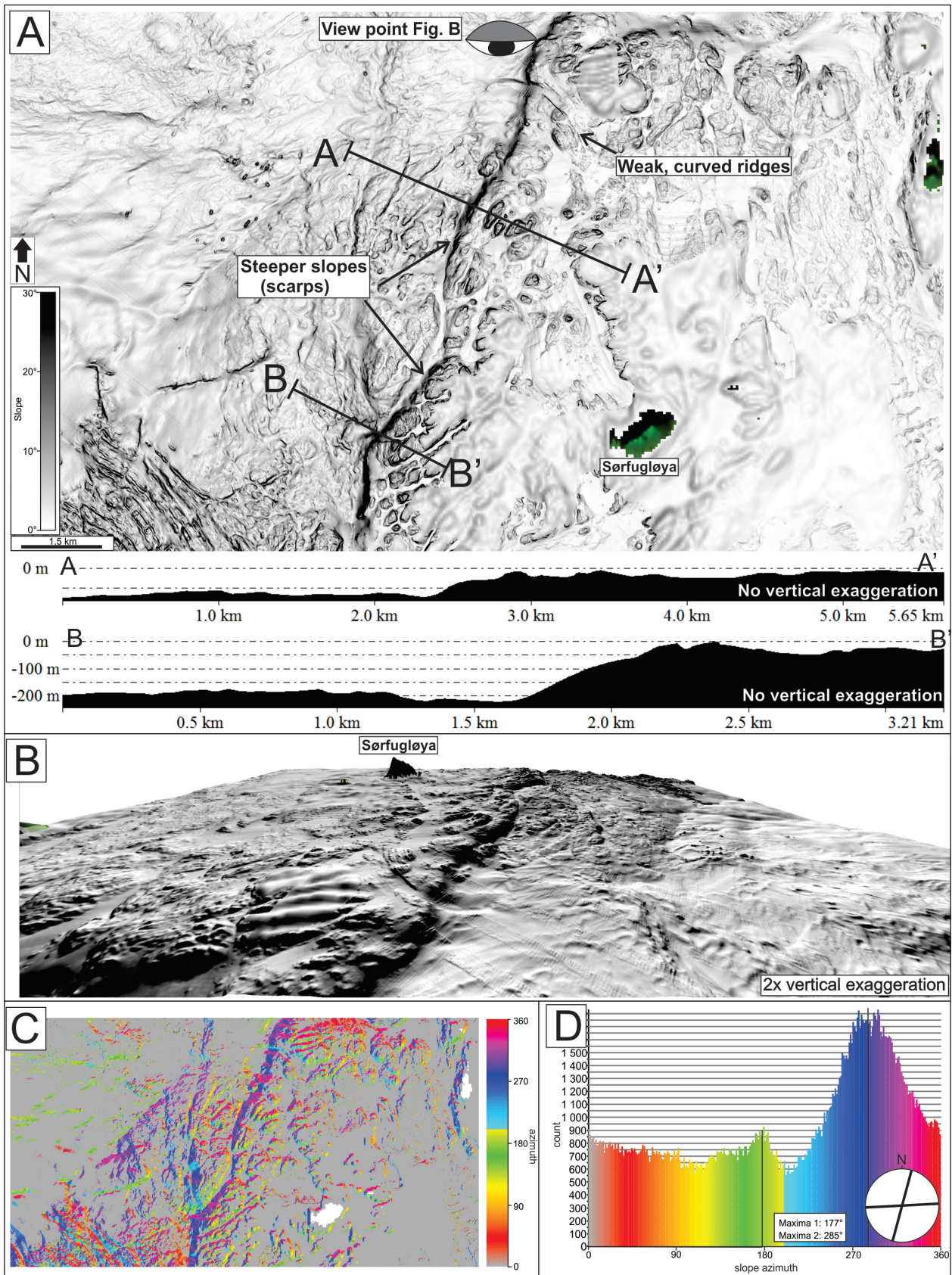
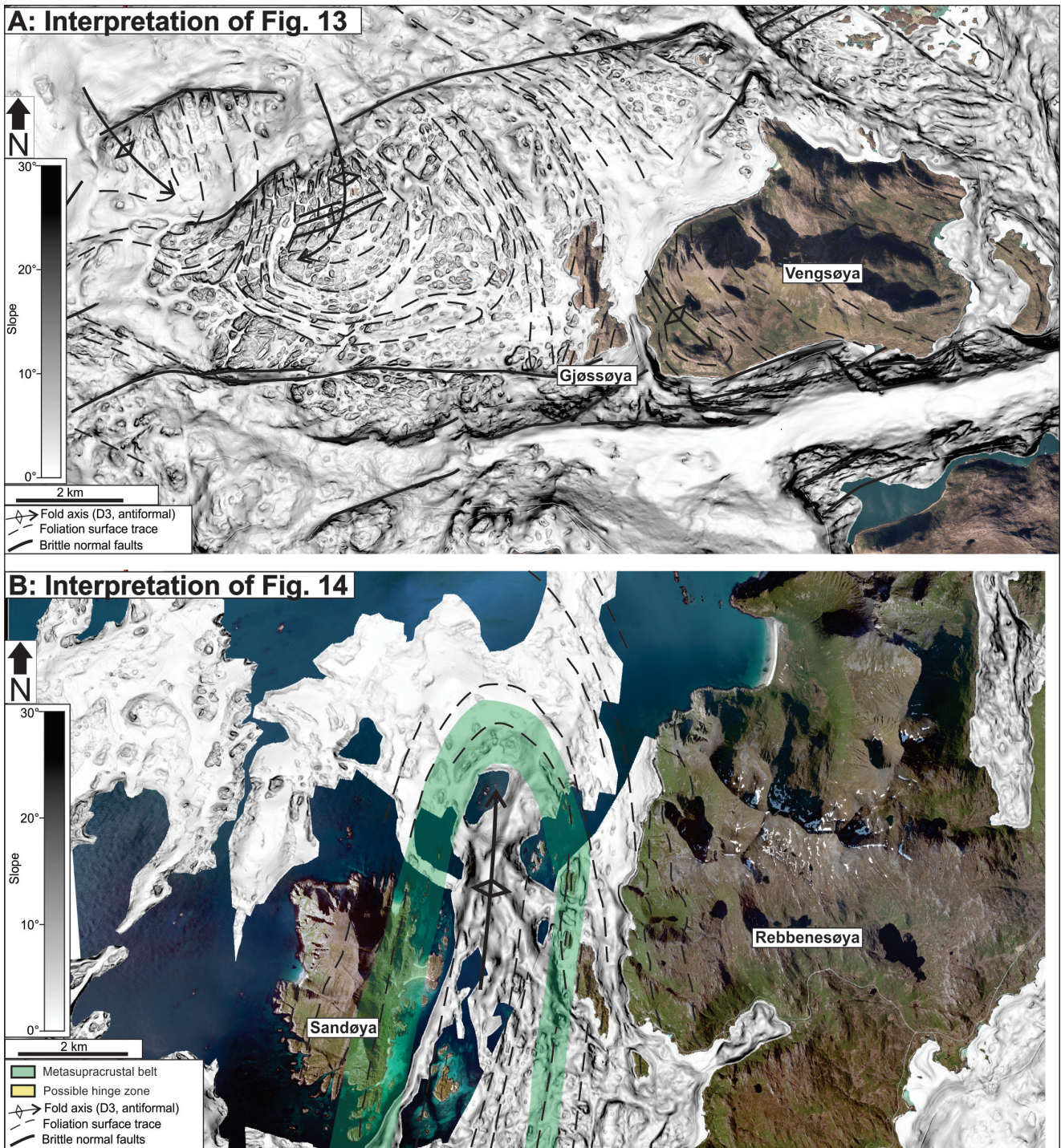


Figure 17. Detailed illustrations of the strandflat within Area 2 (see Fig. 12 for location). (A) Dip map covering the strandflat northwest of Sørfugløya with location of the cross-section shown below. Note the zigzag shape of the slope trending in general NE–SW and the weak trace of curved, parallel ridges in the northern parts of the subarea. The viewpoint for the 3D illustration is marked. (B) 3D illustration of the subarea, which highlights the slope and the weak curved parallel ridges. (C) Aspect map and (D) histogram showing the preferred direction of dips for slopes steeper than 5°. The preferred strikes of slopes from the aspect analysis are shown in the small circular inset (simplified rose diagram).



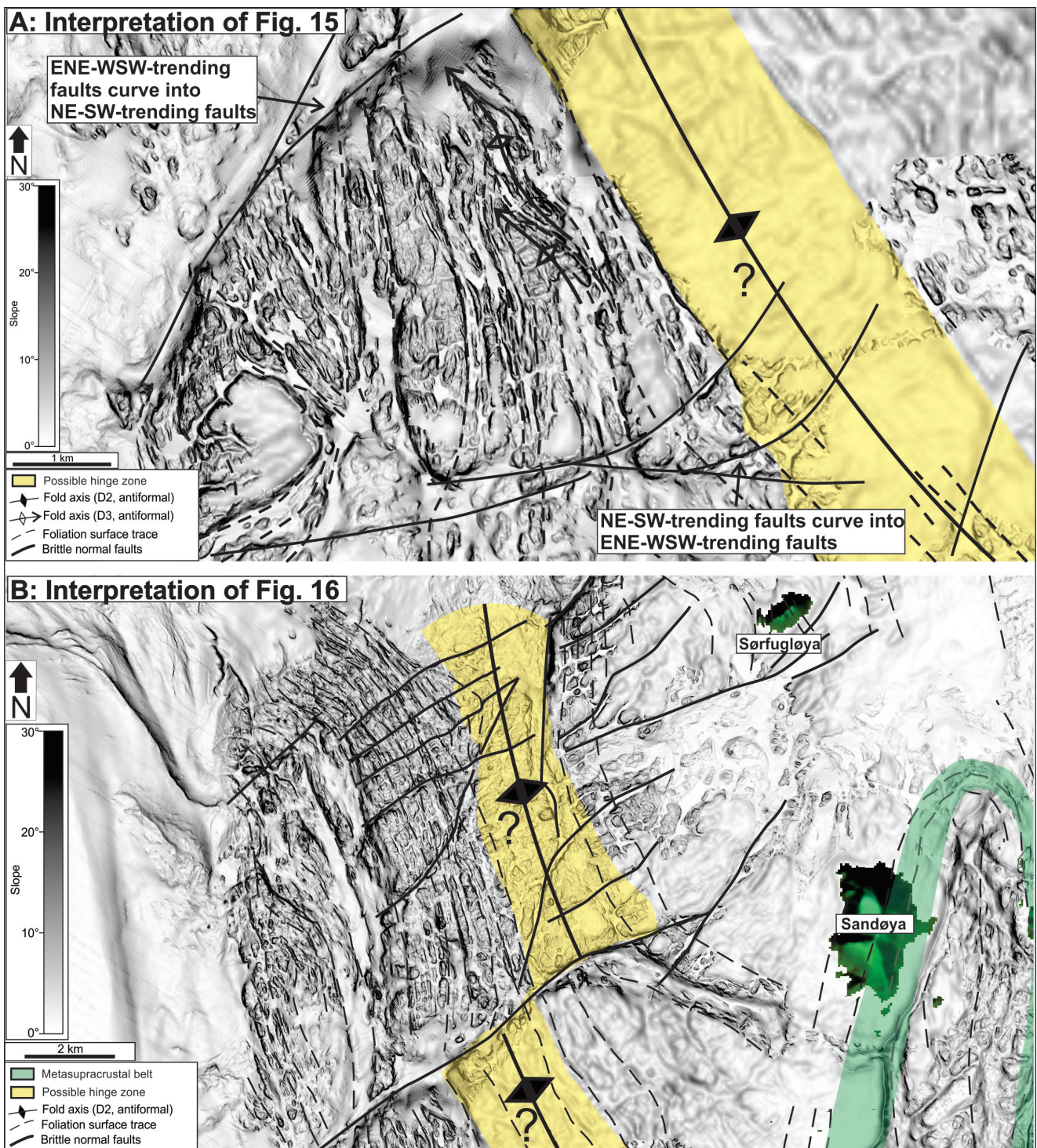


**Figure 18.** Interpretation of lithologies and structures present on the strandflat in Area 2 (see Fig. 12 for locations), based on correlation with known onshore structures. (A) The curved, parallel ridges of subarea 2.1 are interpreted as folded TTG-gneiss foliation, similar to what is observed on Vengsøya. The truncating trenches in the centre of the fold are interpreted as minor brittle faults, while the larger trenches to the north and south of the fold are interpreted as major brittle faults. (B) The ridge traceable from Sandøya is thought to be a continuation of the quartzite unit on Sandøya. It is interpreted to be folded around a N–S-trending, subvertical fold axis and may thus explain the different strikes of the foliation on Sandøya and Rebbenesøya.

Svecofennian ductile shear zones (e.g., Bergh et al., 2010). The orientation of the foliation and hence the contact towards the low-strain zone along the northern portion of the zone is estimated to dip  $\sim 35^\circ$  towards west, based on the asymmetric relief of the ridges (Fig. 16A, B). The shear-zone foliation is bent and asymmetrically folded (sinistrally), most likely by steep-plunging folds (D3) (Fig.

19A). Importantly, this shear zone may be the strandflat expression of the offshore continuation of the Kvalsund shear zone (Myhre et al., 2013). The abrupt divide between well-foliated ridges and a less lineated morphology to the east of this inferred high-strain zone is interpreted to represent a hinge zone of a sub-horizontal, upright, NW–SE-trending, D2 anticlinal fold (Fig. 19A, B), as is present





**Figure 19.** Interpretation of lithologies and structures covering the strandflat in Area 2 (see Fig. 12 for locations), based on correlation with known onshore structures. (A) The internally curved parallel ridges are interpreted as intrafolial folds that formed within a high-strain ductile shear zone. The highlighted, NNW–SSE-trending, more diffuse area to the east is interpreted to mark the position of either a more competent lithology, such as e.g., quartzite, or the hinge zone of an upright, sub-horizontal macro-fold. Truncating trenches are interpreted as brittle faults that bend into parallelism with each other. Note that NNE–SSW-trending faults bend into parallelism with ENE–WSW trending faults in the south of the subarea, whereas the opposite is apparent in the northern part of the subarea. (B) The curved, parallel ridges are the northward continuation of the high-strain ductile shear zone in (A). The ENE–WSW-trending trench in the southern parts of the subarea is interpreted as a major brittle fault that apparently displaces the interpreted quartzite unit or macro-fold hinge-zone dextrally (yellow colour).

along the Kvalsund shear zone onshore. Alternatively, this zone may be interpreted as a shear zone or lithological boundary against the high-strain shear zone in the west, with, e.g., non-migmatized tonalitic gneisses and/or

metaquartzite horizons such as those observed on the island of Sandøya (Armitage, 2007). The inferred offshore continuation of the Kvalsund shear zone is cut and offset by numerous NNE–SSW to



ENE–WSW-trending gullies and narrow depressions (Fig. 19A, B). These depressions are interpreted as major brittle faults transecting the entire strandflat in localised zones. The boundary between the high-strain ductile shear zone and an apparently less strained zone to the east (interpreted as a hinge zone) may be dextrally displaced across one such major brittle fault zone in the south of this subarea (Fig. 19B). By assuming pure normal dip-slip displacement along the major brittle fault, a northwards  $60^\circ$  dip of the fault plane and a  $35^\circ$  westward dip of the foliation surface, the apparent 2.2 km dextral displacement of the high-strain zone across the fault is calculated to correspond to a 1.8 km downstep to the north, normal displacement. Notably, NNE–SSW-trending brittle faults are observed to curve into the ENE–WSW-trending faults and visa-versa (Fig. 19A).

North in Area 2, an escarpment with zigzag geometry is dominating the seabed morphology (Fig. 20). The zigzag character of the escarpment corresponds with the character of the offshore Troms–Finnmark Fault Complex and the onshore Vestfjorden–Vanna Fault Complex (Gabrielsen et al., 1990; Olesen et al., 1997; Indrevær et al., 2013), and is therefore considered to reflect Late Palaeozoic–Mesozoic brittle normal faults that are defining the western boundary of the strandflat. These inferred faults are well outlined in the cross-sections (Fig. 17A) as a major, overall NW-dipping set of escarpments that vertically offsets the basement surface of the strandflat to a lower elevation and thus allowing for glacial sediments to be partly deposited on top (Fig. 20). A set of

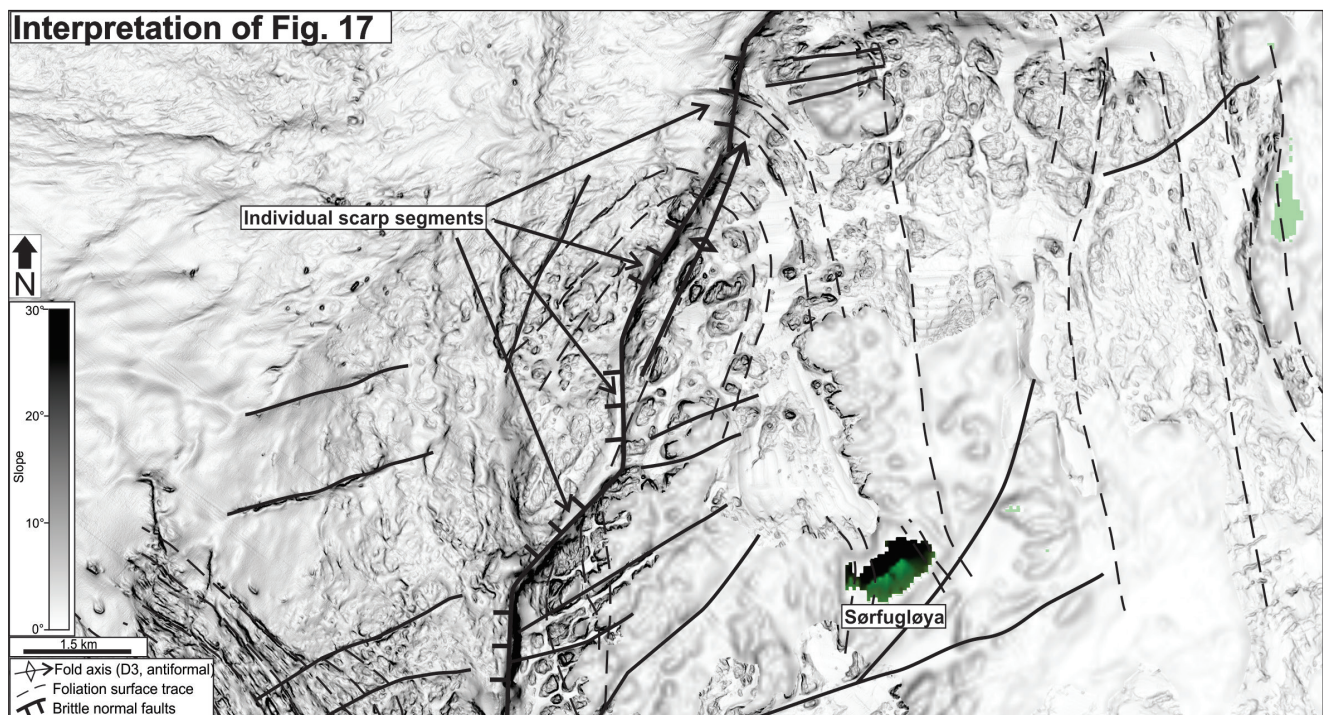
curved ridges just to the east of the major scarp suggests that the foliation in this area is tightly folded by a N–S-trending, steeply dipping macrofold (D3).

In summary, the seabed morphology within Area 2 is interpreted to contain at least three D3 macrofolds (Figs. 18, 20). The folds are associated with the offshore continuation of the Kvalsund shear zone (Fig. 19), which is interpreted to show intrafolial D1 folding (Fig. 19A), and the hinge zone of an upright D2 fold (Fig. 19A, B). The ductile fabrics are cut by numerous, inferred Late Palaeozoic–Mesozoic, brittle normal faults that truncate the strandflat. The westernmost scarp of the strandflat is suggested to be associated with Late Palaeozoic–Mesozoic brittle faulting (Fig. 20).

### Area 3:

#### Local onshore geology

Area 3 covers the islands of Vanna and Nord–Fugløya and the strandflat north of these islands (Fig. 21). Vanna is the northernmost island of the exposed West Troms Basement Complex and consists of Neoarchaean tonalitic gneisses that locally are unconformably overlain by the parautochthonous metasupracrustal units, the Vanna Group and rocks of the Skipsfjord Nappe (Fig. 21; Binns et al., 1980; Johansen 1987; Opheim & Andresen, 1989; Bergh et al., 2007a). The Vanna Group succession is also exposed on the island of Spenna, 5 km along strike east of Vanna (Roberts, 1974). In general, the tonalitic gneiss foliation on Vanna is folded by a N–S-trending, macroscale, upright antiform plunging south (Fig. 21). The Skipsfjord



**Figure 20.** Interpretation of main structural features within a subarea on the strandflat in Area 2 (see Fig. 12 for location), based on correlation with known onshore structures. The zigzag-shaped slope is interpreted as an array of alternating N–S and NE–SW-trending, brittle normal faults that down-drop basement rocks to the west. The weakly curved, parallel ridges in the northern parts of the subarea are interpreted to mark the position of a N–S-trending subvertical fold.







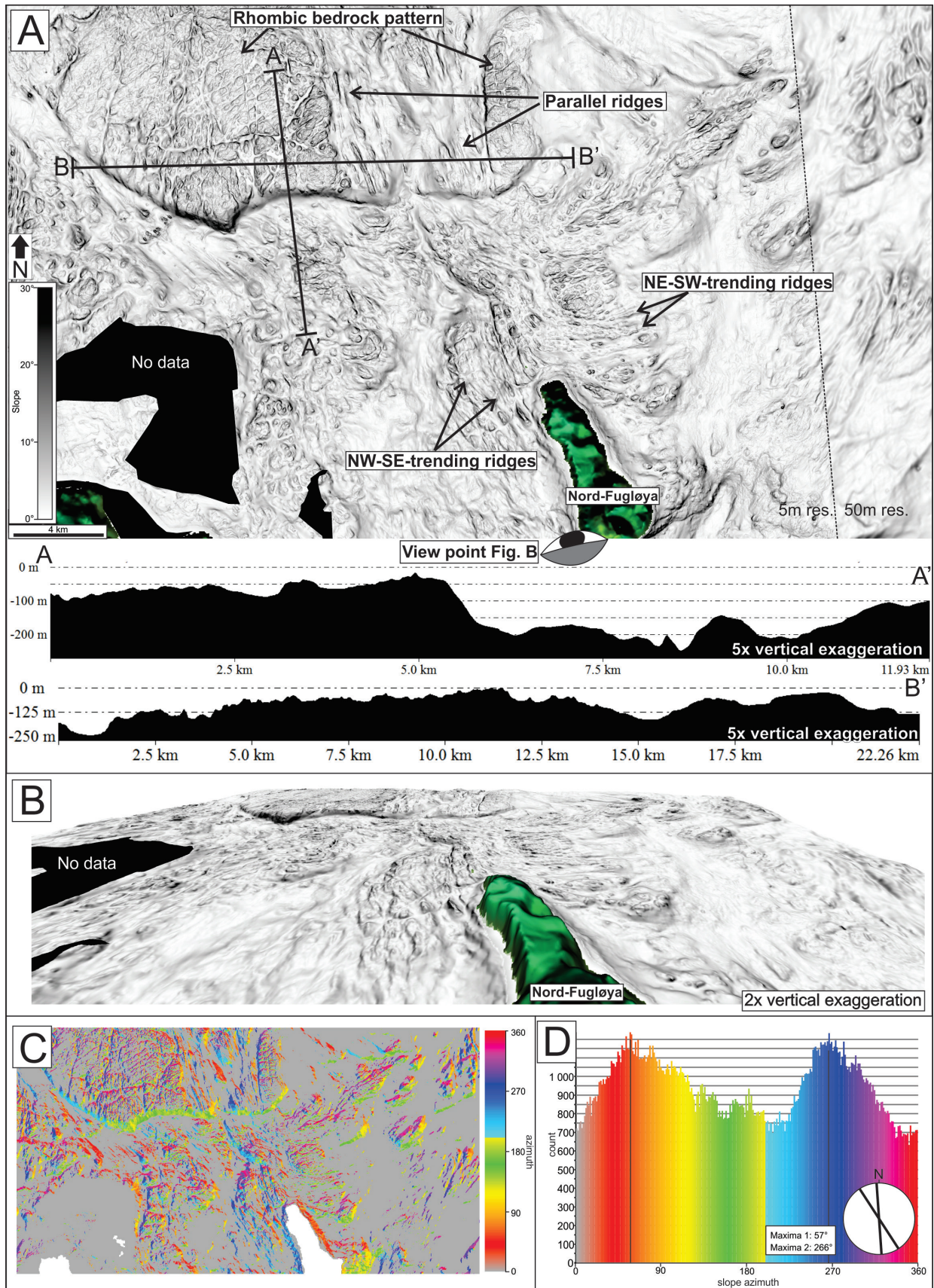


Figure 22. Detailed illustrations of the strandflat within Area 3 (see Fig. 21 for location). (A) Bathymetric dip map of the strandflat and northern parts of Nord-Fugløya. Note the prominent rise in elevation in the north, the NE-SW-trending ridges northeast of Nord-Fugløya and the NW-SE trending ridges southwest of Nord-Fugløya. Locations of the cross-sections are given by lines and shown below. The viewpoint for the 3D illustration is marked. (B) 3D illustration of the subarea, which highlights NW-SE-trending ridges to the west and north of Nord-Fugløya. (C) Aspect map and (D) histogram showing the preferred direction of dips for slopes steeper than 5°. The preferred strikes of slopes from the aspect analysis are shown in the circular inset (simplified rose diagram).



Nappe is in the north down-faulted by at least 3 km along the SSE-dipping Vannareid–Brurøysund fault zone (Fig. 21), of presumed Mesozoic age (Opheim & Andresen, 1989). This fault zone constitutes a well-defined ENE–WSW-trending topographic valley underlain by a >20 m-wide zone of brittle, cataclastic fault rocks.

The islands of Nord–Fugløya and Arnøya northeast of Vanna (Fig. 21) both consist of metamorphic Palaeozoic rocks in thrust sheets of the Middle Allochthon (Roberts, 1974; Ramsay et al., 1985). Dominant rocks are garnet-mica schists and marble units (Roberts, 1974) with a foliation on average dipping gently to the NW. The sound between Vanna and the two islands therefore defines a prominent regional boundary between the Caledonian thrust nappes to the northeast and the Precambrian rocks of the WTBC to the southwest. Indrevær et al. (2013) considers this sound to be underlain by a major Late Palaeozoic–Mesozoic transfer fault zone that formed by reactivation of a Proterozoic–Palaeozoic ductile shear zone (the Bothnian–Kvænangen Fault Complex) (Doré et al., 1997).

#### Morphotectonic elements on the strandflat

The bathymetry data north of Vanna seem to be more influenced by a glacially moulded morphology than farther south (Fig. 21). Still, within the western parts of the area, N–S- to NNW–SSE-trending parallel ridges and gullies are visible (Fig. 22A, B). In the northern parts, a larger raised portion of the strandflat defines a plateau

delimited by a major south-facing escarpment in the south, marked as a green-coloured feature on the aspect map (Fig. 22C). The escarpment separates a seabed morphology that differs by ~200 m in depth (Figs. 21, 22A). While the southern, down-dropped part has a diffuse glacial-fill morphology, the plateau itself shows distinct sets of intersecting trenches. The western portion of the plateau comprises smaller E–W, NE–SW and ~N–S-trending, rhombic bedrock patterns, which are illustrated by blue, red and green colours on the aspect map (Fig. 22C). This pattern is abruptly replaced farther to the east on the plateau by a c. 6 km-wide zone of ~NNW–SSE-trending parallel ridges that occur within a major trough (Fig. 22A, B). East of the N–S-trending trough, the rhombic bedrock pattern visible in the western portion of the plateau reappears.

The prominent zone of ~NNW–SSE-trending parallel ridges that run across the plateau can be traced southwards along the western side of the island of Nord–Fugløya, where it merges into a system of broad, E–W to NE–SW-trending, undulating ridges and trenches (Fig. 22A, B). This zone of parallel ridges thus reflects a major change in the orientation of morphological elements on the strandflat, from a dominantly NNW–SSE-trending, lineated morphology SW of Nord–Fugløya to a dominantly NE–SW-trending, lineated morphology NE of Nord–Fugløya. This change is clearly visible on the aspect map (Fig. 22C).



**Figure 23.** Detailed interpretation of the inferred WTBC – Caledonian contact and related structures covering the strandflat within Area 3 (see Fig. 21 for location), based on correlation with known onshore structures. The contact is marked by a change in the preferred orientation of NE–SW-trending ridges to the northeast, relative to NNW–SSE-trending ridges in the northwest, i.e., ridges just west of Nord–Fugløya.



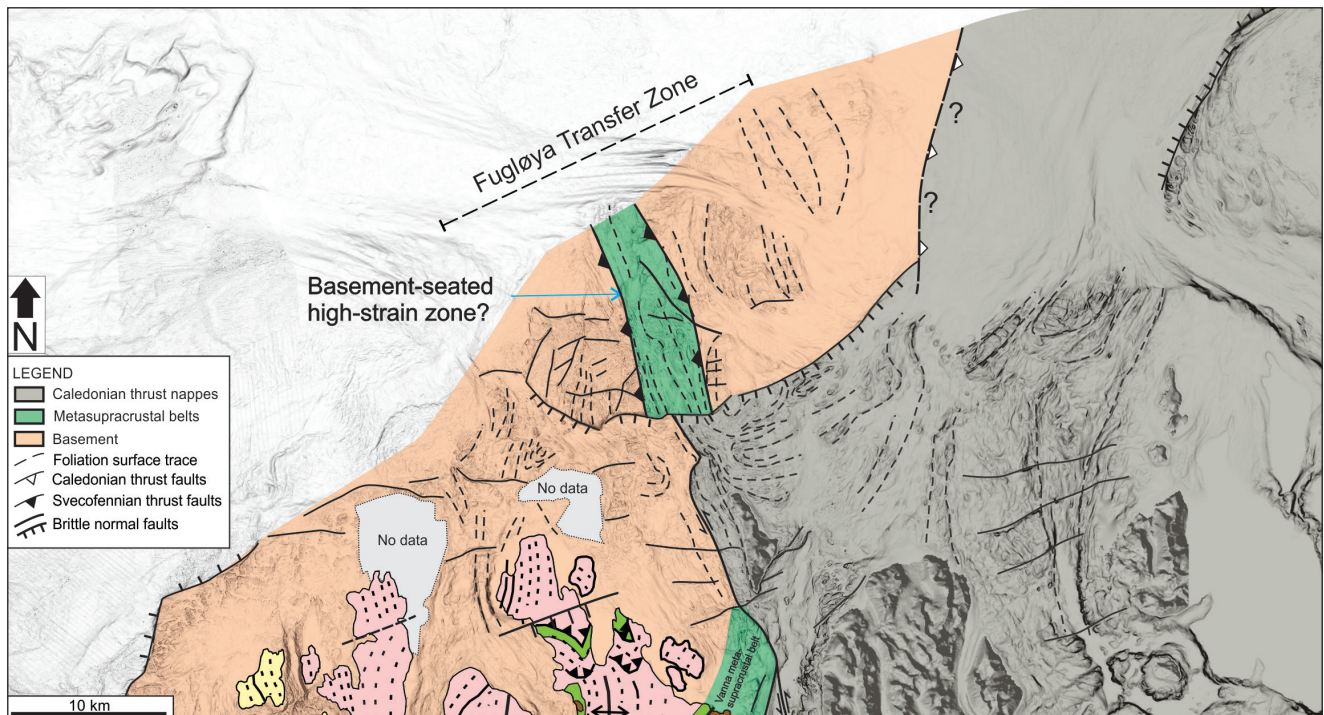


Figure 24. Interpretation of the strandflat bathymetry in Area 3, based on observation and correlation with onshore structures. The interpreted fault that defines the southern limit of the raised plateau has down-faulted Caledonian nappes to the southeast, similar to what is observed along the inner portions of the WTBC. The NNW–SSE-trending parallel ridges that truncate the rise are interpreted as part of a high-strain ductile zone within WTBC rocks, possibly a metasupracrustal belt. If so, the metasupracrustal belt, the contact towards Caledonian nappes and the Fugløya transfer zone, overlaps in the strait between Vanna and Nord–Fugløya.

### Interpretation

The N–S to NNW–SSE-trending, diffuse and locally curved ridges north of Vanna, including similar morphologies in the western part of the raised plateau, are interpreted as the continuation of the TTG-gneiss foliation and possibly the metasupracrustal lithologies analogous to the Skipsfjord Nappe rocks exposed on Vanna (Fig. 23). The wide zone of NNW–SSE-trending parallel ridges that may be traced northwest of Nord–Fugløya and northwards onto the raised plateau is suggested to reflect the boundary zone between the crystalline Precambrian basement of the WTBC and the gently NW-dipping, Caledonian thrust nappes present on Nord–Fugløya (Fig. 23; Roberts, 1974). Northeast of Nord–Fugløya, the observed NE–SW-trending parallel ridges are interpreted to reflect the outcrop of a Caledonian foliation in nappes on the seabed. North of Nord–Fugløya, these ridges bend into a northwest trend, which is interpreted to be an apparent effect of the oblique truncation between the generally gently NW-dipping, Caledonian foliation and the seabed.

The contact between the Caledonian rocks and the WTBC rocks must be present in the sound somewhere in between the islands of Spenna and Nord–Fugløya, as the two islands are underlain by WTBC rocks and Caledonian rocks, respectively (Fig. 24). The contact must thus trend NW–SE, parallel to the general morphotectonic trends

present on the seabed within this sound. A possible continuation of this contact zone is visible on the raised plateau northwest of Nord–Fugløya, defined by the zone of ~NNW–SSE-trending parallel ridges within the major trough (Fig. 23). Here, however, the zone does not separate a ~NNW–SSE-trending linear morphology, typical for basement lithologies, in the southwest from a NE–SW-trending linear morphology, typical for the Caledonian units, in the northwest, but rather obliquely truncates presumed basement lithologies on both sides. The exact location and southeastward trace of the Caledonian–WTBC contact, and its regional implications are discussed in a later section.

The south-facing escarpment delimiting the plateau and displacing the strandflat vertically by *c.* 200 m to the south is interpreted as a Late Palaeozoic–Mesozoic brittle fault. Consequently, this fault may be linked to the Vestfjord–Vanna Fault Complex, and thus implies that the WTBC rocks can be traced farther northeastward along the Barents Sea margin (Fig. 24). This is also inferred from the N–S trend of the ductile basement fabrics visible on the raised plateau. The major brittle fault apparently displaces the strandflat and may therefore post-date this feature, (i.e., in the Quaternary), thus inferring that neotectonic activity has occurred in this region.



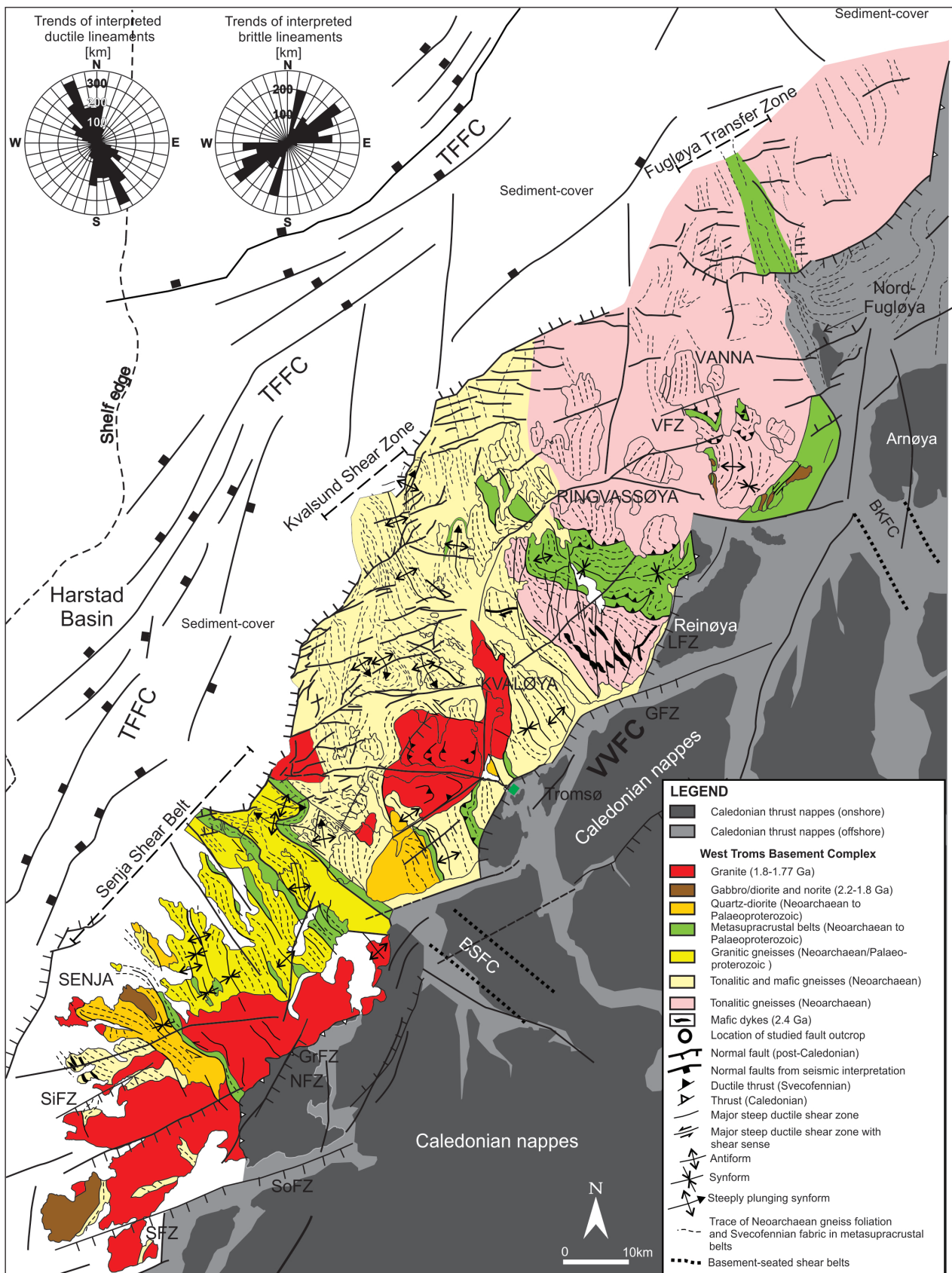


Figure 25. Tentative compiled basement and structural map of the strandflat and adjacent onshore and offshore portions of the SW Barents Sea margin, summarising the interpretations from all areas of the strandflat by extending the onshore geology onto the strandflat. Note how the Senja Shear Belt, the Kvalsund Shear Zone and the Fugløya transfer zone segment the margin laterally. The combined length of all mapped and interpreted ductile and brittle lineaments with respect to their trends are shown in rose diagrams in the top-left corner. BKFC=Bothnian-Kvænangen Fault Complex, BSFC=Bothnian-Senja Fault Complex, GFZ=Grøtsundet fault zone, GrFZ=Grasmyrskogen fault zone, LFZ=Langsundet fault zone, NFZ=Nybygd fault zone, SFZ = Stonglandseidet fault zone, SiFZ=Sifjorden fault zone, SoFZ=Solbergfjorden fault zone, VFZ=Vannareid-Brurøysund fault zone, TFFC=Troms-Finnmark Fault Complex.



## Discussion

Above, we have described and interpreted morphotectonic features visible on the strandflat offshore western Troms and compared them with local onshore ductile and brittle fabric elements. In order to further link and correlate these features, we have combined the two data packages into a simplified onshore-offshore map of all the interpreted morphotectonic features along the studied portion of the WTBC and the transition to the Caledonian nappes in the northeast (Fig. 25). In the following, we discuss the implications of these features in a regional context of onshore-offshore correlation and margin architecture.

### A) Precambrian rocks and ductile fabrics

The morphotectonic elements observed on the strandflat clearly mimic onshore Precambrian basement structures in great detail, both in the form of interpreted lithologies and ductile structures. Dominant lithological elements such as the strongly foliated TTG-gneisses, more competent and massive granitic intrusions and metasedimentary belts can be tentatively identified and separated. Major ductile structures observed onshore, such as the prominent, steep, NW–SE-trending, irregular and anastomosing Neoproterozoic foliation in the TTG-gneisses and the complex Neoproterozoic and later Svecofennian fold structures and ductile shear zones may be identified on the strandflat. In fact, even specific time-generations of folds and shear zones can be inferred in TTG gneisses on the strandflat bathymetry, including macroscale isoclinal (D1), upright (D2) and steeply plunging folds (D3). Distinct zones of high-strain deformation that may represent terrane boundaries are also identified on the strandflat (Fig. 25). These include the Astridal and Torsnes metasedimentary belts of the Senja Shear Belt, which are interpreted to continue NW onto the strandflat (Fig. 11B, C, Zwaan, 1995; Bergh et al., 2010). Farther north, the possible offshore continuation of the Kvalsund shear zone is also identified (Figs. 18, 19). Onshore, the Kvalsund shear zone is related to a terrane boundary where adjacent gneisses are commonly heavily deformed and folded by upright, horizontal folds (Myhre et al., 2013). On the strandflat, along the trend of this zone, the occurrence of upright (D2) and steeply dipping (D3) macrofolds (Fig. 25) indicates that the Kvalsund shear zone continues northwestward onto the strandflat. The great degree of similarity and correlation of morphotectonic elements on the strandflat with the onshore basement features (Fig. 25) suggests that the strandflat, to a large extent, is composed of lithologies of WTBC affinity. In fact, the WTBC suite can be traced westward from the WTBC, all the way out to the western edge of the strandflat, from the island of Senja in the south and northwards to Nord–Fugløy. The contact zone to Caledonian rocks is interpreted to be located just west and south of Nord–Fugløy (Figs. 24, 25) where it is clearly observed on the strandflat (Fig. 23) and mirrored by a distinct change in the morphotectonic character of the seabed, strongly indicating that gently

dipping Caledonian nappes and structures make up the strandflat northeast of this boundary.

### B) Caledonian rocks and ductile fabrics

The Caledonian rocks of western Troms occur in flat-lying to gently NW-dipping thrust nappes with a marked structural difference relative to the rocks of the WTBC. In the northeastern part of the study area (Fig. 24), on the island of Nord–Fugløy and Arnøya, the onshore geology is dominated by units of the Caledonian Kalak Nappe Complex, and northeast of these islands is the only area on the strandflat where Caledonian nappes are interpreted to crop out on the seafloor. Here, curved, parallel ridges that trend NE–SW dominate, as opposed to the NW–SE trending parallel ridges commonly observed within lithologies associated with the WTBC.

In a regional context, the onshore Caledonian–WTBC boundary of the SW Barents Sea margin (Figs. 1, 2) is outlined by a zigzag pattern of NNE–SSW to ENE–WSW-trending (mostly SE-dipping), brittle, normal fault segments of the Vestfjord–Vanna Fault Complex (Forslund, 1988; Olesen et al., 1997) and locally Caledonian thrust faults (on Senja and the northern parts of Ringvassøya). South of Nord–Fugløy, the orientation changes to a NNW–SSE trend, suggesting that the contact is no longer defined by coast-parallel brittle normal faults, but rather a thrust fault or a transfer fault zone of post-Caledonian age. The latter is supported by the recent studies of Indrevær et al. (2013) who advocated the presence of a major sinistral transfer zone (Fugløy) of Late Palaeozoic–Mesozoic age, as a reactivated portion of the Proterozoic–Palaeozoic, Bothnian–Kvænangen Fault Complex, located in the sound between Vanna and Nord–Fugløy. The wide zone of localised, parallel ridges observed on the raised plateau northeast of Vanna (Fig. 22) is therefore interpreted as the continuation of this transfer zone. However, since morphologies similar to those of exposed WTBC bedrock lithologies do occur in the eastern and western parts of the raised plateau, it is suggested that this zone, on the plateau, does not mark the direct continuation of the Caledonian–WTBC boundary, but rather reflects the presence of a Palaeoproterozoic metasedimentary belt, or the continuation of a pre-existing, major, basement-seated, ductile shear zone within WTBC rocks (Fig. 24). This strengthens the idea that the Fugløy transfer zone formed along a pre-existing zone of weakness within Precambrian basement rocks: The conspicuous overlap (Fig. 25) of (i) the Fugløy transfer zone, (ii) the contact between WTBC and Caledonian thrust nappes, (iii) a possible Svecofennian, high-strain, ductile shear zone and (iv) the Proterozoic–Palaeozoic, Bothnian–Kvænangen Fault Complex, suggests that this zone may have played a major role in controlling and accommodating crustal deformation through a very long period of time. This zone may have initiated during the Neoproterozoic and/or Palaeoproterozoic orogenies, e.g., the Svecofennian, and later been overridden by thrust nappes during the Caledonian orogeny. Later Palaeozoic–Cenozoic



crustal rifting, which led to the opening of the North-Atlantic Ocean, then potentially reactivated this zone as a transfer zone, displacing the Caledonian thrust nappes sinistrally and allowing Late Palaeozoic–Mesozoic brittle faults to step and change fault polarity across the transfer zone (Indrevær et al., 2013).

### C) Post-Caledonian brittle structures

Post-Caledonian brittle faults are present throughout the studied passive margin (Indrevær et al., 2013) and are largely controlled by two major fault complexes, the partly onshore Vestfjord–Vanna Fault Complex and the offshore Troms–Finnmark Fault Complex, that bound the WTBC horst (Gabrielsen et al., 1990; Olesen et al., 1997; Indrevær et al., 2013). The margin is segmented along strike by at least two, Late Palaeozoic–Mesozoic, transfer faults, the Senja Shear Zone and the Fugløya transfer zone (Olesen et al., 1997; Indrevær et al., 2013)

The two major fault complexes are both composed of alternating NNE–SSE and ENE–WSW-trending subsidiary fault zones (Gabrielsen et al., 1990; Olesen et al., 1997; Indrevær et al., 2013). A wide spectrum of irregular and linear trenches and escarpments truncates the strandflat bathymetry and the presumed bedrock structures, thus segmenting the strandflat into blocks. These features, including major boundary escarpments such as the westernmost scarp that defines the western edge of the strandflat, produce a zig-zag pattern of alternating ~NNE–ENE and ~ENE–WSW-trending segments (Fig. 25) similar to those observed onshore (e.g., the VVFC) and on the deep shelf (e.g., the TFFC). We thus infer that these trenches and escarpments are, in total, the result of Late Palaeozoic–Mesozoic rifting and brittle faulting that formed the present passive continental margin. The distribution of these faults, as evident from the bathymetry data, suggests that they are a part of a continuous system of horst-internal fault segments that link up onshore fault complexes with offshore complexes across the horst (Fig. 25).

#### Displacement

Estimating the amount of displacement across the trenches on the strandflat that are interpreted as brittle faults is important in order to understand their regional significance. In general, the VVFC, including the Vannareid–Brurøysund fault zone on Vanna, has estimated amounts of displacement of 1–3 km (Olesen et al., 1997). The less prevalent, linked fault system along the outer islands of the WTBC has estimated amounts of displacement of up to hundreds of metres (Indrevær et al., 2013).

From this study, it is evident that the outer faults (e.g., the Bremneset, Tussøya and Hillesøya fault zones (Figs. 8, 10)) have produced only a weak bathymetric morphology. In areas where it is possible to trace them onto the strandflat, they are not comparable in width or depth with the many

trenches that are observed on the strandflat. This suggests that the amount of displacement along the inferred fault-related trenches on the strandflat must have been greater than hundreds of metres in order to produce wider damage zones (so that they may have been more heavily excavated by strandflat-forming processes and glacial erosion). However, the Vannareid–Brurøysund fault zone, for example, defines a topographic valley along its strike that is comparable in size to the offshore trenches (Fig. 21). The larger offshore trenches are thus suggested to have similar amounts of displacement as the VVFC and the Vannareid–Brurøysund fault zone (i.e., 1–3 km). This is supported by the apparent dextral offset of the interpreted fold hinge zone running along the Kvalsund shear zone (Fig. 19B), which yielded an estimated amount of normal displacement of ~1.8 km, down to the northwest.

The estimated displacements for interpreted brittle faults on the strandflat are thus similar to those estimated for the VVFC and implies that fault zones with displacements comparable to the VVFC may be widely distributed across the WTBC horst. Since very few fault zones comparable in displacement with the VVFC have been mapped onshore (e.g., Opheim & Andresen, 1989; Gagama, 2005), these major fault zones may tentatively be located within the larger sounds and fjords along the margin.

#### Timing of brittle faulting

Onshore, the brittle fault activity occurred in the Permian/Late–Triassic and came to a halt during early and deep stages of rifting as the rift activity propagated westward to offshore fault complexes in the Late Jurassic/Early Cretaceous (Davids et al., 2013; Indrevær et al., 2013, 2014). A similar westward progressive migration of fault activity may thus be expected for the brittle faults located on the strandflat. However, in order to preserve the entire WTBC horst as a uniform basement outlier, it is likely that most of these faults also became largely inactive after the Late Permian/Early Triassic rifting event.

Several other indicators, which may shed light on the relative timing of fault segments and possible later reactivation, have been observed on the strandflat bathymetry. First, the relative timing of the alternating NNE–SSW and ENE–WSW-trending brittle faults that constitute the two major fault complexes of the WTBC horst (Indrevær et al., 2013) can be inferred, since both the NNE–SSW and the ENE–WSW-trending faults merge into parallelism (Fig. 19A), suggesting that the two fault sets formed contemporaneously.

Secondly, the apparent sub-planar strandflat shows a vertical offset of *c.* 200 m across inferred fault scarps. Examples include (i) the westernmost escarpment running along larger portions of the studied strandflat, which apparently has down-faulted the strandflat ~200 m to the west (Fig. 20), (ii) the brittle fault zone that defines the southern limit of the raised plateau in Area 3, where the strandflat is displaced by ~200 m down to the south



(Fig. 22), and (iii) the presence of strandflat-internal smaller basins within Area 1 (Fig. 11B). The apparent ~200 m vertical displacement across these scarps may be interpreted as the reactivation of the Late Palaeozoic–Mesozoic brittle faults after the formation of the strandflat, i.e., advocating Quaternary fault activity. Fenton (1991, 1994) and Wood (1993) have listed criteria that may be used to separate neotectonic faults from older faults. The two most relevant criteria for this study are (i) that the amount of displacement is more or less constant along the entire length of the fault scarp and (ii) that the height-to-length ratio of neotectonic fault scarps is typically in the range of 1:10,000 to 1:1,000, rarely exceeding the latter. The observed scarps do not show any increase in height from the scarp tips to their centres (e.g., Fig. 20), thereby supporting their origin as neotectonic. However, if considering individual scarp segments, the height-to-length ratio of the scarps does exceed 1:1000, typically falling in the range of *c.* 1:100 (Fig. 20). Only by considering the entire *c.* 200 km western boundary of the strandflat as one continuous fault scarp (Fig. 25) does the ratio approach 1:1.000.

The scarps may also be the result of glactectonic ice-plucking of the hangingwall of the Late Palaeozoic–Mesozoic faults. Alternatively, the scarps may separate basement lithologies with contrasting susceptibility to the pre-Cretaceous tropical weathering. If so, the apparent displacement of the strandflat across the scarps may purely be a result of contrasting amounts of Quaternary erosion.

#### *D) Relationship of bathymetry to present onshore topography and landscape forms*

The analysis of aspect values (dip directions) for topographic surfaces dipping more than 5° (Fig. 5) shows that NNW–SSE, N–S and ENE–WSW-trending slopes dominate on the strandflat. The N–S and ENE–WSW orientations are the same that make up the zigzag pattern as evidently characterises the onshore WTBC-boundary fault zones and fault segments (i.e., VVFC) as well as the offshore Troms–Finnmark Fault Complex (Fig. 25; Indrevær et al., 2013). Onshore, the topography is dominated by NW–SE and NE–SW to E–W-striking slopes, mirroring the orientations of ductile and brittle fabrics, respectively (Fig. 25, upper left corner). The SW Barents Sea margin landscape is therefore clearly influenced by Late Palaeozoic–Mesozoic brittle faulting, and to some extent, also Precambrian structural elements. Both the topography and the bathymetry show strong NW–SE trends close to the Senja Shear Belt and Fugløya transfer zone (Figs. 5, 25), supporting the regional significance of these structures as terrane boundaries and later transfer zones (Olesen et al., 1997; Indrevær et al., 2013).

A similar study of the margin in Lofoten–Vesterålen has shown that the local topography is strongly influenced by brittle faults and fracture sets (Bergh et al., 2007b; Eig, 2008; Hansen, 2009). The brittle faults in Troms have similar orientations as the faults and fractures

in Lofoten–Vesterålen, but their effect on topography is apparently less. A possible explanation for this is the heterogeneous nature of the WTBC. In Lofoten, the basement is largely dominated by homogeneous Palaeoproterozoic magmatic rocks (Griffin et al., 1978; Corfu, 2004). As few pre-existing zones of weakness existed for faults to utilise, the fault zones formed freely, in that they reflected the regional stress field and produced the alternating NNE–SSW and ENE–WSW-trending fault zones that are present today. These were then the only zones of weakness that the main landscape forming element, the glaciers, could utilise and excavate during the Quaternary, enhancing the tectonic effect on topography. In the relatively heterogeneous WTBC, however, zones of weakness with more variable orientation, as produced by lithological boundaries, macro-scale folds, foliation and ductile shear zones, were present and free to be utilised by faults and glaciers alike. As a result, the topography of the WTBC shows a larger degree of correlation with ductile basement structures and a lesser correlation with Late Palaeozoic–Mesozoic brittle faults than that of the Lofoten–Vesterålen margin.

## Conclusions

- Morphotectonic features observed on the high-resolution bathymetry data covering the strandflat outboard Troms, mimic in great detail the basement structures observed onshore, such as duplexes, steeply plunging tight folds, intrafolial macro-folds and shear zones, including the offshore continuations of high-strain metasupracrustal belts. This strongly suggests that the lithologies of the WTBC are also present on the strandflat.
- The contact between WTBC lithologies with a mainly subvertical N–S-striking foliation and gently NW-dipping Caledonian nappes is interpreted to run in the sound southwest of Nord–Fugløya, clearly visible as a distinct change in seabed morphology across the contact zone. The same sound marks the location of the Mesozoic Fugløya transfer zone, a possible reactivated portion of the Svecofennian Bothnian–Kvænangen Fault Complex, which has displaced the Basement–Caledonian contact sinistrally. The spatial overlap of these features suggests that the sound has exerted an important role in controlling and accommodating deformation of the margin through a very long time span.
- NNE–SSW to ENE–WSW-trending trenches commonly truncate interpreted ductile structures on the strandflat and are interpreted as brittle faults based on their similar orientation to known onshore fault zones and fault zones on the continental shelf. Based on a comparison of the impact of onshore fault zones on topography and the apparent offset of bedrock structures across a trench, the fault zones on the strandflat are suggested to have accommodated displacement in the order of kilometres.



- The structural relationship between faults of different orientation suggests that the Late Palaeozoic–Mesozoic fault zones, independent of their orientations, formed contemporaneously. Some of the interpreted fault zones on the strandflat, however, define escarpments that displace the strandflat vertically by as much as 200 m, inferring neotectonic activity. Alternatively, the vertical offset across the fault scarps may be due to glacitectonics, or lithological contrasts in susceptibility to pre-Cretaceous tropical weathering.
- Comparing topography and strandflat slope aspects reveals that the common orientations of basement structures and brittle faults onshore are reflected in the topography as well as in the strandflat bathymetry. This supports the notion of a tectonic influence on the present-day coastal landscape and the SW Barents Sea margin architecture

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