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Structural elements of the Norwegian continental shelf

Part II: The Norwegian Sea Region

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PREFACE

The present work has been carried out over a period of six years; from 1988 to 1995. There are several reasons for this long working period. Firstly, a data coverage of acceptable quality sufficient to allow for the necessary structural resolution in the Vøring and Møre Basins was not achieved until 1992/1993. Secondly, in spite of improved data coverage, the structural geology of the Vøring and Møre Basins has been a subject of heated debate. Thirdly, in certain periods the committee members had to give priority to concession rounds rather than nomenclature work. However, considering the improved data base in the Vøring and Møre Basins and subsequent professional discussions, the final product has actually benefitted from the extended working period.

The completion of the present work was only possible as a result of major efforts by Harald Brekke and Bjørn T. Larsen during the last twelve months, supported by the active participation of Jakob Skogseid.

The committee would like to thank the following companies and institutions for granting permission to publish the geoseismic profiles based on their seismic data:

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The committee is grateful to Norsk Hydro, NPD, Saga Petroleum, Statoil, and the University of Oslo for permitting employees to devote valuable working hours to prepare the structural nomenclature.The committee would also like to thank the following persons for taking part in the work of achieving publication of the present nomenclature: Erling Vågenes (Norsk Hydro a.s), Ørjan Birkeland (Statoil), Pål Haremo (Norsk Hydro a.s), Lars N. Jensen (Statoil), Magnar Larsen (Statoil), and Pål Scott (Norsk Hydro a.s).

Free of charge, the map (Plate I) was given its final design and converted to digital format by the drawing office in Norsk Hydro, and the drawing office in Statoil carried out the very last corrections and provided the technical solution for the transfer of the map to the printers.

The profiles were given their final design and digital format by Teknisk Tegne Service, Stavanger. The costs were met by NPD.

The Norwegian Committee on Stratigraphy (NSK) and the Norwegian Language Council have been very efficient and given well founded criticism and constructive comments to the numerous proposals from the nomenclature committee and their contribution has been imperative for the formal standard of the nomenclature. In particular the comittee would like to express their thanks to Johan Petter Nystuen, the Chairman of NSK.

Finally, the committee would like to acknowledge the work of Dr. Richard Binns in proofreading the English text.

CONTENTS

INTRODUCTION

The first licences in the Norwegian Sea region of the Norwegian continental shelf were allocated in the Haltenbanken area in 1980. Seismic data began to be acquired by the Norwegian authorities in 1969. By the end of 1994, 108 exploration wells had been drilled and approximately 600,000 km of seismic data had been acquired. The first well was spudded on the Trøndelag Platform and was dry. Subsequently, activity has mostly been concentrated on the Halten Terrace and several commercial discoveries have been made.

Exploration activity is steadily expanding into new areas, and in 1994 the whole of the Møre and Vøring Basins and areas west of the Lofoten Ridge were opened for exploration drilling. At the same time, the amount of data has been and is steadily increasing. The need for proper definitions of structural as well as stratigraphic units has been emphasised. In 1988, a lithostratigraphic scheme for offshore central and northern Norway was published (Dalland et al. 1988). In 1990, the first part of an updated nomenclature for structural elements on the Norwegian continental shelf was published (Gabrielsen et al. 1990) dealing with the Barents Sea region. It was partly based on Gabrielsen et al. (1984) who proposed a preliminary structural nomenclature for the continental shelf north of 62°N.

A committee was appointed by the Norwegian Petroleum Society in 1988 to continue the work of revising the structural nomenclature of the Norwegian Continental Shelf and to work out a formalized nomenclature for the Norwegian Sea region. The committee has had representatives from the Norwegian Petroleum Directorate (NPD), Statoil, Norsk Hydro a.s., Saga Petroleum a.s. and the University of Oslo.

This paper summarizes the work of the committee. It formalizes the nomenclature and definitions of the main structural elements in the Norwegian Sea region based in part on the preliminary structural nomenclature proposed by Gabrielsen et al. (1984). The paper is organized in the same manner as the nomenclature for the Barents Sea region (Gabrielsen et al. 1990). The structural elements are arranged in alphabetical order in the description that follows. Type sections have been selected for all structural elements that are formally defined and identified in the text by line identification, shot-point numbers and stratigraphic reference level. The type sections used are the seismic sections which best describe the structural element concerned. Most of these type sections are parts of the interpreted profiles included in this publication (Profiles AA' - OO'). Although most of the seismic data base for these profiles is available to oil companies working in the area, some is not easily accessible. Reference sections can then be used instead of type sections. Reference sections have been selected for structural elements that are characterized by strong geometrical variations laterally or for type sections that are not easily accessible. Academic institutions may not have access to all the quoted data. Publication of all the type sections would have been preferable, but is regarded as impractical because of the large number of lines used and the commercial rights to the use of the data.

15 line drawings of regional key lines have been included in this paper (Profiles AA' - OO'). These have been selected to include almost all of the formally defined structural elements. To achieve this, compromises have been necessary and not all the elements are shown in their most typical form. The positions of the profiles are shown in Plate I.

PRINCIPLES OF NOMENCLATURE

A set of rules for nomenclature in Norway has been published by the Norwegian Committee on Stratigraphy (NSK) (Nystuen 1986, 1989). The present work follows these principles, and formal names have been reviewed and accepted by NSK according to their recommendations.

- Firstly, for the nomenclature of structural elements on the continental shelf NSK recommends that names from the shelf (bathymetric features, fishing grounds, names of ocean areas, etc.) are given first priority.

- Secondly, names from hydrocarbon fields may be used.

- Thirdly, names with another association than geographical to the structural element concerned are recommended (e.g. names from local fauna or names with cultural affinity to the area in question).

- A fourth alternative is available for elements situated close to the coast, for which names from the nearby coastal district are allowed.

NSK has in general argued against the use of names from the mainland in the nomenclature of geological phenomena offshore because these may be confusing and misleading. However, already established mainland names for major structural elements relatively close to the coast have not been changed. Where new definitions are proposed the above principles have been honoured.

The principle that two features should not carry the same name has been acknowledged. However, already well established uses of the same name have not been changed as long as the name is used for different categories; e.g. Jan Mayen Lineament vs Jan Mayen Fracture Zone and Vøring Basin vs Vøring Marginal High.

Table 1 lists the present, formally approved names which replace formerly published names.

The spelling and notations indicating formal names are in accordance with official Norwegian rules as cited by Nystuen (1986, 1989) (see also NOU 1983). This means that in English formal names are written with capitalized initial letters for all words except "the" (e.g. the Viking Graben), whereas in Norwegian they are written in one word with a capitalized initial letter (e.g. Vikinggrabenen).

STRUCTURAL DEVELOPMENT OF THE NORWEGIAN SEA CONTINENTAL MARGIN

Tectonic framework and history

The Norwegian Sea region of the Norwegian continental shelf in the sense of the Law of the Sea (United Nations 1983) comprises most of the continental margin (in the geological sense) between 62°N and 69°30' N. This part of the Norwegian continental margin may be described as a rifted passive continental margin. The tectonic development of the Norwegian Sea was more closely influenced by the break-up and formation of the North Atlantic in the Tertiary than other parts of the Norwegian continental shelf.

Two major plate tectonic episodes, the Caledonian Orogeny and the break-up of the North Atlantic, divide the tectonic history of the area into three epochs:

1) The *pre-Late Devonian* epoch which ended with the final closure of the Iapetus Ocean (Proto-Atlantic) during the Caledonian Orogeny in Late Silurian and Early Devonian time.

2) The *Late Devonian to Palaeocene*, a period of episodic extensional deformation culminating with the continental separation between Eurasia and Greenland at the Palaeocene-Eocene boundary.

3) The *Earliest Eocene to Present*, a period of active sea-floor spreading between Eurasia and Greenland.

The two major tectonic episodes, the Caledonian Orogeny and the continental break-up, also constituted important changes in the regional stress regimes. The lithospheric plates were in compressional stress before the Late Devonian. This changed to extensional stress from the Late Devonian until the continental separation in the Eocene. During the subsequent Tertiary sea-floor spreading, the plates were in a weakly compressional stress regime.

After the Caledonian Orogeny, the orogen collapsed in *Middle to Late Devonian* time forming intramontane extensional basins such as the Hornelen Basin in onshore Western Norway and the Devonian sedimentary rocks on Hitra, Fosna and at Ørlandet. Regional strike-slip movements were possibly also active (Steel & Gloppen 1980, Steel et al. 1985, Ziegler 1988).

The subsequent 350 m.y. of geological history prior to the Early Tertiary continental break-up is of principal interest for petroleum exploration in the area. During this period, major rifting episodes occurred in the Late Carboniferous (?) and Early Permian, in the Late Jurassic and Early Cretaceous, and in the Late Cretaceous and earliest Tertiary. In addition, several extensional tectonic phases (Triassic, Early Jurassic, Aptian/Albian, post-Cenomanian Late Cretaceous and Palaeocene) affected the area.

Carboniferous rocks are not found onshore on the mainland along the Norwegian Sea, but we anticipate that they exist as sedimentary rocks beneath the continental margin.

The *Late Carboniferous to Early Permian* was an active tectonic period over large parts of the proto-North Atlantic area, and is particularly well documented in East Greenland (Surlyk et al. 1984). A block-faulted terrain probably generated by a late Early Permian rifting episode may be mapped beneath the Trøndelag Platform and the Halten Terrace. This block faulting seems to have affected a large part of the area, with planar basement-involved normal faults, mostly on NNE trends. The Froan Basin was formed during this episode. Similar basins with the same age and NNE strike are seen on the eastern part of the Trøndelag Platform northwest of the Froan Basin, but are difficult to map due to limited data quality.

Some block faulting took place in *Middle to Late Triassic* time, continuing the Permo-Triassic basin development east of the Nordland Ridge and Frøya High. Two Triassic evaporite intervals are observed in these basins, varying from halites up to 400 m thick in some places to anhydrites elsewhere. The ages are thought to be latest Ladinian and latest Carnian for the lower and upper evaporites, respectively (Jacobsen & van Veen 1984). These two evaporites act as important detachment levels for normal faults during the later rifting episode and subsequent episodes of normal faulting (Withjack et al. 1989).

The *Late Triassic and earliest Jurassic* seems to have been a period of tectonic quiescence until Sinemurian/Pliensbachian time when prominent, NNE trending growth faults may be observed to have detached in the Triassic evaporites. Some of these faults were not reactivated during later tectonic episodes.

When the Early Jurassic growth faulting ceased, possibly after the deposition of the Tofte Formation sand, Fangst Group sediments were deposited, mostly as "blanket sands", during a quiet episode through Aalenian, Bajocian and most of Bathonian times.

The latest Bathonian was a time of transition into a strong *late Middle Jurassic-Early Cretaceous* rifting episode which can be subdivided into three phases. Phase one occurred during Bathonian/Callovian time, phase two in the Kimmeridgian, and phase three in the Neocomian. During the first two phases, the Halten and Dønna Terraces constituted the western, and tectonically most active, parts of the Trøndelag Platform and pronounced flexuring and faulting took place along the eastern flanks of the Møre and Træna Basins. During the Neocomian phase, the basin margins developed further and the separation between the platform and the terraces became more accentuated.

In the Lofoten-Vestfjorden area, seismic data indicate the existence of remnants of pre-Jurassic basins of unknown age and history. However, the prominent half grabens and basement horsts of the area were initiated in the Jurassic, but had their main phase of developmen t in the Early Cretaceous.

The large-scale faulting and flexuring clearly involved the basement, whereas smaller-scale tectonics on the Trøndelag Platform and especially on the Halten and Dønna Terraces involved shallow listric faults detaching into the Triassic evaporites.

A characteristic effect of the second rifting phase was the uplift and deep erosion of the western edges of the Halten Terrace (the Sklinna Ridge) and the Trøndelag Platform (the Frøya High and Nordland Ridge).

In the period between the Neocomian rifting phase and the *end of the Cenomanian,* the Vøring and Møre Basins experienced mainly thermal subsidence. However, the pronounced expansion of Lower Cretaceous strata in the Ribban, Rås and Træna Basins indicates prominent faulting activity along the boundary faults during Aptian/Albian times, too. The probable extensional nature of this tectonic phase is difficult to prove due to lack of well information in critical areas. The Ylvingen Fault Zone was also considerably reactivated at this time, both by normal dip-slip extension and possibly with an oblique dextral component (Lokna 1993).

Evidence for the onset of an episode of tectonic activity at the end of the *Cenomanian/Early Turonian* may be observed north of the Jan Mayen Lineament. The formation of the Gjallar Ridge was initiated by the uplift and eastward tilting of the westernmost parts of the Vøring Basin. This resulted in onlap of the post-Cenomanian onto the eastward-sloping upper surface of the Cenomanian along the Gjallar Ridge. A mirror image of this onlap may be observed on the Trøndelag Platform, especially across the Frøya High (profile KK'), resembling "steerhead structures"

(Dewey 1982). This tilting of the basin flanks was immediately followed by renewed rifting, block faulting and an increased subsidence rate in the Vøring Basin in the Turonian, continuing into *Campanian* times. Faulting was concentrated along the Nordland Ridge and the Halten Terrace on the Revfallet, Bremstein and Vingleia Fault Complexes which formed the eastern flank of the Late Cretaceous Vøring Basin. Faulting of that age may also be observed along the Gjallar Ridge, which constituted the western flank of the basin. The *post-Cenomanian* was also the main period of subsidence in the Hel Graben and Någrind Syncline, controlled by the Surt Lineament. This tectonic episode may have been related to rifting in adjacent areas, for instance in the Rockall Trough, and the onset of sea-floor spreading in the Labrador Sea (Srivastava & Tapscott 1986).

The final intra-continental rifting episode between Eurasia and Greenland probably lasted from *Campanian/ Maastrichtian* times until continental separation at the Palaeocene-Eocene boundary. The rifting had its centre west of the Møre and Vøring Escarpments, but major mobile zones to the east, like the Jan Mayen Lineament, the Fles Fault Complex and the Surt Lineament, were apparently reactivated leading to local folding in the Vøring Basin along the Fles Fault Complex. The late syn-rifting period of the Maastrichtian-Palaeocene episode involved central rift uplift that strongly affected western parts of the margin and areas north of the Jan Mayen Lineament. This caused erosion of the Møre and Vøring Marginal Highs, highs and ridges in the Vøring Basin, and the Vestfjorden-Lofoten area. Increased clastic input also indicates uplift and erosion of the mainland at that time.

Additional uplift may have affected the outer margin areas due to emplacement of igneous material at the base of the crust, whereas widespread and voluminous igneous activity characterizes the phase of continental break-up and initiation of sea-floor spreading (Skogseid et al. 1992).

The subsidence of the northeastern Atlantic margins following the break-up indicates that significant lithospheric extension affected an approximately 300 km wide area along the final break-up axis (Skogseid 1994). In the Vøring Basin, the region west of the Fles Fault Complex shows extensional deformation by normal faulting, pronounced Cenozoic subsidence, and igneous activity, indicating a spatial correlation between areas affected by crustal and lithospheric thinning and melt generation.

The Møre Basin was apparently tectonically quiet and experienced continued subsidence throughout the Cretaceous and Tertiary. However, the structural expression of the Late Cretaceous and earliest Tertiary tectonics may be hidden under the wide area of lavas on the Møre Marginal High and the landward zone of "inner flows" (see Plate I).

Active spreading started in the *earliest Eocene*, and from this time the regional stress regime changed from extensional to weakly compressional.

The mechanism behind the formation of the major anticlines in the area; the Modgunn and Helland-Hansen Arches and the Vema and Naglfar Domes, is a matter of dispute among the present authors. One view is that the anticlines are mainly a result of tectonic reactivation in the reverse sense along the major mobile zones like the Jan Mayen Lineament, the Fles Fault Complex and the Surt Lineament, during regional tectonic phases in the *Late Eocene-Early Oligocene* and *Late Miocene*. The other view is that the eastern anticline, i.e. the Helland-Hansen Arch, is mainly a result of differential subsidence between the eastern and western Vøring Basin owing to: 1) Maastrichtian-Palaeocene rifting and subsequent subsidence of the western basin province, and 2) Late Pliocene loading and compaction of the eastern province. The western anticlines, i.e. the Vema and Naglfar Domes and part of the Gjallar Ridge have been interpreted as inversions due to magmatic underplating (see also Skogseid & Eldholm 1989, Skogseid et al. 1992 and Stuevold et al. 1992).

The last important tectonic period started in the *Neogene*, possibly in latest *Miocene to Early Pliocene*, with strong differential tilting and asymmetric uplift of mainland Norway. This uplift initiated strong erosion of the sedimentary cover and basement rocks of Scandinavia, creating an up to 1500 m thick Plio-Pleistocene prograding succession across the shelf. The increased Pliocene sedimentation rate can be linked to a possible glacial rebound, and similar deposits are found in the western Barents Sea and on the margins of the Lofoten area as well as in the eastern North Sea and Skagerrak (Eidvin & Riis 1989, Riis & Fjeldskaar 1992, Jensen & Schmidt 1992).

Structural style of the late Middle Jurassic-Early Cretaceous rifting episode

The structural style of the late Middle Jurassic-Early Cretaceous rifting episode on the continental margin of the Norwegian Sea has been a widely discussed topic. Even though there is general agreement that the driving mechanism was extension and crustal stretching, there are three "schools" of interpretation of the details in this process:

a) dextral and/or sinistral faults, mostly along a NNE trend, are important (Gabrielsen & Robinson 1984, Hamar & Hjelle 1984, Caselli 1987, and partly Larsen 1987).

b) the stretching generated a general orthogonal fault pattern of normal faults and accommodation faults (Bukovics et al. 1984, Bøen et al. 1984, Bukovics & Ziegler 1985 and Brekke & Riis 1987).

c) active salt tectonics are an important part of the tectonic style (Jackson & Hastings 1986).

Folding of strata combined with normal faults is typical of the structural style in the area. Larsen & Skarpnes (1984) explained the folding as being related to compression, but interchange between compression and extension caused the structural style. Gowers & Lunde (1984) explained the observations in terms of mostly extensional tectonics modified by sinistral strike-slip faulting and flexuring.

Our present interpretation of the kinematics and dynamic development of the late Middle Jurassic-Early Cretaceous rifting episode is less complex and involves three important structural and deformational patterns:

a) Extension and normal faulting are the dominant features. The normal faults include both deep basement-involved and shallow listric detachment faults. Many listric faults appear to detach into Triassic evaporite beds.

b) Strike-slip faults may be positively identified in a few places only, mainly on the Halten Terrace, and seem to be dextral. These faults are of minor importance in explaining the general structural style.

c) The Triassic evaporites occur both as halite and anhydrite beds. No salt diapirs or well- developed salt pillows are observed. The salt layers function as two prime detachment planes for listric faults (Withjack et al. 1989).

Volcanic margins and marginal highs

During recent years, many continental margins around the world have been found to have a marginal high and a volcanic overprint (Hinz 1981, White & McKenzie 1989). These have been termed volcanic margins. The volcanic margins off Norway, comprising the Møre, Vøring and Lofoten-Vesterålen Margins, are generally subdivided into three zones, I-III, having different acoustic 'basement' characters (Hinz et al. 1982, Talwani et al. 1983). To the west these zones are bounded by normal oceanic crust. Zone I represents a flow/sill complex east of the Faeroe-Shetland and Vøring Escarpments. Zone II lies west of these escarpments and is characterized by an almost flat-lying, smooth and shallow volcanic surface under a thin Cenozoic sediment cover. Zone III has a smooth, shallow volcanic surface, like Zone II, but is underlain by a thick wedge of westward-dipping reflectors. A broad, low-frequency, high-amplitude basal wedge reflector (reflector K in Hinz et al. 1982) is found under the eastern parts of this zone, also extending eastwards beneath Zone II. The western part of Zone III is normally associated with the oldest magnetic sea-floor spreading anomalies (24B, 24A and 23).

Note that magmatic activity, related to the Early Tertiary rifting, is expressed by sills and volcanic vents which are mapped within Cretaceous and Palaeocene sediments as far as 150 km east of the continent-ocean boundary (Skogseid & Eldholm 1989).

Zones II and III are much elevated with respect to the adjacent 'normal' oceanic crust as well as the sedimentary basins to the east. Structurally, the two zones therefore form a 'marginal high'. The present understanding of these highs is closely linked to advances made in the understanding of passive margins in general. The concept of classifying elevated, predominantly 'basement'-related, structural highs along divergent passive margins was introduced by Schuepbach & Vail (1980). They described these features as 'Outer Highs' that developed in the late rifting stage of continental separation due to a median rift uplift. The structures are accordingly located at the transition between continental and oceanic crust. In the Norwegian-Greenland Sea, such highs were first mapped by Talwani & Eldholm (1972) and Eldholm & Windisch (1974), the regional nature of these features being discussed by Eldholm & Sundvor (1980). The term 'marginal high' was introduced by Eldholm et al. (1984). In the context of continental margin studies, both in the North Atlantic and worldwide, we find the term 'marginal high' suitable for describing these outer margin structures.

Similar volcanic features as described for the Norwegian volcanic margins are found along the conjugate northeast Greenland and Jan Mayen Ridge margins, as well as the Rockall-Hatton Bank and southeast Greenland margins to the south. They all form parts of the Early Tertiary North Atlantic Volcanic Province (Morton & Parson 1988).

AGE CORRELATIONS AND ALTERNATIVES

All correlations and age determinations are updated to the standards of the wells available to the committee. Notations and correlations used in profiles and plates are in Table 2, and Figure 1 gives a colour code for the profiles.

Because of long-range seismic correlations, the dating of reflectors in the Møre and Vøring Basins is a matter of debate. The colour code and stratigraphic notation in Profiles AA' - OO' follow the interpretation of the Norwegian Petroleum Directorate, but several committee members would recommend alternative correlations for some of the reflectors in the deep basins. This concerns especially the Cretaceous reflectors in the western parts of the Vøring Basin; the basal Cretaceous unconformity being a particularly difficult case.

West of the Fles Fault Complex, Skogseid & Eldholm (1989) placed this unconformity at the reflector named "Top Cenomanian" in the profiles. In that alternative, the unconformity defines a ridge beneath the Vigrid and Någrind Synclines. Skogseid et al. (1992) proposed the name Fulla Ridge for this structural element which has important implications for the rifting models of the area. However, because this is a standard for nomenclature, the Fulla Ridge is being left out on this occasion because of the present uncertainties and differences of opinion concerning the position of the basal Cretaceous unconformity.

Other alternative interpretations either remain unpublished or have fewer implications for the geological modelling of the area. The most critical of the various alternatives to the NPD age correlations in Profiles AA' - OO' are listed in Table 2 to allow the reader to investigate the correlation problems on his own.

FORMAL DEFINITIONS

Bivrost Fracture Zone

(Norwegian: Bivrostbruddsonen)

Rank: Formal.

References: First mentioned in Hagevang et al. (1983) who named it the Lofoten Fracture Zone.

Name: Named after Bivrost, the bridge leading from earth to heaven in Norse mythology.

Type section: There is no seismic type section for this element as it is defined by magnetic anomalies.

Description: The Bivrost Fracture Zone is situated north of the Vøring Marginal High between 68° 15'N - 69°N and 7° 30'E - 8° 20'E. It is subparallel with the Jan Mayen and Gleipne Fracture Zones and marks a sinistral step in the earliest magnetic anomalies, 24B and 24A. Consequently, it also represents a sinistral step in the continent/ocean boundary and may terminate the Vøring Marginal High to the north. Landward of the oldest magnetic anomaly (24B), the Bivrost Fracture Zone is in continuation with the Bivrost Lineament.

Age: The Bivrost Fracture Zone was formed when the continents broke up in the Early Eocene and was active during the formation of the first 3-4 m.y. of sea-floor spreading (Hagevang et al. 1983). During this relatively short period the area was a system of ridge segments and intersecting fracture zones (Skogseid & Eldholm 1987). Shortly before anomaly 23, the spreading axis shifted westwards and both the Gleipne and Bivrost Fracture Zones became extinct (Hagevang et al. 1983, Skogseid & Eldholm 1987).

Bivrost Lineament

(Norwegian: Bivrostlineamentet)

Rank: Formal.

References: Named the Lofoten Lineament by Blystad et al. (1989), but not described in detail. This name has been used by later workers in the area (Mokhtari & Pegrum 1992, Goldschmidt-Rokita et al. 1994) in the sense defined here. The committee decided to change the name to avoid confusion with mainland geology.

Name: The lineament is named after Bivrost, the bridge leading from earth to heaven in Norse mythology.

Type section: Seismic line GMNR-94-201. The Bivrost Lineament is defined at several levels, possibly from the crystalline basement to the Late Tertiary.

Description: The Bivrost Lineament is a dubious lineament found between 68°N - 66° 30'N and 8° 30'E - 10°E, separating the Vøring Basin and the Lofoten-Vesterålen margin. Planke et al. (1991) described the transition as an abrupt change in average depth to crystalline crustal velocities (4.2-6.0 km/s), from about 6 km on the Vøring margin to about 2 km on the Lofoten-Vesterålen margin. To the south, the continental margin is dominated by the deep regional Vøring Basin, whereas in the Lofoten-Vesterålen area to the north the continental margin is characterized by narrower basins and basement highs.

The lineament is defined as a dextral shift in the Eocene lava front and as the main transition zone between the low-lying Vøring Basin to the south and the elevated Lofoten-Vesterålen area to the north. The Bivrost Lineament also defines an apparent dextral shift in the main structural elements associated with the northern terminations of the Vøring Basin and the Trøndelag Platform. The Bivrost Lineament is parallel to the Surt and Jan Mayen Lineaments, and the fiords on the mainland in the extension along strike of the lineament have the same trend. This indicates that the Bivrost Lineament may be the expression of a fundamental structural grain in the basement. The Eocene Bivrost Fracture Zone formed in the approximate western continuation of the lineament.

Age: The Bivrost Lineament may represent a deep and probably old lineament that has separated structural provinces through later geological events.

Bremstein Fault Complex

(Norwegian: Bremsteinsforkastningskomplekset)

Rank: Formal.

References: New name. The Bremstein Fault Complex approximately coincides with the Haltenbank Segment of the Kristiansund-Bodø Fault Complex of Gabrielsen & Robinson (1984).

Name: The Bremstein Fault Complex is named after Bremstein lighthouse off the Helgeland coast (southern Nordland).

Type Section: Seismic lines -84-102 and -801-414 in Profile JJ'. Reference sections to illustrate diversity in the fault style are -726-460 and -713-460 in Profile FF' and SG-8710-410 in Profile EE'. The reference horizon to define the Bremstein Fault Complex is the unconformity at the base of the Cretaceous.

Description: The Bremstein Fault Complex extends from 64° 30'N - 66°00'N and 7° 40'E - 8° 20'E and forms an almost N-S striking boundary zone between the Trøndelag Platform in the east and the Halten Terrace in the west. The main fault trends present are NNE, N and NNW, and the complex terminates against the Vingleia Fault Complex in the south and the Rødøy High in the north. The Bremstein Fault Complex forms a relatively broad transition zone between the Halten Terrace/southern part of the Nordland Ridge and the Trøndelag Platform and is composed of individual horsts, grabens and rotated fault blocks. The westward-verging basement boundary fault against the Trøndelag Platform acts as a master fault along most of the Bremstein Fault Complex. Other faults are probably linked with the master fault through common detachment zones in Triassic salt layers in parts of the fault complex, forming a ramp-flat-ramp geometry.

Two internal (lower order) structural elements have been described separately in the northern part; the Ellingråsa Graben and the Høgbraken Horst.

Age: The Bremstein Fault Complex has played an important role in the structuring of the Haltenbanken area since at least the Middle Triassic, as shown by growth along some of the individual faults. Major periods of movement occurred in the Late Triassic-Early Jurassic and in the Late Jurassic. The final structuring in the Bremstein Fault Complex was mainly concentrated along the eastern master fault and took place in the Late Cretaceous (Turonian to Campanian).

Dønna Terrace

(Norwegian: Dønnterrassen)

Rank: Formal.

References: The name Dønna Terrace was first used by Aasheim et al. (1986), but further reference or description of the structure was not provided in their paper. Hastings (1986) described it as a northward extension of the Halten Terrace.

Name: Named after the island of Dønna on the coast of the county of Nordland.

Type section: NRGS-84-429 in Profile EE'. Defined relative to the base of the Cretaceous.

Description: The Dønna Terrace occurs between approximately 65° 20'N - 66° 30'N and 6° 40'E - 8° 30'E and is bounded by the Revfallet Fault Complex against the Nordland Ridge to the east-southeast and the Ytreholmen Fault Zone to the west-northwest. The terrace dies out northwest of the Rødøy High in the north. In the south, the Dønna Terrace becomes somewhat wider and less well defined as it approaches the northern part of the Halten Terrace. The Dønna Terrace is internally deformed by faults which form local horsts, grabens and rotated fault blocks. A relatively thick Jurassic sequence underlain by Upper Triassic sediments is present on the Dønna Terrace. The Jurassic sequence is covered by thin Lower Cretaceous sediments below Upper Cretaceous and Cenozoic deposits. The Norne petroleum field is located on the Dønna Terrace close to the Revfallet Fault Complex.

Age: The structural development of the Dønna Terrace is related to crustal stretching in the Jurassic with the peak of activity at the Jurassic-Cretaceous boundary. The terrace was further downfaulted relative to the Nordland Ridge by renewed movement on the Revfallet Fault Complex in the Late Cretaceous (Turonian to Campanian).

Ellingråsa Graben

(Norwegian: Ellingråsgrabenen)

Rank: Formal.

References: New name for a structure previously called the eastern graben system by Gabrielsen & Robinson (1984).

Name: The structure is named after Ellingråsa lighthouse west of Namsos in the county of Nord-Trøndelag.

Type section: SG-8710-410 in Profile EE'. A reference section is given by seismic lines -731-460 and 726-460 in Profile FF'. The structure is defined relative to the base of the Cretaceous.

Description: The Ellingråsa Graben is located between 65° 00'N - 65° 45'N and 7° 40'E - 8° 00'E and occupies a downthrown, strongly elongated area between the eastern master fault in the Bremstein Fault Complex and an easterly-dipping antithetic fault against the Høgbraken Horst. The Ellingråsa Graben is regarded as a subelement in the Bremstein Fault Complex. A number of almost N-S striking, mainly antithetic, faults are present within the graben. The domal shape of the interior of the graben may be attributed to salt swells or fault geometry.

Age: The earliest movement along the master fault forming the eastern side of the Ellingråsa Graben took place in the Late Triassic, and the western boundary fault was activated shortly afterwards. The main periods of faulting and subsidence in the graben were in the Late Triassic-Early Jurassic and the late Middle Jurassic-Early Cretaceous.

The Ellingråsa Graben is interpreted as an extensional structure formed in periods of crustal stretching. After the rifting period in late Middle Jurassic-Early Cretaceous time, the boundary faults to the Ellingråsa Graben were reactivated during a Late Cretaceous tectonic phase.

Faeroe-Shetland Escarpment

(Norwegian: Færøy - Shetland-skrenten)

Rank: Formal.

References: The Faeroe-Shetland Escarpment was first mapped and named by Talwani & Eldholm (1972). See also Smythe et al. (1983), Eldholm et al. (1984) and Talwani et al. (1983, 1984).

Name: The Faeroe-Shetland Escarpment is named after its relative location, partly between the Faeroes and Shetlands. Type section: -6330-92 in Profile MM'. A reference section is given by -6445-92 in Profile JJ'.

Description: The Faeroe-Shetland Escarpment extends from the region east of the Faeroe Islands to the Jan Mayen Fracture Zone between 61o 20'N - 65oN and 4oW - 3o 15'E, bounding the Møre Marginal High to the west and the Møre Basin to the east. The structural expression of the escarpment varies along strike. To the south, it locally reveals a lobate edge, apparently defining the front of a volcanic flow and/or a faulted front. North of about 63oN, on the other hand, the escarpment is well-expressed, fairly linear, and may reflect an interrelationship between a volcanic edge and a deeper structural setting.

Age: The Faeroe-Shetland Escarpment mainly developed as a volcanic escarpment in association with the continental break-up and the separation of Eurasia and Greenland in the Palaeocene-earliest Eocene.

Fenris Graben

(Norwegian: Fenrisgrabenen)

Rank: Formal.

References: The Fenris Graben is part of the Smøla Rift that was initially defined by Rønnevik et al. (1983). This rift has now been divided into two structural elements; the Gjallar Ridge (this volume) and the Fenris Graben. To avoid further confusion, and in view of the established practice that onshore names should be reserved for onshore geology, the name of the island of Smøla should be avoided here.

Name: The Fenris Graben is named after Fenris, half-man, half-wolf, described in Norse mythology. Fenris lived in Hel and was the ruler of the dead.

Type section: VB-15-89 (sp 1500 - 2100) in Profile GG'. The Fenris Graben is defined at the base of the Tertiary.

Description: The Fenris Graben is situated between 67oN - 67o 30'N and 4oE - 6oE. It is a half graben bounded to the east by faults along the western flank of the Gjallar Ridge. To the south and west, the graben is masked by Early Tertiary volcanics adjacent to the Vøring Escarpment. It is bounded to the north by the Rym Fault Zone. The Fenris Graben is characterized by a growth in thickness of the Palaeocene and Eocene rocks to a maximum of 400-500 m across the main eastern bounding faults. The prominent unconformity at the base of the Tertiary seen on the Gjallar Ridge is downfaulted and forms the floor of the Palaeogene graben fill. The bounding faults are formed by reactivation of some of the Late Cretaceous NE-SW trending faults typical of the Gjallar Ridge.

Age: The Fenris Graben was probably formed by reactivation of the western flank of the Gjallar Ridge during rifting in Maastrichtian-Palaeocene time preceding the continental break-up.

Fles Fault Complex

(Norwegian: Flesforkastningskomplekset)

Rank: Formal.

References: The Fles Fault Complex is a new name. First mapped by Skogseid & Eldholm (1989) who did not suggest a name.

Name: The Norwegian word «fles» means a rock awash.

Type Section: Seismic line VB-2-87-A, -B (sp 2000 - 2370) in Profile FF'. Reference sections are ST-8604-412-A in Profile DD', NH-1-79 in Profile EE' and -6445-92 in Profile JJ'. The Fles Fault Complex is defined at both Lower and Upper Cretaceous levels.

Description: The Fles Fault Complex is situated between 63° 50'N - 67° 5'N and 3° 50'E - 9°E, between the Jan Mayen Lineament in the south and the Bivrost Lineament in the north. South of 65°N, the complex has a N-S trend, but swings to a NE-SW trend to the north. The Fles Fault Complex separates the Rås and Træna Basins to the east from the rest of the Vøring Basin. The southern part of the fault complex has a westward polarity and comprises a system of large rotated fault blocks named the Slettringen Ridge east of the main fault. At around 65° 20'N, the fault zone flips to eastward polarity and forms the eastern, elevated edge of the Vigrid and Någrind Synclines - the eastern edge of the Någrind Syncline being named separately the Utgard High.

The Lower Cretaceous is displaced in a normal sense all along the fault zone. The Upper Cretaceous is seen to have been displaced in alternating reverse and normal sense along the strike of the fault complex (compare Profiles FF' and EE'). The pre-Late Miocene part of the Tertiary succession has been inverted resulting in domes and arches on the eastern side of the complex - in places the faults also cut the Palaeocene and Lower Eocene with a reverse sense (Profile FF').

Age: The displacement pattern indicates that the Fles Fault Complex initiated as important normal faults during the late Middle Jurassic-Early Cretaceous episode of extension. The fault complex was then reactivated by normal faulting in the Late Cretaceous, especially in the Maastrichtian-Palaeocene rifting episode. Indications of folding in the Rås Basin and the formation of domes and arches along the complex indicate intermittent periods of possible strike-slip and/or compressional movements during the Late Cretaceous (post-Cenomanian) and in Late Eocene and Late Miocene times.

Froan Basin

(Norwegian: Frobassenget)

Rank: Formal.

References: The Froan Basin was defined by Gabrielsen et al. (1984) as a basin with moderately thick Mesozoic and Tertiary sequences, and as part of the Trøndelag Platform. This definition is revised here. Gabrielsen et al. (1984) also refer to Bøen et al. (1984). The basin was named the Hitra Basin by Hamar & Hjelle (1984) and Bukovics et al. (1984).

Name: After the small Froan islands on the outermost coast of the county of Sør-Trøndelag.

Type section: Lines ST-8707-483 and MB-04-84 in Profile KK'. A reference section is given by lines ST-8804-472, -A in Profile EE'. The Froan Basin is defined at the pre-Jurassic level.

Description: The Froan Basin is situated between 63o 25'N - 65o 10'N and 7o 10'E - 10o 30'E. It is elongated on a NNE trend and is about 250 km long and 50 km wide at its widest in the north. The shape of the basin is difficult to outline towards the north. Internal faults defining the block-faulted terrain mostly have NNE-SSW to E-W trends.

The Froan Basin is essentially a set of half grabens of alternating polarity along strike. In the south, the boundary fault is to the west along the eastern flank of the Frøya High. The thickest basin fill is about 2000-3000 m of Late

Permian-Early Triassic strata. A Late Triassic and Early Jurassic fill of equal thickness may also be present. The Froan Basin is the southernmost of several fairly poorly defined Permo-Triassic extensional basins on the eastern part of the Trøndelag Platform.

Age: The Froan Basin is supposedly Permo-Triassic in age, and the floor is defined at a block-faulted, supposedly late Early Permian, level. In Late Jurassic and Cretaceous times, the Froan Basin was only moderately tectonically active, and only minor faults of Jurassic age can be seen.

In the Late Jurassic, the Frøya High and the southwestern part of the Froan Basin were uplifted and deeply eroded.

Frøya High

(Norwegian: Frøyhøgda)

Rank: Formal.

References: The Frøya High was defined by Gabrielsen et al. (1984) and mentioned earlier by Hinz (1972) and Hamar & Hjelle (1984). Price & Rattey (1984) called it the Smøla High, a name we cannot recommend.

Name: After the large island of Frøya on the coast of Sør-Trøndelag.

Type section: Seismic line MB-04-84 (sp 1550 - 2350). The Frøya High is defined at the level of the basal Cretaceous unconformity.

Description: The Frøya High is located between 63°N - 64° 30'N and 6° 30'E - 7° 20'E. It outlines a N-S trending horst about 120 km long and 30-40 km wide, constituting the southwesternmost part of the Trøndelag Platform. It is fault bounded on both the eastern and western sides. The Klakk and Vingleia Fault Complexes constitute the western boundary faults, the eastern flank being the boundary fault of the adjacent Froan Basin.

The summit of the high is a flat, smooth, composite Late Jurassic-Early Cretaceous unconformity surface dipping gently towards WNW. Along the deeply eroded Klakk Fault Complex, the base of the Cretaceous drops around 3000-4000 m into the Møre Basin, whereas along the Vingleia Fault Complex it is displaced about 800 m on to the Halten Terrace. The basal Cretaceous displacement on the eastern boundary fault is negligible.

Internally, the Frøya High consists of a basement block to the south that continues as a basement ridge along the western flank, narrowing towards the north. To the east of this basement spur, thin erosional remnants of an older (Carboniferous-Permian?) basin sequence lie unconformably on the basement. This sequence shows internal angular unconformities and a complex pattern of NNE trending normal faults. The Frøya High is well expressed on gravity and aeromagnetic maps due to the shallow basement.

Age: The prominent angular unconformity on the summit of the high and onto the Froan Basin implies that the area was uplifted during the Jurassic-Cretaceous rifting episode and remained elevated during the Early Cretaceous.

The Frøya High has a long tectonic history. By analogy to East Greenland (Surlyk et al. (1984), it may have been block faulted during a supposed Early Permian rifting episode. The eastern flank developed movements on the boundary fault during the Late Permian and the Triassic. In the west, the major tectonic event was the late Middle Jurassic-Early Cretaceous polyphasal rifting episode. The strongest faulting in the west took place before the deposition of the Late Jurassic to Ryazanian Spekk Formation, and this shale was unconformably deposited on the unconformity. However, along the western margin the Spekk Formation shales were eroded during the next rifting phase (earliest Cretaceous), and a less prominent unconformity was formed here.

Both the western and eastern fault boundaries must have been active as normal faults in Early Cretaceous time, but with less displacement than in the Late Jurassic. Minor faulting took place in post-Cenomanian time, too. A well-developed «steer-head structure» (Dewey 1982) can be observed at the post-Cenomanian level across the Frøya High (Profile KK') showing that these parts of the Trøndelag Platform were tilted westward at that time (also noted by Brekke & Riis 1987).

Gimsan Basin

(Norwegian: Gimsbassenget)

Rank: Formal.

References: New definition.

Name: Named after the small Gimsan islands and lighthouse just south of Halten lighthouse in Sor-Trøndelag.

Type section: Lines -84-102, -801-414 and HBGS-83-456 in Profile JJ'. The top of the Garn Formation is the reference level.

Description: The Gimsan Basin is located between 64° 17'N - 64° 32'N and 7° 10'E - 7° 28'E. It is an elliptically-shaped structural depression with its long axis oriented N-S. It is located within a rhomboid segment defined by the Vingleia and Bremstein Fault Complexes, the Gjæslingan Lineament and the Kya Fault Zone. The depression corresponds to a magnetic anomaly. The southeastern margin of the basin is faulted at the reference level.

Age: The Gimsan Basin was formed by subsidence and rapid sedimentation during an extensional phase in the late Middle Jurassic and Upper Jurassic. The characteristic style of the basin is assumed to reflect subsidence controlled by deep cross-cutting faults which define blocks with rhombohedral shapes. At Aptian level, the basin loses its expression as a separate structural unit and becomes part of the subsiding Halten Terrace.

Giske High

(Norwegian: Giskehøgda)

Rank: Formal

References: The name Giske High was first mentioned by Hamar & Hjelle (1984).

Name: The structure is named after Giske, a small island west of Ålesund, in the county of Møre & Romsdal.

Type section: Seismic line MB-06-92 (sp 1120 - 1400) in Profile MM'. The Giske High is defined at the base of the Cretaceous.

Description: The Giske High is an elongate structural element, trending NE-SW and situated between 62° 45'N - 62° 55'N and 4° 45'E - 5° 20'E. It follows the same trend as the Gnausen and Gossa Highs which form part of the Magnus-Fosen Fault Zone (Brekke & Riis 1987) and which are included in the Møre-Trøndelag Fault Complex. Lower Cretaceous sediments onlap the structure, indicating that it became structurally defined during the Late Jurassic-Early Cretaceous. At its northern end, the high is bisected by a WSW trending graben filled by pre-Cretaceous sediments. Slight structural inversion occurred in Early Tertiary time, but without significantly affecting the pre-Cretaceous structure.

Age: The high parallels the Møre-Trøndelag Fault Complex trend and is the result of Late Jurassic-Early Cretaceous extension.

Gjallar Ridge

(Norwegian: Gjallarryggen)

Rank: Formal

References: The Gjallar Ridge is part of the Smøla Rift, defined by Rønnevik et al. (1983). The Smøla Rift is now divided into two structural elements; the Gjallar Ridge and the Fenris Graben. Bukovics et al. (1984) noted the presence of a narrow ridge at the base of the Tertiary in the southern part of the area and named this the Lovund Ridge.To avoid further confusion and considering the established practice that onshore geographical names should be reserved for onshore geology, the names of the islands of Smøla and Lovund should not be used for any of these elements.

Name: The Gjallar Ridge is named after the bridge of Gjallar described in Norse mythology. It crossed the River Gjallar to Hel, the world of the dead (Hell). The myths state that «north and down lies Hel» relative to this bridge.

Type section: Seismic line VB-6-87 (sp 1500 - 2500). Reference sections are VB-17-90 in Profile EE', VB-15-89 in Profile GG', VB-7-90-A, -B, -C, -D in Profile HH and VB-4-90-B in Profile II'. The ridge is defined at a combination of the base of the Tertiary and an intra Upper Cretaceous level.

Description: The Gjallar Ridge is part of the Vøring Basin and consists of a NE trending system of deeply eroded, rotated fault blocks between 65° 30'N - 67° 30'N and 3°E - 6°E. The faults have a westward polarity and mainly involve the pre-Tertiary sequences. To the east, the ridge is bounded by the Vigrid Syncline. The western part of the ridge is partly hidden beneath Eocene lava flows, except in the north where it is bounded by faults along the Fenris Graben. To the north, the Gjallar Ridge stops against the Rym Fault Zone in the Surt Lineament, and to the south it ends at the Jan Mayen Fracture Zone.

Along the eastern flank of the ridge, the pre-Tertiary sequence dips gently southeastwards into the Vigrid Syncline. Along the top of the ridge, the fault blocks and the pre-Tertiary sequence are deeply eroded leaving a prominent erosion surface at the base of the Tertiary along the length of the ridge. The Palaeocene interval onlaps this erosion surface along the eastern flank of the ridge so that Eocene sediments rest directly on pre-Tertiary rocks on the central part of the ridge.

Age: The upper part of the Cretaceous sequence thins and has an internal onlap on the eastern flanks of the ridge. The age of this onlapping surface is strongly debated, and age correlations among workers in the area vary from the base of the Cretaceous to the top of the Cenomanian. However, the onlap dates the initiation of the ridge. Faulting started at approximately the same time, although the main phase of faulting probably took place later, during the Late Cretaceous to Early Palaeocene.

In the south, an even deeper eastward-dipping surface is observed onto which all the overlying, pre-Tertiary sequences thin and onlap (Profiles HH' and II'). Workers favouring a deep interpretation alternative for the base of the Cretaceous correlate this with the base of the Cretaceous and suggest that it is a remnant of the eastern flank of a Cretaceous platform bounding the Vøring Basin to the west.

The maximum elevation and erosion of the ridge must have taken place in very late Cretaceous (Maastrichtian?) to earliest Eocene time. The present Gjallar Ridge, Fenris Graben and Vøring Marginal High were probably at the same elevation then and formed a continuous erosional unconformity surface along the western flank of the Vøring Basin (now covered by Eocene lava flows)

The Cretaceous faulting in the Gjallar Ridge was probably due to regional extension between Greenland and Norway associated with rifting in the Rockall Trough and opening of the Labrador Sea. The Maastrichtian-Palaeocene faulting was associated with the rifting leading to the continental break-up in the Norwegian-Greenland Sea.

Gjæslingan Lineament

(Norwegian: Gjæslinglineamentet)

Rank: Formal.

Reference: New name.

Name: The Gjæslingan Lineament is named after Gjæslingan lighthouse, west of Namsos in Nord-Trøndelag.

Type section: Line HBGS-83-456 in Profile JJ'. The structure is defined relative to the top of the Fangst Group.

Description: The Gjæslingan Lineament strikes NE-SW across the central part of the Halten Terrace, in a broad zone from 64° 20'N, 6° 5'E in the Klakk Fault Complex to 64° 50'N, 7° 40'E in the Bremstein Fault Complex. In the southwest, the Gjæslingan Lineament consists of an indentation in the Klakk Fault Complex, a depression in the Sklinna Ridge and a southeasterly-dipping fault across the Halten Terrace. Towards the northeast, the lineament is defined by several minor faults and a pronounced depression in the unconformity at the base of the Cretaceous. In the broad picture, the Gjæslingan Lineament is the zone of change in strike of the structural grain in the Halten Terrace; from N-S trends to the south to NE-SW trends to the north.

Age: The Gjæslingan Lineament was a controlling structural element during the tectonic phases in the Early to Middle Jurassic and in the late Middle Jurassic-Early Cretaceous.

Gleipne Fracture Zone

(Norwegian: Gleipnebruddsonen)

Rank: Formal.

References: This structural element was first mentioned by Hagevang et al. (1983) who named it the Vøring Fracture Zone.

Name: The Gleipne Fracture Zone is named after the magic chain used to tie up the wolf, Fenris, an enemy of the gods in Norse mythology.

Type section: There is no type section for this element as it is defined by magnetic anomalies. However, seismic line VB-11-90-A (sp 2500 - 2700) shows the Gleipne Fracture Zone expressed as a minor break in the sequence of dipping reflectors beneath the Vøring Marginal High.

Description: The Gleipne Fracture Zone is situated on the Vøring Marginal High between 67° 30'N - 68° 30'N and 2° 45'E - 4°E. It is subparallel to the Jan Mayen and Bivrost Fracture Zones and is the location of a sinistral step of the earliest magnetic anomalies, 24B and 24A.

Age: The Gleipne Fracture Zone was formed when the continents broke up in the Early Eocene and was active during the first 3-4 m.y. of sea-floor spreading (Hagevang et al. 1983). During this relatively short period, the area was a system of ridge segments and intersecting fracture zones (Skogseid & Eldholm 1987). Shortly prior to anomaly 23, the spreading axis shifted westwards and both the Gleipne and Bivrost Fracture Zones became extinct (Hagevang et al. 1983, Skogseid & Eldholm, 1987).

Gnausen High

(Norwegian: Gnausehøgda)

Rank: Formal.

References: This structural element was first mentioned by Hamar & Hjelle (1984) who named it the Sande High.

Name: Sande is a name from the mainland and should be avoided in offshore geology. We therefore suggest the name Gnausen High. Gnausen is a fishing ground west of Molde in approximately the same geographical position as the structural element itself.

Type section: Seismic lines SMB-405-D (sp 42100 - 42483) and GMSI-91-112 (sp 600 - 880) in Profile NN'. The Gnausen High is defined at the basal Cretaceous unconformity.

Description: The Gnausen High is situated between 62° 25'N - 62° 35'N and 3° 40'E - 4° 10'E. It is an ENE-WSW trending, elongated, structural high which is defined at the basal Cretaceous unconformity and has a complicated internal fault pattern. On the southeastern side, it is bounded by eastward-dipping faults towards the northwestern flank of the Slørebotn Sub-basin. To the southwest, it consists of two subparallel ridges which merge in the northwest. The Gnausen High is accompanied by gravity and magnetic anomalies, indicating basement involvement. Sediments of Lower Cretaceous age onlap the structure. It is one of several basement-involved highs in the outer parts of the Møre-Trøndelag Fault Complex, such as the Giske, Ona and Gossa Highs further north.

The Gnausen High, together with the Gossa and Giske Highs, constitutes part of the western margin of the Slørebotn Sub-basin and forms the transition between the shallower eastern part and the deeper central part of the Møre Basin.

Age: The Gnausen High is the result of late Middle Jurassic-Early Cretaceous extension. It parallels the Møre-Trøndelag Fault Complex. Brekke & Riis (1987) proposed the occurrence of late Middle Jurassic-Early Cretaceous sinistral movements along this trend and Price & Rattey (1984) suggested dextral movements along the same trend from Middle Cretaceous time.

Gossa High

(Norwegian: Gossehøgda)

Rank: Formal.

References: The name was introduced by Hamar & Hjelle (1984).

Rank: Formal.

Name: Named after Gossa, an island in Møre & Romsdal.
Type section: Line NM1-85-416, -A in Profile LL'. The structure is defined at the base of the Cretaceous.

Description: The Gossa High is located between 62° 50'N - 63° 15'N and 5° 05'E - 6° 15'E and is in the Møre-Trøndelag Fault Complex. The outline and topography of the Gossa High at the base of the Cretaceous reflect infill and compaction on a relief created by earlier faulting. The northwestern part of the high is an ENE-WSW trending basement high. In the eastern and southern parts, a thin sequence of pre-Cretaceous sediments unconformably overlies the basement. To the east, the high is bounded by a train of highly rotated fault blocks which probably involve the basement. To the south, the high is bounded by a complex fault zone with possible local transcurrent movements.

To the west and north, the flanks of the high slope towards the Møre Basin.

Age: At reference level, the Gossa High is a result of Jurassic-Early Cretaceous faulting. These faults, which dip steeply in the southeast, apparently flatten out at a common detachment surface to the northwest. The development of this feature is probably affected by, and involves, the basement high presently located in the northwesternmost part of the structure. Some of the faults were reversely reactivated in Early Eocene times.

Grinda Graben

(Norwegian: Grindgrabenen)

Rank: Formal.

References: New name. The structural development of the northern part of the Grinda Graben was discussed by Gabrielsen & Robinson (1984).

Name: The Grinda Graben is named after Grinda lighthouse south of Vikna, an island in Nord-Trøndelag.

Type section: Lines -726-460 and -713-460 in Profile FF'. The structure is defined relative to the base of the Cretaceous.

Description: The Grinda Graben is found from about 64° 45'N - 65° 30'N to 6° 40'E - 7° 40'E. It consists of southern and northern segments. The southern segment strikes approximately NE-SW and may be regarded as a simple graben structure. Towards the north, the fault trend changes to NNE-SSW and the structure becomes more composite with internal horsts and rotated master-fault blocks. The eastern boundary fault is interpreted as having a relatively shallow detachment in Triassic evaporites. The faults bounding the internal structures in the Grinda Graben may be interpreted as joining up with the shallow detachment.

Dome-like features within the Grinda Graben have been attributed to possible salt swells or tectonic inversion (Gabrielsen & Robinson 1984). Alternating reverse and normal movements along faults indicate local strike-slip or oblique-slip movements within the graben, possibly caused by overall oblique extension of the graben. Profile FF' is located at a reverse segment of one of the internal graben faults.

Age: The present configuration of the Grinda Graben was primarily formed during Early Cretaceous times. Movement along its master faults started in the Late Triassic and a main phase of extension occurred in the Early to Middle Jurassic. The next main period of faulting took place in the Late Jurassic to Early Cretaceous. Further movement in the Late Cretaceous mainly took place along the boundary faults.

Grip High

(Norwegian: Griphøgda)

Rank: Formal.

Name: Named after the island of Grip in Møre & Romsdal. The name Grip has previously been used as an informal name for the lithostratigraphic group now formally named the Viking Group (Dalland et al. 1988).

Type section: Seismic line GMME-94-303 (sp. 6500 - 4000). The reference line is seismic line MB -6410-91 (sp 1600 - 2200). The high is defined at the base of the Cretaceous.

Description: The Grip High is situated between 64°N - 64° 40'N and 4° 45'E - 5° 20'E. It is a SSW-NNE trending, elongated structural high bounded to the west by major westward-dipping faults separating it from the Slettringen Ridge. On the eastern flank of the high, the unconformity at the base of the Cretaceous forms an eastward-dipping slope onlapped by the Lower Cretaceous and Cenomanian successions, indicating that the high was not buried until Turonian times.

Age: The Grip High, at reference level, was formed by large-scale faulting during the Middle Jurassic/Early Cretaceous rifting episode.

Grønøy High

(Norwegian: Grønøyhøgda)

Rank: Formal.

References: The element was introduced by Larsen & Skarpnes (1984) and was formally defined by Gabrielsen et al. (1984).

Name: The structure is named after an island on the coast of Nordland.

Type section: Seismic line NH-8102-430 (shown in Larsen & Skarpnes (1984)). The Grønøy High is defined relative to the basal Cretaceous unconformity overlain by Upper Cretaceous strata.

Description: The Grønøy High is situated between 66° 20'N - 66° 50'N and 9° 10'E - 10° 30'E and trends NE-SW to ENE-WSW. It is regarded as a subelement on the Nordland Ridge. Towards the southwest, the Grønøy High is separated from the Rødøy High by a N-S trending fault transecting the Nordland Ridge. To the north, it is bounded by the Revfallet Fault Complex. To the south, there is a slightly faulted, gradual transition towards the Helgeland Basin. The Grønøy High is defined relative to the unconformity at the base of the Cretaceous on which Upper Cretaceous deposits overlie truncated Lower to Middle Jurassic strata.

Age: The Grønøy High was initiated as part of the Nordland Ridge in the Early Cretaceous. Further uplift and erosion of the high took place during the early Late Cretaceous. A final phase of slight uplift is recorded in the Late Miocene, possibly during a compressional phase also recorded in the Vøring Basin. Larsen & Skarpnes (1984) describe reverse reactivation of Triassic faults associated with this Miocene event.

Halten Terrace

(Norwegian: Haltenterrassen)

Rank: Formal.

References: The term was used by Bøen et al. (1984), Jacobsen & van Veen (1984), Caselli (1987), Hastings (1986), Jackson & Hastings (1986), Heum et al. (1986) and others. Gabrielsen et al. (1984) did not describe the element or give it a formal name, but instead included it (as a subplatform) within the larger structural element, the Kristiansund-Bodø Fault Complex. The term Halten Terrace has been so widely used that we choose to formalize and define it.

Name: After the small Halten (Haltvær) islands and lighthouse on the outermost coast of Sør-Trøndelag.

Type section: Three type sections cross the Halten Terrace. One in the north (-731-460, -726-460, -713-460, -725-460, ST-8403-459, ST-8501-441 and VB-2-87-D (sp 220 - 500), all in Profile FF') crosses the Smørbukk and Midgard Fields, one in the middle (-84-102, -801-414, HBGS-83-456, ST-8501-416 and MB-6445-91, all in Profile JJ') crosses the Draugen Field, and one in the south (MB-04-84 in Profile KK') crosses the southern tip of the terrace. The Halten Terrace is defined at the base of the Cretaceous.

Description: The Halten Terrace is located between 64°N - 65° 25'N and 6°E - 7° 40'E. It is about 80 km wide and 130 km long (about 10,000 km2), and is situated between the Trøndelag Platform in the east and the Rås Basin in the west. It contains several lower-ranked structural elements, such as the Sklinna Ridge in the west and the Grinda Graben, Kya Fault Zone, Gjæslingan Lineament and Gimsan Basin.

The Halten Terrace is separated from the Trøndelag Platform in the east and northeast by the Bremstein Fault Complex, from the Frøya High in the southeast by the Vingleia Fault Complex and from the Møre and Rås Basins in the west by the Klakk Fault Complex. To the north, the terrace plunges into the northeastern part of the Rås Basin in the northwest and merges into the narrower Dønna Terrace towards the north.

Cretaceous strata are about 1200 m thick, with about equal thicknesses of Upper and Lower Cretaceous. About 2000 m of Tertiary strata occur on the terrace. Jurassic strata are present in all parts of the terrace except the western part of the Sklinna Ridge along the Klakk Fault Complex where the Jurassic is eroded and older strata generally dip steeply towards the east.

The terrace is criss-crossed by a complex pattern of normal faults of different ages, usually with two dominating trends, N-S and NNE-SSW. These two trends are responsible for the rhombic shape of the terrace.

Informally, the Halten Terrace may be divided into three subareas with different internal fault patterns. The easternmost area, east of the Grinda Graben and the Kya Fault Zone, is flat, smooth and unfaulted at the level of the base of the Cretaceous. The area southwest and west of the Kya Fault Zone comprises a high and a broad sag, with an internal NNE-SSW and NNW-SSE conjugate fault pattern. The area in the northwest, west of the Grinda Graben, is tilted towards southwest down-dip from the Heidrun oil field and there is a narrow, fault-controlled N-S sag towards the northern end of the Sklinna Ridge in the west. In addition, the SW-NE striking Gjæslingan Lineament bisects the terrace, separating the northern subarea from the two to the south.

Age: The Halten Terrace started to form in the late Middle Jurassic-Early Cretaceous rifting phase and developed its final expression during the Late Cretaceous faulting associated with the Bremstein and Vingleia Fault Complexes. The terrace initiated as an integral part of the Trøndelag Platform, separating it from the Rås Basin in the west in latest Bathonian or earliest Callovian time. Jurassic faulting was very pronounced in the Halten Terrace area. The eastern part of the terrace contains curved NE trending Early Jurassic growth faults which have not been reactivated later. In the southwest, prominent Late Jurassic faults can be seen, many of them not cutting the unconformity at the base of the Cretaceous, but in the northwestern area most faults were reactivated in Early Cretaceous time.

During the late Middle Jurassic-Early Cretaceous rifting episode there was a shift in the development of the master faults. During the early phase of the rifting (Callovian), most of the movement took place along the Klakk Fault Complex to the west and in the latest phases (Kimmeridgian and Neocomian), most of it took place along the Bremstein Fault Complex in the east. After the deep erosion of the uplifted western margins of the early platform (Frøya High, and Sklinna and Nordland Ridges), faulting along the Bremstein and Vingleia Fault Complexes started to separate the Halten Terrace from the Trøndelag Platform in the Neocomian. During the Aptian/Albian, there may again have been some movements on the Klakk Fault Complex. The final separation of the platform and terrace occurred through movement along the eastern boundary faults in Cenomanian/Turonian to Campanian time and may have been linked to a tectonic phase in the Vøring Basin.

Havbåen Sub-basin

(Norwegian: Havbåenunderbassenget)

Rank: Formal.

References: New.

Name: Named after a rock awash off Austvågøy in the Lofoten archipelago, Nordland.

Type section: Seismic line LO-30-87 (Profile BB') provides a type section through the sub-basin, which is defined at the unconformity at the base of the Cretaceous.

Description: The Havbåen Sub-basin is situated between 68° 10'N - 68° 30'N and 12° 30'E - 14° 30'E, creating the northern part of the Ribban Basin. It is separated from the Skomvær Sub-basin by a high. It is a half graben infilled with Lower Cretaceous sediments. Its western termination is defined by the gently eastward-dipping surface of the Utrøst Ridge, and in the east it is bounded by a fault along the Lofoten Ridge. In the northern part of the basin, close to the margin, the fault polarity changes as easterly-dipping faults with a NNE-SSW orientation determine the basin geometry.

Age: The Havbåen Sub-basin was initiated in late Middle Jurassic-Early Cretaceous times as a result of crustal stretching and thermal subsidence. The great thickness of Lower Cretaceous sediments indicates an affinity to the Harstad Basin north of Andøya, which is also characterized by thick Lower Cretaceous sediments (Gabrielsen et al. 1984, 1990). The basin experienced tectonic uplift during latest Cretaceous and possibly Tertiary times.

Hel Graben

(Norwegian: Helgrabenen)

Rank: Formal.

References: The Hel Graben was defined by Skogseid & Eldholm (1989) who called it the Fleina Rift.

Name: The Hel Graben is named after Hel, the ruler of the world of the dead. Hel is the daughter of Loke and Angerboda and the sister of Fenris the wolf (see the Fenris Graben).

Type section: Seismic line VB-10-87 (sp. 1500 - 2500) in Profile DD'. A reference section is given by seismic line VB-7-90 (sp 1 - 2600) in Profile HH'. The Hel Graben is defined at an intra Cretaceous level.

Description: The Hel Graben is located between 66° 50'N - 68°N and 6° 20'E - 10°E within the northwestern part of the Vøring Basin and trends N-NE, more or less parallel with the trend of the Vøring Escarpment. It is bounded to the east by the Nyk High and becomes deeper towards the northeast. The western part of the graben is partly masked by Early Tertiary volcanics along the eastern flank of the Vøring Escarpment. These volcanics also inhibit seismic interpretation of the northeastern continuation of the graben, which, on the other hand, may be inferred by the use of seismic refraction data (Mjelde et al. 1993) and the location of a marked gravity low (Planke et al. 1991). To the south, the Hel Graben is bounded by the Rym Fault Zone in the Surt Lineament.

The Hel Graben is characterized by a central SE trending ridge at Lower Cretaceous level and a thick basin fill of disputed age that expands considerably across the southern graben boundary. The dating of the basin fill depends on the seismic interpretation and correlations across the Rym Fault Zone. Opinions on the age of the expanded basin fill may therefore vary from Campanian to Palaeocene.

Maastrichtian-Palaeocene extension, leading to continental break-up between Norway and Greenland in the earliest Eocene, caused tectonic deformation by listric faulting within the pre-existing graben, as well as sill intrusions into the Cretaceous sediments. Tectonic events in the Late Eocene-Early Oligocene and the Late Miocene caused the inversion observed in the graben, forming the Naglfar Dome (Profile DD').

Age: The Hel Graben probably developed as the northern part of the Vigrid Syncline in the Early Cretaceous. It became a separate graben structure in the Campanian or Palaeocene to earliest Eocene through subsidence governed by the Surt Lineament and the boundary faults along the Nyk High.

Helgeland Basin

(Norwegian: Helgelandsbassenget)

Rank: Formal.

References: Defined by Gabrielsen et al. (1984). Earlier described by Rønnevik et al. (1975) and Jørgensen & Navrestad (1979, 1981).

Name: After the coastal area of the southern part of Nordland.

Type section: Seismic lines ST-8808-826 (sp 3500 - 4954), NR-04-85 (sp 2560 - 3080) and GMT-84-422 (sp 13250 - 12750), all in Profile DD'. The Helgeland Basin is defined at the base of the Cretaceous.

Description: The Helgeland Basin is a broad, isolated depression in the northern part of the Trøndelag Platform between 66° 25'N - 65° 40'N and 11°E - 8° 40'E. The synclinal basin axis strikes approximately NE-SW and the basin is approximately 150 km long and 70 km wide. It may be divided into two equally sized sub-basins, one in the northeast and the other in the southwest, separated by a gentle saddle.

The Helgeland Basin is partly fault-bounded, with normal faults mostly striking parallel with the basin on the northwest side against the Nordland Ridge. To the southeast, it is bordered by a gentle downwarp. In the far southeast, the northeast-striking Vega High forms the margin of the basin.

The Helgeland Basin is filled with a nearly complete sequence of Cretaceous strata, up to 1500 m thick. Lower Cretaceous strata constitute about 1200 m of this in the deepest part. The Cretaceous and Tertiary strata in the Helgeland Basin area dip gently northwestwards.

Age: The Helgeland Basin was formed by weak normal faulting in the northwest and downwarping in the southeast during a late stage (primarily Early Cretaceous) in the late Middle Jurassic-Early Cretaceous rifting episode. The initial downwarp of the basin started in Late Jurassic time. The basin suffered gentle, passive subsidence during Cretaceous time, with a symmetrical, axial, synclinal downwarp pattern. The basin downwarp ended in early Late Cretaceous time. The formation and basin fill of the Helgeland Basin are genetically linked to the uplift and erosion of the Nordland Ridge towards the northwest. The basin was later tilted northwestwards together with the rest of the Trøndelag Platform during the Pliocene uplift of mainland Norway.

Helland-Hansen Arch

(Norwegian: Helland-Hansen-hvelvet)

Rank: Formal.

References: The Tertiary arch structure, the Helland-Hansen Arch, was originally named Structure D by Hinz et al. (1982, 1984), but is probably best known as the Molde High, a name given by Hamar & Hjelle (1984). However, this name has since been given to a structure at the base of the Cretaceous, partly below the Tertiary arch (Bukovics et al. 1984, Brekke & Riis 1987, Skogseid & Eldholm 1989).

Name: The Helland-Hansen Arch is named after R/V «Helland-Hansen» (University of Bergen), which sank 16 nautical miles west of Svinøy lighthouse on 10 September 1976.

Type section: Seismic line VB-2-87-A (sp 1250 - 2300) in Profile FF'. Reference sections are given by VB-17-90 (sp 2200 - 2550) in Profile EE' and -6445-92 (sp 250 - 1250) in Profile JJ'. The arch is defined at an intra Miocene level.

Description: The Helland-Hansen Arch is an elongated structure, about 280 km long and of variable width, in the area between 64°N - 66° 20'N and 4° 25'E - 6° 20'E. In the south, the structure is fairly narrow and trends N-S, but it becomes wider northwards and at 65° 50'N its strike approaches NE-SW. North of 66°N, the arch again becomes narrower. In the north, it is asymmetrical with a steeper northwestern than eastern limb.

The western flank of the Helland-Hansen Arch is bounded by a set of reverse faults belonging to the Fles Fault Complex. North of 65°N, these faults generally offset the base of the Tertiary and locally also the earliest Eocene tuff marker horizon (Skogseid & Eldholm 1989). South of 65°N, the underlying Fles Fault Complex still controls the western flank of the arch, but the faults do not seem to breach the Upper Cretaceous or Tertiary. The arch is well expressed at the intra Miocene reflector (probably the Middle Miocene unconformity) which is onlapped by the Upper Miocene and Pliocene.

Age: Like the other arches and domes in the Vøring Basin, the Helland-Hansen Arch developed during two major phases; the first in Eocene-Oligocene and the second in Late Miocene.

The present authors disagree amongst themselves concerning the importance of fault tectonics versus differential subsidence in the formation of the Helland-Hansen Arch. The majority view holds that the two phases of structuring are due to reverse reactivations along the Fles Fault Complex associated with regional tectonic phases in the general plate tectonic regime of the Norwegian-Greenland Sea, and that the present shape of the arch is mainly a result of these tectonic movements. The minority view does not rule out tectonic reactivations, but argues that the western flank of the arch mainly reflects differential Palaeogene and Early Neogene subsidence due to its position on the eastern margin of the area affected by Maastrichtian-Palaeocene rifting (see also Skogseid & Eldholm 1989, Skogseid et al. 1992, Stuevold et al. 1992).

Høgbraken Horst

(Norwegian: Høgbrakhorsten)

Rank: Formal.

References: New name for a structure originally described by Gabrielsen & Robinson (1984).

Name: The Høgbraken Horst is named after a rock awash west of Brønnøysund in Nordland.

Type section: Seismic line -713-460 in Profile FF'. The structure is defined relative to the base of the Cretaceous.

Description: The Høgbraken Horst is found from about 64° 55'N - 65° 30'N and 7° 30'E - 7° 40'E and is regarded as a subelement within the Bremstein Fault Complex. The Midgard Field (gas) is situated in the southernmost part of the horst. The boundary faults of the Høgbraken Horst trend nearly N-S and coincide with the master faults of the Grinda and Ellingråsa Grabens to the west and east, respectively. The Høgbraken Horst is bounded by a NW trending fault in the south. Faults on the same trend form a local depression or graben further north. North of the internal graben, the horst complex is less transected by faults. To the north, the Høgbraken Horst borders on the Nordland Ridge.

Age: The boundary faults to the Høgbraken Horst were initiated in the Late Triassic. Major periods of faulting took place in Early Jurassic, late Middle Jurassic-Early Cretaceous and late Early Cretaceous. The Høgbraken Horst is interpreted as having formed together with the adjacent graben structures (the Ellingråsa and Grinda Grabens) due to crustal stretching in the Late Jurassic to Early Cretaceous.

Jan Mayen Fracture Zone

(Norwegian: Jan Mayen-bruddsonen)

Rank: Formal.

References: Sykes (1965) attributed an E-W trending pattern of earthquake epicentres near the island of Jan Mayen to a major fracture zone that offsets the ridge crest. The extent, importance and compositional nature of the fracture zone are discussed by Johnson & Heezen (1967), Talwani & Eldholm (1972, 1977), Nunns (1983), Hagevang et al. (1983) and Skogseid & Eldholm (1987).

Name: The Jan Mayen Fracture Zone is named after the island of Jan Mayen.

Type section: There is no type section for this element as it is defined by magnetic anomalies.

Description: The Jan Mayen Fracture Zone consists of three distinct segments informally named the western, eastern and central Jan Mayen fracture zones, respectively. The western segment, between 70° - 72°N and 2° - 15°W with an azimuth of 110°, includes the presently active transform fault offsetting the mid-ocean spreading axis, the Mohns Ridge to the north and the Kolbeinsey Ridge to the south. The eastern and central Jan Mayen fracture zones run subparallel to each other across the northern Norway Basin between about 65° - 71°N and 7°W - 3°E. The trend of the fracture zone changes from N130°E at its western end to about N150°E at its eastern end. The easternmost part of the central Jan Mayen fracture zone defines the continent/ocean boundary at the offset between the Møre and Vøring margins. The Jan Mayen Lineament represents a possible pre-existing structural continuation of the fracture zone trend. The oceanic parts of all three segments of the Jan Mayen Fracture Zone are characterized by large-scale basement relief forming elongated ridges and troughs with associated free-air gravity anomalies. Where the central Jan Mayen fracture zone defines the continent-ocean transition, a gravity high is found on the oceanic side.

Age: The Jan Mayen Fracture Zone developed as a transform fault related to the Early Tertiary opening of the Norwegian-Greenland Sea. The more northerly trend of the eastern and central Jan Mayen fracture zones compared with the presently active western transform fault reflects the more northerly relative plate motion between Greenland and Norway during the Eocene and earliest Oligocene.

Jan Mayen Lineament

(Norwegian: Jan Mayen-lineamentet)

Rank: Formal.

References: New element (see Skogseid & Eldholm 1989). Name: Named after the island of Jan Mayen because it marks a continuation of the Jan Mayen Fracture Zone.

Type section: Seismic line -6445-92 in Profile JJ'. The Jan Mayen Lineament is defined at several levels from the crystalline basement to the Late Tertiary.

Description: The Jan Mayen Lineament is a lineament that divides the deep Møre Basin to the southwest from the Vøring Basin and Haltenbanken area to the northeast. It can be followed from about 65° 30'N and 3°E to 63°10'N and 6° 30'E. It is a broad feature with a NW-SE strike and is a direct continuation of the Jan Mayen Fracture Zone in the continental crust. It is defined by complex NW-SE trending transverse faults in the generally N-S trending Fles Fault Complex and by a sinistral shift in the basin axis and basin margins (including the volcanic escarpments) between the Møre and Vøring Basins. The Jan Mayen Lineament meets the Møre-Trøndelag Fault Complex between the Gossa High and the southern end of the Frøya High. It is parallel to both the other important lineaments in the Vøring Basin, the Surt and Bivrost Lineaments, and to the strike of major faults and fiords on the mainland. This supports our suggestion that this is a fundamental structural grain in the basement.

Age: The Jan Mayen Lineament represents a regional, deep and probably old, lineament that has complexly divided regional areas through later geological events.

Jennegga High

(Norwegian: Jenneggh∅gda)

Rank: Formal.

References: New.

Name: The name is from Jennegga, part of the continental shelf west of Vesterålen.

Type section: Seismic line LO-18-86 in Profile AA'. The Jennegga High is defined at the unconformity at the base of the Cretaceous.

Description: The Jennegga High is found from 68°40'N - 69°N and 13°E - 14°E and is regarded as the northeastern termination of the Utrøst Ridge. It is bounded by faults to the east and west. The structure is deeply eroded centrally and crystalline bedrock is exposed on the sea bed (Rokoengen et al. 1977).

Age: Determining the age of the Jennegga High is problematical owing to the deep erosion of its central part. It existed as an elevated element in the Early Cretaceous as shown by onlapping Lower Cretaceous sediments. Truncation of the Cretaceous succession (Profile AA') indicates that the main uplift phase commenced in the latest Cretaceous or earliest Tertiary. Further phases in the Tertiary are probable, but cannot be substantiated at present. The Jennegga High is interpreted as a positive structural element mainly related to Late Cretaceous and Tertiary plate tectonism tied to the opening of the Norwegian Sea. The uplift mechanism is not fully understood, but transpression has been suggested (Brekke & Riis 1987).

Klakk Fault Complex

(Norwegian: Klakksforkastningskomplekset)

Rank: Formal.

References: New structural element.

Name: A fishermen's term from northern Norway describing a steep submarine slope on the fishing grounds.

Type section: Seismic lines MB-6445-91 and MB-6445-91-A in Profile JJ'. Reference sections are given by lines MB-04-84 in Profile KK' and VB-2-87-D in Profile FF'. The Klakk Fault Complex is defined relative to the base of the Cretaceous.

Description: The Klakk Fault Complex strikes N-S from about 63° 5'N to 65° 30'N between 6°E and 6° 15'E. It is a more than 10-15 km broad, westward-dipping, partly eroded escarpment zone of complex faults along the western margins of the Sklinna Ridge and Frøya High. Its length is about 270 km. The length, width, complexity and long-lived activity of this zone of faults are reasons for defining it as a fault complex.

The complex has a displacement of 2.5 sec TWT down to the west and separates the Sklinna Ridge and Frøya High in the east from the Rås Basin in the west. Most internal faults are synthetic normal faults. Some minor horst blocks can be seen. The internal dip in the sedimentary strata in downfaulted blocks in the complex is mainly towards the west, indicating that the escarpment is partly produced by downward flexuring in the direction of the basin and/or involves steepening of a basement fault system. The escarpment itself was deeply eroded during and after the faulting episode, and deeply incised valleys developed in several locations on the margins of the Frøya High. The northern half of the complex (along the Sklinna Ridge) is broader than the southern half (along the Frøya High). Along the Frøya High, late gravitational collapse of the steep, narrow escarpment produced a complex set of highly rotated fault blocks, partly involving basement rocks.

Age: The Klakk Fault Complex formed during the late Middle Jurassic-Early Cretaceous rifting episode. It was probably also activated in extensional faulting in the Aptian/ Albian.

Kya Fault Zone

(Norwegian: Kyforkastningssonen)

Rank: Formal.

References: Newly described structural element.

Name: Named after a lighthouse off the northernmost coast of Sør-Trøndelag, between Halten and Vikna.

Type section: Seismic line HBGS-83-456 (sp 500 - 1000) in Profile JJ'. The Kya Fault Zone is defined at the top of the Fangst Group (Middle Jurassic).

Description: The Kya Fault Zone is a N-S striking zone composed of several faults. It can be followed from about 64° 15'N to 64° 50'N between 6° 50'E and 7° 5'E. In the north, the zone merges into the Grinda Graben. In the south, it meets the northern end of the Frøya High and the Vingleia Fault Complex west of the Njord oilfield. Its length is about 70 km and its width varies up to about 5 km. The Upper Jurassic Gimsan Basin is located to the east of the southern part of the zone.

The Kya Fault Zone is composed of many parallel and subparallel faults with different polarities. It lacks uniformity along strike, and as a whole, is best expressed at the top of the Fangst Group.

Age: The Kya Fault Zone has a complex and long tectonic history. The major activity seems to have been in Late Jurassic time, during an early phase of the late Middle Jurassic-Early Cretaceous rifting episode. This seems to be the only period when activity took place along the entire zone. Minor faulting occurred along the northern half of the zone in Early Jurassic time. The northernmost part was also active in Early Cretaceous time, when movement in the south had ceased.

Lofoten Ridge

(Norwegian: Lofotryggen)

Rank: Formal.

References: Named by Mokhtari & Pegrum (1992) who used the name in the same sense as it is defined here.

Name: After the Lofoten archipelago.

Type Section: Seismic line LO-08-87-B (sp 2100 - 2300) in Profile CC'. The structural element is defined at the top of the basement.

Description: The Lofoten Ridge is located between 67°N - 69° 30'N and 10° 30'E - 16° 30'E. It has a NE-SW trend and is about 350 km long. It is bounded in the west and north by the Ribban and Harstad Basins and in the east by the Vestfjorden Basin and Andfjorden. In the south, the structure is a narrow, fault-bounded basement horst the highest points of which form the islands of Røst and Værøy. It becomes wider to the north and includes several NE trending basement horsts along which the islands of Lofoten, Vesterålen and Andøya are situated. The ridge is deeply eroded and crystalline basement is exposed on the sea bed and on the islands all along the ridge, except in the northeastern part of Andøya where Jurassic and Early Cretaceous rocks are exposed onshore in a half graben (Dalland 1975).

Age: Because of the deep erosion of the area it is not possible to give details of the Tertiary history of the Lofoten Ridge. However, it is clear that the ridge was formed as a set of horsts as early as in the Late Jurassic-Early Cretaceous and was accentuated by faulting throughout the Cretaceous and probably in the Early Tertiary. The relatively thin cover of Triassic and Jurassic strata on crystalline basement in the down-flank basin areas indicates that the Lofoten Ridge has been part of an elevated area since Late Palaeozoic times.

Manet Ridge

(Norwegian: Manetryggen)

Rank: Formal.

References: The structure was defined by Hamar et al. (1980) using the name Nordfjord Horst. Gabrielsen et al. (1984) called it the Nordfjord Ridge. It has also been dealt with by Hinz et al. (1982), Brekke & Riis (1987), Nelson & Lamy (1987) and Graue (1992).

Name: The Manet Ridge is named after the Norwegian word for jellyfish.

Type section: Seismic line MS-85-410 in Profile OO'. The ridge is defined at the base of the Cretaceous.

Description: The Manet Ridge is located within the southwestern part of the Møre Basin. As defined in the Norwegian sector, the structure is situated between 61° 58'N - 62° 15'N and 1° 20'E - 2° 15'E. It is said to represent the northeastern extension of Margareta's Spur in the UK sector (Nelson & Lamy 1987), as defined by the basal Late Cretaceous marker by Duindam & Van Hoorn (1987).

In the Norwegian sector, the Manet Ridge represents a northeast-plunging structure which changes from an approximately 10 km wide feature to a horst not more than 1 km in width to the northeast. Further northeast to north-northeast, structural highs defined at the base of the Cretaceous occur along the same structural grain and separate the shallower southeastern part of the Møre Basin from the overall deeper main parts of the basin to the northwest.

At the base of the Cretaceous and at deeper structural levels, the southwestern part of the Manet Ridge has been mapped as a strongly faulted and very complex structural feature, and Mesozoic and Palaeozoic strata become truncated at this level. In the area of maximum elevation, the top is a flat erosional unconformity on which Turonian strata overlie pre-Mesozoic rocks. The structure is associated with gravity and magnetic anomalies caused by shallow basement rocks underlying the high.

Age: An early period of structuring is indicated by a possible pre-Permian unconformity on the Manet Ridge. The main development of this structural feature is related to late Middle Jurassic-Early Cretaceous tectonism. The structural relief was levelled in the Late Cretaceous.

The Manet Ridge apparently results from considerable NW-SE extension. In the UK sector, Margareta's Spur, which may represent a southwesterly extension of the Manet Ridge, is interpreted as an enormous, eastwardly-tilted crustal block (Duindam & Van Hoorn 1987). Nelson & Lamy (1987) suggest considerable northwestward translation of the Manet Ridge as part of a very large detached block of continental basement. A sole fault, on which the translation took place, is assumed to be at a depth of approximately 12 km. Graue (1992) further develops this model for the Manet Ridge.

Marmæle Spur

(Norwegian: Marmæleutstikkeren)

Rank: Formal.

References: New element.

Name: Named after the Marmæle, a tiny sea creature mentioned in fairy tales from Vesterålen. If you can catch one, your fishing will prosper and you will become wealthy.

Type section: Seismic line LO-10-88 (sp 1500 - 2000) in Profile CC'. The Marmæle Spur is defined at the base of the Cretaceous.

Description: The Marmæle Spur is situated between 67° 30'N - 68°N and 11°E - 11° 30'E. It is the NE-SW trending crest of a rotated basement fault block forming the southeastward termination of the Utrøst Ridge. The crest of the block plunges southwards and the element is bounded by faults to the west. In the central part, the spur is eroded and exposed on the sea bed. The Marmæle Spur separates the Ribban Basin to the east and the possible northern extension of the Træna Basin to the west.

Age: The Marmæle Spur probably existed as an elevated area in the Early Mesozoic, as the crest of a rotated fault block. It was uplifted in latest Cretaceous time as part of the Utrøst Ridge (see the description of the Utrøst Ridge).

Modgunn Arch

(Norwegian: Modgunnhvelvet)

Rank: Formal.

References: New name for a feature not described previously.

Name: Named after the maiden Modgunn who guarded the Gjallar bridge. She recorded the names and ancestry of persons passing the bridge on their way to Hel.

Type Section: Seismic line -6445-92 (sp 2250 - 3000) in Profile JJ'. The Modgunn Arch is defined at the Middle Miocene level.

Description: The Modgunn Arch is situated between 64° 40'N - 65° 40'N and 3°E - 4°E. The arch has a N-S trending axis and occurs where the Jan Mayen Lineament truncates the southern end of the Gjallar Ridge and the northern end of the Faeroe-Shetland Escarpment. The Modgunn Arch is characterized by onlaps onto the Middle Miocene unconformity along the flanks, and the top and much of the western flank are truncated by the base of the Upper Pliocene.

Age: The onlaps of the Late Miocene onto the Middle Miocene unconformity indicate that the arch formed in the early Late Miocene. One view among the present authors is that it was formed by space problems brought about by its particular position on the Jan Mayen Lineament during a tectonic (transpressional or compressional) phase that also affected the other large domes and arches in the Vøring Basin. Another view is that it may be a mound related to a sedimentary sequence prograding from the elevated area close to the Jan Mayen Fracture Zone.

Møre Basin

(Norwegian: Mørebassenget)

Rank: Formal.

References: The element was named by Rønnevik et al. (1975) and was formally defined by Gabrielsen et al. (1984). It has been discussed by Jørgensen & Navrestad (1981), Hinz et al. (1982), Bucovics et al. (1984), Bøen et al. (1984), Hamar & Hjelle (1984), Price & Rattey (1984) and Brekke & Riis (1987).

Name: Named after the Møre area in the county of Møre & Romsdal.

Type section: Seismic lines MB-06-92 and -6330-92 in Profile MM'. The Møre Basin is defined at the base of the Cretaceous and by a greatly expanded Cretaceous sequence. Description: The Møre Basin is situated between 62°N - 65°N and 0°E - 6° 30'E. It is bounded to the south by the northern termination of the Tampen Spur and to the north by the Jan Mayen Lineament which separates it from the Vøring Basin. To the east, it is bounded by the Cretaceous subcrop/onlap towards the Norwegian mainland and the southern termination of the Frøya High. The Slørebotn Subbasin on the landward side of a row of highs is the easternmost part of the Møre Basin. To the west, it is bounded by the Faeroe-Shetland Escarpment along the Møre Marginal High .

The Møre Basin has an overall NE-SW trend which is also reflected in the structuring of the unconformity at the base of the Cretaceous here. Cretaceous sediments onlap this unconformity along the western and eastern basin margins, indicating that the Møre Basin was a symmetrical feature mainly formed by downwarping of its flanks on which the early faults show polarity away from the basin centre (see Profile MM'). In contrast to the Vøring Basin north of the Jan Mayen Lineament, the Møre Basin seems to have been tectonically quiet, experiencing passive subsidence since the late Middle Jurassic-Early Cretaceous rifting, with no observable Cretaceous and Tertiary reactivations except for minor movements along the Faeroe-Shetland Escarpment and the Jan Mayen Lineament. However, the structural expression of Late Cretaceous to Palaeocene tectonism may be hidden under the wide area of lavas on the Møre Marginal High and east of the escarpment («inner flows»). In western and central parts of the basin, seismic data indicate the existence of igneous rocks, both as sills and lava flows.

The thickness of the Cretaceous sediments is considerable and may exceed 6000 m. The Upper Cretaceous sequence is probably somewhat thicker than the Lower Cretaceous sequence (Brekke & Riis 1987). In Late Cretaceous time, the Møre Basin also included the Magnus and Marulk Basins.

Age: The Møre Basin is a result of Late Jurassic-Early Cretaceous crustal stretching and thinning, faulting and subsequent thermal cooling and subsidence. Brekke & Riis (1987) pointed out that the eastern margin of the Møre Basin is characterized more by downwarping than down-to-the-basin faulting, which indicates a high degree of crustal thinning. The expansion of the Upper Cretaceous sequence with strong basinward- thickening indicates that the Møre Basin responded by further subsidence to the Late Cretaceous tectonic events to the north and probably to the west.

The interpretation of the Møre Marginal High as an Early Tertiary, subaerially exposed flood basalt province further indicates substantial Tertiary subsidence of the outer basin province. According to Skogseid (1994), this may be linked with Maastrichtian-Palaeocene lithospheric thinning and associated earliest Eocene continental separation.

The probable presence of igneous rocks within the basin has attracted special interest. Formation of oceanic crust of Cretaceous age as a continuation of possible oceanic crust within the Rockall Trough has been suggested by Bott (1973), Roberts (1975), Woodhall & Knox (1979), Hanisch (1984) and Price & Rattey (1984). It has been suggested that lava flows east of the Faeroe-Shetland Escarpment date from the Early Cretaceous (Hamar et al. 1980) as well as the Tertiary (Rønnevik et al. 1983), but Profile MM' shows that they are of Late Palaeocene-Early Eocene age.

Møre Marginal High

(Norwegian: Mørerandhøgda)

Rank: Formal.

References: The Møre Marginal High has earlier been called the Møre Platform (Hamar & Hjelle 1984). See also Smythe et al. (1983), Talwani et al. (1983), Eldholm et al. (1984) and Talwani et al. (1984).

Name: The Møre Marginal High is named after the Møre area in Møre & Romsdal.

Type section: Seismic line -6330-92 (sp 156 - 1800) in Profile MM'. The Møre Marginal High is defined at the top of the Eocene lavas.

Description: The Møre Marginal High is situated between the Faeroe Plateau and the Jan Mayen Fracture Zone, from 62°N - 65°N and 5°W - 3°E. It is bounded to the east by the Faeroe-Shetland Escarpment and to the west by the transition to «normal» oceanic crust. The Møre Marginal High includes two zones of different structuring beneath the top Eocene lava reflector (Zones II and III in the notation of Hinz et al. (1982) and Talwani et al. (1983)).

The western zone (Zone III) is underlain by a seaward-dipping reflector sequence representing a westward-thickening lava pile, probably the upper part of thick oceanic crust. The eastern zone (Zone II) forms a 15 to more than 100 km wide area west of the Faeroe-Shetland Escarpment, in which reflectors of poor continuity are subparallel to the uppermost Eocene lava or dip gently landwards. Zone II is probably underlain by continental or transitional crust. The marginal high is widest in the south where it maps as a continuous volcanic sheet, including the Faeroe Islands. The southeastern termination at the escarpment only appears to be a volcanic flow limit and build-up (Smythe et al. 1983). Gibb & Kanaris-Sotiriou (1988) correlated this with the Faeroe Middle Series Lavas. Between 63°N and 64°N, the escarpment is more prominent and some Profiles show internal deeper structures within the marginal high. The high is more poorly defined north of 64°N.

Hinz et al. (1982) demonstrated the occurrence of a high-amplitude, low-frequency reflector (the «K reflector» in their terminology) at the assumed base of the volcanics, and Smythe et al. (1983) traced this reflector continuously beneath the marginal high to correlate it with volcanic rocks landwards of the Faeroe-Shetland Escarpment. Gibb & Kanaris-Sotiriou (1988) correlated these volcanics with the Faeroe Lower Series Lavas.

Age: The Møre Marginal High developed as part of the volcanic passive margin formed by regional Maastrichtian-Palaeocene continental extension leading to the separation of Eurasia and Greenland in Palaeocene to earliest Eocene time. During this process, the outer parts of the Møre Basin, as well as the marginal high, experienced uplift and magmatic activity.

Møre-Trøndelag Fault Complex

(Norwegian: Møre-Trøndelag-forkastningskomplekset)

Rank: Formal.

References: This structural feature was termed the «Møre-Trøndelag Line» by Price & Rattey (1984) and includes the Møre-Trøndelag Fault Zone defined on the Norwegian mainland by Gabrielsen & Ramberg (1979) using satellite imagery. The onshore part of this structure has also been described by Oftedahl (1975), Aanstad et al. (1981), Grønlie & Roberts (1989) and Bering (1989). Gabrielsen et al. (1984) gave the onshore and offshore parts of the feature the status of a fault zone and suggested the name Møre-Trøndelag Fault Zone.

Name: Named after the Møre area in the county of Møre & Romsdal and the dual counties of Sør-Trøndelag and Nord-Trøndelag.

Type section: Seismic lines SMB-405, A, B, C, D and GMSI-91-112 in Profile NN'. Reference sections are given by MB-06-92 in Profile MM' and NM1-85-416, A, B in Profile LL'. The Møre-Trøndelag Fault Complex is expressed at the base of the Cretaceous and at basement levels.

Description: Elements of the Møre-Trøndelag Fault Complex are identified between 61° 40'N - 64° 20'N and 0° - 13°E. To the southwest, a similar structural grain is represented by the West Shetland and Faeroe Basins and associated subelements.

On the Norwegian mainland, the Møre-Trøndelag Fault Complex affects Precambrian and, in part, Lower Palaeozoic rocks, which are dominated by an ENE-WSW structural grain.The complex includes some of the major faults known in the area, such as the Hitra-Snåsa Fault, the Verran Fault and the Beistadfjorden Fault (Oftedahl 1972, 1975).

Seismic and gravimetric data indicate that the northwest coast of Norway is part of a laterally more extensive ENE-WSW trending zone. The presence of the Tarva Fault has been inferred between the islands of Hitra and Smøla in the southeast and Frøya in the northwest (Oftedahl 1975). North of Hitra, the Tarva Fault separates the downfaulted remnants of a sedimentary basin of possible Jurassic age to the northwest from the basement to the southeast (Bøe 1991).

An ENE-WSW trending fault occurs southeast of Vikna and Gabrielsen et al. (1984) viewed this as part of the Rana Fault Complex. It separates metamorphic basement with remnants of possible Jurassic basins (Bøe 1991) in the southeast from Mesozoic and possibly pre-Mesozoic strata in the northwest. Faults and fault-related basins and highs in offshore areas to the west-southwest define a pronounced ENE-WSW structural grain at Palaeozoic and Mesozoic levels.

Brekke & Riis (1987) introduced the term Magnus-Fosen Fault Zone for an element trending ENE-WSW from the Manet Ridge to the Gossa High. In the present work, this is regarded as part of the Møre-Trøndelag Fault Complex separating the shallower southeastern part of the Møre Basin from the overall deeper, main parts of the basin to the northwest.

The strongest effect of N-S trending elements and the most complex structural configuration within the Møre-Trøndelag Fault Complex are in the area where it intersects the northerly extension of the Sogn Graben and Øygarden Fault Zone.

At Mesozoic levels, the Møre-Trøndelag Fault Complex is characterized by listric normal faults and associated hanging-wall deformation. The most spectacular faults of this generation are those south of the Gossa High and the fault representing the northwestern boundary of the Manet Ridge.

Age: The Møre-Trøndelag Fault Complex represents a fundamental zone of basement weakness. The ENE-WSW structural grain in northwestern Norway can be related to Caledonian deformations. Slivers of Devonian sediments (Siedlecka & Siedlecki 1972) occur within the complex. Reactivation of the Møre-Trøndelag Fault Complex took place in several episodes. The most prominent subsidence along the complex presumably occurred in Permo-Triassic and Late Jurassic-Cretaceous times. Mesozoic reactivation of onshore parts of the complex is inferred from the presence of Middle Jurassic sediments associated with movements along the Verran-Beistadfjorden Fault (Oftedahl 1972, 1975, Bøe & Bjerkli 1989).

Naglfar Dome

(Norwegian: Naglfardomen)

Rank: Formal.

References: The Naglfar Dome was previously included in the Vema Dome as defined by Skogseid & Eldholm (1989).

Name: The Naglfar Dome is named after Naglfar, a ship described in Norse mythology. It was built from the nails of the dead and was used to carry the Jotnes, the enemies of the gods, to Vigrid which was the scene of the ultimate, cataclysmic battle called Ragnarok.

Type section: Seismic line VB-7-90 (sp 1 - 2600) in Profile HH'. The Naglfar Dome is defined at Eocene to Middle Miocene levels.

Description: The Naglfar Dome is situated between 67° 20'N - 68°N and 6° 20'E - 7° 40'E and is slightly elliptical with a N-S trending long axis. The dome generally follows the outline of the underlying Hel Graben. The structure is characterized by onlaps around its flanks onto two separate surfaces; one in the Late Eocene-Early Oligocene and the other being the Middle Miocene unconformity. The base of the Late Pliocene truncates the Late Miocene and Early Pliocene across the dome and is itself in part slightly domed over the top of the dome.

The fill of the Hel Graben is so thick and reflects such a large subsidence that the trough shape of the basin dominates the basin-fill sequences even under the centre of the Naglfar Dome.The dating of the basin-fill sequences of the Hel Graben is debatable (see the description of the Hel Graben). Whether the dome shape is seen at the level of the base of the Tertiary or not depends on the correlation chosen.

Age: The onlaps and truncations in the Eocene to Late Pliocene described above show that the Naglfar Dome was formed during that period. One view amongst the present authors is that the dome was mainly formed during tectonic reactivation in the reverse sense along the bounding faults of the Hel Graben, the Rym Fault Zone in particular, in the Late Eocene-Early Oligocene and in early Late Miocene. The other view is that the dome was formed as an inversion due to magmatic underplating associated with the Maastrichtian-Palaeocene rifting episode (Skogseid et al. 1992, Stuevold et al. 1992).

The truncation at the base of the Upper Pliocene indicates a period of submarine erosion of the dome, whereas the slight doming of the Upper Pliocene sediments shows that the growth of the dome may have continued up to recent times.

Nordland Ridge

(Norwegian: Nordlandsryggen)

Rank: Formal.

References: The Nordland Ridge was originally defined by Rønnevik et al. (1975) and further details derive from Jørgensen & Narvestad (1979, 1981), Rønnevik et al. (1979, 1983), Hinz et al. (1982), Gabrielsen & Robinson (1984) and Price & Rattey (1984), as well as the descriptions and interpretations of Gowers & Lunde (1984), Larsen & Skarpnes (1984), Brekke & Riis (1987) and Caselli (1987).

Name: The structure is named after the county of Nordland. Type section: Seismic lines NRGS-84-429 (sp 2000 - 2460) and SG-8710-410 (sp 629 - 1090), both in Profile EE'. A reference section is given by lines GMT-84-422-A (11599 - 12750) and NRGS-84-481 (sp 1 - 500) in Profile DD'. The Nordland Ridge is defined relative to the basal Cretaceous unconformity and the base of the Tertiary where Cretaceous strata are missing due to erosion.

Description: The Nordland Ridge is an elongated structural high situated between 65° 15'N - 66° 50'N and 7° 30'E -12° 30'E. It is delimited to the northwest by the Revfallet Fault Complex and to the east and southeast by the northern end of the Bremstein Fault Complex and the Helgeland Basin. Whereas its boundaries are well defined along the Revfallet and Bremstein Fault Complexes, its boundary against the Helgeland Basin appears to be more transitional.

The Nordland Ridge is regarded as a subelement of the Trøndelag Platform. Along the extension of the Nordland Ridge, its orientation changes from NNE-SSW to NE-SW. The ridge is transected by deep faults, and three individual highs have been described; from south to north: the Sør High, Rødøy High and Grønøy High.

The Nordland Ridge is defined relative to an unconformity representing a major hiatus. Rocks truncated by the unconformity vary in age from Late Permian to Jurassic. Deposits overlying the unconformity range in age from Early Cretaceous to Pliocene. Generally, the truncated sequence increases in age towards the north up to the Rødøy High. Further north, younger strata again underlie the unconformity. Gradually older sequences are present above the unconformity from south to north. It is obvious that the hiatus related to the unconformity on the Nordland Ridge is composite in the sense that it resulted from several events of erosion and nondeposition.

Age: Structuring of the Nordland Ridge area started in Late Carboniferous-Early Permian time (Gowers & Lunde 1984). Continued activity in the Triassic and Jurassic culminated in an increase in faulting in the late Middle Jurassic-Early Cretaceous (Gabrielsen & Robinson 1984, Larsen & Skarpnes 1984). Uplift and erosion of the ridge have been attributed to this period. Later periods of tectonic activity and erosion affecting the Nordland Ridge have been described from the Middle Cretaceous (Price & Rattey 1984), Late Cretaceous-Early Tertiary (e.g. Gabrielsen & Robinson 1984, Brekke & Riis 1987) and Late Tertiary (Larsen & Skarpnes 1984).

The Nordland Ridge area was in general subject to extensional phases in the Late Carboniferous-Early Permian, Late Permian-Early Triassic, Jurassic and Early Cretaceous. Inversion has been related to strike-slip faulting in the Late Jurassic (Gabrielsen & Robinson 1984, Caselli 1987). It has also been suggested that strike-slip faulting and inversion took place in the Middle Cretaceous (Price & Rattey 1984) and Late Cretaceous-Early Tertiary (Gabrielsen & Robinson 1984, Larsen & Skarpnes 1984, Brekke & Riis 1987).

Nyk High

(Norwegian: Nykhøgda)

Rank: Formal.

References: Newly described structural element.

Name: The Norwegian word «nyk» means a high, steep, isolated bird-nesting cliff. It is used both as a separate name «Nykan» and as a suffix for several small, steep islands, such as «Hernyken» and «Trenyken» in Røst.

Type section: VB-10-87 (sp. 1200 - 1500) in Profile DD'. The Nyk High is defined at intra Upper Cretaceous levels. Description: The Nyk High is a complex NE-SW striking high forming the southern part of the eastern flank of the Hel Graben. It can be recognized from about 67°N - 67° 25'N and 6° 40'E - 8° 15'E and extends about 75 km along strike. Its width is about 15-20 km. It is shallow and only the latest Tertiary sediments blanket the highest point around 67°15'N and 7° 30'E (line VB-12-87) where the Neogene sedimentary cover is less than 100 m thick.

The internal dip of the sub-Upper Cretaceous sediments is relatively steep towards the southeast, into the Någrind Syncline. Complex faults defining the western side of the high are mostly northwestward-dipping normal faults. Folding and possible reverse faulting can also be observed, and a strike-slip component in the formation of the high is likely. The high is more deeply buried and structurally more complex towards its termination in the northeast where some eastward-dipping faults occur. To the southwest, the high terminates at the eastern end of the Rym Fault Zone in the Surt Lineament.

Age: The Nyk High is linked to the formation of the Hel Graben and the Någrind Syncline. In the Early Cretaceous, the area was part of the Vigrid Syncline, but the greatly expanded Upper Cretaceous succession in the Hel Graben, Nyk High and Någrind Syncline formed by differential subsidence across the Surt Lineament in the post-Cenomanian. The present configuration of the Nyk High mostly dates from the Late Cretaceous to Earliest Tertiary and probably involved both extension and compressional/-transpressional reactivation. The dating of the main period of structuring depends on the dating of the sedimentary fill of the Hel Graben (see the description of the Hel Graben). A thin Palaeocene succession in the Hel Graben means that the main development of the Nyk High took place in the Late Cretaceous. Lack of internal Upper Cretaceous onlaps on the eastern flank of the high indicates that it took place in the latest Cretaceous, probably in the Maastrichtian. Alternatively, a thick Palaeocene succession would put the main phase in the Palaeocene. Irrespective of the alternative chosen, the formation of the Nyk High was associated with the Maastrichtian-Palaeocene tectonic phase. The faults on the western flanks of the high were active as normal faults in several phases during theTertiary.

Någrind Syncline

(Norwegian: Någrindsynklinalen)

Rank: Formal.

References: The Någrind Syncline is a new name used for a structure named the Røst Syncline by Rønnevik et al. (1983) and the Røst Sub-basin by Gabrielsen et al. (1984). See also Hinz et al. (1982) and Bøen et al. (1984).

Name: Någrind is the name of the set of gates leading to the world of the dead, Helheim, in Norse mythology.

Type section: Seismic lines ST-8604-412 (sp 1270 - 1800) and VB-10-87 (784 - 1200) in Profile DD'. A reference strike line is given by VB-7-87 in Profile II'. The element is defined at intra Cretaceous level.

Description: The Någrind Syncline is a NE-SW trending Cretaceous-Tertiary structure located between 66° 30'N - 67° 25'N and 6° 30'E - 9° 15'E. It is bounded by the Nyk High to the northwest and the Utgard High to the southeast. To the south, the Surt Lineament separates the Någrind Syncline from the broader, shallower Vigrid Syncline (see Profile II'). The northern boundary is formed by the Bivrost Lineament. There is an apparent dextral shift in the main structuring across the Bivrost Lineament (see the description of that element) and it is therefore uncertain whether the Någrind Syncline extends northeastwards into the Lofoten area as indicated on Profile CC'.

The depth to the basal Cretaceous unconformity in the deepest parts of the syncline may be up to 9 sec TWT. The thickness of the Cretaceous sedimentary fill in the syncline may correspond to as much as 5.5-6 sec TWT along the deepest part of the synclinal axis, but the position of the basal Cretaceous unconformity is strongly debated.

Age: The development of the Någrind Syncline was closely linked with the Hel Graben, Nyk High and Utgard High (see the discussion under the Nyk High). The present configuration of the Någrind Syncline is mostly a Late Cretaceous to earliest Tertiary element, probably involving both extension and compressional/transpressional reactivation. In post-Palaeocene times, the syncline was slightly reversed along a NW-SE axis, probably during the major inversion of the neighbouring Hel Graben.

Ona High

(Norwegian: Onahøgda)

Rank: Formal.

References: The Ona High was first mentioned by Hamar & Hjelle (1984).

Name: Named after Ona lighthouse west of Molde in Møre & Romsdal.

Type section: Seismic line MB-06-92 (sp 1800 - 2100) in Profile MM'.The structure is a sub-Cretaceous basement high defined at the base of the Cretaceous.

Description: The Ona High is a westward-dipping, elongated basement high defined at the level of the basal Cretaceous unconformity. It is located between 62° 50'N - 63° 10'N and 4° 50'E - 5°E and has a NE-SW orientation. The structure is also accompanied by gravity and magnetic anomalies, confirming the basement-involved structuring. The Ona High is the rotated, uplifted footwall of a small half graben along its southeastern flank. The other flanks are not clearly fault-bounded and seem to be integral parts of the generally downwarped, steeply sloping eastern margin of the Møre Basin. Lower Cretaceous sediments onlap the structure, indicating that it developed in the Upper Jurassic.

The high is one of several such pairs of half graben/ footwall uplifted, rotated basement highs within the Møre-Trøndelag Fault Complex (see Profile NN').
Age: The Ona High is a result of Late Jurassic-Early Cretaceous extension.

Ormen Lange Dome

(Norwegian: Ormen Lange-domen)

Rank: Formal.

References: New element.

Name: Named afte r the largest ship of the Norwegian Viking king Olav Trygvasson.

Type section: Combined seismic lines 6345-92 (sp 1700 - 1635) and 6345-92-C (sp 2000 - 2550). The Ormen Lange Dome is defined at Eocene to Middle Miocene levels.

Description: The Ormen Lange Dome is situated between 63° 30'N - 63° 50'N and 5°E - 5° 35'E. The dome lies within the Jan Mayen Lineament and its elongated shape with a NW-SE trending axis is one of the major features defining the lineament at the Palaeogene levels. The Ormen Lange Dome is characterized by thinning and onlap of post-Eocene to Middle Miocene deposits onto its flanks which consist of parallel-bedded Lower Eocene strata. At the level of the Middle Miocene unconformity, the dome is more open than at older levels and the unconformity surface is onlapped by almost flatlying Late Miocene and Pliocene strata.

Age: The onlap geometries and the tightening of the dome at the older levels relative to the Middle Miocene level indicate that the Ormen Lange Dome was formed in two separate phases, the first in Late Eocene and the other in Late Miocene. The dome was probably formed by movements in the underlying complicated set of large fault blocks within the Jan Mayen Lineament.

Revfallet Fault Complex

(Norwegian: Revfallsforkastningskomplekset)

Rank: Formal.

References: New name. The structure has previously been illustrated in a number of papers as the western fault boundary of the Nordland Ridge (e.g. Rønnevik & Navrestad 1976, 1977, Gowers & Lunde 1984, Bukovics & Ziegler 1985, Hastings 1986). It is part of the previously defined Kristiansund-Bodø Fault Complex (Gabrielsen & Robinson 1984).

Name: Named after a rock awash southwest of Bodø.
Type section: Seismic lines NRGS-84-429 (sp 1500 - 2100) in Profile EE'. Reference line is NRGS-84-481 (sp 500 - 1500) in Profile DD'. The complex is defined relative to the base of the Cretaceous.

Description: T he Revfallet Fault Complex occurs from 65° 15'N - 66° 50'N and 7°E - 12°E. In its southern part, it is composed of westerly-dipping, left-stepping, en echelon normal faults oriented NNE-SSW. North of 66°, it is mainly a downflexed slope at the base of the Cretaceous leading into the Rås and Vestfjorden Basins, and many of the earlier Jurassic faults show an eastward polarity away from the basins (similar to the eastern margin of the Møre Basin, see the description of that). Both the Lower and Upper Cretaceous basin sequences onlap this slope, indicating that it formed in the Late Jurassic-Early Cretaceous. Many of the younger faults have a downthrow to the basin polarity like the majority of faults in the southern segment (south of 66°N). The most pronounced single fault in the Revfallet Fault Complex is in the southwest where displacements of more than 2000 m are recorded. Towards the south, the Revfallet Fault Complex nearly dies out before it approaches the Sklinna Ridge. It defines the western boundaries of the Nordland Ridge and Trøndelag Platform and separates these from the Dønna Terrace (in the south) and the Træna and Vestfjorden Basins.

Age: Pre-Jurassic movements are difficult to detect along the Revfallet Fault Complex. An increase in the thickness of the Middle and Upper Jurassic sequence in the hanging wall suggests faulting at that time. A major period of movement occurred in the Late Jurassic to Early Cretaceous and considerable subsidence also took place along the complex in the Cretaceous. The pronounced increase in thickness of the post-Cenomanian succession along the southern segment shows that this part of the fault complex was activated during the Late Cretaceous.

The development of the Revfallet Fault Complex was related to crustal stretching and subsidence in the late Middle Jurassic-Early Cretaceous rifting episode. It has also been suggested that strike-slip movements governed its development in the Late Jurassic and Cretaceous (Caselli 1987). The fault complex was reactivated in the Late Cretaceous (Turonian and Campanian)

Ribban Basin

(Norwegian: Ribbebassenget)

Rank: Formal.

References: New definition.

Name: Named after a fishing ground west of the Lofoten islands.

Type section: Seismic lines LO-08-87-B (sp 1674 - 2100) and LO-10-88 (sp 928 - 1500) in Profile CC'. Reference lines are given by LO-18-86 in Profile AA' and LO-30-87 in Profile BB'. The basin is defined at the base of the Cretaceous.

Description: The Ribban Basin is situated west of the Lofoten islands between 67° 30'N - 68° 30'N and 11° 30'E - 14° 30'E. A structural high divides it into northern and southern sub-basins, the Havbåen and Skomvær Sub-basins, respectively. The basin is mainly filled with Early Cretaceous sediments and has an overall half-graben geometry. The boundary fault separates the graben from the Lofoten Ridge to the east, and the western margin is the eastern slope of the Utrøst Ridge. In the very north, the bounding faults change to an eastern polarity.

Age: The Ribban Basin initiated as a half graben along westerly-dipping faults west of the Lofoten archipelago due to late Middle Jurassic-Early Cretaceous crustal stretching and later cooling and subsidence. The increasing thickness of the Lower Cretaceous sediments towards the north shows greater subsidence in the northern part than in the southern part, indicating a basin margin in the south. This shows an affinity to the Harstad Basin north of Andøya, which is also characterized by thick Lower Cretaceous sediments (Brekke & Riis 1987).

The western margin of the basin experienced tectonic uplift in Late Cretaceous times. However, the greatest uplift probably occurred in Middle to Late Tertiary times when the basin was inverted causing considerable erosion of Tertiary and Cretaceous sediments.

The evolution of the basin is closely related to the development of the Utrøst Ridge.

Rym Fault Zone

(Norwegian: Rymforkastningssonen)

Rank: Formal.

References: New element not described earlier.

Name: The fault zone is named after Rym; the helmsman of the Naglfar, a ship described in Norse mythology. It carried the Jotnes, the enemies of the gods, to Vigrid which was the scene of the ultimate, cataclysmic battle called Ragnarok.

Type section: VB-7-90 (sp 2600 - 2750) in Profile HH'. Seismic line VB-15-89-A in Profile GG' is a reference section. The Rym Fault Zone is best defined at the Upper Cretaceous and Palaeogene levels.

Description: The Rym Fault Zone is located between 67° 5'N - 67° 35'N and 6°E - 6° 40'E. It is composed of northeasterly-dipping faults with a NW-SE trend in the eastern part of the zone; near the western end, the faults curve towards a N-S trend. The zone forms the southern boundary of the Hel Graben and the northern boundary of the Gjallar Ridge and Vigrid Syncline. The Rym Fault Zone is part of the complicated southern boundary of the Nyk High where the western bounding faults of the Nyk High are partly cut by and partly curve into the Rym Fault Zone.

The Rym Fault Zone probably originated as a zone of normal faults that were later reversed during the formation of the Naglfar Dome. The fault zone is part of the NW-SE trending Surt Lineament and is part of the expression at a shallow level of this underlying basement structure.

Age: The great expansion of the basin fill of the Hel Graben across the Rym Fault Zone indicates that the main normal movements on the fault zone took place during this period. However, whether this reflects Late Cretaceous (Cenomanian to Maastrichtian) or Palaeocene movements depends on the interpretation of the age of the basin fill (see the description of the Hel Graben). The present data cannot substantiate whether the fault zone had an earlier history.

The reverse movements on the Rym Fault Zone took place during the formation of the Naglfar Dome (see the description of the Naglfar Dome).

Rødøy High

(Norwegian: Rødøyhøgda)

Rank: Formal.

References: The Rødøy High was originally defined by Gowers & Lunde (1984) and Larsen & Skarpnes (1984) and was formally defined by Gabrielsen et al. (1984).

Name: Named after a small island on the coast of Nordland. Type section: Seismic lines GMT-84-422-A (sp 12200 - 11599) and NRGS-84-481 (sp 1 - 500) in Profile DD'. The Rødøy High is defined at probable intra Permian level.

Description: The Rødøy High is located between 65° 50'N - 66° 25'N and 8° 20'E - 9° 10'E. It is a subelement of the Nordland Ridge and is defined relative to an unconformity of probable Early Carboniferous-Early Permian age. Cambro-Silurian metamorphic rocks and a relatively thin cover of Permo-Triassic sediments underlie the high. A major hiatus (see the description of the Nordland Ridge) separates Late Cretaceous sediments from the Triassic sediments. Another major hiatus has been recorded in the Tertiary. The preserved Early Mesozoic and Late Palaeozoic sediments become thicker towards the southwest, southeast and northeast, away from the central part of the high. The Late Mesozoic and Cenozoic deposits are generally thicker on the northeastern part of the high.

Age: The Rødøy High started its evolution in the Late Carboniferous-Early Permian (Gowers & Lunde 1984) when it was uplifted and deeply eroded. Afterwards, it subsided and was covered by Permo-Triassic sediments before being uplifted again and eroded in the Late Jurassic to Early Cretaceous. It remained a stable high unttl the end of the Miocene.

Røst High

(Norwegian: Røsthøgda)

Rank: Formal.

References: The Røst High was mentioned by Eldholm et al. (1979).

Name: The name derives from the small island of Røst in the southern part of the Lofoten archipelago.

Type section: Seismic line LO-10-88 (sp 3000 - 3850) in Profile CC'. The Røst High is defined at the unconformity at the base of the Cretaceous.

Description: The Røst High is located between 67° 30'N - 68° 30'N and 10°E -11° 30'E and is an elongated NE-SW striking high. It is accompanied by strong gravimetric and magnetic anomalies, indicating a thin, or absent, cover of sediments above basement rocks. The high is regarded as an element on the Utrøst Ridge. It is bounded by faults to the west, north and east and is separated from the Jennegga High in the north by a saddle. The Røst High is defined by several unconformities. Its eastern part is defined by the basal Cretaceous unconformity overlain by Lower Cretaceous sediments. In its central and western parts, the high is deeply eroded and is overlain by Tertiary and Quaternary sediments. Crystalline basement is exposed on the sea bed in some areas.

Age: The dating of the Røst High is problematical due to the deep erosion of its central part. However, the greater thickness of the Triassic-Jurassic sedimentary sequence in the hanging wall along the eastern boundary fault suggests that the area was elevated at that time. The high remained elevated in the Early Cretaceous as shown by onlapping Lower Cretaceous sediments. The truncation of the Cretaceous succession (Profile CC') indicates that the main uplift phase commenced in the latest Cretaceous/earliest Tertiary. Further phases of uplift in the Tertiary are probable, but cannot be substantiated at present. The Røst High is interpreted as a positive structural element mainly related to Late Cretaceous and Tertiary plate tectonism tied to the opening of the Norwegian Sea. The mechanism for the uplift of the area is not fully understood, but transpression has been suggested (Brekke & Riis 1987).

Rås Basin

(Norwegian: Råsbassenget).

Rank: Formal.

References: The Rås Basin has previously been referred to as the Halten Trough (Rønnevik et al. 1983, Bøen et al. 1984, Hagevang & Rønnevik 1986, Skogseid & Eldholm 1989) and theVikna Graben (Bukovics et al. 1984).

Name: The Norwegian word «rås» means a fairway or navigable channel for ships.

Type section: Seismic line VB-2-87, -A, -D (sp 300 - 2050) in Profile FF'. Reference sections for the northern and southern segments of the basin, respectively, are given by NH-1-79 (sp 2950 - 3901) and VB-17-90 (sp 1972 - 2400) in Profile EE' and MB-6445-91-A and -6445-92 (sp 220 - 1100) in Profile JJ'. The Rås Basin is defined at the base of the Cretaceous and by the Lower Cretaceous basin fill.

Description: The Rås Basin underlies the southeastern part of the Late Cretaceous Vøring Basin and is located between 64°N - 66° 40'N and 4° 30'E - 7° 20'E. It is separated from the Halten and Dønna Terraces to the east by the Klakk Fault Complex and theYtreholmen Fault Zone, respectively. The Fles Fault Complex separates the Rås Basin from the Vigrid Syncline to the west. The southern and northeastern boundaries of the basin are defined by the Jan Mayen and Surt Lineaments, respectively. The Rås Basin is arc-shaped with its southern segment trending N-S and its northen segment turning NE-SW north of 65° 45'N. The basin is defined by its Lower Cretaceous sediments which may in places reach a thickness corresponding to about 2 sec TWT (measured relative to the intra Lower Cretaceous reflector, see the Profiles). The maximum thicknesses are seen along the central axis of the basin. The basin floor at the base of the Cretaceous lies at 6-8 seconds TWT, its deepest parts being in the north. Along the eastern margin, the basin sequences onlap the Klakk Fault Complex and the Ytreholmen Fault Zone in the south and north, respectively. Along the western margins, the basin fill thins by onlap onto the eastern slopes of the Slettringen Ridge in the south (Profile JJ') and by fault displacement along the eastward-facing part of the Fles Fault Complex in the north (Profiles FF' and EE').

During the Cenomanian, the Rås Basin and its flanks were transgressed and became part of the regional Vøring Basin. Where the basin axis changes its strike, the Cretaceous strata seem to be folded (see Profile FF'). The Rås Basin forms the core of the Helland-Hansen Arch.

Age: The Rås Basin developed in response to the late Middle Jurassic-Early Cretaceous episode of extension which caused subsequent basin subsidence. It has been an integral part of the Vøring Basin since Early Cretaceous times. The expansion of the post-Cenomanian succession in the basin and the possible later folding were probably associated with reactivations of the Fles Fault Complex. The folds do not extend up into the Tertiary strata, indicating that the basin experienced inversion and subsequent erosion prior to the deposition of a thin Palaeocene succession, probably linked to the Maastrichtian-Palaeocene rifting episode. The mechanism of the later formation of the Helland-Hansen Arch is open to debate (see the description of the Helland-Hansen Arch).

Selje High

(Norwegian: Seljehøgda)

Rank: Formal.

References: The name Selje High was used by Nelson & Lamy (1987).

Name: Named after an island on the coast of the county of Sogn & Fjordane.

Type section: Seismic line SMB-405-B, -C (sp 21250 - 31450) in Profile NN'. The Selje High is defined at the base of the Cretaceous.

Description: The Selje High strikes NE-SW and is situated within the Møre-Trøndelag Fault Complex on the northern part of the Måløy Terrace between 61° 50'N - 62° 10'N and 3° 55'E - 4° 15'E. The structure is a rotated basement block which is the uplifted footwall of a half graben to the east. The western flank is an unfaulted slope into the Sogn Graben. The northern part of the Selje High apparently has a strongly elevated, narrow, flat top. However, some seismic lines indicate that this is a thin intrusive sill masking the real crest of the basement block (see the interpretation in Profile NN').

Gravimetric and magnetic modelling indicates that the Selje High is a basement feature. Its formation is related to the development of the Møre-Trøndelag Fault Complex and is attributed to Jurassic basement-involved faulting.

Age: The Selje High became a prominent structural feature as a result of Jurassic-Early Cretaceous faulting.

Sklinna Ridge

(Norwegian: Sklinnaryggen)

Rank: Formal.

References: Heum et al. (1986) called the uplifted western flank of the Halten Terrace the Sklinna High. Bukovics et al. (1984) and Bukovics & Ziegler (1985) had earlier called it the Nidaros Arc, but their definition and exact location were less clear.

Name: Named after the small island of Sklinna with its lighthouse off the northernmost coast of Nord-Trøndelag. The elongated shape of the feature makes the term ridge more appropriate than high.

Type section: Seismic lines ST-8501-441 (sp 300 - 576) and VB-2-87-D (sp 220 - 300) in Profile FF'. The Sklinna Ridge is defined at the base of the Cretaceous. Reference sections are given by MB-6445-91 in Profile JJ' and MB-04-84 in Profile KK'.

Description: The Sklinna Ridge is the westernmost margin of the Halten Terrace. It has a N-S trend and occurs between about 64°N - 65° 25'N and 6°E - 6° 25'E. Its width is about 10-15 km. The ridge can be followed for about 140 km and is bounded towards the west by the northern part of the Klakk Fault Complex.

The ridge has an uneven top with deeply eroded, easterly-dipping beds. Gravity data indicate that it has a shallow basement core. Cretaceous strata may unconformably overlie the basement on the western flank of the ridge in the south (Profile KK'). The Sklinna Ridge consists of distinctly separate segments and may be divided into three, two flatly eroded highs and an intervening saddle. The northern high is relatively narrow and ends towards the south in a steep, narrow horst. The southern high is broader.

A complex internal fault pattern can be seen in most parts of the Sklinna Ridge. The faults strike N-S and NE-SW. The southern part of the saddle area is underlain by a complex fault zone or lineament named the Gjæslingan Lineament, which is an old, reactivated structure.

Age: The Sklinna Ridge was formed in the Late Jurassic as a flank uplift along the Klakk Fault Complex in the early stage of the formation of the Halten Terrace and Trøndelag Platform system, together with the other flank uplifts (the Frøya High and Nordland Ridge) (see the description of the Trøndelag Platform). There seems to have been two important phases in this development, one during the Middle to Late Jurassic (latest Bathonian to Oxfordian) and another possibly during Aptian/Albian time.

Skomvær Sub-basin

(Norwegian: Skomværunderbassenget)

Rank: Formal.

References: The structure was termed the Værøy Basin by Mokhtari et al. (1987).

Name: Named after the little island of Skomvær in the southernmost part of Lofoten.

Type section: Seismic lines LO-08-87, -B (sp 1674 - 2100) and LO-10-88 (sp 928 - 1500) in Profile CC'. The Skomvær Sub-basin is defined at the unconformity at the base of the Cretaceous.

Description: The Skomvær Sub-basin is situated between 67° 30'N - 68°N and 11° 30'E - 12° 30'E. It is a half graben bounded by faults to the east and against the gently rising Utrøst Ridge to the west.

Age: The Skomvær Sub-basin was initiated in Early Cretaceous times. It followed the tectonic evolution of the Ribban Basin and developed initially as a half graben. The basin is characterized by a considerable sequence of Lower Cretaceous clastic sediments which onlaps its margin and increases in thickness northwards.

The basin experienced tectonic uplift during latest Cretaceous and possibly Tertiary times.

Slettringen Ridge

(Norwegian: Slettringsryggen)

Rank: Formal.

References: New definition.

Name: Named after Slettringen lighthouse on the western tip of Frøya in Sør-Trøndelag..

Type section: Seismic line -6445-92 (sp 500 - 1150) in Profile JJ'. The Slettringen Ridge is defined at the basal Cretaceous unconformity.

Description: At the basal Cretaceous unconformity level, the Slettringen Ridge is a set of N-S trending, rotated fault blocks situated between 64° 30'N - 65° 30'N and 4° 40'E - 5° 10'E and running from the central and deepest part of the Møre Basin northwards along the Fles Fault Complex. The ridge is developed below the Helland-Hansen Arch in the complicated southern part of the Fles Fault Complex where the faults change polarity from west-facing in the south to east-facing in the north. The ridge was identified, but not named, by Brekke & Riis (1987). Lower Cretaceous sediments onlap the ridge.

Age: The Slettringen Ridge developed during the late Middle Jurassic-Early Cretaceous rifting episode and was probably accentuated during the phases of reactivation of the Fles Fault Complex.

Slørebotn Sub-basin

(Norwegian: Slørebotnunderbassenget)

Rank: Formal.

References: New definition.

Name: Named after a fishing ground west of Molde.

Type section: Seismic line MB-06-92 (sp 600 - 1200) in Profile MM'. Seismic lines SMB-405-C, -D in Profile NN' and NM1-85-416-A in Profile LL' are reference sections. The Slørebotn Sub-basin is defined at the base of the Cretaceous.

Description: The Slørebotn Sub-basin is the easternmost part of the Møre Basin and is situated between 62°N - 63° 5'N and 3° 20'E - 6° 20'E. It is an elongated, ENE-WSW trending structural feature. To the southeast, the steeply sloping basal Cretaceous unconformity defines its margin. To the west, it is bounded by the basement-involving composite ridge defined by the northeastward continuation of the Tampen Spur and the Gnausen, Giske and Gossa Highs. The deepest part of the sub-basin at reference level is southeast of 5° 40'E. To the northeast, the basin floor is shallower and becomes undulating, which reflects the relief of deeper fault blocks.

Age: The Slørebotn Sub-basin was initiated in the late Middle Jurassic-Early Cretaceous and continued to develop during the Lower Cretaceous, eventually losing its expression as a separate structural unit in Cenomanian time.

Surt Lineament

(Norwegian: Surtlineamentet)

Rank: Formal.

References: New name for a feature not described previously.

Name: Named after Surt, the ruler of the underground fire in Norse mythology.

Type section: VB-7-87 (sp 1500 - 2000) in Profile II'. Seismically, the Surt Lineament is best defined at the Upper Cretaceous level.

Description: The Surt Lineament is situated between 66° N - 67° 40'N and 5° 40'E - 7° 30'E. It strikes NW-SE parallel to the strike of the other important lineaments that are associated with oceanic fracture zones. The same strike also dominates the fiords, fractures and faults in the basement along the coast of Møre and Trøndelag. The Surt Lineament separates the Hel Graben, Nyk High, Någrind Syncline, Utgard High and Træna Basin to the north from the Gjallar Ridge, Vigrid Syncline and Rås Basin to the south. At shallow levels, the Surt Lineament is best defined as the hinge zone bounding the expanded Upper Cretaceous succession north of the Vigrid Syncline. It is also defined as a gravimetric lineament, probably reflecting structural development in the basement.

At its northwestern end, the lineament is parallel to and includes the Rym Fault Zone. At the southern end of the Utgard High, the Surt Lineament links with a more NNW-SSE striking lineament evident in gravity data that match up with the strike of the southern termination of the Nordland Ridge and the Bremstein Fault Complex.

Age: Since it is aligned parallel with basement structures on the mainland, the Surt Lineament is probably, itself, an old basement structure. Movements on a swarm of faults on the same strike on the coast of Nord-Trøndelag are dated to the Late Devonian or younger (see Brekke et al. 1992).

However, the earliest documented movements on the Surt Lineament took place in the Late Cretaceous when it was the location of the hinge zone that controlled the subsidence of the northern part of the Vøring Basin, producing the expanded Upper Cretaceous sequences in the Nyk High and the Någrind Syncline. Expressed through the Rym Fault Zone, the Surt Lineament also controlled the subsidence of the Hel Graben, which, depending on the interpretation, took place in the Late Cretaceous or the Palaeocene. One view amongst the present authors is that the Surt Lineament was a controlling element in the reverse movements forming the Naglfar and Vema Domes in the Late Eocene-Early Oligocene and in the early Late Miocene. Another view is that the domes formed due to magmatic underplating and that faulting along the Surt Lineament was of little importance (Skogseid et al. 1992, Stuevold et al. 1992).

Sør High

(Norwegian: Sørhøgda)

Rank: Formal.

References: New element not described earlier.

Name: Intended to give associations to the southern peak of the Nordland Ridge.

Type Section: Seismic line NRGS-84-429 (sp 2150 - 2450) in Profile EE'. The Sør High is defined at the base of the Tertiary.

Description: The Sør High is situated between 65° 15'N - 66° 15'N and 7° 20'E - 8° 40'E on the southern part of the Nordland Ridge. It is characterized by a pronounced erosional unconformity on which the Tertiary rests directly on Triassic to Middle Jurassic rocks and the outline of the Sør High is defined at the line of the subcrop of the upper surface of the Cretaceous beneath the Tertiary.

The unconformity surface forms an arcuate ridge with a relatively flat top, a steep, faulted western flank and a gently sloping eastern flank (Profile EE'). The erosional level of the unconformity becomes progressively deeper northwards so that Tertiary rocks overlie Middle Jurassic strata in the south and Triassic strata in the north. The Tertiary onlaps the unconformity progressively on all flanks, and the youngest onlap is in an area in the centre of block 6507/6 where the Upper Pliocene unconformably overlies the Lower Jurassic.

Age: The Sør High was formed by several pulses of uplift and erosion in the period from Late Cretaceous to Late Miocene. Faults in the Revfallet Fault Complex along the western boundary of the high were extensively reactivated in the post-Cenomanian and the Tertiary during tectonic phases in the Vøring Basin. The first phase of uplift of the Sør High (as a separate high on the Nordland Ridge) was probably linked to this reactivation as both the uplift and the faulting activity died out in the same area just north of 66°N.

Træna Basin

(Norwegian: Trænbassenget)

Rank: Formal.

References: Rønnevik & Navrestad (1976) called this element the Træna Basin and the name was formalized by Gabrielsen et al. (1984).

Name: Named after an island on the outermost coast of Nordland.

Type section: Seismic lines NRGS-84-481 (sp 500 - 2650) and ST-8604-412-A (sp 3550 - 3300) in Profile DD'. The Træna Basin is defined relative to the base of the Cretaceous and by its Lower Cretaceous basin fill.

Description: The Træna Basin is located between 66° 5'N - 67° 5'N and 7° 30'E - 10°E. It is an elongated structural element with a NE-SW trend and underlies the northeastern part of the Vøring Basin. The Træna Basin is bounded to the east by the Ytreholmen Fault Zone along the Dønna Terrace in the south and the Revfallet Fault Complex along the Nordland Ridge to the north. The western flank is formed by the Fles Fault Complex along the Utgard High. To the south and north, the basin is bounded by the Surt and Bivrost Lineaments, respectively. There is an apparent dextral shift in the main structure across the Bivrost Lineament, making it uncertain whether the basin extends northeastwards into the Utrøst Ridge as indicated in Profile CC'.

The Træna Basin is defined by its Lower Cretaceous basin fill with a thickness of sediment corresponding to perhaps 2 sec TWT. The basin floor at the base of the Cretaceous lies at 6-7 sec TWT, becoming shallower towards the north. Through the Late Cretaceous, the basin lost its integrity and became an integral part of the Vøring Basin. Seismic data indicate a rather thin or absent sequence of pre-Cretaceous sediments on the basement across the basin. Several strong, parallel seismic reflectors in the Lower Cretaceous sequence in the central part of the basin may be sills related to the Early Tertiary opening of the Norwegian Sea and associated igneous activity. This is in accordance with similar reflectors in large parts of the Vøring Basin. Several minor NE-SW trending domes defined at the base of the Tertiary and intra Miocene levels are observed across the basin, probably associated with reverse reactivation along the Fles Fault Complex (see Profile DD').

Age: The Træna Basin was initiated by late Middle Jurassic-Early Cretaceous crustal extension, faulting and subsequent thermal subsidence. Prior to the Early Cretaceous, it was an integral part of the Vøring Basin.

Trøndelag Platform

(Norwegian: Trøndelagsplattformen)

Rank: Formal.

References: The Trøndelag Platform was formally defined by Gabrielsen et al. (1984). The name was introduced by Hollander (1981, 1982), but he gave no definition. Also described by Aanstad et al. (1981).

Name: Named after t he Trøndelag counties in central Norway.

Type section: Three representative regional cross sections have been chosen for the Trøndelag Platform due to its complexity: Profile DD' (seismic lines ST-8808-826, -A, NR-04-85, GMT-84-422-A and NRGS-84-481), Profile EE' (seismic lines ST-8804-472, -A, SG-8710-410 and NRGS-84-429) and Profile KK' (seismic lines ST-8707-483 and MB-04-84). The element is defined relative to the base of the Cretaceous.

Description: The Trøndelag Platform covers an area of more than 50,000 km2. It is roughly rhomboid and is situated between 63°N - 65° 50'N and 6° 20'E - 12°E. This has been a large stable area since the Jurassic and the platform is covered by relatively flatlying and mostly parallel-bedded strata which usually dip gently northwestwards.

The Trøndelag Platform is one of the major structural elements off central Norway and includes several subsidiary elements like the Nordland Ridge, Helgeland Basin, Frøya High, Froan Basin, Ylvingen Fault Zone and Vega High.

The platform is bounded to the east by outcropping Caledonian crystalline basement. The Møre-Trøndelag Fault Complex forms the southeastern boundary. In the north and west, the platform is bounded by the Revfallet Fault Complex which runs along the Nordland Ridge separating it from the Vestfjorden and Træna Basins in the north and the Dønna Terrace in the south. Further south, the platform is separated from the Halten Terrace to the west by the Bremstein Fault Complex. In its southwestern corner, it meets the Jan Mayen Lineament and the Møre Basin, from which it is separated by the southern part of the Klakk Fault Complex.

Most of the scattered internal normal faulting on the platform has minor displacement and a NNE to NE trend. The same trend is present in the axis of the Helgeland Basin, which is located on the northern to central part of the Trøndelag Platform. The Helgeland Basin is the only part of the platform where a pronounced Cretaceous basin exists. Cretaceous strata are thin and partly absent over the rest of the platform, but both Lower and Upper Cretaceous strata occur.

The platform surface (base of the Cretaceous) is underlain by a uniform thickness of Jurassic overlying deep basins filled by Triassic and Upper Palaeozoic sediments. The pre-Jurassic rocks are arranged in NE-SW trending, en echelon basins which contain a profound unconformity of probable Middle Permian age that separates an early period of intense block faulting from the tectonically quieter Late Permian and Triassic. The Froan Basin is the southernmost of these pre-Jurassic basins.

Age: The Trøndelag Platform was initiated during the late Middle Jurassic-Early Cretaceous rifting episode when the Nordland Ridge and Frøya High were uplifted. The Nordland Ridge experienced further uplift during the Late Cretaceous. These western margin areas of the Trøndelag Platform have the character of an uplifted footwall. The margin acted as the hinge line for the stretching, footwall uplift and later thermal subsidence.

The area was also tectonically active during earlier episodes, in Carboniferous to late Early Permian and Middle to Late Triassic times. Some minor Early Jurassic normal faulting occurred in parts of the platform area. The only active fault zone cutting through the Trøndelag Platform is the Cretaceous Ylvingen Fault Zone (Lokna 1993), which formed in Early Cretaceous time when the Helgeland Basin was downwarped and the Vega High uplifted.

Utgard High

(Norwegian: Utgardshøgda)

Rank: Formal.

References: The name Utgard High replaces the Bodø High which Bøen et al. (1984) described as a poorly defined, narrow, NE-SW oriented, deeply buried high, bounded to the east and west by large normal faults. As originally defined, the Bodø High extends too far south relative to the new definition of the Utgard High.

Name: The Utgard High is named after the land of the Jotnes who represented the forces of nature and chaos and were enemies of the gods

Type section: Seismic lines ST-8604-412, -A in Profile DD'. This structural element is defined at intra Cretaceous level, but can also be defined at shallower Cretaceous levels. The depth of the base of the Cretaceous above the high is very doubtful.

Description: The Utgard High is located between 66° 20'N - 67° 15'N and about 6°40'E - 9°E and can be followed for about 300 km along strike on a NE trend. Its shape may be described as a faulted anticline at Cretaceous levels (Profile DD'). The Någrind Syncline lies northwest of the Utgard High. To the northeast and east, the high is separated from the Træna Basin by the prominent NE trending Fles Fault Complex which downthrows the sub-Tertiary sequences to the southeast. The main fault was reversed in the Late Miocene forming an arch along the Træna Basin in which the Palaeogene and the base of the Tertiary are situated higher than across the Utgard High. The northeastern extension of the high contains a strong positive gravity anomaly, indicating a relatively shallow (6 km) basement high, or a shallow magmatic body, or both, along the eastern margin of the Utgard High.

To the south, the Utgard High ends in the Surt Lineament. Large parts of the high are divided into several subparallel fault blocks. The internal strata in the high dip relatively steeply northwestwards.

A complex set of supposedly Early Tertiary magmatic sills intruded into several parts of the Cretaceous strata decreases the seismic resolution and complicates the seismic interpretation of the Utgard High area. No exploration wells have yet confirmed the position of the basal Cretaceous reflector. Wells in block 6607/5, however, confirm a thick Upper Cretaceous sequence and the presence of magmatic sills of basaltic composition.

Age: The Utgard High probably initiated as a flanking high to the Træna Basin in the late Middle Jurassic-Early Cretaceous rifting episode. The development of the high was closely linked with that of the Nyk High and the Någrind Syncline. In its present configuration, the Utgard High is the eastern limb of the Någrind Syncline which is mostly a

Late Cretaceous to earliest Tertiary element, probably involving both extension and compressional/transpressional reactivation along the flanking Fles Fault Complex. The high was uplifted and eroded during the late stages of this development.

Utrøst Ridge

(Norwegian: Utrøstryggen)

Rank: Formal.

References: The Utrøst ridge was described by Talwani & Eldholm (1972) who named it the Røst High.

Name: The Utrøst Ridge is named after Utrøst, the extensive area of land west of Lofoten featuring in local fairy tales. Utrøst is populated by underground creatures and the ghost of the sea, the Draugen. Utrøst occasionally emerges and can be seen by seafarers.

Type section: Seismic line LO-10-88 (sp 1500 -5100) in Profile CC'. Reference lines are LO-30-87 in Profile BB' and LO-18-86 in Profile AA'. The Utrøst Ridge is defined at the level of a combined unconformity spanning the period from the base of the Cretaceous on the flanks to intra Quaternary horizons on the crest.

Description: The Utrøst Ridge is located between 67° 30'N - 69°N and 10°E - 14°E. It is a NE-SW oriented structural element bounded by faults to the north, west and south. To the east, the ridge is adjacent to the Ribban Basin. It is accompanied by very strong gravity and magnetic anomalies, indicating that the basement has a thin pre-Cretaceous sedimentary cover.

It consists of several highs, the most prominent being the Røst High in the southwest, the Marmæle Spur in the southeast and the Jennegga High in the north. The ridge is strongly eroded, and crystalline rocks of presumed Caledonian age are locally exposed on the sea bed (Rokoengen et al. 1977). The erosion makes the dating of the tectonic events uncertain.

Age: The Utrøst Ridge was probably initiated in Early Mesozoic time. Growth faults along the eastern margin of the Røst High suggest that this part of the Utrøst High was an elevated element in Triassic-Jurassic times. The high remained as an elevated element in Early Cretaceous time, as shown by onlapping Lower Cretaceous sediments. The truncation of the Cretaceous succession (Profile BB') indicates that the main uplift phase commenced in the latest Cretaceous/earliest Tertiary. Further phases of Tertiary uplift are probable, but cannot be substantiated at present. The Utrøst High is interpreted as a positive structural element mainly related to Late Cretaceous and Tertiary plate tectonism tied to the opening of the Norwegian Sea. The mechanism for the uplift of the area is not fully understood, but transpression has been suggested (Brekke & Riis 1987).

Vega High

(Norwegian: Vegahøgda)

Rank: Formal.

References: Rønnevik & Navrestad (1976) called the structure the Vega Ridge, but it was described, redefined and renamed the Vega High by Gabrielsen et al. (1984). See also Rønnevik & Navrestad (1977), Aanstad et al. (1981) and Hamar & Hjelle (1984). The overlying graben structure was termed the Vega Fault Zone by Price & Rattey (1984).

Name: Named after the island of Vega in Helgeland.

Type section: Seismic line ST-8808-826-A (sp 3400 - 4500) in Profile DD'. The high is defined relative to the base of the Cretaceous.

Description: The Vega High is part of the Trøndelag Platform. It is a NE-SW oriented domal feature situated southeast of the Helgeland Basin between 65° 32'N - 66° 2'N and 8° 55'E - 10° 45'E and elongated roughly NE-SW. It is divided into two by a NE trending central graben branching off the Ylvingen Fault Zone. The high is bounded to the southeast by the Ylvingen Fault Zone which forms a narrow, complex graben structure along its entire southeast flank. The boundary towards the northwest is a well-defined, but gentle, downwarp into the Helgeland Basin.

Age: Gabrielsen et al. (1984) gave the age of the Vega High as Early Cretaceous, relating its formation to the later part of the late Middle Jurassic-Early Cretaceous rifting episode. Some faulting took place throughout the Cretaceous (Lokna 1993), but due to the thinness of the Cretaceous sequence the duration of this tectonic activity is uncertain. For further discussion, see the Ylvingen Fault Zone.

Vema Dome

(Norwegian: Vemadomen)

Rank: Formal.

References: The structure was named by Skogseid & Eldholm (1989).

Name: The Vema Dome is named in recognition of its discovery in 1969 during cruise 27 made by the R/V «Vema». The ship was owned by Lamont Doherty Geological Observatory, Columbia University, New York.

Type section: Seismic line VB-15-89-A (sp 4350 - 5250) in Profile GG'. The Vema Dome is defined at Eocene to Middle Miocene levels.

Description: The Vema Dome is situated between 66° 45'N - 67° 20'N and 6°E - 6° 50'E and is elongated in a NNE-SSW direction. Structurally, the Vema Dome is located at the southern end of the Nyk High where the bounding faults of the Nyk High terminate in the Rym Fault Zone on the Surt Lineament. The structure is characterized by onlaps around its flanks onto two separate surfaces; one in the Late

Eocene-Early Oligocene, the other being the Middle Miocene unconformity. The base of the Late Pliocene truncates the Late Miocene and Early Pliocene across the dome and is itself in part slightly domed over the top of the dome. Mud diapirs are found above the Vema Dome, some of them piercing the sea floor.

Age: The onlaps and truncations in the Eocene to Late Pliocene described above show that the Vema Dome was formed during that period. One view amongst the present authors is that the dome was formed mainly during tectonic reactivation along the Surt Lineament in the Late Eocene-Early Oligocene and the early Late Miocene. The other view is that the dome was formed as an inversion due to magmatic underplating associated with the Maastrichtian-Palaeocene rifting episode (Skogseid et al. 1992, Stuevold et al. 1992). Further minor uplift and mud diapirism have continued until the present day.

Vesterdjupet Fault Zone

(Norwegian: Vesterdjupforkastningssonen)

Rank: Formal.

References: New element.

Name: The name is from a local bathymetric depression west of Lofoten.

Type section: Seismic line LO-10-88 (sp 1900 - 1950) in Profile CC'. The Vesterdjupet Fault Zone is defined relative to the unconformity at the base of the Cretaceous.

Description: The Vesterdjupet Fault Zone is located between 67°N - 68°N and 10°E - 11° 20'E and is composed of westerly-dipping faults oriented NE-SW and NNE-SSW. To the west, a half graben (the possible continuation of the Træna Basin) forms the downfaulted side. In the north, the fault zone forms the western boundary of the Marmæle Spur, and in the central part it forms the southern boundary of the Ribban Basin.

The fault zone is mainly made up of one major fault with a few smaller faults in the footwall, parallel to the main one. In the central and northern parts, displacement exceeds 2000 m.

The faults are steep and the main one is a deeply rooted listric fault. This is specially clear in the northern part of the zone where considerable uplift and erosion has taken place, increasing the seismic resolution in supposed basement bedrock. In the south, the zone merges into a NE-SW trending fault zone with easterly-dipping faults, and this ends at the Nordland Ridge.

Age: Pre-Jurassic movements are difficult to detect along the Vesterdjupet Fault Zone. However, the increased thickness of the Triassic-Jurassic sequence in the hanging wall suggests faulting at that time, although this sequence thins towards the north indicating the proximity of the basin margin. Most of the movement and subsidence occurred in Cretaceous times.

Vestfjorden Basin

(Norwegian: Vestfjordsbassenget)

Rank: Formal.

References: The Vestfjorden Basin was named by Rønnevik & Navrestad (1977), and was later described by Jørgensen & Navrestad (1979, 1981) and Bøen et al. (1984) before being formally defined by Gabrielsen et al. (1984).

Name: The structure is named after the major Vestfjorden embayment south and east of the Lofoten archipelago.

Type section: Seismic lines LO-08-87-B,-C (sp 2300 - 3500) in Profile CC'. The basin is defined at the base of the Cretaceous.

Description: The Vestfjorden Basin is situated between 66° 50'N - 68° 10'N and 10°E - 15°E and separates the Lofoten archipelago in the west from the mainland coast of Nordland in the east. The basin is a half graben with its main boundary fault to the west along the Lofoten Ridge. Its axis has an ENE-WSW trend in the southern part and a NE-SW trend in the northern part. The southern flank of the Vestfjorden Basin is the Revfallet Fault Complex along the Nordland Ridge. In the north, the basin becomes gradually shallower towards southeast where the sediments are truncated by a Late Pleistocene unconformity. NNE-SSW trending normal faults occur on the eastern basin margin.

New data indicate that the basal Cretaceous unconformity is considerably lower than suggested by Bøen et al. (1984) who viewed the basin as Palaeozoic. This reinterpretation turns the Vestfjorden Basin into a Cretaceous basin (Brekke & Riis 1987); Cretaceous sediments can be seen onlapping its eastern and western flanks. Nevertheless, Palaeozoic sediments may also exist in the basal part. The Cretaceous (and possible Palaeocene) basin-fill strata are deeply truncated by the Upper Pliocene basal unconformity (Profile CC').

Age: The Vestfjorden Basin was initiated in response to late Middle Jurassic-Early Cretaceous crustal stretching and subsidence. Late, deep erosion of the basin prevents details being given about the latest Cretaceous and Tertiary development of the basin. However, the evolution of the basin was probably closely related to the development of the Ribban Basin and the Utrøst Ridge whose main period of uplift started in the latest Cretaceous.

Vigra High

(Norwegian: Vigrahøgda)

Rank: Formal.

References: Described by Hamar & Hjelle (1984).

Name: After the island of Vigra near Ålesund in Møre & Romsdal.

Type section: Seismic line MB-06-92 (sp 3400 - 3810) in Profile MM'. The high is defined at the base of the Cretaceous.

Description: The Vigra High is located between about 63° 20'N - 63° 50'N and 3° 50'E - 5°E. It is oriented roughly NE-SW and is located centrally in the northern part of the Møre Basin. It is a large, rotated fault block onlapped by the Lower Cretaceous. A NE trending fault constitutes the northwestern flank of the high. This fault ends at the Jan Mayen Lineament in the north and dies out at the southern end of the Vigra High in the south. It has a maximum throw along the Vigra High of about 2500 m. The high is deep with its top at about 6 sec TWT. Internal reflectors parallel to its eastward-sloping summit indicate the existence of pre-Cretaceous sediments within the high.

Age: The Vigra High was formed by large-scale faulting during the late Middle Jurassic-Early Cretaceous rifting episode.

Vigrid Syncline

(Norwegian: Vigridsynklinalen)

Rank: Formal.

References: New name for an element not described previously. However, the Vigrid Syncline covers the same area as the Fulla Ridge described by Skogseid et al. (1992).

Name: The Vigrid Syncline is named after Vigrid, the battlefield for the final, cataclysmic battle (Ragnarok) between the Jotnes and the gods in Norse mythology.

Type section: Seismic line VB-17-90 (sp 2400 - 4400) in Profile EE'. The Vigrid Syncline is defined at Upper Cretaceous levels.

Description: The Vigrid Syncline is situated between 65° 20'N - 67° 10'N and 3° 20'E - 6° 20'E. The syncline strikes NE-SW and is bounded to the west by the Gjallar Ridge, to the east by the Fles Fault Complex, to the north by the Surt Lineament and the Vema Dome, and to the south by the Jan Mayen Lineament. The Vigrid Syncline is formed by the Upper Cretaceous sequences, which thin along the western flank against an internal onlap surface. The base of the Tertiary shows a low-angle truncation of the sequences in both the eastern and western limbs of the syncline. The Palaeocene onlaps and downlaps the base of the Tertiary towards both east and west, indicating that the Palaeocene sediments were deposited in an open syncline above the slightly tighter Cretaceous syncline.

Age: The eastward dip of the onlap surface in the western limb is a combination of the early uplift of the Gjallar Ridge (see the description of the Gjallar Ridge for a discussion on the age of this surface) and the later folding of the Vigrid Syncline. The formation of the eastern limb did not involve any thinning and internal onlaps in the Upper Cretaceous and probably took place in the latest Cretaceous (Late Maastrichtian?). The erosion of the limbs and flanking highs at the base of the Tertiary and the onlapping nature of the Palaeocene in the more open syncline at the base of the Tertiary, indicate that the growth of the syncline continued into the Palaeocene.

Vingleia Fault Complex

(Norwegian: Vingleiforkastningskomplekset)

Rank: Formal.

References: New definition.

Name: Named after the Vingleia lighthouse off Sør-Trøndelag.

Type section: Seismic line MB-04-84 (sp 2300 - 2450) in Profile KK'. Reference lines are -84-102 (sp 590) in Profile JJ' and lines ST-8804-472 (sp 350 - 490) and ST-8804-472-A (sp 1489 - 1690) in Profile EE'. The Vingleia Fault Complex is defined at the base of the Cretaceous in the southwest and at pre-Jurassic levels in the northeast.

Description: The Vingleia Fault Complex is a NE-SW trending element in the area between 63° 55'N - 65° 10'N and 6° 30'E - 10° 45'E. Faults belonging to this complex terminate to the southwest in the area where they intersect the overall north-south grain represented by the Klakk Fault Complex and the Sklinna Ridge. In the south, the Vingleia Fault Complex is the boundary between the Trøndelag Platform/Frøya High and the Halten Terrace. This segment of the complex therefore forms the eastern boundary of the Vøring Basin in this area. East of the Bremstein Fault Complex, the Vingleia Fault Complex foms the northwestern boundary of the Froan Basin at pre-Cretaceous levels. This part of the complex is marked by an increase in the gravity gradient which may be followed to the northeast across the Trøndelag Platform. The marked increase in the gravity gradient along the lineament suggests that the fault complex is deeply rooted. Fault trends within the Vingleia Fault Complex are N-S, NE-SW, ENE-WSW and WNW-ESE.

Age: Triassic activity on ENE-WSW trending faults has been found in the Njord oilfield area. On the Trøndelag Platform, Permo-Triassic movement on NE-SW and ENE-WSW oriented faults along the margins of the Froan Basin has been suggested (e.g. Brekke & Riis 1987). The main separation between the structural highs to the southeast and the Halten Terrace results from Middle and Late Jurassic faulting. Faults of this generation often display listric profiles and, in places, complex hanging-wall deformation.

Fault movement within the Vingleia Fault Complex is also evident at Cretaceous levels. South of the Njord Field, the final separation between the Frøya High and the Halten Terrace took place in Turonian time and continued at least into the Campanian.

Caselli (1987) suggested that the central Norwegian Shelf was affected by oblique-slip tectonics since the Late Jurassic. In this model, the Vingleia Fault Complex acted as a right-lateral wrench fault. However, the listric nature of fault planes indicates that this is basically an extensional feature.

Vøring Basin

(Norwegian: Vøringbassenget)

Rank: Formal.

References: This structural element was first defined by

Åm (1970) and then by Rønnevik et al. (1975). See also Jørgensen & Navrestad (1981), Bukovics et al. (1984), Bøen et al. (1984), Eldholm et al. (1984), Hinz et al. (1984), Mutter (1984), Eldholm & Mutter (1986) and Skogseid & Eldholm (1989).

Name: Named after its location beneath the Vøring Plateau. The «Vøring» part of the name alludes to D/S «Vøringen» of Bergen, built in 1872. The ship was first used for scientific purposes during the "Norwegian North Atlantic Expedition» of 1876-1878.

Type section: Profile FF' from seismic line -713-460 (sp 770) through seismic lines -725-460, ST-8403-459, ST-8501-441, VB-2-87, -A, -B, -C, -D, VB-18-87-A and VB-18-87-T (sp 1780). The relevant parts of Profiles DD', EE', GG', HH', II' and JJ' may be regarded as reference lines to show the diversity of the basin. The Vøring Basin is defined as a Cretaceous basin; the position of the base of the Cretaceous is, however, a matter of dispute over large parts of the basin.

Description: The Vøring Basin is a large sedimentary basin province between 64°N - 68°N and 2°E - 10°E and comprises grabens, basins and structural highs. The eastern province includes the deep Træna and Rås Basins and the Halten and Dønna Terraces to the east, and the western province includes the Vigrid and Någrind Synclines, the Hel and Fenris Grabens, the Nyk and Utgard Highs and the Gjallar Ridge. The Fles Fault Complex separates the eastern and western provinces.

The Vøring Basin is bounded to the north and south by the Bivrost and Jan Mayen Lineaments, respectively. Parallel to these lineaments, the Surt Lineament is an important structural divide within the basin. South of the Surt Lineament, the Vøring Basin is characterized by a central anticline in the Cretaceous along the Fles Fault Complex flanked by two synclines; the Vigrid Syncline to the west and the Rås Basin to the east (Profile EE'). North of the Surt Lineament, the Vøring Basin is divided into three synclines: the Træna Basin (east), the Någrind Syncline and the Hel Graben (west) (Profile DD') separated by the Utgard and Nyk Highs.

Numerous, generally strata-parallel, strong seismic reflectors observed throughout the basin province are interpreted as igneous sills and dykes. Generally, these sills inhibit seismic resolution to deeper levels. Hence, the seismic interpretation of the Early Cretaceous and pre-Cretaceous levels is very difficult in parts of the basin area. The minimum regional thickness of the pre-Cretaceous sedimentary sequence has been estimated to be 3 km (Bøen et al. 1984, Skogseid & Eldholm 1989), but as much as 10 km of sediment have been inferred to exist locally (Eldholm & Mutter 1986, Planke et al. 1991). If so, the thickness of pre-Cretaceous sediment in the Vøring Basin is comparable to that on the Trøndelag Platform as well as in the East Greenland sedimentary sequences. However, recent seismic data indicate a considerably thicker sequence of Cretaceous sediment than previously anticipated, leading to a reduced thickness of pre-Cretaceous sediments.

The Vøring Basin is traditionally regarded to be bounded to the west by the Vøring Escarpment and the Vøring Marginal High.

The description of the Cretaceous basin configuration depends on the seismic correlation chosen for the base of the Cretaceous west of the Fles Fault Complex. The description given below is based on the deep alternative supported by the NPD for the base of the Cretaceous and given in the Profiles and Table 2. (The consequences of a shallower correlation are discussed in the «age» section below.)

In the interpretation presented here, the pre-Cenomanian western boundary of the Vøring Basin may have been an eastward-dipping slope delimiting a pre-Cenomanian platform area underlying the present Vøring Marginal High. In the southwest, Profiles HH' and II' indicate that this slope formed at the base of the Cretaceous in the location of the future Gjallar Ridge and was later onlapped by the entire Cretaceous succession. Further north, Eocene flood basalts hide the details of this flank This pre-Cenomanian basin margin was close to the present Vøring Escarpment.

The pre-Cenomanian eastern basin margin is formed by the Klakk Fault Complex, the Ytreholmen Fault Zone and the northern part of the Revfallet Fault Complex.

In the Turonian, the western basin margin shifted eastwards along the Gjallar Ridge which runs along the Vøring Escarpment in the western part of the basin. The eastern flank of the ridge is defined at the top of the Cenomanian which is onlapped by post-Cenomanian strata, demonstrating that the Gjallar Ridge formed the western flank of the Vøring Basin during the post-Cenomanian part of the Cretaceous (Profiles EE' and FF').

In the post-Cenomanian, the eastern basin margin was formed by the active Revfallet, Bremstein and Vingleia Fault Complexes (Profiles EE', FF' and KK'), thus including the Dønna and Halten Terraces in the Vøring Basin.

The Maastrichtian-Palaeocene extension centred west of the Vøring Escarpment, and leading to the break-up of the continent and separation of Norway and Greenland, probably affected the area west of the Fles Fault Complex giving late syn-rifting uplift and erosion and associated massive, subaerial extrusive magmatic activity that extended 10-40 km to the east of the Vøring Escarpment (Eldholm et al. 1989, Skogseid & Eldholm 1989). The erosional products of this uplift were deposited in the western Vøring Basin area, where the main Palaeogene depocentre seems to have been bounded by the Surt and Jan Mayen Lineaments, the Vøring Escarpment and the reversed Fles Fault Complex (Profiles EE', FF', GG' and HH').

During the Tertiary, the Cretaceous eastern basin margin and the entire Trøndelag Platform were overstepped making it impossible to define the Tertiary eastern basin margin. Including the Tertiary in the definition of the Vøring Basin is therefore very problematical, and the Vøring Basin *sensu stricto* is a Cretaceous basin. However, the Tertiary tectonics (possibly starting in the Maastrichtian) have strongly modified the basin configuration, especially in the western regions.

Tertiary deformation within the Vøring Basin is also represented by regional domes and arches, or elongated antiforms. The Vema and Naglfar Domes, the Helland-Hansen and Modgunn Arches, and domes in the Træna Basin, are all linked to reactivated faults and lineaments. These structures are clearly defined at the level of the Middle Miocene unconformity.

Age: The Vøring Basin was initiated by the extensional phase in the late Middle Jurassic-Early Cretaceous. This divided the basin area into three separate basins: the Rås and Træna Basins between the eastern platform/terrace area and the Fles Fault Complex to the west, and a shallower basin west of the Fles Fault Complex that included the whole of the present western basin province (see above). An alternative interpretation placing the base of the Cretaceous to the west of the Fles Fault Complex at the reflector named «Top Cenomanian» in the present Profiles (e.g. Skogseid & Eldholm 1989), results in a ridge structure at the base of the Cretaceous beneath the Vigrid and Någrind Synclines. Skogseid et al. (1992) proposed the name Fulla Ridge for this structural element. Because of the uncertainties concerning the position of the base of the Cretaceous in the western basin province, this name is at present excluded from the formal nomenclature pending more conclusive data.

During thermal subsidence in the Cenomanian, the various Early Cretaceous basins (and possible ridges) progressively lost their integrity and became inseparable parts of the Vøring Basin. The late Cretaceous tectonic phase in Turonian-Campanian times led to renewed margin faulting and subsidence of the entire basin area within its reorganized post-Cenomanian basin margins. In this stage, the Dønna and Halten Terraces became part of the basin, whereas the Gjallar Ridge was excluded from it.

The final Maastrichtian-Palaeocene rifting episode strongly affected the part of the basin west of the Fles Fault Complex. Although mainly extensional, this episode probably involved an early phase of minor transpressional/compressional folding of the basin deposits. Subsequent to the folding, the entire area of the basin was uplifted and eroded in Maastrichtian-Early Palaeocene times ending the development of the Vøring Basin *sensu stricto*. This was followed by Palaeocene-Eocene igneous activity and subsequent subsidence in the western part of basin.

A view shared by some of the present authors is that tectonic phases in the Late Eocene and Late Miocene reactivated the major mobile zones leading to the growth of large domes and arches within the basin area. The other view (Skogseid et al. 1992, Stuevold et al. 1992) is that the domes and arches were formed in response to differential subsidence and magmatic underplating (see the discussion under the descriptions of the separate structural elements). In Neogene times, the Norwegian mainland and adjacent regions were strongly uplifted and eroded. During this process, huge amounts of Plio-Pleistocene sediments were transported westwards, building the shelf edge to its present position.

Vøring Escarpment

(Norwegian: Vøringskrenten)

Rank: Formal.

References: The Vøring Escarpment was first described by Talwani & Eldholm (1972). They named it the Vøring Plateau Escarpment.

Name: Named after its location on the Vøring Plateau. The «Vøring» part of the name alludes to D/S «Vøringen» of Bergen, built in 1872. The ship was first used for scientific purposes during the «Norwegian North Atlantic Expedition» of 1876-1878.

Type section: Seismic lines VB-18-87-A and VB-18-87-T in Profile FF'. Reference sections are seismic lines VB-10-87-A in Profile DD', VB-17-90 in Profile EE' and VB-15-89-A in Profile GG'.

Description: The Vøring Escarpment is a linear feature along the entire Vøring Plateau between 66° 5'N - 68° 15'N and 1° 55'E - 8° 20'E. It separates the Vøring Marginal High to the west from the Vøring Basin to the east. North of the intersection with the Bivrost Lineament, the escarpment is not clearly defined by seismic data. However, Talwani & Eldholm (1972) and Eldholm et al. (1979) traced the possible, but less pronounced, continuation of the structure north to 69° 10'N -12° 30'E. A minor modification of its location was finally made by Sellevoll & Mokhtari (1988). The structural expression of the escarpment varies along strike. To the south, it is well expressed and is a combination of the front of a volcanic build-up and a partly faulted boundary of differential subsidence between the Tertiary Vøring Marginal High and the basin area to the east (Profiles EE' and FF').

North of the Bivrost Lineament, the escarpment seems to represent a volcanic build-up, or just a flow front.

Although the detailed expression of the escarpment varies locally, Hagevang et al. (1983) demonstrated that it is associated with a continuous, sharp negative magnetic anomaly on the Vøring Plateau.

Age: The Vøring Escarpment may have developed as a fault scarp in the Maastrichtian-Palaeocene rifting episode and was subsequently covered by flood basalts during the Palaeocene-Eocene continental break-up separating Greenland and Eurasia. During the period from the Early Eocene to the Pliocene, the Vøring Marginal High was further separated from the basin by flexural, differential subsidence of the basin along the Vøring Escarpment.

Vøring Marginal High

(Norwegian: Vøringrandhøgda)

Rank: Formal.

References: The Vøring Marginal High has been described as part of the volcanic margin by Hinz (1981), Talwani et al. (1983), Mutter (1984), Eldholm et al. (1984), Hinz et al. (1984), Mutter et al. (1984) and Skogseid & Eldholm (1987). The term «marginal high» was first used by Eldholm et al. (1984).

Name: The Vøring Marginal High is named after its location on the Vøring Plateau. The «Vøring» part of the name alludes to D/S «Vøringen»of Bergen, built in 1872. The ship was first used for scientific purposes during the»Norwegian North Atlantic Expedition» of 1876-1878. Type section: Seismic lines VB-18-87-T (sp 1319 - 1775) and NH-1-79 (sp 7243 - 8180) in Profile FF'.

Description: The Vøring Marginal High occurs as a NE-SW trending structure between 66° N - 69° 15'N and 0° 15'E - 13° E. The southern boundary is located near the Jan Mayen Fracture Zone. It is bounded to the east by the Vøring Escarpment and to the west and north by the transition to «normal» oceanic crust. South of 68°N, this transition is abrupt and fault defined, but it is more smooth and gradual to the north.

The Vøring Marginal High has two zones with different structural development beneath the top Eocene lava reflector (Zones II and III in the notation of Hinz et al. 1982 and Talwani et al. 1983). The western zone (Zone III) is underlain by a seaward-dipping reflector sequence representing a westward-thickening lava pile which is the upper part of thick oceanic crust (Profile FF'). The eastern zone (Zone II) forms a 10 to 40 km wide area west of the Vøring Escarpment where reflectors with poor continuity are subparallel to the top Eocene lava or dip gently landwards. ODP well 642 shows that these reflectors represent lavas and volcanoclastics probably overlying Mesozoic or Palaeozoic sediments above continental or transitional crystalline crust (Profiles EE' and FF').

The marginal high comprises two oceanic fracture zones, the Vøring and Lofoten fracture zones of Hagevang et al. (1983), that subdivided the high when it formed during continental break-up and the subsequent 3-4 m.y. of sea-floor spreading. These have now been renamed the Gleipne and Bivrost Fracture Zones, respectively.

Age: The Vøring Marginal High developed as part of the volcanic passive margin formed in response to regional Maastrichtian-Palaeocene continental extension leading to the separation of Eurasia and Greenland in the Palaeocene-earliest Eocene. During this process, the outer parts of the Vøring Basin, as well as the marginal high, experienced major uplift, erosion and magmatic activity. The marginal high was further separated from the basin to the east during the period from the Early Eocene to the Pliocene by differential subsidence along the Vøring Escarpment.

Ylvingen Fault Zone

(Norwegian: Ylvingforkastningssonen)

Rank: Formal.

References: New structural element, but includes parts of what Price & Rattey (1984) called the Vega Fault Zone and the graben described along the Vega High by Gabrielsen et al. (1984). The fault zone was recently described by Lokna (1993).

Name: After the small island of Ylvingen east of the island of Vega in Helgeland.

Type section: Seismic line ST-8808-826-A (sp 3000 - 4150) in Profile DD'. The Ylvingen Fault Zone is defined at the base of the Cretaceous.

Description: The Ylvingen Fault Zone is part of the Trøndelag Platform and is located southeast of the Helgeland Basin and the Vega High between 65° 25'N - 66° 5'N and 8° 10'E - 11°E. It was described by Gabrielsen et al. (1984) as part of the Vega High, and by Price & Rattey (1984) as part of their Vega Fault Zone.

The Ylvingen Fault Zone can be followed as a crescent-shaped zone for about 120 km, in a roughly NE-SW direction. The southwestern part trends ENE-WSW. It has its maximum width of about 25 km at around 10°E where the main fault zone turns to a NE-SW trend (Lokna 1993). In the same area, a branch of the zone splays off as a separate graben towards the NE and bisects the Vega High. The fault zone consists of a complex pattern of tilted blocks, horsts, grabens and half grabens.

Age: The Ylvingen Fault Zone was formed in close connection with the Vega High in Early Cretaceous time during a late phase of the late Middle Jurassic-Early Cretaceous rifting episode. Owing to the thinness of the Cretaceous strata on the platform and difficulties in tying Cretaceous reflectors to the grabens, the exact age is uncertain. The most probable age for the most active tectonic phase is Neocomian. Some activity may have taken place in Late Jurassic times, and there is evidence of movement along the most important normal fault throughout the Cretaceous. Gabrielsen et al. (1984) describe the Vega High as a domal feature with a central graben-collapse structure. This «collapse-graben» is part of the present Ylvingen Fault Zone (Lokna 1993).

Ytreholmen Fault Zone

(Norwegian: Ytreholmsforkastningssonen)

Rank: Formal.

References: New name.

Name: Named after Ytreholmen, a small island with a lighthouse west of Mo i Rana in Nordland.

Type section: Seismic lines NRGS-84-429 (sp 204 - 350) and NH-1-79 (sp 2800 - 3250) in Profile EE'. The Ytreholmen Fault Zone is defined at the base of the Cretaceous.

Description: The Ytreholmen Fault Zone is situated between 65° 20'N - 66° 40'N and 5° 50'E - 8° 30'E and forms the boundary between the Dønna Terrace in the east and the Rås and Træna Basins in the west. It is composed of several northwest-dipping normal faults, partly forming an en echelon pattern. Its displacement decreases to the north, approximately where the strike of the Nordland Ridge changes from NNE-SSW to NE-SW (just north of 66°N). In the south, the zone dies out just south of its intersection with the Sklinna Ridge and where it meets the N-S trending faults in the southern part of the Rås Basin.

Age: The development of the Ytreholmen Fault Zone is linked to the formation of the Dønna Terrace. The main movements seem to have occurred in the Late Jurassic to Early Cretaceous. The zone was probably also active during the thermal contraction phase after the rifting in the Cretaceous.

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PROFILES

Geoseismic profiles referred to in the descriptions. Location of profiles shown in Plate I. Colour code is given in Figure 1, letter code is given in Table 2.

NEW. FORMAL NAME	PREVIOUS NAME
Bivrost Fracture Zone	Lofoten Fracture Zone (Hagevang et al. 1983)
Bivrost Lineament	Lofoten Lineament (Blystad et al. 1989)
Bremstein Fault Complex	Haltenbank segment of Kristiansund-Bodø Fault Complex (Gabrielsen & Robinson 1984)
Ellingråsa Graben	Eastern graben system of Gabrielsen & Robinson (1984).
Fenris Graben	Northwestern part of Smøla Rift (Rønnevik et al. 1983)
Froan Basin	Hitra Basin (Hamar & Hjelle 1984, Bukovics et al. 1984)
Frøya High	Smøla High (Price & Rattey 1984)
Gjallar Ridge	Lovund Ridge (Bukovics et al. 1984)
Hel Graben	Fleina Rift (Skogseid & Eldholm 1989)
Helland-Hansen Arch	Structure D (Hinz et al. 1982, 1984), Molde High (Hamar & Hjelle 1984)
Høgbraken Horst	Central Horst (Gabrielsen & Robinson 1984)
Magnus Basin	Magnus Embayment (Duindham & Van Hoorn 1987, Nelson & Lamy 1987)
Manet Ridge	Nordfjord Horst (Hamar et al. 1980) Nordfjord Ridge (Gabrielsen et al. 1984)
Møre Marginal High	Møre Platform (Hamar & Hjelle 1984)
Møre-Trøndelag Fault Complex	Møre-Trøndelag Line (Price & Rattey 1984)
Måløy Terrace	Måløy Fault Blocks (Rønnevik et al. 1975)
Någrind Syncline	Røst Syncline (Rønnevik et al. 1983) Røst Sub-basin (Gabrielsen et al. 1984)
Revfallet Fault Complex	Part of the Kristiansund-Bodø Fault Complex (Gabrielsen & Robinson 1984)
Rås Basin	Halten Trough (Rønnevik et al. 1983) Vikna Graben (Bukovics et al. 1984)
Gnausen High	Sande High (Hamar & Gjelle 1984)
Sklinna Ridge	Nidaros Arch (Bucovics et al. 1984) Sklinna High (Heum et al. 1986)
Skomvær Sub-Basin	Værøy Basin (Mokhtari et al. 1987)
Utgard High	Bodø High (Bøen et al. 1984)

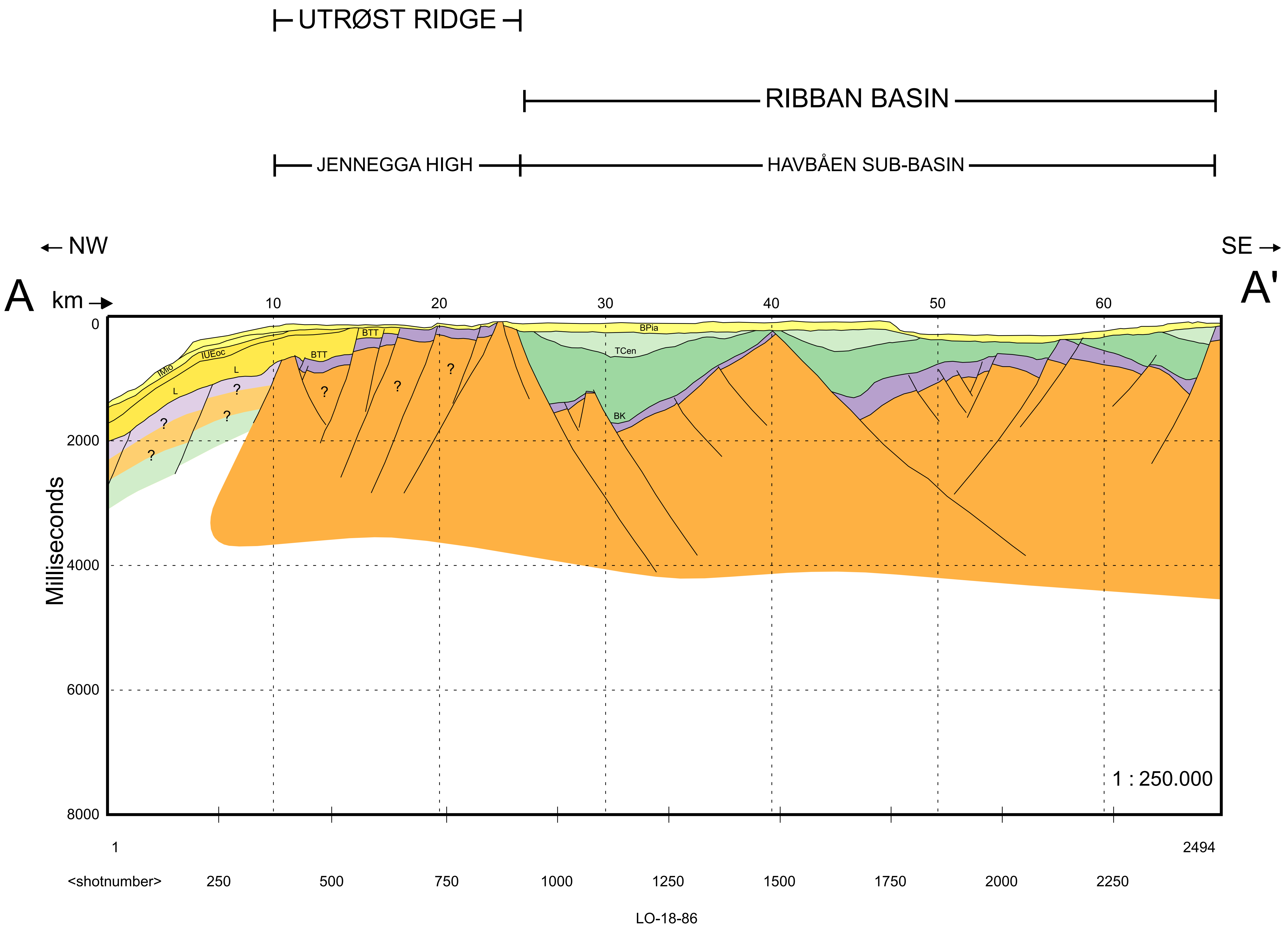
TABLE 1. *Formal names replacing previously published names.*

	NPD INTERPERTATION	ALTERNATIVE INTERPRETATIONS
IQ	Intra Quaternary	—
BPia	Base Upper Pliocene (unconf.)	—
TMio	Top Miocene	—
IMio	Intra Miocene (unconf.)	—
IUEoc	Intra Upper Eocene (unconf.)	—
L	Top Eocene lavas	—
TPal	Top Palaeocene	—
BTT	Base Tertiary (unconf.)	Intra Palaeocene in the Hel Graben
ICam	Intra Campanian	Base Tertiary in the Hel Graben
TCen	Top Cenomanian (unconf.)	Base Cretaceous west of the Fles Fault Complex
ILK	Intra Lower Cretaceous	Base Cretaceous west of the Fles Fault Complex
BK	Base Cretaceous (unconf.)	Intra pre-Cretaceous west of the Fles Fault Complex
BUJ	Base Upper Jurassic	—
TTr	Top Triassic	—
BTr	Base Triassic	—
IP	Intra Permian (unconf.)	—

TABLE 2. *Letter code for the dating of horizons in Profiles AA' OO'. Well-documented alternatives to the NPD dating of horizons in the deep western basins are listed under the heading "Alternative Interpretations".*

COLOUR CODE

- Quarternary
- Neogene and Quarternary, undifferentiated
- Paleogene, undifferentiated
- Paleocene
- Upper Cretaceous younger than Cenomanian
- Lower Cretaceous and Cenomanian
- Upper Jurassic
- Jurassic, undifferentiated
- Upper Triassic
- Lower and Middle Triassic
- Triassic, undifferentiated
- Triassic and Jurassic, undifferentiated
- Paleozoic and Mesozoic, undifferentiated
- Paleozoic, undifferentiated
- Basement and Paleozoic, undifferentiated
- Crystalline basement
- Eocene lavas
- Sills and dykes


UTRØST RIDGE
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JENNEGGA HIGH
HAVBÅEN SUB-BASIN
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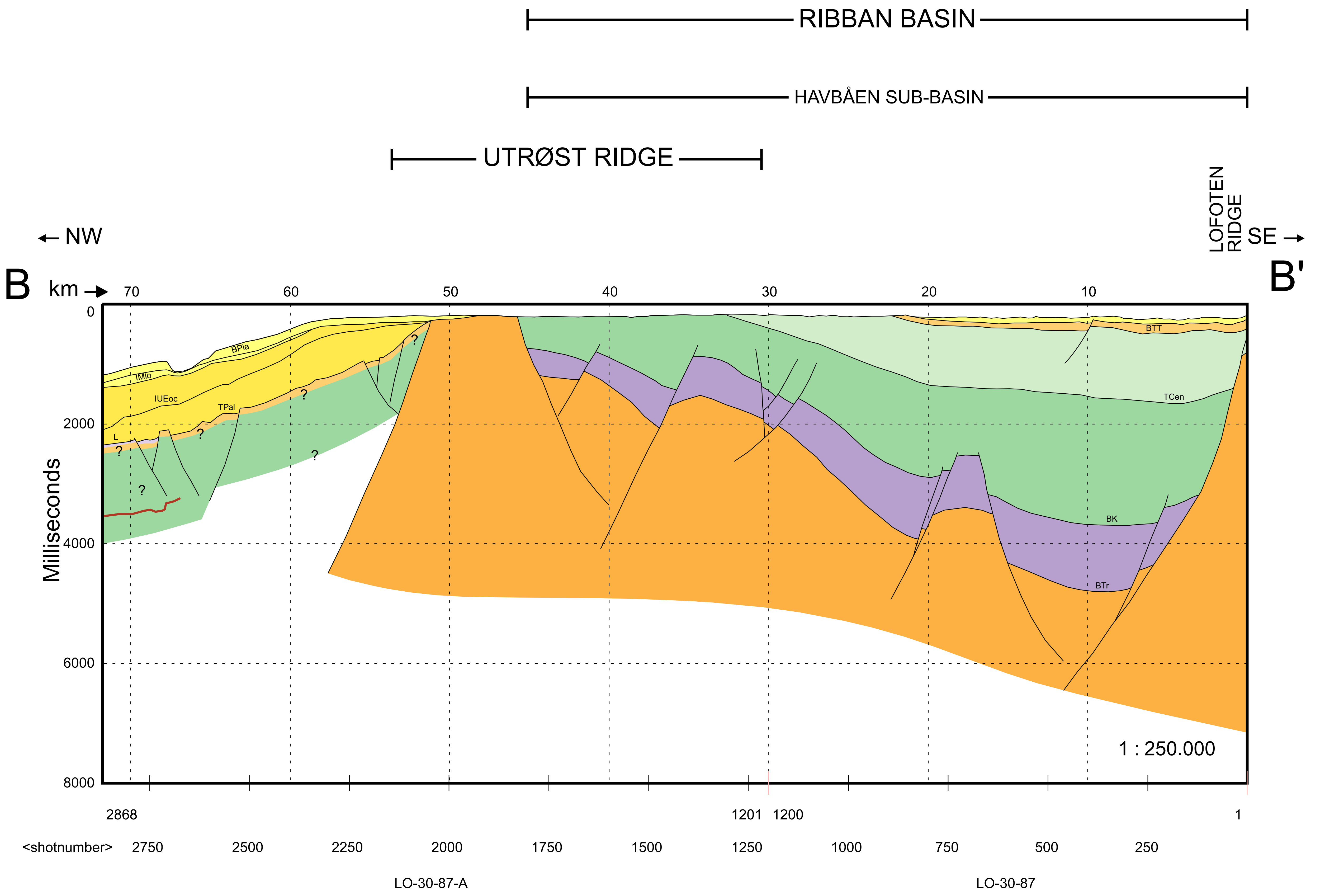
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HAVBÅEN SUB-BASIN
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2000
4000
6000
8000
Milliseconds
BPla
IMio
IUEoc
TPal
L
BTT
TCen
BK
BTr
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2868
1201
1200
1
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1750
1500
1250
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750
500
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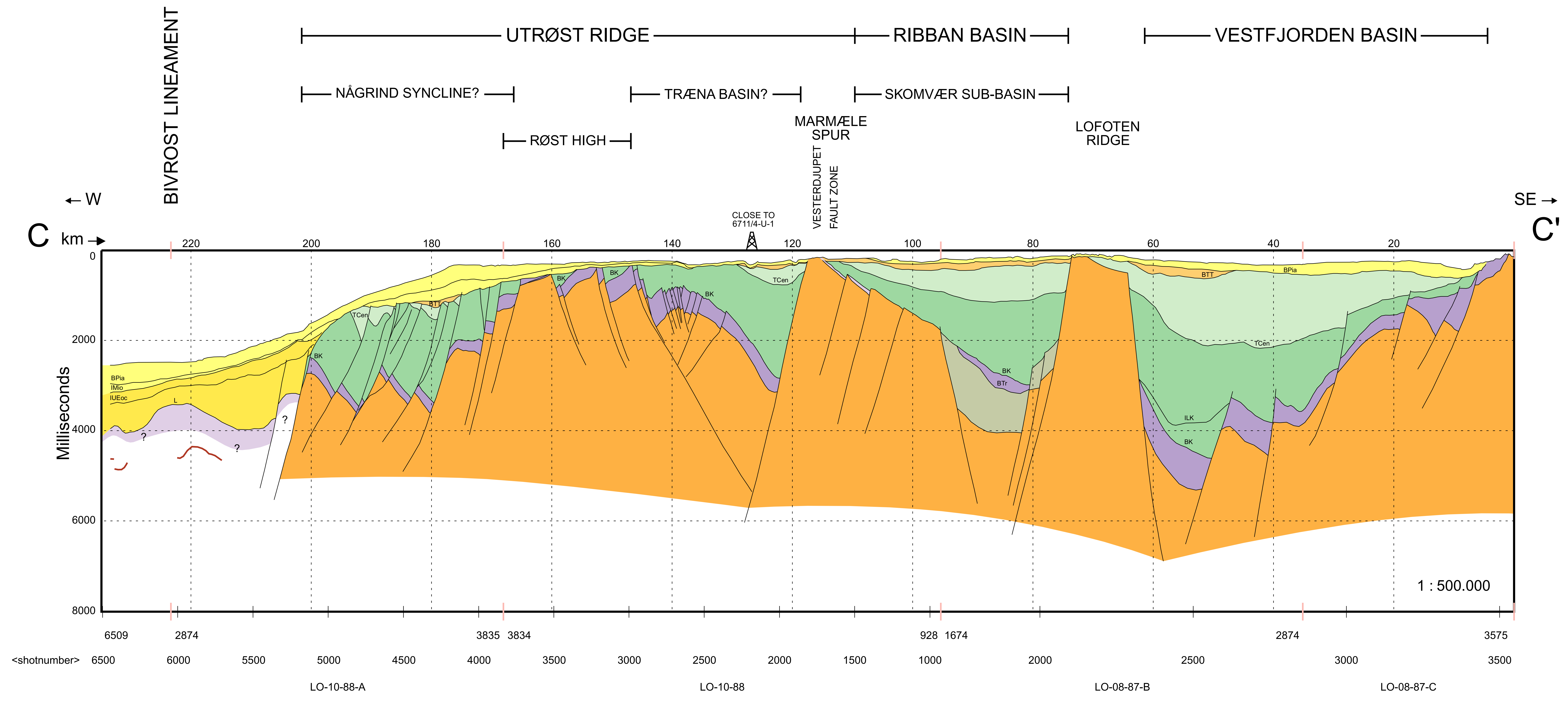
LO-30-87



UTRØST RIDGE
RIBBAN BASIN
VESTFJORDEN BASIN
NÅGRIND SYNCLINE?
TRÆNA BASIN?
SKOMVÆR SUB-BASIN
RØST HIGH
MARMÆLE SPUR
LOFOTEN RIDGE
BIVROST LINEAMENT
VESTERDJUPET FAULT ZONE
CLOSE TO 6711/4-U-1
← W
SE →
C
C'
km →
220
200
180
160
140
120
100
80
60
40
20
Milliseconds
0
2000
4000
6000
8000
BPia
IMio
IUEoc
L
TCen
BTT
BK
BTr
ILK
?
1 : 500.000
6509
2874
3835
3834
928
1674
2874
3575
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6000
5500
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4500
4000
3500
3000
2500
2000
1500
1000
2000
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3000
3500
LO-10-88-A
LO-10-88
LO-08-87-B
LO-08-87-C

VØRING MARGINAL HIGH
VØRING BASIN
TRØNDELAG PLATFORM
VØRING ESCARPMENT
FENRIS GRABEN
GJALLAR RIDGE
VIGRID SYNCLINE
RÅS BASIN
HELLAND-HANSEN ARCH
FLES FAULT COMPLEX
YTREHOLMEN FAULT ZONE
DØNNA TERRACE
REV-FALLET FAULT COM-PLEX
SØR HIGH
NORDLAND RIDGE
ELLINGRÅSA GRABEN
BREM-STEIN FAULT COM-PLEX
VINGLEIA FAULT COMPLEX
FROAN BASIN
ANOMALY 24B
6507/6-1
← NW
SE →
E
E'
km
Milliseconds
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VB-17-90
NH-1-79
NRGS-84-429
SG-8710-410
ST-8608-472
ST-8804-472
ST-8804-472-A


VØRING MARGINAL HIGH
VØRING ESCARPMENT
VØRING BASIN
TRØNDELAG PLATFORM
FENRIS GRABEN
GJALLAR RIDGE
VIGRID SYNCLINE
RÅS BASIN
HELLAND-HANSEN ARCH
FLES FAULT COMPLEX
HALTEN TERRACE
BREMSTEIN FAULT COMPLEX
ANOMALY 24A
ANOMALY 24B
CLOSE TO ODP 642
ODP 643
YTREHOLMEN FAULT ZONE
KLAKK FAULT COMPLEX
SKLINNA RIDGE
GRINDA GRABEN
HØGBRAKEN HORST
ELLINGRÅSA GRABEN
6506/11-3
6506/12-1
6507/11-3
← NW
ESE →
F
F'
km
Milliseconds
1 : 500.000
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VB-18-87-T
VB-18-87-A
VB-2-87-C
VB-2-87-B
VB-2-87-A
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VB-2-87-D
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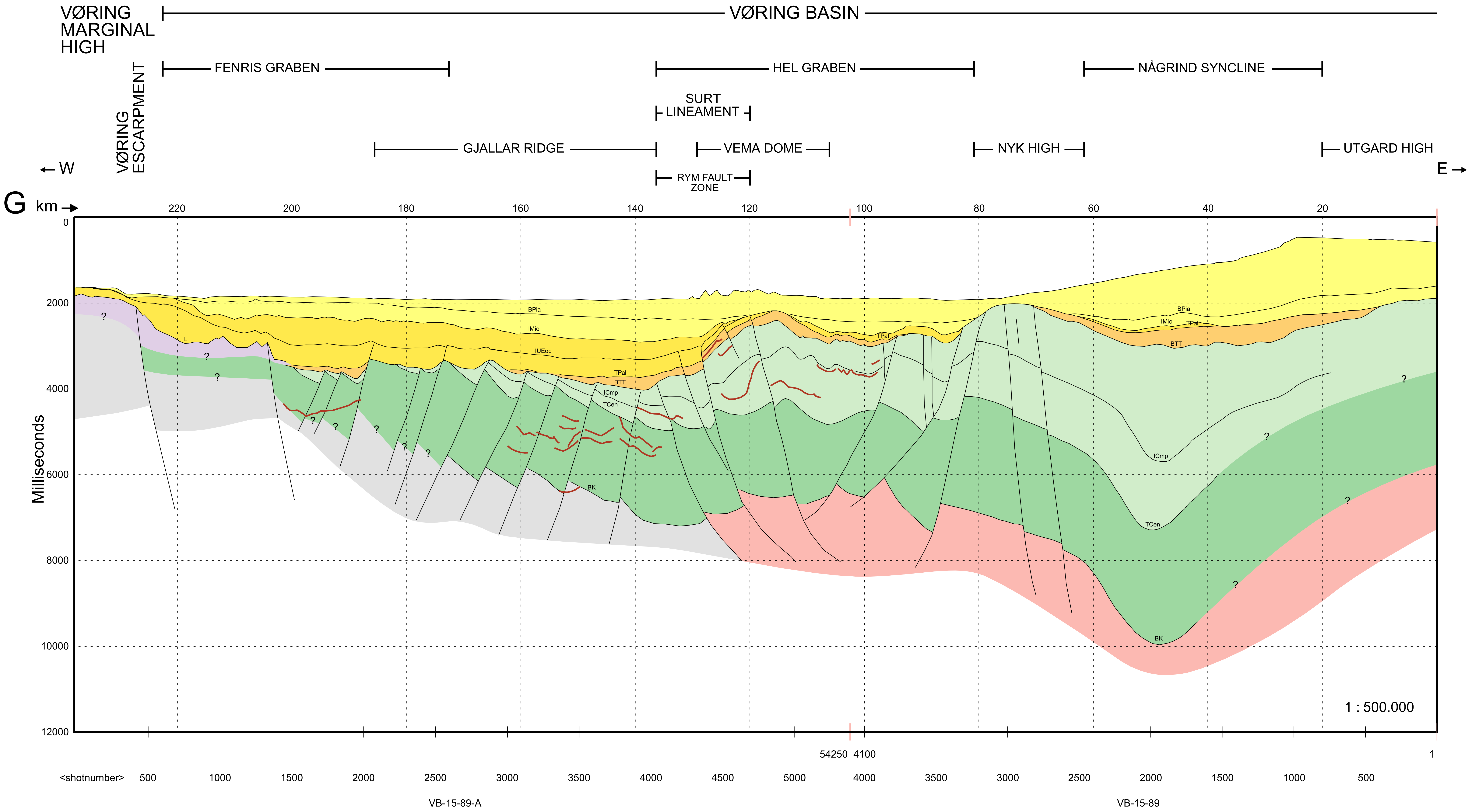
-726-460
-731-460


VØRING MARGINAL HIGH
VØRING BASIN
VØRING ESCARPMENT
FENRIS GRABEN
HEL GRABEN
NÅGRIND SYNCLINE
SURT LINEAMENT
GJALLAR RIDGE
VEMA DOME
NYK HIGH
UTGARD HIGH
RYM FAULT ZONE
← W
E →
G
G'
km →
220
200
180
160
140
120
100
80
60
40
20
0
2000
4000
6000
8000
10000
12000
Milliseconds
BPla
IMio
IUEoc
TPal
BTT
ICmp
TCen
BK
L
?
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54250 4100
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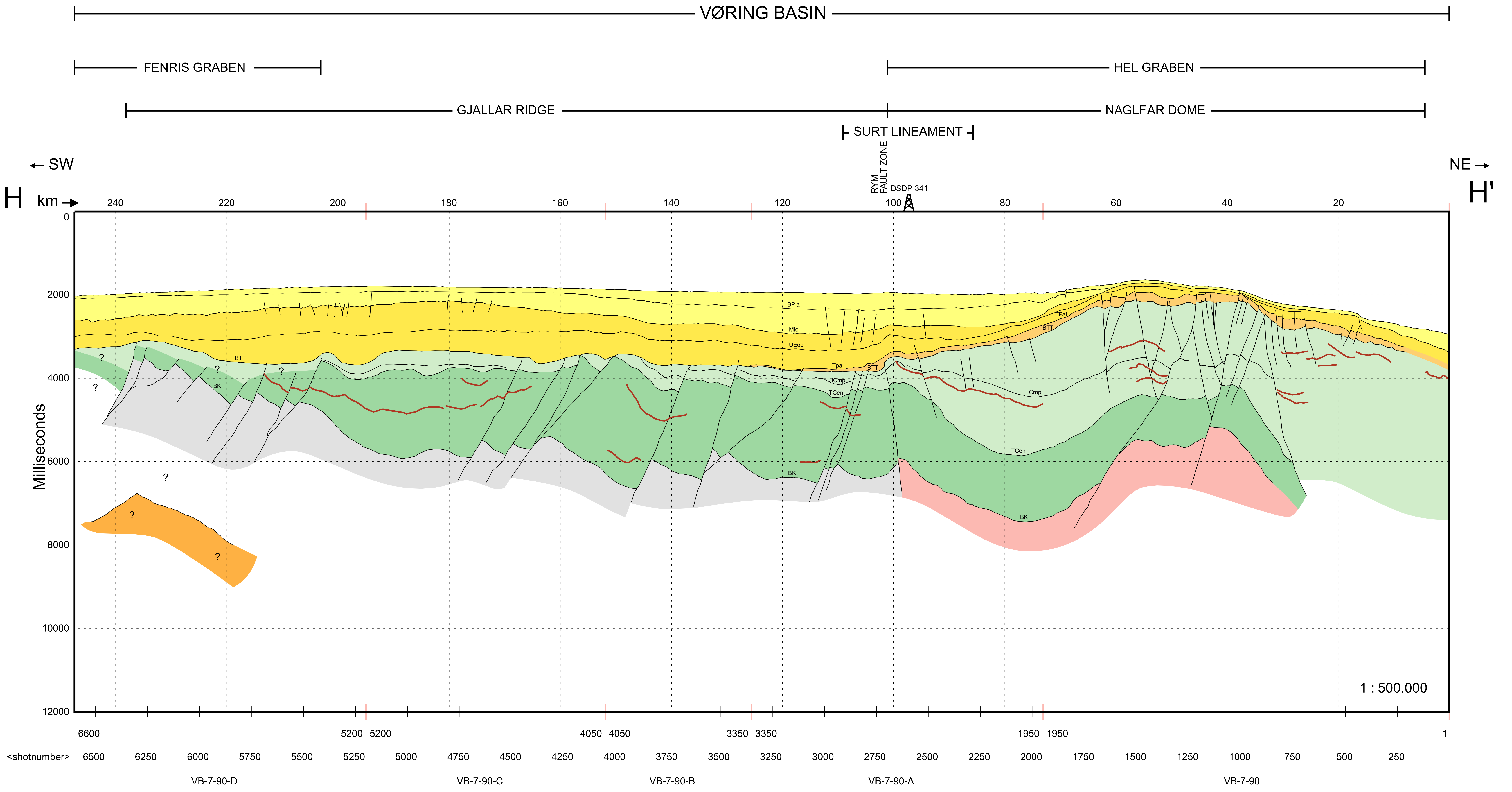
VB-15-89


VØRING BASIN
FENRIS GRABEN
HEL GRABEN
GJALLAR RIDGE
NAGLFAR DOME
SURT LINEAMENT
← SW
NE →
RYM FAULT ZONE
DSDP-341
H
H'
km
240
220
200
180
160
140
120
100
80
60
40
20
0
2000
4000
6000
8000
10000
12000
Milliseconds
BPia
IMio
IUEoc
Tpal
TPal
BTT
ICmp
TCen
BK
?
1 : 500.000
6600
5200 5200
4050 4050
3350 3350
1950 1950
1
<shotnumber>
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6250
6000
5750
5500
5250
5000
4750
4500
4250
4000
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
VB-7-90-D
VB-7-90-C
VB-7-90-B
VB-7-90-A
VB-7-90


VØRING BASIN
JAN MAYEN LINEAMENT
BIVROST LINEAMENT
VIGRID SYNCLINE
NÅGRIND SYNCLINE
GJALLAR RIDGE
SURT LINEAMENT
← SW
NE →
I
I'
km
Milliseconds
BPia
IMio
IUEoc
TPal
BTT
ICmp
TCen
ILK
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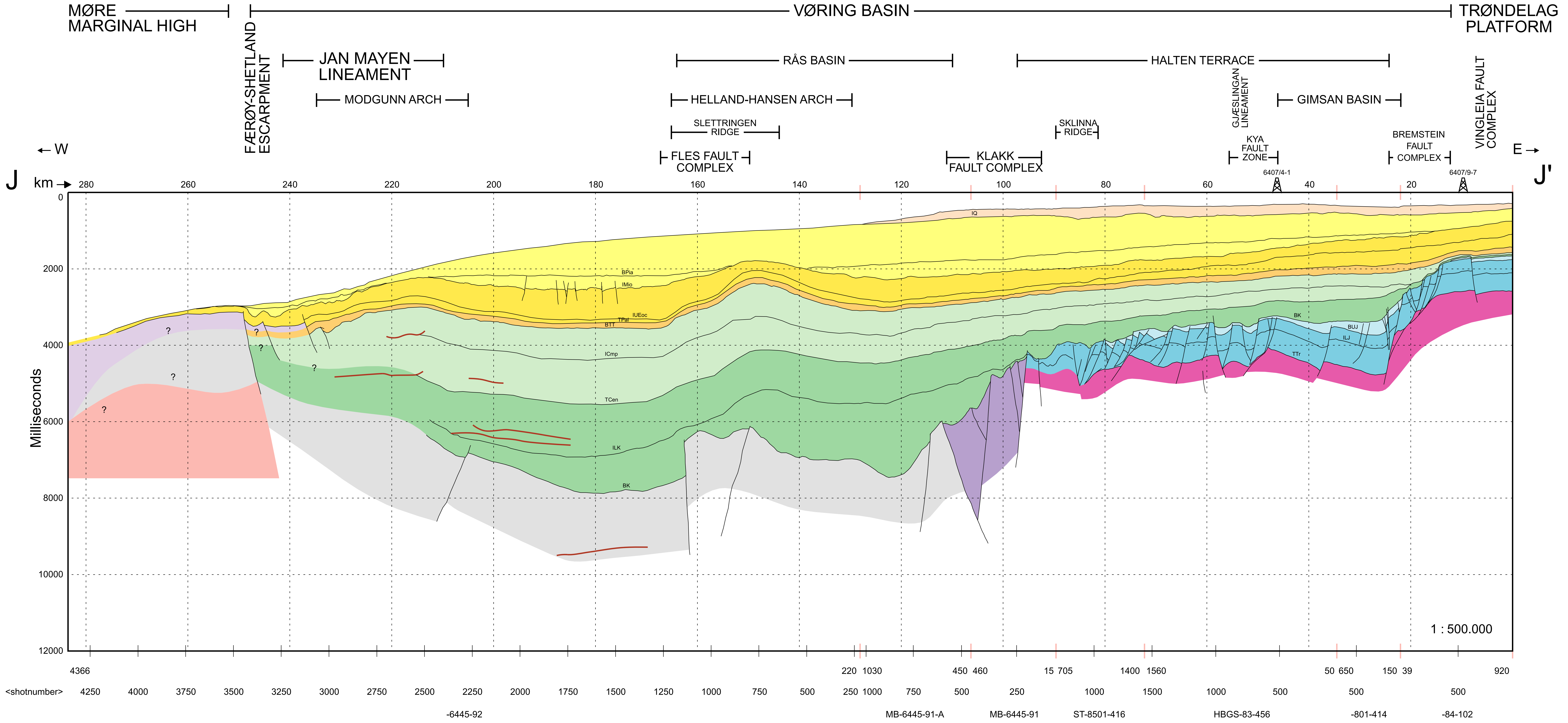
VB-4-90
VB-7-87
VB-7-87-A


MØRE MARGINAL HIGH
VØRING BASIN
TRØNDELAG PLATFORM
FÆRØY-SHETLAND ESCARPMENT
JAN MAYEN LINEAMENT
MODGUNN ARCH
RÅS BASIN
HALTEN TERRACE
HELLAND-HANSEN ARCH
SLETTRINGEN RIDGE
FLES FAULT COMPLEX
KLAKK FAULT COMPLEX
SKLINNA RIDGE
GJÆSLINGAN LINEAMENT
KYA FAULT ZONE
GIMSAN BASIN
BREMSTEIN FAULT COMPLEX
VINGLEIA FAULT COMPLEX
← W
E →
J
J'
km
280 260 240 220 200 180 160 140 120 100 80 60 40 20
6407/4-1
6407/9-7
Milliseconds
0 2000 4000 6000 8000 10000 12000
IQ
BPia
IMio
IUEoc
TPal
BTT
ICmp
TCen
ILK
BK
BUJ
ILJ
TTr
?
1 : 500.000
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220 1030 1000 750 450 460 500 250 15 705 1000 1400 1560 1500 1000 500 50 650 500 150 39 500 920
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MB-6445-91-A
MB-6445-91
ST-8501-416
HBGS-83-456
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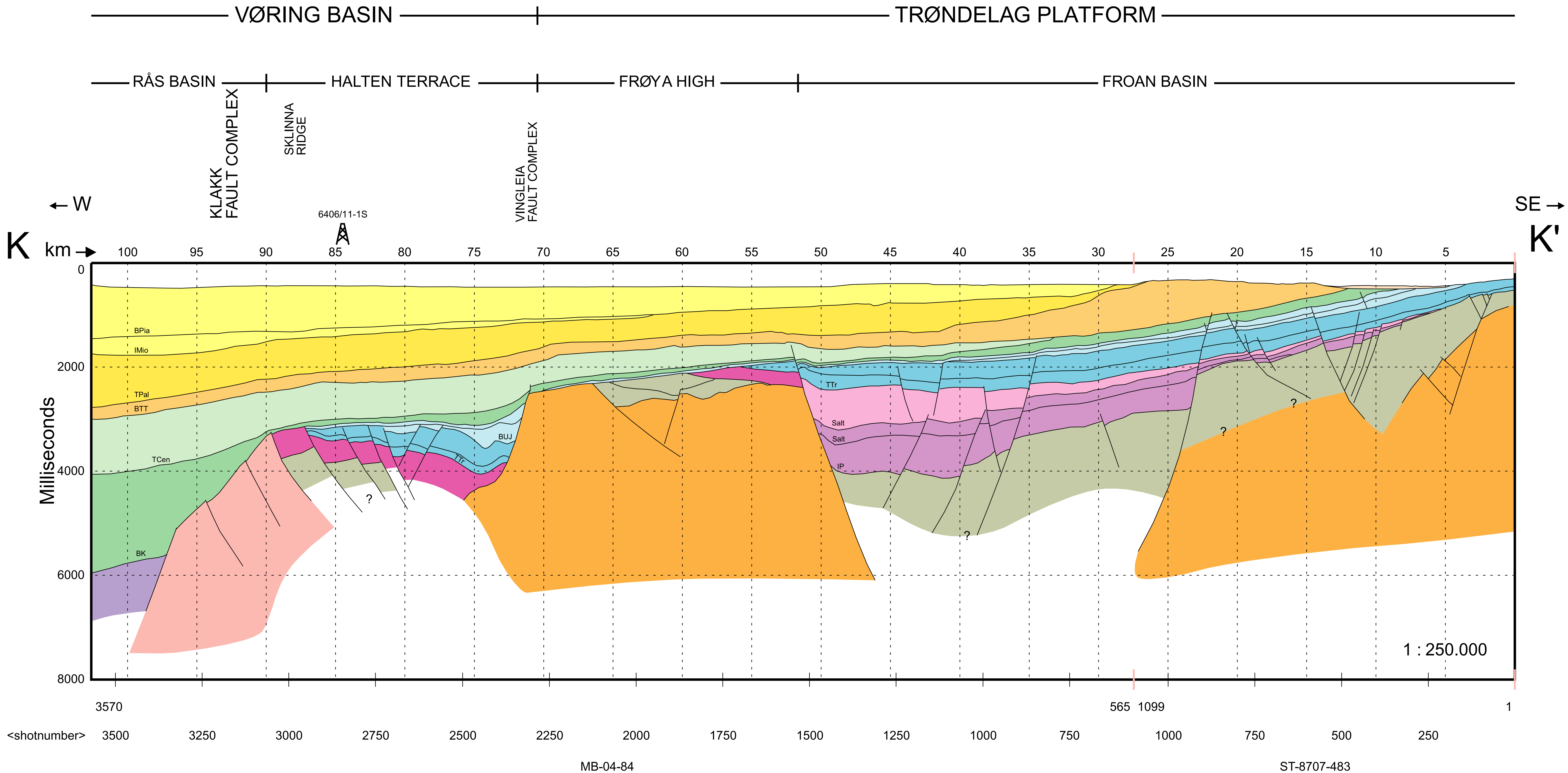
VØRING BASIN
TRØNDELAG PLATFORM
RÅS BASIN
HALTEN TERRACE
FRØYA HIGH
FROAN BASIN
KLAKK FAULT COMPLEX
SKLINNA RIDGE
VINGLEIA FAULT COMPLEX
← W
SE →
6406/11-1S
K
K'
km
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
Milliseconds
0
2000
4000
6000
8000
BPia
IMio
TPal
BTT
TCen
BK
BUJ
TTr
Salt
IP
?
1 : 250.000
3570
565
1099
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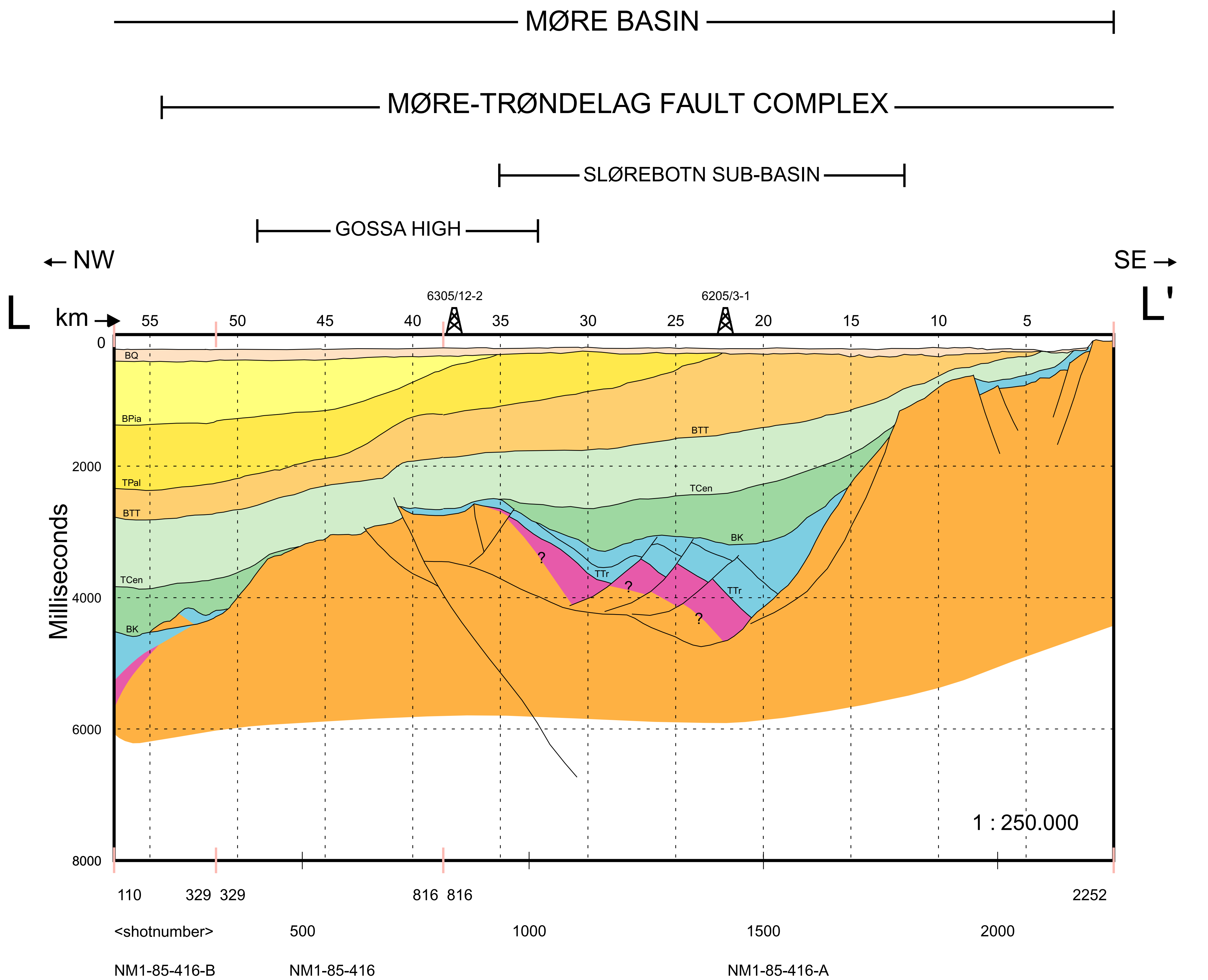

MØRE BASIN
MØRE-TRØNDELAG FAULT COMPLEX
SLØREBOTN SUB-BASIN
GOSSA HIGH
← NW
SE →
L
L'
km →
55 50 45 40 35 30 25 20 15 10 5
6305/12-2
6205/3-1
0
2000
4000
6000
8000
Milliseconds
BQ
BPia
TPal
BTT
TCen
BK
TTr
?
1 : 250.000
110 329 329 816 816 2252
<shotnumber>
500
1000
1500
2000
NM1-85-416-B
NM1-85-416
NM1-85-416-A


MØRE MARGINAL HIGH
FÆRØY-SHETLAND ESCARPMENT
MØRE BASIN
MØRE-TRØNDELAG FAULT COMPLEX
SLØREBOTN SUB-BASIN
VIGRA HIGH
ONA HIGH
GISKE HIGH
← W
SE →
M
M'
km
Milliseconds
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
2000
4000
6000
8000
10000
12000
BPia
IMio
IUEoc
TPal
BTT
ICmp
TCen
ILK
BK
IP?
L
?
1 : 500.000
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5216 3810
101
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3750
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4250
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4750
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3500
3000
2500
2000
1500
1000
5000
-6330-92
-6330-92-A
-6330-92-B
MB-06-92


VØRING MARGINAL HIGH
VØRING ESCARPMENT
VØRING BASIN
TRØNDELAG PLATFORM
HEL GRABEN
NÅGRIND SYNCLINE
TRÆNA BASIN
HELGELAND BASIN
NAGLFAR DOME
NYK HIGH
UTGARD HIGH
NORDLAND RIDGE
VEGA HIGH
FLES FAULT COMPLEX
REVFALLET FAULT COMPLEX
RØDØY HIGH
YLVINGEN FAULT ZONE
← NNW
SE →
D
D'
km
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
CLOSE TO 6609/7-1
CLOSE TO 6609/10-1
6609/11-1
Milliseconds
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2000
4000
6000
8000
10000
12000
1 : 500.000
IQ
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IMio
IUEoc
TPal
BTT
L
ICmp
TCen
ILK
BK
IUJ
ILJ
TTr
Salt
IP
?
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VB-10-87
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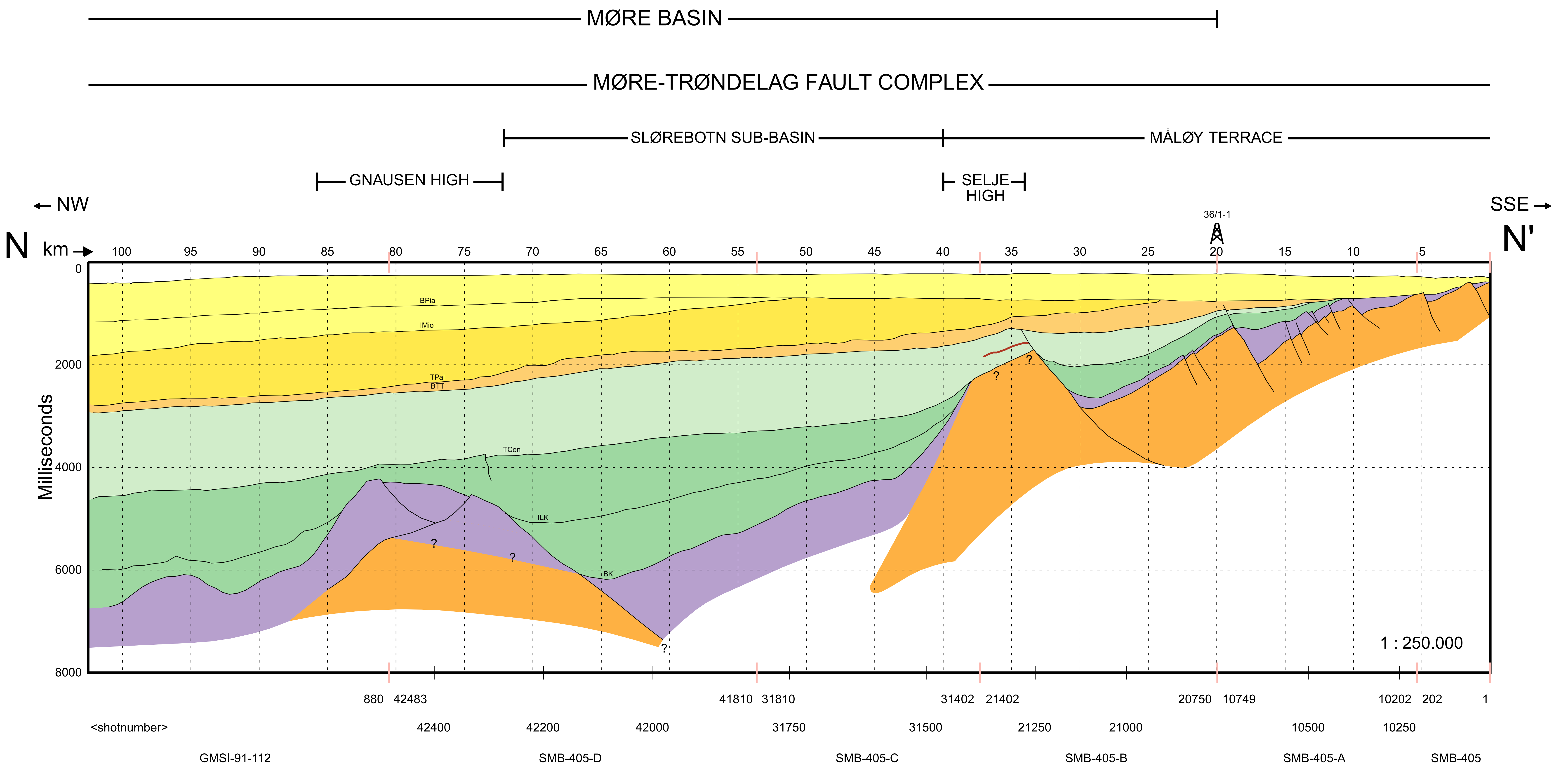
MØRE BASIN
MØRE-TRØNDELAG FAULT COMPLEX
SLØREBOTN SUB-BASIN
MÅLØY TERRACE
GNAUSEN HIGH
SELJE HIGH
← NW
SSE →
N
N'
km
36/1-1
Milliseconds
BPia
IMio
TPal
BTT
TCen
ILK
BK
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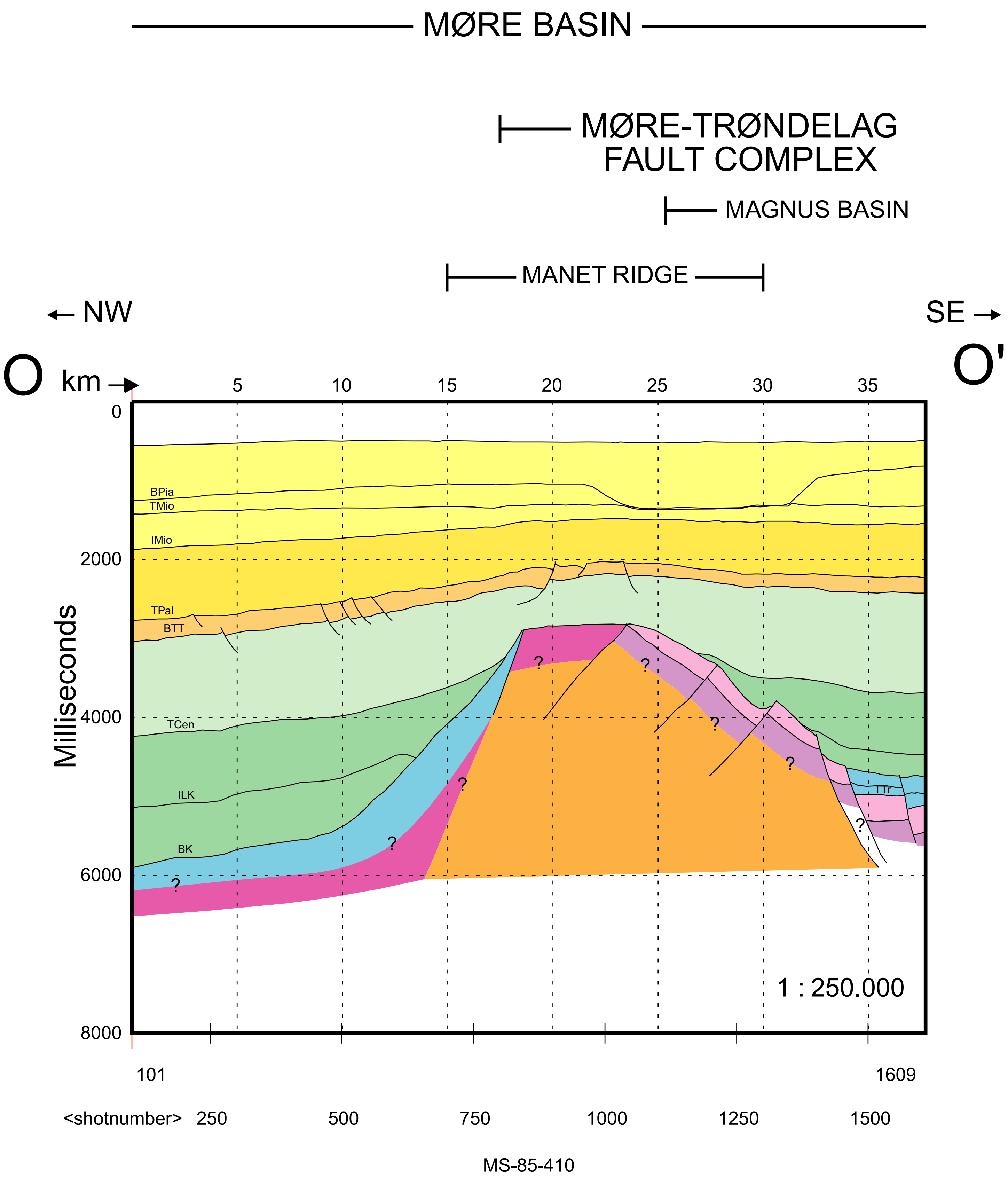
SMB-405-D
SMB-405-C
SMB-405-B
SMB-405-A
SMB-405



MØRE BASIN
MØRE-TRØNDELAG FAULT COMPLEX
MAGNUS BASIN
MANET RIDGE
← NW
SE →
O
O'
km →
5
10
15
20
25
30
35
0
2000
4000
6000
8000
Milliseconds
BPia
TMio
lMio
TPal
BTT
TCen
ILK
BK
TTr
?
1 : 250.000
101
1609
<shotnumber> 250
500
750
1000
1250
1500
MS-85-410

Structural elements of the Norwegian continental shelf

Part II: The Norwegian Sea Region

P. Blystad, H. Brekke, R.B. Færseth, B.T. Larsen, J. Skogseid and B. Tørudbakken
Plate I, NPD-Bulletin no. 8 (1995)

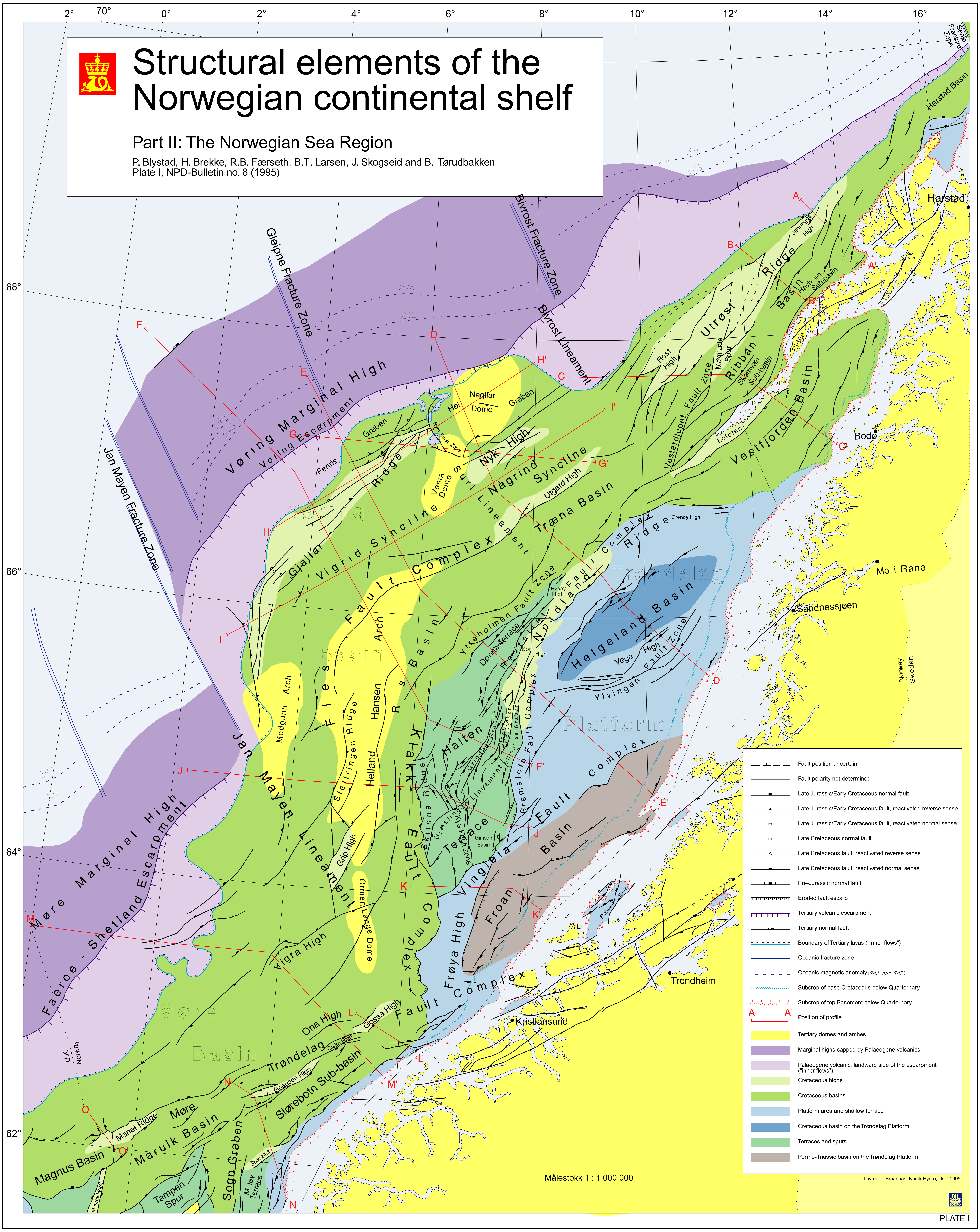


PLATE I