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Harmonized stratigraphic chart for the North Sea area NL-DE-DK

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GENERAL INTRODUCTION

Work package 3 (WP3) of the GeoERA research project ”3D Geomodelling for Europe (3DGEO-EU)” aims to integrate existing national (and regional) geomodels into a harmonized, consistent cross-border geomodel of the North Sea area between the Netherlands, Germany and Denmark. TNO – Geological Survey of the Netherlands (TNO, NL), the Geological Survey of Denmark and Greenland (GEUS, DK) and the Federal Institute for Geosciences and Natural Resources (BGR, DE) are responsible for the cross-border harmonization in this pilot area.

The following harmonized stratigraphic charts for the NL-DE-DK North Sea area, the third deliverable of WP3, will provide an overview of the relationship of Dutch, German and Danish North Sea lithostratigraphy.

The results from this report together with the correlation profiles in report 3.4: “Lithostratigraphic/ chronostratigraphic correlation profiles through the study area”, are fundamental to ensure a successful harmonized cross-border 3D model.

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1 PROJECT BACKGROUND

1.1 Rationales and aims

Harmonization of geological data across geological, topographical, but especially across national borders is one of the most important work steps to create a base for trans-European assessments of resource potentials and possible conflicts of use of European subsurface. In the last decades a variety of different thematic maps were developed, but often not on a similar and consistent data base. Differences in the geological & geophysical interpretation (e.g. stratigraphy, velocity-model, structural interpretation, different methods of assessments) across the borders remain unchanged and were masked by generalizations in an overview scale. In the last years these “border-discontinuities” have become obvious by a variety of 3D-modeling projects. But workflows for harmonization of different geological 3D models are yet not established and proofed.

The GeoERA research project ”3D Geomodeling for Europe (3DGEO-EU)” aims to show on the example of cross-border pilot areas (work packages 1 - 3) how harmonization across the borders can be established and maintained with the progress of the national models. The pilot area of work package 3 (WP3) spans thereby the offshore cross-border North Sea area between the Netherlands, Germany and Denmark. In this region, the partners TNO – Geological Survey of the Netherlands (TNO, NL), the Geological Survey of Denmark and Greenland (GEUS, DK) and the Federal Institute for Geosciences and Natural Resources (BGR, DE) intent to integrate existing national (and regional) geomodels into a harmonized, consistent cross-border geomodel of the North Sea area. One of the main tasks of WP3 in this context will be to find and exemplarily test efficient workflows for harmonization or the consistent translation between the established national concepts. The methodologic advantages (agreements on best practices, optimized workflows, etc.) and the gain in experience on cross-border 3D harmonization work will be a keystone for further transnational harmonization projects.

As part of the work integrating regional and national geomodels into a harmonized, consistent cross-border geomodel of the NL-DE-DK North Sea area a correlation of the regional lithostratigraphy is presented. The objectives of the study are to show the relationship of Dutch, German and Danish lithostratigraphy. This initial study presents the present-day status for the different countries and differences in the geological and geophysical interpretation across the borders are discussed.

2 LITHOSTRATIGRAPHIC CHARTS

The offshore cross-border North Sea area between the Netherlands, Germany and Denmark comprises a number of structural elements (*Figure 1*) with individual stratigraphic succession. For the most significant structural elements in each country, lithostratigraphic charts in a comparable layout and with a harmonized legend have been compiled by the project partners. In each chart the nationally accepted lithostratigraphic nomenclature is used. The dominant lithology/depositional environment representative for the formations is indicated with a standard color code describing the various depositional environments. The assigned depositional environment is a generalization and not fully comprehensive and therefore added supplementary note where applicable. As different approaches were used to establish the lithostratigraphic charts in the three countries a short description on the methodology and references is given in the following section.

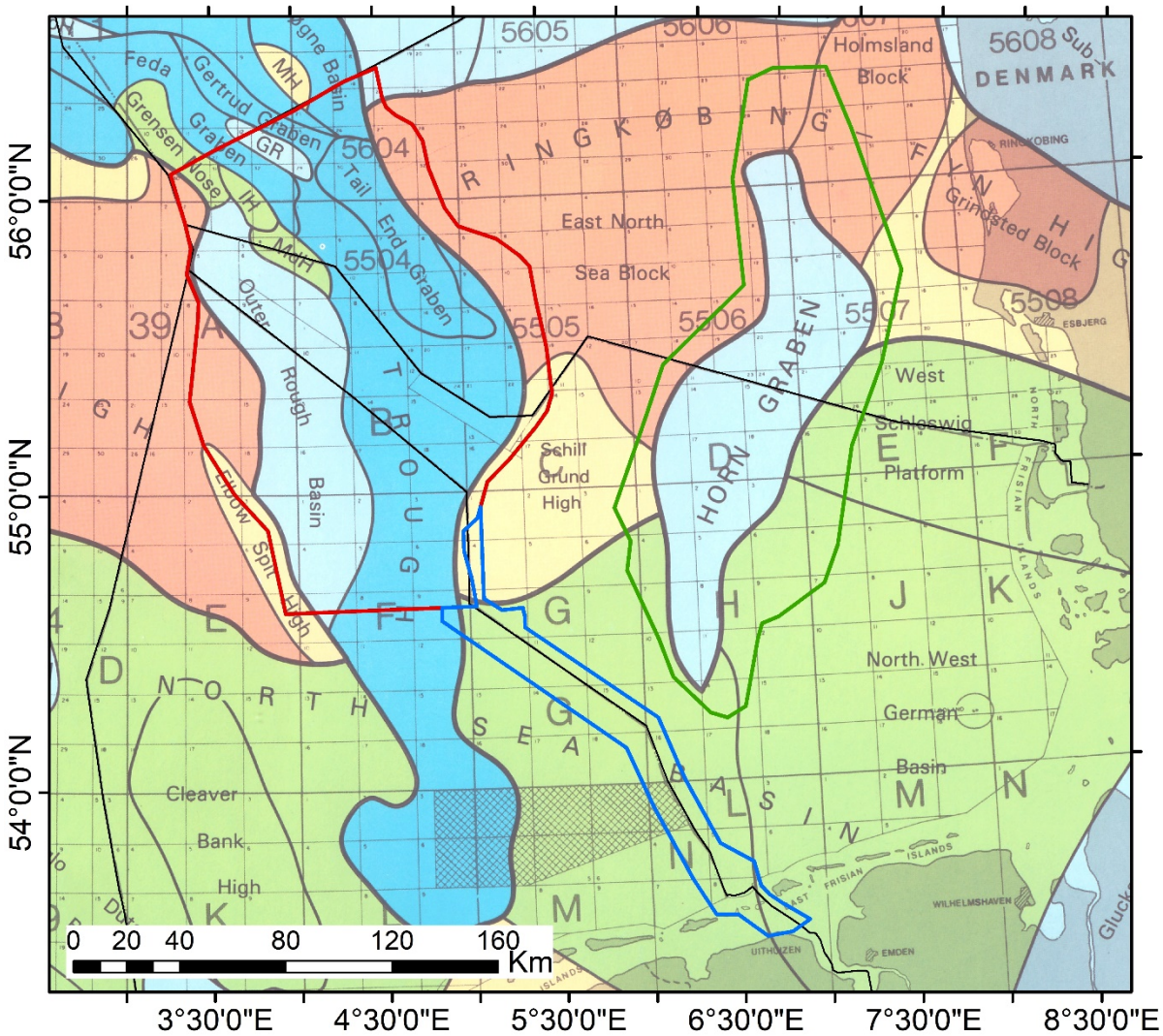


Figure 1. Structural element map for the NL, DE, DK North Sea areas. The study areas for the 3DGEO-EU cross-border pilot study are highlighted in red, blue & green (Thöle et al. 2019). Base map from NOPEC (1988).

2.1 Danish stratigraphy

The lithostratigraphic charts for the Danish area (*Figures 3 and 4*) comprises 6 structural elements. In the Danish Central Graben area (*Figure 3*) the charts refer to the 4 structural elements: Outer Rough Basin, Heno Plateau, Tail End Graben and Ringkøbing Fyn High (*Figure 2*). The lithostratigraphic charts in Figure 4 represent the Horn Graben and the Danish Norwegian Basin east of the Central Graben.

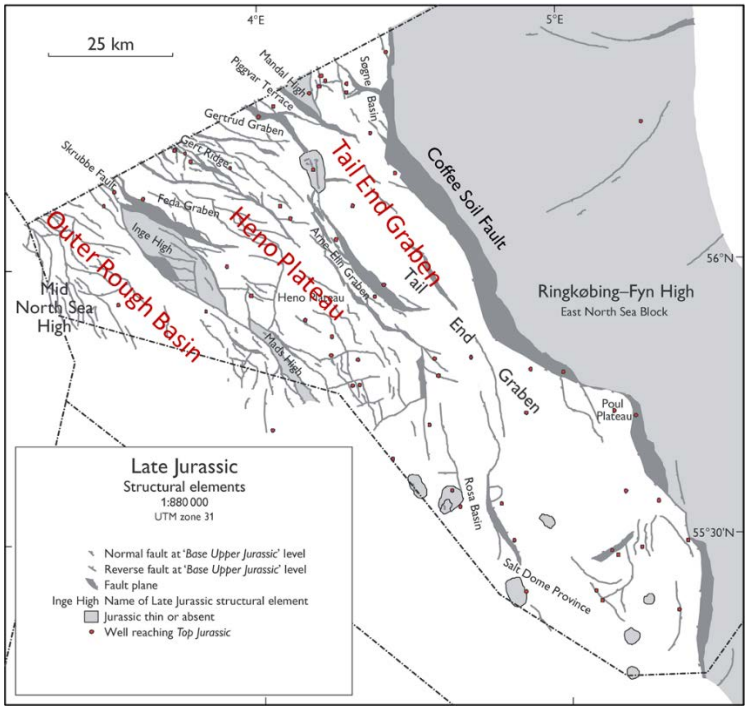


Figure 2. Structural element map for the Danish Central Graben area with outline of the structural elements represented in the lithostratigraphic schemes. Modified map from Japsen et al. (2003).

The lithostratigraphy for the Danish area is a compilation of published data and results of in-house GEUS work and represents the most updated lithostratigraphy for the Danish Central Graben area (*Figure 3*).

For the Pre-Jurassic succession the lithostratigraphy is primarily based on the Millennium Atlas stratigraphic breakdown. For the Triassic succession the lithostratigraphy is based on the publication of Michelsen & Clausen (2002).

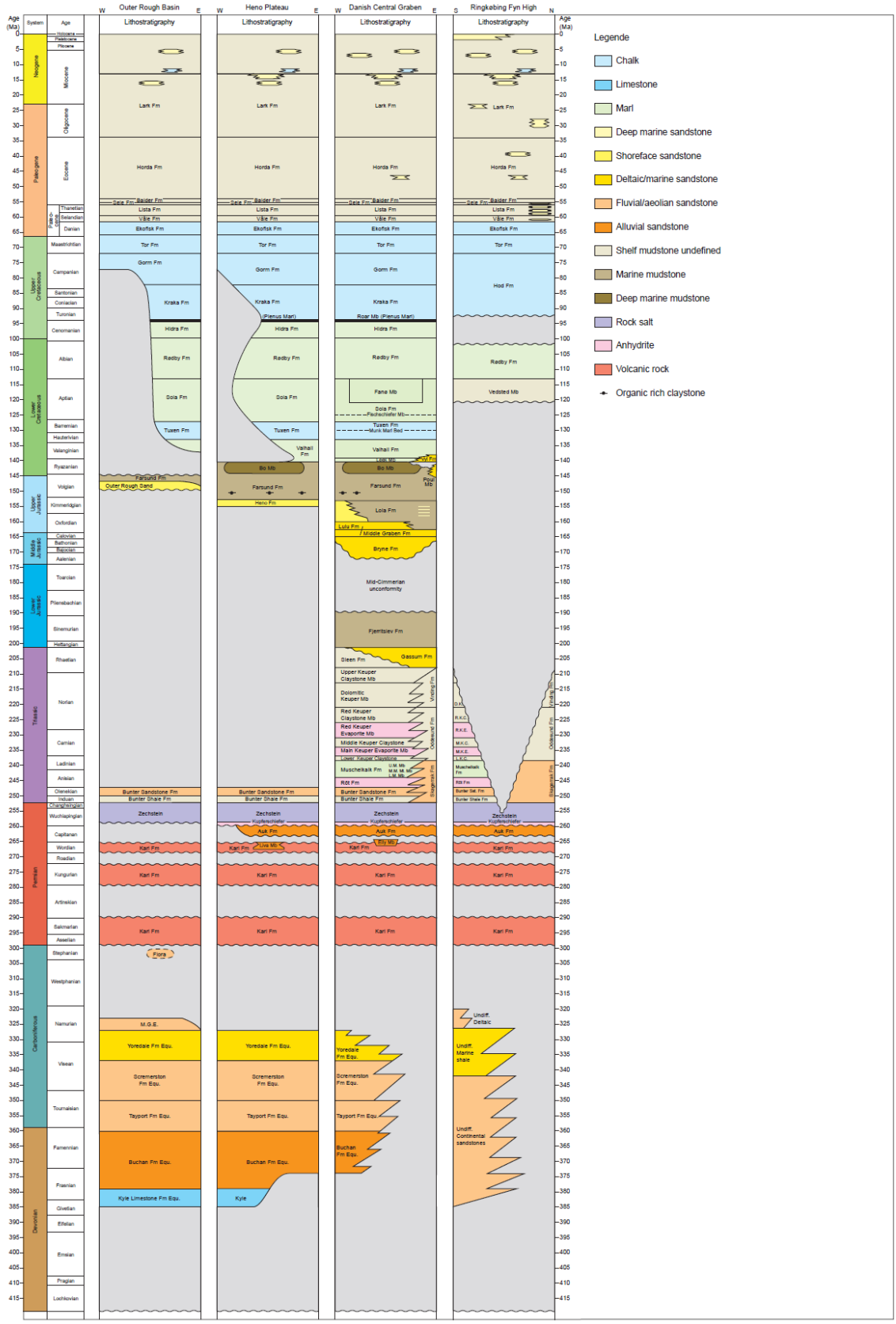


Figure 3. Lithostratigraphic schemes for the four structural elements in the Danish Central Graben area: Outer Rough Basin, Heno Plateau, Danish Central Graben (Tail End Graben) and the Ringkøbing Fyn High.

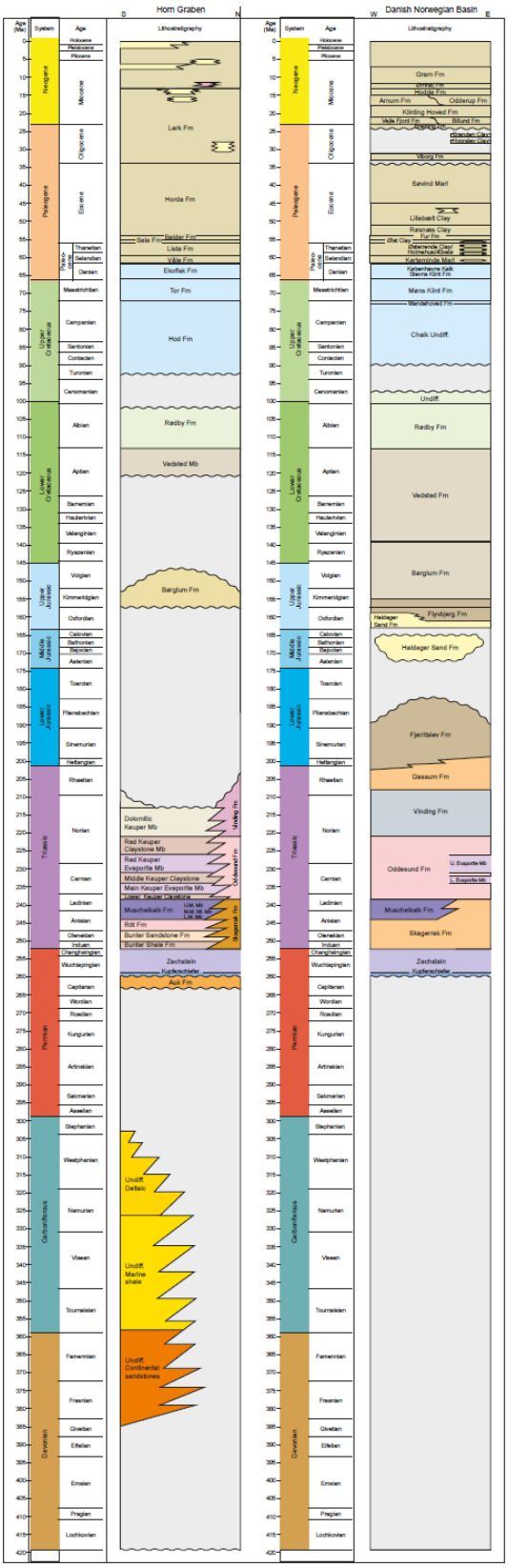


Figure 4. Lithostratigraphic schemes for the Horn Graben and Danish-Norwegian Basin. (see for lithology legend in Figure 3)

The lithostratigraphic subdivision of the Jurassic is based on the results from the GEUS PETSYS project: Jurassic Petroleum System in the Danish Central Graben (The PETSYS project (2014)).

All Jurassic lithostratigraphic formations and members used in the PETSYS project are illustrated in a simplified scheme for the whole Danish Central Graben (*Figure 5*). The lithostratigraphic subdivision follows generally the lithostratigraphy of Michelsen et al. (2003) for the Danish Central Graben. No new lithostratigraphic units have been defined formally in the PETSYS project, but the informal unit ”Outer Rough Sand”, is used for the shallow marine, Lower Volgian, sand present in the Outer Rough Basin. The Gita Sand Mb and Svane Sand Mb are used for turbiditic/fan sand units of Kimmeridgian age in the Tail End Graben.

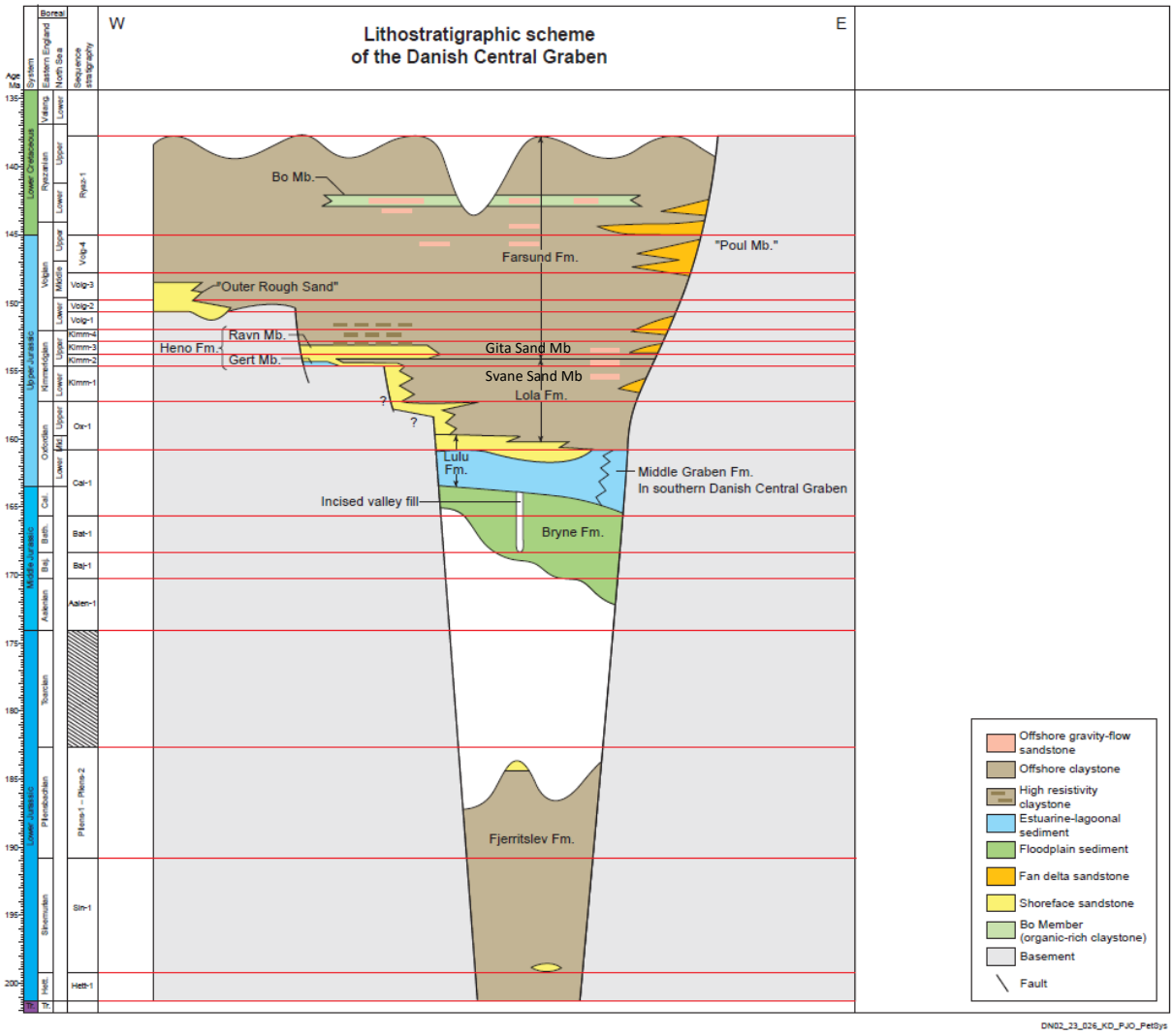


Figure 5: Lithostratigraphic units used in the PETSYS project, correlated with sequence stratigraphy and chronostratigraphy.

The Cretaceous lithostratigraphic subdivision is the result of the work carried out in the GEUS CRETSYS Project: “The Cretaceous Petroleum System in the Danish Central Graben”. The scope of the project was to establish a consistent stratigraphic framework for Upper and Lower Cretaceous and Danian and concluded in an updated stratigraphic framework and improved the understanding of the regional stratigraphic architecture and depositional setting (The CRETSYS Project 2017).

The integrated stratigraphy presented on the CRETSYS website for the entire Cretaceous–Danian succession is a composite framework incorporating classical lithostratigraphy together with sequence stratigraphy where applicable (primarily the Lower Cretaceous) and seismic stratigraphy. The broad lithostratigraphic subdivision corresponds in great detail to the recent revision of the Cretaceous lithostratigraphy in the Danish Central Graben presented by Van Buchem et al. (2017), see *Figure 6*. The sequence stratigraphic framework for the Cromer Knoll Group follows, to a large extent, the framework presented by Jakobsen et al. (2004, 2005).

The Cenozoic lithostratigraphy is based on results from the CENSYS project: “The Cenozoic Petroleum System in the Danish North Sea”.

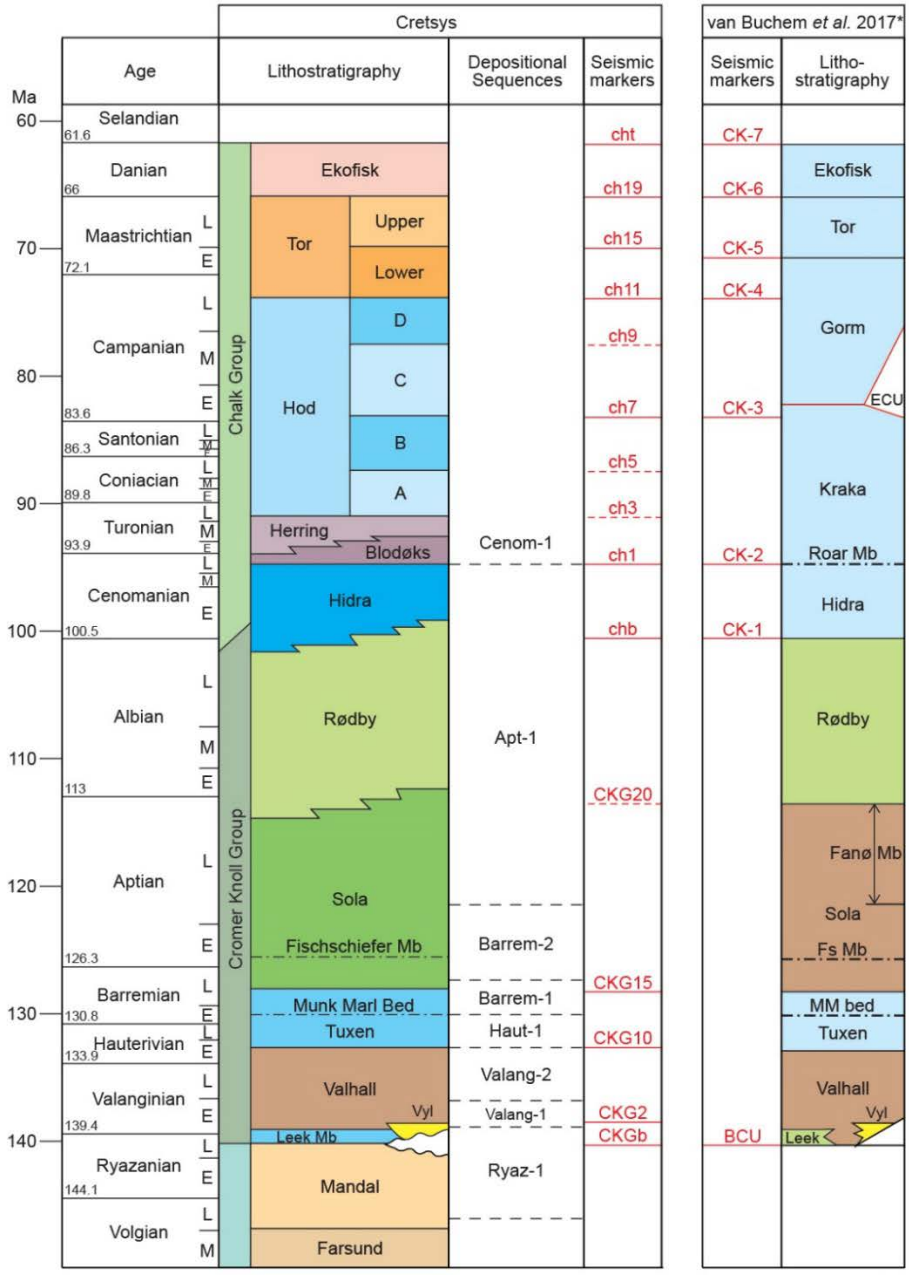


Figure 6. Comparison of the CRETSYS stratigraphic framework with the formal stratigraphy defined by Van Buchem et al. (2017).

2.2 German stratigraphy

The lithostratigraphic charts presented here for the German sector of the North Sea comprise 7 structural elements. For the northwestern part of the German offshore area, also referred to as the Entenschnabel, these are the Outer Rough Basin/High, the Step Graben System, and the German Central Graben (*Figure 7A*). For the area of the central German North Sea, these includes furthermore the Schillgrund High, the Horn Graben, the West Schleswig Block, and the L- and G-Platform areas (*Figure 7B*).

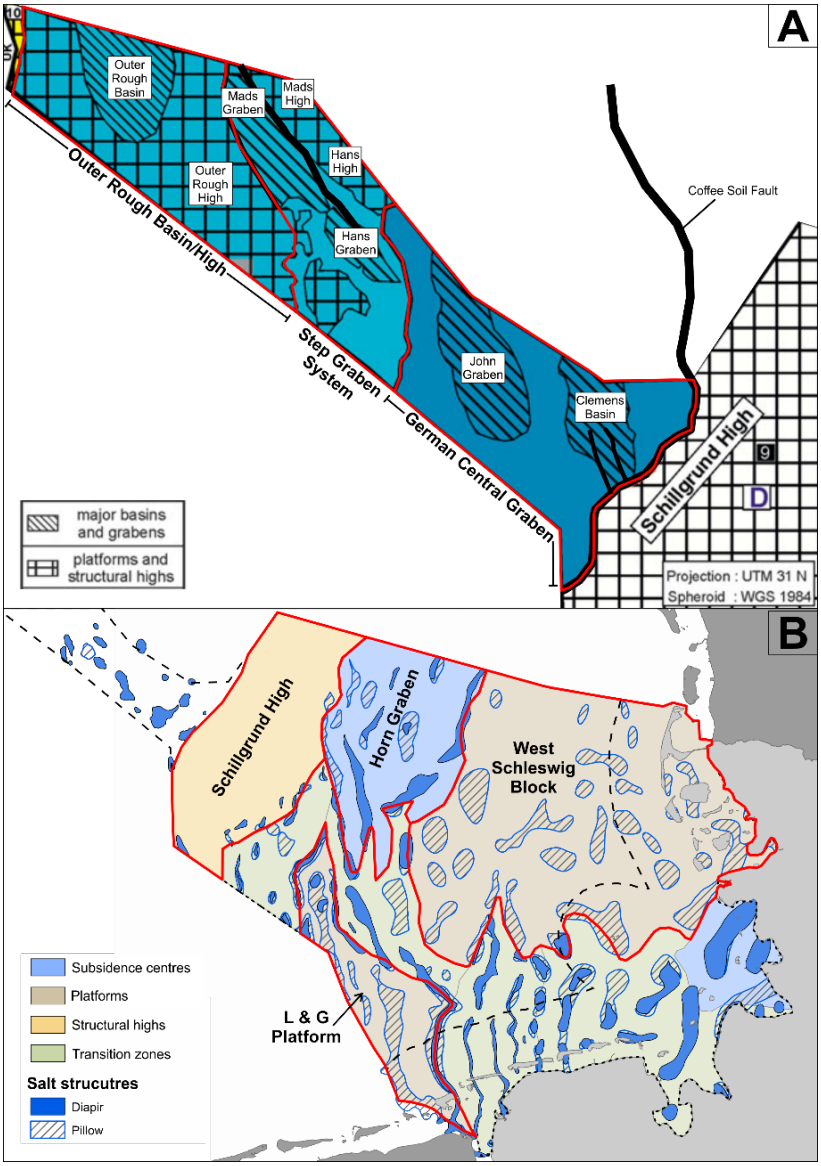


Figure 7. Structural element maps (A) for the Entenschnabel area and (B) the central German North Sea with outline of the structural elements represented in the lithostratigraphic charts. Modified maps from Arfai et al. (2014) and Bense & Jähne-Klingberg (2017).

For the Triassic succession, the lithostratigraphic charts compiled for the central German North Sea (*Figure 8*) are mainly based on recent seismic mapping activities of BGR in the framework of the TUNB project (German acronym for ”Subsurface Potentials for Storage and Economic Use in the North German Basin”). The Triassic was differentiated here for the first time on formational level (Wolf et al., in prep) generally following the subdivision of the Triassic

according to the Stratigraphic Table of Germany 2016 (Menning & Hendrich, 2016). Because reliable biostratigraphic markers are scarce in the German North Sea, the subdivision is established almost exclusively on the basis of seismic characteristics which indicate lithological changes and erosional unconformities. For the other structural elements in the Entenschnabel area, the studies of Barnasch (2009) and Arfai et al. (2014) served as a basis for the stratigraphic charts. A differentiation on formation level, similar to those established for the Triassic in the central German North Sea, is only viable for the German Central Graben. Further to the north, in the Step Graben System and Outer Rough Basin/High, the seismic character of the Triassic succession differs from those in the central German North Sea allowing no adaption of the seismo-stratigraphic concept into this area of the North Sea. As a consequence, no differentiation on formational level could be established for this area so far. The lithofacies distribution of the Triassic shown in the lithostratigraphic charts (*Figures 8 and 9*) is largely compiled from Beutler et al. (2005), Barnasch (2009) and Doornenbal & Stevenson (2010).

For the post-Triassic succession, there exists generally relatively limited lithostratigraphic subdivision, compared with adjacent areas of the North Sea Basin, and a formal classification at formation and group level has often not been established for the area of the German North Sea. Therefore, Dutch and Danish lithostratigraphy terms have been partly taken as an alternative (*Figures 8 and 9*). In the German Central Graben, the lithostratigraphic subdivision of the Jurassic follows the stratigraphic nomenclature of the Netherlands (Van Adrichem Boogaert & Kouwe 1993-1997). The Dutch terms were adopted here because their formations were recently mapped by Müller et al. (2019) into the German Central Graben. Arfai et al. (2014) shows that these formations are also traceable into the Step Graben System. Therefore, the Dutch formation names were used for this structural element as well. For the Upper Jurassic deposits mapped by Arfai et al. (2014) in the Outer Rough Basin/High and along the Mads High and John High, no formation names have been assigned because the age of these deposits cannot be accurately determined due to inconsistent stratigraphic well markers (Tithonian to Oxfordian). Furthermore, the term ”Scruff Greensand equivalent” is used for shallow marine, lowermost Cretaceous to uppermost Jurassic, sands present in the German Central Graben and the central German North Sea (*Figures 8 and 9*).

The Lower Cretaceous lithostratigraphy of the Outer Rough Basin/High and the Step Graben System relies mainly on mapped distribution of Arfai et al. (2014), and follows the lithostratigraphic subdivision presented by van Buchem et al. (2017) for the Danish Central Graben area. This subdivision is adopted because the German part of the Outer Rough Basin with its thickened Lower Cretaceous succession is comparable to the Danish Outer Rough (Figure 2). For the German Central Graben, the Lower Cretaceous lithostratigraphy is based on recent mapping activities of BGR in the framework of the TUNB project. The Vlieland Claystone Formation and the Holland Formation were mapped here into the German Central Graben (Müller et al., in prep). For the area of the central German North Sea, there exists currently no lithostratigraphic subdivision on formation or group level, and the regional age trend of the basal Lower Cretaceous unconformity has been compiled here from stratigraphic well markers.

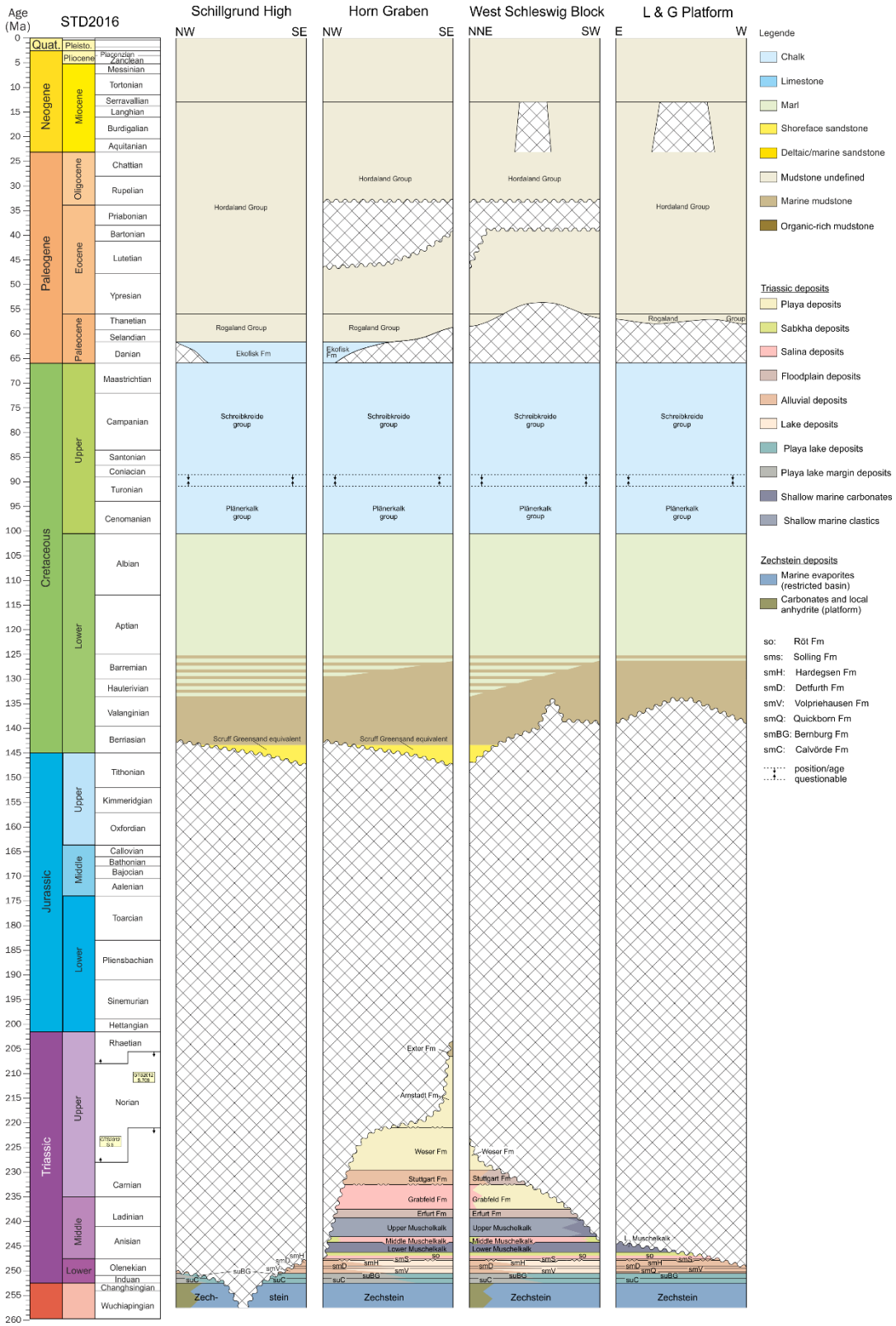


Figure 8. Generalized lithostratigraphic charts for the Schillgrund High, the Horn Graben, the West Schleswig Block, and the L- & G platform areas. Time scale and ages according to the Stratigraphic Table of Germany 2016 (Menning & Hendrich, 2016). Local changes in stratigraphy related to salt structures or faults are generally not included into the charts. Because most horizons are based on seismic stratigraphic definitions without spatial chronostratigraphic control the age assignment of erosional gaps is approximated.

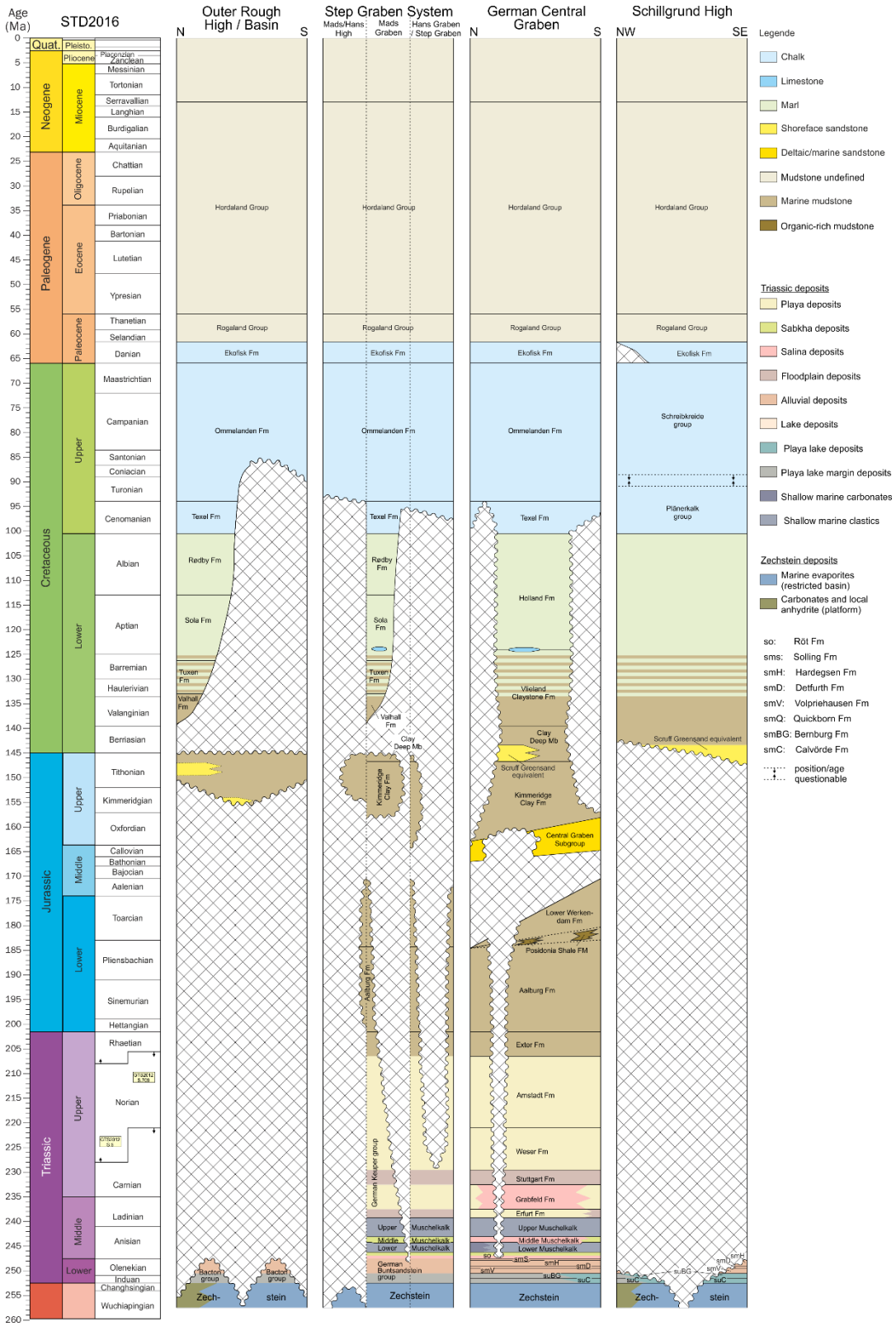


Figure 9. Generalized lithostratigraphic charts for the Outer Rough High/Basin, the Step Graben System, the German Central Graben and the Schillgrund High. Time scale and ages according to the Stratigraphic Table of Germany 2016 (Menning & Hendrich, 2016). Local changes in stratigraphy related to salt structures or faults are generally not included into the charts. Because most horizons are based on seismic stratigraphic definitions without spatial chronostratigraphic control the age assignment of erosional gaps is approximated.

For the Upper Cretaceous and Danian, the lithostratigraphic charts compiled for the Entenschnabel area are mainly based on mapped distribution from Arfai et al. (2014, 2016). Since the Chalk Group is developed here in the same lithofacies as in adjacent areas of the North Sea Basin and because the German North Sea is not fully considered in the German lithostratigraphic nomenclature of the Upper Cretaceous, the lithostratigraphic subdivision of the Netherlands (Van Adrichem Boogaert & Kouwe 1993-1997) has been adopted for this area. Towards the southeast, however, the relation between the North German Chalk Group and the Dutch and Danish equivalents is not well defined. Therefore, as a generalization, the nomenclature proposed by Menning & Hendrich (2016) for onshore Northern Germany is taken for the central parts of German North Sea. Due to differences in the structural evolution of the Entenschnabel area and the central German North Sea the transition between the different nomenclatures is set to the eastern border of the German Central Graben.

For the post-Danian succession, the lithostratigraphic charts compiled for the German North Sea mainly rely on the structural depth maps of the "Geotectonic Atlas of Northwest Germany and the German North Sea" (GTA, Baldschuhn et al., 2001) and detailed biostratigraphy analysis (Köthe, 2011). The lithostratigraphic subdivision into the Rogaland and Hordaland groups has been adopted from the Stratigraphic Table of Germany 2016 (Menning & Hendrich, 2016). For the post-Mid-Miocene strata, no formal classification at formation or group level has been yet established. However, a detail seismic stratigraphic framework was established by Thöle et al. (2014). The scattered distribution of Pliocene to Pleistocene fluviatile systems and glacial features with coarse clastic facies is not included in the lithostratigraphic charts.

Regional lithostratigraphic charts for the Carboniferous and Rotliegend within the German offshore have not been developed and not included in the charts. Subregional charts for this section are published in among others Doornenbal & Stevenson (2010).

2.3 Dutch stratigraphy

The interpreted seismic horizons, ranging from Carboniferous to Neogene in age, are the bases of lithostratigraphic units, which are defined in the Stratigraphic Nomenclature of the Netherlands.

In terms of structural elements, the Danish Central Graben is continued southwards by the Dutch Central Graben. To the west of that graben, the Step Graben and Elbow Spit High/Platform are located, connected to the Danish Outer Rough Basin and Heno Plateau to the north. To the east of the Dutch Central Graben lies the Schillgrund Platform which change in German offshore towards north to a high and even further north merge with the Danish Ringkøbing-Fyn High.

The stratigraphic charts presented here for the Dutch sector of the North Sea (*Figures 10 and 11*) are based on 'Tectono-stratigraphic charts of the Netherlands continental shelf' published online in 2011. They represent the most recent overview publication of stratigraphy for this area. Since 2011 new insights have developed. These insights—albeit minor—have been incorporated in the presented charts. With the coming new release of the Dutch lithostratigraphic website (early 2020), several names of Cenozoic lithostratigraphic units will change. The new names have also been incorporated in the presented charts.

For the purpose of this chart, the stratigraphic column of the 'Schillgrund Platform (western margin)' and 'Schillgrund Platform (central and north)' from the abovementioned publication have been merged into one column named Schillgrund Platform.

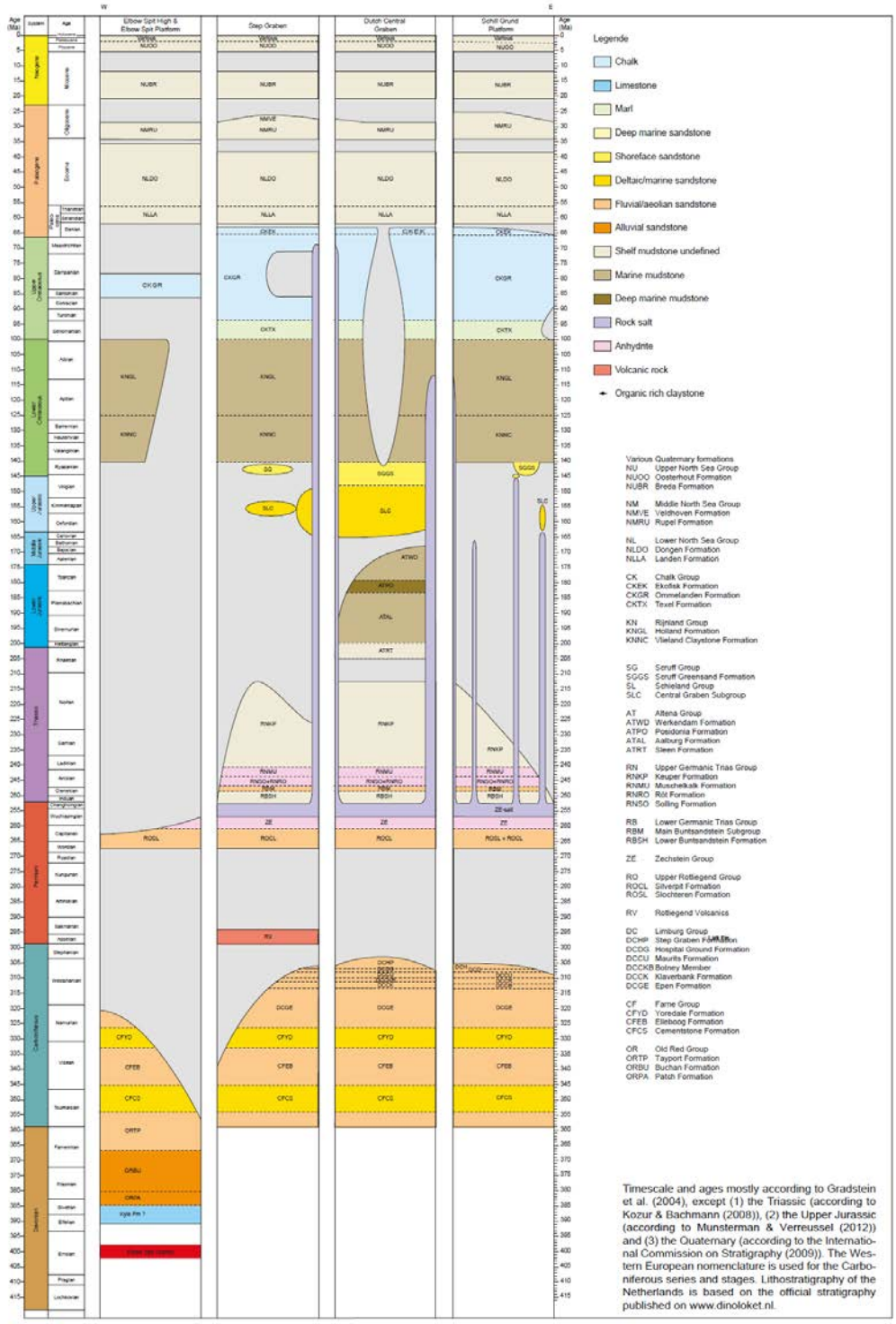
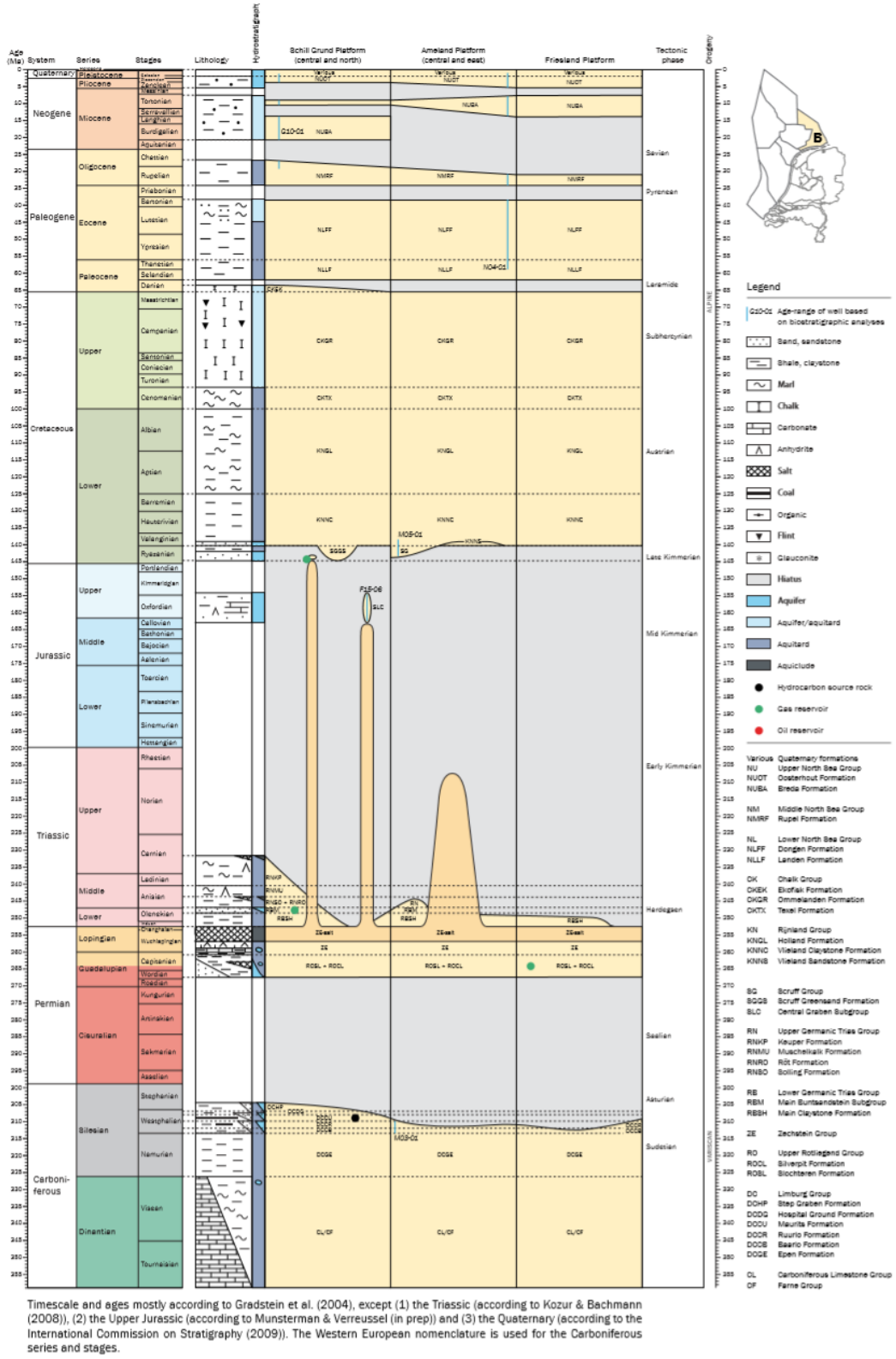


Figure 10. Tectono-stratigraphy of the northern section of the Dutch continental shelf, bordering Germany. After: Tectono-stratigraphic charts of the Netherlands continental shelf (2011).



Timescale and ages mostly according to Gradstein et al. (2004), except (1) the Triassic (according to Kozur & Bachmann (2008)), (2) the Upper Jurassic (according to Munsterman & Verreussel (in prep)) and (3) the Quaternary (according to the International Commission on Stratigraphy (2009)). The Western European nomenclature is used for the Carboniferous series and stages.

Figure 11. Tectono-stratigraphy of the southern section of the Dutch continental shelf including the Ameland and Friesland platforms. After: Tectono-stratigraphic charts of the Netherlands continental shelf (2011).

2.4 Cross-border compilation and comparison

Identifying lithostratigraphic discrepancies and their causes represents an important first step in the cross-border harmonization process. The purpose of this report is therefore to compilate and compare the Danish, German and Dutch lithostratigraphy along adjacent structural elements in order to elucidate stratigraphic similarities and discrepancies between the three countries.

The cross-country comparison of the lithostratigraphy is not always straight forward due to differences in nomenclature, differences in detailed subdivision of the stratigraphic intervals and differences in basin development. Additional complications for a comparison of the lithostratigraphic charts arose from different timescales used as well as from differing geographical orientations of the charts. For example, the lithostratigraphic chart of the Outer Rough Basin has been prepared for the Danish part in a W-E direction (*Figure 3*) whereas the German counterpart shows a N-S orientation (*Figure 9*). The lithostratigraphic charts clearly mirror further the differences in the national interest in different stratigraphic intervals. Because of the thick and predominant Triassic in the German sector, the Triassic succession is subdivided and studied in more detail in Germany. The focus in the Danish offshore lies on a detailed description from the Jurassic up to the Cenozoic. In the Netherlands offshore emphasis have been made in addition to the Jurassic on the siliciclastics of the Rotliegend play, Permian level.

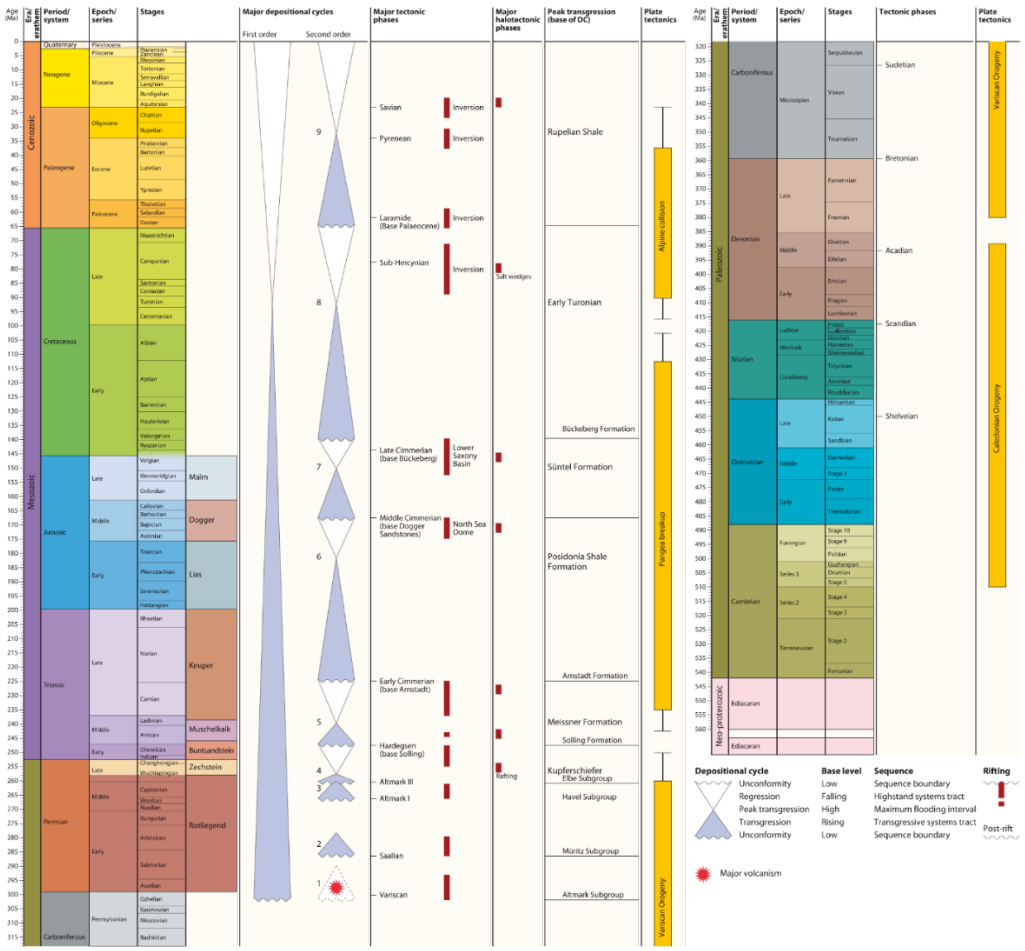


Figure 12. Paleozoic to Cenozoic timescale of the tectonic episodes, major depositional cycles (DC) 1 to 9 (2nd order), major unconformities, peak transgressions, rifting phases and halotectonic phases of the Southern Permian Basin (Pharaoh et al., 2010).

It is, however, clear that the study area is affected by the same tectonic history and the sedimentation related to analogous depositional cycles. In *Figure 12* the tectonic episodes, major depositional cycles, major unconformities, peak transgressions, rifting phases and halotectonic phases in the Southern Permian Basin are shown for the Paleozoic to Cenozoic timescale.

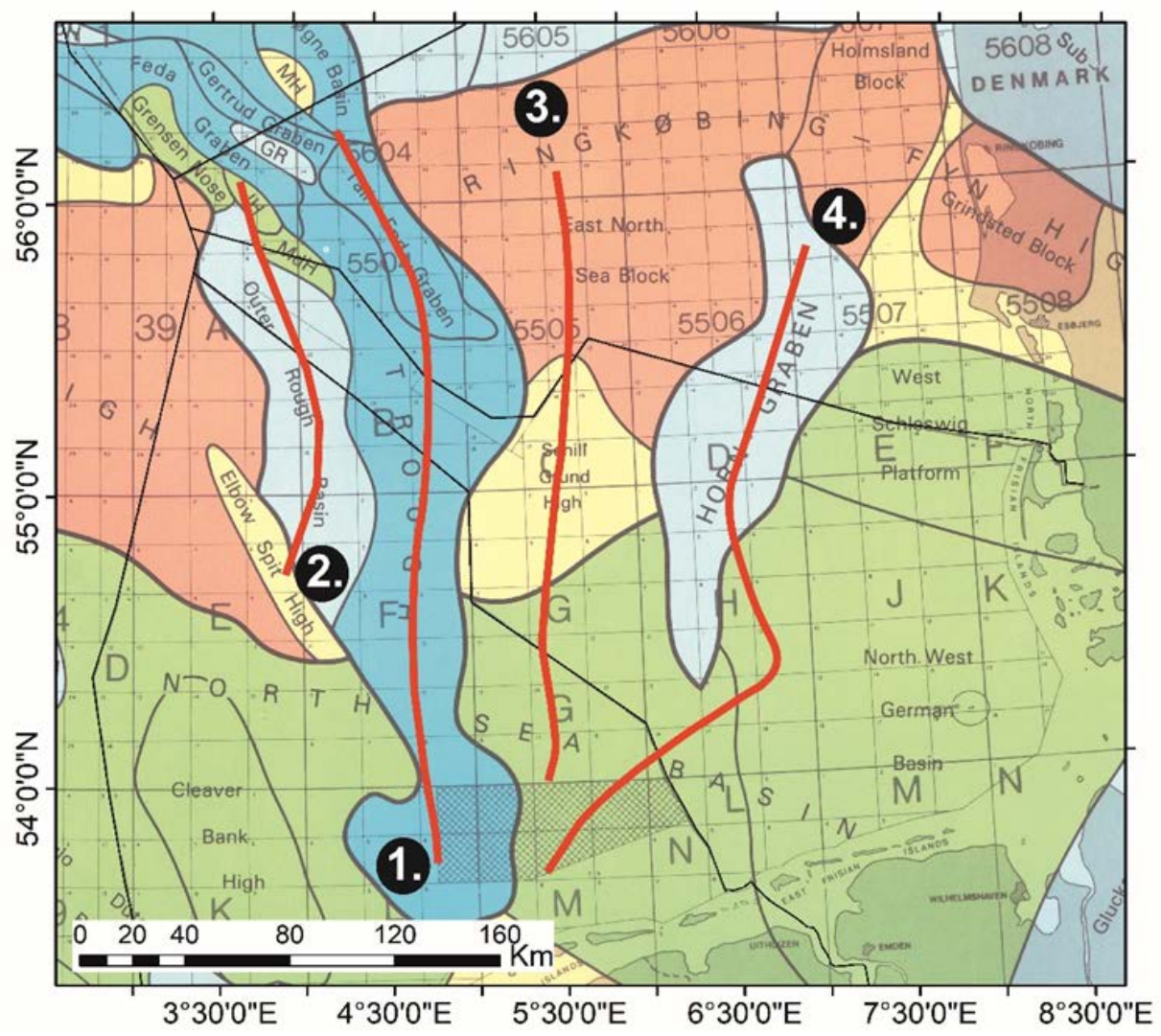


Figure 13. North-South correlation paths across the various structural elements in the study area. Base map from NOPEC (1988).

Comparison of the lithostratigraphy has been carried out on four North-South trending transects associated with the following structural elements (*Figure 13*):

1) Danish, German and Dutch Central Graben (*Figure 14*)
2) Heno Plateau, Outer Rough Basin, Step Graben and Elbow Spit High (*Figure 15*)
3) Ringkøbing-Fyn High, German and Dutch Schillgrund High / Platform (*Figure 16*)
4) Horn Graben, West Schleswig Block, L&G Platform and Ameland Platform (*Figure 17*)

(1) Danish, German and Dutch Central Graben

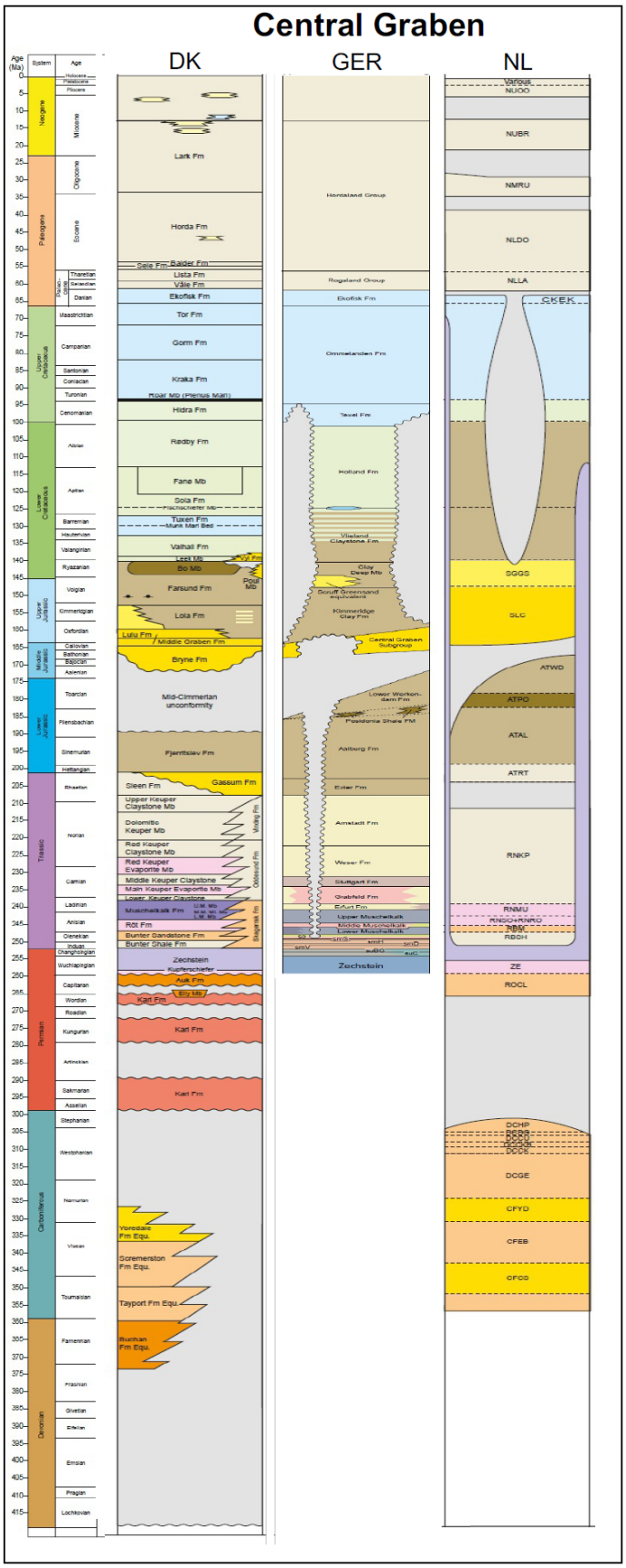


Figure 14. Regional correlation of the lithostratigraphy in the Danish, the German and the Dutch Central Graben

The comparison of the lithostratigraphic charts for the Danish, German and Dutch Central Graben (*Figure 14*) clearly shows the disparities between national nomenclatures, but also differences in basin development and depositional environment (lateral differences in the distribution of the various lithologies).

Significant discrepancies can be seen in the Triassic succession. The lithostratigraphic subdivision of the Triassic is different in all three countries and a clear correlation of the various units is hampered by the different degree in details. The Danish Triassic lithostratigraphy is closely related to previous published Triassic lithostratigraphic subdivisions (e.g. Michelsen and Clausen, 2002). In contrast, the newer seismostratigraphic mapping of the Triassic in the German sector (Wolf et al., in prep) is based on long-established lithostratigraphic (allostratigraphic) subdivisions of the Germanic Triassic (summarized e.g. in Röhling, 2013; Beutler et al., 2005; Menning & Hendrich, 2016).

The Jurassic succession shows large variation and change in lithofacies from north to the south partly with deep marine conditions in Denmark and shallow marginal condition in the Dutch sector. Furthermore, the Jurassic is dominated by several diachronous local formations related to the diachronous development of the Central Graben. A correlation and harmonization between these formations can therefore only be achieved by a detailed log-correlation applying sequence stratigraphy. A detailed log-correlation is carried out in the subproject D3.4.

The correlation of the Lower and Upper Cretaceous and the Cenozoic indicate a rather comparable lithostratigraphy indicative of an analogous basin development and depositional environment. The Danish chart reveals a more detailed subdivision of the sequence. It is uncertain if the Danish units represent local lateral restricted basins or may be found in the German and Dutch Central Graben.

(2) Outer Rough Basin, Heno Plateau, Step Graben system, Elbow Spit High

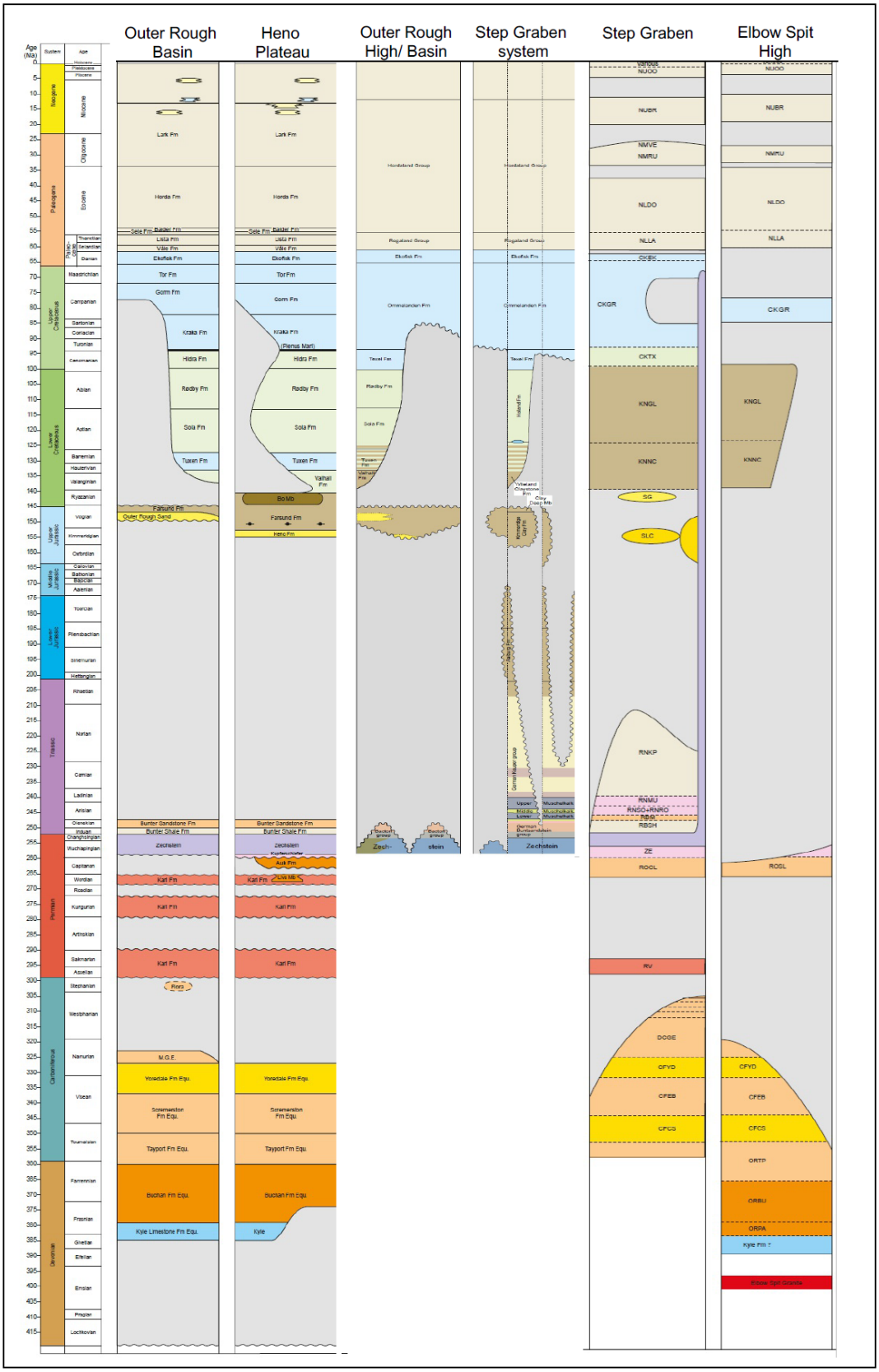


Figure 15. Regional correlation of the lithostratigraphy for the Danish, German and the Dutch structural elements: Outer Rough Basin/High, Heno Plateau, Step Graben system and Elbow Spit High.

The lithostratigraphic charts for the western part of the Entenschnabel region (*Figure 15*) demonstrate a complex tectonic history and different structural development in the area. The stratigraphy is dominated by major hiatii in the Triassic, the Jurassic and the Lower Cretaceous. Local basins comprise Triassic and occasionally Jurassic sediments.

The area act as a structural high during early and middle Jurassic. Initial flooding of the area took place during Kimmeridgian in the low laying areas. Successively more high-lying areas were transgressed giving rise to diachronous lithofacies. Therefore, the Jurassic formations defined in the Danish, German and Dutch sector are not directly comparable.

The correlation of the Cretaceous and the Cenozoic indicate a rather comparable lithostratigraphy. The lithostratigraphy is indicative of an analogous basin development and depositional environment although the lithostratigraphic charts indicate facies change towards more clay-rich deposits in the Dutch sector in Lower Cretaceous time. However, these differences in lithology could also be related to a different approach in the sedimentary description, rather than a shift in facies. Furthermore, the Danish chart reveals generally a more detailed subdivision of the Cretaceous and it is uncertain if the Danish units represent local lateral restricted basins or may be found in the German and Dutch Central Graben. Cretaceous tectonic activity gave rise to a differentiate uplift and subsequent erosion on distinct blocks which result in a complex outline of the lithostratigraphic charts.

(3) Ringkøbing-Fyn High, German Schillgrund High and Dutch Schillgrund Platform

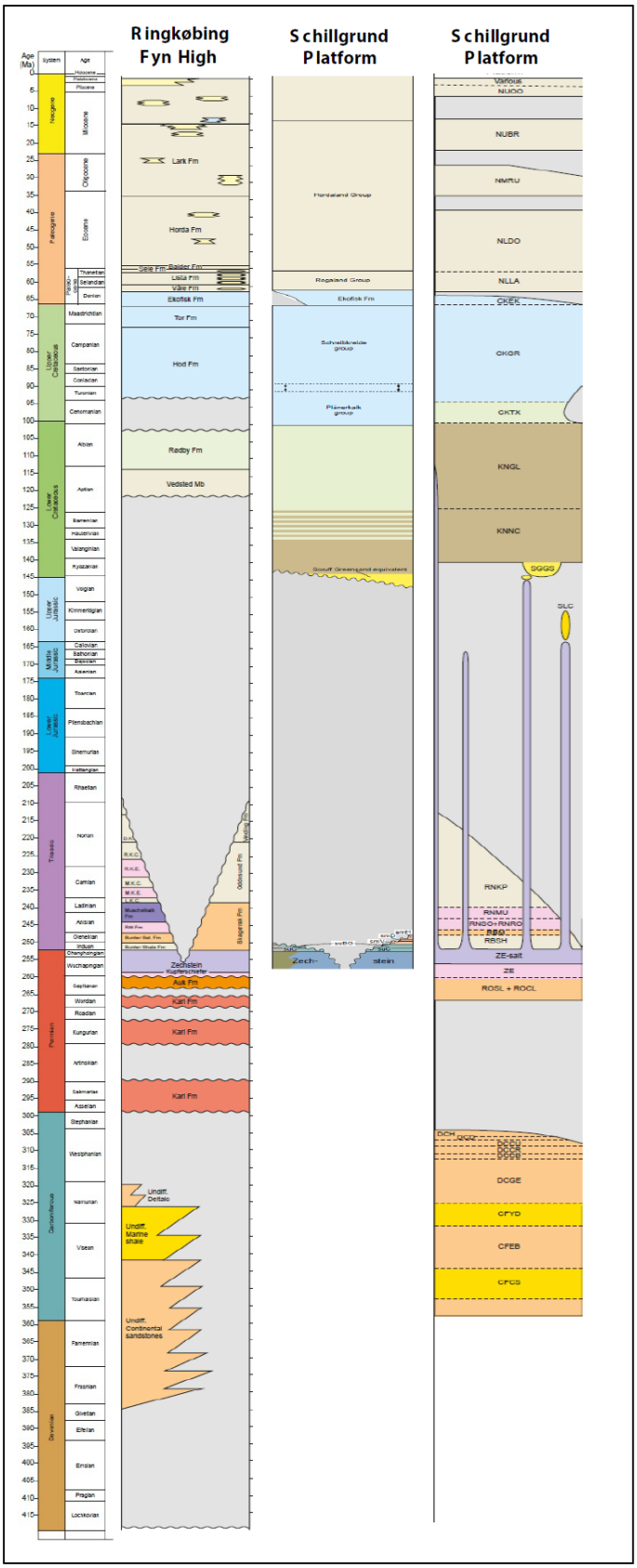


Figure 16. Regional correlation of the tectono-stratigraphy for the Danish Ringkøbing Fyn High and the German and Dutch Schillgrund platform

The structural elements bounded to the west by the Schillgrund Fault (also known as the Coffee Soil Fault in the Danish North Sea) are dominated by uplift and erosion during the Jurassic (*Figure 16*). Triassic and Early to Middle Jurassic sediments are largely missing on the German Schillgrund High. To the south the German Schillgrund High partly continues as a platform area into the Dutch sector, where Cretaceous sediments overlie Triassic and Permian rocks. After the Jurassic erosion, initial deposition occurred at the transition from Jurassic to Lower Cretaceous in the German and Dutch sectors. The Ringkøbing Fyn High submerged later during Early Cretaceous.

Different lithofacies are indicated for the Lower Cretaceous interval showing more clay-rich deposits in the Dutch North Sea sector. These differences in lithology could be related to changes in the depositional environment or different approaches in the sedimentary description. Local hiatii partly obscure the correlation in the Cretaceous and Cenozoic.

(4) Horn Graben, West Schleswig Block, L&G Platform and Ameland Platform

The lithostratigraphy of the Danish and German Horn Graben (*Figure 14*) partly differ at certain stratigraphic intervals from each other. For example, lowermost Cretaceous sediments are missing in the Danish Horn Graben, whereas in the German part no hiatus is indicated. Both the thin lower Cretaceous as well as the low density of wells in the German Horn Graben make the deciphering of areas with or without hiatii rather difficult.

The Ameland Platform in the Dutch North Sea and the L- and G-Platform areas in the German sector show a comparable lithostratigraphy, with uplift and erosion during the Jurassic. Only local hiatii in the Cenozoic obscure the correlation in this area.

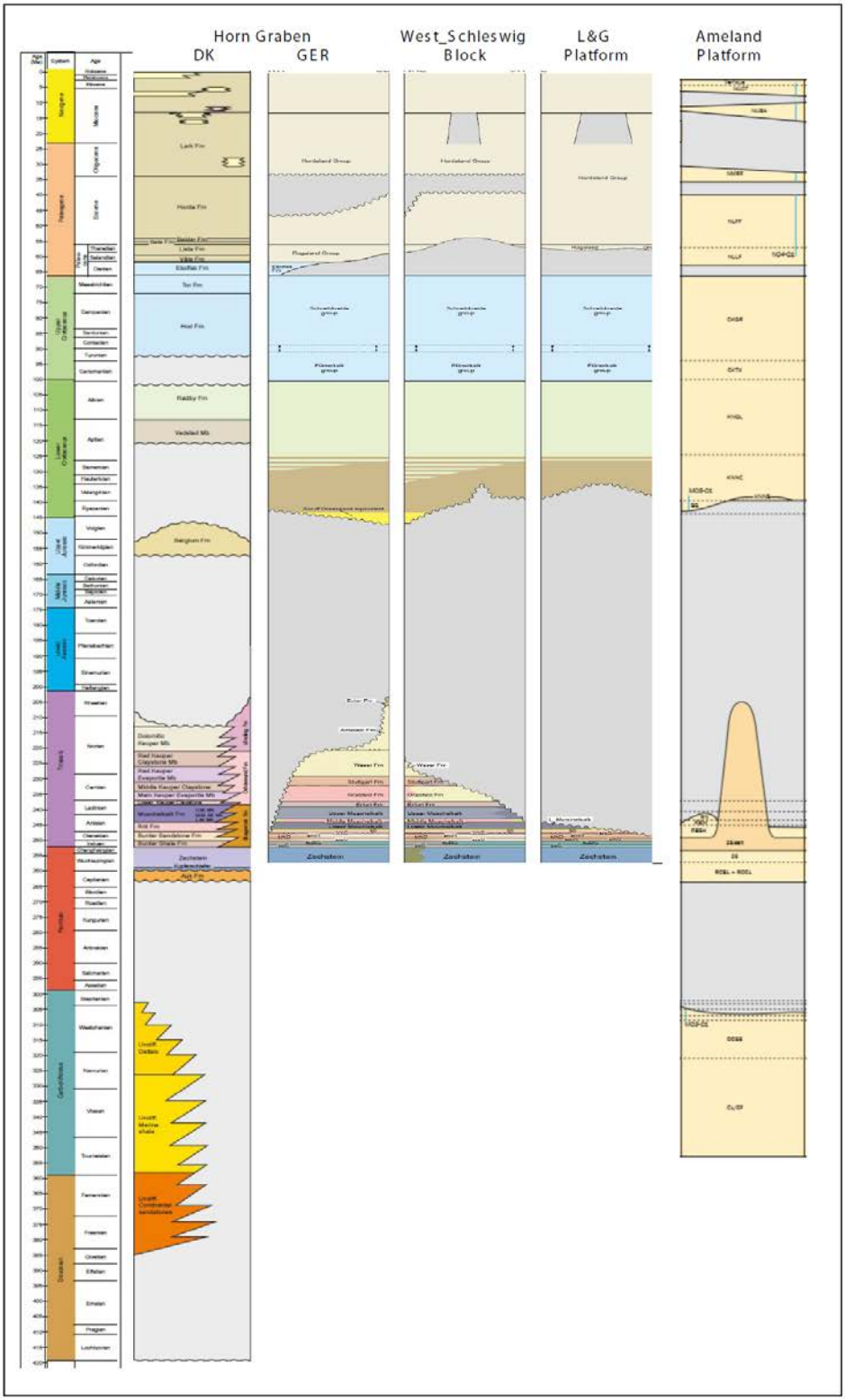


Figure 17. Regional correlation of the tectono-stratigraphy for the Horn Graben, West Schleswig Block, the L&G Platform and the Ameland Platform.

3 SUMMARY OF CROSS-COUNTRY COMPILATION

The comparison of the lithostratigraphic charts show much resemblances across the country borders but it is also evidence that there is a limitation for harmonization. Especially diachronous units are by nature difficult to correlate. The local distribution and diachronous appearance of specific lithofacies show that a detailed cross-border comparison is often only possible after time-consuming well log correlations applying sequence stratigraphy. It is not within the framework of this report to harmonize the discrepancies in the stratigraphic charts. This report merely points out the cross-border stratigraphic discontinuities and highlight future work within the field of lithostratigraphic tables.

An example of a detailed log-correlation is shown in the Report D3.4: “Lithostratigraphic/ chronostratigraphic correlation profiles through the study area” where a log correlation of the Jurassic succession in the Danish, German and Dutch Central Graben has been generated.

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