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Report file no.
14974

Priority sub-project I.5.a.
Reservoir zonation within the Valdemar and Adda fields

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Copenhagen
20-08-1998

DANMARKS OG GRØNLANDS GEOLOGISKE UNDERSØGELSE RAPPORT 1998/25

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CONFIDENTIAL
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Copy No. 6

To be released 1.4.2003

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March 1998

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1. Introduction

A subdivision of the Lower Cretaceous reservoir sequence into Aptian Shale, Aptian Limestone, Barremian Limestone 1 and Barremian Limestone 2 has been proposed and used by Mærsk Olie og Gas AS for their reservoir modelling of the Valdemar and Adda fields. The sequences as defined by Mærsk Olie og Gas AS exhibit, however, a wide range in lithologies, and even in the "pure" carbonate reservoir intervals there is a range in clay content (giving rise to different rock properties) which justify a more detailed subdivision of the Lower Cretaceous reservoir sequence into descriptive units of common characters.

In this report a new zonation has been proposed. The overall division of the reservoir sequence is adjusted to the sequence stratigraphy defined in Ineson (1994), Ineson et al. (1997) and Ineson (in prep. (sub-project I.3.a)). The detailed zonation describes the variation in lithology and is primarily based on log motifs (gamma ray and neutron/density) and corresponding high resolution biostratigraphy, from Simon Petroleum Technology (1994a and 1994b), Robertson Group (1992), Mærsk Olie og Gas AS (1990a, 1990b, 1991, 1992, 1994b and 1997) and Jutson, (1997).

The subdivision into zones corresponds in some detail to the systems tracts as defined by Ineson et al. (1997), and may be expanded regionally into other parts of the Danish Central Graben area. However, lateral facies variation on regional and semi-regional scale is seen and the reservoir properties related to the proposed zones presented in this report are therefore valid for the Valdemar field only. The zonation may be extended to the Adda field (and the Tyra field area) with some modifications related to reservoir properties, primarily caused by facies changes and local inversion tectonics resulting in the development of hiatii and condensed units. Due to the discrepancies in the zonation within the two fields, the Valdemar field and the Adda field are described separately.

This report summarises the work carried out during phase 1 (reservoir zonation) of the subproject I.5.a. The work initiated under phase 2 (reservoir characterisation) and phase 3 (diagenesis) will be reported separately but refers to this subdivision.

1.1 Reference wells

In establishing a detailed zonation of the Lower Cretaceous reservoir sequence, wells from the most intensively drilled Lower Cretaceous structures (the Valdemar and Adda fields, fig. 1) have been examined. Wells from both fields are included in order to examine the facies variation related to paleogeography and structural development.

The North Jens-1 well (representing the Valdemar field) and Adda-3 well (representative of the Adda field) were selected as reference wells. Both wells are intensively cored and the penetrated sections represent the most complete Lower Cretaceous sequence within the respective areas.

2. Subdivision

According to Ineson (1994) the Cromer Knoll Group of the Danish Central Trough can be divided into seven sequences (A-G in figure 2). Five of these sequences are further subdivided into systems tracts reflecting various stages of relative sea-level changes. The reservoirs chalks of Late Hauterivian - Barremian and Aptian ages are confined to the highstand systems tracts (HST) of sequence C, D and E (fig. 3). The regional development of these reservoir chalks is explained by the interplay between differential subsidence and truncation at sequence boundaries.

From recent work carried out at GEUS (Ineson et al., 1997) in which palynological and nannofossil data have been integrated with log data, the position of the major sequence boundaries within the Late Hauterivian - Late Aptian section as defined in 1994 has largely been confirmed. In addition this work has also identified a new sequence boundary, between the CK4 and CK5 sequences in figure 4, within the upper Tuxen Formation. This boundary defines the base of one of the best reservoir chalk intervals in the succession and as such it is an important stratigraphic surface for regional and intra-field correlation. The new data have also resulted in significant modification of the sequence subdivision into systems tracts and in a better understanding of basin evolution in the Early Cretaceous.

The sequence stratigraphic breakdown of the Tuxen and Sola Formations, based on an integrated study of the cored section of the North Jens-1 well, is shown in figure 4. This section is subdivided into four sequences CK3, CK4, CK5 and CK6. The succeeding Albian section is tentatively subdivided into two sequences (CK7 and CK8).

The new sequence stratigraphy established for the Lower Cretaceous reservoir interval in North Jens-1 well is illustrated in figure 5. The sequence boundaries (SB) are associated with distinct log responses. It is, however, also clear that a further differentiation in lithologies and reservoir properties within the various sequences can be made. To improve the reservoir characterisation, the Lower Cretaceous has thus been subdivided into reservoir zones which still are laterally correlatable.

2.1 Reservoir zonation

A subdivision of the Lower Cretaceous reservoir interval into 16 zones in the North Jens-1 well is shown in figure 5. A proposed nomenclature for the zones and the correlation to previous subdivisions is shown in figure 6.

In our proposal for the reservoir zonation, the Tuxen Formation is subdivided into three major reservoir units named Lower, Middle and Upper Tuxen. These units have been further subdivided as also shown in figure 6. The Munk Marl Bed separates the Lower Tuxen from the Middle and Upper Tuxen units. Within the Upper Tuxen unit a lithostratigraphic boundary can be placed at the base of the Upper Tuxen-2 zone (the boundary is defined by a gamma log break and is expressed by low gamma reading) and the Upper Tuxen-2 zone has been included in the Sola Formation. However, the Upper Tuxen-2 zone is of Barremian age and topped by a distinct sequence boundary. Therefore the former S1 unit is now included in the Upper Tuxen unit.

The Sola Formation is subdivided in a similar way as the Tuxen Formation and two major reservoir units, Lower and Upper Sola, have been established and further subdivided as shown in figure 6. The Lower and Upper Sola units are separated by the clay-rich Fischschiefer Member and the Albian Shale forms the uppermost part of the Sola Formation.

The reservoir zonation is based on the character of both the gamma ray and the neutron/density logs, and the boundaries are placed at the transition between distinct changes. As a consequence of the heterogeneity within the zones (i.e. caused by the presence of thin claystone stringers/laminae below log resolution) the zones have been characterised by overall uniformity in log motifs and their average values with respect to gamma ray readings, porosity, bulk density, shale volume and saturation.

The most distinct zones are the Munk Marl, Lower Sola-1, the Fischschiefer Member and Upper Sola-2 representing intervals with high clay content and low porosity. The zones between these clay rich intervals appear less distinct, but a new zone is introduced when the change in clay content (on average) is more than 5-10% (log shale volume) and/or at porosity changes in the order of 5 porosity units (p.u.).

The best reservoir intervals characterised by high porosity and low clay content, are the Upper Sola-1, Upper Tuxen-1, Middle Tuxen-1 and Lower Tuxen-3 zones. Among these intervals, the Upper Tuxen-1 unit constitutes the cleanest reservoir unit and has the best overall reservoir properties.

The reservoir subdivision proposed herein corresponds in outline to the subdivision into sequences as described by Ineson et al. (1997). However, because the new reservoir zonation primarily focuses on lithological variations within sequences, the individual reservoir zones only to some extent correspond to the systems tracts defined from the sequence stratigraphy (fig. 7). In some cases the reservoir zonation is more detailed than the subdivision into systems tracts (e.g. the Lower Tuxen zones).

2.2 Reservoir zonation and biostratigraphy

The zonation in vertical and slightly deviated wells is primarily based on differences in wireline log patterns. There is, however, a direct correlation between zonation and geological age. A high resolution biostratigraphic breakdown of the North Jens-1 well (and the Valdemar-2P well) has been carried out (Jutson, in prep., sub-project I.3.a) and from this work it is possible to determine the approximate age of the individual reservoir zones (fig. 8). For comparison, figure 8 also includes the high resolution biostratigraphical zonation used by Simon Petroleum Technology (used as reference in the Final Well Reports from Mærsk Drilling).

2.3 Zonation in horizontal wells

In horizontal wells the log motif appears less distinct and is generally not directly comparable with log motifs from vertical wells. Therefore the subdivision of the horizontal wells is made primarily on the basis of biostratigraphic information and only secondarily related to variations in the log signature.

2.4 Lateral variation

In the Adda field the recognition of the zones is hampered by the presence of hiatii. Also facies changes towards more proximal conditions complicate reservoir subdivision. The subdivision of the Adda-3 well (fig. 9) can be correlated to the zonation of the North Jens-1 well using the gamma ray log. However, the density and porosity log responses do not correspond fully with the log motifs of North Jens-1.

The Lower Cretaceous sequences comprises a mixed pelagic carbonate-siliciclastic system and the recognition of depositional sequences at a specific basin location requires consideration of factors such as submarine erosion processes and controls on pelagic carbonate production. The Adda field is considered to be situated more proximal compared to the Valdemar field, and identification of systems tracts on the basis of petrophysical logs in the Adda field therefore necessitates modification because the increased volume of siliciclastic material affects the gamma ray log response as indicated in figure 10.

In addition to the variation in log response, also the information available from core data indicates that the lithology and reservoir properties of the various zones in the Adda field differ from the corresponding zones in the Valdemar field. Therefore the reservoir characterisation will be carried out separately for the individual fields.

2.5 Justification of zonation

For testing of the validity of the detailed zonation a plot of average porosities, permeabilities and water saturation based on log data from the North Jens-1 well has been made (fig. 11a). In general, no abrupt variation in average porosity for the various zones is recognised. Differences in average figures for the various zones are in the order of 5 p.u. According to the direct relationship between core porosity and permeability (fig. 12) this will give rise to variations in permeabilities in the order of 0.1-0.5 mD. However, looking at the average figures for permeability (fig. 11a) there seems to be more variation in the reservoir quality than indicated by porosity alone. The same indication can be read from the saturation values.

The variation in permeability and saturation may be due to the variation in clay content as defined by the gamma ray log and the core description. The core description indicates that intervals high in gamma ray log response consist of alternating carbonate-rich and clay-rich laminae. However, at present there are not sufficient data on insoluble residue, clay mineralogy etc. to quantify this variation within the zones. A plot of the scarce information on insoluble residue, clay minerals and bulk densities are inserted as figure 11b. It can be seen that there is a large variation in content and amount of clay minerals within the various zones but no direct correlation to the permeability and saturation data can be seen. This indicates that despite minor variations in the porosities, there might be a major variation in reservoir properties due to variation in clay mineralogy and amount of insoluble residue. Some similarities for various zones, however, cannot be ruled out.

With reference to the proposed reservoir zonation a more detailed characterisation of the individual zones will be carried out. The basis for this study will be the data base set up for the Priority Project. Evaluation of data, including coverage and representativity, will be carried out as a part of this sub-project.

3. VALDEMAR FIELD

3.1 Zonation within the Valdemar field

The subdivision of the Lower Cretaceous reservoir interval into 16 zones as introduced for the North Jens-1 well (fig. 5) has been extended to all wells drilled in the Valdemar field. In the vertical to sub-vertical exploration and pilot holes the zonation has primarily been based on correlation of log motifs. All Valdemar production wells are drilled from the same platform and located within a limited distance from North Jens-1 well, but some discrepancies in log characters and thicknesses are observed.

In the horizontal wells the zonation was made primarily on the basis of the detailed biostratigraphy carried out by Simon Petroleum Technology (in the Final Well Reports from Mærsk Drilling). The general log responses, interpreted porosities and oil saturation have been used as supplementary information in establishing the zonation. A number of obstructions using the log motif were recognised during this work: First of all, the high number of faults/fractures blurs the log motif. Secondly, the zones are often only partly penetrated with respect to vertical extension and therefore a typical log motif representing a complete unit is frequently not present.

The subdivision of the Lower Cretaceous section in the wells North Jens-1, Valdemar-1P, Valdemar-1H, Valdemar-2P, Valdemar-2H, Valdemar-3P, Valdemar-3H and Valdemar-4H, all drilled in the Valdemar field, are shown on plots enclosed in Appendix 1. Also plots of the wells Bo-1 and Boje-1 are enclosed in Appendix 1.

The tops and zonal thicknesses of the Valdemar wells are listed in table 1. In the horizontal wells a large number of re-entries are seen, implying that the entire zone is not necessarily penetrated. Indications of thicknesses from horizontal wells are therefore most likely erroneous. Also thicknesses calculated in deviated wells are associated with uncertainties, especially if the wells penetrate dipping layers.

3.2 Thickness distribution

Most of the wells related to the Valdemar field are drilled from the same platform located on the crest of the structure. Therefore the overall thickness pattern recorded from the various wells, especially the vertical to sub-vertical exploration and pilot wells, is expected to exhibit a rather uniform thickness distribution. However, going into more detail some thickness variation can be observed which could be interpreted as either local variations in subsidence or related to fault cut-out/repetition.

The thickness variation for the various zones is shown in figure 13. The plot does not point to neither a constant zonal thickness or a clear relationship between thickness and well location. In figure 13 the wells are organised according to there structural position and listed anti-clock wise starting with the wells drilled towards the north (Valdemar-1P and -1H) going westward (Valdemar-4H, North Jens-1, Valdemar-2P and -2H) to the south (Valdemar-3P and -3H and Bo-1) ending to the east (Boje-1). Because the wells are drilled in different directions, the observed thickness variation presumably indicates local variations in the structuring of the Valdemar field. In table 2 the thickness of the various zones in the wells are listed. If a thickness value significantly deviates from that of the reference well, a possible mechanism causing the variation in thickness is proposed.

Based on the available well data the average thicknesses for the various zones are estimated. However, to produce a more realistic figure for the entire field, the structural deformation has to be taken into consideration.

3.3 Structural history

In the Valdemar area compression and inversion structuring have taken place at all levels from Base Cretaceous to Mid Miocene. From the seismic interpretation (Mærsk, 1994a) it is evident that an uplift of the Valdemar field was initiated during late Early Cretaceous (contemporaneously with the deposition of the Albian Shale and the Rødby Formation). A distinct uplift took place during Late Cretaceous, but the main inversion took place in Paleocene. The uplift diminished during Early Tertiary, and terminated prior to Mid Miocene (Fig. 14).

At Barremian level the present structure forms a large elongated N-S trending antiform feature 3.5 km long and 2 km wide. At Top Barremian level the crest of the structure is 7250 ft SS with a vertical closure 250 ft deeper at the saddle point between the Valdemar structure and the Bo structure (fig. 15). A higher relief is recognised in the E-W direction.

The thickness distribution due to structuring is obvious when looking at a correlation profile encompassing North Jens-1, Bo-1 and Boje-1, where a downflank increase in thickness can be seen. This lateral trend have been taken into account when estimating thicknesses along the horizontal well traces.

In addition, the regional tectonic framework have been taken into consideration when estimating the thickness variation. Figures 16 to 18 illustrate how the pre-Cretaceous WNW-ESE trending fault systems still have some impact on unit thicknesses in the Lower Cretaceous.

The most distinct thickness variation is seen in the Albian Shale and Rødby Formation where intrabasinal inversion were followed by regional tectonic events and eustatic sea level changes. In general thin condensed Rødby and Albian Shale sequences are found on top of the structures, whereas thick complete sequences are found off-structure.

Based on the structural history of the Valdemar field the variation in thickness over the field for the various zones is estimated (table 3).

3.4 Lateral facies variation

In addition to the thickness variation the structuring of the Valdemar field give rise to minor lateral facies variation. In structurally high areas, condensed and relatively pure carbonates are deposited whereas thick clay-rich deposits are found in the relatively deeper off-structure subbasins. A gradual change downflank into higher clay content is observed within the Sola Formation in the direction from the North Jens-1 well to the Boje-1 area and from North Jens-1 to Bo-1.

Lateral thickness variation is seen in the Munk Marl and the Fischschiefer. In both zones the thickness decreases away from the top of the structure. The Munk Marl and the Fischschiefer are characterised by a high organic content. The organic content, however, varies according to the different influx of clay into the sub-basins.

The overall lateral variation in clay content is indicated in figure 19. The reference facies is related to the situation in the crestal area and the figure shows the variation in clay content away from the crest.

3.5 Cross-sections

Based on facies variation and well data, including information on thickness and biostratigraphy, three stratigraphical cross-sections along the well traces of the horizontal wells have been made (App. 2), and the proposed new zonation of the Tuxen, Sola and Rødby Formation is presented in the cross-sections. The zonation of the horizontal wells is made primarily on the basis of the high resolution biostratigraphy available from Valdemar-1H, -2H, -3H and -4 and is only secondarily related to differences in log signature, porosities or saturation. If the thickness variation within a particular unit cannot be inferred from the well data, a constant layer thickness has been assumed but with due respect to the structural variation (table 3). Cross-section no. 1 (App. 2.1) is a WSW-ESE profile following the well trace of Valdemar-4; Cross-section no. 2 (App. 2.2) is also a WSW-ENE profile following the well trace of Valdemar-2H, whereas Cross-section no. 3 (App. 2.3) is a N-S trending profile following the well trace of Valdemar-1H and Valdemar-3H. A high number of faults can be identified from the biostratigraphy, but for clarity only faults with major offsets are included in the cross-sections.

The cross-sections have been prepared in order to illustrate the geological model and for visualising the position of the horizontal well traces within the framework of geological layering. The geological model defined by the cross-sections will serve as input to the planned reservoir modelling of the Valdemar field. The thickness of the various zones is plotted in accordance with the thickness variations listed in table 3. However, minor adjustments of thicknesses and tops, primarily related to seismic interpretation, are envisaged and will be carried out concurrently with the progress of the Priority Project. Also adjustments related to fracture orientation and dip as defined from fracture log interpretation will be carried out.

In the cross-sections the reservoir units are displayed in light colours whereas units with a high clay content and low porosity are displayed in darker colours. The chronostratigraphic boundary Top Barremian is illustrated by a change in colouring from dark green to red; the lithostratigraphic boundary between the Sola and the Tuxen Formations corresponds to top Upper Tuxen-1 (light pink). The three Lower Tuxen units are illustrated by blue colours whereas the Middle and Upper Tuxen reservoir units are displayed in pink colours. The best reservoir units in the Sola Formation (Lower Sola-3, Upper Sola-1 and -2) are illustrated by light red colours. For further information on colouring reference is made to the cross-sections enclosed (App. 2).

4. ADDA FIELD.

4.1 Zonation within the Adda field

The subdivision of the Lower Cretaceous reservoir interval into 16 zones, as introduced in the North Jens 1 well, has been extended to the Adda field. However, the characteristic log motif for the zones are to some degree different from the Valdemar field due to a more proximal position of the Adda field. The Lower Cretaceous sequence in the Adda field is characterised by a higher content of siliciclastic deposits, especially in the Sola Formation and both the gamma ray and neutron density log readings differ from distinctive log motif characteristic of the Valdemar field. Also the number of hiatii and local formation of hard-grounds give rise to non-correlatable surfaces. In addition, the biostratigraphic analysis available from the Adda wells is based on conventional stratigraphy which, in addition to the differences in log motif, hampers a reliable correlation between the Valdemar field and the Adda field.

A proposed zonation for the Adda field is shown in figure 9, represented by the Adda-3 well. In general the lower part of the sequence appears with the same log motif as in the wells from the Valdemar field. A hiatus corresponding to the M. Tuxen units are seen in the central part of the field. Also a hiatus in the Lower Sola units are observed locally in Adda-3. Above the hiatus no corresponding log motif between the Valdemar field and the Adda field can be seen. The gamma ray log readings are generally higher with reverse trends compared with log data from the Valdemar field. Also the increased content in clastic material give rise to subtle changes in the neutron/density readings.

The subdivision of the Lower Cretaceous section in the wells Adda-1, Adda-2, Adda-3, Deep Adda-1, S.E.Adda-1 and N.W.Adda-1 drilled in the Adda field area, the E-1 and E-3 wells drilled in the Tyra field and the Roar-2 well is present in Appendix 3.

The tops and thicknesses of the zones are listed in table 4.

4.2 Thickness distribution

The thickness variation for the various zones is illustrated in figure 20. Most of the wells related to the Adda field are drilled scattered on the structure, delineating a large variation in thickness due to the structural development. Based on the available well data the average thicknesses of the various zones are estimated. However, to produce realistic figures that are representative of the entire field the structural deformation has to be taken into consideration as well.

4.3 Structural history

The Lower Cretaceous of the Danish Central Trough records the transition from active extensional rifting during the Jurassic with significant subsidence and deposition of Upper Jurassic clastic material, to a phase of more moderate and regional subsidence during the Cretaceous and Tertiary periods.

The Adda structure is expressed with a 700 ft relief at Base Chalk Group level, but with only limited structural closure at Top Chalk Group. Structural relief was generated by inversion of the Cretaceous and Upper Jurassic section. The basin transpression generated reverse movement on the Ringkøbing Fyn fault (Coffee Soil Fault), creating a series of relatively small closures along the length of the fault (fig. 21).

At Barremian level the present structure form a large circular closure 10 km in diameter. The crest of the structure is 7500 ft SS with a structural closure 700 ft deeper (fig. 22).

The thickness distribution due to structuring is obvious when looking at a correlation profile encompassing Deep Adda-1, S.E.Adda-1, Adda-3 and Adda-2 (App. 3.1) and Adda-1, Adda-2, E-1, E-3 and Roar-2 (App. 3.2). Condensation, erosion and downflank increase in thickness associated with the presence of complete sequences can be seen. This is also indicated in figure 23. The structuring of the Adda field give rise to lateral facies variation which is discussed below.

4.4 Lateral facies variation

The base of the Lower Cretaceous reservoir sequence is characterised by an unconformity. This unconformity is recognised as a distinct log break in the Adda wells. The bio-stratigraphic analysis suggests that the truncation in the Adda wells mainly has affected the Tuxen Formation. In the Tyra wells the transition from Top Tuxen into the deeper units appears more gradual and it is suggested that a more continuous section is present in these wells.

The Tuxen Formation has an upward increasing carbonate content resulting in a distinctive upward decrease in gamma ray readings. This characteristic log motif allows the correlation of the individual units and subunits between the Adda wells and the regional wells. The Tuxen Formation can be divided into the same zones as defined in the Valdemar field but comprises in general debris flow deposits.

The shaly Lower Tuxen 1 can be correlated in most wells but it is condensed in the Deep Adda-1 and Adda-1 wells.

The Lower Tuxen 2 and 3 can also be correlated in a large number of wells. These zones are relatively clean and have the best reservoir properties. Truncation of the Lower Tuxen 3 zone is observed in the Adda-1, Adda-2 and Adda-3 wells. In the Deep Adda-1 well a hardground at the top of the Lower Tuxen 3 has developed, giving rise to an atypical log motif.

The hiatus recognised at the top of the Lower Tuxen 3 also locally comprises the Munk Marl and the Middle Tuxen 1-2. The well correlation suggests that the Munk Marl and Middle Tuxen units are absent in the Adda-1, Adda-2 and Adda-3 wells. Most likely the Munk Marl is missing over the crestal part of the structure, and only appears downflank as it is clearly present in the S.E. Adda-1 well and in the Tyra wells.

The Upper Tuxen 1 constitutes the cleanest reservoir unit and has the best overall reservoir properties. Its characteristic blocky gamma ray log motif can be recognised in most wells in the Adda area. The Upper Tuxen 1 is locally truncated and only in some wells overlain by the Upper Tuxen 2. In the Deep Adda-1 well the top of the Upper Tuxen 1 constitutes a hardground overlain by the Sola Formation. The hardground represents a period of non-deposition and suggests the presence of an unconformity at the top of the Upper Tuxen-1. The truncation of the Upper Tuxen is related to the well defined Aptian/Barremian boundary.

The Sola Formation comprises interbedded shales, marlstones and locally in deeper basinal settings relatively clean chalk with reasonably good reservoir potential. A correlation of reservoir units within the Sola Formation proved to be difficult due to the presence of local hiatii within the sequence and a different lithology compared to the Valdemar field. The zonation of the Sola Formation may therefore not be directly comparable with the zonation of the Valdemar field.

The top of the Sola Formation is defined by a decrease in the gamma ray into the overlying Rødby Formation. The Rødby Formation subcrops the Chalk Group and it consists of shale and marls of Albian to Aptian age. The transition to the Chalk Group is usually sharp and can be easily defined from the gamma ray log. However, where the formation is marly, as is the case in Adda-2 wells, the transition is more gradual.

5. Further work

The zonation of the Lower Cretaceous reservoir interval is part of the work carried out in the sub-project I.5: Reservoir Rock Properties. The zonation is considered as a reference tool for further characterisation of the variation in lithology and petrophysical properties carried out in sub-project I.5.a: Compositional and diagenetic variation of the reservoir sequence.

A final reservoir zonation with indication of geological parameters characterising the variation within the individual units is expected to form the basis for the reservoir simulation on the Valdemar field carried out by the Department of Chemical Engineering, DTU.

The cross-sections along the horizontal well traces are indicative for the structural situation and may be adopted as illustration for well stability problems and definition of compartmentalisation of the Valdemar field. Further work related to fracturing is however needed.

The zonation is primarily based on variations in clay content and porosity and the reservoir rock properties are therefore related to these parameters. The variation in average porosity in the individual zones is relatively low and in some units major differences in the behaviour of the reservoir properties is not to be expected. A more pronounced variation is seen in the clay content as recorded by the gamma ray log. The variation is related to the degree of clay lamination which is much more distinct in the Lower Cretaceous compared to the Upper Cretaceous sequence. It is, however, assumed that the variation in reservoir properties seen in the Lower Cretaceous sequence related to clay content and clay mineralogy can be extended to the Upper Cretaceous chalk sequence.

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TABLES

STRATIGRAPHICAL UNITS AND THICKNESSES

Revised 17.12.97

		Biozone	Formation	North Jens 1			Valdemar	1P		Valdemar	1H		Valdemar	2P		Valdemar	2H	
				MD	TVD	Thickness	MD	TVD	Thickness	MD	TVD	Thickness	MD	TVD	Thickness	MD	TVD	Thickness
Rødby	Rødby	NLK 1-3	Rødby	7309	7154	17	7370	7150	20	7436	7150	20	7409	7164	6	7502	7149	8
S5	Albian Marl	NLK 4		7326	7171	15	7392	7170	51	7469	7170	61	7417	7170	26	7516	7157	30
S4B	Upper Sola 2	VN 1		7341	7186	15	7449	7221	20	7578	7231	21	7444	7196	22	7570	7187	17
S4A	Upper Sola 1	VN 2		7356	7201	26	7470	7241	25	7622	7253	15	7468	7218	18	7601	7204	14
S3	Fischschiefer	VN 3		7382	7227	8	7499	7266	8	7652	7268	9	7488	7236	8	7630	7218	2
S2C	Lower Sola 3	VN 4	Sola	7390	7235	13	7507	7273	11	7670	7276	10	7496	7244	10	7635	7220	9
S2B	Lower Sola 2	VN 4-5		7403	7248	12	7518	7284	14	7694	7287	12	7508	7254	15	7651	7229	9
S2A	Lower Sola 1	VN 5		7415	7260	21	7533	7297	25	7724	7299	26	7524	7269	19	7670	7238	10
S1	Upper Tuxen 2	VN 6-10		7436	7281	31	7561	7322	20	7786	7325	20	7544	7288	29	7694	7248	29
T3C	Upper Tuxen 1	VN 11-14		7467	7312	25	7583	7342	26	7841	7345	31	7575	7317	33	7755	7277	27
T3B	Middle Tuxen 2	VN 15-18		7492	7337	25	7613	7368	40	7936	7376		7611	7350	24	7814	7304	27
T3A	Middle Tuxen 1	VN 19-23a	Tuxen	7517	7362	37	7657	7408	59				7638	7374	29	7876	7331	34
Munk Marl	Munk Marl	VN 23b		7554	7399	10	7722	7467	3				7669	7403	7	7967	7365	5
T1C	Lower Tuxen 3	VN 24-25		7564	7409	27	7725	7470	25				7676	7410	29	7982	7370	
T1B	Lower Tuxen 2	VN 26-30		7591	7436	30	7754	7495	50				7707	7439	23	8101	7397	
T1A	Lower Tuxen 1	VN 31		7621	7466	14	7809	7545	14				7733	7462	16			
Valhall				7635	7480		7825	7559					7750	7478				
Re-entry	incomplete sections																	
	Alb shale																	
	U.S.2 re1																	
	U.S.1 re1																	
	Fisch sch																	
	L:S.3 re1																	
	L.S.1 re1									9341	7462							
	L.S.1 re2									9526	7481							
	L.S.1 re3									9845	7529							
	U.T.2 re1									9257	7454							
	U.T.2 re2									9392	7466							
	U.T.2 re3									9665	7501							
	U.T.2 re4									9912	7539							
	U.T.1 re1									9026	7448							
	U.T.1 re2									9795	7522							
	U.T.1 re3									9996	7552							
	U.T.1 re4																	
	U.T.1 re5																	
	M.T. 2 re1									10101	7566							
	M.T. 2 re2																	
	M.T.1 re1																	
	M.T.1 re2																	
	MM															9687	7419	
	L.T.3 re1															9546	7417	
	L.T.3 re2															9721	7419	

TABLE 1

STRATIGRAPHICAL UNITS AND THICKNESSES

Revised 17.12.97

		Biozone	Formation	Valdemar 3 P			Valdemar 3 H			Valdemar 4H			Bøje 1			Bo-1		
				MD	TVD	Thickness	MD	TVD	Thickness	MD	TVD	Thickness	MD	TVD	Thickness	MD	TVD	Thickness
Rødby	Rødby	NLK 1-3	Rødby	7674	7112	12	7700	7116	12	7782	7163	19	8115	8000	52	7461	7352	65
S5	Albian Marl	NLK 4		7690	7124	34	7722	7128	26	7831	7182	50	8167	8052	21	7526	7417	40
S4B	Upper Sola 2	VN 1		7734	7158	13	7770	7154	19	7989	7232	16	8188	8073	32	7566	7457	44
S4A	Upper Sola 1	VN 2		7751	7171	6	7811	7173	14	8044	7248	31	8220	8105	29	7610	7501	17
S3	Fischschiefer	VN 3		7758	7177	8	7842	7186	2	8149	7280	6	8249	8134	4	7627	7518	5
S2C	Lower Sola 3	VN 4	Sola	7768	7185	15	7847	7188	8	8171	7286	8	8253	8138	7	7632	7523	7
S2B	Lower Sola 2	VN 4-5		7788	7200	14	7866	7196	39	8198	7293	17	8260	8145	17	7639	7530	17
S2A	Lower Sola 1	VN 5		7806	7214	14	7961	7235	10	8265	7310	5	8277	8162	28	7656	7547	25
S1	Upper Tuxen 2	VN 6-10		7824	7228	28	7986	7245	12	8289	7315	15	8305	8190	35	7681	7572	36
T3C	Upper Tuxen 1	VN 11-14		7860	7256	36	8023	7257	32	8355	7330	17	8340	8225	23	7717	7608	23
T3B	Middle Tuxen 2	VN 15-18		7908	7292	31	8148	7289		8445	7347	7	8363	8248	19	7740	7631	12
T3A	Middle Tuxen 1	VN 19-23a	Tuxen	7948	7323	35	8276	7307		8999	7354		8382	8267	24	7752	7643	26
Munk Marl	Munk Marl	VN 23b		7994	7358	6	10504	7402	6				8406	8291	5	7778	7669	9
T1C	Lower Tuxen 3	VN 24-25		8002	7364	41	10563	7408					8411	8296	40	7787	7678	31
T1B	Lower Tuxen 2	VN 26-30		8055	7405	24							8451	8336	30	7818	7709	38
T1A	Lower Tuxen 1	VN 31		8086	7429	22							8481	8366	39	7856	7747	40
Valhall				8115	7451								8520	8405		7896	7787	
Re-entry	incomplete sections																	
	Alb shale									11235	7277							
	U.S.2 re1									11137	7267							
	U.S.1 re1									10979	7261							
	Fisch sch									10958	7261							
	L:S.3 re1									10885	7259							
	L.S.1 re1									10790	7256							
	L.S.1 re2																	
	L.S.1 re3																	
	U.T.2 re1						11641	7466		10316	7261							
	U.T.2 re2						12733	7526										
	U.T.2 re3						13012	7529										
	U.T.2 re4																	
	U.T.1 re1						11543	7463		9001	7354							
	U.T.1 re2						11964	7481		9511	74477							
	U.T.1 re3						12258	7516		9983	7289							
	U.T.1 re4						12840	7526										
	U.T.1 re5						13310	7545										
	M.T. 2 re1						13787	7598		9058	7351							
	M.T. 2 re2						14803	7627		9868	7299							
	M.T.1 re1						10832	7424										
	M.T.1 re2						14013	7623										
	MM																	
	L.T.3 re1																	
	L.T.3 re2																	

TABLE 1

TABLE 2. Thickness variation for the various zones. Valdemar field.

Well	Rød-by	Alb shale	Upper Sola		Fisch-schief	Lower Sola			Upper Tuxen		Middle Tuxen		Munk Marl	Lower Tuxen		
			2	1		3	2	1	2	1	2	1		3	2	1
North Jens-1	***17***	***15***	***15***	***26***	***8***	***13***	***12***	***21***	***31***	***25***	***25***	***37***	***10***	***27***	***30***	***14***
Valdemar -1P	20	51	20	25	8	11	14	25	20	26	40	59	3	25	50	14
Valdemar -1H	20	61	21	15	9	10	12	26	20	31						
Valdemar -2P	6	26	22	18	8	10	15	19	29	33	24	29	7	29	23	16
Valdemar -2H	8	30	17	14	2	9	9	10	29	27	27	34	5			
Valdemar -3P	12	34	13	6	8	15	14	14	28	36	31	35	6	41	24	22
Valdemar -3H	12	26	19	14	2	8	39	10	12	13	32		6			
Valdemar - 4H	19	50	16	31	6	8	17	5	15	17						
Bøje -1	52	21	32	29	4	7	17	28	35	23	19	24	5	40	30	39
Bo -1	65	40	44	17	5	7	17	25	36	23	12	26	9	31	38	40

Legend:

Fault cut-out	0
Fault repetition	0
Structural uplift/condensation	0
Subsidence/flank increase	0
Isochore/dip effect	0

TABLE 3. Thickness variation within the Valdemar field area.

Well	Rød-by	Alb shale	Upper Sola		Fisch-schief	Lower Sola			Upper Tuxen		Middle Tuxen		Munk Marl	Lower Tuxen		
			2	1		3	2	1	2	1	2	1		3	2	1
Average	**23**	**35**	**22**	**20**	**6**	**10**	**17**	**18**	**26**	**25**	**26**	**35**	**6**	**32**	**33**	**24**
Crest	20	40	20	20	8	10	15	20	30	25	25	30	5	25	25	15
North	20	55	20	25	9	10	15	25	20	25	40	50	3	25	50	15
West	10	30	20	25	6	10	15	15	30	25	25	30	5	25	35	20
South	60	40	45	15	6	10	15	25	35	25	10	25	8	30	40	40
East	50	40	30	30	5	5	15	30	35	25	20	25	5	40	30	40

Legend:

Area with maximum subsidence

Area with minimum subsidence

STRATIGRAPHICAL UNITS AND THICKNESSES

		Biozone	Formation	Adda-1			Adda-2			Adda-3			Adda-4			Deep Adda-1		
				MD	TVD	Thickness	MD	TVD	Thickness	MD	TVD	Thickness	MD	TVD	Thickness	MD	TVD	Thickness
Rødby	Rødby	NLK 1-3	Rødby	7513	7401	14	7721	7607	12	7681	7555	18				7955	7828	6
S5	Albian Marl	NLK 4		7527	7415	6	7733	7619	3	7699	7573	3				7961	7834	6
S4B	Upper Sola 2	VN 1		7533	7421	9	7736	7622	15	7702	7576	17				7967	7840	3
S4A	Upper Sola 1	VN 2		7542	7430	13	7751	7637	10	7719	7593	7				7970	7843	1
S3	Fischschiefer	VN 3	Sola	7555	7443	10	7761	7647	16	7726	7600	11				7971	7844	1
S2C	Lower Sola 3	VN 4		7565	7453	14	7776	7663	0	7737	7611	21				7972	7845	18
S2B	Lower Sola 2	VN 4-5		7579	7467	17	7777	7663	0	7758	7632	31				7990	7863	14
S2A	Lower Sola 1	VN 5		7596	7484	24	7777	7663	0	7789	7663	8				8004	7877	8
S1	Upper Tuxen 2	VN 6-10		7620	7508	14	7777	7663	1	7797	7671	0				8012	7885	7
T3C	Upper Tuxen 1	VN 11-14		7634	7522	25	7778	7664	17	7797	7671	20				8019	7892	5
T3B	Middle Tuxen 2	VN 15-18		7650	7538	0	7795	7681	0	7817	7691	0				8024	7897	2
T3A	Middle Tuxen 1	VN 19-23a		7650	7538	0	7795	7681	0	7817	7691	0				8026	7899	4
Munk Marl	Munk Marl	VN 23b	Tuxen	7650	7538	0	7795	7681	0	7817	7691	1				8030	7903	6
T1C	Lower Tuxen 3	VN 24-25		7650	7538	22	7795	7681	1	7818	7692	18				8036	7909	10
T1B	Lower Tuxen 2	VN 26-30		7672	7560	24	7796	7682	50	7836	7710	35				8046	7919	8
T1A	Lower Tuxen 1	VN 31		7696	7584	1	7846	7732	12	7871	7745	12				8054	7927	1
Valhall				7697	7585		7858	7744		7883	7757					8055	7928	

		Biozone	Formation	S.E.Adda-1			N.W.Adda-1			E-1			E-3			Roar-2		
				MD	TVD	Thickness	MD	TVD	Thickness	MD	TVD	Thickness	MD	TVD	Thickness	MD	TVD	Thickness
Rødby	Rødby	NLK 1-3	Rødby	7733	7603	9				8160	8038	4	8301	8201	0	8442	8326	16
S5	Albian Marl	NLK 4		7742	7612	10				8164	8042	6	8301	8201	4	8458	8342	12
S4B	Upper Sola 2	VN 1		7752	7622	6				8170	8048	5	8305	8205	13	8470	8354	12
S4A	Upper Sola 1	VN 2		7758	7628	17				8175	8053	7	8318	8218	9	8482	8366	17
S3	Fischschiefer	VN 3	Sola	7775	7645	10				8182	8060	5	8327	8227	5	8499	8383	10
S2C	Lower Sola 3	VN 4		7785	7655	27				8187	8065	7	8332	8232	0	8509	8393	41
S2B	Lower Sola 2	VN 4-5		7812	7682	28				8194	8072	12	8332	8232	0	8550	8434	20
S2A	Lower Sola 1	VN 5		7840	7710	18				8206	8084	10	8332	8232	0	8570	8454	40
S1	Upper Tuxen 2	VN 6-10		7858	7728	9				8216	8094	0	8332	8232	15	8610	8494	14
T3C	Upper Tuxen 1	VN 11-14		7867	7737	7				8216	8094	17	8347	8247	29	8624	8508	16
T3B	Middle Tuxen 2	VN 15-18		7874	7744	2				8233	8111	0	8376	8276	47	8640	8524	25
T3A	Middle Tuxen 1	VN 19-23a		7877	7746	3				8233	8111	0	8423	8323	23	8665	8549	0
Munk Marl	Munk Marl	VN 23b	Tuxen	7879	7749	3				8233	8111	3	8446	8346	8	8665	8549	4
T1C	Lower Tuxen 3	VN 24-25		7882	7752	10				8236	8114	13	8454	8354	8	8668	8552	20
T1B	Lower Tuxen 2	VN 26-30		7892	7762	21				8249	8127	25	8462	8362	19	8688	8572	27
T1A	Lower Tuxen 1	VN 31		7913	7783	9				8274	8152	21	8481	8381	16	8715	8599	35
Valhall				7922	7792					8295	8173		8497	8397		8750	8634	

TABLE 4

ADDA FIELD AREA

TABLE 5. Thickness variation for the various zones. Adda and Tyra fields

Well	Rød-by	Alb shale	Upper Sola		Fisch-schief	Lower Sola			Upper Tuxen		Middle Tuxen		Munk Marl	Lower Tuxen		
			2	1		3	2	1	2	1	2	1		3	2	1
Adda-1	14	5	9	12	10	14	17	24	13	16	0	0	0	23	23	2
Adda-2	12	3	15	10	16	0	0	0	1	18	0	0	0	1	50	12
Adda-3	18	3	16	7	11	21	31	8	0	20	0	0	0	18	36	11
Adda-4																
D.Adda-1	6	5	4	1	1	19	14	7	8	4	3	4	6	11	8	1
S.E.Adda-1	9	9	6	16	10	27	29	18	9	7	3	3	3	10	21	9
N.W.Adda-1																
E-1	4	6	5	7	5	7	12	10	0	17	0	0	3	13	25	21
E-3	0	4	13	9	5	0	0	0	15	29	47	23	8	8	19	16
Roar-2	16	12	13	18	10	41	20	40	14	17	25	0	3	20	27	35

Legend:

Fault cut-out
Fault repetition
Structural uplift/condensation
Subsidence/flank increase
Isochore/dip

TABLE 6. Thickness variation within the Adda field area.

Well	Rød-by	Alb shale	Upper Sola		Fisch-schief	Lower Sola			Upper Tuxen		Middle Tuxen		Munk Marl	Lower Tuxen		
			2	1		3	2	1	2	1	2	1		3	2	1
Crest	15	5	15	10	10	20	25	10	5	20	0	0	0	20	40	10
North	No	data					No	data						No	data	
West	15	10	10	15	10	30	20	30	15	20	30	15	3	15	25	30
South	2	5	5	7	5	5	10	5	5	23	0	0	5	10	25	20
East	8	8	5	5	5	20	20	10	8	5	3	3	5	10	15	5

Legend:

Area with maximum subsidence
Area with minimum subsidence

FIGURES

DISTRIBUTION AND THICKNESS VARIATION OF THE LOWER CRETACEOUS

TUXEN FORMATION

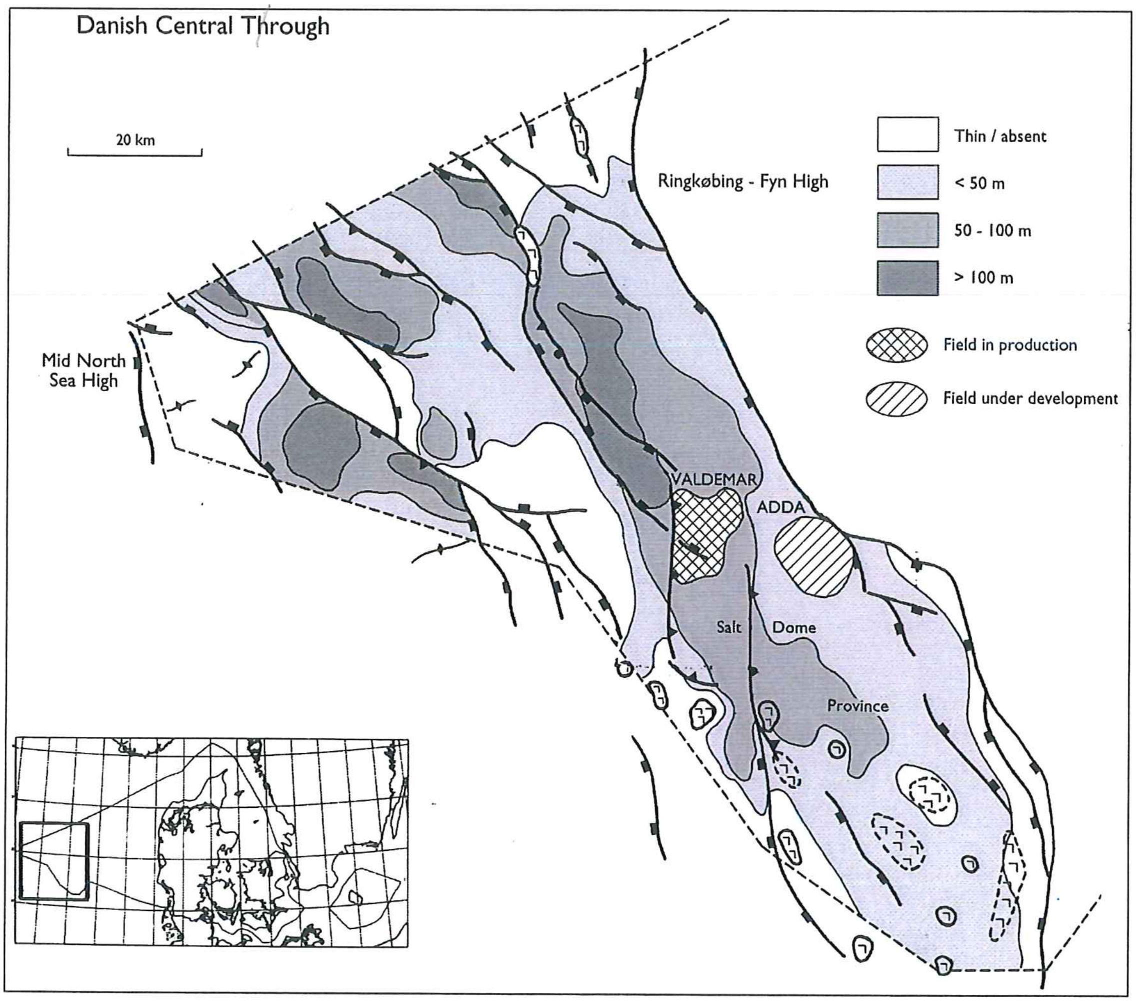


Figure 1. Distribution and gross thickness of the Upper Hauterivian - Barremian chalks (Tuxen Formation) in the Danish Central Trough, based on borehole and seismic data (adapted after Damtoft et al. 1992). The map also shows the location of the Lower Cretaceous fields in production (the Valdemar field) and under development (the Adda field). (From Ineson, 1994).

LOWER CRETACEOUS LITHOSTRATIGRAPHY

Age	Lithostratigraphy		Log Units	Seqs
Cenomanian	Chalk Group			
	Cromer Knoll Group	Rødby Fm.	R2	G
Albian			R1	F
		Sola Fm.	S5	
Aptian			S4	E
			S2-3	
			?	
Barremian			S1	D
		Tuxen Fm.	T3	
			T2	
			T1	C
Hauterivian		Valhall Fm.	V6	B
			V5	
			V4	
Valanginian			V3	
			V2	A
Ryazanian			V1	
	Farsund Fm.			

Figure 2. Lower Cretaceous lithostratigraphy in relation to the log units and depositional sequences. (From Ineson, 1994).

SEQUENCE STRATIGRAPHIC SUBDIVISION

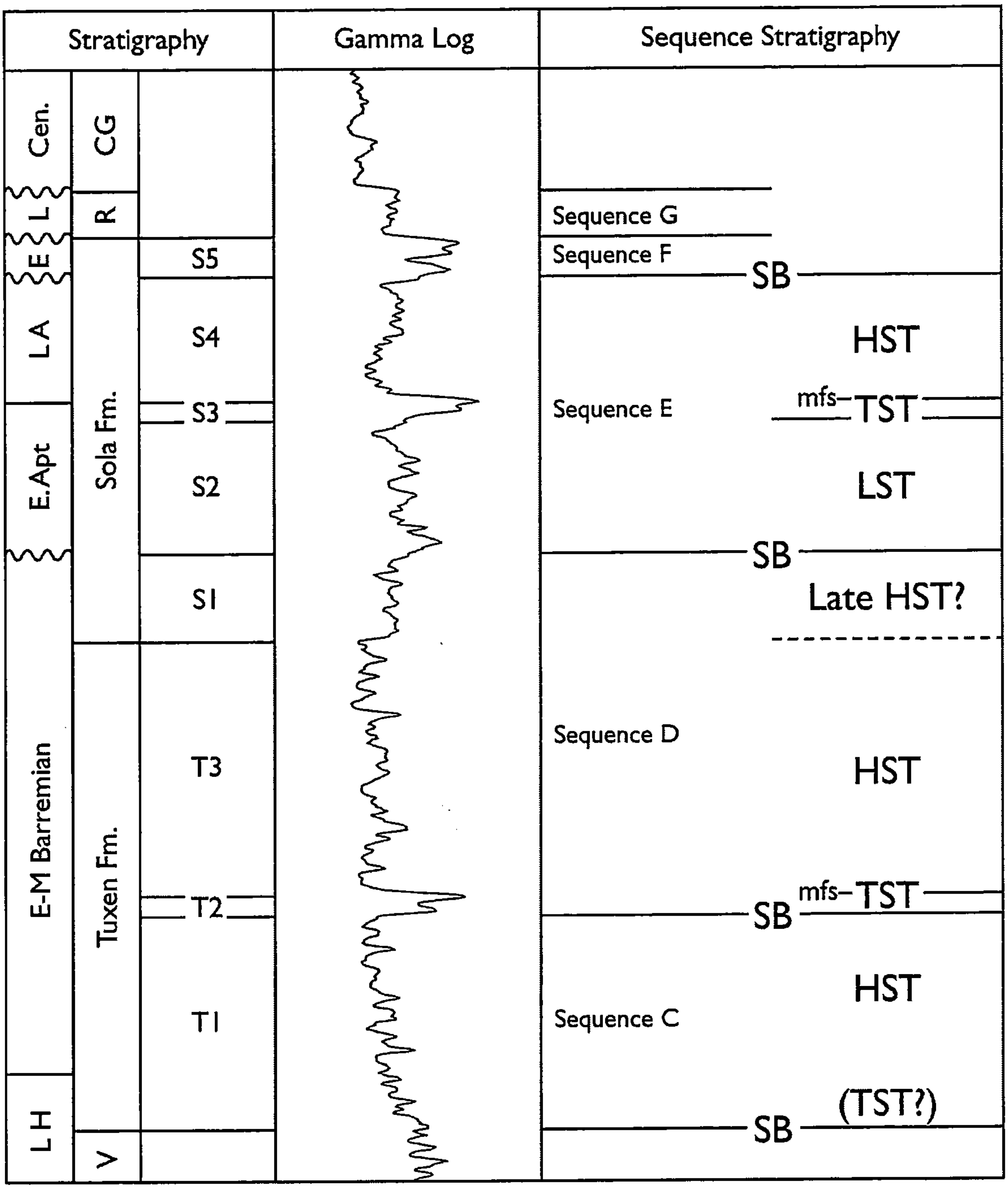


Figure 3. Sequence stratigraphic subdivision of the Tuxen and Sola Formations in the North Jens-1 well (From Ineson, 1994).

**UPDATED SEQUENCE STRATIGRAPHY
OF THE TUXEN AND SOLA FORMATIONS**

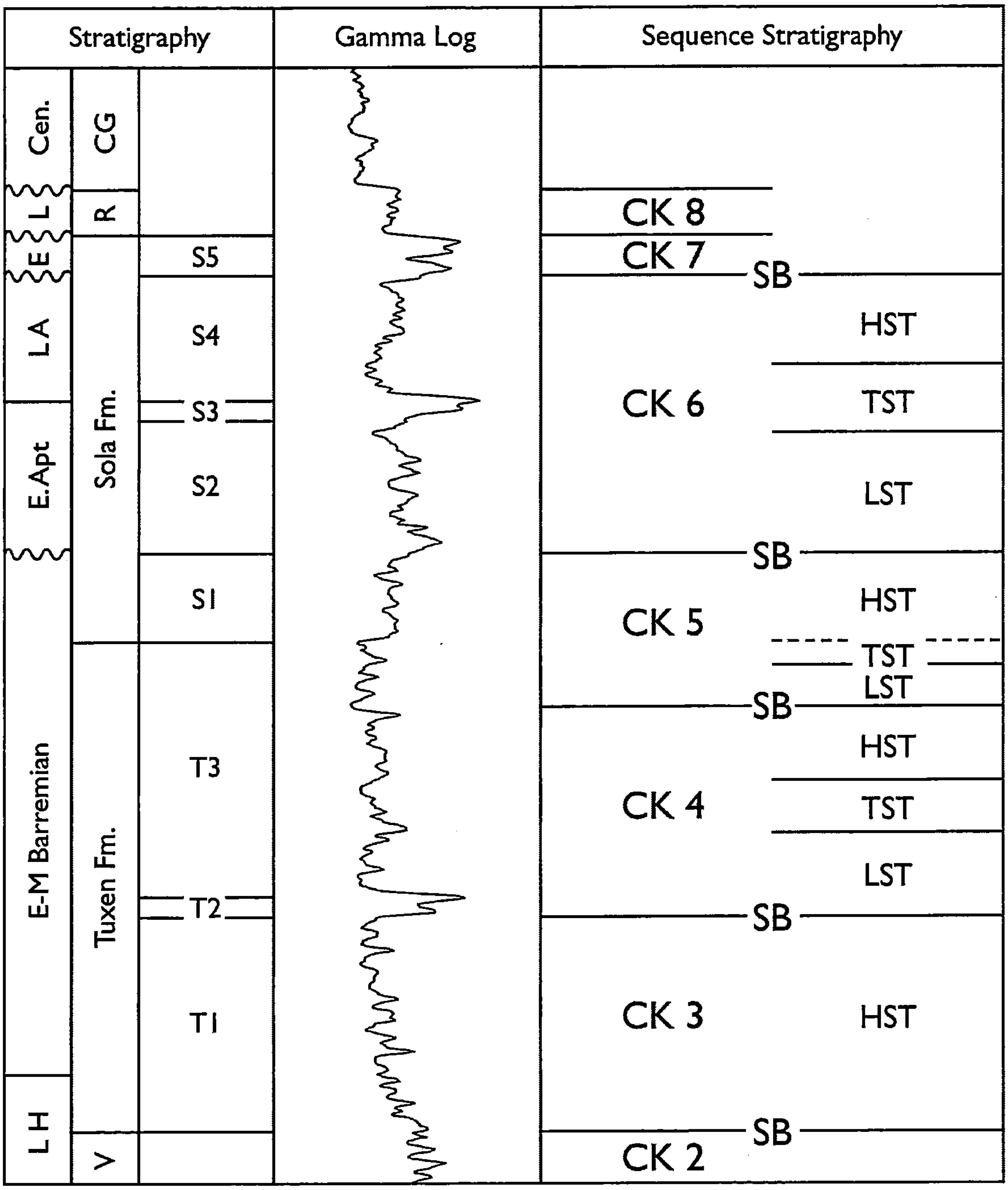


Figure 4. Updated sequence stratigraphic subdivision of the Tuxen and Sola Formations in the North Jens-1 well with new sequence nomenclature and adjusted systems tracts. The subdivision is implemented with a new sequence (CK5) introduced by Ineson et al., 1997.

RESERVOIR ZONATION OF THE NORTH JENS-1 WELL

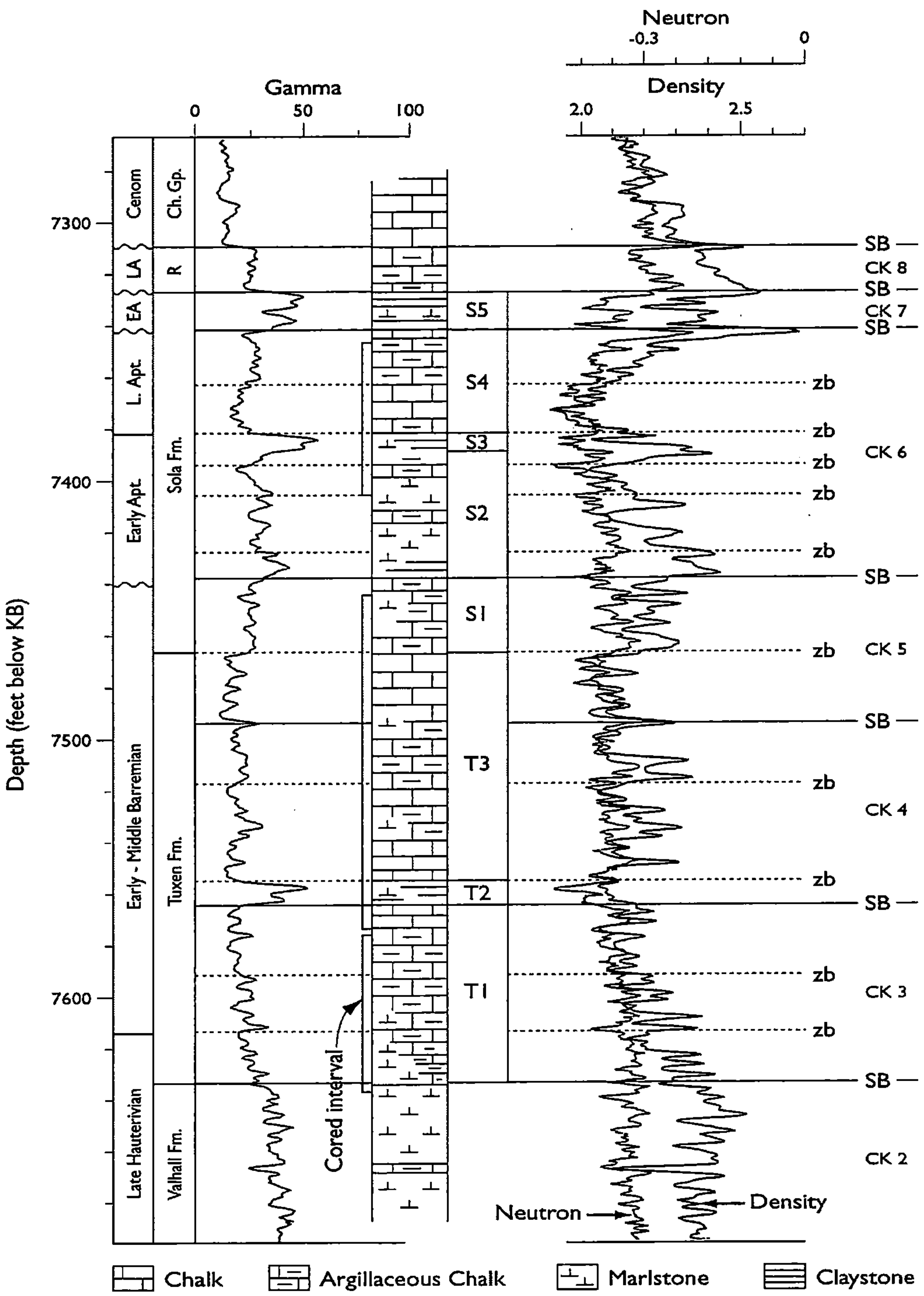


Figure 5. Reservoir zonation in the North Jens-1 well. The overall division is controlled by the sequences boundaries, whereas the more detailed division is based on changes in log pattern (gamma ray and neutron/density).
(SB = sequence boundary, zb = zone boundary).

PROPOSED ZONATION FOR THE VALDEMAR FIELD

STRATIGRAPHICAL UNITS

Stratigraphy	Mærsk nomencl		GEUS 1994.		GEUS 1997 SEQUENCE		PRIORITY proposal	Biozone
A	Rødby		Rødby		CK 8		Rødby	NLK 1-3
L				S5	CK 7		Albian Shale	NLK 4
B.	S		S			HST	Upper Sola-2	VN 1
/	O		O	S4			Upper Sola-1	VN 2
A	L		L	S3		TST	Fischschiefer	VN 3
P	A		A		CK 6		Lower Sola-3	VN 4
T.				S2		LST	Lower Sola-2	VN 4-5
							Lower Sola-1	VN 5
		Barr. shale		S1	CK 5	HST	Upper Tuxen-2	VN 6-10
B						LST/TST	Upper Tuxen-1	VN 11-14
A	T	B1	T	T3		HST	Middle Tuxen-2	VN 15-18
R	U		U		CK 4	TST	Middle Tuxen-1	VN 19-23a
R	X	Munk Marl	X	T2		LST	Munk Marl	VN 23b
E	E		E				Lower Tuxen-3	VN 24-25
M.	N	B2	N	T1	CK 3	HST	Lower Tuxen-2	VN 26-30
							Lower Tuxen-1	VN 31
HAUT.	Valhall		Valhall		CK 2		Valhall	

Figure 6. Proposed nomenclature for the zonation of the Barremian to Albian section in the Valdemar field. The proposed zonation is correlated to previous subdivisions of the Lower Cretaceous section.

SEQUENCE STRATIGRAPHY AND RESERVOIR ZONATION

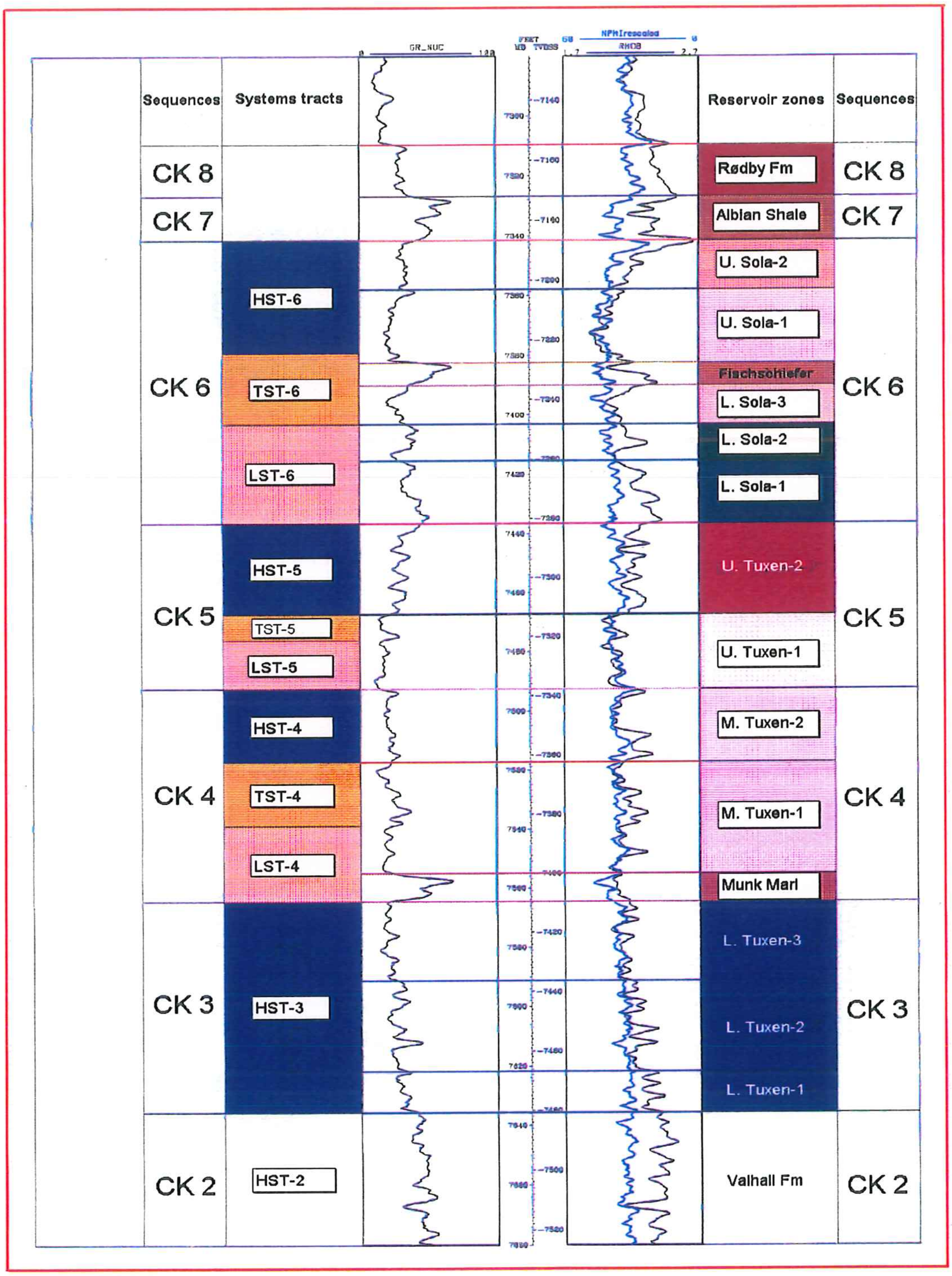


Figure 7: Proposed zonation of the Barremian to Albian section in the North Jens-1 well correlated with recent established sequence stratigraphiy and determined systems tracts. The zonation corresponds only to some degree with the systems tracts due to the lithological variation within the various systems tracts.

Valdemar Zonation

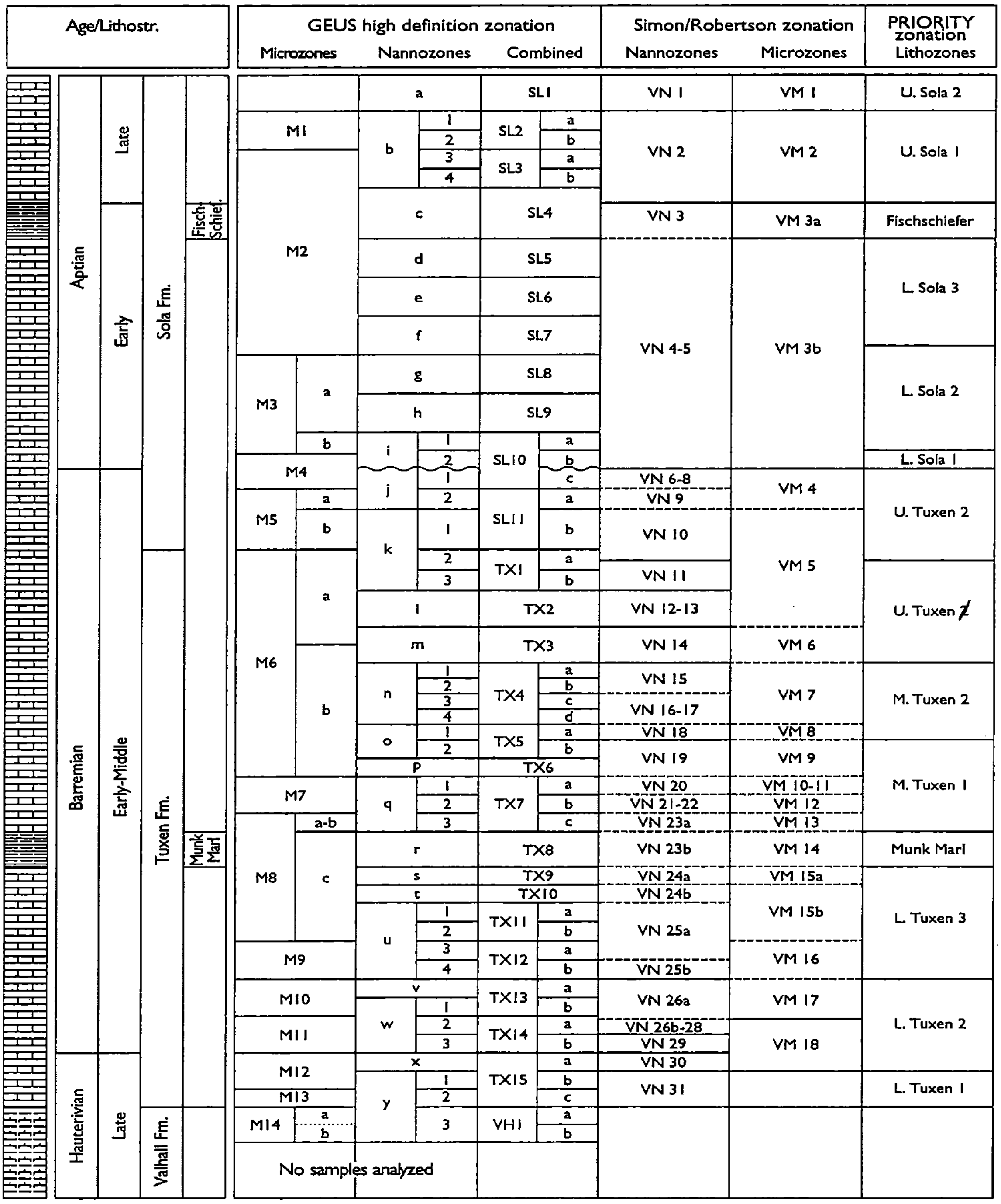


Figure 8. Biostratigraphic zonation of the Valdemar field. A high definition zonation based on micro- and nannofossils has been carried out in the North Jens-1 and Valdemar-2P wells (Jutson, in prep.). The appropriate lithozones in the same wells are indicated to the right. For comparison, the high resolution biozonation used by Simon Petroleum Technology/Robertson Group for Mærsk Olie og Gas A/S is included the scheme.

RESERVOIR ZONATION OF THE ADDA-3 WELL

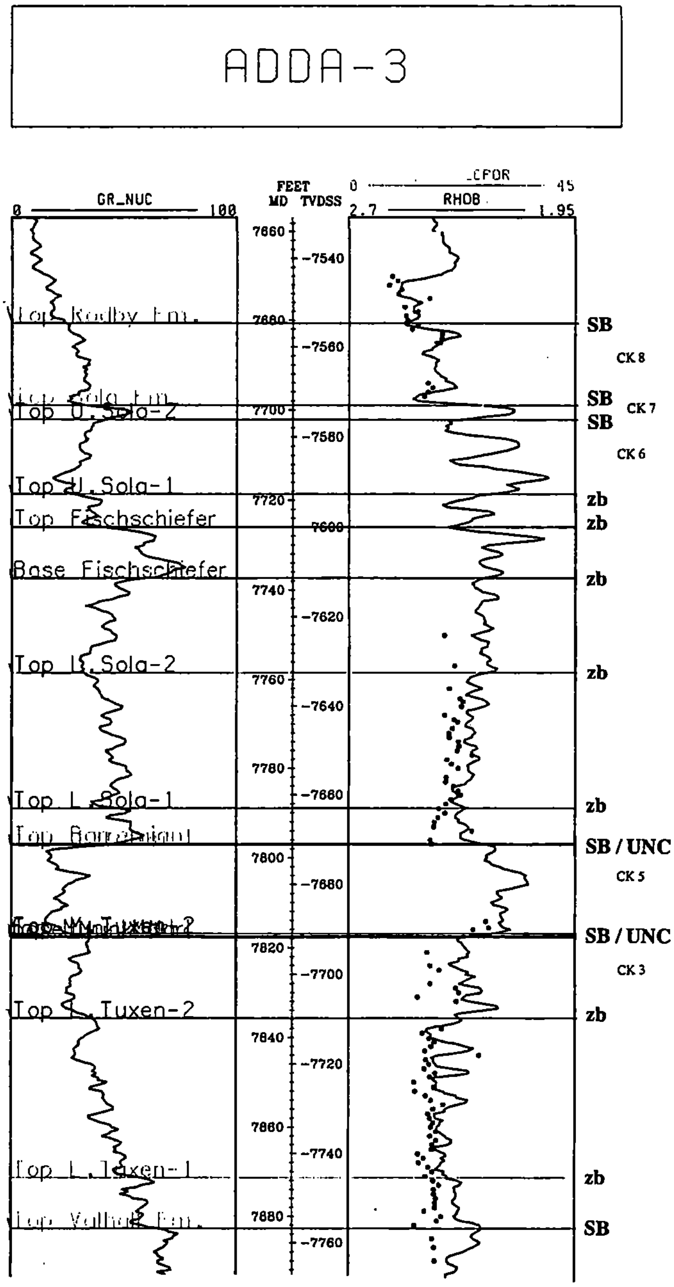


Figure 9. Reservoir zonation in the Adda-3 well. The overall division is controlled by the sequences boundaries whereas the more detailed division is based on changes in log pattern (gamma ray and neutron/density). Due to a more marginal position the density and porosity logs responses in Adda-3 do not fully correspond with the log motifs of the North Jens-1 well.

SB = sequence boundary, zb = zone boundary, unc = unconformity.

LATERAL FACIES VARIATION IN HEMI-PELAGIC BASINS

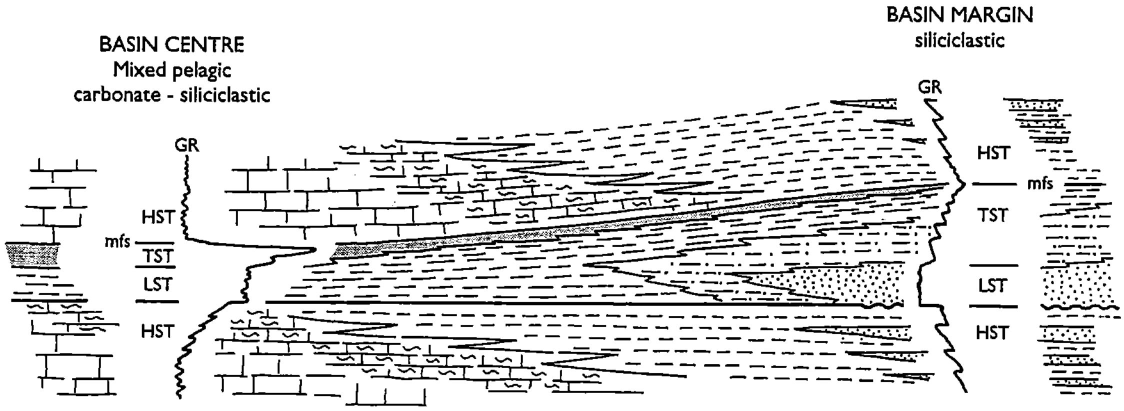


Figure 10. Schematic diagram showing the lateral variation in the log expression of an idealised depositional sequence passing from basin-margin siliciclastic-dominated facies to basin-centre pelagic-carbonate dominated facies. (From Ineson, 1994).

ZONATION VERSUS PARAMETRES

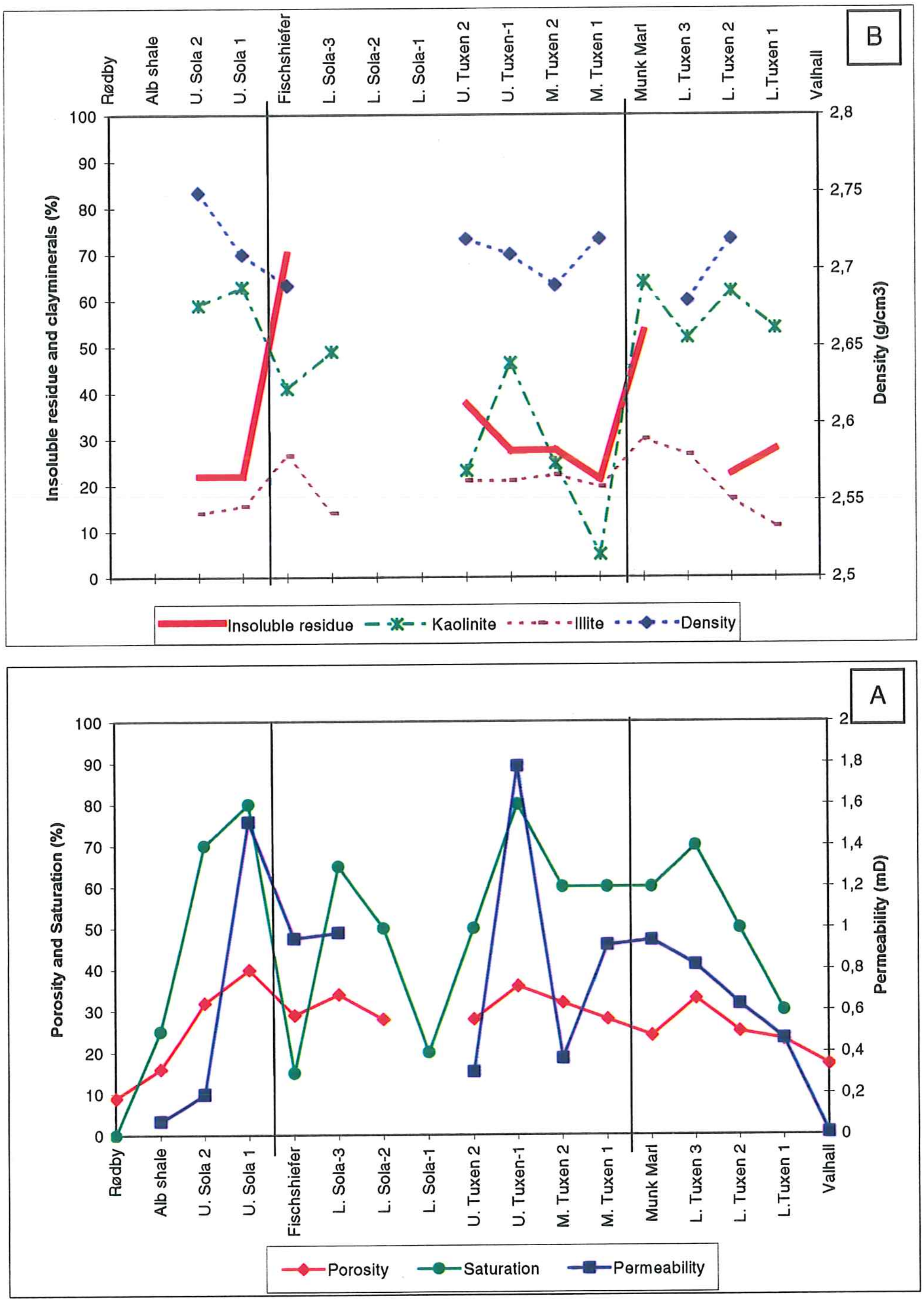


Figure 11. Diagrams showing the variation in average values for selected parameters within the zones proposed for the Barremian to Albian sequence. A: Porosity, permeability and saturation distribution. B: Insoluble residue, clay mineralogy and density.

POROSITY VERSUS PERMEABILITY

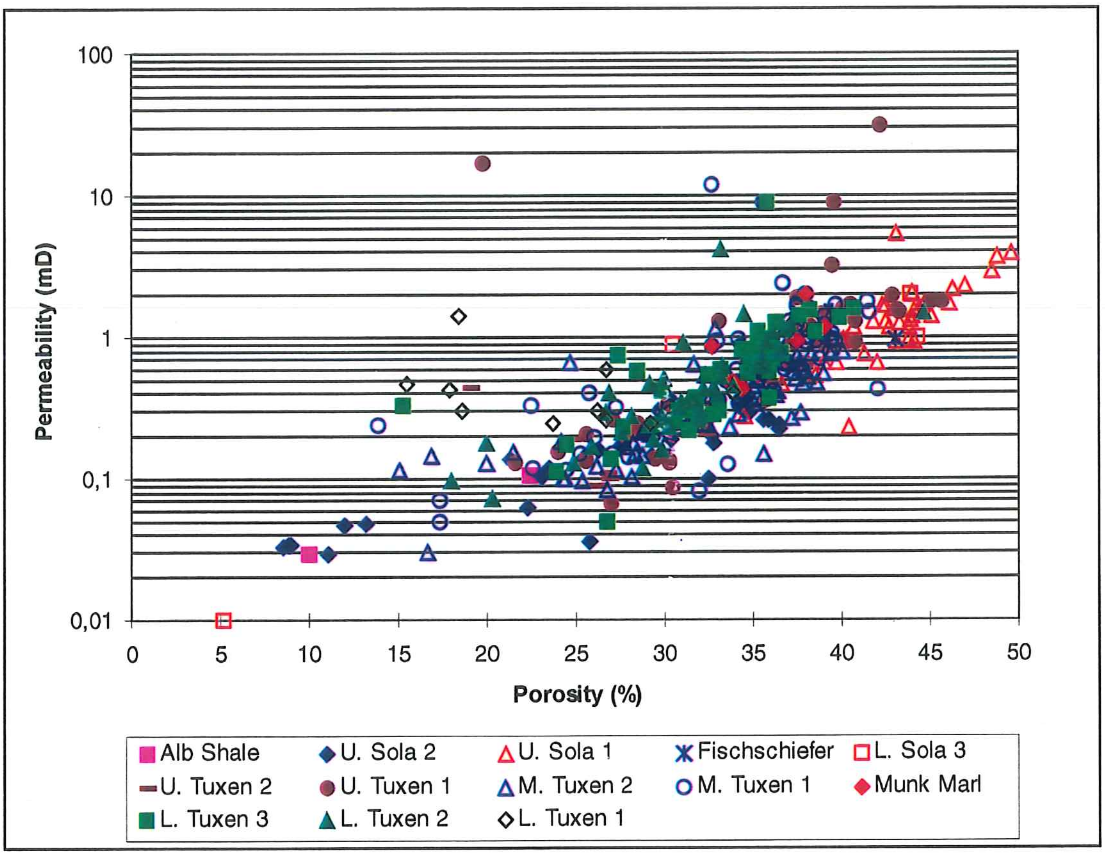


Figure 12. Permeability versus porosity plot for samples related to the Lower Cretaceous reservoir sequence. For comparison the permeability vs. porosity trends for the Maastrichtian chalks and Danian chalks from the North Sea is indicated.

THICKNESS OF THE RESERVOIR ZONES IN THE VALDEMAR FIELD AREA

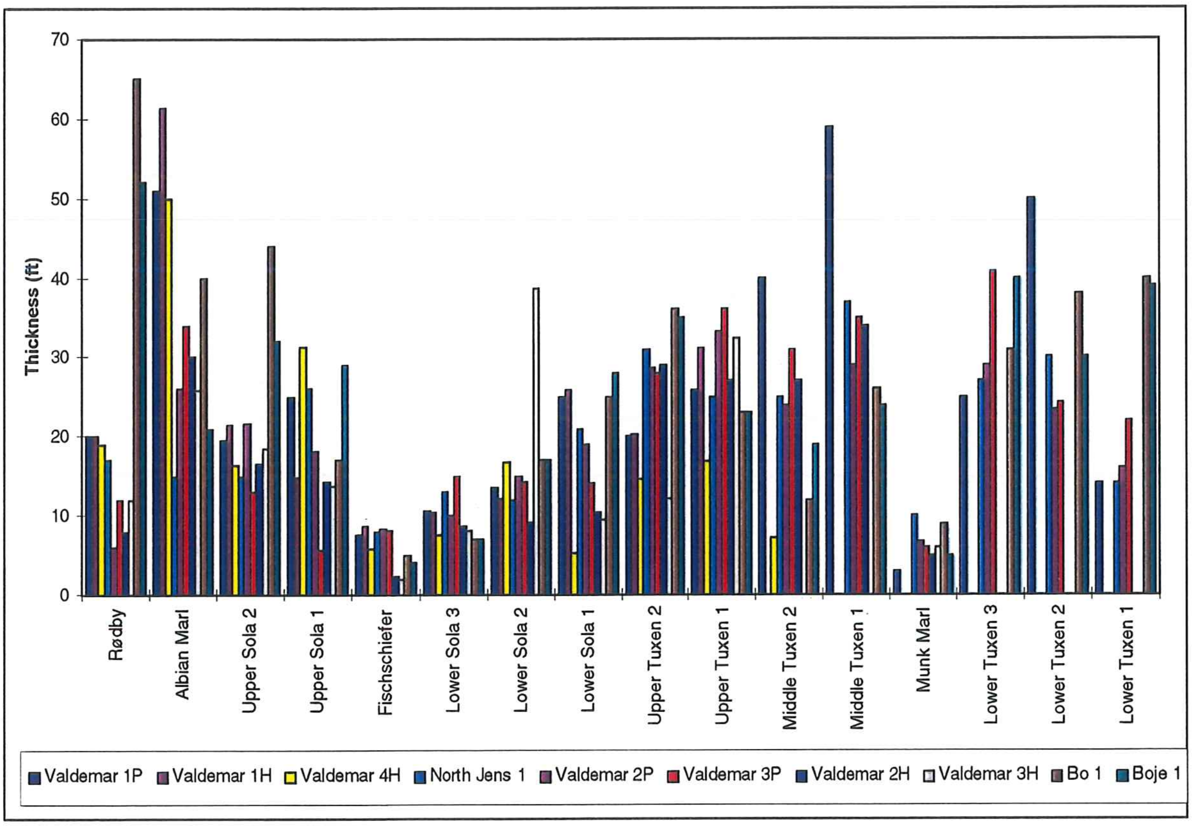


Figure 13. Diagram showing the thickness of the zones in wells drilled in or adjacent to the Valdemar field.

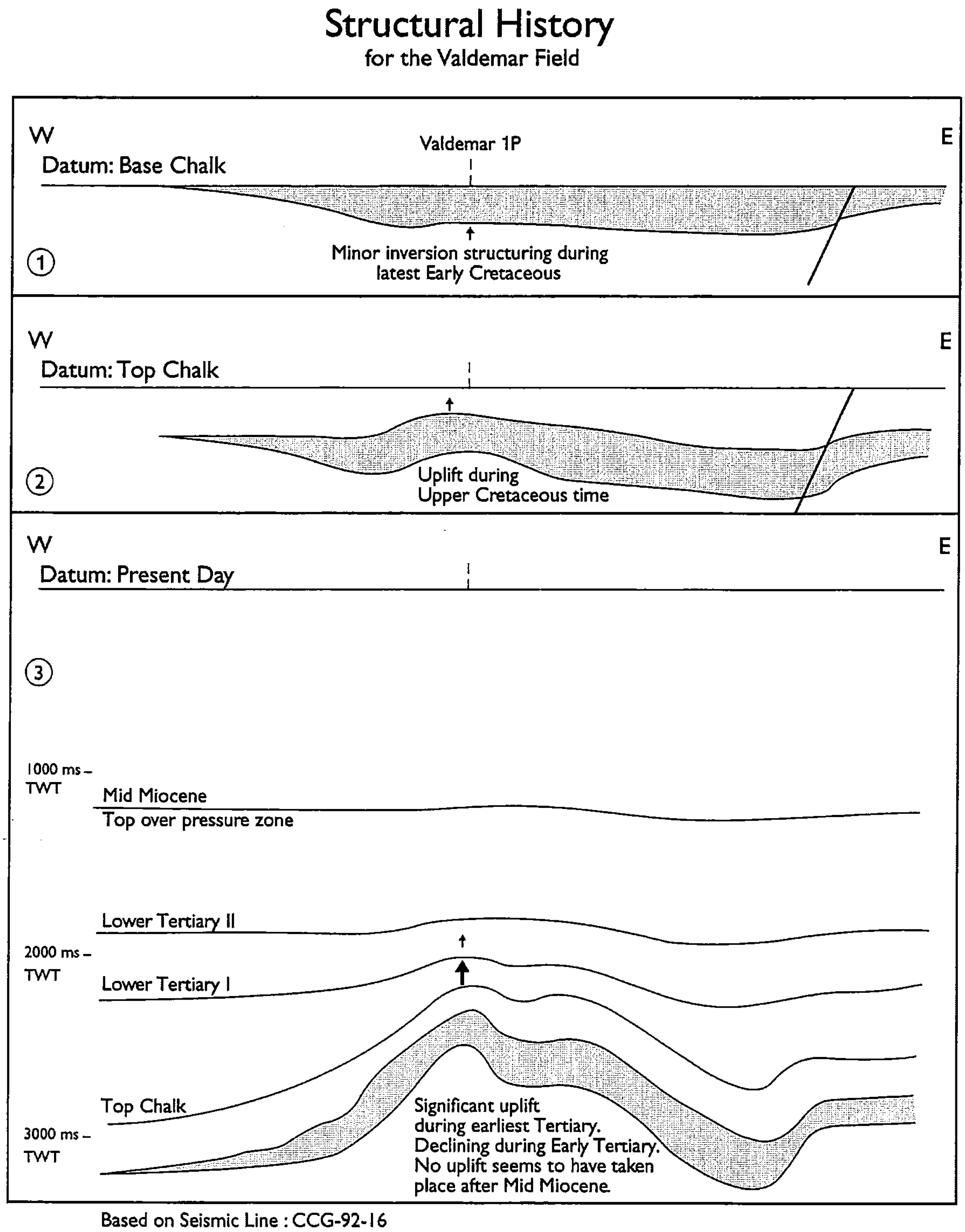


Figure 14. Structural history for the Valdemar field. The uplift of the Valdemar structure is illustrated by back-stripping of the seismic line CCG-92-16 using Base Chalk (a), Top Chalk (b) and present day (c) as datum levels. No correction for compaction has been made.

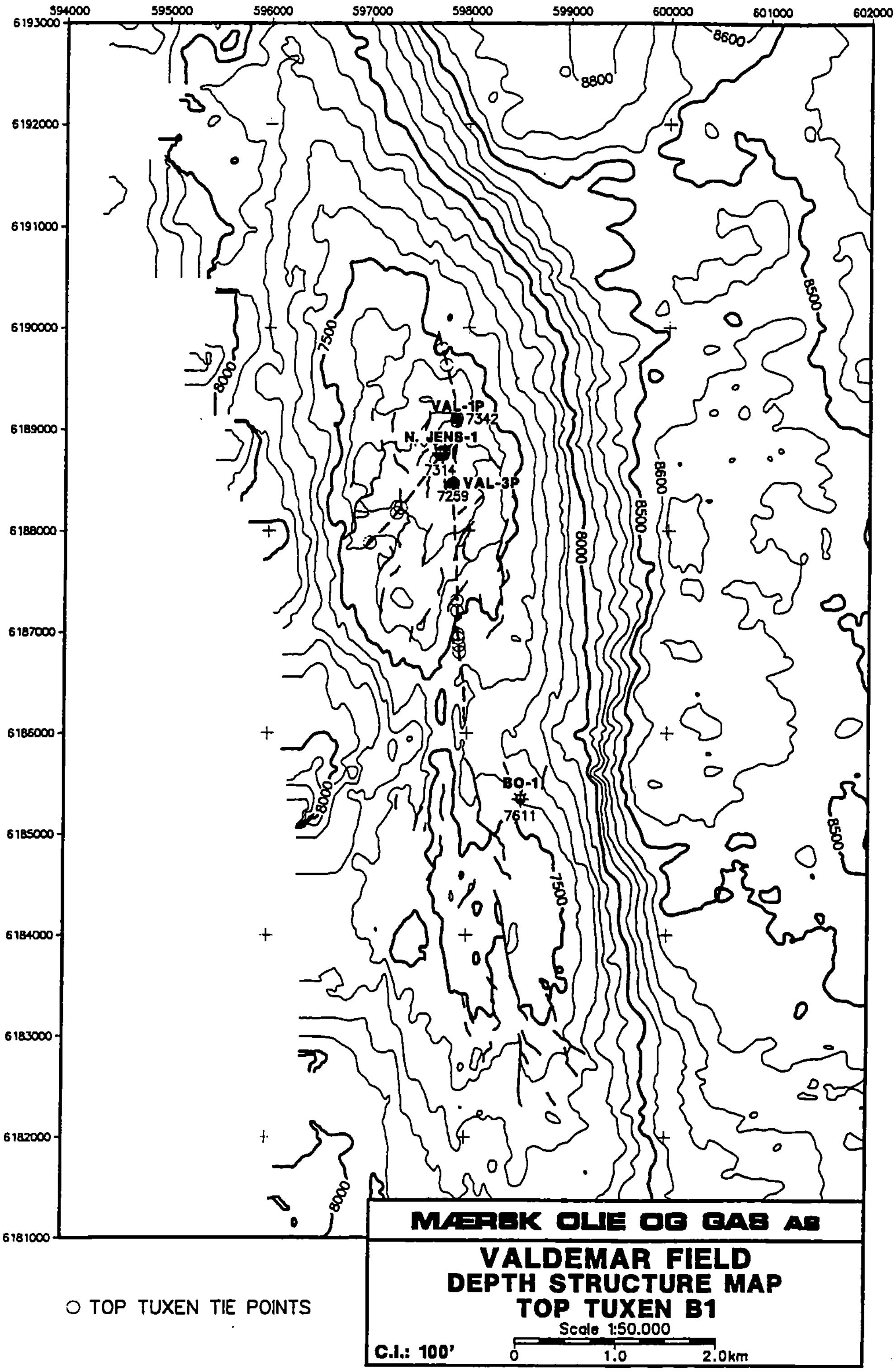


Figure 15. Structural depth map at top Tuxen level. (From Mærsk Olie og Gas A/S, 1994a)

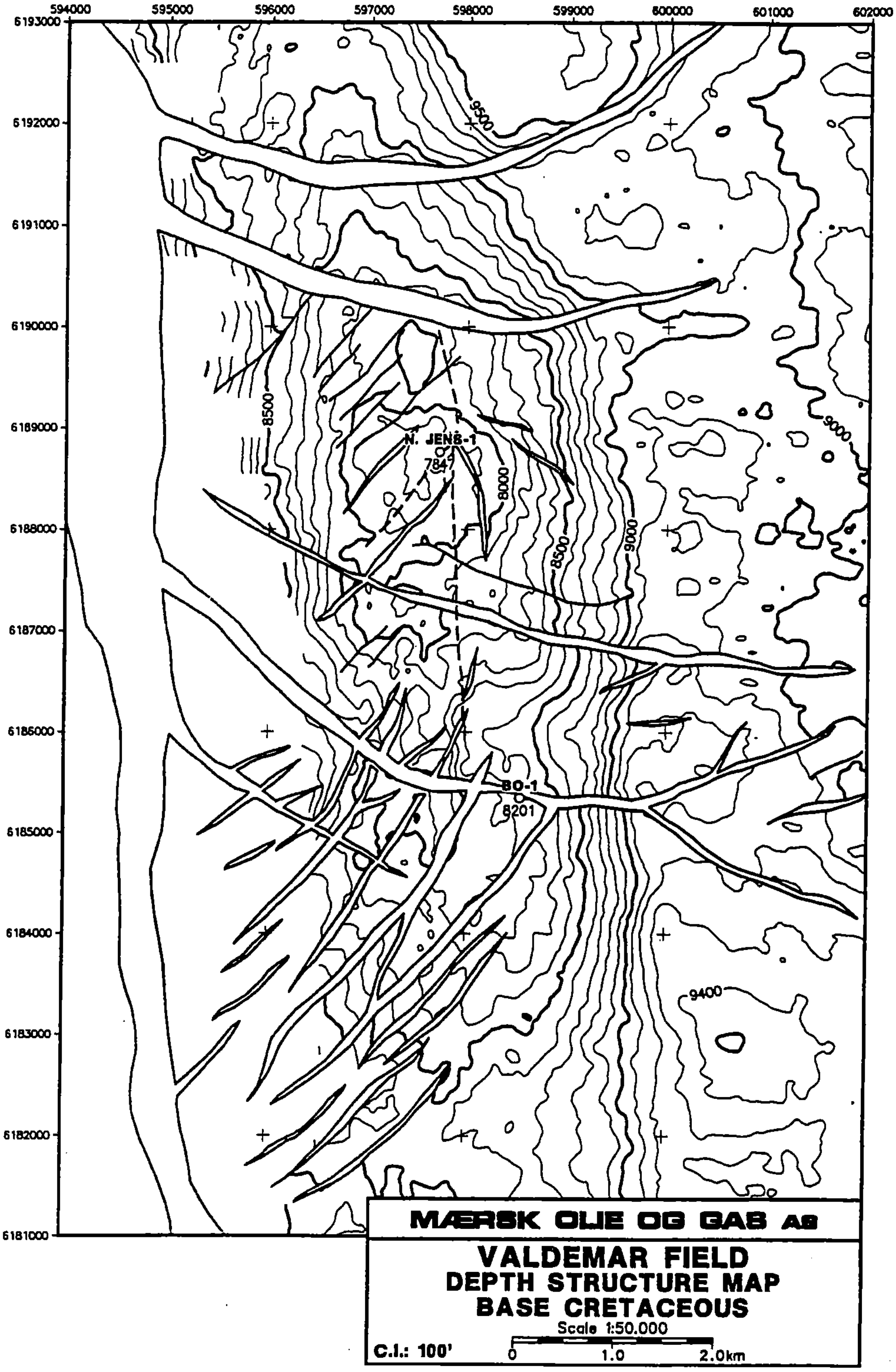


Figure 16. TWT structure map at Base Cretaceous level. (From Mærsk Olie og Gas A/S, 1994a)

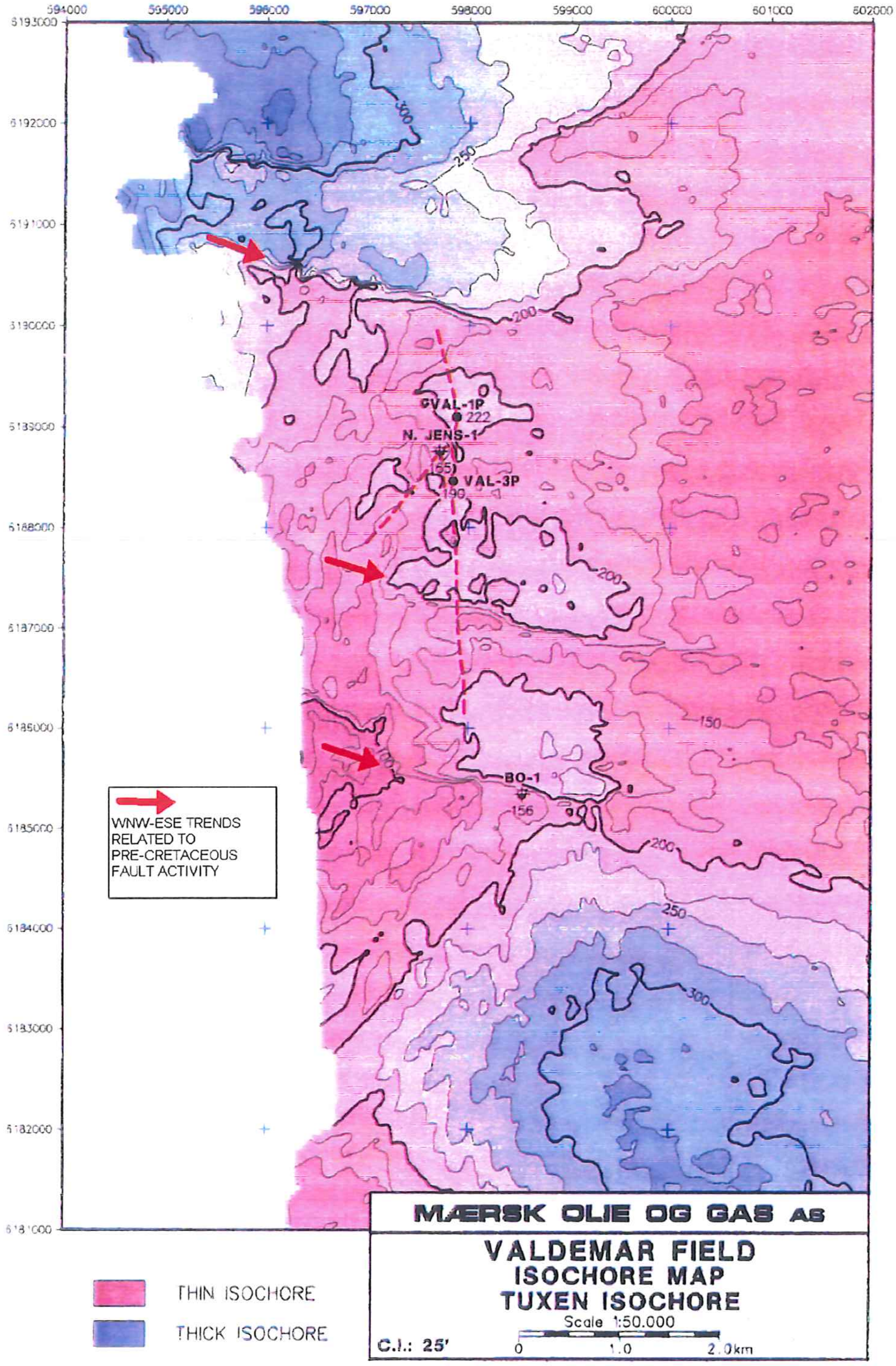


Figure 17. Isochore map for the Tuxen Formation. The map indicates that the thickness distribution during the deposition of the Tuxen Formation still is affected by the WNW-ESE trending pre-Cretaceous faults (After Mærsk Olie og Gas A/S, 1994a)

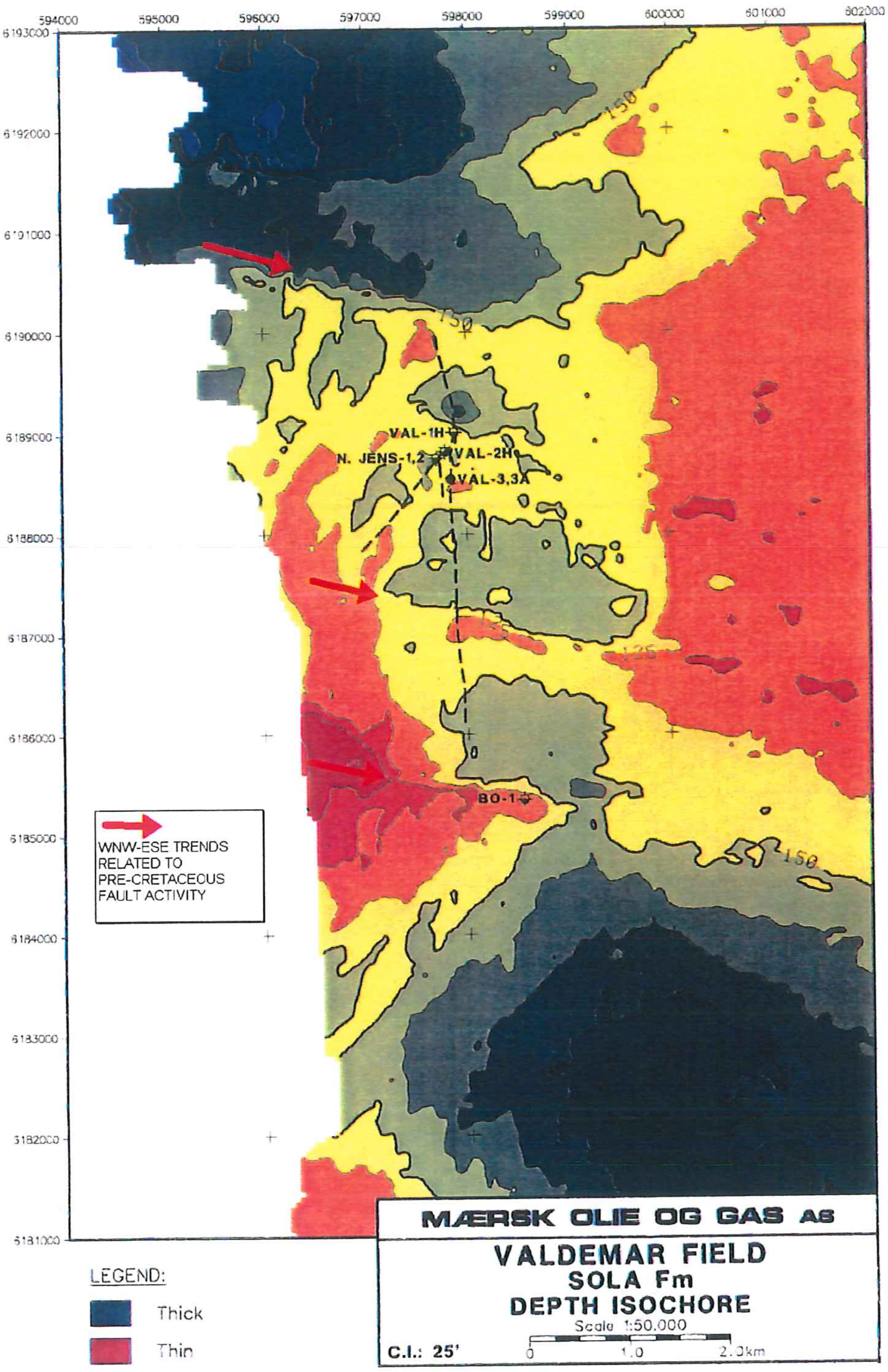


Figure 18. Isochore map for the Sola Formation. The map indicates that the WNW-ESE trending pre-Cretaceous faults also have some impact on the thickness distribution during the deposition of the Sola Formation. (After Mærsk Olie og Gas A/S, 1994a)

LATERAL VARIATION IN CLAY CONTENT

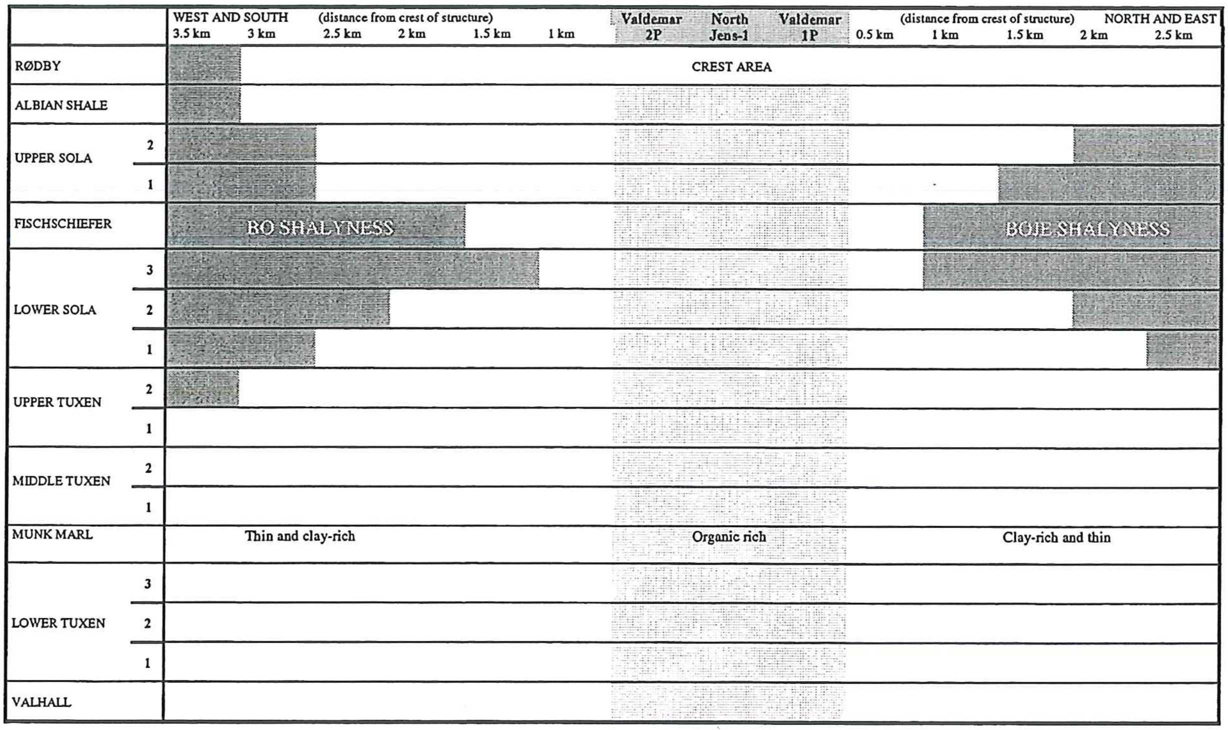


Figure 19. Diagram showing the overall lateral variation in clay content within the individual zones. The reference facies is related to the situation in the crestal area and the diagram indicate the relative variation in clay content away from the crest.

THICKNESS OF THE RESERVOIR ZONES IN THE ADDA FIELD AREA

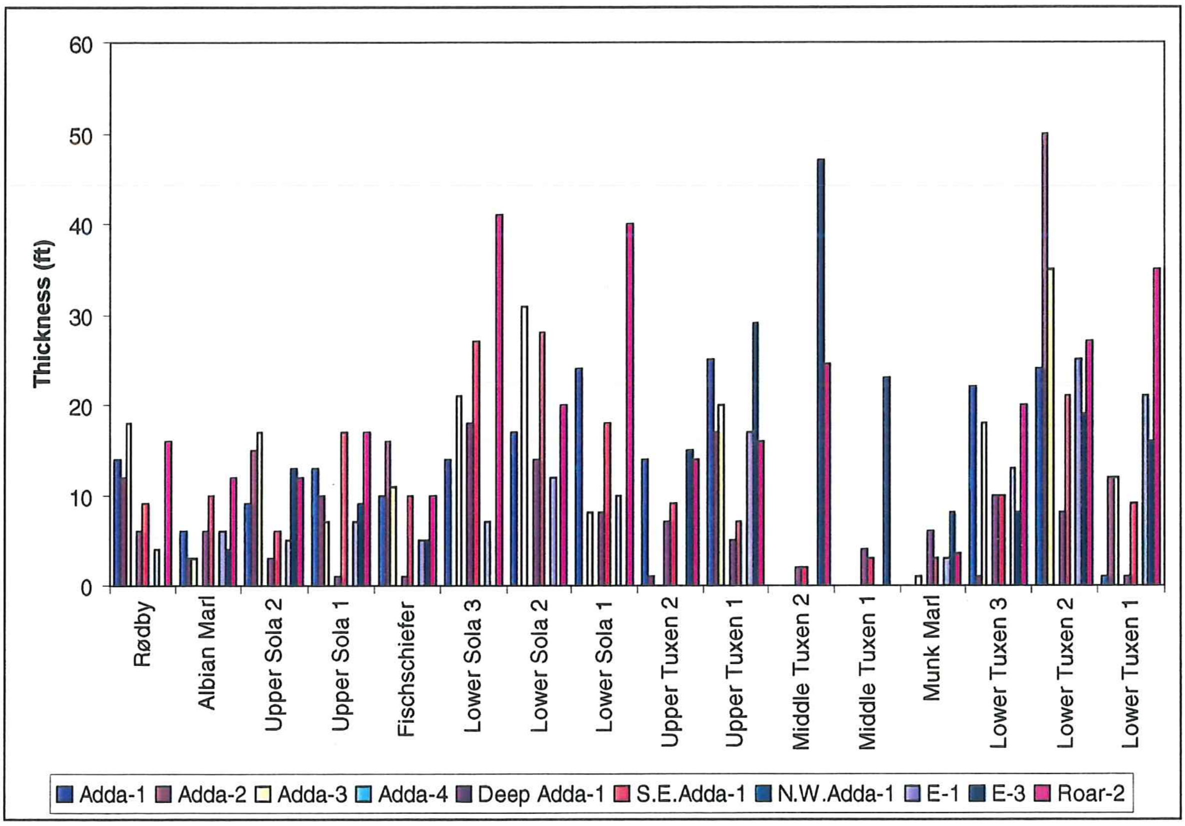


Figure 20. Diagram showing the thickness of the zones in wells drilled in or adjacent to the Adda field.

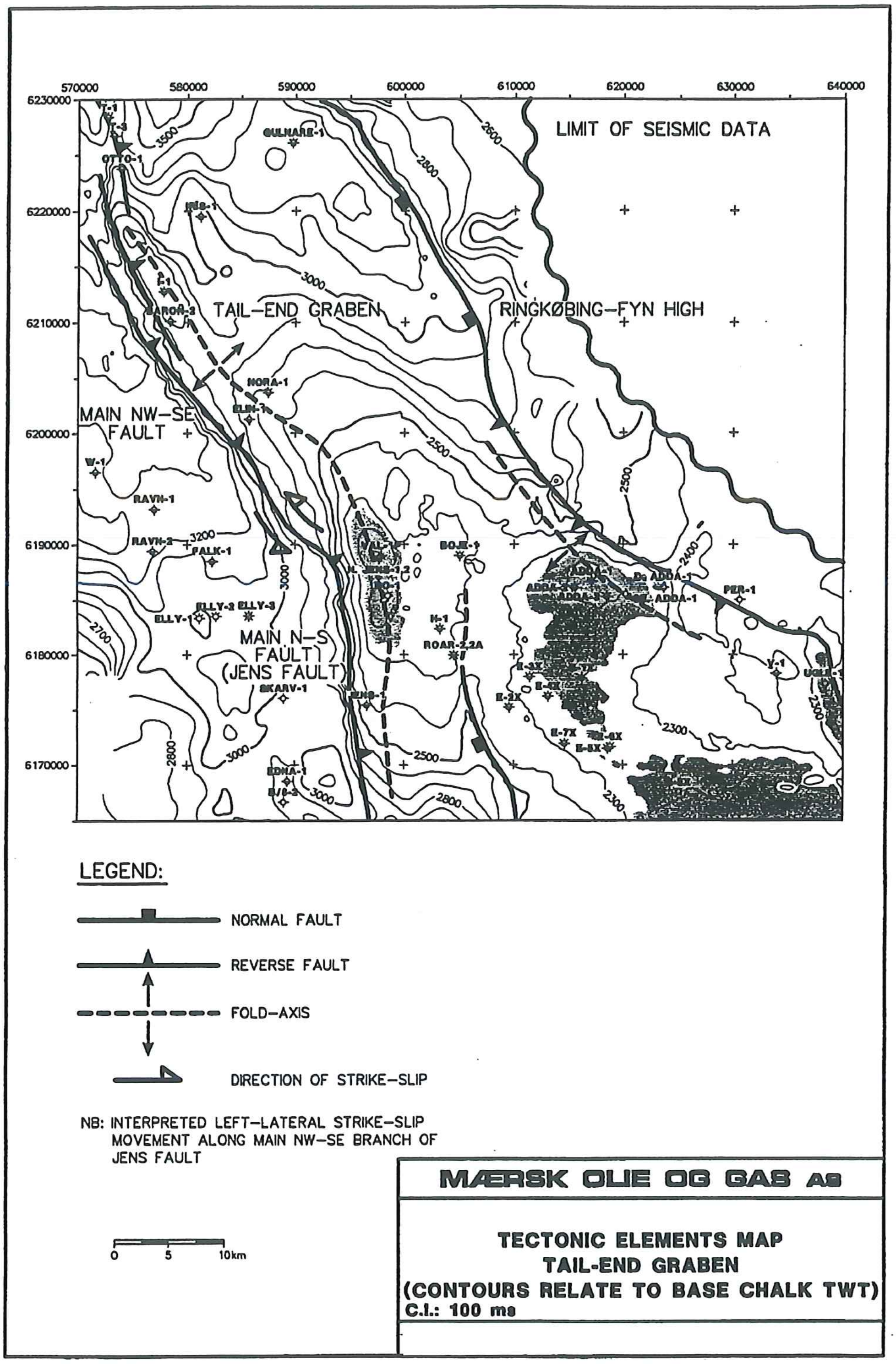


Figure 21. Tectonic elements map for the Tail-End Graben (From Mærsk Olie og Gas A/S, 1994a)

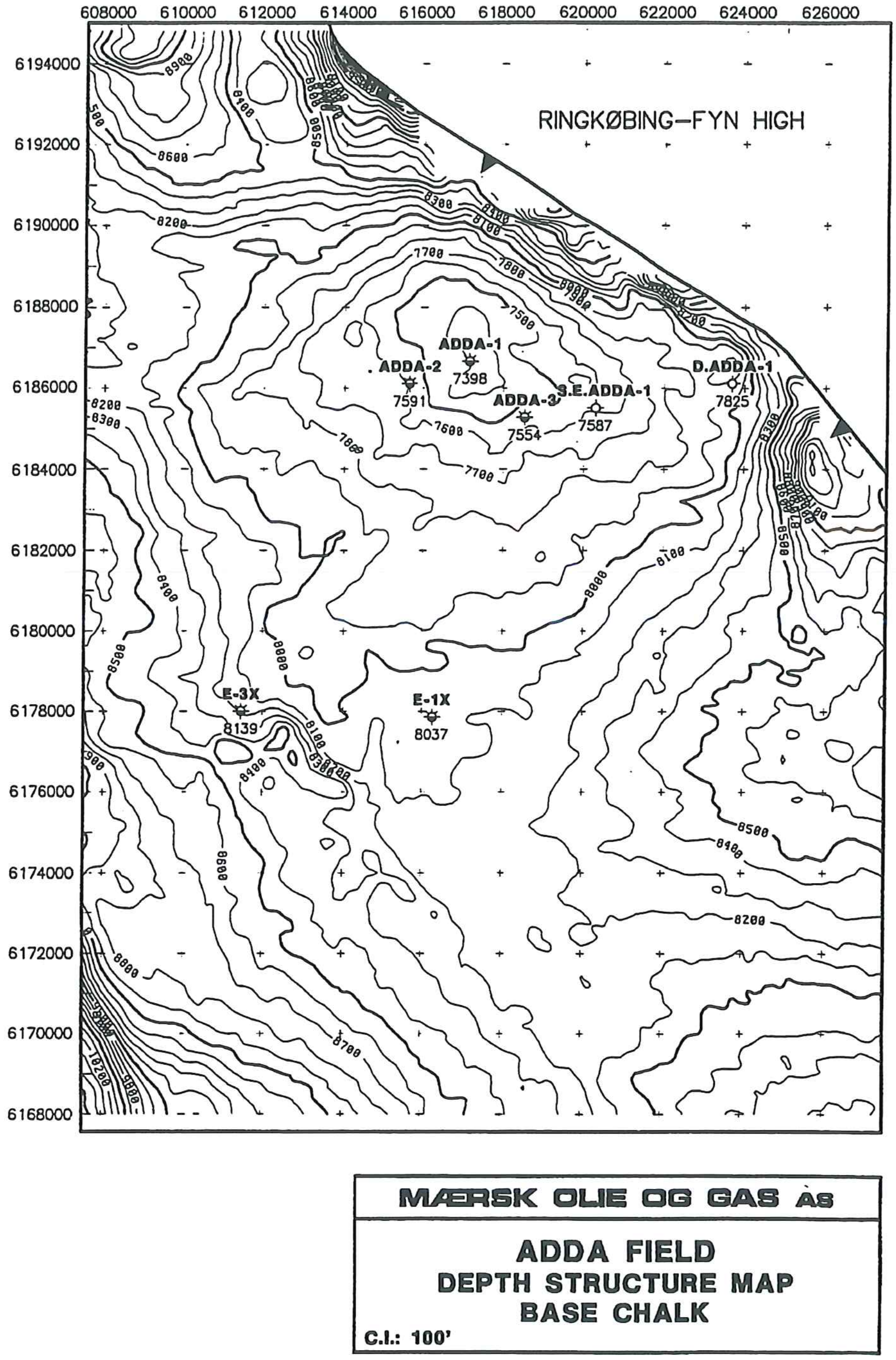
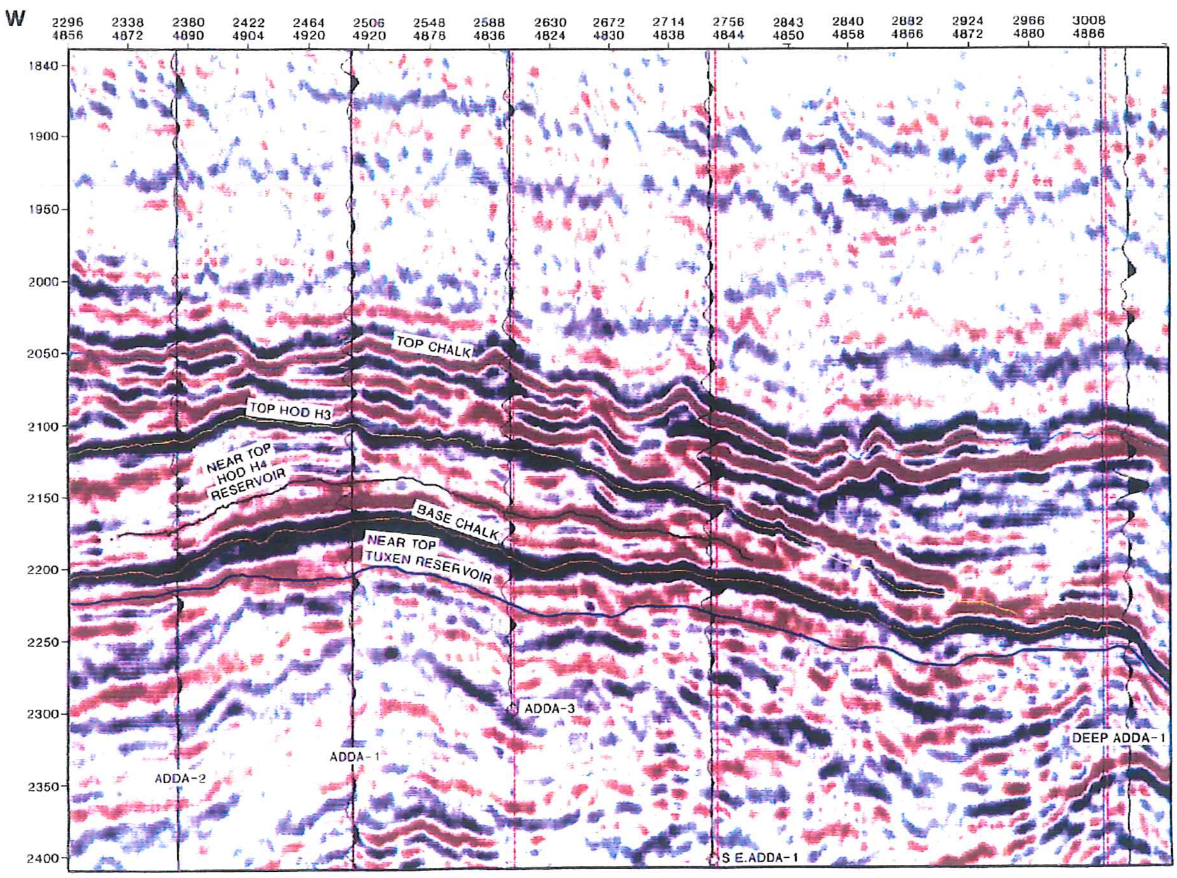


Figure 22. Depth structure map at base Chalk level. Adda field (From Mærsk Olie og Gas A/S, 1994a)

SEISMIC CROSS-SECTION IN THE ADDA FIELD



3D RANDOM LINE TIEING ADDA WELLS

Figure 23. 3D seismic random line tying Adda wells. The thickness variation of the Lower Cretaceous is related to the structuring of the Adda field which give rise to lateral facies variation. (From Mærsk Olie og Gas A/S, 1994a)

APPENDIX 1

Reservoir zonation of wells drilled in the Valdemar field area.

App. 1.1: Zonation and correlation between N. Jens-1, Valdemar-2P, Valdemar-3P, Valdemar-1P, Bo-1 and Boje-1
App. 1.2: Zonation of Valdemar-3H, Zonation of Valdemar-4H
App. 1.3: Zonation of Valdemar-1H, Zonation of Valdemar-2H

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App. 1.1

App. 1.2

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Report File no
Enclosure
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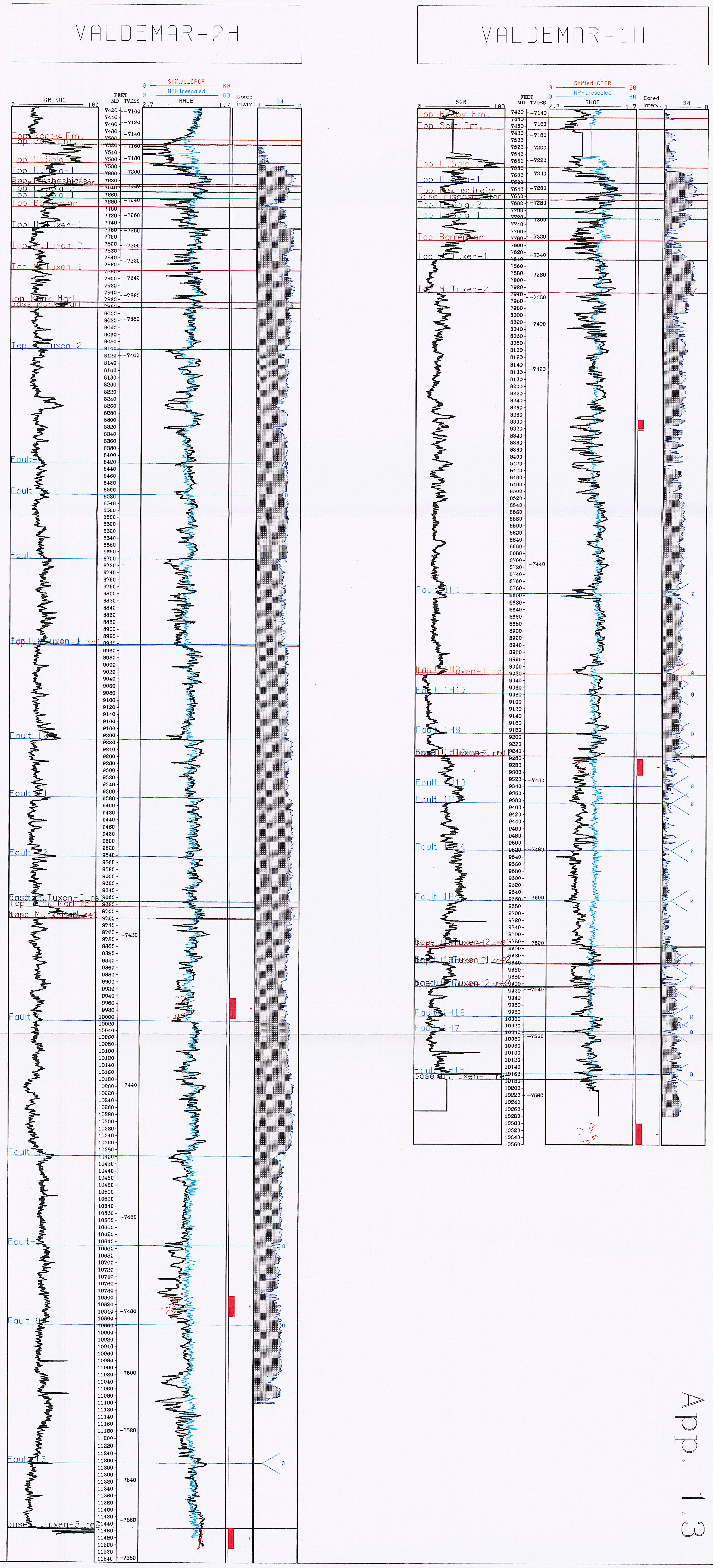

App. 1.3

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Report File no
Enclosure
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APPENDIX 2

Cross-sections along horizontal well traces

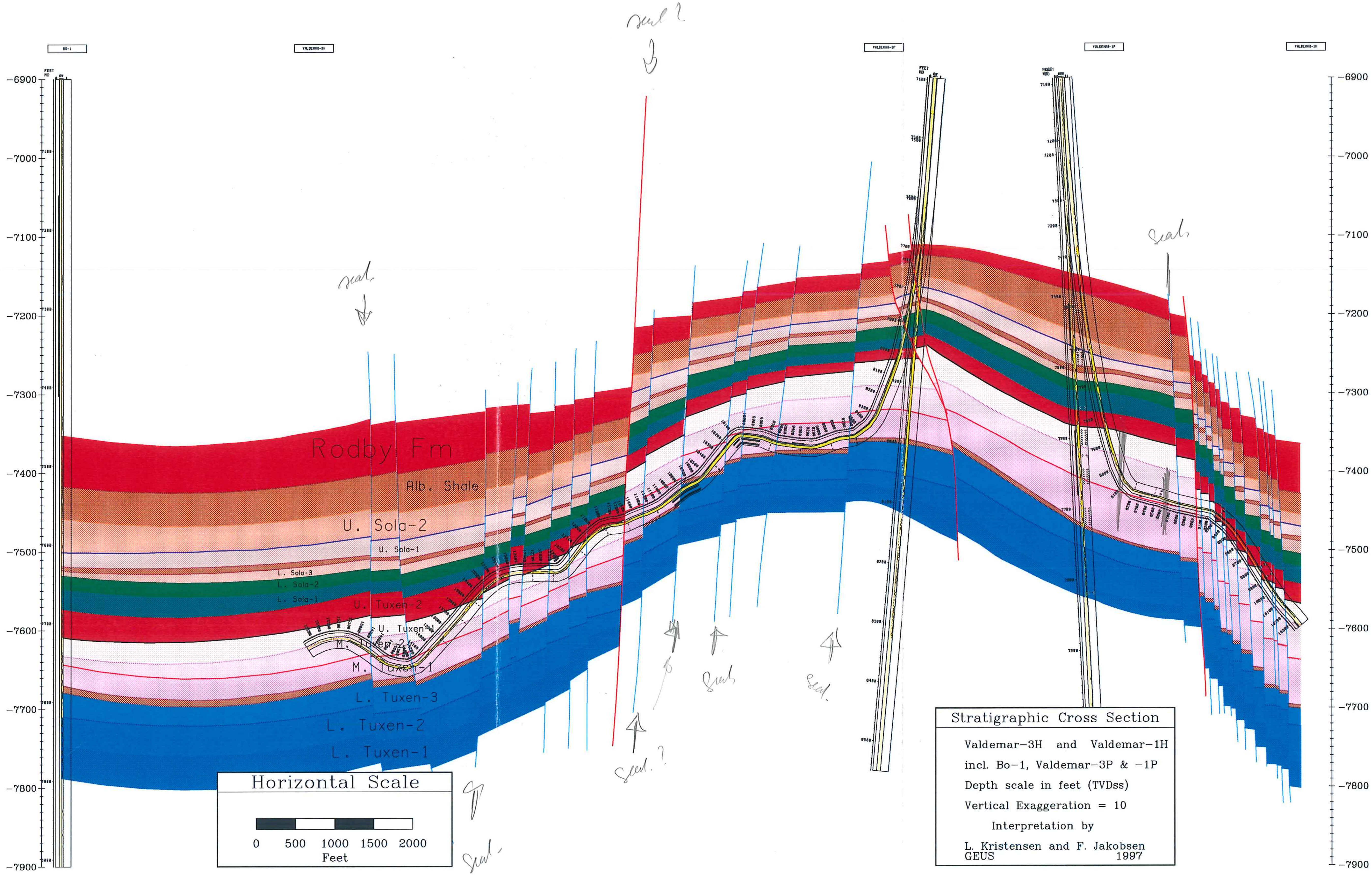
App. 2.1: Cross-section along the Valdemar-3H well trace (incl. the Valdemar-1H, Valdemar-1P, Valdemar-3P and Bo-1 wells). Vertical exaggeration : 8x

App. 2.2: Cross-section along the Valdemar-2H well trace (incl. the Valdemar-2P and the North Jens-1 wells). Vertical exaggeration : 4x

App. 2.3: Cross-section along the Valdemar-4H well trace (incl. the Valdemar-1P well). Vertical exaggeration : 4x

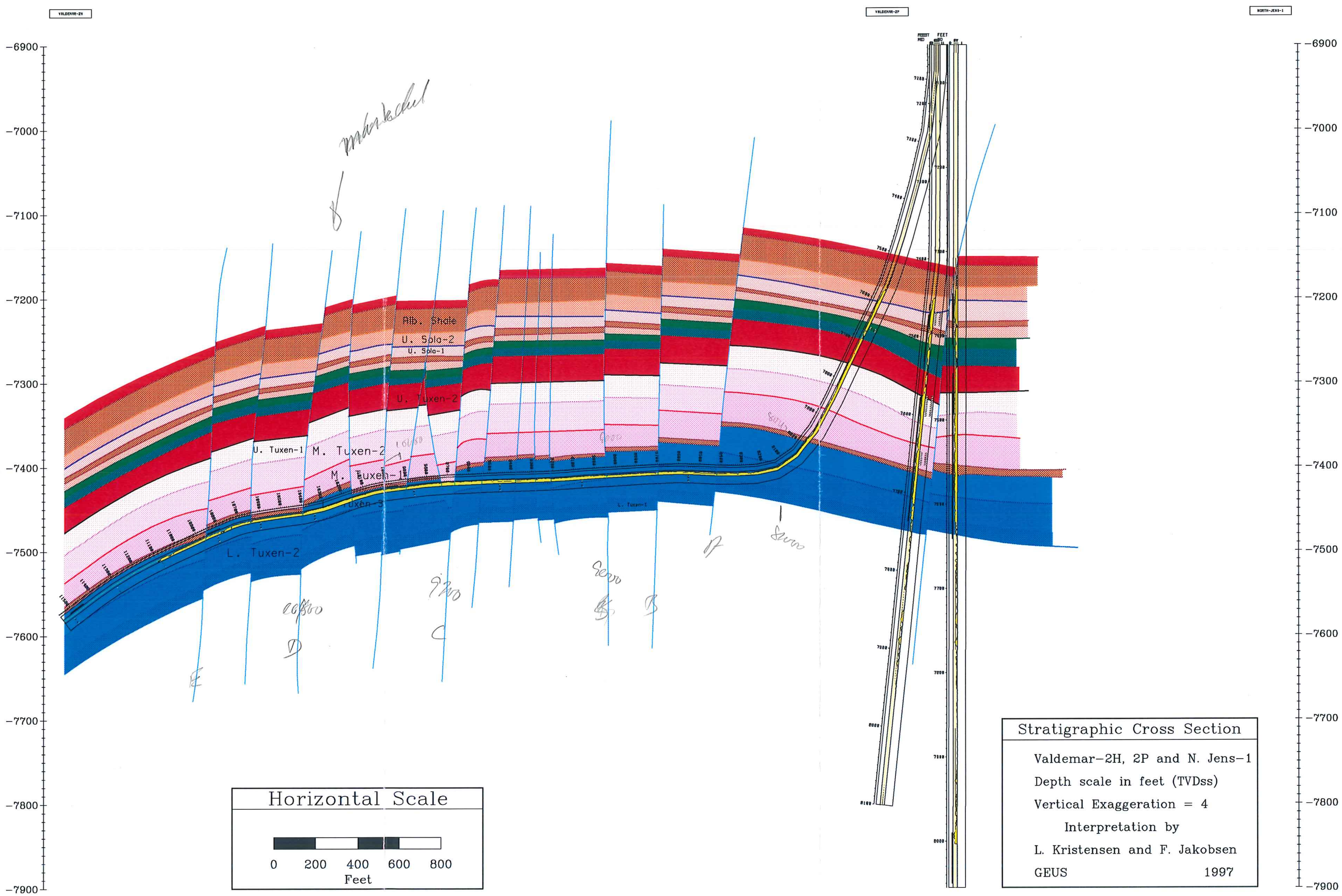
S Bo-1 Valdemar-3H-3P-1P-1H N

App. 2.1



Valde-2H, Valde-2P, N.jens-1

App. 2.2



Stratigraphic Cross Section

Valdemar-2H, 2P and N. Jens-1

Depth scale in feet (TVDss)

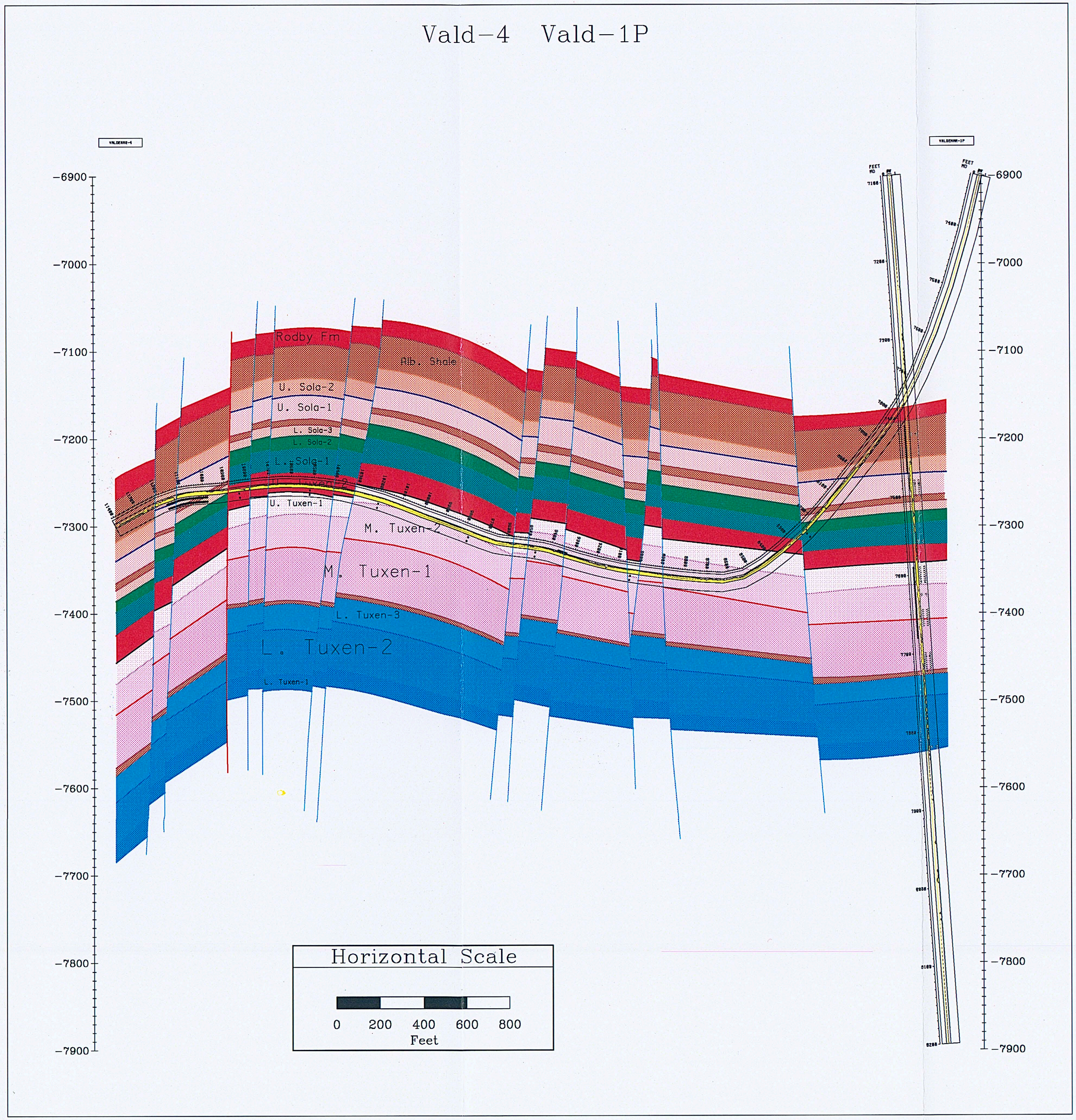
Vertical Exaggeration = 4

Interpretation by

L. Kristensen and F. Jakobsen

GEUS 1997

App. 2.3



Stratigraphic Cross Section

Valdemar-4H and Valdemar-1P

Depth scale in feet (TVDss)

Vertical Exaggeration = 4

Interpretation by

L. Kristensen and F. Jakobsen

GEUS 1997

APPENDIX 3

Correlation profiles
Adda, Tyra and Roar fields

App. 3.1: Correlation profile between Adda-2, Adda-1, Adda-3, S.E.Adda-1 and Deep Adda-1.

App. 3.2: Correlation profile between Adda-1, Adda-3, E-1, E-3 and Roar-2.

App. 3.1


ADDA-2
ADDA-1
ADDA-3
S.E. ADDA-1X
DEEP-ADDA-1
GR
GR_NUC
SGR
FEET
MD TVDSS
NPHIrescaled
Shifted_CPOR
RHOB
Cored interv.
Top Rodby Fm.
Top Sola Fm.
Top U. Sola-2
Top U. Sola-1
Top Fischschiefer
Base Fischschiefer
Top L. Sola-2
Top L. Sola-1
Top Barremian
Top U. Tuxen-1
Top M. Tuxen-2
Top M. Tuxen-1
Top Munk Marl
Base Munk Marl
Top L. Tuxen-2
Top L. Tuxen-1
Top Valhall Fm.

App. 3.2


ADDA-1
ADDA-3
E-1X
E-3X
ROAR-2
GR
RHOB
NPHI
FEET
MD TVDSS
Cored interv.
Top Rodby Fm.
Top Sola Fm.
Top U. Sola-2
Top U. Sola-1
Top Fischschiefer
Base Fischschiefer
Top L. Sola-2
Top L. Sola-1
Top Barremian
Top U. Tuxen-1
Top M. Tuxen-2
Top M. Tuxen-1
Top Munk Marl
Base Munk Marl
Top L. Tuxen-2
Top L. Tuxen-1
Top Valhall Fm.
LK