DGU
DANMARKS GEOLOGISKE UNDERSØGELSE • KORTSERIE • NR. 47
GEOLOGICAL SURVEY OF DENMARK • MAP SERIES NO. 47

Geological map of Denmark
Geologisk kort over Danmark
1 : 200 000

The Danish Central Graben / Den danske Centralgrav

'Top Chalk' and the Post Chalk Group
(two-way traveltime, depth and interval velocity)

'Top Kalk' og Post Kalk Gruppen
(to-vejs løbetid, dybde og intervalhastighed)

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Miljø- og Energiministeriet • København 1995
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Geologiske kort – et værktøj

Det geologiske kort er et værktøj, der bruges af brøndborere, ingeniørfirmaer, offentlige myndigheder, undervisere og mange andre.

DGU's vigtigste opgave er at kortlægge, dokumentere og informere om vort lands geologiske forhold: Hvad landet består af, hvorledes det er opbygget og dannet. DGU har over 100 års erfaring med udarbejdelse af sådanne geologiske kort.

Kortlægningen gælder undertiden mere specielle geologiske områder, f.eks. kortlægningen af fremstillingsråstoffer som grus, kalk og ler, og til andre tider er det energiråstoffer som brunkul, olie og geotermisk varme, men som regel indgår kortlægning af grundvand altid.

Det geologiske kort er den bedst egnede måde at beskrive landets opbygning og naturressourcernes fordeling på. Man kan imidlertid ikke fremstille et kort, der indeholder alt, og som kan anvendes til alle formål. Det enkelte kort indeholder derfor oftest et bestemt tema. Der findes således kort over bjergarternes udbredelse, såvel de overfladenære som de dybtliggende, hydrogeologiske kort, kort over prækvartæroverfladens højdeforhold, kort over grundvandsboringer, kort over strukturforholdene i den dybere undergrund og meget andet.

Ved udformningen og anvendelsen af kort er målforholdet af største betydning. Præcisionen i afgrænsningen mellem forskellige geologiske fænomener er afhængig af målforholdet. En ændring af målforholdet fra et lille til et stort (en forstørrelse af kortet) vil medføre en formindsket nøjagtighed. Det må endvidere tages i betragtning, at mængden af oplysninger på kortene ofte har måttet begrænses på grund af pladshensyn.

Et geologisk kort er, ligesom andre publikationer, udtryk for den viden, man har på det tidspunkt, kortet blev fremstillet. Men på grund af udviklingen i den geologiske videnskab og fremkomsten af nye oplysninger, kan der være behov for i tidens løb at revidere kortet.

Geological maps – a tool

The geological map is a tool used by well drillers, construction firms, public authorities, teachers, to mention a few.

The main tasks of the DGU are the mapping of the country, and providing documentation and information on the geological features of Denmark, the materials, their structures and genesis. The DGU has more than 100 years of experience in the preparation of geological maps of our country.

In addition the mapping aims at economic and public interest. It may be the mapping of manufacturing raw materials, i.e. clay, lime and gravel, or it may be energy raw materials such as lignite, oil and geothermal heat. The mapping of groundwater resources and the movement of the groundwater is an essential part of the work carried out by the DGU.

The geological map is the most suitable way to describe the geology of the country. Of course it is not possible to prepare a geological map which contains all available information and which can be used for all purposes. Therefore, specialized thematic maps are made, showing the geology of the subsurface, hydrology, position of water borings, preQuaternary surface, structural outline of the underground and much more.

In the presentation and the use of maps the scale is significant. The exactness of the boundaries between different geological phenomena depends on the scale of the map. A change of the scale from a small one to a larger one (an enlargement of the map) will diminish the accuracy. Furthermore, it must be considered that the geological documentation on the map frequently is limitated due to lack of space.

Like other publications a geological map expresses the knowledge of the area at a certain time. Because of the progress in geology and discoveries of new information it will be necessary to revise the map in the course of time.

DGU Danmarks Geologiske Undersøgelse
Miljø- og Energiministeriet

Danmarks Geologiske Undersøgelse (DGU) er en rådgivnings- og forskningsinstitution under Miljø- og Energiministeriet.

DGU har som hovedopgave at varetage dataindsamling og kortlægning samt forskning, rådgivning og formidling med sigte på at forbedre kendskabet til materialer, processer og sammenhænge, der har betydning for nyttiggørelsen og beskyttelsen af Danmarks geologiske naturværdier.

Blandt DGU's opgaver på miljøområdet kan nævnes rådgivning og forskning vedrørende miljøbeskyttelse, vandforsyning, råstofindvinding og naturbeskyttelse. På energiområdet bistår DGU med administration af lovgivningen om udnyttelsen af forekomster i Danmarks undergrund, herunder varetagelse af statens tilsyn med efterforskningen og indvindingen af olie, naturgas og jordvarme m.m. Desuden udfører DGU i vidt omfang opgaver for private firmaer på kontraktvilkår på miljøområdet såvel som på energiområdet.

Danmarks Geologiske Undersøgelse blev oprettet i 1888, og der er i de forløbne år publiceret en lang række afhandlinger om instituttets videnskabelige og praktiske virksomhed.

DGU *Geological Survey of Denmark*
Ministry of Environment and Energy

The Geological Survey of Denmark (DGU) is an advisory and research institution under the Danish Ministry of Environment and Energy.

DGU's primary function is to provide the essential geological service for the utilization and protection of Denmark's natural resources. This involves mapping, data collection and basic research, in addition to providing impartial advice and presenting geological results to both the general public and the scientific community.

Within the environmental sphere, DGU has both an advisory and a research role with respect to environmental protection, water supply, exploitation of raw materials and nature conservation. Within the energy sphere DGU assists in the administration of the utilization of deposits in the subsurface, including the supervision of exploration for and exploitation of oil, natural gas, geothermal energy etc. In addition, DGU undertakes numerous contract assignments for private firms, concerning both environmental and energy areas.

The Geological Survey of Denmark was established in 1888, and over the years a large number of papers have been published on the Survey's scientific and practical activities.

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Description

This publication comprises regional two-way traveltime and depth maps of the *'Top Chalk'* surface together with an interval-velocity map of the Post Chalk Group (Cenozoic excluding Danian, Nielsen & Japsen, 1991). The maps are at a scale of 1:200,000 covering up to 13,000 km^2 in the western part of the Danish North Sea sector. The maps are part of the results of an integrated mapping project sponsored by the Amoco 3rd Round Group, comprising Amoco Denmark, FLS-Energy, DENERCO, and DOPAS. The aim of the project was to model and map interval velocities and depths of the main mappable units in the Danish Central Graben. This mapping project has resulted in the publication of three additional map sets (Britze, Japsen & Andersen, 1995a, b, c).

The mapped area covers the Danish Central Graben and part of the eastern foot-wall block, the East North Sea Block, a part of the Ringkøbing-Fyn High system of elevated basement blocks (Rasmussen, 1978). Where data are available, adjacent parts of Norwegian, British, and German waters are included to define structural trends.

This study is based on well data and time structure maps of four well-defined marker horizons illustrating both the syn-rift and post-rift phases which have affected the area. Rifting in the area, largely during the Late Jurassic, resulted in a complex of grabens which form part of the North Sea Central Graben system. Cenozoic post-rift subsidence aligned over the former grabens created the North Sea Basin (Ziegler, 1990). In the context of this publication, however, the Central Graben refers to the area in the central part of the North Sea dominated by pre-Mid Cretaceous extensional faulting. The term 'Central Graben' as used in this wider geographical sense, has gained wide acceptance, in preference to 'Central Trough' as originally suggested by Rønnevik, van den Bosch & Bandlien (1975). It is, however, stressed that the area has experienced a complex poly-phase tectonic development, which since Mid Jurassic times has included segmentation due to faulting, subsidence, block rotation, and localized inversion followed by regional subsidence.

Database

All 1994 public domain petroleum industry seismic and well data were available for the study. The well database comprises 96 released exploration and appraisal wells drilled, as a minimum, into the Late Cretaceous – Danian Chalk Group, Lieberkind, Bang, Mikkelsen & Nygaard, 1982 (equivalent to the Shetland Group of the Norwegian shelf, Isaksen & Tonstad, 1989). The lithostratigraphic subdivision of most of the wells is presented in Nielsen & Japsen, 1991. Supplementary information is extracted from Danish Energy Agency, in press. Data from the recently drilled Alma-1 and Amalie-1 wells were made available for the publication of the maps by Mærsk Oil and Gas and Statoil, Denmark, respectively.

The seismic database varies in quality from 1979 2D sections to 1988 3D data. A selection of public domain 2D data is shown on the time structure maps for reference. This selection comprises regional speculative surveys acquired during the early and mid 1980s and proprietary surveys acquired by Mærsk Oil and Gas. Data from these surveys form the basis of the regional interpretation. The seismic interpretation of a number of fields is based on 3D data.

The structural traveltime map is primarily a compilation of unpublished interpretations carried out by the DGU as regional studies or as detailed field mappings. Supplementary mapping is carried out on the East North Sea Block and to cover gaps. The drafts of the time structure maps are compiled manually in the scale of 1:100,000. The final maps are produced digitally with the ZMAP Plus mapping system using a 200 m gridding interval.

Seismic interpretation

The structural traveltime map of the base of the Tertiary deposits, excluding the Danian *('Top Chalk')* represents the top of the Chalk Group everywhere except over the crests of the John and East Rosa salt diapirs. Here the mapped surface locally represents the top of the Zechstein Group.

The *'Top Chalk'* reflector is in general welldefined, and is picked on a high amplitude, laterally continuous trough marking a considerable increase in acoustic im-

pedance at the boundary between the Chalk Group including thin overlying marls and the Tertiary claystones. Phase reversals may occur locally, e.g. at the Tyra field where highly porous Danian Chalk is gas invaded (Megson, 1992). However, interpretation of this seismic marker is complicated over heavily faulted and fractured salt piercement structures. A reduction in or a total loss of amplitude strength caused by gas chimney effects in the overlying Tertiary may further reduce the seismic definition of the top of the Chalk Group (e.g. the Svend and Valhall fields).

Depth conversion

The depth to *'Top Chalk'* is calculated by a three-layer model. The water column is treated as a separate layer. The Post Chalk Group is subdivided into an upper and a lower unit separated at the base of the Cen-5 Unit, Kristoffersen & Bang, 1982 (equivalent to base Nordland Group, close to the level of the onset of overpressure in the area). The thickness of each of these units is calculated by velocity-anomaly depth conversion (Japsen, 1993). Depths in the lower unit are referred to the base of the Cen-5 Unit. This shift in reference level is chosen due to the overpressuring of the lower unit (Japsen, 1994). The choice of depth conversion method is based on an analysis of the relative success of a number of methods (Japsen, 1994).

In velocity-anomaly depth conversion the thickness of each layer is calculated sequentially from the top downwards from the seismic traveltime thickness by assuming the velocity of the layer to increase linearly with depth. Laterally, however, velocity is calibrated to match well data. The deviations, or the velocity anomalies, between the linear velocity-depth functions and well-derived interval velocities, represent the lateral velocity variation of the layer when the influence of depth is removed. The velocityanomaly map, the seismic traveltime maps, and the linear velocity parametres for each layer constitute input for velocity-anomaly depth conversion. The output is depth and interval-velocity maps. The velocity-anomaly maps for the upper and lower Post Chalk Group are based on data from 95 wells; simplified versions of these maps are presented by Japsen, 1994. In 23 wells without recordings of traveltime to the base of the Cen-5 unit, velocity anomalies in the upper layer were estimated from data from neighbouring wells. Around the T-1 well the velocityanomaly contours for the upper layer are based on mapping of the gas chimney visible on seismic sections. The regional velocity function for the upper Post Chalk Group is taken to be $V = 1725\ m/s + 0.4\ s^{-1} \cdot Z$ (Z is depth in metres below mean sea level) and for the lower part $V = 1975\ m/s + 0.2\ s^{-1} \cdot Z_r$ (Z_r is the depth in meters below base Cen-5 Unit), Japsen, 1994. These functions are based on an analysis of time-depth relationships recorded in wells in the area.

The interval-velocity map of the Post Chalk Group is calculated by dividing the thickness of the Post Chalk Group (depth to *'Top Chalk'* minus water depth) by its traveltime thickness. The interval velocities are generally very uniform across the mapped area, typically varying between 2025 and 2075 m/s. Abnormally low velocities (about 1900 m/s), recorded in the T-1 well on the crest of the Svend Field are caused by gas invasion into the Tertiary section. In contrast, velocities in excess of 2100 m/s were recorded in flank wells adjacent to salt piercement structures to the southwest near the Danish – German border. These high velocities might be caused by near-to-normal compaction of the Lower Tertiary due to bleed-off of overpressure through fractures (Japsen, 1994). The velocity field over the eastern margin of the mapped area is defined by data from a small number of wells further east.

The *'Top Chalk'* structural depth map approximates the isochore of the Post Chalk Group, as water depths in the area are limited (30–70 m). Depth to base Post Chalk Group is found to vary between 618 m below mean sea level in the John-1 well, where Zechstein salt is piercing the Chalk Group, and 3350 m east of the T-1 well. Minimum depth to the Chalk Group is 1287 m recorded in the East Rosa-1 well.

Brief review of geological evolution

During the Cenozoic the mapped area experienced rapid subsidence with development of predominantly deep water shales during the Paleogene and generally coarser more shallow marine clastics since late Miocene times (Kristoffersen & Bang, 1982). The area subsided as part of the Cenozoic North Sea Basin by broad regional down-warping (Ziegler, 1990). The axis of the North Sea Basin is aligned with the former Viking and Central graben systems. The rapid subsidence since late Miocene is responsible for maturation of the organic-rich shales of Late Jurassic age, the main source rock of the area (Damtoft et al., 1992). Owing to the high sedimentation rate in the late Cenozoic and the low permeability of the lower Tertiary, formation water has not yet escaped and normal com-paction is not established, leading to overpressure conditions in the pre-Upper Miocene sediments (cf. Japsen, 1994).

A dominant, structural feature on the *'Top Chalk'* depth map is the broad NW-SE trending zone deeper than 3100 m extending from Norwegian waters into the mapped area. This zone is termed the Jeppe Basin (new name, the Cenozoic structural nomenclature is indicated on the *'Top Chalk'* depth map). From this depocentre the thickness of the Cenozoic decreases steadily towards both east, south and west. This rather simple basin geometry is interrupted by inversion ridges, intra-graben horsts and halokinetic structures. The central part of the

Lindesnes Ridge (Skjerven, Riis & Kalheim, 1983) located in Norwegian waters suffered intense flexural inversion during the early Tertiary (Gowers, Holtar & Swensson, 1993). Another marked inversion zone formed in the early part of the Tertiary is the broad NW-SE trending Tyra-Igor Ridge (new name) in the south. Here the *'Top Chalk'* surface is shallower than on the adjacent, stable East North Sea Block.

Two pre-existing intra-graben horsts, the Mandal High (Rønnevik et al., 1975) and the Inge High (Møller, 1986) are both expressed as subtle drape structures on the *'Top Chalk'* surface.

Halokinetic movements of Zechstein rock salt were active during the Cenozoic, and the *'Top Chalk'* surface displays a number of salt piercement structures as well as more gentle pillows, both with associated rim-synclines. The majority of the halokinetic structures are located in the Salt Dome Province to the south (Møller, 1986). In the north-eastern part of the mapped area a number of salt-induced swells and low angle listric faults are recognized indicating rejuvenation of halokinetic structures during the Cenozoic on the flanks of the predominantly Permo-Triassic Norwegian-Danish Basin.

Hydrocarbon aspects

The status of a well with respect to hydrocarbons encountered in a given stratigraphic interval is expressed by the well symbol shown on the maps. A distinction between oil and/or gas, and between shows and pay-zones where hydrocarbons could be produced in tests, is attempted. The presence of hydrocarbons in the Chalk Group is indicated on the *'Top Chalk'* structure maps (47a, b), while hydrocarbons in the Post Chalk Group are indicated on the interval-velocity map (47c).

Exploration of the Late Cretaceous – Danian chalk play has been successful in the mapped area, where at present 11 oil and gas fields of varying sizes are producing with the Chalk Group as primary reservoir (Danish Energy Agency, in press, and Norwegian Petroleum Directorate, 1994). The fields are expressed as structural closures at *'Top Chalk'* level and are indicated on the *'Top Chalk'* depth map (47b). These are the Dagmar, Dan, Gorm, Kraka, Regnar, Rolf, Skjold, and Tyra fields in Danish waters and the West and East Hod, and Valhall fields in Norwegian waters. The East Harald, Roar and Svend fields are under development, and the minor accumulations of the Adda and Igor discoveries have been declared commercial, but await future development.

The hydrocarbons are predominantly trapped in Danian and Maastrichtian chalks (equivalents of the Ekofisk and Tor Formations, Isaksen & Tonstad, 1989) with Paleocene shales acting as top-seal. Several types of structural traps can be distinguished (Andersen & Doyle, 1990):

- Broad low-relief closures caused by Tertiary inversion movements (the Tyra, Roar, and Igor gas fields). The reservoirs are largely unfractured but usually exhibit very high matrix porosities.
- Domal, low relief closures, created by underlying mobile salt (the Dan, Gorm, Kraka, and East Harald fields). The reservoirs show a variable degree of fracturing depending upon the structural position of the reservoir relative to the underlying salt.
- Pinnacle type, high relief closures created by salt piercement: Here the chalk is rafted up on a salt stock and in places dislocated by ring faults from the surrounding chalk strata (the Skjold, Regnar, Dagmar, Rolf, and Svend fields). These high relief structures tend to be highly fractured, and matrix porosity and permeability are characteristically lower than for the other trap types.

The exploration for hydrocarbons in chalk in the Danish Central Graben area is in a mature stage as all significant structural closures at *'Top Chalk'* level have been drilled. However, a number of accumulations trapped within the chalk by an intra-chalk top-seal have been encountered. The most outstanding is the Coniacian-Turonian reservoir unit in the Adda-1 well (Andersen & Doyle, 1990, and Megson, 1992).

Both gas and oil shows have frequently been recorded in thin sand stringers in the Tertiary section overlying the chalk in wells predominantly drilled on the crests of salt piercement structures. These shows are generally imaged in the seismic sections as 'bright spots'. None of these shows are of commercial potential, but have rather been considered a drilling hazard during exploration work for deeper objectives. However, hydrocarbons have been produced from the Tertiary section, e.g. gas was produced from a 20 m thick sand sequence in the Palaeocene in the Elna-1 well, located on the shoulder of the East North Sea Block and drilled with a Palaeozoic target.

Dansk sammendrag

De foreliggende regionale kort viser de strukturelle forhold i reflektionstid og dybde for *'Top Kalk'*-fladen samt intervalhastigheden for Post Kalk Gruppen (Kænozoikum undtagen Danien, Nielsen & Japsen, 1991). Kortene er udarbejdet som led i en samlet kortlægning af Den danske Centralgrav baseret på seismiske data og boringer. Yderligere tre kortudgivelser indgår i denne kortlægning (Britze, Japsen & Andersen, 1995a, b, c). Kortene dækker den danske del af Centralgraven og dele af Den østlige Nordsøblok. Dele af den nærliggende norske, engelske og tyske sektor er inddraget i kortlægningen for

at definere strukturelle retninger, hvor data var tilgængelige.

'Top Kalk' betegner den flade, der udgør basis af de tertiære aflejringer (undtagen Danien). Fladen repræsenterer toppen af Kalk Gruppen i størstedelen af det kortlagte område på nær lokalt over Øst Rosa og John saltdiapirerne. Her er fladen identisk med toppen af Zechstein Gruppen. Det seismiske tidskort er en sammenstilling af upublicerede tolkninger udført af DGU som led i regionale studier eller feltkortlægninger.

Dybden til *'Top Kalk'* er beregnet ud fra en tre-lags model. Vandsøjlen er behandlet som et separat lag, og Post Kalk Gruppen er underinddelt i to lag. De seismisk bestemte tider er digitalt omregnet til dybder efter en metode hvor et lag tilskrives en lineær hastighedsstigning med dybden (Japsen, 1993). Afvigelser fra hastighedsmodellen beregnes i boringerne og sammenstilles på et kort for hvert lag i modellen. Disse hastighedsanomalikort er på digital form anvendt til korrektion af den lineære hastighedsmodel. Den regionale hastighedsfunktion for den øverste del af Post Kalk Gruppen er bestemt til $V = 1725\ m/s + 0.4\ s^{-1} \cdot Z$ (Z er dybden i meter under havniveau) og for den nederste del til $V = 1975\ m/s + 0.2\ s^{-1} \cdot Z_r$ (Z_r er dybden i meter under basis Cen-5 Unit), Japsen 1994.

Intervalhastigheden for Post Kalk Gruppen er beregnet til typisk at variere mellem 2025 og 2075 m/s. Dybden til basis af Post Kalk Gruppen varierer mellem 618 m under havniveau i John-1 boringen og 3350 m øst for Svend feltet. Minimumsdybden til toppen af Kalk Gruppen er 1287 m i Øst Rosa-1 boringen.

I kænozoisk tid udvikledes et større indsynkningsområde dækkende det meste af den nuværende Nordsø med akse langs sporet af de tidligere graben systemer. Maksimum indsynkning med afsætning af sedimenter med en tykkelse på mere end 3000 m fandt sted i den nordvestlige del af det kortlagte område. Herfra aftager dybden til *'Top Kalk'* overfladen både mod øst, syd og vest. Denne simple bassin-geometri brydes dog af en række NV-SØ gående inversionsrygge af tidlig tertiær alder, relikter af tidligere intra-graben horste samt af et større antal diapirer og puder forårsaget af flydning af underlejrende Zechstein salt.

Ialt 11 producerende olie og gas felter befinder sig indenfor det kortlagte område (heraf tre på norsk sokkel). Disse har alle hovedreservoir i kalksten i den øverste del af Kalk Gruppen og er forseglet af lersten af tertiær alder. Hertil kommer yderligere tre felter under udbygning samt to mindre, som er erklæret kommercielle med henblik på senere udbygning. Fælles for disse kulbrinteakkumulationer (pånær en) er, at de fremtræder som strukturelle lukninger på *'Top Kalk'* fladen. Hovedparten af fælderne er knyttet til saltstrukturer, mens et mindre antal er knyttet til inversionsstrukturer med lavt relief. Gas og olie er også påvist i de tertiære aflejringer over kalken. I enkelte tilfælde er sådanne forekomster blevet prøveproduceret.

Navne på kænozoiske strukturelementer samt navne på kalkfelterne er angivet på *'Top Kalk'* dybdekortet (47b). En karakteristik af kulbrinteforekomsterne er angivet på kortene. Kulbrinteforekomster i Kalk Gruppen er markeret på de strukturelle kort over *'Top Kalk'* (47a, b), mens forekomster i Post Kalk Gruppen er angivet på intervalhastighedskortet (47c).

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DGU Map Series no 47. Map 47a.

The Danish Central Graben

'Top Chalk'

Base of the Tertiary deposits (excluding the Danian)

Time structure map

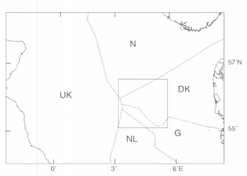
Contour interval 50 milliseconds

Mapped and compiled by
P. Britze, C. Andersen and P. Japsen

0 2 4 6 8 10 km

1:200.000, UTM zone 31
Spheroid: Hayford 1909

Printed 1995



Geological Survey of Denmark
Ministry of Environment and Energy

Legend

Structural geology

- Normal fault
- Reverse fault
- H Structural high
- L Structural low

Well information

- Mona–1 Well name
- Well symbol related to hydrocarbons iin the Chalk Group
- 2967 Two-way time to 'Top Chalk', measured in the well (msec)
- Anne–3 Well name of a deviated well
- Trace of deviated well between surface and subsurface location
- 1773 Vertical two-way time to 'Top Chalk', measured in the well (msec)
- (Tobita–1) Well name, data not in public domain
- Surface location

Well symbols related to hydrocarbons in the Chalk Group / Chalk Group not penetrated

- No shows
- Oil show
- Gas show
- Oil production (test)
- Gas/condensate production (test)
- Well drilled into older strata than the Chalk Group, Chalk Group absent

MPBC–11 Seismic line

Two-way travel time
in milliseconds below mean sea level

Not mapped (gas chimney)

Norway
Denmark

Germany
Netherlands

Produced using Landmark's ZMAP Plus application

6,260,000 6,240,000 6,220,000 6,200,000 6,180,000 6,160,000 6,140,000 6,120,000

520,000 540,000 560,000 580,000 600,000 620,000 640,000 660,000

DGU Map Series no 47. Map 47b.

The Danish Central Graben

'Top Chalk'

Base of the Tertiary deposits (excluding the Danian)

Depth structure map

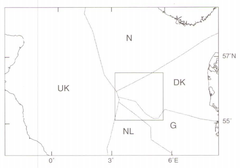
Contour interval 50 metres

Mapped and compiled by
P. Britze, P. Japsen and C. Andersen

0 2 4 6 8 10 km

1:200.000, UTM zone 31
Spheroid: Hayford 1909

Printed 1995



DGU
Geological Survey of Denmark
Ministry of Environment and Energy

Legend

Structural geology

Normal fault

Reverse fault

Inge High — Cenozoic (excl. Danian) structural element

Well information

Mona-1 — Well name

Well symbol related to hydrocarbons in the Chalk Group

2989 — Depth to 'Top Chalk', measured in the well (m)

Anne-3 — Well name of a deviated well

Trace of deviated well between surface and subsurface location

1801 — Vertical depth to 'Top Chalk', measured in the well (m)

(Tabita-1) — Well name, data not in public domain

× — Surface location

Well symbols related to hydrocarbons in the Chalk Group / Chalk Group not penetrated

No shows

Oil show

Gas show

Oil production (test)

Gas/condensate production (test)

Well drilled into older strata than The Chalk Group, Chalk Group absent

Fields and discoveries with main reservoir in the Chalk Group

Dan — Producing fields

Igor — Commercial discovery

Depth

in metres below mean sea level

above 1500
1500-1600
1600-1700
1700-1800
1800-1900
1900-2000
2000-2100
2100-2200
2200-2300
2300-2400
2400-2500
2500-2600
2600-2700
2700-2800
2800-2900
2900-3000
3000-3100
3100-3200
3200-3300
3300-3400

Lindesnes Ridge
Not mapped (gas chimney)
Valhall
Hod
West
Jeppe Basin
Mandal High
Harald East
Svend
Inge High
Tyra
Igor Ridge
Rolf
Dagmar
Gorm
Skjold
Salt Dome
Dan
Kraka
Regnar
Adda
Roar
Tyra
Igor
Norway
Denmark
Germany
Netherlands
North Sea Basin
Province
Landmark Produced using Landmark's Z-MAP Plus application

DGU Map Series no 47. Map 47c.

The Danish Central Graben

Post Chalk Group

Cenozoic excluding Danian

Interval velocity map

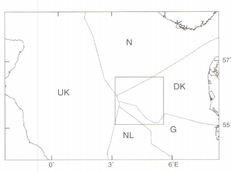
Contour interval 25 metres/second

Mapped and compiled by
P. Japsen

0 2 4 6 8 10 km

1:200.000, UTM zone 31
Spheroid: Hayford 1909

Printed 1995



Geological Survey of Denmark
Ministry of Environment and Energy

Legend

Structural geology

Normal fault at 'Top Chalk' level

Reverse fault at 'Top Chalk' level

Well information

Mona–1 — Well name

Well symbol related to hydrocarbons in the Post Chalk Group

2031 — Interval velocity of the Post Chalk Group, measured in the well (m/sec)

Anne–3 — Well name of a deviated well

Trace of deviated well between surface and subsurface location

2049 — Interval velocity of the Post Chalk Group, measured in the well (m/sec)

(Tabita–1) — Well name, data not in public domain

Surface location

A–2 — Well name

2031 — Interval velocity of the Post Chalk Group, from seismic and well data (m/sec)

Well symbols related to hydrocarbons in the Post Chalk Group

No shows

Oil show

Gas show

Gas/condensate production (test)

Interval velocity
in metres/second

- below 1950
- 1950-1975
- 1975-2000
- 2000-2025
- 2025-2050
- 2050-2075
- 2075-2100
- 2100-2125
- 2125-2150
- 2150-2175

Not mapped (gas chimney)

Norway
Denmark

Germany
Netherlands

Landmark Produced using Landmark's Z-MAP Plus application

3°15′00″ 3°30′00″ 3°45′00″ 4°00′00″ 4°15′00″ 4°30′00″ 4°45′00″ 5°00′00″ 5°15′00″ 5°30′00″

6,260,000 6,240,000 6,220,000 6,200,000 6,180,000 6,160,000 6,140,000 6,120,000

520,000 540,000 560,000 580,000 600,000 620,000 640,000 660,000

This publication comprises regional two-way traveltime and depth maps of 'Top Chalk' together with an interval velocity map of the Post Chalk Group (Cenozoic excluding Danian) covering an area of some 13,000 km^2 located in the western part of the Danish North Sea sector. The maps represent an integrated geological and geophysical interpretation based on public domain petroleum industry seismic and well data.

De foreliggende regionale kort viser de strukturelle forhold i reflektionstid og dybde for 'Top Kalk'-fladen samt intervalhastigheden for Post Kalk Gruppen (Kænozoikum undtagen Danien) i et ca. 13.000 km^2 stort område beliggende i den vestlige del af den danske sektor i Nordsøen. Kortene er resultatet af en samlet geologisk og geofysisk tolkning baseret på reflektions-seismiske data og boringsinformationer indsamlet som led i efterforskning og indvinding af kulbrinter.

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