

GAS FIELDS OF BERGEN CONCESSION, THE NETHERLANDS¹

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ABSTRACT

Van Lith, J. G. J. 1983 Gas Fields of Bergen Concession, The Netherlands. In: J. P. H. Kaasschieter & T. J. A. Reijers (eds.): Petroleum geology of the southeastern North Sea and the adjacent onshore areas (The Hague, 1982) — Geol. Mijnbouw 62: 063-074.

The Bergen Concession is located onshore in the Netherlands province of Noord-Holland, about 25 km NW of Amsterdam and 150 km SW of Groningen gas field. The Concession was granted on May 1, 1969, on the basis of gas discoveries drilled in 1964 and 1965. In 1972 the first field came on stream. Currently five fields are producing and one more is planned to be connected in 1983. The gas from all fields is treated at a central gas drying plant and is delivered to the Netherlands marketing organization N.V. Nederlandse Gasunie. The gas is sold to German power companies.

Productive reservoirs have been found in Permian Upper Rotliegend Slochteren sandstone, Upper Permian Zechstein 3 Carbonate (Platten dolomite) and Lower Triassic Main Buntsandstein (Middle Bunter sandstone).

Operations in the Concession have progressed slowly due to environmental considerations. The area contains nature-reserve and drinking-water areas in the dunes which protect polder areas from the sea. The ecological and economic quality of the polder land below sea level is maintained by strict management of surface and ground water.

The geology of the Concession area and the impact of environmental requirements on the gas exploration and producing operations are discussed.

INTRODUCTION

General Concession history

The Bergen Concession is located in the Netherlands province of Noord-Holland, about 25 km northwest of Amsterdam and 150 km southwest of Groningen gas field (Fig. 1). The Concession area measures 252 km² (62270 acres).

Exploration for hydrocarbons by Amoco Netherlands Petroleum Company as operator for a group including Exploratie- en Productie Maatschappij Dyas N.V. (now B.V.) and Gelsenkirchener Bergwerks (later Gelsenberg AG, now Veba Oil Nederland B.V.) started with seismic activities in 1962. At that time exploration in The Netherlands was not regulated by law and required only the permission of land owners. Production of hydrocarbons ('bitumina') and other natural resources onshore was, and is, subject to the Mining Law 'Loi Concernant les Mines, les Minières et les Carrières' enacted by Napoleon in 1810.

In 1964 and 1965 the Amoco Group discovered gas at Schermer and Heiloo and applied for the Concessions 'Bergen' and 'Limmen', covering together approximately the area of the present Bergen Concession. Pending enactment of Exploration Legislation the Netherlands Government acted to halt exploration drilling in November 1965. The Minerals Exploration Act (Wet Opsporing Delfstoffen) was promulgated on May 3, 1967, and under this law a Licence was issued to the Amoco Group in November 1968 to allow drilling in the Bergen area until the Production Concession applications would be honoured. The existing Concession was granted on May 1, 1969, and the State elected to participate for a 40 % interest through its agency DSM Aardgas B.V. Development of the discoveries in Bergen Concession was delayed considerably as a result of slow zoning procedures. In addition to the period of four years from the Bergen discovery until the grant of the Concession it took another seven years to obtain the necessary permits for the Bergen field to build a surface location and to drill the development wells. The first field to come on stream was Bergermeer in September 1972 followed by Groet in January 1974, Bergen in October 1978, Alkmaar and Schermer in September 1979. The Heiloo field is planned to be connected in 1983.

¹ Manuscript received: 1982-11-26.

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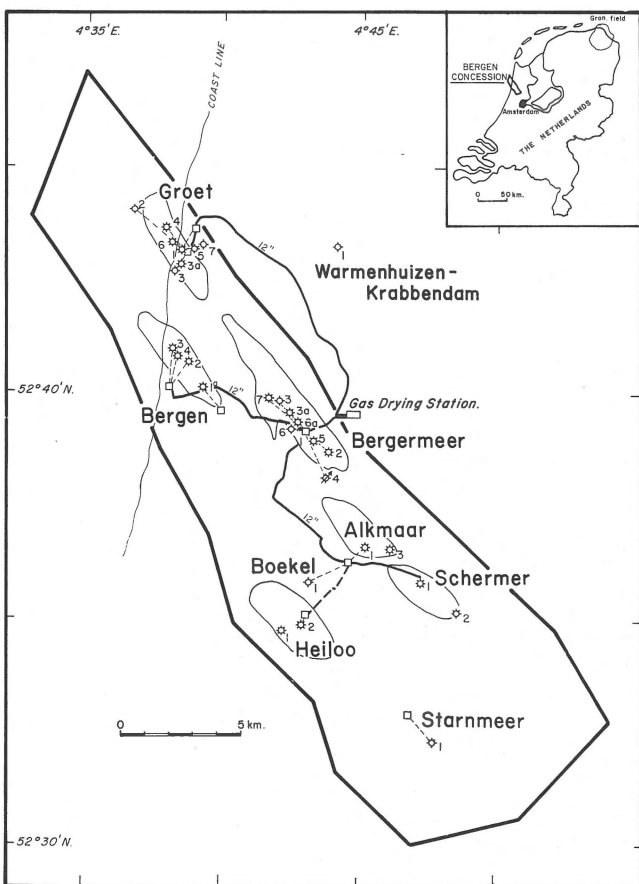


Fig. 1
Location map showing outline of Bergen Concession, gas fields, wells and pipe lines.

The gas from the Bergen Concession is sold to utility companies in Western Germany. As production in Bergen Concession is distant from the point of delivery at the Dutch/German border, a gas-exchange agreement was made with the Netherlands gas distribution and sales company, N.V. Nederlandse Gasunie, whereby Gasunie furnished Groningen gas at the Netherlands/Germany border while Amoco furnished equivalent Bergen gas to Gasunie at the Bergen gas-treating facility.

Exploration drilling history

The first well drilled in the Bergen Concession area, Schermer-1, was a success. It was completed in October 1964 as a gas well in the Zechstein. Subsequently, the rig was moved off to a location at Warmenhuizen-Krabbendam, outside the present Concession. This well was dry and abandoned. It was followed by Heiloo-1 which was suspended in March 1965 as a Bunter gas well. Further drilling took place at Bergen-1A, which was suspended in June 1965 as a gas discovery in the Rotliegend; at Schermer-2 which had gas shows in the Zechstein, but was abandoned as a dry hole in May 1965 and at Groet-1, which was completed as a gas well in

the Rotliegend in October 1965. Finally, in this series, Schermer-3 was suspended as a gas well in the Zechstein in September 1965.

As a result of the drilling moratorium imposed by the Government in November 1965, drilling in the Bergen area did not resume again until the summer of 1969, when Bergermeer-1 was completed as a gas discovery in the Rotliegend. The next series of wildcats was drilled in 1975. The Starnmeer well in the southern part of the Concession found non-commercial gas in the Zechstein. Boekel-1 and Alkmaar-1 were drilled from one surface location. The Boekel well found a reduced Platten Dolomite with the reservoir possibly faulted out but Alkmaar-1 encountered a good Platten reservoir and became the first Zechstein producer in the Concession. The first Zechstein discovery, Schermer-1, was not put on stream but was deepened in 1976 and completed as a producer in the Rotliegend. Lastly, Heiloo-2 was drilled in March 1982, and will probably be connected in 1983 as a Bunter producer.

Development

After follow-up of the Bergermeer discovery in 1970, this field was further developed in 1972 by four additional development wells. The no. 4 well was made into a water-injection well. Nos. 3 and 6 wells were kicked back into the producing zone because they originally terminated too low in the reservoir. The Groet field was developed in 1971, but the Bergen field was not developed until 1976, when three development wells were drilled from a surface location outside the field area. The last development wells in Bergen Concession were drilled in 1980. These were Groet-7 which was not successful, and Bergermeer-7 which extended the Bergermeer field beyond Bergermeer-3.

STRATIGRAPHY

General

The formation names in this paper follow as closely as possible the Stratigraphic Nomenclature of the Netherlands (NAM & RGD, 1980). However, some historically accepted and regularly used other names are also mentioned. The general stratigraphy of the Bergen Concession area is shown in figure 2.

The oldest formations drilled in the Concession area belong to the Limburg Group, and are Westphalian B or C in age. The Limburg Group is unconformably overlain by the Early Permian Upper Rotliegend Slochteren Sandstone, which is the main gas reservoir. It is followed upward by the Late Permian Zechstein Group of which only three cycles are more or less completely developed. The Z3 Carbonate or 'Platten Dolomite' is the second gas reservoir in Bergen Concession. The Lower Germanic Trias Group is truncated by the Hardegsen Unconformity down to a level between the Detfurth

AGE	GROUP	FORMATION	MEMBER	LITHOLOGY	
QUATERNARY					
TERTIARY	NORTH SEA				
EARLY CRETACEOUS	RIJNLAND	HOLLAND			
		VLIELAND			
EARLY JURASSIC	ALTENA	AALBURG SHALE			
TRIASSIC	UPPER GERMANIC TRIAS	SLEEN SHALE			
		KEUPER			
		MUSCHELKALK			
	LOWER GERMANIC TRIAS	RÖT	UPPER RÖT CLAYSTONE MAIN RÖT EVAPORITE		
		MAIN BUNTSANDSTEIN	DET FURTH < CLAYST. SANDST. VOLPRIEH < SANDST.		
		LOWER BUNTSANDSTEIN	ROGENSTEIN		
PERMIAN	ZECHSTEIN	ZECHSTEIN 4	Z3 SALT		
		ZECHSTEIN 3	Z3 MAIN ANHYDRITE Z3 CARBONATE GREY SALT CLAY Z2 ROOF ANHYDRITE		
		ZECHSTEIN 2	Z2 SALT Z2 BASAL ANHYDRITE Z2 SHALE		
		ZECHSTEIN 1	Z1 ANHYDRITE Z1 CARBONATE COPPER SHALE		
		UPPER ROTLIEGEND	SLOCHTEREN SANDSTONE		
	CARBONIF.	LIMBURG			

Fig. 2
General Stratigraphy.

Shale and the Volpriehausen Sandstone. The Main Buntsandstein or 'Middle Bunter' sandstones constitute a third reservoir in the Bergen Concession area. The Upper Germanic Trias Group consists of Röt evaporites followed by Röt claystones which are overlain by Muschelkalk and Keuper deposits. Rhaetian and Jurassic rocks are found only in the central and eastern part of the Concession and are represented by shales equivalent to the Altana Group. Early Cretaceous Rijnland sands and claystones are found in a nearly complete section in most wells but are truncated by the Laramide Unconformity in the Heiloo area. Tertiary and Quaternary sands and claystones complete the sequence to the present-day surface.

Reservoir formations

Rotliegend – The most important reservoir in Bergen Concession, as elsewhere in The Netherlands, is the Upper Rotliegend (Fig. 3). Thicknesses of the Rotliegend in the Bergen Concession are of the order of 200 to 270 m. The Bergen Concession is located in the area of Rotliegend aeolian deposits (Fig. 4).

Although the Rotliegend in the Bergen Concession is mainly of aeolian origin, it is usually possible to divide the

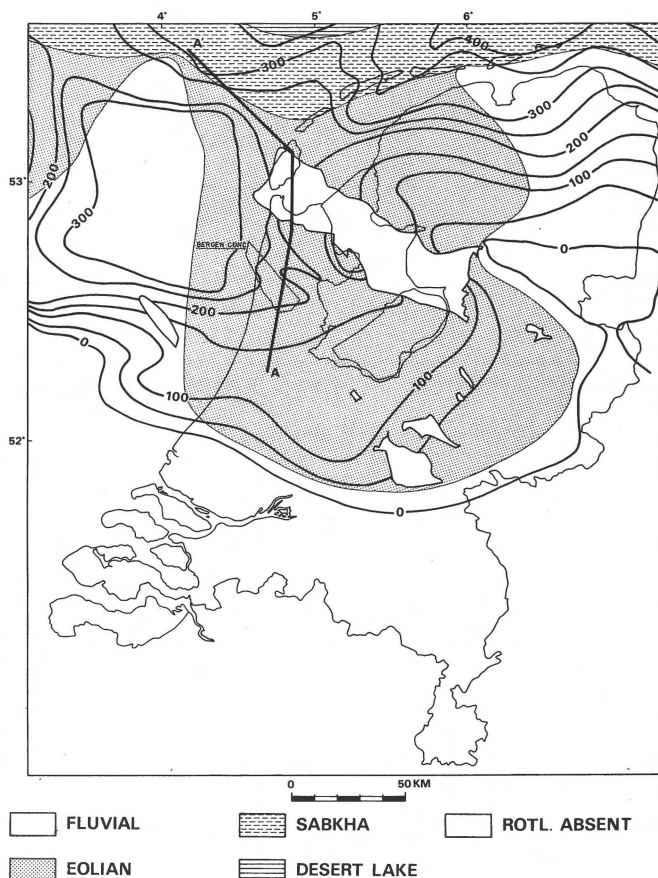


Fig. 3
Rotliegend regional isopach and facies, after Van Adrichem Boogaert, 1976, Van Wijhe et al., 1980.

section into three main units: a basal unit of low porosity, a middle unit of high porosity and an upper unit of low porosity. Study of core and dipmeter data indicates that the upper and lower units were deposited partly in water and that the middle unit was deposited under aeolian conditions. Figure 5 shows this tripartite division in the Schermer, Bergermeer and Groet wells.

The basal water-laid unit, which is characterized by poor sorting and high clay content, has porosities of approximately 15%. The middle aeolian unit can be shown by dipmeter evidence to consist of a number of aeolian depositional cycles that vary in thickness from 15 to 70 m and consist of a basal 5 to 8 m thick bed with low internal dip, overlain by a large-scale foreset ensemble of varying thickness with internal dips increasing upward. The average spread between the lowest and highest dips in a single aeolian cycle is approximately 25° to 30°. Low dip beds have porosities averaging less than 20%, while high dip beds have porosities averaging more than 25%. Above the aeolian Rotliegend and beneath the marine shale and carbonates of the basal Zechstein is a sand interval characterized by planar rather than foreset bedding. Porosities in this interval vary from 15% to 20%. In all wells examined, except Schermer-3 and Groet-5, porosity decreases gradually upward from base to top in this unit. In

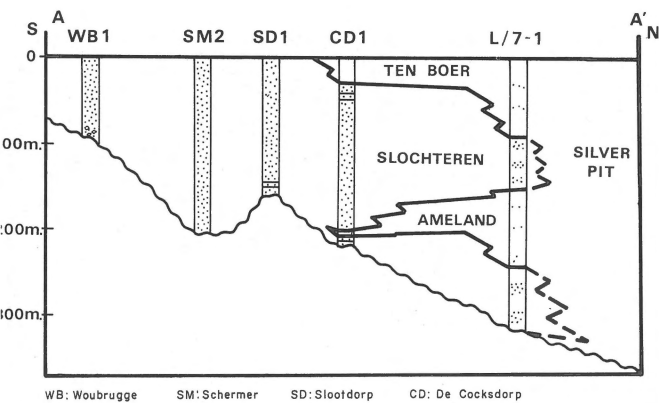


Fig. 4
Rotliegend regional cross-section, modified after Van Adrichem Boogaert, 1976.

Schermer-3, such porosity gradient occurs in the lower half of the unit, while the upper half is composed of sand having a uniform 15% porosity. In Groet-5 the entire drilled Rotliegend section is of uniformly low porosity.

The low porosity of the upper unit is probably not diagenetic in origin for two main reasons: (1) a synergetic log analysis of Groet-4 shows no increase of clay (authigenic or otherwise) or dolomite, and petrographic studies of a number of wells show no evidence of secondary quartz overgrowths or other diagenetic reduction of porosity; and (2) except in Groet-5, where the bedding appears chaotic, the upper unit shows planar rather than aeolian foreset bedding. It may be concluded that the sands of the upper unit were deposited in an environment which was different from that of the middle aeolian unit, and probably aqueous in character. The occurrence of planar bedding, together with the overall regional setting, suggests that the upper unit may be composed of beach or bar deposits made up of reworked aeolian material and deposited rapidly during the initial stage of the Late Permian transgression. Recent work by GLENNIE & BULLER (in press) has shown that homogenisation of the sands may be

largely due to entrapment of pockets of air followed by liquidisation and collapse.

Zechstein – The Zechstein will be described in some detail because it is a key factor to the interpretation of the Rotliegend structural configuration. The regional development of the Zechstein is shown in figure 6.

Immediately overlying the Rotliegend sandstone, is the thin, dark-coloured Coppershale of 'Kupferschiefer', which is easily distinguished on gamma logs by its characteristically high readings. It marks the base of the first Zechstein cycle (Z1), and occurs at a constant thickness of about one meter throughout the area. It is succeeded by a 20 to 40 m thick sequence of limestone, dolomite and shale, the Z1 Carbonate Member or 'Zechsteinkalk'. Uniform lithology and thickness in this marine unit suggest deposition on a relatively flat surface.

The upper part of the Z1 cycle consists of a massive anhydrite, ranging from 25 to over 100 m in thickness. This Z1 Anhydrite Member marks the onset of sabkha-type conditions, which followed a regional lowering of the sea level.

The top of the Z1 cycle is taken at the base of a thin anhydritic shale which immediately overlies the massive anhydrite. This unit is not, however, a continuous marker throughout the area, and it is often difficult to pick the boundary between the Z1 and Z2 cycles.

The Z2 cycle lacks the usual basal Carbonate, or 'Hauptdolomite', and starts either with the above mentioned anhydritic shale or with the Z2 Basal Anhydrite Member, which may be up to 90 m thick as at Groet-4. This basal unit is succeeded by the Z2 Salt Member, composed of relatively pure halite with interbeds of shale and anhydrite. It is believed that these halites were deposited in topographically low areas containing saline lagoons, whilst anhydrites, which were lateral facies equivalents, were accumulating on the highs. The thickness of the Z2 halite varies enormously from a few

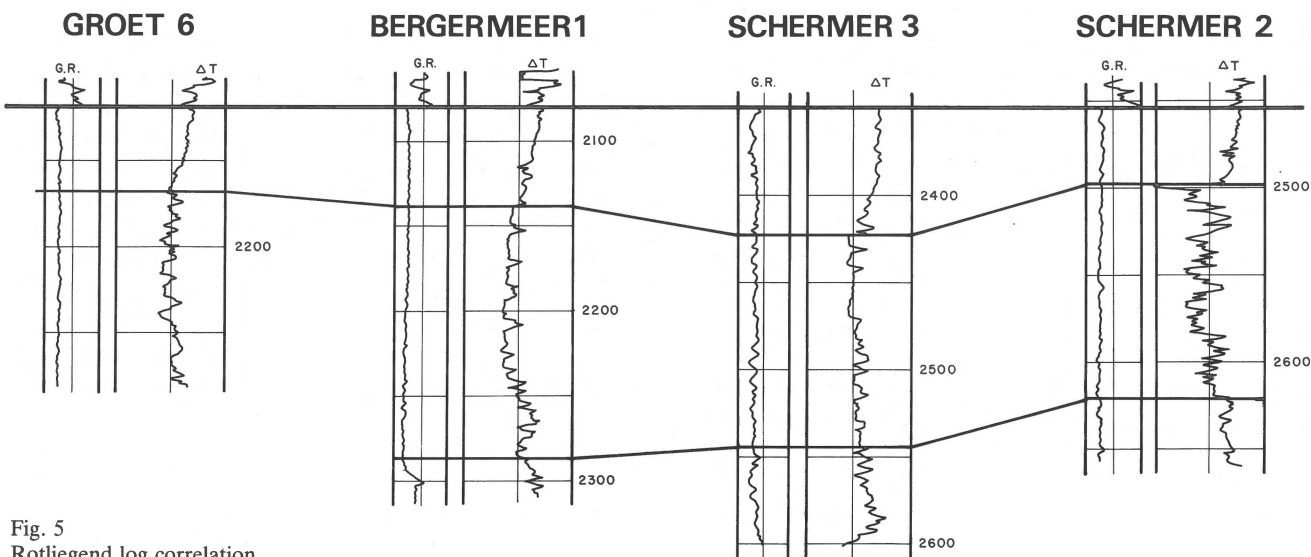


Fig. 5
Rotliegend log correlation.

meters in some of the Bergermeer wells to over 150 m in Groet-5. Where the thick halite occurs, its upper part is frequently rich in potassium salts, identified as distinctive high gamma-ray readings on the logs. Occurrence of potash-salts is considered to indicate a topographically low area. In general the thickening of the halite is associated with a compensatory

thinning of the underlying anhydrites. An anhydrite of 20 to 40 m thickness may represent the Z2 Roof Anhydrite Member.

The basal unit of the Z3 Formation is the Grey Salt Clay Member or 'Grauer Salzton'. It is represented by an anhydritic dolomitic shale unit (0 to 55 m) containing small amounts of salt, and a salt-anhydrite unit (4 to 24 m) consisting of a thin salt bed underlying a bed of shaly anhydrite. A thin halitic/potassic unit is often present near the top of the interval. The Z3 Carbonate Member, or Platten Dolomite, is relatively constant in thickness between 37 and 55 m.

The Platten Dolomite was laid down in a shallow marine environment; its relatively uniform thickness throughout the area is evidence that it was deposited on a surface of low relief. It is lithologically composed of micrite and biomicrite interbedded with occasional oolite and algal patches. Diagenesis caused the Platten to be highly dolomitised at Groet and Bergermeer, but at Schermer, dolomitisation had only a slight effect.

The Platten Dolomite in the northern part of the Concession is tight. Only in the south, at Schermer and Alkmaar, good porosity has been found. Figure 7 shows the sonic logs over the Platten section in some wells in the Schermer, Alkmaar, Bergermeer area. Alkmaar-1 clearly has the best porosity. Unfortunately the Platten in this well was not cored so that a direct petrological interpretation of this porosity development is not possible. Cores of Schermer and Heiloo-2 wells, where porosity is less developed than at Alkmaar, show that this porosity is a result of leaching of algal and oolitic grains. The Bergermeer wells have poor porosity in the Platten. Correlation of porosity zones in the Platten is hardly possible and the areal distribution is not clear. Although it may be assumed that algal development occurred on the topographically high anhydrite wall of the underlying Z2 Formation the locations of the wells in the Schermer-Bergermeer area do not allow such a conclusion. At Bergen and Groet the porosity of the Platten is low in all wells and cores are too few to infer an algal development.

The Z3 Main Anhydrite Member is represented by a thin anhydrite, consistent throughout the area. This is succeeded

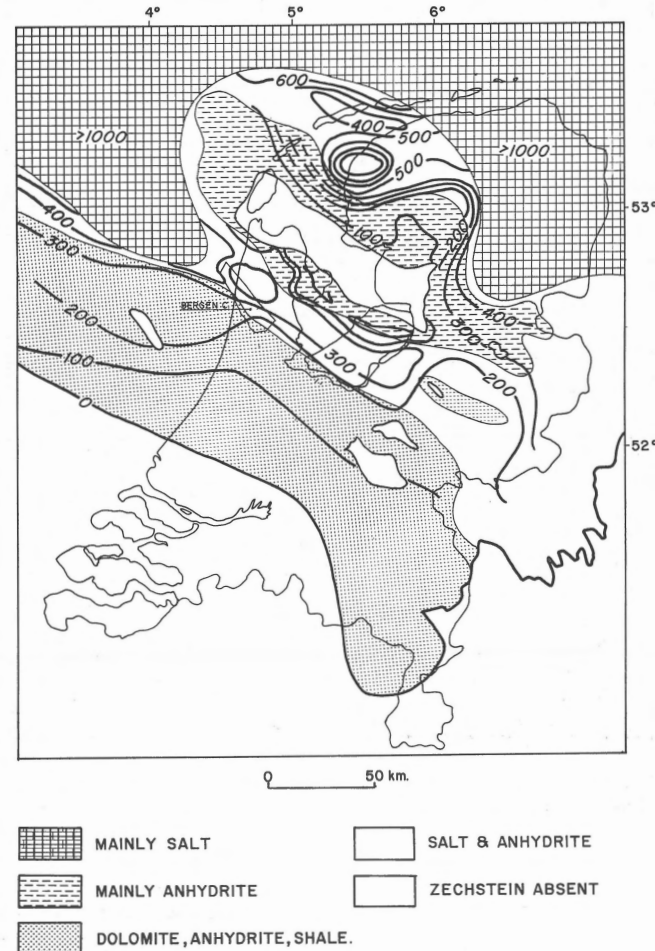


Fig. 6
Zechstein regional isopach and facies, mainly after Van Adrichem Boogaert & Burgers, 1983.

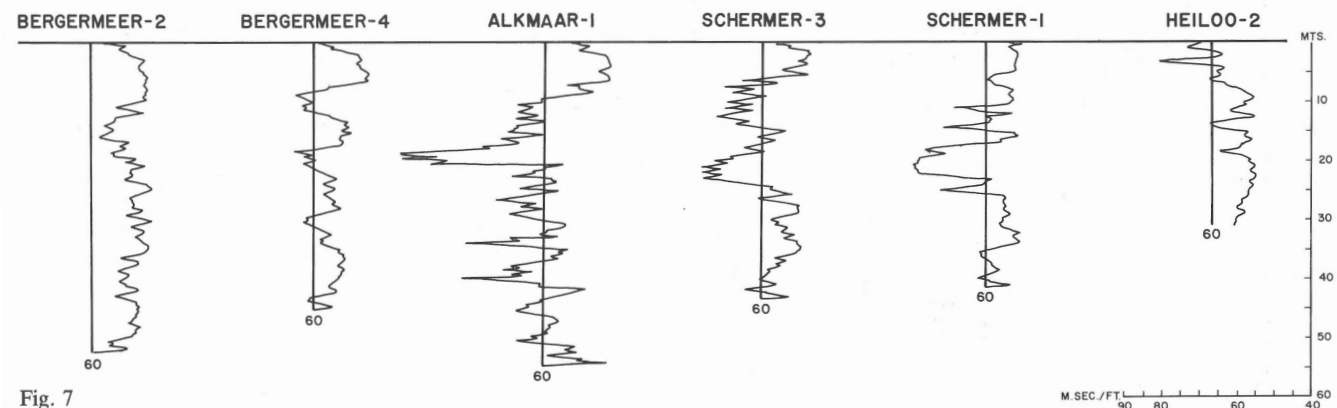


Fig. 7
Z3 Carbonate (Platten) sonic logs.

by the Z3 Salt Member, which, though absent in several wells, may be up to 60 m thick.

The uppermost part of the Zechstein in the Bergen Concession consists of shaly halite, interbedded with anhydrite and polyhalite, overlain by a unit of thin shaly anhydrites and mudstones marking the base of the Triassic. This section is attributed to Z4.

Main Buntsandstein – The sands of the Main Buntsandstein, ‘Middle Bunter’, or Bunter Sandstone Formation (BRENNAND 1975) constitute the third and least important reservoir in Bergen Concession. Regionally these sandstones are developed in a sandstone-claystone alternation equivalent to the Volpriehausen, Detfurth, Hardegsen sequence. Figures 8 and 9 show that the Main Buntsandstein is truncated by Late Kimmerian erosion just north of the Concession area. Within the Concession the intra-Bunter Hardegsen Unconformity has removed the Hardegsen Sandstone; the Detfurth is locally removed, whereas the Volpriehausen Sandstone has been fully preserved. Figures 8 and 9 also show the Röt caprock which is developed as a halite in most of the Concession area but is an anhydrite at Bergermeer and Groet.

The porosities in the lower part of the Volpriehausen Sandstone are rather low, but the upper part has porosities in the 12 to 25% range and permeabilities from 50 to 500 mD. Bunter tests at Groet and Schermer were unsuccessful, but at Bergermeer the Bunter tested gas at a rate of 5 MMCFD. At Heiloo the Bunter is the producing formation.

STRUCTURE

The structural geometry of the Rotliegend and Zechstein in Bergen Concession is thought to be the result of interaction between tectonic movements and depositional variations. These variations are seen clearly in the upper part of the Z1

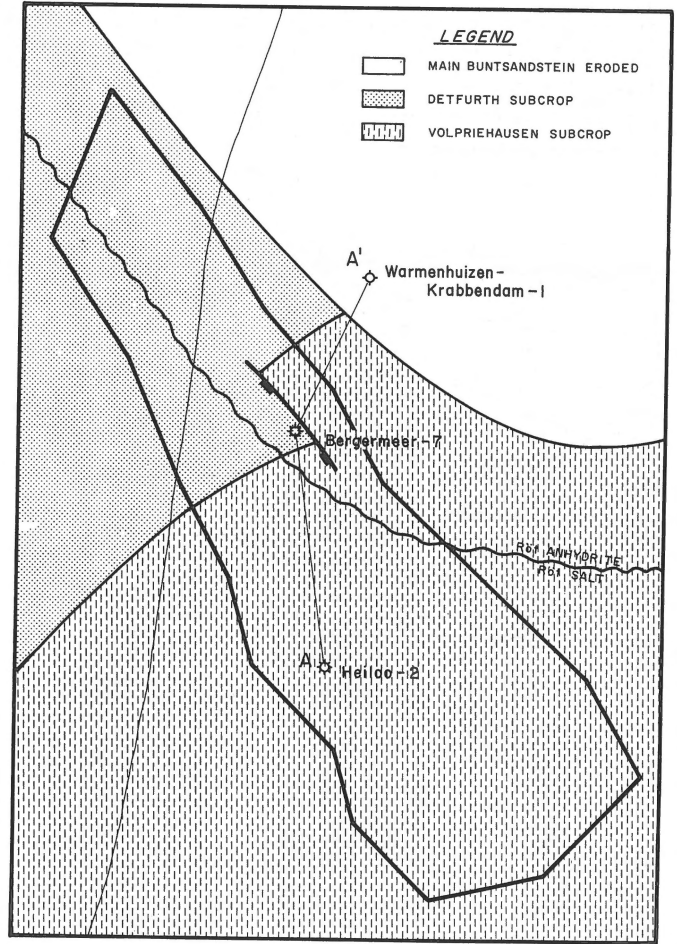


Fig. 8 Hardegsen subcrop.



Fig. 9 Middle Bunter cross-section.

cycle and in the Z2 and Z3 cycles. As an example, the situation at Groet is shown in figure 10. Groet-5 is located in an area of relatively rapid subsidence where thick salt sections accumulated in Z2 and Z3. Groet-3A represents a Zechstein section in a relatively positive area and Groet-3, its down-flank equivalent. While anhydrites were developing on the high area, the low was accumulating mainly halite. These variations are the result of variable subsidence of tilting fault blocks. The faults are probably Carboniferous in origin and were reactivated after Rotliegend deposition, causing tilting in Late Permian time. However, indications in Heiloo-2 are that faulting may have been active also in Early Permian time.

Figure 11 shows the structural configuration of the same Groet wells. Groet-5 is located in the downthrown block while Groet-3 and 3A are situated on the tilted upthrown block. The section shows the effect of underlying structural variations on Zechstein deposition, and in turn on the internal geometry of the structure.

The disharmony of Zechstein and Rotliegend structural configurations has an important practical consequence in structural mapping. As the Rotliegend is difficult, in fact usually impossible to pick on seismic records, structural mapping in the Bergen Concession is done mainly on the Z3 Carbonate (Platten Dolomite) which usually provides an easily identifiable seismic marker. The structure at Rotliegend level is obtained from whatever reflections may be available, in combination with geological isopaching of the Lower Zechstein section between the Platten and the Rotliegend. Dipmeter data from wells are also incorporated. The

isopaching is done using the depositional model as described above.

The resulting structure map of the Rotliegend surface (Fig. 12) became more reliable when map-based volumetric data were compared with material-balance calculations, and adjustments were made for apparent discrepancies. Whereas the shapes along trend of the structures are now fairly well-known, the occurrence of cross-trend structural features is still not completely clear. The Groet and Bergermeer fields are probably parts of a single tilted fault block. This structural interpretation explains why both fields have an apparently common gas/water contact. The fact that the production histories of these fields suggest separate accumulations may be due to a saddle between the two culminations. On this saddle only the upper 25 m of low-porosity Rotliegend is above the gas/water contact, thus forming a permeability barrier. Although not seen on seismic, cross faults may also be present and contributing to this barrier. Bergermeer-3 was drilled towards this saddle and, finding the Rotliegend low, it was sidetracked up-structure. However, Bergermeer reservoir performance suggested that the structure did extend beyond Bergermeer-3. Subsequent seismic identified a separate culmination in the saddle area and this was successfully tested by Bergermeer-7. It is the author's opinion that many transverse complications exist across the main fault blocks

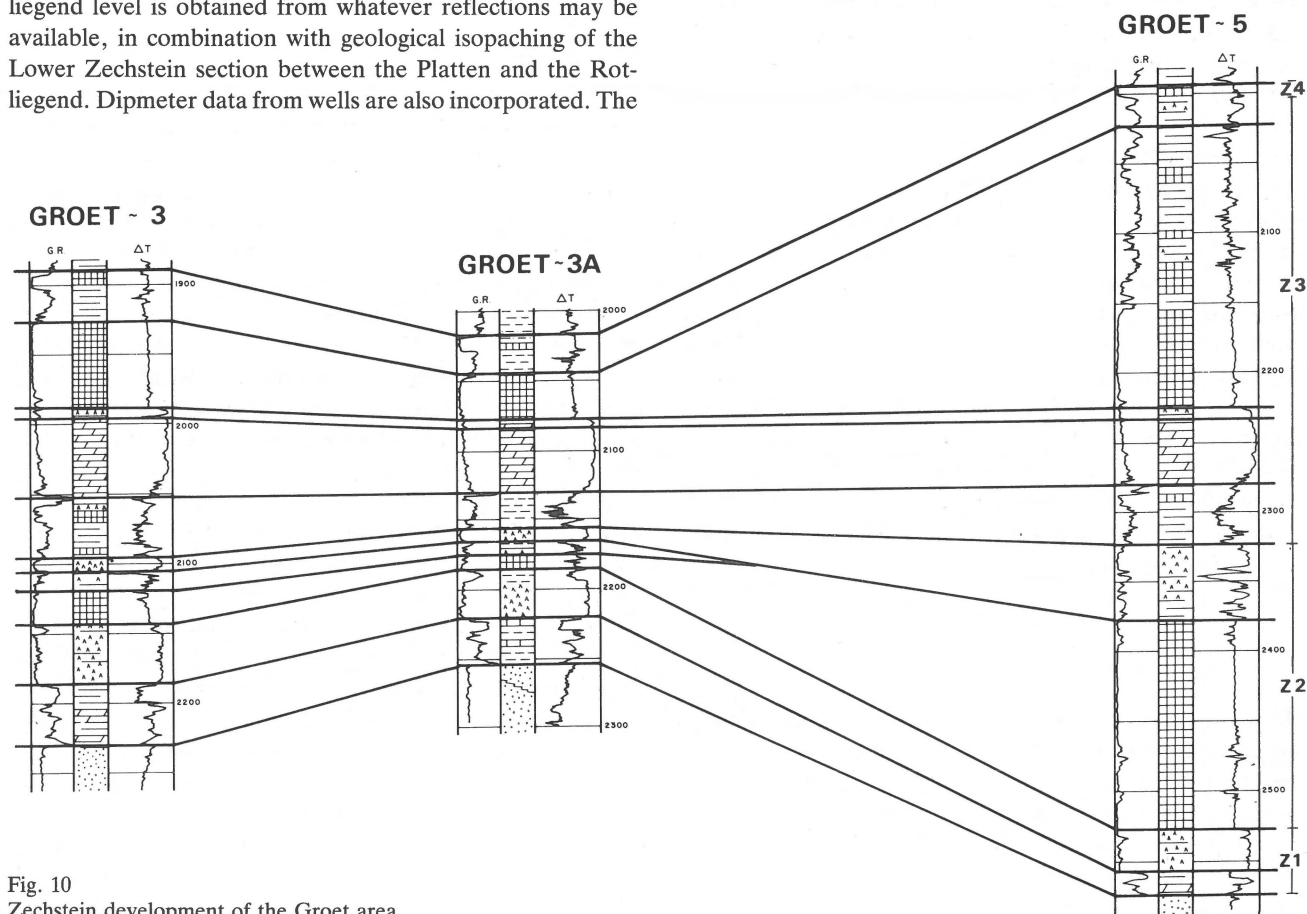


Fig. 10
Zechstein development of the Groet area.

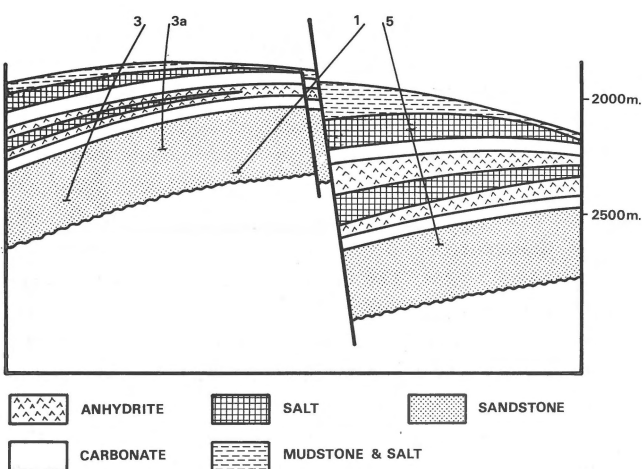


Fig. 11
Structural cross-section of the Groet Field.

and that the Rotliegend and possibly also the Platten surface of these structures is in detail much more like a stepstone mosaic than the smooth surface that can be mapped from seismic records. Development along trend is thereof a hazardous undertaking, as Bergermeer-3 has shown.

Two migrated seismic sections and their depth conversions are shown in figures 13 and 14 to illustrate the structural style in Bergen Concession. The section shown in figure 13-A was shot single-fold as long ago as 1964 along the North Sea beach and is of excellent quality for its age and type. The main reflections are picked and depth converted in figure 14-A but the top of the Rotliegend can be picked only in a few places. Most of the top Rotliegend and top Carboniferous on the depth conversion were established by isopaching as described above. The variable Zechstein thickness is clearly visible. The Bergen field has a distinct roll-over at the Zechstein and Rotliegend levels. However, at Groet the Rotliegend does not exhibit reversal whereas the top of the Zechstein does show roll-over. The section seen in figure 13-B was shot six-fold in 1972 and passes through the Heiloo, Boekel and Alkmaar structures. The basal Zechstein isopach in this area is not well known and for this reason the Rotliegend and Carboniferous are not shown on this section. The Triassic section is highly complicated by a set of low-angle faults that may locally cut as deep as Platten level.

ENVIRONMENT

The development of most gas fields in Bergen Concession did not take place until several years after the discoveries. These delays were caused by environmental problems resulting in resistance by action groups. It has always been recognized by the operator that the surface environment of the Concession area does present certain problems with respect to exploration and production operations. The Concession is located in

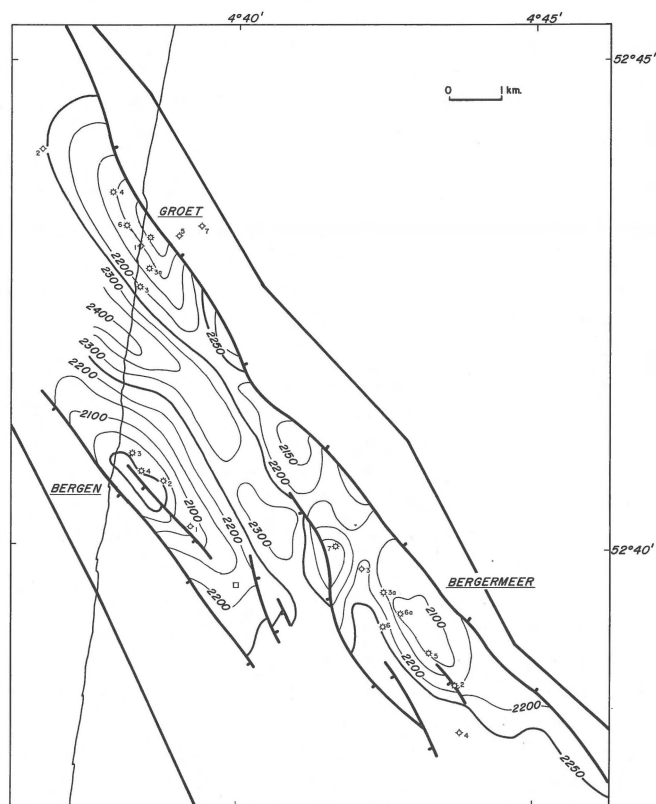


Fig. 12
Rotliegend structure map.

the northwestern part of the country where most of the land area is below sea level. This low land or 'polder land' is protected from the sea by the dunes. Both the dunes and the polder land have their own ecological balance, largely controlled by ground-water conditions, which may be affected by seismic or drilling operations. (Fig. 15)

In the polder land a careful balance is maintained between the surging salt ground-water and the influx of rain water and fresh surface-water. The surge of ground-water ('kwel') is contained naturally by sealing clay layers which occur at a depth of normally some 8 m, and artificially by adjusting the pumping rates of the polder mills to the situation at hand. Some 10 years ago the polder authorities became increasingly aware of the possibility of 'kwel' as a result of seismic shotholes through the sealing clay layers. These authorities then laid down rules for seismic work which until that time had been under no restriction from the part of the polders. In Bergen Concession, and most of Noord-Holland, the depth of seismic shot-holes is now limited to 2.5 m. A few seismic surveys have been conducted by means of Vibroseis. However, some areas are inaccessible for any tool. The Alkmaar field, for instance, is located under the historic city of Alkmaar, with its famous cheese market, where any damage to the centuries-old buildings would be unacceptable.

Not only seismic operations but even more so the drilling and pipe-laying in Bergen Concession have been influenced by environmental requirements, especially in the dunes area.

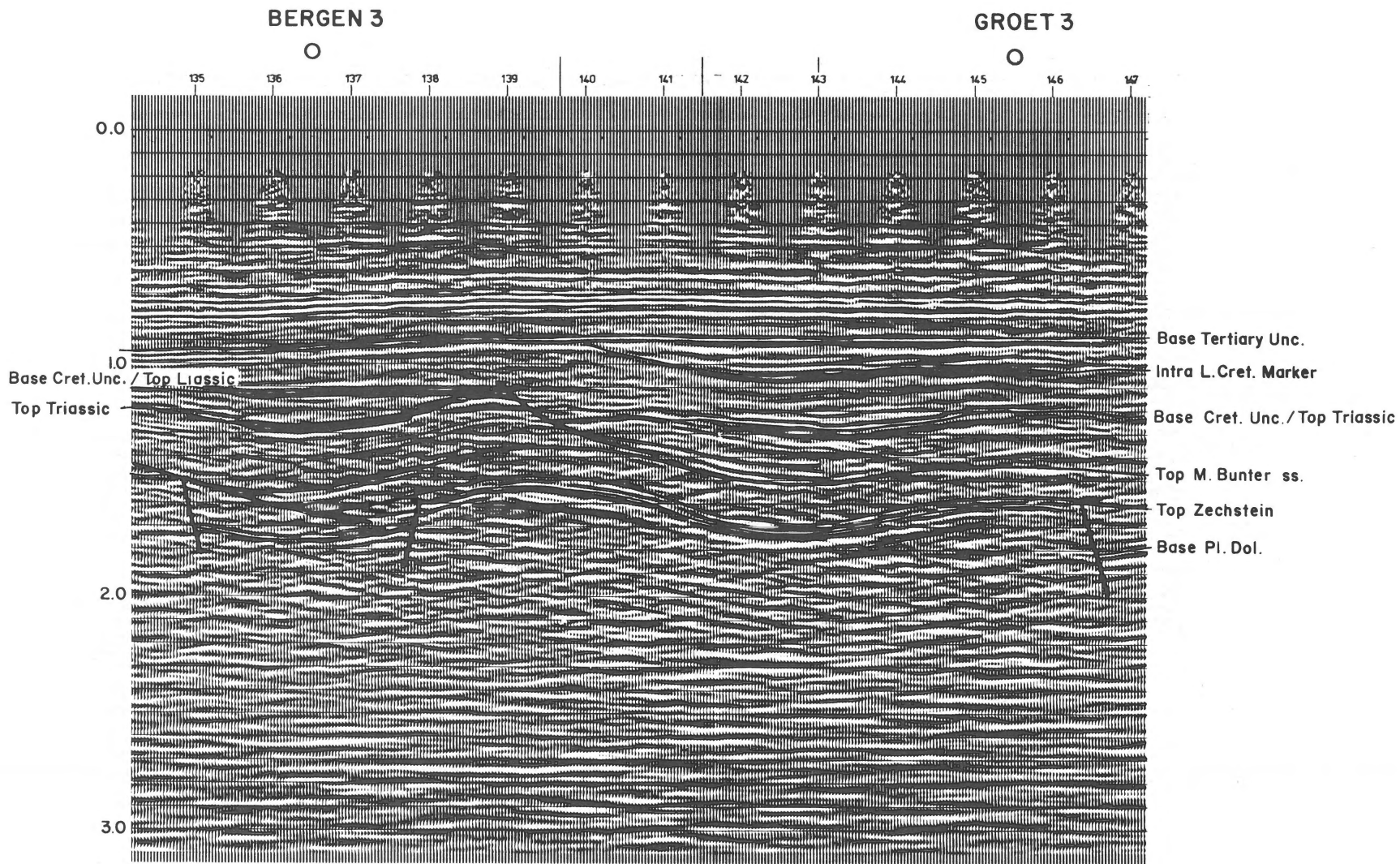


Fig. 13A
Bergen-Groet: seismic section.

BOEKEL-ALKMAAR

HEILOO 2

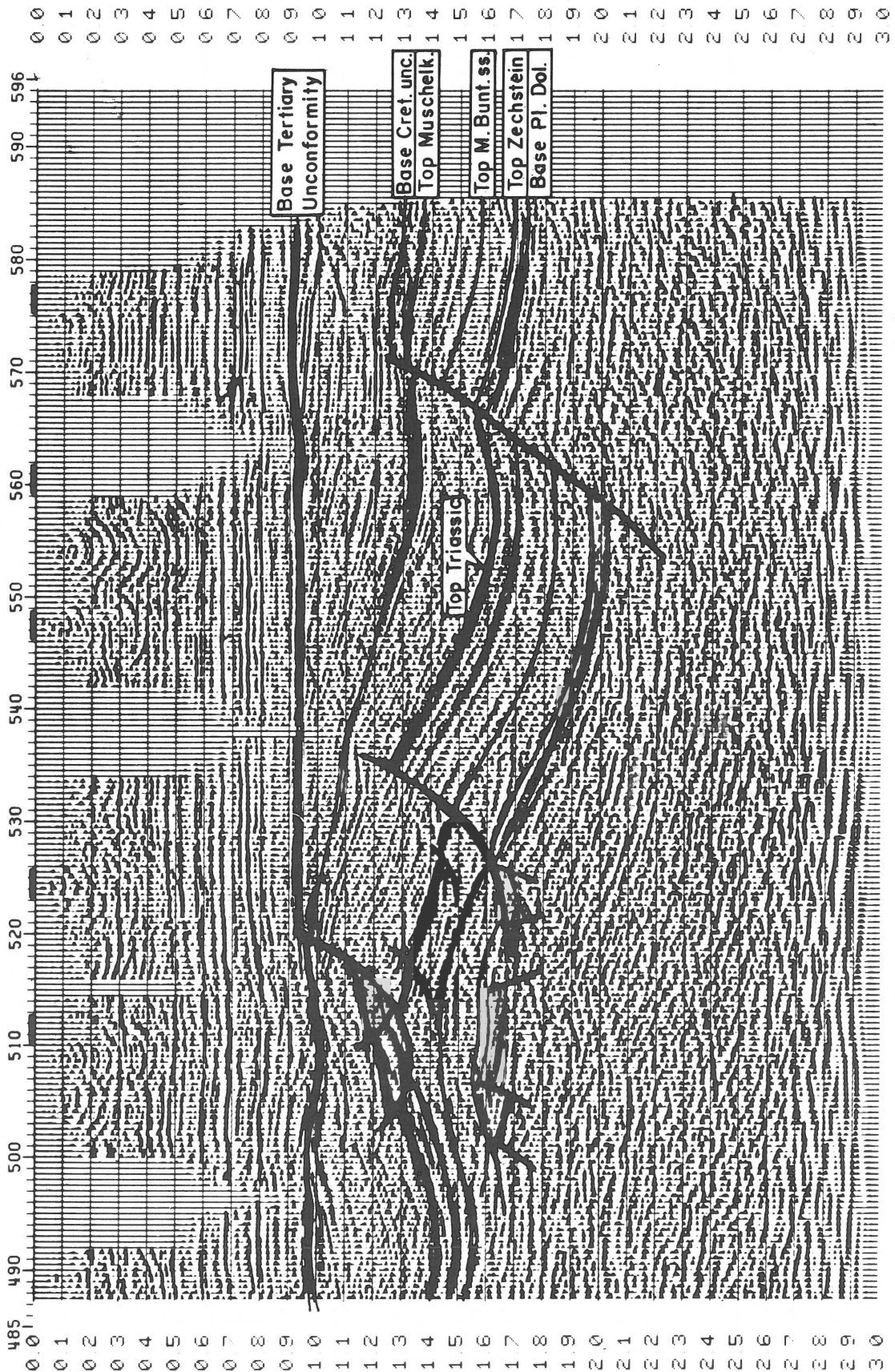


Fig. 13B Heilo-Boekel-Alkmaar. seismic section.

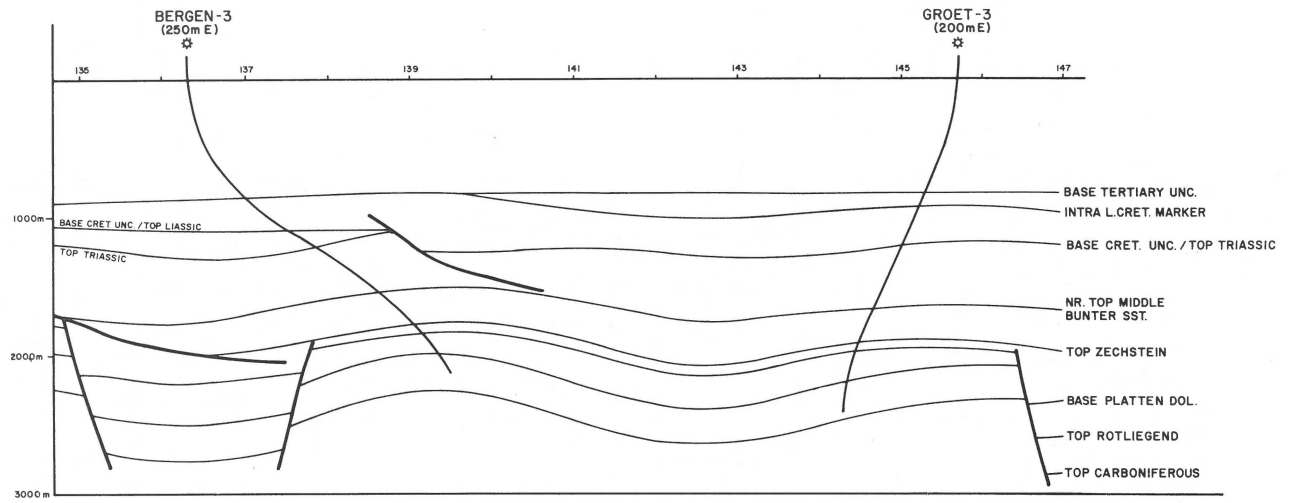


Fig. 14A
Bergen-Groet: depth conversion.

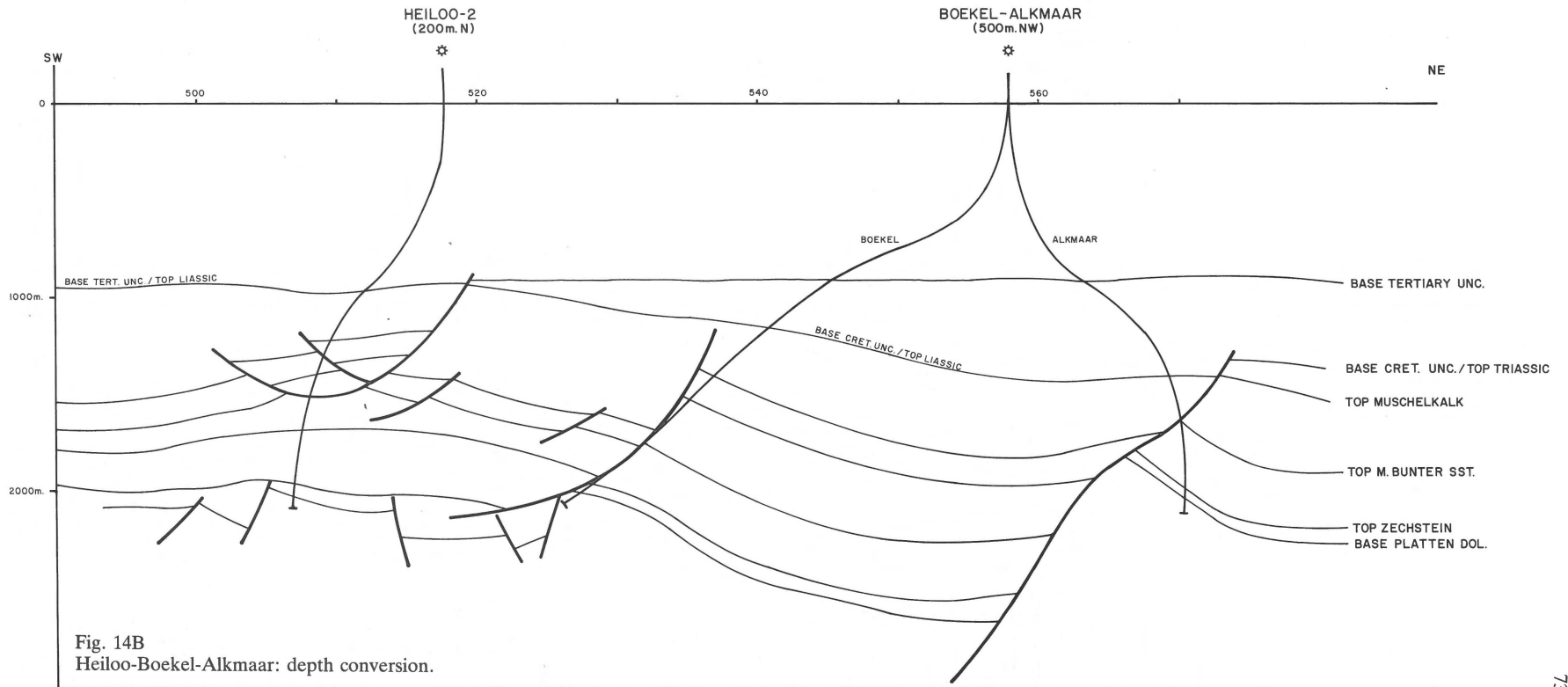


Fig. 14B
Heiloo-Boekel-Alkmaar: depth conversion.

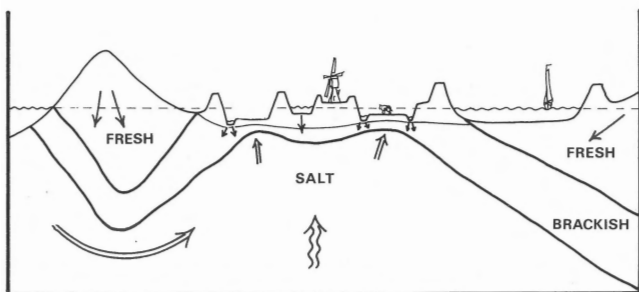


Fig. 15
Schematic cross-section of Noord-Holland showing ground water conditions.

The dunes constitute an enormous fresh-water reservoir that is used as a drinking-water reserve, and as such is carefully protected against any influence that may jeopardize the quality of the water. The specific flora and fauna of the dunes have special attention from nature conservation groups and the vegetation is maintained with utmost care to prevent erosion of this major sea defense. Both wildcats that were drilled to targets below the dunes had to be drilled from surface locations outside the dune area. In the case of Groet a surface location for the producing well-cluster was allowed in the dunes. As in most other locations in the Concession, the well heads are placed in cellars so that no visual disturbance occurs. Furthermore, the Groet site is protected by artificial dunes from a nearby road leading to a major parking place for beach tourists. Also Bergen-1 had to be drilled from outside the dunes area and the surface location had to be removed immediately after completion of the well. In spite of a Crown decision in 1973 to quash the refusal by the Municipality of Schoorl of a building permit for the so-called Pirola location, the resistance by environmental action groups against this location remained so heavy that Amoco decided to cooperate in finding an alternative location. A site in the Municipality of Bergen seemed to be more satisfactory, but the Bergen Council also refused a building permit and again a decision by the Crown was necessary. When development drilling could finally start in 1976 the delay due to environmental problems had been six years. The well heads at Bergen also are placed in cellars and artificial dunes protect the site from outside vision. The other production locations, situated outside the dunes, did not meet with excessive resistance but were built under very strict rules to reduce visual and other pollutions.

Furthermore, considerable zoning problems had to be overcome in designing the pipeline routes connecting the production locations to the central gas-drying plant. The pipe-line connecting Schermer and Alkmaar with the plant was originally designed to run south of the town of Limmen. A considerably shorter route could be followed when agreement was reached on crossing the Heiloo woods. This protected area consists of a 1 km wide strip of woods on an old Holocene beach barrier. The pipeline was pushed over a distance of 210 m under this area without affecting in anyway the vegetation. Also for environmental reasons, treatment of the gas was

concentrated in a central plant at the Noord-Hollands Kanaal near Koedijk. At this plant the gas from all fields flows through a slug catcher directly into the gas-drying system, which consists of three parallel trains based on the dry-desiccant process. The plant is fully landscaped, all equipment is painted green and the buildings are in the historic regional farm style. In building the office and warehouse, a distance of at least 200 m had to be maintained to a nearby windmill by virtue of the windright. In the last few years the outskirts of the City of Alkmaar have spread to the Canal near the plant. For this reason considerable modifications have been made to further reduce the already minimal nuisance due to smell and noise. The recently completed first compression phase at this plant is installed in a heavily insulated building, reducing the noise of the running gas turbines and compressors to a maximum level of 40 db (A) at 100 m from the plant fence. After some major problems in the past the operations in Bergen Concession can now be carried out with understanding and cooperation of the authorities involved.

ACKNOWLEDGEMENTS

This paper is based on the work of several Amoco geologists and geophysicists. The author likes to acknowledge the assistance by P. Fenemore (Figs. 13 and 14) and J. J. Klasen (Figs. 8 and 9) and wishes to thank J. G. C. M. Fuller, D. E. Jackson and J. J. Klasen for their critical reading of the manuscript. Thanks are also extended to Mrs. I. S. Oei for the typescript and to A. J. de Koning for drafting the figures. The author thanks Amoco Netherlands Petroleum Company, Exploratie- en Productie Maatschappij Dyas B.V. and Veba Oil Nederland N.V. for permission to publish this paper and to release the information that it contains.

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