THE MEER WELL IN NORTH BELGIUM[1]

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The presence of a potential geothermal source in North Belgium is known already from the results of the Turnhout well, drilled in 1953-1955 (Grosjean, 1954). The lateral extension of the water bearing zone in the top of the Lower Carboniferous limestone was shown some years later by the Loenhout-Heibaart well. Enough information on the regional geology and the properties of the water bearing zone were thought to be available, and confirmed by a vibroseis study in the Hoogstraten-Meer area, so that, under the pressure of the rising energy price, a low enthalpy geothermal doublet project was set up in the late seventies (Vandenberghe & Bouckaert, 1980). The project was organized by the regional economic development organisation G.O.M. Antwerpen.

The Belgian Geological Survey organized the drilling of a first well at Meer, which unfortunately did not confirm the geological model conceived (Vandenberghe, 1984).

The localisation of the Meer well is shown in fig. 1. The well coordinates are x = 177 378,47; y = 237 303,54; z = + 13,22 m. The original well descriptions are kept in the files of the Belgian Geological Survey under the number 7E/205 IIIb. The well number in the Campine Basin series is KB 149.

CHAPTER I

DRILLING AND WELL ARCHITECTURE

The drilling contractor was SMET-DB, Dessel, Belgium. A Salzgitter B 210/39 rig was used with a 170 ton dynamic capacity. The maximal depth reached was 2517 m and the actual drilling took place between 27.07.80 and 2.04.81.

For technical reasons, a first well was abandoned after it had reached 729,3 m depth.
A well scheme, including bit sizes, casing types and sizes is given in Fig. 2.

The upper 215 m were drilled with a water counter flush technique. Below, a conventional rotary drilling was used with different roller bit sizes as shown in Fig. 2 depending on the expected geology. Cuttings were recovered at least every 5 m. Table 1 indicates the cored depths. On Fig. 3 the drilling progress is represented. Till 1150 m depth a HEC (hydroxyethylcellulose) based mud was used, whilst deeper, in the Upper Carboniferous shales, a bentonite mud was used. The geometry of the hole was controlled at several depths by a BGL, an example of which is shown in Fig 4.

The final depth of 2515 m could only be reached after a side track was initiated with a dynadrill at 2014,8 m. The side track was necessary because of lost drill pipe.
Nevertheless the instability of the hole, even with barite mud required the setting of a 7" casing at 2275 m.
The cementation top in the annulus (985 m) and the plug inside the casing (fig. 2) were documented by a CBL. The hole was cleaned through a coiled tubing end 1981 and set free for additional logging till 2087 m. In 1982, the well has been adapted to bring the Maastrichtian chalk aquifer into production (see chapter VI). Table 2 resumes the time-use during the drilling period. The daily record of technical data can be found in the BGS files (Vandenberghe, 1982a).

CHAPTER II

THE POST-PALEOZOIC STRATIGRAPHY OF THE MEER WELL

The stratigraphy has been established by the inspection of the available cuttings, some paleontological determinations, the drilling rate curve and the different geophysical logs (table 3). The main data are represented graphically on Figure 5. The interpretation is summarised in Table 4.

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[1] *Manuscript deposited 1984.*

Figs 5, 11 and 15 are separated at the end of this paper.

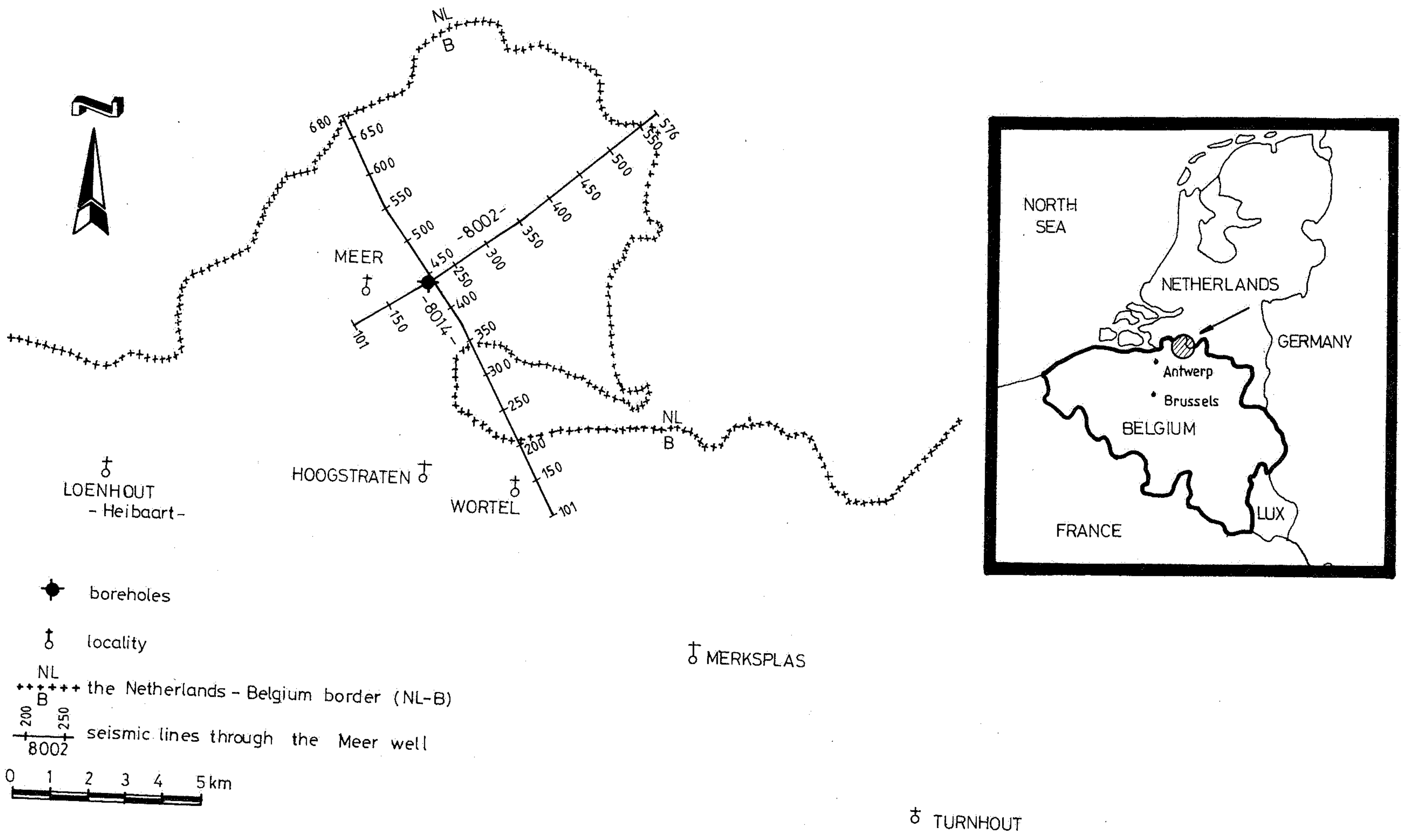

FIG. 1.- Localisation of the Meer well

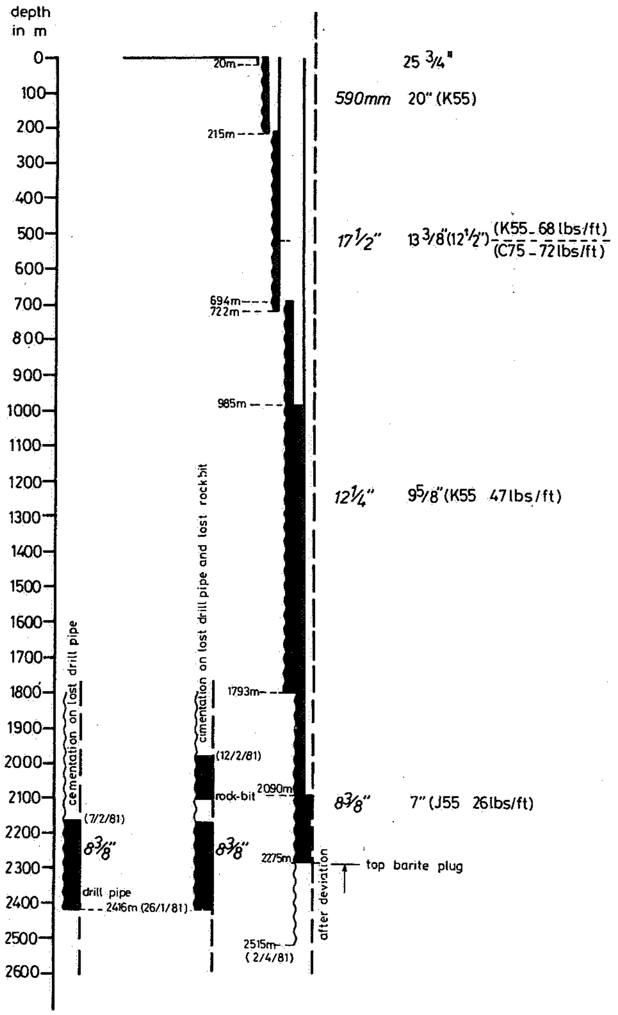

FIG. 2.- Architecture of the Meer well

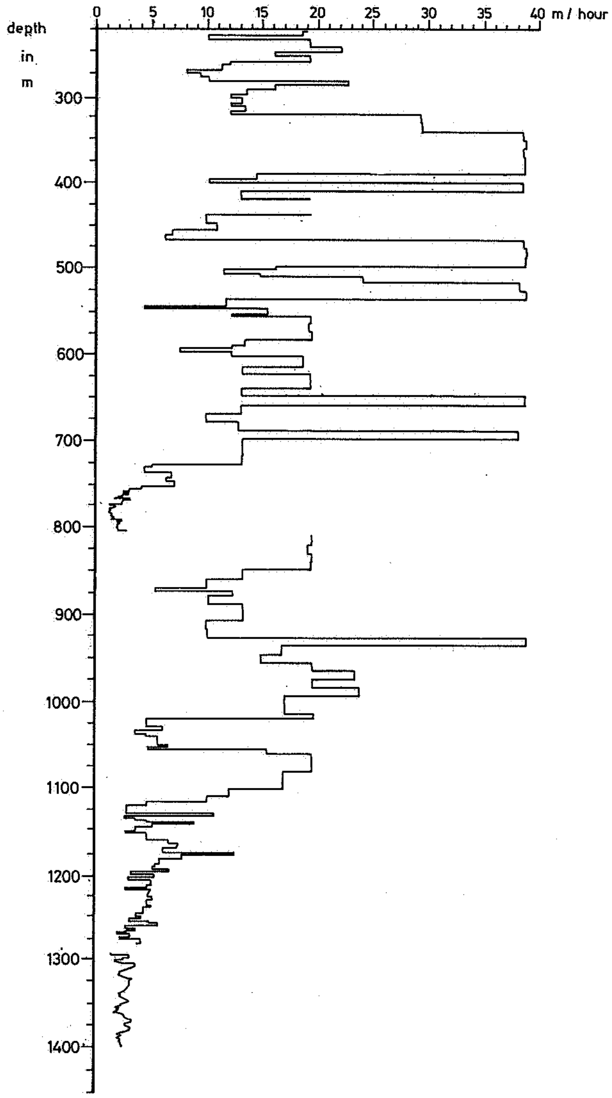

FIG. 3.- Drilling rate meter/hour

Table 1.- Cored intervals in the Meer well

depth	type	diam.	date	length of the core
676,70 - 677,70 m	press corer		23/08/80	60 cm
695,00 - 696,00 m	press corer		25/03/80	10 cm
813,31 - 822,31 m	core barrel	158 mm	3/10/80	5 m recovery
871,00 - 875,00 m	core barrel	158 mm	6/10/80	1 m recovery
1281,00 - 1286,40 m	core barrel	158 mm	28/10/80	5,40 m recovery
1518,25 - 1525,35 m	core barrel	158 mm	12/11/80	7,10 m recovery

Table 2.- Time-use in the period 28/09/80 - 2/04/81

Drilling + trips	Casing + cementation	Coring + trips	Logging	Side tracking	fishing	Reparations, work at the drilling site	Stops, interruptions	Total
1970 hours	174,5 hours	150 hours	130 hours	121,25 hours	237 hours	1081,25 hours		
82 days	7,3 days	6,25 days	5,4 days	5 days	10 days	45 days	82 days	243 days
34%	3%	2,4%	2,22%	2%	4%	18,5%	34%	100%

1.- The sediments overlying the Boom clay

The sands overlying the Boom clay have been subdivided through a comparison with the interpretation of the nearby wells, represented on a Meer-Baal profile (P. Laga, 1977, wells 7E/179 and 195). The Campine Sands and Clays complex and the underlying Merksplas Sands extend certainly downwards till 75 m. Grain-size curves (fig. 6) shown a mixture of a fine and a medium sand population. The sand unit between 75 and 95 m contains more shell debris and some glauconite. The fauna of the samples at 81 m and 90 m showed *Corbula gibba, Lyropecten opercularis, Ditrupa, Bryozoa, Astarte ...,* a typical association for the Lillo formation. These elements however are also known to occur reworked at the base of the Merksplas Sands. Although the grain-size distribution resembles better the Merksplas Sands than the reference curves for Merksem Sands (Lillo Formation) in the Zandvliet area, north of Antwerpen (fig. 7), the thickness of the unit, the increase in shell debris over the whole thickness and the appearance of glauconite however lead us to consider these 20 m unit as belonging to the Lillo Formation. The sands below 95 m are for the largest part belonging to the Diest Formation. The upper fine sands, between 95 and 133 m, although rather thick, compared to neighbouring wells, probably correspond to the Lower Pliocene, Kattendijk Sands.

The sands between 133 m and 173 m have grain sizes comparable to normal Diest Sands, while the above lying (the Kattendijk Sands) and underlying sands are finer. The lower fine sands resemble in a sense the grain size of the Dessel Sands (fig. 8). The presence of *Terebratula,* together with *Ostrea, Lingula* at 196 m indeed indicates, together with the fine grain-size of the sand, the Dessel Sands. The base of the coarse sand unit contains black angular silex granules. Samples at 204, 206, 208 m contain *Elphidium subnodosum,* characteristic for the foraminiferal association of the Voort Sands.

2.- The top of the Boom clay is located at 205 m by the cuttings, the drilling progress change and major changes in the sonic, resistivity and spontaneous potential curves.

The base of the Boom clay is located at 338 m, especially based on a sudden change on the gamma ray, corresponding also to a change in the sonic log and a small resistivity change. The earlier appearance of sand and glauconite in the cuttings indicates the more sandy nature of the base of the

Table 3.- Geophysical logs run at Meer

Companig	Date	Log	Interval
SSL	27-28/8/80	VSP	208 - 620 m
Schlumberger	27-28/8/80	GR	208 - 620 m
		BGL	0 - 602 m
		CAL	0 - 602 m
		FDC	170 - 578 m
		CNL	170 - 578 m
		ISF	170 - 578 m
		T	0 - 648 m
		SONIC DDBHC	170 - 594 m
Schlumberger	5/12/80	BGL	675 - 1800 m
Schlumberger	9-20-11/12/80	T	700 - 1800 m
		FDC-CNL-GR-CAL	500 - 1800 m
		ISF-SP-LSS	720 - 1800 m
SSL	10-11/12/80	VSP 7	1800 m
Schlumberger	5/2/81	T, BGL	1794 - 2259 m
Schlumberger	1/4/81	ISF-SONIC-FDC	1794 - 2258 m
		FDC-CNL-GR-WST	1794 - 2258 m
Schlumberger	10/8/81	CBL	750 - 1639 m
		T	0 - 1698 m
Schlumberger	2/81	T	0 - 2090 m
SSL	2/82	VSP	1800 - 2090 m

Table 4.- Postpaleozoic stratigraphic interpretation

depth	level top base	litho. unit	time unit	
0- 75	+13,2- - 62		Pleistocene	Quaternary
0- 47	+13,2- - 34	Campine Clays and Sands		
47- 75	- 34- - 62	Merksplas Sands		
75- 95	- 62- - 82	Lillo Formation	Upper Pliocene	Tertiary
95- 133	- 182- - 120	Fine glauconitic sands Kattendijk Sands	Lower Pliocene	
133- 200	- 133- - 187	Diest Formation	Upper Miocene	
133- 173	- 120- - 160	Coarse glauconitic sands		
173- 200	- 160- - 187	Dessel Sands		
200- 205	- 187- - 192	Voort Formation	Upper Oligocene	
205- 338	- 192- - 325	Boom Clay (Rupelian)	Middle Oligocene	
338- 350	- 325- - 337	"Lower Rupelian Sands"	Lower Oligocene	
350- 451	- 337- - 438	Kallo Complex		
350- 367	- 337- - 354	s4	Upper Eocene	
367- 372	- 354- - 359	a4		
372- 394	- 359- - 381	s3 Basseveldе Sands		
394- 399	- 381- - 386	a3		
399- 409	- 386- - 396	s2		
409- 424	- 396- - 411	a2		
424- 429	- 411- - 416	s1 Asse Sands	Bartonian	
429- 451	- 416- - 438	a1 Asse Clay		
451- 472	- 438- - 459	Wemmel Sands	Middle Eocene	
472- 546	- 459- - 533	Lede Sands, and probably equival Brussels, Panisel Sands		
546- 692	- 533- - 679	Ieper Clay	Lower Eocene	
692- 790	- 679- - 777	Landen Formation	Paleocene	
790- 808	- 777- - 795	Heers Formation		
808- 834	- 795- - 821	Vroenhoven Chalk		
834- 911	- 821- - 898	Maastricht Chalk	Upper Cretaceous	Mesozoic
911-1015	- 898- -1002	Upper Gulpen Chalk		
1015-1057	-1002- -1044	Dense Marl		
1057-1116	-1044- -1103	Lower Gulpen Chalk		
1116-1186	-1103- -1173	Herve Formation marl-clay		

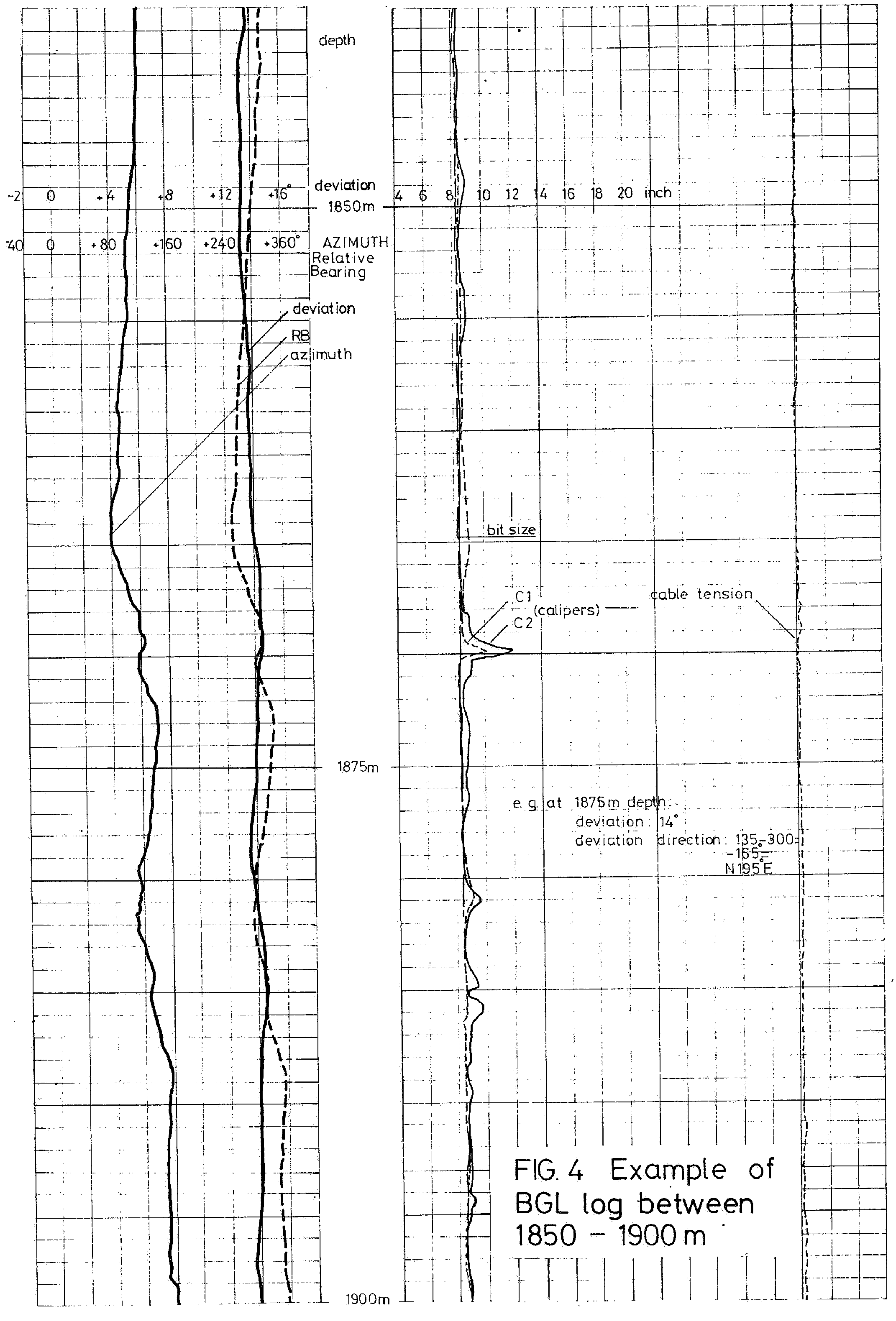

FIG. 4.- Example of BGL log between 1850-1900 m

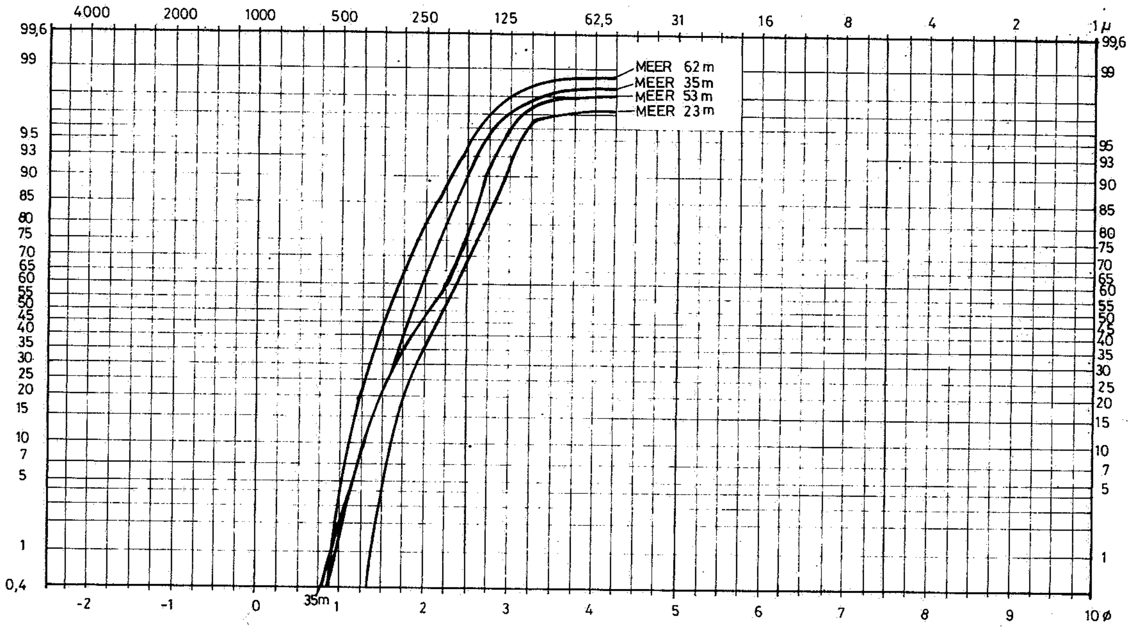

FIG. 6.- Grain size cumulative curves of the Campine clays (23,35) and the Merksplas sands (53,62)

clay. Lithological variations in the Boom clay are known in the type area (Vandenberghe, 1978) and the Boom clay in the Meer well can indeed be subdivided in at least four or five units based on the well logs as shown on Fig. 5. Coarsening and fining sequences can be seen on the gamma ray curve. Typically the clay also coarsens upwards quite quickly towards the top. Besides, in the more sandy clay the rythmic sedimentation on the scale of some 50 to 100 cm, so characteristic for the Boom clay, is shown clearly by the short spacing resistivity curve (see also Neerdael *et al.,* 1980).

3.- The major gamma ray peak at 451 m represents the glauconitic base of the Asse clay (bande noire). The thickness of the whole sequence between the base of the Asse clay and the base of the Boom clay being 113 m, compares well to the equivalent 124 m between the base of Boom and Asse clay in the Woensdrecht drill hole. Stratigraphic interpretation in terms of the symbols a_1, s_1 on Fig. 5 is inspired by Gulinck *et al.* (1969, fig. 2). The units a_1 to s_1 are called here the Kallo Complex. A more formal lithostratigraphic nomenclature can be found in Jacobs (1978). The base of the Asse clay is sandy over about 9 m; although the occurrence of such a sandier basal unit is known in the outcrop area in the south (the Asb unit of the geological map), it is thicker developed here. While in the lower part of this Kallo complex, the clay units a_1 and a_2 are thicker than s_1, in the upper part the situation is reversed and the sandier units s_2 and s_3 are thicker than the clay units a_3 and a_4. On Figure 9 a correlation is shown between the cored Kallo well and the Meer resistivity log interpretation.

The correlation is remarkably good although the precise base of the Boom clay and the position of the Lower Rupelian (R1b) sands is difficult to correlate between a cored well without logs and a logged well without cores. The silty base of the Boom clay does not help in this respect ! Also, in the upper sand unit it is hard to separate the Lower Rupelian sands (R1b) from the s4 unit. This might be explained by lateral facies changes in the Lower Rupelian sands as these are known even as far south as the Boom area, changing from the more classical glauconitic medium sized water-bearing sands to very clayey fine greenish sands resembling in fact the sandy units of the Kallo complex.

The R1b/s4 limit is tentatively put at 350 m depth, based on small log changes and on a comparison with the Kallo well (fig. 9). Below the Asse Clay base at 451 m occurs a sandy interval extending downwards till 546 m.
This Eocene sand unit can be particularly well recognized on the gamma ray, resistivity and sonic logs.
At 508 m depth, the sonic log separates an upper part with sandstone layers occurring every few meters from a lower part with a limited number of sandstones.

Also the gamma ray log shows a sharp increase in intensity at that depth (glauconitic ?). The lower part of the unit, between 515 and 550 m, is more clayey than the upper part, and the sequence becomes gradually more clayey upwards. The upper part then takes up more sand till 472 m and then becomes again more clayey up till the top at 451 m. Nummulites are abundant from the top of the sandy unit till 485 m. This sand unit undoubtly is the lateral equivalent of the Middle Eocene sandy formations : Wemmel, Lede, Brussel, Panisel. Although the poor foraminifera content did not allow a detailed stratigraphic analysis, some useful information could be drawn from their determination (Hooyberghs, 1983).

The sample at 462 m shows a dominant population of *Asterigerina bartoniana* which is typical for the Asse Formation (Gerits et al., 1981); seen the sandy character of the sediment, the subunit between 451 and 472 m is considered as the Wemmel Sands. The abundance of *Polymorphinidae* between 483 and 535 m could point to the presence of the Lede Sands (Gerits et al., 1981).

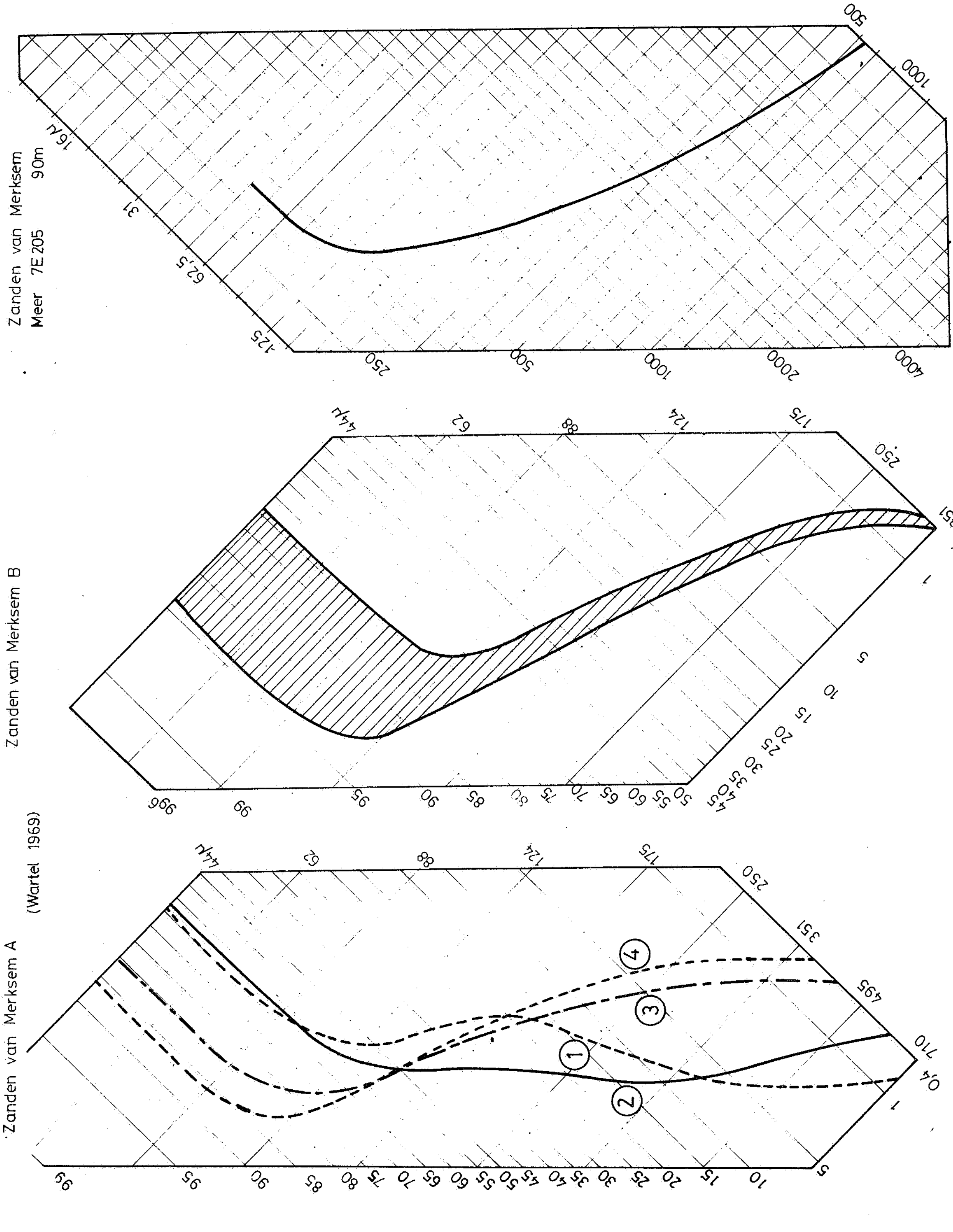

FIG. 7.- Grain size cumulative curves of the Merksem sands

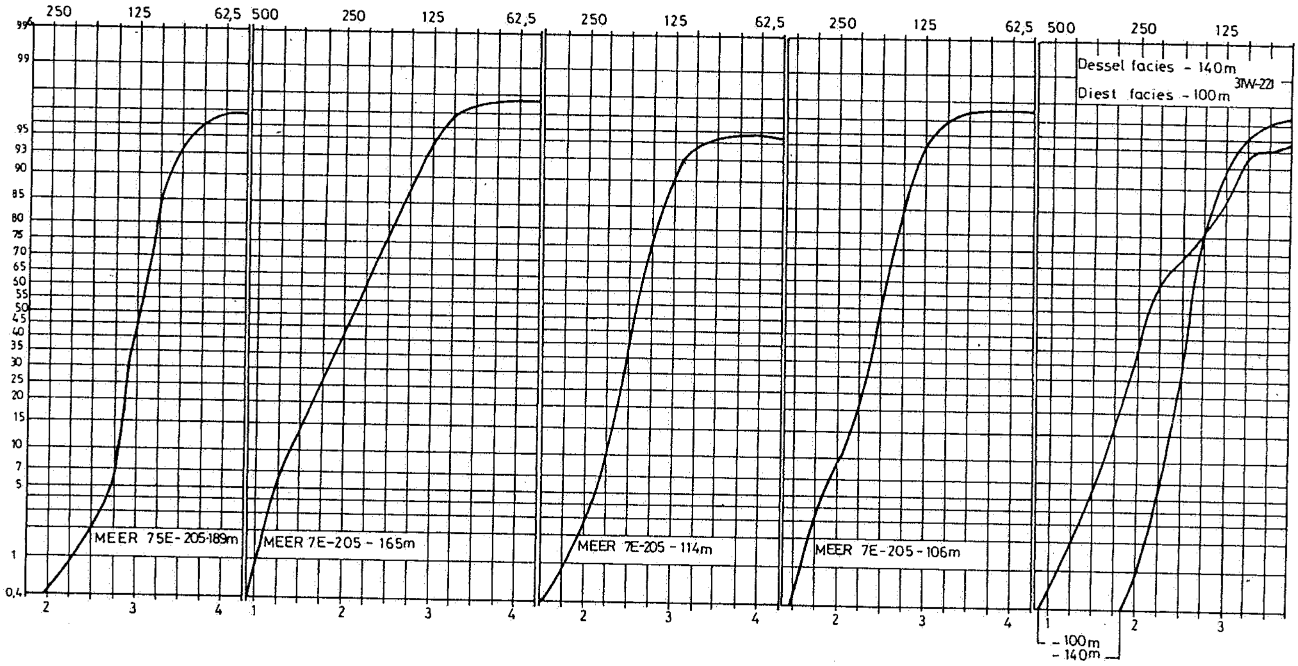

FIG. 8.- Diest and Dessel sands in Meer compared to these sands in Mol
Curves at Mol drawn from data in Gulinck *et al.* (1963)

Anyhow the planktonic foraminifera are younger than the Brussels Sands foraminifera, even at 535 m, and *Cibicides westi,* abundant in the Brussels Sands was not present at all. Nevertheless it would be very exceptional if the Brussels or Panisel Sands would be lacking, the more as the Lede Sands then would have about five times their type area thickness.

4.- At 546 m a lithology change is detected by all the logs, confirmed by the nature of the cuttings. The whole sequence between 546 and 790 m is essentially a clay unit. For technical reasons, only a few data are available between 570 and 725 m.

Two cores (table 1) were taken in this interval. The core at 677 m showed a hard silty calcareous grey clay; the silt occurs in thin laminae and small bioturbation patches (mm size); some of the worm tracks are pyritized. The core at 696 m shows a grey very sandy clay with laminae of pure sand. Samples at 560 m contain *Nummulites planulatus.* The change in density-porosity and especially gamma ray intensity at 692 m is tentatively interpreted as the Ieper-Landen formation boundary. The natural radioactivity increase between 675 m and 692 m is interpreted as a glauconitic basal clay.

The Landen Formation is built up by several subunits. From the base on - at 790 m, a grading into more silty or sandy marly clay is overlain at 765 m by a grading into again more heavier clay. A more uniform heavy clay unit then persists up till 715 m, as shown on the density-porosity log, overlain by a more sandy clay between 715 and 692 m.

5.- At 808 m sharp changes in sonic, SFL and density-porosity mark the start of the chalks. Cutting analysis already shows the appearance of chalk between 790 and 808 m. Between 790 and 808 m, the gamma-ray intensity becomes very low, whilst density reaches even 2.3 gr/cmr, resistivity and spontaneous potential curves individualize as separate units and interval velocity reaches 2750 m/sec.

Hence the 790 - 808 m interval is interpreted as the Heers formation, with a basal glauconitic sand as expressed on the gamma ray and sonic curves.

6.- The petrophysical properties of the chalk mass between 808 and 1015 m are, broadly speaking, similar. The sharp gamma-ray intensity increase at 834 m marks the Mesozoic-Tertiary boundary (Rijks Geologische Dienst, Haarlem, pers. comm.). Hence the porous chalks between 805 and 834 m have to be considered as the Dano-Montian Vroenhoven tuffeau (1). Thin sections from the cores showed between 815 and 820 m a calcarenite, porous chalk, made-up almost entirely of small fossil debris, showing different shapes;

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(1) Since the manuscript was submitted micropaleontological investigation (Steurbaut, 1986) confirmed the 813-822 m interval to be of Danian age (NP 3, 4) and the 871-875 m interval of Maastrichtian age.

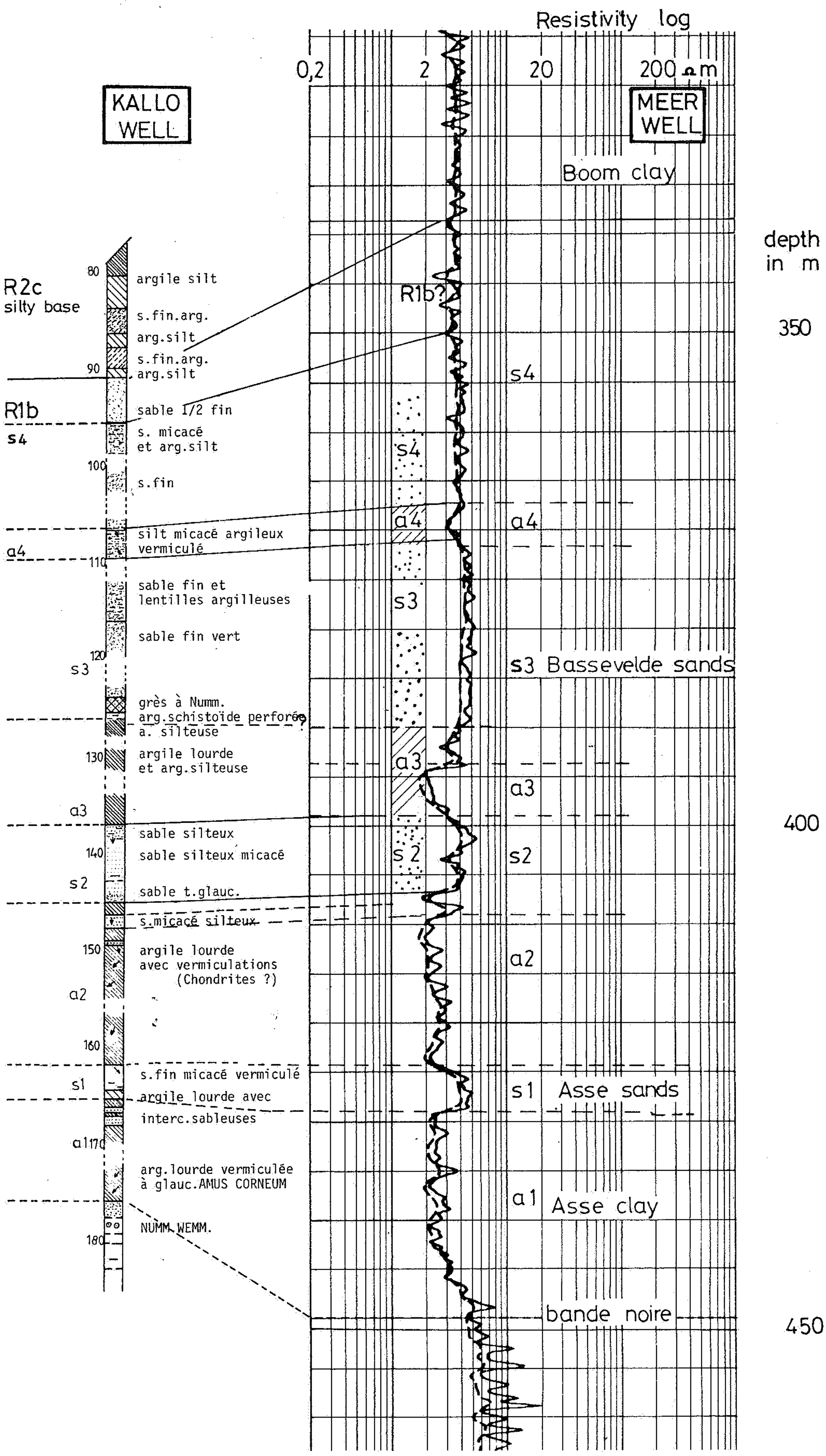


FIG. 9.- Comparison of the Kallo Complex in the Kallo well and in the Meer well

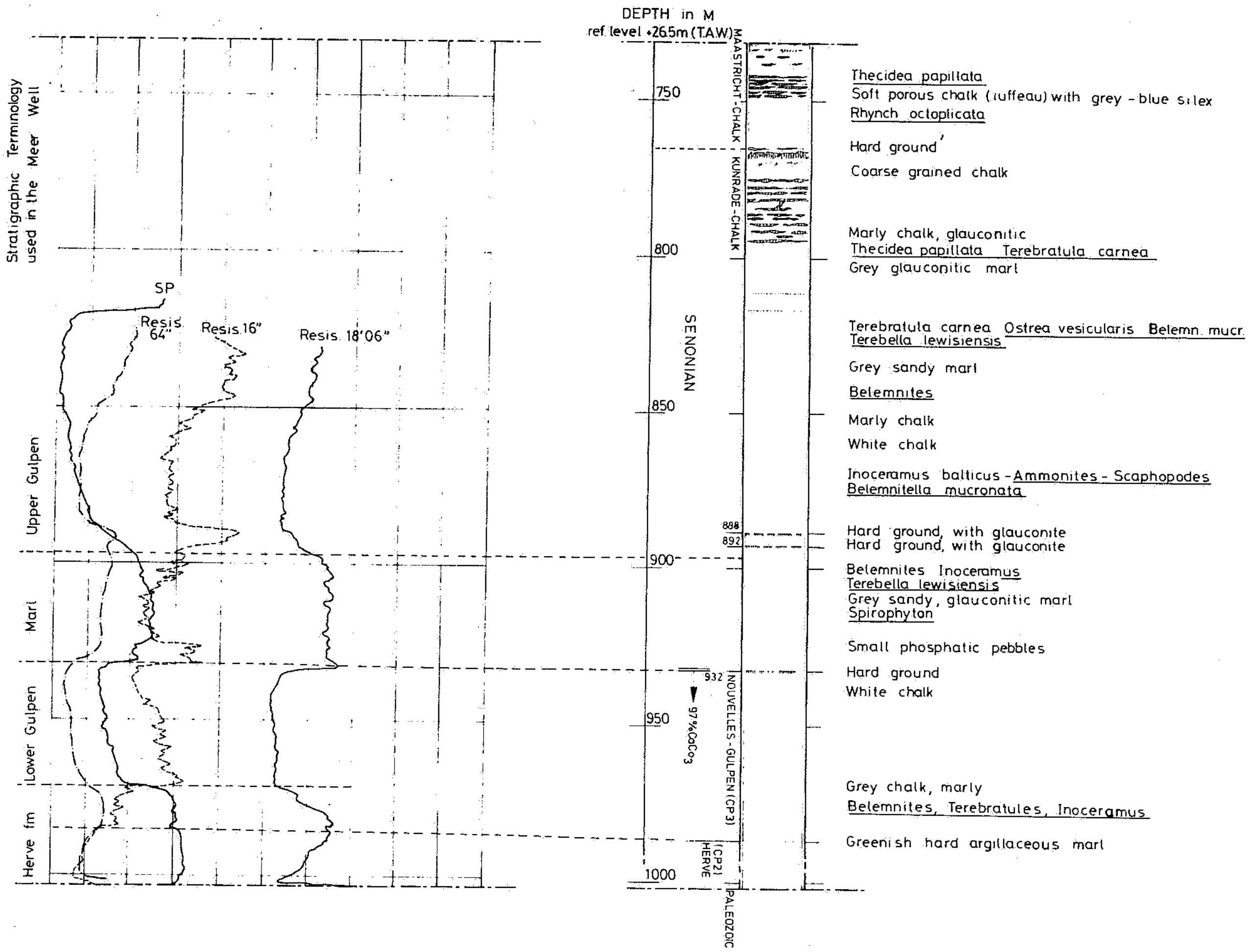


FIG. 10.- The mesozoic of the Turnhout well 17E/225
(after M. Gulinck, 1953)

some opaques and rare grains of angular quartz also occur. Recrystallization of the calcite as overgrowths is common.

At 911 m a sharp geophysical change occurs, resulting in a gamma ray intensity increase, a density increase from 2,1 to 2,25 gr/cm^5, a marked SP change and an interval velocity increase from 2900 m/sec to 3386 m/sec.

Downwards, these values gradually return to the common values of the chalk above 911 m. The cuttings suggest that at 910 m the denser white Gulpen chalk sequence starts. Hence the 834 - 911 m interval is considered as the Maastricht Calcarenite (or Formation). The 873 m core shows in thin section many angular quartz grains and glauconites; also some microcline grains occur; several thin undulatory laminae are expressed by opaque material.

The 911 - 1015 m interval is considered as the Maastrichtian, Upper Gulpen Chalk.

The 1015 - 1057 m interval is a geophysically well defined unit. Especially the higher density (2,36 -2,40), the SP, the higher interval velocity 3585 m/sec, and the resistivity changes (ILD increases, SFL decreases) define the unit. From these petrophysical data and the cuttings, the interval is thought to represent a dense marl. The low gamma ray may indicates the smectitic nature of the clay, but might also be influenced by bad hole conditions (Caliper).

The 1057 - 1116 m interval is again made up by chalk, whilst the Mesozoic sequence starts at the base (1196 - 1116 m interval) with a dense marl or clay unit, with similar petrophysical properties as the 1015 - 1057 m interval, but with almost no permeability as shown by the comparison of the two resistivity curves with different spacing and hence penetration.

The stratigraphic interpretation within the Cretaceous as given on Fig. 5, can be compared very well with the stratigraphic interpretation of the Turnhout well as given by M. Gulinck (1953-1954), through the use of the well logs (fig. 10). On this basis an Upper and Lower Gulpen formation (911 - 1015 m and 1057 - 1116 m) are distinguished and separated by dense marl unit the Beutenaken marl (1015 - 1057 m). The 1116 - 1186 m unit is attributed to the Herve formation.

CHAPTER III
THE CARBONIFEROUS

1.- LITHOLOGICAL DESCRIPTION

Borehole Meer 2 has reached the top of the Carboniferous at 1186 m or -1173 m TAW. Borehole Meer 2 has progressed till a depth of 2420 m whereas borehole Meer 2a was drilled till a depth of 2513 m or -2500 m TAW (fig. 2). The first Carboniferous cuttings have not been recorded before reaching a depth of 1263 m. The identification of the top of the Carboniferous subcrop was relatively easy as a result of the clear differenciation between Carboniferous and Cretaceous strata on natural gamma ray, resistivity, sonic and density (fig. 11).

The lithological succession is rather monotonous consisting predominantly of dark grey silty mudstone. Fine dark grey to black cuttings are derived from marine or brackish-water horizons also recognized by a bad hole rugosity in these intervals. Cuttings of coal or carbonaceous mudstone indicating the presence of coal seams have been observed down to a depth of 1850 m. Siltstones, fine grained sandstones and light coloured quartzitic sandstones occur regularly but are clearly subordinate to the silty mudstones.

Two cores were taken in the Carboniferous sequence (table 1). Lithology, flora and fauna suggest a lower Westphalian age.

Core 1 :

(1280.975 - 1286.375 m = 5.50) L = 5.30
inclination 3° to 5°.

Plant fossils :

Calamites, Cordaites, Asterophyllites, Lepidophyllum, Trigonocarpus, strobilus, all badly preserved.

Faunal remains :

Juvenile *Anthraconaia* and *Naiadites* fragments, fish scales and egg-capsules, perforating trace fossils.

Core 2 :

(1518.25 - 1525.35 m = 7.10 m) L = 7.26.
inclination 7° to 10°.

Lithology : (in cm)

0- 25 : dark silty micaceous mudstone
25- 75 : dark grey fissile mudstone with sideritic lenses and nodules
75-195 : dark grey bituminous mudstone
195-230 : clayey coal alternating with black bituminous mudstone
230-305 : seatearth with thin coal lenses in upper part
305-350 : grey silty mudstone, perforated, with sideritic nodules
350-535 : grey fine grained, finely straticulated sandstone with loadcasts and plant debris, slightly perforated
535-726 : grey finely straticulated fine grained sandstone and silty mudstone, with quartz veins.

Plant fossils :

Calamites, Sigillaria, Stigmaria, haecksel.

Faunal remains :

Many fish scales and egg-capsules, mollusc fragment, *Beloraphe kochi* and perforating trace fossils.

2.- PALYNOLOGY

Several samples of the Carboniferous strata in the Meer borehole have been studied for their miospore content by M. Streel (Univ. Liège) in order to check the stratigraphic interpretation based on petrophysical logs and compared to the zonation established by Van Wijhe & Bless (1973).

Only the uppermost sample at 1299 m has allowed a precise datation based on the presence of *Dictyotriletes bireticulatus* and rare *Vestispora,* characterizing the Zone III of Van Wijhe & Bless (Upper Westphalian A/Lower Westphalian B) possibly corresponding to the base of the *V. costata - V. pseudoreticulata* (CP) miospore zone (Paproth et al., 1983). Samples 1345 m and 1719 m are extremely rich in *Lycospora* (80 % of the miospore count). The absence of *Vestispora* excludes a Westphalian B - C age however. Samples 1384 m and 1889 m did not yield any miospores suitable for age determinations. The paucity in miospores does not allow the establishment of a more elaborate miospore zonation. The poor miospore preservation can possibly be explained by the high coalification observed at these levels.

3.- STRATIGRAPHIC INTERPRETATION

All rocks between 1186 m and 2513 m (or total depth) are assigned to the Upper Carboniferous (Silesian). Based on palynological datations, the Westphalian A/B stage limit should be situated near the top of the Carboniferous subcrop.

Two marine horizons are identified with certainty at 2075 m and 2235 m respectively, based on exceptional gamma ray peaks. The marine horizon at 2235 m has been identified as the Sarnsbank marine band at the Westphalian-Namurian subsystem limit. The marine horizon at 2075 m has been identified as the Finefrau Nebenbank marine band. Furthermore the Finefrau Nebenbank horizon also marks the transition from a prodelta to a deltaic depositional environment (cfr. infra).

In the Westphalian interval no striking marker beds were recorded and unequivocal correlations with the mining areas are not possible as long as other logged boreholes and reference sections are not available in the vicinity of the Meer borehole. With the aid of M.J.M. Bless, H. Fiebig and D. Schmitz, several tentative correlation have been made with the Peel and Niederrhein districts.

The coal seam groups occurring in the 1870 - 1940 m and 1765 - 1835 m intervals possibly correspond to the Girondelle and Plasshofsbank groups respectively (Kimpe, 1961).
In the 1600 - 1740 m interval two giant foresets are observed attaining a thickness of 70 m each (partly corresponding to the «grande stampe stérile» ?).

The Wasserfall eulittoral horizon constituting the limit between the intra-Westphalian A Floriffoux and Mons Members (Paproth et al., 1983) is equally not typical. Its most likely position is at 1665 m.

The Katharina = Quaregnon marine horizon (Westphalian A/B stage limit) - if traversed - is certainly not typically developped. Based on petrophysical correlations its most likely positions are at 1334 m or at a higher not-preserved level.

The sequence traversed between 1186 m and 1215 m, at the top of the Carboniferous subcrop possibly forms the base of a megacycle, or the base of a younger sequence unconformably overlying the Westphalian A deposits. Since no rock cuttings from this sequence were recovered the identification of this sequence cannot be proven.

4.- DEPOSITIONAL ENVIRONMENT

The Carboniferous sequence recognized in the Meer 2/2a boreholes forms part of the Upper Carboniferous paralic basin in northwest Europe. Its sedimentary characteristics and cyclicity can be deduced from the petrophysical logs (natural gamma ray, resistivity, sonic and neutron) run over the interval 1186 m - 2250 m (fig. 11).

The Finefrau Nebenbank and Sarnsbank marine horizons are very striking by their high gamma ray peaks (due to a high uranium content). Underneath the Finefrau Nebenbank horizon at 2075 m the sedimentary facies is more homogeneous indicative of prodeltaic turbidites, whereas above this horizon deltaic sedimentary patterns predominate. The horizon at 2075 m thus also marks the limit between two different sedimentary environments.

Megacycles ranging between 115 m and 200 m in thickness can be clearly distinguished, especially in the lower part of the section (base of successive cycles possibly at 2235, 2075, 1870, 1665, 1510, 1335, 1220 m). The base of these megacycles is generally constituted by a marine or brackish horizon whereas the top consists of a more sandy sequence containing coal seams. These cycles thus may be compared to the 60 m cycles described from Namurian deposits in Belgium and Germany (Fiege & Van Leckwijck, 1964; Van Leckwijck, 1964).

The deltaic progradation cycles have an average thickness of 70 m (eg. 1665 - 1735 m interval) or 30 m (eg. 1735 - 1765 m interval). In the more sandy and coaly floodplain deposits, the thickness of the delta foreset cycles is reduced to 10 - 15 m (eg. 1510 - 1550 m interval). The latter thickness corresponds to the average cycle thickness described by Van Leckwijck (1949) for Westphalian B deposits in the Campine.

Equally outside the coal-bearing intervals 10 m cycles may be separated from larger 30 m (15 - 35 m) cycles as shown most typically in the 1455 - 1490 m interval.

5.- COAL SEAMS

Several coal seams and coaly mudstone beds of Westphalian A age have been intersected between 1220 m and 2075 m. Compared to coal seams at stratigraphically identical levels in the Campine and Limburg mining fields, they are thinner (max. 75 cm), more argillaceous (high gamma-ray readings and ash-content) and less abundant, which means that they do not seem to be exploitable, certainly taking into consideration the considerable depth of the overburden. A general decrease in coal content from SE to NW has already been postulated in the Campine-Brabant basin.

The coalification rate, as indicated by the volatile matter content, seems higher than in the well explored southeastern part of the Campine basin (e.g. around the Westphalian A/B stage limit, the volatile matter content varies from 20-25 % at Meer to 35 % at Beringen and 26 % at Eisden). An increase in coalification towards the depocenters of the Campine-Brabant basin thus is discernible.

The volatile matter content has been measured

Table 5.- Volatile matter content of coal cuttings, analysed Eisden colliery (N.V. K.S.)

DEPTH M	DENSITY	WEIGHT %	ASH %	V.M. %	V.M. daf
1348	- 1.4 + 1.4	4.6 95.4	6.1 89.6	15.1 --	16.1 --
1352	- 1.4 + 1.4	5.3 94.7	7.1 89.1	15.0 --	16.1 --
1766	- 1.4 + 1.4	12.8 87.2	3.1 86.9	9.4 --	9.7 --

Table 6.- Volatile matter content of cored coal samples analysed Chemisch Instituut Schopping. Maastricht

DEPTH	MOISTURE %	ASH %	V.M. %
1520.20 - 31	3.40	40.13	9.95
1520.31 - 55	3.88	33.75	9.45
1520.55 - 77	3.10	65.28	9.53

on coal cuttings in the laboratory of the Eisden colliery (1348 m, 1352 m and 1766 m) (table 5) and on coal core samples in the chemical laboratory Schopping, Maastricht (1520 m) (table 6). A decrease in volatile matter content with depth is noticed although the number and the spacing of the samples does not allow the calculation of a precise gradient. However they correlate well with the reflectance data.

6.- COAL PETROGRAPHY

Thirteen samples were studied for their vitrinite reflectance by M. Wolf (RWTH Aachen). The average vitrinite reflectance was measured although the high coalification of the organic matter would favour the measurement of maximum reflectivities. These could not be measured because of the extremely small size of the plant remains.

A clear increase in reflectance with depth is observed (fig. 12). In the uppermost sample at 1300 m depth presumably close to the Westphalian A/B stage limit, the organic matter has reached the low volatile bituminous coal stage with circa 20 % volatile matter content (d.a.f.). At total depth at 2500 m (of presumed Upper Namurian age), it has reached the upper limit of the meta-anthracite stage containing less than 4 % of volatile matter (fig. 12). The coalification gradient attains 0,17 % Rm per 100 m depth increase. It is suggested that a small break in coalification gradient may occur in the 1800 - 2075 m (near base Westphalian) interval, coinciding with a change in sedimentary history.

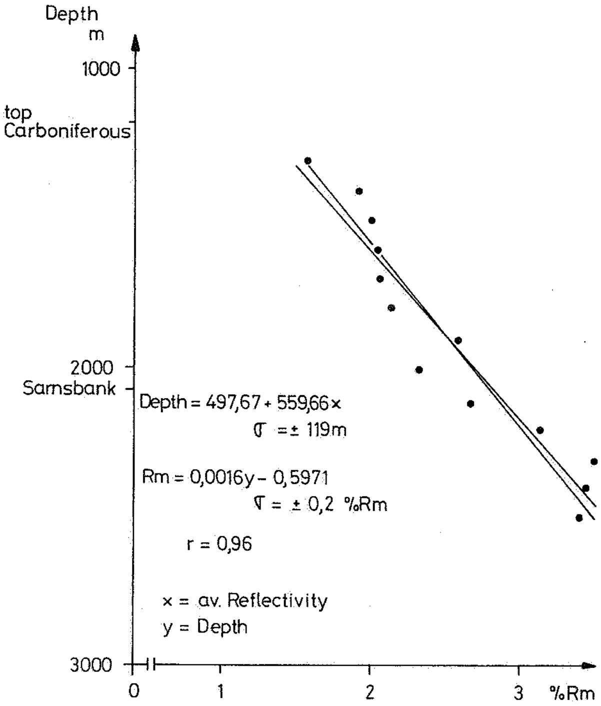


FIG. 12.- Increase of vitrinite reflectivity : Borehole Meer 7E205 (after M. Wolf)

7.- SOURCE ROCK EVALUATION
(fig. 13, 14)

62 Cuttings samples have been analysed on the Rock-Eval by P. Leplat (Département Laboratoires-Exploration, Labofina, Brussels). As could be supposed the organic matter is essentially derived from continental higher plants (gas-source rock type III kerogen). The organic matter content of the Upper Carboniferous mudstones and sandstones varies around 1 %.

The source rock evolutionary pathways match the coalification increase deduced from vitrinite reflectance data and volatile matter content of coal. The temperatures of the S2 peak generally exceed 500°C thus indicating that the thermal degradation of the organic matter is practically completed. Below 1800 m the organic matter is carbonised and unable to generate hydrocarbons. The maximal paleotemperature of these sediments has probably ranged from 160°C to 200°C

8.- PALEOGEOGRAPHIC IMPLICATIONS

Although the distance between the Turnhout and Meer boreholes is only about 20 km, and both are situated in the Campine-Brabant basin, stratigraphic correlations within the Upper Carboniferous are hardly possible. In the Turnhout borehole (where no petrophysical data are

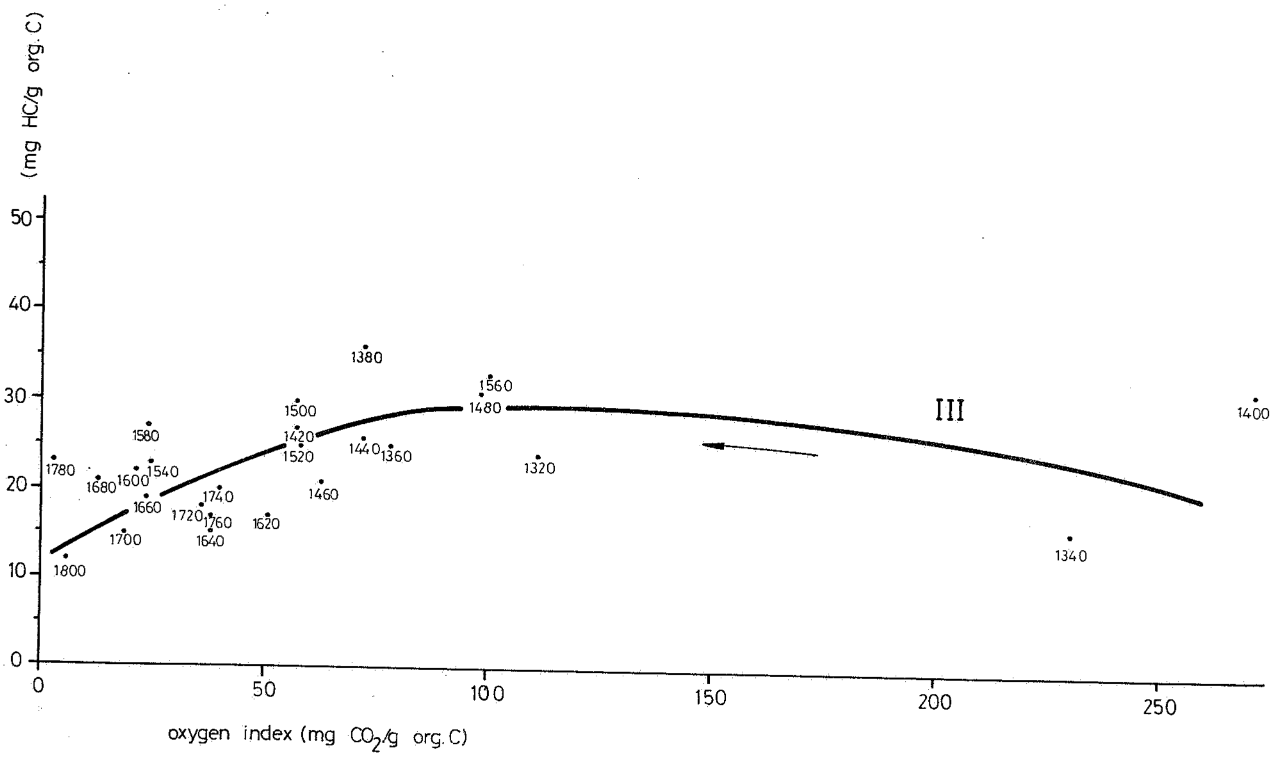


FIG. 13.- Borehole 149 (7E205) Meer 2 +2a
Source rock classification of the Carboniferous sequence
Geological Survey of Belgium based on Labofina Report PL 81-5

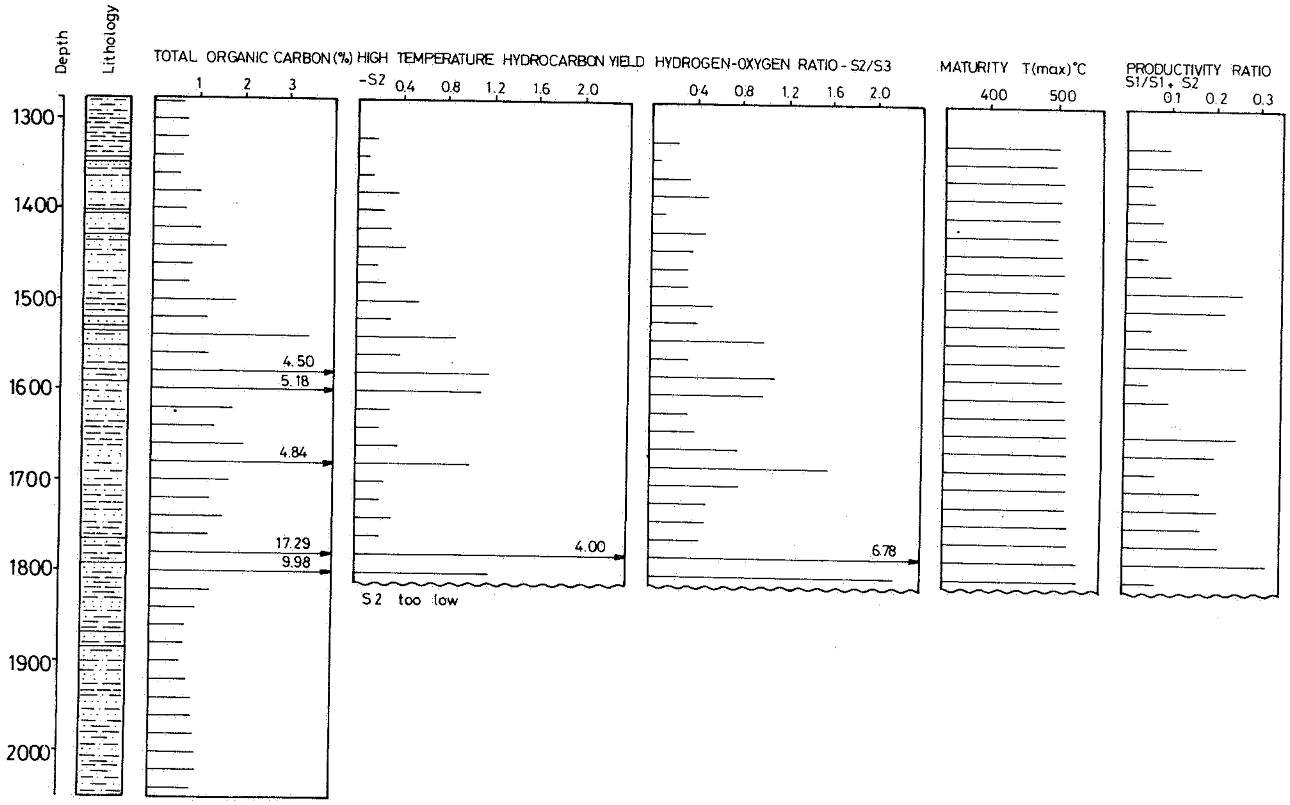


FIG. 14.- Borehole 149 (7E205) Meer 2 + 2a
Geochemical well log in upper Carboniferous sequence

available for the Carboniferous strata), the Sarnsbank horizon has been identified by the presence of *Gastrioceras* cf. *subcrenatum* at 1660.60 m (Delmer, 1958). On the 1963 mining map however the Westphalian-Namurian subsystem limit has been drawn 110 m higher without any obvious reasons (Delmer, 1963). The Sarnsbank marine band resulted from a major sea incursion recognized in different coal basins.

The total thickness of the Namurian strata in the Turnhout borehole attains 501 m (compared to minimum 278 m for the late Namurian only in Meer).

Possibly a thickness reduction in the Turnhout area is partly due to faulting, such as described by Delmer (1958) at 1712 (disappearance of the Hauptflöz and Neuflöz horizons) and at 1824 m. On the other hand the lack of late Namurian (Yeadonian) beds in Turnhout could indicate an unconformable contact between Namurian and Westphalian strata, such as suggested from a slight Westphalian onlap on the continuous seismic reflector, representing the Sarnsbank marine band and underlying sandstone (Dreesen et al., 1985). Another unconformity may occur near the Westphalian A/B stage limit.

However a particular depositional mechanism (Vandenberghe, 1982b, 1984) is invoked to explain the abnormal thickness increase in Namurian strata which may attain about 1500 m as suggested by seismic profiling over the Meer borehole.

CHAPTER IV

VERTICAL SEISMIC PROFILING, SYNTHETIC SEISMOGRAM AND SURFACE REFLECTION SEISMICS

1.- VSP ACQUISITION AND PROCESSING

A VSP and check shot survey was carried out in three steps by SSL Ltd.

The first survey consisted of 30 levels from 563,5 - 3,5 m below groundlevel (casing shoe at 166,5 m). A second survey consisted of 60 levels from 1783,5 m - 196,5 m below groundlevel (casing shoes at 215 and 722 m). A third survey consisted of 16 levels from 2062 - 1000 m (casing shoe at 1793 m). In the VSP 74 levels have been found suitable to be processed, namely in the intervals 2062 - 1737 m, 1708,5 - 563,5 m, 543,5 - 323,5 m, 296,5 - 196,5 m and at 171,2 m.

A single bolt air gun (40 cu.in. capacity) was used for all three surveys. This has produced a reasonably consistent waveform both within and between each survey, although some variation is present.

After editing of the data, an automated trace alignment procedure was applied to align and stack the constant depth traces and to attenuate random noise. An amplitude recovery curve was then applied and the traces were shifted to align the first arrivals at the corrected two-way time below the depth reference level (at + 16,7 m). A bandpass filter (14 - 18, 98 - 122 Hz) was then applied to these aligned data. Continuity of the upgoing events was improved considerably by removing the downgoing energy. The application of a 9:1 median pick was preceded and followed separately by bandpass filtering. The special VSP deconvolution operators were designed from the first 230 ms of downgoing wave. Diffractions and events with moveout were enhanced with tracking filters. For comparison with the surface seismic survey front corridor trace displays have been produced from the deconvolved data.

2. SYNTHETIC SEISMOGRAMS

A combination of the interval velocities and the corresponding interval densities were combined in an acoustic impedance log. The latter was then transformed in a set of reflection coefficients marking interval boundaries.

Taking into account transmission losses with depth, the reflection coefficients were convolved with a klauder wavelet. To make a comparison with the surface vibroseis survey more easy, seismograms with different frequency bandpasses were generated.

3.- A COMPARISON BETWEEN VSP RECORD-SYNTHETIC SEISMOGRAM AND VIBROSEIS SURFACE SEISMIC AT THE MEER WELL LOCATION

The Meer well is located at the intersection of two surface seismic profile lines. The VSP survey, and also the synthetic seismograms, were produced in order to help the interpretation of the seismic profiles, more precisely in order to establish a better interpretation of the reflection pattern in stratigraphic terms.

In order to compare the three types of records, they have to be brought to the same reference level. Indeed the reference level for the vibroseis survey is the zero or sea level, for the synthetic seimogram it is the ground level (+13,2 m) and for the VSP display the reference level is the rotary table (+16,7 m).

Averaging the surface layer (10 - 20 m thickness) velocities obtained by uphole shooting in the area leads to 820 m; using this figure, the shift to be applied should be between 30 and 40 m and indeed a 30 m shift is found to give a good match.

The correction of the sonic log by the seismic check shots allows a good match between the time domains of the VSP and surface seismics and the depth domain of the registered well log interpreted in terms of particular stratigraphic intervals. In this way it is possible to transfer the stratigraphic sequence known from all the log data and the study of cuttings and cores in the well via the synthetic seismograms and via the VSP to the reflector pattern on the surface vibroseis sections.

In this way the stratigraphic interpretation from chapter II and III is transferred to the seismic profile (fig. 15). Time-depth curves, to be used in the depth calculation of seismic reflections from the vriboseis surveys in the area, can be obtained from the integration of the corrected sonic log and from the processing of the VSP. The latter curves are given in Fig. 16a, b.

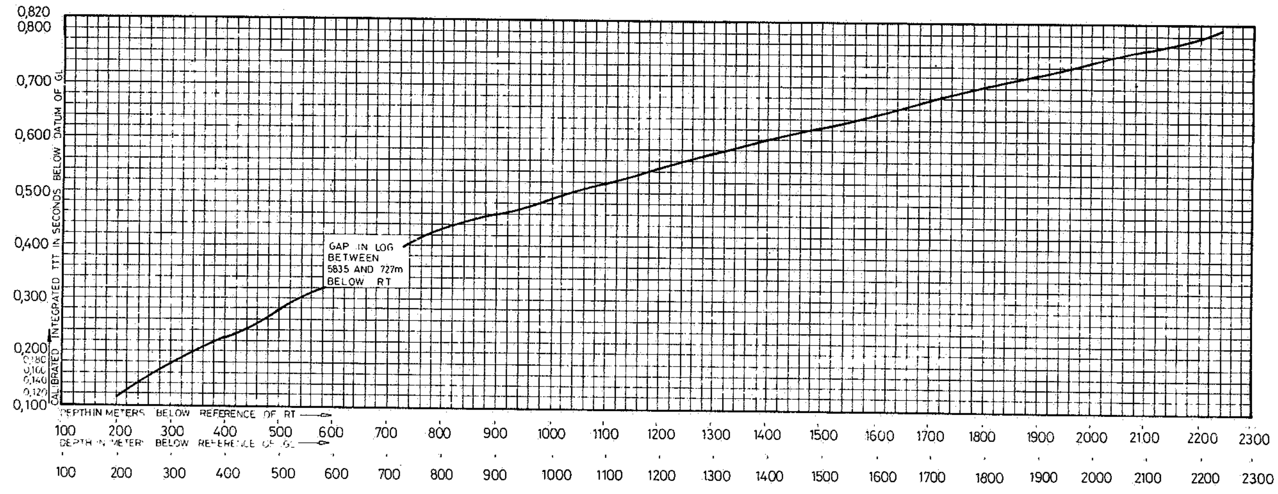


FIG. 16a.- Calibrated sonic time depth curve

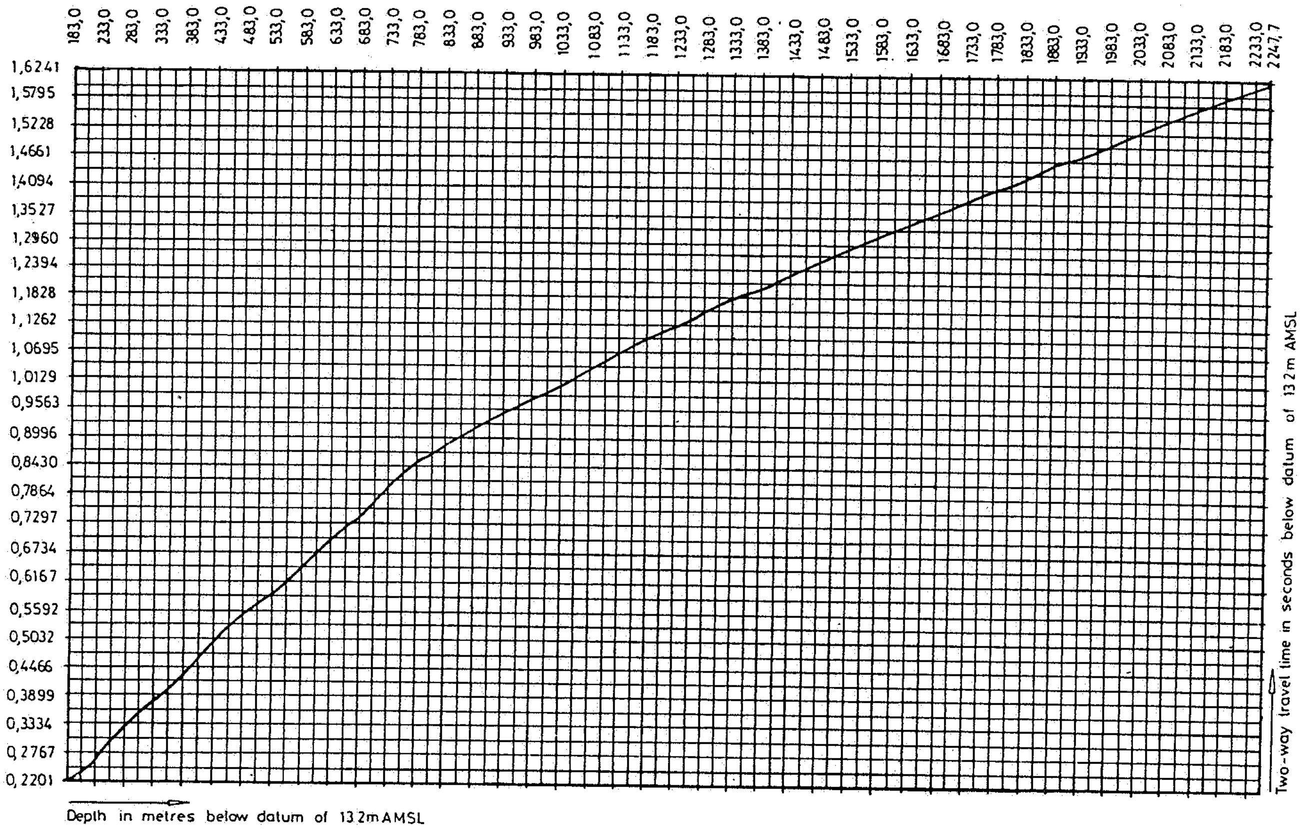


FIG. 16b.- V.S.P. derived time (T.W.T.) - depth relationship

CHAPTER V
TEMPERATURE DATA

1.- Several temperature logs were run till a maximum depth of 2260 m under different conditions, e.g. hole conditions and equilibration time. A selected range of temperature data with depth are given in tables 7 to 10 each time with the specific conditions for each run.

2.- On Figure 17 the most relevant data are graphically represented. The most reliable, equilibrated log is drawn thickly. At the base (1700 - 2230 m) it has been completed by assuming the same gradient as the less equilibrated T-log.
At the very top the seasonal temperature inverse can be noticed around 20 m. The gradient in the Tertiary, between 100 m and 834 m is regular and its average is 2,9° C/100 m. It can be noticed that in general the gradients in the Tertiary clays lie below 3° C/100 m, even lower than 2° C in some cases. This effect is due to a higher thermal conductivity in the sands and maybe also to a groundwater movement in the sands, as the recharge zone in outcrop for the sands occurs only some tens of kilometers to the south. The gradient in the Vroenhoven chalks and the whole Mesozoic chalk and marl sequence (808 - 1186 m) is also regular and averages 3,36° C/100 m. It varies between 2,9° C and 3,7° C/100 m; particular gradient values seem to be bound to the lithological units. It is remarkable that in the less equilibrated, open hole T-log, the water bearing Vroenhoven-Maastricht chalks have as expected a low gradient, whilst after casing and longer equilibrium times, the gradient turned normal.

In the Upper Carboniferous detrital sequence of shales and sandstones, the average gradient between 1186 m and 1700 m is 4,34° C/100 m; the gradient between 1750 m and 2234 m, read off the less equilibrated T-log, is only 3,14° C/100 m. This leads to an average gradient between 1186 m and 2234 m in the Upper Carboniferous of 3,82° C/100 m, comparable to the mean value of 3.62° C/100 m calculated from the Legrand data (Legrand, 1975).

CHAPTER VI
THE VROENHOVEN-MAASTRICHT CHALK RESERVOIR

As an economic use of the Upper Cretaceous chalk aquifer in the area can be foreseen for the future, this reservoir has been shortly tested for its hydrodynamic properties. Economic use can be found in the production of biomass e.g. brine

Table 7.- Temperature log, 27/08/80, T.D. 722 m

Depth	Temperature	Gradient °C/100 m
35 m	15 °C	
		0,47
78 m	15,2°C	
		0,91
100 m	15,4°C	
		0,53
138 m	15,6°C	
		0,52
215 m	16 °C	
		0,31
280 m	16,2°C	
		0,57
315 m	16,4°C	
		0,48
357 m	16,6°C	
		0,50
397 m	16,8°C	
		0,38
450 m	17 °C	
		0,61
488 m	17,2°C	
		0,51
527 m	17,4°C	
		0,65
558 m	17,6°C	
		1,18
575 m	17,8°C	
		1,28
622 m	18,4°C	
		1,92
648 m	18,9°C	

Date : 27-08-1980
Time since circulation stopped : 4 hours
T.D. at date : 722 m
Casing 20" shoe at 166,5 m
Openhole 166,5 - 722 m in 17 1/2"

Table 8.- Temperature log, 10/12/80, T.D. 1800 m

Depth	Temperature	Gradient °C/100 m
652 m	33,50°C	
		2,40
700 m	34,65°C	
		2,70
750 m	36 °C	
		0,60
800 m	36,30°C	
		0,90
850 m	36,75°C	
		1,10
900 m	37,30°C	
		2,80
950 m	38,70°C	
		3,00
1000 m	40,20°C	
		2,60
1050 m	41,50°C	break at 1081 m
1100 m	43,70°C	break at 1104 m
1150 m	45,50°C	
		1,20
1200 m	45,65°C	
		2,70
1250 m	47 °C	
		4,50
1300 m	49,25°C	
		3,90
1350 m	51,20°C	
		4,50
1400 m	53,40°C	
		4,90
1450 m	55,85°C	
		3,60
1500 m	57,65°C	
		2,90
1550 m	59,10°C	
		6,00
1600 m	62,10°C	
		5,50
1650 m	64,85°C	
		5,70
1700 m	67,70°C	
		6,10
1750 m	70,75°C	
		7,10
1800 m	74,30°C	

Date : 10-12.1980
Time since circulation stopped : 7 days
TD at date : 1800 m
casing 20" shoe at 215 m, 13 3/8" shoe at 722 m
openhole 722 m - 1800 m in 12 1/4"

shrimp (Brisset et al., 1982; Sorgeloos, 1983), in the use for space heating through heat pumps and the direct use in swimming pools as has been the case for several years in Turnhout and Herentals.

1.- POROSITY DISTRIBUTION IN THE CHALK

The well logs in the porous Vroenhoven-Maastricht chalks and in the white chalks of the Upper Gulpen Formation are shown in Fig. 18. It is possible that the lower part of the Upper Gulpen Chalk (975 - 1015 m) is as porous as the Vroenhoven-Maastricht chalk (808 - 1011 m) but probably its permeability is much lower.

2.- PERFORATION OF THE CASING

It was originally planned to cut the 7" casing (fig. 2) at 980 m depth as a CBL has shown the cement top behind the 7" casing at 987 m. After cutting however the casing could not be removed. Probably, the barite mud behind the casing and above the cement has hardened in the time lapse since the cementing job was done. A free-point indicator showed the 7" casing free only from 610 m depth on. Finally the 7" was cut at 607 m and then removed (fig. 19). Four perforations were carried out, between 822 - 832 m, 845 -855 m, 880 - 890 m and 890 - 900 m. For each 10 m string 134 charges, all in the same direction, were fired, through the 7" and 9 5/8" casing.

3.- PUMPING TEST RESULTS

Before the actual pumping tests, a short drawdown test was done with a 5 m^3/h flow rate. Afterwards an acid stimulation job was carried out in three steps, with a total of 1050 kg hydrochloric

Table 9.- Temperature log, 5/2/81, T.D. 2416 m

Depth	Temperature	Gradient °C/100 m
1750 m	63,15°C	
		1,86
1755 m	63,15°C	
		1,00
1790 m	63,80°C	
		3,70
1810 m	64 °C	
		2,59
1837 m	65 °C	
		3,86
1876,60 m	66 °C	
		2,06
1901,50 m	67 °C	
1925 water bearing sandstone		
		0,61
1950 m	68 °C	
		8,80
2031 m	68,50°C	
2040,50 m break		
2042 m	69,38°C	
		1,56
2069 m	69,80°C	
		11,56
2091,50 m	72,40°C	
		2,64
2152 m	74 °C	
		4,88
2193 m	76 °C	
		4,55
2215 m	77 °C	

2233 m	78,40°C sandstone	
		- 2,50
2253 m	77,95°C	

Date : 5-02-1981

time since circulation stopped : 10 hours

TD at date : 2416 m

casing 20" shoe at 215 m, 13 3/8" shoe at 722 m (plus at 2253 m),
9 5/8" shoe at 1793 m

openhole 1793 m - 2416 m in 8 3/8"

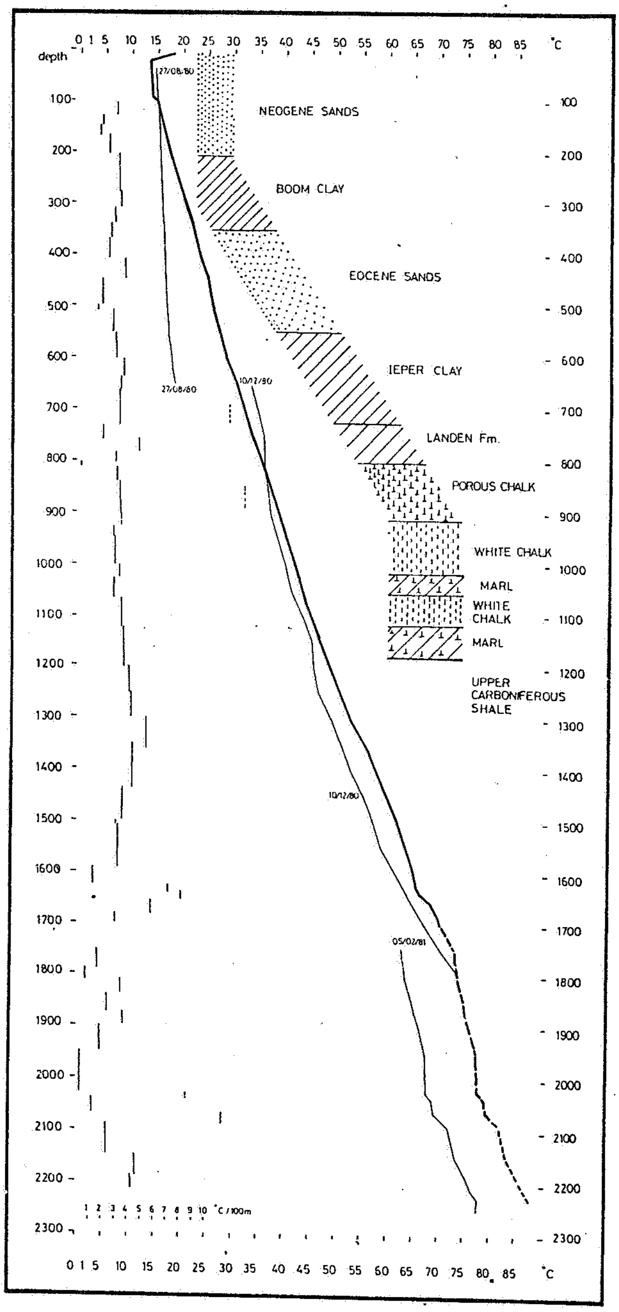


FIG. 17.- Borehole 149 (7E205) Meer 2 + 2a

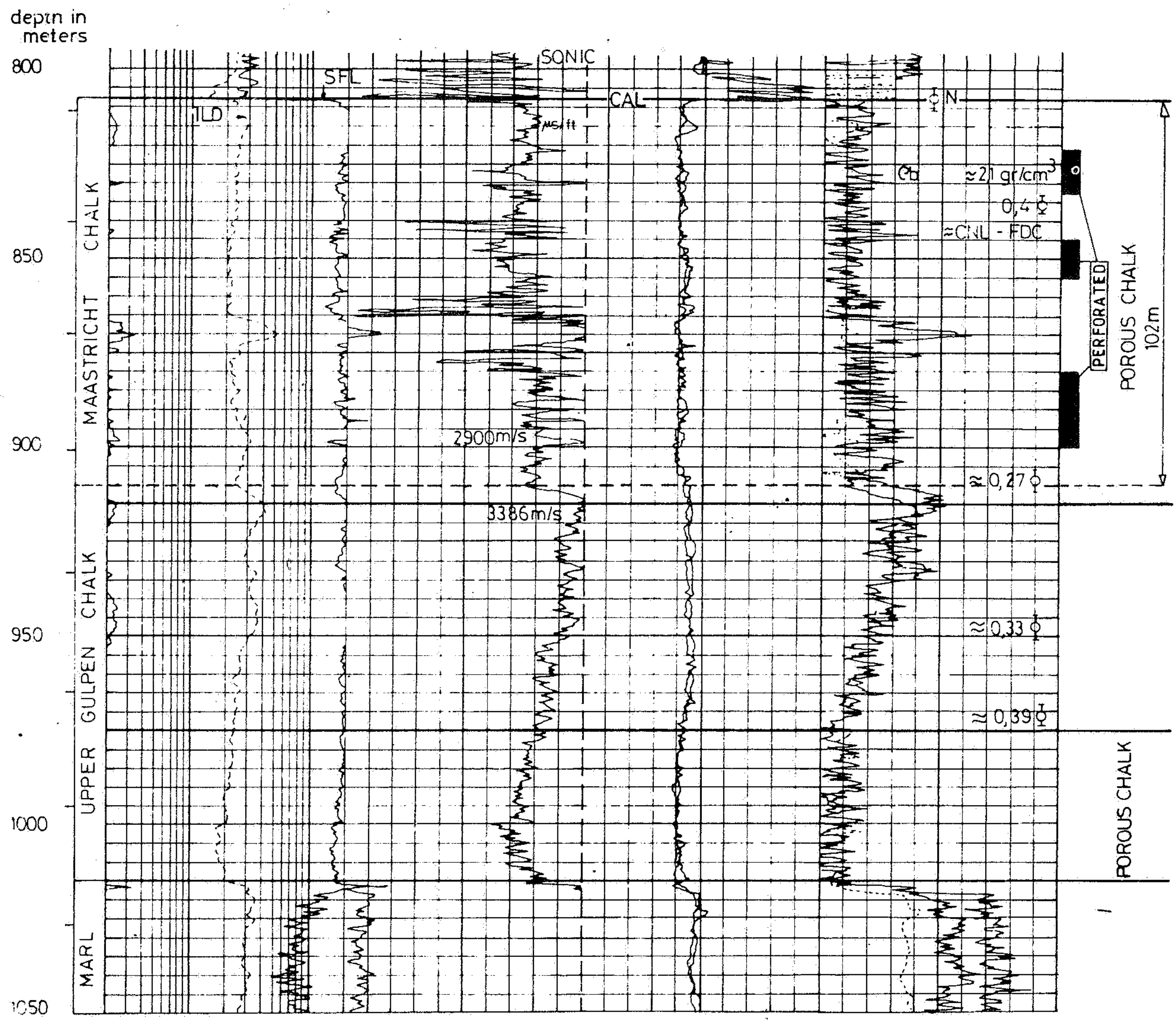


FIG. 18.- Cretaceous chalk reservoir

acid injected. The well is flowing with a rate of 2,8 m^3/h at an artesian pressure corresponding to 18 m above ground level.

The pumping data are given in Table 11.

A Jacob-type analysis is performed on the first part of the test with constant flowrate $Q = 12{,}4\ m^3/h$. The data, plotted on fig. 20, give $K.D = 11{,}33\ m^2/day$.

The reservoir thickness of 102 m is used to calculate K value. Theoretically a correction for incomplete well perforation should be added. The obtained value for K is 133 md.

A Jacob-Cooper analysis was made for the 18 m^3/h step, after the calculation of t for some values (Kruseman, Deridder, 1979). The data, plotted on fig. 21, were used to calculate $K.D. = 9{,}6\ m^2/day$ and $K = 113$ md.

The data on the pressure recovery in the well after the pumping was stopped are given in Table 12. As no equilibrium was reached yet at the end of the pumping, a weighted mean a value of 14,86 m^3/h was used in the Jacob formula (fig. 22). The value for K obtained from the recovery analysis is only 11 md, an order of magnitude less than from the pumping analysis.

4.- CHEMICAL DATA AND TEMPERATURE

The total dissolved solids content at the end of the test was 30 gr/liter, the pH 6,6 and the temperature at the well head 35°C.

In order to avoid acid treatment influence, a pH was measured after the well flowed freely during three weeks. The pH then measured was 7,6.

Table 10.- Temperature log, 10/8/81, T.D. 2515 m, log limited to 1699 m

Depth	Temperature	Gradient °C/100 m
5 m	18,60°C	
20 m	13,84°C	
40 m	13,87°C	
90 m	14,25°C	0,76 break
100 m	15,23°C	
125 m	16 °C	3,08
145 m	16,39°C	1,95
168 m	16,80°C	1,78
201 m	17,60°C	2,42
276 m	20 °C	3,20
306 m	21 °C	3,33
337 m	21,90°C	2,90
364 m	22,60°C	2,60
405 m	23,60°C	2,44
443 m	25 °C	3,68
496 m	26 °C	1,89
508,50 m	26,20°C	1,60
551,50 m	27,40°C	2,79
598 m	28,80°C	3,01
637 m	30,20°C	3,59
660,50 m	31 °C	3,40
690 - 725 iregular zone		3,31
730 m	33,30°C	
755 m	33,80°C	2,00
780 m	35 °C	4,80
800 m	35,60°C	3,00
805 m	35,62°C	0,40
811 m	36 °C	6,33
837 m	36,80°C	3,10
		3,38
845 - 890 m rather irregular		
902 m	39 °C	
925 m	39,80°C	3,48
946 m	40,40°C	2,86
1000 m	42 °C	2,96
1024 m	42,80°C	3,33
1066 m	44 °C	2,86
1123 m	46 °C	3,51
1150 m	47 °C	3,70
1204 m	49 °C	3,70
1253 m	51 °C	4,08
1300 m	53 °C	4,25
1362 m	56,40°C	5,48
1438 m	59,80°C	4,47
1500 m	62,10°C	3,71
1509 m	62,39°C	3,22
1563 m break		3,39
1589 m break		
below 1580 somewhat iregular		
1592 m	65,20°C	
		1,52
1625 m	65,70°C	3,33
1640 m	66,80°C	7,33
1657 m	68,60°C	10,59
1684 m	70,20°C	5,93 6,64
1699 m	70,65°C	3,21

Max. temperature 1698 m 71,15°C
equilibration time : 4 months
Date : 10-08-1981
Time since circulation stopped : 4 months
T.D. at date : 2515 m drilled, cement plug inside casing 2090 m, mud selection at 1699 m (cfr. Fig. 2)
casing 20" shoe at 215 m, 13 3/8" shoe at 722 m, 9 5/8" shoe at 1793 m,
7" shoe at 2275 m
openhole 2275 - 2515 m in 8 3/8"
max. Temp. recorded at 1698 m : 71,15°C.

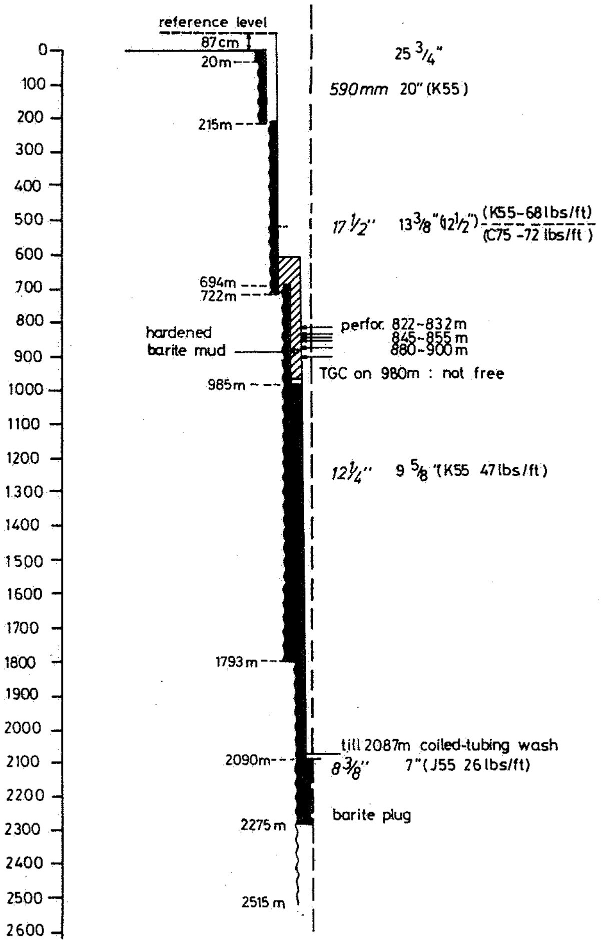


FIG. 19.- Meer well after perforation

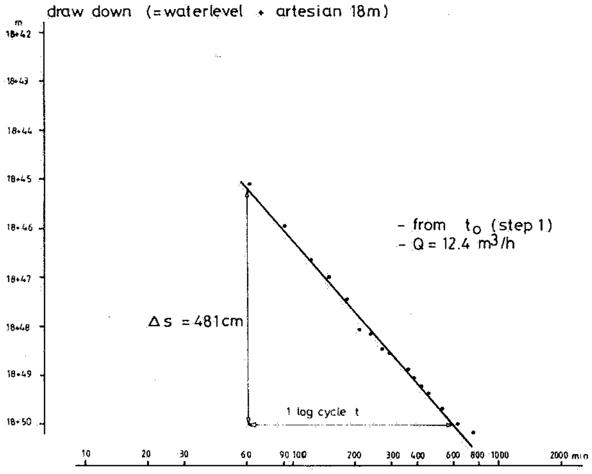


FIG. 20.- Jacob analysis of the 12,4 m³/h step

Table 11.- Pumping data, Vroenhoven-Maastricht chalk reservoir

time	flow m³/h	time in min	waterlevel*	density
7,30 h	12,4	0	Start proefpomping	
8 h	12,4	30	-43,82	
8,30 h	12,4	60	-45,09	
9 h	12,4	90	-45,94	
9,30 h	12,4	120	-46,64	
10 h	12,4	150	47,00	
10,30 h	12,4	180	47,45	
11 h	12,4	210	47,84	1,01
11,30 h	12,4	240	47,94	
12 h	12	270	48,22	
12,30 h	12	300	48,51	1,015
13 h	12	330	48,74	1,01
13,50 h	12	360	48,86	1,01
14 h	12	390	49,04	1,013
14,30 h	12	420	49,20	
15 h	12	450	49,37	1,012
15,30 h	12	480	49,47	1,012
16 h	12	510	49,64	1,012
16,30	12	540	49,72	1,012
17 h	12	570	49,85	
17,30 h	12	600	49,90	1,015
18 h	12	630	50,00	
18,30 h	12	660	50,02	1,012
19 h	12	690	50,14	
19,30 h	12	720	50,11	1,012
20 h	12	750	50,16	
20,30 h	12	780	50,21	1,012
21 h	12	810	50,27	
21,30 h	12	840	50,31	1,013
22 h	12	870	50,34	
22,30 h	12	900	50,37	1,012
23 h	12,4	930	50,39	
23 h			Start proefpomping 18 m³/u	1,012
23,30 h	18	960	81,15	1,010
24 h	18	990	84,23	
0,30 h	18	1020	85,01	1,01
1,00 h	18	1050	85,49	1,01
1,30 h	18	1080	85,85	1,01
2,00 h	18	1110	86,09	
2,30 h	18	1140	86,34	1,01
3,00 h	18	1170	86,56	
3,30 h	18	1200	86,80	1,01
4,00 h	18	1230	86,96	
4,30 h	18	1260	87,14	1,01
5,00 h	18	1290	87,29	
5,30 h	18	1320	87,38	1,01
6,00 h	18	1350	87,46	
6,30 h	18	1380	87,57	1,01
7,00 h	18	1410	87,77	
7,30 h	18	1440	87,88	1,01
8,00 h	18	1470	87,94	
8,30 h	18	1500	88,00	1,01
9,00 h	18	1530	88,09	
9,30 h	18	1560	88,14	1,01
10,00 h	18	1590	88,22	
10,30 h	18	1620	88,30	1,01
11,00 h	18		88,40	1,01
	Einde proefpomping 11 h			

* the reference level is groundlevel (+ 13,2 m) + 0,85 m.

Table 12.- Pressure recovery after pumping, Vroenhoven-Maastricht chalk reservoir

time	s"	s"	t"	t	t/t"	s"/Q*
11.00 h	88,40 + 18					
11.05 h	77,70 + 18	95,70 m	5 min	1665 min	6,44	6,44
11.10 h	55,60 + 18	73,60 m	10 min	1660 min	116	4,953
11.15	44,00 + 18	62,00 m	15 min	1665 min	111	4,172
11.20	25,00 + 18	53,00 m	20 min	1670 min	83,5	3,567
11.25	27,80 + 18	45,80 m	25 min	1675 min	67	3,082
11.30	21,80 + 18	39,80 m	30 min	1680 min	56	2,678
11.35	17,10 + 18	35,10 m	35 min	1685 min	48,1	2,362
11.40	13,25 + 18	31,25 m	40 min	1690 min	42,2	2,103
11.45	10,05 + 18	28,05 m	45 min	1695 min	37,7	1,888
11.50	7,45 + 18	25,45 m	50 min	1700 min	34	1,713
11.55	5,35 + 18	23,35 m	55 min	1705 min	31	1,571
12.00	3,60 + 18	21,60 m	60 min	1710 min	28,5	1,454
12.05	2,20 + 18	20,20 m	65 min	1715 min	26,4	1,359
12.10	0,00 + 18	18,00 m	70 min	1720 min	24,6	1,211

* mean Q was used (14,86 m^3/h)

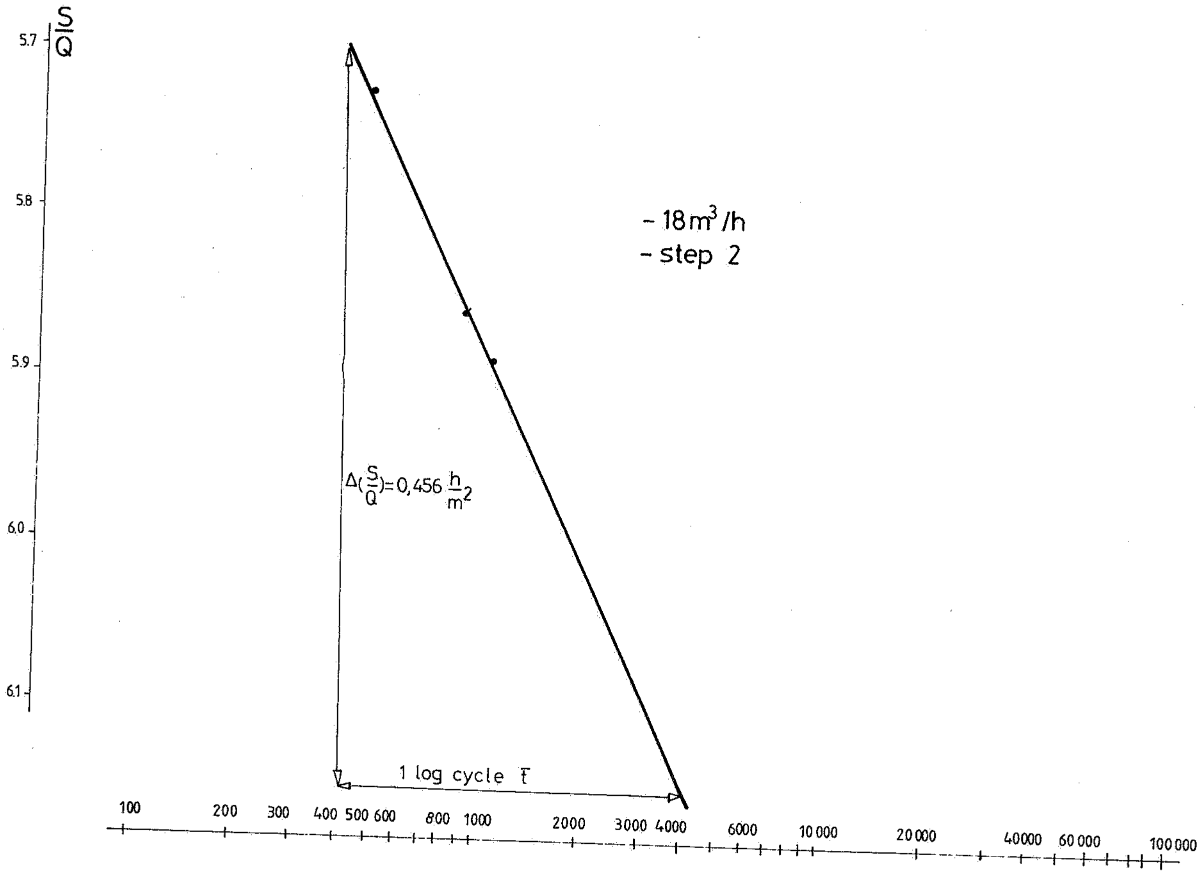


FIG. 21.- Jacob - Cooper analysis of step 2, 18 m^3/h

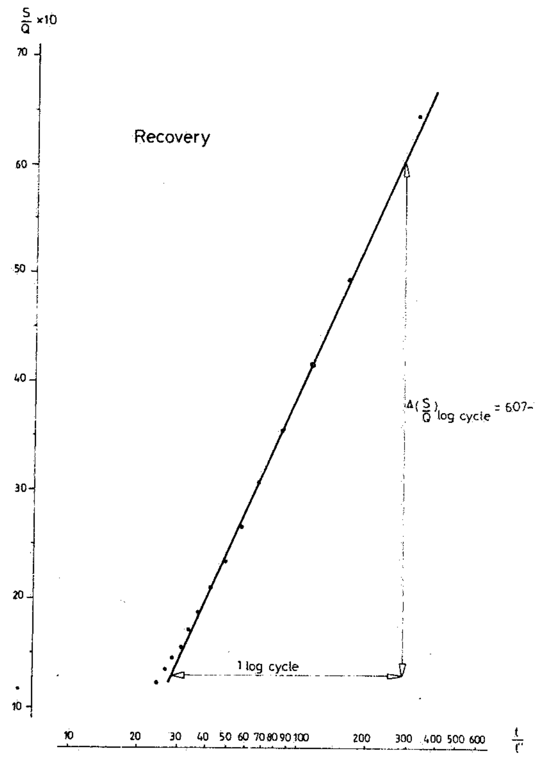


FIG. 22.- Jacob - Cooper test of the recovery after the pumping test

REFERENCES

BRISSET, P., VERSICHELE, D., BOSSUYT, E., DE RUYCK, L. & SORGELOOS, P., 1982. High density flow-through culturing of brine shrimp Artenia on inert feeds-preliminary results a modified culture system. Aquacultural Engineering 1, 1982 : 115-119.

DELMER, A., 1962. Sondage de Turnhout n° 120. Ann. Mines Belg. : 101-138.

DELMER, A., 1983. Mijnkaart van het Kempens Kolenbekken. Ann. Mines de Belgique, 1963, 6: 739-754.

DREESEN, R., BOUCKAERT, J., DUSAR, M., SOILLE, P. & VANDEN BERGHE, N., 1985. Collapse structures at the Dinantian-Silesian contact in the subsurface of the Campine basin, N of the Brabant Massif (N. Belgium). C.R. 10e Congrès Strat. Géol. Carbonifère, Madrid, 1983, II: 7-14.

FIEGE, K. & VAN LECKWIJCK, W., 1964. Le développement stratinomique du Namurien A et B en Belgique méridionale. C.R. 5e Congrès Strat. Géol. Carbonifère, Paris, 1963, I : 415-430.

GERITS, M., HOOYBERGHS, H. & VOETS, R., 1981. Quantitative distribution and paleoecology of benthonic foraminifera recorded from som Eocene deposits in Belgium. Belg. Geol.Dienst. Prof. Paper, n° 182, 1981/3.

GROSJEAN, A., 1954. Mesures de températures aux profondeurs de 2185 et 2225 m dans le sondage de Turnhout (Campine Belge). Bull. Soc. géol. Belg. 63: 193-201.

GULINCK, M., 1953. Sondage de Turnhout 17E/225. Coupe des morts-terrains du 1/1000. Unpublished document, Belg. Geol. Dienst.

GULINCK, M., 1954. Coupe résumée des terrains post-paléozoïques du sondage de Turnhout. Bull. Soc. belg. Géol., 63 : 147-154.

GULINCK, M., GEETS, S. & VAN VOORTHUYSEN, J.H., 1964. Note sur les sondages du centre nucléaire à Mol. Bull. Soc. Belg. Géol., 72: 283-294.

GULINCK, M., DROOGER, C.W. & MARLINI, E., 1969. Le sondage de Kallo. Mém. Expl. Cart. Géol. et Min. Belg. n° 11.

HOOYBERGHS, H., 1983. Micropaleontologisch onderzoek van cuttings uit de boring Meer. Unpublished communication.

JACOBS, P., 1978. Lithostratigrafie van het Boven-Eoceen en van het Onder-Oligoceen in Noordwest België. Belg.Geol.Dienst. Prof. Paper nr. 151, 1978/3.

KIMPE, W.F.M., 1961. Stratigrafische ontwikkeling en correlatie van de koollagen van de Baarlo-groep, Onder-Westfalien A, in Zuid-Limburg met een vergelijking tot die in de omliggende gebieden. Geologie en Mijnbouw, 40 : 265-296.

KRUSEMAN, G.P. & DE RIDDER, N.A., 1979. Analysis and evaluation of pumping test data. International Institute for land reclamation and improvement / ILRI, P.O. Box 45 - 6700 AA Wageningen -The Netherlands.

LAGA, P., 1977. Boorbeschrijvingen 7E/179, 195, B40 archief 7E (Hoogstraten), Belg. Geol. Dienst.

LAGA, P. & VAN MONTFRANS, H.M., 1977. Rapport betreffende de inventarisatie van geologische gegevens van de Contactgroep Grondwaterbeheer Grensstreek Nederland-België (West-Noord-Brabant / Noordelijke Kempen). Gezamelijk rapport 1977. Belgische Geologische Dient Brussel, Rijks Geologische Dienst, Haarlem.

LEGRAND, R., 1975. Jalons Géothermiques. Mém. Expl. Cartes Géol. et Min. Belg., n° 16, 46 p.

LEPLAT, P., 1981. Etude géochimique du sondage de Meer (Hoogstraten 7E 205), Belgique. Labofina SA, exploration. Rapport, PL 81-5, Bruxelles, octobre 1981.

NEERDAEL, B., VANDENBERGHE, N., BONNE, A., FIERENS, E., LAGA, P. & MANFROY, P., 1981. Utilisation des diagraphies dans la détermination des caractéristiques lithologiques dans l'argile de Boom et leur intérêt pour les corrélations dans l'argile. Proceeding, NEA Workshop Siting of Radioactive waste repositories in geological formations, Paris 19-22 mai 1981 : 133-149.

PAPROTH, E., DUSAR, M., BLESS, M.J.M., BOUCKAERT, J., DELMER, A., FAIRON-DEMARET, M., HOULLEBERGHS, E., LALOUX, M., PIERART, P., SOMERS, Y., STREEL, M., THOREZ, J. & TRICOT, J., 1983. Bio- and Lithostratigraphic subdivisions of the Silesian in Belgium. A Review. Ann. Soc. géol. Belg., 106 : 241-283.

SORGELOOS, P., 1983. Potential of the Mass Production of Brine shrimp, Artimia. Journal of the Society for Underwater technology, spring 1983 : 27-30.

VANDENBERGHE, N., 1978. Sedimentology of the Boom clay (Rupelian) in Belgium. Kon. Acad. België, Kl. Wet. Verhand., Jg. XL, n° 147.

VANDENBERGHE, N., 1982a. Le sondage géothermique de Meer-Hoogstraten. Projet de démonstration dans le domaine de l'énergie géothermique. Contrat n° CE 6/79-B. Rapport non publié.

VANDENBERGHE, N., 1982b. Carboniferous north of the Brabant Massif in the area of Heibaart, Turnhout and Meer; seismics and boreholes. Public. Natuurhist. Gen. Limburg, XXXII (1-4) : 24-26.

VANDENBERGHE, N., 1984. The subsurface geology of the Meer area in North Belgium, and its significance for the occurrence of hydrocarbons. J. Petrol. Geology, 7 (1) : 55-56.

VANDENBERGHE, N. & BOUCKAERT, J., 1980. Geologische aspekten van de mogelijkheid tot de aanwending van geothermische energie in Noord-België. Belg. Geol. Dienst. Prof. Paper, 168.

VAN LECKWIJCK, W., 1949. Sur la sédimentation dans le terrain houiller de la Campine belge à l'époque du Westphalien B inférieur (zone d'Asch). Ann. Soc. géol. Belg., 72 : 439-468.

VAN LECKWIJCK, W., 1964. Le Namurien en Belgique et dans les régions limitrophes. Kon. Acad. België, Kl. Wet. Verhand. in 4° tweede reeks, XVI, 2 : 1-58.

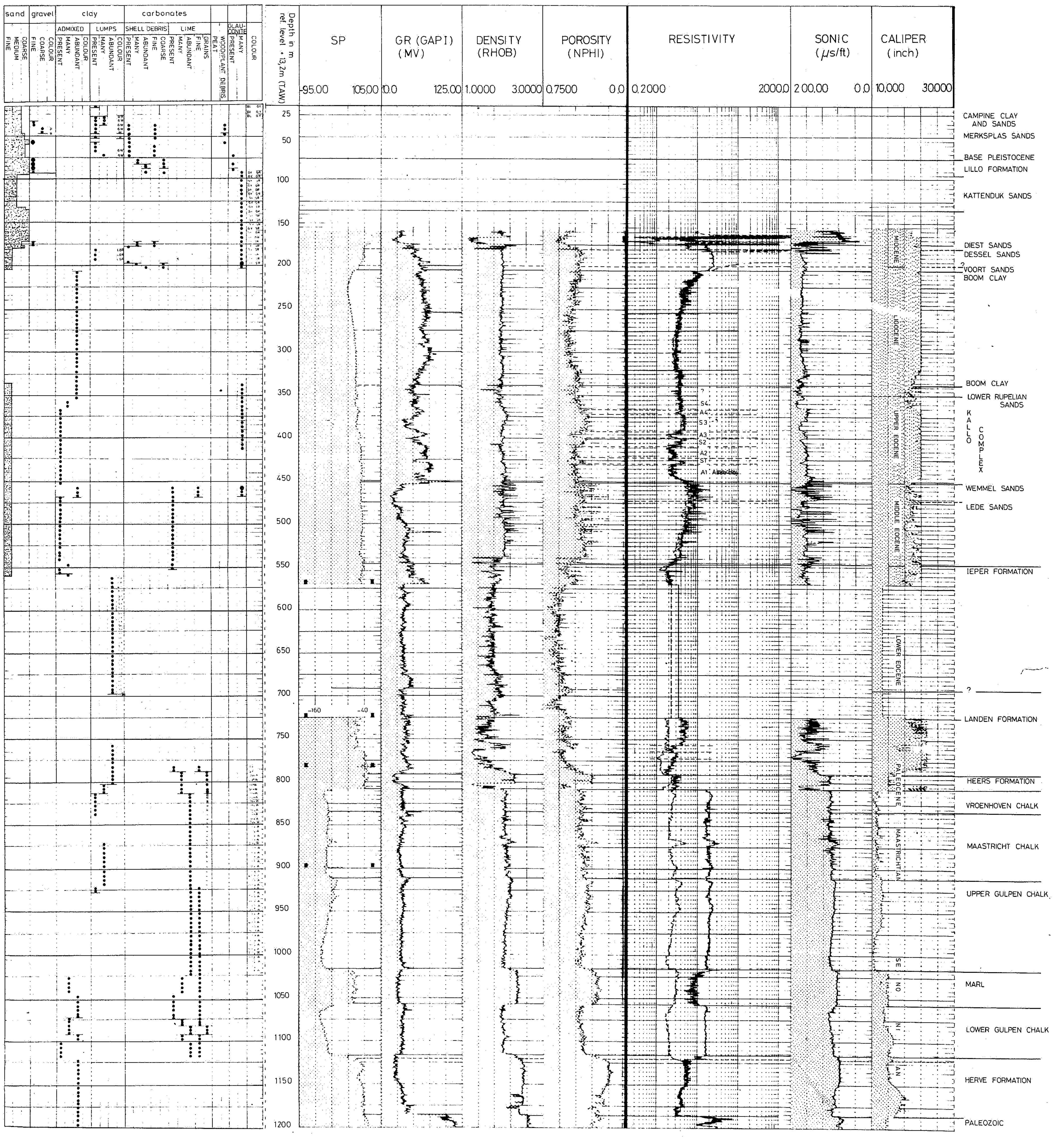
VAN WIJHE, D.H. & BLESS, M.J.M., 1974. The Westphalian of the Netherlands with special references to miospore assemblages. Geologie en Mijnbouw, 53 : 295-326.

WARTEL, S., 1969. Sedimentologisch Onderzoek der Kwartaire en Holocene afzettingen ten Noorden van Antwerpen. Licentiaatsverhandeling, K.U.L., 1969.

FIG. 5

R ROLLED
• PRESENT
● ABUNDANT
GY GREY
▨ SAND

GR GREEN
W WHITE
BL BLUE
GW GREY WHITE
B BLACK



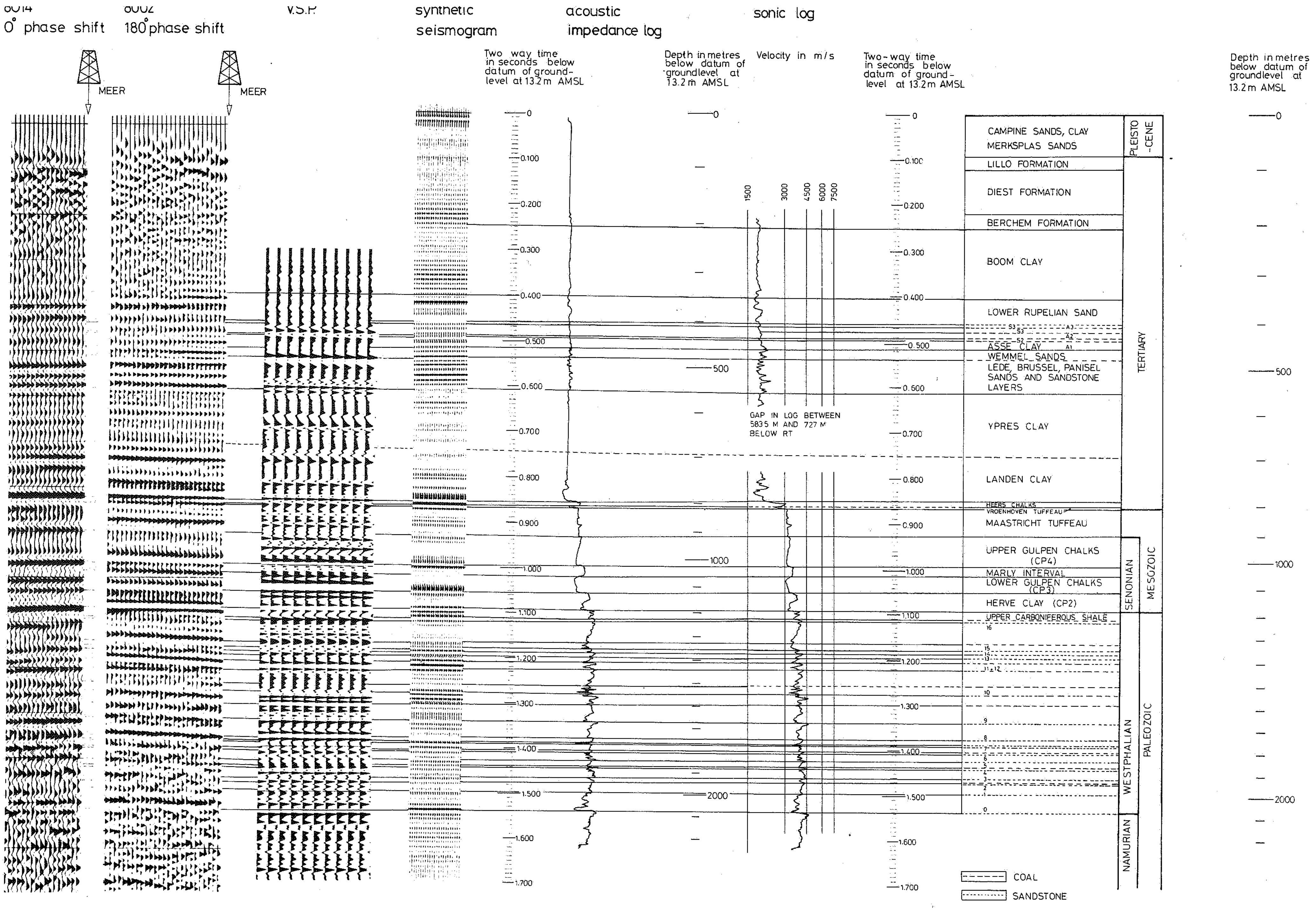
0° phase shift
180° phase shift
V.S.P
synthetic seismogram
acoustic impedance log
sonic log
MEER
MEER
Two way time in seconds below datum of ground-level at 13.2 m AMSL
0
0.100
0.200
0.300
0.400
0.500
0.600
0.700
0.800
0.900
1.000
1.100
1.200
1.300
1.400
1.500
1.600
1.700
Depth in metres below datum of groundlevel at 13.2 m AMSL
0
500
1000
2000
Velocity in m/s
1500
3000
4500
6000
7500
GAP IN LOG BETWEEN 583.5 M AND 727 M BELOW RT
Two-way time in seconds below datum of ground-level at 13.2 m AMSL
CAMPINE SANDS, CLAY
MERKSPLAS SANDS
LILLO FORMATION
DIEST FORMATION
BERCHEM FORMATION
BOOM CLAY
LOWER RUPELIAN SAND
S3
S3
S2
A3
A2
A1
ASSE CLAY
WEMMEL SANDS
LEDE, BRUSSEL, PANISEL SANDS AND SANDSTONE LAYERS
YPRES CLAY
LANDEN CLAY
HEERS CHALKS
VROENHOVEN TUFFEAU
MAASTRICHT TUFFEAU
UPPER GULPEN CHALKS (CP4)
MARLY INTERVAL
LOWER GULPEN CHALKS (CP3)
HERVE CLAY (CP2)
UPPER CARBONIFEROUS SHALE
16
15
14
13
11+12
10
9
8
7
6
5
4
3
2
1
0
PLEISTO-CENE
TERTIARY
SENONIAN
MESOZOIC
WESTPHALIAN
NAMURIAN
PALEOZOIC
COAL
SANDSTONE
Depth in metres below datum of groundlevel at 13.2 m AMSL
0
500
1000
2000

FIG.11 Borehole 149 (7E 205) Meer 2 + 2a Stratigraphy of the Carboniferous.

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