LITHO- AND BIOSTRATIGRAPHICAL STUDY OF QUATERNARY DEEP MARINE DEPOSITS OF THE WESTERN BELGIAN COASTAL PLAIN.

LITHOSTRATIGRAPHY

by L. LEBBE (*)

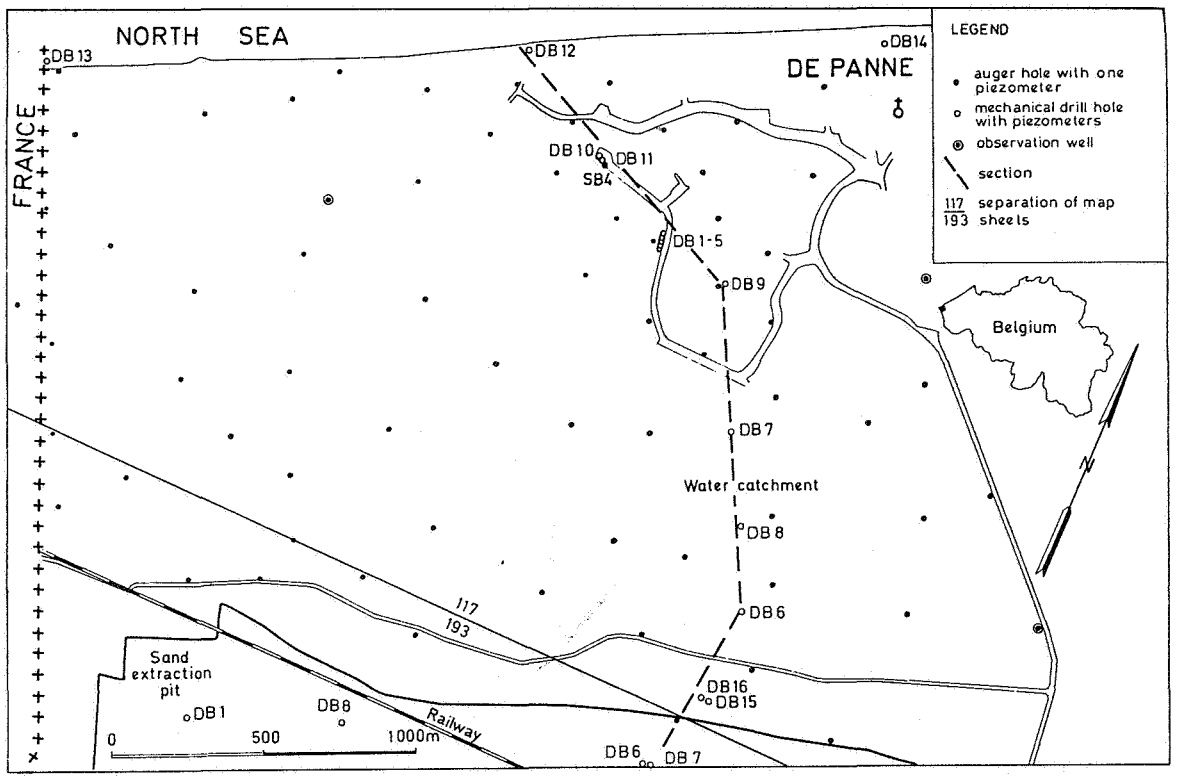

Fig. 1 - Localisation of holes and lithostratigraphical section.

This part is a summary of the lithostratigraphical study conducted in the scope of the hydrogeological study. Twinty mechanical drill holes were dug following the cable-tool method. The drilling was accomplished by regular lifting and dropping of a bailer while a casing was lowered to prevent caving of the borehole. The samples were taken at 50 cm interval. The level of the ground surface was accuratly measured by water-levelling so that we can construct a lithostratigraphical profile. All layer indicated by a number, were characterised by grain-size analyses. This gives us a first estimate of the hydraulic conductivity.

The grain-size analyses were made on samples without removal of $CaCO_3$ and organic matter. The gravel content was determined on the whole sample. They were done on 50 g of air-dry gravel-free samples (< 2 mm). The clay plus silt fraction (< 50 μm) was removed by wet sieving; when the clay plus silt fraction was larger than 5 % of the fine earth (< 2 mm), it was further separated into 50-20 μm, 20-10 μm and < 2 μm fractions by the pipette method of KÖHN. The air-dry sand fraction (2000-50 μm) was sieved on eighteen normalized TYLER-sieves with a darn ratio of $\sqrt[4]{2}$

From the results of the grain-size analyses, the mean grain-size (first moment) and the standard deviation (second moment) were calculated (S. GEETS & P. JACOBS, 1975). The specific surface (N. A. DE RIDDER & K. E. WIT, 1965) and the hydraulic conductivity were also derived from these date. For estimating the hydraulic conductivity two methods were applied : the first proposed by ERNST and the second by HAZEN. The first method was modified according to the method proposed by LEBBE (1978). The most important characteristics of the different layers are given in tabels 1 to 6.

TERTIARY SUBSTRATUM.

The top of the tertiary substratum occurs within the levels -24,5 (117 DB6) and -31,6 ☆ (117DB14). The upper boundary shows an undulating topography. The medium to coarse medium sand with shells rest on the tertiary substratum.

☆ TAW Datum level of the second general leveling (National Geographical Institute, Belgium)

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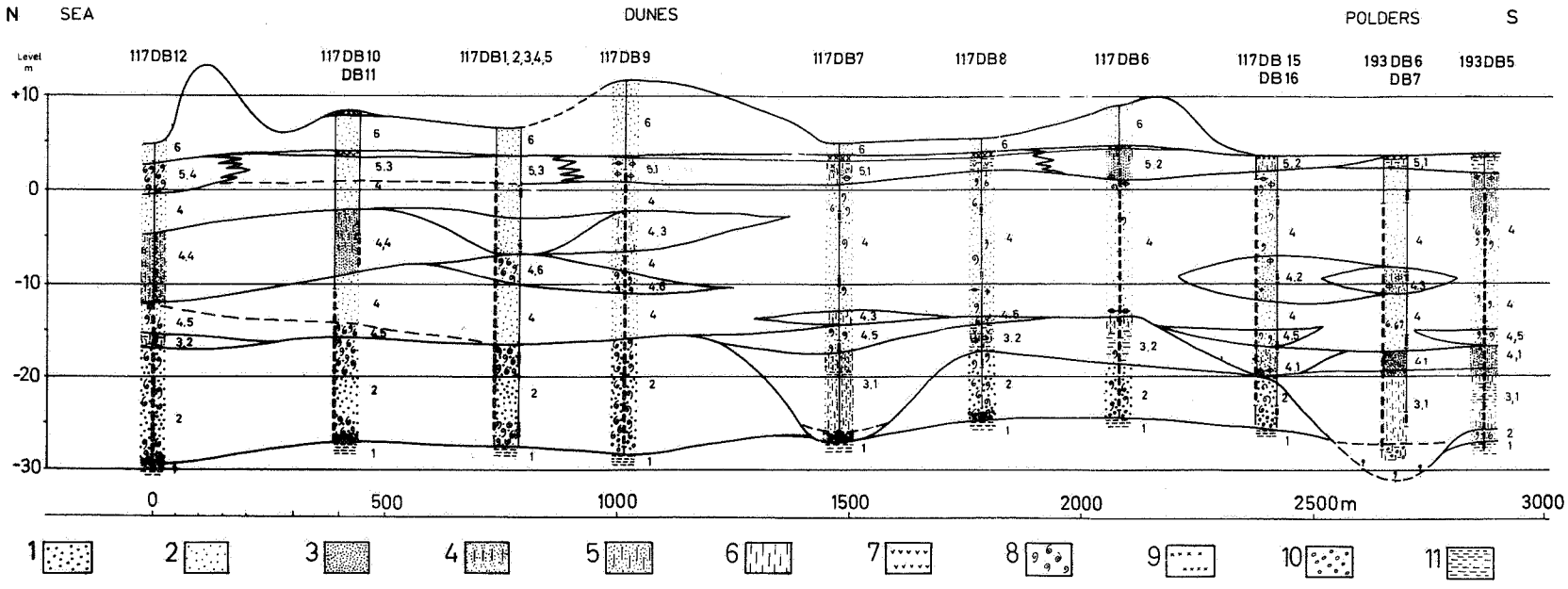

Fig. 2_ LITHOSTRATIGRAPHICAL PROFILE

1_ medium to coarse medium sands

2_ medium sands

3_ fine sands

4_ slightly silt-bearing fine sands

5_ silt-bearing fine sands

6_ silt

7_ peat

8_ shells

9_ humus

10_ gravel

11_ clay

Table 1

Characteristics of layer 2, medium to coarse medium sands (13 samples)

		Mean value	Standard deviation	Max. value	Min. value
Mean grain size (first moment)	in Φ	1,73	0,30	2,12	1,33
	in µm	301	-	398	228
Standard deviation (second moment)	in Φ	0,68	0,22	1,01	0,30
Specific surface (2000-20 µm)		37,4	5,97	45,6	28,6
% gravel		10,7	9,6	35	0,11
Hydraulic conductivity in m/d (according to ERNST)		24,1	5,3	35,8	18,3
Hydraulic conductivity in m/d (according to HAZFN)		22,6	4,0	28,2	15,4

Table 2

Characteristics of layer 3, clay-silty complex (9 samples)

		Mean value	Standard deviation	Max. value	Min. value
Mean grain size (first moment)	in Φ	4,86	1,27	6,44	2,75
	in µm	34,4	-	149	11,5
Standard deviation (second moment)	in Φ	3,40	0,56	4,28	2,76
Specific surface (2000-20 µm)		119	38	182	74,7
% silt (50-2 µm)		24,7	11,9	41,6	7,2
% clay (<2 µm)		13,9	7,0	25,7	5,5

Table 3

Characteristics of layer 4, medium to fine sands (24 samples)

		Mean value	Standard deviation	Max. value	Min. value
Mean grain size (first moment)	in Φ	2,56	0,14	2,76	2,18
	in µm	170	-	221	148
Standard deviation (second moment)	in Φ	0,41	0,08	0,62	0,28
Specific surface (2000-20 µm)		63,5	5,7	70	50
Hydraulic conductivity in m/d (according to ERNST)		8,7	2,7	14,4	3,5
Hydraulic conductivity in m/d (according to HAZEN)		8,9	2,1	14,2	5,1

Lenses	4.1			4.2		4.3			4.4		4.5			4.6		
Number of examined samples	3			2		3			2		6			2		
Sample number or Statistic parameters	193DB6M28	193DB9M29	117DB7M38	117DB15M27	117DB15M35	193DB5M44	193DB6M45	117DB15M46	117DB12M33	117DB10M29	Mean value	Standard deviation	Maximum value	Minimum value	117DB1M32	117DB9M42
Mean graine size in Φ	3,14	2,99	3,05	2,76	2,86	3,01	3,02	2,81	3,41	3,65	2,06	0,20	2,31	1,87	2,00	1,91
(first moment) in µm	113	126	121	148	138	124	123	143	94	80	240	-	274	202	250	266
Standard deviation in Φ (second moment)	1,31	1,23	1,41	0,43	0,43	0,44	0,51	0,61	1,90	2,25	0,83	0,13	1,02	0,65	0,71	0,73
Specific surface (2000-20 µm)	83	78	87	73	78	87	120	80	93	96	50	8	62	39	45	42
% silt-clay (<50 µm)	4,3	4,1	7,5	3,1	2,4	4,3	8	4,3	11,6	14,9	-	-	-	-	-	-
% gravel (>2 mm)	-	-	-	-	-	-	-	-	-	-	10,1	9,1	27,6	2,0	2,7	4,0
Hydraulic conductivity in m/d according to ERNST	2,9	3,2	1,7	5,2	5,0	3,4	0,9	3,1	N.B.	N.B.	10,9	4,3	18,7	6,3	14,8	14,6
Hydraulic conductivity in m/d according to HAZEN	4,2	8,0	2,5	5,1	4,6	4,0	2,5	2,8	0,93	0,22	9,7	3,4	15,1	5,4	11,6	13,0

Table 4 - Characteristics of the lenses in layer 4.

Facies	5.1				5.2		5.3			5.4
Number of examined samples	4				2		3			1
Sample number or Statictic parameters	193DB6M3	117DB8M5	117DB7M6	117DB7M9	117DB15M3	117DB6M11	117DB10M	117DB1M	117DB9M23	117DB12M8
Mean grain size in Φ	7,42	9,10	6,29	4,69	3,45	4,06	2,58	2,64	2,56	2,31
(first moment) in µm	5,8	1,8	12,8	38,7	92	60	167	160	170	202
Standard deviation in Φ (second moment)	3,56	3,45	3,61	3,15	2,04	2,70	0,33	0,31	0,32	0,58
Specific surface (2000-20 µm)	180	154	163	123	98	113	62	64	61	53
% silt	54,0	50,3	44,5	34,6	12,1	15,1	-	-	-	-
% clay	27,5	48,8	19,9	8,2	3,2	6,9	-	-	-	-
% gravel	-	-	-	-	-	-	-	-	-	17
Hydraulic conductivity in m/d according to ERNST	-	-	-	-	-	-	10,6	8,0	10,6	14,3
Hydraulic conductivity in m/d according to HAZEN	-	-	-	-	-	-	11,0	10,5	11,1	13,0

Table 5 - Characteristics of the facies in layer 5.

LAYER 2 : MEDIUM TO COARSE MEDIUM SANDS.

These sands occur almost everywhere in the study area, except at the borings 117DB7 and 193DB6. The thickness of these layers varies between 6 and 12 while their upper boundary is situated between levels -15,5 and -18,5. Table 1 gives the characteristics derived from the grain-size analyses.

LAYER 3 : CLAY-SILT COMPLEX.

A clay-silt complex (layer 3) overlies the medium to coarse medium sands (layer 2). The composition, the thickness and the level of this complex vary significantly from place to place. In the northern part of the area it is almost completely absent except in borings 117DB12 and 117DB14. These is a ca. 2 m thick silty sand layer in which shell waste and clay-silt lenses occur. The upper part consists of silts, 0,1 m to 0,5 m thick, with thin clay layers of a few centimeters. In the southern part of the area the clay-silt complex occurs more frequently and shows strong differences in thickness and facies. In boring 117DB7 layer 3 rests directly on the tertiary substratum. The deposit lies between the levels -17,3 and -26,8. The lower part of the sediment is sandy silt, 2,5 m thick, with shell waste, clay pieces and gravel at the base. The middle part is a 4,5 m thick silt layer covered by some clay. The upper part is a siltbearing sand to a sandy silt which becomes more granulated at the top. At this location, lenses of silt with organic matter and very small pale shell pieces are also present. In the south, in borings 117DB6 and 117DB8, the deposit is only 3 to 4 m thick and is located between levels -18 and -14. This layer consists of an alternation of silt and strongly silt-bearing sands. In the borings 117DB15 and 117DB16 this layer is reduced to lenses of silt at the level -16.

The thickness of the layer increases again in the southern part of the study area (193DB5, 193DB6 and 193DB7). It consists of heavier material and lies between the levels -19 and -27. In boring 193DB5 the layer changes gradually into the underlying layer 2. In boring 193DB6 layer 3 rests upon a very heterogeneous deposition of sand, clay and silt mixed with organic matter. The tertiary clay substratum was not reached at this location. In borings 193DB1 and 193DB8 layer 3 was not observed.

From a hydrogeological viewpoint it can be concluded that there are mainly two kinds of facies : a silty one (3.1), between the levels -14 and -18 with a maximum thickness of 4 m and a rather small hydraulic resistance, and a clayey one (3.2), between the levels -17 and -27 with a maximum thickness of 10 m and a large hydraulic resistance. The grain-size characteristics of layer 3 are given in table 2.

LAYER 4 : MEDIUM TO FINE SANDS.

This deposit rests on layer 2 or on layer 3. The basis is situated between the level -14,5 and -17,5; the top is found between +1 and +3. Layer 4 consists mainly of well sorted medium to fine sands (table 3).

In the southern part of the study area this deposit tends to be slightly finer in grain-size. Lenses with slightly different composition occur : lenses 4.1 and 4.2 contains fine sand, lens 4.3 has small amounts of siltbearing fine sand, lens 4.4 contain siltbearing fine sand and finally lenses 4.5 and 4.6 with medium shell bearing sand (tabel 4).

LAYER 5 : CLAY-SILT-SAND COMPLEX.

This sediment overlies layer 4 throughout the study area. The top is located at about +4 and reaches the surface in the southern part of the region. This layer was found in the twenty borings which penetrate into the Eocene clay substratum and in the sixty handborings of the hydrogeological study (L. LEBBE & R. DE CEUNINCK, 1980).

Four facies can be distinguished. The first, 5.1, is a clay or a clay-silt layer with a thickness between 0,2 and 1,0 m which rests in strongly siltbearing sands, which become more sandy downwards. In some borings peat underlies the clay, in others a humusrich or a peaty soil layer is found on top of the clay.

The second facies, 5.2, is mainly a strongly siltbearing fine sand with silt- and clay lenses (less than 0,1 m thick). In most cases, a humusbearing or peaty soil layer is found on top.

The third facies, 5.3, occurs under the dunes in the northern part of the area and is formed by very well sorted fine sands. Finally, at the seaside under the fore-dunes and under the back-shore in the eastern part, the fourth facies 5.4 occurs. It is formed by a bank of pale, rubiginous shells and shellwaste. The characteristics of the four facies are given in tabel 5.

LAYER 6 : WELL SORTED FINE MEDIUM SANDS.

These sediments occur from the surface in the dunes to a depth corresponding with level +4. Within this layer different brown bands of light humus bearing sands can occur at several levels. The beach sands are less well sorted and slightly finer than the sands of the dunes (tabel 6).

Table 6
Characteristics of layer 6, well sorted fine medium sands

		underneath the dunes (7 samples)				underneath the beach
		Mean value	Standard deviation	Max. value	Min. value	
Mean grain size (first moment)	in ϕ	2,34	0,07	2,44	2,25	2,49
	in µm	198	-	210	184	178
Standard deviation (sedond moment)	in ϕ	0,31	0,04	0,39	0,28	0,40
Specific surface (2000-20 µm)		53	2	56	51	59
Hydraulic conductivity in m/d (according to ERNST)		13,5	3,2	16,7	7,2	11,9
Hydraulic conductivity in m/d (according to HAZEN)		13,8	1,8	15,8	11,1	11,6

REFERENCES.

DE RIDDER, N. A. & WIT, K. E. (1965) - A comparative study on the hydraulic conductivity of unconsolidated sediments. *J. Hydrol. 3, 180-200.*

GEETS, S. & JACOBS, P. (1975) - Sedimentologische en mineralogische kenmerken van de klei van Boom (R2b) in de Rupelstreek. *Natuurwet. Tijdschrift. 57, 103-126.*

LEBBE, L. (1978) - Hydrogeologie van het duingebied ten westen van de Panne. *164 p. Gent : Geologisch Instituut (Verh. Dr. Aard- en Delfstofkunde).*

LEBBE, L. & DE CEUNINCK, R. (1980) - Lithostratigrafie van het Duingebied ten Westen van De Panne. *Professional Paper van de Belgische Geologische Dienst 1980-4, 171, 1-26.*

LEBBE, L. (1980) - Lithostratigrafie en hydraulische doorlatenheid van het freatisch reservoir te De Panne. *Natuurwet. Tijdschrift, 61, 29-58.*

LEBBE, L. (1981) - The subteranean flow of fresh and salt water underneath the Western Belgian beach. *Proceedings of Seventh Salt Water Intrusion Meeting, Uppsala, Sveriger Geologiska Undersökning, Rapporten och meddelanden, 27, 193-219.*