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THE WATER-TABLE AQUIFER IN THE EASTERN COASTAL AREA OF BELGIUM

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ABSTRACT

A resistivity survey in Wenner arrangement has been conducted in the water-table aquifer in the eastern part of the Coastal Area of Belgium. Bore holes have been drilled to test the geoelectrical data and also to collect water samples. The chemical characteristics and the distribution of different water types explain the hydrochemistry of the water-table aquifer. The fresh-/brackish-water boundary as determined by the resistivity survey has been expressed in terms of total dissolved-solids content.

RESUME

Une prospection géoélectrique d'après la disposition de Wenner a été effectuée dans la nappe phréatique de la partie orientale de la région côtière de la Belgique. Les données géoélectriques ont été contrôlées par des forages, qui ont également servi au prélèvement d'échantillons d'eau. Les caractères chimiques et la distribution des types d'eau expliquent l'hydrochimie des eaux phréatiques. La limite de salinité, détectée par sondages électriques, a été précisée en teneur en sel totale.

INTRODUCTION

The areal extent of the water-table aquifer and some of its characteristics have been determined by an electrical resistivity survey. More than 600 resistivity soundings in Wenner arrangement with electrode spacings up to 100 m have been performed between August 1965 and January 1968. Test holes have been drilled both to confirm and to interpret the resistivity data. These bore holes ranging in depth from 7 to 35 m have been used for sampling water in the aquifer penetrated. Chemical analyses of the water samples have provided information on the composition and the areal and depth distribution of the different waters and to establish the relationship between the resistivity and the composition of the pore waters.

The water-table aquifer is formed mainly by Quaternary sediments which attain a maximum thickness of 35 m and reach a depth of −25 (†) (fig. 1). The Tertiary substratum consists of bedded clay and sand of Eocene age dipping gently in a northeasterly direction (fig. 2). The deepest Quaternary deposit is a bed of coarse sand of Eemian age. This deposit is covered by fine sediments of Late Pleistocene and Holocene age (fig. 3). The uppermost part consists of a complex of peat, clay and sand of Subboreal and Subatlantic age. Since 200 B.C. three Dunkerquian transgressions have inundated the peat-covered landscape that had developed on the Atlantic sandy deposits. Those transgressions and the influence of man have shaped the actual polder landscape. Dunes formed along the shore have contributed largely to the development of the coastal plain.

In the western part of the area, where exposed Dunkerquian-II sediments rest directly upon Subboreal peat or Atlantic deposits, an inversion of the landscape has occurred. The sandy creek deposits have become the highest topographic features; the clay-covered peat terrane which originally occupied the highest parts, has settled very intensely, markedly as a result of compaction and water loss.

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(†) Depths are given in meters below the zero level of Ostend.

South of the Coastal Area, Tertiary sediments are overlain by a relatively thin cover of Pleistocene sand. Most of the Tertiary strata are of Paniselian age. East of Sijsele the substratum is Asschian clay.

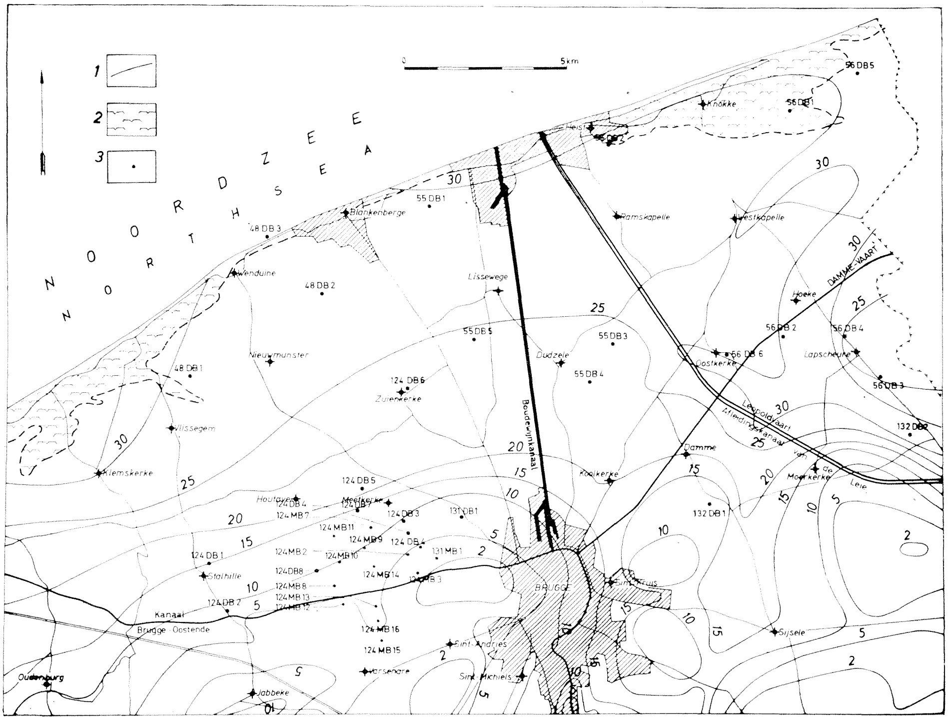

Fig. 1 — Thickness of the Quaternary sediments in meters: 1. Isopach; 2. In the dune area only the thickness below level +5 is shown; 3. Drilling site.

HYDROGEOLOGICAL ZONES

The resistivity survey has enabled subdivision of the water-table aquifer into four hydrogeological zones (fig. 4). The distinction between zones 3 and 4 is rather arbitrary but has been made because of the significant difference in aquifer thickness. Zone 4 is the least known, since field investigations are still being pursued there.

Zone 1 is formed by two dune areas, one between Bredene and Vlissegem and one between Heist and Knokke. The resistivity of the top layer varies between 30 and 80 ohm-m and the resistivity of the substratum between 6 and 12 ohm-m. The geoelectrical contact surface lies at a depth between 25 and 35 m and corresponds to the top of the Tertiary clayey substratum (Asschian east of Heist and Paniselian west of Vlissegem).

In this zone a fresh-water body has developed which has gradually flushed the original sea water. The fresh water probably rests directly upon the Tertiary clay preventing the encroachment of seawater in these areas.

Zone 2 comprises the main part of the region and corresponds approximately to the polder area. The resistivity of the top layer shows values between 15 and 60 ohm-m, while the resistivity of the bottom layer varies between 15 and 2 ohm-m and remains mostly below 4 ohm-m. The geoelectrical contact surface was assumed to be the boundary between the fresh and the brackish water.

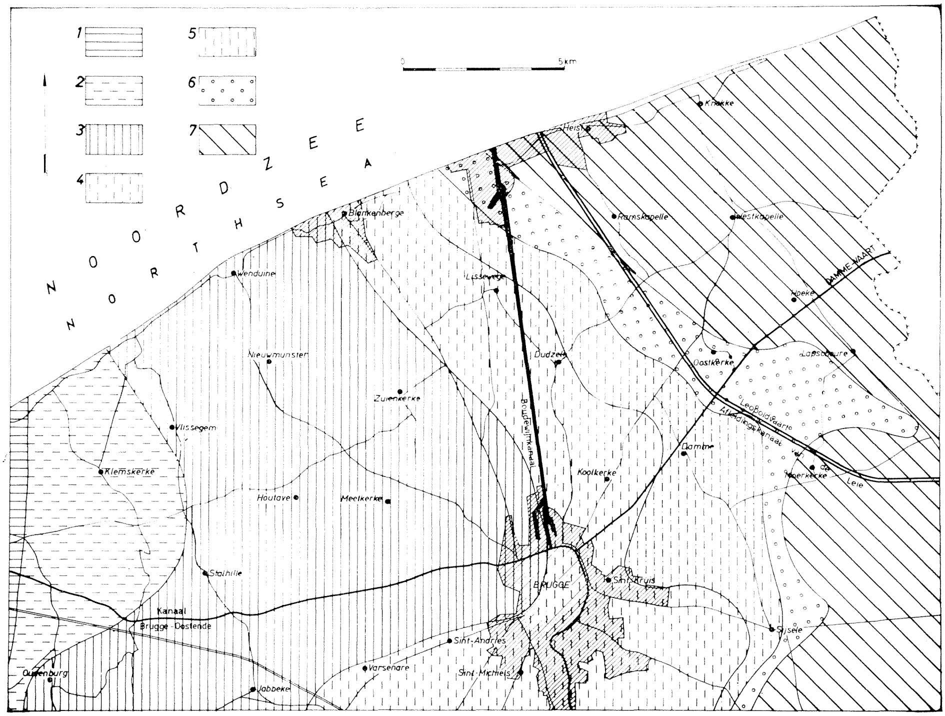

Fig. 2 — The Tertiary substratum: 1. Ypresian clay; 2. Ypresian sand; 3. Lower-Paniselian clay and sandy clay; 4. Lower-Paniselian sand; 5. Upper-Paniselian sand; 6. Ledian and Wemmelian sand; 7. Asschian clay.

The boundary between fresh and brackish water is very irregular. The depth changes from less than 2 to more than 30 m. The southernmost limit of the brackish-water area corresponds almost to the polder limit. The areas with a thick fresh-water layer show a gully pattern and coincide with the sandy surface deposits. The places with shallow brackish waters show a platy appearance and correspond to the clay-covered peat areas. West of the Boudewijn canal the creek pattern coincides with the fresh-water distribution but east of this canal there seems to be no relationship between the boundary of the fresh and the brackish water and the lithology of the Dunkerquian sediments.

The canals seem to influence the fresh-/brackish-water boundary. The Boudewijn canal introduces salt water into the aquifer; the Damme canal has expelled the brackish water.

WATER SAMPLES

In all of the drilling sites observation wells have been constructed. In most places one-meter-long screens have been installed at different depths. Each of the screens is at the bottom of a separate tube and is completely sealed by a clay cover on top of the gravel packing. Sixty water samples have been pumped from these observation wells. Pumping was performed with a discharge of less than 2 m^3/hr. and a drawdown of maximum 3 m. When pumping from one tube the level in the other tubes at the same spot has been checked. A drop in level has never been observed so that one can be fairly sure that no mixing has occurred.

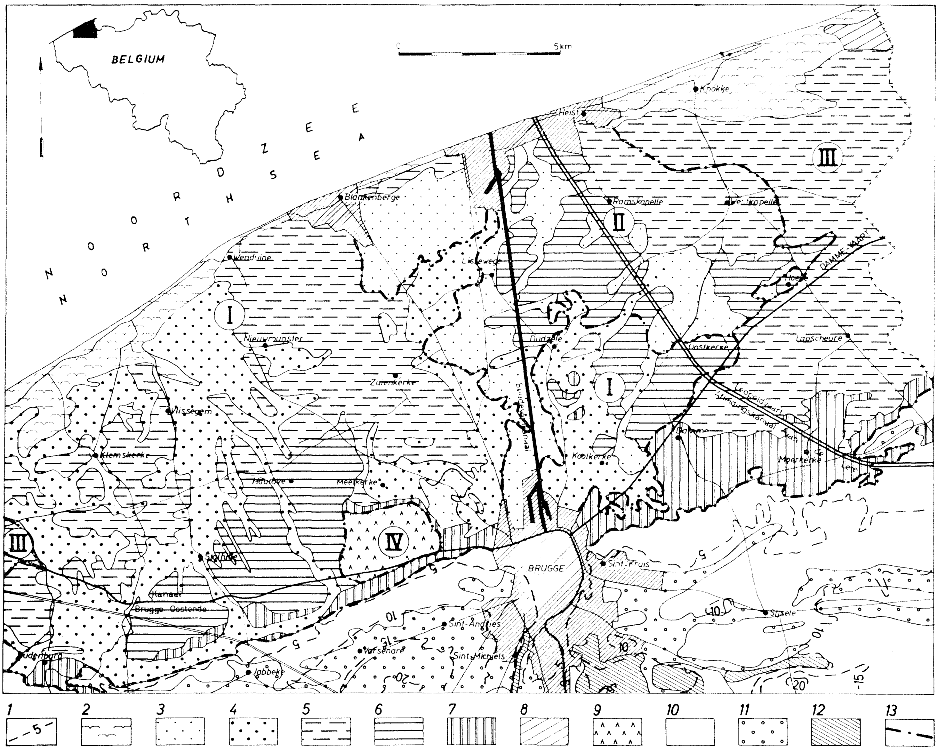

Fig. 3 — Topography and surface sediments: 1. Contour line in meters. In the dune area no contour lines are shown; the elevation varies between +5 and +20; 2. Holocene dune sands; 3. Dunkerquian shore sediments (sand to clay on heavy clay); 5. Dunkerquian creek sediments (clay on sand); 5. Dunkerquian backland sediments (heavy clay); 6. Dunkerquian backland sediments (heavy clay on peat); 7. Dunkerquian clay and loam on sand; 8. Salt-march sediments (clay to sand); 9. Atlantic sands formerly covered by peat which has been removed; 10. Weichselian cover sand; 11. Tardiglacial and Holocene sand; 12. Holocene clayey and loamy alluvium; 13. Limit between the genetic units.—Areas where the youngest transgression dates from:

the Dunkerquian 2	I
the Dunkerquian 3A	II
the Dunkerquian 3B and younger . .	III
before the Subboreal	IV

The following properties have been determined: dry residue, ash rest, hardness (carbonate and non-carbonate), alkalinity, pH, specific conductance (at 18 °C), free carbon dioxyde, oxygen, silica, organic constituents, and B.O.D. (5 days at 20 °C). The ion balance has been established by the determination of the following cations: sodium, potassium, calcium, magnesium, ferrous and ferric iron, ammonia, and hydrogen and the following anions: chloride, sulfate, nitrate, bicarbonate, carbonate, phosphate, and hydroxyl ion. The concentrations are expressed in mg/l and also in milligram equivalent per liter (mé/l).

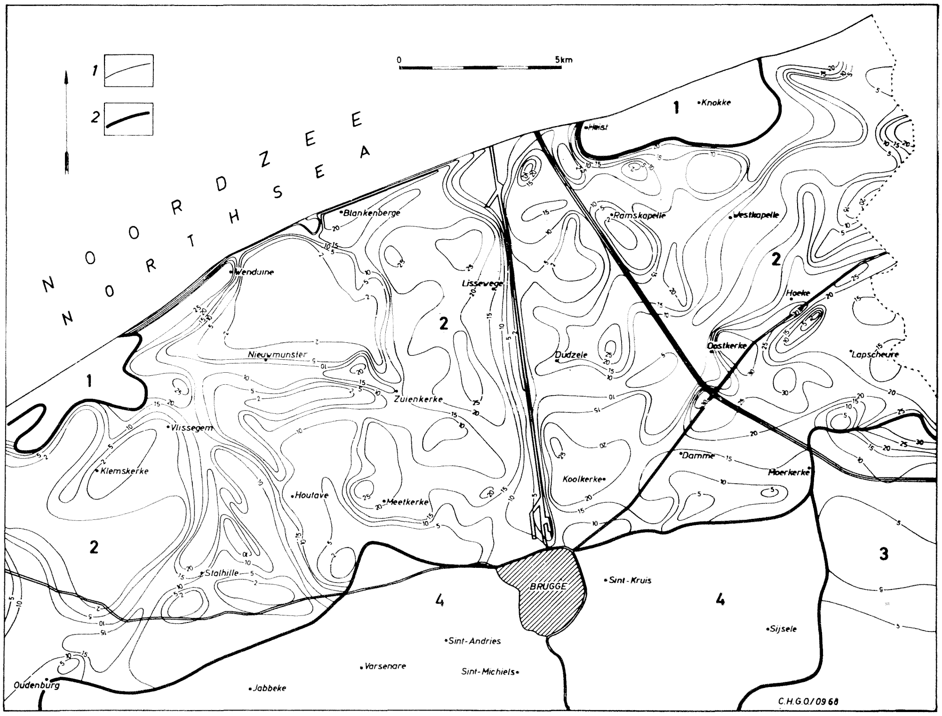

Fig. 4 — Hydrogeological zones: 1. Contour line of the geoelectrical contact surface (in meters below the surface); 2. Limit of the zones:

1 Dune area without brackish water in the aquifer.
2 Area with brackish water. The contour lines are here isopachs of the fresh-water layer (with less than 1500 mg/l, total dissolved solids).
3 Area with fresh water in Quaternary sands which rest upon Asschian clay. Contour lines are isopachs of the Quaternary cover.
4 Area with fresh water in Quaternary and Paniselian sands, resting upon Paniselian clay.

WATER QUALITY

All analyses have been plotted in a Piper diagram, which shows the relative distributions of the main cations (Ca, Mg and Na+K) and the principal anions (Cl, SO_4 and CO_3+HCO_3).

In the discussion of water quality three other characteristics have been considered: the magnesium-calcium ratio, the sulfate-chloride ratio and the total dissolved-solids content.

The total concentration of dissolved solids equals here the sum of the cations and anions, used in the ion balance established in mé/l. Thus the total dissolved solids are directly proportional to the specific conductance of the water (Hem, 1959). The waters can be subdivided in the classes of total dissolved-solids content shown in table 1. Based on the preceding assumptions eight water quality groups can be distinguished.

WATER-QUALITY GROUPS

Group 1 can be considered as having the composition of sea water. Indeed, the total dissolved-solids content is higher than 1000 mé/l, which corresponds to more than 29 g/l. Analysis 48DB3a-0467 represents the composition of this water group. The water contains (fig. 5) much sodium and 15 to 20 per cent of magnesium. Chloride content is very important. The sulfate-chloride ratio is less than 5. This kind of water is found at great depth and at short distance from the sea shore (48DB2 at 19 m, 48DB3 at 25 m and 55DB1 at 28 m). It also occurs in the peat area near the dunes between Blankenberge and Wenduine (48DB2 at 7 m).

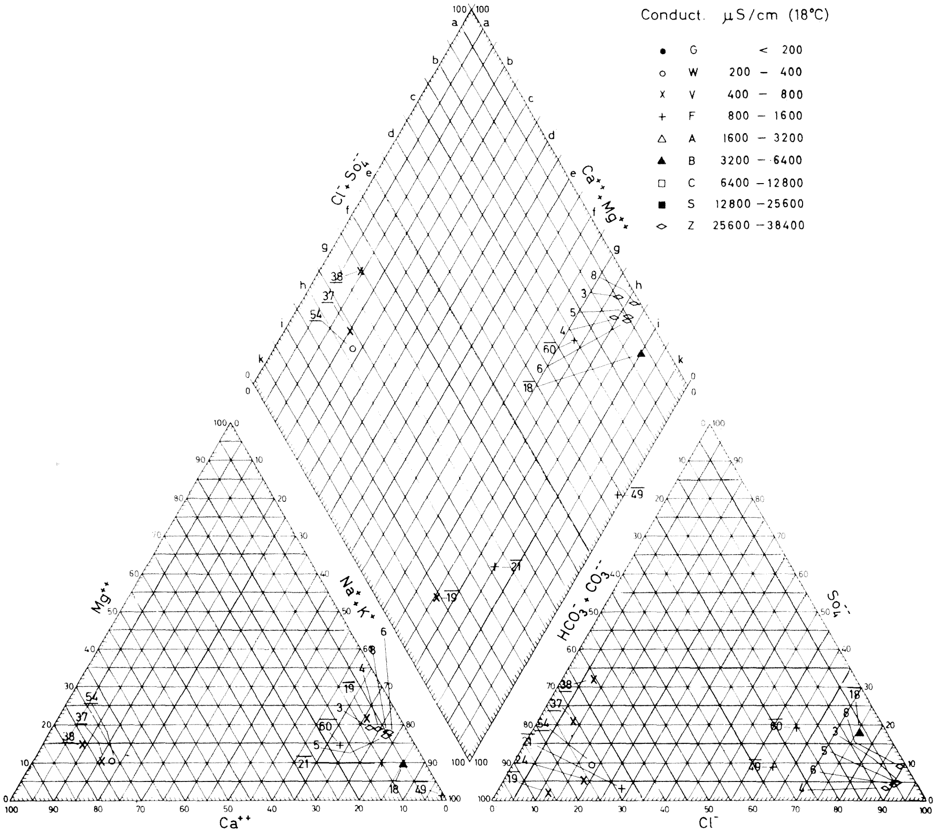

Fig. 5 — Relative ion distribution of group 1, 3 and 4. The waters of group 3 are underlined, those of 4 have a line above the number of the analysis.

The relative ion concentration of the waters of group 2 is very much the same as in group 1, but they are moderately salt to very brackish. Analysis 56DB5-0267 shows the chemical composition of this group. The relative ion distribution is given in figure 6. This kind of water is found in the dunes above the waters of group 1 (48DB3 at 9 m, 55DB1 at 19 m) while farther inland it occupies the deepest layers (55DB3 at 19 m, 55DB4 at 22 m, 56DB6 at 26.5 m and 132DB1 at 17 m). In one place (56DB5 at 2.8,10, 3,13.8 and 26.7 m) it forms the hydrochemical profile over the whole depth.

TABLE 1

Specific conductance (at 18 °C) μS/cm	Total dissolved solids mé/l	Approximate weight concentration mg/l	Appreciation
< 200	< 4	< 200	very fresh
200- 400	4- 9	200- 400	fresh
400- 800	9- 20	400- 800	moderately fresh
800- 1 600	20- 36	800- 1 600	weakly fresh
1 600- 3 200	36- 72	1 600- 3 200	moderately brackish
3 200- 6 400	72-180	3 200- 6 400	brackish
6 400-12 800	180-400	6 400-12 800	very brackish
12 800-25 600	400-800	12 800-25 600	moderately salt
25 600-38 400	800 <	25 600-38 400	salt

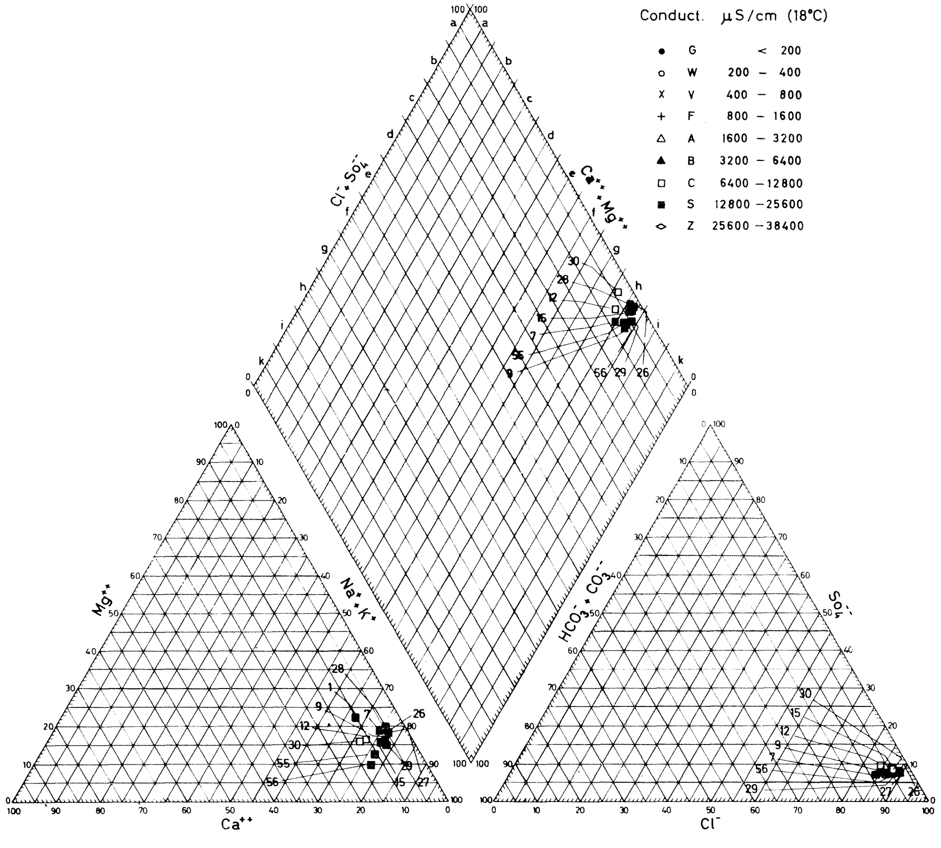

Fig. 6 — Relative ion distribution of group 2.

Group 3 (fig. 5) comprises fresh to moderately fresh waters, characterized by an abundance of calcium, that amounts to more than 80 per cent of the cations. Bicarbonate ions vary between 65 and 95 per cent of the anions; their total hardness is situated between 25 and 35 French degrees. Absolute sulfate content remains fairly low, but the chloride content changes considerably so that the sulfate-chloride ratio varies between 10 and 100. This water normally occurs in Pleistocene sediments in the Inner-Flanders but has been observed in two spots in the Coastal Area (124BD3 at 8 m and 124MB16 at 8.7 m).

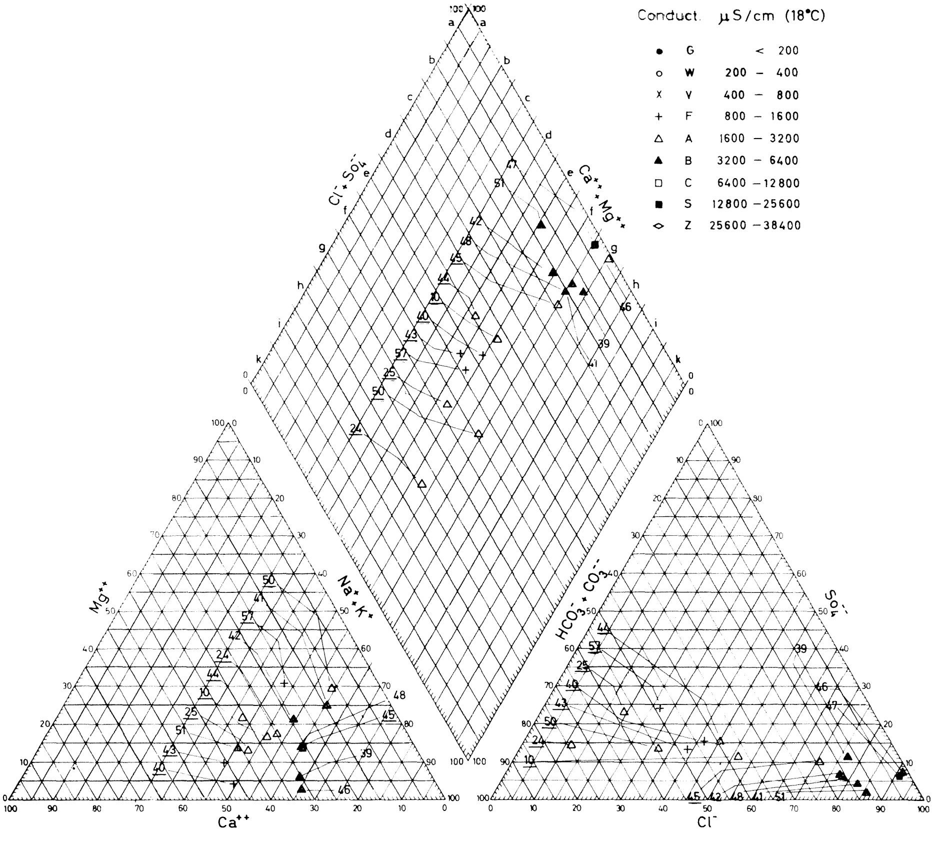

Fig. 7 — Relative ion distribution of group 5 and 6. The waters of group 6 are underlined.

The waters of group 4 are brackish to moderately fresh; they show a much lower content of dissolved solids than group 1. The relative sodium content reaches 85 to 95 per cent and since calcium remains relatively unchanged the magnesium-calcium ratio is lower than in group 1. The relative chloride content is extremely variable. Analysis 55DB5-0367 represents the chemical composition of group 4 and figure 5 shows the relative ion distribution of the analyses. These waters are found at several places (55DB5 at 22 m, 56DB1 at 23.5 m, 56DB2 at 24.8 m, 124MB12 at 2.8 m and 132DB2 at 19 m).

The brackish to salt waters of group 5 have a relative cation distribution of 45 to 60 per cent of sodium, 25 to 35 per cent of calcium and 15 per cent of magnesium. The relative anion distribution is very much the same as in group 1. Analysis 124MB9a-0667 typifies the group, while the relative ion distributions are shown in figure 7. The occurrence of the group is restricted to the saline area of Meetkerke, a former peat excavation.

The moderately brackish to moderately fresh waters of group 6 have the same relative sodium content of 40 to 60 per cent, but the magnesium-calcium ratio is higher. The relative anion distribution is very much different: chloride varies between 20 and 50 per cent and bicarbonate amounts to 40 and even 60 per cent. The chemical composition is given by analysis 124MB12a-0667 and figure 7 shows the different analyses. These waters occur in the saline area of Meetkerke (124DB4 at 2.6 m, 124MB9 at 3 m and 124MB12 at 6.4 m) and in other spots in the coastal plain (56DB3 at 6.8 and 12.3 m, 124DB6 at 6 and 22.5 m and 132DB1 at 5 m). They seem to be situated near the southern salinization limit or to be resting upon more brackish waters.

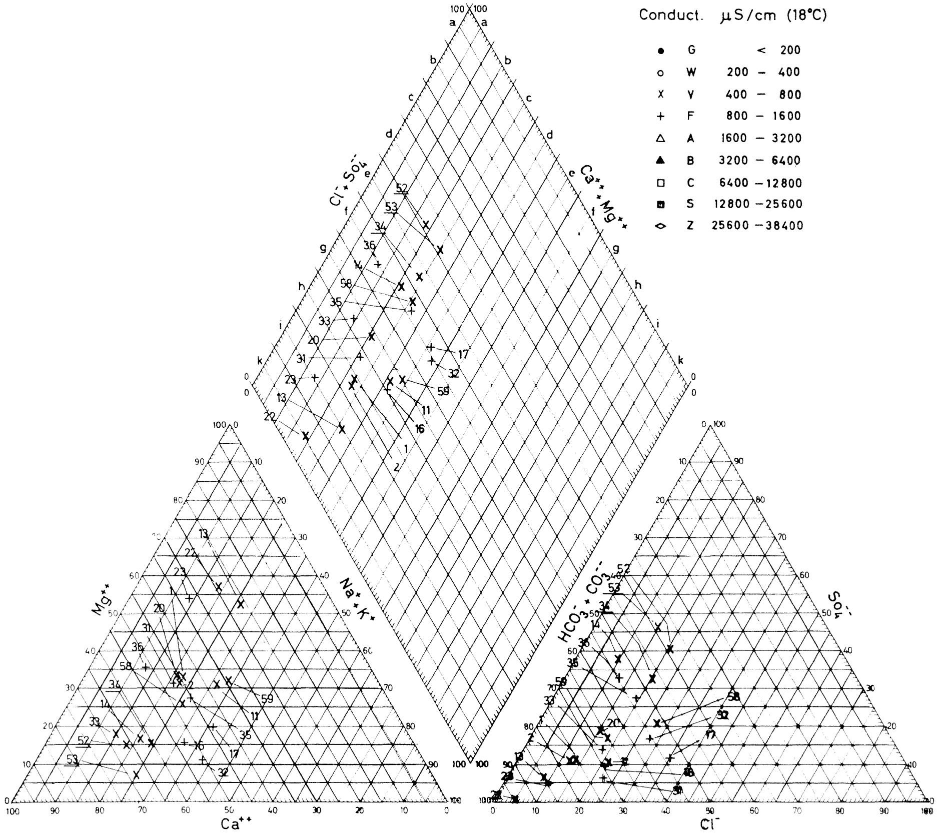

Fig. 8 — Relative ion distribution of group 7 and 8. The waters of group 8 are underlined.

The weakly fresh to fresh waters of group 7 show a low relative sodium content and relative chloride content of less than 30 per cent. Magnesium and calcium account for more than 60 and sometimes 90 per cent of the cation distribution. Bicarbonate is relatively very important with sometimes 90 per cent of the anions. Analysis 124DB2-0267 shows the typical chemical composition and figure 8 pictures the relative ion distribution of all the analyses. These waters are found in many places in the saline coastal plain above the geoelectrically detected fresh-/brackish-water boundary. Group 7 rests upon group 2 (55DB3 at 9 and 14 m, 55DB4 at 7 and 14 m and 56DB6 at 2.5, 10.5 and 16 m), upon group 4 (56DB1 at 13 m), upon group 6 (56DB2 at 12.5 m and 132DB1 at 3.5 m) or upon group 8 (124DB1 at 3.9 m). These waters were also

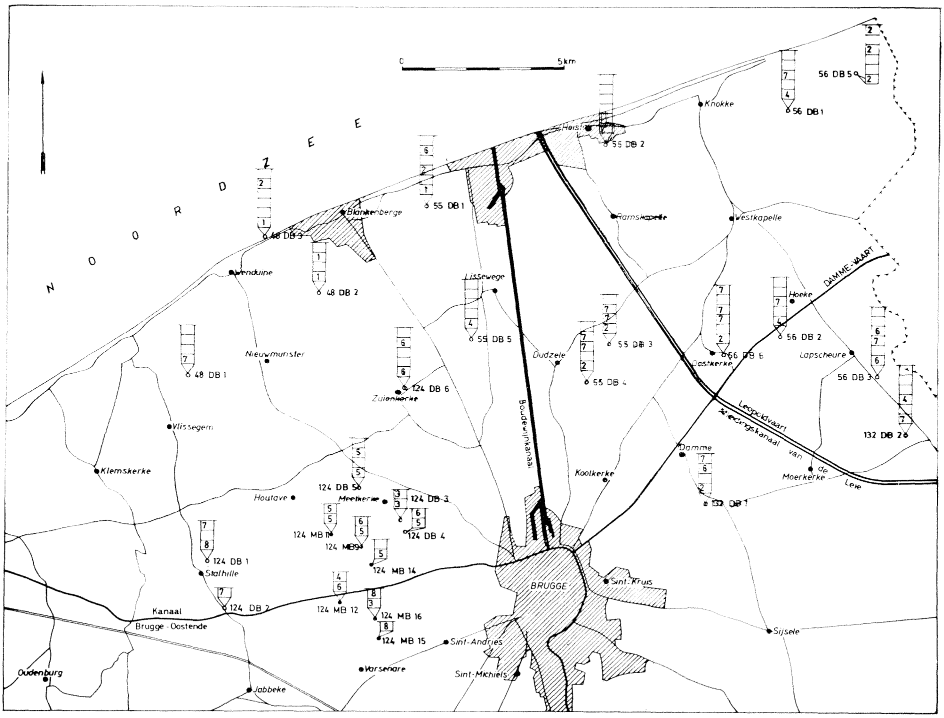

Fig. 9 — Distribution of the different waters. In every drilling site the depth is given in five-meter sections below the surface. The number of the water group is shown in the corresponding compartment

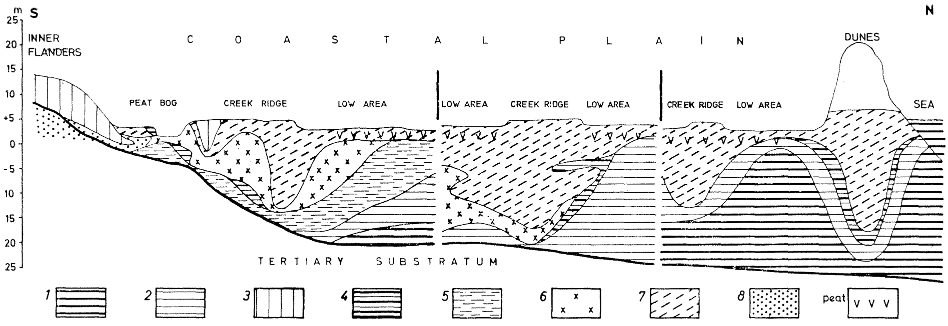

Fig. 10 — Schematic hydrochemical sections.

observed at some other places (48DB1 at 17.8 m, 56DB2 at 12.5 m and 124DB2 at 4 m) and in one place under water of group 4 (132DB2 at 30.2 m).

Group 8 comprises moderately fresh waters with 20 to 30 per cent sodium and 60 to 80 per cent calcium in relative ion distribution. The relative bicarbonate content varies between 30 and 50 per cent and sulfate accounts for more than 30 and sometimes more than 50 per cent of the anions. Analysis 124MB16b-0667 typifies the chemical composition. The ion distributions of the analyses are shown on figure 8. These waters have been sampled at one spot in the freshwater body of a creek ridge (125DB1 at 10 m) and at two other places outside the coastal plain (124MB15 at 2.6 m and 124MB16 at 2.6 m).

ORIGIN, GENESIS AND EVOLUTION OF THE WATERS

The areal and depth distribution of the different water groups (fig. 9 and 10) and also the chemical relationship (fig. 11) make it possible to advance some hypothesis about the origin, the genesis and the evolution of the water-table aquifer.

Two of the groups are native (Piper *et al.*, 1953) waters. Their supply is large enough to leave their composition unchanged by the reservoir rock. Group 1, with its sea-water composition, is

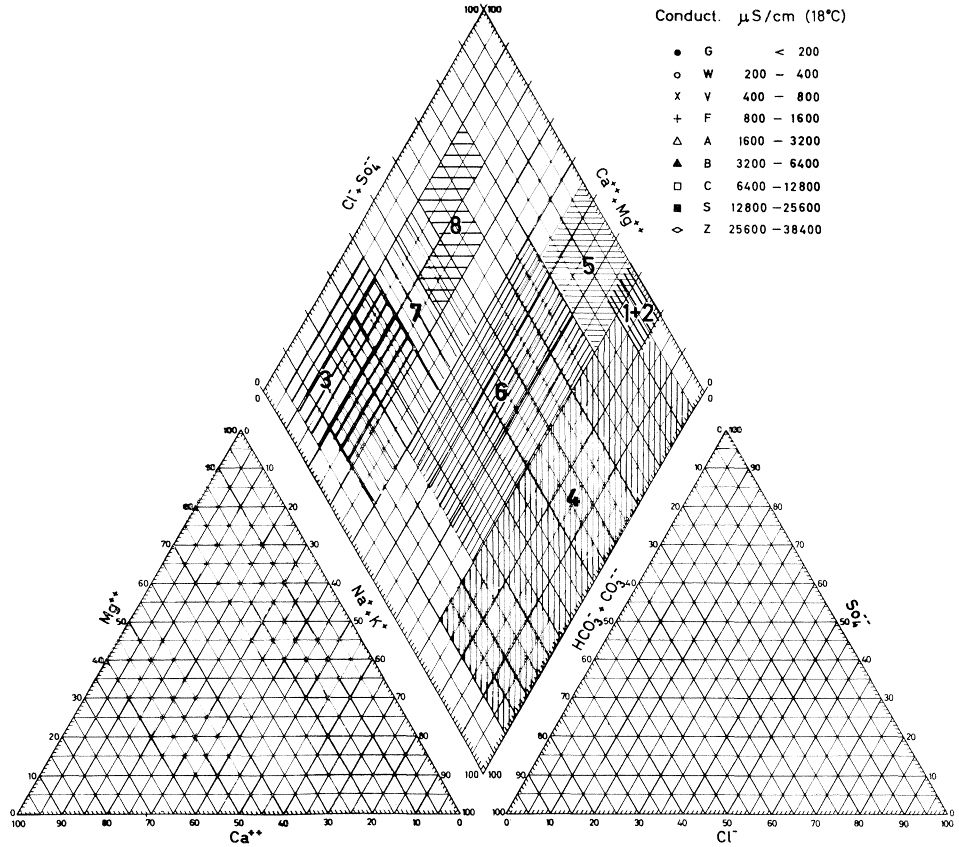

Fig. 11 — Schematic picture of the different water groups.

constantly supplied from the sea by pulse recharge (Kohout and Klein, 1967). Group 3 is being fed by percolating rain water and infiltration from the higher parts inland. The other groups have evolved from these two groups. Sometimes this evolution is limited to a change in total dissolved-solids content. Usually though they undergo a change in relative ion content as a result of mixing and diffusion between two waters of different composition or base exchange between water and sediment. This last phenomenon is particularly operative when the water moves through permutolite-containing sediments, such as clays and organic deposits.

Waters of group 1 originally filled the reservoir completely. This sea water has been driven out of the surface layers on several occasions by rainwater and run off from the higher backland. Since the Coastal Area has been completely closed from the sea, first by the dune belt and later by man, no superficial sea water enters this area. Rainwater, run off and underground current from inland have expelled the former sea water and reduced its occurrence to the small area along the coast. Here exists a dynamic equilibrium, the sea-water supply being continuously renewed by pulse recharge and tidal action. The fresh-water body in the dunes does not everywhere rest upon an impervious substratum so that sea water can move in freely. Indeed, the superficial clay beds continue in many places under the dunes and in other parts the Tertiary substratum is made up by sandy deposits so that the aquifer reaches a thickness of more than 60 m. In the coastal plain the deeper layers contain water of group 2 which is less brackish as a result of the mixing of group 1 and group 6.

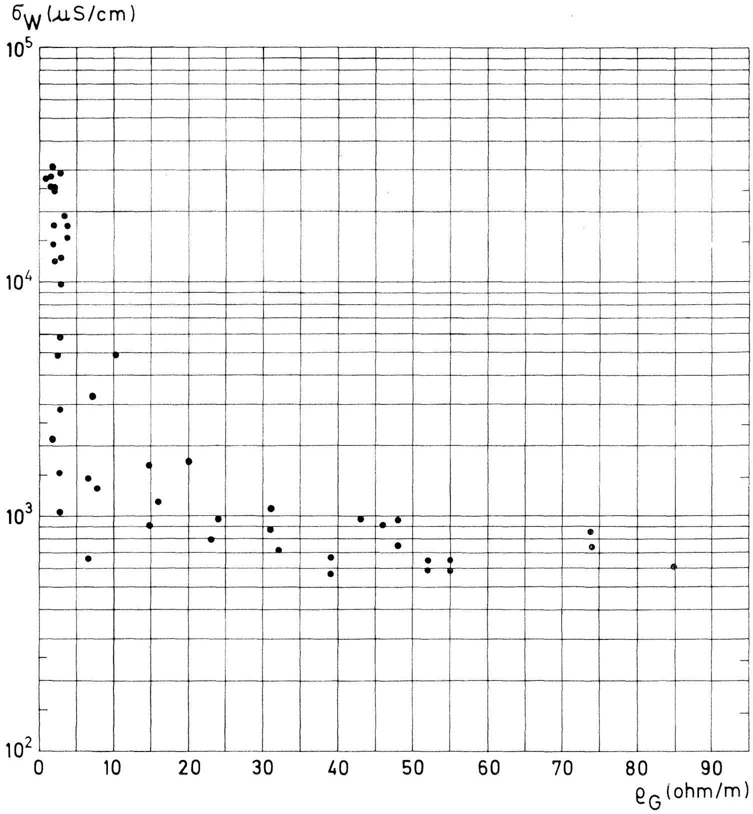

Fig. 12 — Relationship between the conductance of the pore water and the resistivity of the layer.

The depth of group 2 decreases as one approaches the coast where these waters form sometimes the whole hydrochemical section. In the Meetkerke area most of the waters belong to the 5 group, less brackish but with the same composition as group 1. Their presence is related to the evolution of the coastal plain. The sea water in the marine deposits has gradually been diluted and expelled by fresh water (De Moor and De Breuck, 1969).

The group 3 is a native water, found frequently in the Inner-Flanders in Pleistocene sands, where it is formed by percolating rainwater. Its presence is very rare in the Coastal Area since the percolating waters undergo rapid changes in composition in contact with the reservoir rocks.

In the coastal plain the sandy zones usually coincide with important fresh-water bodies, where the fresh-/brackish-water boundary is situated at great depth. This is mainly the case in the inversion landscape near Houtave. Here the higher sandy creek ridges contain fresh-water

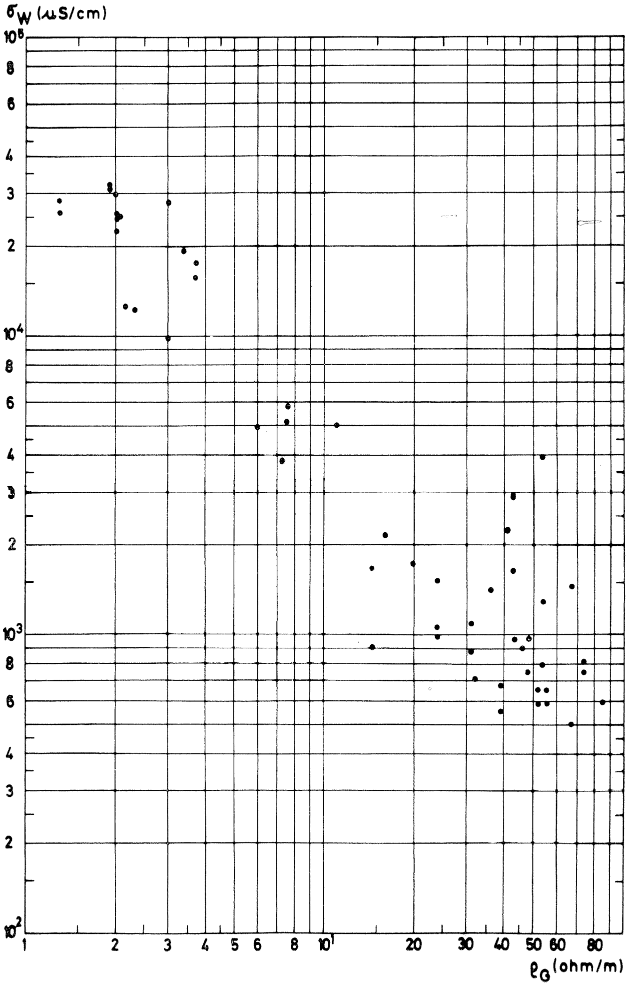

Fig. 13 — Bilogarithmic relationship between the conductance of the pore water and the resistivity of the layer.

pockets, while in the lower clay-on-peat grounds brackish water is found at shallow depth (fig. 3 and 4).

After the reclamation of the polder area the surface water was evacuated through the creeks, which formed the prolongation of the water courses of the higher backland. The surface water did not percolate into the clay-on-peat layers but was continuously evacuated, first in a natural way and later by pumping when inversion had taken place. The result is that these layers have almost not been flushed. In the Meetkerke area, a former high peat bog where the peat has been worked, is being drained by pumping. Hence the ground water belongs to group 5 since it has never been flushed. There may also be some influence from the canal Bruges-Ostend, interrupting the ground-water current from the South.

In the polder land one finds group 4 above group 1 or 2. It contains relatively more sodium than the latter two and a very variable chloride content. This can be the result of differential ion diffusion. In other places the sodium enrichment is due to base exchange between percolating water and the rock.

On group 4 is found group 6, richer in calcium and carbonate, which forms the transition to group 7. Group 7 comprises hard waters but with more magnesium than group 3. This can be attributed to ion diffusion and mixing. The sulfate content of the hard waters of group 8 are due to the sulfate minerals in the Paniselian sediments.

HYDROCHEMICAL SIGNIFICANCE OF THE RESISTIVITY DATA AND THE GEOELECTRICALLY DETERMINED SALINIZATION SURFACE

From the comparison between the resistivity data and the drilling sections a few conclusions can be drawn. As long as the resistivity of the layers does not fall below 10 ohm-m and sometimes below 7 ohm-m, the value is only influenced by the lithology and eventually by the degree of saturation with water. Resistivities below 5 ohm-m indicate always the presence of brackish pore water.

The interpretation of the measured resistivity curves as compared with a set of standard curves always indicate a rather sharp boundary between a fresh- and a brackish-water layer. This boundary had to be precised in terms of total dissolved-solids content. Thus all analyses of the samples included the conductance of the water at 18°C. Figures 12 and 13 show the relationship between the conductance of the water and the resistivity as interpreted from the measurements. The conductance of the water increases very rapidly as soon as the resistivity of the deposit falls below 10 ohm-m. As long as the resistivity remains above this value, the conductance does not reach 1000 μS/cm, which corresponds to a total dissolved-solids content of 25 mé/l. Below 5 ohm-m, the resistivity can only drop a few units but with a very important increase in conductance. The conductance value at 5 ohm-m would correspond to 1500 to 2 000 μS/cm with total dissolved-solids content of 30 mé/l or 1 500 mg/l. This is the top limit for the brackish waters. It corresponds to the boundary measured in the field. Interpretation of resistivity values ranging between 5 and 10 ohm-m may prove doubtful but since the pore water, in the worst case, can only contain at most 25 to 30 mé/l, it may even be situated above the fresh-/brackish-water boundary.

Although there seems to be a transitional section rather than a sharp boundary it seems very well possible that the increase in total dissolved-solids content is very much the same as described in papers by Cooper and Kohout (Cooper *et al.*, 1964; Kohout, 1961).

Figure 14 shows the relationship between the conductance of the pore water and the chloride and sulfate content and also the total hardness. Combining figures 13 and 14 it seems possible to interpret the measured field resistivity values in terms of chloride, sulfate and total hardness.

CONCLUSION

The hydrochemistry of the water-table aquifer is closely related to the genesis of the coastal plain and the actual drainage. As a result the fresh-/brackish-water boundary is strongly influenced by the lithological differences in the surface layers.

The fresh-/brackish-water boundary can be located in the field by a resistivity survey. There are limitations to this method. Interpreted resistivities are mean values for layers that seldom are homogeneous. In the case of increasing salinity with depth only the lowest value corresponding to the highest dissolved-solids content is obtained. It is not possible to figure out intermediate values. This is the reason why water samples taken at intermediate depth show too low a resistivity compared to their conductance value.

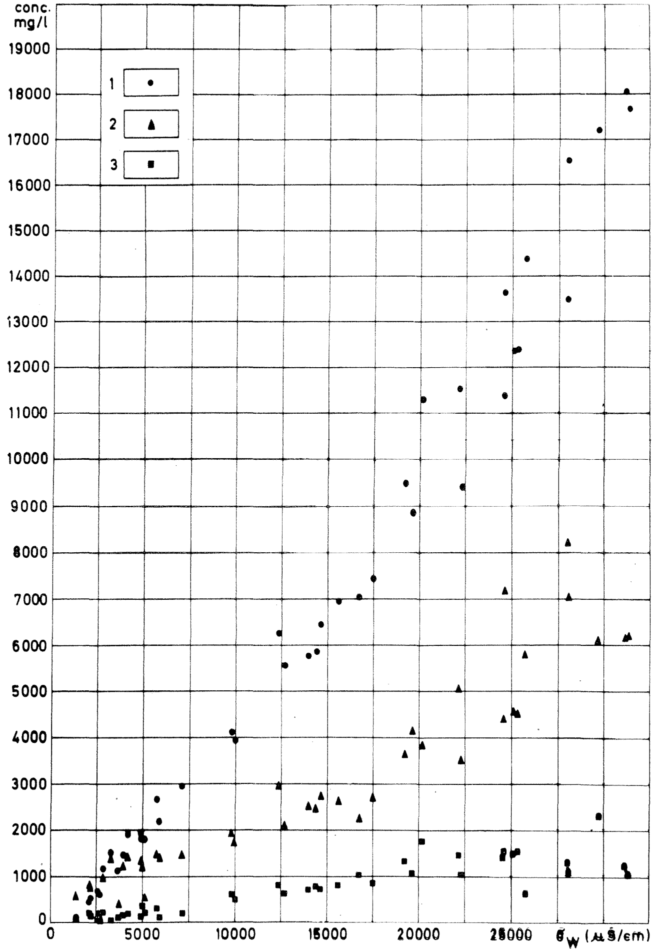

Fig. 14 — Relationship between the conductance of the pore water and (1) the chloride content, (2) the total hardness, and (3) the sulfate content.

Another source of error resides in the fact that the measured curve is being compared with a standard curve. In the low-value area, since one works on bilogarithmic paper, the reading error becomes very important.

With these restrictions in mind resistivity sounding is a very useful tool for locating fresh-water bodies in an area with saline-water encroachment.

Nr.	Analysis	Depth m	Cl^- mg/l mé/l	SO_4^{--} mg/l mé/l	$HCO_3^- + CO_2^{--}$ mg/l mé/l	$Na^+ + K^+$ mg/l mé/l	Ca^{++} mg/l mé/l	Mg^{++} mg/l mé/l	Total Fe mg/l	Tot. N-compounds mg/l	Conduct. µS/cm	Total diss. solids mg/l	pH	Total hardness Fr. degrees	Non-carbon. hardness Fr. degrees	Temp. of water °C	Agressive CO_2 mg/l	SiO_2 mg/l	$\frac{So_4}{Cl}\times100$	$\frac{Mg}{Ca}\times100$	Group
1.	48 DB 1-0866	17,5	42,00 1,18	47,00 0,99	412,40 6,76	59,70 2,01	80,40 4,01	36,00 2,96	0,29	0,76	654	679,20	8,09	34,90	11,50	--	0,0	28,70	83,40	73,80	7
2.	DB 1-0367	17,5	37,00 1,04	45,10 0,94	407,50 6,68	60,7[illegible] 1,99	80,40 4,01	33,30 2,74	0,18	1,34	593	666,20	8,00	33,80	6,80	9,8	0,0	66,30	90,10	68,30	7
3.	DB 2a-0267	19,0	16.540,00 466,44	1.115,00 23,23	1.446,00 23,70	8.734,00 375,19	841,00 41,99	1.205,00 99,10	0,12	5,50	28.050	29.886,80	6,84	706,00	613,00	8,3	0,0	26,70	3,30	293,30	1
4.	DB 2b-0267	7,0	14.380,00 405,53	651,00 13,56	2.245,00 36,80	7.854,00 337,29	588,00 29,36	1.047,00 86,10	0,06	23,40	25.740	26.790,10	7,18	578,00	405,00	7,2	0,0	31,40	4,90	236,00	1
5.	DB 3a-0167	25,0	18.050,00 509,02	1.260,00 26,25	1.623,00 26,60	9.894,00 423,66	585,00 29,21	1.137,00 93,50	0,00	12,94	31.100	23.562,00	7,28	614,00	476,00	—	--	5,80	8,30	300,80	1
6.	DB 3a-0467	25,0	17.670,00 498,31	1.058,00 22,04	1.940,00 31,80	10.173,00 437,06	484,00 24,16	1.213,0 99,75	0,10	18,00	31.300	32.558,40	7,05	620,00	492,00	12,0	0,0	34,50	4,40	412,80	1
7.	DB 3b-0467	9,0	6.480,00 182,74	727,00 15,15	1.105,00 18,12	3.788,00 161,33	271,60 13,56	496,00 40,79	0,66	47,70	14.640	12.917,30	7,40	272,00	199,00	11,5	0,0	57,30	5,20	320,10	2
8.	55 DB 1a-0367	25,0	17.200,00 485,00	2.330,00 48,54	581,90 9,54	9.906,00 424,86	468,00 23,37	1.196,00 98,36	0,08	1,08	29.650	31.613,70	7,20	609,00	563,00	9,0	0,0	21,40	10,00	420,90	1
9.	DB 1b-0367	19,0	5.575,00 157,22	635,00 13,23	827,20 13,56	3.384,00 143,48	220,00 10,98	369,00 30,35	0,11	5,15	12.700	11.016,50	7,60	150,00	150,00	9,5	0,0	24,40	8,40	276,30	2
10.	DB 1c-0367	8,2	539,00 15,20	160,00 3,33	673,40 11,04	404,00 15,19	194,00 9,69	60,50 4,98	0,09	1,57	2.222	2.034,50	7,50	73,30	22,50	10,0	3,5	38,60	21,90	51,40	6
11.	DB 2-0467	25,0	69,00 1,95	44,10 0,92	373,00 6,12	82,50 2,81	55,20 2,78	40,60 3,34	0,06	6,00	710	670,90	7,78	30,50	6,20	11,3	0,0	40,20	47,20	121,10	7
12.	DB 3a-0367	19,0	4.125,00 116,33	613,00 12,77	547,80 8,98	2.384,80 102,10	309,00 15,43	274,00 22,53	0,10	20,99	9.820	8.267,70	7,32	190,00	146,00	9,0	0,0	35,50	10,10	146,10	2
13.	DB 3b-0367	14,0	29,00 0,82	32,50 0,68	524,60 8,60	81,30 2,58	42,00 2,10	62,00 5,10	0,03	0,93	678	772,70	7,92	36,00	6,40	10,0	0,0	48,20	82,80	243,10	7
14.	DB 3c-0367	9,0	27,00 0,76	141,00 2,94	248,90 4,08	40,00 1,64	96,80 4,83	15,30 1,26	0,06	0,36	552	569,80	8,20	30,50	12,90	10,5	0,0	20,00	385,90	26,00	7
15.	DB 4a-0367	22,0	9.480,00 267,34	1.334,00 22,79	731,00 11,98	5.531,00 237,60	492,00 24,56	581,00 47,78	6,56	6,95	19.230	18.164,00	7,20	362,00	306,00	10,4	0,0	23,00	10,40	194,50	2
16.	DB 4b-0367	14,0	88,00 2,48	51,90 1,08	492,90 0,08	105,60 3,78	126,00 6,29	22,40 1,84	0,09	4,26	889	891,90	7,40	40,70	7,60	11,0	0,0	29,70	43,50	29,30	7
17.	DB 4c-0367	7,0	186,00 5,25	80,30 1,67	490,40 8,04	135,90 5,32	130,00 6,44	35,50 2,92	0,08	13,37	1.095	1.072,60	7,60	47,10	12,60	10,4	0,0	21,40	31,90	45,30	7
18.	DB 5-0367	22,0	1.798,00 50,71	209,00 4,35	723,50 11,86	1.362,00 58,22	74,00 3,69	77,00 6,33	0,66	3,27	5.138	4.248,70	7,93	50,20	5,50	10,0	0,0	35,50	8,60	171,40	4
19.	56 DB 1a-0367	23,5	37,00 1,04	7,40 0,15	452,60 7,42	150,70 6,04	14,00 0,70	22,10 1,82	0,50	3,74	593	689,80	8,17	12,60	2,10	9,5	0,0	47,90	14,80	259,90	4
20.	DB 1b-0367	13,0	52,00 1,47	87,80 1,83	394,10 6,46	53,20 1,98	87,20 4,35	38,90 3,20	0,04	1,08	656	714,60	8,05	37,80	10,90	10,0	0,0	18,70	10,30	99,10	4

Nr.	Analysis	Depth m	Cl- mg/l mé/l	SO_4-- mg/l mé/l	HCO_3-+CO_2-- mg/l mé/l	Na^++K^+ mg/l mé/l	Ca^{++} mg/l mé/l	Mg^{++} mg/l mé/l	Total Fe mg/l	Tot. N-compounds mg/l	Conduct. µS/cm	Total diss. solids mg/l	pH	Total hardness Fr. degrees	Non-carbon. hardness Fr. degrees	Temp. of water °C	Agressive CO_2 mg/l	SiO_2 mg/l	$\frac{So_4}{Cl}\times100$	$\frac{Mg}{Ca}\times100$	Group
21.	**56** DB 2a-0467	24,5	176,00 496	24,50 0,51	732,00 12,00	330,80 13,80	34,40 1,72	20,70 1,70	0,47	5,70	1.302	1.326,30	7,90	17,10	1,00	12,0	5,0	18,40	124,80	73,50	7
22.	DB 2b-0467	12,5	20,00 0,56	3,50 0,07	677,00 11,10	74,80 2,19	56,00 2,80	79,90 6,57	0,08	4,84	797	916,70	8,00	46,90	5,70	11,8	0,0	48,40	12,90	235,00	7
23.	DB 3a-0268	16,4	35,90 1,01	21,40 0,45	491,60 8,06	39,00 1,39	108,00 5,39	38,90 3,20	5,00	2,50	906	731,60	7,45	43,00	4,40	11,6	0,0	2,60	44,10	59,30	7
24.	DB 3b-0268	12,3	70,00 1,97	120,00 2,50	786,90 12,90	300,00 8,60	98,00 4,89	34,00 2,80	2,50	0,84	1.669	1.412,90	7,65	38,50	0,60	12,3	0,0	5,10	126,60	57,10	6
25.	DB 3c-0268	6,8	106,50 3,00	170,00 3,54	534,30 8,80	228,00 6,48	34,60 1,73	62,90 5,17	17,50	2,94	1.644	1.158,70	8,30	34,50	1,20	13,1	0,0	3,75	117,90	299,50	6
26.	DB 5a-0268	26,7	2.389,00 349,38	1.540,00 32,08	518,50 8,50	7.070,00 302,38	360,00 17,97	874,80 71,94	2,82	5,09	25.311	22.765,60	7,50	450,00	392,00	11,7	0,0	6,50	9,20	400,30	2
27.	DB 5b-0268	13,8	12.354, 348,39	1.500,00 31,25	610,00 10,00	7.200,00 308,39	368,00 18,37	882,00 72,53	3,54	3,88	25.089	22.925,50	7,45	455,00	414,00	11,4	0,0	6,60	9,00	394,80	2
28.	DB 5c-0268	10,3	1.380,00 320,92	1.420,00 29,58	607,60 9,96	6.480,00 277,44	336,00 16,77	865,00 71,13	5,52	6,15	24.560	21.104,60	7,45	440,00	382,00	11,7	0,0	6,25	9,20	424,10	2
29.	DB 5d-0268	2,8	9.407,50 265,30	1.040,00 21,67	832,60 13,65	6.005,00 258,76	640,00 22,97	571,0 46,96	3,44	6,14	22.258	18.332,10	7,60	350,00	264,00	10,9	0,0	7,75	8,2	204,50	2
30.	DB 6a-0268	26,5	6.260,00 176,54	818,85 17,06	473,97 7,77	3.484,80 148,99	521,94 26,06	397,05 32,65	0,09	8,71	12.350	11.965,50	7,29	293,60	258,60	11,2	0,0	27,90	9,7	125,30	2
31.	DB 6b-0268	16,0	130,00 3,67	51,088 1,06	728,34 11,94	103,60 3,45	154,35 7,71	61,65 5,07	0,15	1,19	1.062	1.230,50	7,48	63,90	9,70	12,1	0,0	37,80	29,00	65,80	7
32.	DB 6c-0268	10,5	220,00 6,20	175,10 3,65	756,40 12,40	272,40 8,31	220,97 11,02	29,77 2,45	0,13	3,10	1.505	1.680,10	7,25	67,40	12,40	12,0	0,0	33,00	58,80	22,20	7
33.	DB 6d-0268	2,5	76,00 2,14	76,00 1,58	478,80 7,85	46,00 1,86	168,40 8,41	27,70 2,28	9,50	23,69	993	909,10	7,35	53,50	15,60	10,0	0,0	4,10	73,90	27,10	7
34.	**124** DB 1a-0267	10,0	76,00 2,14	164,80 3,43	305,00 5,00	65,70 2,53	128,00 6,39	19,40 1,60	0,03	2,21	755	761,60	6,89	39,90	16,70	8,2	38,9	26,70	160,20	25,00	8
35.	DB 1b-0267	3,9	90,00 2,54	175,30 3,65	433,10 7,10	101,00 3,67	123,00 6,14	44,70 3,68	0,02	10,18	980	977,50	8,00	49,20	22,30	8,2	0,0	14,00	143,90	59,90	7
36.	DB 2-0267	4,0	60,00 1,69	211,60 4,41	451,40 7,40	46,90 1,75	138,00 6,69	58,10 4,78	0,01	1,44	904	967,90	7,32	58,50	22,20	6,2	0,0	13,30	260,50	69,30	7
37.	DB 3a-0267	8,0	29,00 0,82	94,60 1,97	414,80 6,80	38,40 1,45	143,00 7,14	12,40 1,02	0,01	0,62	653	733,10	7,60	40,90	8,80	7,9	0,0	49,00	240,90	14,30	3
38.	DB 3b-0267	4,0	25,00 0,71	160,90 3,35	379,40 6,22	23,00 0.21	153,00 7,64	18,00 1,48	0,01	0,45	691	760,00	7,56	45,70	17,50	8,2	0,0	23,50	475,50	19,40	3
39.	DB 4a-0267	5,5	1.814,00 51,16	358,90 7,48	497,80 8,16	959,60 41,19	390,00 19,47	46,20 3,80	0,03	11,70	4.975	4.079,10	7,25	116,40	81,60	7,2	0,0	32,70	14,60	19,50	5
40.	DB 4b-0267	2,6	188,00 5,30	96,60 2,01	330,60 5,42	147,00 6,25	114,00 5,69	7,80 0,64	0,06	4,26	970	888,60	7,70	31,80	10,70	7,4	0,0	21,20	38,00	11,30	6

Nr.	Analysis	Depth m	Cl- mg/l mé/l	SO_4-- mg/l mé/l	HCO_3-+CO_2-- mg/l mé/l	Na^++K^+ mg/l mé/l	Ca^{++} mg/l mé/l	Mg^{++} mg/l mé/l	Total Fe mg/l	Tot. N-compounds mg/l	Conduct. S/cm	Total diss. solids mg/l	pH	Total hardness Fr. degrees	Non-carbon hardness Fr. degrees	Temp. of water °C	Agressive CO_2 mg/l	SiO_2 mg/l	$\frac{So_4}{Cl}\times 100$	$\frac{Mg}{Ca}\times 100$	Group
41.	124 DB 5a-0267	18,5	1.922,00 54,20	135,10 2,82	524,60 8,60	942,70 39,90	194,00 9,69	200,00 16,45	0,03	5.60	4.910	3.924,80	7,47	130,70	90,30	9,4	0,0	26,30	5,20	169,80	5
42.	DB 5b-0267	8,3	1.460,00 41,17	171,00 3,56	523,40 8,58	678,50 28,33	254,00 12,68	133,00 10,94	0,62	3,86	3.958	3.220,50	7,42	118,00	78,30	8,4	0,0	32,10	8,60	86,20	5
43.	DB 6a-0267	22,5	210,00 5,92	97,20 2,03	442,90 7,26	172,00 6,75	140,00 6,99	18,20 1,50	0,08	1,17	1.170	1.082,10	7,50	42,50	11,60	9,1	0,0	31,10	34,20	21,40	6
44.	DB 6b-0267	6,0	465,00 13,11	215,50 4,49	699,00 11,46	284,70 11,90	200,00 9,99	72,20 5,94	0,04	3,96	2.145	1.938,40	7,60	79,60	31,30	8,2	0,0	44,80	34,20	59,50	6
45.	MB 9b-0667	3,0	1.164,00 32,83	226,00 4,71	541,70 8,88	659,90 28,03	244,00 12,18	79,30 6,52	0,06	2,55	2.885	2.917,90	7,65	93,60	56,90	12,4	0,0	48,30	14,30	53,50	6
46.	MB 9a-0667	7,0	2.666,00 75,18	304,00 6,33	28,80 0,96	1.291,40 55,34	536,00 26,76	29,20 2,40	0,06	4,73	5.755	4.874,30	9,82	145,70	137,40	12,5	0,0	13,40	8,40	9,00	5
47.	MB 11b-0667	4,6	3.490,00 380,43	1318,00 27,46	539,20 8,84	5.861,00 253,02	2.120,00 105,84	713,00 58,64	4,64	0,13	28.000	24.049,80	6,59	822,00	776,00	11.8	18,0	29,30	7,50	55,40	5
48.	MB 11a-0667	8,5	1.912,00 53,92	198,00 4,13	658,80 10,80	1.065,00 41,61	336,00 17,77	120,00 9,87	0,07	5,92	4.205	4.316,10	7,22	138,30	90,50	10,8	0,0	33,20	7,60	55,50	5
49.	MB 12b-0667	2,8	448,00 12,63	86,70 1,81	281,40 7,48	505,90 21,62	2,00 0,10	2,70 0,22	0,52	0,72	1.726	1.328,10	10,19	1,60	1,40	13,8	0,0	59,10	14,30	222,00	4
50.	MB 12a-0667	6,4	212,00 5,98	121,00 2,52	622,00 10,20	274,00 10,80	42,90 2,14	64,90 5,34	0,05	8,57	1.415	1.345,80	7,52	37,40	4,80	13,2	59,7	36,20	42,20	249,20	6
51.	MB 14-0667	5,5	1.520,00 42,87	48,80 1,02	368,40 6,04	537,80 22,85	406,00 20,27	81,70 6,72	0,01	5,63	3.290	2.968,90	7,18	134,90	119,60	12,0	0,0	48,70	2,40	33,10	5
52.	MB 15-0667	2,6	43,00 1,21	114,00 2,38	140,00 2,30	30,90 1,18	84,90 4,24	11,70 0,96	0,02	23,92	458	448,60	7,25	26,00	18,80	11,2	7,9	21,60	195,80	22,70	8
53.	MB 16b-0667	2,6	47,00 1,33	202,00 4,21	215,90 3,54	55,20 2,24	123,00 6,14	7,50 0,62	0,04	0,31	602	615,10	7,69	33,80	22,10	11,6	0,0	32,30	317,60	10,50	8
54.	MB 16a-0667	8,7	23,00 0,65	15,80 0,33	155,00 2,54	17,20 0,65	52,10 2,60	4,60 0,38	0,04	2,23	253	270,20	7,79	14,90	9,50	12,2	7,3	25,90	50,70	14,50	3
55.	132 DB 1a-1066	17,0	7.440,00 209,81	860,00 17,92	927,20 15,20	4.237,40 183,74	619,90 30,91	279,90 23,02	0,13	18,19	17.500	14.382,00	6,58	270,00	77,40	—	0,0	20,30	8,70	115,30	2
56.	DB 1a-0367	17,0	6.950,00 196,00	815,00 16,98	899,10 14,74	4.011,60 174,03	484,00 24,16	338,00 27,80	0,62	10,73	15.610	14.510,00	7,05	260,00	184,00	9,7	0,0	28,90	8,50	74,50	2
57.	DB 1c-0268	5,0	184,00 5,19	223,51 4,66	567,30 9,30	307,20 9,06	82,04 4,10	70,04 5,76	0,64	13,78	1.459	1.448,80	7,24	49,30	14,20	11,6	12,5	12,15	89,70	0,60	6
58.	DB 1d-0268	3,5	70,00 1,97	70,86 1.48	225,70 3,70	47,32 1,84	68,22 3,41	22,45 1,85	0,50	8,23	502	513,60	7,61	26,30	10,30	12,5	1,7	8,30	74,80	54,20	7
59.	DB 2a-0268	30,2	47,90 1,35	60,00 1,25	295,20 4,84	62,00 2,46	52,80 2,64	31,60 2,60	4,34	1,50	748	555,70	7,65	26,20	4,90	11,9	0,0	5,10	92,50	98,60	7
60.	DB 2b-0268	19,0	258,40 7,29	110,00 2,29	143,90 2,45	216,00 8,18	41,60 2,08	20,90 1,72	2,44	2,85	861	796,20	8,70	19,00	11,00	13,0	0,0	3,25	31,40	55,90	4

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