ROYAUME DE BELGIQUE

MINISTERE DES AFFAIRES ECONOMIQUES ET DE L'ENERGIE
ADMINISTRATION DES MINES - SERVICE GEOLOGIQUE DE BELGIQUE

13, rue Jenner - 1040 BRUXELLES

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SH. BRUGGE - 23 W, 372

by

R. PAEPE, R. VANHOORNE and D. DERAYMAEKER

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EEMIAN SEDIMENTS NEAR BRUGES (BELGIAN COASTAL PLAIN)

by R. PAEPE, R. VANHOORNE and D. DERAYMAEKER.

1. INTRODUCTION

Eemian wadden sediments under a fairly thin cover of successively Weichselian and Dunkirkian deposits were for the first time observed in profile in a sandpit at Meetkerke (near Bruges) by R. PAEPE and R. VANHOORNE (1972). About the same time the study of the borings along the highway Bruges - Calais (R. PAEPE , 1971) showed that these Eemian deposits extend as a rather continuous fringe along the southern border of the coastal plain. They even reach a further inland position than the present polder deposits.

Earlier J. B. AMERIJCKX, while establishing the soil map of Sheet Brugge, 23 W (1958), revealed the existence of Pleistocene deposits at less than 1 m depth in the coastal plain, which areas are indicated with oblique dashes on the outline map of the present profile drawing. It may be noticed that the site of Meetkerke and the present one (Bruges, St. Pieters) occur within this area of undeep Pleistocene substratum.

2. DESCRIPTION OF THE PROFILE

At Bruges, St. Pieters, several sections were carefully studied during both summers of 1970 and 1971, one of which is chosen here on behalf of its most complete litho-stratigraphical sequence. It runs from N.W. to S.E. , perpendicular to the southern limit of the coastal plain with a total length of say 100 m and 7 - 8 m in depth.

2.1. Holocene Deposits

In this part of the coastal plain (polder), the surficial sediments are rather heterogeneous in composition and show a textural variety which corresponds to different lanscape units. A sandy (dotted) area extends west of Bruges between the roads to Blankenberge and Ostend and bends around the northern edge of the Lege Moere in the direction of Meetkerke. It is a filled up tide gully of the DUNKIRK 2 transgression. The Lege Moere then is a presumed former high moor which should explain why Dunkirkian deposits are rather scarce or completely absent here. In between both areas extends a clay sedimentation basin (vertical dashes) with islands of undeep pleistocene (oblique dashes).

The present profile is entirely situated in the sandier area along the road linking the Ostend and Blankenberge roads.

Because of its landscape position the section starts with a fairly continuous cover of clay, 1 - 1,5 m in thickness. The so-called Dunkirkian deposits rest on an even continuous slightly undulating horizon of peat, since long known as HOLLAND PEAT and dated from Late Atlantic to Sub-atlantic (F. STOCKMANS and R. VANHOORNE, 1954). Underneath , and most often in those places where the Holland peat is slightly doming, occurs a podzolic soil, developed as we shall see further in underlying yellowish-brown coversands. Therefore, the soil is considered postglacial in age, too.

2.2. Weichselian Deposits

2.2.1. Late Glacial

The yellowish coversands, with a faint horizontal stratification (sample nr 16) and of overall homogeneous aspect, are believed to be eolian. The lower boundary is slightly undulating but nevertheless subhorizontal as a whole. Occasionally a thin oxidized zone (short oblique dashes) occurs along this limit. In one particular place (at 17 m of the profile) even rootlets may descend from this lower limit downwards into the underlying crossbedded sands. It is quite evident that these rootlets and oxidized zone are part of a buried soil development. In other parts along the same boundary, fine needle-like (frost) wedges (G) are observed. They certainly developed after the fossil soil formation which they penetrate; as of then the soil is to be looked at as being interstadial in age. This view encompasses fairly well with the position of the ROKSEM SOIL (R. PAEPE, 1968) which is of Allerød age.

Under these top sands, large crossbedded sands occur (samples 15 and 14) containing numerous humic bands. The latter become more frequent towards the base; it is not entirely clear whether they are formed after or contemporaneously with the deposition. In this zone of the profile also frost wedges (F) which deform the continuity of the bands locally, are observed. This could point to the fossil character of the humic bands.

Moreover, the above stated succession of humic horizons, frost wedges and two different types of coversands reminds to the lithological sequence of the Late Glacial period. In this light the crossbedded eolian sands point to an Early Dryas age with probably remnants of the Bølling interstadial (humic bands = STABROEK SOIL) at its base.

2. 2. 2. Upper Pleniglacial

Coarser textured sands with definite marks of fluvial transport occur in a zone of 20 cm thickness below the Late Glacial deposits (sample nr 13). It is a fluvially reworked eolian deposit, to which the name COVERSAND 2 was given. They overly a pebble band horizon containing many wind worn flint and quartz pebbles as well as reworked shells; also gullies may be observed just underneath - although stratigraphically linked to this level - in some places (15 - 20 m and 87 - 100 m) of the profile. At the contact between gullies and pebble band, another oxidized zone (oblique dashes) is observed.

Eolian and fluvial activity is assumed to have influenced deposition of these pebble beds. That this action was certainly not always contemporaneously is shown clearly by the succession of gullies overlain by the subhorizontal pebble pavement. After a period of fluvial deposition, eolian activity has reworked and flattened the gully material to form a desert pavement typical of the cold dry regions. This level is quite characteristic and occurs over widespread areas. In the Netherlands it is referred to as BEUNINGEN GRAVEL BED. Since there are several of such pebble bands, it is called in Belgium "DESERT PAVEMENT 3" (R. PAEPE and R. VANHOORNE , 1967).

This sequence also indicates that during formation of the gravel and pebble beds climate evolved from cold/wet towards cold and dry. Actually, it is along the pebble line that one finds the largest frost wedges(E). Pebbles derived from the desert pavement, are found in the bottom part of the frost wedge so that the wedge must have formed after development of the desert pavement.

Underneath DESERT PAVEMENT 3, another coversand, COVERSAND 1 (sample nr 12) appears. It is partly ravinated by the gullies of the base of DESERT PAVEMENT 3. Still it is bounded by festoonlike disturbances known as "druipstaarten" in the Dutch literature. Here, too, frost wedges (D) appear along the lower (festoon) boundary.

The whole sequence of coversands and pebble bands belong to the Upper Pleniglacial of the Weichselian Glacial period (W. H. ZAGWIJN and R. PAEPE , 1968). However, the palynological study of peat samples coming from the layer with "druipstaarten" shows a spectrum with (thermophilous elements as Carpinus, Ulmus, Quercus, Corylus and Alnus besides Pinus, Betula and Salix. According to these spectra, the landscape should have been a park-landscape in which Pinus was a most frequently occurring tree. The high percentages of Chenopodiaceae and the presence of Armeria would perhaps indicate that the vegetation had a steppe character. If these pollen assemblages are not reworked, the layer with "druipstaarten" should be placed in the Early Weichselian, perhaps in the Amersfoort interstadial. This would mean that the Middle Pleniglacial deposits described below should be adhered to the Early Weichselian, too. A more detailed study is still needed.

2. 2. 3. Middle Pleniglacial

A series of sand layers, most often with fluvial and run-off structures appears below the upper-pleniglacial deposits. Nice sedimentary structures such as foresets and climbing sets of ripplemarks (sample nr 10 and 9) occur so that no doubt remains about the totally different climatic conditions under which these deposits formed. Besides some thin eolian, homogeneous sand layers and sporadically occurring frost wedges (C and B) everything points to mainly milder and wetter conditions.

Nevertheless, together with the occurrence of frost wedges the presence of some homogeneous, probably eolian sands (sample nr 11, 8 and 7) point to more severe conditions at the end and the beginning of this sedimentation sequence. In fact, the largest frost wedge (A) is observed at the base of the lowermost eolian sandlayer (7) so that it is almost sure that sedimentation took place after a phase of severe cold. This is a lithostratigraphical argument pleading in favour of Middle Pleniglacial age for this series of sediments. It were similar deposits which were called earlier (Peaty) LOAM FORMATION or SAND FORMATION the latter when dealing with the coversand area. Finally the whole was chronostratigraphically indicated as Middle Pleniglacial (W. H. ZAGWIJN and R. PAEPE, 1968).

In comparing this sequence, especially part of the profile between 52 and 62 metres, to a section of the profile at Tongrinne , in the loess area (in press), a striking resemblage is found. So to say one deals here with a non-locally bounded sedimentation, which then indeed reflects the climato-sedimentological impact on this sequence.

One should expect these sediments to be bounded by deposits belonging to the Lower Pleniglacial. But as in many other places, they seem to lack here, the hiatus being formed by the erosion phase which must have preceded the establishment of the large frost wedge (A) horizon.

2. 2. 4. Early Weichselian

Because of the above mentioned reasons, the loamy shell bearing sand deposits (sample nr 6) filling up ravinating gullies, are considered to belong to the LOAM and COARSE SANDS of R. PAEPE's litho-stratigraphical classification (1967).

Those deposits are believed to correspond chrono-stratigraphically to the Early Weichselian, implying even milder, wetter climatic conditions. This may explain why the lower boundary of the Weichselian deposits is so irregular in contrast to the horizontality of the ones above.

2. 3. Eemian Deposits

Under the ravinating lower boundary of the Weichselian, a series of clay and silty sands (sample nr 5 and 4) , somewhat humic in places, occurs. The texture and structure of these sediments reveal the existence of a typical wadden deposit. Especially the sub-tidal gullies in part 75 to 85 metres of the section add to this assumption.

Towards the base shell bearing layers occur at different levels. One of us (R. VANHOORNE) studied in more detail the malacological composition of them which is a follows :

Amygdala aurea var. eemiensis NORDMANN, Amygdala decussata LINNAEUS, Bittium reticulatum DA COSTA, Cerastoderma edule LINNAEUS, Corbicula fluminalis MULLER, Ensis sp. , Hinia reticulata LINNAEUS, Hydrobia ulvae PENNANT, Littorina littorea LINNAEUS, Littorina saxatilis OLIVI, Macoma balthica LINNAEUS, Ostrea edulis LINNAEUS, Rissoa membranacea ADAMS, Scrobicularia plana DA COSTA.

At a depth of 4,20 m below the surface some seeds were found belonging to Carex div. sp, Mentha sp. , Potamogeton sp. , Rubus sp. , Scirpus lacustris L. and Suaeda maritima (L.) DUMORT.

Finally, a discontinuous peat layer, paves the base of the wadden series; it is ravinated by small gullies containing large amounts of shells as well.

As a final result, the Eem character of these sediments appears clearly so that from now it can be ascertained that Eem marine deposits may reach the level of approximately - 1 m. Ostend Datum (O. D.) in this area. It is to be remembered that elsewhere (R. PAEPE, 1971, 1972) this could even occur at about + 2 m. O. D. in height.

2.4. Saalian Deposits

Homogeneous green grayish sands appear below the wadden sediments (sample nr 3, 2, 1 and 17). It is difficult to say whether or not the sediment is reworked from the Tertiary. But here grain size analysis could throw some light(see hereunder) and it is believed that one deals here with an eolian deposit.

A ferro-humic podzolic soil profile is present in its top layers thus separating the eolian sand from the Eemian deposits above. The soil is called BRUGGE SOIL and believed to be still Eemian in age, too. R. VANHOORNE came to this conclusion by a pollen analysis of the humic A_1 - horizon of this soil (sample nr 3). The pollen diagram shows a dominance of Pinus. Corylus is well represented, while Quercus, Ulmus, Alnus and Betula appear only in low percentages.

In the amount of anemophilous herbs the Ericales are the most important component, while the Chenopodiaceae are very rare. Striking is the extremely regular trend of the differrent curves which might indicate a rapid formation of this A_1 -horizon. The vegetation which covered the landscape at that time was a heath forest in which Pinus was the most frequent tree, while Corylus was an important component of the shrub vegetation. Here and there grew Quercus, whereas Alnus was probably limited to the most humid areas. Finally Betula appeared at the top of this A_1-horizon in very few quantities. This vegetation picture is until now unknow in the Eemian so that it is impossible to incorporate it in one of the pollen zones of the Eem interglacial. However on the basis of its stratigraphical position underneath a marine Eemian deposit which corresponds with or which occurred short after the maximum of the climate, we may conclude that the soil belongs to the first half of the interglacial. When we look at the vegetation evolution during the Holocene, we can observe that , after the initial Preboreal Betula- Pinus forest, Corylus was the first thermophilous immigrant in the Boreal followed by Ulnus Quercus and Alnus (VERBRUGGEN, C. , 1971). So it is possible that the podzol soil developed in the beginning of the Eemian after the Betula-Pinus forests. The presence of Ericales which belongs mostly to Calluna, indicates that the heath was a natural landscape in the Eemian in contradiction with the opinion of the greater part of actual botanists, who consider that the establishment of the heath in Western Europe is due to anthropological influences.

In conclusion, this pedogenesis is an independent soil formation which formed prior to the Eem peat development above. The continuous and horizontal display pleads in favour of this opinion. Also it is the same soil horizon which was observed in other parts of the excavation, overlain directly by Weichselian sediments in complete absence of an Eem peat layer. This adds to the opinion that the soil represents an old surface at the top of the eolian sands. It has not been disturbed by the Eemian wadden flood which sediments protected it from destruction by sediment deposition during the Early Weichselian.

For all those reasons the homogeneous sands are considered to be at least Saale in age.

3. GRAIN SIZE ANALYSIS

The grain size analysis was carried out by D. DERAYMAEKER mainly for the purpose of the origin and nature of the so-called Saalian deposits. The results of the analyses are summarized in tables 1 - 4. Graphically they are represented first on a triangular diagram and, secondly, on four Doeglas-diagrams (see annexe).

3.1. Triangular Diagram

The triangular diagram is based on the criteria used by the Belgian Soil Survey (Ghent).

It can readily be seen that all eolian sands are narrowly grouped together in the extreme sand corner. Not only those of presumed Saalian age (1, 2, 3 and 17) but also the two eolian samples (8 and 11) of the Middle Pleniglacial must be added.

Slightly aberrant from this group are 9 and 14 which in both cases are samples taken in the transition from cold dry to cold wet climatic conditions. Samples 7 and 10 are then to be considered as the most representative fluvially reworked sediments of the Middle Pleniglacial. Texturally they already belong to the loamy sand and sandy loam classes.

Sample 6, clayey loam, is quite aberrant and it justifies to some extent the stratigraphical separation of the formation to which it belongs, from the overlying Middle Pleniglacial deposits.

Also the Eemian samples 4 and 5, light clay in texture, permit perfect distinction from the afore mentioned groups.

3. 2. Doeglas Diagram

A representation of cumulative curves on Doeglas diagrams yields even more identification of the distinct litho-stratigraphic members .

A striking grouping of the Late and Pleniglacial coversands is shown by the sigmoidal type of curves which they represent. Even the texturally aberrant sample nr 14 follows perfectly the general trend and it can be observed that the anomaly is due to an increase in the 50 - 150 micron interval.

Sample 8 and 11 from the Middle Pleniglacial deposits still adhere to this group whereas 9 and 10 are shifted towards the loam curve area. Here also, the greatest anomaly is to be observed in the trend of curve 10.

The shifting in the direction of the loam curve area is still more noticeable in curve nr 7. The form of this curve very much resembles the one of sample nr 10.

A typical loessoid curve is obtained by the trend of sample nr 6 with an outspoken break between the steep loess "line" and the flat, low lying non-disrupted coarse "tail".

In the sequence from samples 6, 7 and 9 a gradual shift from loessoid towards coversand deposits may thus be noticed. A similar conclusion was drawn from a former grain size study in the profile of Zemst by R. PAEPE (1972).

The Eemian deposits, especially sample 5, show the typical trend of a slow sedimentation from suspension. This perfectly tallies with a sedimentation under wadden conditions. Its separation from the other deposits is once again clearly shown.

Finally, the grouping of sample curves nr 1, 2, 3 and 17 let no doubt about the homogeneity and equal origin of the lowermost homogeneous sands. Its parallelization with a coversand sedimentation finds its proof in the striking similitude in both position and trend of these curves with the ones of the above described Weichselian coversands. This parallelism adds to the assumption of a Saale coversand formation for this deposit.

4. CONCLUSION

The presence of undeep Pleistocene deposits, just underneath a thin cover of Dunkirkian sediments and Holland peat may be generalized in this part of the Belgian coastal plain.

A sequence of Weichselian, Eemian and Saalian deposits are found.

The presence of Weichselian Middle Pleniglacial sediments is called in question by the Early Weichselian nature of the layer of "druipstaarten" at the base of the Weichselian Upper Pleniglacial coversands.There might exist a stratigraphical hiatus at this level although lithostratigraphically this does not seem so.

The Eemian marine transgression has reached a much higher topographical level in its most southern extension as was generally accepted till recently. The transgression was preceded by an Eemian heath forest phase which landscape developed on eolian sands from the Saalian.

The coversand nature of Saalian deposits is supported by the grain size analysis of the sediments. This analysis also added to an earlier assumption for a continuous evolution in the textural trend of the Weichselian sediments , from initially loamy textures towards pure coversand.

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A N N E X E

1) TABLES

2) DIAGRAMS

3) PHOTOPLATES

4) GEOLOGICAL SECTION
(BRUGGE ST. PIETERS).

TABLE 1

SAMPLE	<2 μ	2 - 10 μ	10 - 20 μ	20 - 53 μ	2 - 53 μ	53 - 74 μ	74 - 105 μ	105 - 149 μ	149 - 211 μ	211 - 295 μ	295 - 420 μ	420 μ 2 mm	50 μ - 2 mm
1	2,84	1,24	1,20	0,17	2,61	3,26	13,78	31,56	32,48	5,89	7,58	-	94,55
2	2,76	0,32	0,10	0,97	1,39	2,12	12,21	34.16	33,33	10,99	3,04	-	95,85
3	1,50	0,94	1,84	0,62	3,40	1,96	11,57	33,60	33,96	11,09	2,92	-	95,10
17	3,44	0,48	0,62	0,35	1,45	5,57	20,94	44,01	21,42	2,64	0,53	-	95,11

TABLE 2

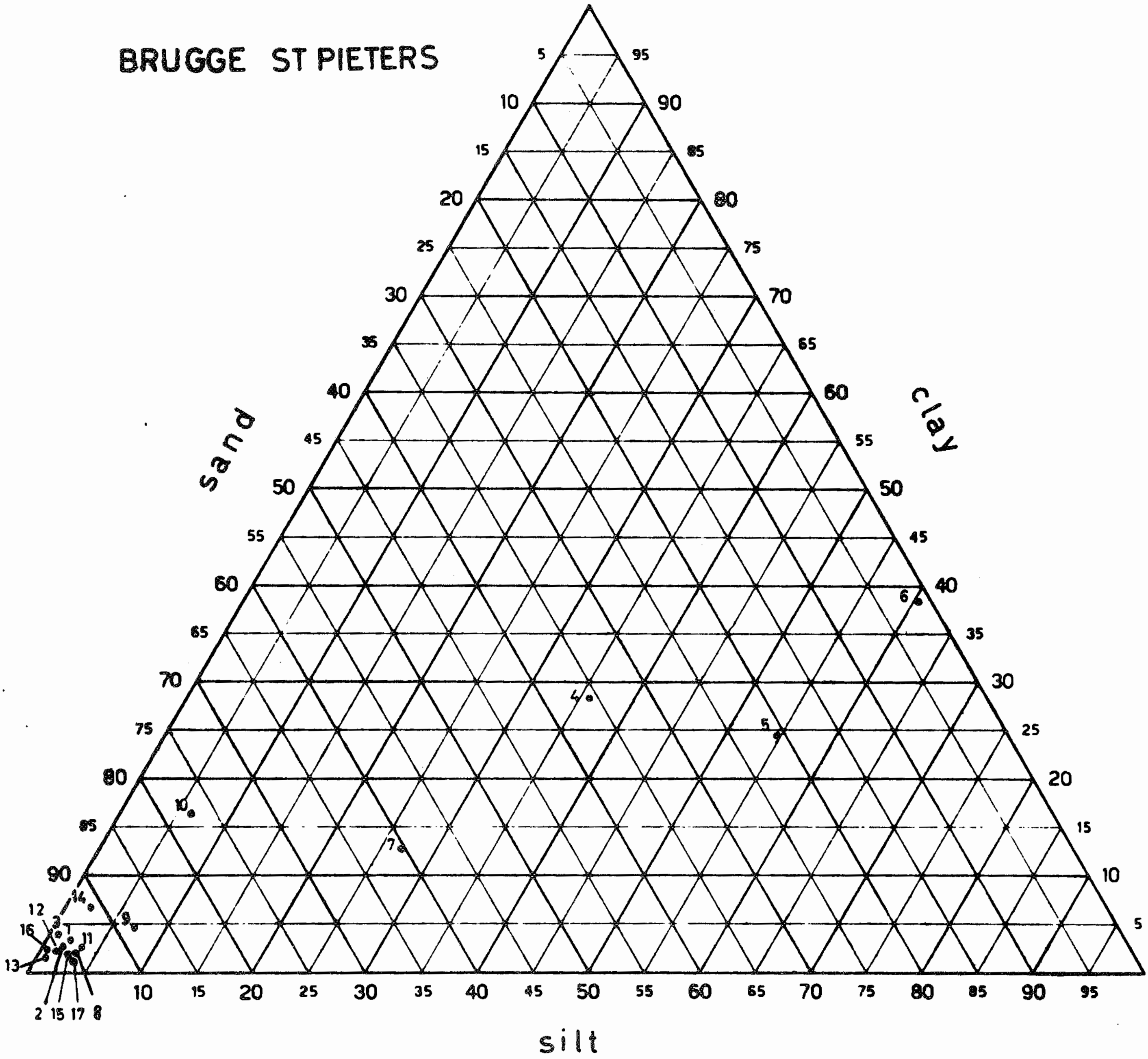
SAMPLE	< 2 µ	2 - 10 µ	10 - 20 µ	20 - 53 µ	2 - 53 µ	53 - 74 µ	74 - 105 µ	105 - 149 µ	149 - 211 µ	211 - 295 µ	295 - 420 µ	420 µ 2 mm	50 µ - 2 mm
4	28,14	19,66	13,04	2,91	35,61	2,58	9,66	12,69	7,34	3,98	-		36,25
5	24,38	16,40	14,60	23,98	54,98	7,74	4,14	2,49	2,47	1,42	2,38		20,64

TABLE 3

SAMPLE	< 2 µ	2 - 10 µ	10 - 20 µ	20 - 53 µ	2 - 53 µ	53 - 74 µ	74 - 105 µ	105 - 149 µ	149 - 211 µ	211 - 295 µ	295 - 420 µ	420 µ 2 mm	50 µ - 2 mm
6	38,08	20,70	21,50	17,96	60,16	-	-	-	-	-	-	-	1,76
7	12,84	2,96	6,48	17,86	27,30	18,30	33,64	7,24	0,40	0,28	-	-	59,86
8	2,06	1,26	0,74	0,98	2,98	1,75	7,39	33,67	33,77	16,04	2,34	-	94,96
9	4,56	0,06	5,64	2,15	7,85	8,36	22,77	37,96	17,67	0,83	-	-	87,59
10	6,14	2,80	1,46	11,62	15,88	2,26	11,41	34,68	26,20	3,06	0,37	-	77,98
11	3,62	0,62	1,00	0,63	2,25	6,43	15,13	38,45	28,96	4,34	0,82	-	94,13

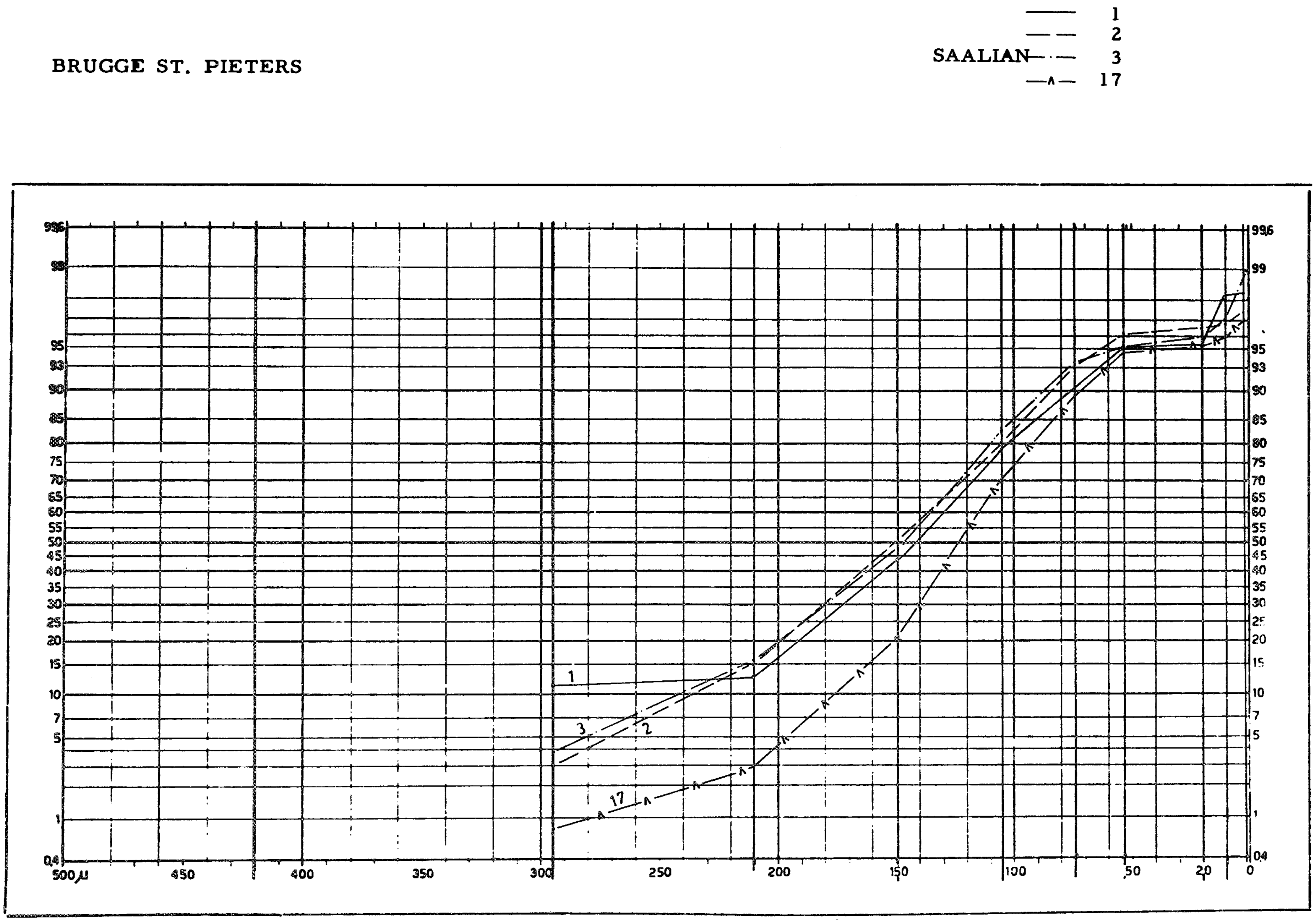
T A B L E 4

SAMPLE	<2 /u	2 - 10 /u	10 - 20 /u	20 - 53 /u	2 - 53 /u	53 - 74 /u	74 - 105 /u	105 - 149 /u	149 - 211 /u	211 - 295 /u	295 - 420 /u	420 /u 2 mm	50 /u - 2 mm
12	2,02	0,56	0,30	0,62	1,48	2,35	11,31	43,60	32,99	5,32	0,93	-	96,50
13	1,72	0,32	0,44	0,26	1,02	8,12	27,64	43,30	13,68	3,26	1,26	-	97,26
14	2,78	0,78	0,46	4,65	5,89	12,92	25,87	38,29	8,88	4,15	1,22	-	91,33
15	2,66	0,36	0,34	1,22	1,92	9,19	25,42	42,20	16,84	1,50	0,27	-	95,42
16	1,10	0,32	0,36	1,14	1,82	4,55	17,88	40,36	25,90	6,57	1,82	-	97,08


BRUGGE ST PIETERS
sand
clay
silt
10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

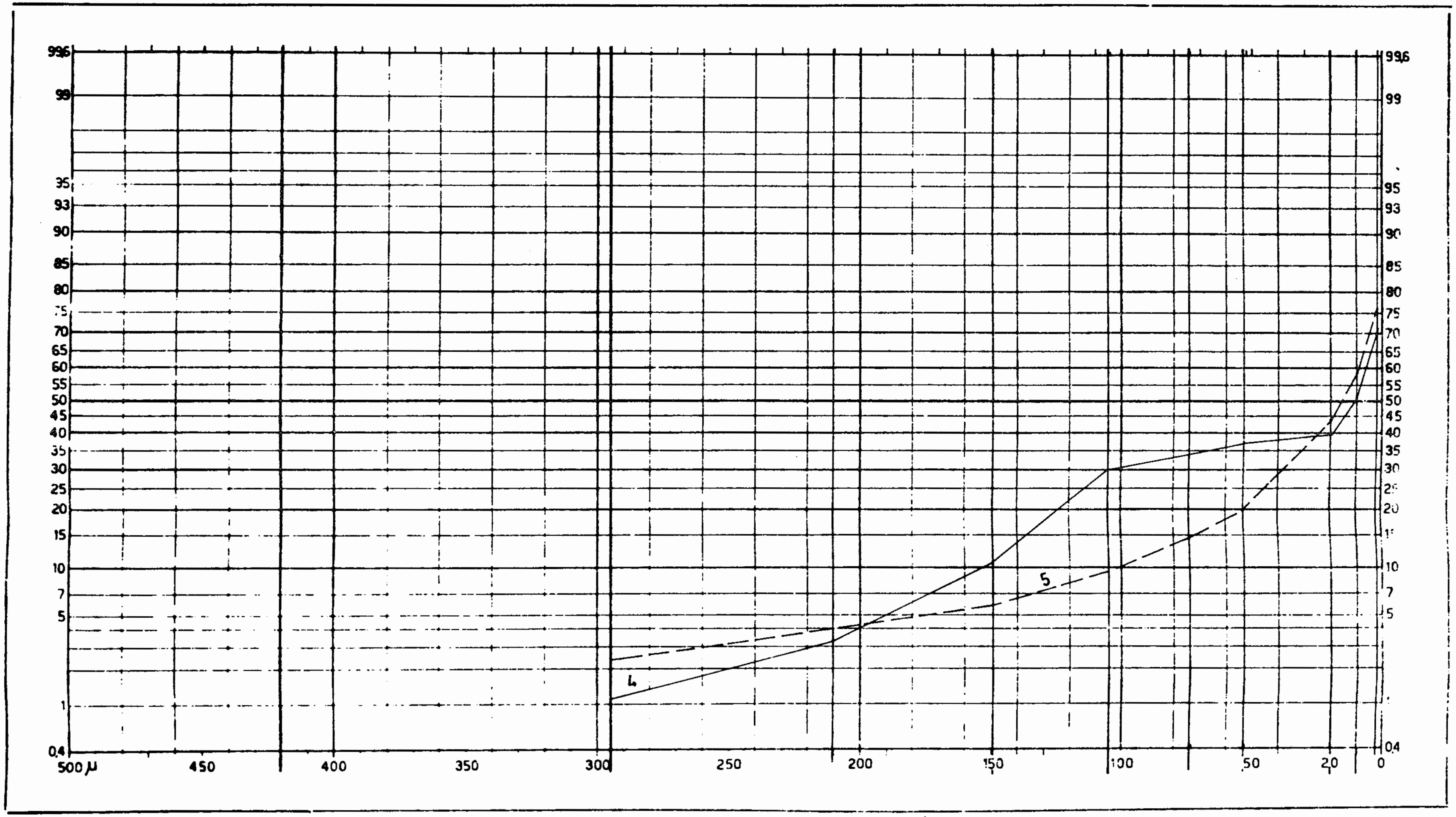
BRUGGE ST. PIETERS

SAALIAN



BRUGGE ST. PIETERS

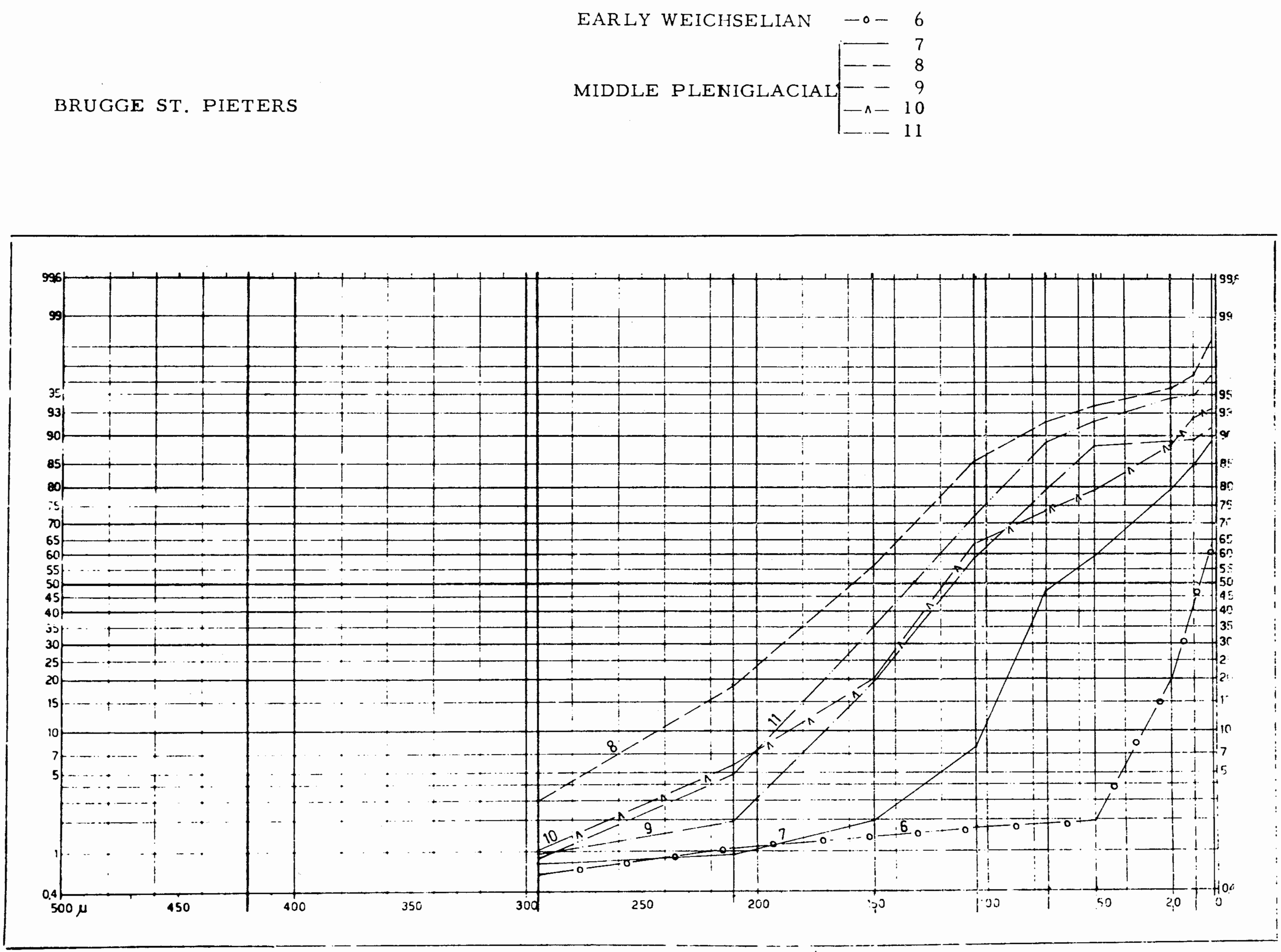
EEMIAN —— 4
EEMIAN — — 5



BRUGGE ST. PIETERS

EARLY WEICHSELIAN —o— 6

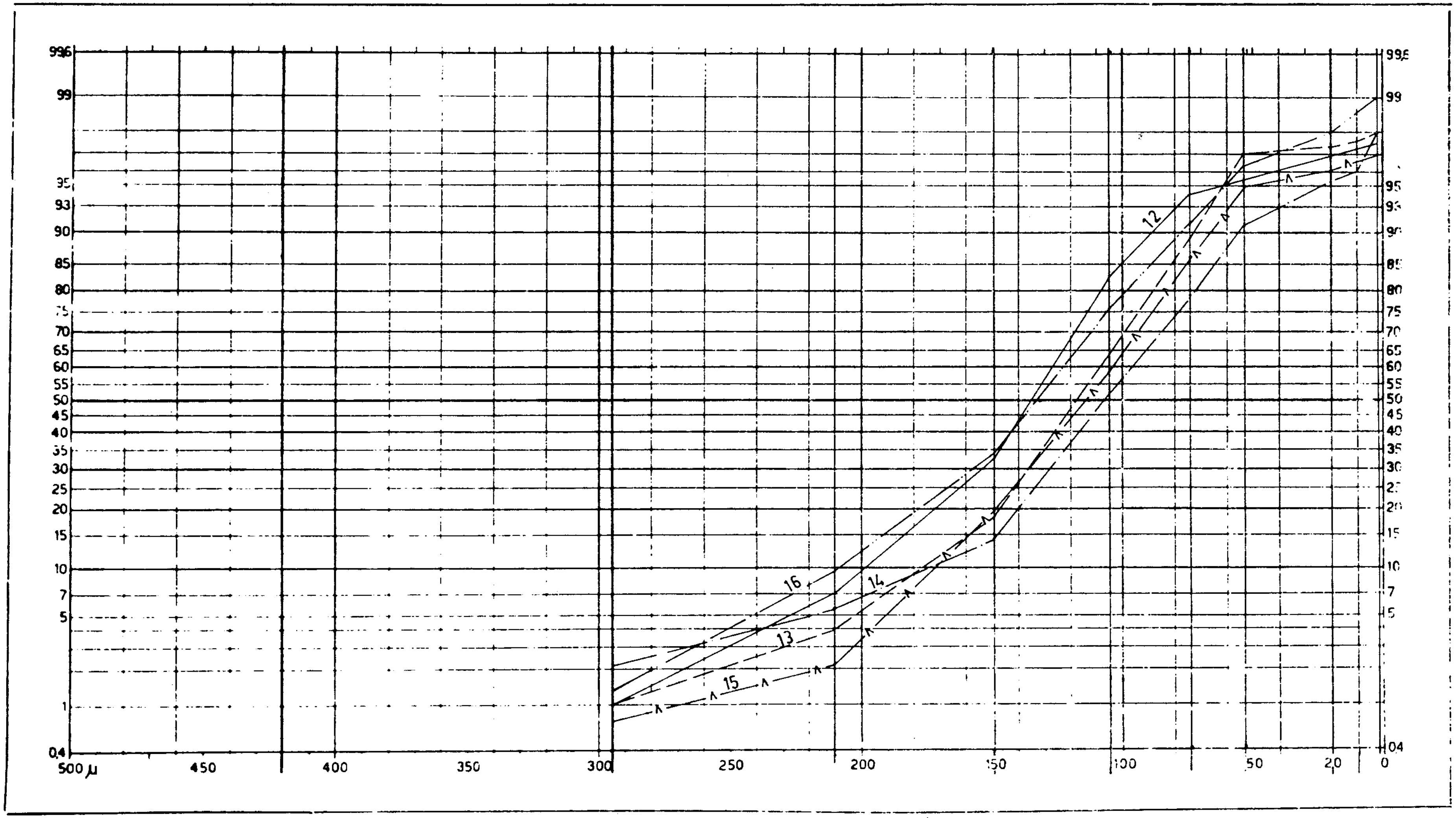
MIDDLE PLENIGLACIAL: 7, 8, 9, 10, 11



BRUGGE ST. PIETERS

UPPER PLENIGLACIAL COVER SANDS: 12, 13

LATE COVER SANDS: 14, 15, 16



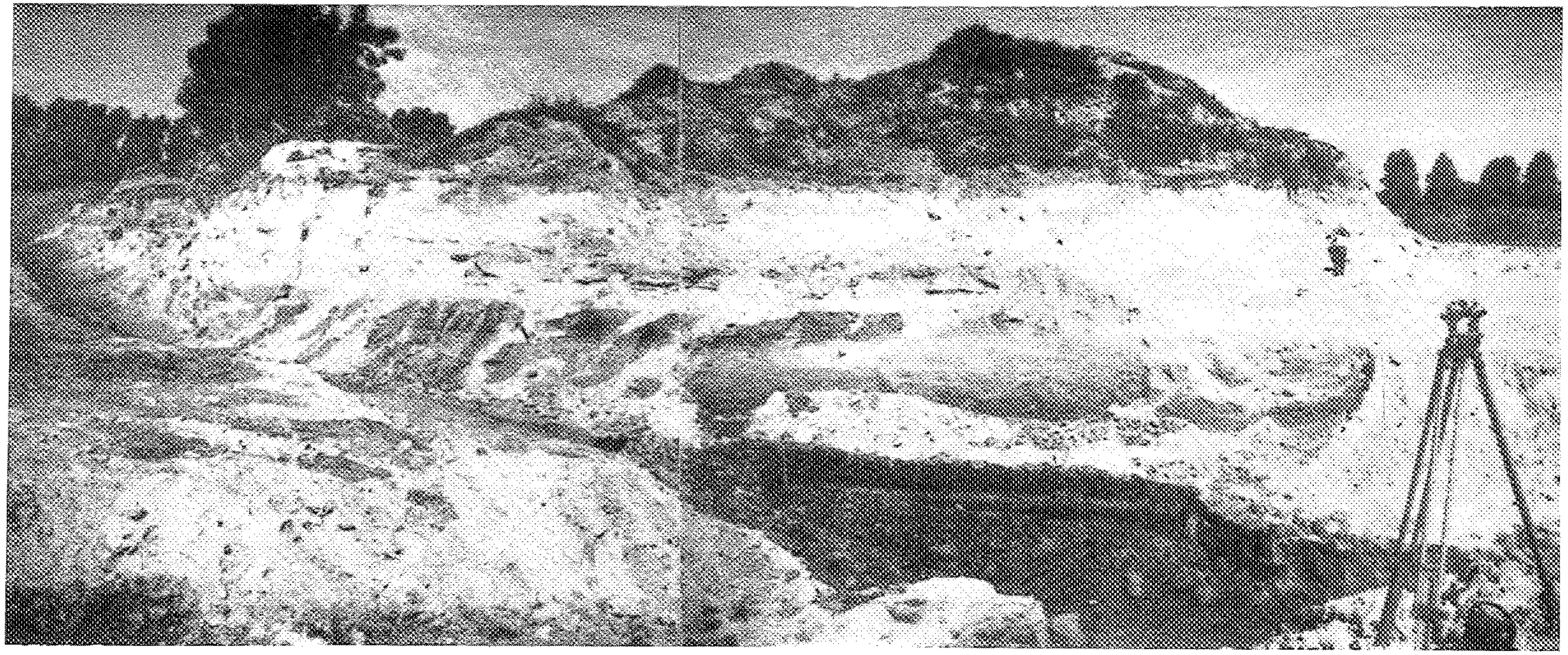


Photo 1 : General view of the outcrop at Brugge. At the base one may observe the Brugge soil overlain by the Wadden deposits and Weichselian sands.

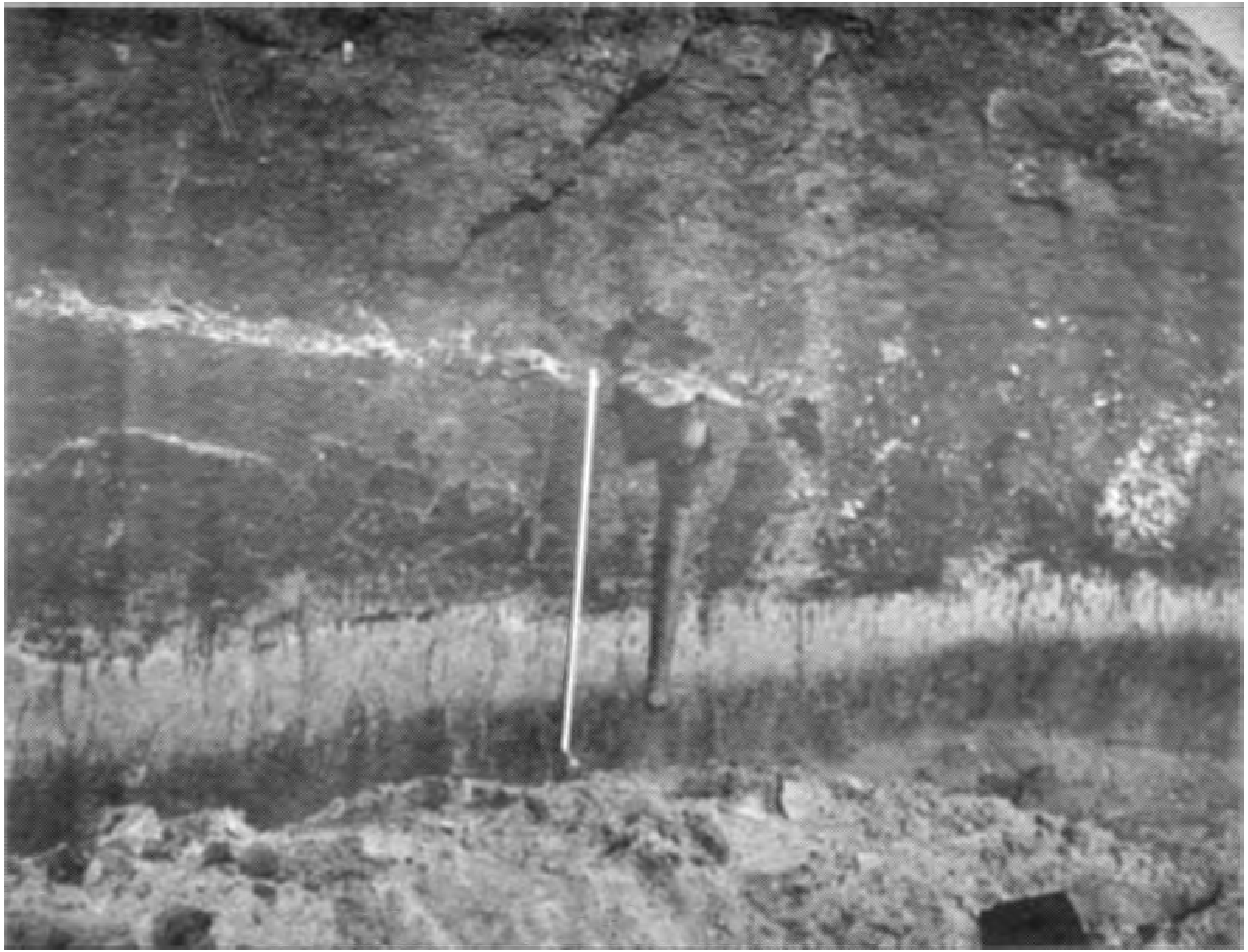


Photo 2 : Close-up of the Brugge soil and shell layers
in overlying wadden deposits.

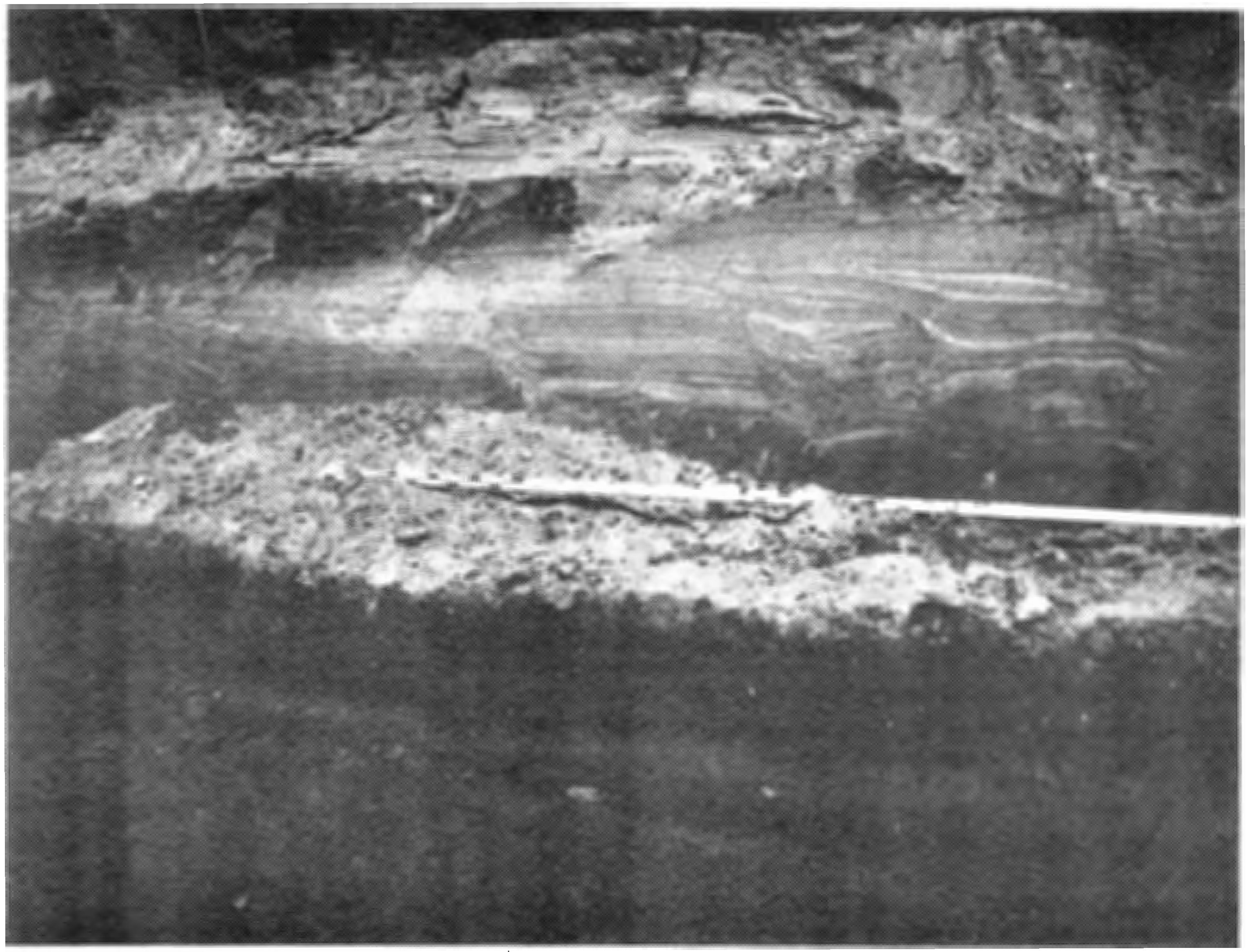


Photo 3 : Close-up of the Brugge-soil and the overlying Wadden deposits with sub-tidal gullies.

Photo 4 : Frost-wedge from the base of the
Weichselian, pearcing through the
Wadden deposits.

Photo 5 : Fine frost wedge in Middle (Weichselian) Pleniglacial, with tail in Early Weichselian loams and sands.

Photo 6 : Humic bands in Late-Coversands with probably Bøllingthe-horizon at the base.

PROFESSIONAL PAPER 1972-9

BRUGGE (St-Pieters) 1971