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# A PLIOCENE RIVER DEPOSIT IN MID-BELGIUM

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ABSTRACT - In the summer of 1979, a Pliocene continental formation was discovered on the Gasthuisberg, a Diestian hill S.W. of Louvain. An examination of the profiles and a sedimentological analysis of the material (chiefly coarse sand and gravel) leads to the conclusion that the formation was deposited by an important river. Because of the deep-red and very strong weathering of the material, the structure of the deposit (clearly pointing to a braided river), and the topographical position (at the summit of a hill), we consider the formation to be deposited during the Pliocene.

This is believed to be the first paper where unmistakable Pliocene continental formations in Belgium are described. Therefore, we propose the name formation of Gasthuisberg for the continental facies of Pliocene Belgian deposits.

## INTRODUCTION.

The Pliocene deposits thusfar in Belgium described, are all sea deposits. Pliocene continental deposits were until recently in Belgium unknown. There is no certainty about the exact age of the ONX-gravel (either Late Pliocene or Young Pleistocene), but there seems to be a tendency to consider them to the Pleistocene rather than to the Pliocene. In the Ardennes there have been found remnants of a very old weathering zone (the so-called rubified horizonts), but these rubified horizonts are developed in top of the Paleozoic formations, and do not form a proper deposit.

As a result of the construction of the A2 highway, important ground-works were carried out S.W. of Louvain at the end of 1979. In one of the excavations we discovered an important gully, which was developed on the top of the Diestian, and which was completely covered with Late Pleistocene Weichselian loess. The sediments of this gully were most probably deposited during Pliocene times, for reasons which shall be discussed below. They show remarkable and very striking structures.

Several samples of the deposit were taken by the Centre de Physique du Globe (Dourbes) for paleomagnetical examination. The results of this examination are not yet known; consequently, in this paper the interpretation of the river deposit will be limited to a simple lithostratigraphical interpretation. The magnetostratigraphical interpretation will be published later.

It has to be noticed that as a result of ground-works in November 1979, nearly the whole deposit has been dug away. Only at a few places is it still perceptible.

## SITUATION.

The excavation where the gully (we called it "B.H.-Gasthuisberg gully") was discovered, is situated very close to the summit of the Gasthuisberg, a S.W.-N.E. oriented hill S.W. of Louvain. Fig. 1 gives the exact location.

The Gasthuisberg forms part of the southernmost Diestian hill of the Hageland. As can be shown in fig. 1, this Diestian hill is bordered in the south by the depressions of the Voer (west of the Dijle) and the Molenbeek (east of the Dijle). The Dijle itself has eroded a wide gap into the hill, thus dividing it into two portions. The gully was found at an absolute height of about 73 m; this is 50 m above the actual alluvial plain of the Dijle.

## DESCRIPTION OF THE PROFILES.

In the excavation, a pit in which a bridge was constructed, the river gully could be studied by two walls standing perpendicular to each other : a western wall and a northern wall (see fig. 2). In consequence of this, it was possible to determine the exact orientation of the river-bed.

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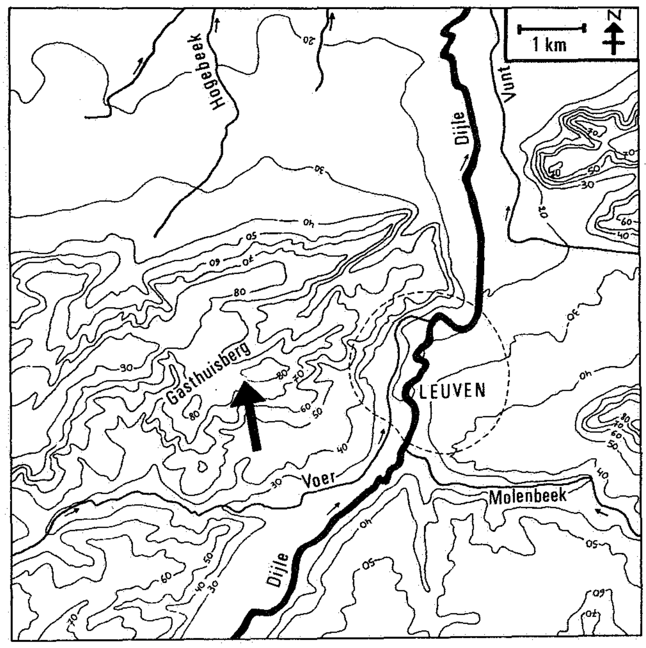
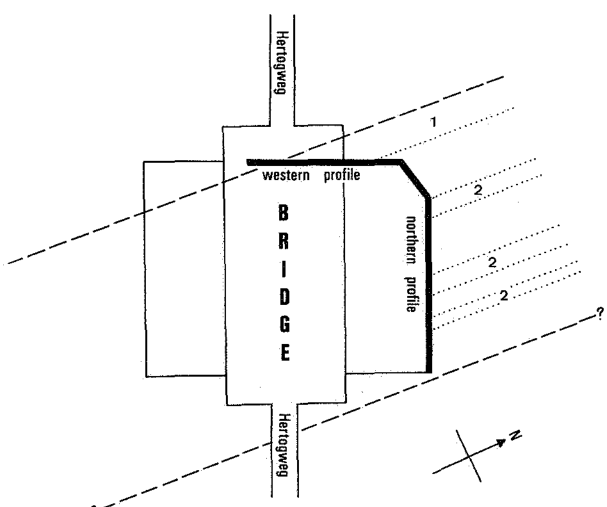



*FIG.1 SITUATION*

*FIG. 2 SITUATION OF THE PROFILES*




1 *main channel*
2 *important secundary channels*
—— *presumable limit of the river bed*

This orientation seemed to be due N-S. The zones of the western wall are in general also found in the northern wall; some zones however are restricted either to the western, or the northern wall. The numbering of the zones, which probably can come over somewhat confused, has been influenced by this.

## 1. THE WESTERN WALL.

The western wall gives a nice profile through the main channel of the river deposit. See fig. 3. From the bottom upward, we distinguish the following zones :

Zone 1 : coarse green (2,5 Y 4/6) sands, very rich in glauconite. Close by the gully, the colour becomes browner (2,5 Y 4/4).
The sands of this zone are the well-known sands of Diest, which occur at the top of the Diestian hills of the Hageland.

Zone 8 : a small zone in the Diestian sand, which is not coloured greenish-brown, but clearly yellowish-brown (2,5 Y 5/6).

Zone 7 : the basic gravel of the gully. We can distinguish two sub-zones :
zone 7a : coarse gravel (diameter of the pebbles usually more than 2 cm), in a mould of coarse sand.
zone 7b : fine gravel (diameter of the pebbles 4 at 5 mm), in a mould of coarse sand.

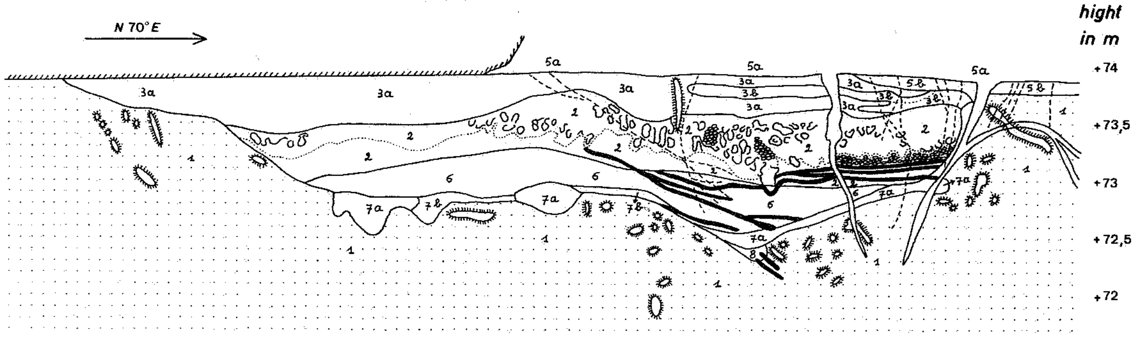
Zone 6 : a zone consisting of yellowish-brown to yellowish-green (10 YR 5/8), medium sized sand, in which a lot of small pebbles (diameter 5 mm) are found. The zone is characterized by a strikingly cross-stratification.

Zone 2 : practically the uppermost part of zone 6. The material is the same (medium-sized sand with a lot of small pebbles), but in contrast with zone 6, where the material was coloured yellowish-brown to yellowish-green (10 YR 5/8), the colour of zone 2 is clearly brownish-red to red (5 YR 4/6). Moreover, in zone 2 a markedly, concentrated iron precipitation appears. This iron precipitation appears in different forms (see fig. 3) :
- as long-stretched, thin iron bands with a thickness of 2 cm,
- as small rings with a diameter of 1 to 1,5 cm,
- as large (often not fully closed) rings with a diameter of more than 5 cm.

According to D.E.B. BATES & J.F. KIRKALDY (1976), we consider both the small and the large rings as typical Liesegang rings.

Zone 3 : forms the top of the river deposit. We can distinguish two sub-zones :
Zone 3a : a gravel layer with large pebbles (sometimes 3 cm diameter). The pores between the pebbles are filled with very coarse sand.
Zone 3b : contains only the very coarse sand. Pebbles are absent.
As zone 2, both zone 3a and zone 3b have an intense red colour (2,5 YR 4/6).

*FIG.3 WESTERN PROFILE*




- 1 green Diestian sand
- 2 brownish-red coarse sand with pebbles
- 3a brownish-red gravel
- 3b brownish red coarse sand
- 5a calcareous loess
- 5b calcareous loess with silex pebbles
- 6 yellowish green sand with pebbles (showing a cross-stratification)
- 7a coarse basic gravel of the gully
- 7b mixture of fine basic gravel and coarse sand
- 8 yellowish-brown Diestian sand

- iron concretion
- small Liesegang ring
- large Liesegang ring
- iron band
- ---- frost crack, filled up with loess
- ...... under limit of the brownish-red coloured zone

0,5 m    0,5m

Zone 5 : this zone doesn't belong to the river deposit anymore. It's the Quaternary loess layer, which covers both the gully material and the Diestian sand. We distinguished between :
zone 5b : calcareous loess, which still contains a bit pebbles and Diestian sand.
zone 5a : calcareous loess without pebbles or sand.

As can be seen in fig. 3, several frost cracks and frost fissures occur in the western profile. At some places these frost cracks can reach considerable proportions (for example the two large frost cracks right in the profile).

2. THE NORTHERN WALL.

The northern wall permitted us to get an idea of the total width of the river gully (see fig. 2). The profile is shown in fig. 4. We distinguish the following layers :

Zone 1 : the greenish-brown (2,5 Y 4/4) Diestian sand we already described earlier. In contrast to the western wall, the Diestian of the northern wall contains several hard iron crusts of limonite (thickness : about 0,5 cm). See fig. 4.

Zone 7a : appears only in a tiny gully in the west of the profile. As in the western wall, the zone consists of coarse gravel with a markedly red colour (2,5 YR 5/6).

Zone 6 : appears also only in the tiny gully in the west of the profile. Zone 6 consists of very coarse sand with small pebbles in it. The colour is the same as that for zone 7a : 2,5 YR 5/6).

Zone 2 : appears only in the west and the east of the profile. It's a small zone of very coarse sand, the colour of which is again intense red (5 YR 4/6).

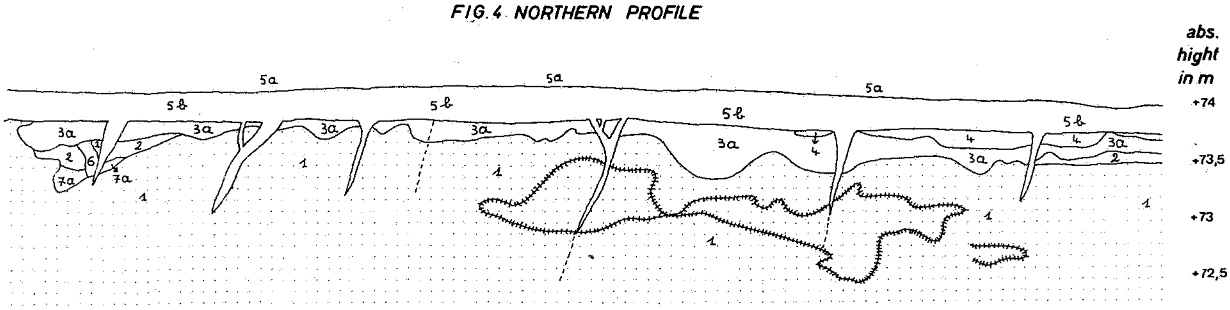
Zone 3 : in the northern wall, only zone 3a is present. It consists of coarse gravel, with in the pores very coarse sand. Also here, the colour is intense red (5 YR 4/6).
As can be seen in fig. 4, zone 3a occurs over the whole width of the profile. The contact with zone 1 (Diestian sand) is very irregular : it shows a lot of gullies, some of which are more than 0,5 m deep and wide.

Zone 4 : a zone which occurs only in the east of the profile. It's a 10 cm thick, brownish-red (5 YR 4/6) coloured band of very coarse sand.

Zone 5 : the Quaternary loess layer we described earlier. It is composed of :
zone 5b : calcareous loess with pebbles and sand,
zone 5a : calcareous loess without pebbles or sand.

Also in the northern wall of the excavation, a lot of frost cracks and frost fissures are present. Their depth can reach more than 1,5 m.

*FIG.4 NORTHERN PROFILE*




| | |
|---|---|
| *1 green Diestian sand* | *5b calcareous loess with silex pebbles* |
| *2 brownish-red coarse sand with pebbles* | *6 coarse sand with pebbles* |
| *3a brownish-red gravel* | *7a yellowish-red basic gravel* |
| *4 brownish-red coarse sand* | *++++ iron-sandstone band* |
| *5a calcareous loess* | *--- frost crack, filled up with loess* |

↔ 0,5m    ↕ 0,5m

## SEDIMENTOLOGICAL INTERPRETATION.

The profiles show very clearly that we have to deal here with a river deposit. The zones 7a and 7b (undermost gravel zones) form the bed gravel, that during the period that the gully still was active, settled down as the most heavy material. The zones 6 and 2, which have the same composition (mixture of sand and small pebbles) and the same structure (cross-stratification) form the main mass of the material deposited by the river. The zones 4 and 3 (uppermost coarse sand and uppermost gravel) form the top of the deposit. They were also deposited by the river, in a period where the stream velocity and/or the quantity of water was considerably great (this explains the presence of the great mass of ravel; the finer material (fine and medium-sized sand) is not present because the water possessed enough energy to transport it).

Zone 5b, consisting of a mixture of loam, sand and gravel, doesn't belong to the river deposit anymore, but agrees with the rinsed zone that is found everywhere on the base of the Quaternary loess deposits. Zone 5a is the typical Weichselian loess, which covers almost everywhere in Mid-Belgium the Tertiary substratum.

The total depth of the river deposit alone (i.e. the zones 7, 6, 4, 3 and 2) reaches at maximum 1,5 m. However, there are some arguments to assume that the original depth has been considerably greater. These arguments will be discussed in part "Stratigraphical interpretation".

The total width of the river deposit is at least 46 m. Indeed, for the construction of the A2 highway, a notch of 46 m wide was dug out, and we could establish that the river deposit was present over the whole width of the notch. Therefore, the total width of the river during times of peak discharges has been at least 46 m, and probably more than 50 m (there is no indication that the river has moved up in the course of time, for example in a meander). So we can conclude that we have to deal with a reasonably important river.

## LABORATORY ANALYSIS OF THE SEDIMENTS.

### 1. THE GRAVEL.

The river deposit contains two gravel zones : zone 7a and zone 3a. Zone 7a was examined once, zone 3a twice : a first time with gravel above zone 3b, and a second time with gravel underneath zone 3b.

#### a. The petrography.

From each of the samples, a random test of 200 pebbles was taken.

The results are given in table I.

From the 600 examined pebbles, only 2 are no silex or ironsandstone crust (1 sandstone in zone 3a (above 3b), 1 sandstone in zone 7a). The silexes are the most represented : 91,5 % for zone 3a (above 3b); 81,5 % for zone 3a (underneath 3b); 91,5 % for zone 7a. The rest of the gravel consists exclusively of ironsandstone crusts.

The rounded silexes are re-worked from the Diestian. Indeed, from the Tertiary formations in the vicinity of Louvain, only the top of the Diestian contains similar rounded and unflattened silexes.

The ironsandstone crusts are also reworked from the Diestian.

The disc-shaped black silexes are primary of Rupelian origin (R 1a), but at many places they are also present at the base of the Diestian, because the Diestian sea has reworked them. The fact that these disc-shaped black silexes are also found in the B.H.-Gasthuisberg gully, proves that somewhere at a certain place the river has eroded the base of the Diestian.

| Petrography | | | Number of pebbles in % | | |
|---|---|---|---|---|---|
| | | | zone 7a | zone 3a underneath zone 3b | zone 3a above zone 3b |
| ironsandstone crusts | | | 8,0 | 18,0 | 8,5 |
| rounded silexes | cachalonized | unbroken | 16,0 | 27,0 | 14,0 |
| | | broken | 7,5 | 12,0 | 16,0 |
| | not cachalonized | unbroken | 57,0 | 32,0 | 48,5 |
| | | broken | 9,5 | 8,5 | 11,5 |
| disc-shaped black silexes | | | 1,5 | 1,5 | 1,0 |
| sandstones | | | 0,5 | 0,5 | - |

TABLE I : petrography of the gravel

### b. The morphometry.

In order to determine the mean morphometry of the gravel, we took from each gravel zone a random test of 100 silex pebbles. From each pebble we measured the length (L), the breadth (B), the thickness (D), and the smallest rounding radius in the plane of the length and the breadth ($r_i$).

#### The shape.

The mean shape was determined by calculating for each pebble the ratios B/L and D/B, and by setting out the obtained values in a diagram (according to ZINGG, 1935). Fig. 5 shows that for the three zones, the result is nearly the same : the great majority of the pebbles belong to the classes "disc-shaped" and "spherical". Therefore we can conclude that the gravel of the B.H.-Gasthuisberg gully in general consists of disc-shaped pebbles, which are not yet considerably flattened, and in which the spherical shape is still discernible.

#### The rounding.

In order to quantify the rounding of the pebbles, we used the index $2r_i/B \times 100$, as proposed by KUENEN (1956). The more rounded the pebbles, the higher the value of the index. The maximum value of the index is 100; in this case the pebble is perfectly circular in the plane of the length and the breadth.

Fig. 6 shows that the pebbles generally are rounded very well : the mean rounding index for zone 7a is 81,14 ($\sigma$: 8,37), for zone 3a (underneath 3b) the value is 78,17 ($\sigma$ : 14,73), and for zone 3a (above 3b) the value is 74,96 ($\sigma$ : 13,02). The dispersion around the mean values is not high, as is indicated by the values of $\sigma$ between the brackets. For each of the gravel samples the KUENEN index rarely falls under 60; clearly bad rounded pebbles are therefore exceptional.

The obtained values are significantly higher than those of normal river deposits. (For comparison : for the gravel of the Kempian Plateau, E. PAULISSEN (1973) found values of 48,2 ($\sigma$: 18,0) at 43,5 ($\sigma$ : 19,4) (for quartz), and 53,8 ($\sigma$ : 21,7) at 47,3 ($\sigma$ : 20,3) (for quartzite).

It is striking that the closer the pebbles are situated to the top of the gully, the worse rounded they are : the KUENEN index is 81,14 for the undermost gravel zone, 78,17 for the middle gravel zone, and 74,96 for the uppermost gravel zone.

### c. The ratio broken/unbroken pebbles.

If we compare the total number of broken pebbles (broken by the frost) of each gravel zone, we see that this number decreases as we penetrate deeper into the gully :

- uppermost gravel zone (3a(above 3b)) : 55/200 broken pebbles,
- middle gravel zone (3a(underneath 3b)) : 41/200 broken pebbles,
- undermost gravel zone (7a) : 34/200 broken pebbles.

The frost cracks we found in the northern and the western profile, indicate that since the deposition of the river gravel at least one ice age has been passed. During ice age times, congelifraction (breaking of the pebbles as a result of frost action) occurs frequently. It however is known that congelifraction occurs more frequently at the surface than at large depths, because of the larger number of frost-thaw cycli. One therefore can expect that the total number of broken pebbles will decrease from the surface into the depth. This agrees completely with the results we found above.

### d. The surface structure of the pebbles.

Nearly all the silex pebbles have a surface that is characterized by the typical "semicolon structure" (very numerous tiny dot-shaped or comma-shaped notches in the surface of the pebble, caused by the numerous powerful collisions of the pebbles in the surf zone on a beach). Hence, a semicolon structure is typical for a sea gravel and not for a river gravel. The semicolon

FIG.5 SHAPE OF THE GRAVEL

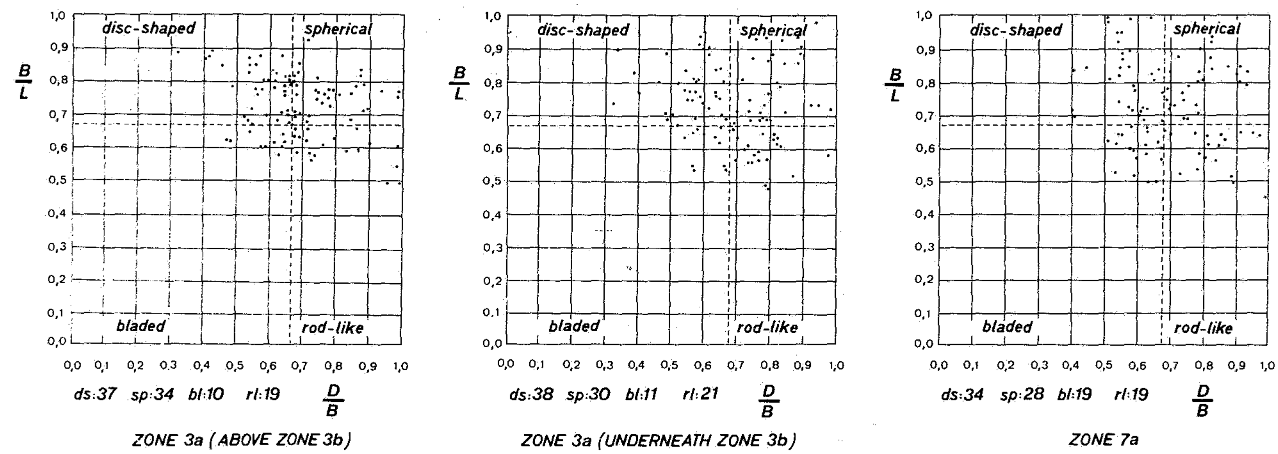
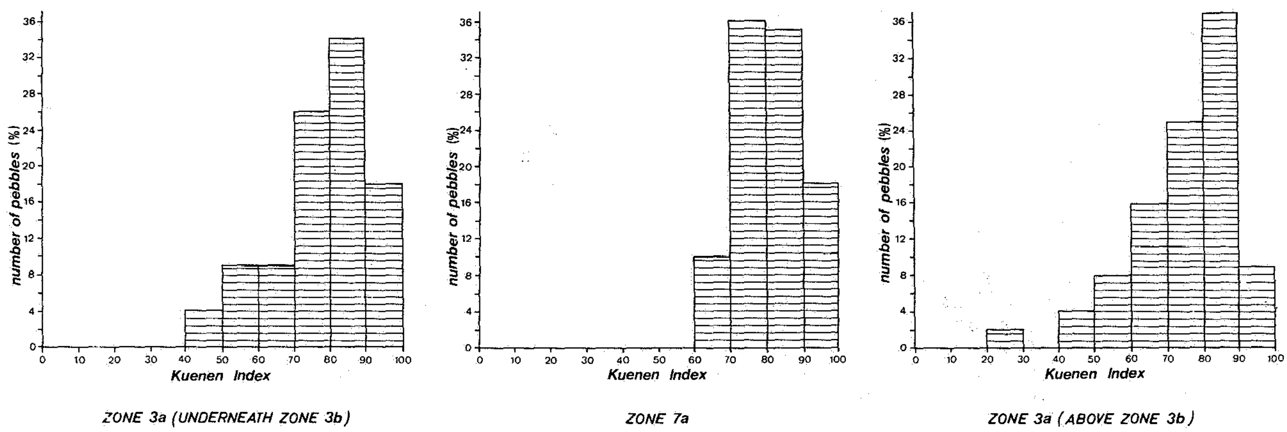



FIG.6 KUENEN INDEX OF THE GRAVEL




structure on the surface of the pebbles of the B.H.-Gasthuisberg gully is therefore not originated in the gully itself, but in the Diestian sea.

e. Conclusion.

The different analyses show clearly that the gravel is in origin a sea gravel, which has been re-worked from the Diestian deposits by the B.H.-Gasthuisberg river. The numerous broken pebbles indicate in addition, that since the deposition of the material, at least one ice age has been passed.

2. GRAIN SIZE DISTRIBUTION OF THE SAND LAYERS.

From each of the sand layers (i.e. the zones 1, 2, 3b and 6), 20 g. was sieved in order to determine the grain size distribution. The results are represented in fig. 7. An analysis of the histograms shows the following :

1. The material of the gully (zones 2, 3b and 6) is clearly coarser than the autochthonous Diestian sand (zone 1).

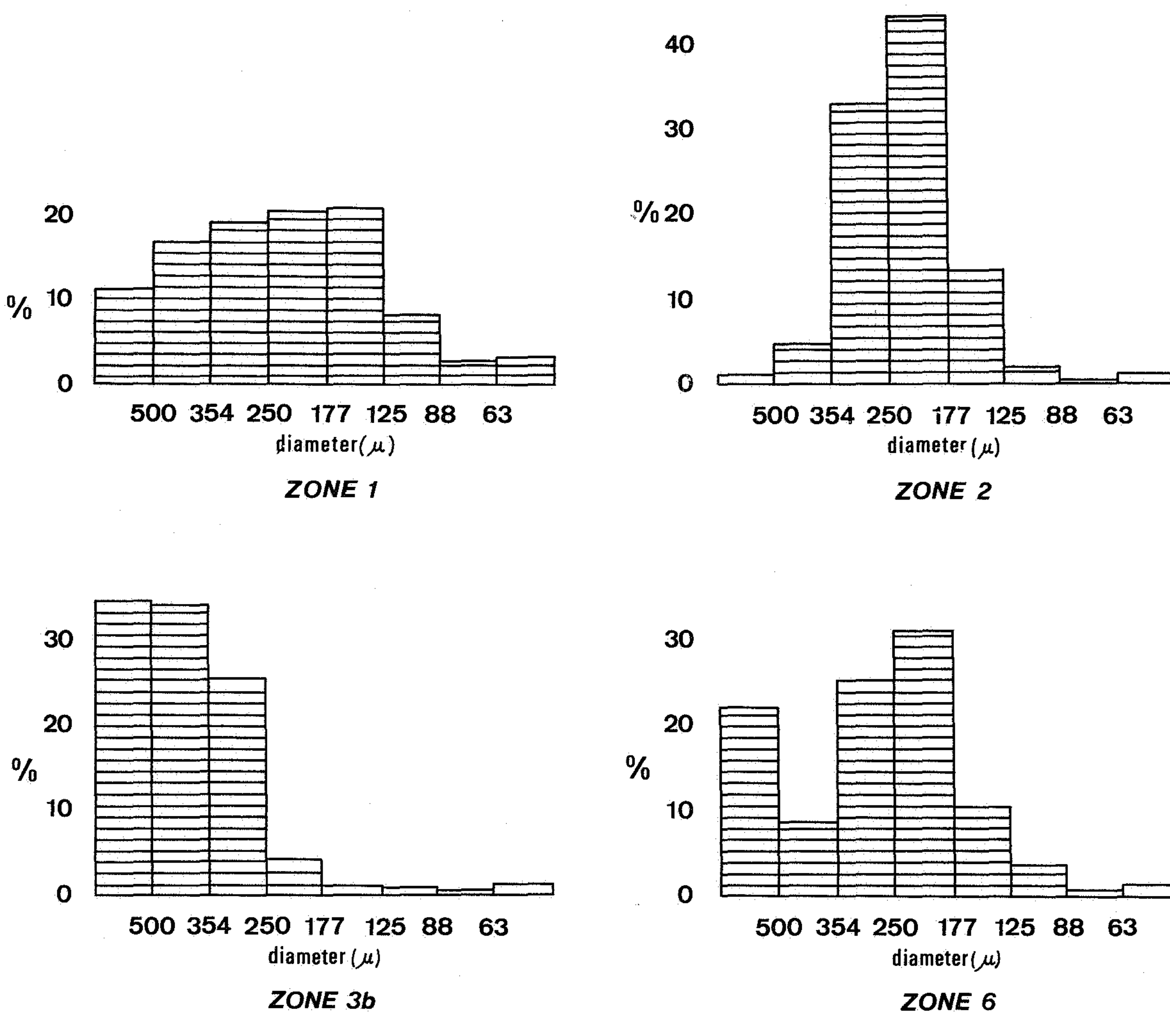
2. The Diestian sand is very heterogeneous : the histogram shows nowhere a peak. This is clearly in contrast to the gully sand, which in each of the zones 2, 3b and 6 appear to be significantly more homogeneous.

3. Zone 3b (i.e. the sand between the gravel layer 3a) is significantly coarser than the other sand zones (94 % of the sand is coarser than 250 $\mu$m). The fraction < 177 $\mu$m is neglectible.

4. The great majority of the gully sand (zones 2 and 6) belongs to the classes 177-250 $\mu$m and 250-354 $\mu$m, and can therefore be labeled as moderate fine sand. The second peak (above 500 $\mu$m) in zone 6 is caused by the small pebbles that occur between the sand of this zone.

We can conclude that the gully sand is significantly coarser and significantly more homogeneous than the Diestian sand. An explanation for this can be the following. Running water does not transport all particles evenly easy. Fine particles (clay, silt and fine sand) are transported without many problems, whereas coarse particles (coarse sand and gravel) are transported more difficultly. Of the initially very heterogeneous Diestian sand that was eroded and transported by the river, only the finest particles could be transported over a large distance. The coarse particles initially were transported too, but as soon as the

## FIG.7 GRANULOMETRY OF THE SAND




stream velocity decreased, they sinked towards the bottom. Along these lines, the finest particles were washed out the Diestian sand, and so it can be explained why the gully sands are significantly coarser and significantly more homogeneous than the autochthonous Diestian sand.

STRATIGRAPHICAL INTERPRETATION.

We know that the gully was formed after the Diestian period, because it is incised in top of the Diestian deposits. Furthermore the gully has to be formed before Weichselian times, because it is completely covered with Weichselian loess. Therefore it can be of Pliocene, Early-Pleistocene or Mid-Pleistocene origin. There are however three elements, which plead for Pliocene origin :

1. THE COLOUR OF THE DEPOSIT.

When we described the profiles of the western and the northern wall of the pit, we more than once emphasized that the upper part of the gully sediment (both the sand and the gravel) is coloured markedly brownish-red to red (mostly 2,5 YR 4/6; sometimes 5 YR 4/6). This brownish-red colour has found to be due to the weathering of the ferruginous glauconite towards hematite. The deep brownish-red colour indicates that the weathering has been very strong. A suchlike intense weathering is only possible in a warm and above all very dry climate (necessary for the deshydration). Hence, since the deposition of the gully sediments, at least one such-like warm and dry period has to be passed.

In the Pleistocene, the warm periods are restricted to the interglacial times. During these interglacial times a weathering horizont (mostly including a soil) developed into the outcropping formations. From the brownish-red zone we found in the B.H.-Gasthuisberg gully, we cannot say that it represents a typical soil : it's only a deep weathered zone, and soil horizonts are completely absent. It's much more probable that we have to do here with the undermost part of the weathering layer, i.e. the part that is developed underneath the proper soil (perhaps also the undermost part of the soil is still present). The uppermost part of the soil was developed higher up in the river gully, but because of later erosion it has disappeared together with the uppermost part of the river deposit. If we accept that the uppermost part of the river deposit has been eroded away, we also can explain why the (actual) depth of the deposit (maximum 1,5 m) is so small compared with the width (more than 50 m).

From some of the interglacials, the fossil soils have been found. These soils however manifest in no way the same intense weathering colour as in the case of the B.H.-Gasthuisberg gully :

| interglacial | soil (in Belgium) | colour |
|---|---|---|
| Holocene | Holocene soil | 10 YR 5/4 (see ref. 3) |
| Eemian | Rocourt soil | 7.5 YR 4/4 (see ref. 1) |
| Holsteinian | As soil | 5-7.5 YR 5/6 (see ref. 2) |
| ? | B.H.-Gasthuisberg | 2.5 YR 4/6 |

Table II : colour of the interglacial soils in Belgium.

We see that the older the weathering, the intenser it becomes. The clearly very deep weathering colour of the material of the B.H.-Gasthuisberg gully suggests that the river deposit has to be reasonably old : probably older than Holsteinian times. Because of the fact that during the Pliocene the climate in our country was warm and dry (mediterraneous or sub-tropical), it even is possible that the gully could be of Pliocene origin. Of course we have to take into account that the strong red colour also is due in great measure to the large quantity of available iron minerals (glauconite). It certainly is not dependent on the intensity of the weathering alone.

2. THE STRUCTURE OF THE DEPOSIT.

There are two elements that indicate that the B.H.-Gasthuisberg river was a braided river :

1. The river gully is very wide (at least 46 m and probably more than 50 m), but very shallow (original depth probably nowhere much more than 1,5 m, except in the main channel). Furthermore, the river bed does not consist of one single channel, but of a very great quantity of small secondary channels (the most important of them are shown in fig. 2) and one main channel. These characteristics (very wide and shallow river bed with numerous small channels) are typical for a braided river, and are not characteristic of any other river type.

2. The material deposited by the river is very heterogeneous (both fine sand and large pebbles). It was deposited in clearly distinctive layers, which either consist exclusively of coarse material (gravel), or exclusively of fine material (sand). Such a deposition is very typical for a braided river.

Braided rivers only appear in two climates :
- in a cold climate (glacial or periglacial),
- in a warm and dry climate (mediterranean or sub-tropical).

The gully therefore could be formed either in a cold climate (Pleistocene) or in a warm and dry one (Pliocene); the structure of the deposit does not produce new data with regard to this.

3. THE TOPOGRAPHICAL POSITION OF THE DEPOSIT.

A very strong argument to make from the B.H.-Gasthuisberg river a Pliocene (Tertiary) river and not a Pleistocene (Quaternary) one, is given by the topographical position of the deposit. The gully lies at an absolute height of about 73 m. The summit of the Gasthuisberg lies at a height of 85 m (see fig. 1), but the thickness of the loess layer at that place is about 7 m (D.GOOSSENS, 1981) as a consequence of which the Tertiary summit of the Gasthuisberg lies at an absolute height of 78 m. This means that, if we think away the Quaternary loess cover, the river deposit appears nearly exactly on the summit of the hill.

A river however does not flow over hilltops, but in depressions. We thus have to accept that at the time that the river still was active, the actual summit of the Gasthuisberg was not a hilltop but a depression. That means that at that time, the relief in the vicinity of Louvain had to be totally different from the actual one. The whole Dijle depression did not exist, otherwise the river would have flowed there. Actually the Dijle flows (near Louvain) at an absolute height of about 20 m; the Dijle depression consequently is incised more than 50 m with regard to the gully. The Dijle depression is also very wide (several km). The total amount of material that has been eroded away since the fossilisation of the gully is therefore tremendously great.

Such an erosion cannot possibly be carried out in a few ten thousands or hundreds of thousands years by a river of the calibre of the Dijle. We have to calculate here with millions of years. That means that the B.H.-Gasthuisberg river does not date from the Quaternary, but from the Tertiary. Because we know that it in every respect must be younger than the Diestian, we consider it as a Pliocene river.

## CONCLUSION.

The deposits of the B.H.-Gasthuisberg river are the first unmistakable continental Pliocene deposits found in Belgium. The red zone at the top of the deposits forms the undermost part of the weathering zone, which was developed during the Pliocene. Perhaps also the undermost part of the Pliocene soil is taken up in it. As a result of later (Pleistocene) erosion, the uppermost part of the river deposit (and of the soil) has disappeared. Only the undermost part has been kept.

We propose the name formation of Gasthuisberg for the continental facies of the Pliocene deposits in Belgium. For the river deposit we described in this paper, we propose the name sands and gravels of Gasthuisberg.

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