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ASYMMETRICAL VALLEYS OF PERIGLACIAL ORIGIN IN SOUTH-EASTERN HESBAYE, BELGIUM

Abstract

In south-eastern Hesbaye, where very few courses of running water exist, shallow linear depressions observed on the plateau form a fossil drainage pattern. These dry valleys are cut in the loess cover. Their cross-profile is asymmetrical, due to prominent lateral planation in periglacial conditions.

Résumé de l'auteur

En Hesbaye liégeoise, ou Hesbaye du sud-est, il n'existe que très peu de cours d'eau, mais les faibles dépressions linéaires qu'on y observe sont des vallées sèches qui forment un réseau hydrographique fossile. Elles sont creusées dans la couverture de loess et leur profil transversal est asymétrique, à cause de processus périglaciaires où prédomine l'érosion latérale.

In the rainy climate of Belgium, a region such as south-eastern Hesbaye (Haspengouw in Dutch), almost devoid of streams, is rather unusual. Between Meuse and Geer rivers, in an area of more than forty kilometres from West to East, there is no river. For instance, the Yerne, which is the main tributary joining the Geer, is not more than a rivulet one or two metres broad. The drainage pattern of the whole Hesbaye has a density of 521 metres of running water per square kilometre, which is low for a country like Belgium. But the Geer basin, mainly constituting the so-called Dry Hesbaye, reaches only 230 m/km^2.

Hesbaye is a gently undulating plateau; its elevation falls steadily from about 200 m in the vicinity of the Meuse River, to 110 m near the Geer. The depressions in the plateau are not scattered by chance, but are grooves connected with one another, forming a system of dry valleys, a fossil drainage pattern going chiefly northward, to the deeper Geer valley (Fig. 1).

The network of dry valleys is sometimes used by run-off during violent thunder-storms, or by snow meltwaters on frozen ground. The drainage density computed by measuring the total length of all channels, including dry valleys, goes up to 724 metres per 1 km^2, from 230.

Thanks to geological profiles drawn by the Water Service of Liège along its collecting galleries in Dry Hesbaye, the substratum is well known along two

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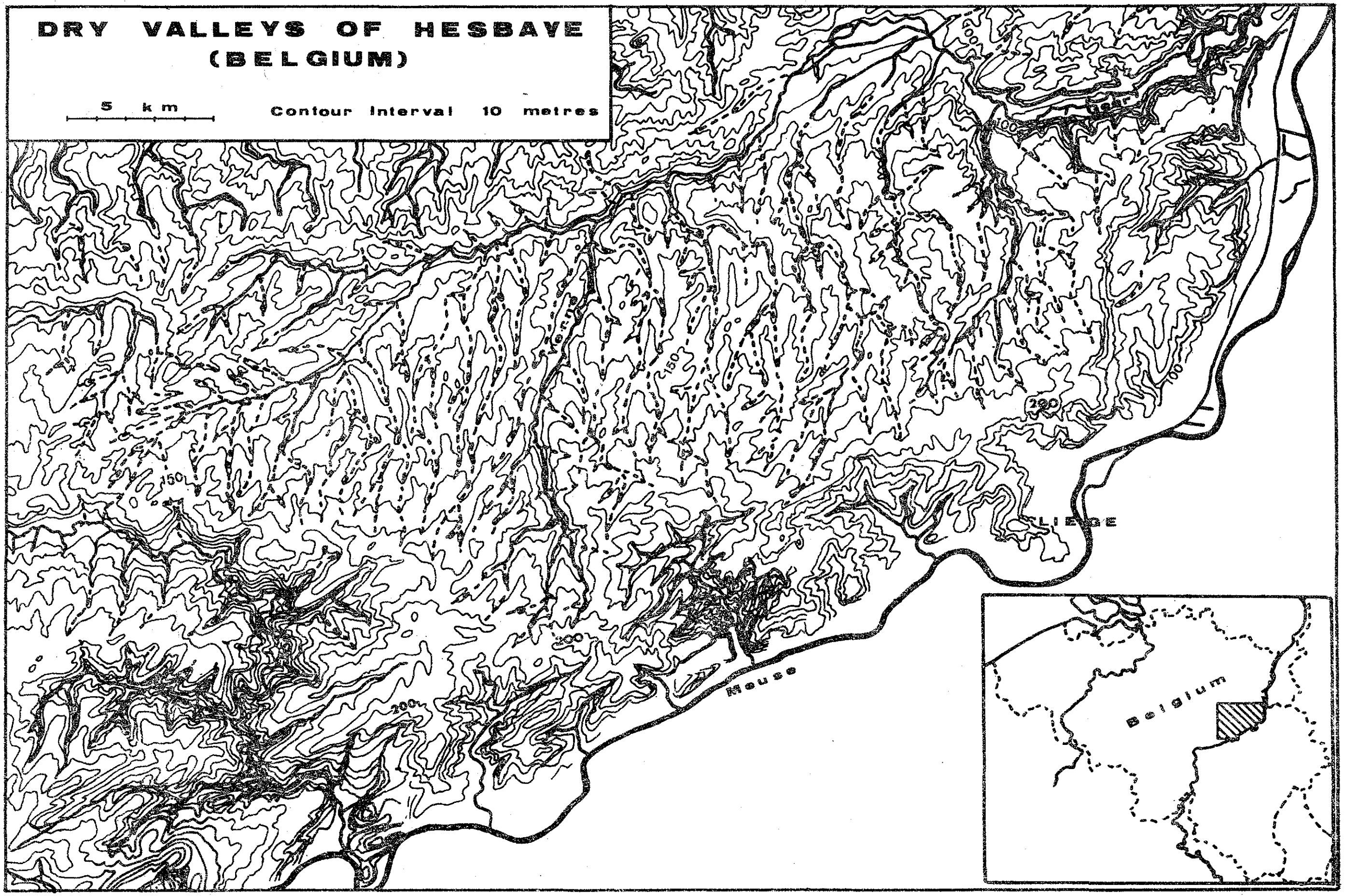

Fig. 1. Map of dry valleys and water courses of south-eastern Hesbaye

west—east axes. Figure 2 shows a typical dry valley at Fexhe-Le-Haut-Clocher. It is a few metres deep and it is cut only in the loam layer, the Quaternary loess which has covered Middle Belgium. The cross-profile of the valley is asymmetrical: the west-facing slope is the steeper. Under the loess cover, a Tongrian (Bartonian) flint conglomerate — not found everywhere — contains altered flints from the underlying strata. These are Mesozoic beds of Maastrichtian (Campanian) age, mainly chalk, with flint seams. The gallery is working the ground water which occupies the chalk beds above a layer of dense clay of extremely low porosity. Percolation being easy through several metres of loess and several sets of ten metres of chalk, the water table is far below the surface and the valley is dry; rivers and rivulets are seldom found.

Having bored the loam cover in one of the dry valleys, PLANCQ (1968) could discriminate primitive loess and colluvium due to recent processes. Some of his cross-profiles showed dry valleys cutting through the whole thickness of the loam cover, with the flint-clay conglomerate also eroded. However, the cross-profiles along the old galleries (GRIMBÉRIEUX, 1954, 1955) and along the new ones I have observed thanks to the Water Service of Liège, demonstrate that most dry valleys of south-east Hesbaye, at least near their head and in their central portion, are cut in the upper part of the loess cover; of course, several valleys did exist before the accumulation of loess and were, afterwards, incompletely filled up by wind-transported material.

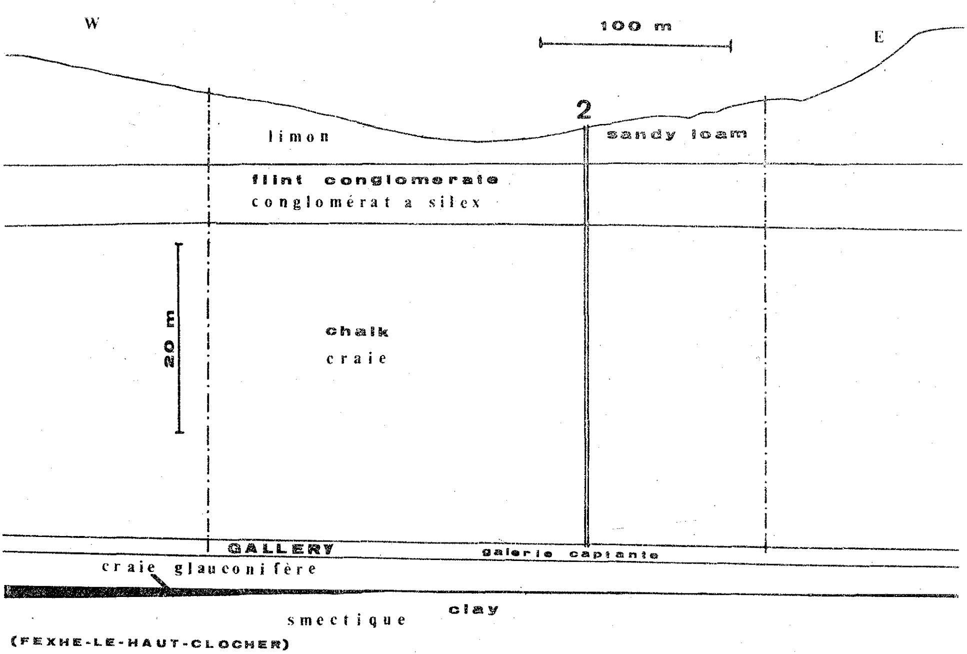

Fig. 2. Cross-section of a dry valley showing the substratum

(After a document of Service des Eaux de la Ville de Liège, 1972)

The series of new cross-sections recently available are corroborating the periglacial origin of the dry valleys of this Belgian region, which had been asserted by Geukens (1947), by Tavernier (1948) and Grimbérieux (1954, 1955) in opposition to Stevens (1934). During the colder periods of the Pleistocene, the deep loess remained permanently frozen, even in summer. Downward percolation of water released in spring and summer by melting of the snow cover was impossible because of the permafrost barrier. Melt-water as surface run-off prevented a complete infilling of the former valleys by wind-deposits, and new valleys were cut in the loess layer. After the disappearance of permafrost conditions, most valleys became dry, except for the deeper ones. Brulard (1962) has, however, pointed out that place names and written documents prove that several rivulets persisted until the fourteenth and even the fifteenth centuries.

In his memoir, Plancq (1968) has discussed the hypothesis that the Dry Hesbaye landscape could be an altered morphology of *gredas*. This word was used in 1967 by Różycki to name, in Bulgaria, narrow strongly elongated ridges, with parallel dry depressions, and which are primary forms of loess accumulation that can be compared, in some respects, with longitudinal dunes. Without forgetting that periglacial processes and recent erosion can explain that Hesbaye *gredas* would be different and more altered, it seems difficult to me to agree. According to Maarleveld (1964) and other authors, prevailing winds were blowing from the north-west when they deposited the loess; the *gredas* they would have built should be elongated from north-west to south-east which is not what is observed in Hesbaye. More important is the fact that the undulations of the Dry Hesbaye plateau die out upstream near the two hundred metres watershed, not far from the Meuse valley, whereas the depressions between the Bulgarian *gredas* are double, with — in each case — a threshold, something like a mountain col, between the two furrows which descend in opposite directions.

In Dry Hesbaye, 20 percent of the observed valley cross-profiles are symmetrical, 8 percent have a steeper east-facing slope, and 72 percent have a steeper west-facing slope. This asymmetry is the same as the asymmetry of the main valleys of Middle Belgium, but less spectacular in a region of rather faint gradients where slope angles do not exceed a few degrees.

Figure 3 is a diagram representing the relation between valley orientation and asymmetry. It has been drawn in half a circle; each half-octant contains the data of a given sector of azimuth and also the data of the diametrically opposed sector. The asymmetry index (AI) used is

$$AI = 1 - \frac{g}{s}$$

g — being the angle of the gentle slope and s — the angle of the steep slope, both in degrees. The AI of a symmetrical cross-profile is thus 0. If the steeper slope is east-facing (inverted asymmetry) a negative sign is used before the AI; of course, west- and east-facing are rough estimates, but each orientation of cross-profile was measured with precision.

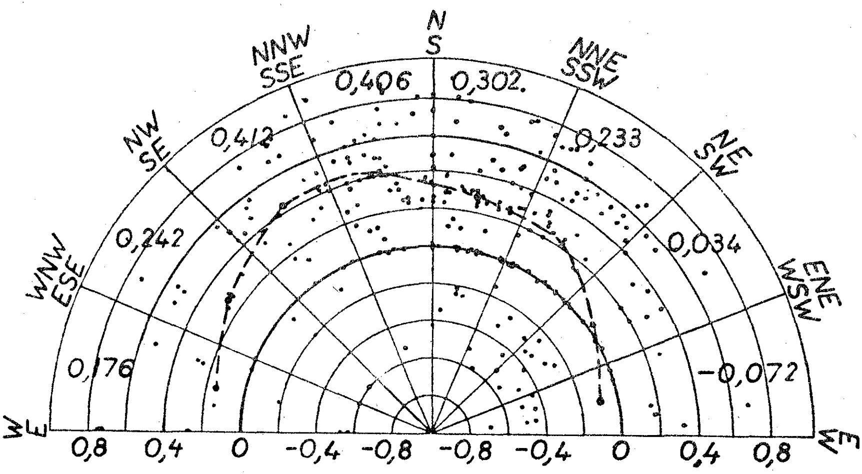

Fig. 3. Variation of asymmetry index in relation to valley orientation (from GRIMBÈRIEUX, 1955)

Group means computed for every half-octant are indicated, and their curve is drawn. One can see that the asymmetry variation is orderly, regarded in relation to the orientation. The highest normal asymmetry (highest positive AI) is found in valleys running from SSE to NNW, or from the diametrically opposed direction, NNW to SSE. The highest inverted asymmetry (negative indices) is observed in valleys which have an orientation perpendicular to this: ENE to WSW, or WSW to ENE. Inspired by SJOSTAKOWITSJ (1927), BÜDEL (1944) and GEUKENS (1947), I think that the most frequent steeper slopes face the afternoon sun, which is warmer, and, during the Pleistocene glaciations, were submitted to more frequent freezing and thawing. Their base was undermined by running meltwater and they became steeper while retreating. This is „secondary asymmetry", due to strong lateral planation, according to POSER and MÜLLER (1951) who called „primary asymmetry" steeper east-facing slopes explained by vigorous solifluction on the other side.

Besides orientation, two other factors often contribute to dry valley asymmetry: the depth of the valley and the gradient of its longitudinal profile. In south-eastern Hesbaye, there are almost as many symmetrical as asymmetrical cross-profiles in dry valleys less than 10 metres deep; then the deeper a valley becomes (chiefly near the Geer River), the more asymmetrical is its cross-profile. On the other hand, the longitudinal gradient, which generally remains very low, and which does not vary so much, shows no significant influence upon the asymmetry index.

Table I puts together, as an example, all the data relating to a 12 km long dry valley which was observed at 200 m intervals. This valley, which ends in the Yerne, looks like many other ones in the neighbourhood and can be considered as a good sample.

Table I

Dry valley La Casaque-Momelette-Fond de Lens-Au Buisson

	Elevation (m)	Azimuth (°)	Depth (m)	Longi-tudinal gradient (%)	East- or north--facing slope gradient (degrees)	West- or south--facing slope gradient (degrees)	Asym-metry index
1	2	3	4	5	6	7	8
0	186	19					
1	179	20	5	20	2.0	2.6	0.23
2	178	29	6	5	1.2	1.6	0.25
3	177	16	5	7.5	0.6	0.8	0.75
4	175	22	4	10	0.6	0.8	0.75
5	173	29	7	7.5	1.0	1.2	0.83
6	172	27	7	5	1.2	1.0	−0.83
7	171	30	7	5	1.4	1.2	−0.14
8	170	357	4	12.5	1.0	0.4	−0.60
9	166	356	6	15	0.6	0.6	0
10	164	341	10.5	7.5	0.8	0.6	−0.25
11	163	326	10.5	5	1.0	0.8	−0.20
12	162	300	8.5	5	1.2	1.0	−0.16
13	161	294	10.5	5	1.2	1.2	0
14	160	347	5.5	5	0.8	1.0	0.2
15	159	347	7.5	6	0.8	1.0	0.2
16	157	350	11	10	1.2	1.2	0
17	155	24	8	7.5	1.8	1.6	−0.11
18	154	27	9	5	2.2	2.2	0
19	153	22	8	7.5	1.6	1.8	0.11
20	151	41	10.5	10	2.4	2.0	−0.16
21	149	26	7	7.5	1.8	2.6	0.30
22	148	21	5.5	5	1.6	1.6	0
23	147	19	7	10	1.4	1.4	0
24	144	14	6	10	1.2	1.4	0.14
25	143	17	8	5	1.4	1.8	0.22
26	142	16	8	7.5	2.0	1.8	−0.10
27	140	15	11	7.5	1.6	2.6	0.38
28	139	14	12	5	2.8	2.6	0.17
29	138	18	12	3.7	3.4	3.2	−0.05
30	137,5	18	10	3.7	1.4	3.0	0.53
31	136.5	19	11	5	1.2	2.8	0.57
32	135,5	15	8	3.7	0.8	1.4	0.42
33	134	6	10.5	7.5	1.4	1.8	0.22
34	132.5	15	11	5	2.0	3.0	0.33
35	132	338	11	2.5	1.4	1.8	0.22
36	131,5	349	9	2.5	1.2	1.8	0.33
37	131	14	12	2.5	1.0	1.8	0.44
38	130	13	13	8.7	0.8	1.8	0.55
39	127.5	15	15.5	10	1.0	2.0	0.50
40	126	13	14	10	1.0	3.0	0.66
41	125	15	14	5	2.4	4.8	0.50
42	124	9	14	5	2.0	2.6	0.23

1	2	3	4	5	6	7	8
43	123	0	16	3.7	2.4	2.0	−0.16
44	122,5	21	16	2.5	2.0	1.0	−0.50
45	122	15	16	3.7	0.8	1.6	0.50
46	121	354	16	5	1.2	1.2	0
47	120	334	17	5	0.6	1.2	0.50
48	119	228	18	5	0.8	1.0	0.20
49	118	329	13	3.7	1.0	1.0	0
50	117,5	341	12.5	2.5	1.2	1.0	−0.16
51	117	330	13	3.7	1.0	1.0	0
52	116	323	12	3.7	2.0	2.2	0.09
53	115.5	272	14.5	2.5	2.4	2.4	0
54	115	268	15	6.2	1.4	1.4	0
55	113	228	17	7.5	2.0	1.4	−0.30
56	112	237	18	7.5	2.4	2.4	0
57	110	292	20	10	2.8	2.2	−0.21
58	108	309	22	10	2.8	6.4	0.56
59	106	346	15	7.5	4.0	4.6	0.13
60	105	355	16	5	1.0	4.8	0.79
61	104	359	18	3.7	1.2	4.0	0.70
62	102.5	10	19	3	1.4	2.8	0.50

According to the generally accepted ideas of the time, I formerly thought that these valleys were formed during the Würm (Vistulian) glacial stage (Grimbérieux, 1955, p. 273). But loess stratigraphy has made great progress, so that I am now convinced they are much older, probably as old as the loess itself; this should be verified by Quaternary stratigraphy studies. Further studies should also determine the influence of slope processes on cross-profile evolution during the Holocene.

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