III

STRATIGRAPHY OF THE GRUBGRABEN LOESS SEQUENCE

by

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GEOMORPHOLOGICAL AND GEOLOGICAL SETTING

Grubgraben is located in the vicinity of Langenlois, 15 km to the north of the Danube River, along an east-west oriented escarpment following the northern edge of the Danubian Plain. The site lies at the bottom of a ravine cut into the Palaeozoic bedrock , and is enclosed by high reliefs caped by Tertiary gravels; the Heiligenstein, at an altitude of 360 m, borders the ravine to the west and to the north, while the Geissberg, a 336 m high butte, forms its eastern edge (Fig. III-1 & Fig. IV.2). The Kamp River, a northern tributary of the Danube which has cut its valley across the Palaeozoic bedrock, flows along the western flank of the Heiligenstein; when joining the Danube Plain, it develops a much larger flood plain at an altitude of about 200 m and turns to the southeast at the foot of Grubgraben.

At Grubgraben, the loess cover is mainly developed in the central part and along the western slope of the ravine, which gives it an asymmetrical profile. Furthermore, those deposits are part of the wide loess belt which extends to the east of Krems in the Danube Plain as far as Hungary, and also to the west in the Wachau where the river has cut a narrow valley across the Palaeozoic rocks of the southern extension of the Bohemian Massif.

Many loess sections have been studied in this area since the beginning of the 1950's, especially those of Krems-Schiesstätte, Paudorf, Göttweig-Aigen, (Felgenhauer et al., 1962; Fink et al., 1976), Willendorf (Brandtner, 1956-59) and Senftenberg (Brandtner, 1954). Nevertheless, a detailed stratigraphic sequence for the Upper Pleistocene loessic deposits of this area, could only be established recently (Haesaerts, 1965, 1990). For the period between 45,000 and 20,000 B.P., this stratigraphic sequence has been based on several Upper Palaeolithic layers present in the loess, which provide good chronological markers because of their typological context but also because of the opportunity for radiocarbon dating they allow. In that respect, the loess record of Grubgraben is of major importance as it incorporates at least four Epigravettian occupation layers, the main layer being dated between 18,400 and 19,000 B.P., a period usually poorly documented in most of the loess sections of Central Europe (Haesaerts, 1985).

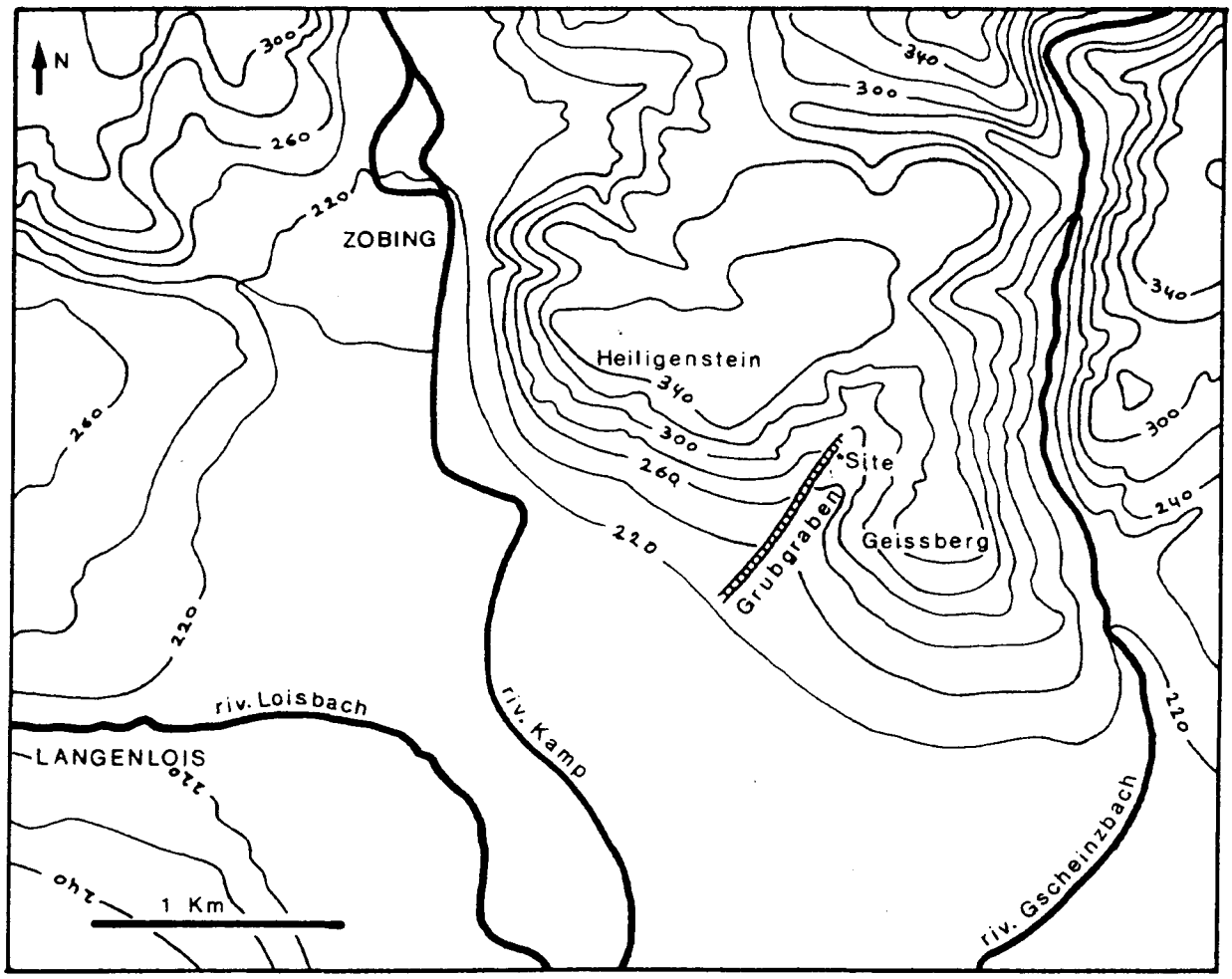


Fig. III-1 . Location of Grubgraben and topography of the surrounding area.

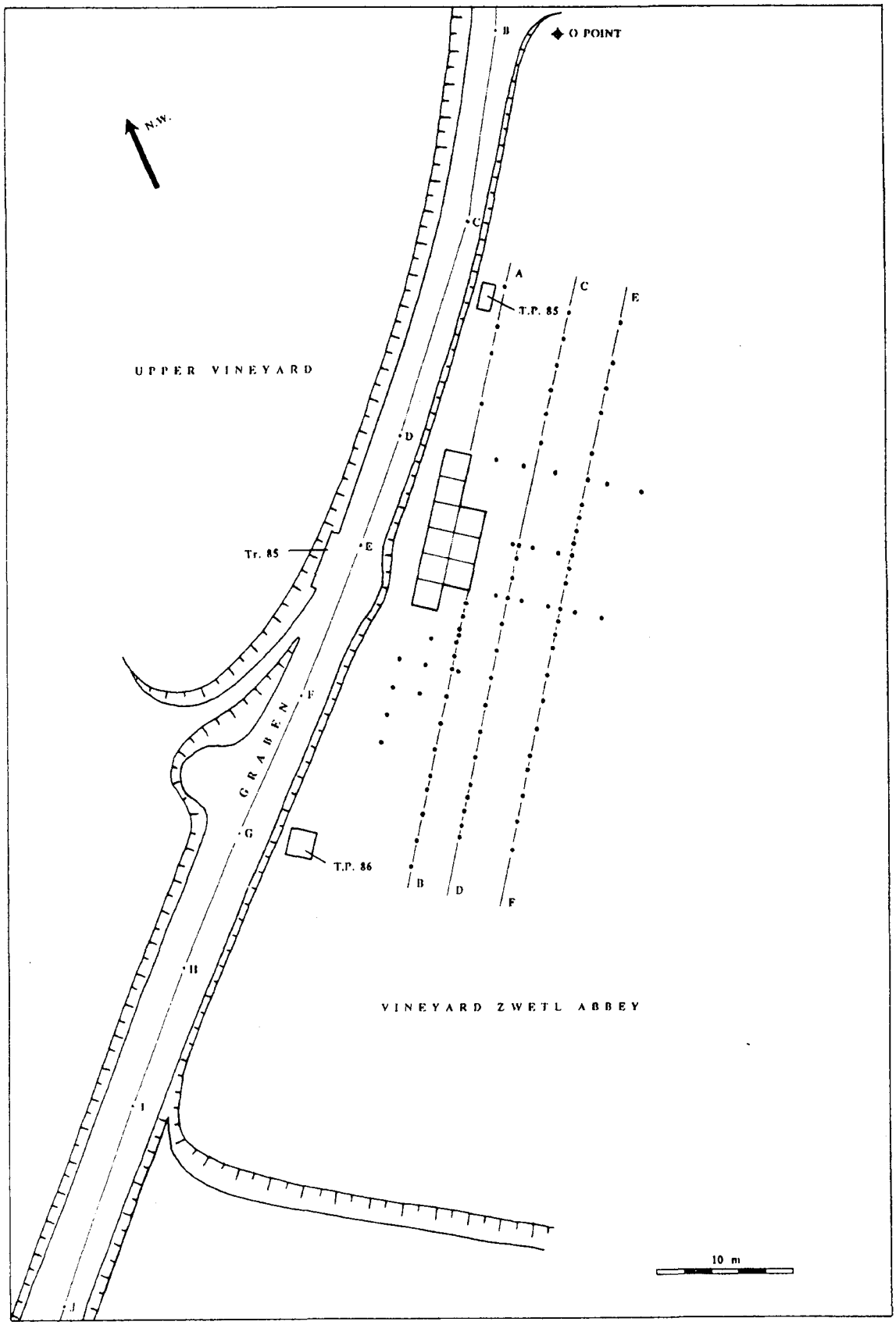


Fig. III-2. Grubgraben : location map of sections and borings

LOCAL STRATIGRAPHY

General context

Most loessic deposits at Grubgraben are accessible along both sides of a deep sunken road sunken road, developed along the western slope of the ravine. The site was first discovered here in the 1870's, more or less 40 m below the point where the graben ends (Fig. III-2). At this place, recent agriculture has strongly modified the former morphology of the top of the loess cover by creating terraces for vineyards. Indeed, at the site the western wall of the road is almost 7 m high, the upper 3 m consisting of fill (Fig. III-3). On the other hand, the height of the eastern wall along the vineyard of Zwettl Abbey does not exceed 2.5 m, which implies that the top of the loess cover has been lowered at least 1.5 m before planting the vineyard. Higher up in the ravine, the loess cover is less continuous and the faulted Palaeozoic bedrock made of gneiss, arkosic conglomerates, sandstones and shales, outcrops in patches along the slopes at a few hundred meters to the north of the Epigravettian settlement (Fig. IV.2).

Archaeologic occurrences

The main archaeological complex (AL2-AL4) was retraced when the western wall of the road was cut back in 1985 to expose the profile (Tr. 85, Fig. III-3). It is a multi-component complex with artifacts, stones, bones and humic stripes present 3 m below the top of the undisturbed loess (Fig. V.13). Two other archaeological layers were also detected at the same place in the loess; the upper one (AL1), 1 m above the main complex, the second (AL5), 0.50 m underneath it. Laterally the main complex is followed over a distance of 55 m along both walls of the graben. Further on, the extension of the main complex was mapped over an area of more than 1,000 m^2 in the parcel of the Zwettl vineyard with the help of a hand auger (Fig. III-7); most of the 95 borings reached it at a depth varying between 0.90 and 3.60 m below the present day surface. Finally, the detailed stratigraphy of the main complex was established in 1987 at the excavation site (Fig. III-4 & III-5) where three distinct occupation horizons (AL2, AL3 and AL4) separated by thin loamy layers were recognized in the prolongation of the road section.

Lithostratigraphical sequence

The stratigraphical sequence of Grubgraben combines different sets of complementary data recorded respectively on both sides of the sunken road, at the excavation site and in the Zwettl vineyard. This sequence encompasses a cumulative thickness of more than 13 m subdivided into 17 sedimentary units and 5 archaeological layers. From the top to the bottom, the succession is as follows (Figs. III-3, III-4, III-5 & III-9):

- Rew. (up to 3 m)

Terrace fill consisting of disturbed pale yellowish loess (2.5 Y 8/6 hum.) with humic lenses; at the base of it a discontinuous gravel incorporates pottery sherds and fresh bones. Only present in the western wall of the road, below the upper vineyard.

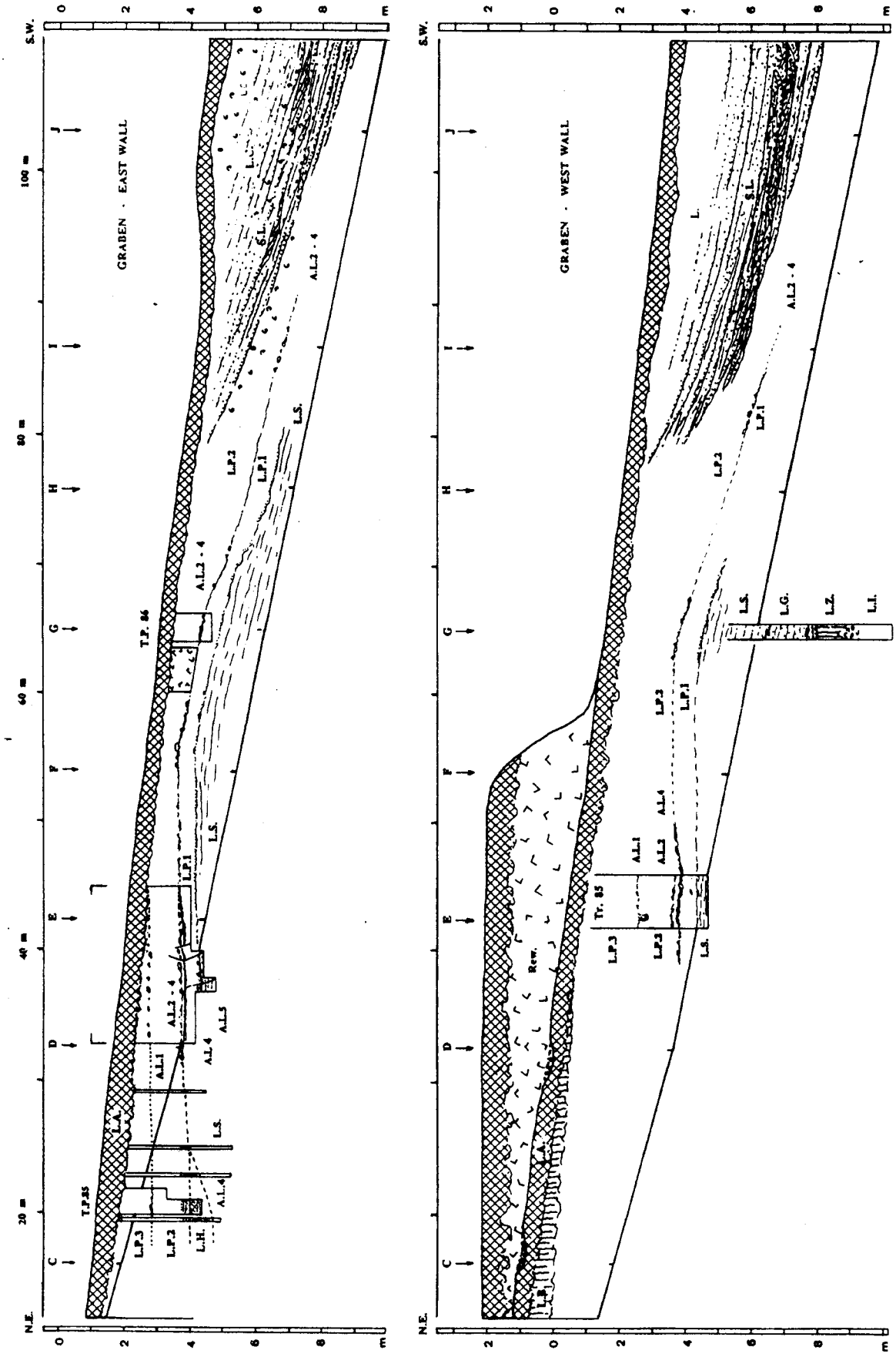


Fig. III-3. Stratigraphy of the graben (graphic symbols : see Figure 4).

- LA (0.20 to 1 m)

Dark gray brown crumbly loam (10 YR 3/2 hum.), frequently enriched in $CaCO_3$ in its lower part. Present almost everywhere at the top of the upper loess cover, it represents the surficial A1 horizon of the present day soil. In the eastern part of the Zwettl vineyard, the thickness of this horizon increases and reaches 1 m, as a result of recent human activity.

- LB (up to 0.5 m)

Yellowish brown loam (10 YR 5/4 hum.) with prismatic structure and humic clay-coatings on it; only observed underneath the recent fill (Rew.) in the western wall of the road north of P. 30, it shows the characteristics of the illuviated B horizon of a gray brown podzolic soil (Alfisol).

- LC (up to 2 m)

Homogeneous, dusty, pale yellowish loess (2.5 Y 7/4 hum.), preserved on both sides of the road south of P. 85 (Fig. III-3). The lowest part of the loess is stratified with sandy lenses; terrestrial molluscs are rather abundant (see Table 1 : mollusc assemblages), with a majority of xerophilus species mainly *Pupilla muscorum* (68.9%) together with a few hydrophilus species among which *Succinea oblonga* (15.8%).

- SL (up to 2 m)

Stratified sand and loess, filling up a gully deeply cut through the upper part of loess LP. The gully starts south of P. 60 and extends downward to the south along the road. Cross-bedded stratifications are frequent in the sandy layers in the lower part of unit SL, together with concentrations of small rounded quartz and feldspar gravels reworked from the Palaeozoic bedrock. Terrestrial molluscs present in the loamy layers of the upper part of unit SL, are dominated by hydrophilus species mainly *Succinea oblonga* (77.6%).

- LP3 (up to 2 m)

Homogeneous, dusty pale yellowish loess (2.5 Y 7/4 hum.), present above the upper archaeological layer AL1; it is only preserved in the northern part of the site where its thickness is close to 2 m in the western wall of the road (P. 45, Fig. III-3).

- Archaeological layer AL1

Upper Epigravettian horizon apparently restricted to the surroundings of the excavation site where it appears as a subhorizontal weak concentration of blocks of sandstone and gneiss, together with a small amount of flint implements and little bone fragments. Elsewhere this layer is absent or has been eroded, except in test pit 85 at the northern edge of the site, where a thin sandy layer with scattered bone fragments is present at the same altitude as AL1 and could be in its prolongation (Figs. III-3 & III-6). Archaeological layer AL1 is clearly at the interface of two loess series (LP3 and LP2); occupants settled on a subhorizontal surface which truncates the top of loess LP2.

Dark gray brown crumbly loam (10 YR 3/2 hum.), frequently enriched in Ca CO_3 in its lower part. Present almost everywhere at the top of the upper loess cover, it represents the surficial A1 horizon of the present day soil. In the eastern part of the Zwettl vineyard, the thickness of this horizon increases and reaches 1 m, as a result of recent human activity.

Table III-1 Mollusc assemblages from Grubgraben : (determination : Prof J. De Coninck and F. Gelaude, Institute for Palaeontology, State University of Gent). * : xerophilus species; **: little hydrophilus species; *** hydrophilus species.

Unit L.C. road section, P. 100 (576 spec.)		
-*Pupilla muscorum* (400 spec.)	69.5%	*
-*Succinea oblonga* (150 spec.)	26.0%	***
-*Helicella geyeri* or *H. striata* (20 spec.)	3.5%	*
-*Trichia hispida* (4 spec.)	0.7%	**
-*Clausilia dubia (2 spec.)*	0,3%	**
Unit S.L. road section, P.100 (361 spec.)		
-*Succinea oblonga* (280 spec.)	77.6%	***
-*Pupilla muscorum* (60 spec.)	16.6%	*
-*Vallonia pulchella (12 spec.)*	3.3%	**
-*Helicella geyeri* or *H.striata* (6spec.)	1.7%	*
- *Tricha hispida* (3 spec.)	0.8%	**
Unit L.P.2 road section, P.67 (491 spec.)		
-*Succinea oblonga* (370 spec.)	75.4%	***
-*Pupilla muscorum* (100 spec.)	20.3%	*
-*Vallonia pulchella* (20 spec.)	4.1%	**
-*Columella columella* (1 spec.)	0.2%	
Unit L.S. road section, P.65 (373 spec.)		
-*Pupilla muscorum (200 spec.)*	53.6%	*
-*Helicella geyeri* or *H. striata* (200 spec.)	40.2%	*
-*Trichia hispida* (20 spec.)	5.4%	**
-*Succinea oblonga* or *S. arenaria* (2 spec.)	0.5%	***
-*Vallonia pulchella* (1 spec.)	0.3%	**

Table III-2 Grain-size compositions of the loess at Grubgraben (cumulative values in %).

sample number	1	2	3	4	5	6	7	8	9	10	11	12
% CaCO3	11,4	22,2	28,9	29,7	14,6	26,6	14,9	14,7	18,4	9,3	7,3	7,0
> 420 m	0,4	1,1	0,3	0,5	0,6	2,5	1,1	0,9	0,5	2,3	4,5	3,4
> 295 m	0,6	1,7	0,6	1,0	1,3	3,3	1,6	1,7	0,9	3,7	7,0	5,1
> 210 m	0,9	2,5	0,9	1,8	2,2	4,2	2,5	2,5	1,6	5,3	9,7	6,9
> 149 m	1,3	3,8	1,6	3,0	4,1	5,7	5,1	4,2	3,2	7,9	13,5	9,4
> 105 m	1,9	5,3	2,5	4,8	6,6	7,6	8,5	6,2	5,5	10,9	17,1	12,1
> 80 m	3,5	7,7	4,0	7,5	10,4	10,2	12,6	8,8	9,0	14,2	20,6	15,6
> 53 m	12,6	17,1	12,9	15,8	20,5	18,1	24,7	18,3	20,4	28,5	27,5	24,1
> 20 m	59,3	67,3	67,4	68,8	71,5	63,4	72,2	76,4	70,4	69,3	57,2	68,2
> 10 m	74,1	79,6	79,2	79,6	81,6	75,1	82,6	81,6	80,1	78,2	66,0	79,2
> 2 m	89,6	88,9	88,6	89,1	89,0	86,8	89,2	89,0	88,9	87,3	82,4	87,8
< 2 m	10,4	11,1	11,4	10,9	11,0	13,2	10,8	11,0	11,1	12,7	17,6	12,2

1 : unit LC
2 : unit LP2
3 : unit LP2 (top)
4 : unit LP2 (base)
5 : unit LR1
6 : unit HH1
7 : unit LP1
8 : unit LS
9 : unit LS (base)
10 : unit LG
11 : unit LZ
12 : unit LI

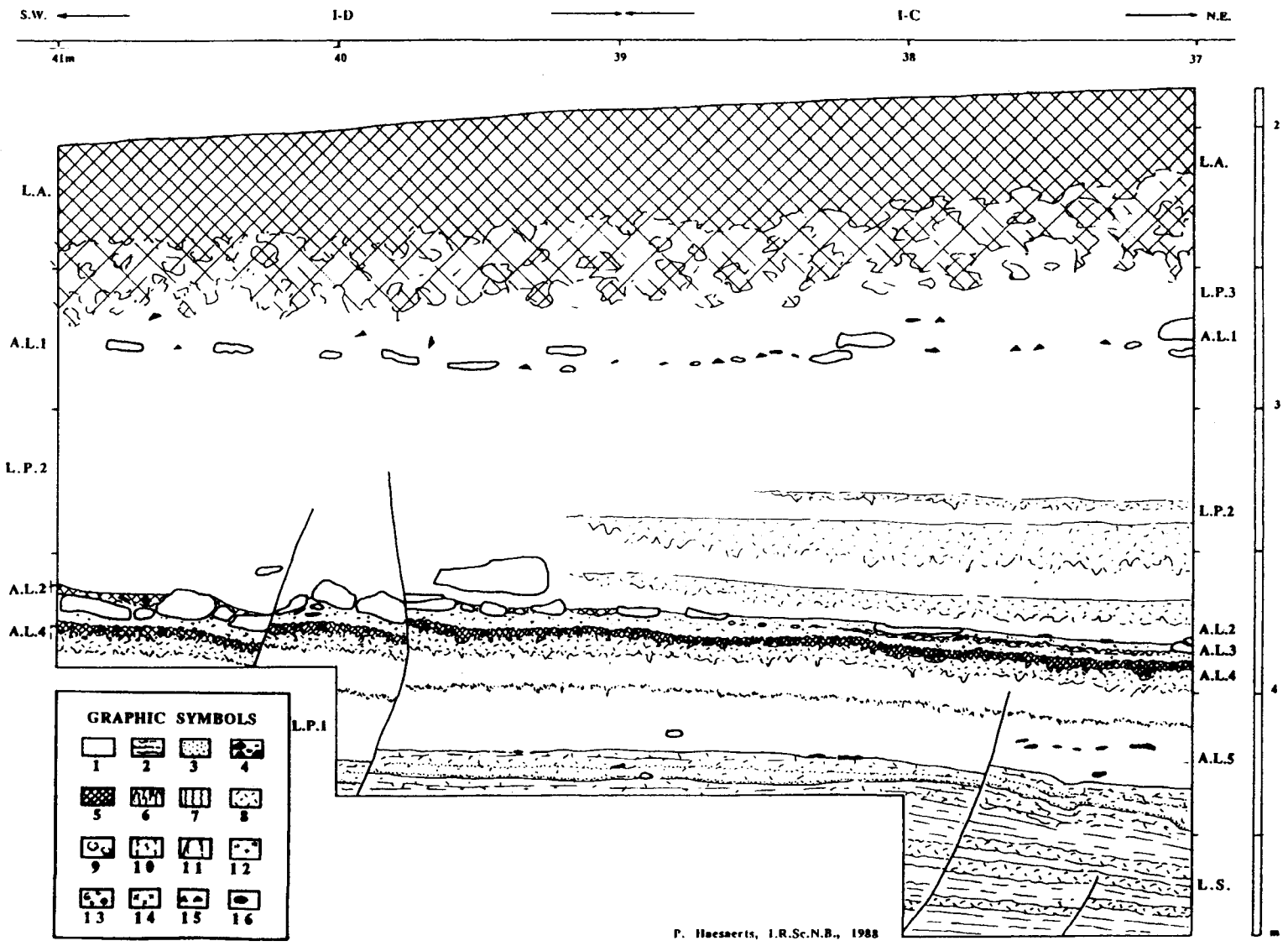
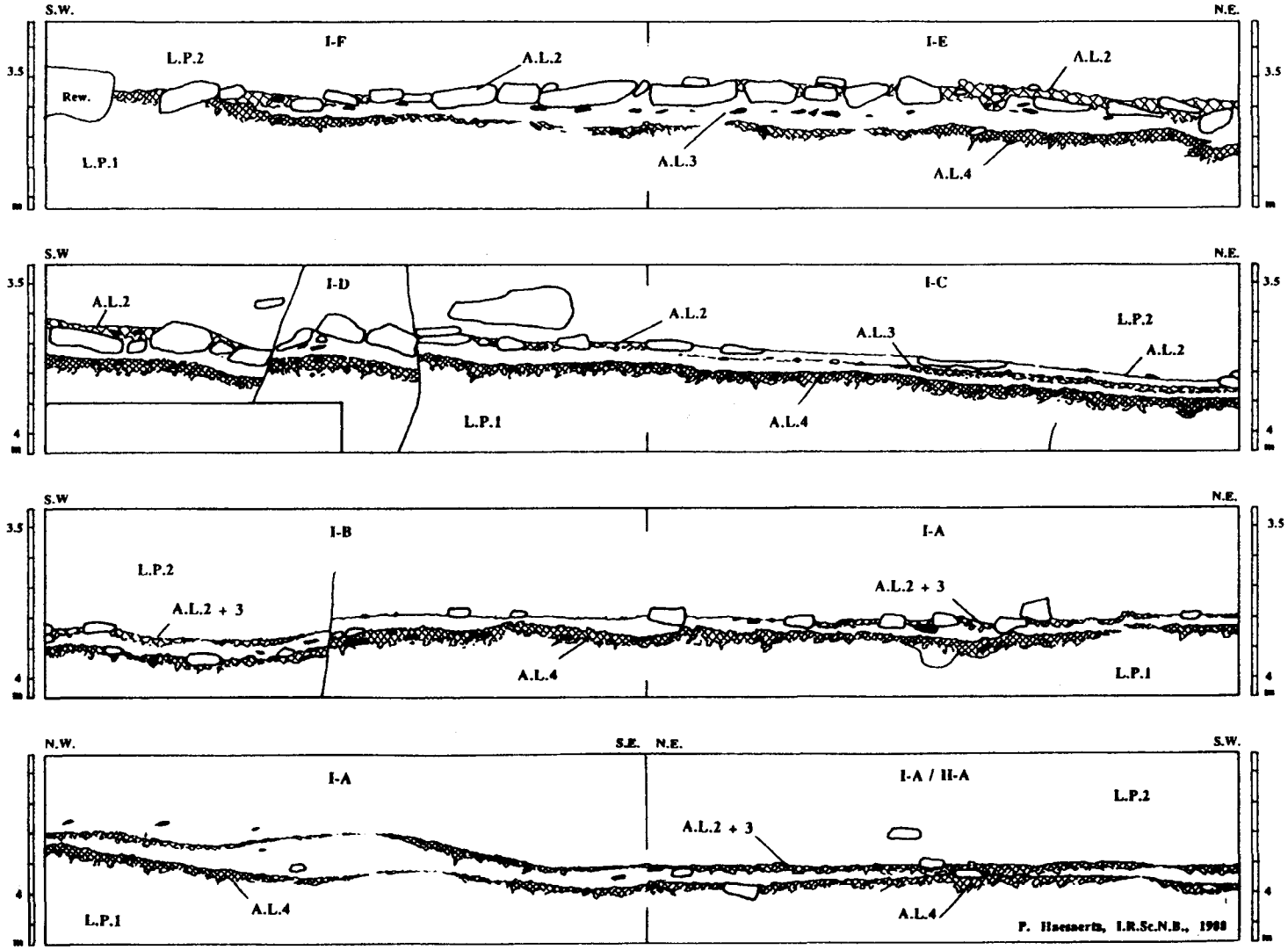
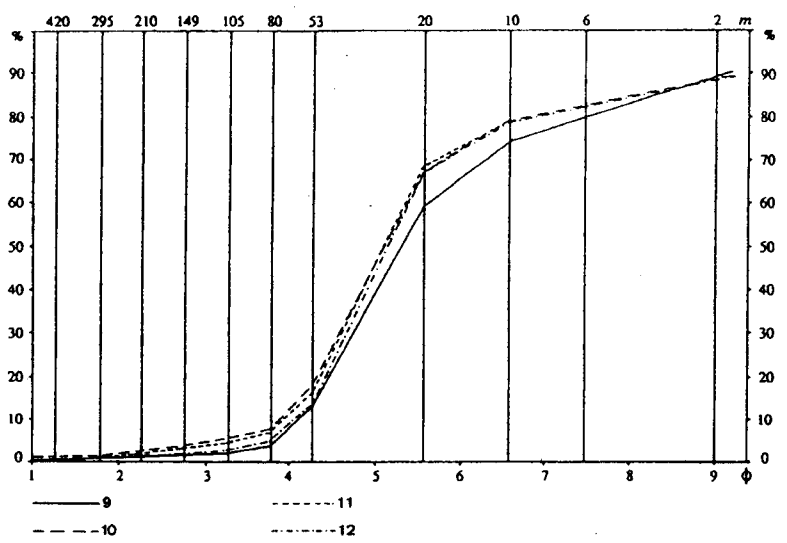


Fig. III-4.
Type section of the excavation site.
Graphic symbols.
1: loess;
2: sandy loam;
3: sand;
4: stones;
5: humic sediment;
6: Alfisol (textural B horizon);
7: brown forest soil (B horizon);
8: bleached horizon (micro-podzol);
9: calcic concretions;
10: pseudo-mycelium;
11: rootcasts;
12: iron-staining;
13: molluscs;
14: charcoal;
15: artifacts;
16: bones.

Fig. III-5.
Stratigraphy of the main archaeological complex (AL2-AL4) at the excavation site (graphic symbols: see Figure 4).





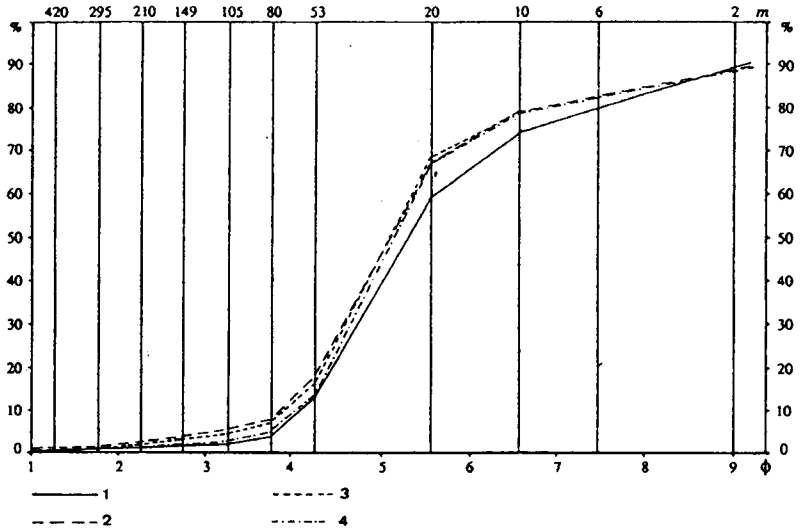
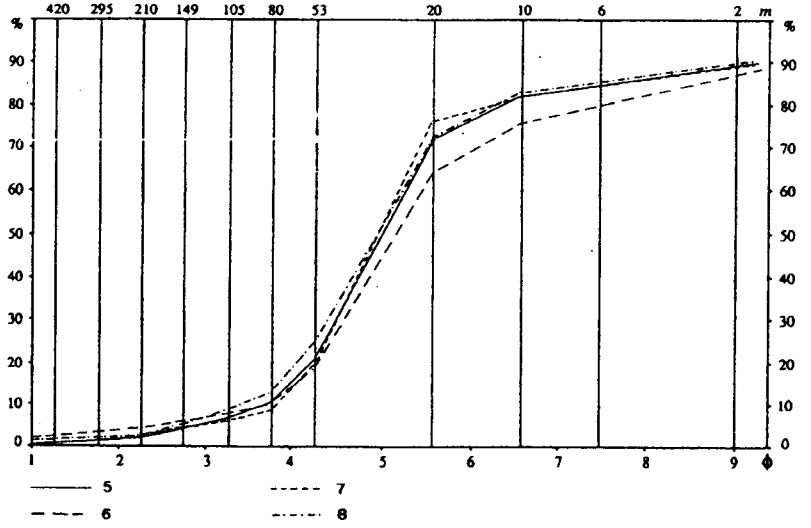


Fig. III-6. Grain-size distributions of the loessic deposits of Grubgraben.



- LP2 (0.5 to 1.5 m)

Dusty, pale yellowish loess, similar to LP3. At the excavation site three discontinuous thin light grayish horizons with iron-staining occur in the lowest part of unit LP2, while in the eastern wall of the road, the upper part of the same loess has provided a mollusc assemblage characterized by a predominance of hydrophilus species similar to the one recovered from unit SL.

- Archaeological layer AL2

Upper occupation horizon of the main archaeological complex, the stratigraphy of which has been distinguished at the excavation site (Figs III-4 & III-5). AL2 occurs here as a pavement of joining blocks of sandstone, arkose and gneiss, 10 to 40 cm in diameter. A prospection in the surroundings of the excavation site, with the use of a hand auger, has shown that the manuports covered a surface of more than 100 m^2 (Fig. III. 7), but the precise stratigraphic attribution of the unexcavated structures remains to be defined. At the excavation site, bones and lithic implements are not very abundant in AL2; sometimes they are found in a thin light brownish discontinuous horizon, usually on top of the stony pavement. Outside the paved structures, bones and artifacts are present on a surface which rests on the top of the discontinuous humic horizon HH2 (Figs. III-4 & III-5, excavation units I-E to I-B).

- LR2 (up to 0.03 m)

Thin, pale yellowish loessic deposit with small brown spots (10 YR 5/3 hum.); only present in the southern part of the excavation site between the bone concentration of AL3 and the stony pavement AL2 (Figs. III-4 & III-5, excavation units I-E, I-D and I-C).

- HH2 (up to 0.04m)

Discontinuous centimetric dark brown layer (10 YR 4/2 hum.), recorded in the western wall of the road (P. 45) as well as in the northern part of the excavation site.

- Archaeological layer AL3

Intermediary occupation horizon clearly distinct from AL2 and separated from it by a few centimeters of sterile loess in excavation units I-F, I-E and I-D. At the excavation site, it occurs as a concentration of bones into a pale yellowish loess with little brownish spots (Figs. III-4 & III-5; excavation units I-E, I-D and I-C). To the north of excavation unit I-C, the discontinuous dark brown layer HH2, which includes flint implements, bone fragments and scattered small blocks of stones, constitutes the continuation of archaeological layers AL2 and AL3.

- LR1 (up to 0.15 m)

Light yellowish, sandy loess (2.5 Y 7/5 hum.), occurring between layers HH2 and HHI at the excavation site, where it shows small gray brown spots and contains scattered bone fragments.

- HH1 (up to 0.04 m)

Almost continuous, 2 to 4 cm thick, black to very dark brown layer (10 YR 4/3 hum.), incorporating rather abundant flint implements, fresh or burned bone fragments and dispersed stony blocks with a diameter seldom beyond 10 cm. The upper boundary of layer HHl is usually regular and more or less sub-horizontal, while its lower boundary shows many small disturbances which are probably related to a rather intense biological activity. In the eastern and western walls of the excavation site, all units up to LP2 are

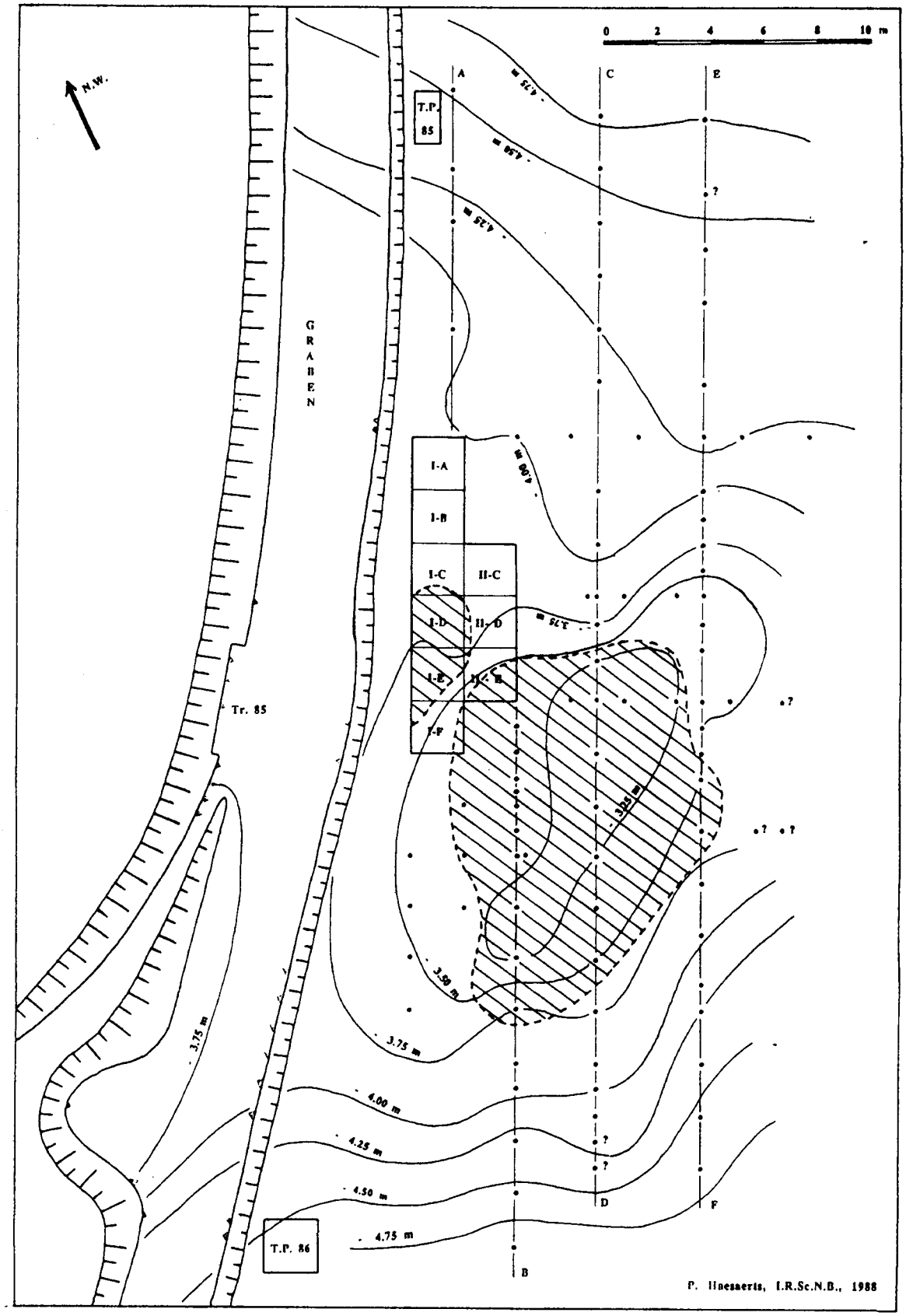


Fig. III-7. Contour lines of the top of the main archaeological complex (AL2-AL4); depths are referring to the Datum Point located at the northern edge of the site; hachured areas show the extension of the continuous stony pavements of AL2.

affected by a set of small faults which cut also across HHl with little effect upon its spatial distribution (Figs. III-4 &III-5).

- Archaeological layer AL4

Main archaeological layer, undoubtedly related to unit HHl; artifacts, bone fragments and stones are usually scattered in the dark brown layer, but at some places small pocket-like structures were also present at the base of it, or just beneath. It is the case in excavation units I-A and I-D, where they were filled with a brown yellowish loam with many little brown spots (Fig. III-5). Another characteristic of AL4 is its remarkable continuity; indeed, outside the areas where the stony pavement of AL2 extends, it has been recorded together with unit HHl over more than 1,000 m², not only in the walls of the sunken road and at the excavation site, but also in most of the borings carried out in the Zwettl vineyard (Fig. III-8). From those data, it appears that AL4 and HHI delimit the pourtour of a small promontory connected to the western slope of the ravine by a shallow depression located at the same place as the present-day sunken road.

The following radiocarbon dates are available for the main archaeological complex (AL2-AL4).

- AA-1746 = 18,960 ± 290 B.P. : bone fragment from AL4, collected in 1985 at P. 45 in the western wall of the road (accelerator facility at the University of Arizona).

- Lv-1680 = 18,400 ± 330 B.P. : several bone fragments from AL4, collected in 1987 at the excavation site (Louvain-la-Neuve, Belgium).

- Lv-1660 = 18,170 ± 300 B.P. : several bone fragments from AL3 and AL4, collected in 1985 at P. 45 in the western wall of the road (Louvain-la-Neuve, Belgium).

LH (up to 0.80 m)

This unit has only been recorded along the northern edge of the site (Fig. III-3); it consists of light gray brown loamy sand (10 YR 8/3 hum.) alternating with layers of dark brown sandy loam (10 YR 5/3 hum.), filling up a large gully oriented perpendicularly to the road. As the archaeological layer AL4 has also been recognized in several borings at the base of unit LH along the southern edge of the gully (Figs. III-7 & III-8), it is likely that the filling occurred at least simultaneously with the development of humic horizons HHl and HH2 as well as during the deposition of units LR1 and LR2.

- LPl (± 0.70 m)

Homogeneous and unstratified pale yellowish sandy loess, present everywhere below humic horizon HH1. In the graben and at the excavation site, a ten centimeter thick, slightly mottled horizon was present at the upper contact.

- Archaeological layer AL5

Lower archaeological occurrence characterized by a thin scatter of artifacts and bone fragments distributed within 10 cm loess at the base of LP1 . This archaeological layer is present locally in secondary position, at the excavation site and also in the road sections at P. 45; elsewhere it is evanescent or absent.

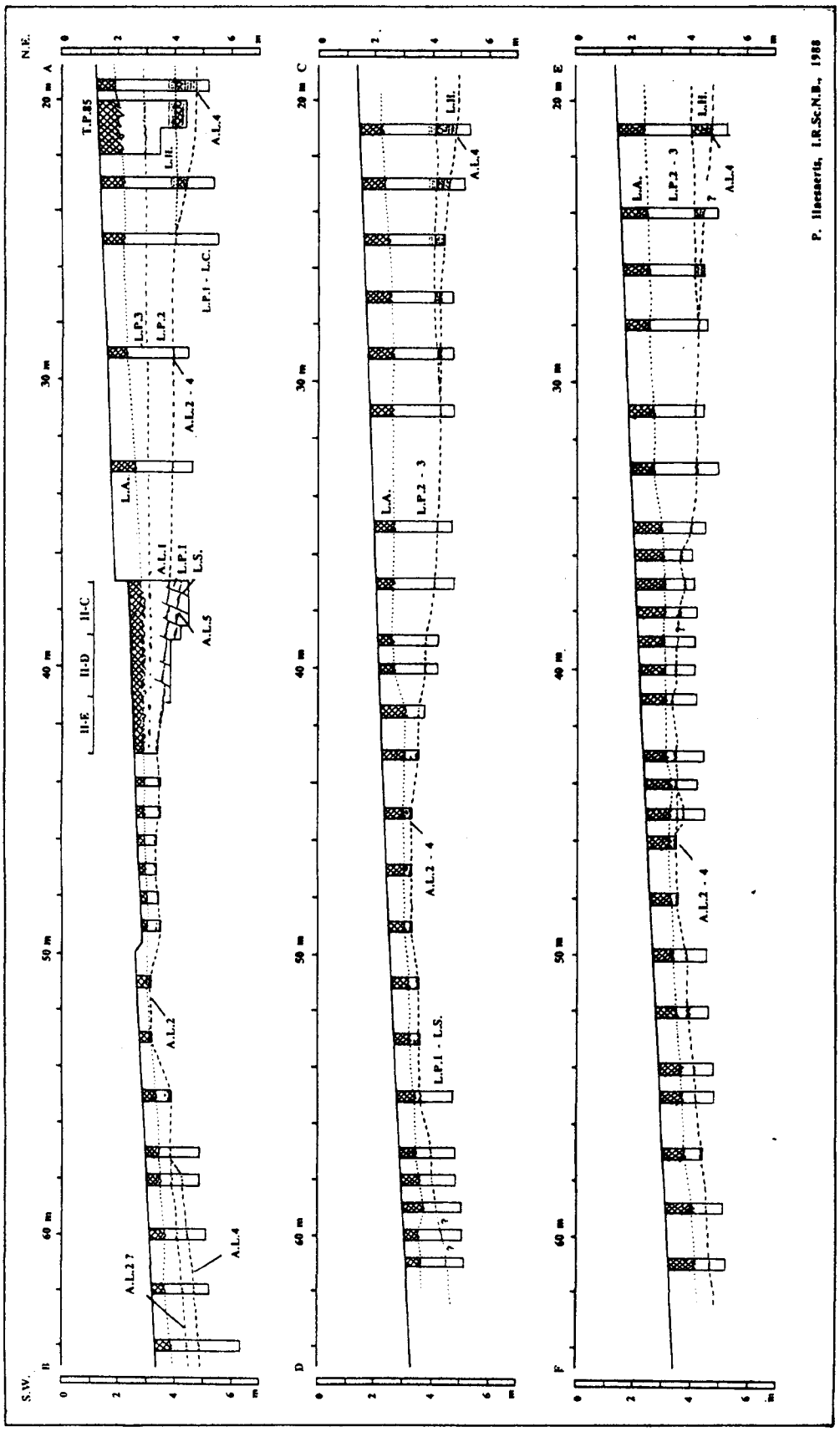


Fig. III-8. Stratigraphical sections across the Zwettl vineyard (graphic symbols: see Fig. 4).

- LS (± 2m)

Yellow loess (2.5 Y 8/6 hum.) with fine lamination and several thin pale grayish horizons with traces of iron-staining. On top of the loess occurs a thin sandy layer used as marker; further on, a mollusc assemblage from the middle of unit LS, collected at P. 65 in the western wall of the road, shows a predominance of xerophilus species, essentially *Pupilla muscorum* (53.6 %) and *Helicella geyeri* or *striata* (40.2 %). At the same place, the lower part of unit LS and the underlying units (LG to LI) were only recorded in a boring (Fig. III-3). To its base, the loess LS incorporates increasingly sandy and gray loamy lenses mixed with small gravels.

- LG (± 1.50 m)

Light yellowish brown sandy loess-like sediment (2.5 Y 5/6 hum.), with recurrent sandy layers and fine gravels, alternating with light grayish brown loamy layers.

- LZ (± 0. 80 m)

Dark brown clayey loam (10 YR 4/3 hum.), with a ten centimeter thick calcic horizon in the upper third of the unit; a second calcic horizon is developed at the contact with the underlying loess.

- LI (up to 1.30m)

Pale yellowish sandy loess with a calcic horizon in the upper part and some fine gravely layers to the base.

SEDIMENTARY AND CLIMATIC ENVIRONMENT

The lithological sequence at Grubgraben consists of five distinct loess bodies separated by several paleosols and marker horizons (Fig. III-9). The most developed paleosol (unit LZ) occurs in the lowest part of the sequence, on top of the oldest loess (unit Ll). Its degree of weathering and the high mobility of $CaCO_3$ are indicative of a major pedological event, most probably related to an interglacial period, the stratigraphical position of which is discussed below.

The overlying loess-like sediments (unit LG) belong to the first part of the following glacial period; because of their degree of hydromorphy and grain-size heterogeneity, they were probably deposited under rather cold and still humid climatic conditions.

The next loess (unit LS) is much more homogeneous and suggests an increasingly cold and dry environment, which is in good agreement with its mollusc assemblage dominated by xerophilus species. The fine lamination of the loess is probably related to the seasonal contrast of the climate at that time, whereas the weak podzolic horizons could have been induced by a recurrence of colder episodes (Haesaerts & Van Vliet-Lanoë, 1981).

A different eolian process starts with the homogeneous sandy loess LPl supposedly formed under drier conditions. It is at the beginning of this episode that the first Upper Paleolithic occupation (AL5) took place at Grubgraben, but only a small area of this oldest archaeological occurrence, mainly in secondary position, has been excavated until now.

The first well dated Epigravettian occupation of the site (AL4) took place immediately after the deposition of the dusty loess LPl , just before and during the formation of a semi-continuous dark brown humic horizon (HH1), most probably between 18,400 and 19,000 B.P. Bones and artifacts of AL4 are associated almost everywhere with the humic horizon; because of its structure and its remarkable continuity, this horizon should be considered as a pedological feature related to a short climatic warming, rather than solely as the result of anthropic activity. Indeed, from the palynological data communicated by Ar. Leroi-Gourhan, it seems that a little rise of temperature, and probably also an increase of humidity, had lead to the development of an open woodland dominated by *Pinus cembra.* At that time, the Palaeolithic settlement extended over an area of more than 1,000 m^2, including the top and the sides of the small promontory in prolongation of the western slope of the ravine, and as far as the edge of the gully which delimits the site to the north.

After a restart of the eolian activity, during which a thin layer of loess partly reworked by rill-wash (unit LR1) covered the humic horizon HHl , a second short improvement of the climate occurred seemingly with the development of a second, but much more discontinuous humic horizon (HH2), which is related to the second Epigravettian occupation of the site (AL3). Moreover, the simultaneous filling of the gully to the north of the side by colluviated sandy loams and humic sediments, implies an increasing activity of springs located higher up the slope and demonstrates also the relatively humid context of the climatic environment at the time of the Epigravettian occupations.

The third Epigravettian settlement (AL2) took place just at the beginning of the following loessic accumulation (unit LP2); the most expressive feature of this occupation is the construction of stone pavements exactly on the top and along the sides of the small promontory.

Usually, a homogeneous and dusty loess such as LP2 is ascribed to a cold and very dry environment; though at Grubgraben this interpretation seems to be at variance with the mollusc assemblage of the upper part of loess LP2 characterized by the predominance of hydrophilus species. Therefore it is probable that during the deposition of the loess LP2 the local climatic environment was rather humid at the site, while at the same time springs were still active higher in the ravine. In the same way, the discontinuous light gray podzolic horizons observed in the lower part of LP2, similar to those frequently recorded in the loess sequences of northwestern Europe (Haesaerts & Van Vliet-Lanoë, 1981), could also be indicative of short episodes with colder and more humid climatic conditions.

Finally, the last Palaeolithic occupation (AL1) occurred at the interface of loess series LP2 and LP3, which corresponds to a rather flat and sub-horizontal erosional unconformity. It probably took place during a short break in the eolian sedimentation, also recorded within the profile of test pit 85, where a thin sandy layer was present at the boundary between LP2 and LP3 in prolongation of ALl (Figs. III-3 & III-8).

A second major unconformity is recorded at the base of unit SL with the development of the large gully deeply cut through the underlying loess (LP2 and LP3) along both walls of the sunken road. In the lower part of the unit the cross-bedded stratifications point to a sedimentation process under running water; to the top the colluvial and loessic facies increase, changing progressively into a kind of melt-water deposit, while the terrestrial molluscs still suggest the persistence of a moist and cold environment. As a whole, unit SL corresponds undoubtedly to a humid period with a high water supply in the gully which was probably fed by several springs and by the seasonal thawing of the snow cover.

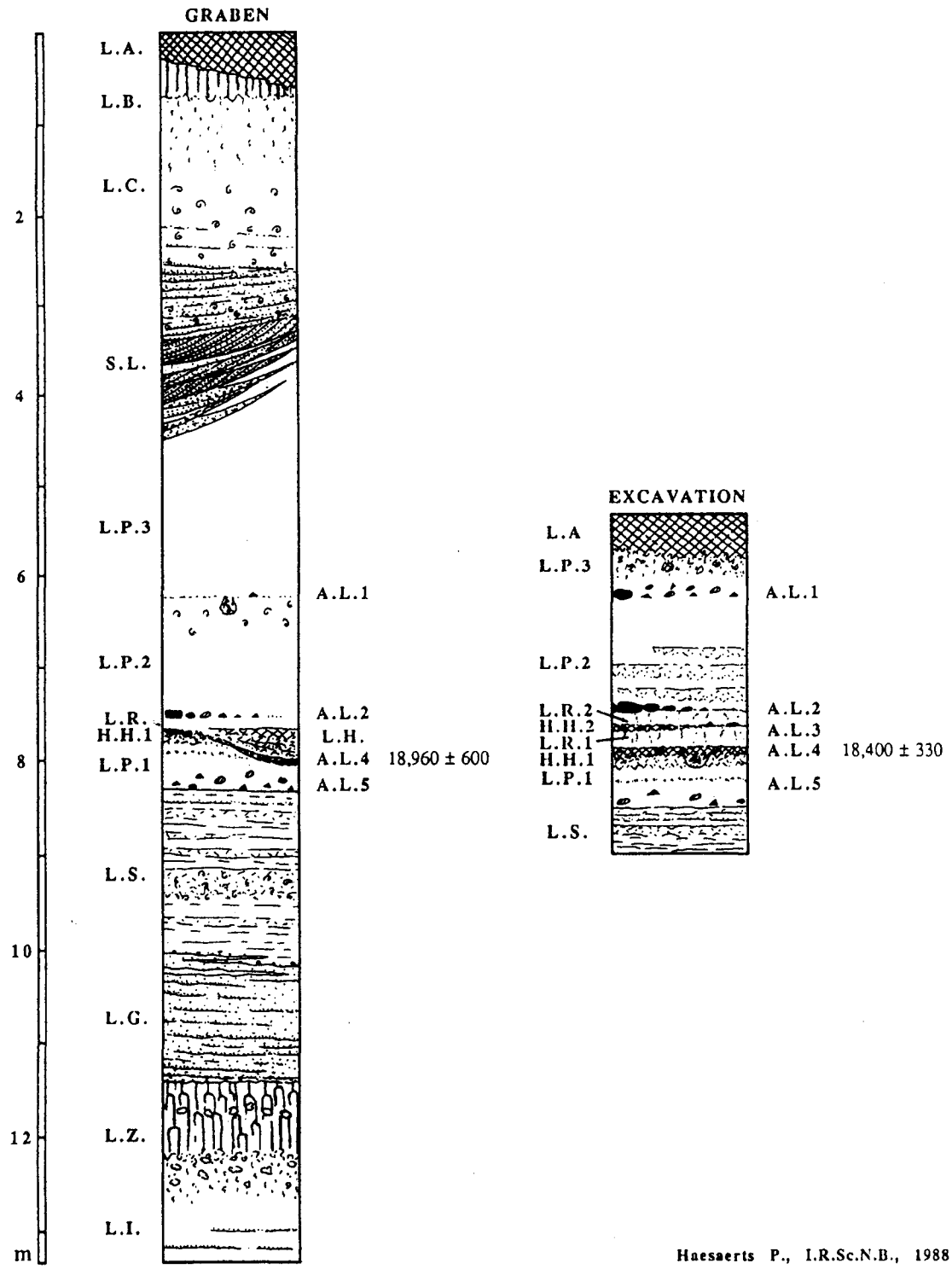


Fig. III-9. Grubgraben : stratigraphical and archaeological sequences (graphic symbols: see Fig. 10).

The upper loess (unit LC) deposited after the filling up of the large gully (unit SL) represents the last cold episode of the sequence. During the deposition of this homogeneous and well-sorted loess the climatic environment of the ravine was much drier than earlier, although some humid places still existed in the vicinity of the site at that time, as suggested by the mollusc assemblage associated with it.

Finally, at the beginning of the Holocene an alfisol developed in the upper part of the loess cover. The illuviated B horizon of this soil (unit LB) is only preserved in the western wall of the road section below the fill (Rew.), while elsewhere, an anthropic humic horizon (unit LA) rests immediately on top of the truncated loess cover.

All together, the different loessic units of Grubgraben have to be related to two different types of climatic environments; the fine laminated loess (unit LS) just prior to archaeological layer AL5 and the uppermost loess of the sequence (unit LC) are indicative of dry and cold conditions. In contrast, the intermediary dusty loess LP2 seems to have been deposited in a more humid environment, as indicated by its mollusc assemblage. In the same way, humid conditions also prevailed during the filling up of the large gully SL cut through the loess LP3, and of the gully LH as suggested by the prevalence of the colluvial processes at those levels. Moreover, the latter episode is also contemporaneous with the main Epigravettian occupations (AL2 - AL4), during which short milder and rather humid climatic events induced the growth of a continuous grass-vegetation and the development of two tiny humic horizons (units HH1 and HH2).

In that respect, it is worth considering how far the sedimentological and pedological processes could have been emphasized by the local context, more especially by the presence of several springs higher up in the ravine. Those springs, most probably in connection with the faulted heterogeneous Palaeozoic bedrock, seemed to have been active during a long period of time and may have induced a favorable biotope particularly attractive to wild life as well as to human groups. Considering the remarkable geomorphological environment of the Grubgraben, which provided a good protection from northern and western winds as well as a broad view of the Danube Plain, such a situation could also partly explain why the Epigravettian hunters settled a number of times, exactly at the same spot, within a period of several thousand years.

Finally, it is notable that almost all paleolithic occupations at Grubgraben did occur outside periods of main loessic accumulation. Indeed, Epigravettian layers AL4 and AL3 are undoubtedly connected with the development of humic horizons during a period of predominant colluvial process, while occupation layer AL2, with its light brown horizon on top, just precedes the sedimentation of loess LP2. In the same way, the last Epigravettian layer AL1, as it rests on a sub-horizontal surface which truncates the top of loess LP2, should also be related to a short pause of the loessic sedimentation.

CHRONOSTRATIGRAPHY

As a whole, the major part of the loess sequence of Grubgraben belongs to the second half of the last glaciation, from a little before 20,000 B.P. up to the Tardiglacial period. This assumption is consistent with the radiocarbon dates of the main archaeological complex (AL2-AL4), but also with the typology of the Epigravettian assemblages. Furthermore, the Grubgraben sequence can be situated within a regional stratigraphic framework based on the loess record of several Upper Palaeolithic open-air sites in the surroundings of Krems, such as Willendorf, Schwallenbach and Stratzing (Haesaerts, 1990). The main interest of these sites lies in their patterned and well documented lithostratigraphical sequences. These include at least 12 Upper Palaeolithic cultural layers, the chronological context of which is fixed by a set of

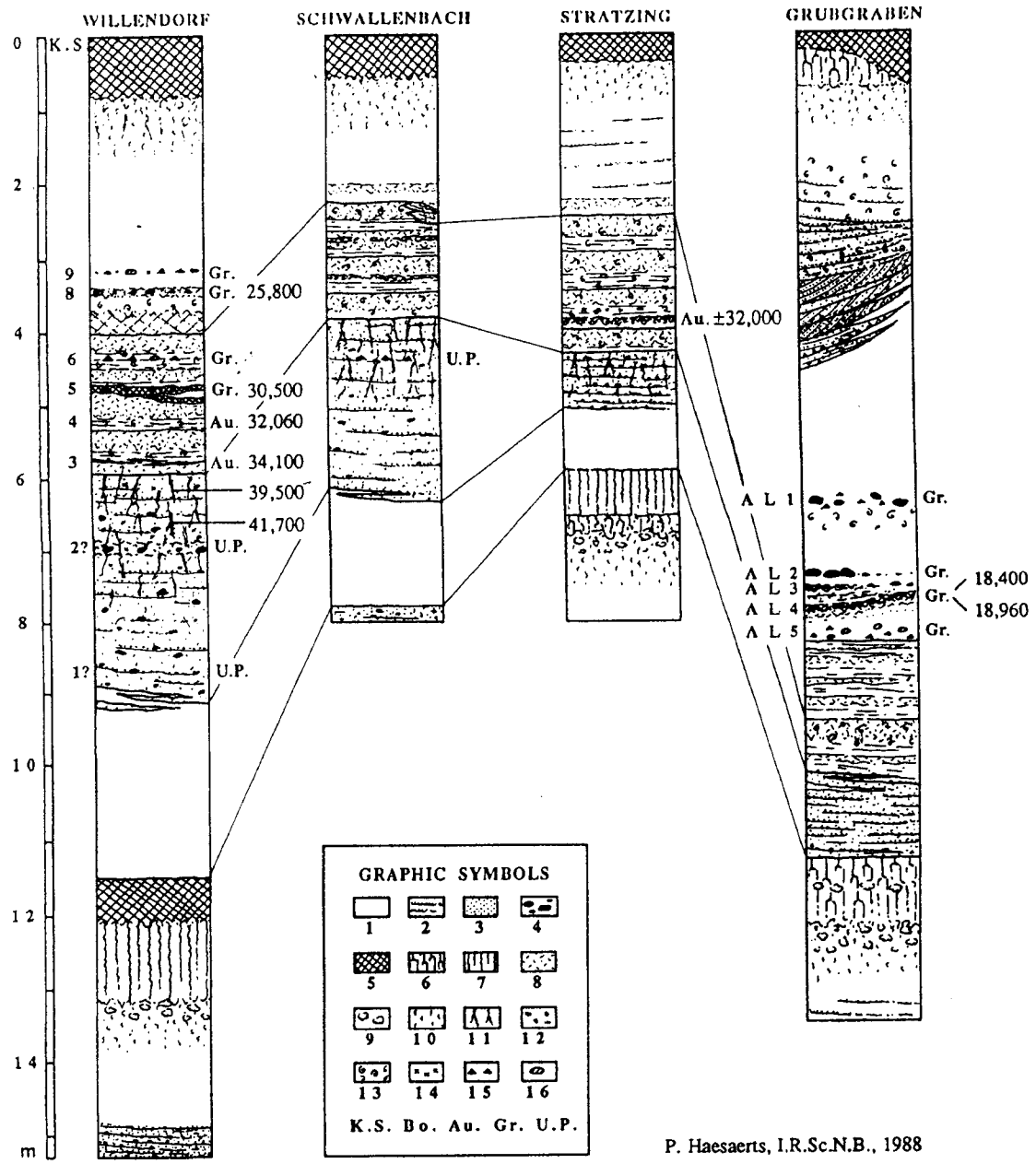


Fig. III-10. Lithostratigraphical sequence of Grubgraben compared to sections in the surroundings of Krems.

Graphic symbols. 1 : loess; 2 : sandy loam; 3 : sand; 4 : stones and gravels; 5: humic sediment; 6 : Alfisol (textural B horizon); 7 : brown forest soil (B horizon); 8: bleached horizon (micro-podzol); 9 : calcic concretions; 10 : pseudomycelium; 11: rootcasts; 12 : iron-staining; 13 : molluscs; 14 : charcoal; 15 : artifacts; 16 : bones, K.S.: cultural layers; Bo. : Bohunician; Au. : Aurignacian; Gr. : Epigravettian and Gravettian; U.P. : undifferentiated Upper Palaeolithic.

consistent radiocarbon dates covering a period between ± 42,000 and 25,000 B.P. (Fig. III-10). In such a system, it is obvious that most of the loessic units of Grubgraben belong to the upper part of the regional sequence and therefore should be younger than 25,000 B.P.

As to the lower part of the sequence of Grubgraben, it is poorly differentiated and has only been recorded in one boring. Nevertheless, the strongly developed paleosol (unit LZ) at the bottom of the sequence has its equivalent in Willendorf and in Stratzing where similar soil horizons represent most probably the last interglacial period. Indeed, at Willendorf, this soil overlies a remnant of a low terrace of the Danube, ascribed to the end of the Middle Pleistocene (Brantner, 1956-69).

The grayish heterogeneous loess-like sediment (unit LG), shows a facies similar to that of the loamy deposits always present on top of the first homogeneous loess of the last glacial period in the three sections taken as reference; those deposits were ascribed to a medium cold but rather humid episode, representing the first half of the Middle Pleniglacial between about 45,000 and 35,000 B.P. (Haesaerts, 1985; 1990). At Willendorf, this loam incorporates the archaeological layers 1 and 2 (undifferentiated Upper Palaeolithic, cfr. J. Hahn, 1977); its upper part was dated on charcoal 41,700 ± 2,500 B.P. (GrN-11195) and 39,500 ± 1,200 B.P. (GrN-11190) (Fig. III-10).

The next unit of Grubgraben is the much more extended fine laminated loess with micropodzolic horizons (unit LS). This loess body shows close similarities with the stratified loessic deposits containing most of the Aurignacian and Gravettian assemblages known in the surroundings of Krems, where they were dated in several localities between 34,000 and 25,000 B.P. (Hahn, 1977; Otte, 1981). As the facies of these deposits is also close to those of the upper loess cover at Stratzing and at Stillfried (Felgenhauer et al., 1959; Fink, 1962; Haesaerts, 1990), it seems most probable that the loess unit LS of Grubgraben encompasses part of the second half of the Middle Pleniglacial and also the beginning of the Upper Pleniglacial.

From this interpretation, it is obvious that the major part of the sequence of Grubgraben, which includes the five archaeological layers, belongs to the second half of the Upper Pleniglacial and has no or little equivalent, until now, in Lower Austria. This does not mean that loessic deposits of this period are totally absent elsewhere in that area, but they probably could not be recognized as it, because of the lack of chronological markers. The same situation also exists in the Moravian loess area (Fig. III-11), where almost all the Upper Palaeolithic settlements, dated between 31,000 and 25,000 B.P., occur at the base or below the Upper Pleniglacial loess cover (Otte, 1981; Svoboda, 1986; Haesaerts, 1985, 1990).

On the other hand the stratigraphical sequence of Grubgraben shows undoubtedly close similarities with the Upper Pleistocene loess record of Hungary (Pecsi, 1978). For instance, at Mende and at Tapiosüly, sections situated to the east of Budapest, sandy stratified rill-washed loess interlayered with pure loess, are associated with two well developed humic horizons dated respectively 20,520 ± 290 B.P. and 16,750 ± 400B.P. on charcoal (Fig. III-11). According to M. Pecsi, E. Szebenyi and M. Pevzner (1979), more humid climatic conditions also prevailed here at the end of the Upper Pleniglacial period, just before the deposition of a last homogeneous sandy loess. In a similar context, at the Palaeolithic site of Sagvar near lake Balaton, two weak humic horizons with Epigravettian material, separated by 2 m loess, were also dated 18,900 ± 100 B.P. (lower horizon.) and 17,160 ± 150 B.P. (upper horizon) on charcoal. Both horizons were ascribed to two short, rather mild and humid climatic events by V. Gabori-Csank (1976), who suggested a possible correlation with the Lascaux interstadial of Southwestern France (Leroi-Gourhan, 1967; 1980).

In such a system, it is obvious that Grubgraben provides invaluable information on the evolution of sedimentation and climate during the final part of the last glaciation. Combined with other records of Lower Austria, those data led to the development of a remarkable regional loess sequence for the Upper Pleistocene, which has to be considered, more and more, as one of the best documented stratigraphical and archaeological references for Central Europe.

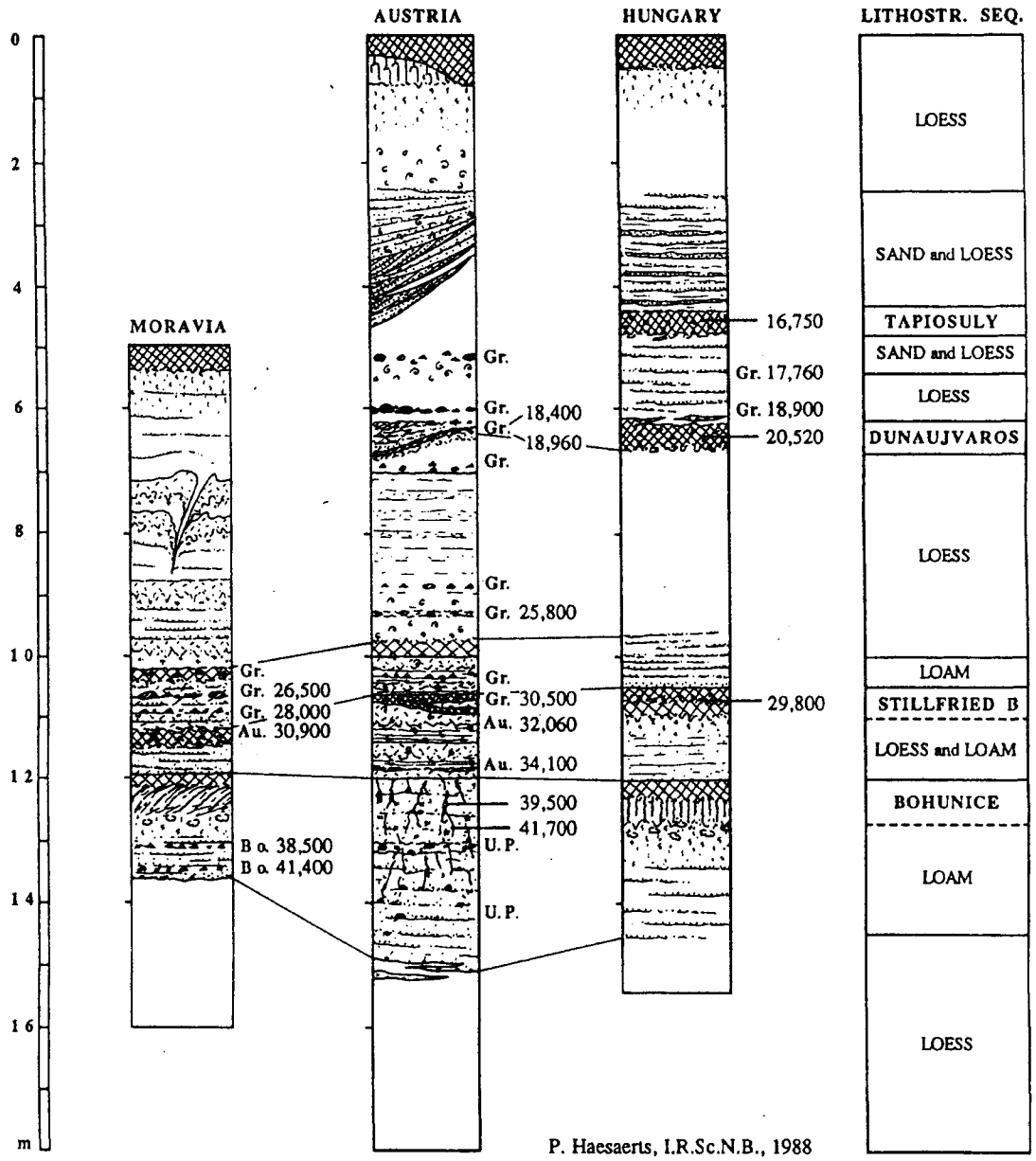


Fig.III-11 . Comparative Upper Würmian loess records of Moravia (Dolnivestonice and Stranskala), Austria (Willendorf and Grubgraben) and Hungary (Mende and Tapiosüly) (graphic symbols : see Figure III. 10).